Electric Circuits Elements

Lec 02

Contents

- Basic circuit elements : Active element and Passive element

Active and Passive Circuit Elements

A **passive element** absorbs (dissipates) energy.

An **active element** is capable of supplying energy.

ACTVIVE ELEMENT AND PASSIVE ELEMENT

Active Element– elements capable of generating electrical energy. For example:

Voltage source

Current source

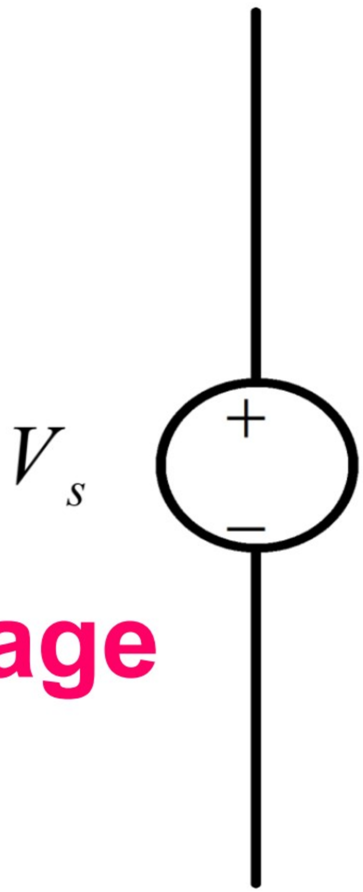
Passive Element – elements are not capable of generating electrical energy. For example:

Resistor (dissipates energy)

Capacitor and Inductor (can store or release energy)

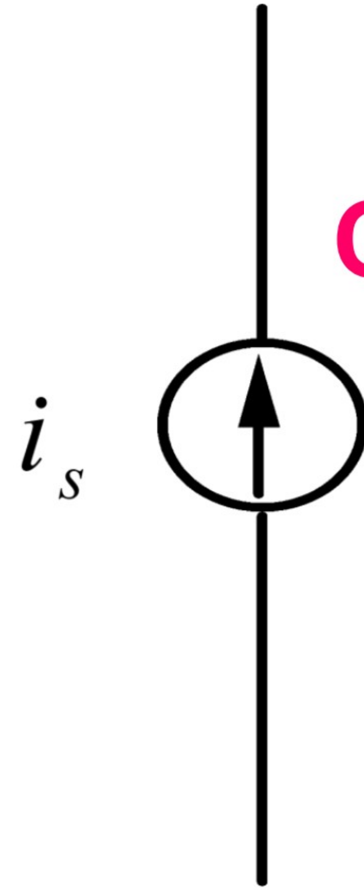
Independent source

This source maintains a specified voltage between its terminals but has no control on the current passing through it. The symbol of the independent voltage source is a plus-minus sign enclosed by a circle.



Voltage

Current

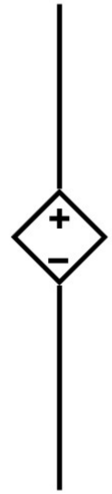


This source maintains a specified current through its terminals but has no control on the voltage across its terminals. The symbol of the independent current source is an arrow enclosed by a circle.

Dependent source

Voltage

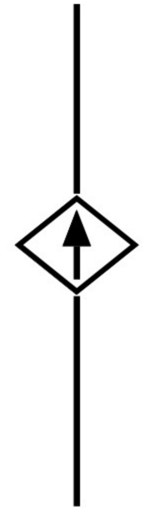
$V_s = \rho i_x$



This kind of voltage source has a specified voltage between its terminals but it is dependable on some other variable defined somewhere in the circuit. The symbol for the dependent voltage source is a plus-minus sign enclosed by a diamond shape. The value of the dependent current source is ρix (ohms) where ρ is the scale factor or gain.

