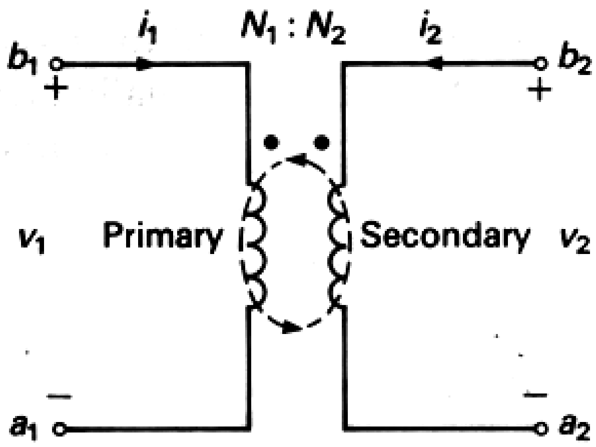
Ideal transformer

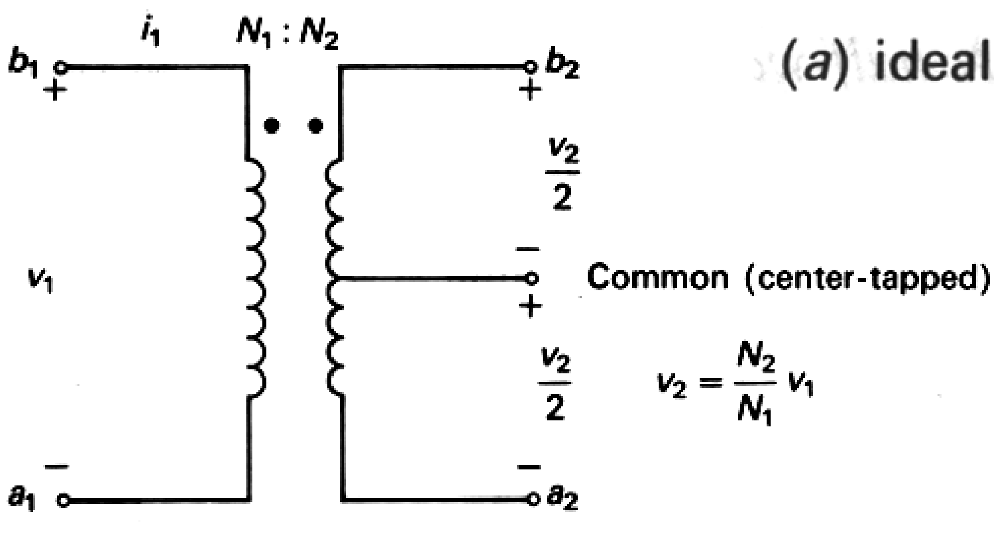


(a)

$$v_2 = \frac{N_2}{N_1} v_1$$

$$i_2 = -\frac{N_1}{N_2} i_1$$

$$p_2 = v_2 i_2 = -v_1 i_1 = -p_1$$



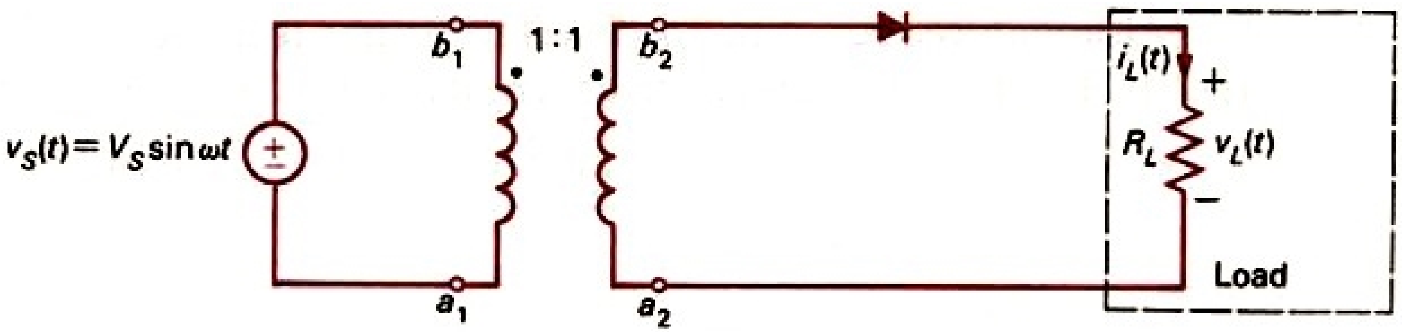
(b)

(a) ideal; (b) center-tapped.

