Ministry of high Education and Scientific Research
Foundation of Technical Education
Technical Institute of kufa

Power Electronics

For Students of second class electrical department

By jaafer sadiq jaafer Lecturer
in electrical Dep.

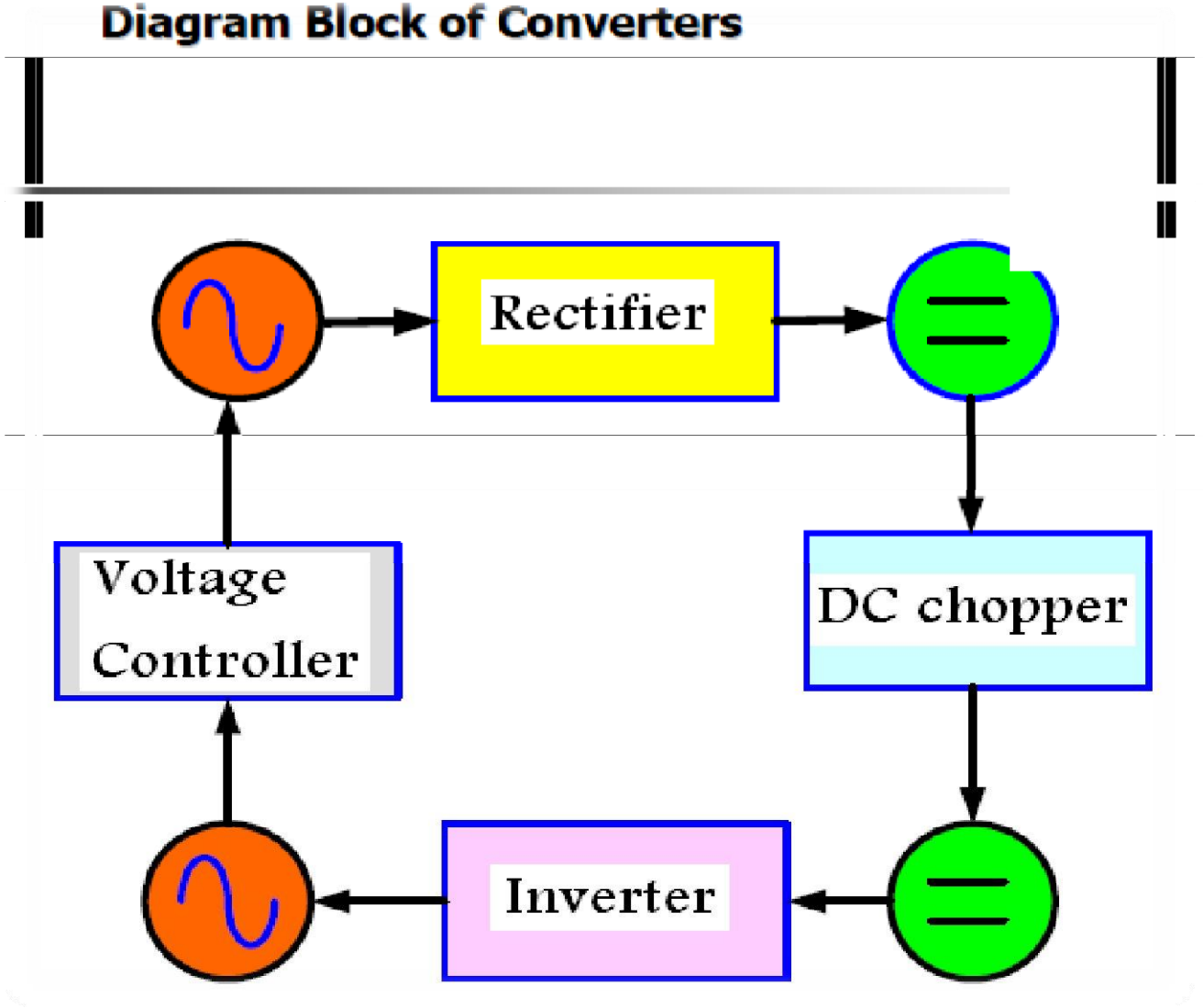
Week No -1

- Power electronic
- Electronic components used in power electronics
  - Power Diode
  - Power transistor
  - Thyristor
- Prevision of single phase rectifier circuits by using diode

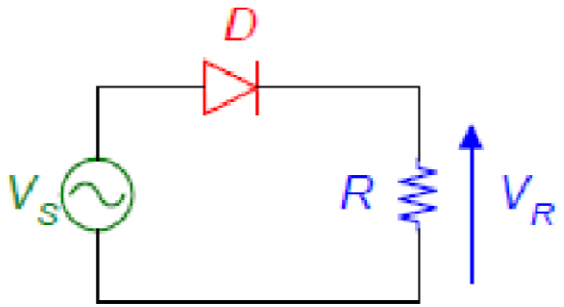
What is Power Electronics ?

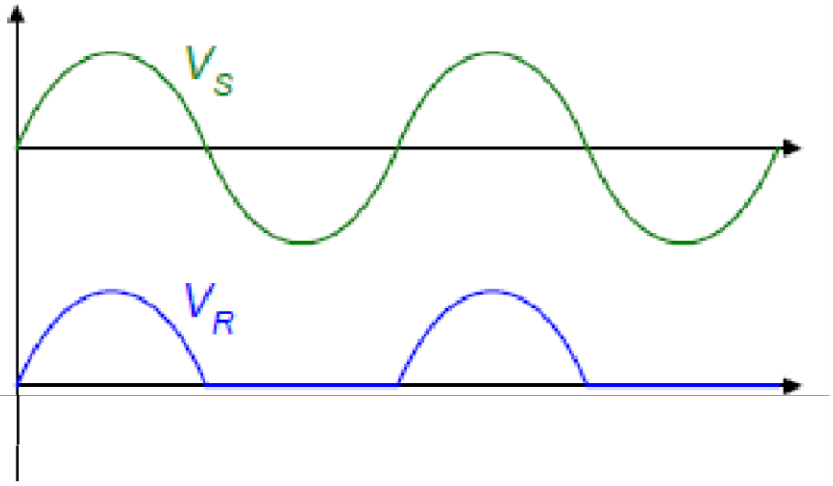
- **Conversion of *Large Amounts of* Electric Power and Energy**
  - **ac to dc**
  - **dc to ac**
  - **dc to dc**
  - **ac to ac**

