Electronic Devices and Circuits

by

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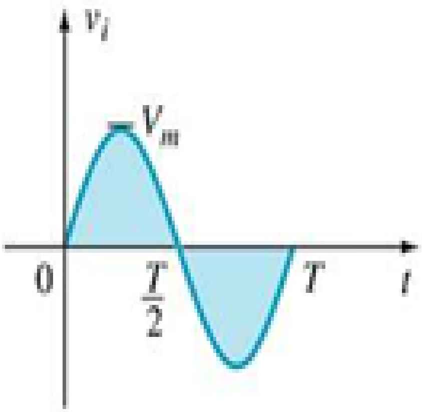
Lecture 4:

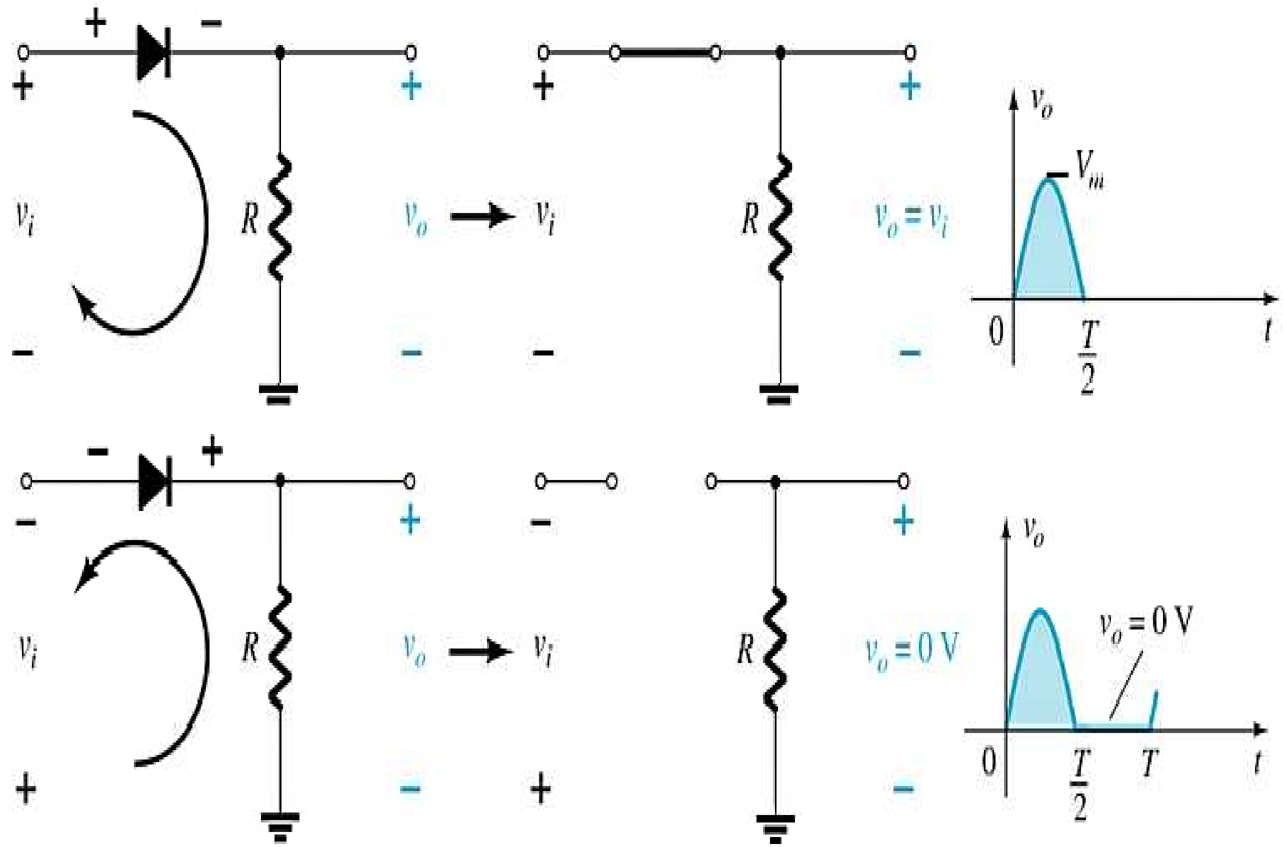
Semiconductor Diodes

Rectifier Circuits

Half-Wave Rectification

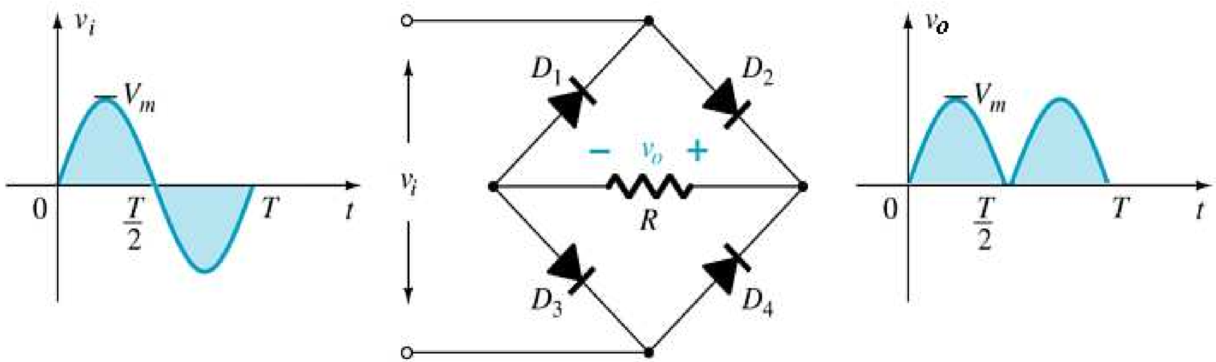


The diode only conducts when it is forward biased, therefore only half of the AC cycle passes through the diode to the output.

