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Unit 2 - Semiconductor Diode applications – Class 21 - Block diagram of regulated power supply, and Half wave rectifier working Principles

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Unit 2 - Class 21 - Block diagram of regulated power supply, and Half wave rectifier working Principles – Text book reference – Section 15.1 – pages 773 to 775

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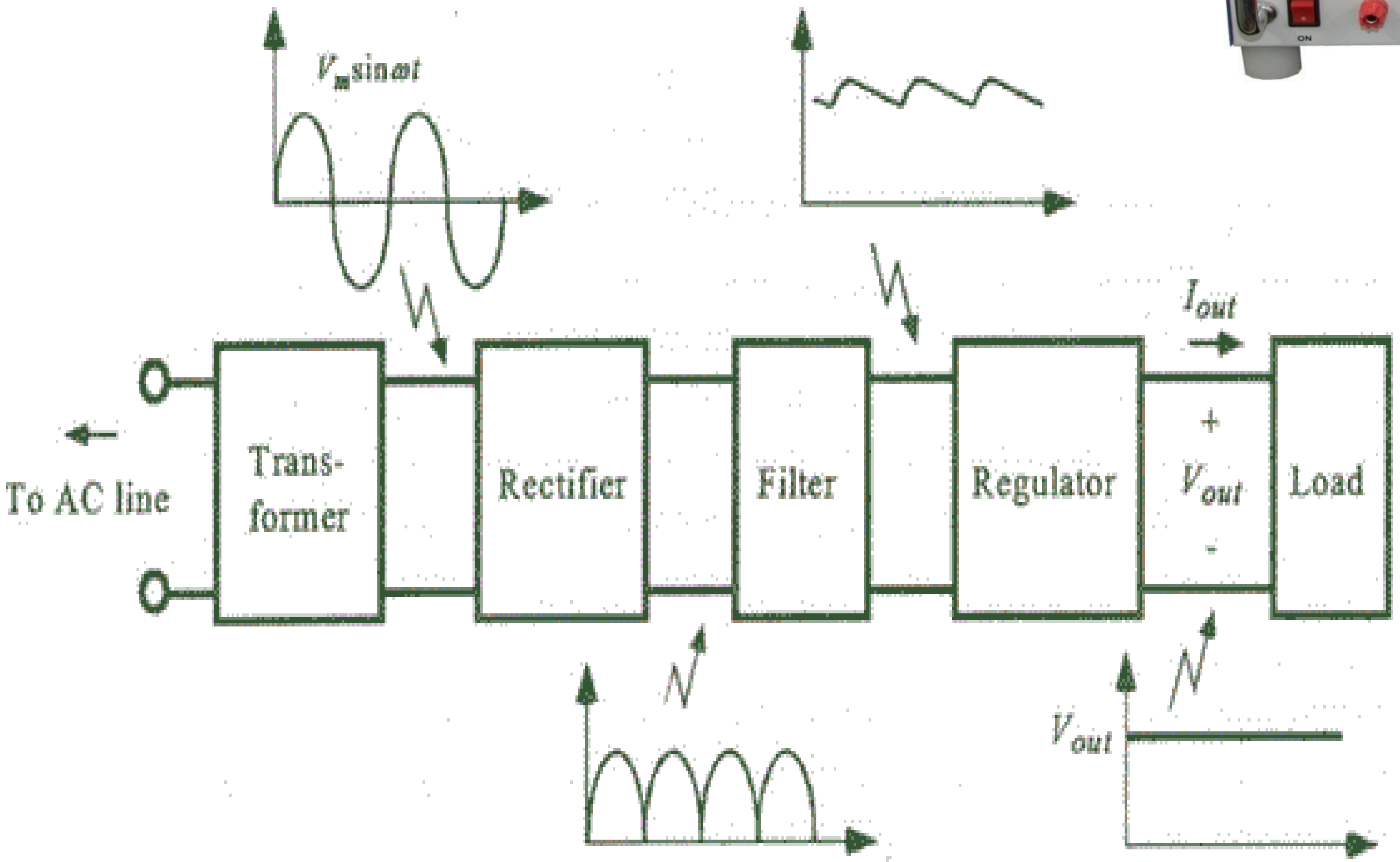
Unit 2 – Class 21 - Regulated Power Supply



Unit 2 – Class 21 - Regulated Power Supply

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

- **Transformer** : The output sinusoid voltage is either step-up or step-down from the input sinusoid voltage value

- **Rectifier** : Converts an alternating current into a direct one by allowing a 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

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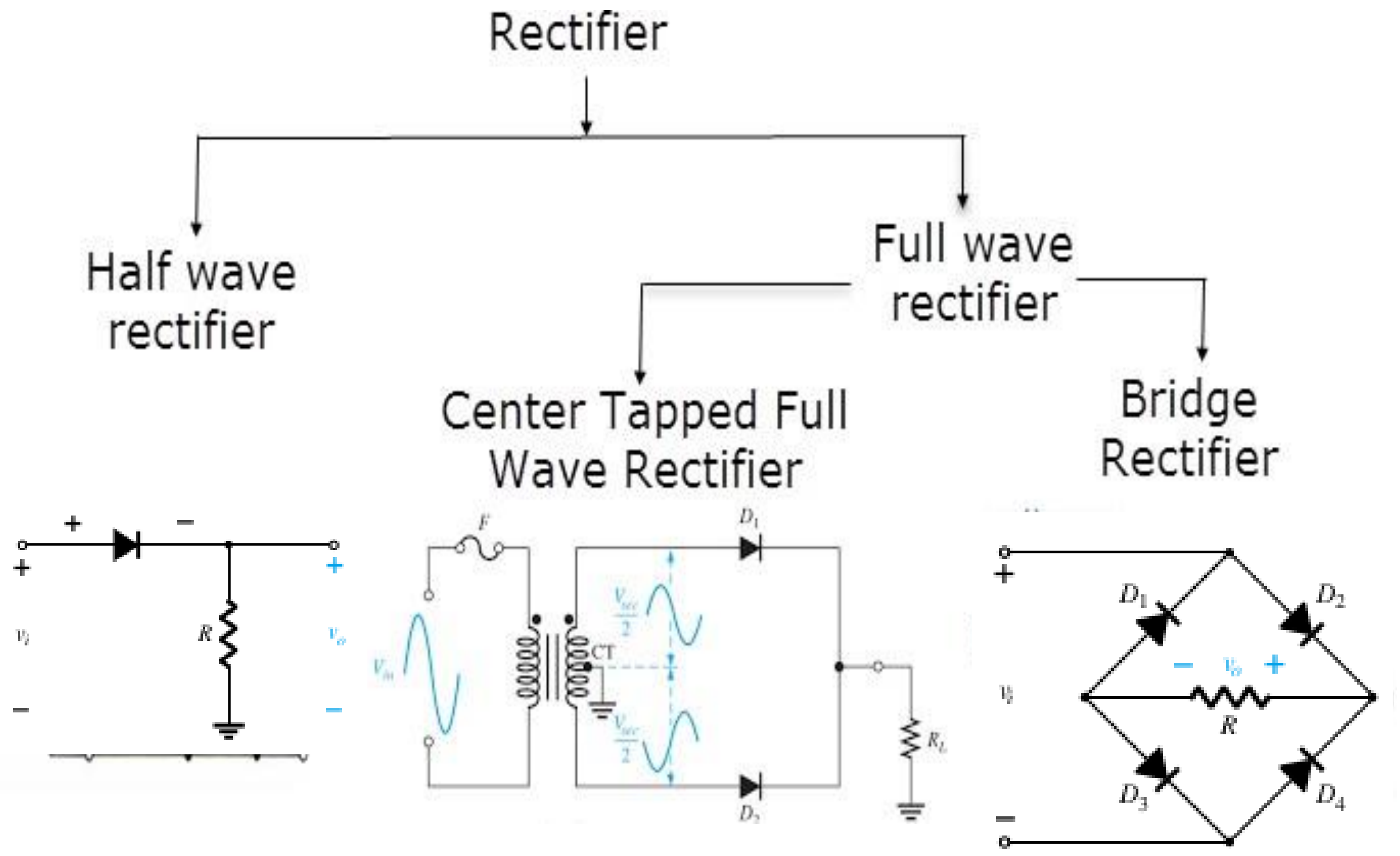
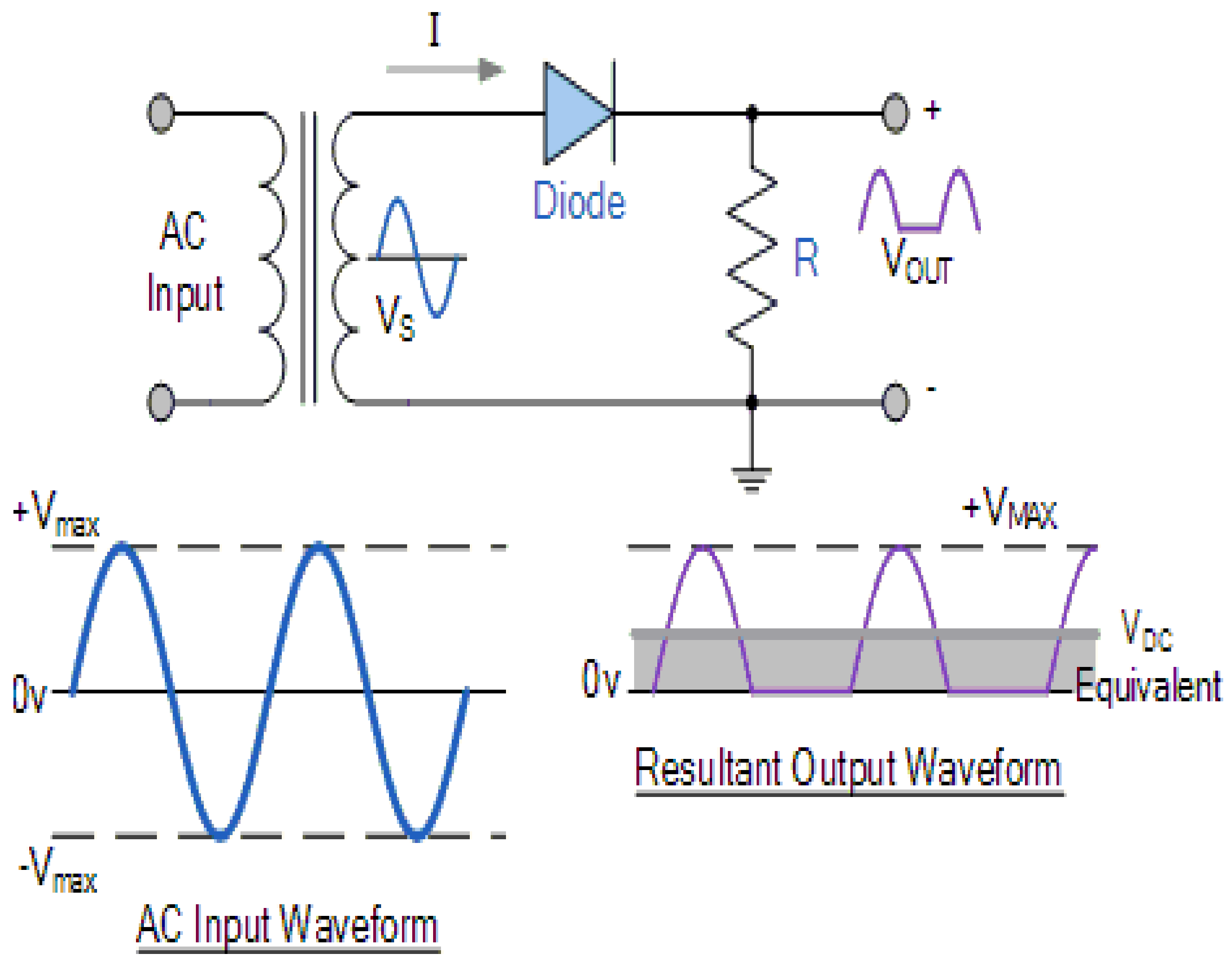
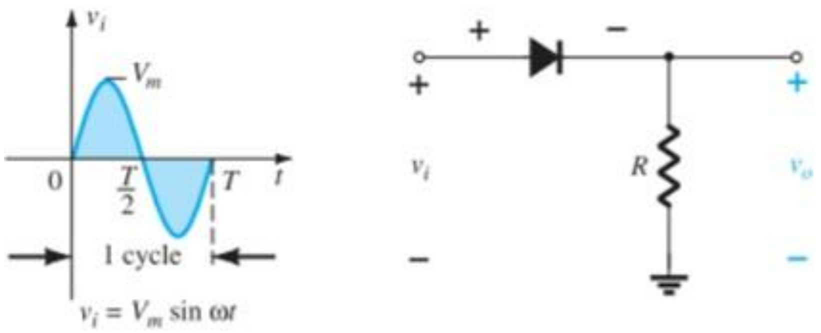
Unit 2 – Class 21 - Rectifiers

