EE215 – FUNDAMENTALS OF ELECTRICAL ENGINEERING

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WEEK 3
CIRCUIT ANALYSIS (I)

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QUESTIONS TO ANSWER

- Terminology
  - What are those terminologies?
- Node Voltage method
  - What is a reference node?
  - How to establish node voltage equations for an electric circuit?
- Supernode
  - What is a supernode?
  - How to apply the technique to analyze an electric circuit?

SYSTEMATIC TECHNIQUES FOR CIRCUIT ANALYSIS

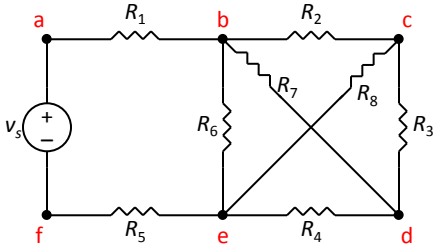
- Kirchhoff's Laws, Ohm's Law, (and Δ-Y-transforms) gave us some basic tools to analyze resistive circuits.
- These tools will become cumbersome for more complex circuits.
- Need to develop more powerful, systematic methods for circuit analysis.
  - "Node-Voltage-Method"
  - "Mesh-Current-Method"

TERMINOLOGY

Definitions

- Essential node:
- Branch:
- Essential branch:
- Mesh:
- Planar circuit:

EXAMPLE



- Essential nodes:
- Essential branches:
- Meshes:
- Planar circuit:

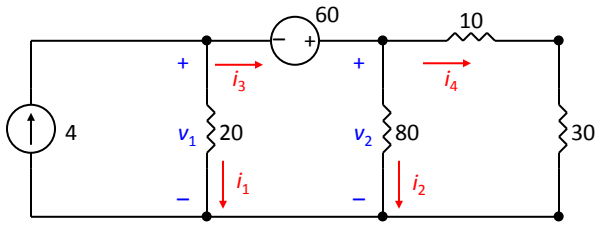
EXAMPLE

- Essential nodes:
  b, c, d, e
- Essential branches:
  bc, bd, be, bafe, ce, cd, de
- Meshes:

- Planar circuit:

NODE VOLTAGE METHOD

Example



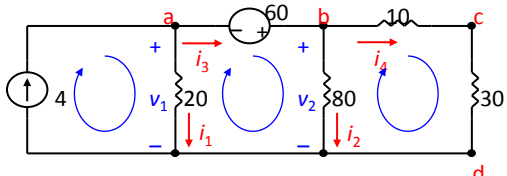
- Nodes:
- Essential nodes:
- Essential branches:
- Meshes:

NODE VOLTAGE METHOD (2)

- How do we solve this system?
- Approach 1

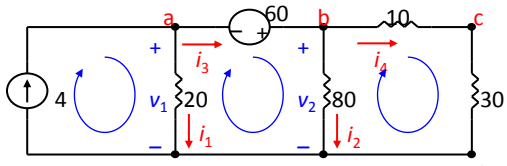
NODE VOLTAGE METHOD (3)

- Approach 2



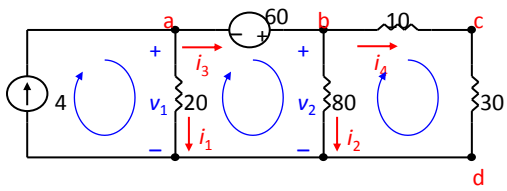
NODE VOLTAGE METHOD (4)

- Essential nodes:
  - a: (1)
  - b: (2)



NODE VOLTAGE METHOD (5)

- b_e = 5 currents (1 is known)
  Need to derive 2 more eq.s from meshes
  - abd: (3)
  - bcd: (4)



NODE VOLTAGE METHOD (6)

- Essential nodes:
  a: $-4 + i_1 + i_3 = 0$ (1)
  b: $-i_3 + i_2 + i_4 = 0$ (2)
- b_e = 5 currents (1 is known)
  Need to derive 2 more eq.s from meshes
  abd: $-60 + 80i_2 - 20i_1 = 0$ (3)
  bcd: $10i_4 + 30i_4 - 80i_2 = 0$ (4)
  From (1):
  Plug into (3):
  From (2)
  Plug into (4):

NODE VOLTAGE METHOD (7)

- Now we have 2 eq.s with 2 unknowns:

NODE VOLTAGE METHOD (8)

- Is there a faster solution?
- Definition:
- Note: Node voltages appeared in eq.s (3) and (4).
- Approach 3:

NODE VOLTAGE METHOD (9)

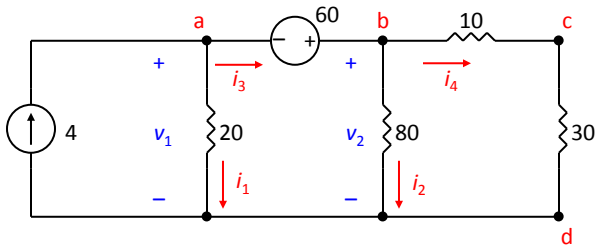
- Node Voltage: Voltages are measured between two points.
- We have been using the ends of circuit elements as the points, and getting the voltage across the element.
- But what if we chose one node and measured all other voltages with respect to that node?
- We call the one node we choose the **reference node**.

