EE1002
Introduction to Circuits and Systems

Part 1 : Lecture 1

Learning Outcomes for EE1002

a) To be able to apply various circuit theories in analysis of electrical and magnetic circuits.

b) To be able to use electrical and electromechanical devices such as transformer, electrical machines, power semiconductor switches, digital logic ICs for building an integrated system.

Learning outcomes

c) To be able to choose appropriate values of circuit components to meet specifications and conduct experiments to demonstrate the circuit operation.

d) To be able to verify the functionality of circuits using circuit simulation software LTspice.

Learning outcomes

d) To be able to use equipment such as DC power supply, signal generator, digital oscilloscope, multi-meter for prototyping circuits in the laboratory.

e) To follow safe working practices and proper waste disposal for recycling.

f) To be able to work in groups by communicating well with team members and supervisors for project implementation.

Assessment

- Assessment (50% hands-on +50% theory)
- Labs (5 expt. (10%) + lab test (10%))
- Project (3 labs + final demo)(30%)
- Midterm test (10%)
- Final Exam (40%)

Learning Resources

- Lecture notes (concise version of text books)
- Lecture slides and in-class discussions
- Tutorials
- Extra questions/Past year papers
- Text books
- Internet…

Introduction

Part1 Syllabus

- Fundamentals of Electric circuits
- Circuit Analysis Techniques

Circuit Analysis

1.

– DC Analysis (Sources are constant in time)

– AC Analysis (Sources are time-varying & periodic)

2.

– Steady-state analysis (constant in time)

– Transient analysis (time-varying)

Circuit Theory

- Ohm’s Law
- Kirchoff’s voltage law
- Kirchoff’s Current law
- Faraday’s Law

Circuit Analysis (steady-state)

- DC Circuit analysis
  - Node voltage Analysis
  - Mesh Current Analysis
  - Superposition technique
  - Equivalent circuit method
    - Thevenin's equivalent
    - Norton's equivalnet
- AC circuit analysis
  - Same as DC circuit analysis but in complex domain

AC steady-state analysis

- Complex algebra
- Phasor
- Impedance

Equipment

- DC Power supply
- Multimeter
- Ammeter
- Signal Generator
- Oscilloscope
- Bread-board
- Soldering PCB
- Misc. wiring tools

Circuit Elements

- Source (Active Element)
  - Voltage source or Current source
  - Independent source or Dependent source
- Load (Passive Element)
  - Resistor
  - Inductor
  - Capacitor