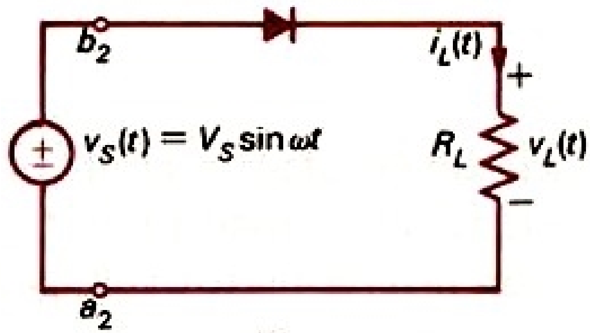
$$v_2 = \frac{N_2}{N_1} v_1$$

Rectifiers

- Half-Wave Rectifier
  - The transformer isolates the load from the source



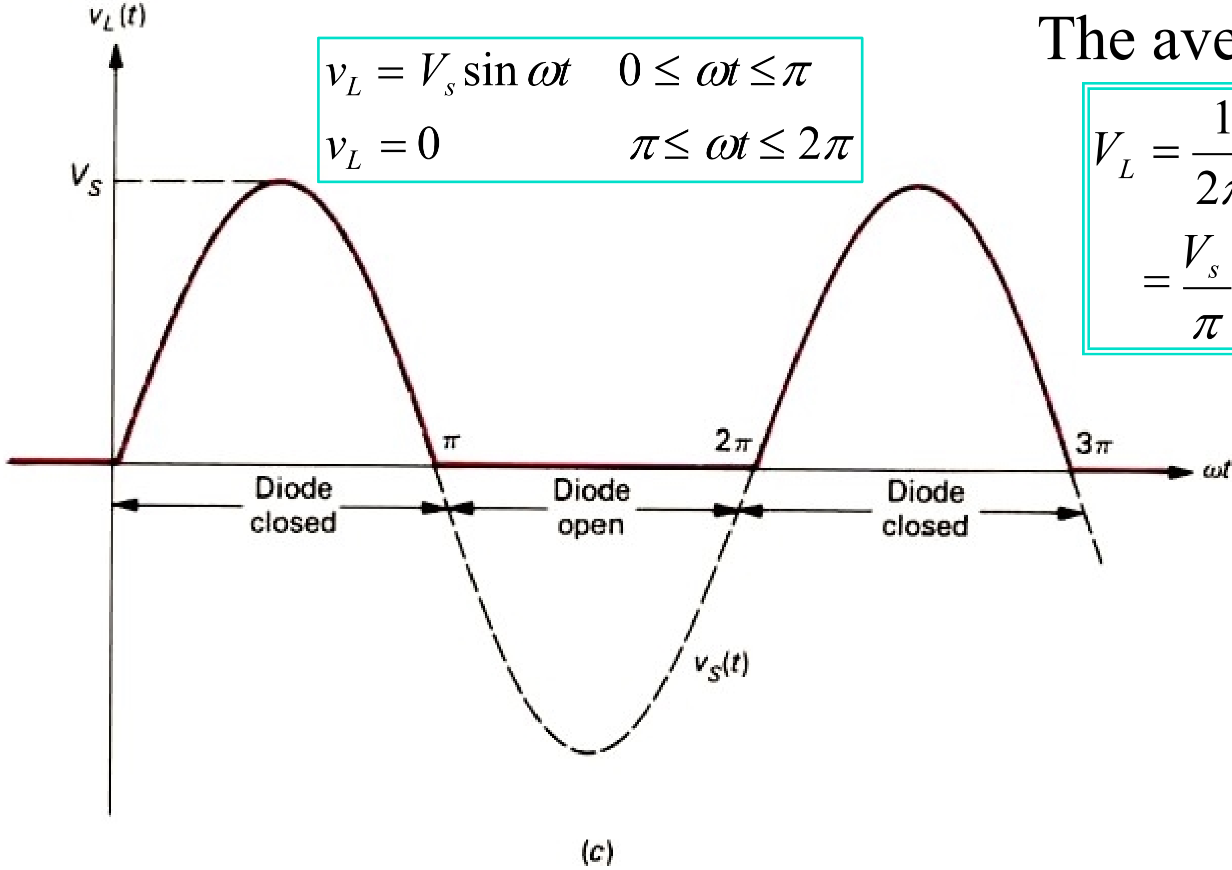
(a)



(b)

Rectifiers

- Half-Wave Rectifier



$$v_L = V_s \sin \omega t \quad 0 \le \omega t \le \pi$$
$$v_L = 0 \quad \pi \le \omega t \le 2\pi$$

The average dc value of v_L

$$V_L = \frac{1}{2\pi}\int_0^{\pi} V_s \sin \omega t \, d(\omega t) = \frac{V_s}{\pi}$$

Rectifiers

- Representing the Half-Wave Rectifier voltage by Fourier series

$$v_L = V_L + a_1 \sin \omega t + a_2 \sin 2\omega t + \ldots\ldots + b_1 \cos \omega t + b_2 \cos 2\omega t + \ldots\ldots\ldots$$

The Fourier coefficients can be determined as

$$a_n = \frac{2}{T}\int_0^T v_L(t)\sin n\,\omega t\,dt; \qquad b_n = \frac{2}{T}\int_0^T v_L(t)\cos n\,\omega t\,dt$$

For the Half-Wave Rectified voltage

$$a_1 = \frac{2}{T}\int_0^T v_L(t)\sin \omega t\,dt = \frac{1}{\pi}\int_0^\pi V_s \sin \omega t \sin \omega t\,d(\omega t) = \frac{V_s}{2}$$

$$a_n = \frac{2}{T}\int_0^T v_L(t)\sin n\,\omega t\,dt = \frac{1}{\pi}\int_0^\pi V_s \sin \omega t \sin n\,\omega t\,d(\omega t) = 0$$

Rectifiers

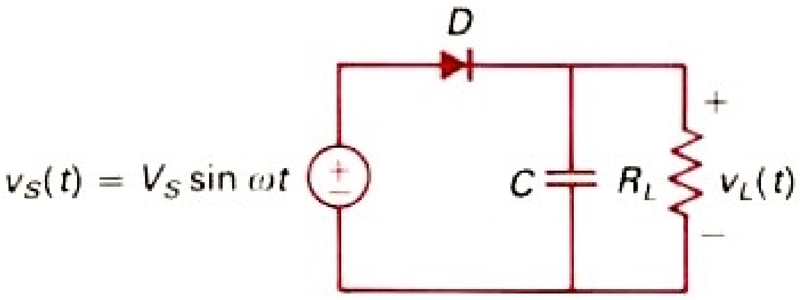
$$b_1 = 0; \quad b_2 = -\frac{2V_s}{3\pi}, \quad b_3 = 0; \quad b_4 = -\frac{2V_s}{15\pi}; \quad b_5 = 0$$