Diagram Block of Converters

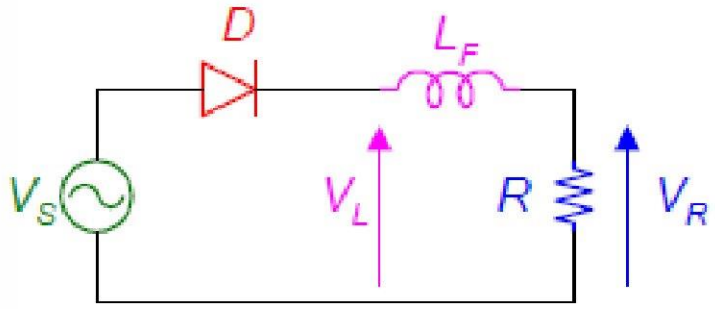


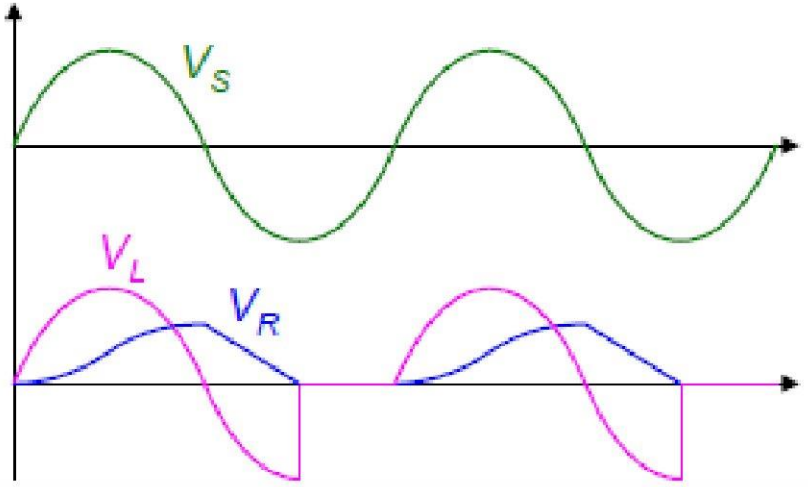
Diode Rectifier





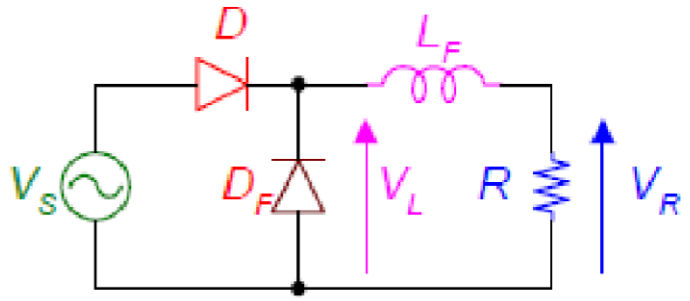
Half Bridge Rectifier

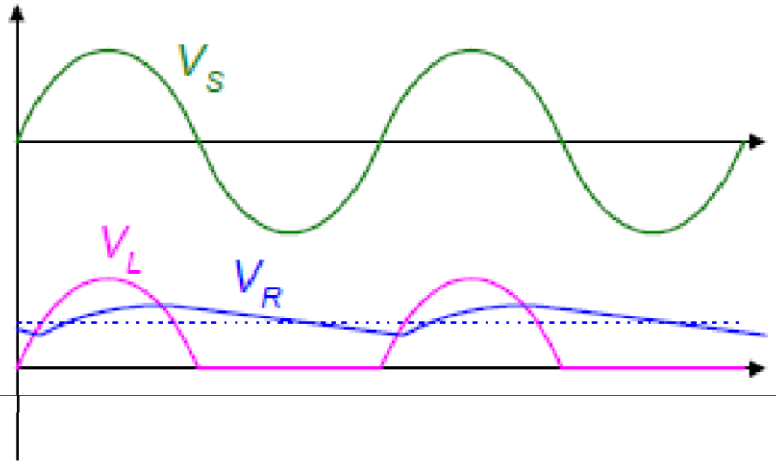




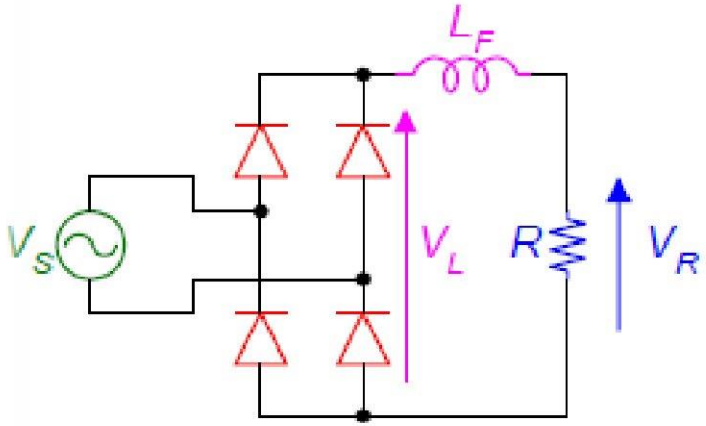
Half Bridge Rectifier with Smoothing Inductor

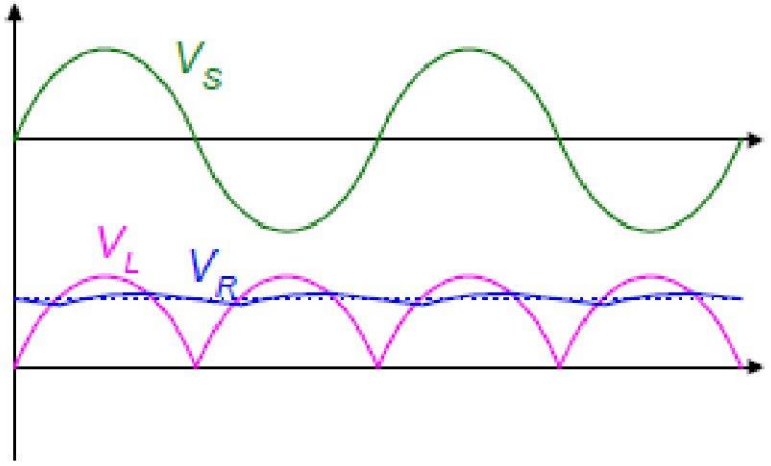
Diode Rectifier (Cnt'd)





