ELECTRONIC PRINCIPLES AND DEVICES

Department of Electronics and Communication.

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Semiconductor Diode applications

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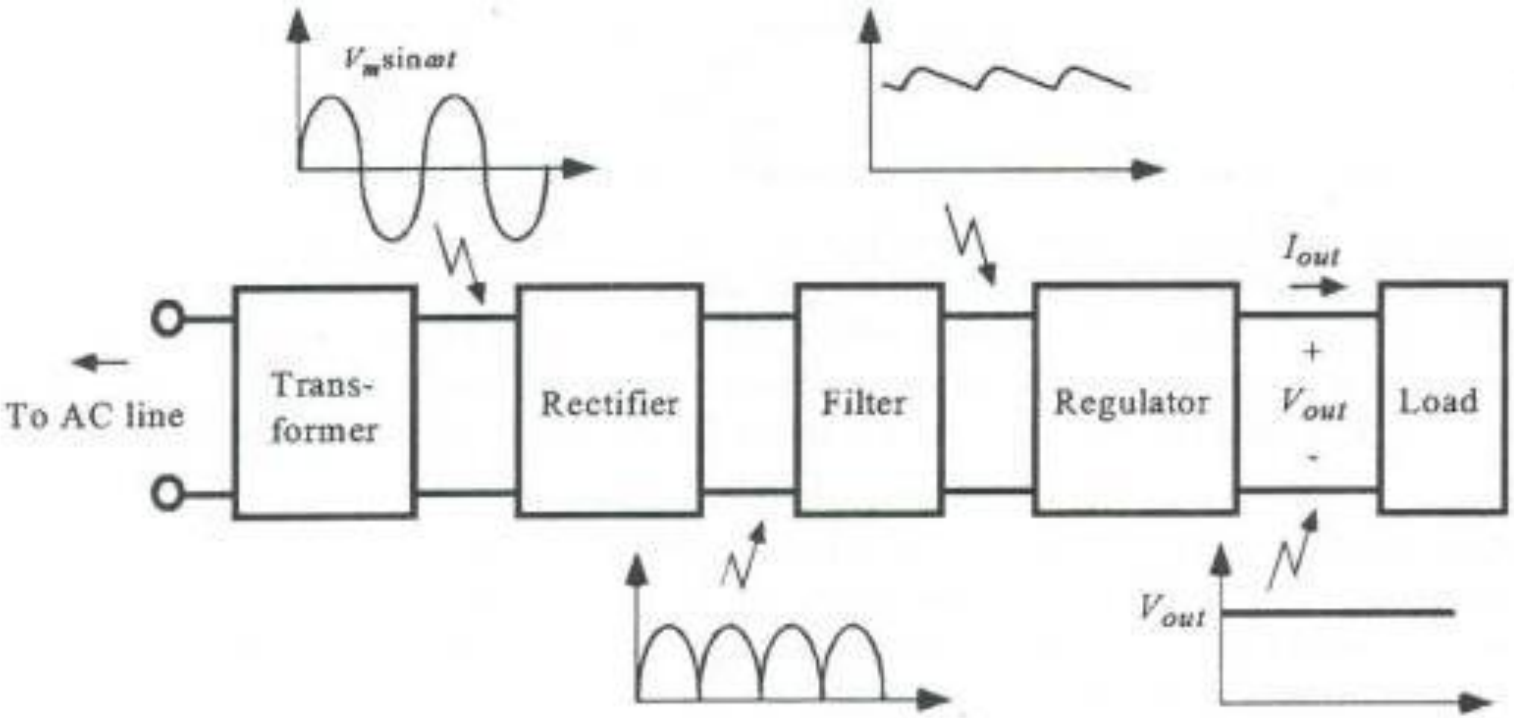
Regulated Power Supply

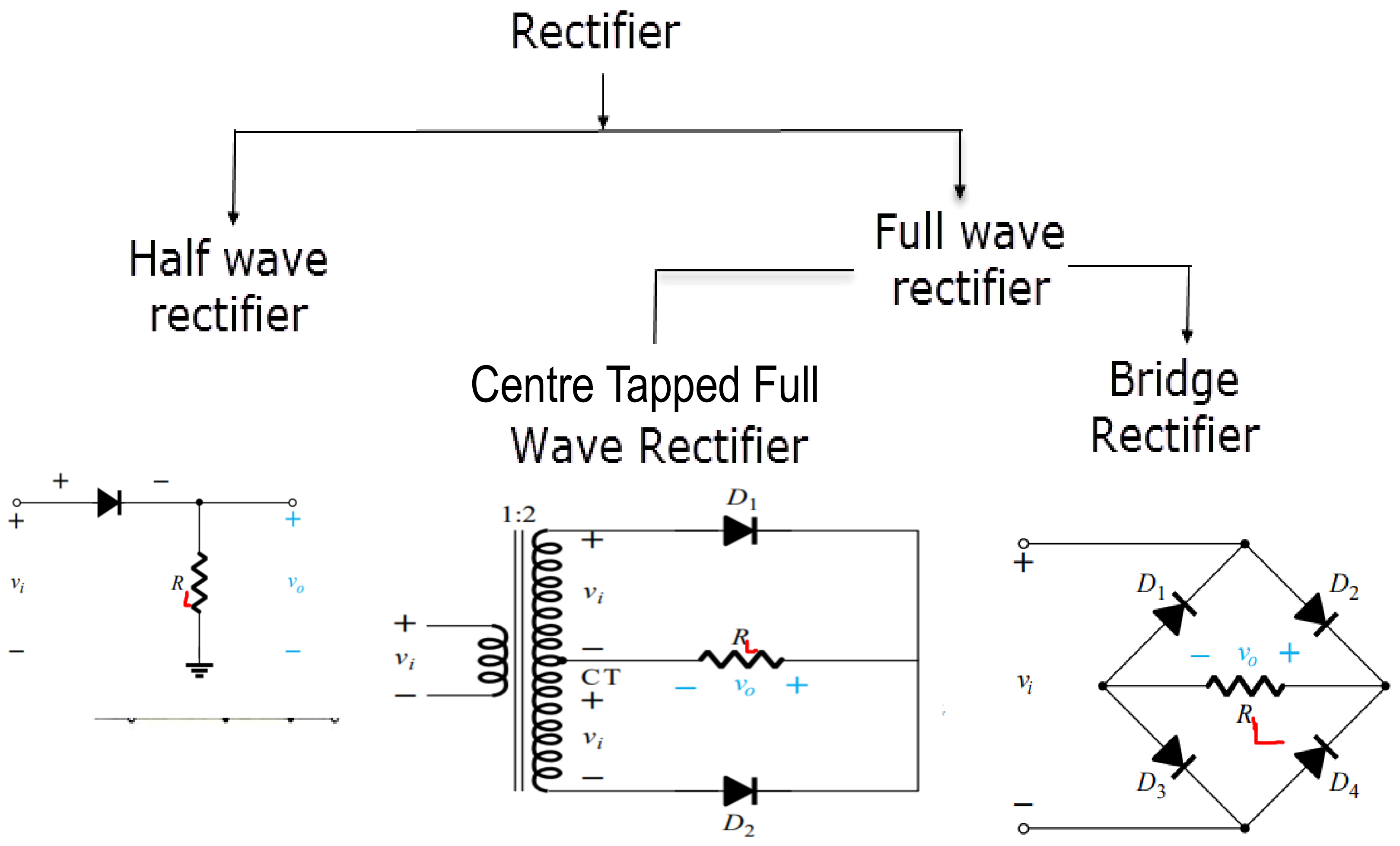


Regulated Power Supply

Regulated power supply converts an alternating current signal to a constant signal.

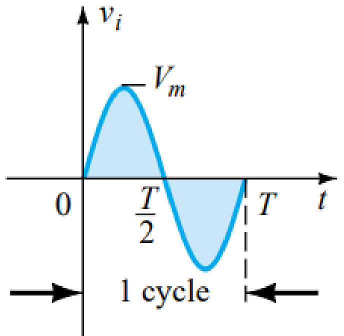
- **Transformer** : The output sinusoidal voltage is either step-up or step-down from the input sinusoidal voltage value
- **Rectifier** : Converts an alternating current into a direct one by allowing the current to flow through it in one direction only.
- **Filter** : Removes the AC ripples from the DC signal obtained from the rectifier.
- **Regulator** : Converts DC voltage into a lower constant voltage

Rectifier


Rectifier
Half wave rectifier
Full wave rectifier
Centre Tapped Full Wave Rectifier
Bridge Rectifier
+
−
v_i
R
v_o
1:2
D_1
D_2
CT
R_L
D_3
D_4

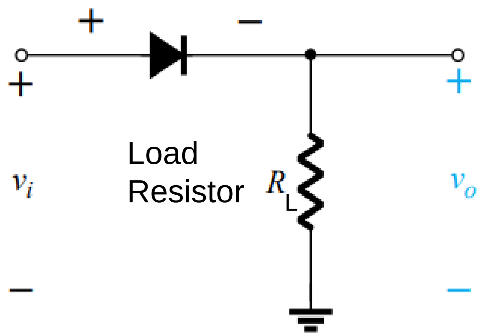
Half Wave Rectifier (HWR) - Ideal Diode

Input Waveform

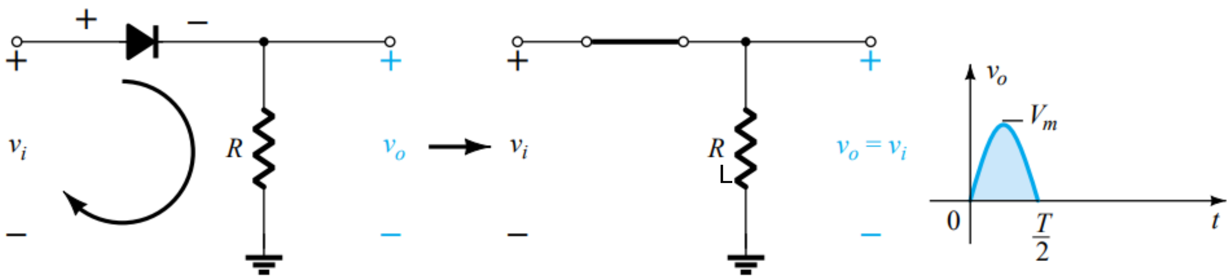


$v_i = V_m \sin \omega t$

HWR Circuit



Positive Half Cycle:

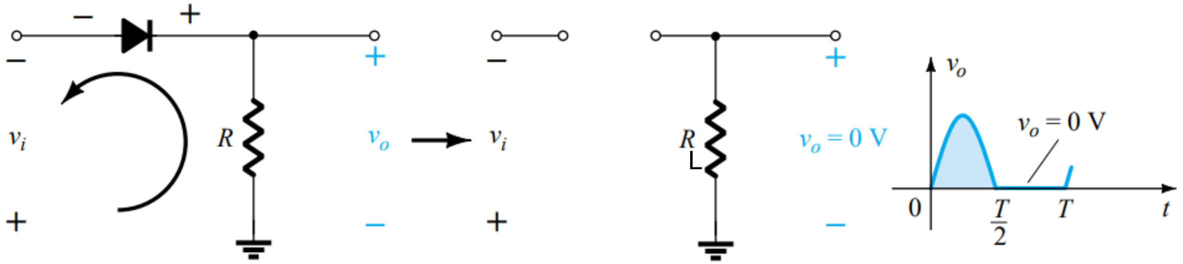


Conduction region ($0 \rightarrow T/2$).

$$I_m = \frac{V_m}{R_L}$$

$$V_o = V_m$$

Negative Half Cycle:

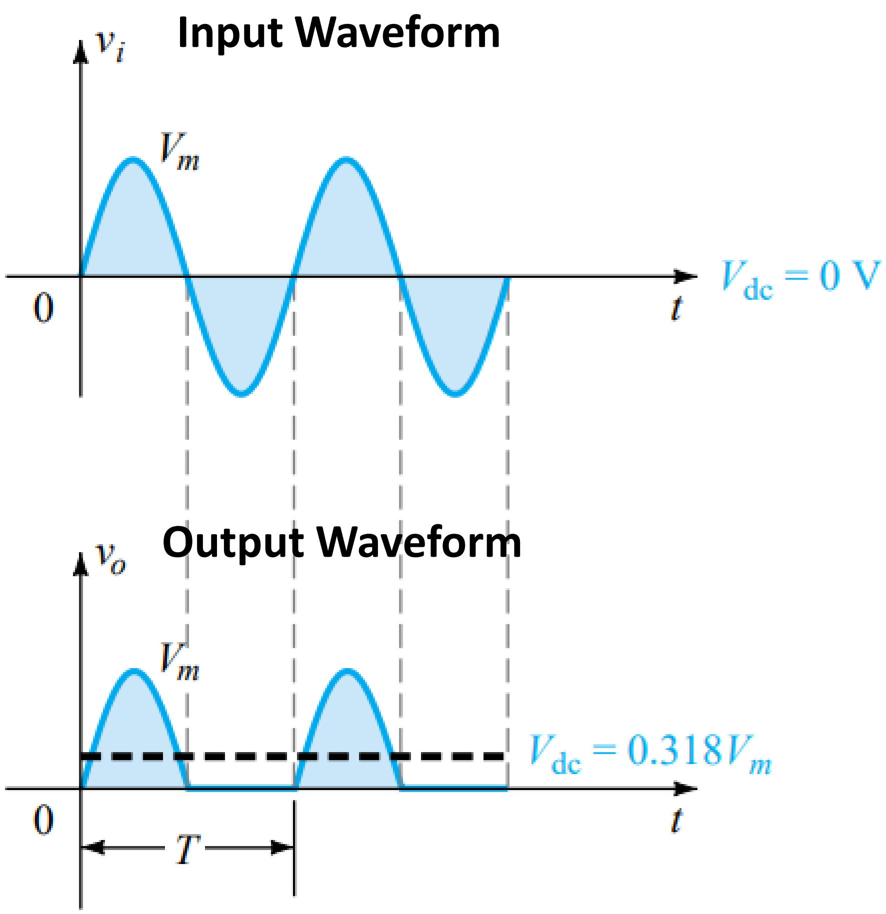


Nonconduction region ($T/2 \rightarrow T$).

