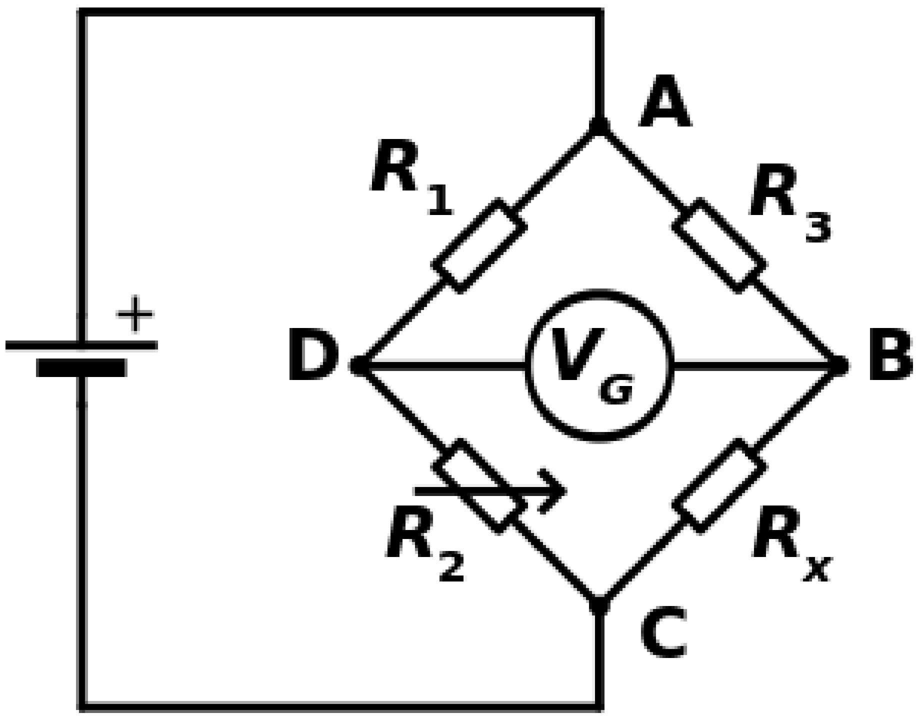
Discussion 2

9/29/2016

Reading: Chapter 4

Wheatstone Bridge

- Measuring Rx
- -How?
- -What's the use of R2?



Nodal vs. Mesh

- In principle both the nodal analysis and mesh analysis are useful for any given circuit.

- What then determines if one is going to be more efficient for solving a circuit problem?

- There are two factors that dictate the best choice:
  - The nature of the particular network
  - The information required

Nodal Analysis if…

- If the network contains:
  - Many parallel connected elements
  - Current sources
  - Supernodes
  - Circuits with fewer nodes than meshes

- If node voltages are what are being solved for
- Non-planar circuits can only be solved using nodal analysis

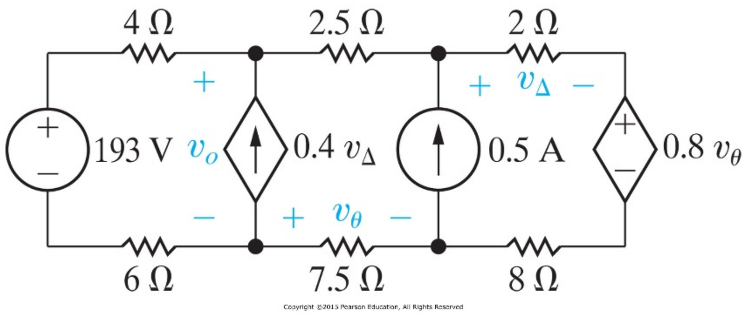
- This format is easier to solve by computer
  - Easy to program

