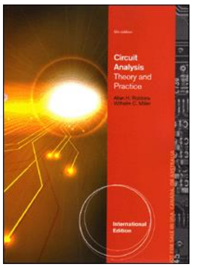


Chapter 08 & 09

Methods of Circuit Analysis

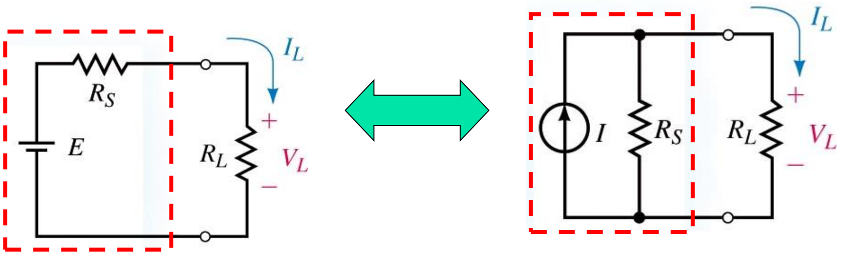
Source: Circuit Analysis: Theory and Practice ©Delmar Cengage Learning

Outline

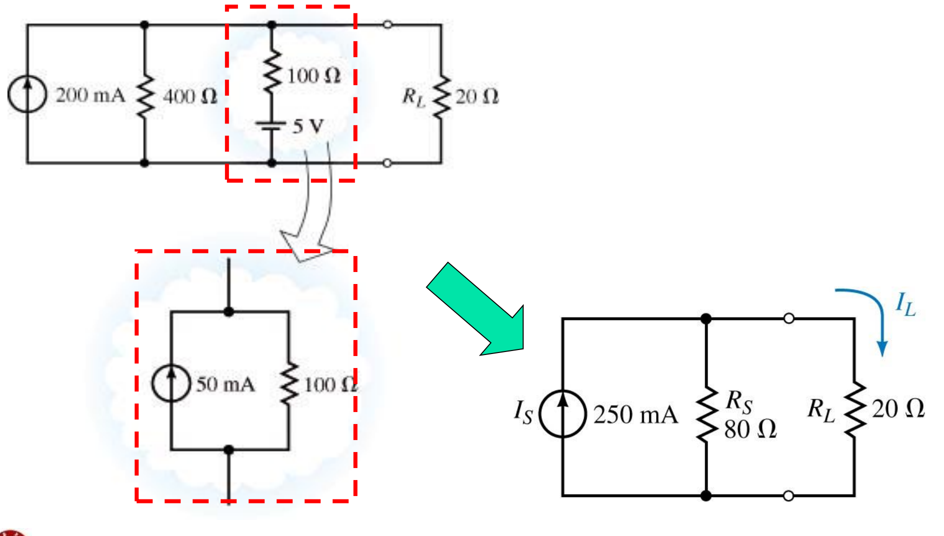
- Source Conversion
- Nodal Analysis
- Bridge Networks
- Superposition Theory
- Thévenin's Theory
- Maximum Power Transfer
- Millman's Theorem

Current and Voltage Sources Exchange

- Sources are only equivalent external to terminals



Example2: Current Sources in Parallel and Series



Nodal Analysis

Step0: Assign a <u>reference node</u> within circuit and indicate node **<u>as ground</u>**

- Convert voltage sources to current sources
- <u>Arbitrarily assign a current direction to each branch</u> where there is no current source

Step1: Assign voltages V_1, V_2, etc. to remaining nodes

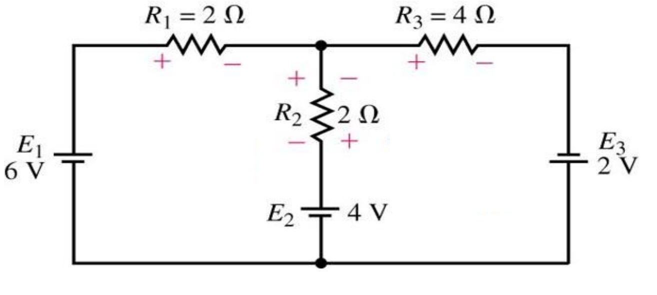
<u>Step2: Apply KCL to all nodes</u> except reference node

