SNS COLLEGE OF TECHNOLOGY
Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB101 – CIRCUIT ANALYSIS AND DEVICES

I YEAR/ II SEMESTER

UNIT 1 – MESH AND NODE ANALYSIS OF ELECTRIC CIRCUITS

TOPIC - Basic Components of electric Circuits

OVERVIEW

- Basic Components and Electric Circuits
  - Units and Scales
  - Charge, Current, Voltage, and Power

Charge

- One of the most fundamental concepts in electric circuit analysis is that of *charge conservation*.
- There are **two types** of charge: positive (corresponding to a proton) and negative (corresponding to an electron).
- There are many devices in which positive charge motion is important to understanding internal operation.
- But external to the device we typically **concentrate on the electrons** which flow through the connecting wires.
- Although we continuously transfer charges between different parts of a circuit, we do nothing to change the total amount of charge.

Charge SI Unit and Representation

- In other words, we neither create nor destroy electrons (or protons) when running electric circuits.
- Charge in motion represents a *current.*
- In the SI system, the fundamental unit of charge is the ***coulomb (C).***
- A quantity of charge that does not change with time is typically represented by *Q.*
- *The instantaneous amount of charge* is commonly represented by *q(t), or simply q.*

Definition of Current using charge

•It is defined in terms of the ***ampere by counting the total charge that*** passes through an arbitrary cross section of a wire during an interval of one second.

•one coulomb is measured each second for a wire carrying a current of 1 ampere.

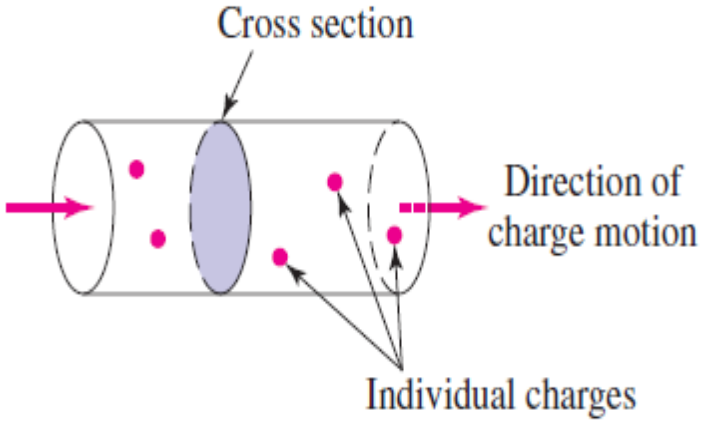


Figure: The definition of current illustrated using current flowing through a wire.

•In this system of units, the charge of **a single electron is −1.*602 × 10−19 C***
a single proton is +1.602 × 10−19 C.

Current

- The idea of **“transfer of charge” or “charge in motion”** is of vital importance to us in studying electric circuits.
- In moving a charge from place to place, we may also transfer energy from one point to another.
- This process is the basis of communication systems such as radio, television, and telemetry.
- The current present in a discrete path has both a *numerical value and a direction* associated with it
- It is a measure of the rate at which charge is moving past a given reference point in a specified direction.