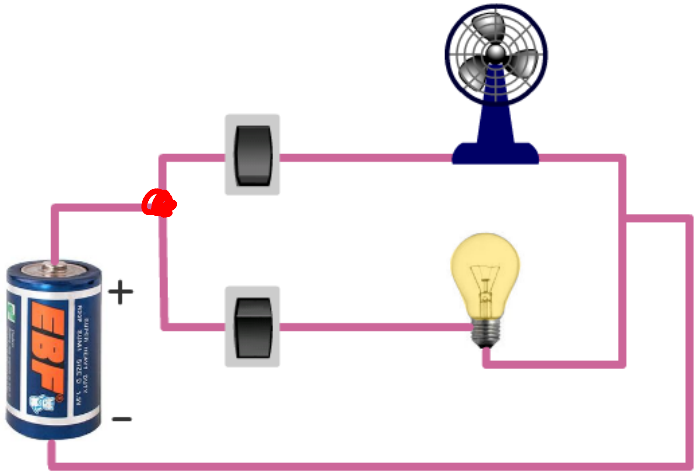
Simulation-Analysis-Experimentation

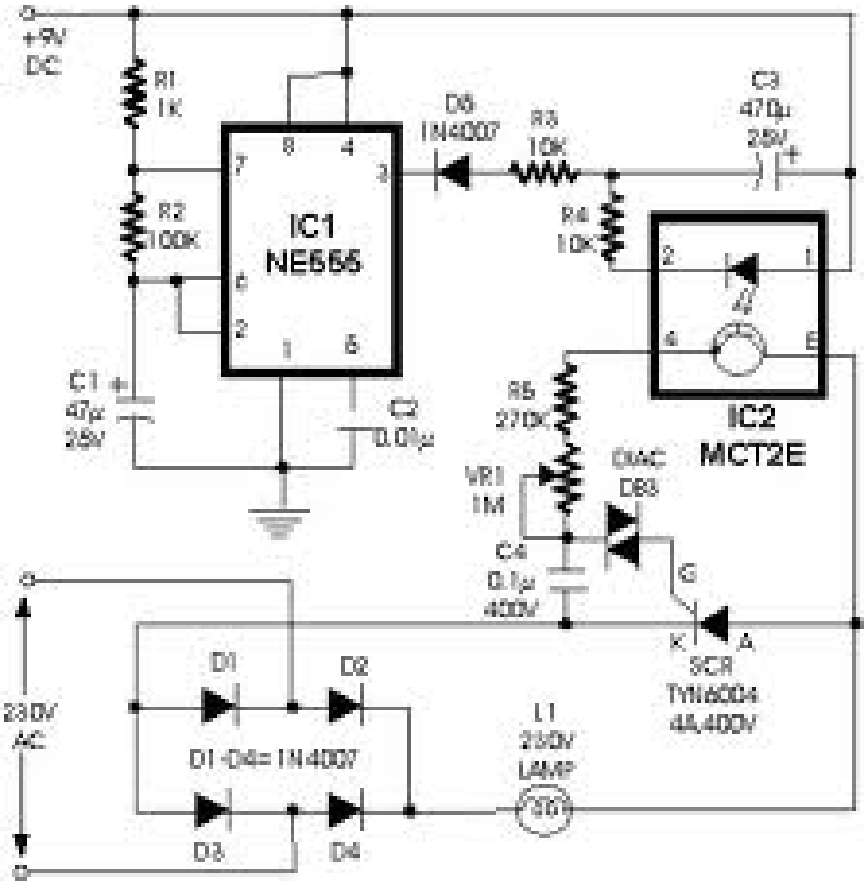
- Computer Simulation using LT Spice

Part1_A Syllabus

- Fundamentals of Electrical Circuits
  - What is meant by electrical circuit?
  - Circuit terminology
  - Electrical quantities
  - Circuit elements

Electrical Circuit examples





Circuit Terminology

- Node
- Branch
- Mesh
- Loop
- Super node

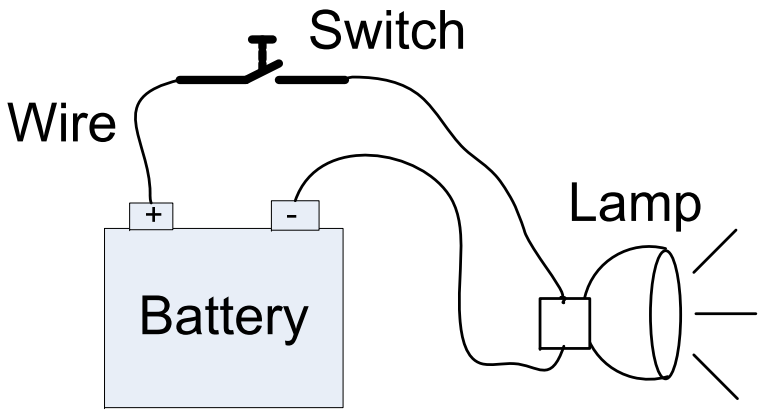
Electrical Quantities

- Charge
- Current
- Voltage
- Power
- Energy

Electrical quantities

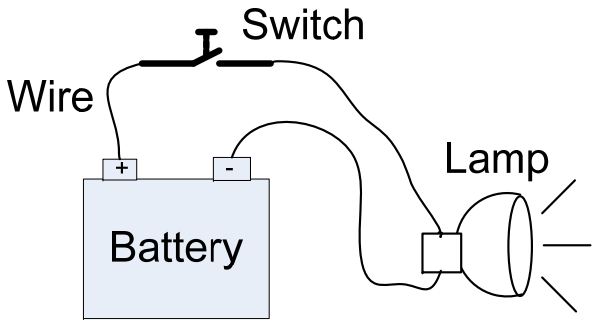
Charge

- Electrons are the most common charge carriers
  - Charge of electron $q_e = -1.602 \times 10^{-19} C$
- Unit : Coulomb, Symbol - *Q*
- Charge carriers move around in closed paths, to carry useful information or energy