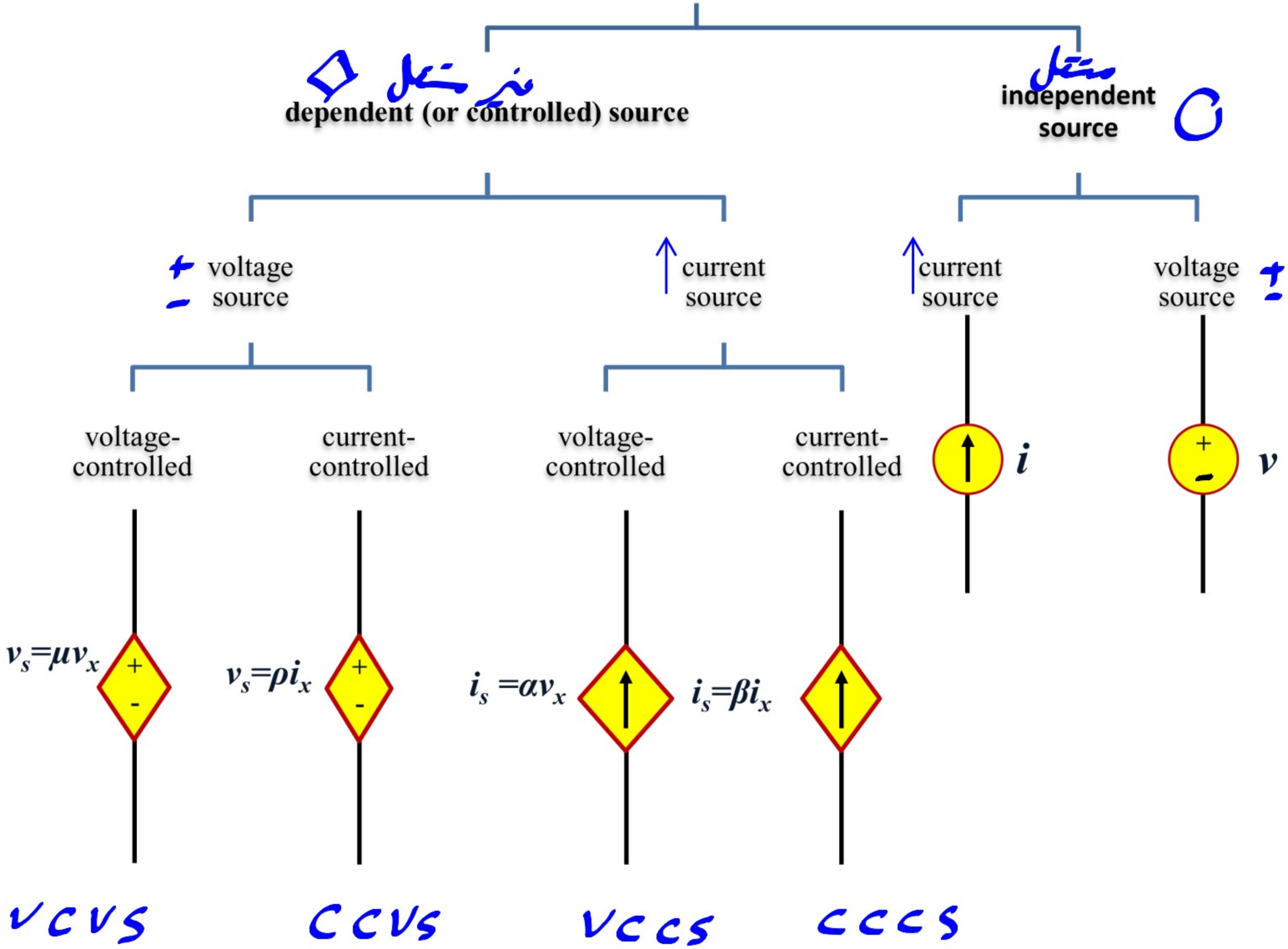
Current

$i_s = \alpha V_x$



This kind of current source has a specified current between its terminals but it is dependent on some other variable defined somewhere in the circuit. The symbol for the dependent current source is an arrow enclosed by a diamond shape. The value of the dependent current source is αVx (in Siemens) where α is the scale factor or gain.

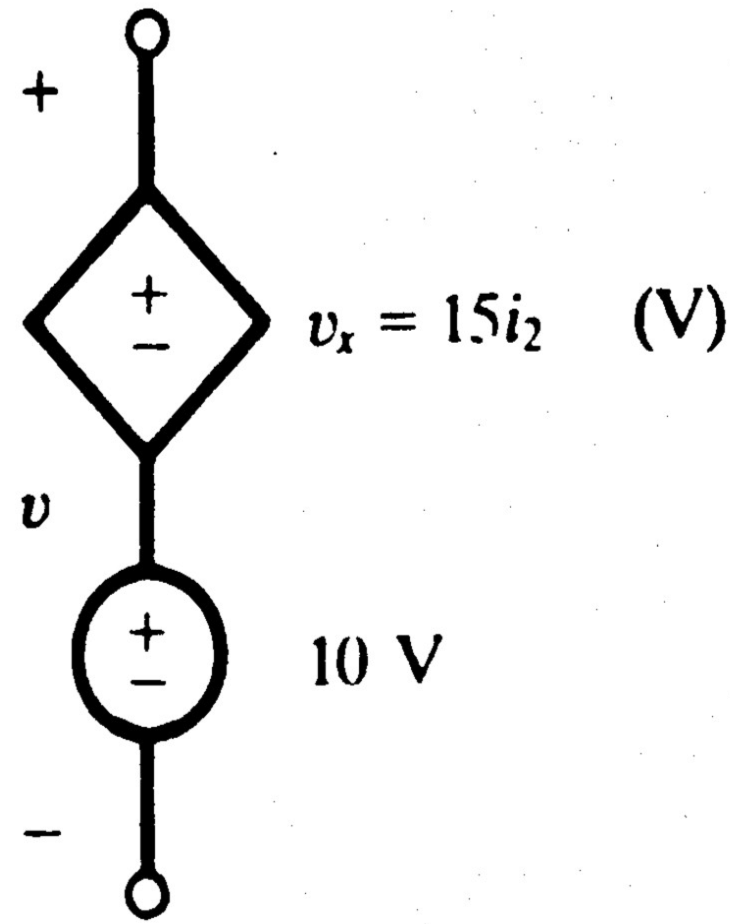
VOLTAGE AND CURRENT SOURCES



EXAMPLE

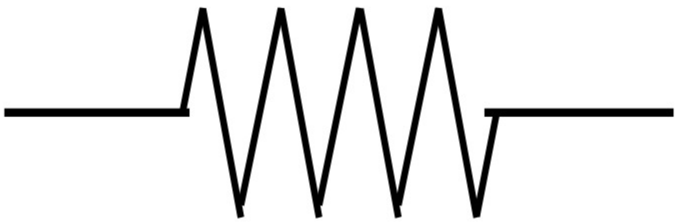
obtain the voltage v in the branch shown in figure below for $i_2 = 1A$.

$v = 10 + v_x = 10 + 15(1) = 25$



Circuit symbol of resistor

Resistor

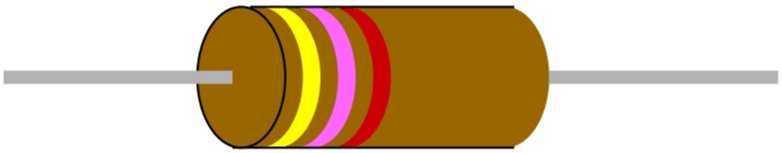


R

UNIT: Ohm (Ω)