Step3: Solve resulting equations for voltages

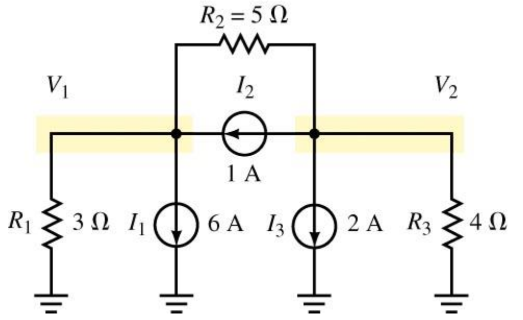
Example0: Nodal Analysis

- Assign voltage at node, then using KVL

$$(V_1-6)/2 + (V_1-4)/2 + (V_1-(-2))/4 = 0$$



Example3: Nodal Analysis



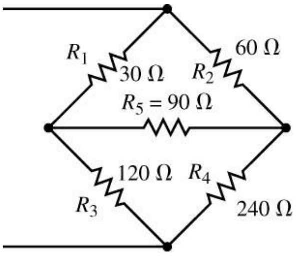
Using KCL for nodes V_1 and V_2

$$V_1/3+(V_1-V_2)/5+6 = 1$$

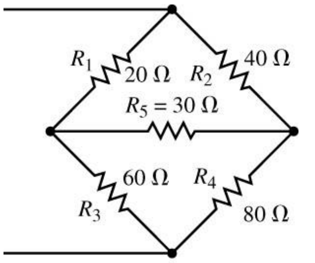
$$V_2/4+(V_2-V_1)/5+2+1 = 0$$

Bridge Networks

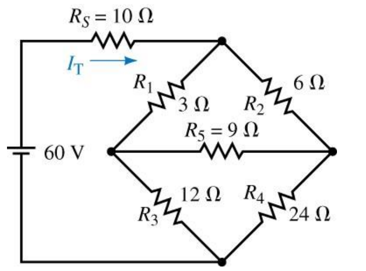
- **Balanced bridge:**
  30*240 = 60*120
  $R_1R_4 = R_2R_3$ and $I_{R5}=0$



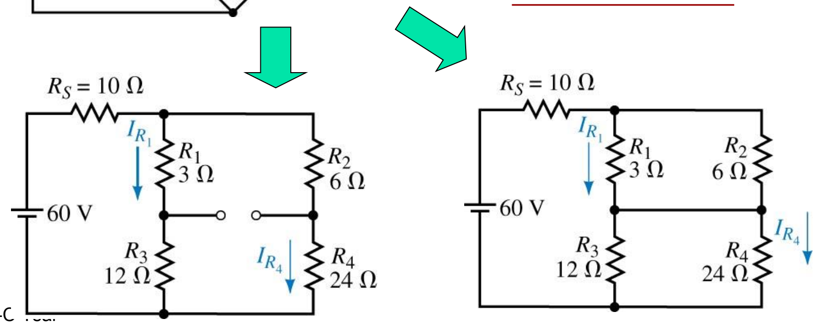
- **Unbalanced bridge:**
  20*80 ≠ 40*60
  $R_1R_4 \neq R_2R_3$ and $I_{R5}\neq 0$