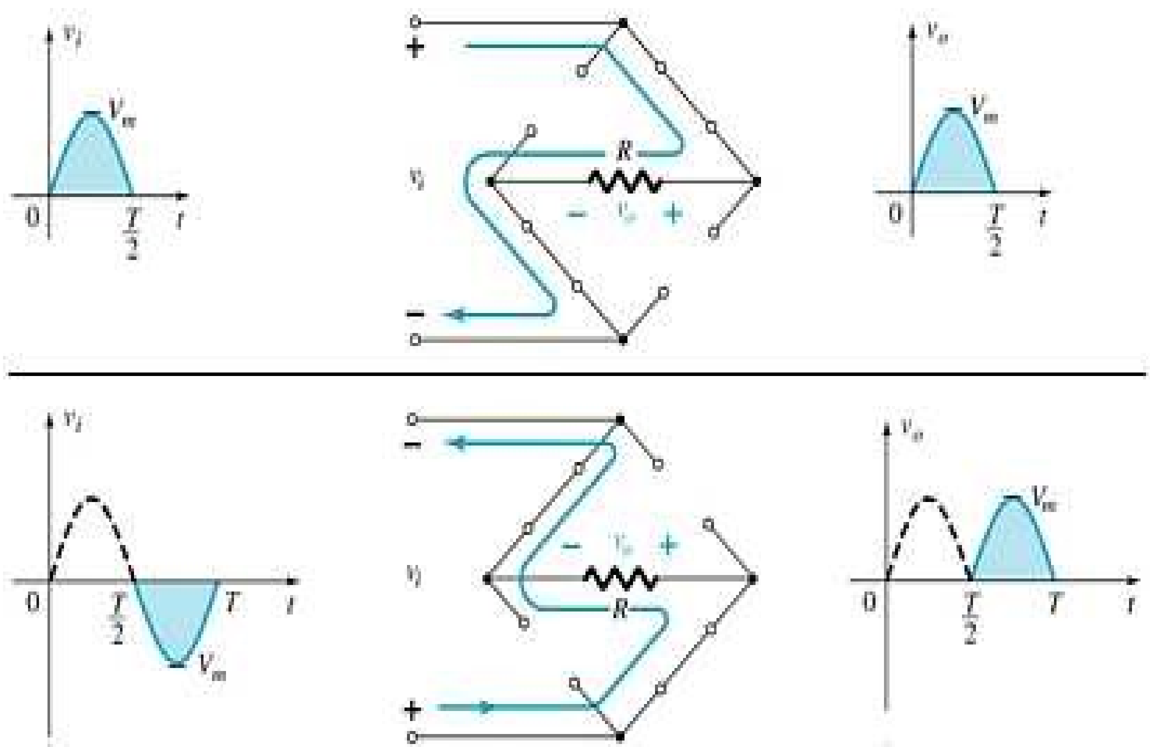


The DC output voltage is $0.318V_m$, where V_m = the peak AC voltage.

