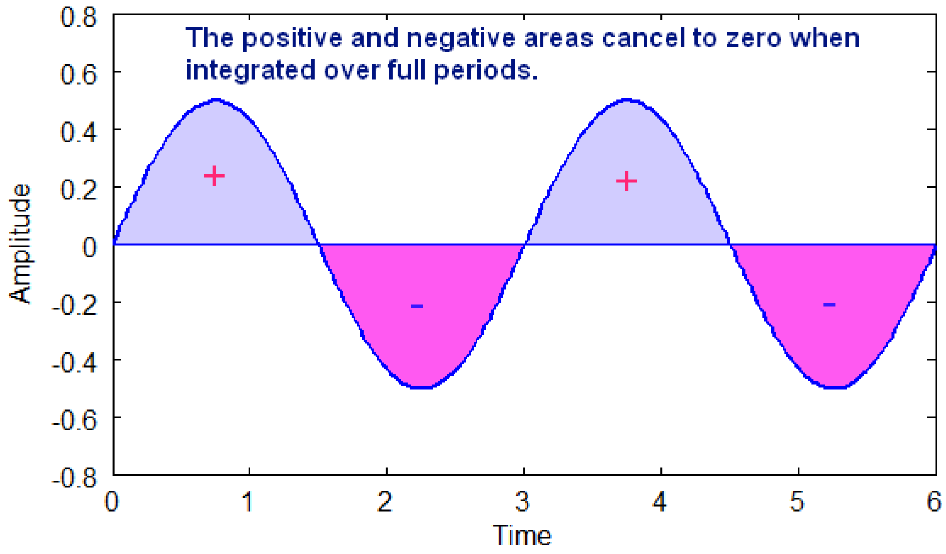
Diode as Rectifiers

Rectification

- Ac signals have zero average or dc value.
- To create dc level, rectification is necessary.



- Rectifiers are of two types, half wave and full wave rectifiers

Half wave rectification

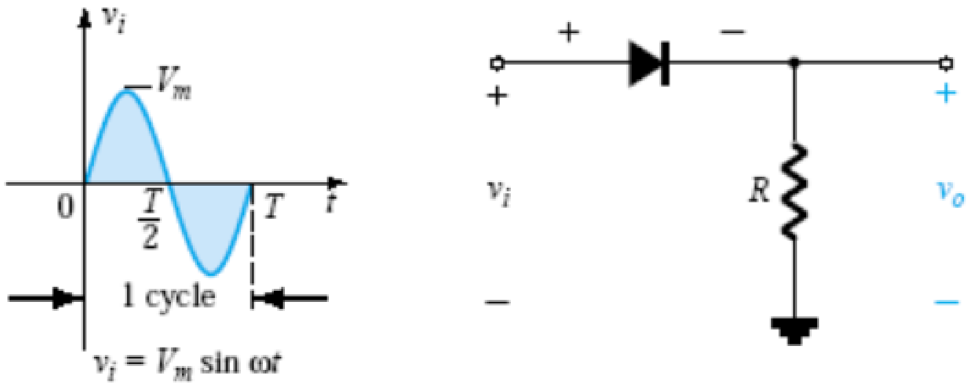


Figure 2.43 Half-wave rectifier.

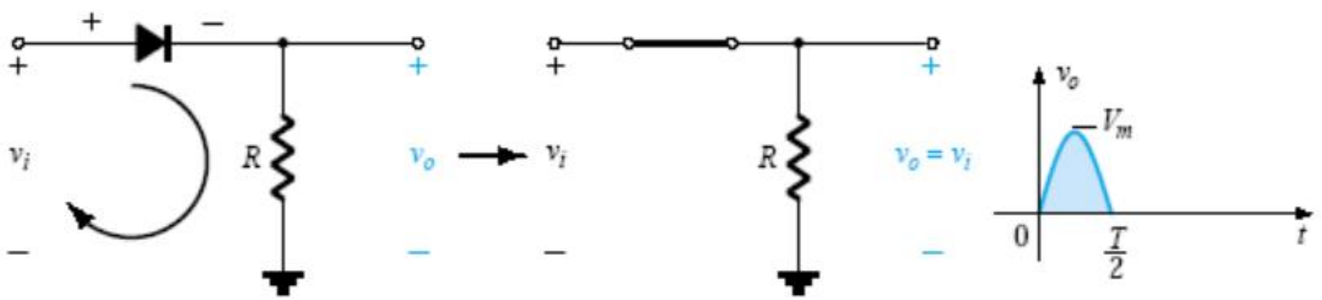


Figure 2.44 Conduction region ($0 \rightarrow T/2$).

HWR (continue..)

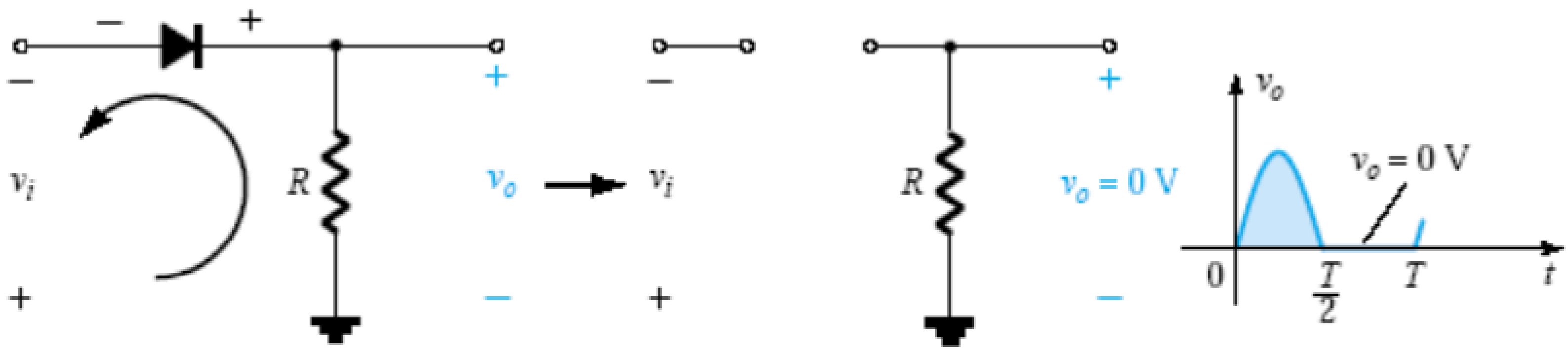


Figure 2.45 Nonconduction region ($T/2 \rightarrow T$).