Thus the Fourier series for the Half-Wave Rectified signal

$$v_L(t) = \frac{V_s}{\pi} + \frac{V_s}{2}\sin\omega t - \frac{2V_s}{3\pi}\cos 2\omega t - \frac{2V_s}{15\pi}\cos 4\omega t + ...$$

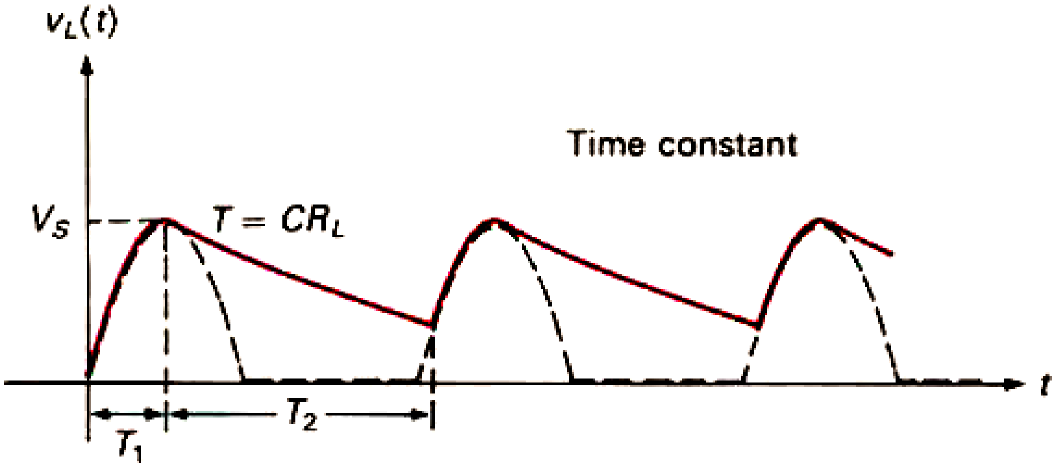
Rectifiers

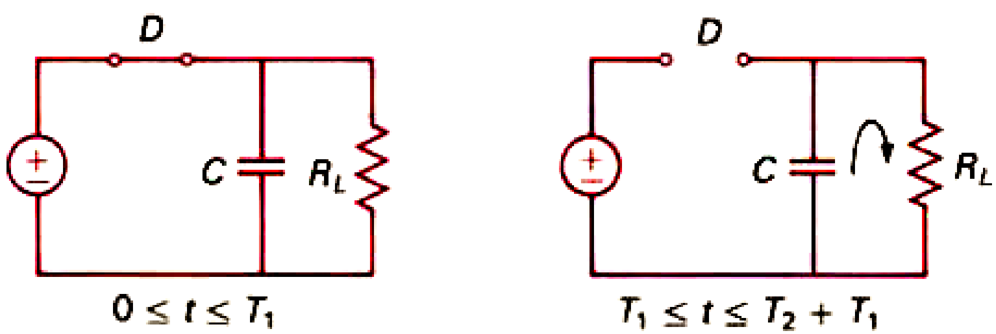
- Filtering the Half-Wave Rectifier



(a)

Capacitor has lower impedance to higher frequencies

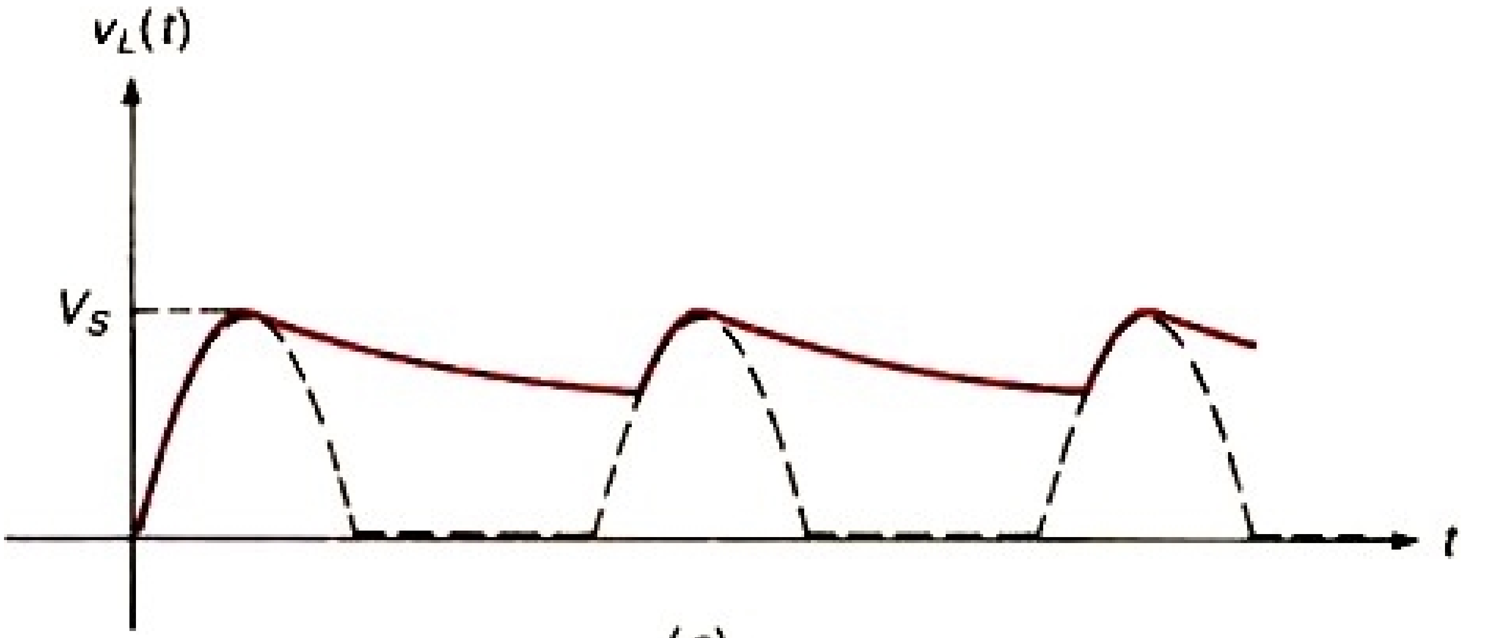




(b)

