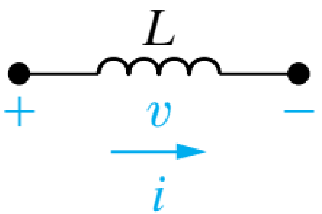
For this course you will responsible from additional content of

Book : Nilsson, Riedel, ‘Electric Circuits’,
Chapters: 6.Inductance, Capacitance, and Mutual Inductance
7.Response of First-order RL and RC Circuits
9.Sinusaidal Steady State Analysis
10. Sinusaoidal Steady-State Power Calculations

6.1 The Inductor

Inductance is the circuit parameter used to describe an inductor. Inductance is symbolized by the letter L, is measured in henrys (H), and is represented graphically as a coiled wire—a reminder that inductance is a consequence of a conductor linking a magnetic field.

(a)

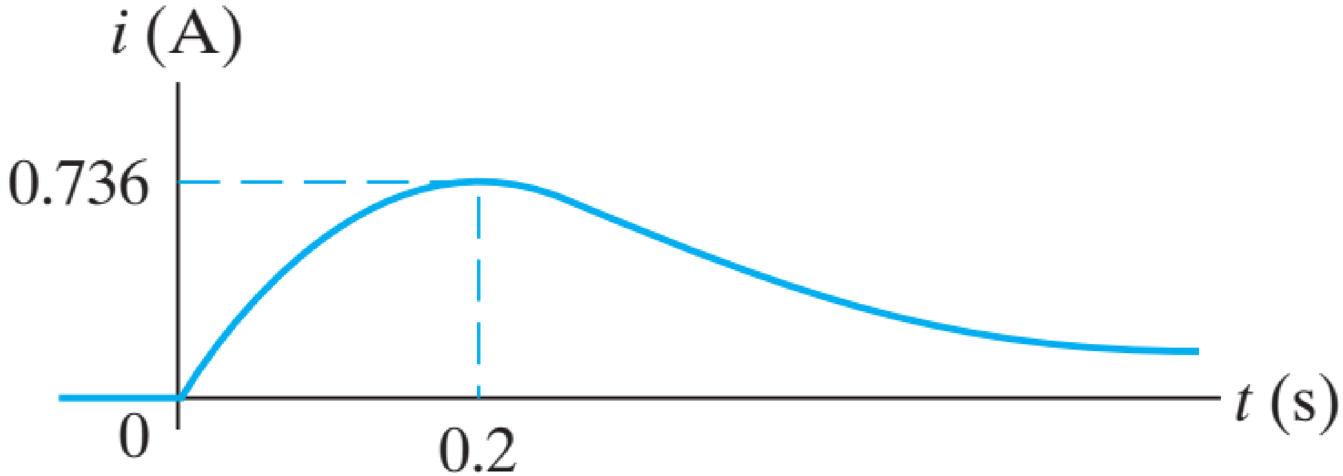


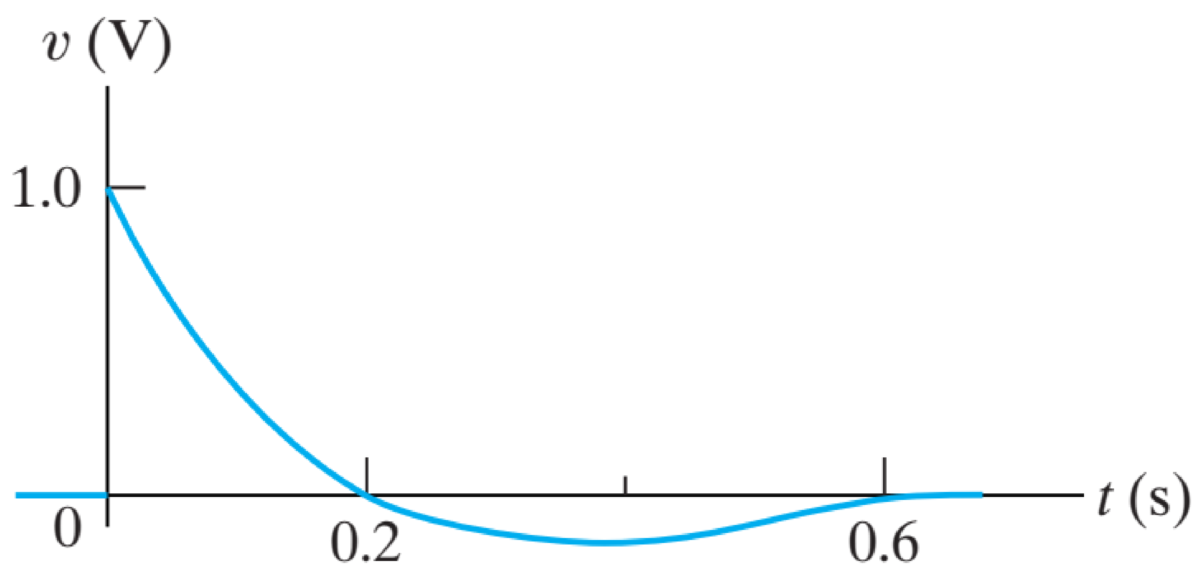
$$v = L\frac{di}{dt},$$

Voltage across the terminals of an inductor is proportional to the time rate of change of the current in the inductor.

First, if the current is constant, the voltage across the ideal inductor is zero. Thus the inductor behaves as a short circuit in the presence of a constant, or dc, current.