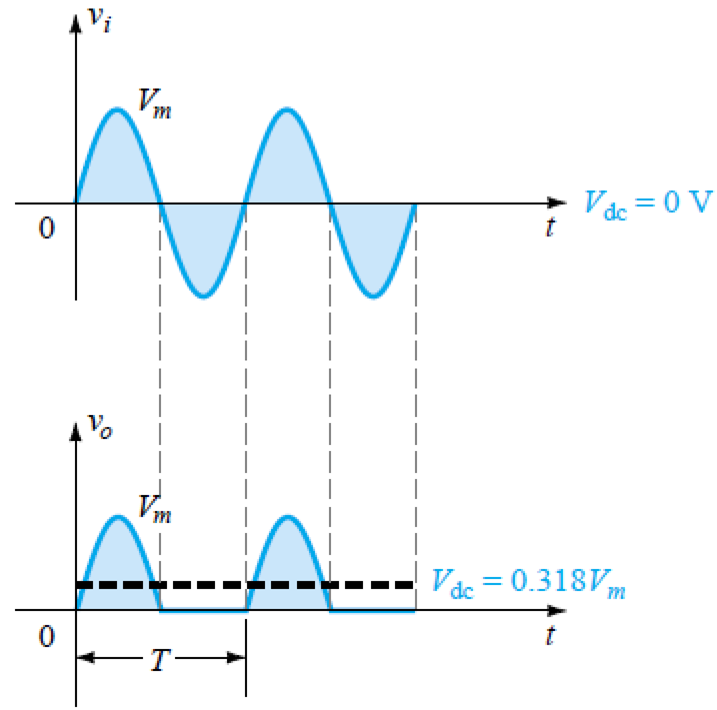


Figure 2.46 Half-wave rectified signal.

HWR (continue..)

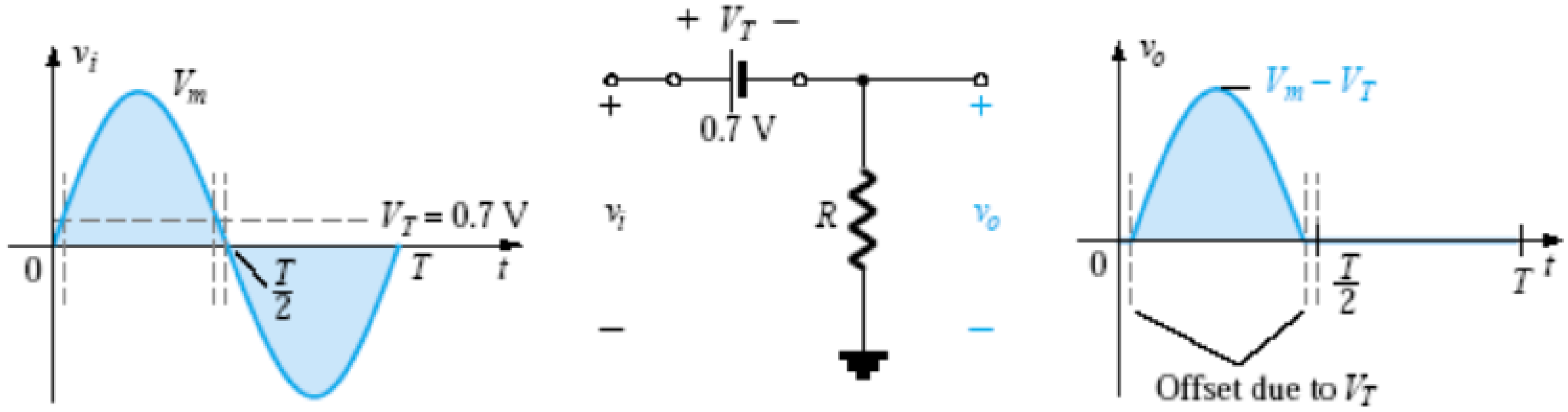


Figure 2.47 Effect of V_T on half-wave rectified signal.

Dc output

- Average or dc value of a signal is-

$$V_{dc} = \frac{1}{T}\int_0^T V_m \sin t dt$$

- For half wave rectifier,

$$V_{dc} = \frac{1}{T}\left[\int_0^{T/2} V_m \sin t dt + \int_{T/2}^{T} 0 \ dt\right] = \frac{V_m}{\pi} = 0.318 V_m$$

For practical diode, $\boxed{V_{dc} \cong 0.318(V_m - V_T)}$

PRV/PRV of Diode

$$\boxed{\text{PIV rating} \geqq V_m} \quad \text{half-wave rectifier} \tag{2.9}$$

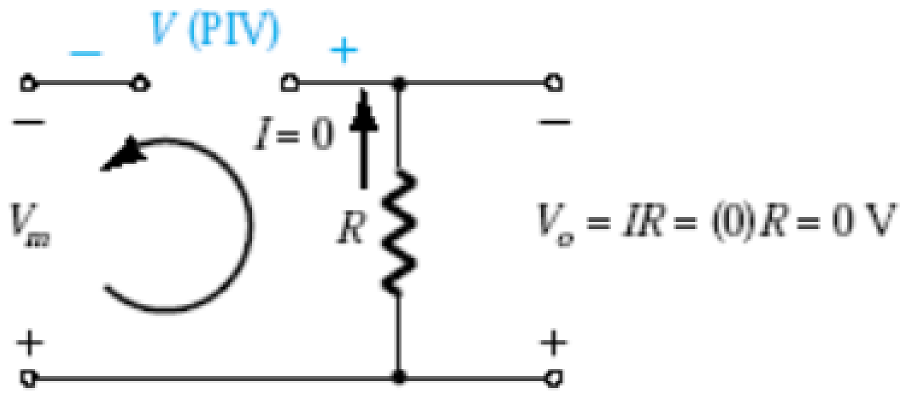


Figure 2.51 Determining the required PIV rating for the half-wave rectifier.