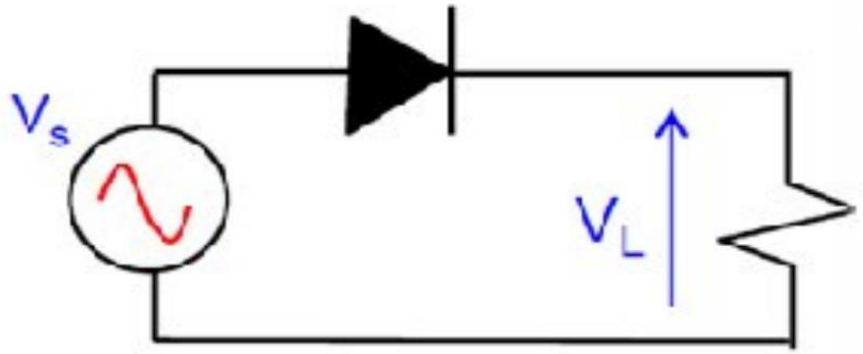
With Free-Wheeling Diode



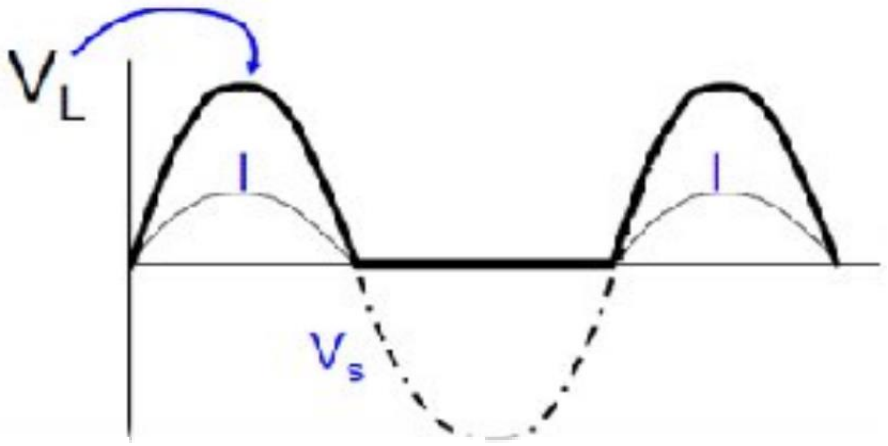


Full Bridge Rectifier

Single phase uncontrolled resistive load rectifier



(a) circuit diagram



(b) waveforms

The main disadvantages of half wave rectifier are:

1- High ripple factor,

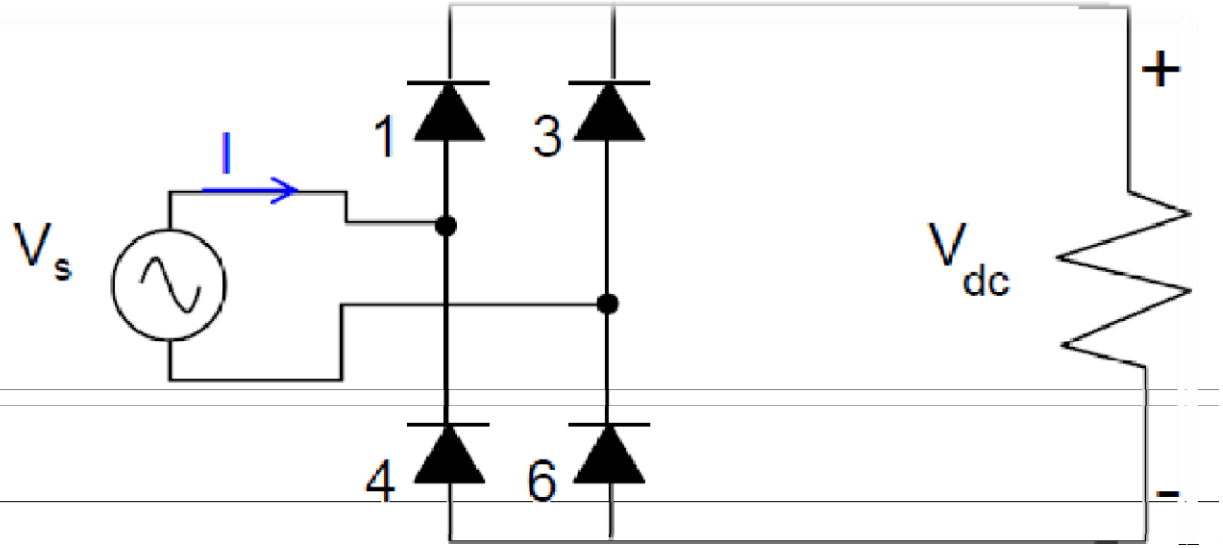
2- Low rectification efficiency,

3- Low transformer utilization factor, and,

4- DC saturation of transformer secondary winding.

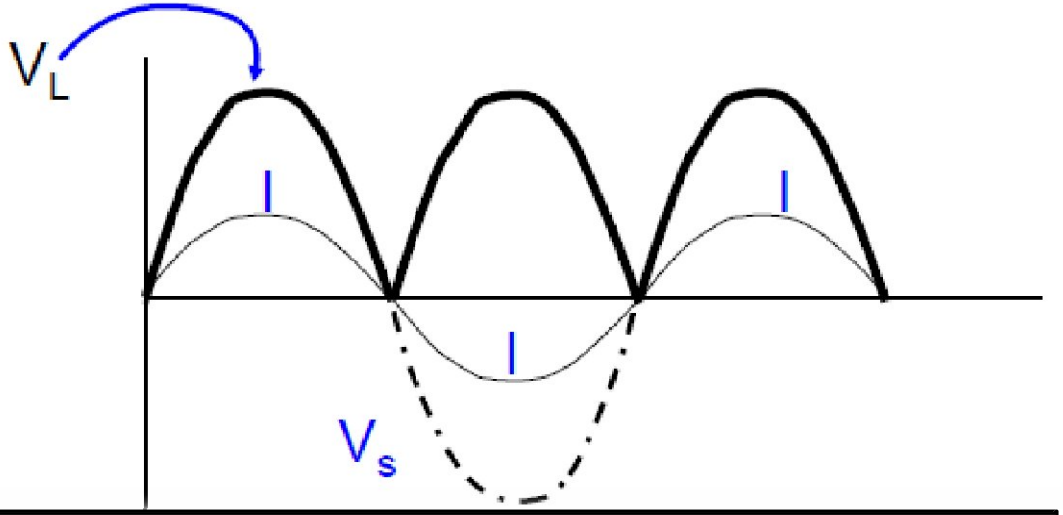
Single phase full wave uncontrolled resistive load rectifier

Full-wave diode rectifier



Ripple of voltage and current is

High



Performance Parameters

- Average value of the output voltage, V_{dc}
- Average value of the output current, I_{dc}
- Output dc power, P_{dc}
  - $P_{dc} = V_{dc}I_{dc}$
- rms value of the input voltage, V_{rms}
- Output ac power, P_{ac}
  - $P_{ac} = V_{rms}I_{rms}$

