Chapter 7

Series-Parallel Circuits

Circuit Analysis with Devices:
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The Series-Parallel Network

- Branch
  - Part of a circuit that can be simplified into two terminals
- Components between these two terminals
  - Resistors, voltage sources, or other elements

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The Series-Parallel Network

- Complex circuits
  - May be separated both series and/or parallel elements
- Other circuits
  - Combinations which are neither series nor parallel

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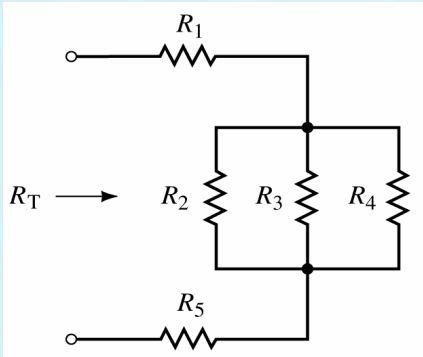
The Series-Parallel Network

- To analyze a circuit
  - Identify elements in series and elements in parallel
- In this circuit
  - R_2, R_3, and R_4 are in parallel
- This parallel combination
  - Series with R_1 and R_5

The Series-Parallel Network



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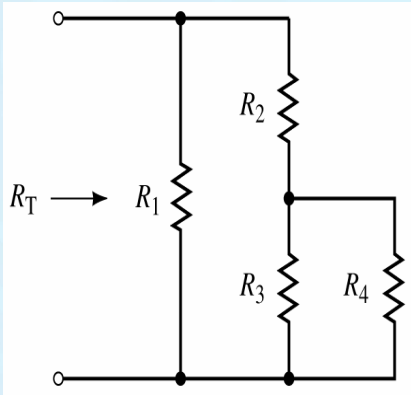
The Series-Parallel Network

- 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



Analysis of Series-Parallel Circuits

- Rules for analyzing series and parallel circuits still apply
- Same current occurs through all series elements

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Analysis of Series-Parallel Circuits

- Same voltage occurs across all parallel elements
- KVL and KCL apply for all circuits
  - Whether they are series, parallel, or series-parallel

Analysis of Series-Parallel Circuits

- Redraw complicated circuits showing the source at the left-hand side
- Label all nodes

Analysis of Series-Parallel Circuits

- Develop a strategy
  - Best to begin analysis with components most distant from the source
- Simplify recognizable combinations of components

Analysis of Series-Parallel Circuits

- Determine equivalent resistance R_T
- Solve for the total current
- Label polarities of voltage drops on all components

Analysis of Series-Parallel Circuits

- Calculate how currents and voltages split between elements in a circuit
- Verify your answer by taking a different approach (when feasible)

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.

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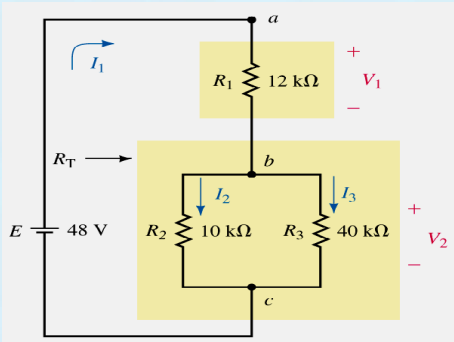
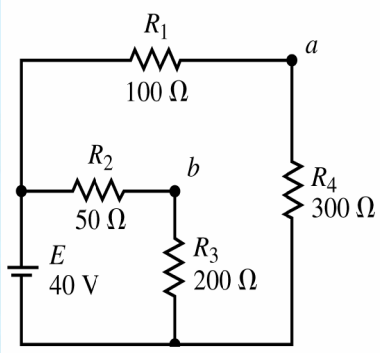
Analysis of Series-Parallel Circuits



Analysis of Series-Parallel Circuits

- To find voltage V_{ab},
  - Redraw circuit in simple form
- Original circuit
  - Two parallel branches