Example: Bridge Networks

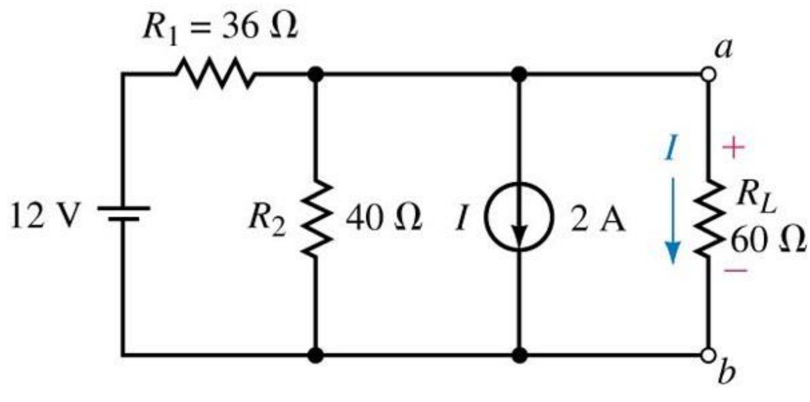


- **Balanced bridge:**
  3*24 = 6*12
  $R_1R_4 = R_2R_3$ and $I_{R_5}=0$
- R_5 can be replaced with **an open circuit** or **a short circuit**.



Problem 14

Determine the voltage V_{ab}

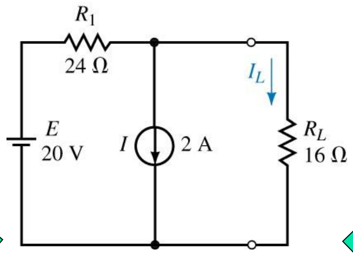


Superposition Theorem

- **Total current through** or **voltage across** a resistor or branch
  - **Determine by adding effects due to each source acting independently**
- **Replace a voltage source with a short**
- **Replace a current source with an open**
- Find results of branches using each source independently
  - **Algebraically combine results**

