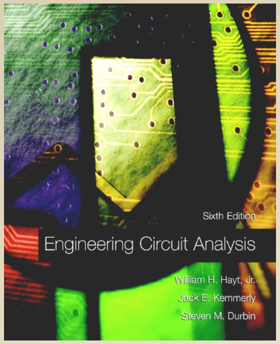

Chapter 7 Capacitors and Inductors

User Note:

Run **View Show** under the **Slide Show** menu to enable slide selection.

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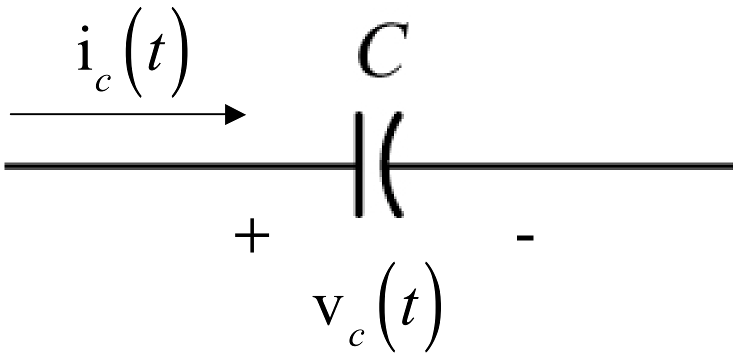


Electrical symbol and current-voltage conventions for a capacitor.

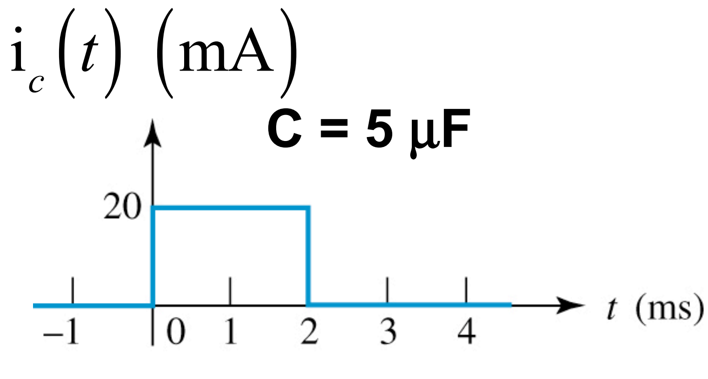
$$i_c(t) = C\frac{d}{dt}\left(v_c(t)\right) \Rightarrow v_c(t) = (1/C)\int_{-\infty}^{t} i_c(\lambda)\,d\lambda$$

$$\text{Stored Energy } = E_c = (1/2)Cv^2$$

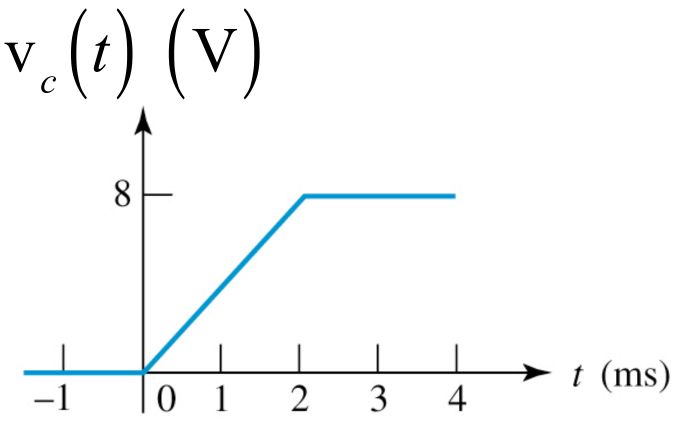
An instantaneous change in capacitor voltage requires an infinite current. Therefore in practical circuits, a capacitor voltage cannot change instantaneously. Also, if the voltage across a capacitor is constant, the current through it is zero.

MENU

Find the capacitor voltage that is associated with the current shown graphically below.