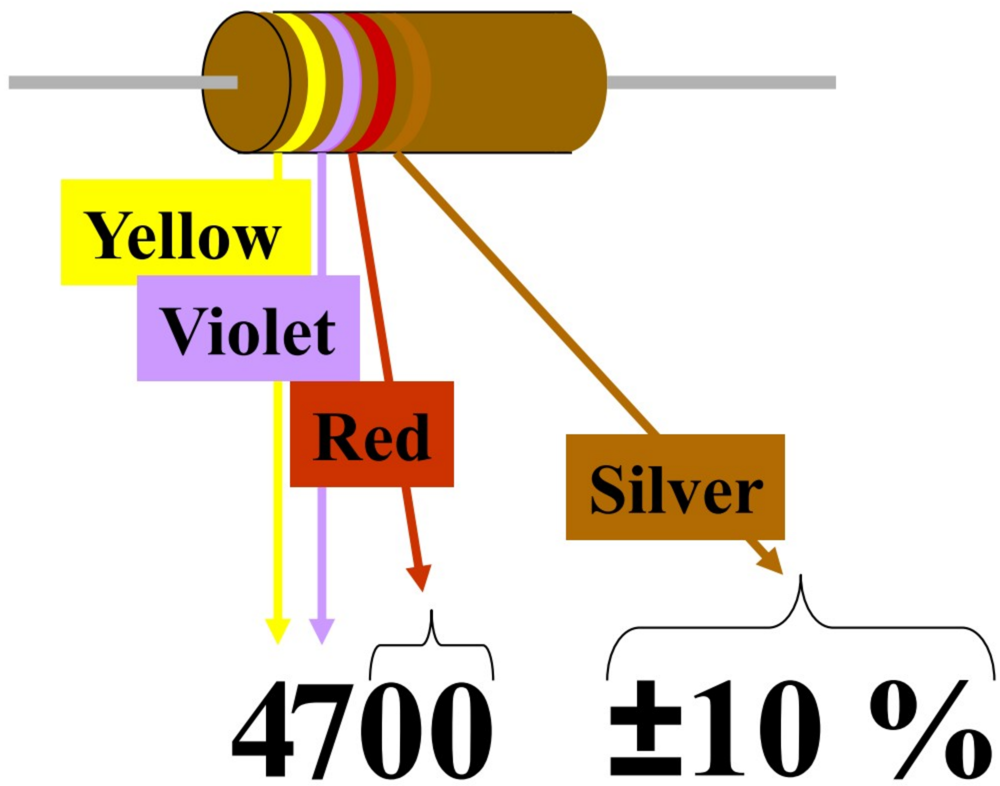
Resistor is passive element that dissipates electrical energy. Linear resistor is the resistor that obeys Ohm's law.