Full-Wave Rectification

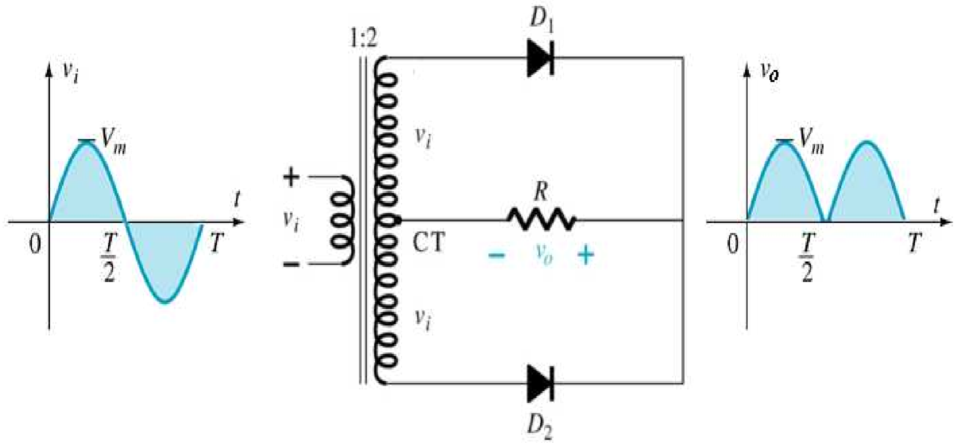


Bridge Rectifier

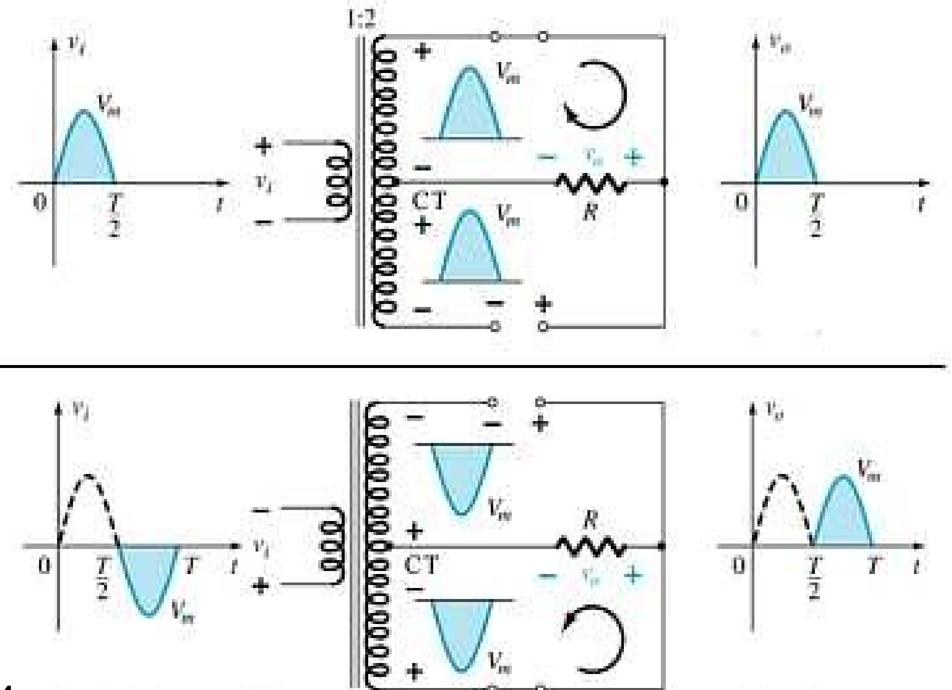


- **Four diodes are connected in a bridge configuration**
- $V_{DC} = 0.636 V_m$

Full-Wave Rectification



Center-Tapped Transformer Rectifier



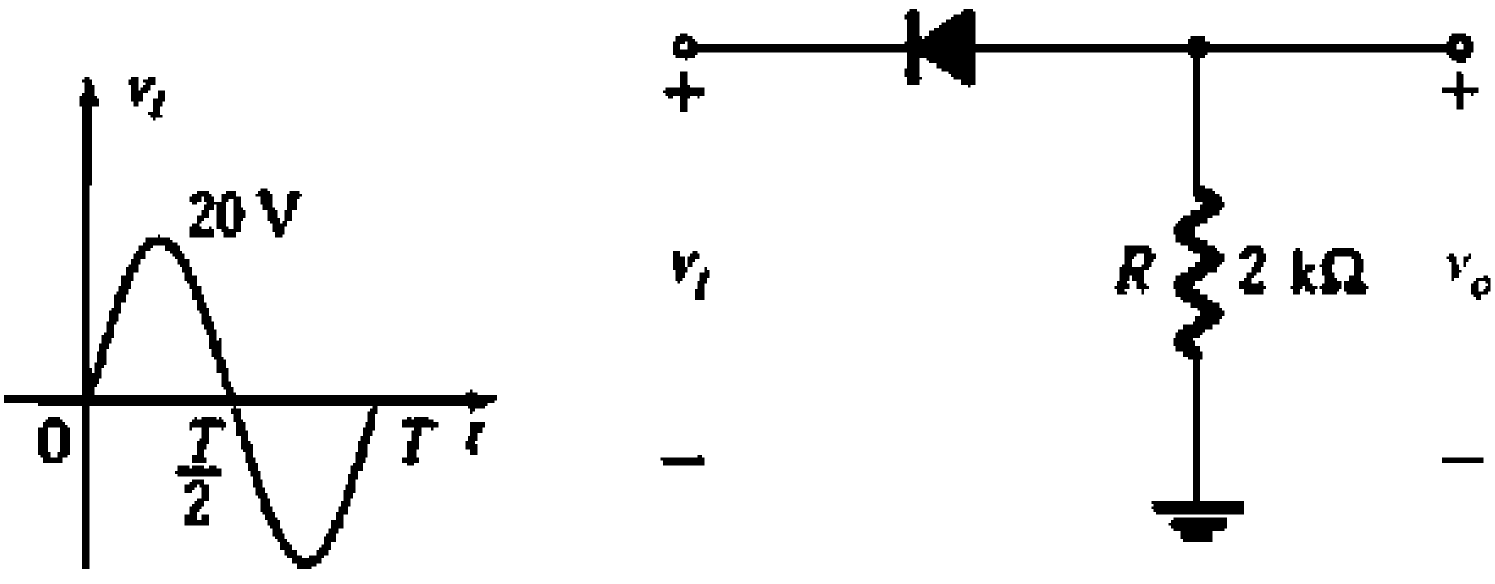
Requires

- **Two diodes**
- **Center-tapped transformer**

$$V_{DC} = 0.636 V_m$$

Example1:

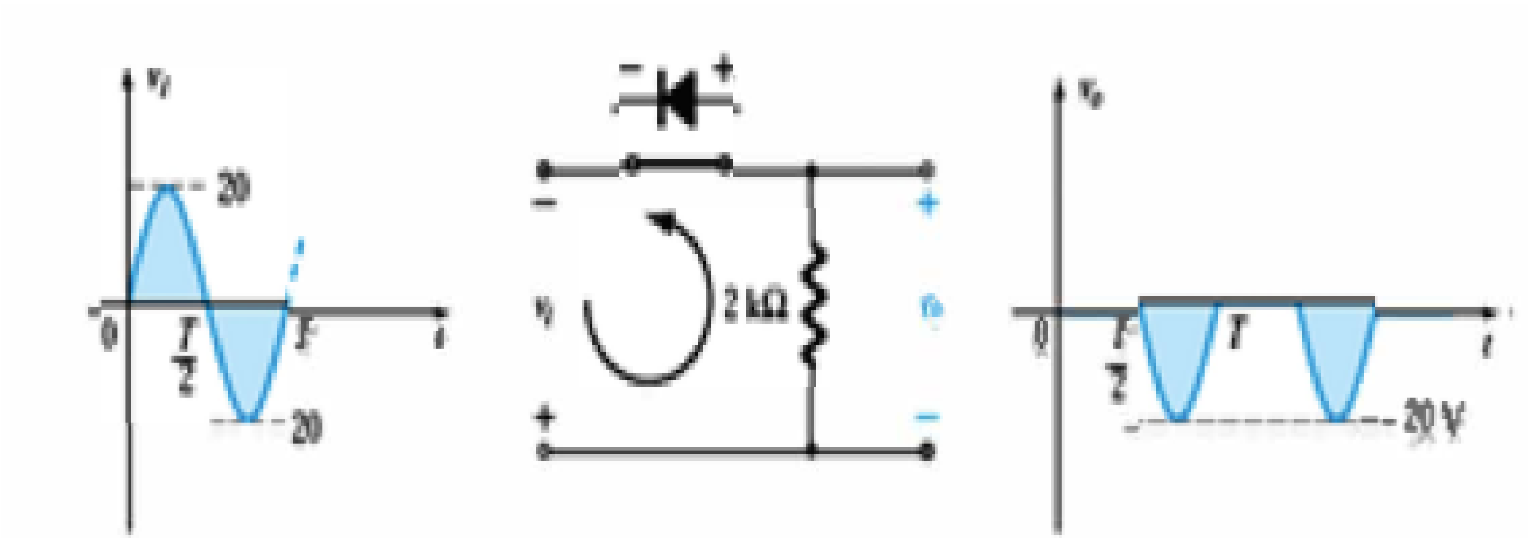
Sketch the output Vo and determine the dc level of the output for the network of figure below.



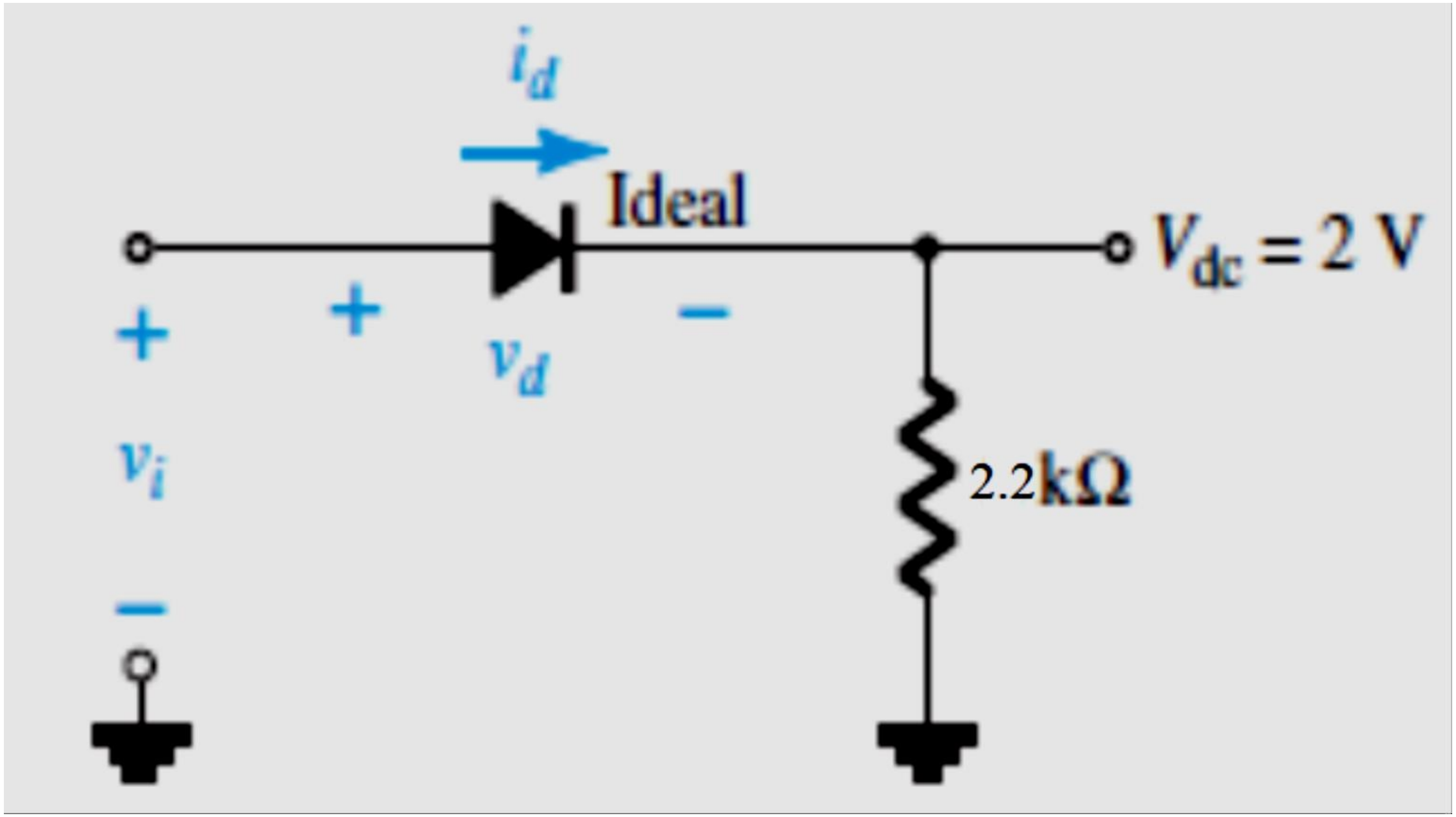
Solution:

