General Information

Course Title Electronics – I

Course Prerequisites

- Electric Circuit analysis 1

Recommended Text Book

- Electronic Circuits Analysis and Design, 3rd Edition, by Donald A Neamen

Reference book

- Electronic Devices and circuit theory, 9th Edition, by Boylestad, Nashelsky
- Microelectronic Circuits by Sedra/smith Fifth Edition

High Level Lecture Breakdown

Topics	Number of lectures
Semiconductor devices and Diodes: semiconductor material and properties, Intrinsic/Extrinsic semiconductors, Drift and Diffusion currents and their densities, Excess carriers, The pn-Junction, Reverse/Forward biased junctions, Ideal voltage/ current relationship, pn Junction diode, Temperature effect, breakdown voltage, switching transient.	3
Diode Circuits: dc analysis and models, Piece-wise linear model, diode circuits, ac equivalent circuits, sinusoidal analysis, Small-signal equivalent circuit, Special diodes (Solar cell, photo-diode, LED, Schottky barrier diode, Zener diode), Diode applications (rectifier circuits, envelop detectors, clippers/clampers), Zener/Photo diode circuits, Multi-diode circuits	5
Bipolar Junction Transistors: Transistor structure, npn Transistor and Forward Bias, Leakage current and breakdown voltages, Current-voltage characteristics, DC analysis and dc load line, Modes of operation, dc analysis of commonly used bipolar transistors, Three basic operations (Switch, digital switch, and amplifier), Transistor biasing (positive/negative) and biasing stability, Integrated circuit biasing	8
BJT Amplifiers: linear amplifiers, AC equivalent circuit, Small signal Hybrid-Pi model and analysis, current gain, voltage gain, input/output impedance, Early effect, basic amplifier configurations (voltage, current, transconductance, transresistance amplifiers), design and analysis of Common emitter and Emitter follower amplifiers.	8
The Field-effect Transistors: MOS Field-effect transistors, Two terminal structure, NMOS/PMOS devices, Current/Voltage ideal characteristics, Short Channel effects, Non-ideal behavior (finite output resistance, body effect, breakdown effects), Common source circuits.	6

Electric Circuit analysis Review

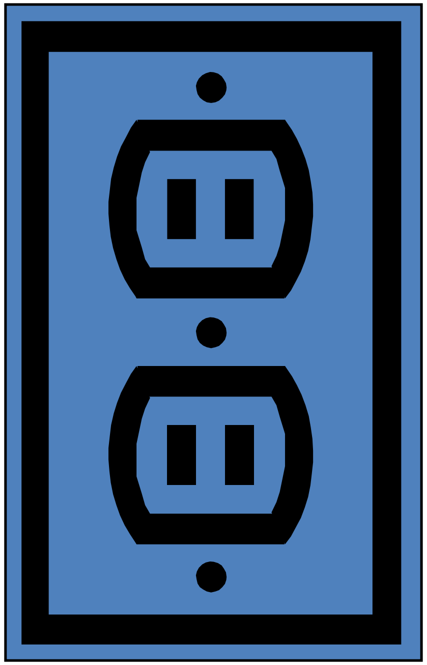
Basic Circuit Elements

There are 5 basic circuit elements:

1. Voltage sources
2. Current sources
3. Resistors
4. Inductors
5. Capacitors

Voltage Sources

- A voltage source is a two-terminal circuit element that maintains a voltage across its terminals.
- The value of the voltage is the defining characteristic of a voltage source.
- Voltage source always replaced by a ‘jumper’ to simplify a circuit.

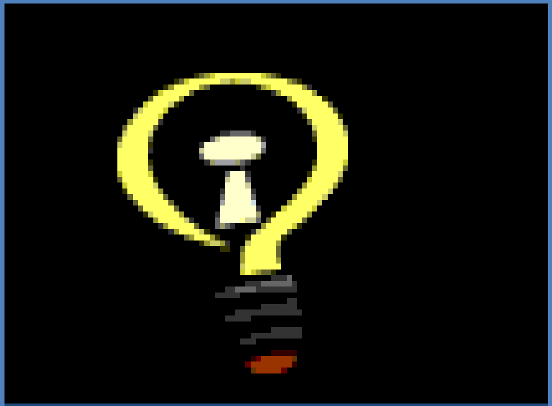


Current Sources

- A current source is a two-terminal circuit element that maintains a current through its terminals.
- The value of the current is the defining characteristic of the current source.
- Any current source is replaced with an ‘open circuit’ when simplifying a circuit.