Current

- Electric current is the time rate of flow of electrical charge through an element



$$i(t) = \frac{dq(t)}{dt}$$

$$q(t) = q(t_0) + \int_{t_0}^{t} i(t)dt$$

- Unit – Ampere, symbol - *I*
- Current has a direction (that of positive charge)
- DC – direct current (unidirectional)
- AC – alternating current (bidirectional and periodic)

Voltage

- Voltage is electrical potential difference (is a measure of the energy transferred per unit charge between two points.
- Unit – Volt, symbol - *V*
- Energy can be gained or lost, thus voltage has polarity: positive and negative
  - $V_{ab} = -V_{ba}$

$V_{ab} = P_a - P_b$

$= V_a - V_b$

Electric Power

- Voltage = Energy per unit charge
- Current = Charge per unit time
- Voltage x current = Energy per unit time
- Electric Power = Voltage x Current

$P = V \times I$

Derive SI units for Voltage

Quantity	Unit	Symbol
Length	Meter	m
Mass	Kilogram	Kg
Time	Second	s
Electric Current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd

$$\text{Voltage} = \frac{\text{Work done}}{\text{charge}} = \frac{\text{Force} \times \text{distance}}{\text{charge}}$$

$$\text{Force} = \text{Mass} \times \text{Accln} = \text{kg} \times \text{m} \times \text{s}^{-2}$$

$$\text{charge} = \text{A} \cdot \text{s}$$

$$\text{Voltage} = \frac{\text{kg} \cdot \text{m} \cdot \text{s}^{-2} \times \text{m}}{\text{A} \cdot \text{s}} = \text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3} \text{A}^{-1}$$

- Circuit Elements
  - Source
  - Resistance
  - Conductor

Sources

- Various sources of electrical energy
  - Batteries
  - Electric Generators
  - Fuel Cells
  - Solar panels

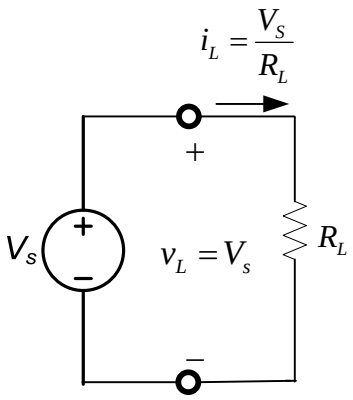
power = $\frac{\text{Energy}}{\text{time}}$

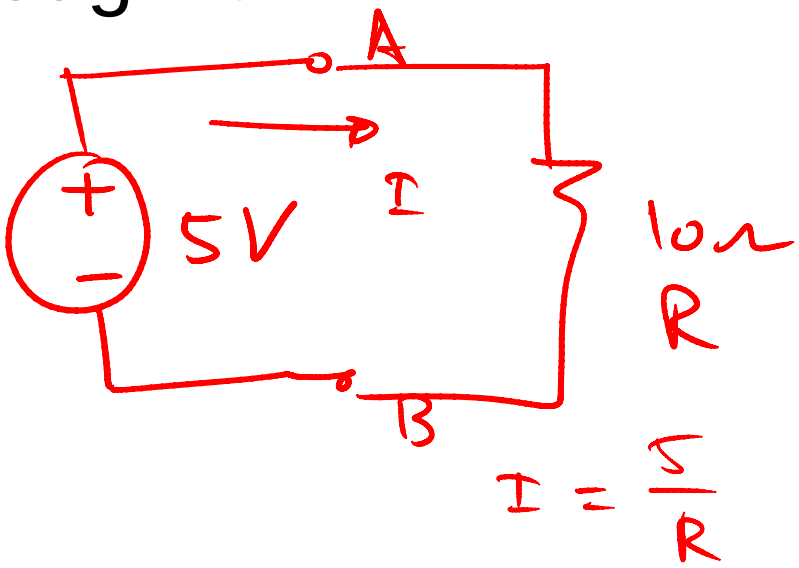
↳ $V \times I$.