Performance Parameters (continued)

- Efficiency , η

  $\eta = P_{dc} / P_{ac}$

- Effective (rms) value of the ac component of the output voltage, V_{ac}

  $V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$

- Form factor, FF

  $FF = V_{rms} / V_{dc}$

- Ripple factor, RF

  $RF = V_{ac} / V_{dc}$

Performance Parameters

- Alternate form for ripple factor

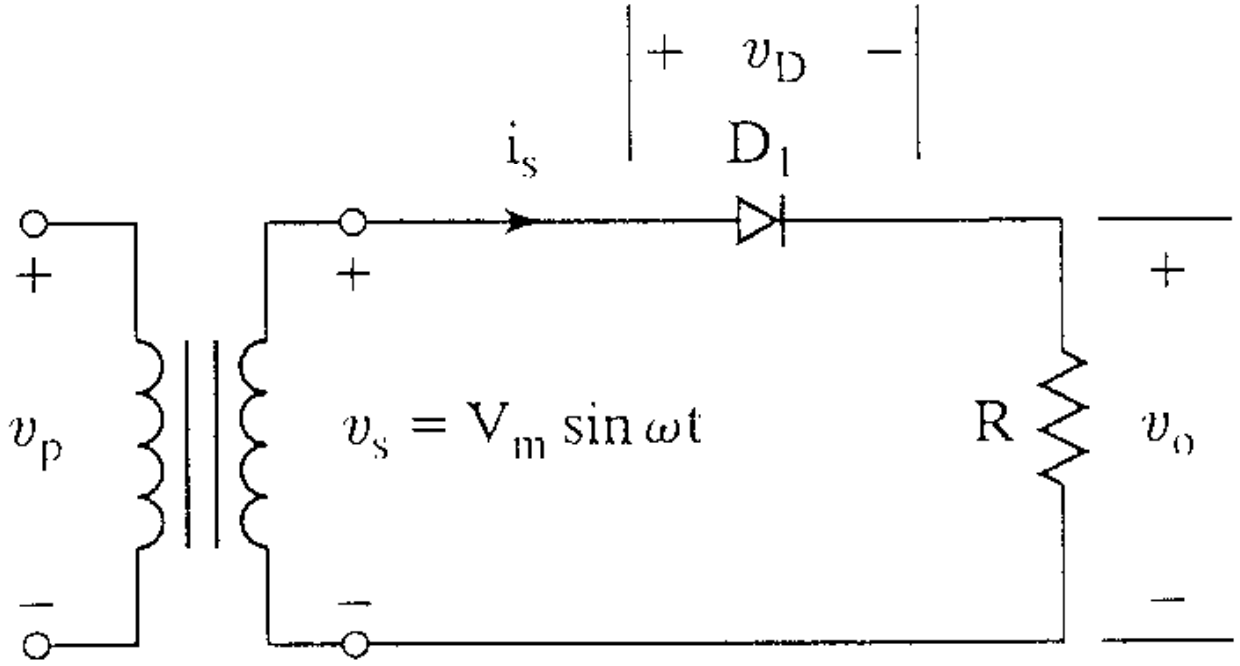
$$RF = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2} - 1 = \sqrt{FF^2 - 1}$$

- Transformer utilization factor, TUF

  $TUF = P_{dc} / V_s I_s$

  V_s , I_s are rms voltage and current of the transformer secondary

- Determine η , FF, RF,TUF, PIV of the diode, when V_s = 120 Sin wt , R_L = 12 Ω .