Rectifiers

- Filtering the Half-Wave Rectifier

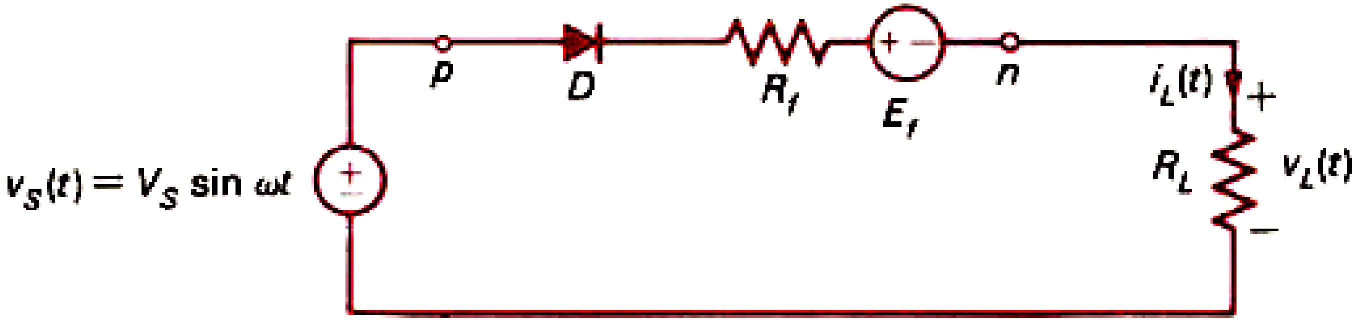


(c)

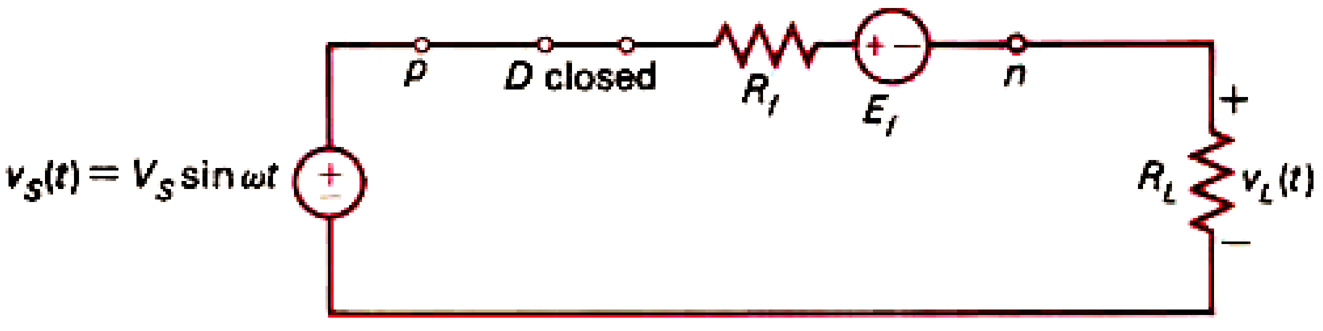
Larger C can be used to increase the time constant RC