In this situation the diode will conduct during the negative part of the input.

Vdc = -0.318Vm = -0.318(20 V) = -6.36 V



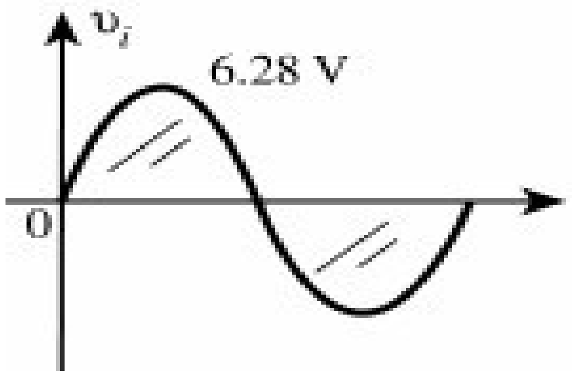
Example2:Assuming an ideal diode, sketch V_i , V_d , and I_d for the half-wave rectifier of Fig. below. The input is a sinusoidal waveform with a frequency of 50 Hz. Determine the value of V_i from the given dc level.

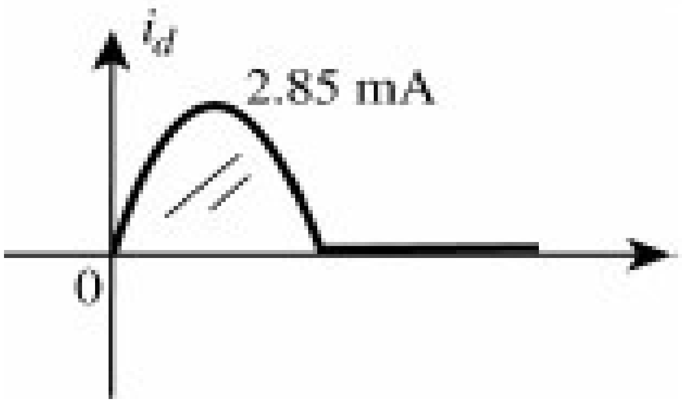


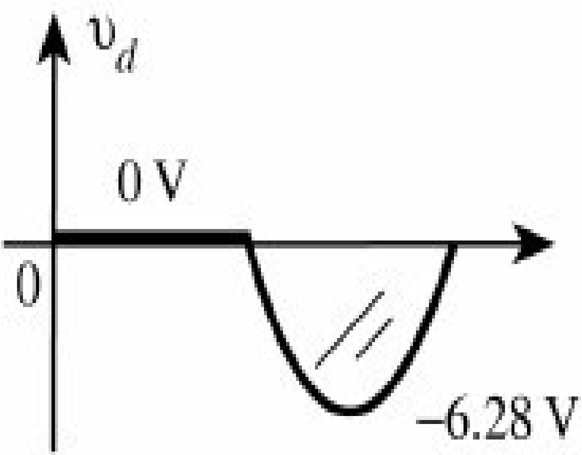
Solution:

$$V_{dc} = 0.318\,V_m \Rightarrow V_m = \frac{V_{dc}}{0.318} = \frac{2\text{ V}}{0.318} = 6.28\text{ V}$$

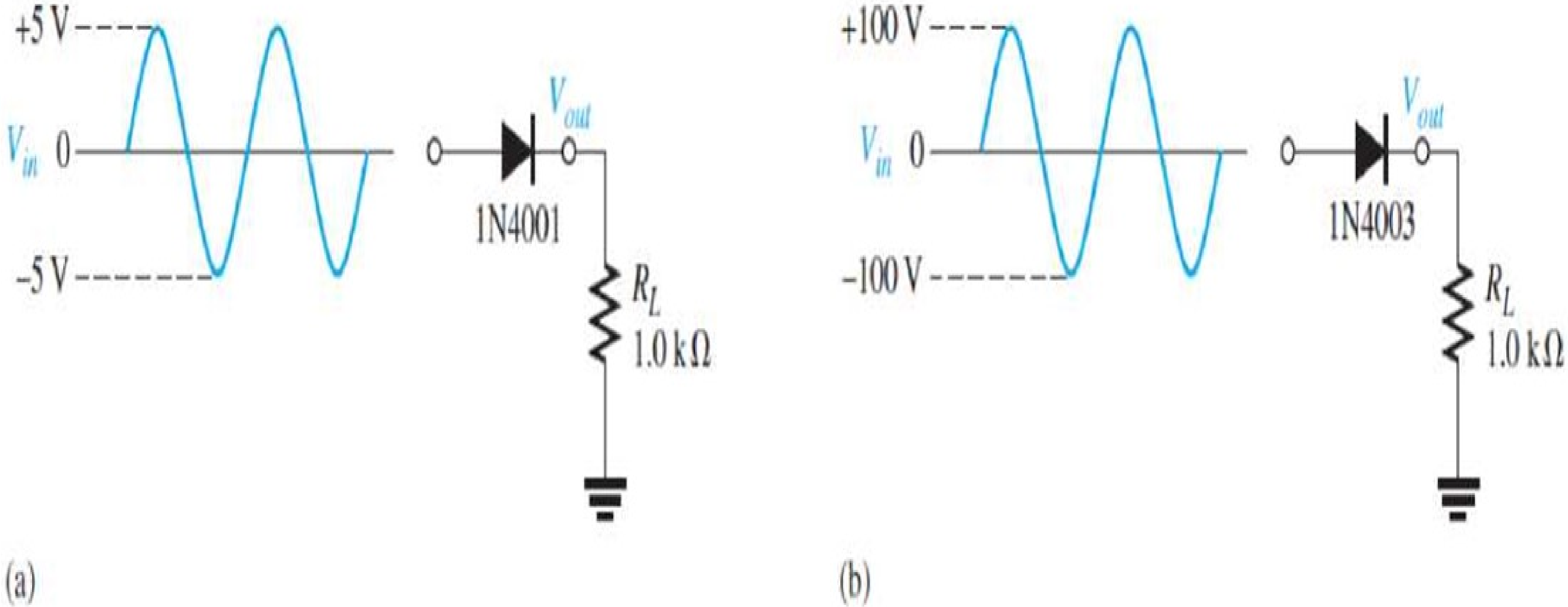
$$I_m = \frac{V_m}{R} = \frac{6.28\text{ V}}{2.2\text{ k}\Omega} = \mathbf{2.85\text{ mA}}$$







<u>Example 3:</u> Draw the output voltages of each rectifier for the indicated input voltages, as shown in Figure. The 1N4001 and 1N4003 are **practical** rectifier diodes.