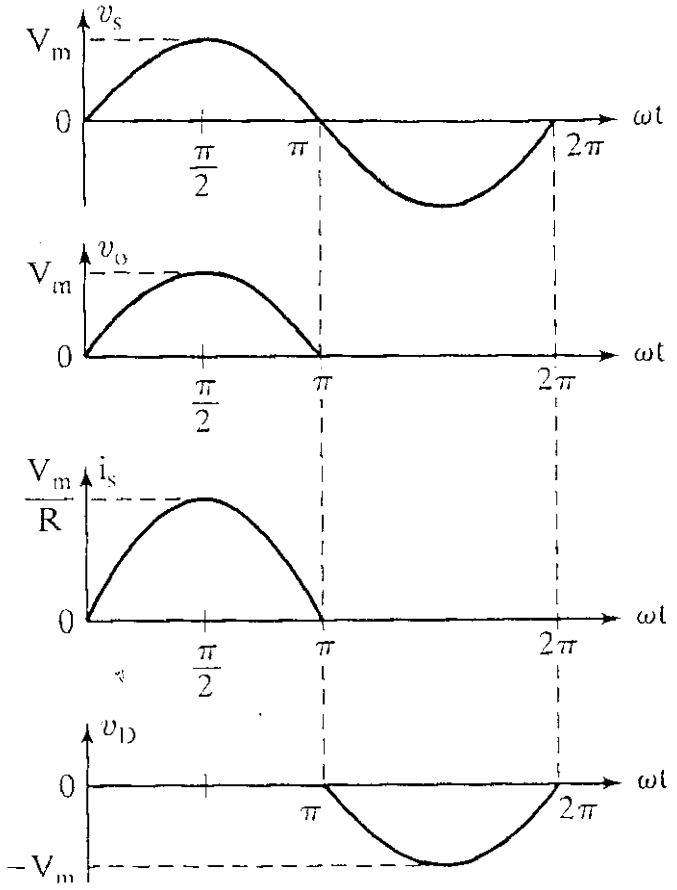


Determine the Average Voltage, V_{dc}

$$V_{dc} = \frac{1}{T}\int_0^T v_L(t)\,dt$$

$$V_{dc} = \frac{1}{T}\int_0^{\frac{T}{2}} V_m \sin\omega t\,dt$$

$$V_{dc} = -\frac{V_m}{\omega T}\left(\cos\frac{\omega T}{2} - 1\right)$$



$$f = \frac{1}{T}$$

$$\omega = 2\pi f$$

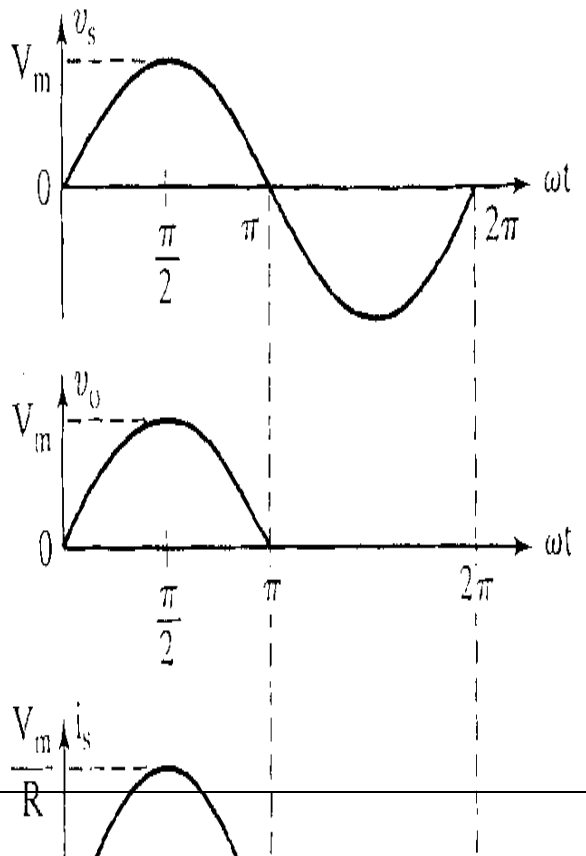
$$V_{dc} = \frac{V_m}{\pi} = 0.318 Vm$$

Determine the rms Voltage, V_{rms}

$$V_{rms} = \left[\frac{1}{T} \int_0^T v^2(t)\,dt \right]^{\frac{1}{2}}$$

$$V_{rms} = \left[\frac{1}{T} \int_0^{\frac{T}{2}} (V_m \sin \omega t)^2 dt \right]^{\frac{1}{2}}$$

$$V_{rms} = \frac{V_m}{2} = 0.5 V_m$$



Determine P_{dc}, P_{ac}, and η

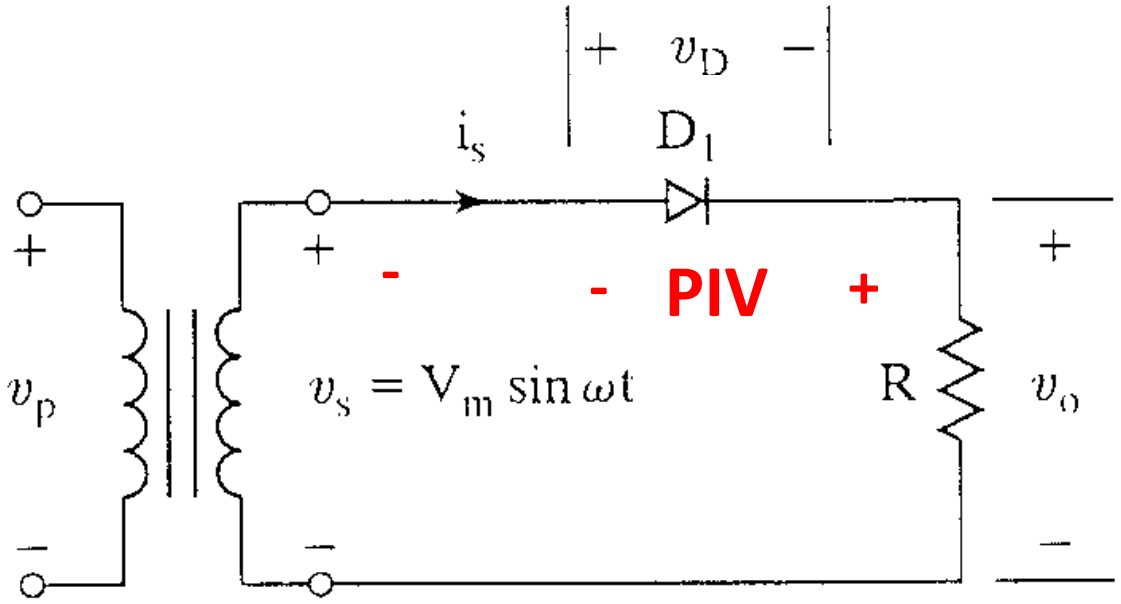
$$P_{dc} = \frac{(0.318V_m)^2}{R}$$

$$P_{ac} = \frac{(0.5V_m)^2}{R}$$

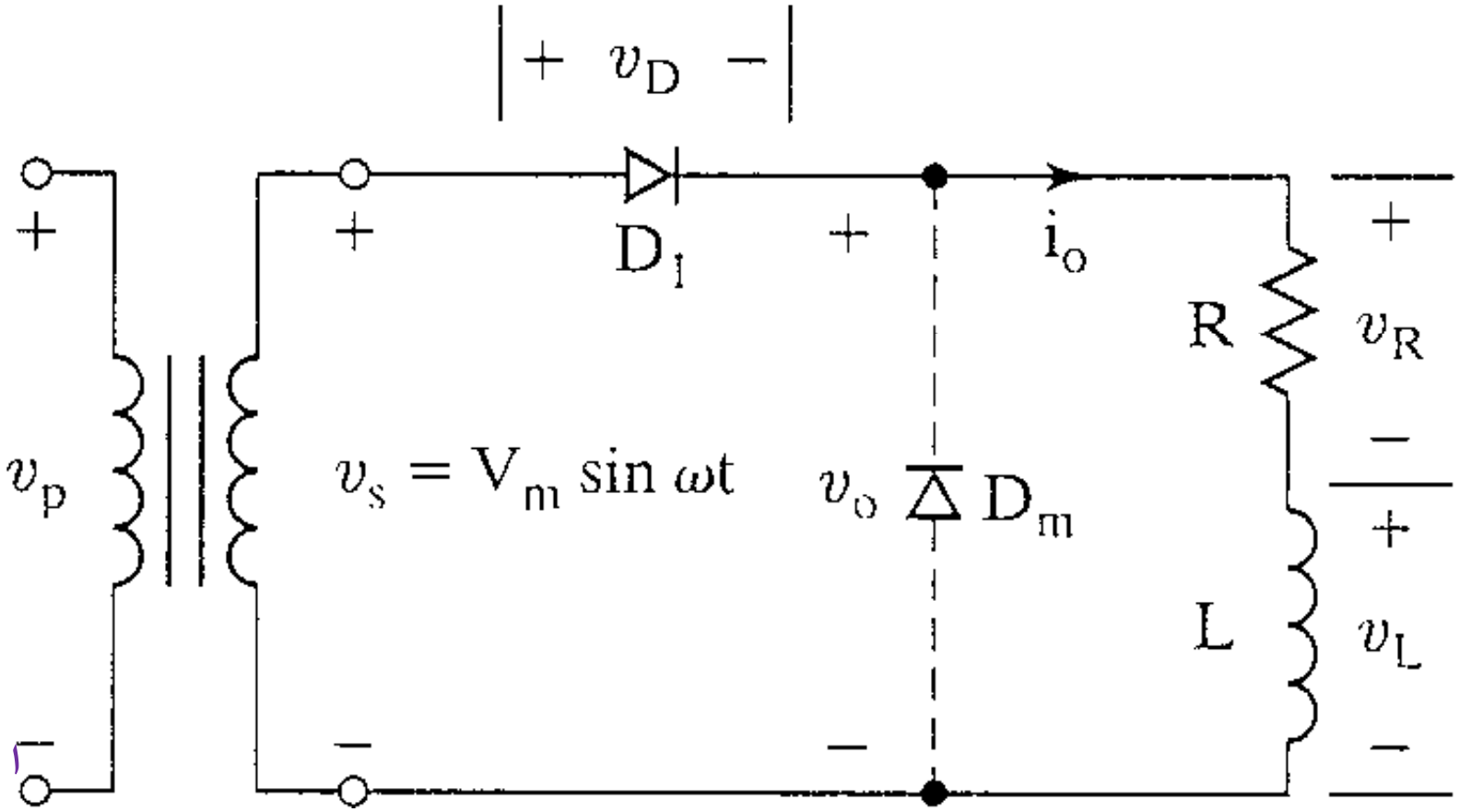
$$\eta = \frac{(0.318V_m)^2}{(0.5V_m)^2} = 40.5\%$$