Mesh Analysis when…

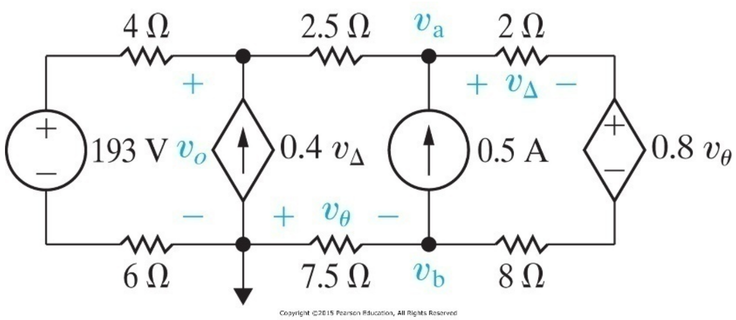
- If the network contains:
  - Many series connected elements
  - Voltage sources
  - Supermeshes
  - A circuit with fewer meshes than nodes
- If branch or mesh currents are what is being solved for.

- Mesh analysis is the only suitable analysis for transistor circuits.
- It is not appropriate for operational amplifiers because there is no direct way to obtain the voltage across an op-amp.

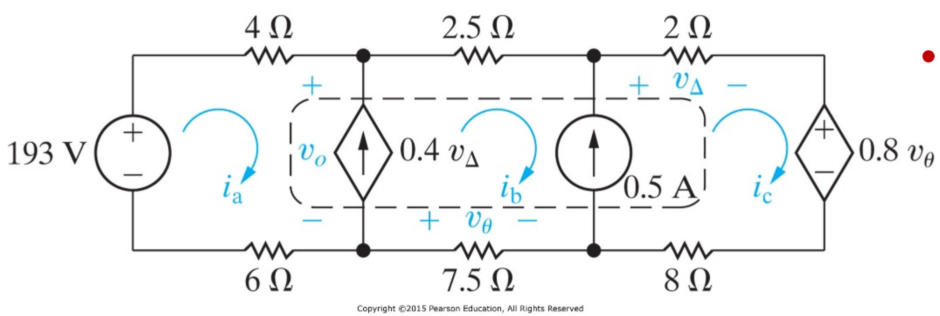
Example



- Find v_0 in the circuit, which has
  - 4 nodes
  - 3 meshes
  - 2 dependent sources

