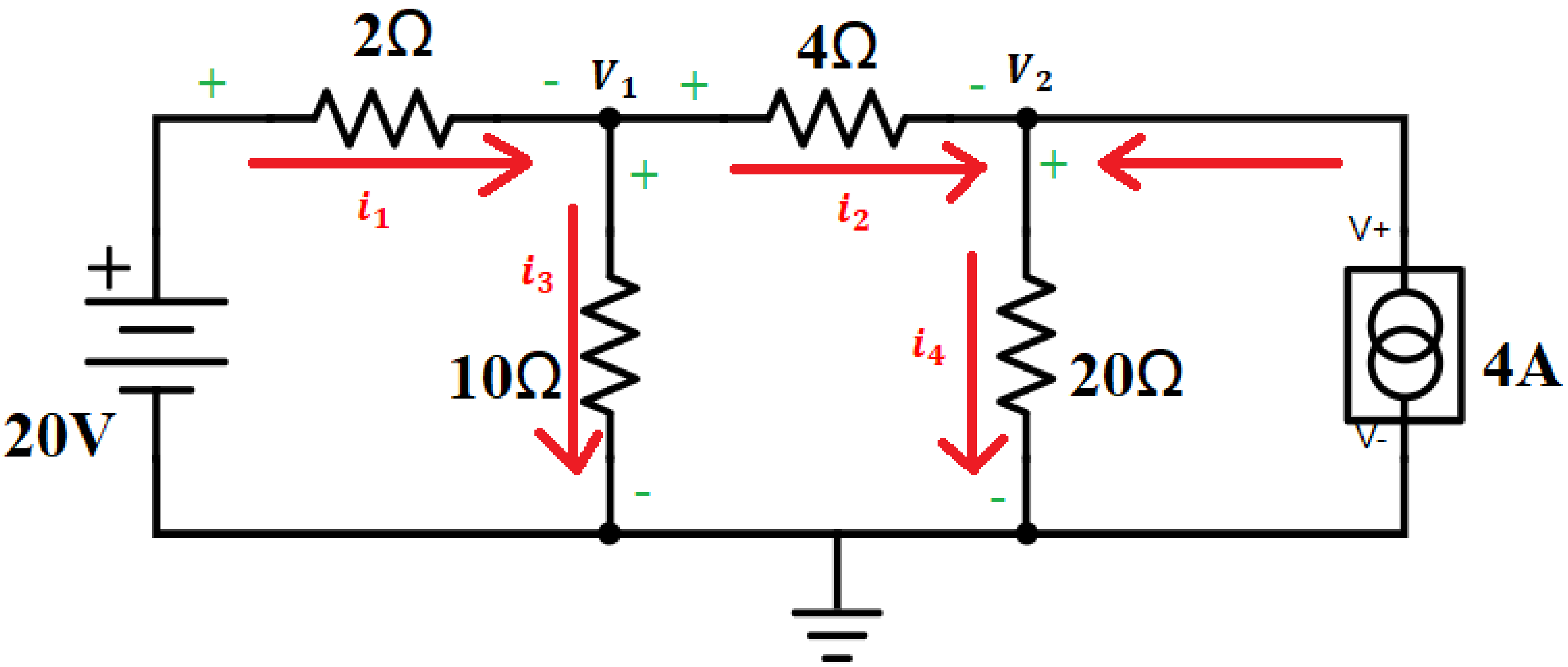
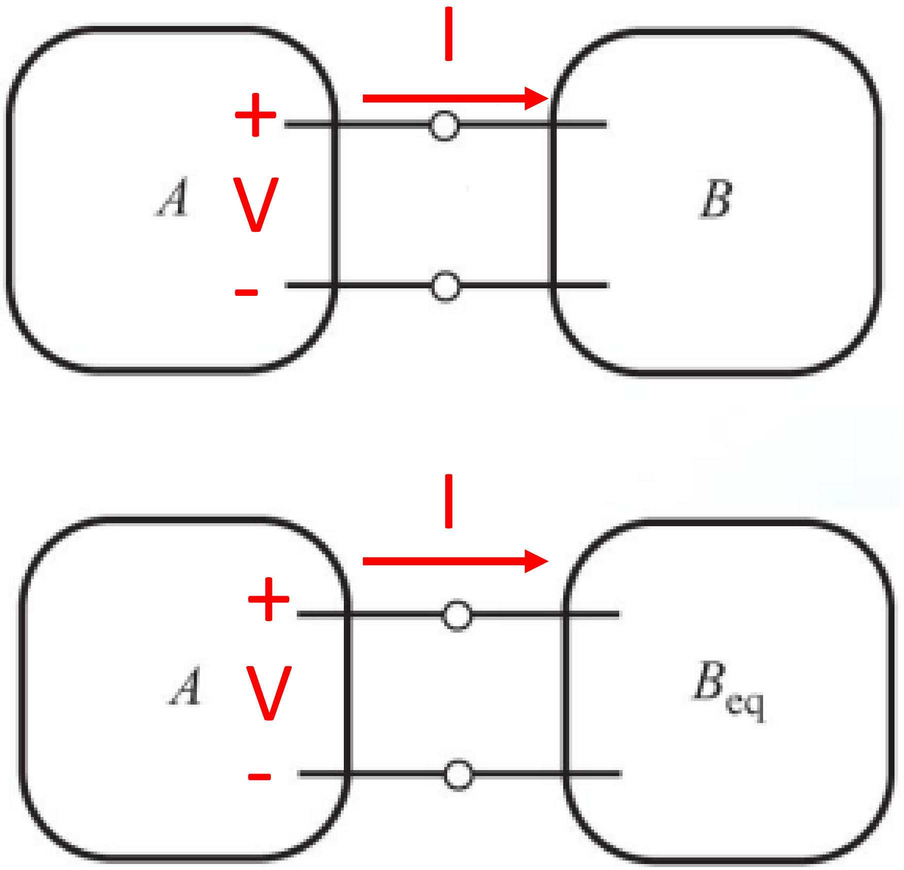
TOPIC #3 CKT Analysis



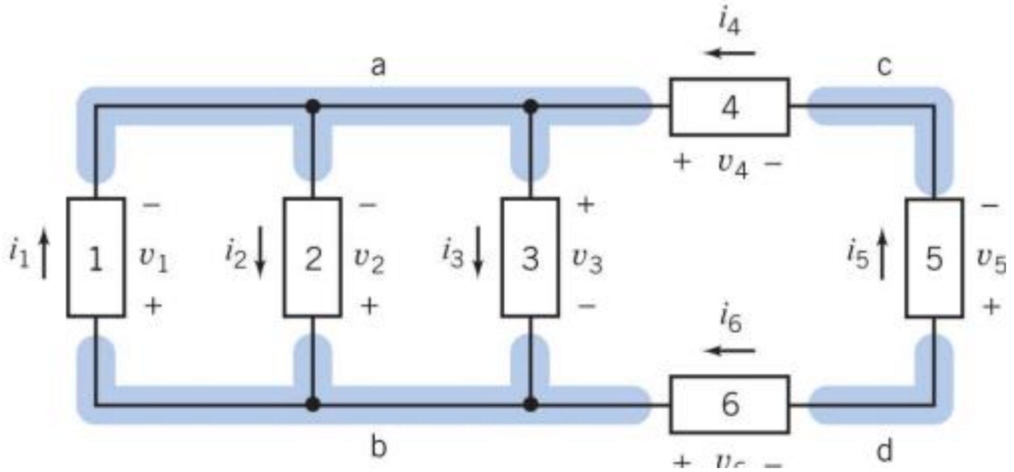
Circuit model

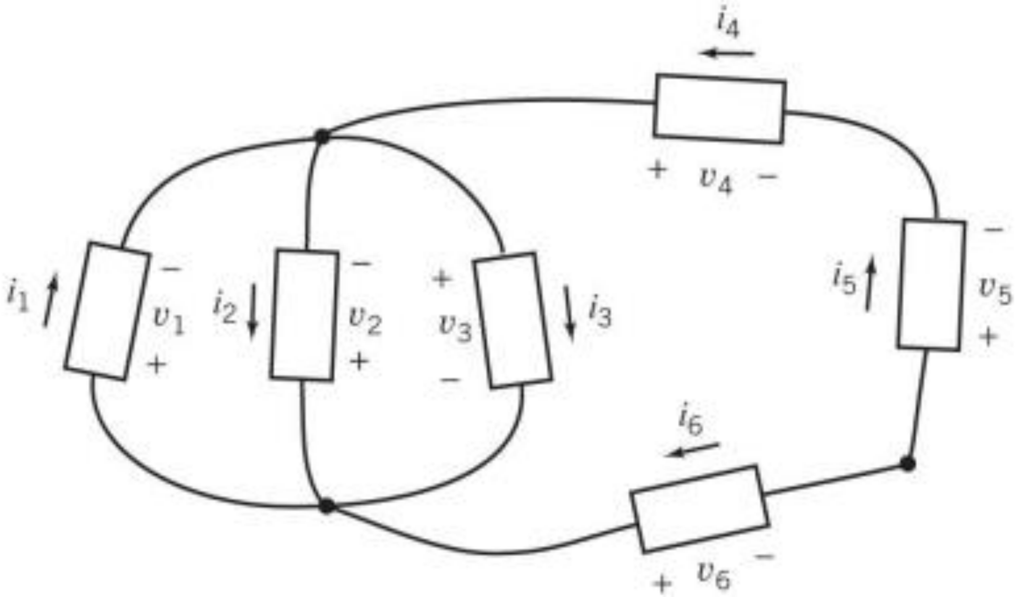
- Circuit model
  - The V/I output behavior of A is independent of the load B.
  - Usually, we have Thevenin and Norton equivalence circuit
  - The main purpose of the circuit model is to focus on the circuit behavior but not how to construct the circuit