Second, current cannot change instantaneously in an inductor; that is, the current cannot change by a finite amount in zero time.


i (A)
0.736
0
0.2
t (s)

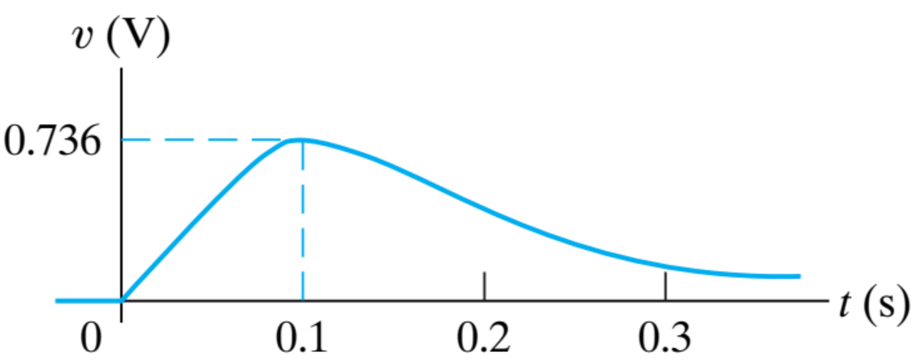

v (V)
1.0
0
0.2
0.6
t (s)

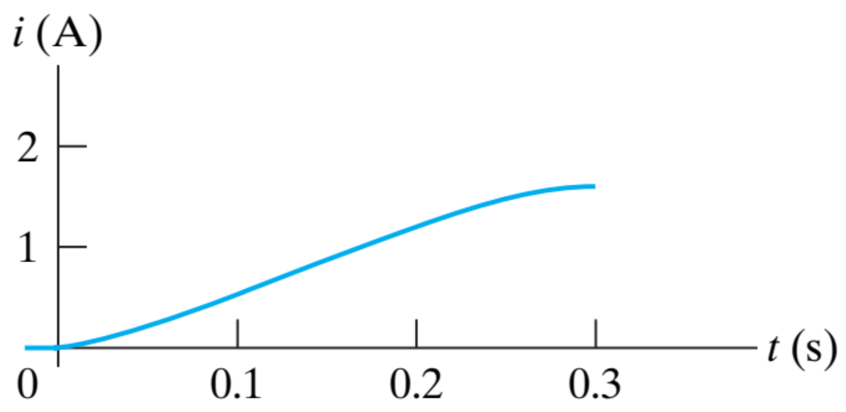
Current in an Inductor in Terms of the Voltage Across the Inductor

$$i(t) = \frac{1}{L}\int_{t_0}^{t} v\,d\tau + i(t_0),$$

In many practical applications, is zero

$$i(t) = \frac{1}{L}\int_{0}^{t} v\,d\tau + i(0).$$





Power and Energy in the Inductor

The power and energy relationships for an inductor can be derived directly from the current and voltage relationships. If the current reference is in the direction of the voltage drop across the terminals of the inductor, the power is

$$p = vi.$$

$$\boxed{p = Li\frac{di}{dt}.}$$

If we express the inductor voltage as a function of the inductor current

We can also express the current in terms of the voltage

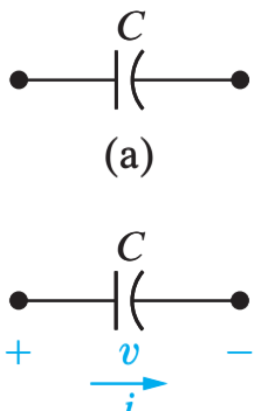
$$p = v\left[\frac{1}{L}\int_{t_0}^{t} v\,d\tau + i(t_0)\right].$$