RESISTOR COLOUR CODE

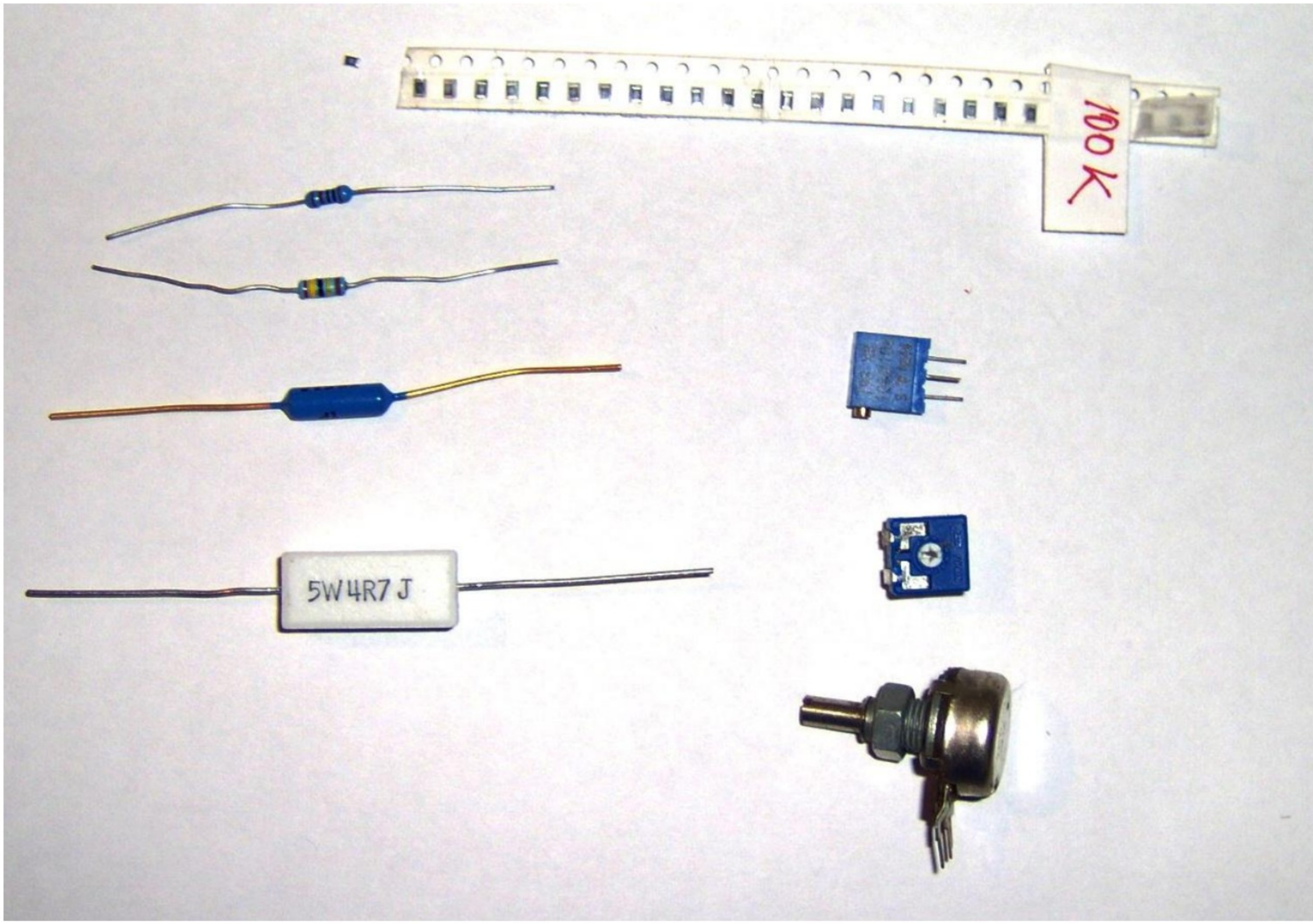


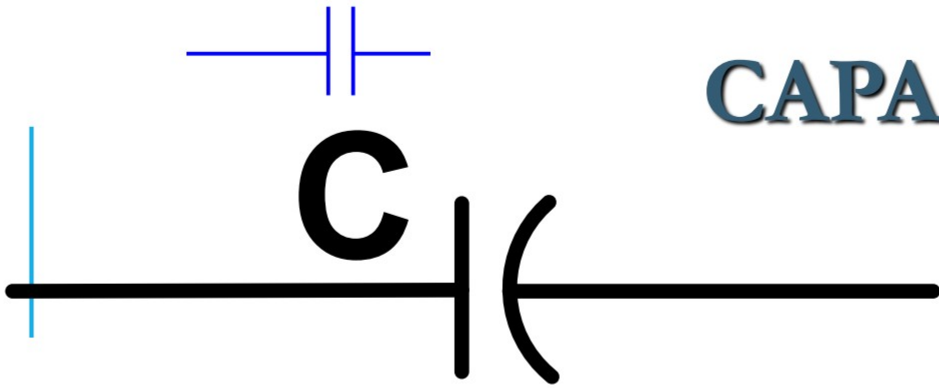
Color	Color Name	1st Digit 1st Stripe	2nd Digit 2nd Stripe	Multiplier 3rd Stripe	Tolerance 4th Stripe
	Black	0	0	x1	-
	Brown	1	1	x10	-
	Red	2	2	x100	-
	Orange	3	3	x1,000	-
	Yellow	4	4	x10,000	-
	Green	5	5	x100,000	-
	Blue	6	6	x1,000,000	-
	Violet	7	7	-	-
	Gray	8	8	-	-
	White	9	9	-	-
	Gold	-	-	-	5%
	Silver	-	-	-	10%

Resistor Colour Codes



RESISTORS





CAPACITOR

UNIT: Farad (F)

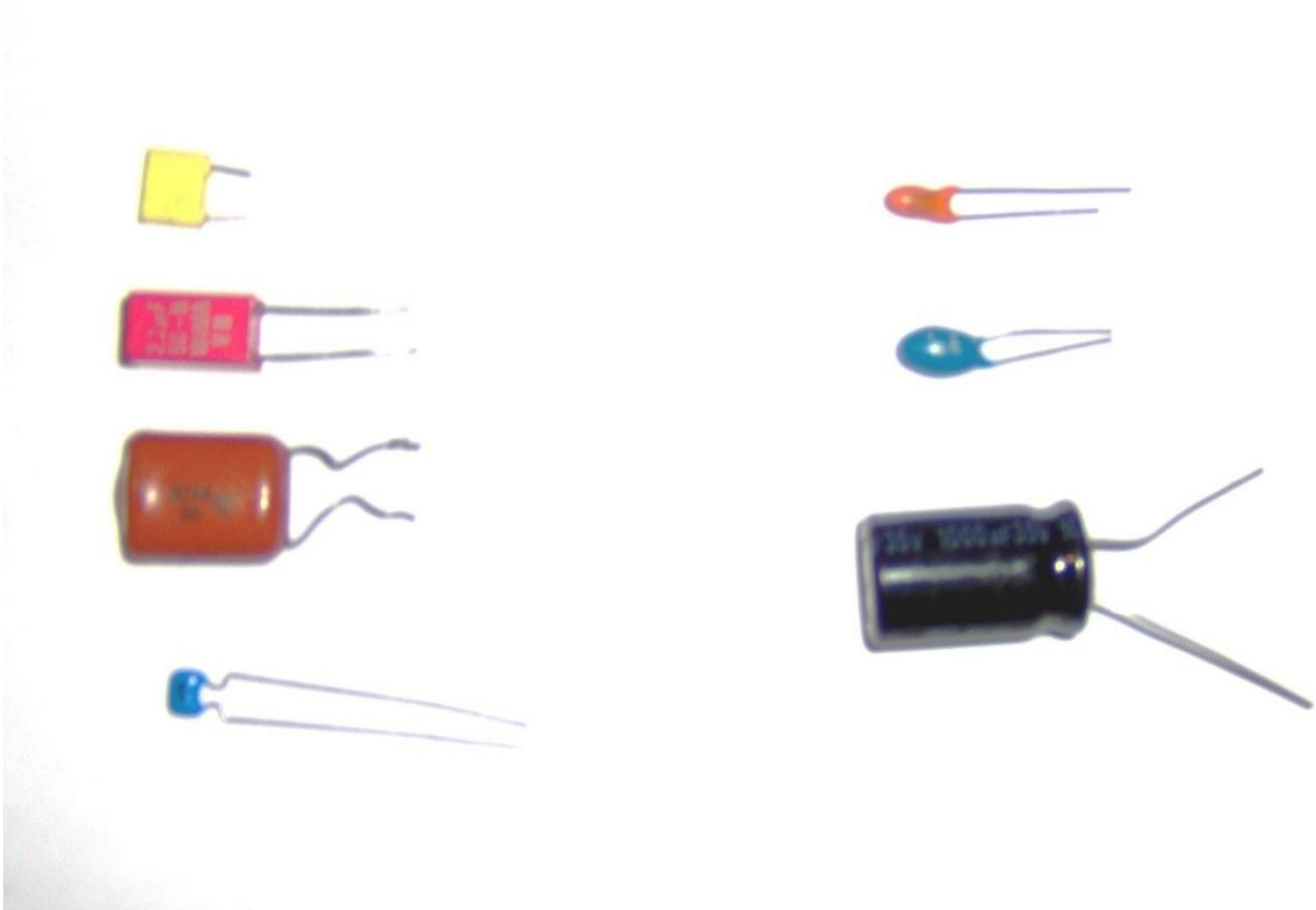
Electrical component that consists of two conductors separated by an insulator or dielectric material.

Its behavior based on phenomenon associated with electric fields, which the source is voltage.