Rectifiers

- Effects of actual diodes



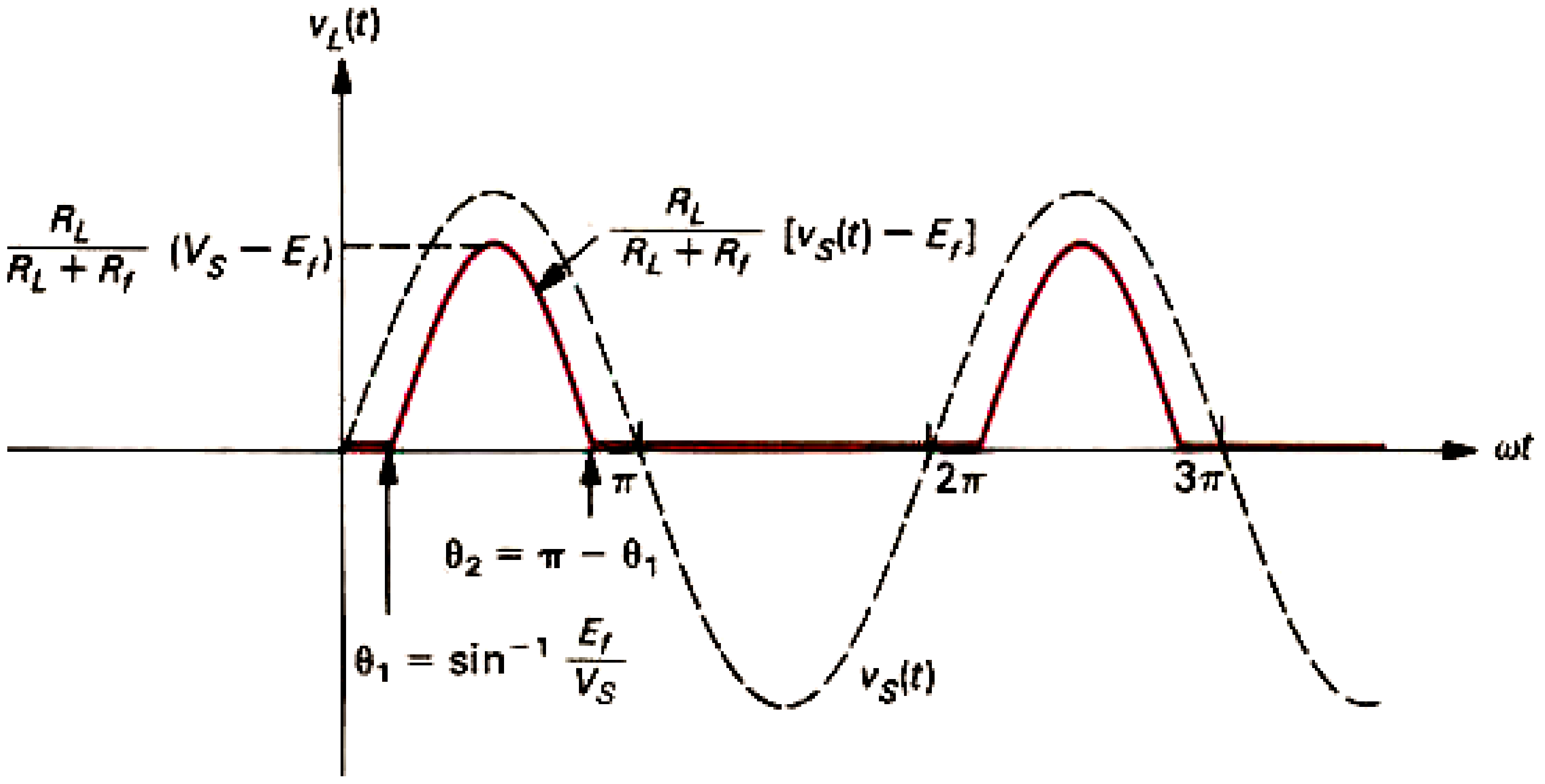
(a)