Full Wave Bridge Rectifier

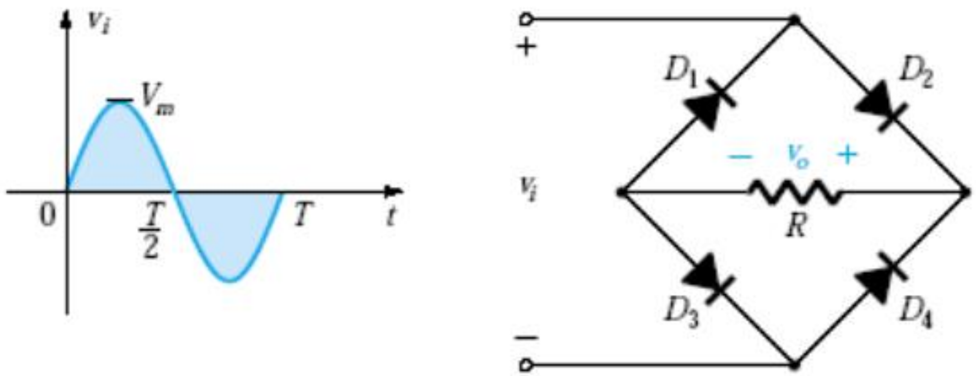


Figure 2.52 Full-wave bridge rectifier.

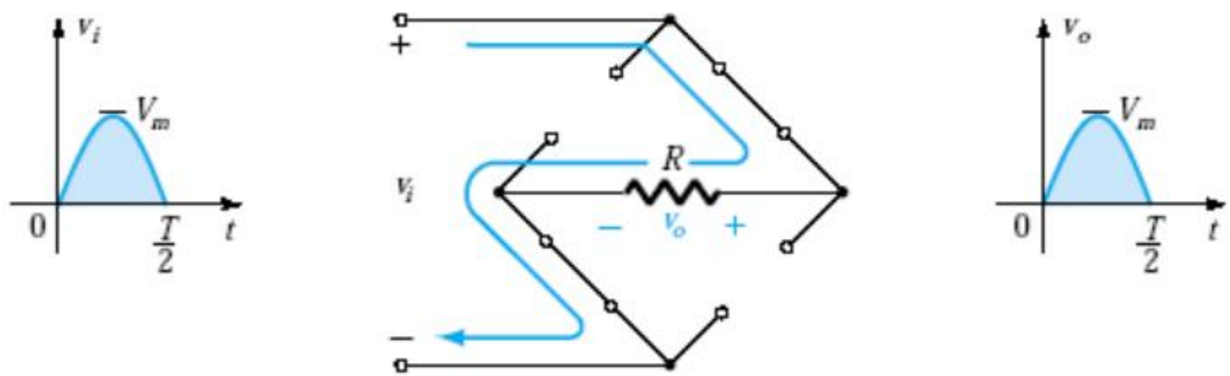


Figure 2.54 Conduction path for the positive region of v_i.

FWBR (continue..)

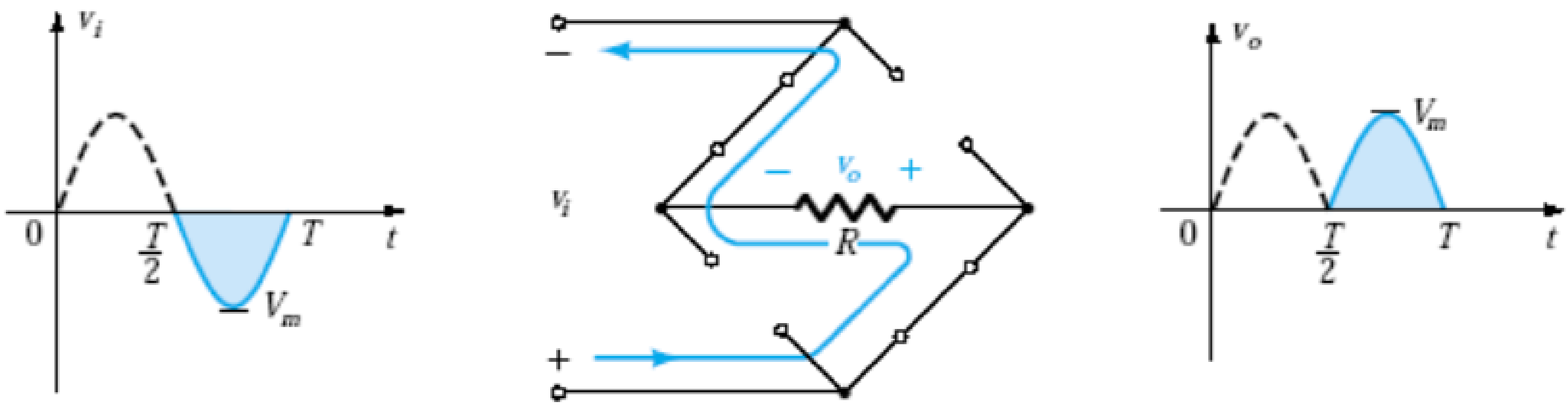


Figure 2.55 Conduction path for the negative region of v_i.

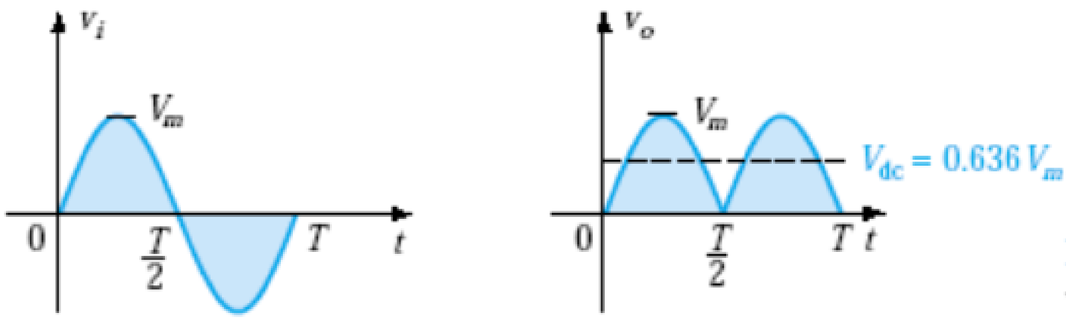


Figure 2.56 Input and output waveforms for a full-wave rectifier.