- All electrical sources have voltage and current at their output, which is a measure of the power output
- Sources are classified as either voltage source or current source

Independent Voltage source

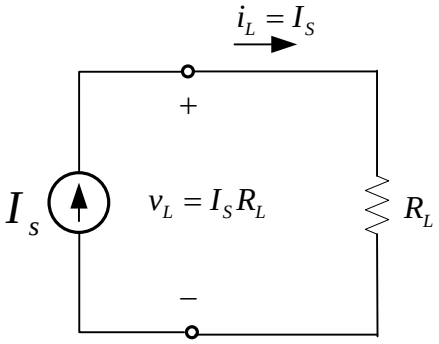
- An ideal voltage source maintains the voltage across its terminals irrespective of the current flowing through it.

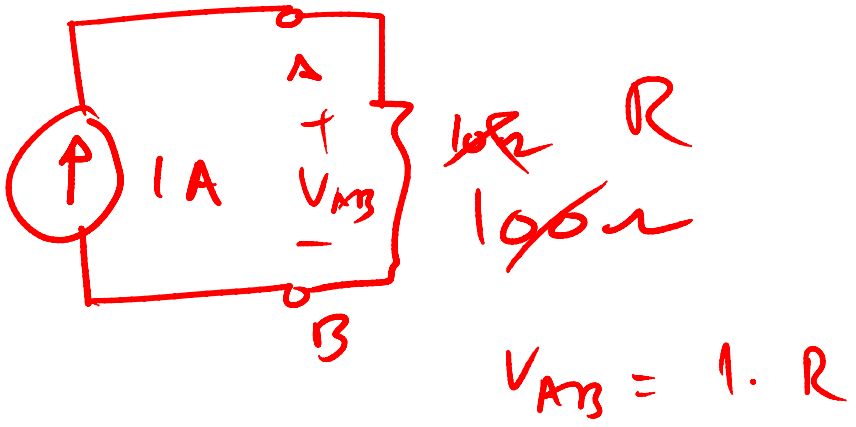




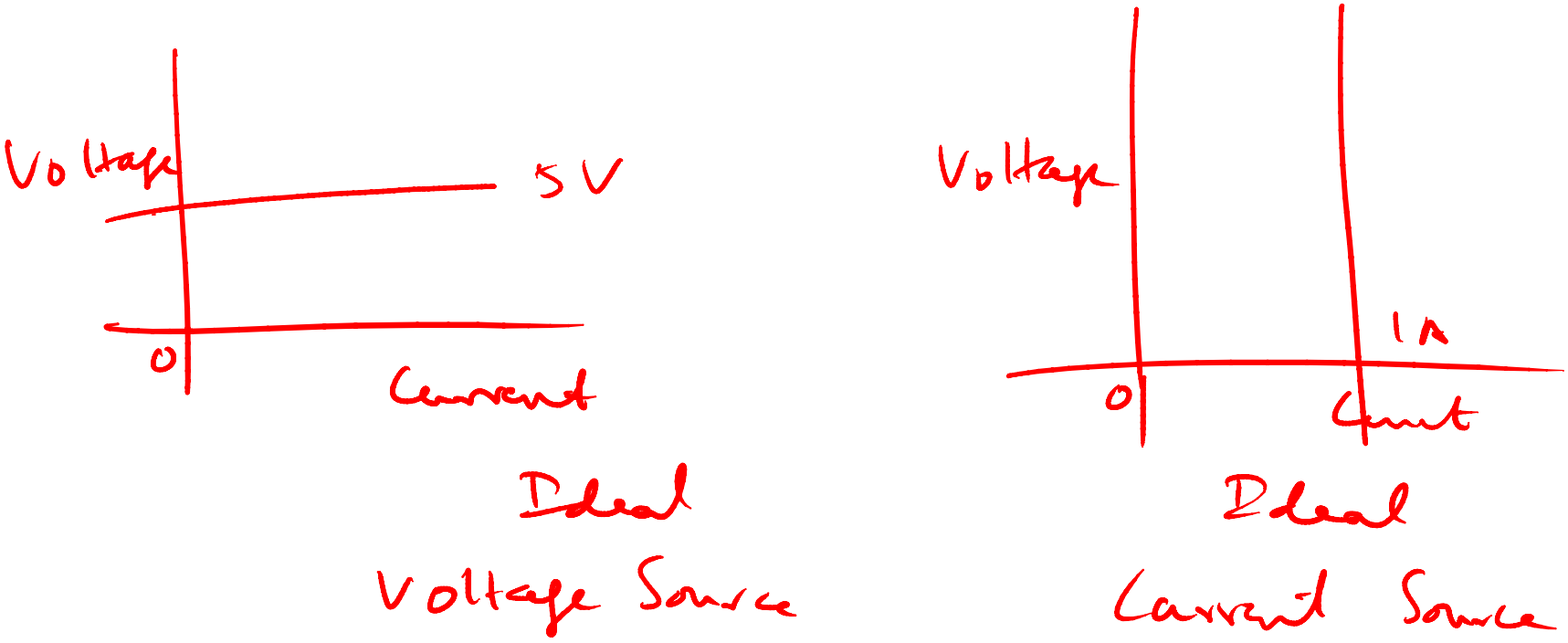
Independent Current source