$v_S(t) > E_f$

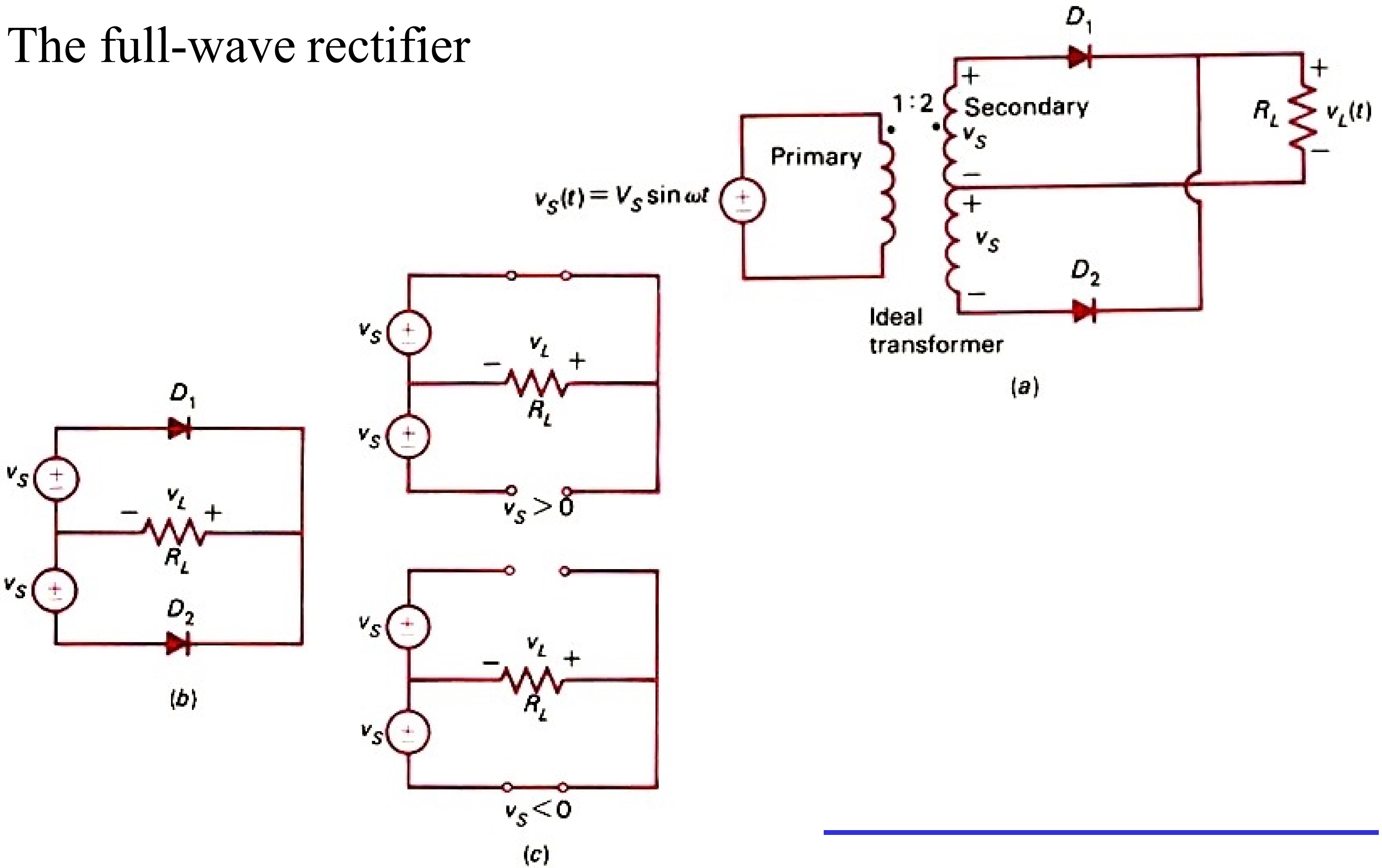
Rectifiers

- Effects of actual diodes



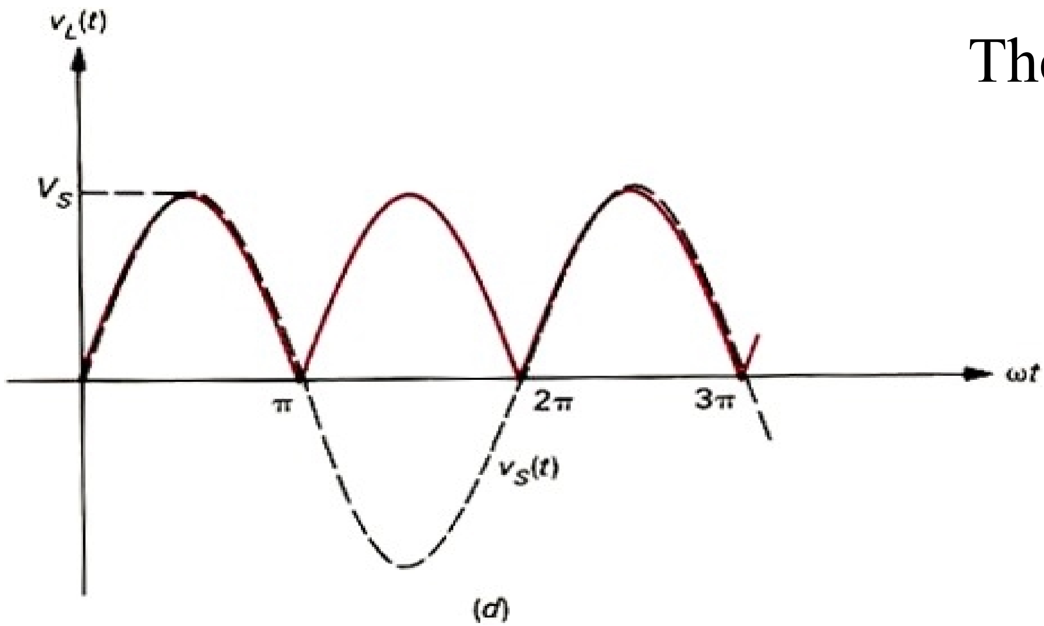
The Full-Wave Rectifiers

- The full-wave rectifier



The Full-Wave Rectifiers

- The full-wave rectifier



The average dc value of v_L