I=0

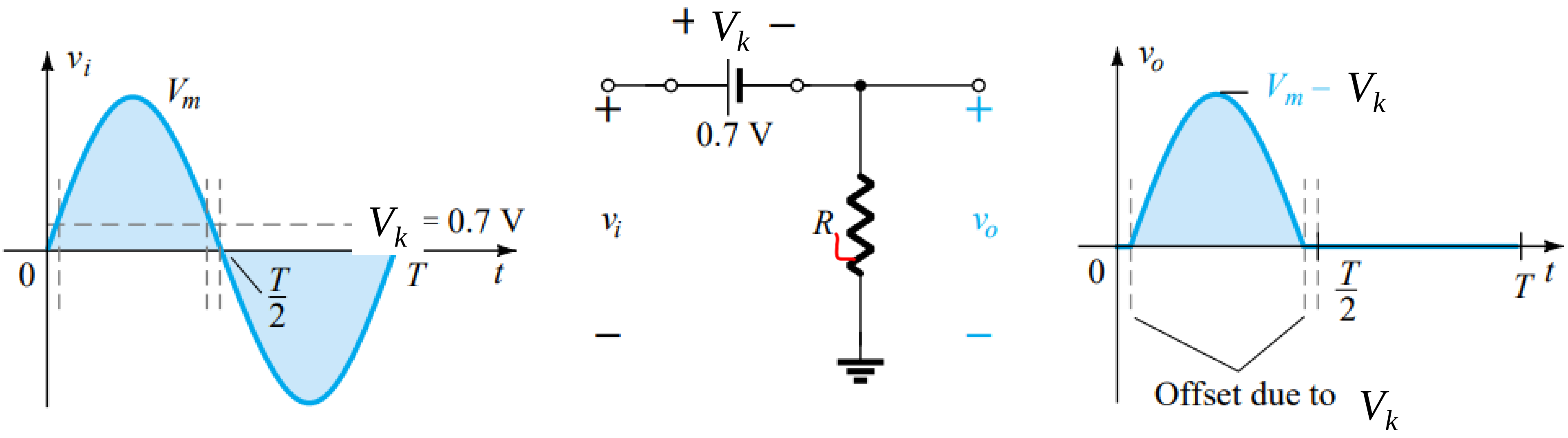
$$V_o = 0$$

Half Wave Rectifier (HWR) - Ideal Diode



Half Wave Rectifier (HWR) - Non Ideal Diode

Positive Half Cycle:

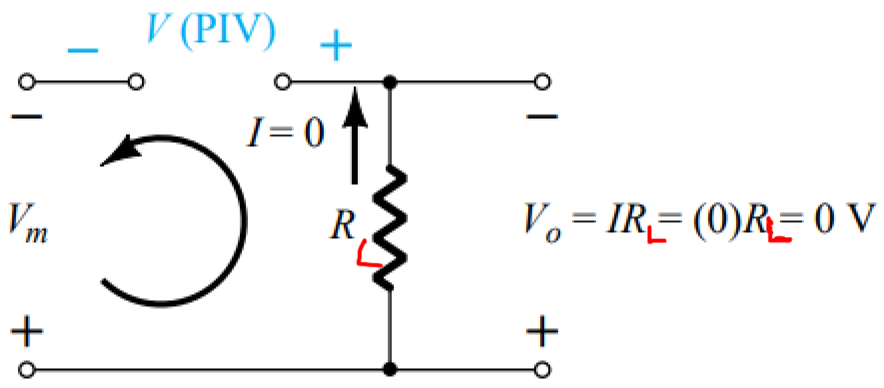


Effect of V_k on half-wave rectified signal.

$$\mathbf{V_{omax} = V_m - V_k}$$

$$I_{omax} = \frac{V_m - V_k}{R_l}$$

Half Wave Rectifier (HWR) PIV - Ideal Diode & Non Ideal Diode



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

Peak Inverse Voltage (PIV) or Peak Reverse voltage (PRV)- (For both Ideal & Non-Ideal) is the maximum reverse biased voltage (Vm) the diode can withstand without entering the breakdown region.

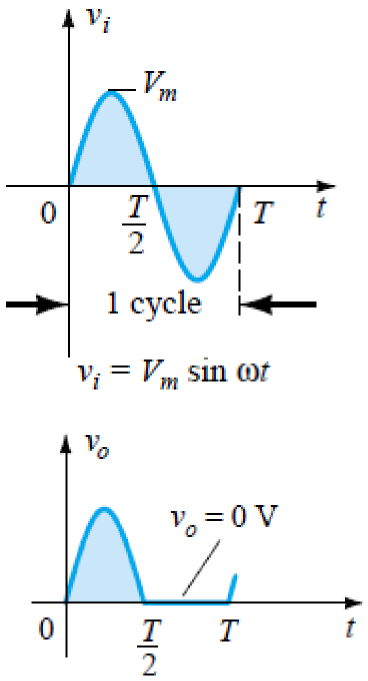
Determining Average voltage/Current for HWR - Ideal Diode

$$V_{dc} = \frac{1}{2\pi}\int_{0}^{2\pi} V_m \ sin\omega t \ d\omega t$$

$$= \frac{1}{2\pi}\int_{0}^{\pi} V_m \ sin\omega t \ d\omega t$$

$$= \frac{V_m}{2\pi}\left[-Cos \ \omega t\right]_0^{\pi} = \frac{V_m}{\pi}$$

$$\boxed{I_{dc} = \frac{V_{dc}}{R_L} = \frac{V_m}{\pi R_L} = \frac{I_m}{\pi}}$$



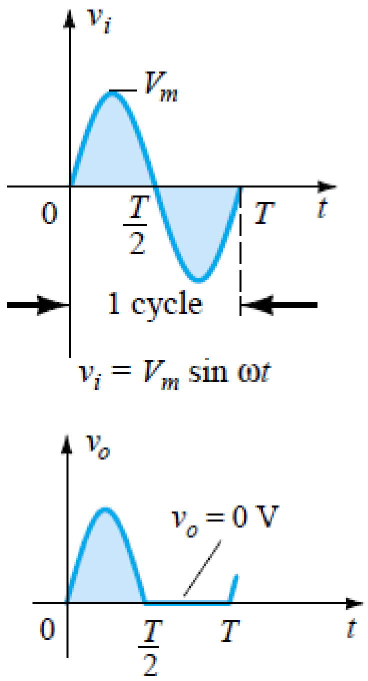
Determining RMS voltage/Current for HWR - Ideal Diode

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

$$= \left[\frac{{V_m}^2}{2\pi}\int_0^{\pi}(sin^2\,\omega t)\;\; d\omega t\right]^{1/2}$$

$$= \left[\frac{{V_m}^2}{2\pi}\int_0^{\pi}\left(\frac{1 - Cos2\,\omega t}{2}\right)\;\; d\omega t\right]^{1/2}$$

$$V_{rms} = \left[\frac{{V_m}^2}{2\pi}\left(\frac{\omega t}{2} - \frac{sin2\omega t}{2}\right)_0^{\pi}\right]^{1/2} = \frac{V_m}{2}$$



$$\boxed{I_{rms} = \frac{V_{rms}}{R_L} = \frac{V_m}{2R_L} = \frac{I_m}{2}}$$

Determining Average & RMS voltage/Current for HWR – Non-Ideal Diode

$$V_{dc} = \frac{V_m - V_k}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{V_m - V_k}{\pi R_L} = \frac{I_m}{\pi} \qquad \left(I_m = \frac{V_m - V_k}{R_L} \right)$$

$$V_{rms} = \frac{V_m - V_k}{2}$$

$$I_{rms} = \frac{V_{rms}}{R_L} = \frac{V_m - V_K}{2R_L} = \frac{I_m}{2} \qquad \left(I_m = \frac{V_m - V_k}{R_L} \right)$$

Ripple factor of HWR

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Ripple Factor is a measure of purity of the dc output of a rectifier and can be defined as

$$r = \frac{rms\ value\ of\ the\ ac\ component\ of\ the\ output}{average\ or\ dc\ value\ of\ the\ output}$$

$$V'_{rms} = \left[V_{rms}^2 - V_{dc}^2\right]^{1/2}$$

$$= \left[\left(\frac{V_m}{2}\right)^2 - \left(\frac{V_m}{\pi}\right)^2\right]^{1/2} = 0.385V_m$$

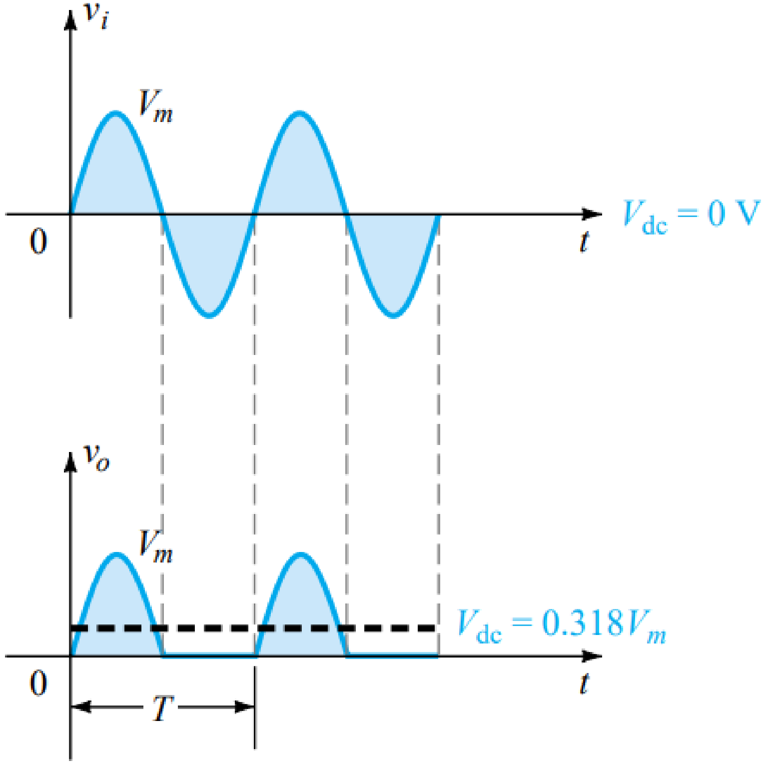
$$\text{Ripple Factor } (\Upsilon_{HWR}) = \frac{V'_{rms}}{V_{dc}} = \frac{\sqrt{V_{rms}^2 - V_{dc}^2}}{V_{dc}}$$

$$= \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{V_m/2}{V_m/\pi}\right)^2 - 1}$$

∴ Ripple factor =1.21

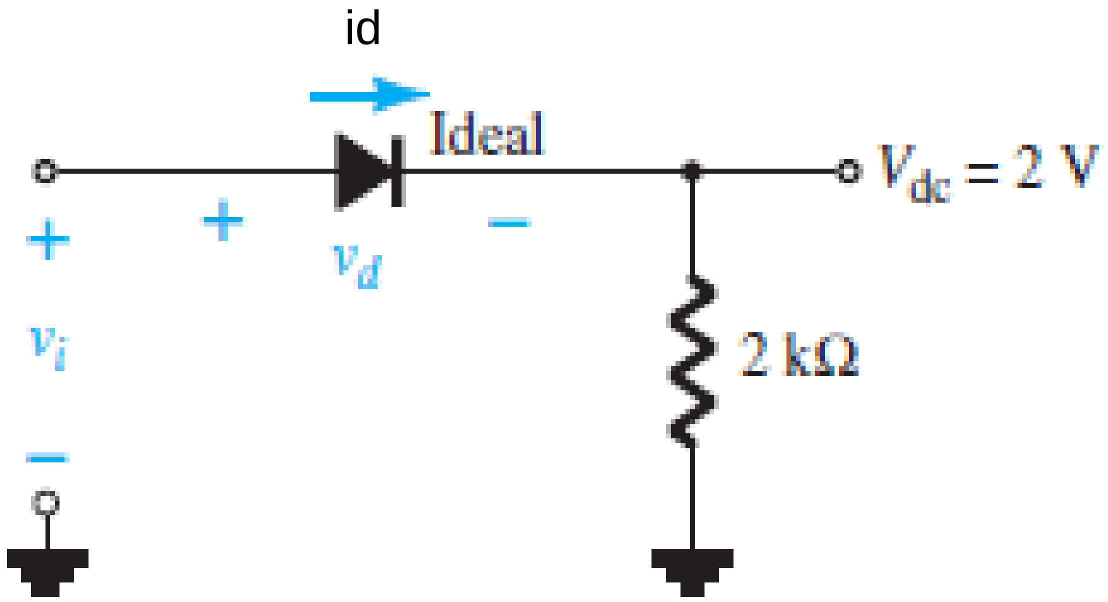
Frequency of HWR

The time duration of 1 cycle of input waveform is T and the time duration of 1 cycle of output wave form is also T , hence $fo = fi$



Numerical on HWR

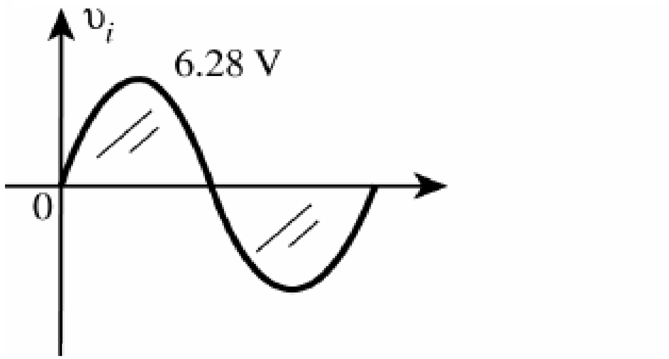
1. a) Assuming an ideal diode, sketch Vi, Vd, and id for the half-wave rectifier. The input is a sinusoidal waveform with a frequency of 60 Hz



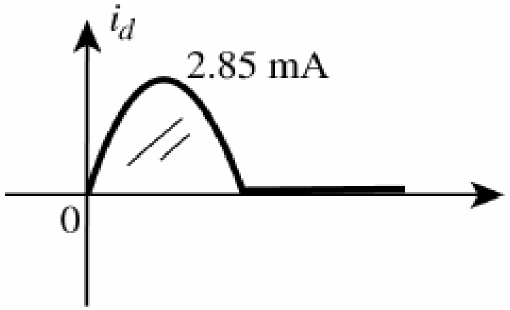
Numerical on HWR

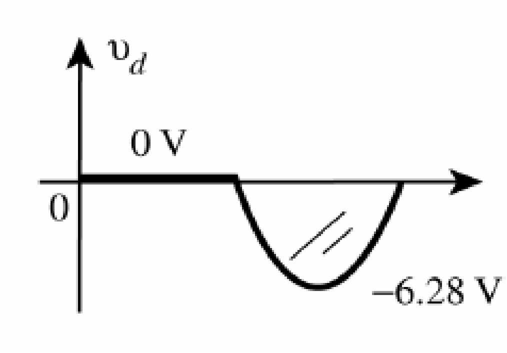
Solution:

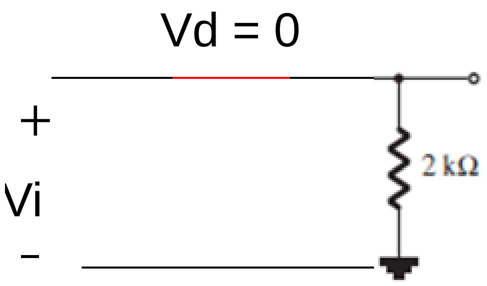
$$V_{dc} = 0.318\,V_m \Rightarrow V_m = \frac{V_{dc}}{0.318} = \frac{2\text{ V}}{0.318} = \mathbf{6.28\ V}$$

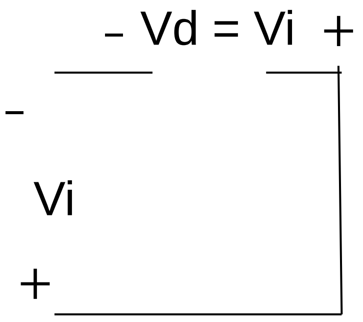


$$I_m = \frac{V_m}{R} = \frac{6.28\text{ V}}{2.2\text{ k}\Omega} = \mathbf{2.85\ mA}$$