Kirchhoff’s Laws(1/5)

- A node is a point where two or more circuit elements join
  - If only two elements connect to form a node, they are in series
  - Elements in series share the same current
- Closed path: a loop starting and ending at the same node and pass intermediate nodes only once





Kirchhoff's Laws(2/5)

- Kirchhoff's current law (KCL)
  - For any node, the algebraic sum of all the currents equals to zero

$$\sum_n in = 0$$

$\boxed{\text{Charge conservation}}$

Kirchhoff's voltage law (KVL)

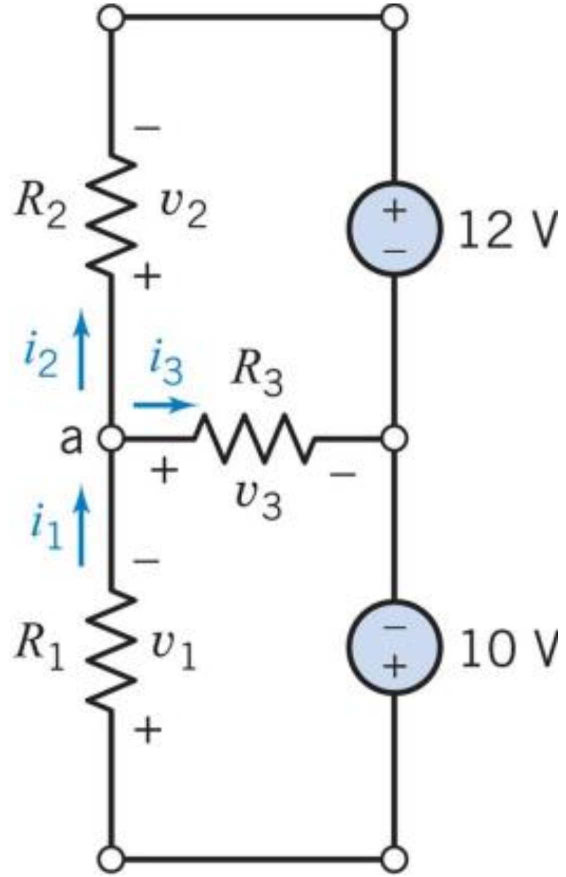
- For any closed path, the algebraic sum of all the voltages equals to zero

$$\sum_n Vn = 0$$

$\boxed{\text{Energy conservation}}$

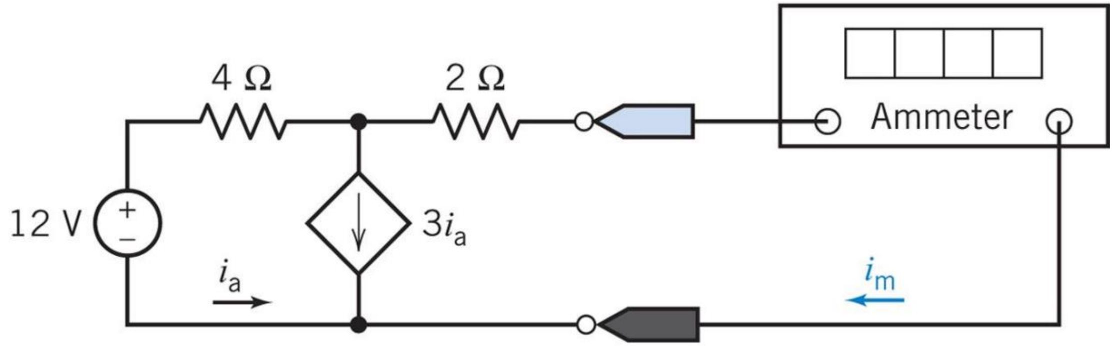
Kirchhoff's Laws(3/5)

- Find each current and each voltage when R1 = 8 Ω, v2 = -10 V, i3 = 2 A, and R3 = 1 Ω. Also, determine the resistance R2 .



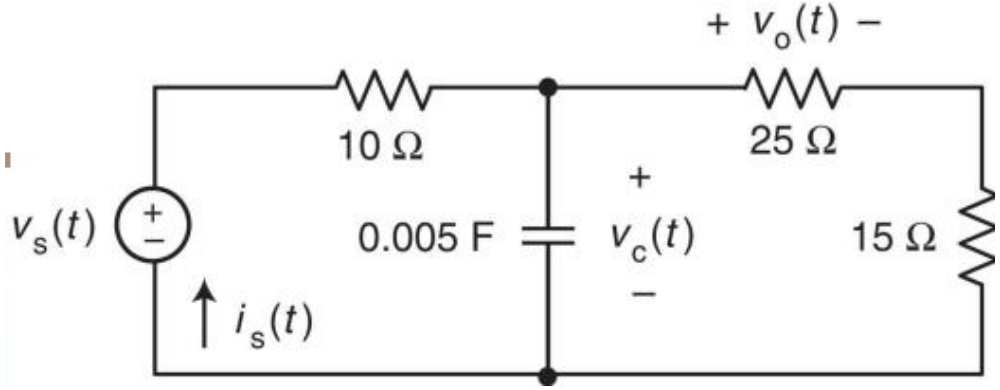
Kirchhoff's Laws(4/5)

- Determine the value of the current



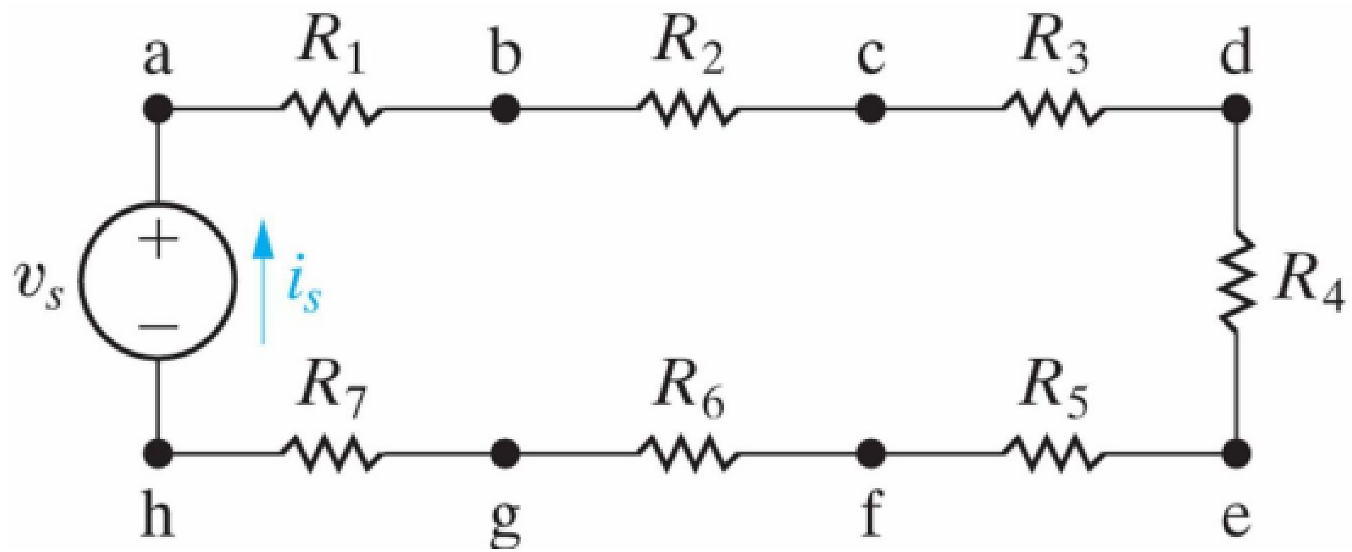
Kirchhoff's Laws(5/5)

- Find Vo (t) when
  - Vs (t)= 50 V; Vc (t)=40-40e $^{-25t}$ V



Voltage division (1/2)

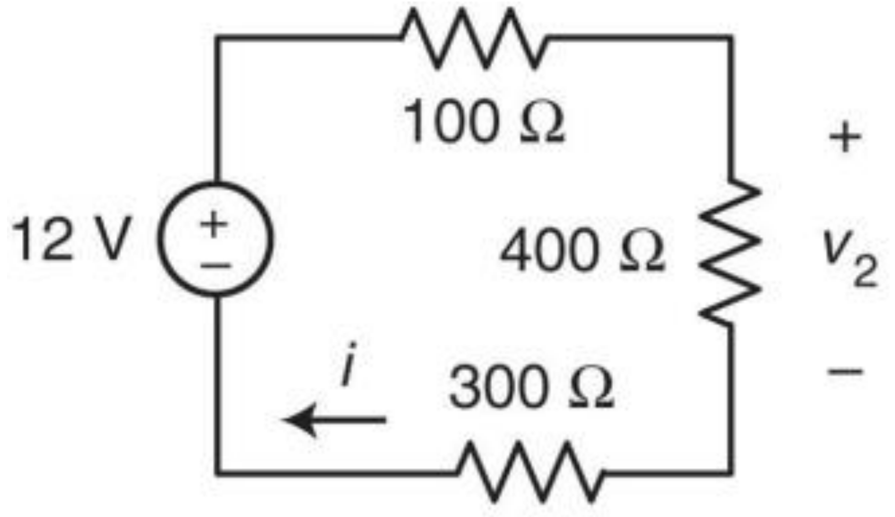
- KCL: all resistors have the same current
- Used to find the voltage drop across a single resistance from a collection of series-connected resistance.