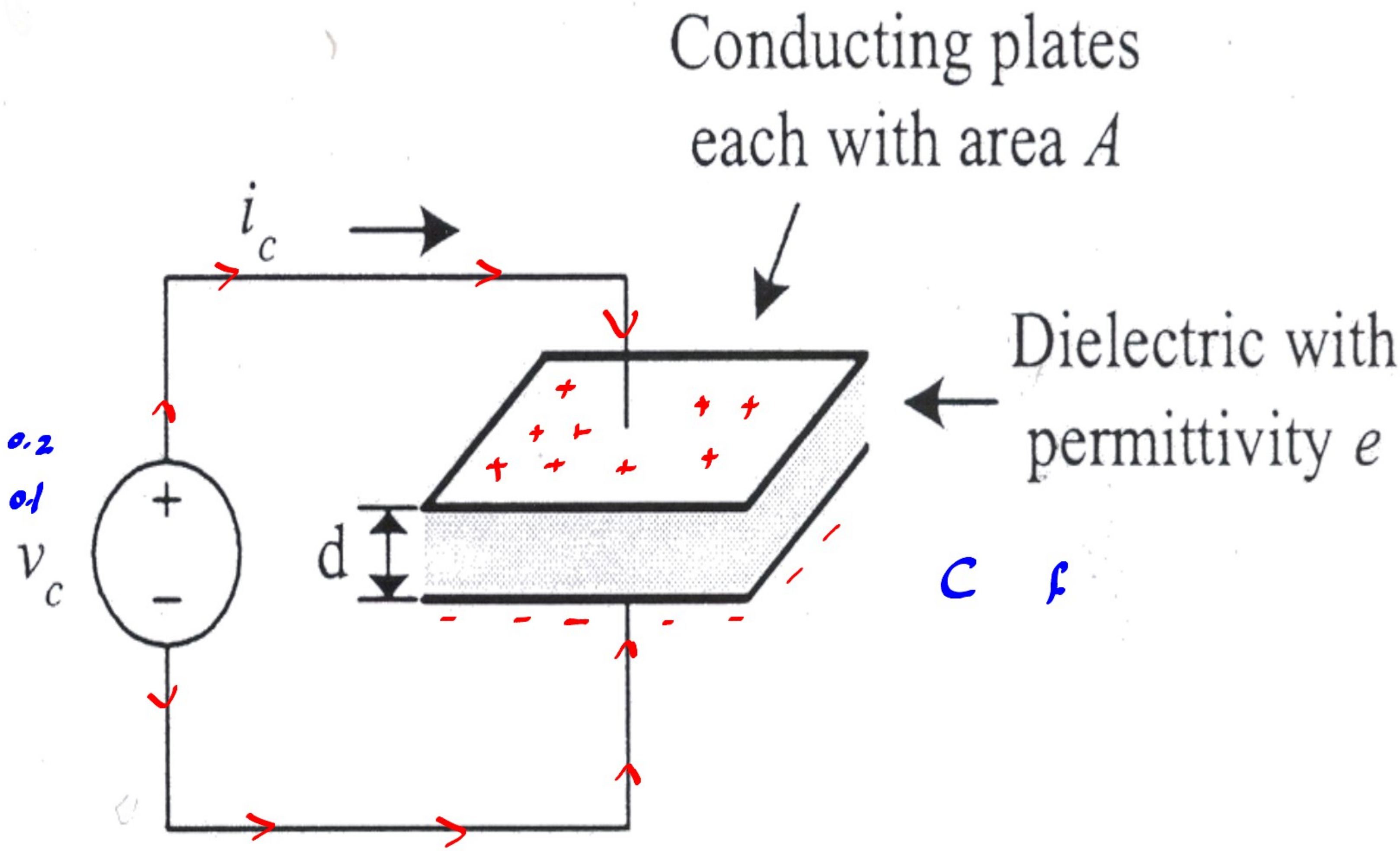
A time-varying electric fields produce a current flow in the space occupied by the fields.

Capacitance is the circuit parameter which relates the displacement current to the voltage.

CAPACITORS



A capacitor with an applied voltage



Plates – aluminum foil

Dielectric – air/ceramic/paper/mica

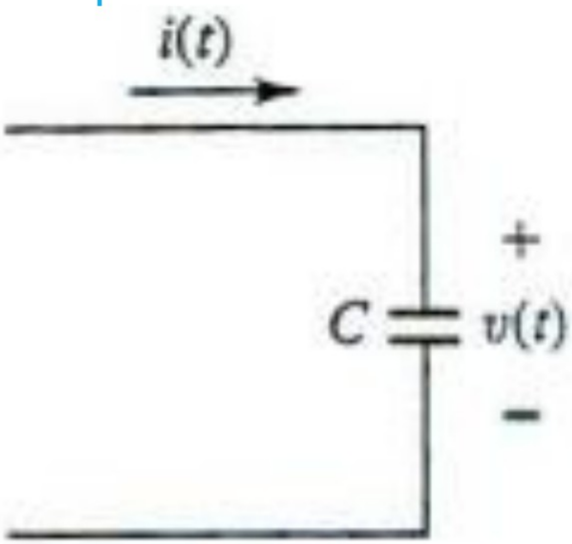


FIGURE 3–3
Capacitance with instantaneous time-varying voltage and current.

$$i(t) = C\frac{dv(t)}{dt}$$

$$v(t) = \frac{1}{C}\int_{-\infty}^{t} i(t)\,dt$$

$$v(t) = \frac{1}{C}\int_{0}^{t} i(t)\,dt + V_0$$

Circuit parameters

- The amount of charge stored, $q = CV$.
- C is capacitance in Farad, ratio of the charge on one plate to the voltage difference between the plates. But it does not depend on q or V but capacitor's physical dimensions i.e.,