Resistors

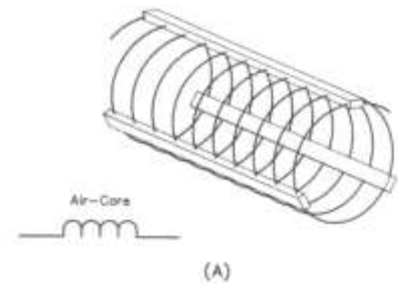
- A resistor is a two terminal circuit element that has a constant ratio of the voltage across its terminals to the current through its terminals.
- The value of the ratio of voltage to current is the defining characteristic of the resistor.

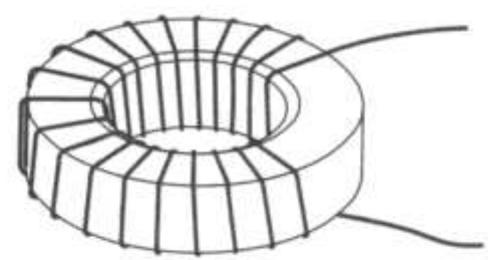


In many cases a light bulb can be modeled with a resistor.

Inductors

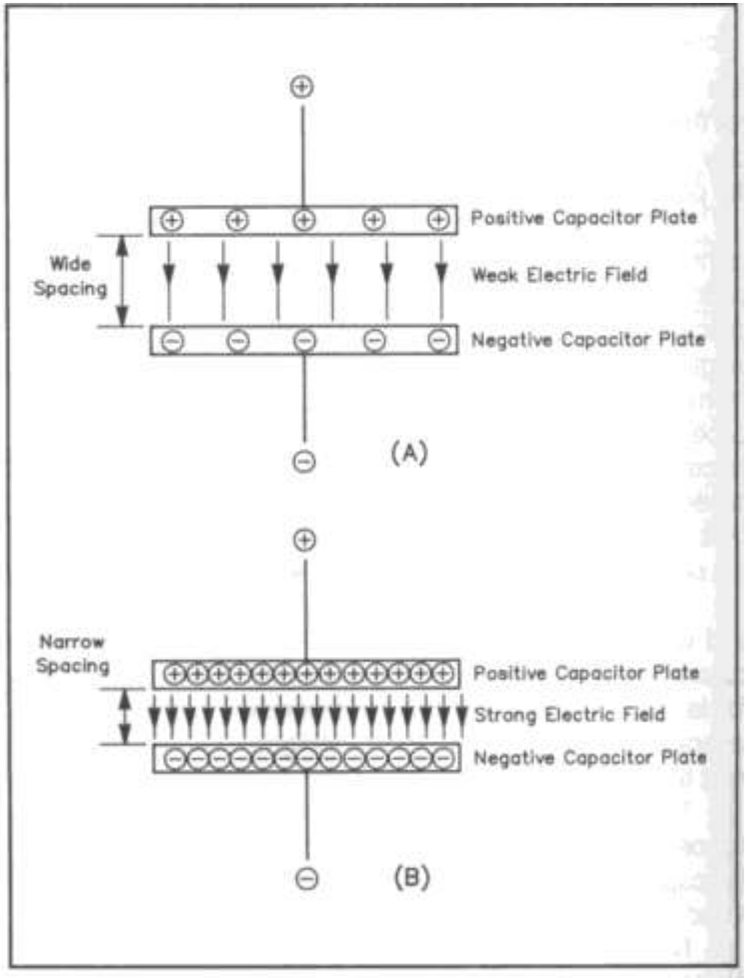
- An inductor is a coil of wire through which electrons move, and energy is stored in the resulting magnetic field.
- Inductors are simply coils of wire.
  - Can be air wound (just air in the middle of the coil)
  - Can be wound around a permeable material (material that concentrates magnetic fields)
  - Can be wound around a circular form (toroid)
- Inductance is measured in Henry(s).





Capacitors

- A device that stores energy in electric field.
- Two conductive plates separated by a non conductive material.
- Think of a capacitor as very small, temporary storage battery.
- The unit of capacitance is the farad.