Dc Output

- Twice as that of a half wave rectifier.

$$V_{dc} = 2(\text{Eq. } 2.7) = 2(0.318 V_m)$$

$$\boxed{V_{dc} = 0.636 V_m}_{\text{full-wave}} \qquad (2.10)$$

- Needs 4 diodes and a resistor.
- Transformer is necessary to step down the input voltage for direct line voltage rectification using ordinary diodes.
- PIV equals Vm, same as half wave rectifier.

FWBR using practical diodes

Applying KVL

$$v_i - V_T - v_o - V_T = 0$$

and

$$v_o = v_i - 2V_T$$

The peak value of the output voltage v_o is therefore

$$V_{o_{max}} = V_m - 2V_T$$

For situations where $V_m \gg 2V_T$, Eq. (2.11) can be applied for the average value with a relatively high level of accuracy.

$$\boxed{V_{dc} \cong 0.636(V_m - 2V_T)} \qquad (2.11)$$

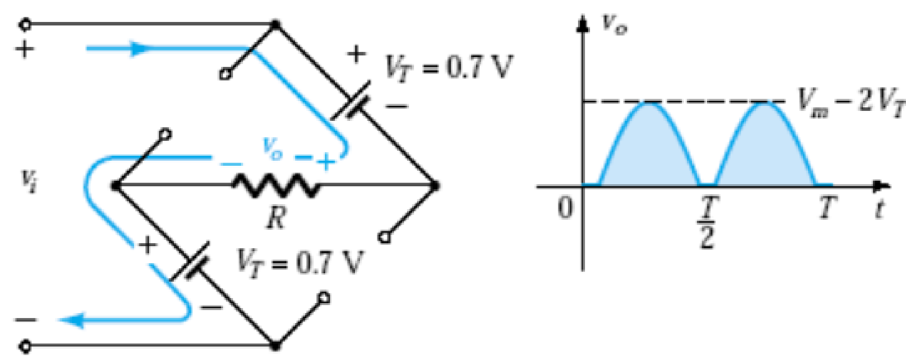


Figure 2.57 Determining $V_{o_{max}}$ for silicon diodes in the bridge configuration.

Then again, if V_m is sufficiently greater than $2V_T$, then Eq. (2.10) is often applied as a first approximation for V_{dc}.

Center-tap Transformer Rectifier

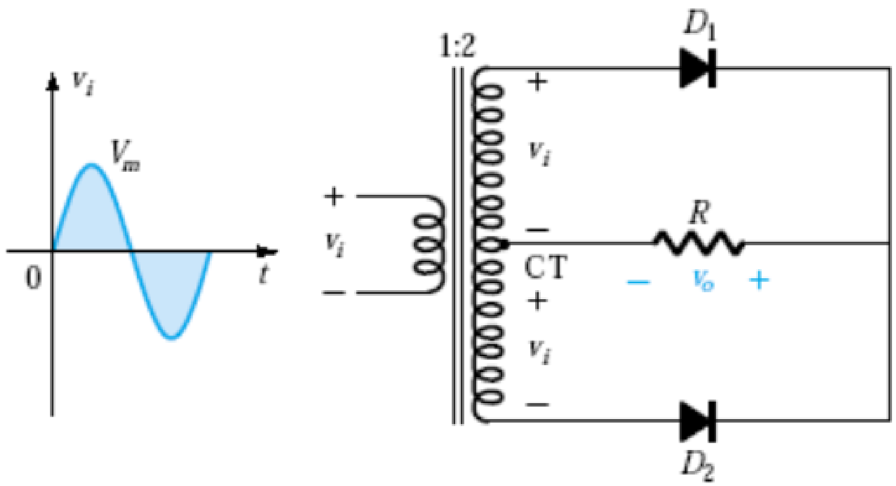


Figure 2.59 Center-tapped transformer full-wave rectifier.

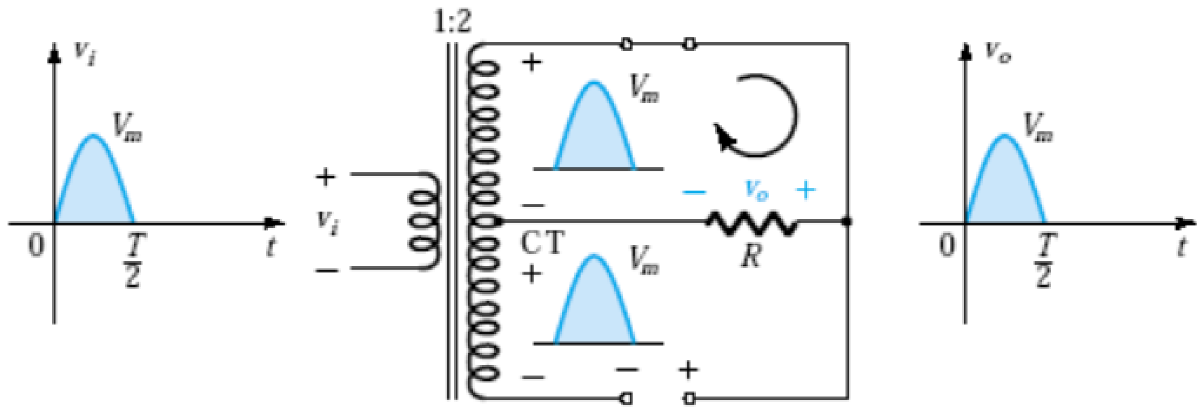


Figure 2.60 Network conditions for the positive region of v_i.

CTTR (continue..)