Power is the time rate of expending energy

$$p = \frac{dw}{dt} = Li\frac{di}{dt}.$$

$$\boxed{w = \frac{1}{2}Li^2.}$$

6.2 The Capacitor



The circuit parameter of capacitance is represented by the letter C, is measured in farads (F), and is symbolized graphically by two short parallel conductive plates, as shown in Fig

The current is proportional to the rate at which the voltage across the capacitor varies with time

$$i = C\frac{dv}{dt},$$

Two important observations follow from Eq.

(1) voltage cannot change instantaneously across the terminals of a capacitor. such a change would produce infinite current, a physical impossibility.
(2) if the voltage across the terminals is constant, the capacitor current is zero. The reason is that a conduction current cannot be established in the dielectric material of the capacitor.

Only a time-varying voltage can produce a displacement current. Thus a capacitor behaves as an open circuit in the presence of a constant voltage.

Expressing the voltage as a function of the current is

$$i\,dt = C\,dv \qquad \text{or} \qquad \int_{v(t_0)}^{v(t)} dx = \frac{1}{C}\int_{t_0}^{t} i\,d\tau.$$

$$\boxed{v(t) = \frac{1}{C}\int_{t_0}^{t} i\,d\tau + v(t_0).}$$

the initial time is zero

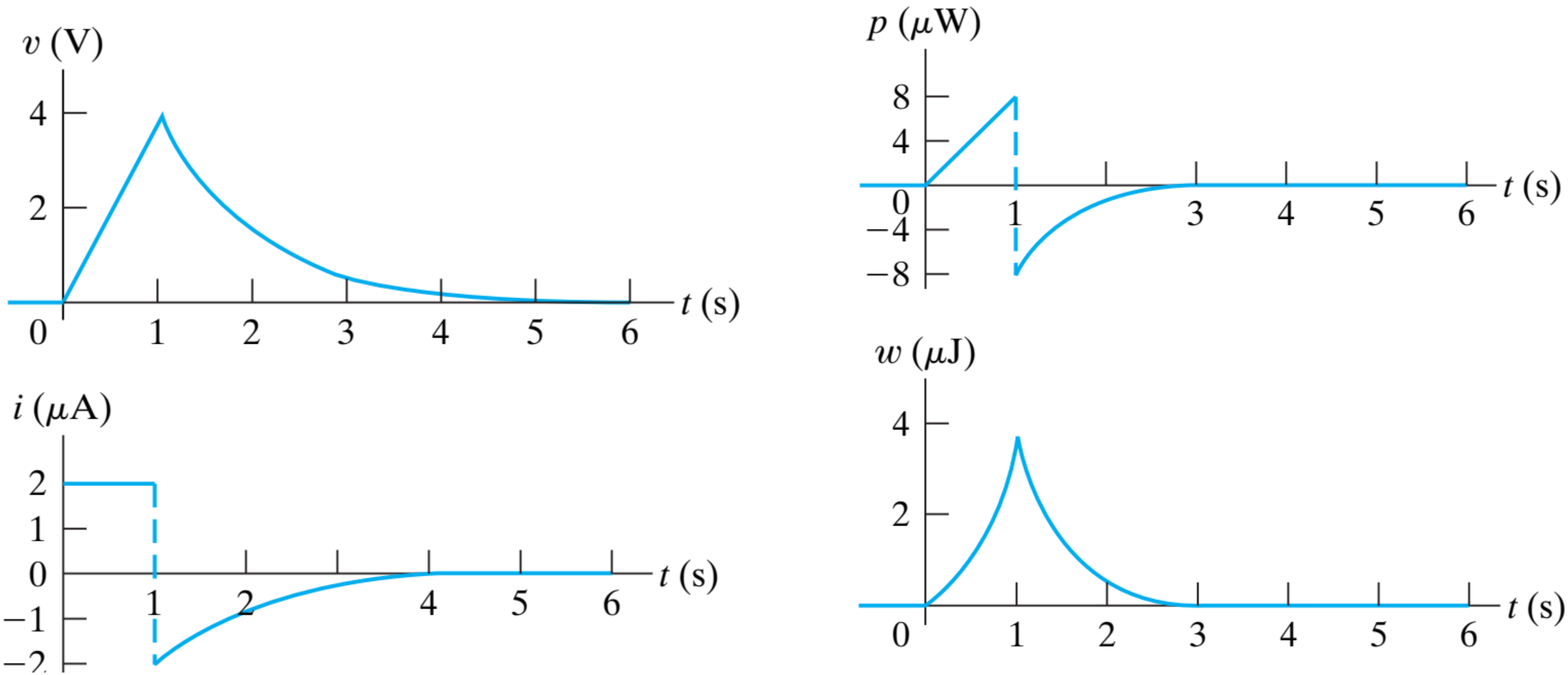
$$v(t) = \frac{1}{C}\int_{0}^{t} i\,d\tau + v(0).$$