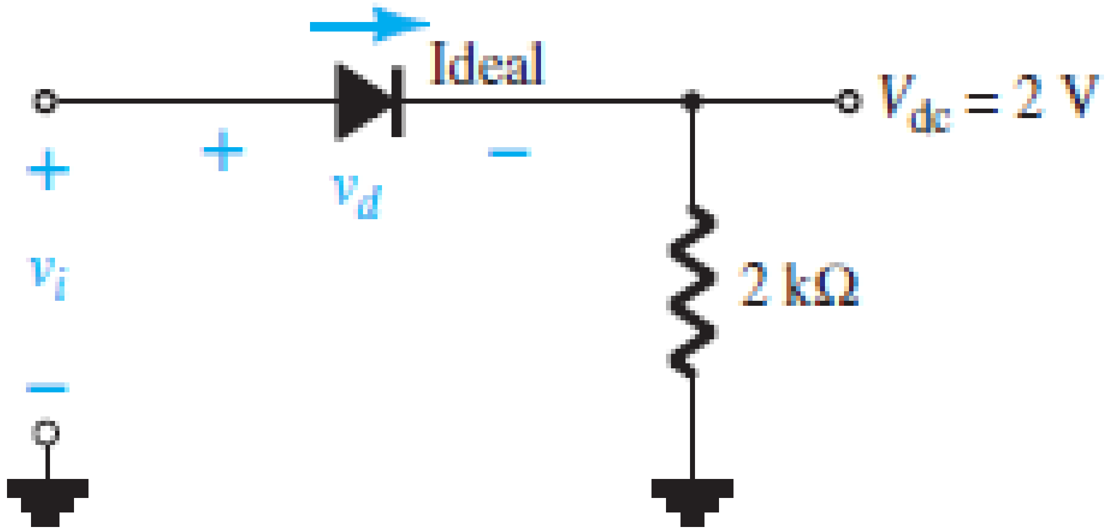






Numerical on HWR

1. b) Assuming a silicon diode (V_k=0.7 V), sketch v_i, v_d, and i_d for the half-wave rectifier . The input is a sinusoidal waveform with a frequency of 60 Hz



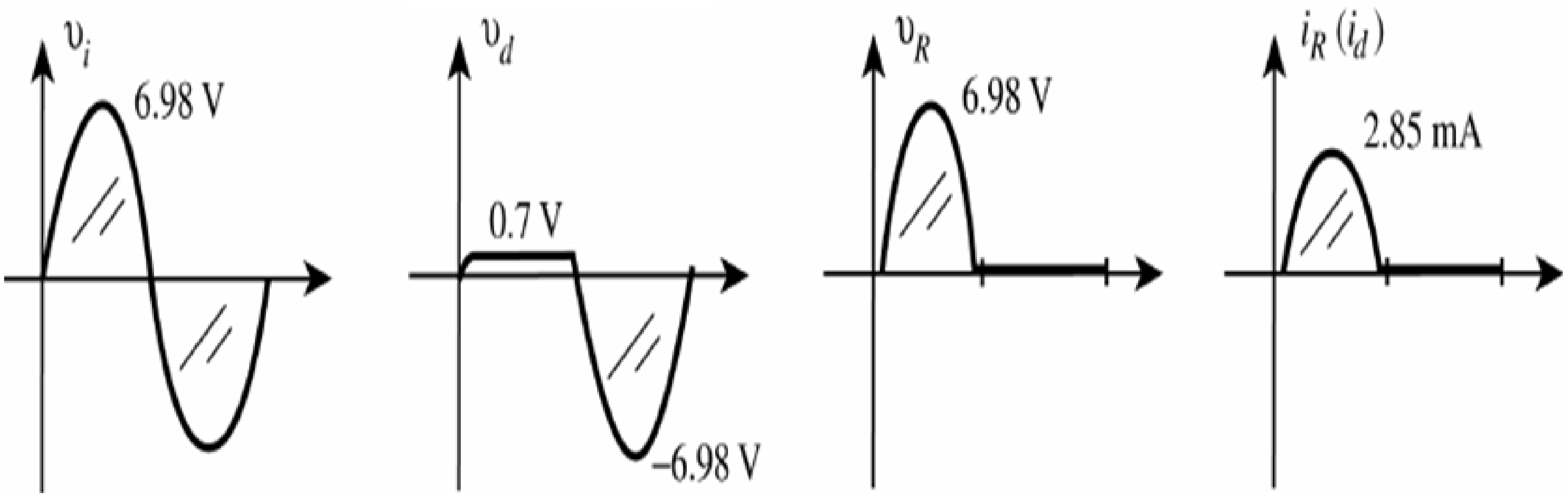
Numerical on HWR

Solution:

Using $V_{dc} \cong 0.318(V_m - V_K)$

$$2\text{ V} = 0.318(V_m - 0.7\text{ V})$$

Solving: $V_m = \mathbf{6.98\ V}$



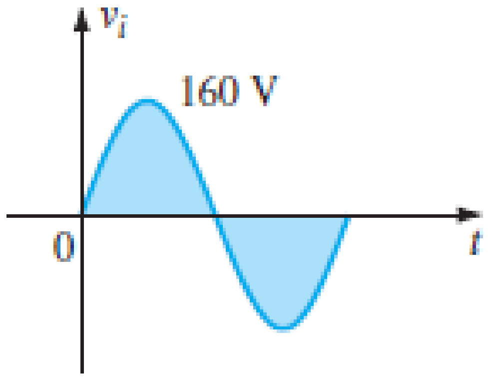
Numerical on HWR

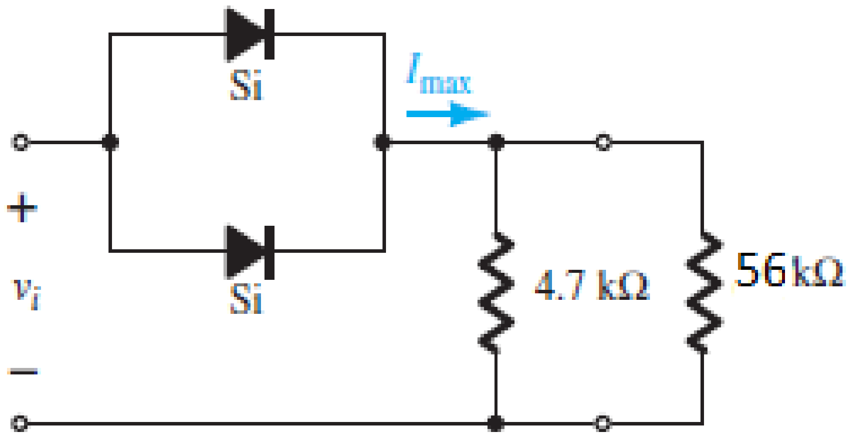
2. (a) Given Pmax= 14 mW for each diode shown, determine the maximum current rating of each diode (using the approximate equivalent model).

(b) Determine Imax for Vimax =160 V.

(c) Determine the current through each diode at Vimax using the results of part (b).

(d) If only one diode were present, determine the diode current and compare it to the maximum rating.





Numerical on HWR

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Solution:

(a) $P_{max} = 14 \text{ mW} = (0.7 \text{ V})I_D$

$$I_D = \frac{14 \text{ mW}}{0.7 \text{ V}} = \mathbf{20\ mA}$$

(b) $4.7 \text{ k}\Omega \parallel 56 \text{ k}\Omega = 4.34 \text{ k}\Omega$

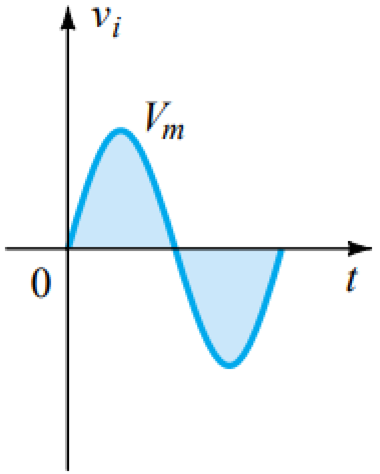
$V_R = 160 \text{ V} - 0.7 \text{ V} = 159.3 \text{ V}$

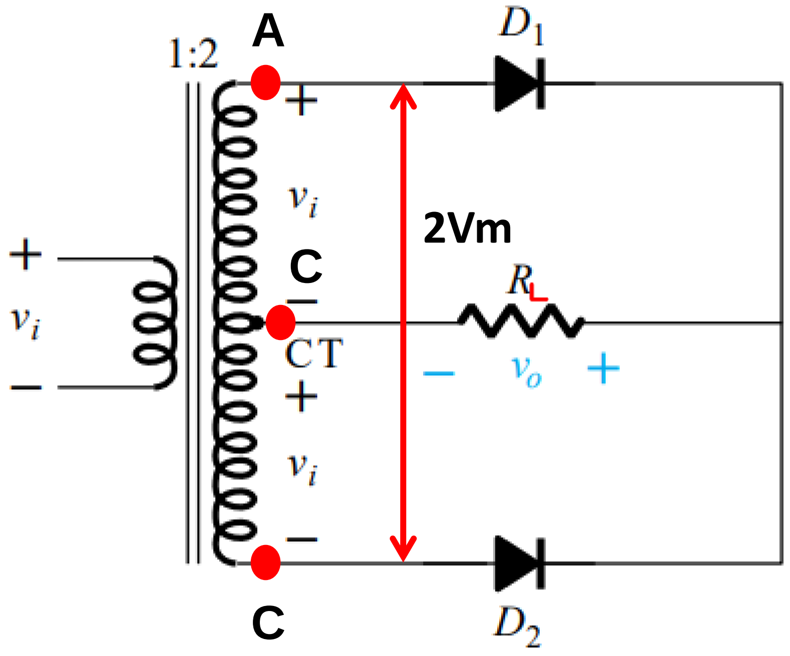
$$I_{max} = \frac{159.3 \text{ V}}{4.34 \text{ k}\Omega} = \mathbf{36.71\ mA}$$

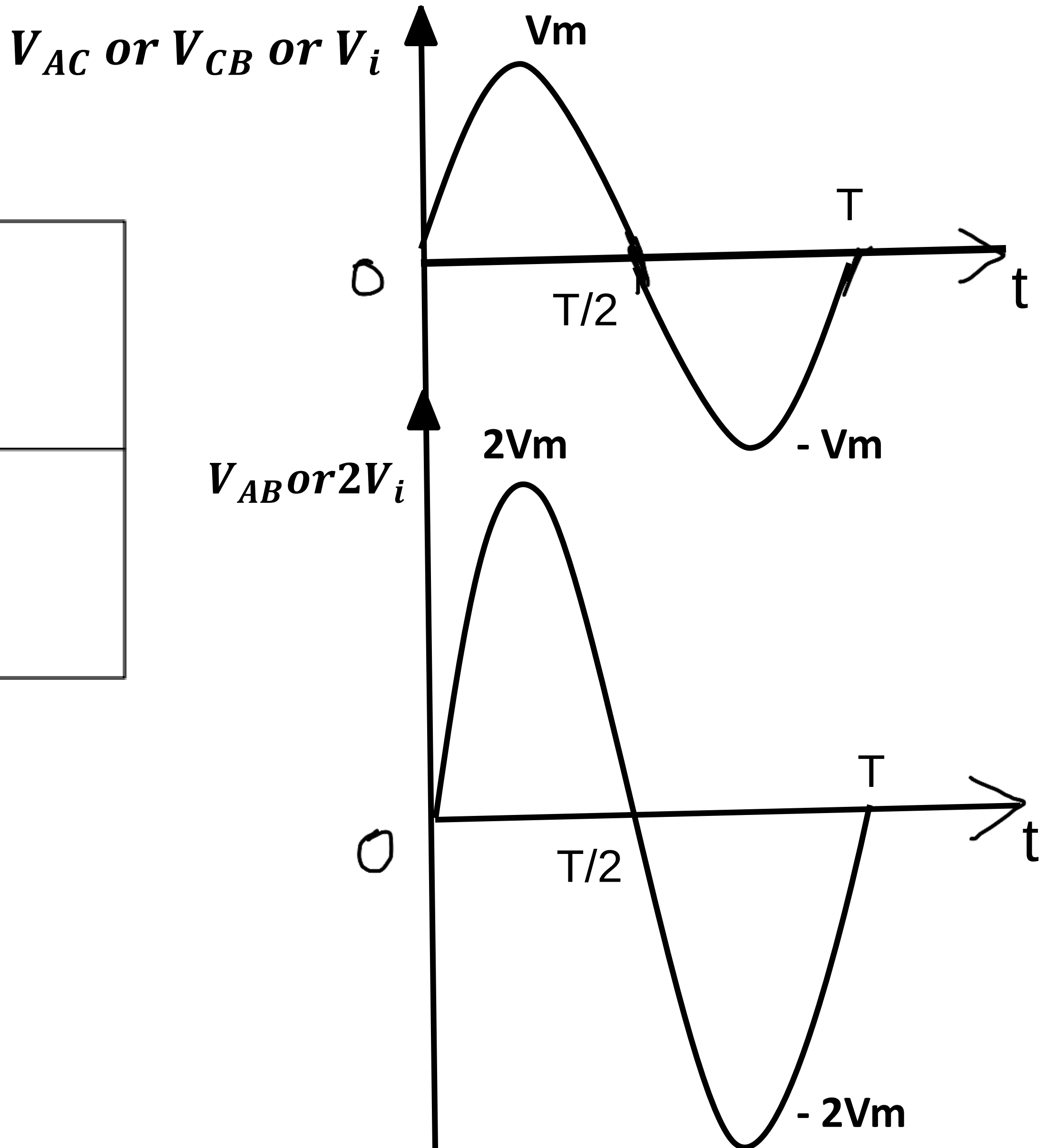
(c) $I_{diode} = \dfrac{I_{max}}{2} = \dfrac{36.71 \text{ mA}}{2} = \mathbf{18.36\ mA}$ $\qquad I_D = 20 \text{ mA} > 18.36 \text{ mA}$

(d) $I_{diode} = 36.71 \text{ mA} \gg I_{max} = 20 \text{ mA}$ Total damage

Full Wave Rectifier : Centre Tap (Ideal Diode)

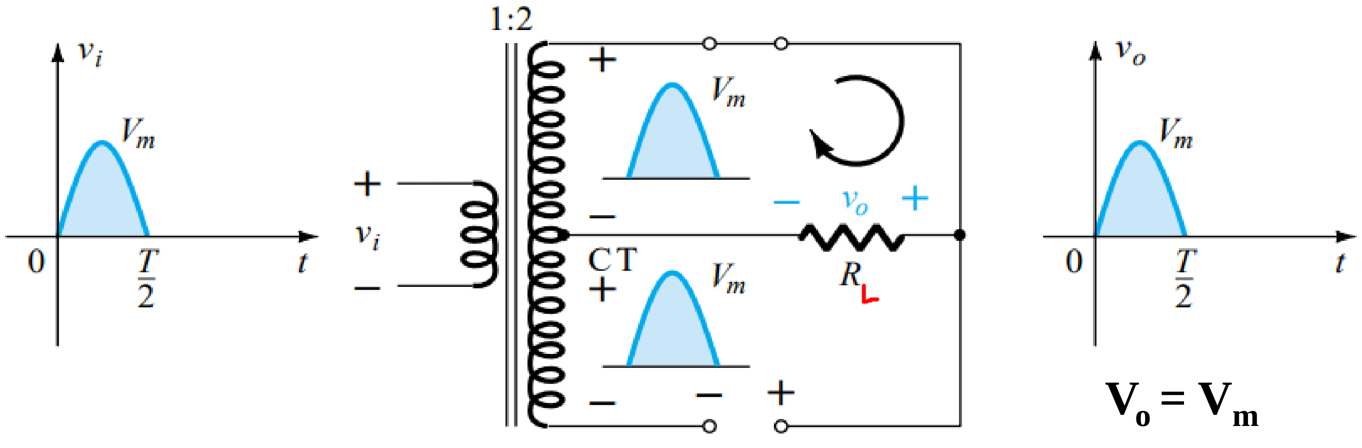






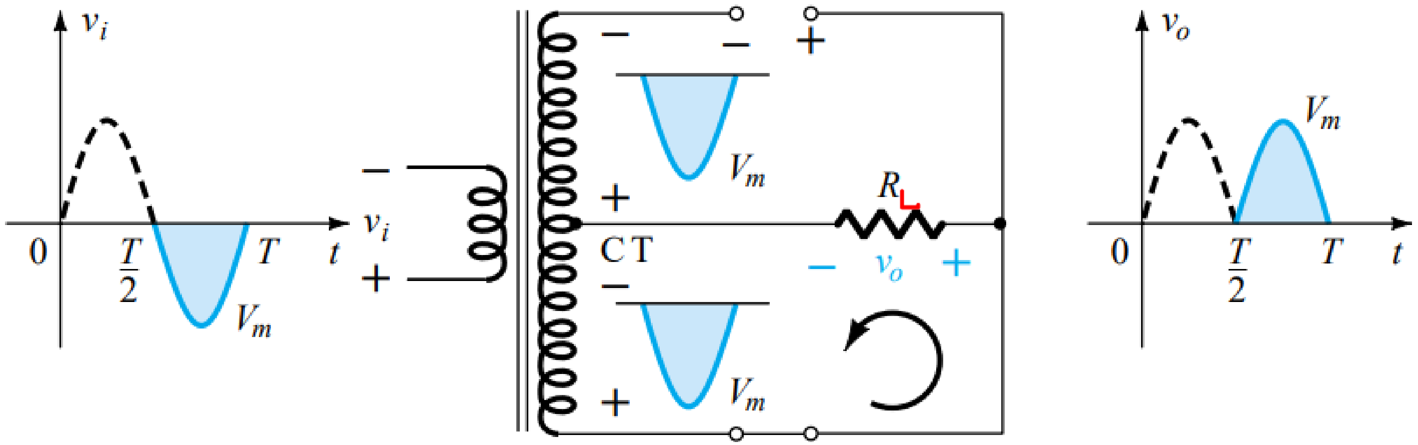
Full Wave Rectifier : Centre Tap (Ideal Diode)