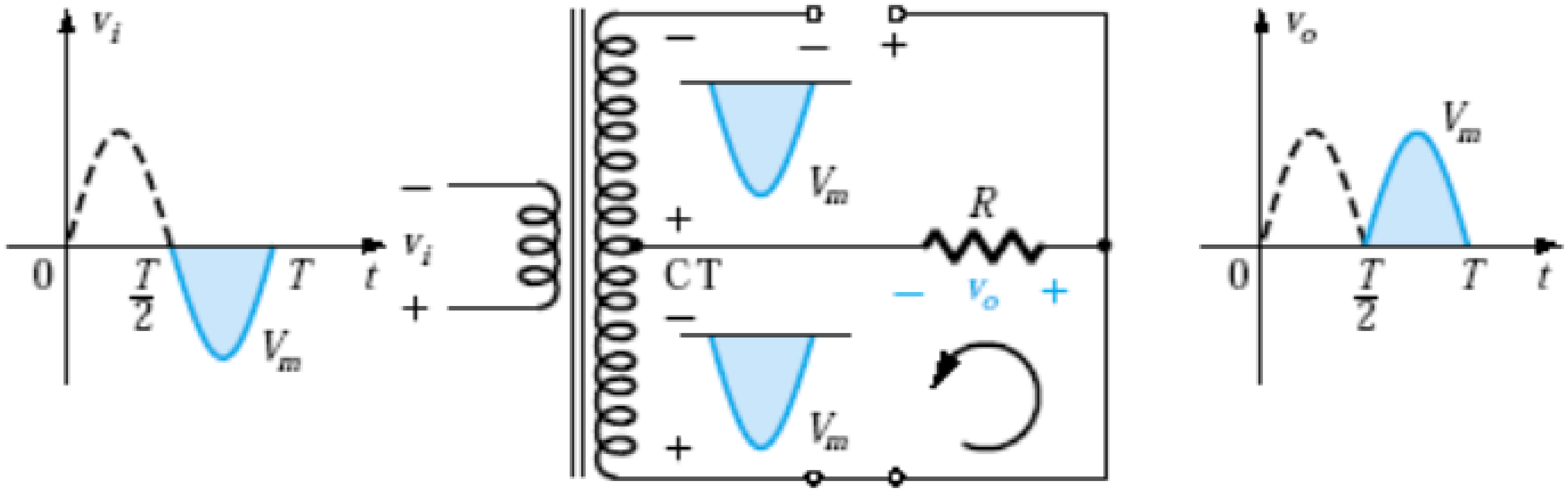


Figure 2.61 Network conditions for the negative region of v_i.

PIV of Diodes

$$\begin{aligned} \text{PIV} &= V_{\text{secondary}} + V_R \\ &= V_m + V_m \end{aligned}$$