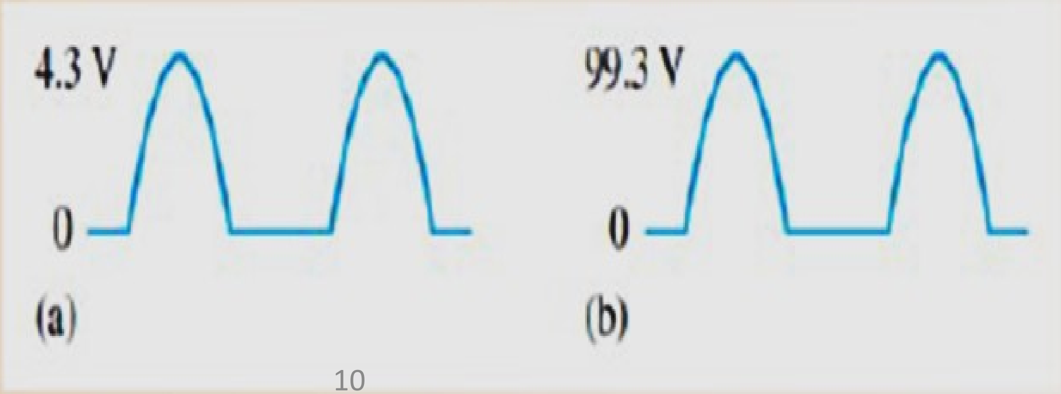
Solution The peak output voltage for circuit (a) is

$$V_{p(out)} = V_{p(in)} - 0.7\text{ V} = 5\text{ V} - 0.7\text{ V} = \mathbf{4.30\text{ V}}$$

The peak output voltage for circuit (b) is

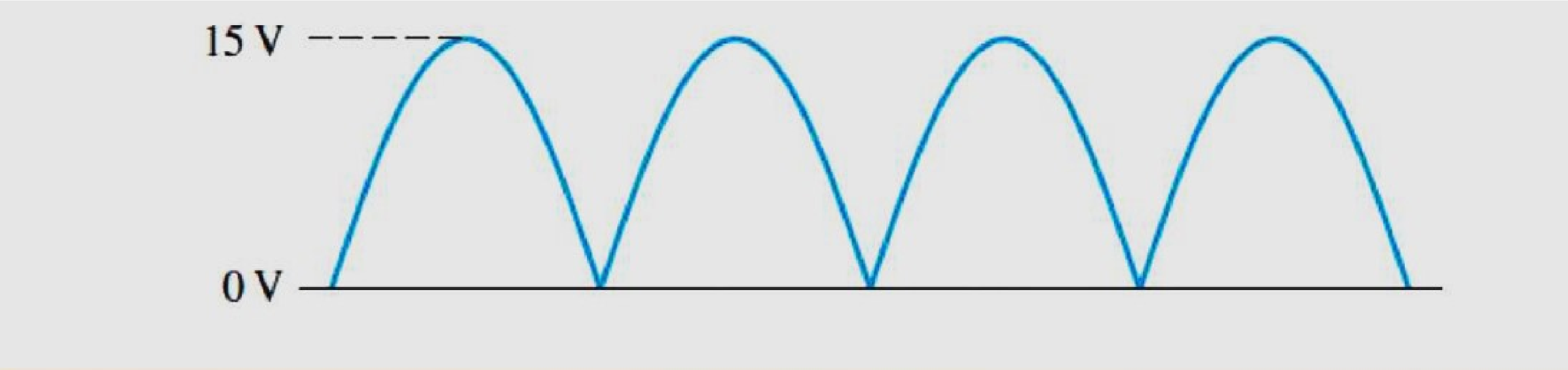
$$V_{p(out)} = V_{p(in)} - 0.7\text{ V} = 100\text{ V} - 0.7\text{ V} = \mathbf{99.3\text{ V}}$$

The output voltage waveforms are shown in Figure belowNote that the barrier potential could have been neglected in circuit (b) with very little error (0.7 percent); but, if it is neglected in circuit (a), a significant error results (0.7percent).



Example 4:

Find the average value of the full-wave rectified voltage in Figure below:



Solution

$$V_{AVG} = \frac{2V_p}{\pi} = \frac{2(15\text{ V})}{\pi} = \mathbf{9.55\text{ V}}$$

V_{AVG} is 63.7% of V_p.

<u>Example 5:</u> In the center-tap circuit shown in Fig. 2, the diodes are assumed to be ideal . Find (i) d.c. output current (ii) peak inverse voltage .

Solution :