Positive Half Cycle:



$$V_o = V_m \qquad I_o = \frac{V_m}{R_L}$$

Negative Half Cycle:

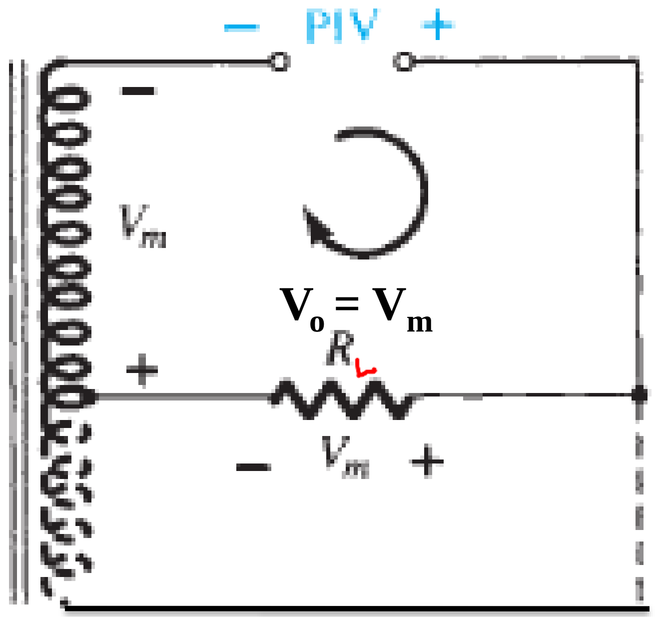


$$V_o = V_m$$

$$I_m = \frac{V_m}{R_L}$$

Full Wave Rectifier PIV - Centre Tap (Ideal Diode)

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



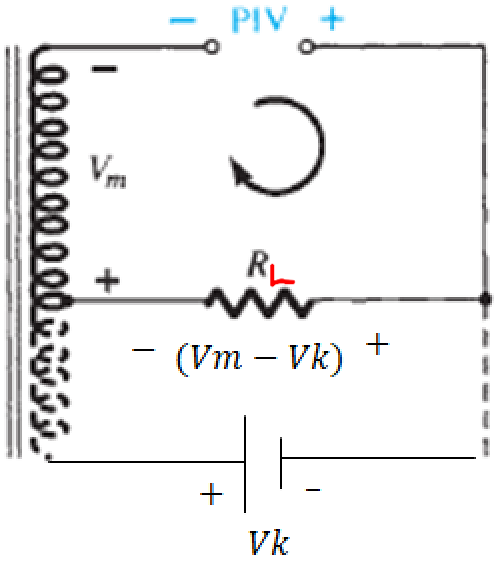
$\boxed{\text{PIV} \geqq 2V_m}$

CT transformer, full-wave rectifier

ELECTRONIC PRINCIPLES AND DEVICES

Full Wave Rectifier : Centre Tap (Non Ideal Diode)

Negative Half Cycle:



$$V_{o\,max} = V_m - V_k$$

$$I_{o\,max} = \frac{V_m - V_k}{R_L}$$

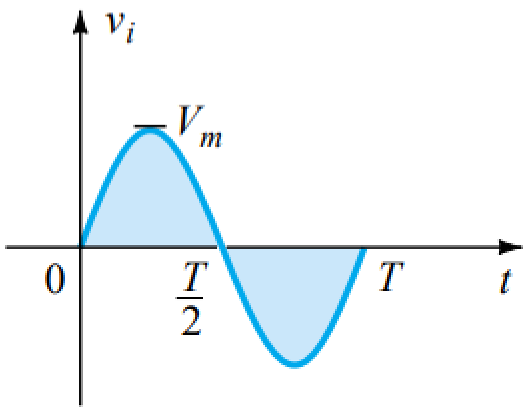
$$\text{PIV} - Vm + Vk - Vm = 0$$

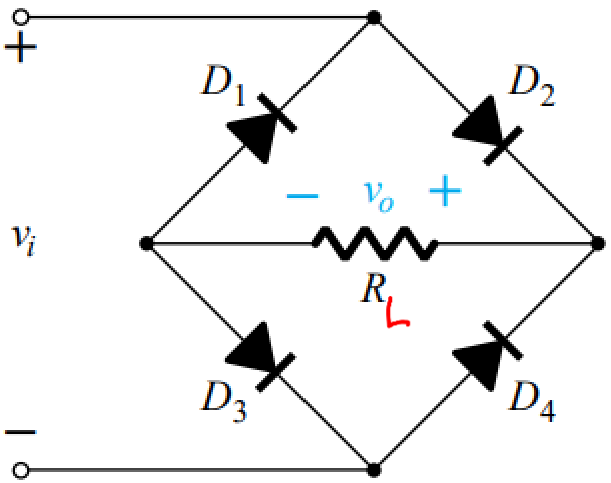
$$\text{PIV} - 2Vm + Vk = 0$$

$$\text{PIV} = 2Vm - Vk$$

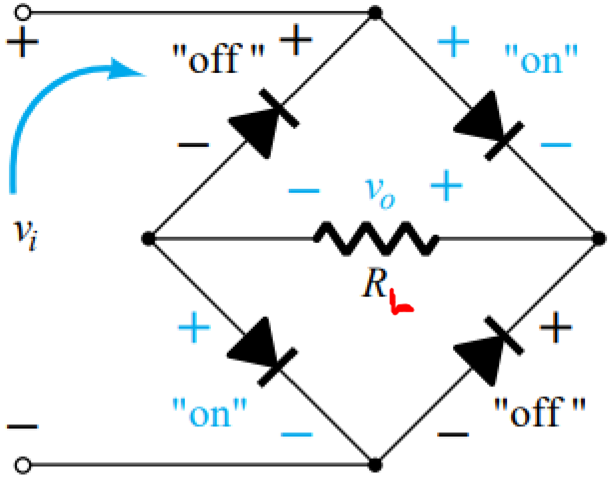
$$Non - Ideal\ diode\text{: PIV} \geq 2Vm - Vk$$

Full Wave Rectifier: Bridge Rectifier (Ideal Diode)



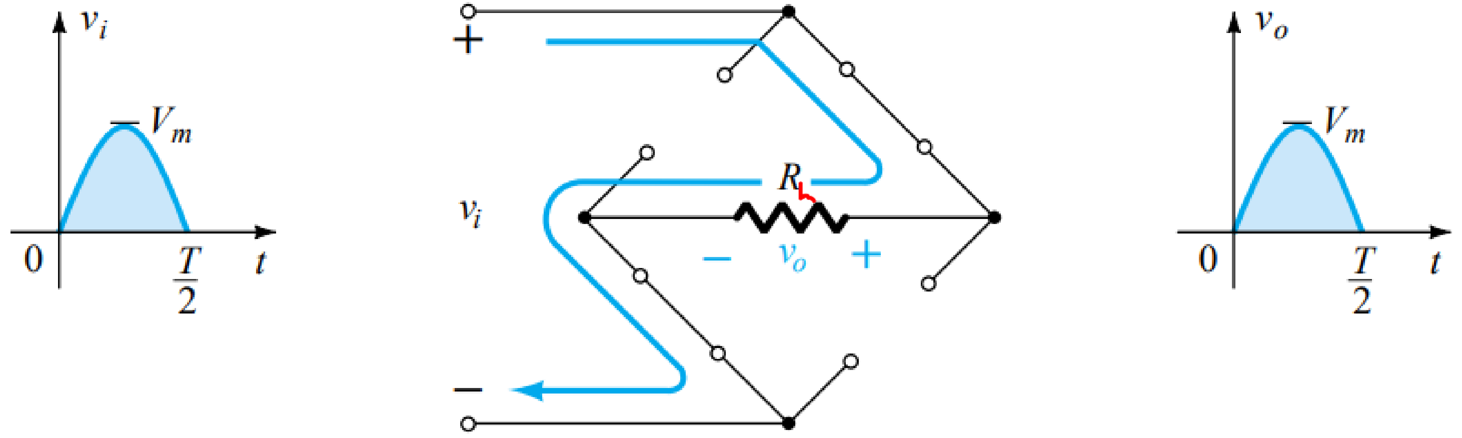


Positive Half Cycle:

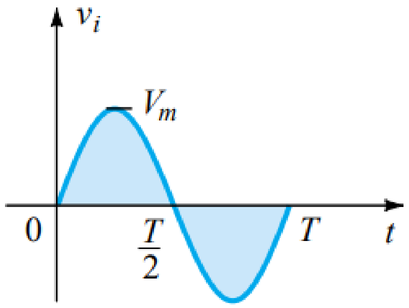


Full Wave Rectifier: Bridge Rectifier (Ideal Diode)

Positive Half Cycle:



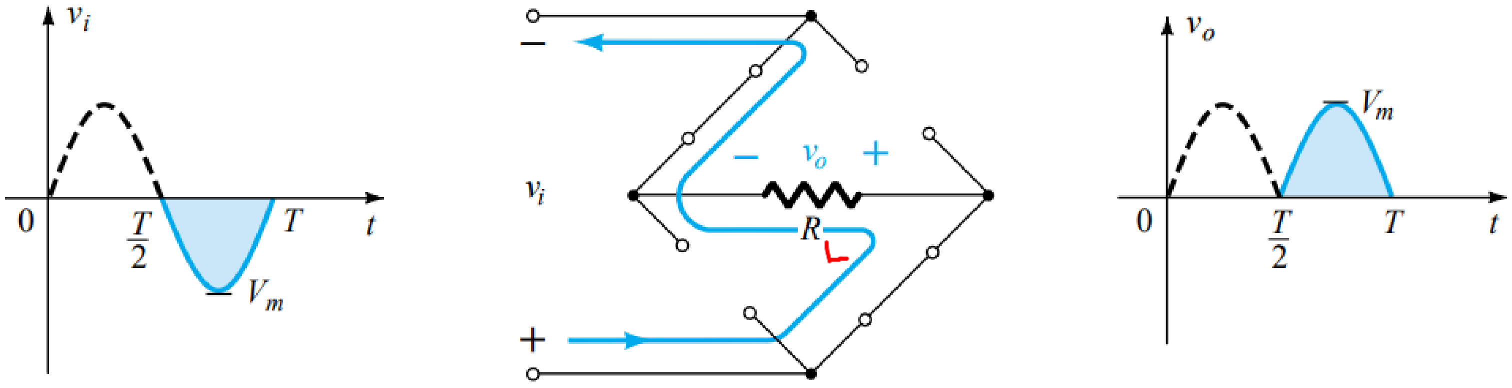
Input Waveform



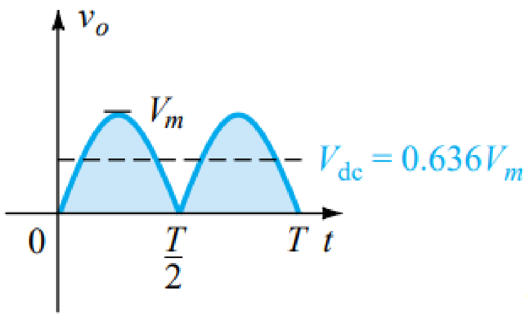
$V_o = V_m$

$I_o = \frac{V_m}{R_L}$

Negative Half Cycle:

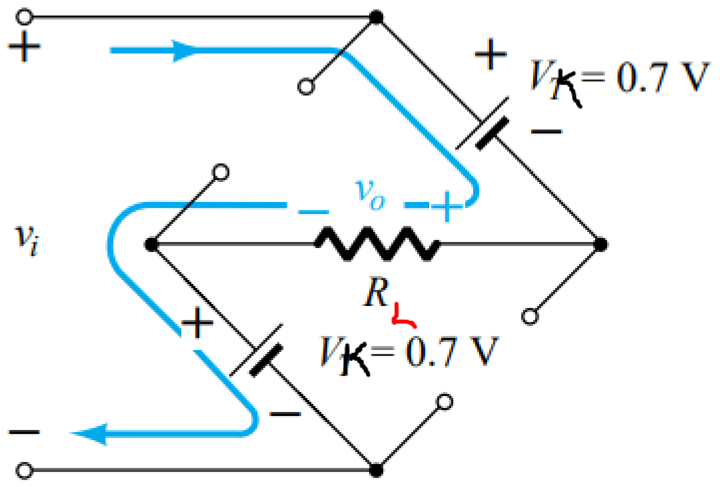


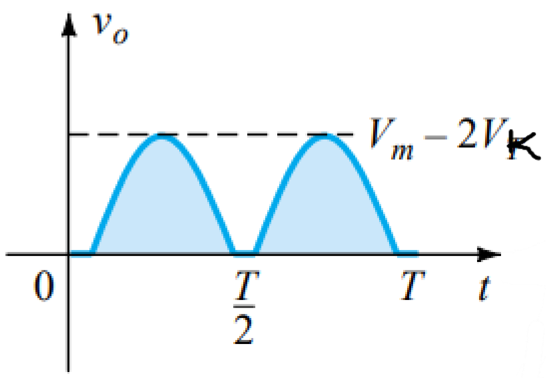
Output Waveform



Full Wave Rectifier: Bridge Rectifier (Non Ideal Diode)

$$\boxed{V_{dc} \cong 0.636(V_m - 2V_K)}$$





$$v_i - V_K - v_o - V_K = 0$$

$$v_o = v_i - 2V_K$$

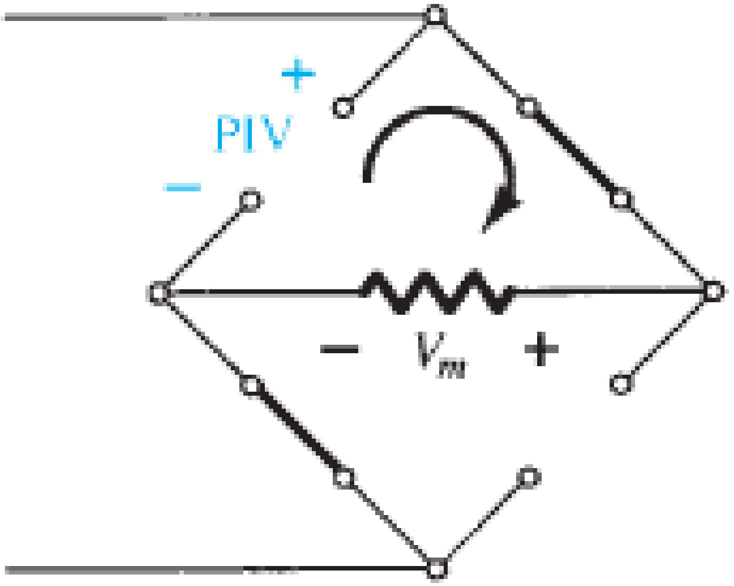
$$V_{o_{max}} = V_m - 2V_K$$

Full Wave Rectifier PIV : Bridge Rectifier (Ideal & Non-Ideal Diode)