$$\boxed{\text{PIV} \geqq 2V_m}$$ CT transformer, full-wave rectifier

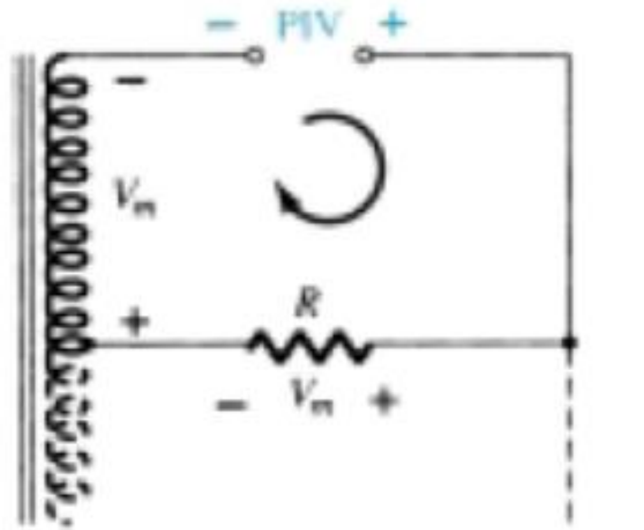
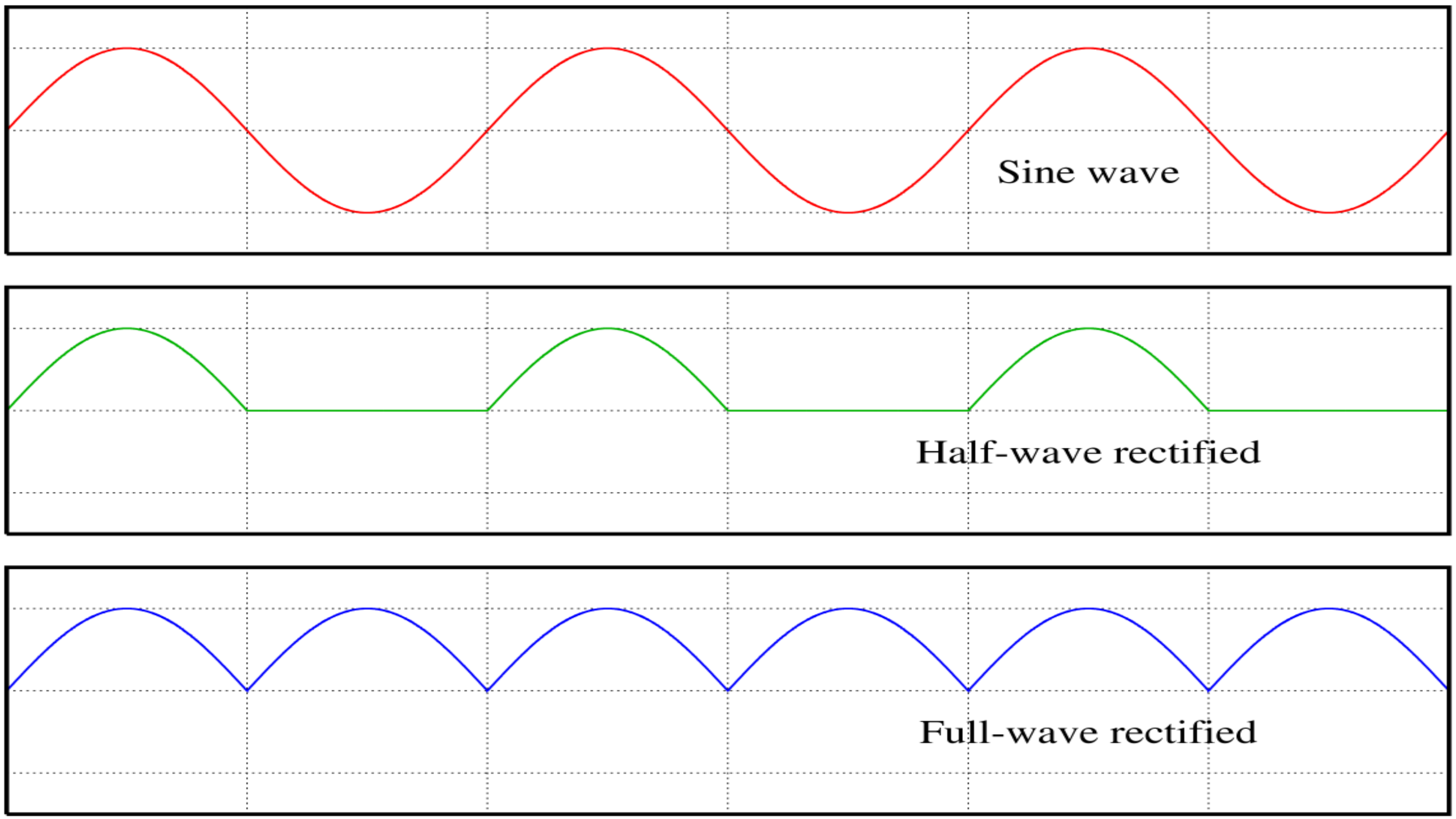
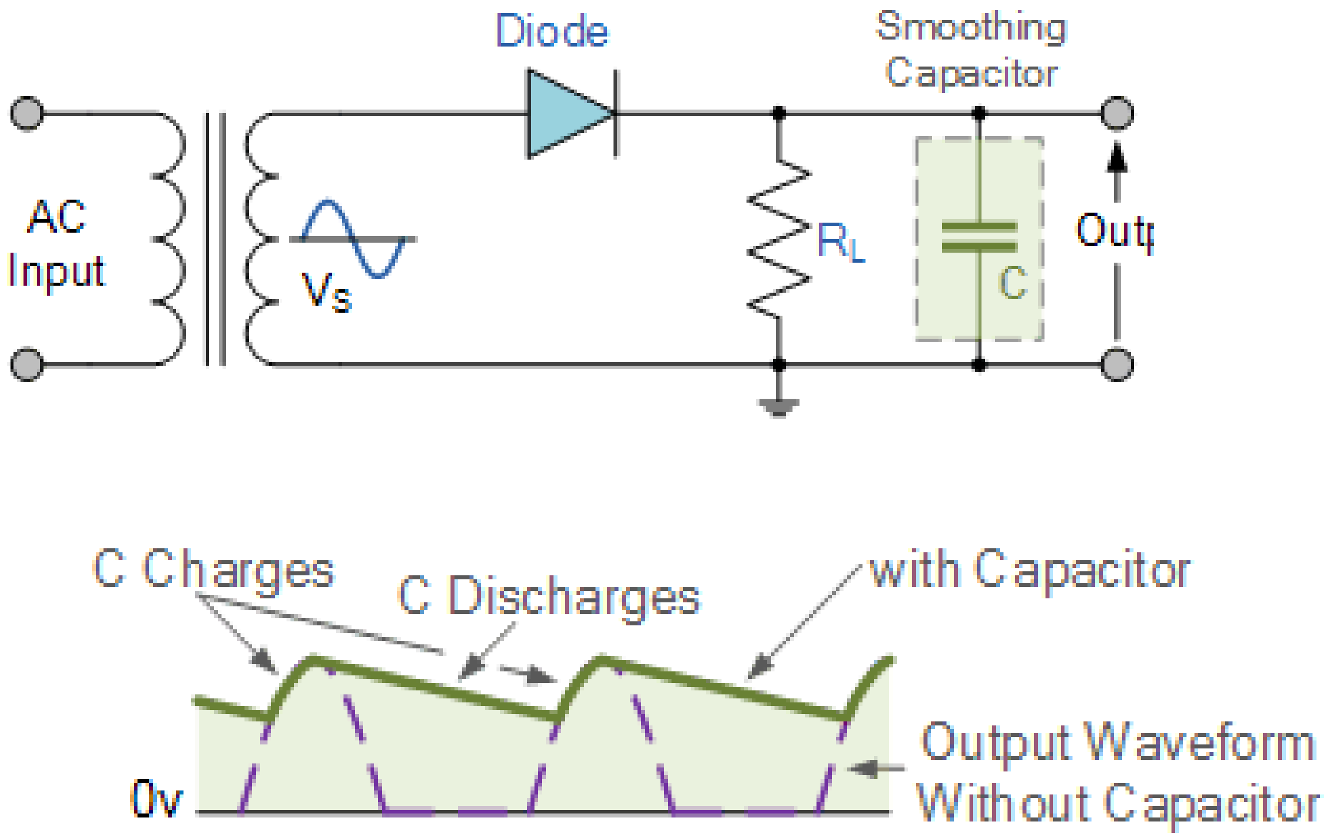


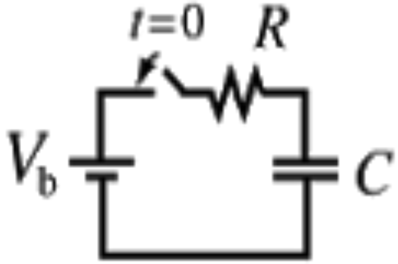
Figure 2.62 Determining the PIV level for the diodes of the CT transformer full-wave rectifier.