Primary to secondary turns, N1 / N2 = 5

R.M.S. primary voltage = 230 V

$\therefore$ R.M.S. secondary voltage

$$= 230 \times (1/5) = 46 \text{ V}$$

Maximum voltage across secondary

$$= 46 \times \sqrt{2} = 65\text{V}$$

Maximum voltage across half secondary winding is

$$V_m = 65/2 = 32.5 \text{ V}$$

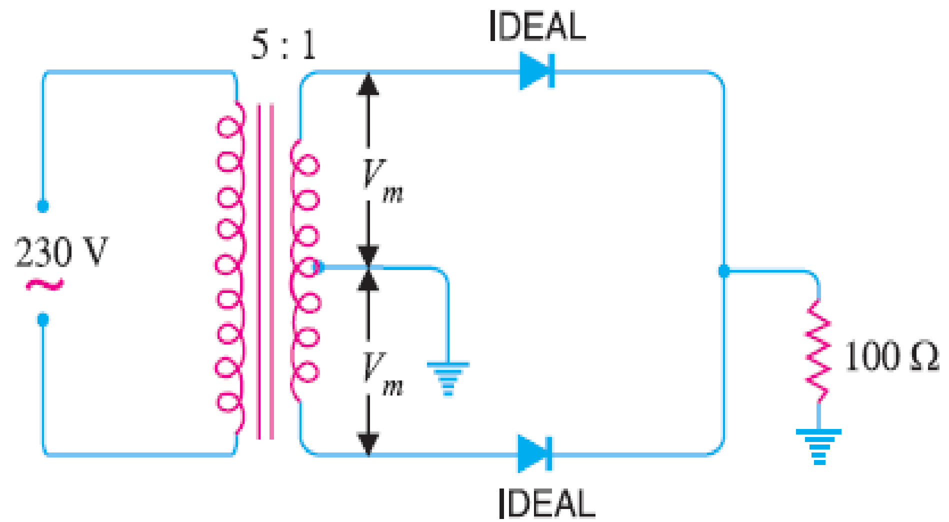


Fig. 2

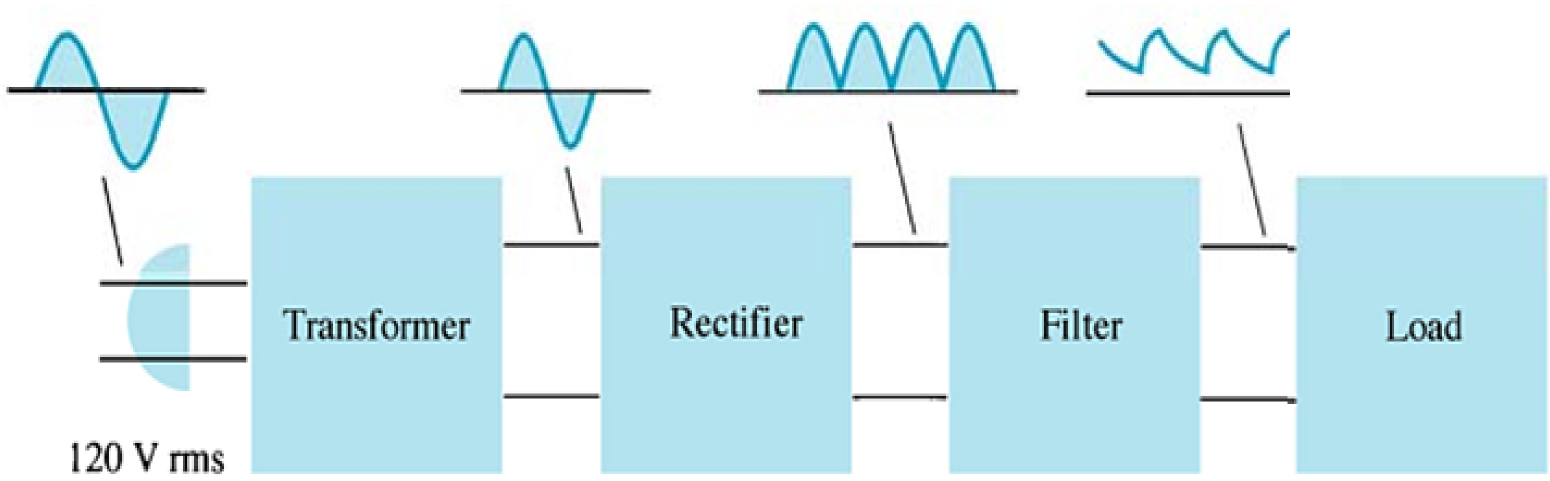
(i) Average current, Idc = $\dfrac{2V_m}{\pi R_L} = \dfrac{2 \times 32.5}{\pi \times 100} = 0.207 \text{ A}$

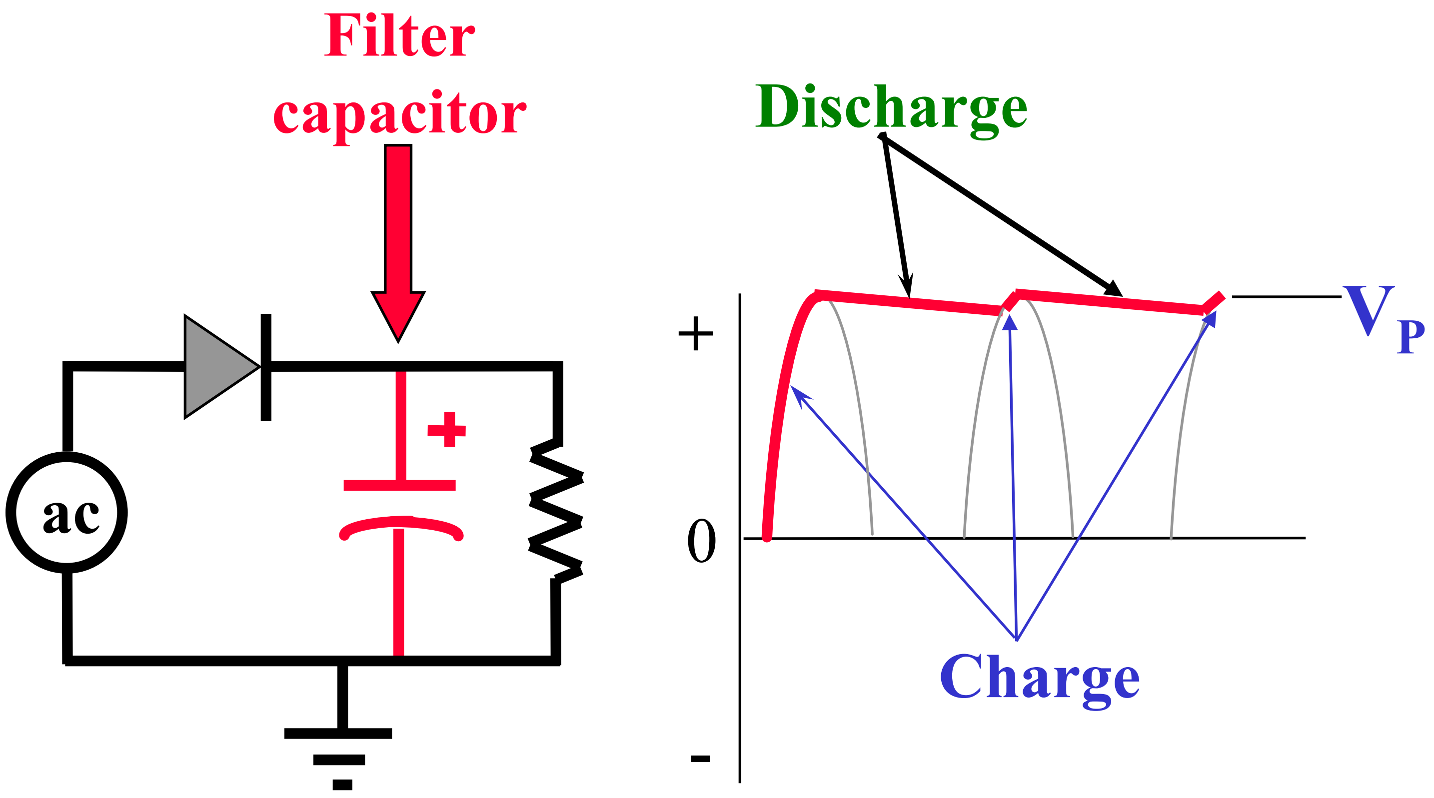
(ii) The peak inverse voltage is equal to the maximum secondary voltage, i.e