Determine the PIV

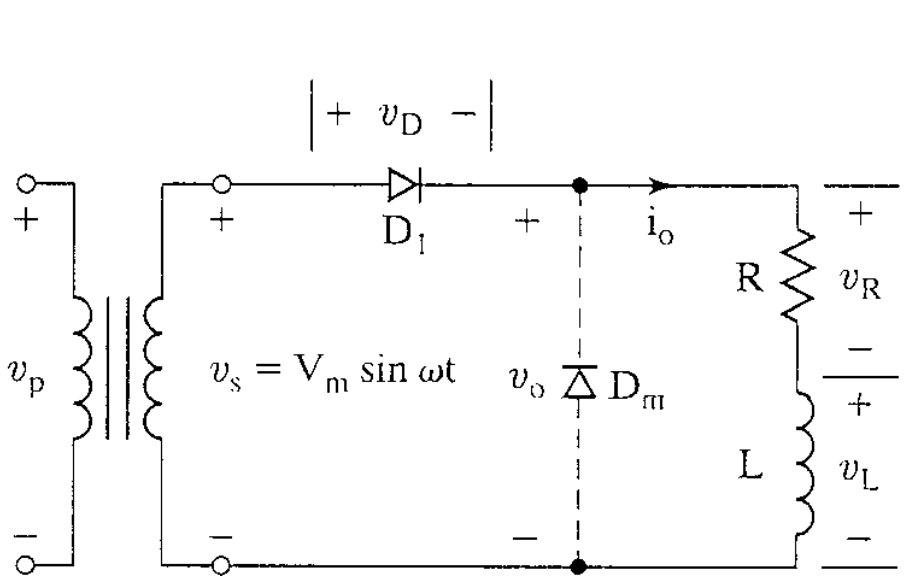
- PIV is the maximum (peak) voltage that appears across the diode when reverse biased. Here, PIV = V_m.