(a)

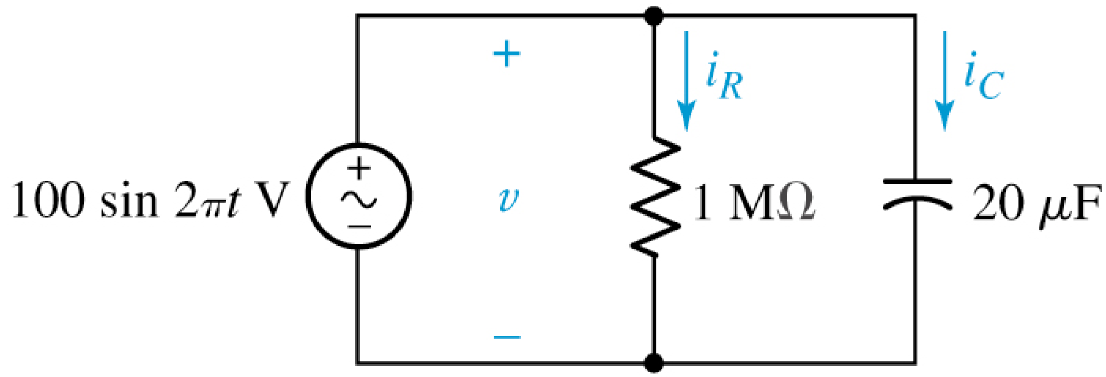


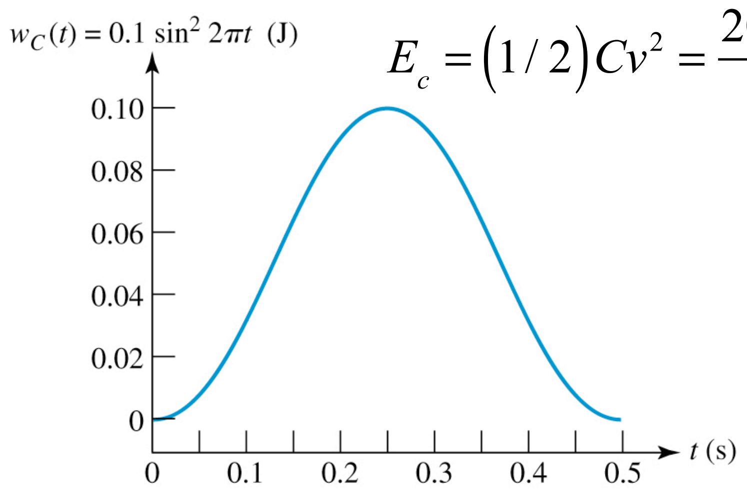
(b)

$$v_c(t) = \frac{1}{5\times10^{-6}\,\mathrm{F}}\int_0^t 20\times10^{-3}\,\mathrm{A}\,d\lambda = 4000t\ \mathrm{V}\,,\ \ 0 < t < 2\ \mathrm{ms}$$

MENU

Find the maximum energy stored in the capacitor of the circuit below, and the energy dissipated in the resistor over the interval $0 < t < 500$ ms.

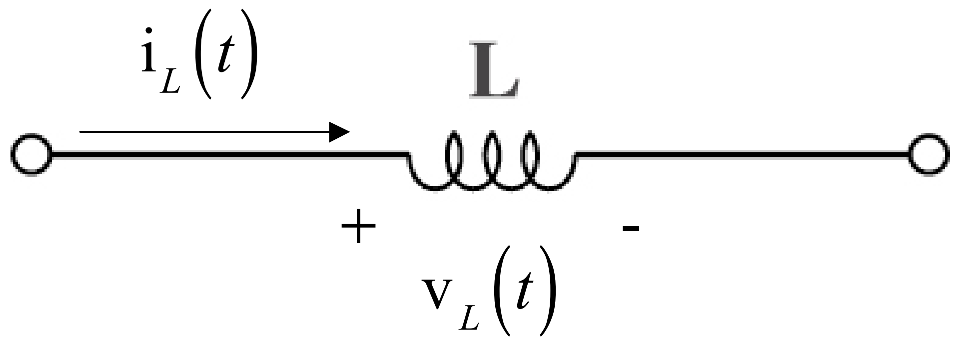




$$E_c = (1/2)Cv^2 = \frac{20\times10^{-6}\,\mathrm{F}}{2}\times 100^2 \sin^2(2\pi t)\,\mathrm{V}^2 = 0.1\sin^2(2\pi t)\ \mathrm{J}$$

Graph of capacitor energy as a function of time.