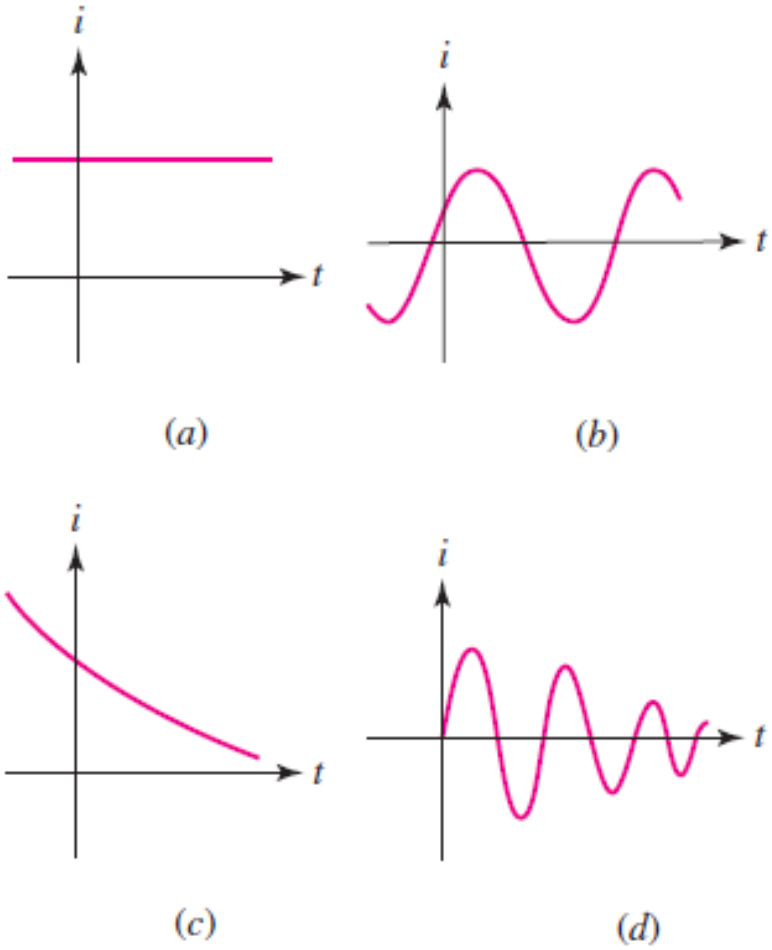
Current SI Unit and Representation

- A contribution to this total charge will be negative if negative charge is moving in the reference direction, or if positive charge is moving in the opposite direction.
- Current is symbolized by *I or i, and so*

$$i = \frac{dq}{dt}$$

- The unit of current is **ampere (A)**, named after A. M. Ampere, a French physicist.
- One ampere equals *1 coulomb per second*.

Types of Current



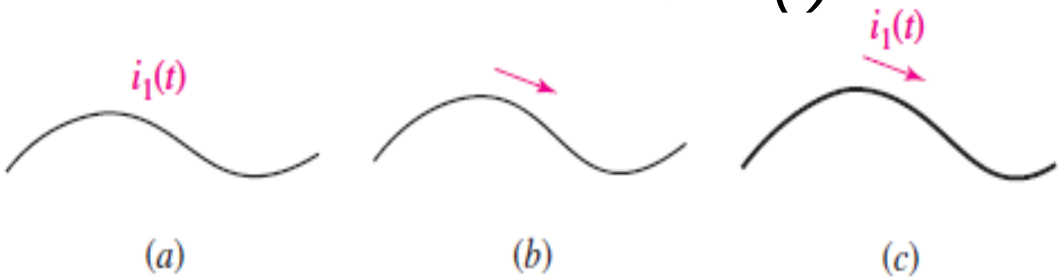
Types of current:

(a) Direct current (dc).
(b) Sinusoidal current (ac).
(c) Exponential current.
(d) Damped sinusoidal current.

Graphical Symbol for Current

Two methods of representation for the exact same current.

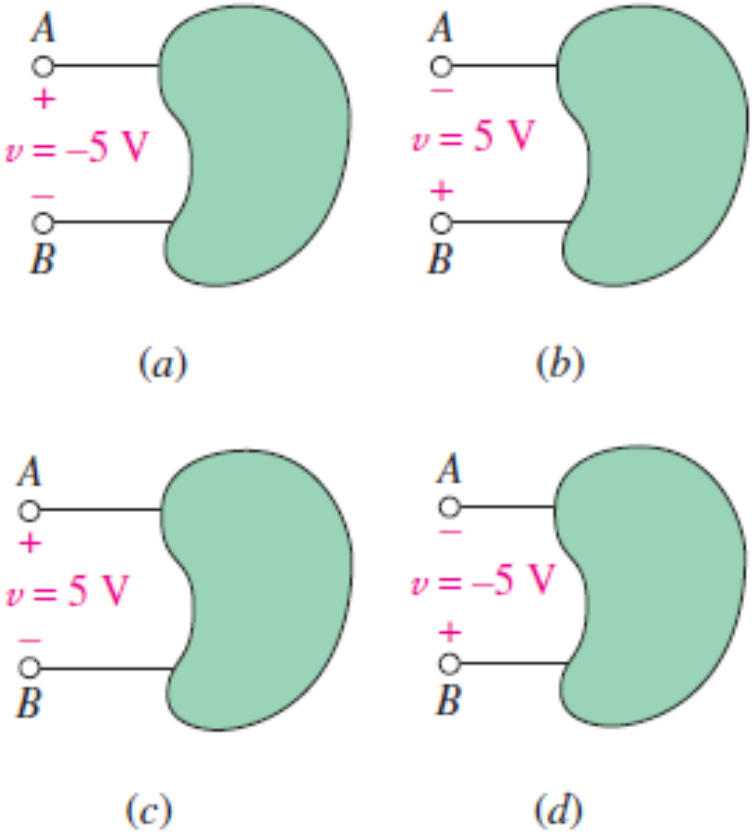
(a, b) Incomplete, improper, and incorrect definitions of a current.
(c) The correct definition of i1(t).