Ohm’s Law

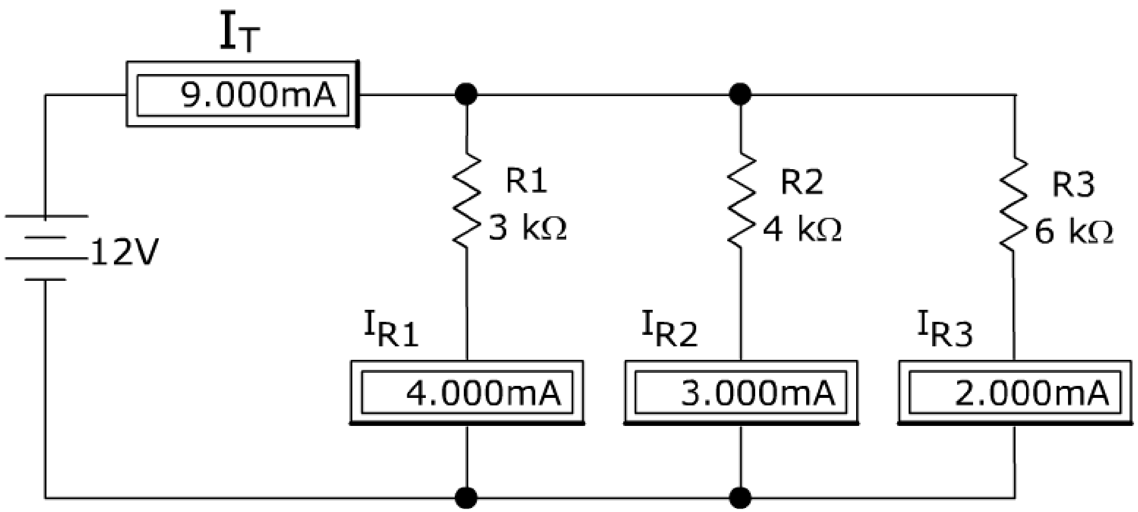
- **Ohm's law**

  states that the current through a conductor between two points is directly proportional to the potential difference across the two points, and inversely proportional to the resistance between them. The mathematical equation that describes this relationship is

$$“V = IR”$$

Kirchhoff's Current Law

KCL states that the sum of the current entering a node will be equal to the sum of the current leaving the node.

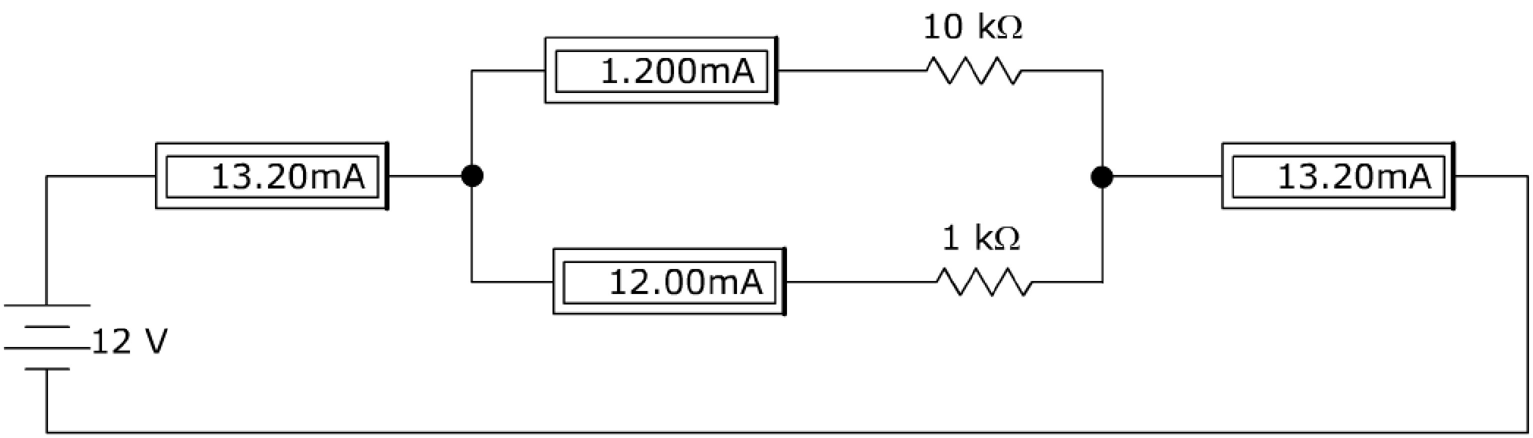


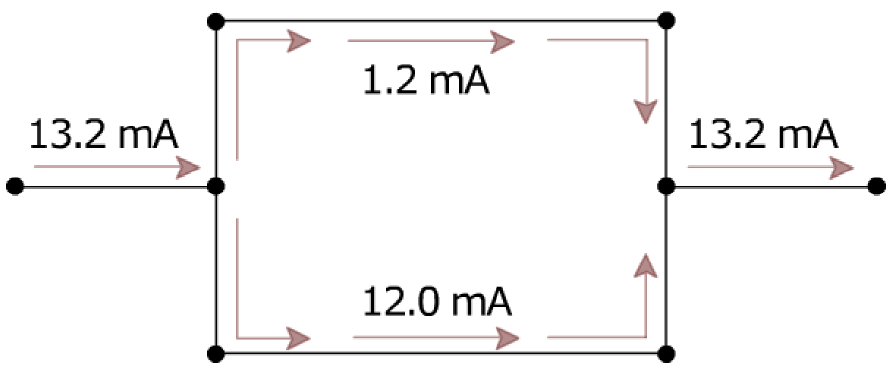
$$\mathbf{I_T} = I_{R1} + I_{R2} + I_{R3} + \ldots + I_{Rn}$$