$$v_n = \frac{R_n}{R_1 + R_2 + \ldots + R_k} \bullet v_s$$

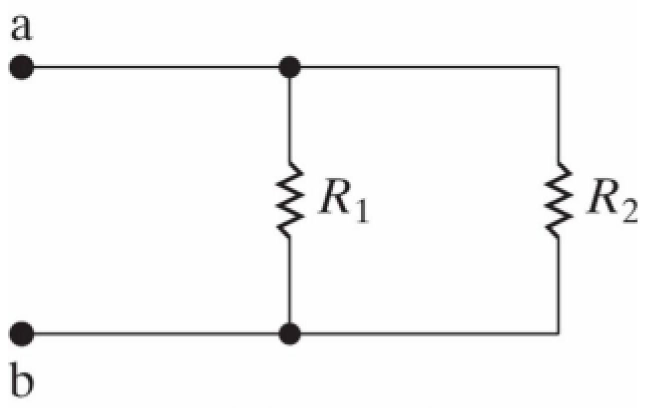
Voltage division(2/2)

- Find V_2



Resistors in Parallel(1/2)

- Equivalent resistance R_{eq} is always smaller than the minimum resistance in parallel connection
- And the smallest resistance dominates the equivalent value
  - Why? Because more current is needed to satisfy KVL
- When we only have two resistors in parallel
  - Current inversely proportional



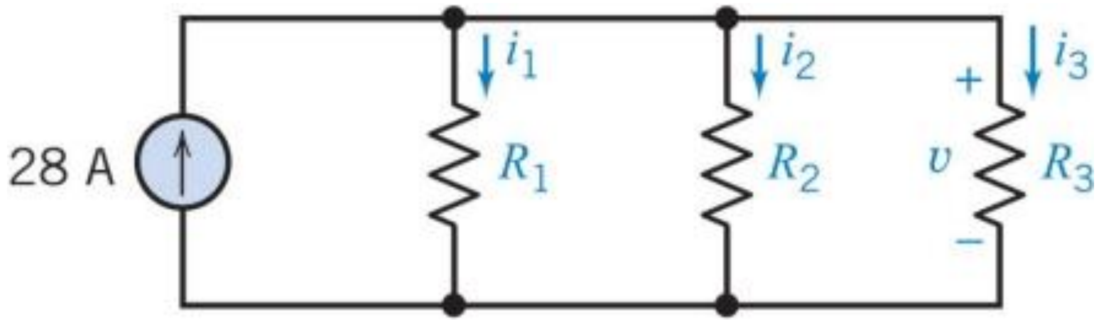
$$R_{eq} = \frac{(R_1 R_2)}{(R_1 + R_2)}$$

$$i_2 = \frac{R_1}{(R_1 + R_2)} i_s$$

Resistors in Parallel(2/2)

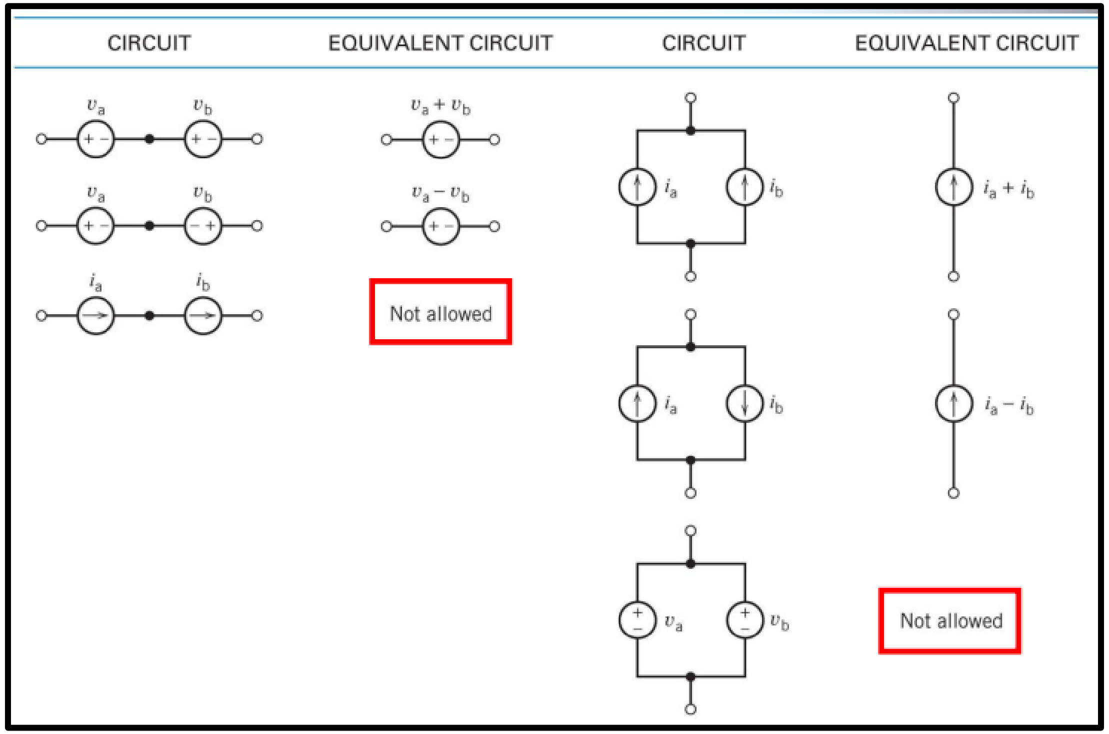
- Find
  - (a) the current in each branch,
  - (b) the equivalent circuit, and
  - (c) the voltage v.

$$R_1 = \frac{1}{2}\Omega;\ R_2 = \frac{1}{4}\Omega;\ R_3 = \frac{1}{8}\Omega$$



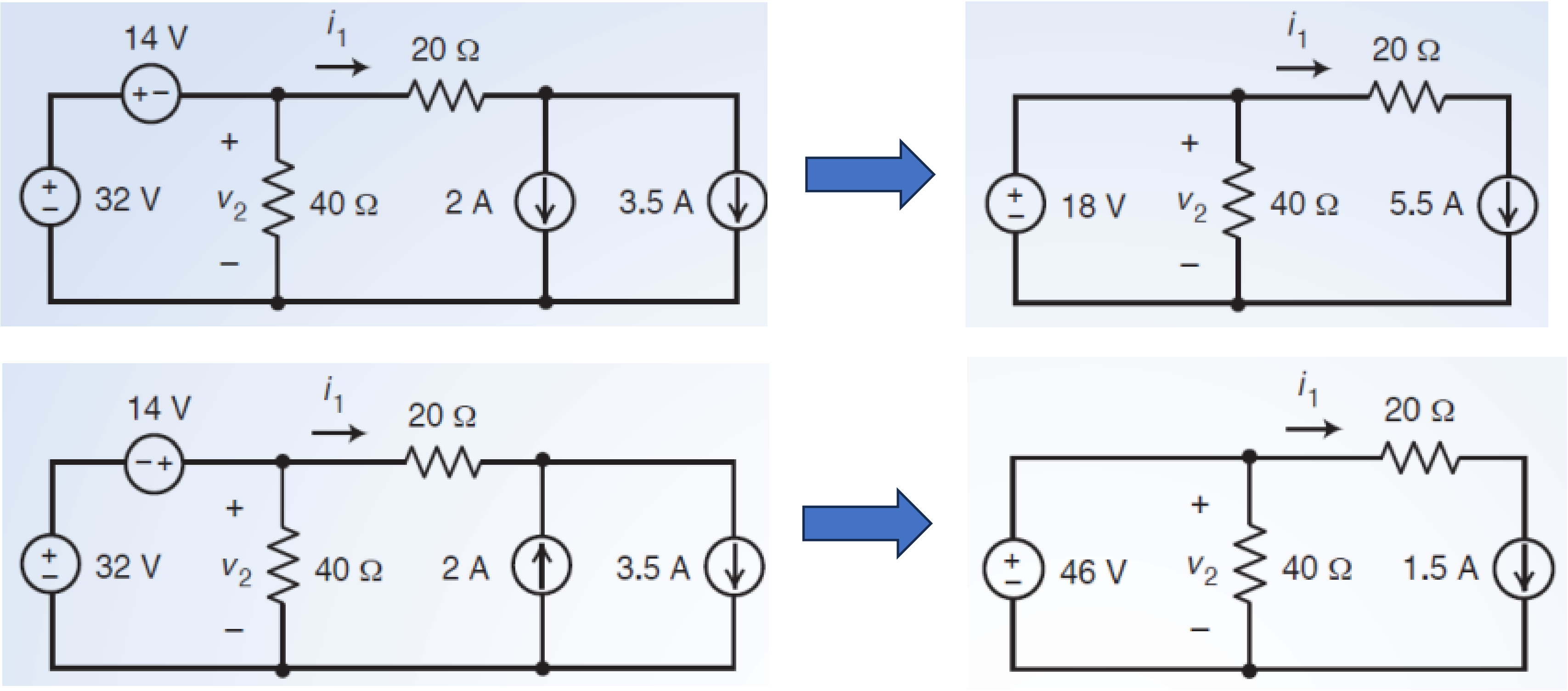
Circuit analysis(1/5)

- Voltage sources connected in series ←→a single voltage source
  - The voltage of the equivalent voltage source is equal to the algebraic sum of voltages of the series voltage sources
- Same concept for current sources