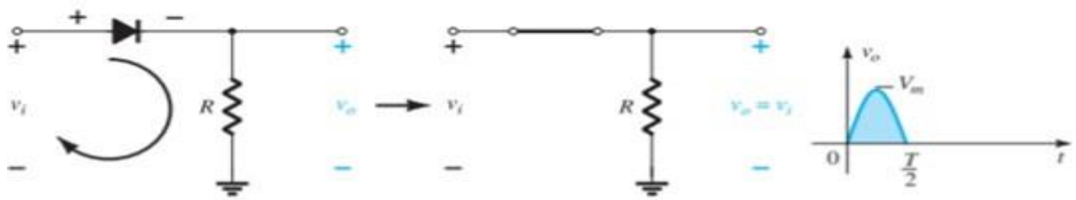


Half Wave Rectifier

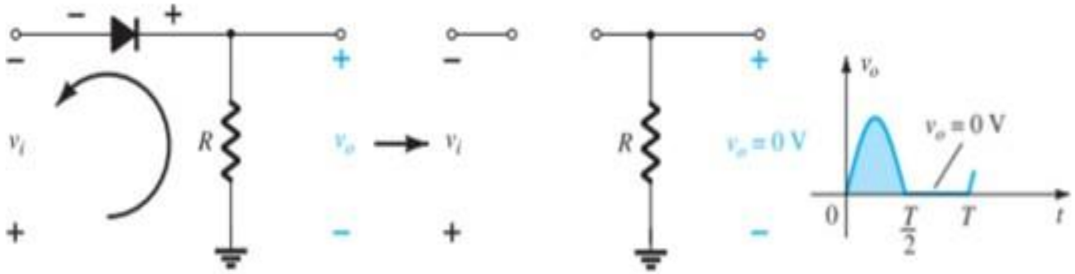


Half Wave Rectifier contd.



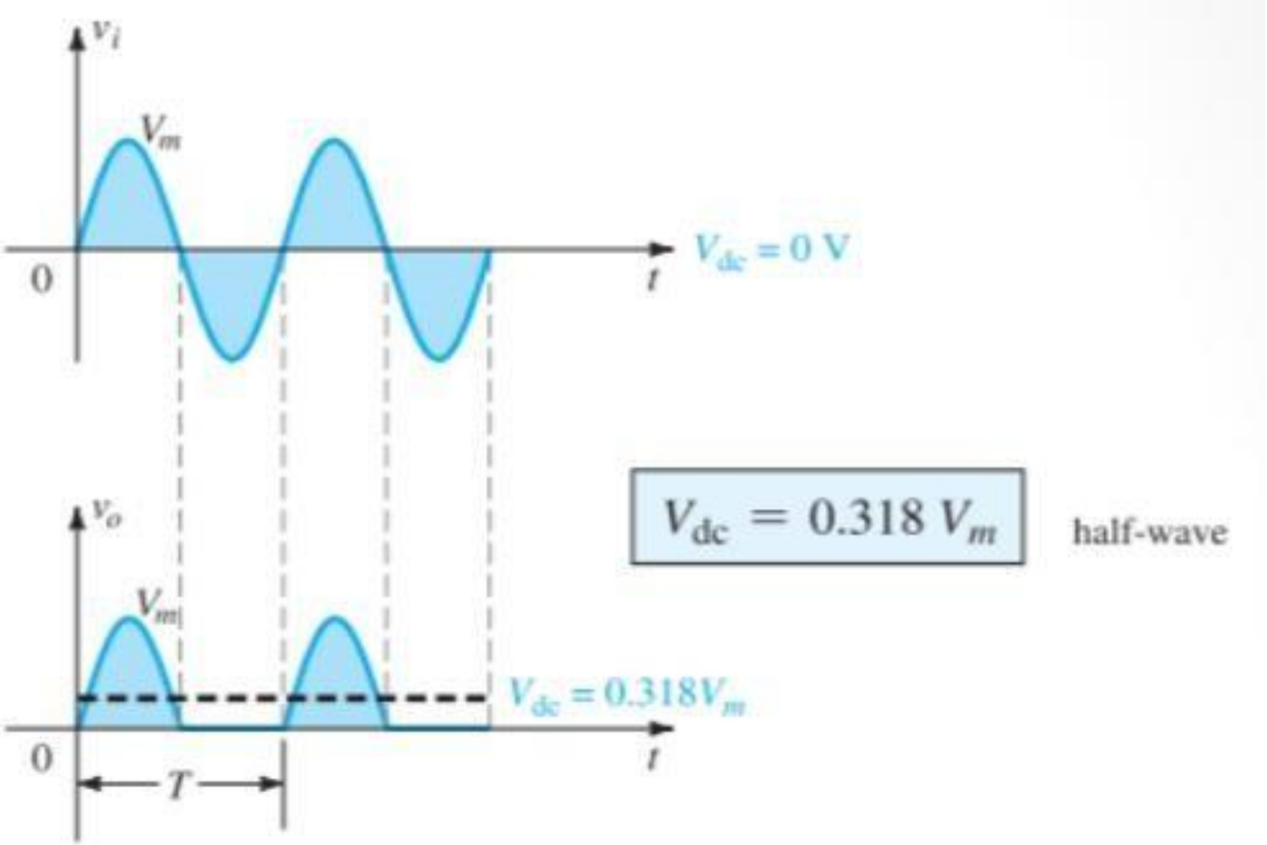


Conduction region ($0 \rightarrow T/2$).



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

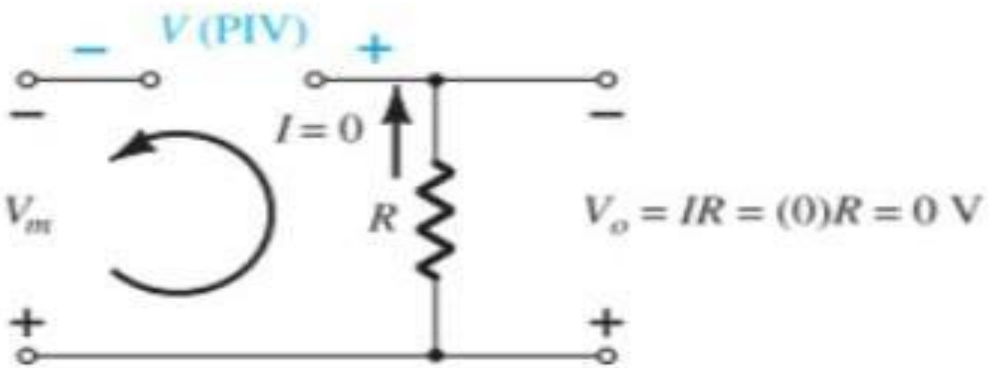
Half Wave Rectifier contd.