Ideal diode: $\boxed{\text{PIV} \geqq V_m}$ full-wave bridge rectifier

$$\text{PIV} - Vm = 0$$

$$\text{PIV} = Vm$$



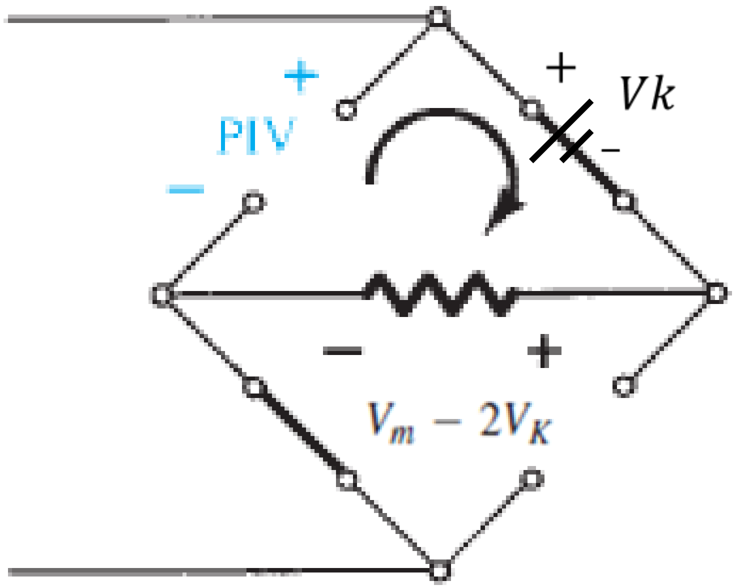
Non − Ideal diode: $\text{PIV} \geq Vm - Vk$

$$\text{PIV} - Vk - Vo = 0$$

$$\text{PIV} - Vk - Vm + 2Vk = 0$$

$$\text{PIV} + Vk - Vm = 0$$

$$\text{PIV} = Vm - Vk$$



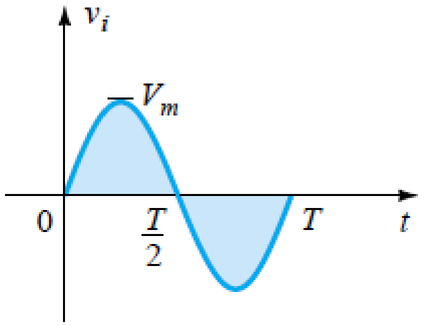
Determining Average voltage/ current for FWR (Ideal Diode)

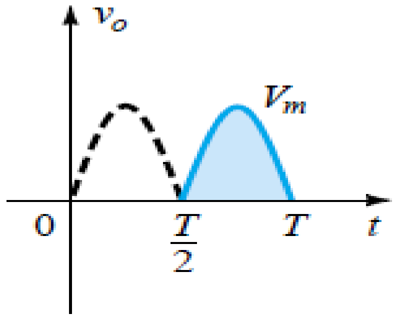
$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m \; sin\omega t \; d\omega t$$

$$= \frac{V_m}{\pi}\left[-Cos\;\omega t\right]_0^{\pi}$$

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

$$\boxed{I_{dc} = \frac{V_{dc}}{R} = \frac{2V_m}{\pi R} = \frac{2I_m}{\pi}}$$





Determining RMS voltage/ current for FWR (Ideal Diode)

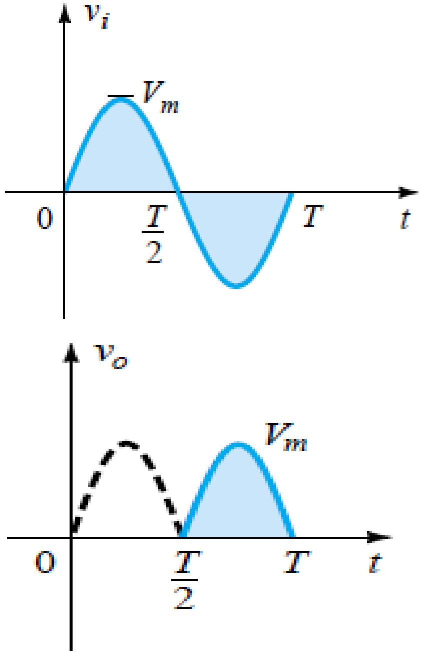
$$V_{rms} = \left[\frac{1}{\pi}\int_0^{\pi}(V_m sin\omega t)^2\ d\omega t\right]^{1/2}$$

$$= \left[\frac{V_m{}^2}{\pi}\int_0^{\pi}\left(\frac{1 - Cos2\,\omega t}{2}\right)\ d\omega t\right]^{1/2}$$

$$= \left[\frac{V_m{}^2}{2\pi}\int_0^{\pi}(1 - Cos2\,\omega t)\ \ d\omega t\right]^{1/2}$$

$$= \left[\frac{V_m{}^2}{2\pi}\left(\omega t_0^{\pi} - \frac{Sin2\,\omega t^{\pi}}{2}{}_0\right)\right]^{1/2} = \left[\frac{V_m{}^2}{2\pi}\ (\pi - 0)\right]^{1/2} = \frac{V_m}{\sqrt{2}}$$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{V_m}{\sqrt{2}R} = \frac{I_m}{\sqrt{2}}$$



Average & RMS voltage/Current for Centre Tap Rectifier - Non Ideal Diode

$$V_{dc} = \frac{2(V_m - V_k)}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2(V_m - V_k)}{\pi R_L} = 2\frac{I_m}{\pi} \qquad \left(I_m = \frac{V_m - V_k}{R_L}\right)$$

$$V_{rms} = \frac{V_m - V_k}{\sqrt{2}}$$

$$I_{rms} = \frac{V_{rms}}{R_L} = \frac{V_m - V_k}{\sqrt{2}R_L} = \frac{I_m}{\sqrt{2}} \qquad \left(I_m = \frac{V_m - V_k}{R_L}\right)$$

Average & RMS voltage/Current for Bridge Rectifier- Non ideal Diode

$$V_{dc} = \frac{2(V_m - 2V_k)}{\pi}$$

$$I_{dc} = \frac{V_{dc}}{R_L} = \frac{2(V_m - 2V_k)}{\pi R_L} = 2\frac{I_m}{\pi} \qquad \left(I_m = \frac{V_m - 2V_k}{R_L}\right)$$

$$V_{rms} = \frac{V_m - 2V_k}{\sqrt{2}}$$

$$I_{rms} = \frac{V_{rms}}{R_L} = \frac{V_m - 2V_k}{\sqrt{2}R_L} = \frac{I_m}{\sqrt{2}} \qquad \left(I_m = \frac{V_m - 2V_k}{R_L}\right)$$

Ripple factor of FWR

Ripple Factor is a measure of purity of the dc output of a rectifier and can be defined as

$$r = \frac{rms\ value\ of\ the\ ac\ component\ of\ the\ output}{average\ or\ dc\ value\ of\ the\ output}$$

$$V^{I}_{rms} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$= \sqrt{\left(\frac{V_m}{\sqrt{2}}\right)^2 - \left(\frac{2V_m}{\pi}\right)^2} = 0.307\ V_m$$

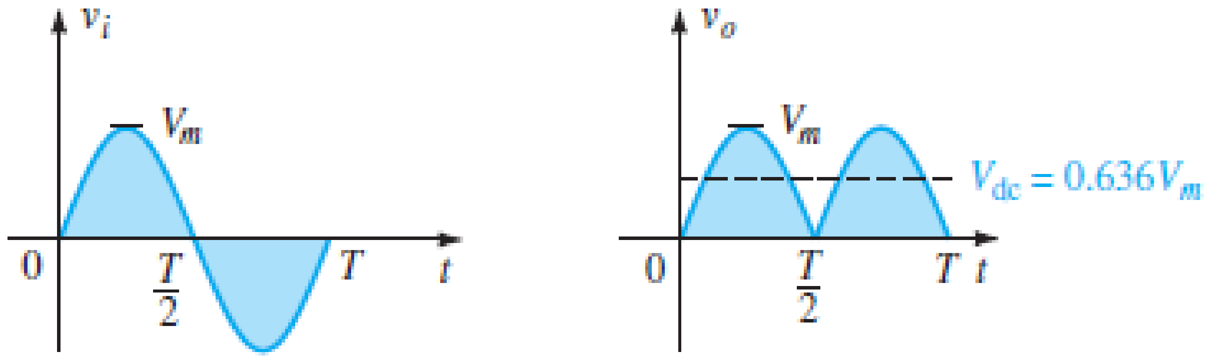
Ripple Factor $(\Upsilon_{FWR}) = \frac{V'_{rms}}{V_{dc}} =$

$$= \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{V_m/\sqrt{2}}{2V_m/\pi}\right)^2 - 1}$$

∴ Ripple factor =0.48

FWR: Frequency

The time duration of 1 cycle of input waveform is T and the time duration of 1 cycle of output wave form is $T/2$, hence fo=2 fi



Comparison Table for HWR & FWR

Measure	HWR Ideal	HWR Practical	CT-Ideal	CT-Practical	Bridge- Ideal	Bridge-Practical
I_{dc}	$\frac{I_m}{\pi}$	$\frac{I_m}{\pi}$	$\frac{2I_m}{\pi}$	$\frac{2I_m}{\pi}$	$\frac{2I_m}{\pi}$	$\frac{2I_m}{\pi}$
V_{dc}	$\frac{V_m}{\pi}$	$\frac{V_m - V_k}{\pi}$	$\frac{2V_m}{\pi}$	$\frac{2(V_m - V_k)}{\pi}$	$\frac{2V_m}{\pi}$	$\frac{2(V_m - 2V_k)}{\pi}$
I_{rms}	$\frac{I_m}{2}$	$\frac{I_m}{2}$	$\frac{I_m}{\sqrt{2}}$	$\frac{I_m}{\sqrt{2}}$	$\frac{I_m}{\sqrt{2}}$	$\frac{I_m}{\sqrt{2}}$
V_{rms}	$\frac{V_m}{2}$	$\frac{V_m - V_k}{2}$	$\frac{V_m}{\sqrt{2}}$	$\frac{V_m - V_k}{\sqrt{2}}$	$\frac{V_m}{\sqrt{2}}$	$\frac{V_m - 2V_k}{\sqrt{2}}$
PIV	V_m	V_m	$2V_m$	$2V_m - V_k$	V_m	$V_m - V_k$

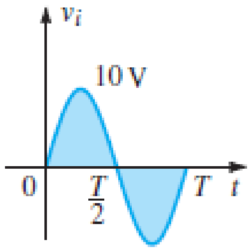
Differences between Centre Tap & Bridge FWR

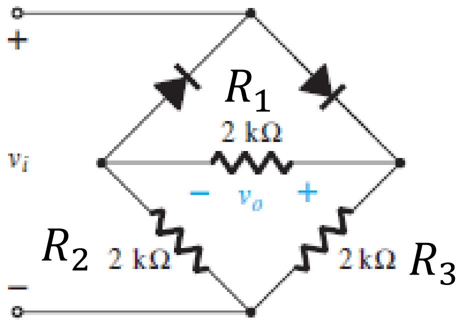
PES UNIVERSITY

Sl No.	Bridge-FWR	CT- FWR
1	Lesser PIV	Comparatively higher PIV
2	Centre tap transformer not required	Centre tap transformer required
3	Uniform input for both half cycles	Difficult to balance both the half cycles due to CT
4	4 diodes are required	2 diodes are required
5	More voltage drop due to two diodes in the path	Comparatively less voltage drop due to only one diode in the path

Numerical on Full Wave Rectifier: Bridge Rectifier

1.Determine the output waveform for the network and calculate the output dc level and the required PIV of each diode.



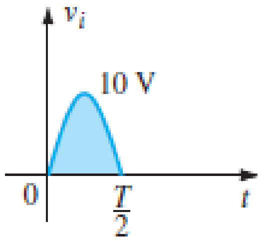


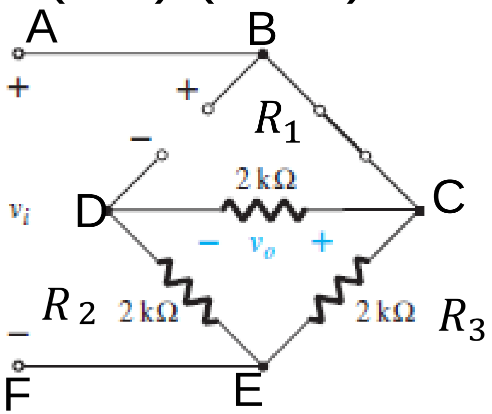
Solution:

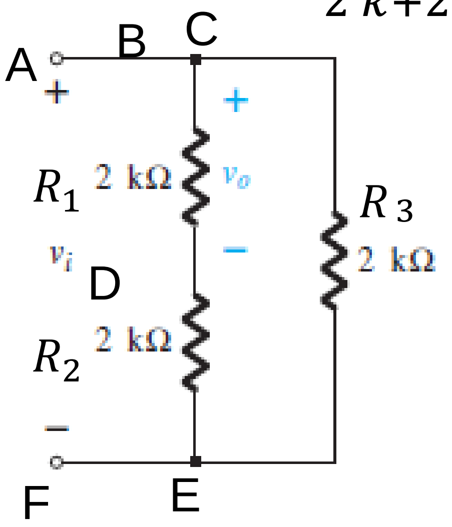
$$Voltage\ Divider\ Rule: \frac{V_i R_1}{R_1 + R_2} = V_0$$

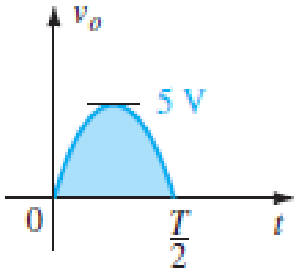
$$V_0 = \frac{10(2\,k)}{2\,k+2\,k} = 5\text{ V}$$