$$V_L = \frac{1}{\pi}\int_0^{\pi} V_s \sin \omega t \, d(\omega t)$$

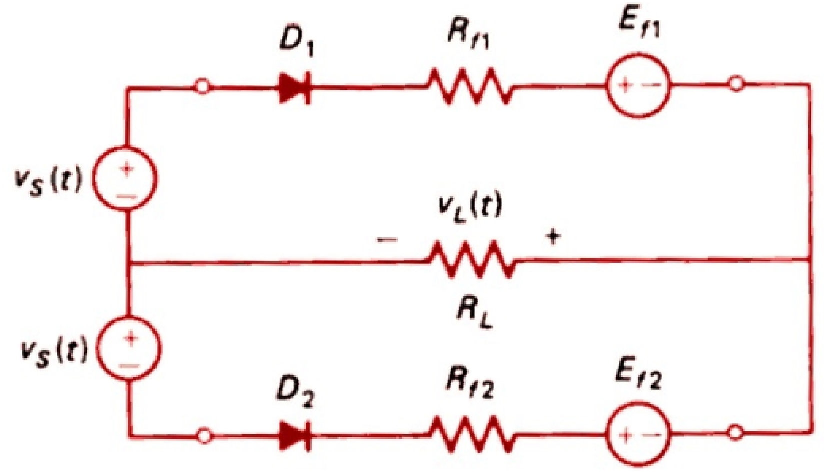
$$= \frac{2V_s}{\pi}$$

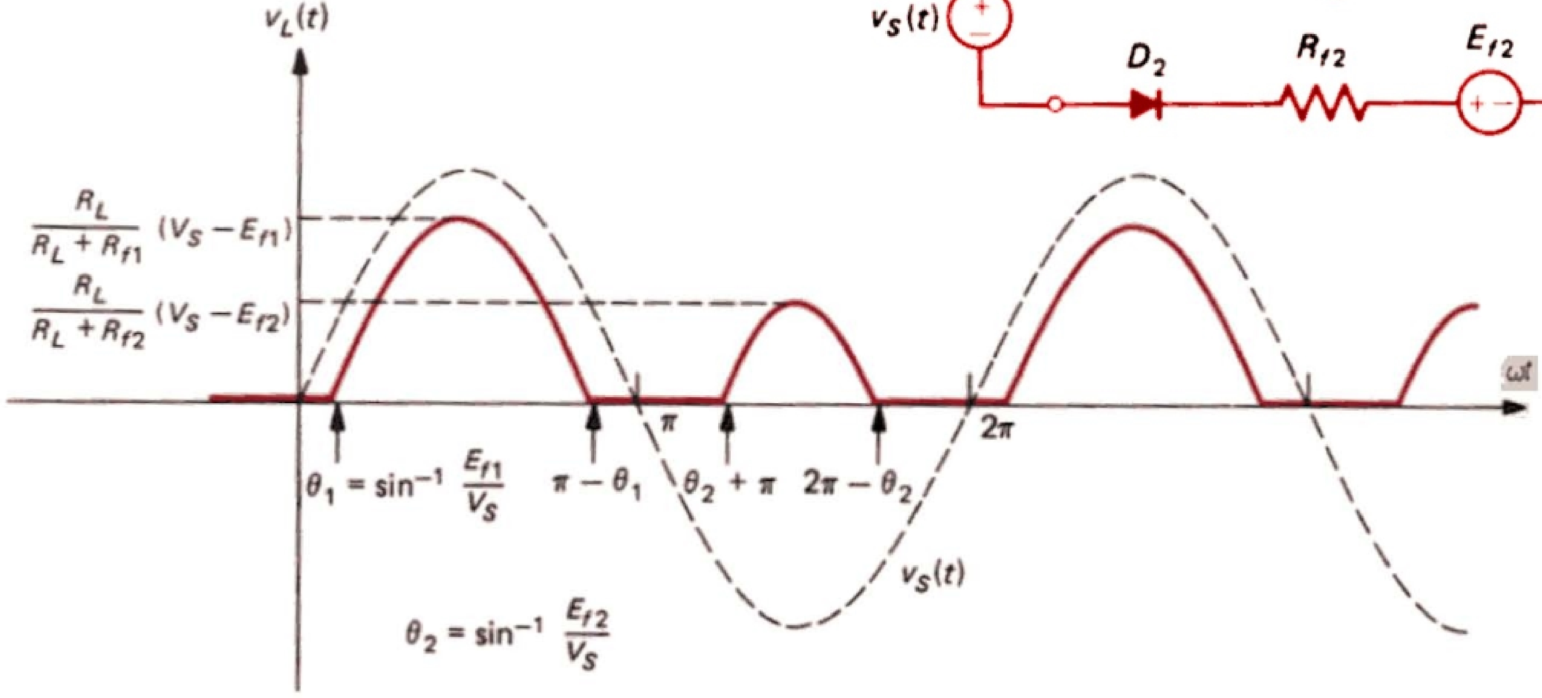
Thus the Fourier series for the Full-Wave Rectified signal

$$v_L(t) = \frac{2V_s}{\pi} - \frac{4V_s}{3\pi}\cos 2\omega t - \frac{4V_s}{15\pi}\cos 4\omega t + ...$$