Half-wave rectified signal.

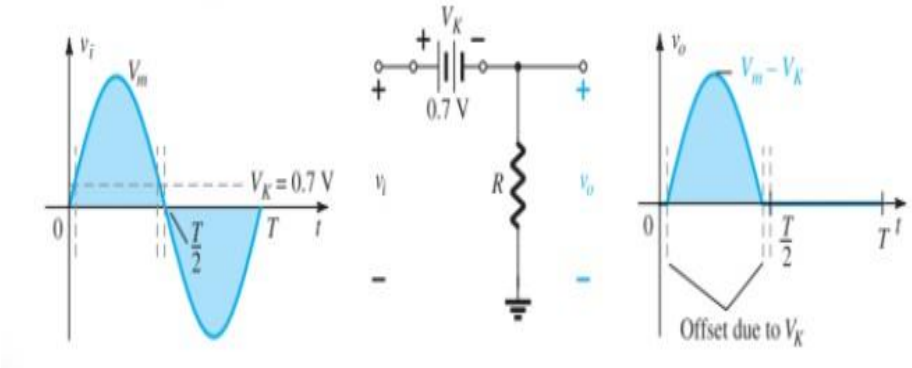
Half Wave Rectifier contd.

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



Half Wave Rectifier contd.

Effect of V_K on half-wave rectified signal.



Cross Over distortion

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

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Unit 2 - Semiconductor Diode applications – Class 22 -

Half wave rectifier – Vdc, Idc, ripple factor & PIV

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Unit 2 - Semiconductor Diode applications – Class 22 -

Half wave rectifier – Vdc, Idc, ripple factor & PIV – text book reference – section 2.6 – pages 76 to 78

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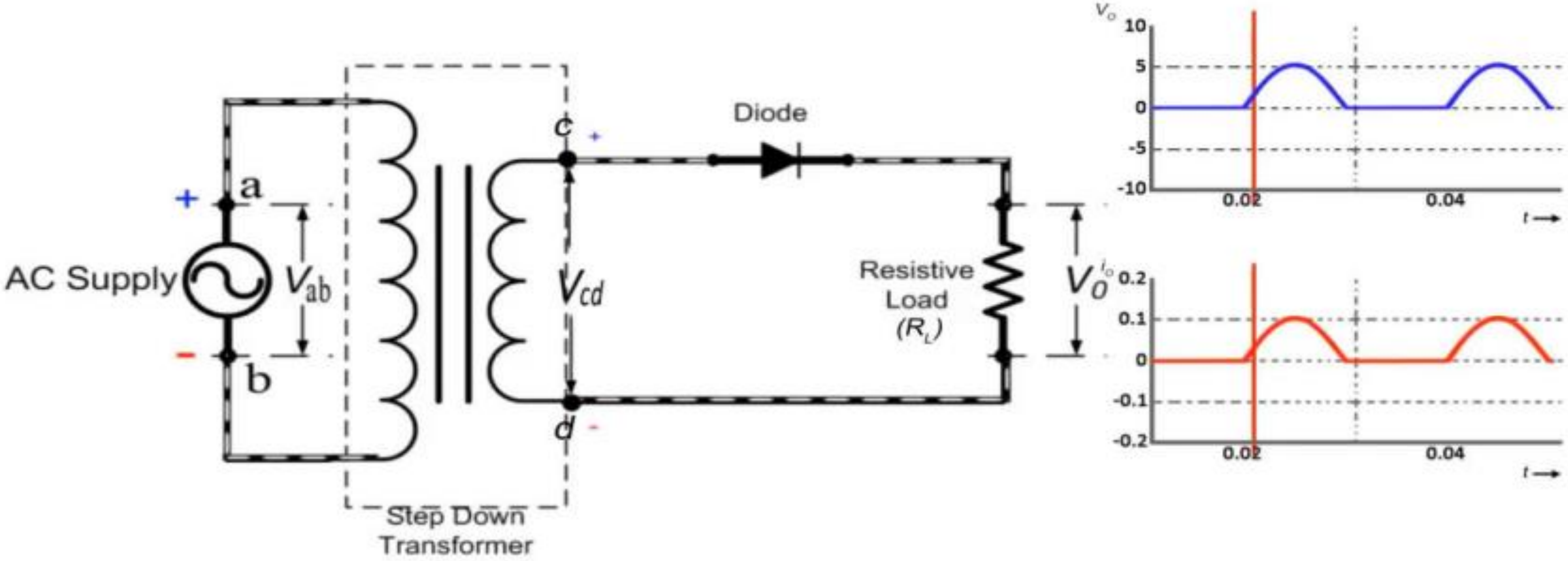
Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T



Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T

$$\text{Ripple Factor}, \gamma = \frac{\text{RMS value of AC component present in Rectifier Output}}{\text{Average Value of Rectifier Output}}$$

$$\gamma = \frac{I'_{rms}}{I_{dc}} = \frac{V'_{rms}}{V_{dc}}$$

where I'_{rms} and V'_{rms} are the rms value of alternating component of load current and voltage respectively.

Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T

$$I'_{rms} = \sqrt{I^2_{rms} - I^2_{dc}}$$ where I'_{rms} = rms value of AC Component

$$r = \frac{I'_{rms}}{I_{dc}} = \sqrt{\frac{(I^2_{rms} - I^2_{dc})}{I_{dc}}}$$

$$\boxed{r = 1.21}$$ For HWR

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

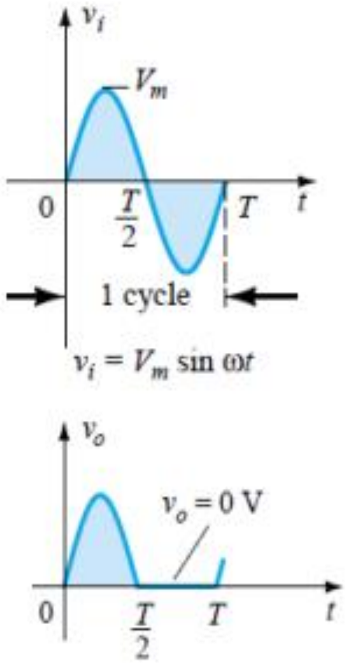
Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T

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

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

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



Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

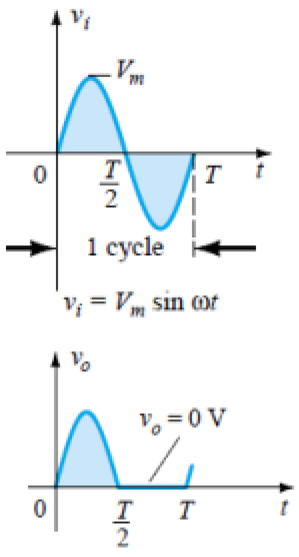
- T

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

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

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

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



Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T

$$V_{ac} = V - V_{dc}$$

$$V'_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} (V - V_{dc})^2 \; d\omega t\right]^{1/2}$$

$$= \left[\frac{1}{2\pi}\int_0^{2\pi} (V^2 - 2vV_{dc} + V_{dc}{}^2) \; d\omega t\right]^{1/2}$$

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

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

Unit 2 – Class 22 – HWR- Vdc, Idc, ripple factor, PIV

- T

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

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

$$\text{Ripple Factor } (\Upsilon_{HW}) = \frac{V'_{rms}}{V_{dc}} = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{V_m/2}{V_m/\pi}\right)^2 - 1}$$

$$= 1.211$$

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Unit 2 - Semiconductor Diode applications – Class 23 & 24 - **Full** wave rectifier configuration & working ;Vdc, Idc, ripple factor,PIV & comparison

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Unit 2 - Semiconductor Diode applications – Class 23 & 24 - Text book reference – section 2.7 – pages 79 to 81