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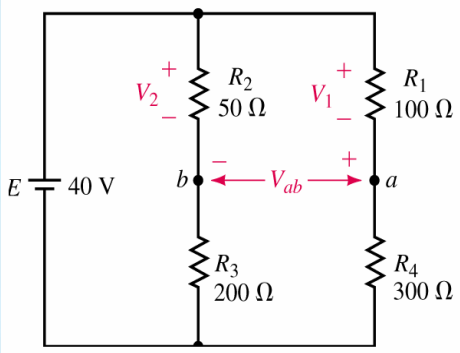
Analysis of Series-Parallel Circuits

- V_{ab}
  - Determined by combination of voltages across R_1 and R_2 , or R_3 and R_4
- Use Voltage Divider Rule to find two voltages
- Use KVL to find V_{ab}

Analysis of Series-Parallel Circuits



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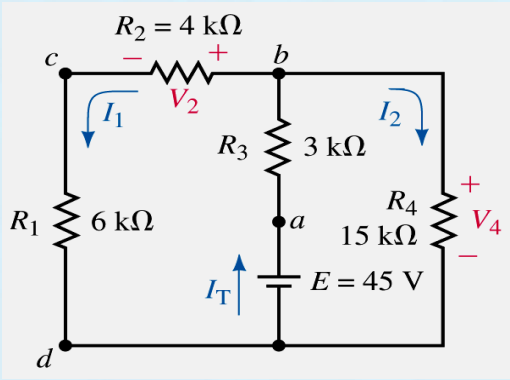
Analysis of Series-Parallel Circuits

- To find currents in the circuit
  - First redraw the circuit
  - Move source branch all the way to left
- Reduce circuit to a series circuit

Analysis of Series-Parallel Circuits



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Analysis of Series-Parallel Circuits

- Voltages
  - Use Ohm's Law or Voltage Divider Rule
- Currents
  - Use Ohm's Law or Current Divider Rule

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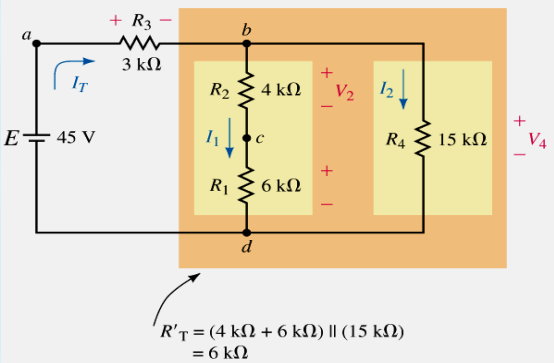
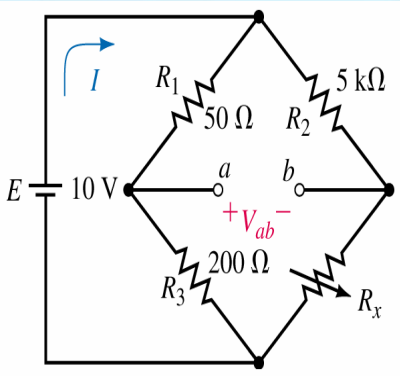
Analysis of Series-Parallel Circuits



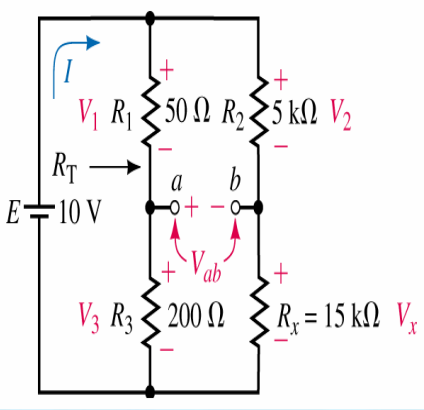
Bridge Circuit

- Circuit has R_x = 15 kΩ
- Determine V_{ab}
- Redraw circuit as shown on slide



Bridge Circuit

- Voltage Divider Rule
  - Determine V_a and V_b.
- Ground reference point
  - Take at bottom of circuit
- V_{ab} = 0.5 V



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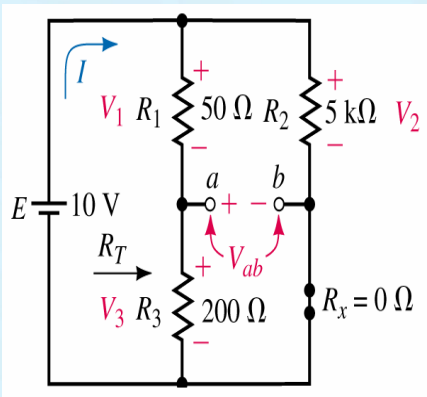
Bridge Circuit

