

AC-DC Rectifier Circuits (Chapter 3)



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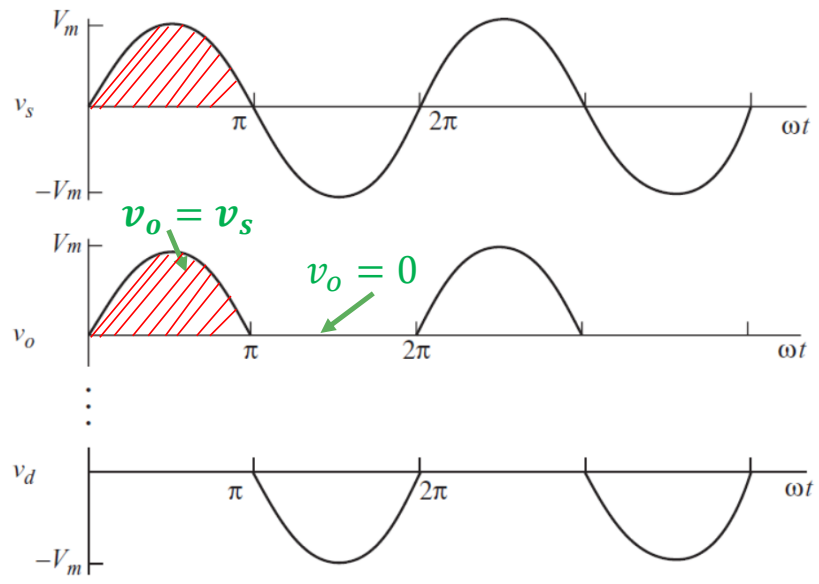
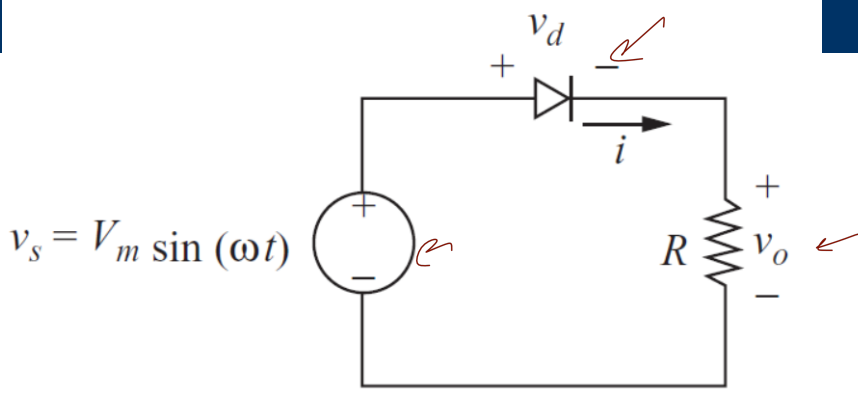
Single phase system (for R Load, R-L Load, and R-L-voltage source):

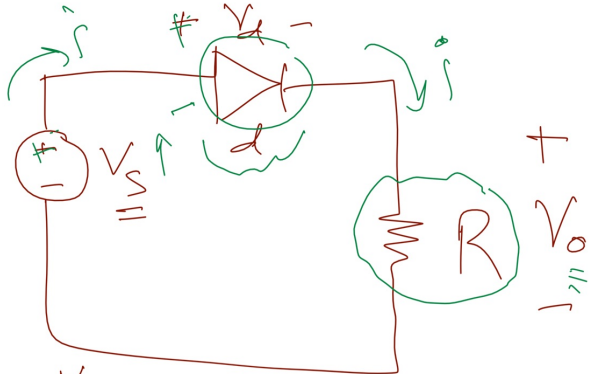
- Uncontrolled half-wave rectifier.
- Uncontrolled full-wave rectifier.
- Controlled half-wave rectifier.
- Controlled full-wave rectifier.

Three-phase system (for R Load, R-L Load, and R-L-voltage source):

- Uncontrolled half-wave rectifier.
- Uncontrolled full-wave rectifier.
- Controlled half-wave rectifier.
- Controlled full-wave rectifier.