Oscilloscope display



HWR with capacitor filter





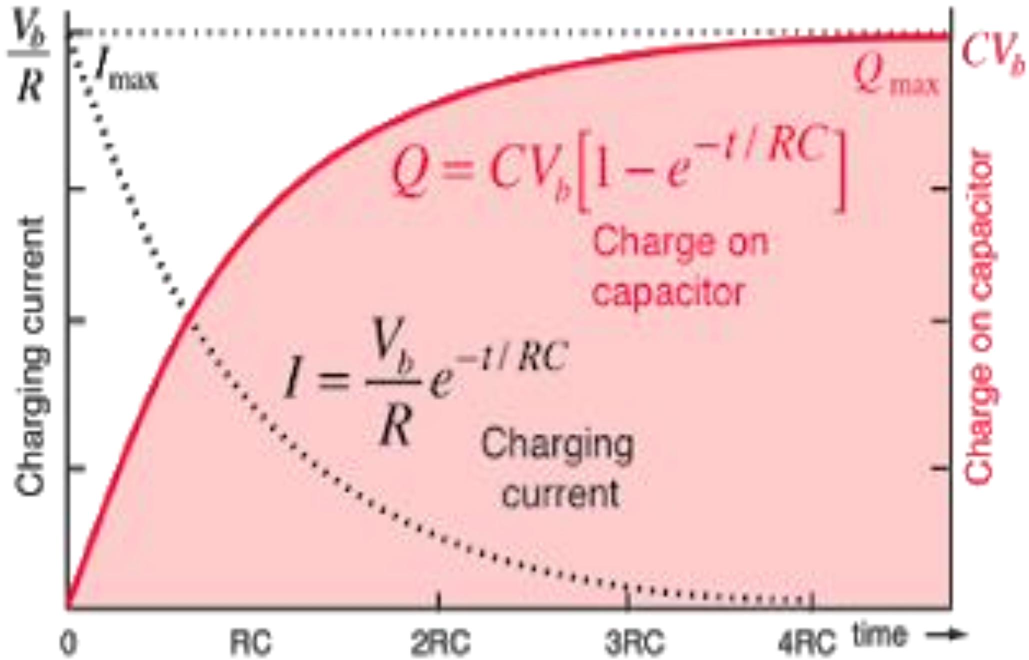
$$V_b = V_R + V_C$$

$$V_b = IR + \frac{Q}{C}$$

As charging progresses,

$$V_b = IR + \frac{Q}{C}$$

current decreases and charge increases.



At $t=0$

$Q=0$

$V_C=0$

$I=\frac{V_b}{R}$

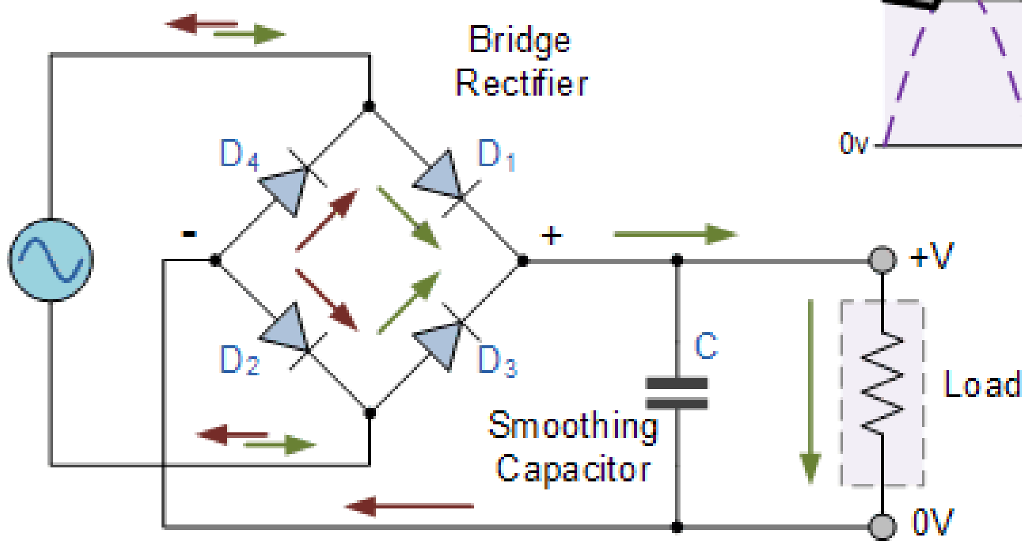
As $t\to\infty$

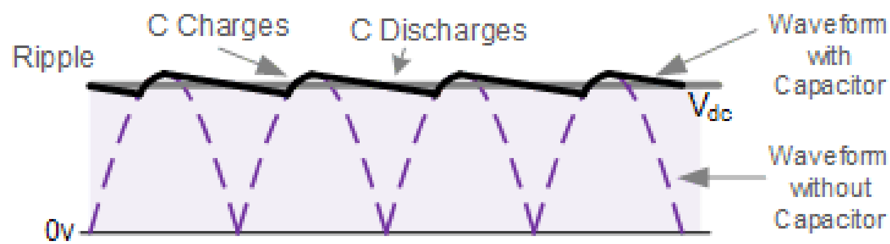
$Q\to CV_b$

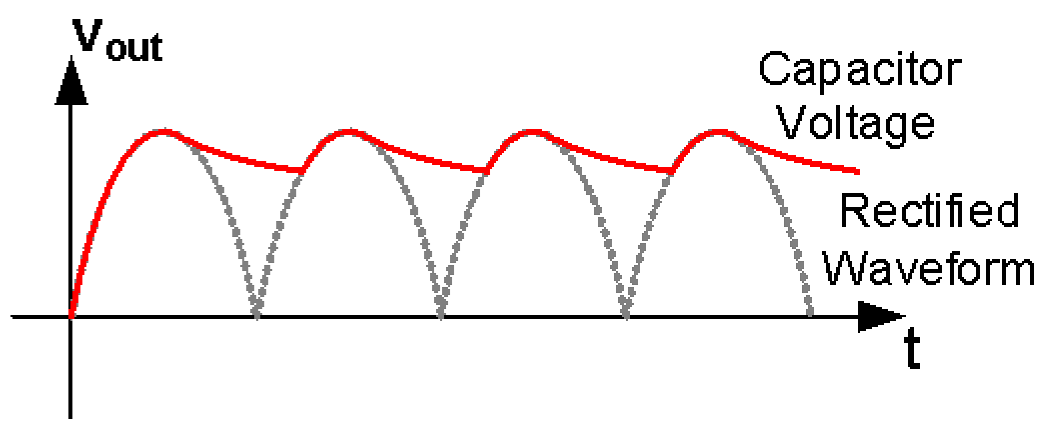
$V_C\to V_b$

$I\to 0$

FWR with capacitor filter







Comparison

	HWR	FWBR	FWCTTR
Available dc	0.318Vm	0.636Vm	0.636Vm
Ripple with filter capacitor	More	Less	Less
PIV of diode	≥Vm	≥Vm	≥2Vm
No of diodes	1	4	2
Conversion efficiency	Less	More	More

Efficiency (Half-Wave and Full-Wave Rectifiers)

$$\text{Efficiency } (\eta) = \frac{\text{DC Output Power}}{\text{AC Input Power}}$$