Vomax = (2/4) Vimax = (2/4) (10 V) = 5 V

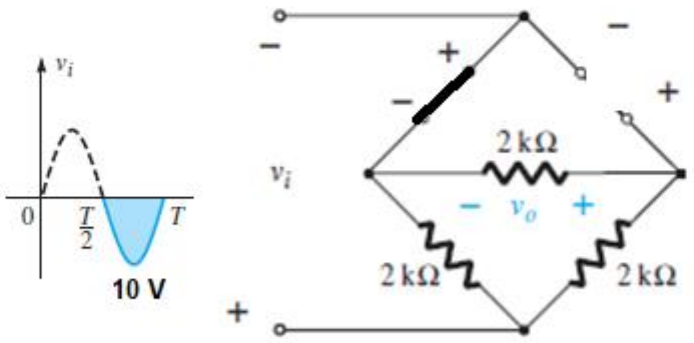


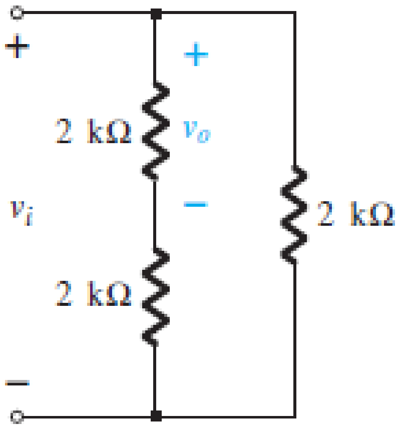


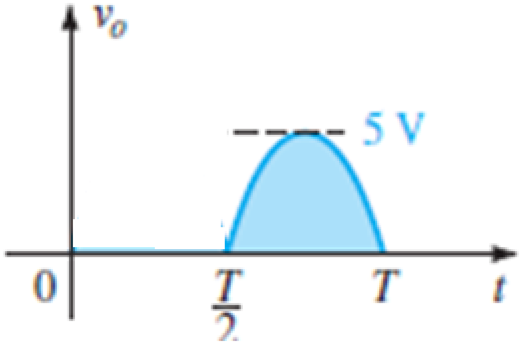


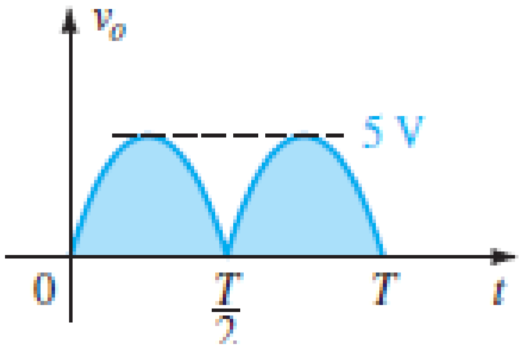


Numerical on Full Wave Rectifier: Bridge Rectifier





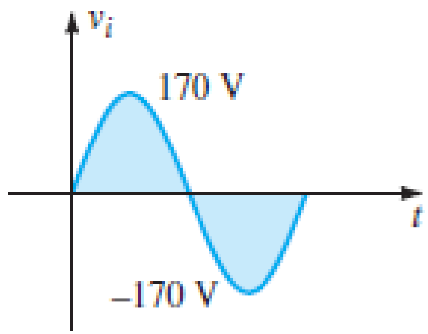


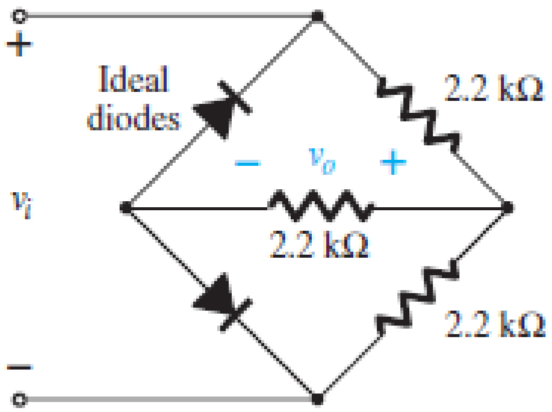


$$V_{dc} = 0.636(5\text{ V}) = 3.18\text{ V}$$

Numerical on Full Wave Rectifier: Bridge Rectifier

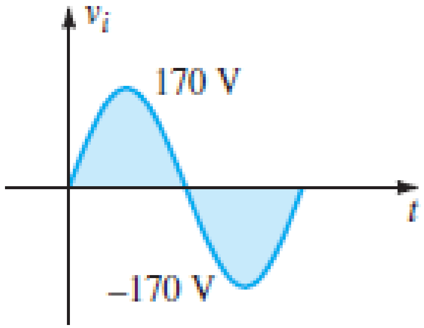
Sketch v_o for the network

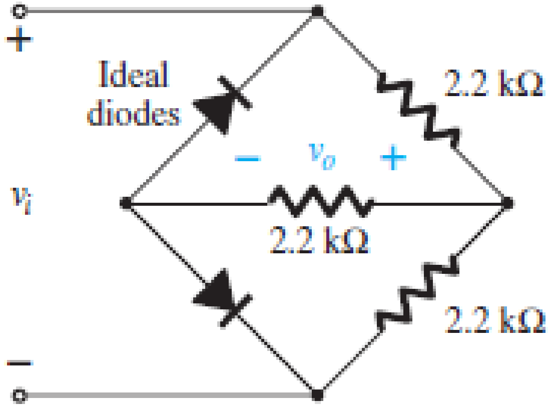




Numerical on Full Wave Rectifier: Bridge Rectifier

Sketch v_o for the network





Positive pulse of v_i:

Top left diode "off", bottom left diode "on"

$2.2\text{ k}\Omega \parallel 2.2\text{ k}\Omega = 1.1\text{ k}\Omega$

$$V_{o_{peak}} = \frac{1.1\text{ k}\Omega(170\text{ V})}{1.1\text{ k}\Omega + 2.2\text{ k}\Omega} = 56.67\text{ V}$$

Negative pulse of v_i:

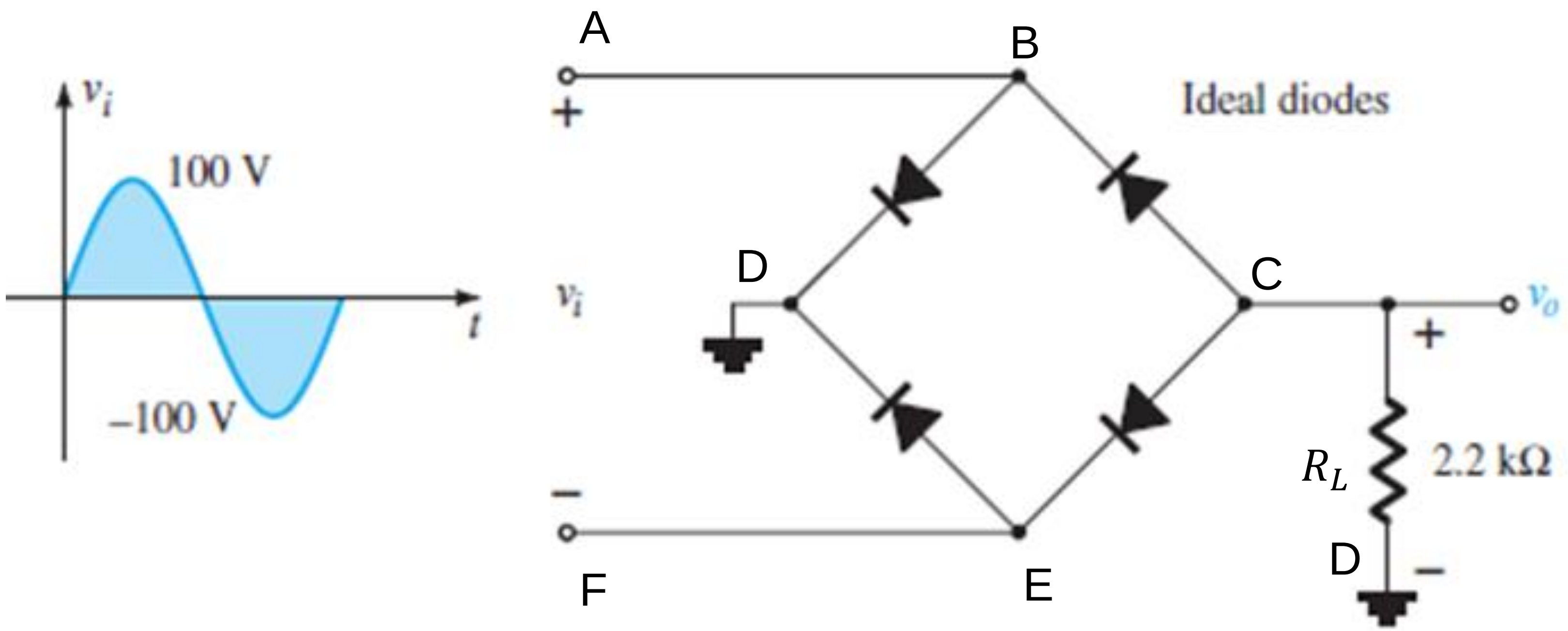
Top left diode "on", bottom left diode "off"

$$V_{o_{peak}} = \frac{1.1\text{ k}\Omega(170\text{ V})}{1.1\text{ k}\Omega + 2.2\text{ k}\Omega} = 56.67\text{ V}$$

$$V_{dc} = 0.636(56.67\text{ V}) = \mathbf{36.04\text{ V}}$$

Full Wave Rectifier

3.Determine Vo and the required PIV rating of each diode for the configuration of Fig. In addition, determine the maximum current through each diode.



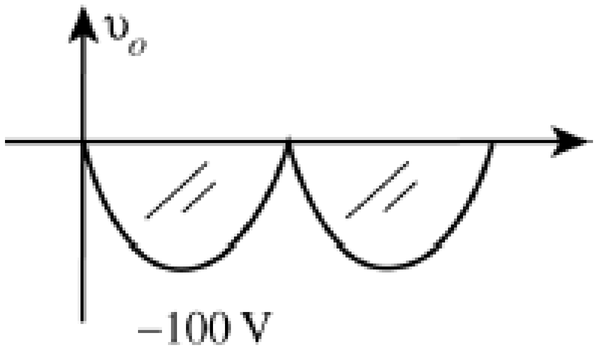
For positive cycle
Path : ABDCEF

Applying KVL

$$V_i + V_0 = 0 \; ; V_0 = -V_i$$

For Negative cycle:
Path : FEDCBA

Numerical on Full Wave Rectifier: Bridge Rectifier

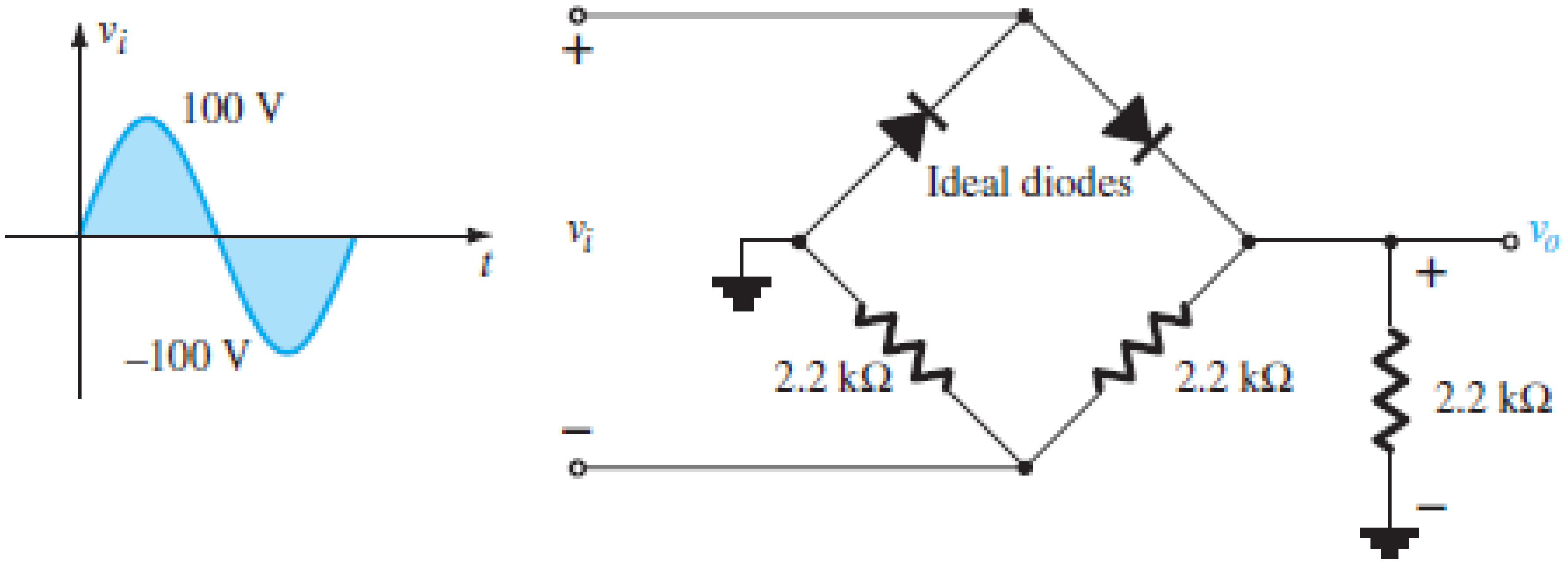


$$\text{PIV} = \mathbf{100\ V}$$

$$I_{\max} = \frac{100\ \text{V}}{2.2\ \text{k}\Omega} = \mathbf{45.45\ mA}$$

Numerical on Full Wave Rectifier: Bridge Rectifier

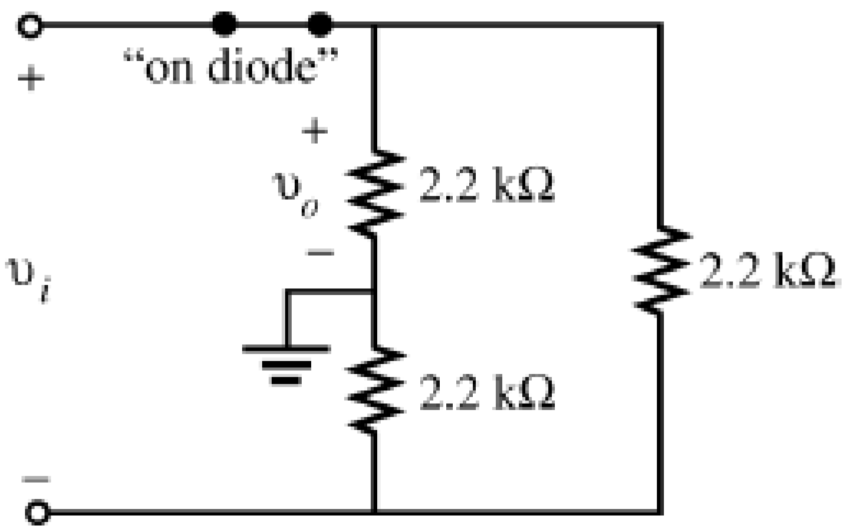
4.Sketch Vo for the network of Fig. and determine the dc voltage available.