Electrical symbol and current-voltage conventions for an inductor.



$$v_L(t) = L\frac{d}{dt}\left(i_L(t)\right) \Rightarrow i_L(t) = (1/L)\int_{-\infty}^{t} v_L(\lambda)\,d\lambda$$

$$\text{Stored Energy } = E_L = (1/2)\,L\,i^2$$

An instantaneous change in inductor current requires an infinite voltage. Therefore in practical circuits inductor current cannot change instantaneously. Also if the current through an inductor is constant, the voltage across it is zero.

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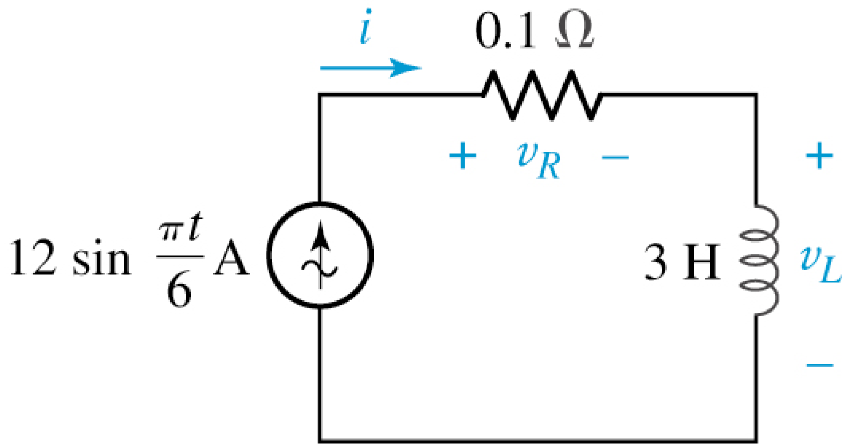
MENU

Find the maximum energy stored in the inductor of the circuit below.



$$E_L = \frac{3\text{H}}{2} \times 12^2 \sin^2(\pi t/6)\text{A}^2 = 216\sin^2(\pi t/6)\ \text{J}$$

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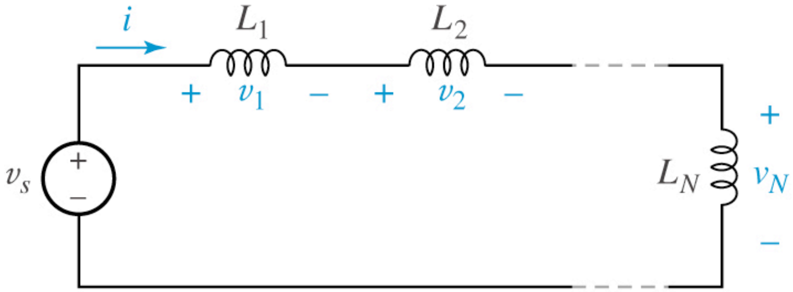
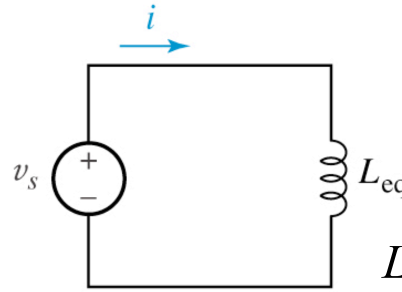
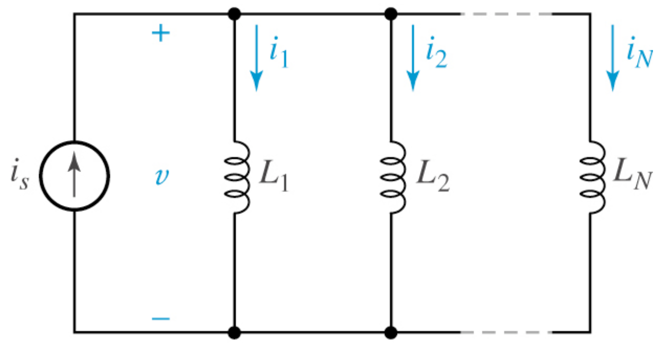


(a)

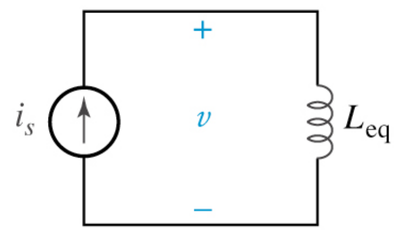


$$L_{eq} = L_1 + L_2 + \cdots + L_N$$

(b)