DC Output Power of Half Wave Rectifier $= V_o . I_o = (I_o)^2 . R_L$

AC Input Power of Half Wave Rectifier $= V_{or} . I_{or} = (I_{or})^2 . R_L$

$$\text{Efficiency } (\eta) = \frac{V_o . I_o}{V_{or} . I_{or}} = \frac{(I_o)^2 . R_L}{(I_{or})^2 . R_L}$$

Assuming Diode used in this circuit is ideal means its forward resistance (R_F) is 0.

$$\text{Efficiency } (\eta) = \frac{(V_m/\pi)^2}{(V_m/2)^2} = \frac{4}{\pi^2} = 40.5\%$$

$P = VI$

$P = I^2 R$

$$\eta\,\% = \frac{P_{Load}}{P_{in}} \times 100\%$$

$$= \frac{I_{dc}^2 \cancel{R}}{I_{rms}^2 \cancel{R}} \times 100\%$$

$I_{dc} = I_m/\pi$

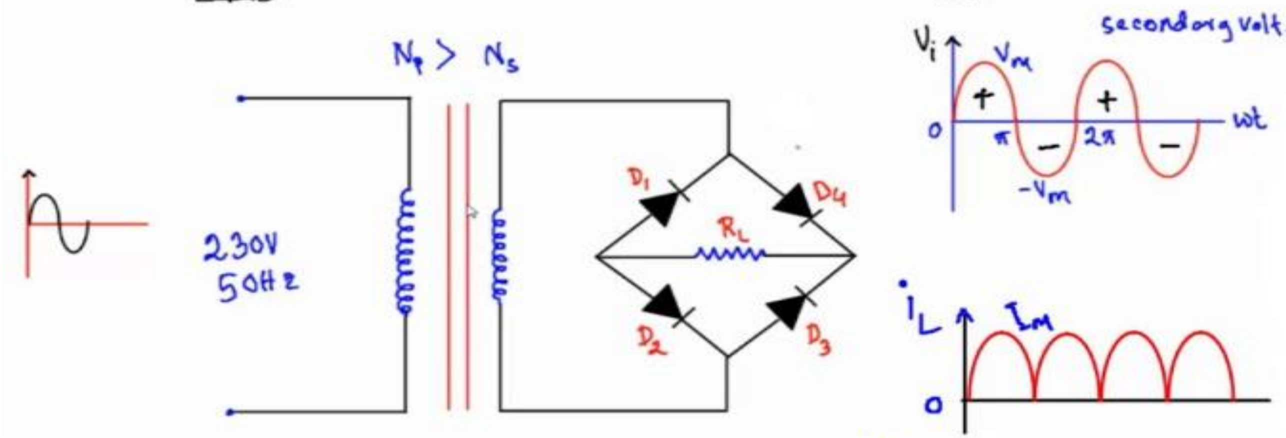
$I_{rms} = I_m/2$

$$= \frac{\cancel{I_m^2}/\pi^2}{\cancel{I_m^2}/4} \times 100\% = \frac{4}{\pi^2} \times 100\%$$

$$\eta\,\% = 40.56\%$$

Transformer Utilization Factor of Full Wave Rectifier:

$$V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707\,V_m$$



$$TUF = \frac{I_{dc}^2 R_L}{V_{rms} I_{rms}}$$

$$= \frac{\frac{4 I_m^2}{\pi^2} \times R_L}{\frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}}}$$

$$= \frac{8 I_m^2 R_L}{\pi^2 \times I_m \times V_m}$$

$$= \frac{8 I_m R_L}{\pi^2 V_m}$$

$$= \frac{8 V_m}{\pi^2 V_m} = 0.812$$

$$TUF = 0.812 = \frac{P_{dc}}{I}$$

Ripple factor

The ripple factor for a half-wave rectifier is 1.21.

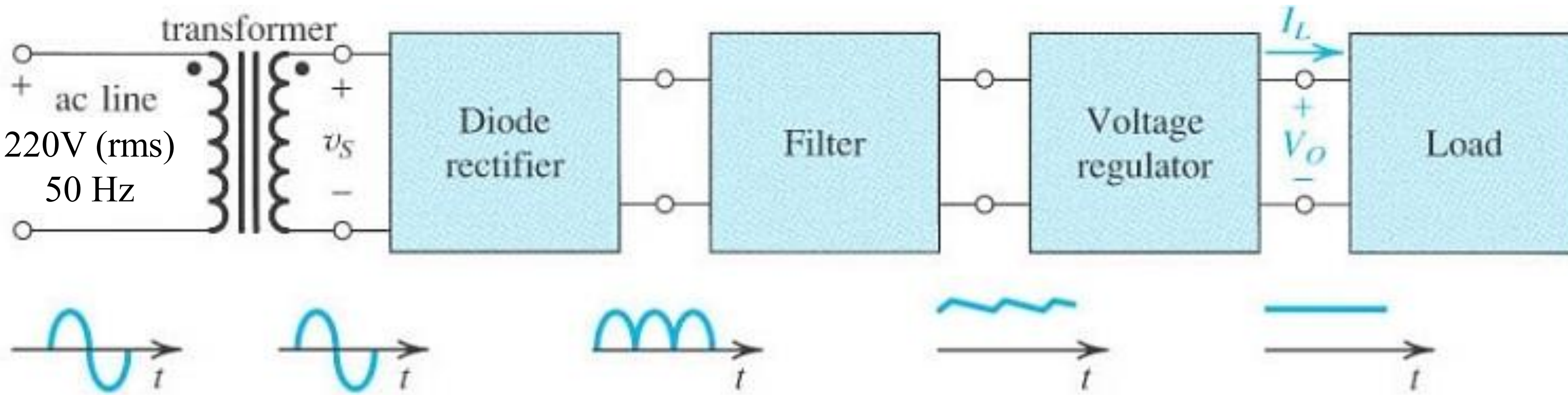
This value indicates the degree of AC ripple present in the rectified output, with a higher value suggesting a greater AC content.

The ripple factor of a full-wave rectifier is 0.48.

This value is a measure of the amount of AC ripple or fluctuations present in the DC output of a rectifier circuit.

A lower ripple factor indicates a cleaner, more stable DC output.

Block diagram of ac to dc conversion



Home work

- Solve problems at the end of Chapter 2
- Problem no 22, 23, 25, 26, 27, 29 and 31.

Thank You