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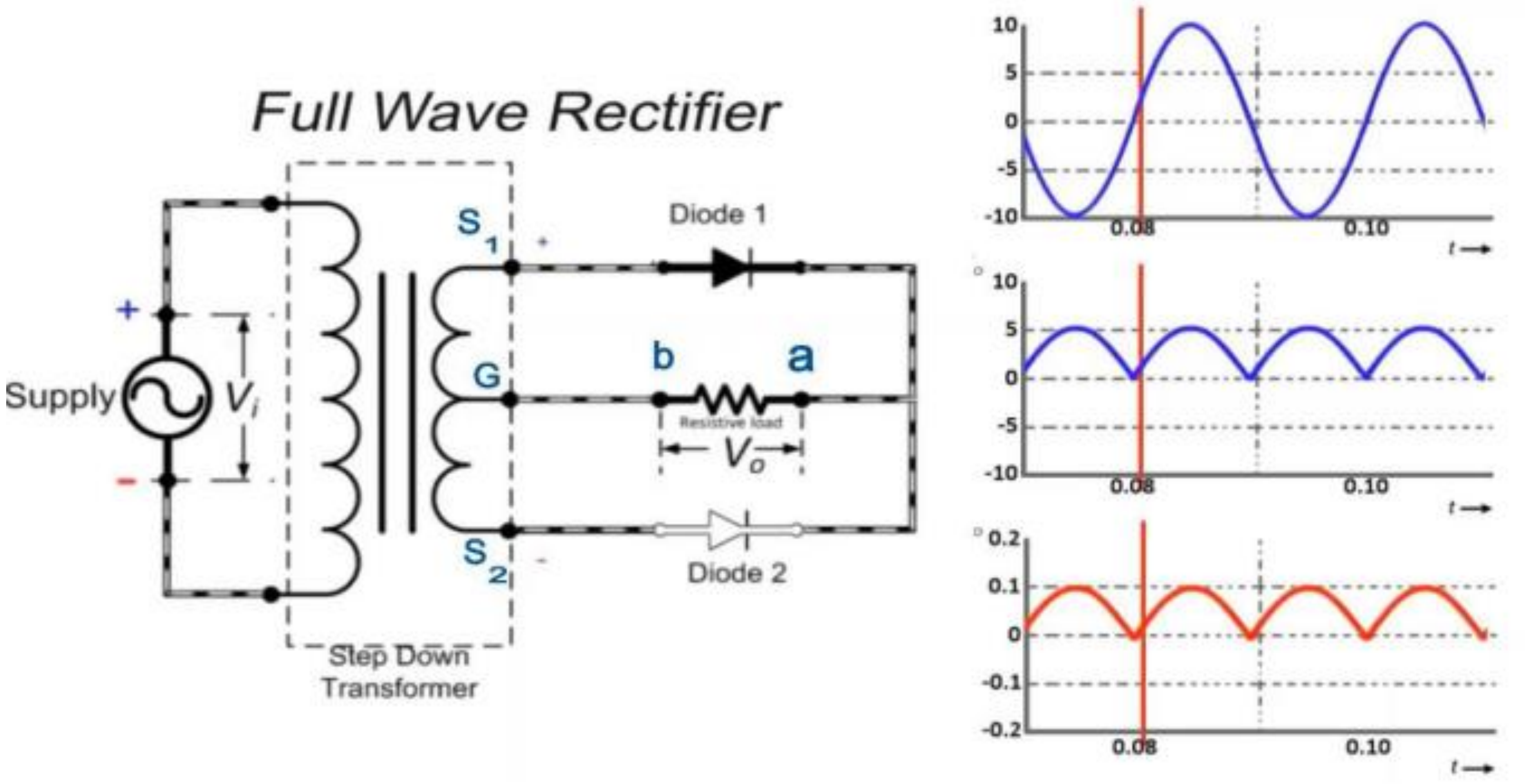
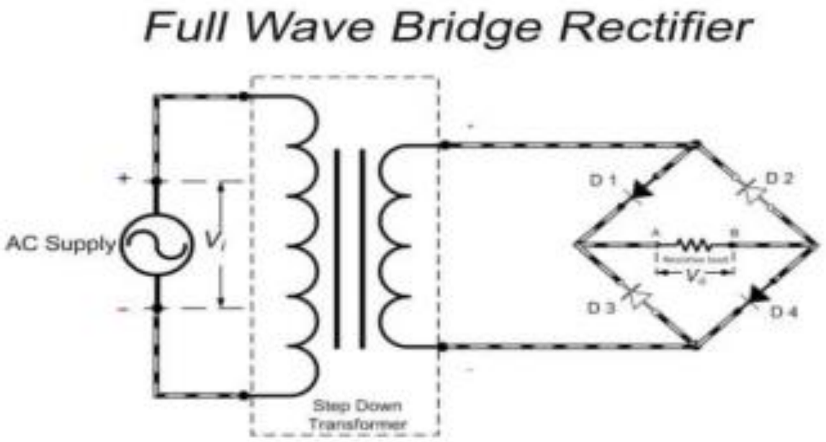
Unit 2 – Class 23 & 24 – Centre Tapped FWR

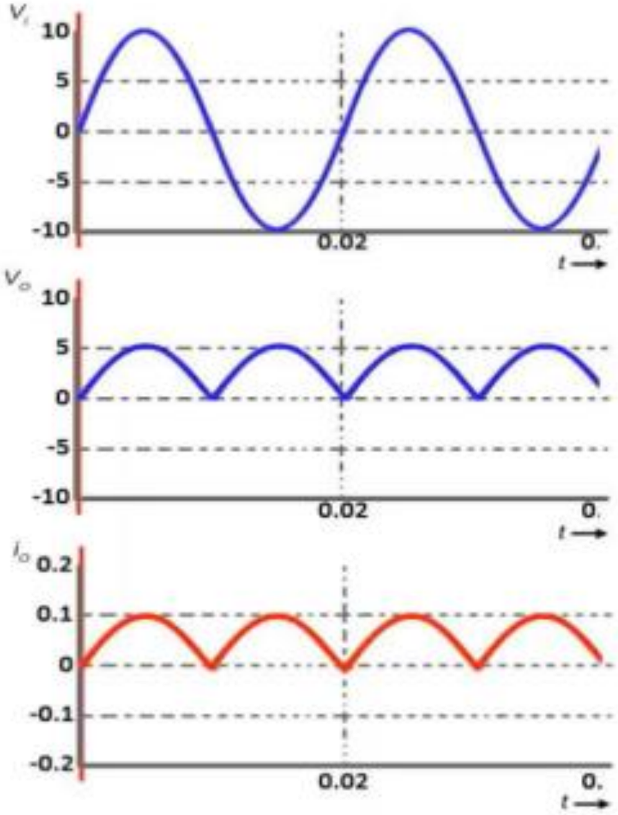
- T



Unit 2 – Class 23 & 24 – Full Wave Bridge Rectifier

- T





Unit 2 – Class 23 & 24 – Expression for Ripple factor

- T

$$\text{Ripple Factor, } \gamma = \frac{\text{RMS value of AC component present in Rectifier Output}}{\text{Average Value of Rectifier Output}}$$

$$\gamma = \frac{I'_{rms}}{I_{dc}} = \frac{V'_{rms}}{V_{dc}}$$

where I'_{rms} and V'_{rms} are the rms value of alternating component of load current and voltage respectively.

Unit 2 – Class 23 & 24 – Expression for Ripple factor

- T

$$I'_{rms} = \sqrt{I_{rms}^2 - I_{dc}^2}$$ where I'_{rms} = rms value of AC Component

$$r = \frac{I'_{rms}}{I_{dc}} = \sqrt{\frac{(I_{rms}^2 - I_{dc}^2)}{I_{dc}}}$$

$$\boxed{r = 0.48}$$ **For FWR**

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

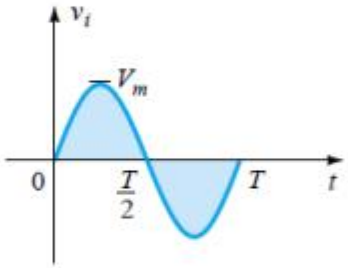
Unit 2 – Class 23 & 24 – Expression for Vdc

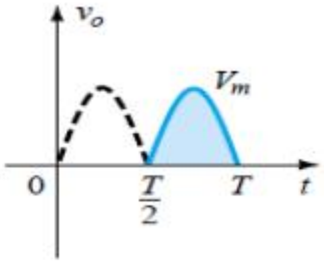
- T

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

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

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





Unit 2 – Class 23 & 24 – Expression for Vrms

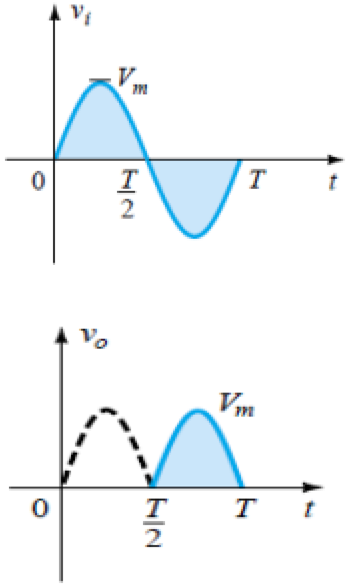
- T

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

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

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

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



Unit 2 – Class 23 & 24 – Expression for Vrms’

- T

$$V_{ac} = V - V_{dc}$$

$$V'_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi}(V - V_{dc})^2 \ d\omega t\right]^{1/2}$$

$$= \left[\frac{1}{2\pi}\int_0^{2\pi}(V^2 - 2vV_{dc} + V_{dc}{}^2) \ \ d\omega t\right]^{1/2}$$

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

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

Unit 2 – Class 23 & 24 – Expression for Vrms' & ripple factor

- T

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

$$= \left[\left(\frac{V_m}{\sqrt{2}}\right)^2 - \left(\frac{2V_m}{\pi}\right)^2\right]^{1/2} = 0.308V_m$$

$$\text{Ripple Factor } (\Upsilon_{HW}) = \frac{V'_{rms}}{V_{dc}} = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{V_m/\sqrt{2}}{2V_m/\pi}\right)^2 - 1}$$

$$= 0.48$$

Unit 2 – Class 23 & 24 – Comparison

- T

Measure	HWR Ideal	HWR Practical	CT-Ideal	CT-Practical	Bridge- Ideal	Bridge-Practica
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	$V_m - V_k$

Unit 2 – Class 23 & 24 – Full Wave Bridge Rectifier

- T

Sl No.	Parameter	HWR	FWR
1	V'_{rms}	$0.385V_m$	$0.305V_m$
2	Efficiency	40.6%	81.2%
3	Ripple factor	1.21	0.48

Unit 2 – Class 23 & 24 – Differences between CT-FWR & Bridge-FWR

•T

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	No isolation between Input and output	Isolation due to CT-Transformer
5	4 diodes are required	2 diodes are required
6	More voltage drop due to two diodes in the path	Comparatively less voltage drop due to only one diode in the path
7	Lesser rectification efficiency	Comparatively better

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Unit 2 - Semiconductor Diode applications – Class 26 – Problems on Half Wave Rectifier

Ms. Ashwini
Department of Electronics and Communication.

ELECTRONIC PRINCIPLES AND DEVICES

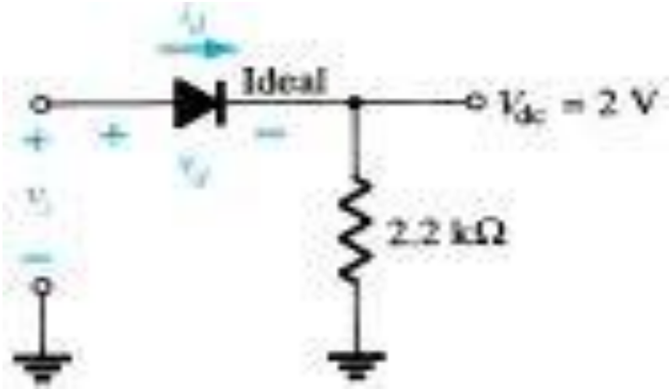
Unit 2 - Semiconductor Diode applications – Class 26 – Text book reference – Section 2.6 – Pages 77 to 80

Ms. Ashwini

Department of Electronics and Communication.