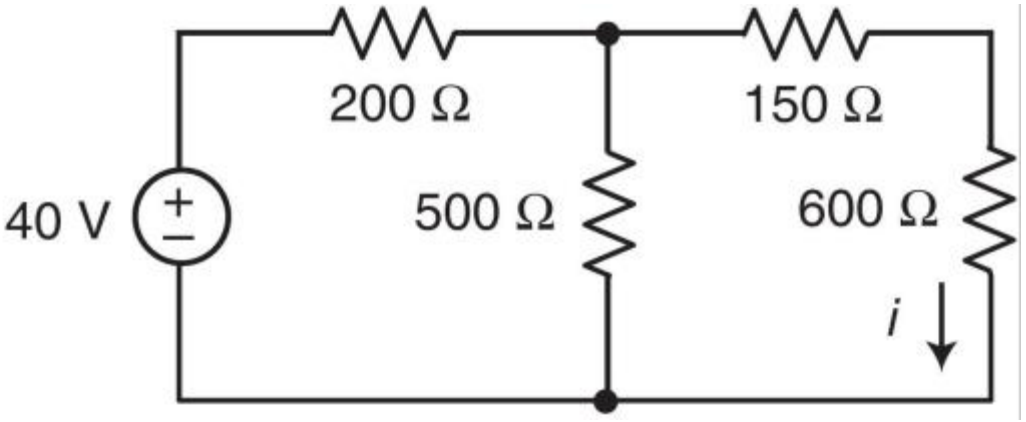
Circuit analysis(2/5)

- In each circuit, replace the series voltage sources with an equivalent voltage source and the parallel current sources with an equivalent current source



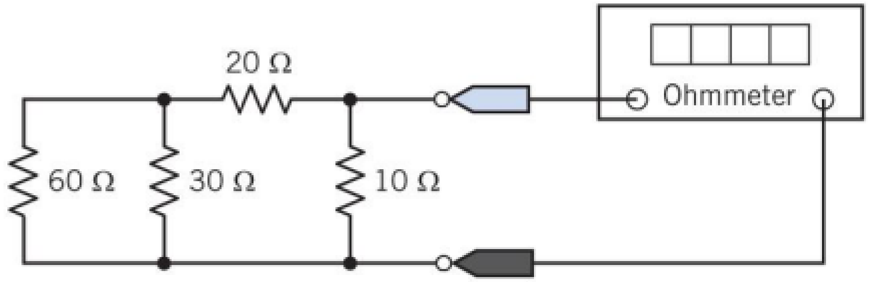
Circuit analysis(3/5)

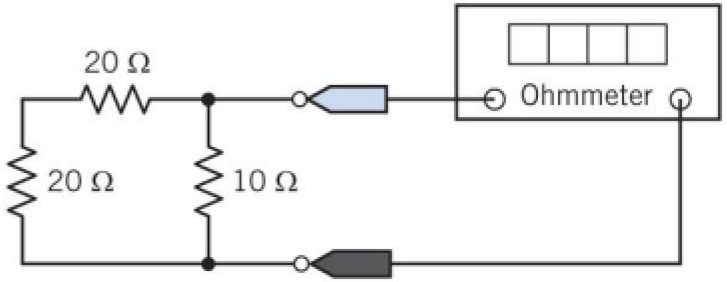
- Determine the value of the current i

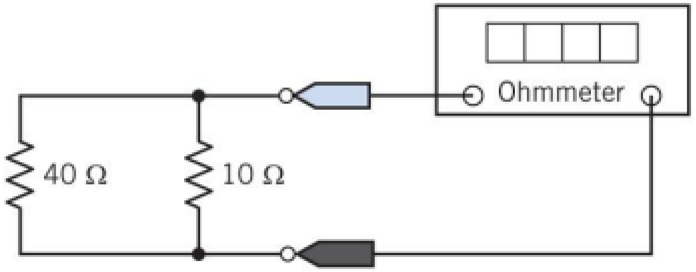


Circuit analysis(4/5)

- Determine the resistance measured

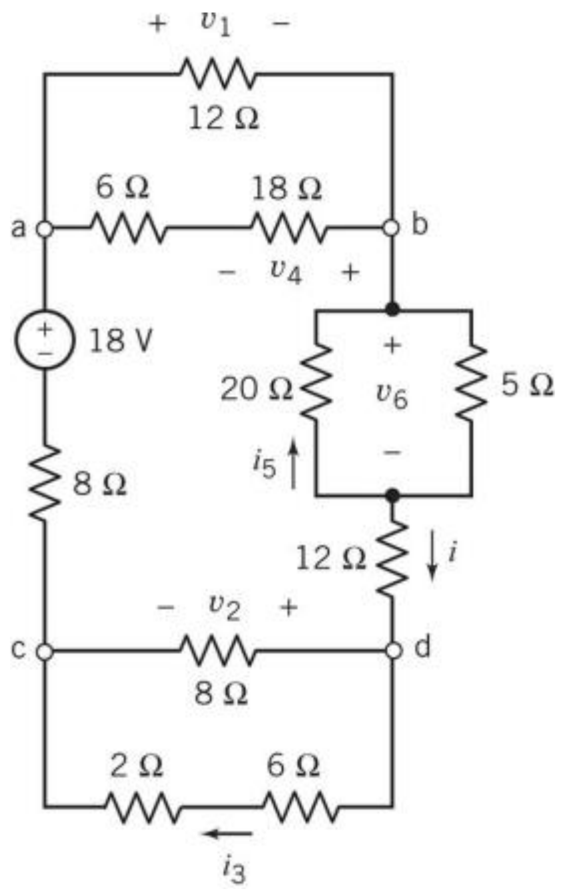






Circuit analysis(5/5)

- Determine the values of i3 , v4 , i5 , and v6 (pay attention to sign)



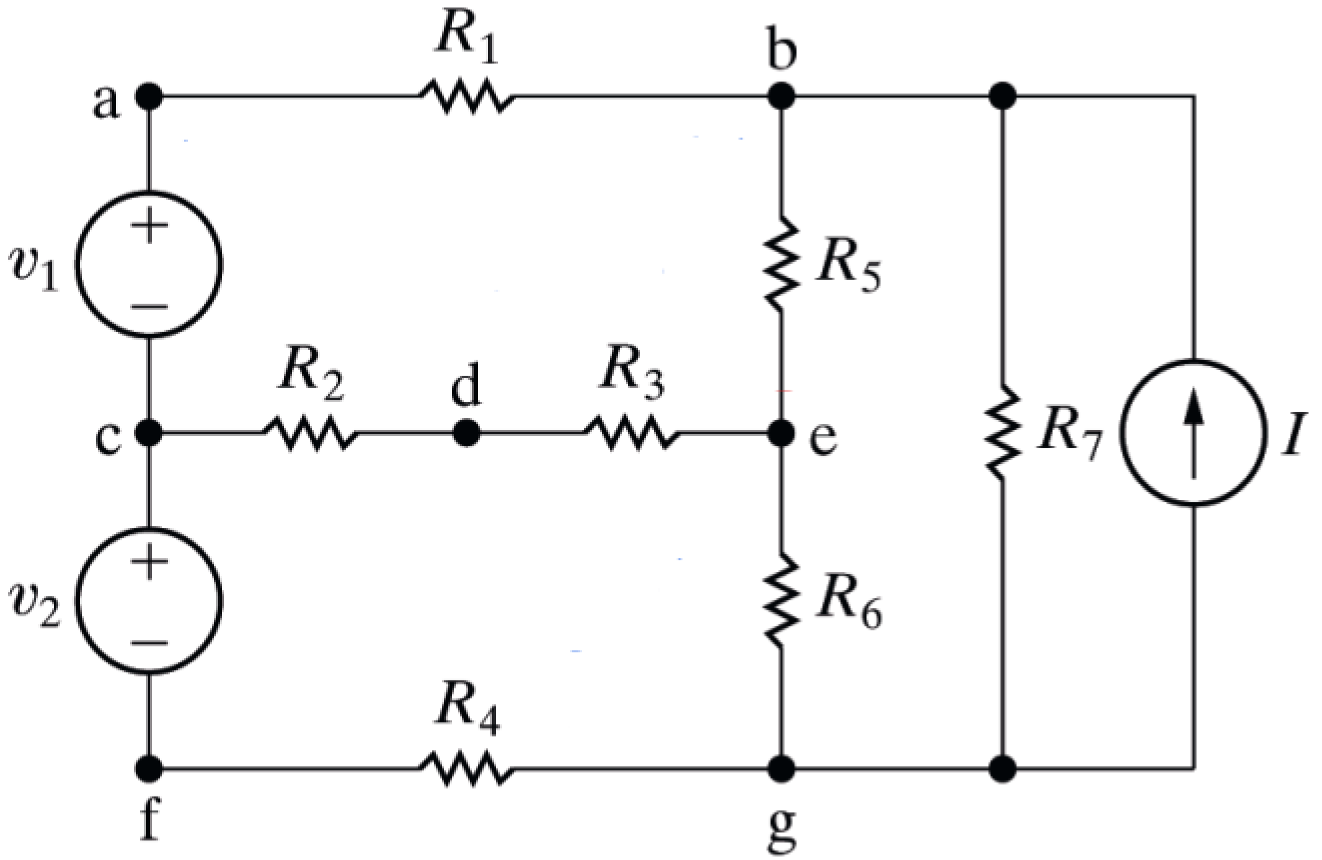
Defining various terms

- Number of essential branch (be) identifies the total unknowns

Name	Definition
node	A point where two or more circuit elements join
$\boxed{\text{essential node}}$	A node where three or more circuit elements join
path	A trace of adjoining basic elements with no elements included more than once
branch	A path that connects two nodes
$\boxed{\text{essential branch}}$	A path which connects two essential nodes without passing through an essential node
loop	A path whose last node is the same as the starting node
$\boxed{\text{mesh}}$	A loop that does not enclose any other loops
planar circuit	A circuit that can be drawn on a plane with no crossing branches