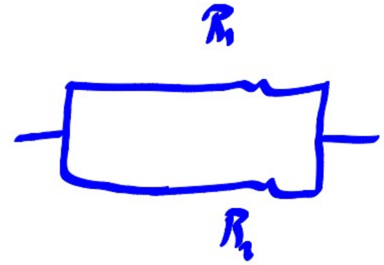
$$C = \frac{\varepsilon A}{d}$$

ε = permeability of dielectric in Wb/Am

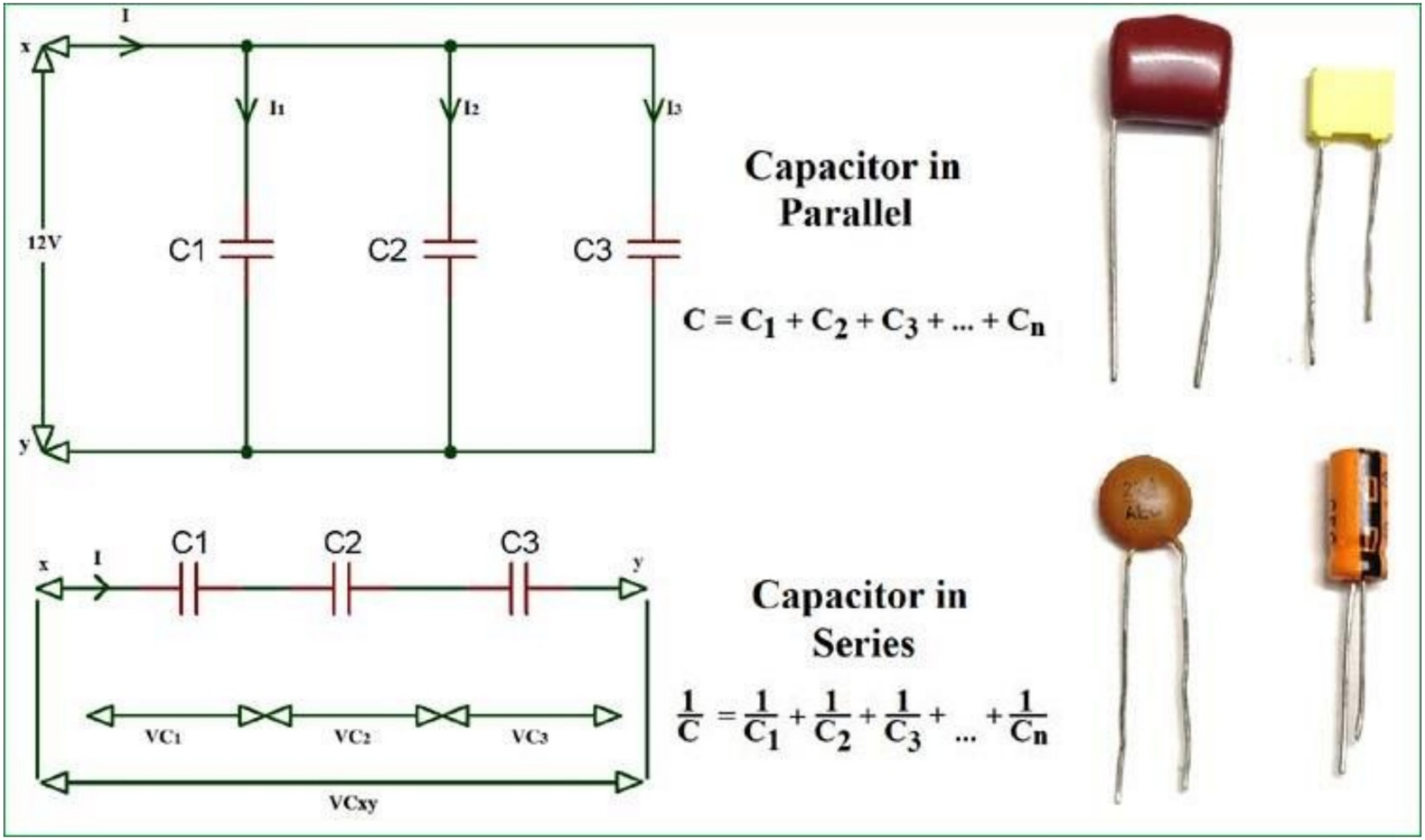
A = surface area of plates in m^2

d = distance between the plates m

$$R_{eq} = R_1 + R_2$$



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$



Example 2.15

Determine the values of capacitance obtainable by connecting three capacitors (of 5 μF, 10 μF and 20 μF) (1) in series, (2) in parallel and (3) in series–parallel.

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{5} + \frac{1}{10} + \frac{1}{20}$$

Solution

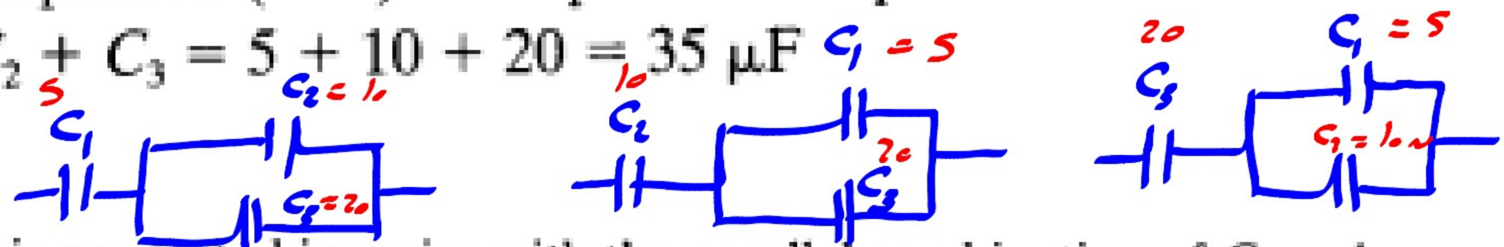
$$1/\left(\frac{1}{5} + \frac{1}{10} + \frac{1}{20}\right)$$

Let the capacitors of 5 μF, 10 μF and 20 μF be C_1, C_2, and C_3, respectively.

1 From Equation (2.24) the equivalent capacitance is the reciprocal of $(1/C_1 + 1/C_2 + 1/C_3)$ i.e.
$1/[(1/5) + (1/10) + (1/20)] = 1/[0.2 + 0.1 + 0.05] = 1/0.35 = 2.86$ μF

2 From Equation (2.25) the equivalent capacitance is

$C_1 + C_2 + C_3 = 5 + 10 + 20 = 35\ \mu F$



3 (a) When C_1 is connected in series with the parallel combination of C_2 and C_3 the equivalent capacitance is the reciprocal of

$[1/C_1 + 1/(C_2 + C_3)] = 1/[1/5 + 1/30] = 1/[0.2 + 0.033] = 4.29\ \mu F$

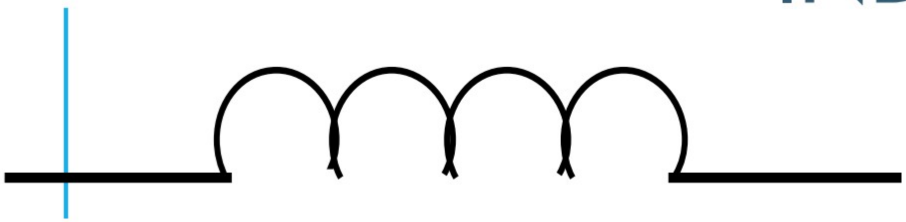
(b) Similarly when C_2 is in series with the parallel combination of C_3 and C_1 the equivalent capacitance is