$$\mathbf{I_T} = I_{R1} + I_{R2} + I_{R3}$$

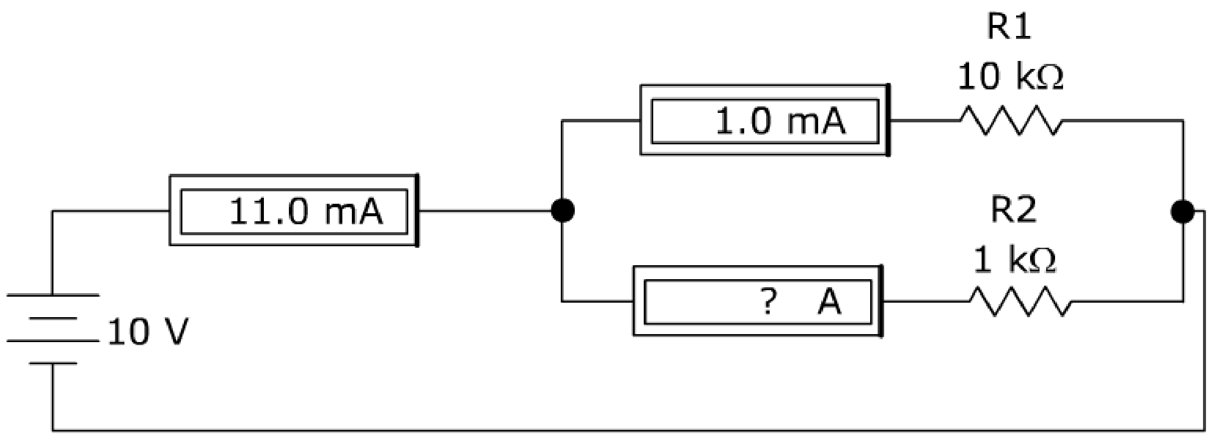
$$\mathbf{9\ mA} = 4\ mA + 3\ mA + 2\ mA$$

Kirchhoff's Current Law (con't)





Kirchhoff's Current Law (con't)