The Full-Wave Rectifiers

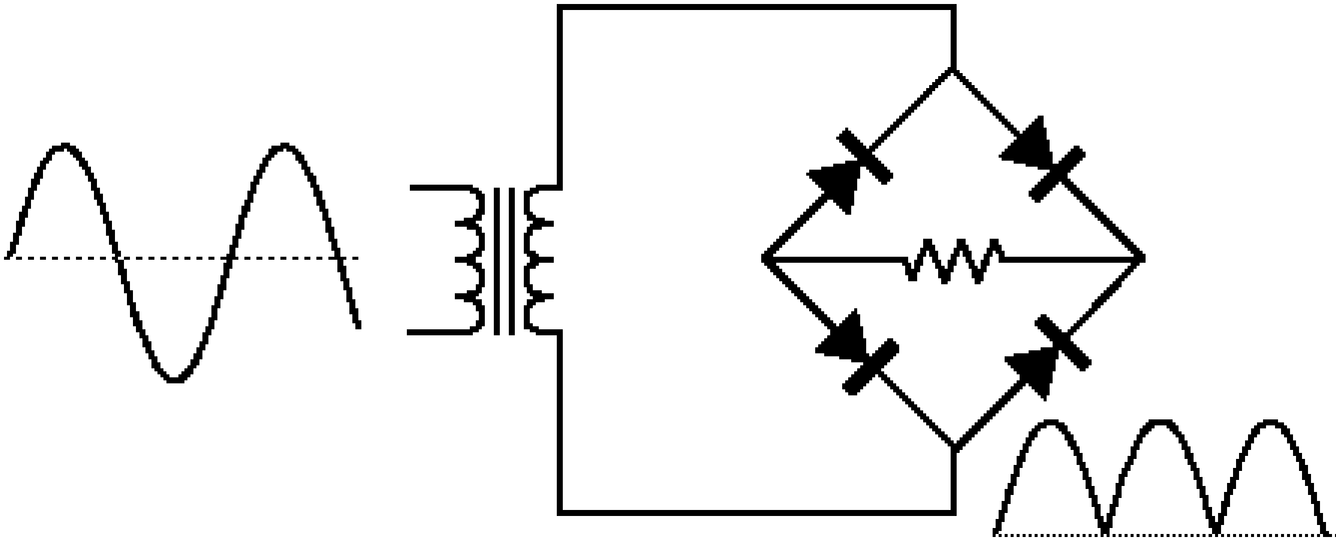
- Effect of actual diodes



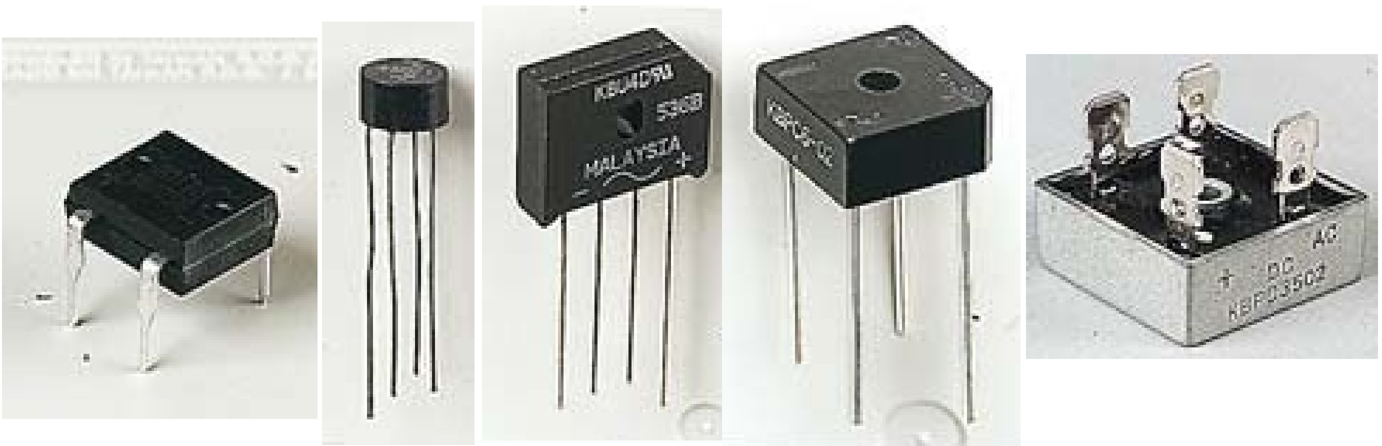


The Full-Wave Bridge Rectifier

- A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.



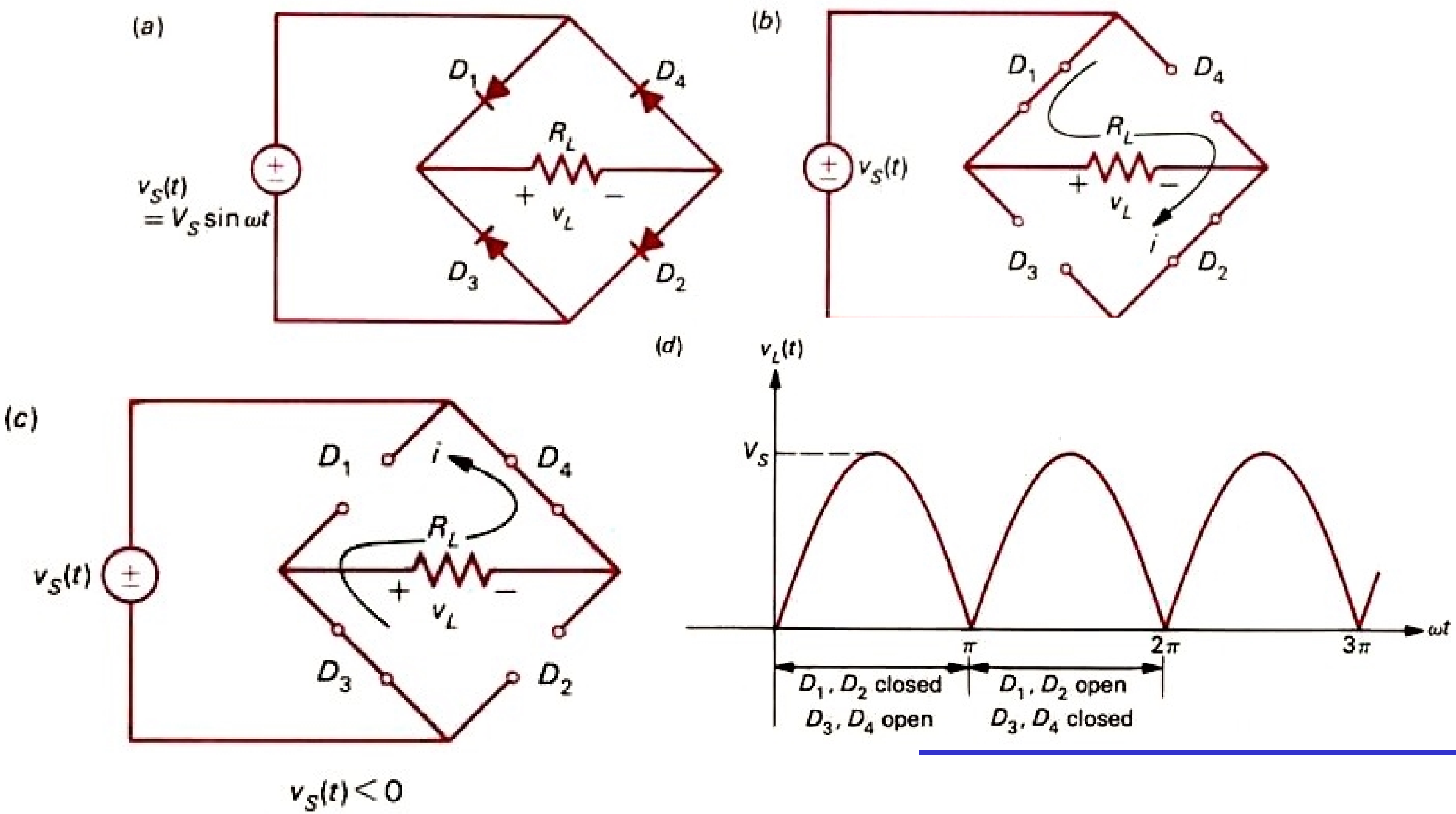
Bridge Rectifiers



Various types of Bridge Rectifiers
Note that some have a hole through their centre for attaching to a heat sink

The Full-Wave Bridge Rectifier

- Bridge Rectifier



The Full-Wave Bridge Rectifier

- Bridge Rectifier with RC Filter and LC filter