$$\boxed{p = vi = Cv\frac{dv}{dt},}$$

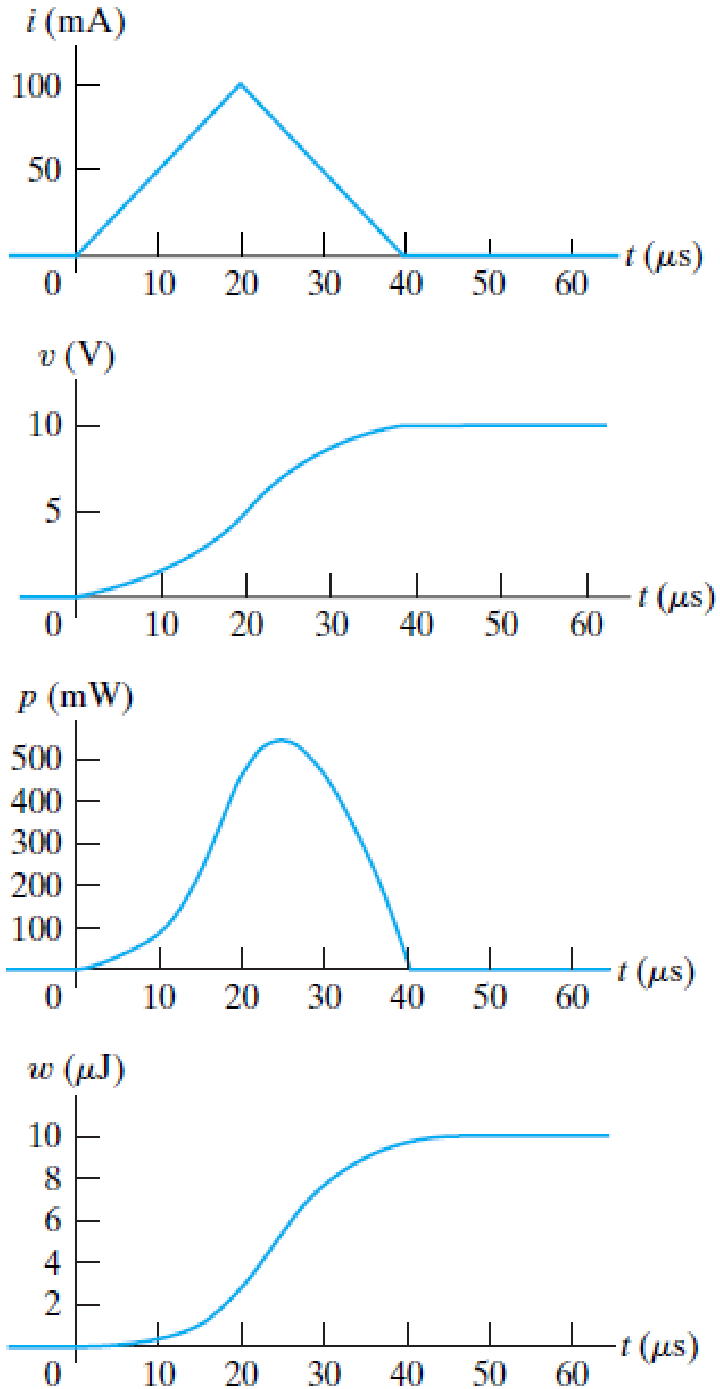
$$p = i\left[\frac{1}{C}\int_{t_0}^{t} i\,d\tau + v(t_0)\right].$$