Resistive Load

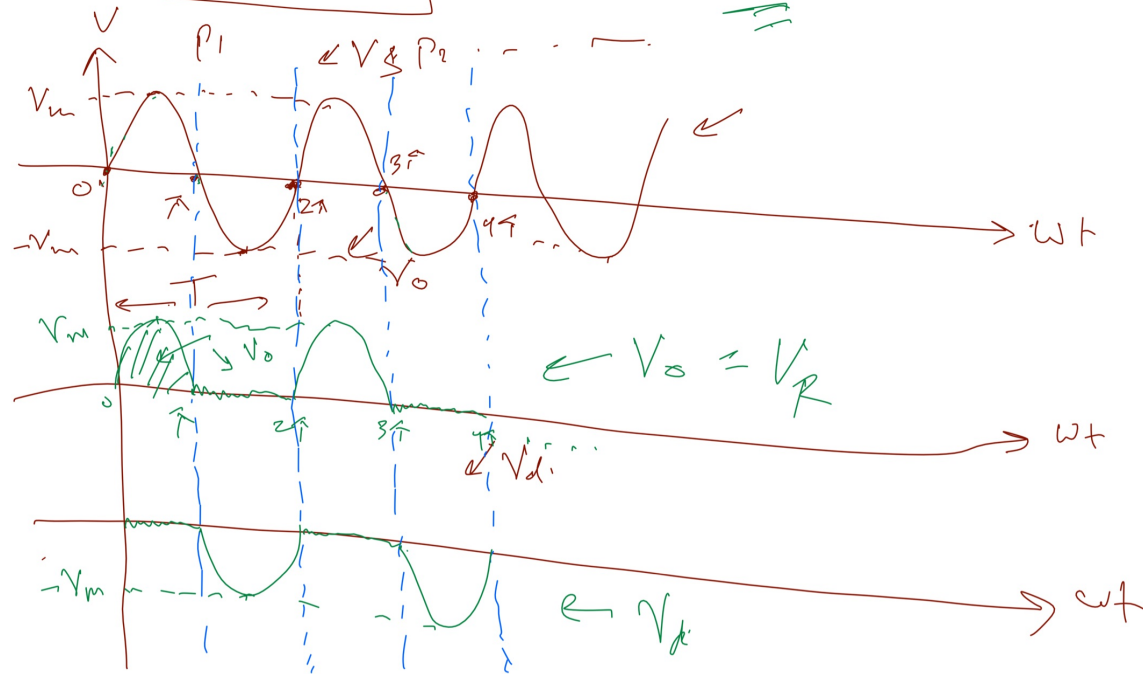




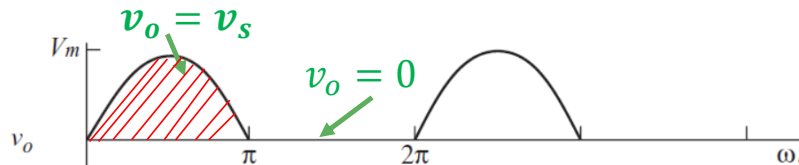
AC $\rightarrow$ DC $\Rightarrow$ —

$$V_s = V_m \sin(\omega t)$$

$$\underline{V_o = iR}$$



Resistive Load



The dc component V_o of the output voltage is the average value of a half-wave rectified sinusoid (**Average output voltage**)

$$V_o = V_{\text{avg}} = \frac{1}{2\pi} \int_0^{\pi} V_m \sin(\omega t) d(\omega t) = \frac{V_m}{\pi}$$

The dc component of the current for the purely resistive load (**Average output current**) is

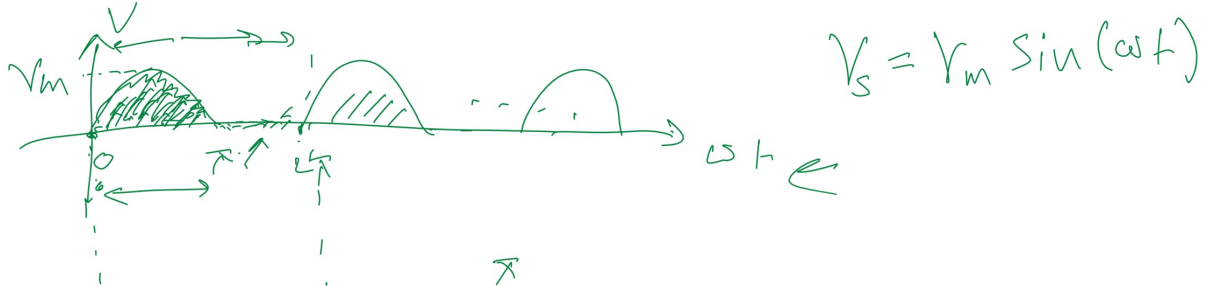
$$I_o = \frac{V_o}{R} = \frac{V_m}{\pi R}$$

