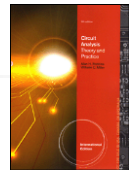


Chapter 07

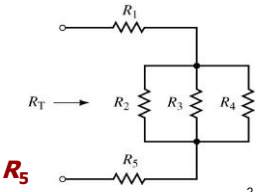
Series-Parallel Circuits

The Series-Parallel Network

- Complex circuits
  - May be separated both series and/or parallel elements
  - Combinations which are neither series nor parallel
- To analyze a circuit
  - Identify elements in series and elements in parallel

For example:

R_2, R_3, and R_4 are in parallel,
Series with R_1 and R_5



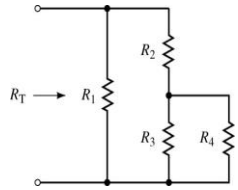
$$R_T = R_1 + (R_2 // R_3 // R_4) + R_5$$

The Series-Parallel Network

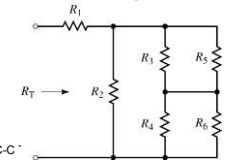
In this circuit:

- R_3 and R_4 are in parallel
- Combination is in series with R_2
- Entire combination is in parallel with R_1

$$R_T = R_1 \parallel [R_2 + (R_3 \| R_4)]$$



Another example:



Analysis of Series-Parallel Circuits

Rules for analyzing series and parallel circuits apply:

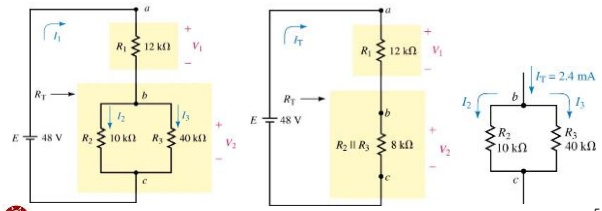
- **Same current occurs through all series elements**
- **Same voltage occurs across all parallel elements**
- **KVL and KCL apply for all circuits**

Steps to simplify a circuit:

- Redraw complicated circuits **showing the source at the left-hand side** and then label all nodes
- Simplify recognizable combinations of components
- Determine **equivalent resistance R_T** and solve for the total current
- Label polarities of voltage drops on all components
- **Calculate how currents and voltages split between elements** in a circuit
- Verify your answer by taking a different approach

Example: Analysis of Series-Parallel Circuits

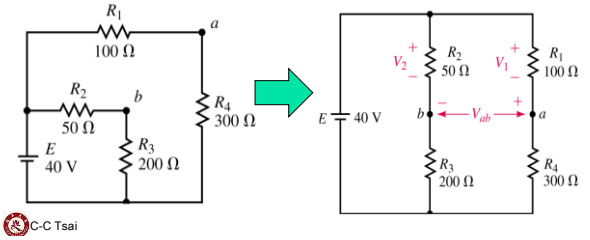
- Combining R_2 and R_3 in parallel
- Circuit reduces to a series circuit
- Use **Voltage Divider Rule** to determine V_{ab} and V_{bc}.
- Note that $V_{bc} = V_2$ is the voltage across R_2 and R_3
- Calculate all currents from **Ohm's Law**.



Example: Analysis of Series-Parallel Circuits

Find the voltage V_{ab}

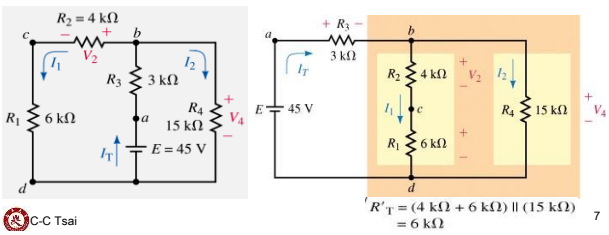
- Redraw circuit in simple form
- Determined by combination of voltages across R_1 and R_2 , or R_3 and R_4 (use voltage divider rule)



Example: Analysis of Series-Parallel Circuits

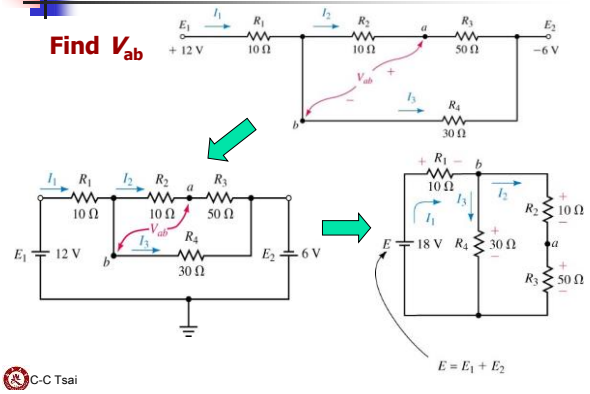
Find currents in the circuit

- First redraw the circuit and move source branch all the way to left and reduce circuit to a series circuit
- **Voltages: Use Ohm's Law or Voltage Divider Rule**
- **Currents: Use Ohm's Law or Current Divider Rule**