Voltage

- The voltage across a terminal pair is a measure of the *work required to move charge* through the element.
- The unit of voltage is the **volt**, and 1 volt is the same as 1 J/C. Voltage is represented by **V or *v***.
- A voltage can exist between a pair of electrical terminals whether a current is flowing or not.
- According to the *principle of conservation of energy*, the energy that is expended in forcing charge through the element must appear somewhere else.
- The sense of the voltage is indicated by a *plus-minus* pair of algebraic signs.

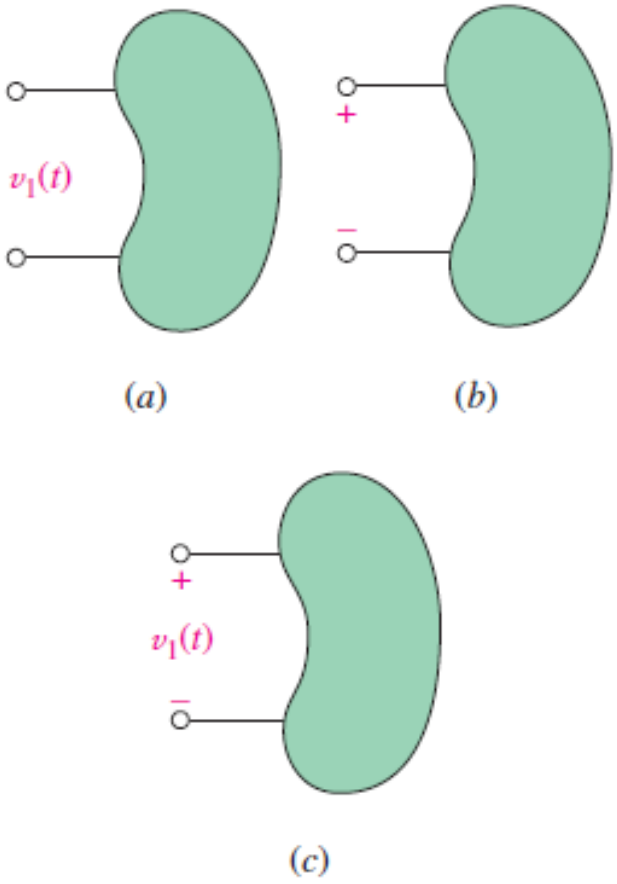
Sign for the Voltage Terminal



(*a, b) Terminal B is 5 V positive with* respect to terminal *A*

(c, d) terminal A is 5 V positive with respect to terminal *B.*

Sign for the Voltage Terminal



(*a, b) These are inadequate* definitions of a voltage.

(*c) A correct definition includes* both a symbol for the variable and a plus-minus symbol pair.

Power

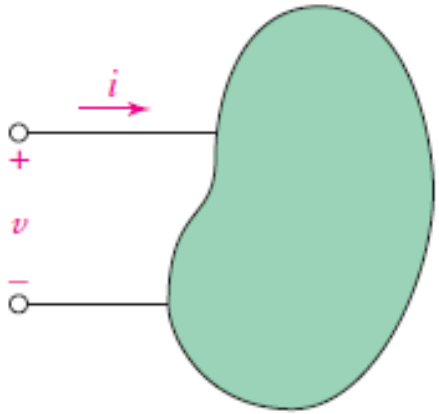
- If *one joule of energy* is expended in transferring one coulomb of charge through the device in one second, then the *rate of energy transfer* is one watt.
- The absorbed power must be proportional both to the number of coulombs transferred per second (current) and to the energy needed to transfer one coulomb through the element (voltage). Thus,

$$p = vi$$

- Voltage was defined in terms of an *energy expenditure*, and power is the rate at which energy is expended.

Sign for the Power Terminal

- If the current arrow is directed into the "+" marked terminal of an element, then *p=vi yields the absorbed* power.
- If the current arrow is directed out of the "+" terminal of an element, then *p=vi yields the supplied power.*