Numerical on Full Wave Rectifier: Bridge Rectifier

Positive half-cycle of v_i:

Network redrawn:



Voltage-divider rule:

$$V_{o_{\max}} = \frac{2.2\ \text{k}\Omega(V_{i_{\max}})}{2.2\ \text{k}\Omega + 2.2\ \text{k}\Omega}$$

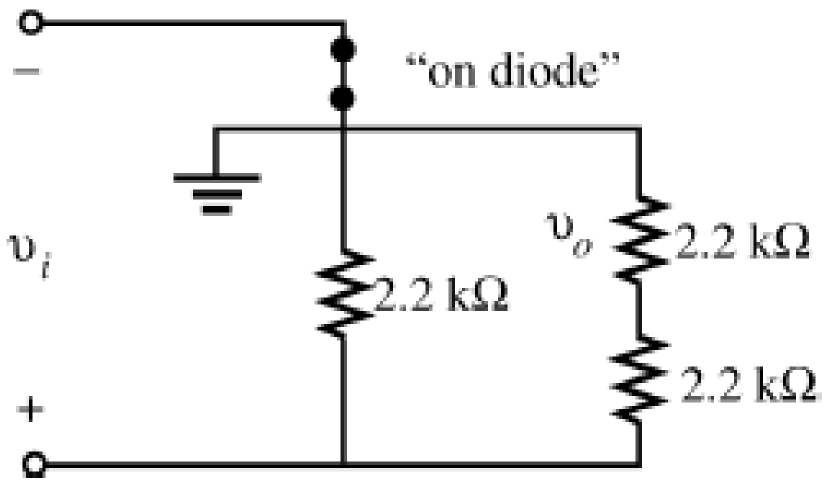
$$= \frac{1}{2}(V_{i_{\max}})$$

$$= \frac{1}{2}(100\ \text{V})$$

$$= 50\ \text{V}$$

Numerical on Full Wave Rectifier: Bridge Rectifier

Negative half-cycle of υ_i :



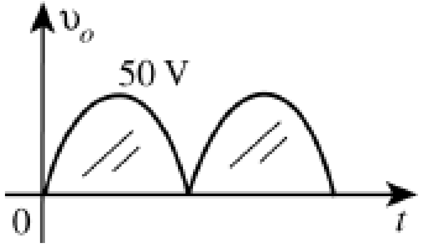
Voltage-divider rule:

$$V_{o_{max}} = \frac{2.2\ \text{k}\Omega (V_{i_{max}})}{2.2\ \text{k}\Omega + 2.2\ \text{k}\Omega}$$

$$= \frac{1}{2}(V_{i_{max}})$$

$$= \frac{1}{2}(100\ \text{V})$$

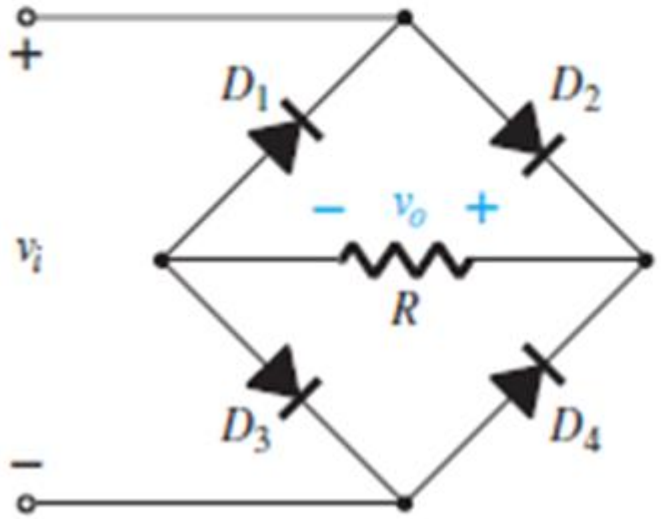
$$= \mathbf{50\ V}$$



$$V_{dc} = 0.636V_m = 0.636\ (50\ \text{V})$$
$$= \mathbf{31.8\ V}$$

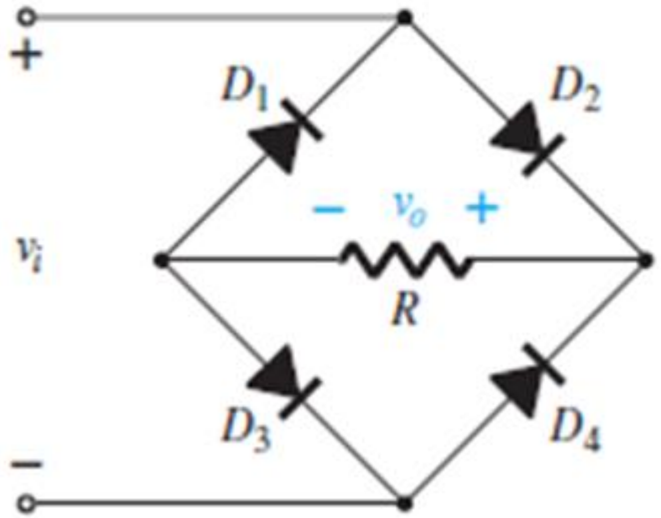
Numerical on Full Wave Rectifier: Bridge Rectifier

5. A full-wave bridge rectifier with a 120-V rms sinusoidal input has a load resistor of 1 kΩ.
   (a) If silicon diodes are employed, what is the dc voltage available at the load?
   (b) Determine the required PIV rating of each diode.
   (c) Find the maximum current through each diode during conduction.
   (d) What is the required power rating of each diode?



Numerical on Full Wave Rectifier: Bridge Rectifier

5. A full-wave bridge rectifier with a 120-V rms sinusoidal input has a load resistor of 1 kΩ.
   (a) If silicon diodes are employed, what is the dc voltage available at the load?
   (b) Determine the required PIV rating of each diode.
   (c) Find the maximum current through each diode during conduction.
   (d) What is the required power rating of each diode?



Numerical on Full Wave Rectifier: Bridge Rectifier

(a) $V_m = \sqrt{2}\,(120\text{ V}) = 169.7\text{ V}$

$$V_{L_m} = V_{i_m} - 2V_D$$

$$= 169.7\text{ V} - 2(0.7\text{ V}) = 169.7\text{ V} - 1.4\text{ V}$$

$$= 168.3\text{ V}$$

$$V_{dc} = 0.636(168.3\text{ V}) = \mathbf{107.04\ V}$$

(b) PIV : $V_m - V_k = 169.7 - 0.7$ $= \mathbf{169\ V}$

Numerical on Full Wave Rectifier: Bridge Rectifier

(c) $$I_D(\text{max}) = \frac{V_{L_m}}{R_L} = \frac{168.3\ \text{V}}{1\ \text{k}\Omega} = \mathbf{168.3\ mA}$$

(d) $$\begin{aligned} P_{\text{max}} = V_D I_D &= (0.7\ \text{V})I_{\text{max}} \\ &= (0.7\ \text{V})(168.3\ \text{mA}) \\ &= \mathbf{117.81\ mW} \end{aligned}$$

Numerical on Full Wave Rectifier: Bridge Rectifier

6. The input to a bridge rectifier is given through a 10 : 1 transformer from a supply of 230 Sin 314 t. If $R_L = 500\ \Omega$. Determine

DC load voltage

RMS load voltage

PIV across diodes

DC power delivered to the load

Frequency of output waveform

Numerical on Full Wave Rectifier: Bridge Rectifier

$$The\ primary\ voltage\ of\ transformer, V_1 = 230\ Sin\ 314\ t$$

$$Transformer\ turns\ ration, \frac{N_1}{N_2} = \frac{10}{1}$$

$$The\ secondary\ voltage\ of\ transformer, V_2 = \frac{N_2}{N_1} V_1 = \frac{1}{10}\ 230\ Sin\ 314\ t$$

$$V_2 = 23\ Sin\ 314\ t$$

$$V_2 = Vm\ Sin\ \omega t = 23\ Sin\ 314\ t$$

$$Therefore, Vm = 23\ V$$

Numerical on Full Wave Rectifier: Bridge Rectifier

$$DC\ load\ voltage, Vdc = \frac{2\,Vm}{\pi} = \frac{2 \times 23}{\pi}$$ **= 14.64 V**

$$RMS\ load\ voltage, Vrms = \frac{Vm}{\sqrt{2}} = \frac{23}{\sqrt{2}}$$ **= 16.26**

$$PIV\ across\ diodes, PIV \geq Vm \geq 23\,V$$

$$DC\ power\ delivered\ to\ the\ load, Pdc = Idc^2 \times R_L = \frac{Vdc^2}{R_L}$$ **= 0.428 W**

$$Frequency\ of\ output\ waveform, f_o = 2f_i = 100\ Hz$$

Numerical on Full Wave Rectifier: Center Tap & Bridge Rectifier

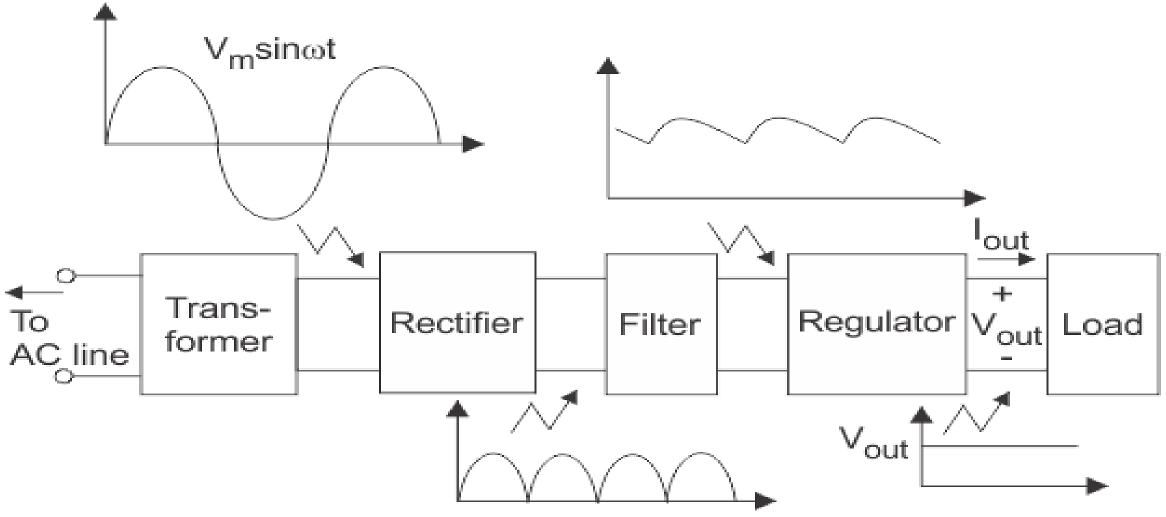
7. In a two diode FWR using Si diodes, the RMS voltage across each half of the transformer secondary is 100V. The load resistance is 975 Ω Find (i) Average current (ii) Average output voltage (iii) PIV of diode.

Ans: V_{dc} = 89.57V, I_{dc} = 91.8mA and PIV= 282.1V.

8. A Bridge rectifier with ideal diodes has an ac source of RMS value 220 V, 50Hz connected to the primary of transformer. If the load resistance is 200Ω and turns ratio of transformer is 4:1, find the dc output volatge, dc output current and output frequency.

Ans: V_{dc} = 49.6V, I_{dc} = 248mA and f_o = 100Hz.

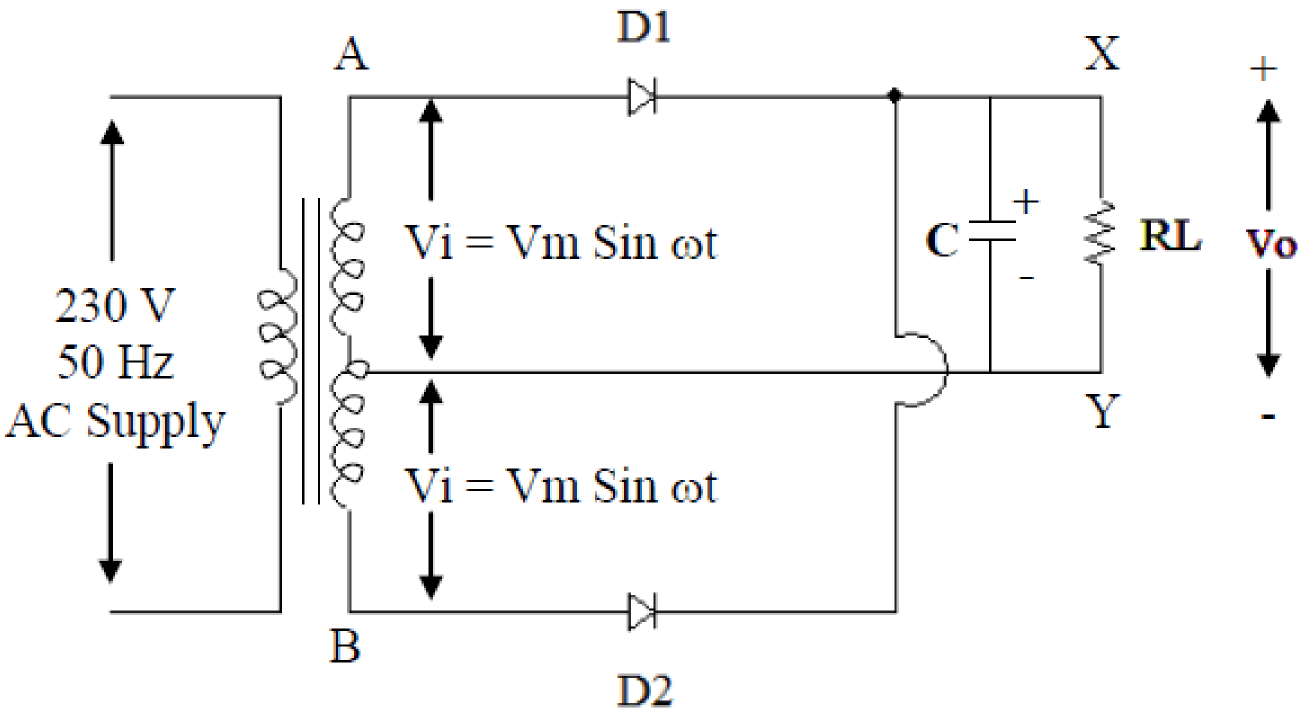
Shunt Capacitor Filter



Components of typical linear power supply

Filter is a circuit which converts pulsating DC to smooth DC. Since the reactance of capacitor and inductor depends on frequency, by connecting a capacitor in parallel with the load or by connecting an inductor in series with the load, the ac ripple present at the output of a rectifier can be reduced.

FWR with Shunt Capacitor Filter

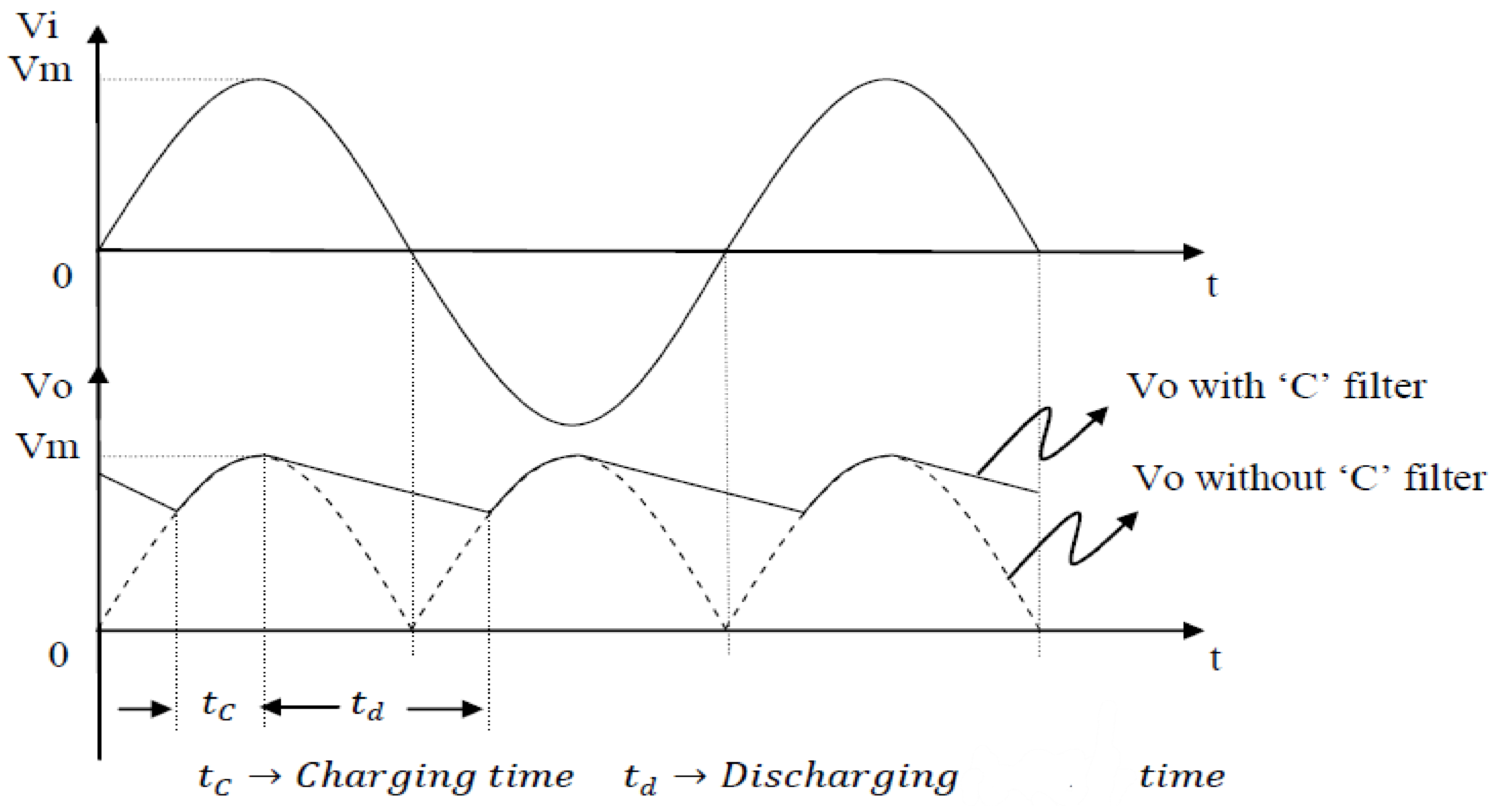


FWR with Shunt Capacitor Filter

Working

During positive half cycle the diode D1 is forward biased in centre tap full wave rectifier and diode D1 and D2 are forward biased in bridge rectifier. Hence the capacitor C will charge from 0 V towards the peak value of input Vm. When input voltage Vi reaches Vm the charge on capacitor will also be equal to Vm, hence the diodes will turn off (since both anode and cathode of diodes will be at same potential). Now the capacitor starts discharging through the load RL, if the load is very light (load resistance is very high and load current is low) the capacitor will discharge by a small amount, by that time next half cycle charges the capacitor back to Vm. Thus the output voltage remains almost constant.