Example: Superposition Theorem

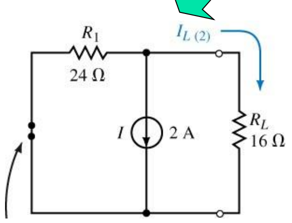
Find I_L



$I_L = I_{L(1)} + I_{L(2)} = -0.7A$

$P_{RL} = 7.84W$

$\neq P_{RL(1)} + P_{RL(2)} = 27.04W$



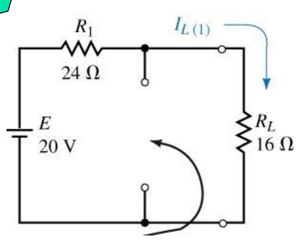
Replace a voltage source with a short

$I_{L(2)} = -2*24/40 = -1.2A$

$P_{(2)} = 23.04W$

$I_{L(1)} = 20/40 = 0.5A$

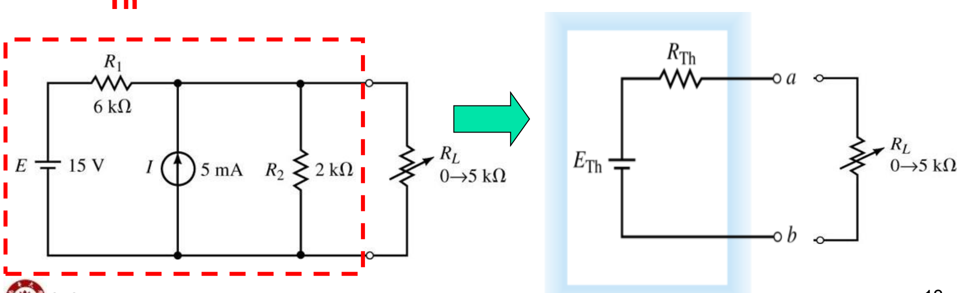
$P_{(1)} = 4W$



Replace a current source with an open

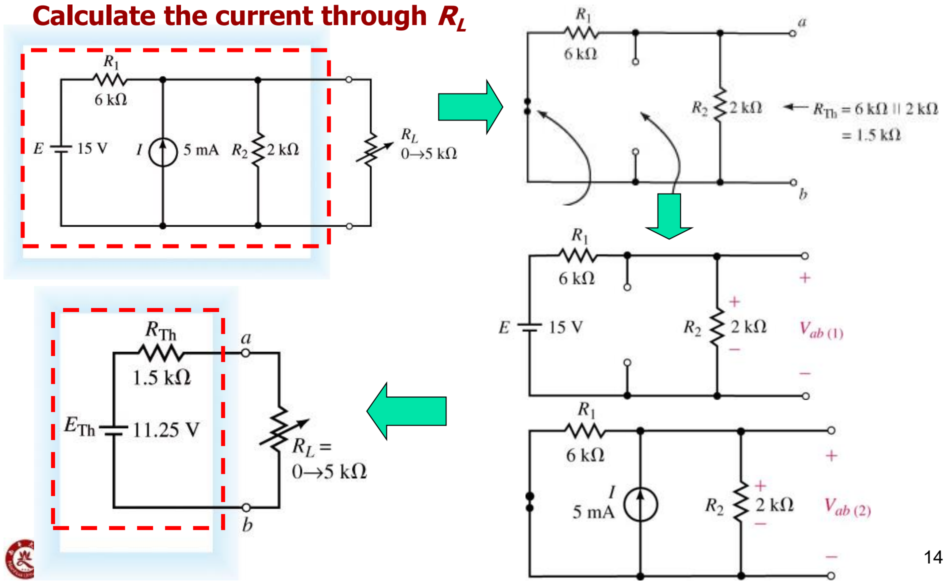
Thévenin’s Theorem

- Any linear bilateral network can be reduced to a **simplified two-terminal circuit with a single voltage source in series with a single resistor**
- Voltage source: Thévenin equivalent voltage, E_{Th}.
- Series resistance: Thévenin equivalent resistance, R_{Th}.



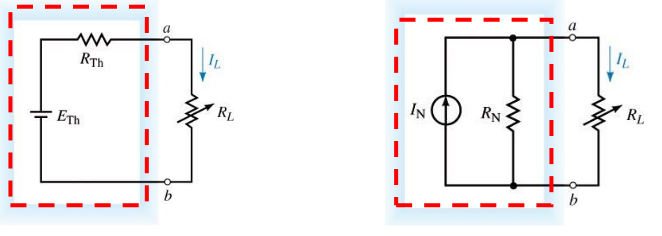
Example2: Thévenin’s Theorem

Calculate the current through R_L



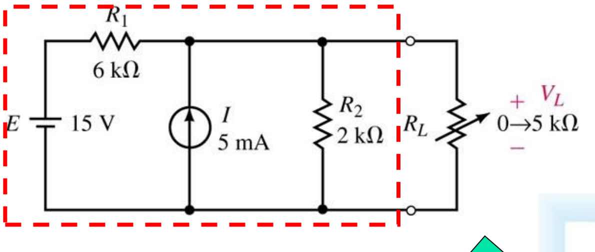
Maximum Power Transfer

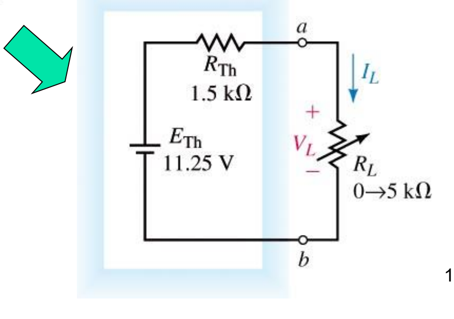
- **A load resistor will receive maximum power** from a circuit when its resistance is the same as the Thévenin (or Norton) equivalent resistance
- Calculate maximum power delivered by source to load by using $P = V^2/R$
- **Voltage across load is one half of Thévenin equivalent voltage**
- Current through load is one half of Norton equivalent current



Example: Maximum Power Transfer

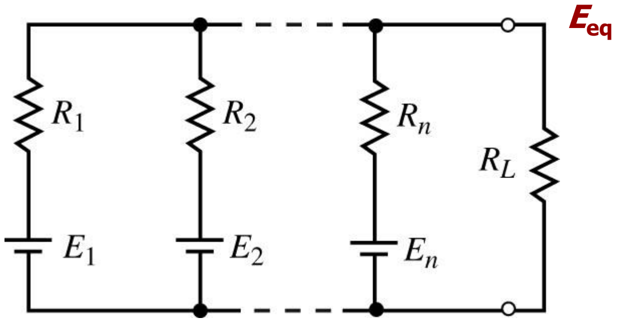
Determine the load resistance to ensure that maximum power is transferred to the load