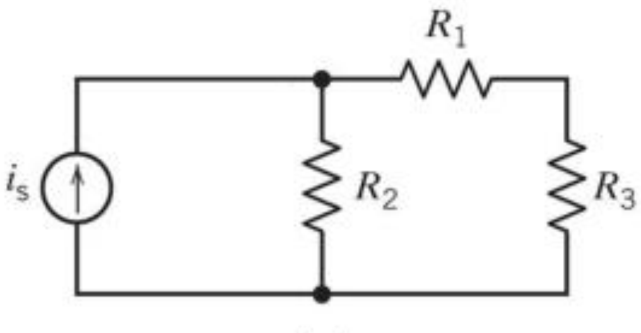
Node, branch, mesh and loop

- 6 unknown currents

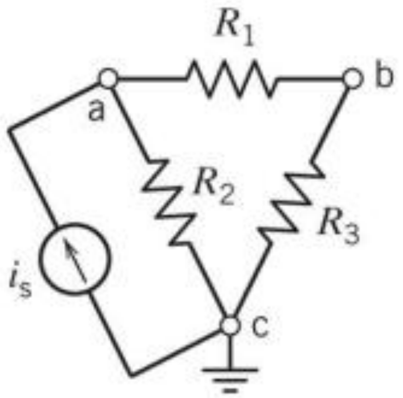


Node-Voltage Method(1/6)

- Meant to simplify our circuit analysis
- A reference node is chosen from among the essential nodes
- Steps:
    1. Identify essential node
    2. Choose an essential node as ground
    3. Using KCL to find the parameters of others node
    4. Super node

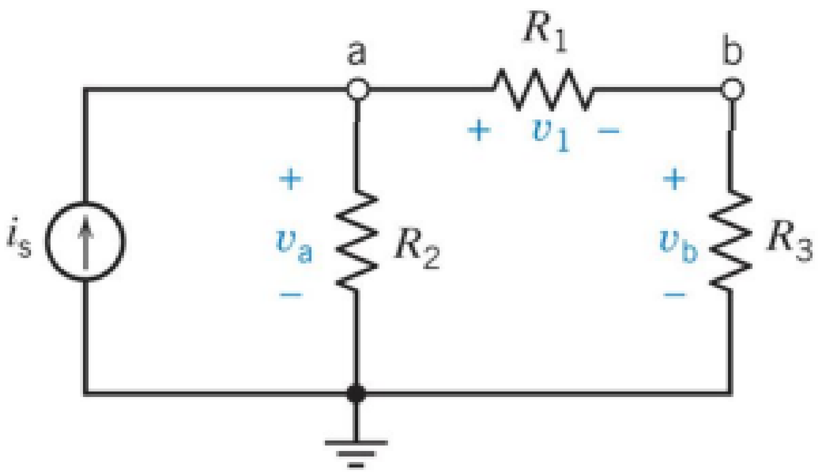


(a)



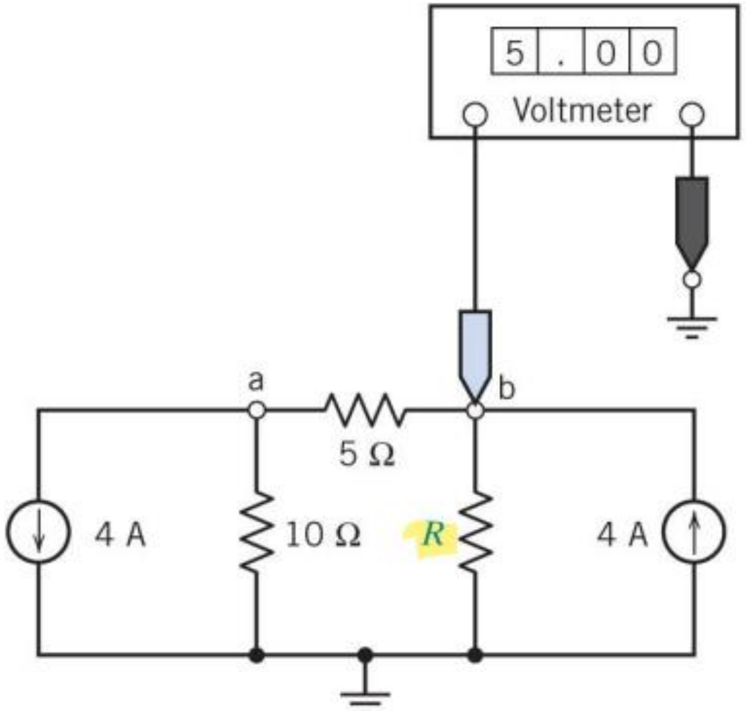
Node-Voltage Method (2/6)

- Writing out the equation sets
  - Do you need to write down KCL for node b?
- If R_1 = 1Ω; R_2 = R_3 = 0.5 Ω, and i_s = 4 A



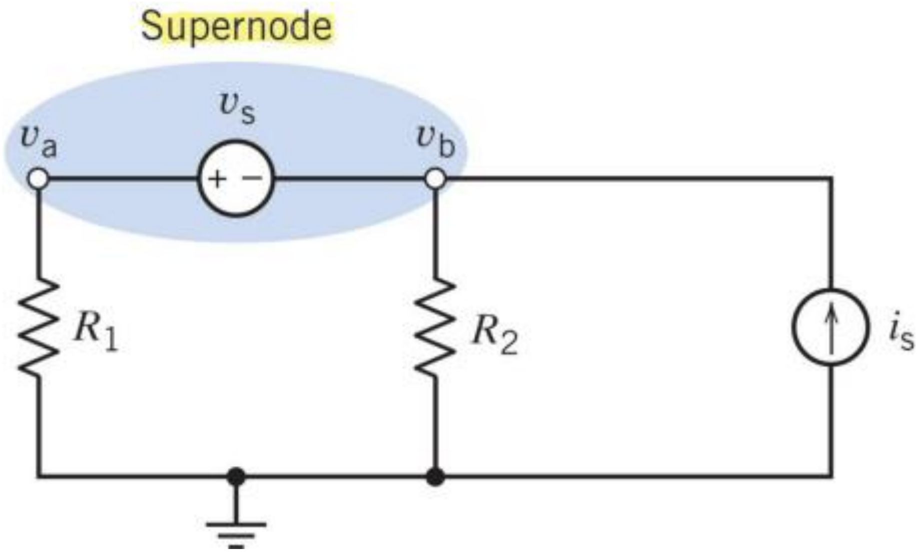
Node-Voltage Method (3/6)

- Writing out the equation sets
  - Do you need to write down KCL for node b?
- If R_1 = 1Ω; R_2 = R_3 = 0.5 Ω, and i_s = 4 A



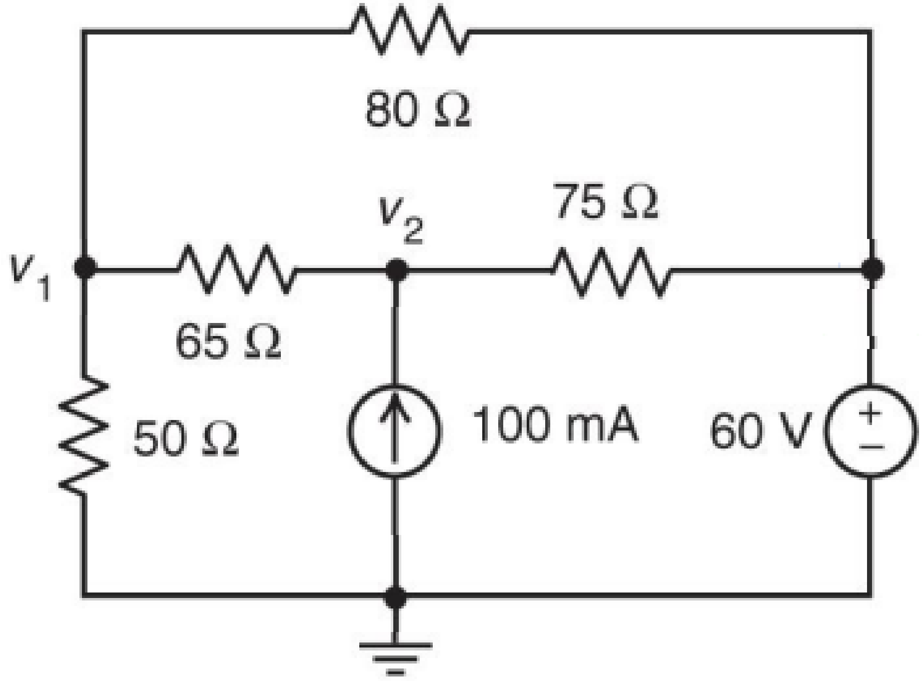
Node-Voltage Method (4/6)

- Introducing supernode
- Two nodes connected by an independent or a dependent voltage source



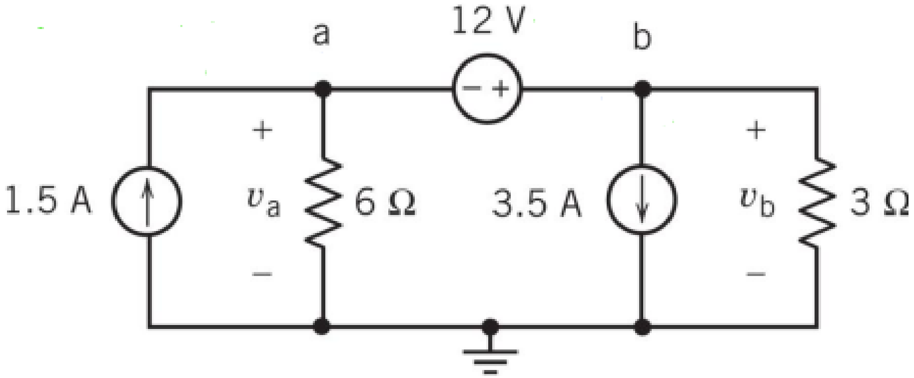
Node-Voltage Method (5/6)