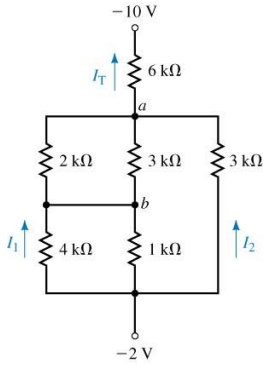
Example: Analysis of Series-Parallel Circuits

Find V_{ab}



Example: Analysis of Series-Parallel Circuits

Find V_{ab}

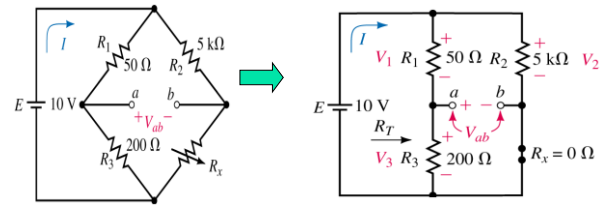


Example: **Bridge Circuit**

- **Determine V_{ab}** and **I** if **R_x is a short circuit (0 Ω)**

  $V_{ab} = V_a - V_b = 8V - 0V =$ **8V**

  $I = 10 / [(50+200) // 5k] = 10 / 238 =$ **42.2mA**

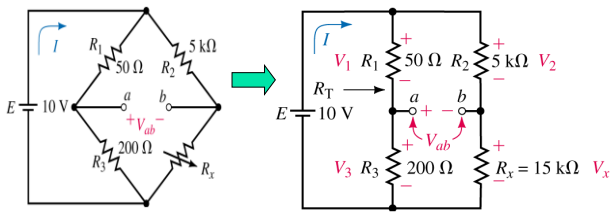


Example: Bridge Circuit

- **Determine V_{ab}** and I if circuit has **R_x = 15 kΩ**

  $V_{ab} = V_a - V_b = 8V - 7.5V = 0.5V$

  $I = 10 / [(50+200) // (5k+15k)] = 10/247 = 40.5mA$

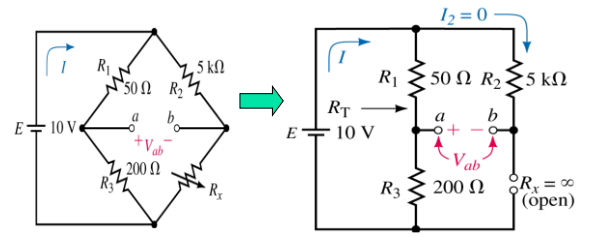


Bridge Circuit

- **Determine V_{ab}** and I **if R_x is open**

  $V_{ab} = V_a - V_b = 8V - 10V = -2V$

  $I = 10 / (50+200) = 10 / 250 = 40mA$



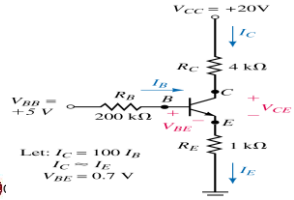
*Transistor Circuit

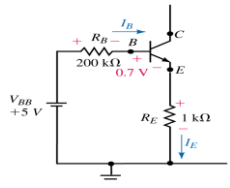
Transistor is a device that amplifies a signal

- Operating point of a transistor circuit is determined by a dc voltage source

Determine some dc voltages and currents

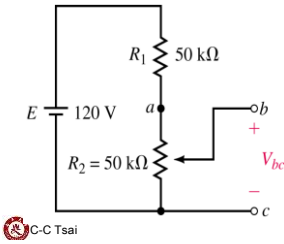
- Apply KVL: $V_{BB} = R_B I_B + V_{BE} + R_E I_E$
- Using $I_E = 100 I_B$, we find $I_B = 14.3\ \mu A$.





Potentiometers

- Example of variable resistor used as potentiometer
- Moveable terminal is **at uppermost position**
  then V_{bc} = 60 V
- **At the lowermost position**
  then V_{bc} = 0 V

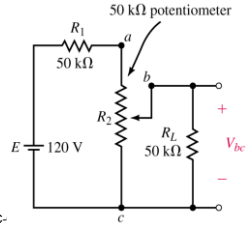


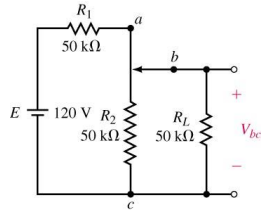
$$V_{bc} = \left(\frac{50\ \text{k}\Omega}{50\ \text{k}\Omega + 50\ \text{k}\Omega}\right)(120\ \text{V}) = 60\ \text{V}$$

Potentiometers

V_{bc} changes

- If load is added to circuit **at upper position**
  then V_{bc} = 40 V
- **At the lower position**
  then V_{bc} = 0 V