(c)



(d)

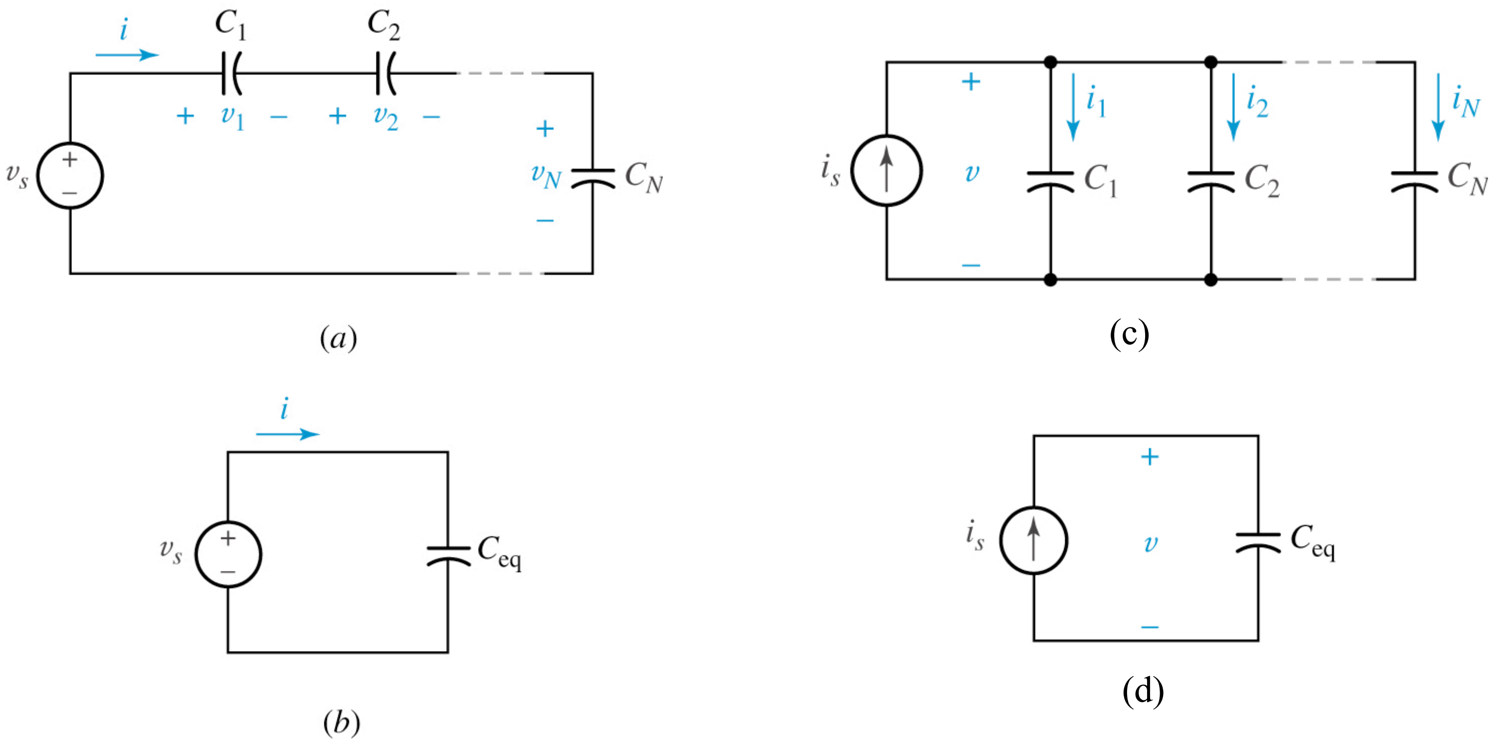
$$1/L_{eq} = 1/L_1 + 1/L_2 + \cdots + 1/L_N$$

(a) N inductors connected in series; (b) equivalent circuit; (c) N inductors connected in parallel; (d) equivalent circuit for circuit in (c).

Inductors in series combine like resistors in series.

Inductors in parallel combine like resistors in parallel.