NODE VOLTAGE METHOD (10)

- **reference node**. :

- We mark the reference node with a special symbol, also called the ground symbol.
- The voltage between any node and the reference node is then a *node voltage*.

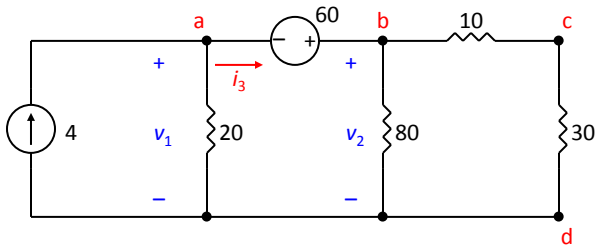
NODE VOLTAGE METHOD (11)



a: (1)
b: (2)
(3)

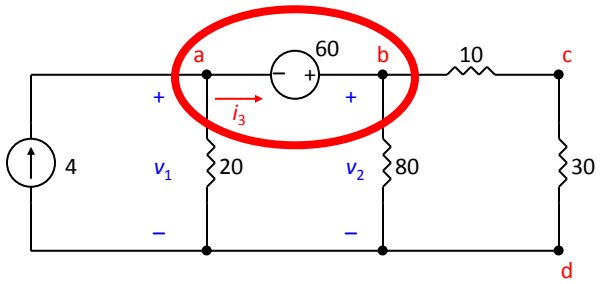
- (1) + (2), plug in (3):

NODE VOLTAGE METHOD (12)



- Can we do even better?
-
-

NODE VOLTAGE METHOD (13)



- KCL holds for this supernode:

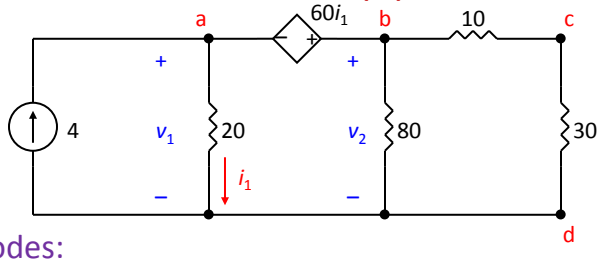
(1')

(3')

DEPENDENT SOURCES IN THE NODE VOLTAGE METHOD (1)

- Modify our previous example:
  - Replace 60V source with current dependent voltage source (CDVS).

DEPENDENT SOURCES IN THE NODE VOLTAGE METHOD (2)



- Solve circuit:

  Find essential nodes:

  Identify node voltages and reference node:

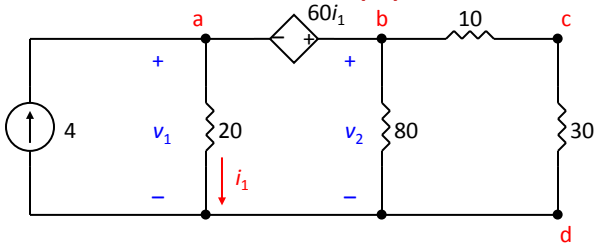
  Identify supernode(s):

  Set up equation(s) for each (super)node:

  (1)

  (2)

DEPENDENT SOURCES IN THE NODE VOLTAGE METHOD (3)

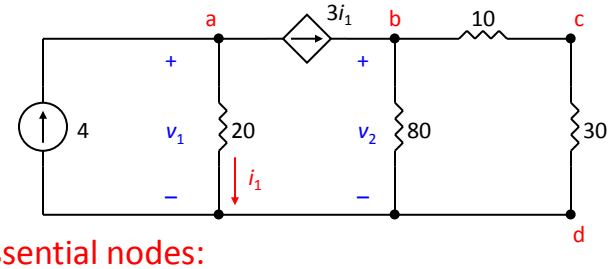


- From (2):

(2')

- Plug (2') into (1):

MODIFIED EXAMPLE: REPLACE CDVS WITH CDCS



- No supernodes!
- Equations for essential nodes:
  At a: (1)
  At b: (2)
- From (1):

- Plug into (2):