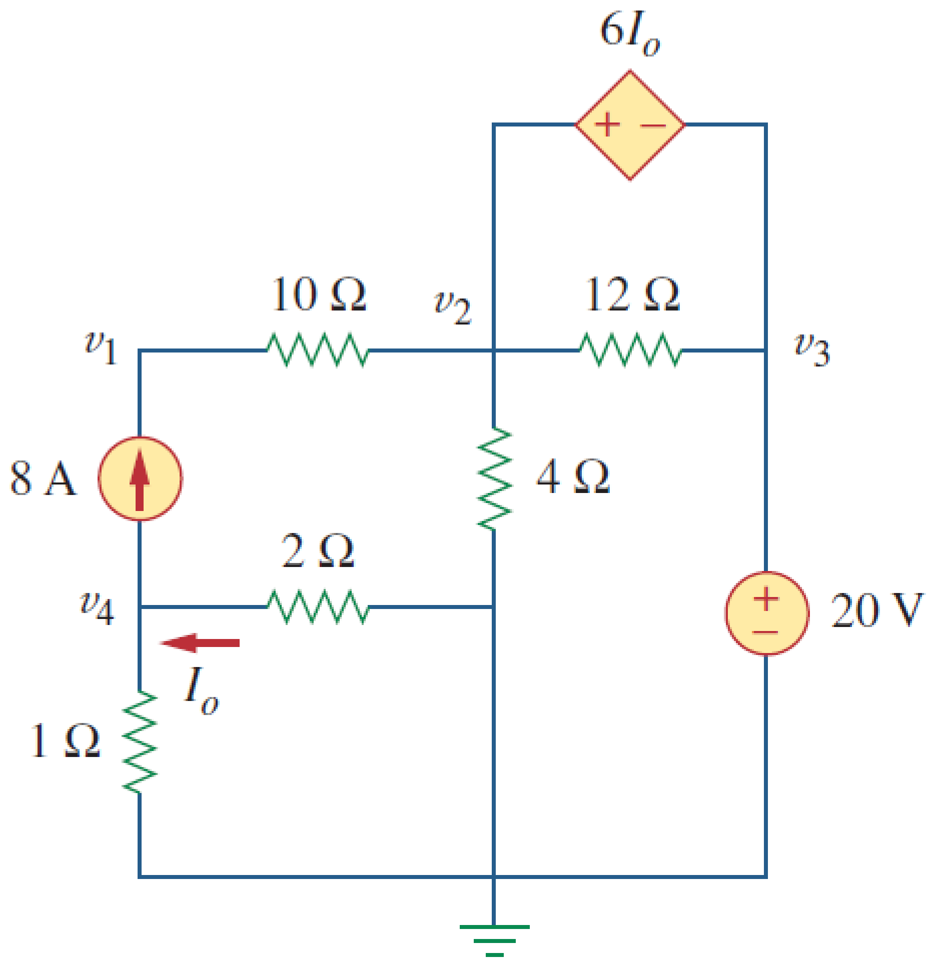


- Nodal
  - 3 node-voltage equations
  - 2 constraint equations



- Mesh
  - 1 supermesh
  - 4 constraint equations

Extra Exercise – Find v1,v2,v3,v4

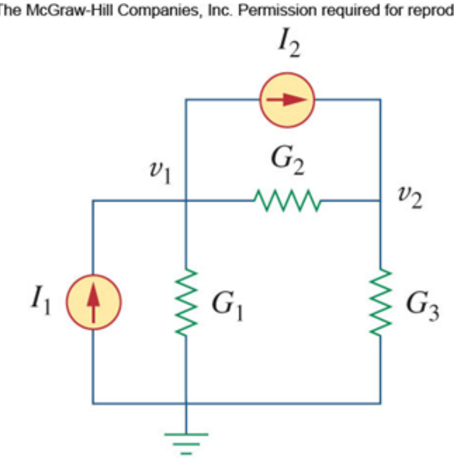


Result

Clearly, v_1 = **84 volts**, v_2 = **4 volts**, v_3 = **20 volts**, and v_4 = **-5.333 volts**

Nodal Analysis by Inspection

- A faster way to construct a matrix for solving a circuit by nodal analysis
  - It requires that the circuit should only have independent current sources.



- The equations for the example

$$\begin{bmatrix} G_1 + G_2 & -G_2 \\ -G_2 & G_2 + G_3 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} I_1 - I_2 \\ I_2 \end{bmatrix}$$