Combining the definition of energy

$$\boxed{w = \frac{1}{2}Cv^2.}$$

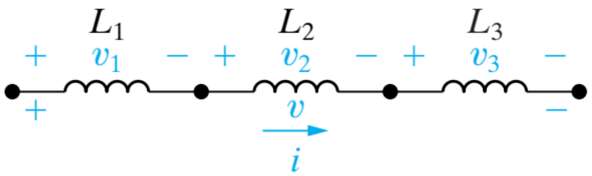


v (V)
4
2
0
1
2
3
4
5
6
t (s)
i (μA)
2
1
0
−1
−2
1
2
4
5
6
t (s)
p (μW)
8
4
0
−4
−8
1
3
4
5
6
t (s)
w (μJ)
4
2
0
1
2
3
4
5
6
t (s)



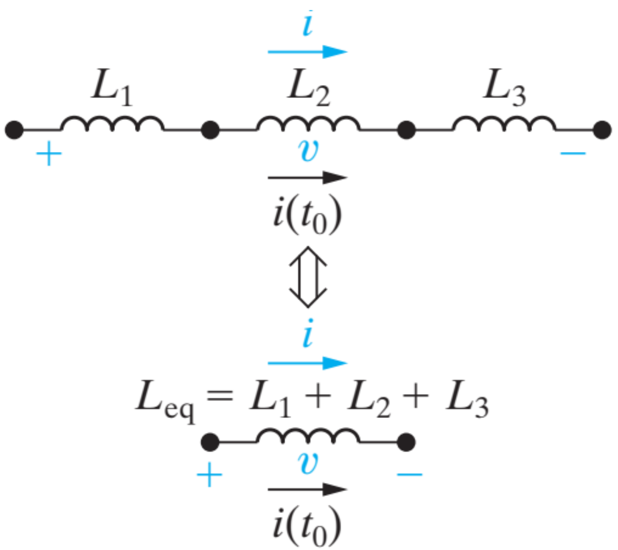
i (mA)
100
50
0
10
20
30
40
50
60
t (μs)
v (V)
10
5
0
10
20
30
40
50
60
t (μs)
p (mW)
500
400
300
200
100
0
10
20
30
40
50
60
t (μs)
w (μJ)
10
8
6
4
2
0
10
20
30
40
50
60
t (μs)

6.3 Series-Parallel Combinations of Inductance and Capacitance



$$v_1 = L_1 \frac{di}{dt}, \qquad v_2 = L_2 \frac{di}{dt}, \qquad \text{and} \qquad v_3 = L_3 \frac{di}{dt}.$$

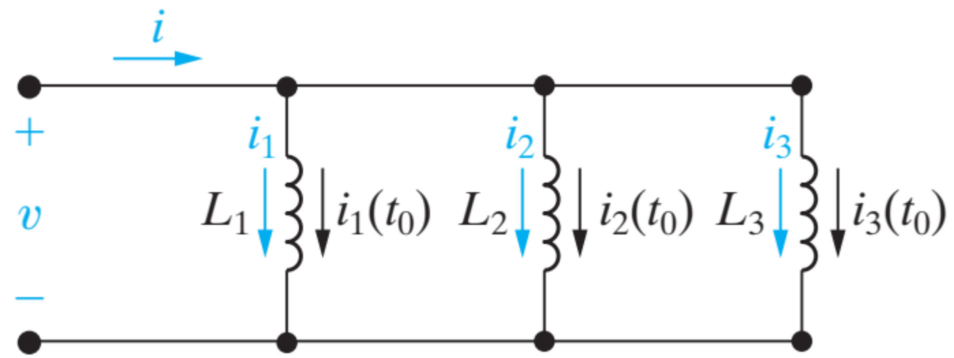
$$v = v_1 + v_2 + v_3 = (L_1 + L_2 + L_3)\frac{di}{dt}$$