RMS values are

$$V_{\text{rms}} = \sqrt{\frac{1}{2\pi} \int_0^{\pi} [V_m \sin(\omega t)]^2 d(\omega t)} = \frac{V_m}{2}$$

Prove!

$$I_{\text{rms}} = \frac{V_m}{2R}$$



$$V_0 = V_{avg} = \frac{1}{2\pi} \int_0^{\pi} V_m \sin(\omega t) d\omega t$$

$$= \frac{V_m}{2\pi} \left[-\cos(\omega t) \right]_0^{\pi} = \frac{V_m}{2\pi} \left[-\cos \pi - \left(-\cos 0 \right) \right]$$

$V = IR$

$$V_0 = \frac{V_m}{2}$$

$$I_0 = \frac{V_0}{R}$$

$$P_{load} = I_{rms}^2 R = \frac{V_{rms}^2}{R}$$

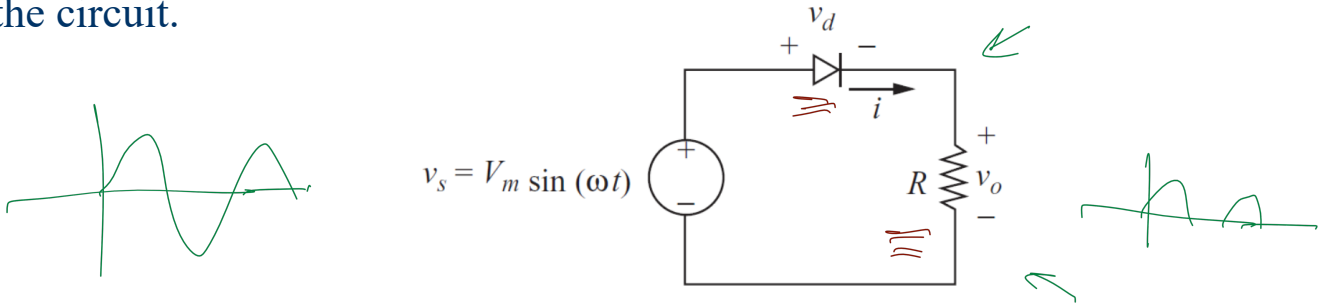
$$V_{rms} = \sqrt{\frac{1}{2\pi} \int_0^{2\pi} [V_m \sin(\omega t)]^2 d(\omega t)}$$

at R_{load}

$$= \left(\frac{V_m}{2} \right) \Rightarrow I_{rms} = \frac{V_{rms}}{R} = \frac{V_m}{2R}$$

Example 3-1

For the half-wave rectifier, the source is a sinusoid of 120 V rms at a frequency of 60 Hz. The load resistor is 5 Ω . Determine (a) the average load current, (b) the average power absorbed by the load and (c) the power factor of the circuit.



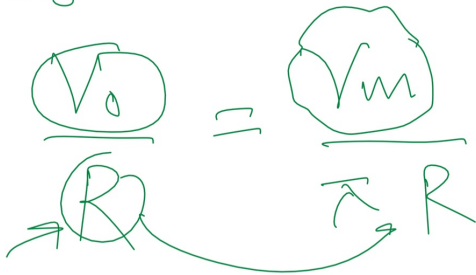
Solution is on the board

$$V_{s,rms} = 120 \text{ V} \Rightarrow V_m = V_{rms} \sqrt{2} = 120 \sqrt{2} = 169.7 \text{ V}$$

$$f = 60 \text{ Hz} \Rightarrow \omega = 2\pi f = 2\pi \cdot 60 = 377$$

$$R = 5 \Omega$$

find I_o

$$I_o = \frac{V_o}{R} = \frac{V_m}{\sqrt{2} R}$$


$$I_o = \frac{169.7}{\sqrt{2} \cdot 5} = 10.8 \text{ A}$$

$$P_{\text{real}} = V_{\text{rms}} \cdot I_{\text{rms}} = I_{\text{rms}}^2 R = \frac{V_{\text{rms}}^2}{R}$$

$$V_{\text{rms}} = \frac{V_m}{2} = \frac{169.7}{2} = 84.9 \text{ V}$$

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{R} = \frac{84.9}{5} \approx 17 \text{ A}$$

$$P = (I_{\text{rms}})^2 R = (17)^2 \cdot 5 = \frac{V_{\text{rms}}^2}{R} = \frac{(84.9)^2}{5} = 1440 \text{ W}$$

$$(c) \text{ pf} = \frac{P_{\text{real}}}{V_{\text{s rms}} \cdot I_{\text{s rms}}} = \frac{1440}{120 \cdot 17} = 0.707$$