The power absorbed by the element is given by the product *p= vi*

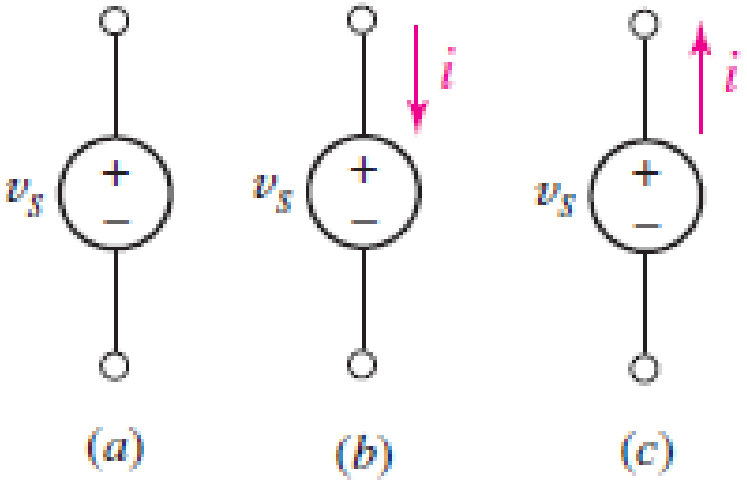
Voltage and Current Sources

Using the concepts of current and voltage, it is possible to be more specific in defining a circuit element.

- The mathematical model which we will use to analyze its behaviour in a circuit.
- All the simple circuit elements can be classified according to the relationship of the current through the element to the voltage across the element.
- The sources are classified as i*ndependent sources* and *dependent sources.*
- *Dependent sources* are used a great deal in electronics to model both dc and ac behaviour of transistors, especially in amplifier circuits.

Independent Voltage Sources

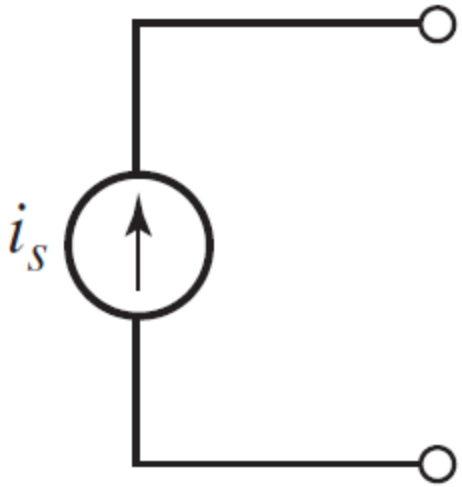
- *An **independent voltage source** is characterized by a terminal voltage which is completely independent of the current through it.*
- The independent voltage source is an *ideal source and does not represent* exactly any real physical device.



Circuit symbol of the independent voltage source.

Independent Current Sources

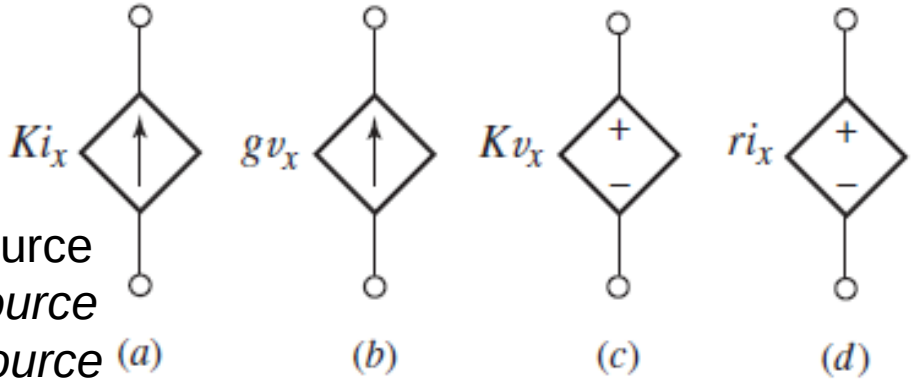
- In the ***independent current source,*** the current through the element is completely independent of the voltage across it.
- In theory it can deliver *infinite power* from its terminals.
- It is, however, a *good approximation* for many practical sources, particularly in electronic circuits.



Circuit symbol for the independent current source.

Dependent Sources

- The *dependent, or controlled, source,* in which the source quantity is determined by a voltage or current existing at some other location in the system.
- To distinguish between dependent and independent sources, the diamond symbols are introduced.
  - *K is scaling* constant.
  - *g is scaling factor (A/V)*
  - *r is scaling factor (V/A).*



(a) current-controlled current source
(b) voltage-controlled current source
(c) voltage-controlled voltage source
(d) Current controlled voltage source.

Assessment

1. Which of the following is not an expression power?

a) P=VI

b) $P=I^2R$

c) $P=V^2/R$

d) P=I/R

2. A 250V bulb passes a current of 0.3A. Calculate the power in the lamp.

a) 75W

b) 50W

c) 25W

d) 90W

3. The symbol used for representing Independent sources

a) Diamond

b) Square

c) Circle

d) Triangle


THANK YOU