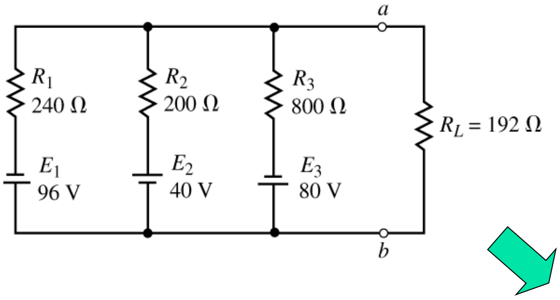
Millman's Theorem

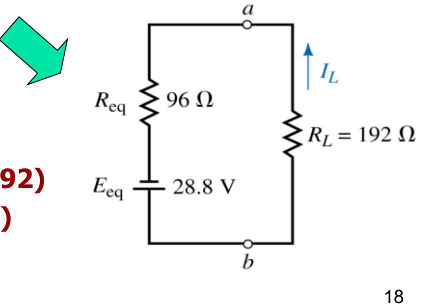
- Used to simplify circuits that have
  - **Several parallel-connected branches containing a voltage source and series resistance**
  - Current source and parallel resistance
  - Combination of both : $E_{eq} = I_{eq}R_{eq}$



Example: Millman's Theorem

- We can simplify a circuit as shown:

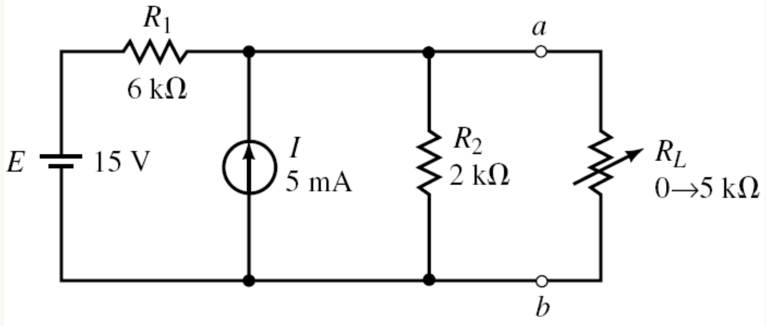




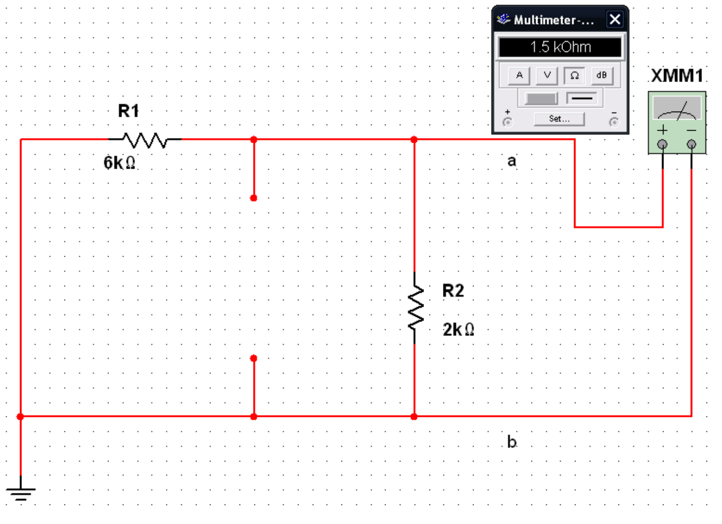
V_{ab} = (-96/240+40/200-80/800+0/192) / (1/240+1/200+1/800+1/192)

Circuit Analysis Using Multisim

- Find both the Thévenin and the Norton equivalent circuits external to the load resistor in the circuit shown



- Use a multimeter to find the equivalent resistance 1.5K Ω



- Use a multimeter to find the open circuit voltage 11.25V