$$PIV = 65 \text{ V}$$

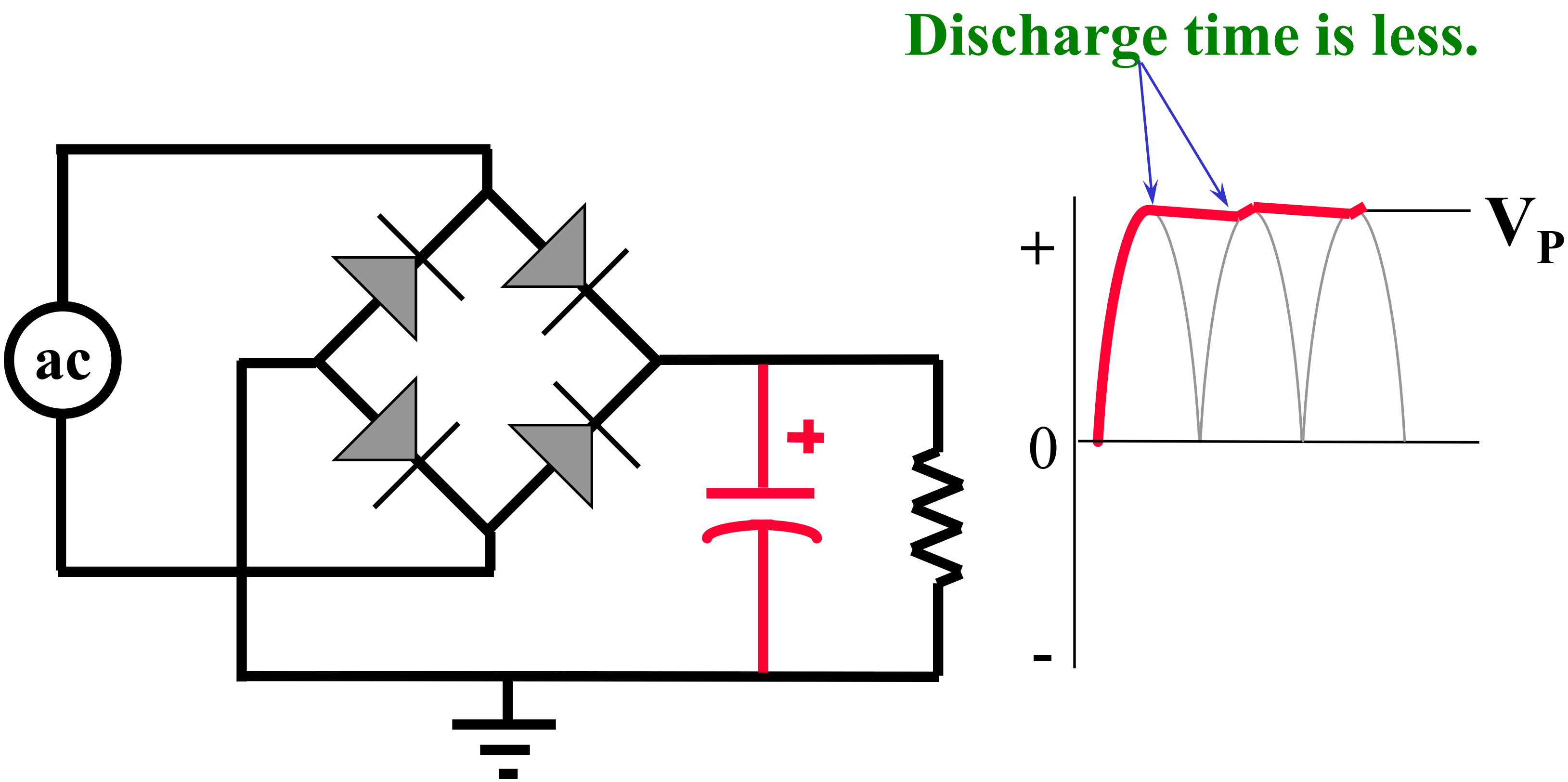
Filter Circuits

- The output from the rectifier section is a pulsating DC.
- The filter circuit reduces the peak-to-peak pulses to a small ripple voltage.





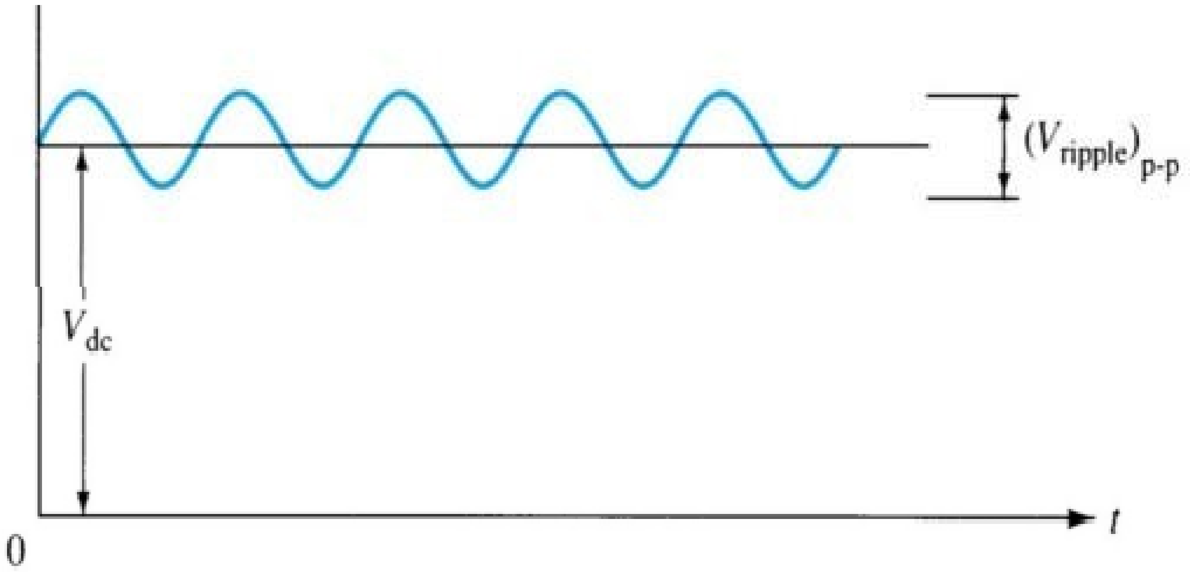
A relatively large filter capacitor will maintain the load voltage near the peak value of the waveform.



Full-wave is easier to filter since the discharge time is shorter than it is for half-wave rectifiers.