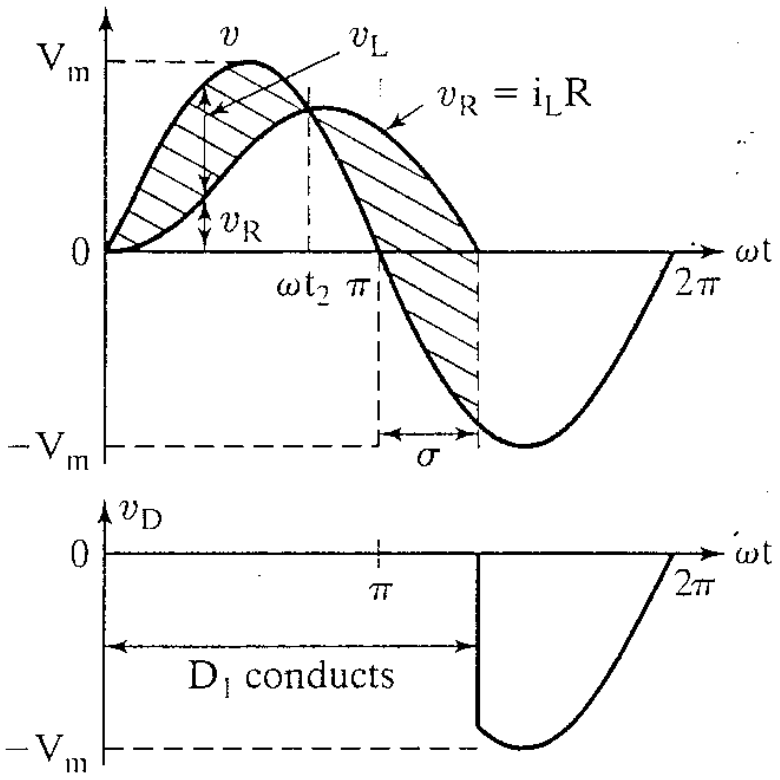


Half-Wave Rectifier with R-L Load



Waveforms of Current and Voltage





Conduction period of D_1 extends beyond $\omega t = \pi$

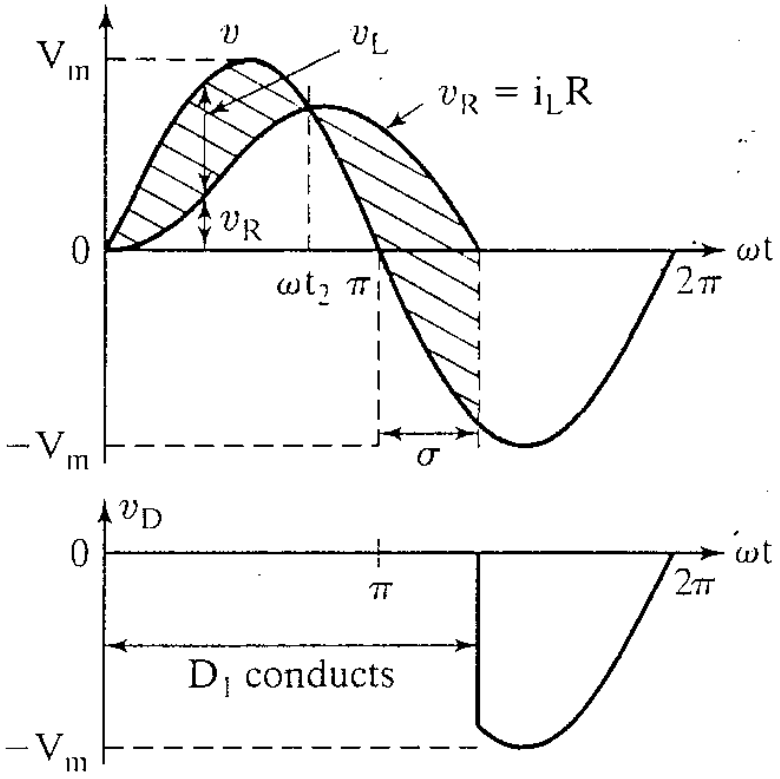
Average Output Voltage

$$V_{dc} = \frac{V_m}{2\pi}\int_0^{\pi+\sigma} \sin\omega t d(\omega t)$$

$$V_{dc} = \frac{V_m}{2\pi}\left[-\cos\omega t\right]_0^{\pi+\sigma}$$

$$V_{dc} = \frac{V_m}{2\pi}\left[1-\cos(\pi+\sigma)\right]$$

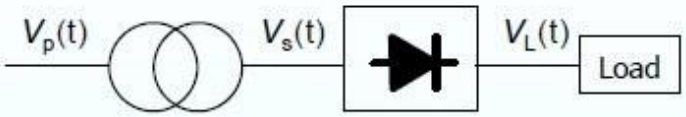
$$I_{dc} = \frac{V_{dc}}{R}$$



Increase average voltage and current by making σ = 0

Comparison among topologies 1-Ph.

- Secondary voltage is sinusoidal: $v_s(t) = V_s \sin(2\pi f_{mains} t)$
- Resistive Load
- Ideal devices (no device losses)



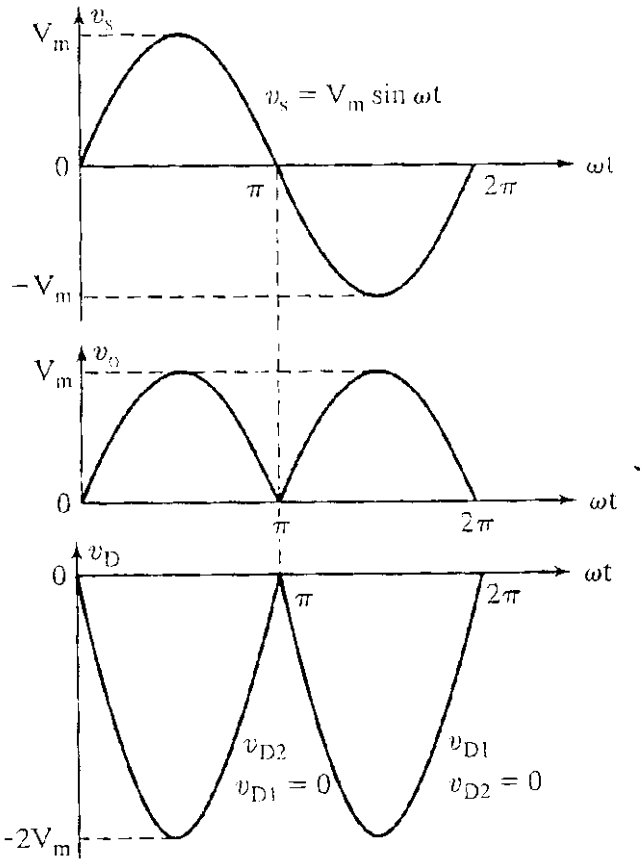
Parameter	Half-Wave	Full - Wave (Center-tapped)	Full - Wave (Bridge)
Rectified Voltage - V_{DC}	$V_s/\pi = 0.318 \cdot V_s$	$2 \cdot V_s/\pi = 0.636 \cdot V_s$	$2 \cdot V_s/\pi = 0.636 \cdot V_s$
rms Output Voltage - V_L	$V_s/2 = 0.318 \cdot V_s$	$V_s/\sqrt{2} = 0.707 \cdot V_s$	$V_s/\sqrt{2} = 0.707 \cdot V_s$
Form Factor - **FF**	1.57	1.11	1.11
Rectification Ratio - η	0.405	0.81	0.81
Ripple Factor - **RF**	1.21	0.482	0.482
Transformer Utilization Factor - **TUF**	0.286	0.572	0.81
Diode Peak Inverse Voltage (PIV) - V_{RRM}	$V_s = \pi \cdot V_{DC}$	$2 \cdot V_s = \pi \cdot V_{DC}$	$V_s = \pi/2 \cdot V_{DC}$
Peak Direct Voltage (PDV - thyristors only) - V_{DRM}	$V_s = \pi \cdot V_{DC}$	$2 \cdot V_s = \pi \cdot V_{DC}$	$V_s = \pi/2 \cdot V_{DC}$
Diode Peak Forward Current - I_{FRM}	$\pi \cdot I_{DC}$	$\pi/2 \cdot I_{DC}$	$\pi/2 \cdot I_{DC}$
Diode Average Current - $I_{F(AV)}$	I_{DC}	$0.5 \cdot I_{DC}$	$0.5 \cdot I_{DC}$
Diode Rms Current - $I_{F(RMS)}$	$\pi/2 \cdot I_{DC}$	$\pi/4 \cdot I_{DC}$	$\pi/4 \cdot I_{DC}$
Fundamental Ripple Frequency - f_R	f_{mains}	$2 \cdot f_{mains}$	$2 \cdot f_{mains}$

Waveforms for the Full-Wave Rectifier

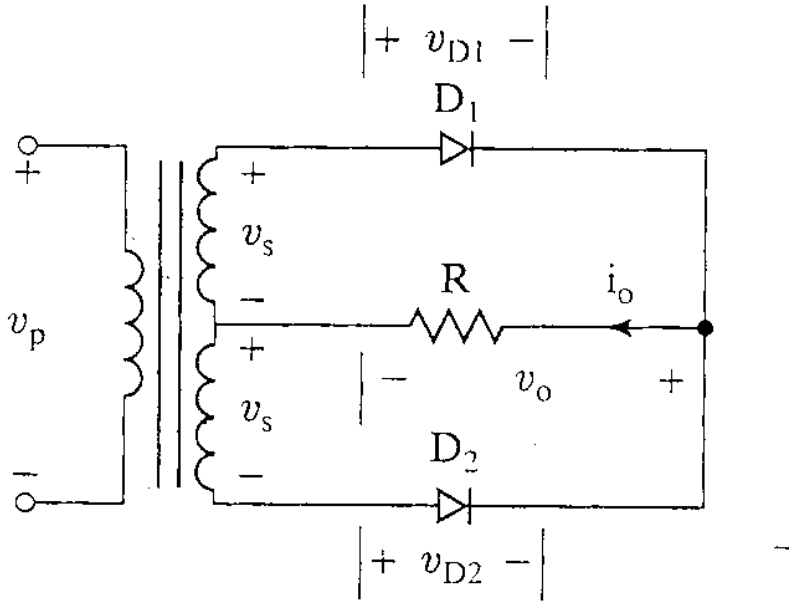
$$V_{dc} = \frac{2}{T}\int_{0}^{\frac{T}{2}} V_m \sin \omega t$$