- R_x is a short circuit (0 Ω)
- Voltage Divider Rule
  - Determine V_{R1}
- V_{R2} = 10 V
- V_{ab} = 8 V



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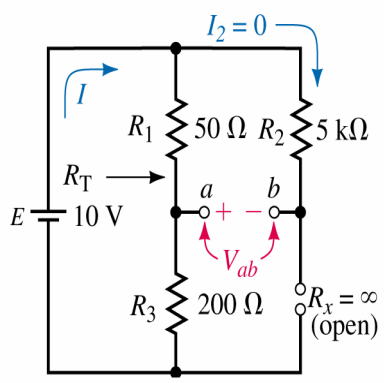
Bridge Circuit

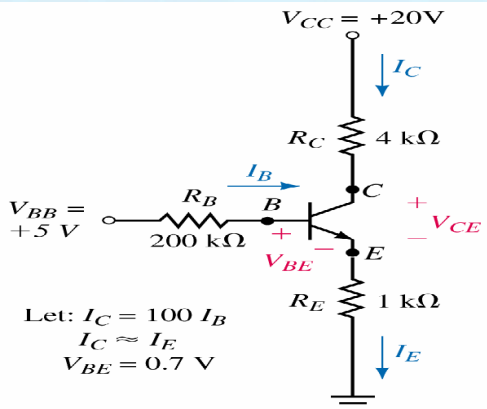
- R_x is open
- Find V_{R1}
- We know V_{R2} = 0 V
  - No current through it
- V_{ab} = –2 V



Transistor Circuit

- Transistor
  - Device that amplifies a signal
- Operating point of a transistor circuit
  - Determined by a dc voltage source
- We will determine some dc voltages and currents

Transistor Circuit



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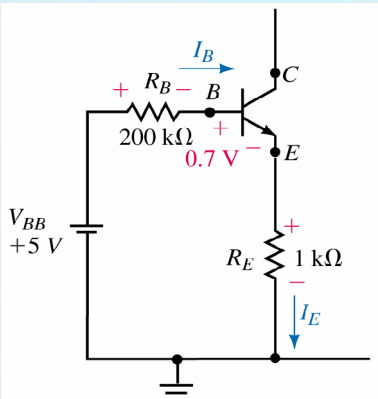
Transistor Circuit

- Apply KVL:
  $V_{BB} = R_B I_B + V_{BE} + R_E I_E$
- Using $I_E = 100 I_B$, we find $I_B = 14.3\ \mu\text{A}$.
- Other voltages and currents can be determined



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Potentiometers

- Example of variable resistor used as potentiometer
  - Volume control on a receiver
- Moveable terminal is at uppermost position
  - V_{bc} = 60 V
- At the lowermost position
  - V_{bc} = 0 V

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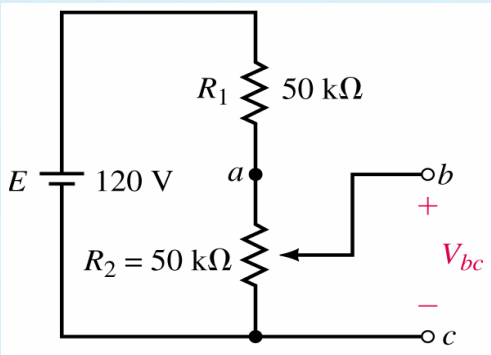
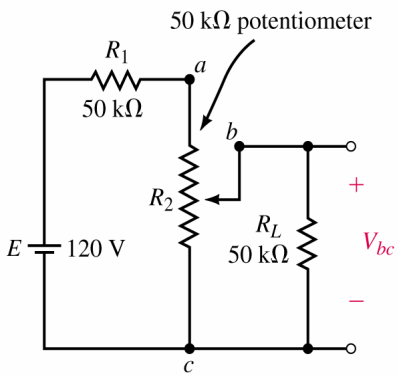
Potentiometers



Potentiometers

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



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