- Determine the node voltages V_1 and V_2



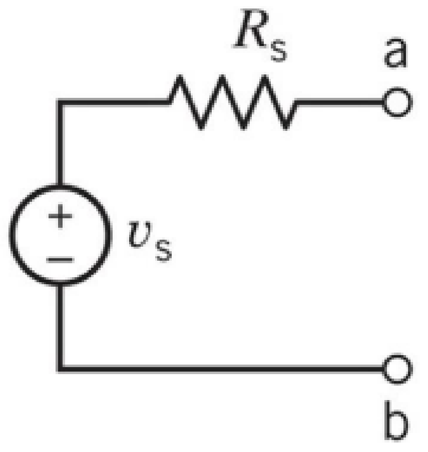
Node-Voltage Method (6/6)

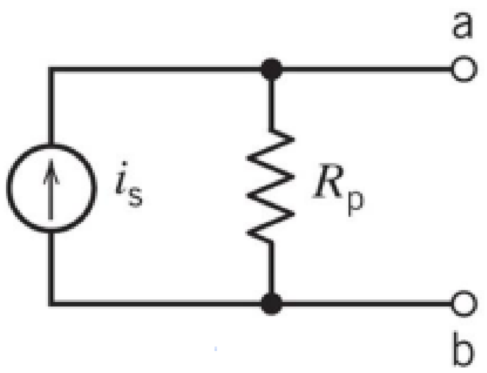
- Determine the values of the node voltages V_a and V_b



Source transformations(1/3)

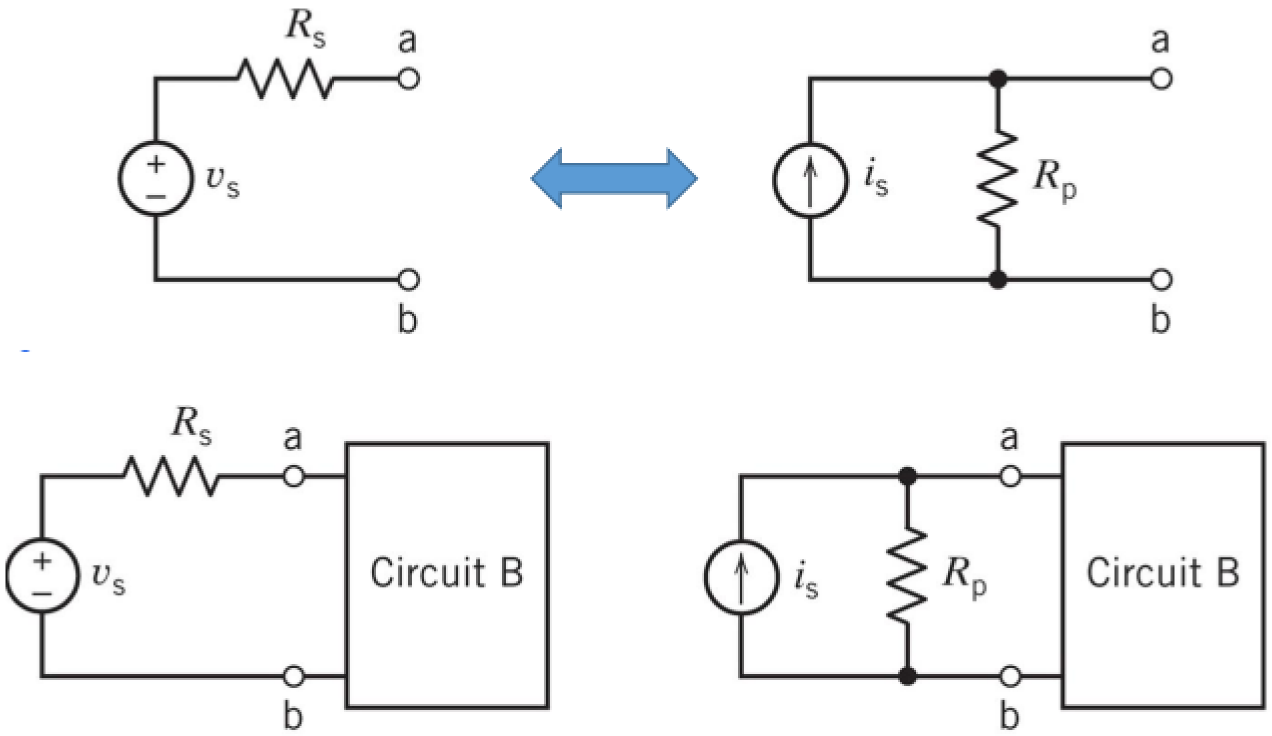
- In reality, we have nonideal sources
- What is an ideal source?
  - Voltage source
    - 100% of the voltage can be applied to the load
  - Current source
    - 100% of the current can be applied to the load
- Real sources: we have loss!
  - Voltage source
    - Need to add series resistance Rs
  - Current source
    - Need to add parallel resistance Rp





Source transformations (2/3)

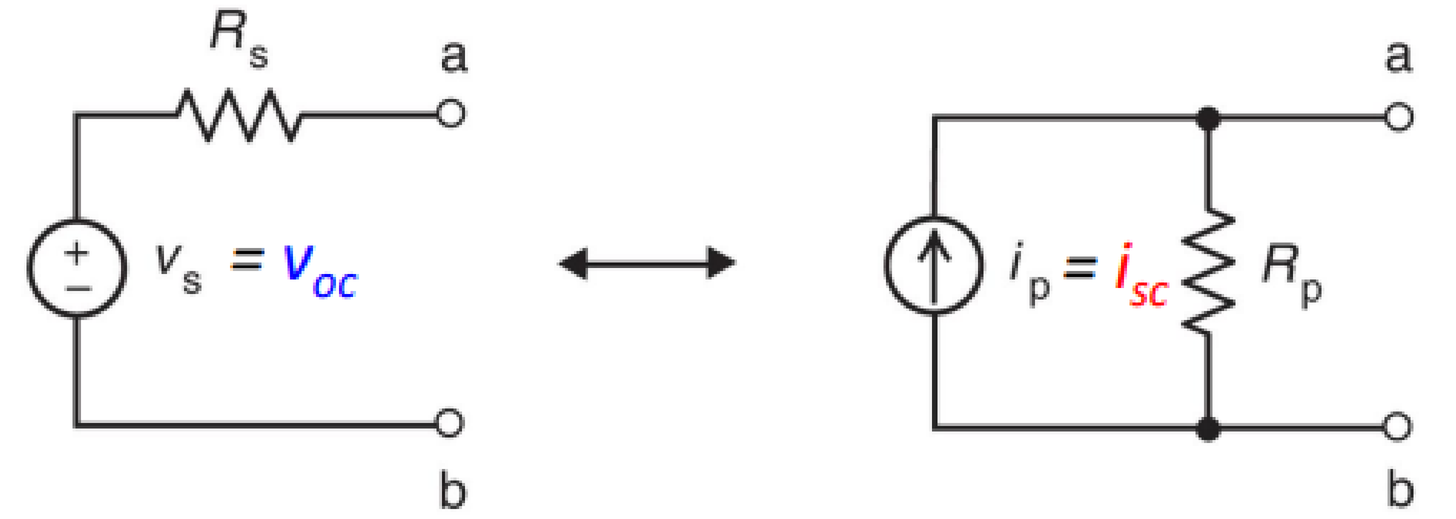
- Allows real voltage/current sources to be interchanged
- How to determine the parameters?
  - Let’s connect a load between a and b



Source transformations (3/3)

Thévenin equivalent ckt

Norton equivalent ckt

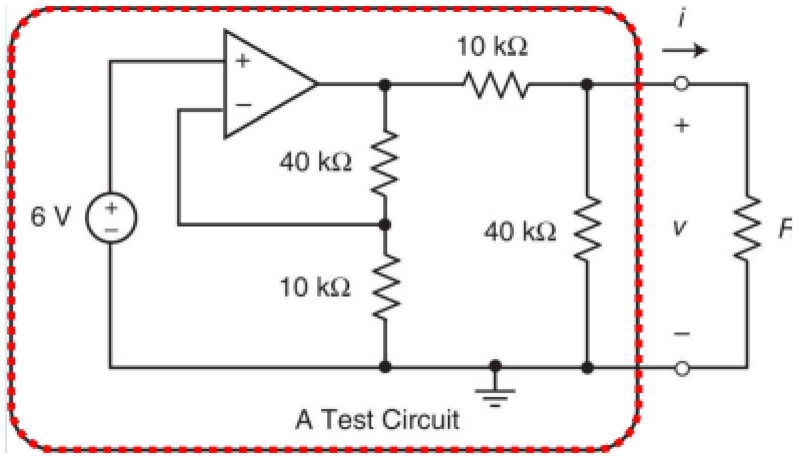


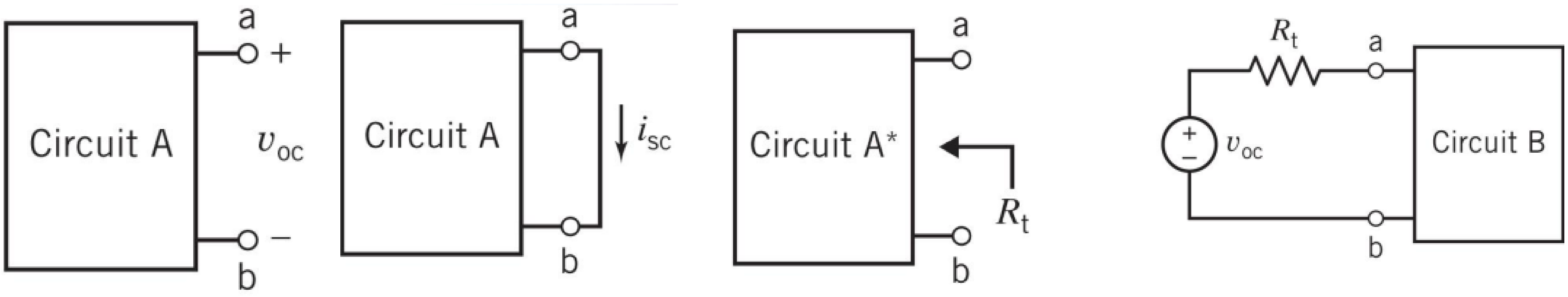
$v_s = R_p i_p$ and $R_s = R_p$

$i_p = \frac{v_s}{R_s}$ and $R_p = R_s$

Thévenin equivalent ckt(1)