Load Effects of Instruments

Actual value

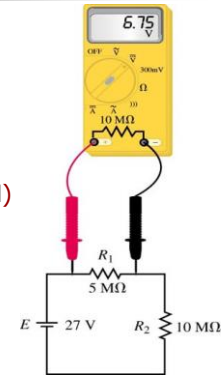
V_{R1} = 27V * **5M**/(**5M**+10M)
= 9V

Reading value

V_{R1} = 27V * **3.3M**/(**3.3M**+10M)
= 6.75V

Loading effect

= (9 - 6.75) / 9 = **25%**



Example: Load Effects of Instruments

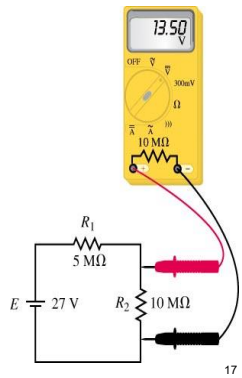
Actual value

V_{R_2} = 27V * **10M**/(5M+**10M**)
= 18V

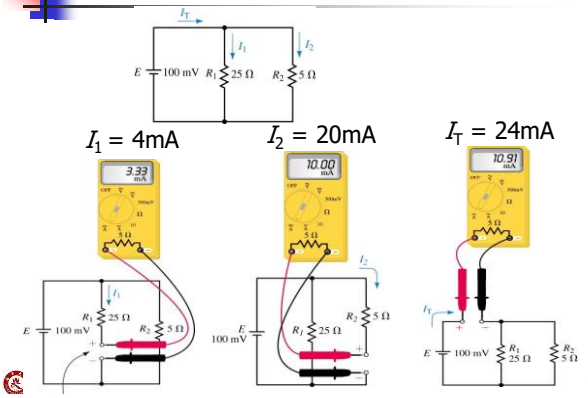
Reading value

V_{R_2} = 27V * **5M**/(5M+**5M**)
= 13.5V

Loading effect
= (18 - 13.5) / 18 = **25%**



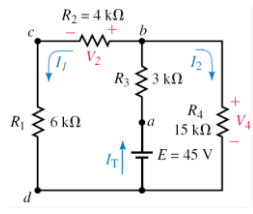
Example: Load Effects of Instruments



Circuit Analysis Using Multisim

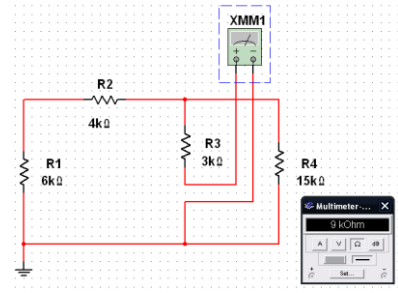
Use Multisim to find the following quantities for the circuit shown

a) **Total resistance, R_T**
b) **Voltages V_2 and V_4**
c) **Currents** I_T, I_1, and I_2

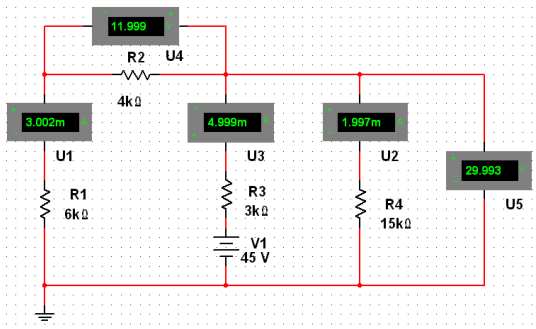


Get R_T Using Multisim

- Construct the circuit for determining the total resistance R_T



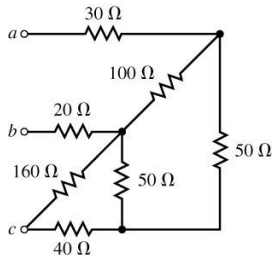
Get *Voltages and currents* Using Multisim



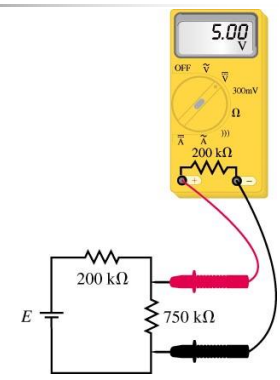
Kernel abilities

1. **Can recognize which parts are in series or parallel for a series-parallel circuit.**
2. **Can compute the total resistance R_t of resistors $R_1 \sim R_n$ in series-parallel.**
3. **Can recognize KVL and KCL for applying a series-parallel circuit.**
4. **Can recognize the voltage divider and current divider for applying a series-parallel circuit.**
5. **Can recognize the loading effect for measuring voltage and current.**

Problem 10: **Find R_{ab} and R_{bc}**



Problem 35: **Find E**



Problem 37: **Find the reading of ammeter**