Method of obtaining Node-Voltage Matrices

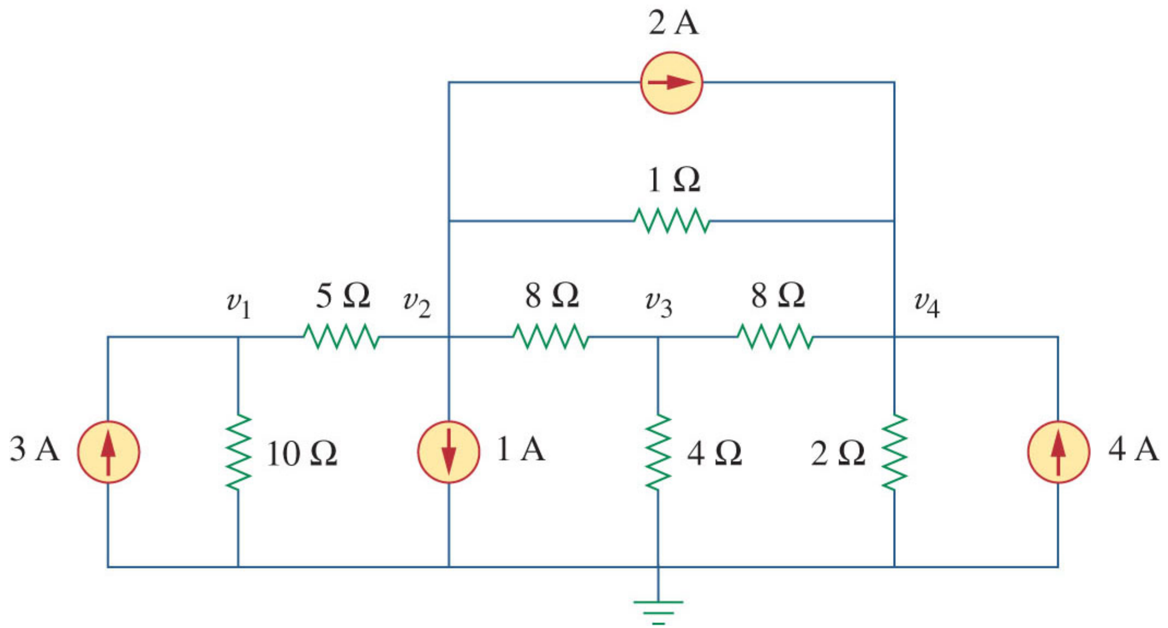
- A circuit with N non-reference nodes:

$$\begin{bmatrix} G_{11} & G_{12} & \cdots & G_{1N} \\ G_{21} & G_{22} & \cdots & G_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ G_{N1} & G_{N2} & \cdots & G_{NN} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_N \end{bmatrix}$$

- G_{kk} = Sum of the conductances connected to node k
- $G_{kj} = G_{jk}$ = Negative of the sum of the conductances directly connecting nodes k and j, k≠j
- V_k = Unknown voltage at node k
- $\boldsymbol{i}_k$ = Sum of all independent current sources directly connected to node k, with currents entering the node treated as positive

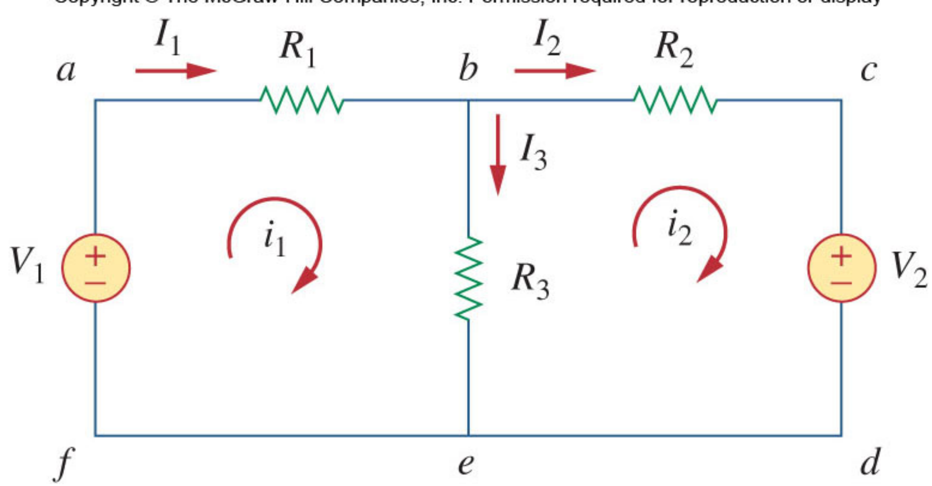
Exercise

- By inspection, obtain the node-voltage equations for the circuit shown below



Mesh Analysis by Inspection

- There is a similarly fast way to construct a matrix for solving a circuit by mesh analysis
  - **It requires that the circuit should only have independent voltage sources.**



$$\begin{bmatrix} R_1 + R_3 & -R_3 \\ -R_3 & R_2 + R_3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ -V_2 \end{bmatrix}$$