- An ideal current source forces a specified current to flow through itself, irrespective of the voltage across it.





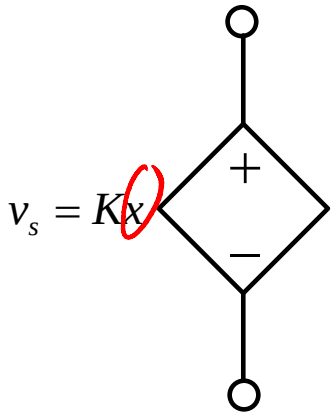
V-I Curve


Voltage
5 V
0
Current
Ideal
Voltage Source
Voltage
1 A
0
Current
Ideal
Current Source

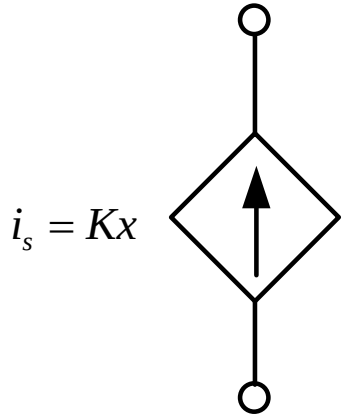
Dependent source

- If the characteristic output of the source is dependent on any other variable (current or voltage) in another part of the circuit, then it is known as dependent source.