$1/[1/10 + 1/25] = 1/[0.1 + 0.04] = 1/0.14 = 7.14\ \mu F$

(c) Similarly when C_3 is in series with the parallel combination of C_1 and C_2 the equivalent capacitance is

$1/[1/20 + 1/15] = 1/[0.05 + 0.066] = 1/0.116 = 8.62\ \mu F$

INDUCTOR



L

UNIT: Henry (H)

- Electrical component that opposes any change in electrical current.
- Composed of a coil or wire wound around a non-magnetic core/magnetic core.
- Its behavior based on phenomenon associated with magnetic fields, which the source is current.
- A time-varying magnetic fields induce voltage in any conductor linked by the fields.
- Inductance is the circuit parameter which relates the induced voltage to the current.

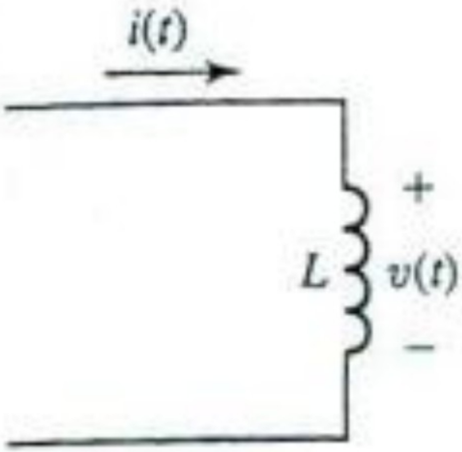


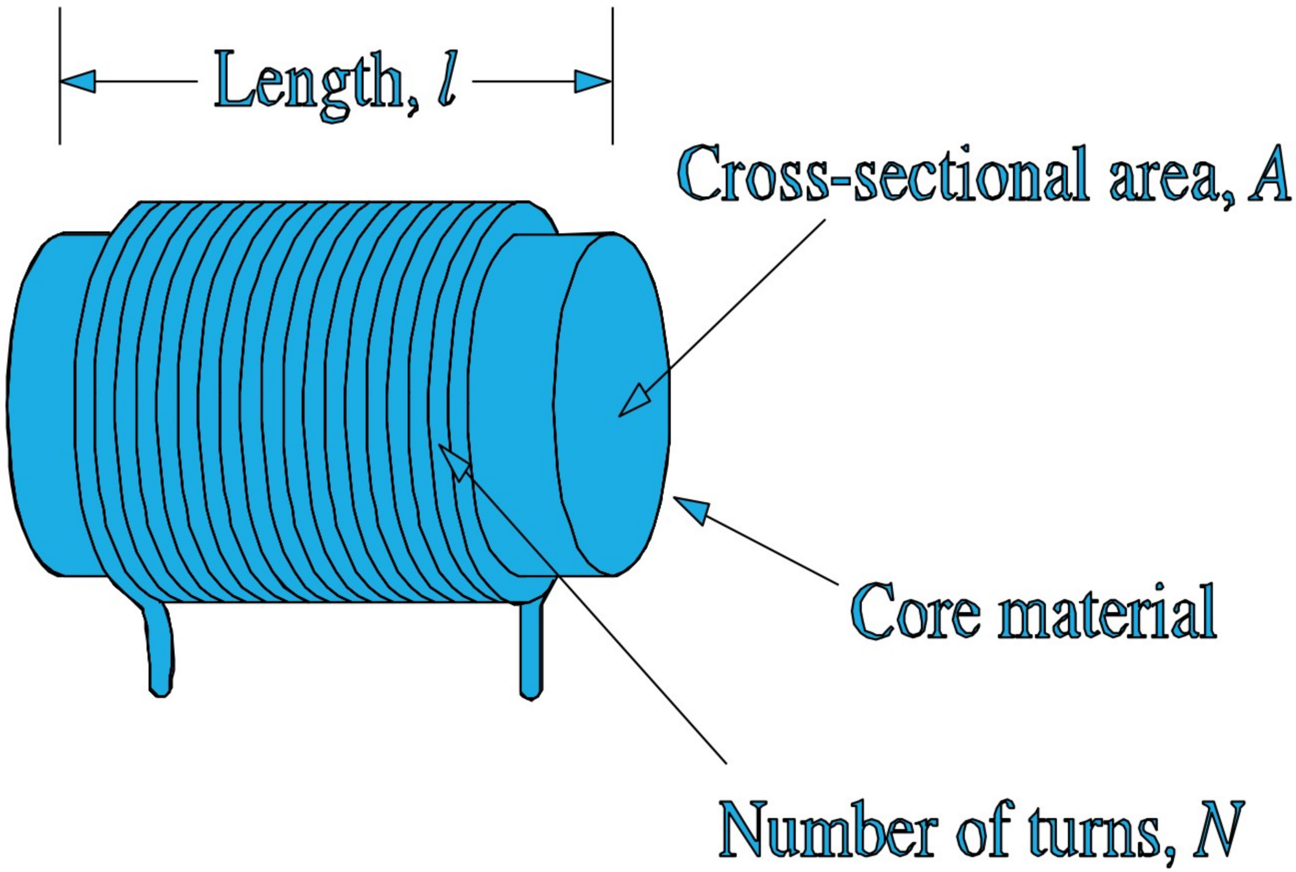
FIGURE 3–2
Inductance with instantaneous time-varying voltage and current.