$$\mathbf{I_T} = I_{R1} + I_{R2} + I_{R3} + \ldots + I_{Rn}$$

$$\mathbf{I_T} = I_{R1} + I_{R2}$$

$$\mathbf{11\ mA} = 1\ mA + ?$$

$$\mathbf{I_{R2}} = I_T - I_{R1}$$

$$\mathbf{I_{R2}} = 11\ mA - 1\ mA$$

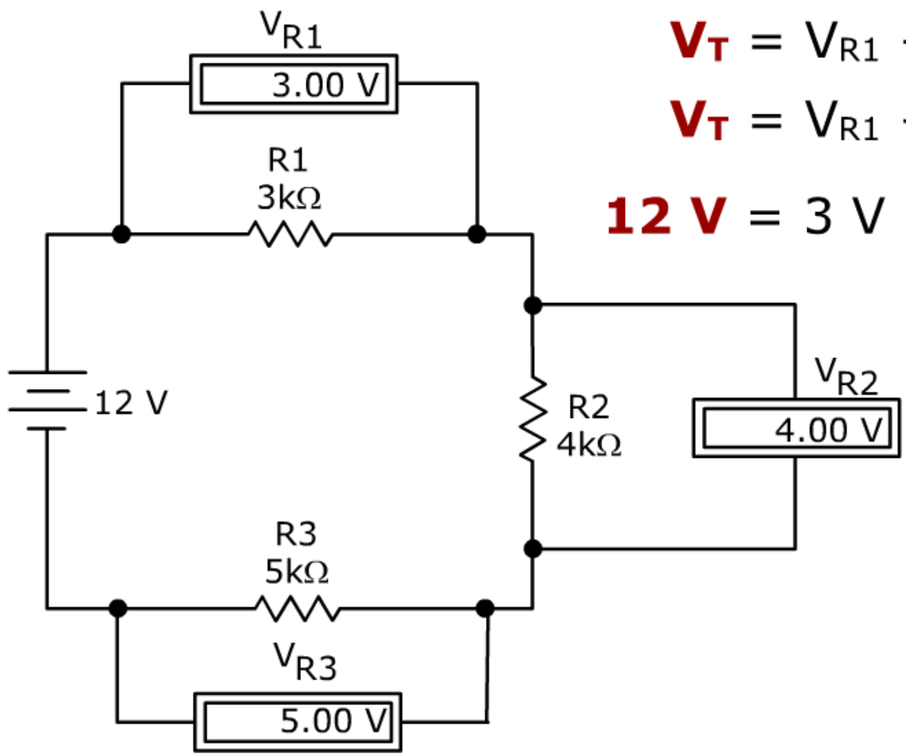
$$\mathbf{I_{R2}} = 10\ mA$$

Kirchhoff's Voltage Law

- Kirchhoff's Voltage Law (or Kirchhoff's Loop Rule) is a result of the electrostatic field being conservative. It states that the total voltage around a closed loop must be zero

Kirchhoff's Voltage Law

KVL states that the sum of the voltage "drops" around a closed loop will equal the applied voltage.

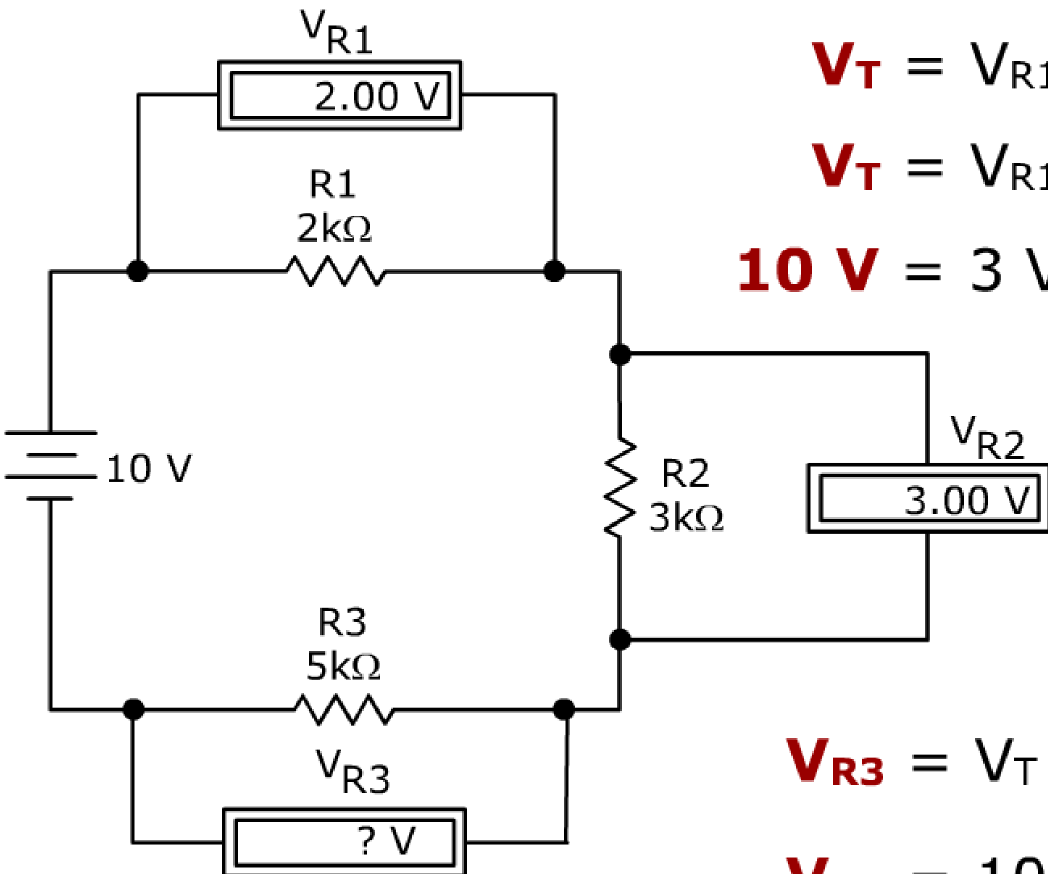


$$V_T = V_{R1} + V_{R2} + V_{R3} + \ldots + V_{Rn}$$

$$V_T = V_{R1} + V_{R2} + V_{R3}$$

$$\mathbf{12\ V} = 3\ V + 4\ V + 5\ V$$

KVL can be used to solve for an unknown voltage drop.