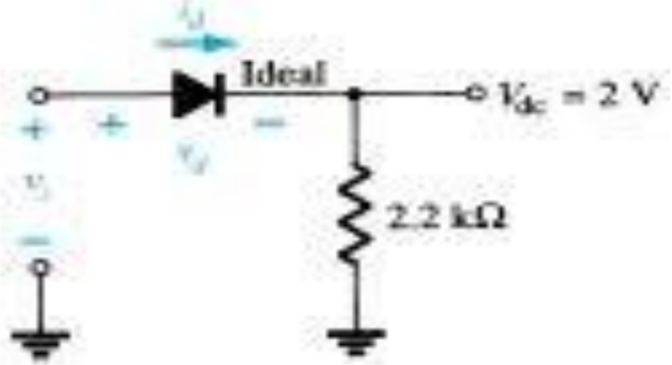
Unit 2 – Class 26 - Solved example

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

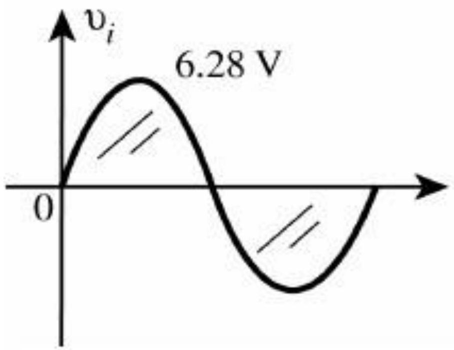


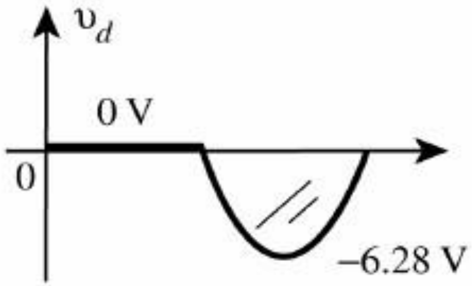
Unit 2 – Class 26 - Solved example

Solution:

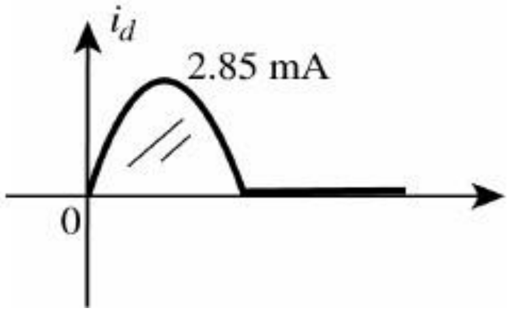


$$V_{dc} = 0.318\, V_m \Rightarrow V_m = \frac{V_{dc}}{0.318} = \frac{2\text{ V}}{0.318} = \mathbf{6.28\ V}$$



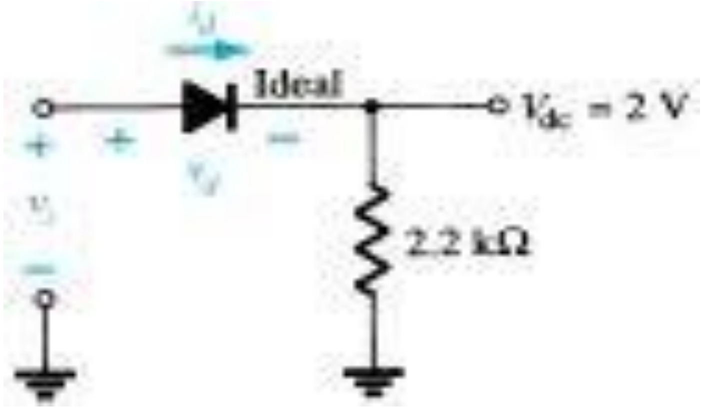


$$I_m = \frac{V_m}{R} = \frac{6.28\text{ V}}{2.2\text{ k}\Omega} = \mathbf{2.85\ mA}$$



Unit 2 – Class 26 - Solved example

Assuming a silicon diode (V_T 0.7 V), sketch *vi*, *vd*, and *id* for the half-wave rectifier . The input is a sinusoidal waveform with a frequency of 60 Hz



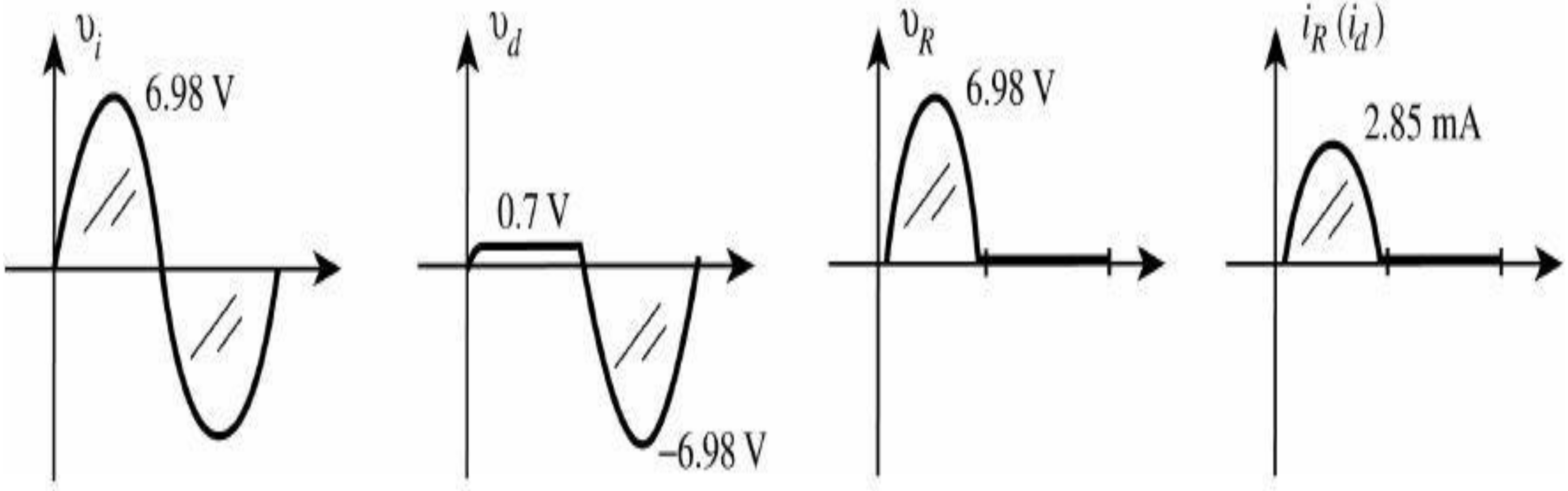
Unit 2 – Class 26 - Solved example

Solution:

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

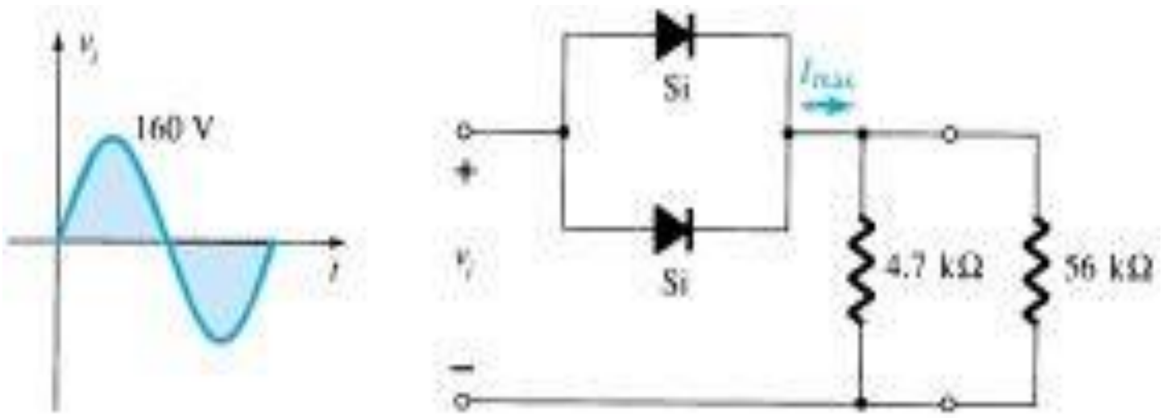
$$2\ \text{V} = 0.318(V_m - 0.7\ \text{V})$$

Solving: $V_m = \mathbf{6.98\ V} \cong 10{:}1$ for $V_m{:}V_T$



Unit 2 – Class 26 - Solved example

(a)Given P_{max} = 14 mW for each diode shown, determine the maximum current rating of each diode (using the approximate equivalent model).
(b) Determine I_{max} for V_{imax} 160 V.
(c) Determine the current through each diode at V_{imax} using the results of part (b).
(d) If both the diodes are present, compare $Idiode$ with the maximum current rating of the diode?
(e) If only one diode is present, compare Idiode with the maximum current rating of the diode?



Unit 2 – Class 26 - Solved example

Solution:

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

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

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

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

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

(c) $$I_{diode} = \frac{I_{max}}{2} = \frac{36.71\text{ mA}}{2} = \mathbf{18.36\text{ mA}}$$

d) I diode = 18.36 mA; maximum rating = 20 mA . Diode is safe

e) Idiode = 36.71 mA; maximum rating = 20 mA ; Diode gets damaged

Unit 2 – Class 26 - Practice problem

Numerical - A diode whose internal resistance is 20 Ω is to supply power to a 1KΩ
load from a 110 V source of supply.
Calculate (i) the peak load current
(ii) r.m.s load current
(iii) peak inverse voltage
(iv) output DC voltage.
Draw the circuit diagram with all the component values.