$$v(t) = L\frac{di(t)}{dt}$$

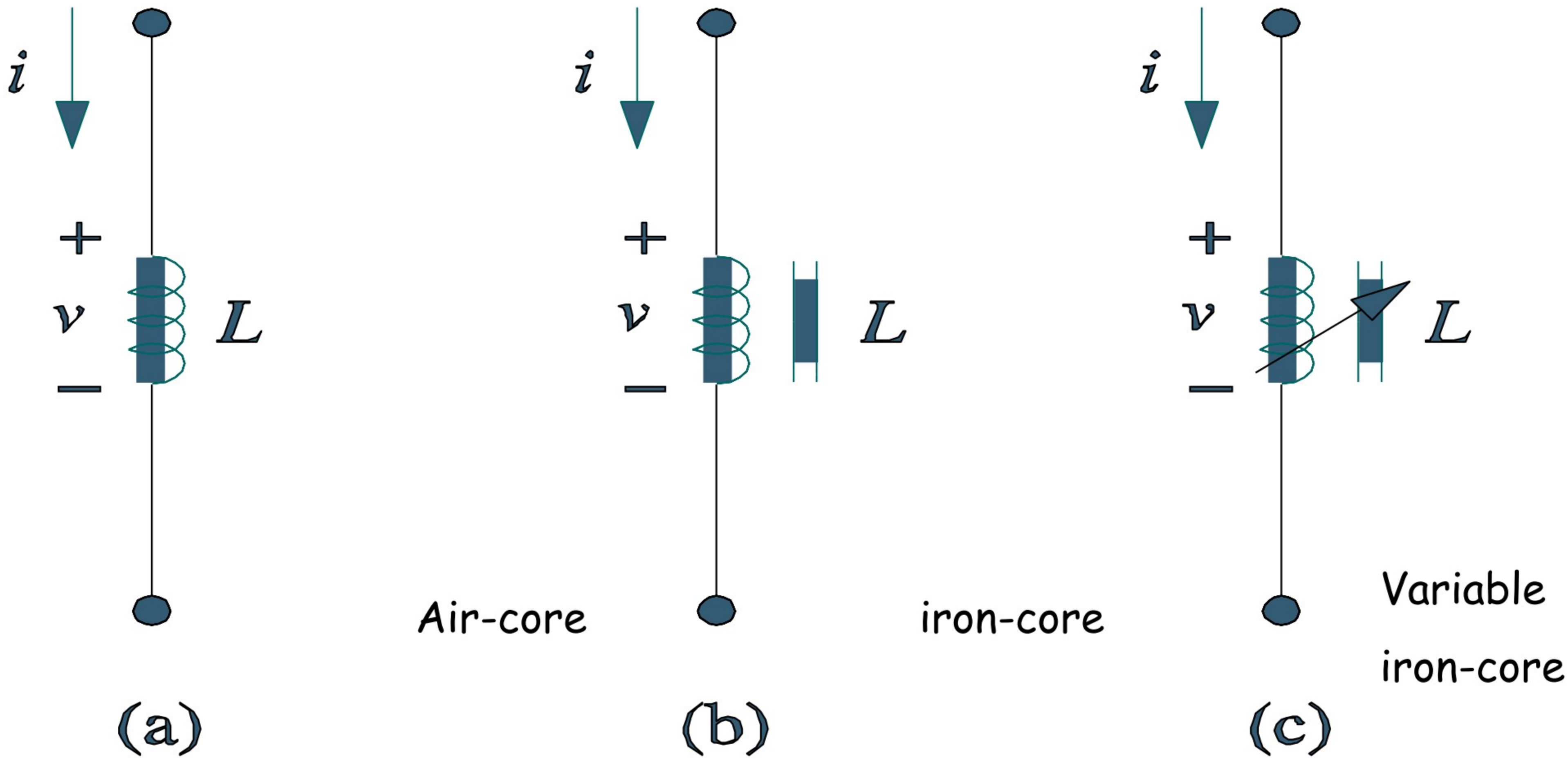
$$i(t) = \frac{1}{L}\int_{-\infty}^{t} v(t)\,dt$$

$$i(t) = \frac{1}{L}\int_{0}^{t} v(t)\,dt + I_0$$

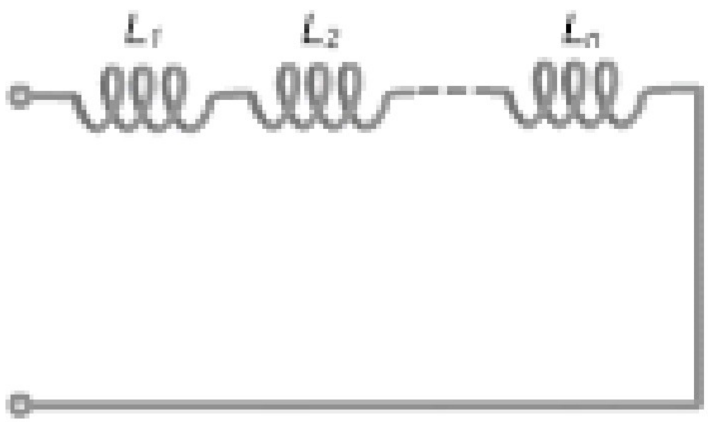
TYPICAL FORM OF AN INDUCTOR

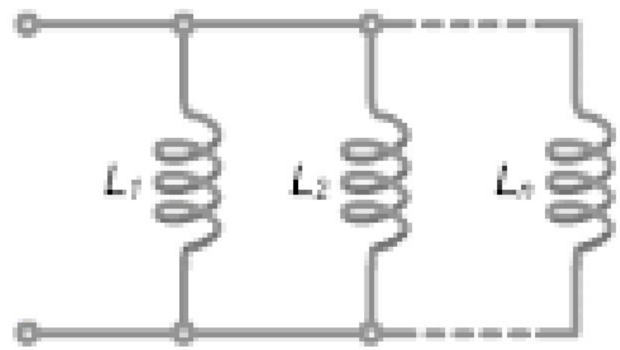


CIRCUIT SYMBOLS FOR INDUCTORS



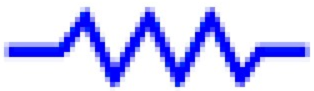
INDUCTORS IN SERIES AND PARALLEL





$$L_T = L_1 + L_2 + L_3 + \ldots L_n$$

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \ldots \frac{1}{L_n}$$

Elements Symbol	**RESISTOR** 	**CAPACITOR** 	**INDUCTOR** 
Denoted by	R	C	L
Equation	$R = \frac{V}{I}$	$C = \frac{Q}{V}$	$L = \frac{V_L}{(di/dt)}$
Series	$R_T = R_1 + R_2$	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$	$L_T = L_1 + L_2$
Parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$	$C_T = C_1 + C_2$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2}$