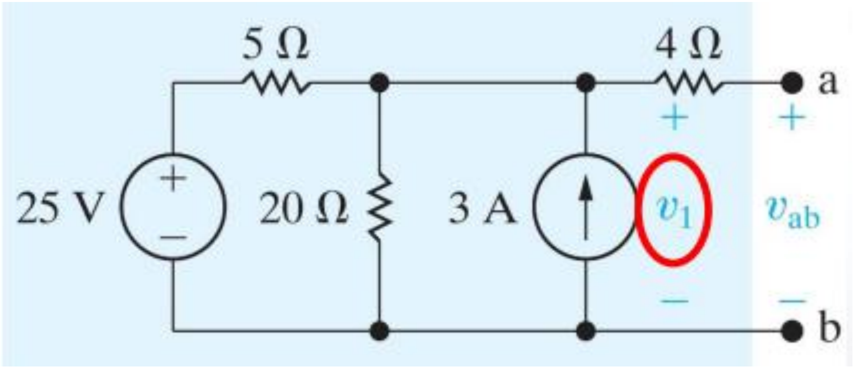
- Thévenin equivalent ckt
  - Open-circuit voltage: V_{oc} or V_{Th}
  - Short-circuit current: i_{sc}
  - Thévenin resistance: R_t or R_{Th}

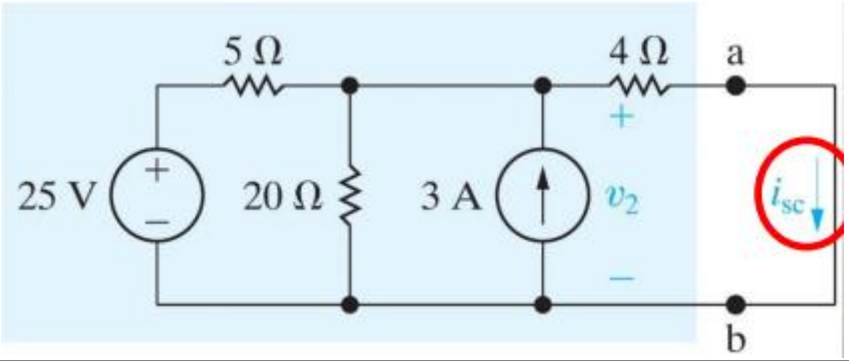


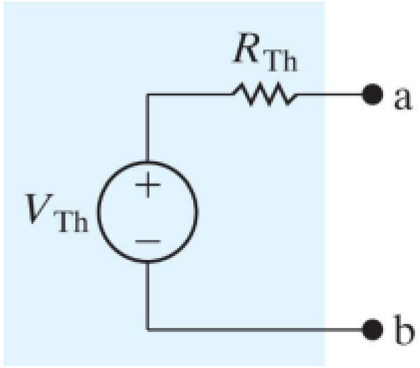


Thévenin equivalent ckt(2)

- Method 1: the obedient way
  - Find open circuit voltage → V_{th}
  - Find short circuit current → i_{sc}

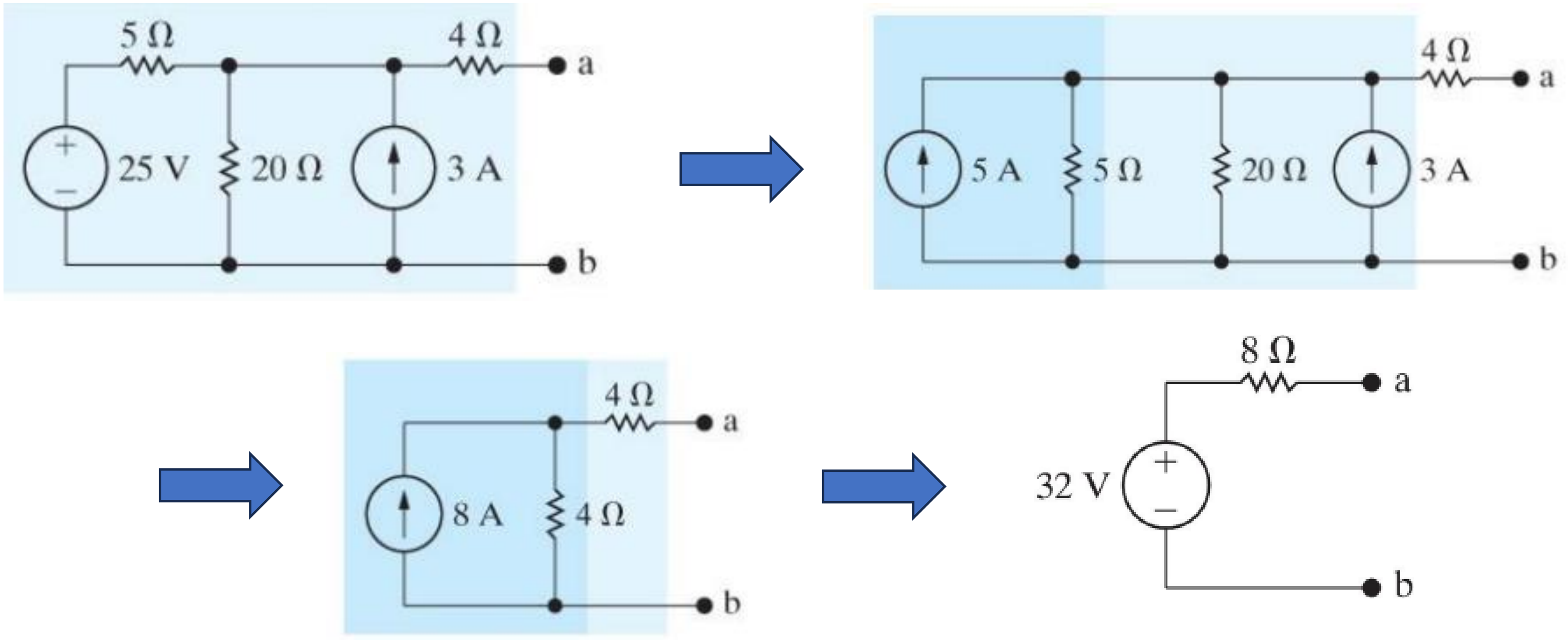






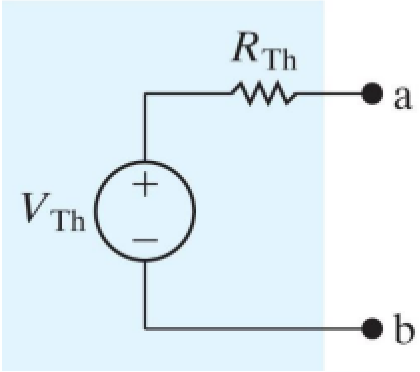
Thévenin equivalent ckt(3)

- Method 2:
  - Use series source transformation when circuit contains ONLY independent sources

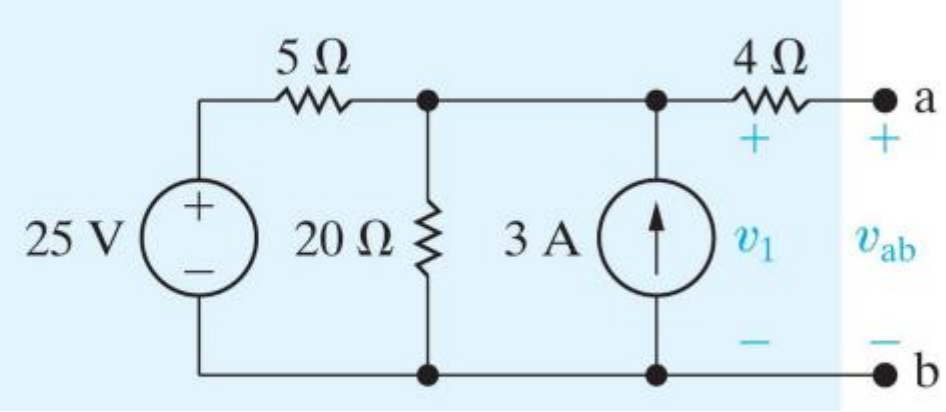


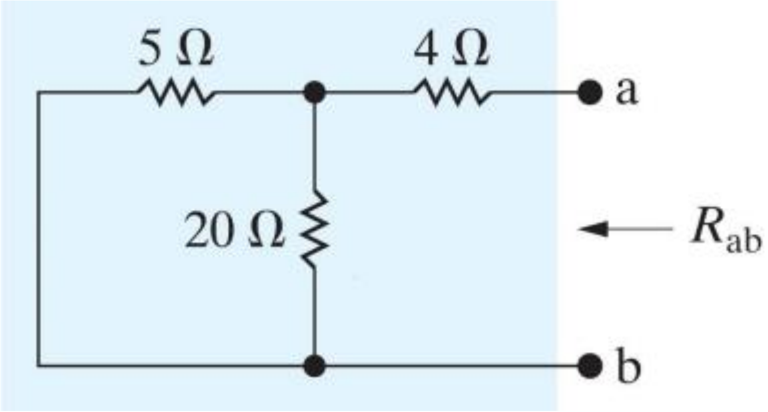
Thévenin equivalent ckt(4)