Solution – Refer Class Notes

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Unit 2 – Semiconductor Diode applications – Class 27 & 28 – Problems on CT Full Wave Rectifier & Bridge Rectifier

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Unit 2 –Class 27 & 28 – Problems on CT Full Wave Rectifier & Bridge Rectifier – Text book reference – 81 to 84 & 776 to 778

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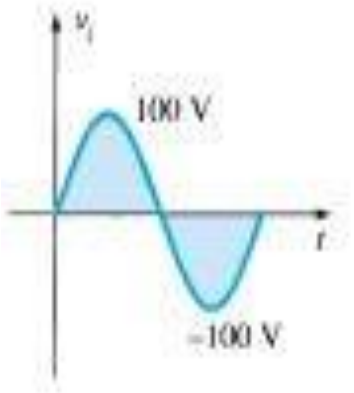
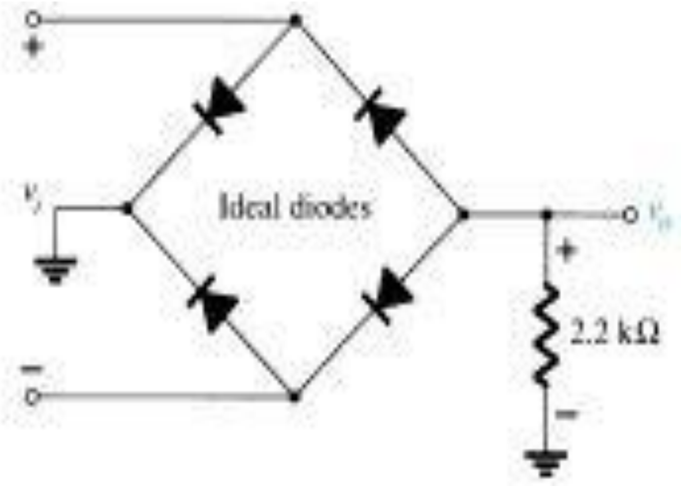
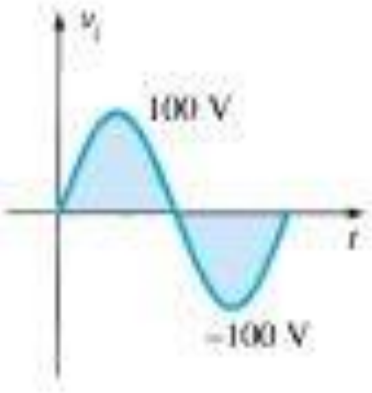
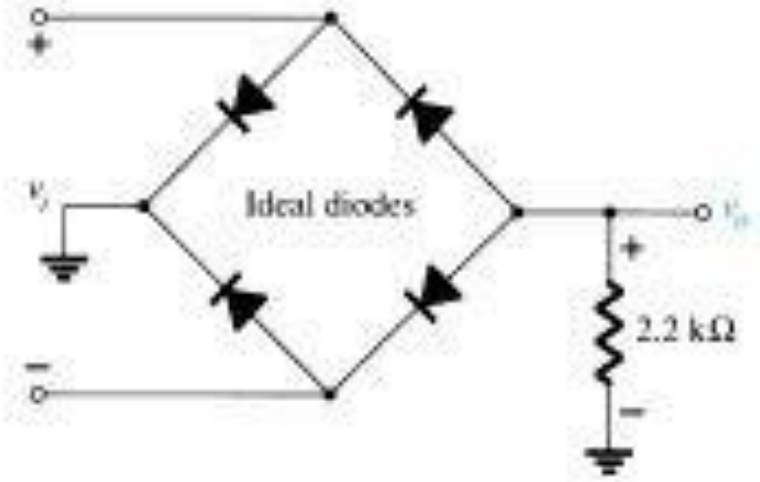
Determine V_o and the required PIV rating of each diode for the configuration

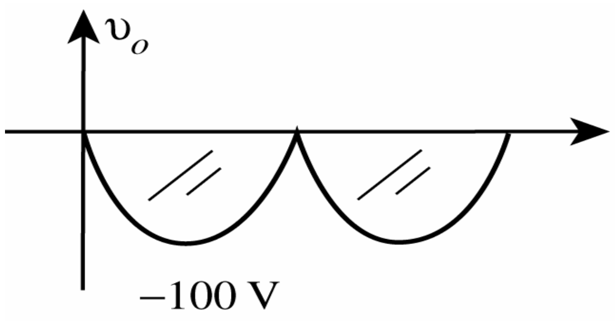




Solution:

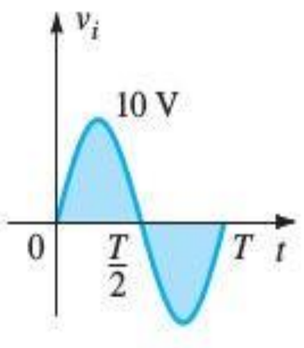


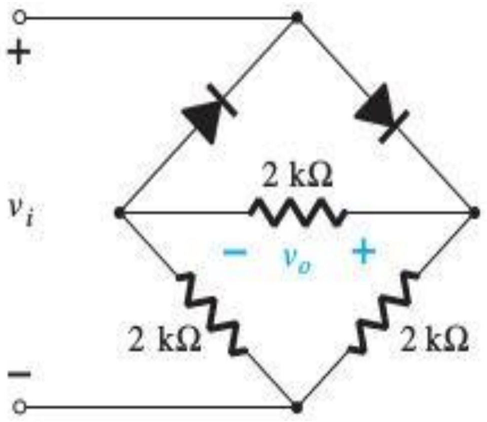




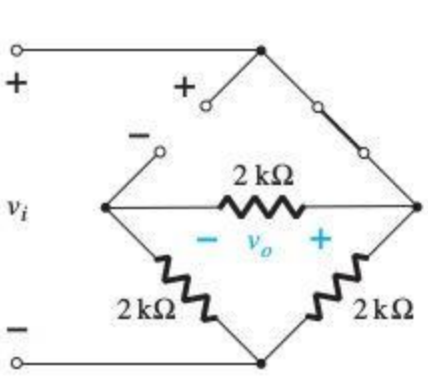
PIV = **100 V**

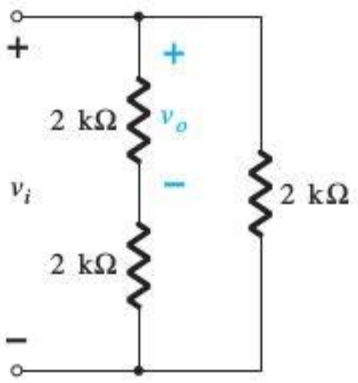
Determine the output waveform for the network and calculate the output dc level and the required PIV of each diode.

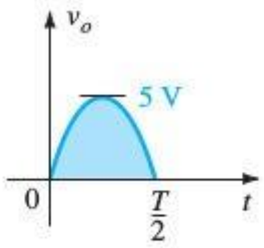


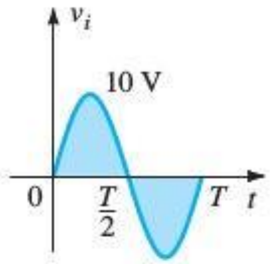


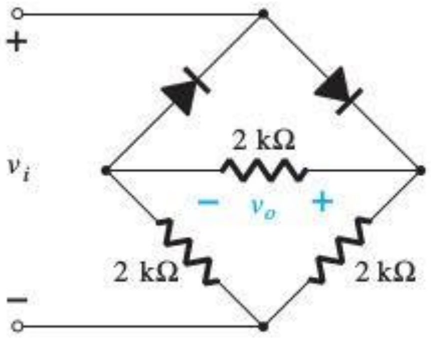
Solution:





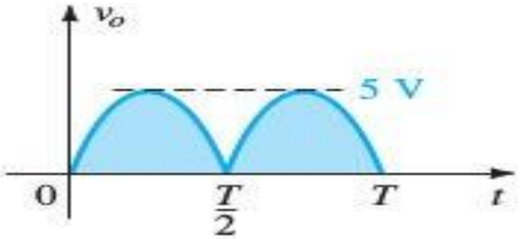






$V_o max = (2/4)\ V_i max = (2/4)\ (10\ V) = 5\ V$

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



A full-wave bridge rectifier with a 120-V rms sinusoidal input has a load resistor of 1 k.

(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?

Solution:

(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) $\text{PIV} = V_m(\text{load}) + V_D = 168.3\text{ V} + 0.7\text{ V} = \mathbf{169\ V}$

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

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

In a centre- tap FWR $R_L = 1K\Omega$, Each diode has forward bias dynamic resistance $r_d = 10\Omega$ …...Voltage across half secondary winding is 220sin314t.

Find I_{dc}, I_m, I_{rms}, r ,η(Efficiency).

Unit 2 – Class 27 & 28 - Solved example

Solution:

Given, $V_m = 220v$

$I_m = (V_m - V_k)/(R_d + R_l)$

$I_{dc} = 2I_m/\pi = 138.173mA$ and $I_{rms} = I_m/\sqrt{2} = 153.53mA$

$$RF = \frac{[I_{rms}^2 - I_{dc}^2]^{1/2}}{I_{dc}} = 0.484$$

$P_{dc} = I_{dc}^2 R_l = 19.09W$ and $P_{ac} = I_{rms}^2 (R_l + R_d) = 23.8W$

$\eta = P_{dc}/P_{ac} = 80.21\%$

Unit 2 – Class 27 & 28 - Solved example

1. 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 and each diode has a forward resistance of 25Ω Find (i) Average current (ii) Average output voltage (iii) PIV of diode.