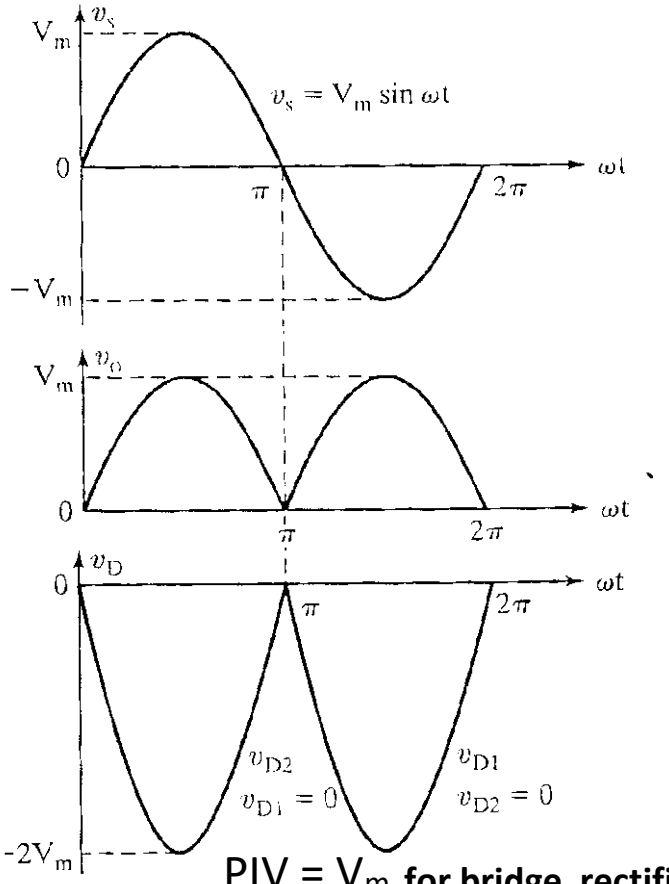
$$V_{dc} = \frac{2V_m}{\pi}$$

$$V_{dc} = 0.636V_m$$



Single-Phase Full-Wave Rectifier

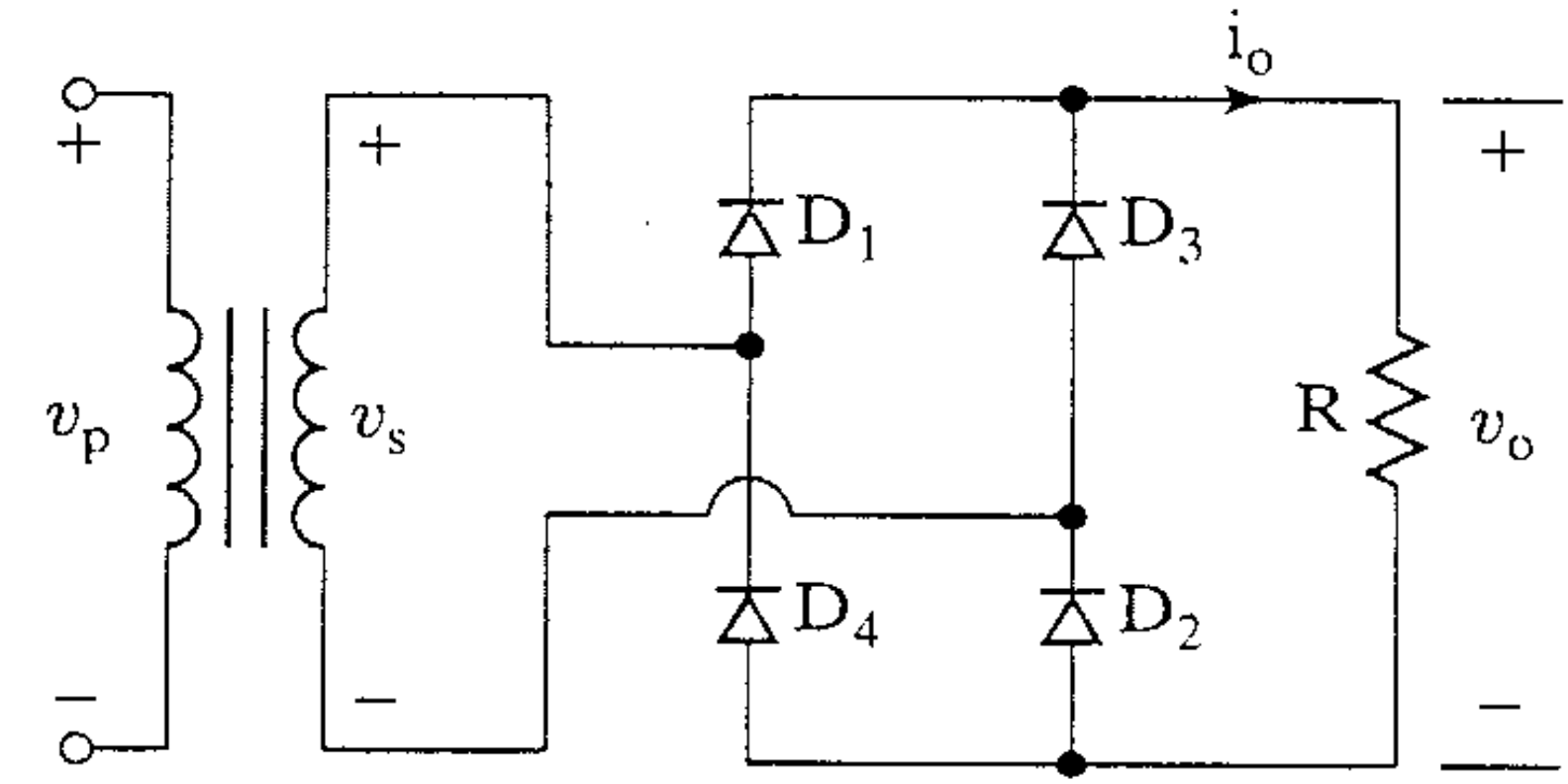




PIV = $2V_m$,for centertap transformer

PIV = V_m **for bridge rectifier**

Full-Wave Bridge Rectifier



Waveforms for the Full-Wave Bridge