- Method 3: finding RTH
  - For circuit with ONLY independent sources



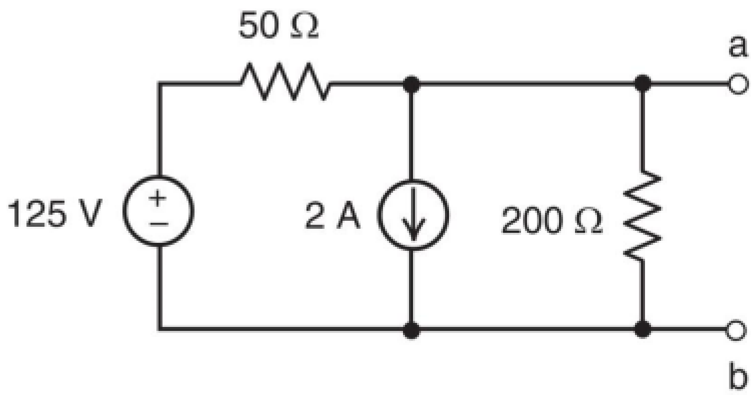
Deactivate all sources
Voltage source → short
Current source → open





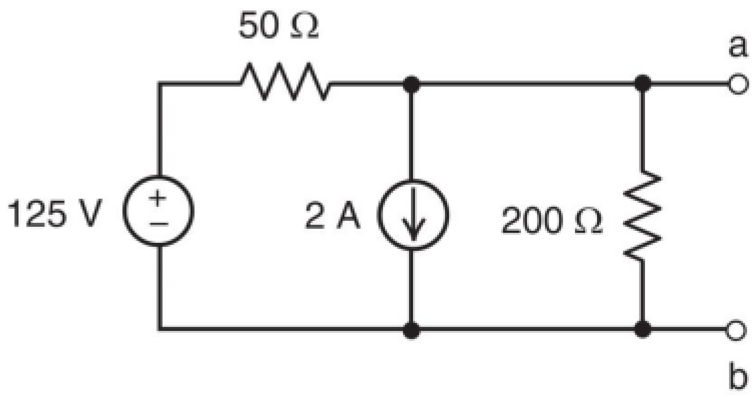
Thévenin equivalent ckt(5)

- Find the Thévenin equivalent circuit
  - Method 1



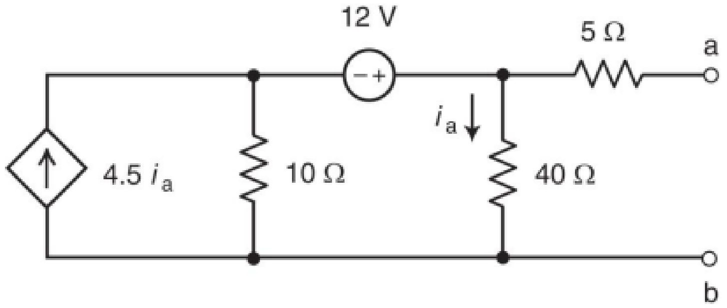
Thévenin equivalent ckt(6)

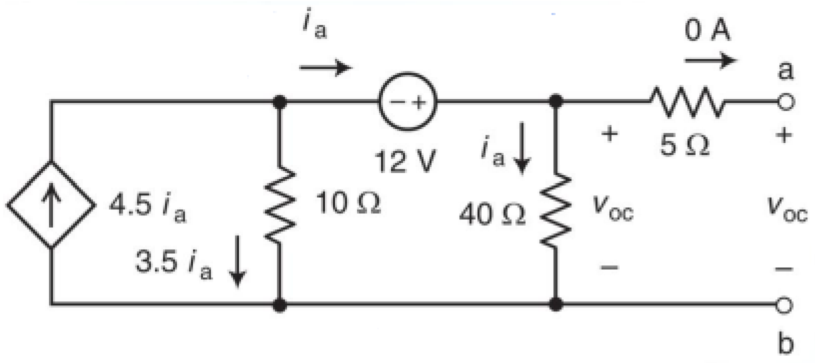
- Find the Thévenin equivalent circuit
  - Method 2

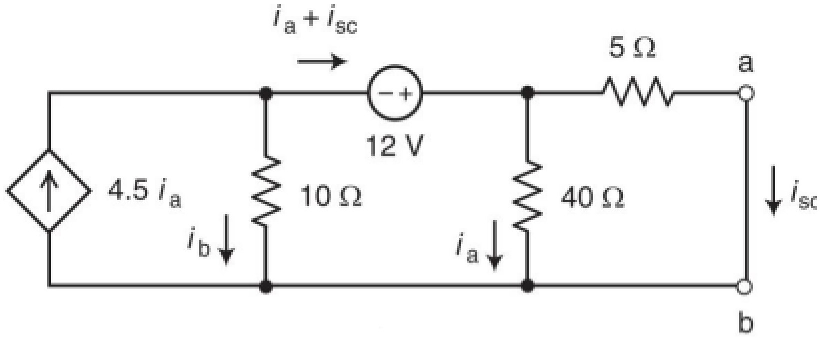


Thévenin equivalent ckt(7)

- Find the Thévenin equivalent circuit

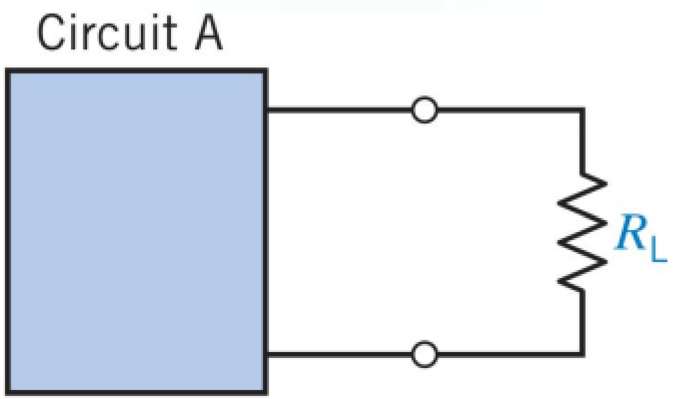


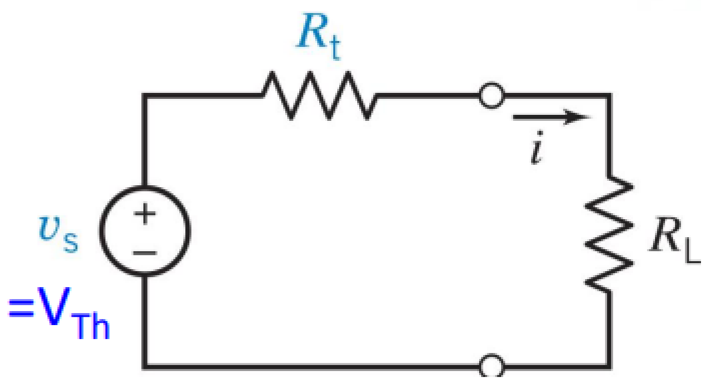


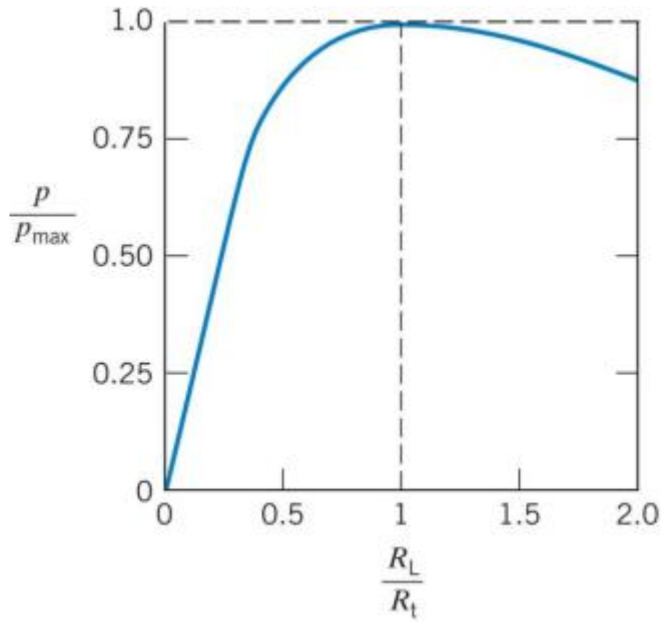


Maximum power transfer

- Maximum power transfer occurs when $R_L = R_t$







$$P_{max} = \frac{V_{Th}^{2} R_L}{(2R_L)^2} = \frac{V_{Th}^{2}}{4R_t}$$

Maximum power transfer

- Find R_L that will result in maximum power delivery
  - Also determine p_{max} delivered to the load resistor