$$\boxed{L_{eq} = L_1 + L_2 + L_3 + \cdots + L_n.}$$

Inductors in parallel have the same terminal voltage

$$i_1 = \frac{1}{L_1}\int_{t_0}^{t} v\, d\tau + i_1(t_0),$$



$$i_2 = \frac{1}{L_2}\int_{t_0}^{t} v\, d\tau + i_2(t_0),$$

$$i_3 = \frac{1}{L_3}\int_{t_0}^{t} v\, d\tau + i_3(t_0).$$

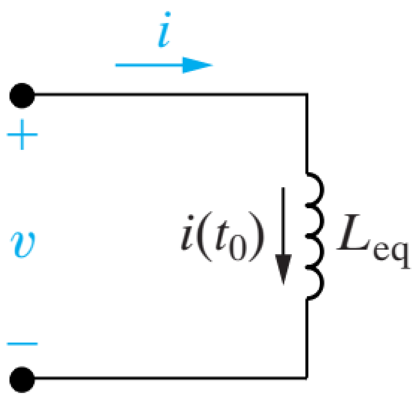
$$i = i_1 + i_2 + i_3.$$

$$i = \left(\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}\right)\int_{t_0}^{t} v\, d\tau + i_1(t_0) + i_2(t_0) + i_3(t_0).$$

$$i = \frac{1}{L_{eq}}\int_{t_0}^{t} v\, d\tau + i(t_0)$$

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

$$i(t_0) = i_1(t_0) + i_2(t_0) + i_3(t_0)$$

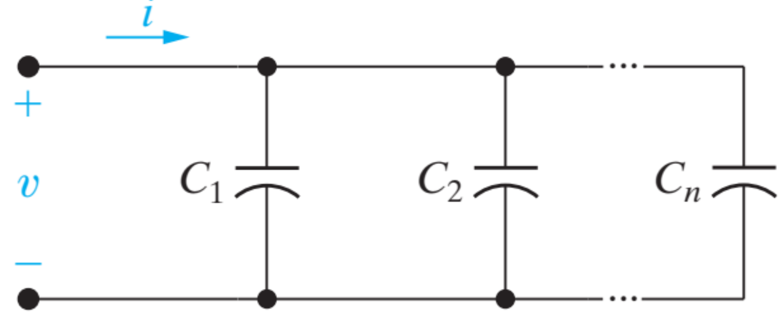


$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

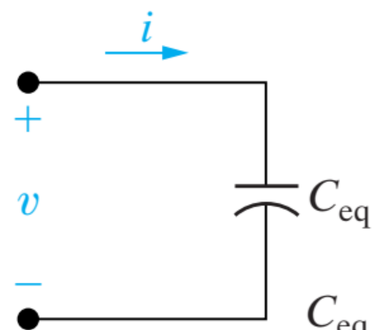
$$i(t_0) = i_1(t_0) + i_2(t_0) + i_3(t_0)$$

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$$

$$i(t_0) = i_1(t_0) + i_2(t_0) + \cdots + i_n(t_0).$$

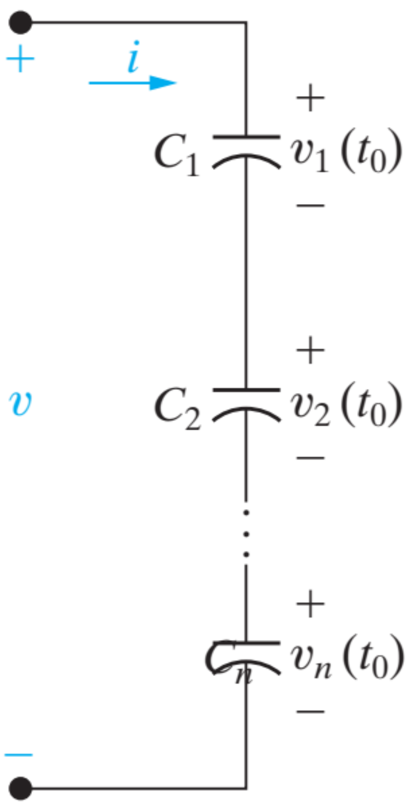


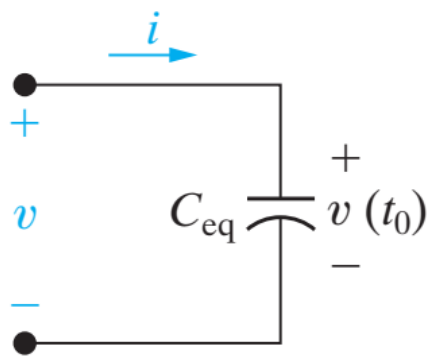
(a)



$$C_{eq} = C_1 + C_2 + \cdots + C_n$$

(b)





$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

$$v(t_0) = v_1(t_0) + v_2(t_0) + \cdots + v_n(t_0)$$