$$V_T = V_{R1} + V_{R2} + V_{R3} + \ldots + V_{Rn}$$

$$V_T = V_{R1} + V_{R2} + V_{R3}$$

$$10\ V = 3\ V + 2\ V + ?$$

$$V_{R3} = V_T - (V_{R1} + V_{R2})$$

$$V_{R3} = 10\ V - (3\ V + 2\ V)$$

$$V_{R3} = 5\ V$$

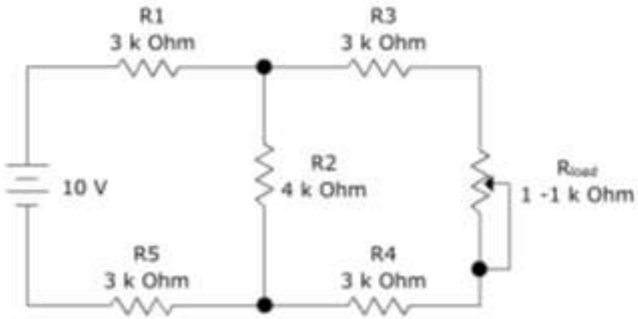
Thevenin's Theorem

Through the use of the Thevenin Theorem, we have the ability to reduce a complex circuit down to a simple series circuit.

The four steps are:

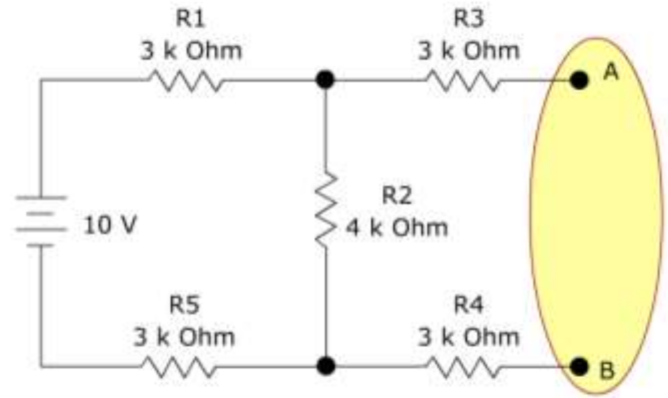
1. Remove the load.
2. Determine the voltage seen by the load (V_{TH}).
3. Replace the voltage source with a short. (Do not short out the power supply -- there is a difference.)
4. Determine the resistance seen by the load (R_{TH}).

Step 1: Remove the load.



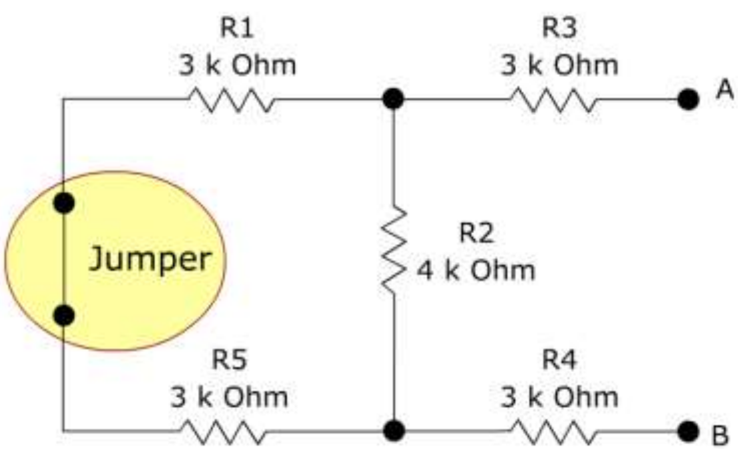
Remove the load.

Step 2: Determine the voltage seen by the load (V_{TH}).