Method of obtaining Mesh-Current Matrices

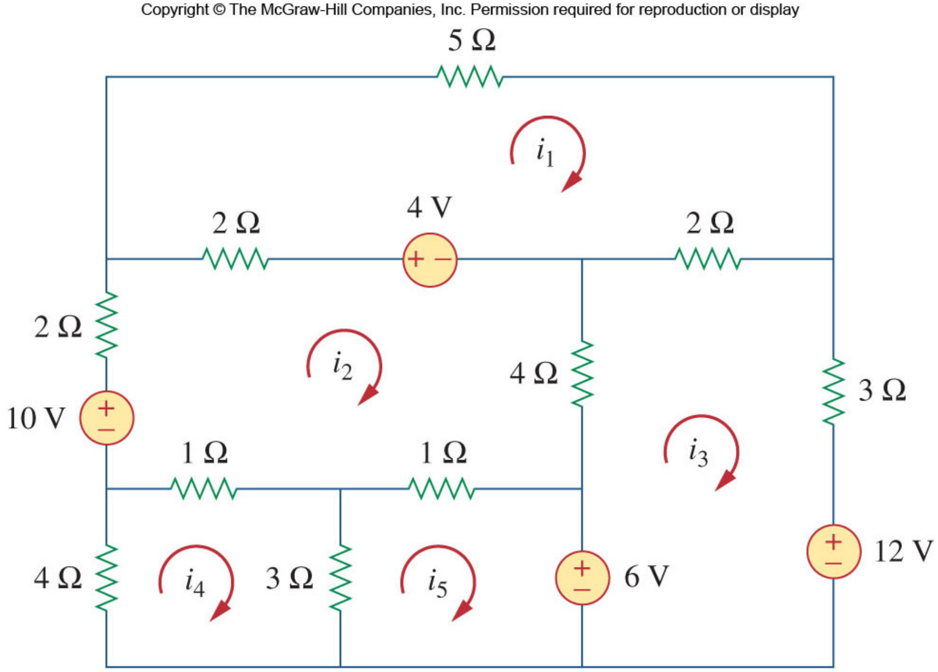
- A circuit with N meshes:

$$\begin{bmatrix} R_{11} & R_{12} & \cdots & R_{1N} \\ R_{21} & R_{22} & \cdots & R_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ R_{N1} & R_{N2} & \cdots & R_{NN} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_N \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{bmatrix}$$