MENU



$$1/C_{eq} = 1/C_1 + 1/C_2 + \cdots + 1/C_N$$

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

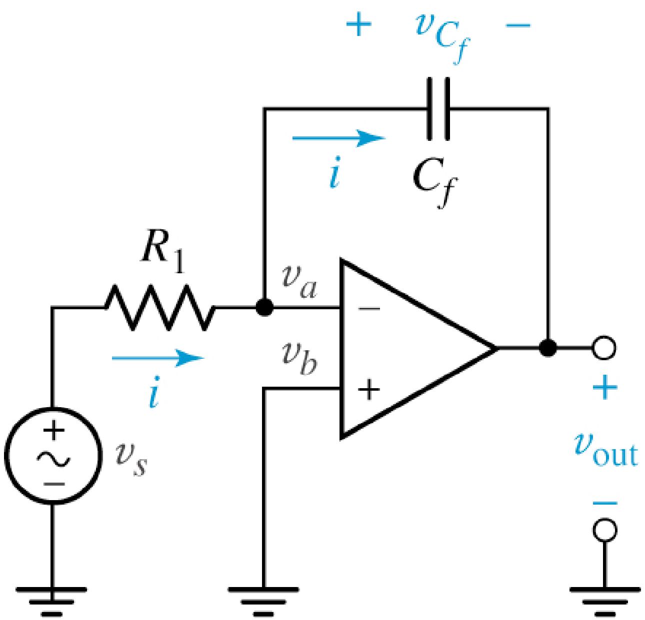
(a) N capacitors connected in series; (b) equivalent circuit; (c) N capacitors connected in parallel; (d) equivalent circuit to (c).

Capacitors in series combine like resistors in parallel.

Capacitors in parallel combine like resistors in series.

MENU

An ideal op amp connected as an integrator.



$$i(t) = v_s(t) / R_1$$

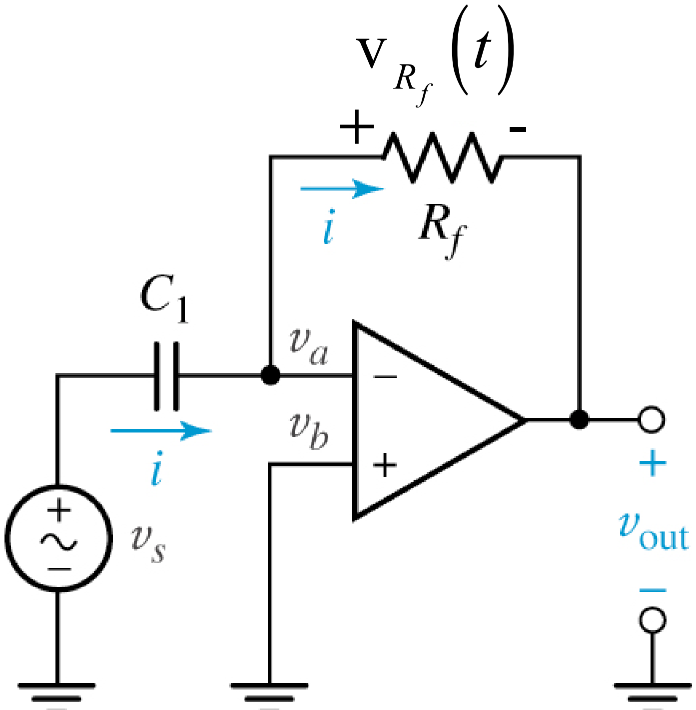
$$v_{C_f}(t) = (1/C_f)\int_{-\infty}^{t} i(\lambda)\,d\lambda$$

$$v_{C_f}(t) = (1/R_1C_f)\int_{-\infty}^{t} v_s(\lambda)\,d\lambda$$

$$v_{out}(t) = -(1/R_1C_f)\int_{-\infty}^{t} v_s(\lambda)\,d\lambda$$

MENU

An ideal op amp connected as a differentiator.



$$i(t) = C_1 \frac{d}{dt}\left(v_s(t)\right)$$

$$v_{R_f}(t) = i(t) R_f$$

$$v_{R_f}(t) = R_f C_1 \frac{d}{dt}\left(v_s(t)\right)$$

$$v_{out}(t) = -R_f C_1 \frac{d}{dt}\left(v_s(t)\right)$$

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