Ans: $V_{dc} = 87.39V$, $I_{dc} = 0.089A$ and PIV = 282V.

2. 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: $V_{dc} = 49.5V$, $I_{dc} = 0.247A$ and $f_o = 100Hz$.

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Unit 2 – Class 29 – Shunt Capacitor Working

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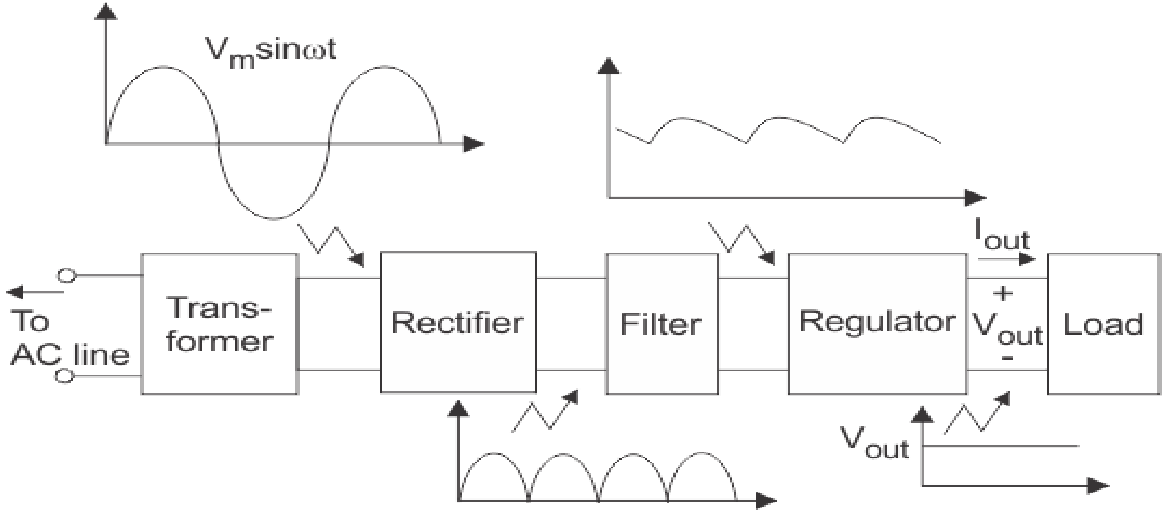
Unit 2 – Class 29 - Filter



Components of typical linear power supply

An electronic circuit which passes desired electrical component & blocks/reduces unwanted is called as filter

Types of Filters:

- AC Filter
- DC Filter

- The filter is an electronic device that allows dc components and blocks the ac components of the rectifier output is said to be DC filter

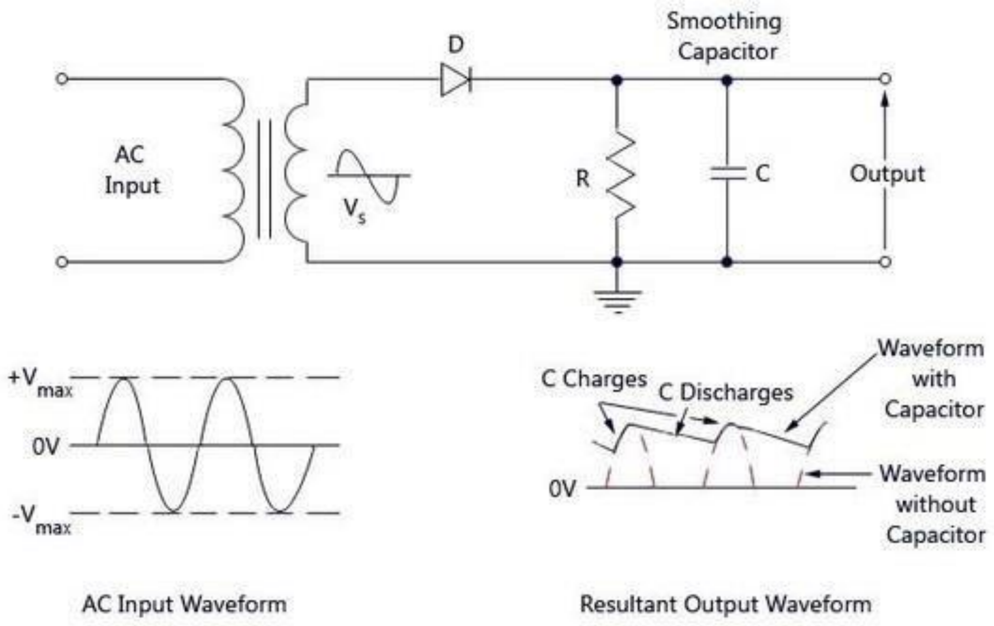
- Filter is made up of a combination of components such as capacitors, resistors, and inductors

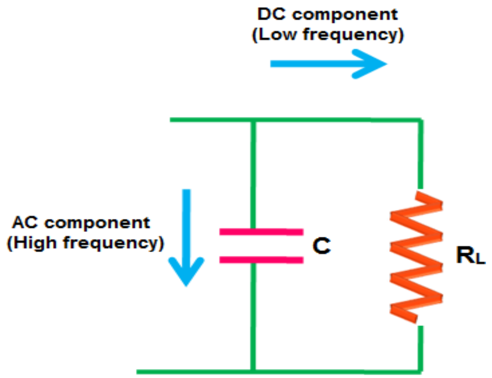
- A capacitor allows the ac component and blocks the dc component. The inductor allows the dc component and blocks the ac component

- A capacitor is connected in parallel to rectifier to form Shunt Capacitor Filter

Unit 2 – Class 29 - Shunt Capacitor Filter

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





The capacitor provides high resistive path to dc components (low-frequency signal) and low resistive path to ac components (high-frequency signal)

Unit 2 – Class 29 - Shunt Capacitor Filter for Half – Wave Rectifier

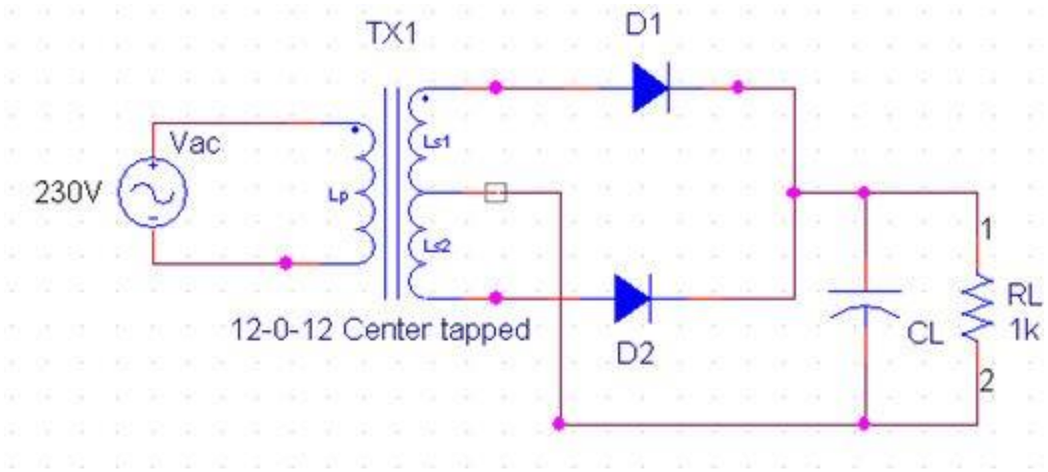
- The main duty of the capacitor filter is to short the ripples to the ground and blocks the pure DC (DC components), so that it flows through the alternate path and reaches output load resistor R_L
- The flow of AC components through the capacitor is nothing but the charging of a capacitor

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

Ripple Factor for a capacitor filter (HWR) = $1/(2\sqrt{3}\, f\, C\, R_L)$

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

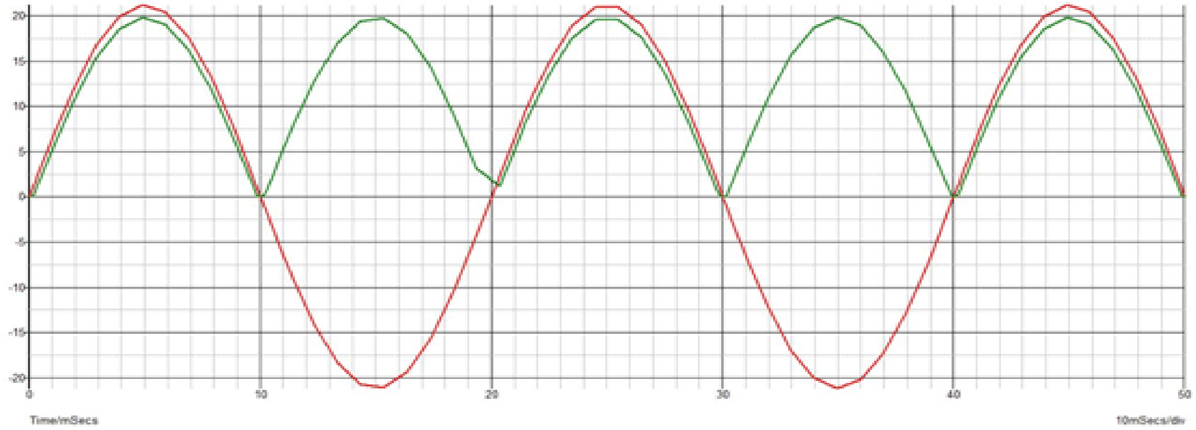
Unit 2 – Class 29 - Shunt Capacitor Filter for Centre-Tapped Full Wave Rectifier