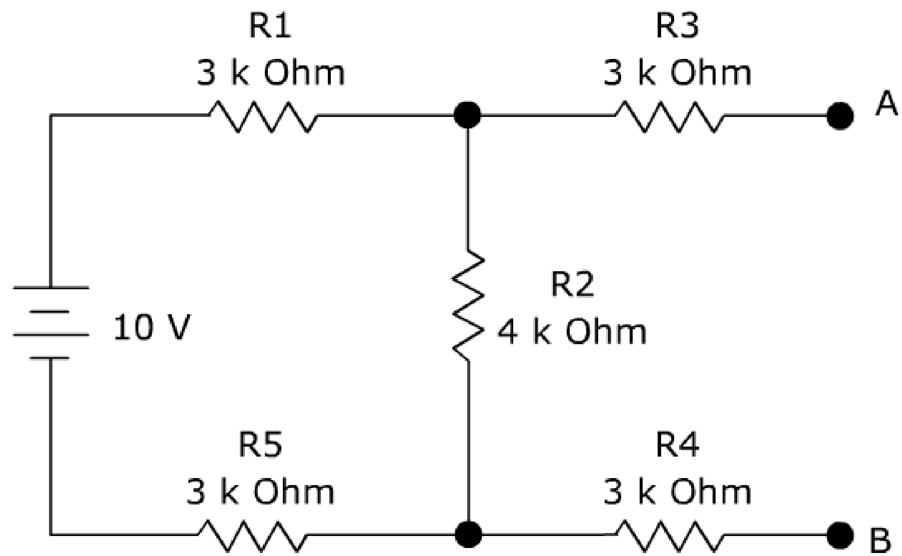
Solve for the voltage seen by the load.

Step 3: Replace the voltage source with a short.



Step 2: Determine the voltage seen by the load (V_{TH}).

Since R_3 and R_4 are not connected on one end, they do not carry current. Therefore, they cannot have a voltage drop. The voltage present between points A and B is the voltage drop across R_2.



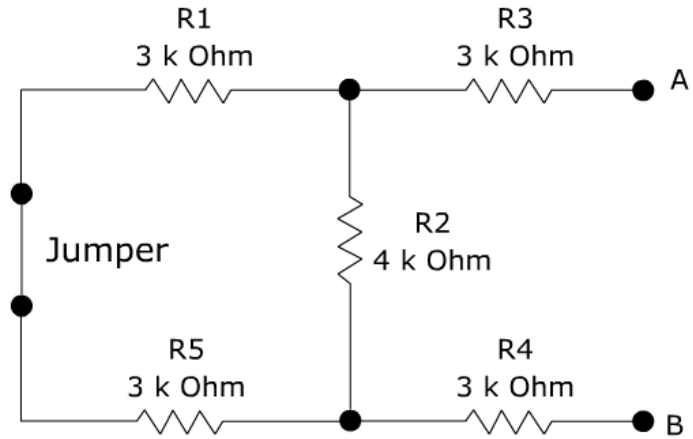
$$V_{R2} = \frac{R_2}{R_1+R_2+R_5} \times V_T$$

$$V_{R2} = \frac{4\ k\Omega}{3k\Omega+4k\Omega+3k\Omega} \times 10V$$

$$V_{R2} = 4\ V$$

$$\mathbf{V_{TH} = V_{R2} = 4V}$$

Step 4: Determine the resistance seen by the load (R_{TH}).

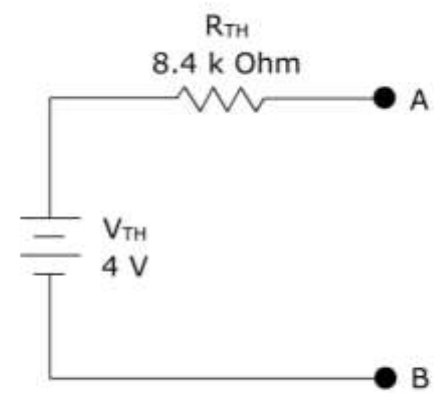


$$R_{TH} = R_3 + ((R_1 + R_5) \parallel R_2) + R_4$$

$$R_{TH} = R_3 + \frac{1}{\frac{1}{(R_1+R_5)} + \frac{1}{R_2}} + R_4$$

$$R_{TH} = 3k\Omega + \frac{1}{\frac{1}{(3k\Omega+3k\Omega)} + \frac{1}{4k\Omega}} + 3k\Omega$$