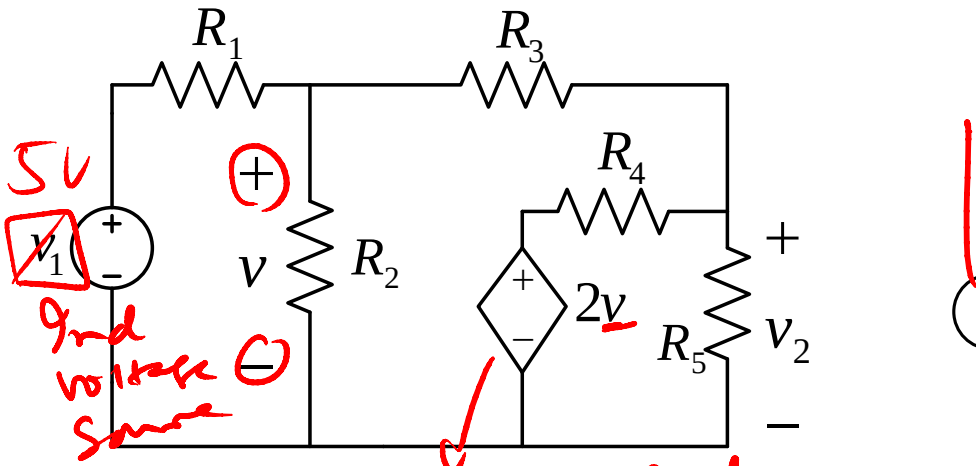
Dependent voltage source



Dependent current source



Examples of Dependent source

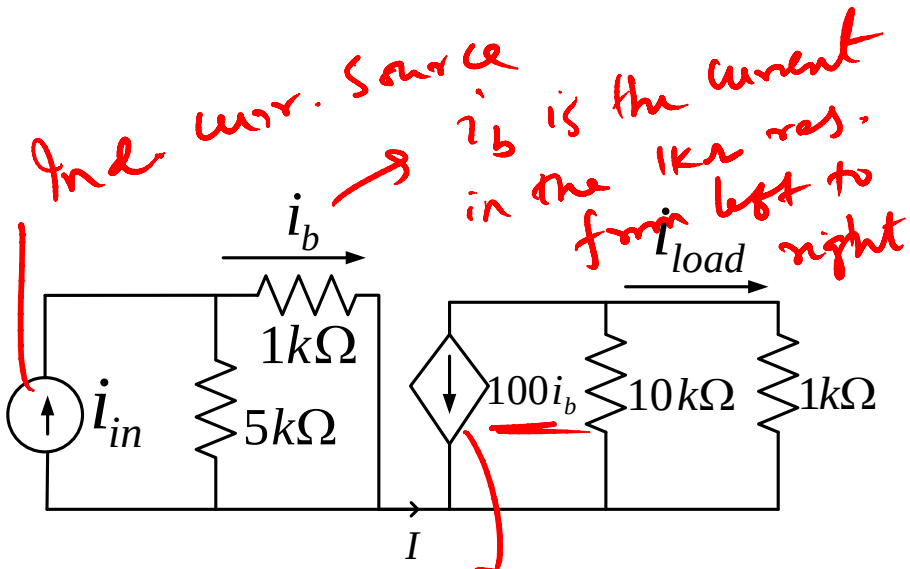


5V

Gnd voltage Source

Dependent voltage Source

V_2 voltage across R_2



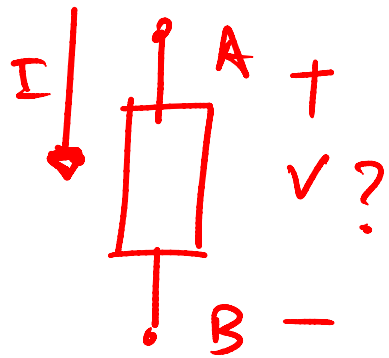
Gnd curr. Source

i_b is the current in the 1kΩ res. from left to right

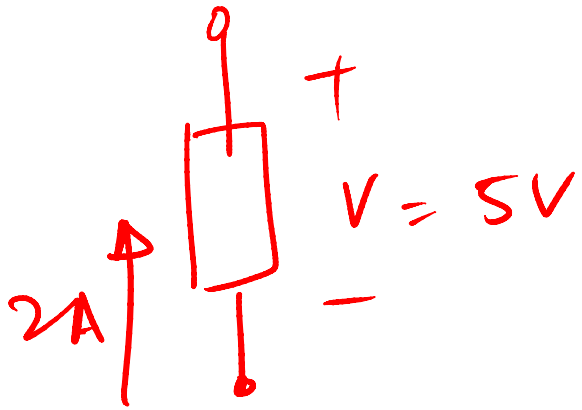
Dependent curr. Source

Source and Load

- Source(Active Element)
  - Charge moves from negative voltage polarity to positive polarity, it gains energy.
  - Current leaves the positive polarity

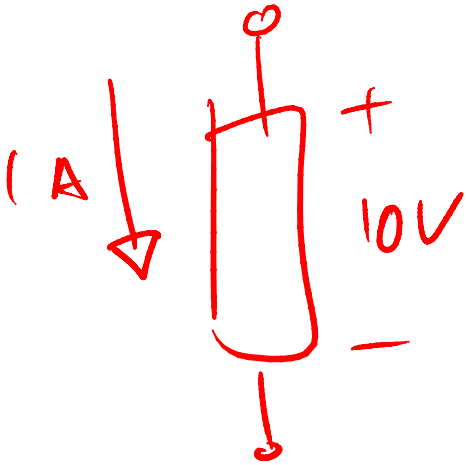


- Load (Passive Element)
  - Charge moves from positive voltage polarity to negative polarity, it losses energy.
  - Current enters the positive polarity



Source

Active Element



Load

Passive element

1. Converts to other form of energy

→ Absorbs, dissipates