Shunt Capacitor Filter



Shunt Capacitor Filter

Expression for ripple factor

$$\gamma = \frac{1}{4\sqrt{3}\, f\, C\, R_L}$$

$f \rightarrow$ *Frequency of input AC signal*

$C \rightarrow$ *Filter capacitor used*

$R_L \rightarrow$ *Load resistance*

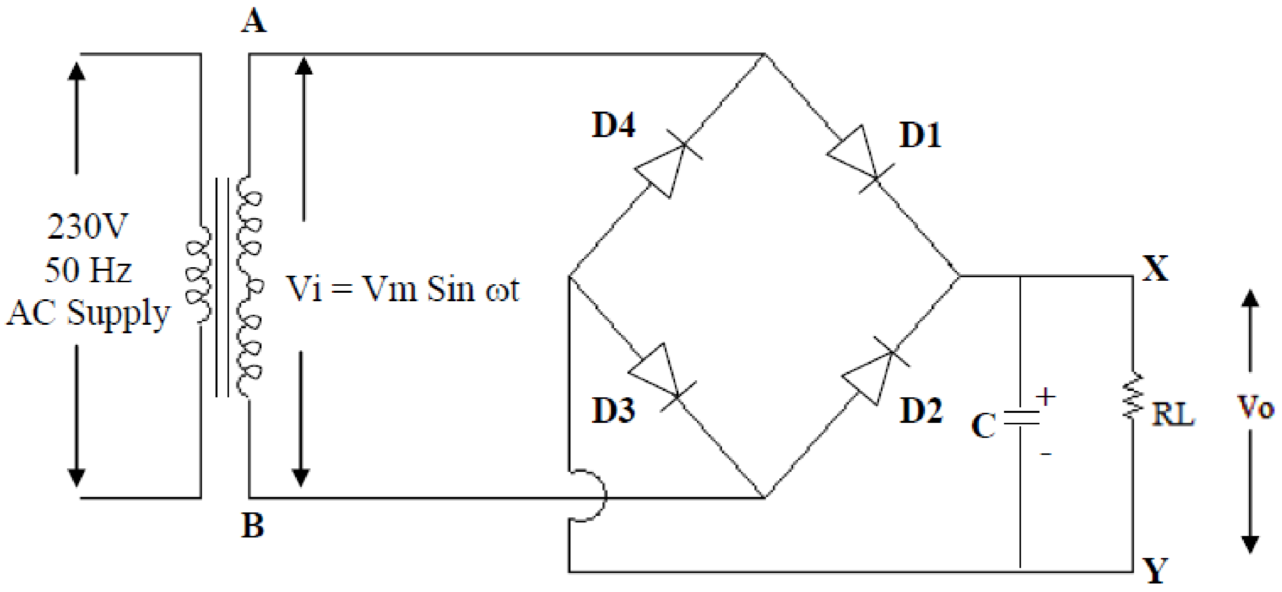
$$\gamma \propto \frac{1}{f} \quad \frac{1}{C} \quad \frac{1}{R_L}$$

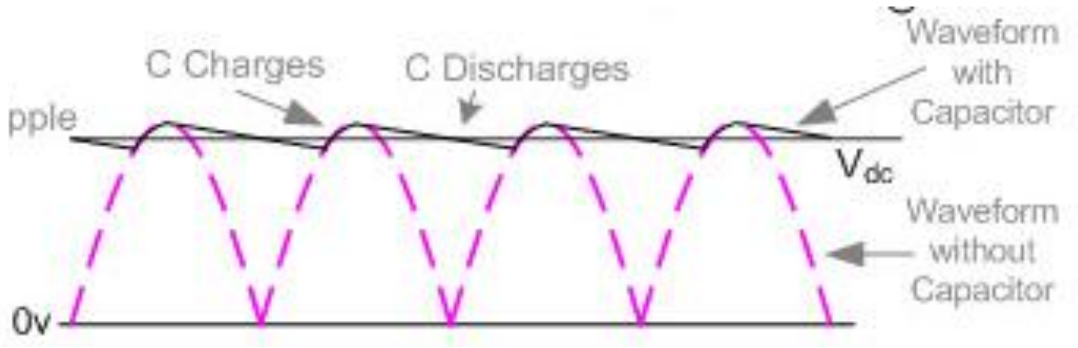
Since ripple is inversely proportional to frequency, capacitor and load resistance, the ripple can be minimized by using high value of C. (R_L and f are not in designer's hand)

$$\gamma = \frac{V_{r(rms)}}{V_{dc}}, V_{r(rms)} = \frac{I_{DC}}{4\sqrt{3} fc},$$

$$V_{dc} = V_m - \frac{I_{DC}}{4 fc}$$

Shunt Capacitor Filter for Bridge Rectifier

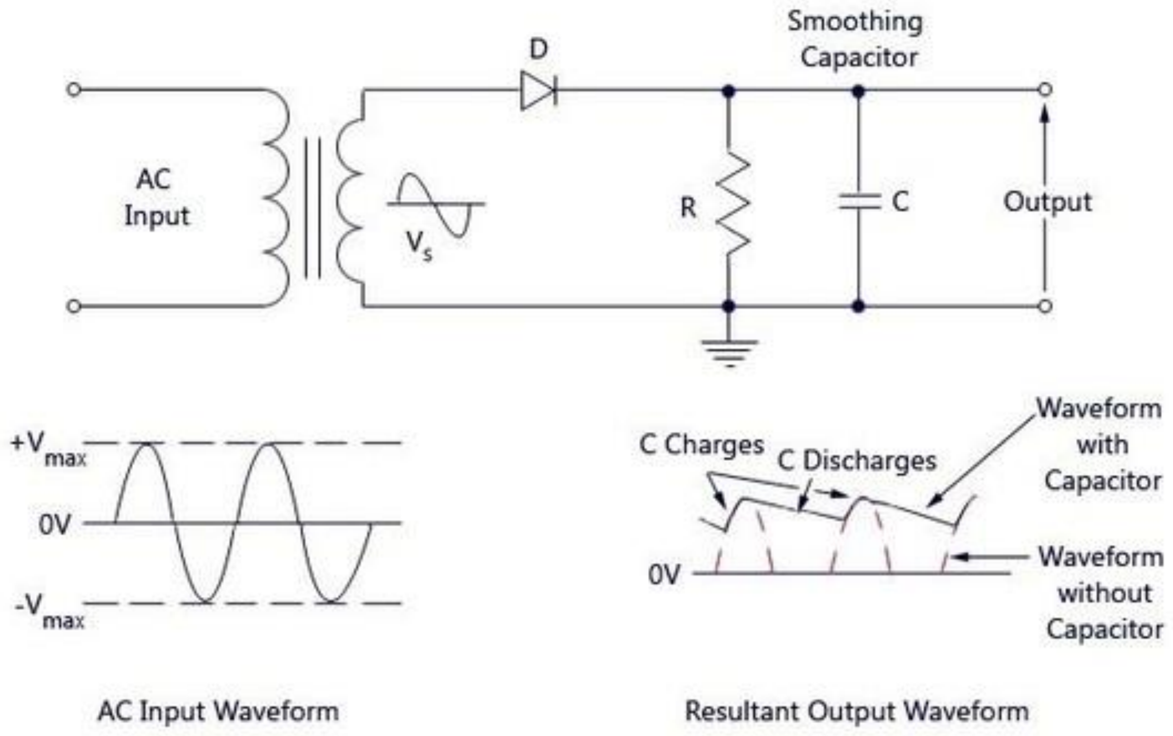


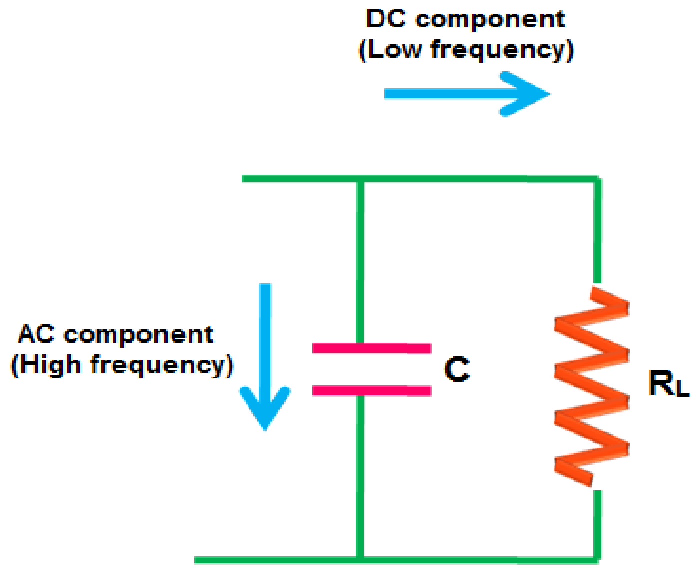


- ➢ AC components fluctuate with respect to time while the DC components remain constant with respect to time
- ➢ So the AC components present in the pulsating DC is an unwanted signal

Shunt Capacitor Filter for Half – Wave Rectifier

Capacitor C is connected in shunt/parallel with load resistor (R_L)





Shunt Capacitor Filter for Half – Wave Rectifier

Ripple Factor for Capacitor Filter of a Half Wave Rectifier is given by

Ripple Factor for a capacitor filter (HWR) = 1/ (2√3 f C R_L)

f – Frequency of AC input Signal
R_L – Value of Load resistor
C – Capacitance of the Shunt Capacitor

$$\gamma = \frac{V_{r(rms)}}{V_{dc}}, V_{r(rms)} = \frac{I_{DC}}{2\sqrt{3}fc},$$

$$V_{dc} = V_m - \frac{I_{DC}}{2fc}$$

Numerical on Shunt Capacitor Filter

1. A full wave rectifier with C filter is supplying a load of 500 Ω. If the ripple factor should not exceed 10 %, find the value of capacitor required. Assume input AC signal frequency is 50 Hz. What is the new value of ripple if capacitor of 500 μF is connected across the load?

Solution:

$Given\ \gamma = 10\ \% = 0.1\ and\ R_L = 500\Omega$

$$\gamma = \frac{1}{4\sqrt{3}\, f\, C\, R_L}$$

$$C = \frac{1}{4\sqrt{3}\, f\, \gamma R_L} = \frac{1}{4\sqrt{3} \times 50 \times 0.1 \times 500} = 57.73\ \mu F$$

$If\ a\ capacitor\ of\ 500\ \mu F\ is\ used\ the\ ripple\ factor\ is$

$$\gamma = \frac{1}{4\sqrt{3}\, f\, C\, R_L} = \frac{1}{4\sqrt{3} \times 50 \times 500 \times 10^{-6} \times 500} = 0.0115$$

Numerical on Shunt Capacitor Filter

2. In a full wave rectifier with C filter the output DC voltage is 10 V and load current is 10 mA. Calculate the value of capacitance required such that the output DC voltage will have ripple ≤ 0.001.

Solution:

$$R_L = \frac{Vdc}{Idc} = \frac{10}{10\ m} = 1\ K\Omega$$

$$Assume\ frequency\ of\ input\ AC\ signal, f = 50\ Hz$$

$$\gamma = \frac{1}{4\sqrt{3}\, f\, C\, R_L}$$

$$C = \frac{1}{4\sqrt{3}\, f\, \gamma R_L} = \frac{1}{4\sqrt{3}\ \times 50 \times\ 0.001\ \times 1 \times 10^3} = 2886\ \mu F$$

Numerical on Shunt Capacitor Filter

3. Calculate the RMS value of the ripple voltage for the FWR in a 100µF Capacitor connected to a load drawing 50mA of current .What is the dc voltage at the output if the peak rectified output voltage is 30V and frequency is 50Hz. Also find the ripple factor

Solution:

$$\gamma = \frac{V_{r(rms)}}{V_{dc}}, V_{r(rms)} = \frac{I_{DC}}{4\sqrt{3}fc},$$

$$V_{dc} = V_m - \frac{I_{DC}}{4fc}$$

Given :
Idc= 50mA, f=50Hz, C=100µF

Therefore Vrms=1.4V

Vm= 30V
Therefore Vdc=27.5 V

Ripple factor=0.05

Numerical on Shunt Capacitor Filter

4. A Half wave rectifier with C filter is supplying a resistive load of 500Ω. If the load ripple content should not exceed 10% find the value of C required

Solution:

For a Half wave rectifier with C filter ,

Ripple Factor=$1/2\sqrt{3}\ f\ C\ R_L$

$0.10=1/\{2\sqrt{3}*50*C*500\}$

C=0.115mF

Numerical on Shunt Capacitor Filter

5. A 100μF capacitor when used as a filter has 15V rms across it with a load resistor of 2.5KΩ. If the filter is the full wave and supply frequency is 50Hz, what is the percentage of ripple factor in the output?

Solution:

For a full wave rectifier with C filter ,

Ripple factor, $\Upsilon = 1/4\sqrt{3}\ f\ C\ R_L$

$= 1/4\sqrt{3}*50*100*10^{-6}*2.5*10^{-3}$

$= 0.01154.$

So, ripple factor is 1.154%

Numerical on Shunt Capacitor Filter

6. A full wave rectifier uses a capacitor filter with 500µF capacitor and provides a load current of 200mA at 8% ripple. Calculate the dc voltage and the value of peak rectified voltage?

Solution:

The ripple factor for Full Wave Rectifier with C filter

$\Upsilon = 1/\ 4\sqrt{3}\ f\ C\ RL$ substituting $RL = Vdc/Idc$

$\Upsilon = Idc/\ 4\sqrt{3}\ f\ C\ Vdc$

after re-arranging

$V_{DC} = 200*10^{-3}/\ 4\sqrt{3}\ *50*500*10^{-6}\ *0.08$

$V_{DC} = 14.43V$

We know, $V_m = V_{dc} + I_{dc}/4fC$

$= 14.43 + \{200*\ 10^{-3} / \{\ 4*50*500*10^{-6}\ \}$

$= 14.43 + 2 = 16.43V$

$V_m = 16.43V$

THANK YOU

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