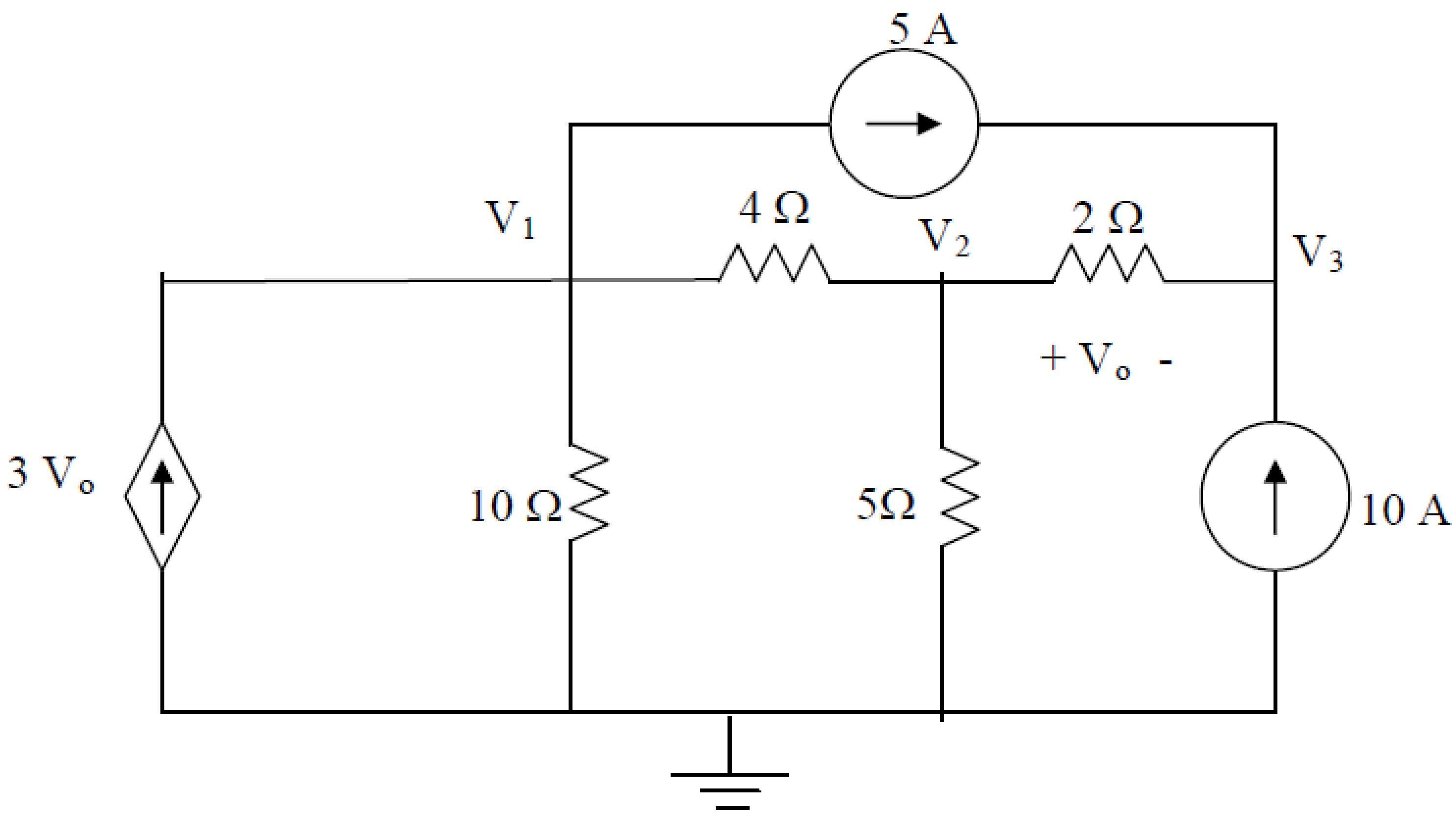
- R_{kk} = Sum of the resistances in mesh k
- $R_{kj} = R_{jk}$ = Negative of the sum of the resistances in common with meshes k and j, k≠j
- i_k = Unknown mesh current for mesh k in the clockwise direction
- V_k = Sum taken clockwise of all independent voltage sources in mesh k, with voltage rise treated as positive

Exercise

- By inspection, obtain the mesh-current equations for the circuit shown below



Actually, dependent sources can also exist when applying inspection method.



Solution:

$$\begin{bmatrix} 0.35 & -0.25 & 0 \\ -0.25 & 0.95 & -0.5 \\ 0 & -0.5 & 0.5 \end{bmatrix} V = \begin{bmatrix} -5+3V_o \\ 0 \\ 15 \end{bmatrix}$$

Since we actually have four unknowns and only three equations, we need a constraint equation.

$$V_o = V_2 - V_3$$

Substituting this back into the matrix equation, the first equation becomes,

$$0.35V_1 - 3.25V_2 + 3V_3 = -5$$

This now results in the following matrix equation,

Final Matrix:

$$\begin{bmatrix} 0.35 & -3.25 & 3 \\ -0.25 & 0.95 & -0.5 \\ 0 & -0.5 & 0.5 \end{bmatrix} V = \begin{bmatrix} -5 \\ 0 \\ 15 \end{bmatrix}$$