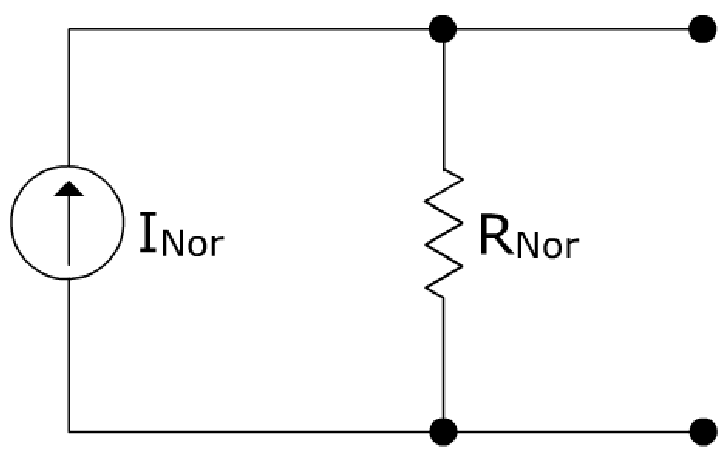
$\mathbf{R_{TH} = 8.4\ k\Omega}$



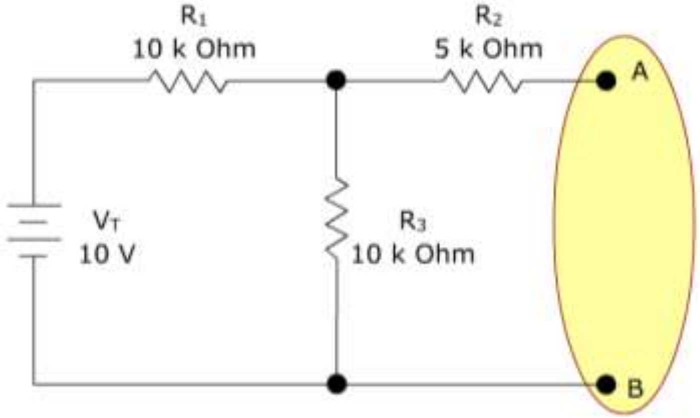
Thevenin's equivalent circuit

Norton’s theorem

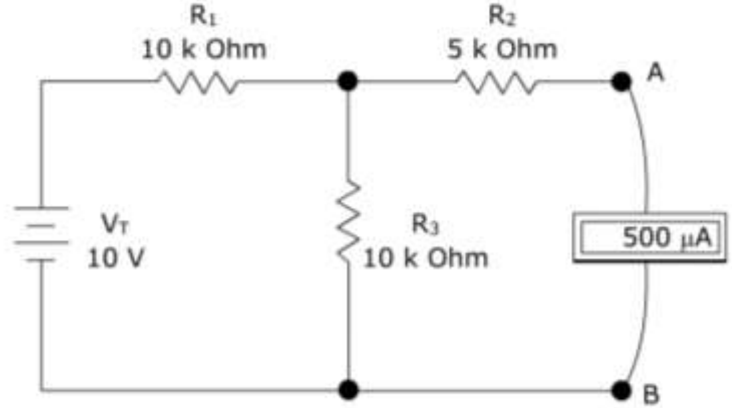
By reducing all of the elements of a complex circuit to a single current source and a single source resistance, which supply power to a load, a simple circuit can be created.



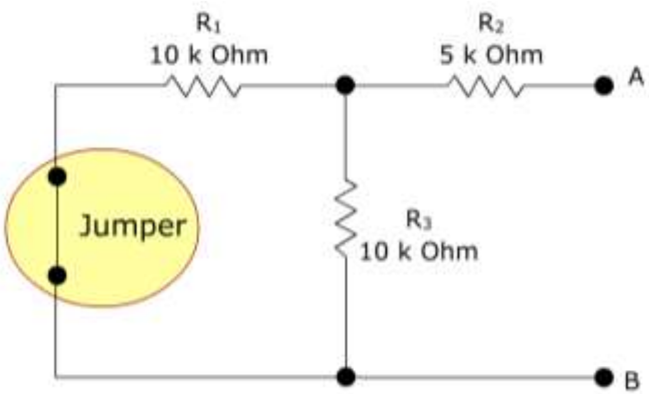
Step 1: Remove the load



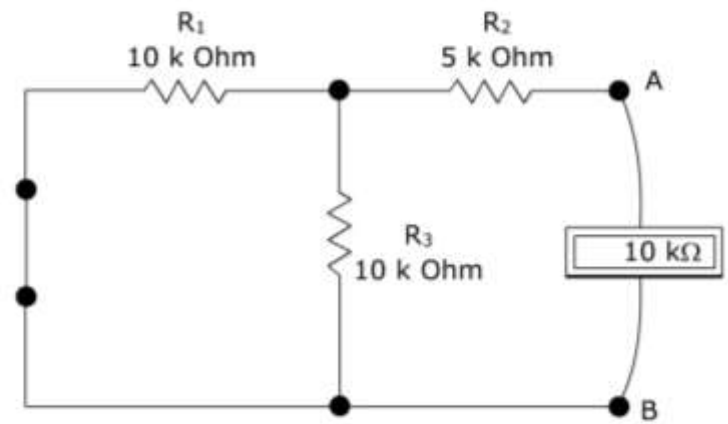
Step 2: Determine the current seen by the load



Step 3: Short circuit the power supply



Step 4: Determine the resistance seen by the load



Equivalent Norton circuit