Ripple Factor

After the filter circuit a small amount of AC is still remaining. The amount of ripple voltage can be rated in terms of ripple factor (r).



$$\%r = \frac{\text{ripple voltage (rms)}}{\text{dc voltage}} = \frac{V_{r(rms)}}{V_{dc}} \times 100$$

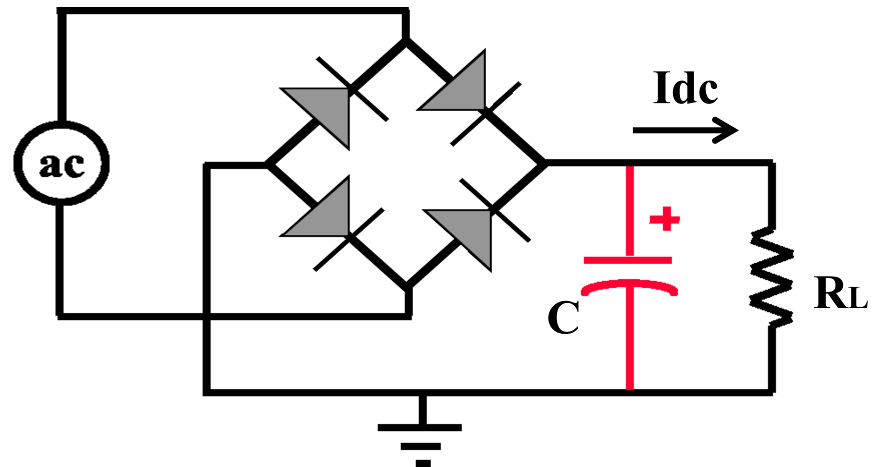
Capacitor Filter

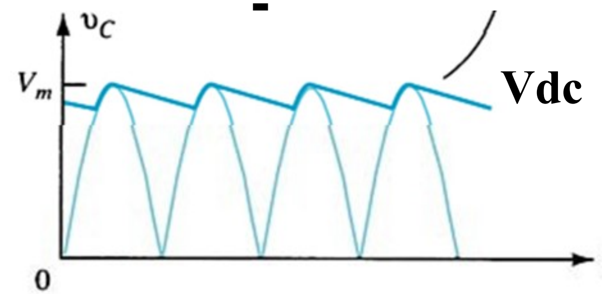
Ripple voltage

$$Vr(P.P) = \frac{Vm}{RL \times C \times f}$$

$$Vr(rms) = \frac{Vr(P.P)}{2\sqrt{2}}$$

The larger the capacitor the smaller the ripple voltage.





DC output

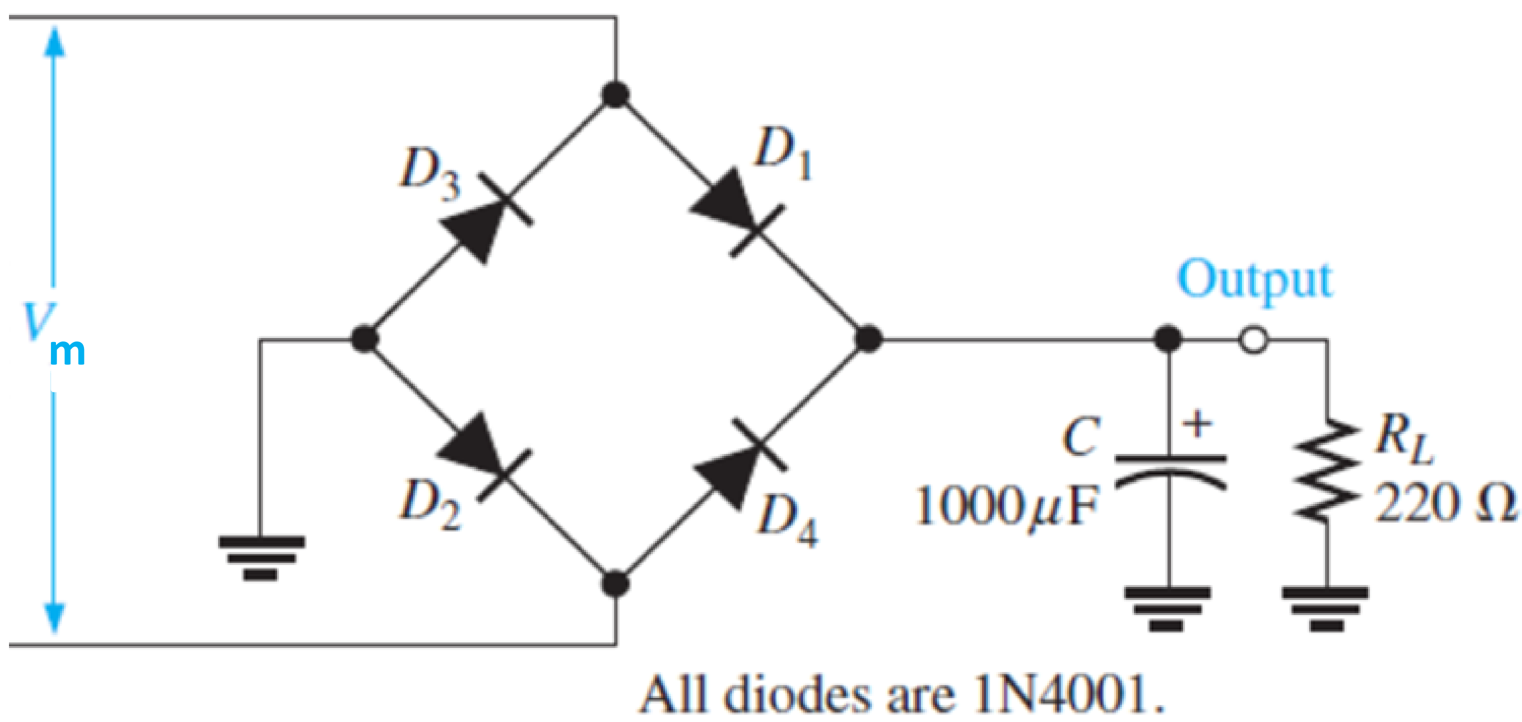
$$Vdc = Vm - \frac{Vm}{2RL \times C \times f}$$

Ripple factor

$$\%r = \frac{V_{r(rms)}}{V_{dc}} \times 100$$

Example:

Determine the ripple factor **%r** for the filtered bridge rectifier with a load as indicated in Figure below: Vm=17V, assume ideal diodes.



SOLUSION:

Ripple voltage

$$Vr(rms) = \frac{Vm}{RL \times C \times f} = \frac{17}{220 \times 1000\mu \times 100} = \frac{0.77}{2\sqrt{2}} = 0.272 \text{ V}$$

DC output

$$Vdc = Vm - \frac{Vm}{2RL \times C \times f} = 17 - \frac{17}{2x220x1000\mu x100} = 16.6 \text{ V}$$

Ripple factor

$$\%r = \frac{V_{r(rms)}}{V_{dc}} \times 100 = \frac{0.272}{16.6} x100 = 1.64\%$$

QUIZ

Calculate the dc voltage that can be obtained from this circuit. Determine how much dc current the millimeter will indicate. Assume ideal diodes.