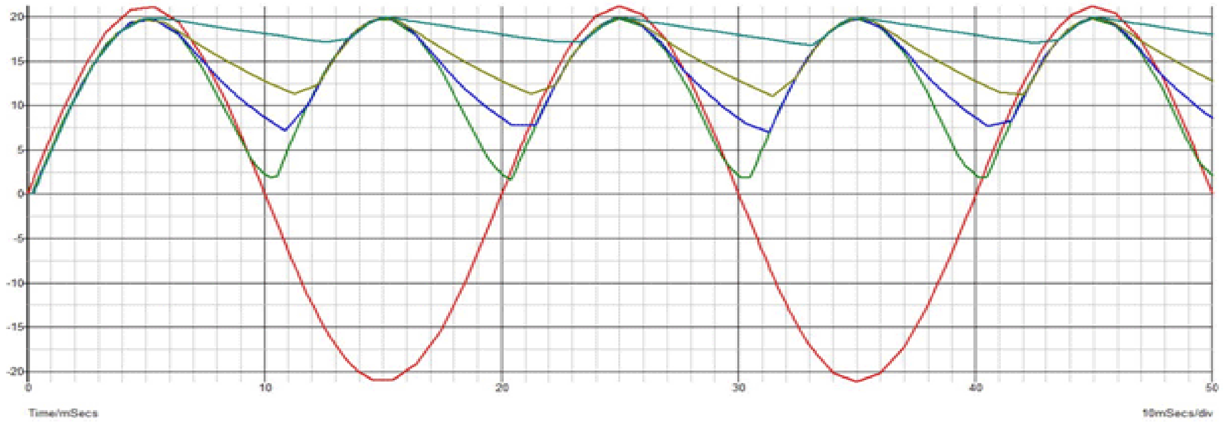
➢ The pulsating Direct Current (DC) produced by the full wave rectifier contains both AC and DC components

➢ DC current that contains both DC components and AC components reaches the filter, the DC components experience a high resistance from the capacitor whereas the AC components experience a low resistance from the capacitor

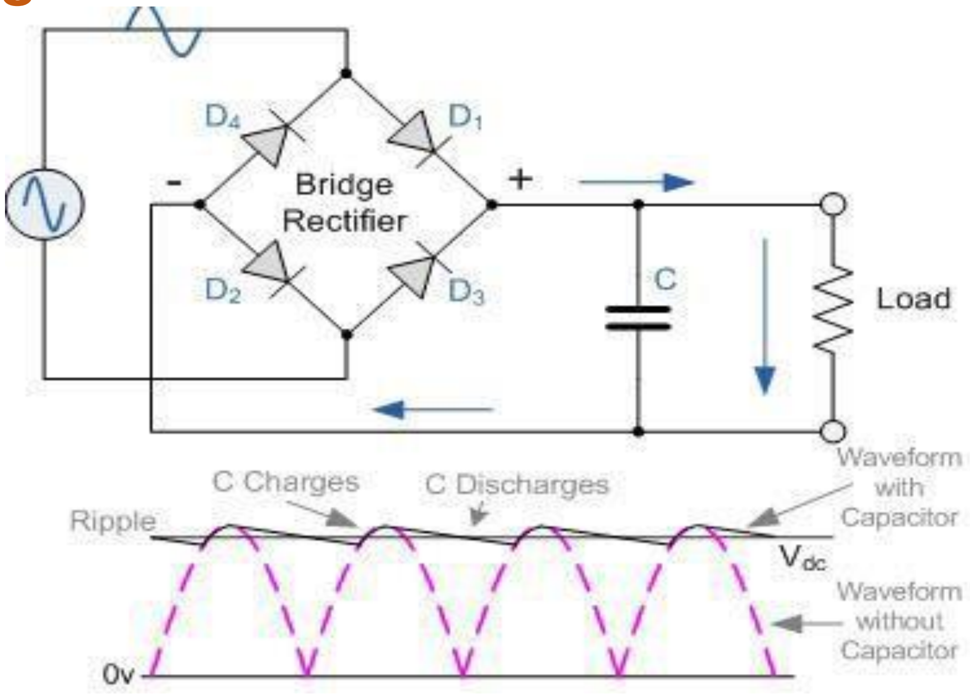
Unit 2 – Class 29 - Shunt Capacitor Filter: Waveforms



Filter output for different values of shunt capacitor



Unit 2 – Class 29 - 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

Unit 2 – Class 29 - Shunt Capacitor Filter for Bridge Rectifier

The capacitor filter present at the output removes the unwanted AC components. Thus, a pure DC is obtained at the load resistor R_L

Ripple Factor for a capacitor filter (FWR) = $1/(4\sqrt{3}\, f\, C\, R_L)$

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

Above Expression Holds the same meaning for both the Full Wave Rectifier Circuits

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UNIT-2: Semiconductor Diode and Applications – Class 30 – Problems on Shunt Capacitor filter

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UNIT-2: – Class 30 – Text book reference – Section 15.3 – Page 777

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UNIT - II: Class 30 - Numerical on Shunt capacitor Filter

Question No. 1: A half wave rectifier, operated from a 50Hz supply uses a 1000µF capacitance connected in parallel to the load of rectifier. What will be the minimum value of load resistance that can be connected across the capacitor if the ripple% not exceeds 5?

Solution: For a half wave filter,

Ripple Factor=1/2√3 f CR_L

$=1/\{2\sqrt{3}*50*10^{-3}*R_L\}$

$\mathbf{R_L=10^3/5\sqrt{3}}$

$\mathbf{R_L= 115.47\Omega}$

UNIT - II: Class 30 - Numerical on Shunt capacitor Filter

Question No. 2: A 100µF capacitor when used as a filter has 15V ac 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 frequency in the output?

Solution:

For a full wave rectifier,

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

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

$= 0.01154.$

So, ripple factor is 1.154%

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Question No. 3: 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.

Solution:

The ripple factor for Full Wave Rectifier

$\Upsilon = I_L / 4\sqrt{3}\, f\, C V_{DC}$

$V_{DC} = 200*10^{-3} / 4\sqrt{3} * 50 * 500 * 8$

$V_{DC} = 14.43V$

Question No. 4: A shunt capacitor of value 500µF fed rectifier circuit. The dc voltage is 14.43V. The dc current flowing is 200mA. It is operating at a frequency of 50Hz. What will be the value of peak rectified voltage?

Solution:

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

$=14.43+ \{200/ (200*500)\} 10^3$

$=14.43+2=16.43V$

$V_m = 16.43V$

Unit 2 – Class 30 - Shunt Capacitor Filter – A Solved Problem

Q. No. 1 Calculate the ripple factor of a capacitor filter connected to a full wave rectifier, C=50μF if the peak rectified output voltage is 30V and a load current is 50mA

Solution:

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

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

$$given V_{dc} = 30V, I_{DC} = 50mA,$$

$$f = 50Hz, C = 50\mu F,$$

$$sustitutingthevalues, \gamma = 0.043$$

UNIT - II: Class 30 - Numerical on Shunt capacitor Filter

Question:64) Draw the circuit diagram of a centre tapped FWR with capacitor filter. If the filter capacitor is 120 micro F and load current of 80mA calculate the %ripple of the output. The FWR is operating from 50Hz supply and develops a peak rectified voltage of 25V.
Vrms= 1.92,,Vdc=21.66 ,,,R=8.8% - For Solution Refer Class Notes

Question: 65) A 500 micro F capacitor filter provides a load current of 200mA at 8% ripple to a FWR . Calculate the peak value of the rectified voltage obtained from a 50Hz supply and the DC voltage across the filter capacitor. Draw the circuit diagram.FWR – For Solution Refer Class Notes
Vdc=14.4,,Vm=16.4

UNIT - II: Class 30 - Numerical on Shunt capacitor Filter

Question : 68) Calculate the size of capacitor filter needed to obtain a filtered Dc voltage of 24V having 5% ripple at a load of 150mA from a full wave rectifier operating with a supply of 60HZ – For Solution – Refer Class Notes

Vrms=12V,,c=300micro

Question:66) Calculate the size of capacitor filter needed to obtain a filtered DC voltage of 24V having 15% ripple at a load of 150mA from a half wave rectifier operating with a supply of 60Hz. – For Solution Refer Class Notes

RL=160,,C=200micro

Question:43) A Bridge rectifier with ideal diode has a ac source of RMS value 220V 50Hz connected to the primary of transformer. If the load resistance is 200 ohm and the turn ratio of transformer 4:1 find the DC voltage , dc output current and output frequency

Vdc=49.51,,,idc=0.247,,fo=100

Question :44) 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 ohm and each diode has a forward resistance of 25 ohm find Average current , Average output voltage and PIV

Vdc=89.52,,,Idc=89.58mA,,,piv=282.14

Question : 45) A full wave bridge rectifier is constructed with si diode and source of Vrms= 120V has a load resistance of 1K . Determine DC voltage across RL , PIV rating of each diode , find the Max current through each diode during conduction , what is the required power rating of each diode

Vdc=107.14,,piv=169,,im=168.3mA,,P=117.81mW

Question : 46) A center tapped full wave rectifier constructed with si diode has a secondary coil voltage of Vrms 20V with the load resistance of 1.5K Determine Im, Idc and Vrms across RL

Im=18.38mA,,,idc=11.7mA,,,vrms=19.5

Question :) 2 diode FWR with secondary winding voltage 100V , load resistance 1K . Find all the parameter

Vm=141.42,,,im=14.72,,,idc=89.6mA,,piv=281.44

Question :47) A full wave bridge rectifier constructed with si diode has a secondary coil voltage of Vrms 20V with the load resistance of 1.5K Determine Im, Idc and Vrms across RL

Vm=28.28,,,,im=18.38mA,,idc=11.7mA,,,Vrms=19.5

Unit 2 – Class 30 - Numerical on Rectifier

Question : Centre tap FWR with load resistance 1K and dynamic resistance of diode 10 ohm with secondary winding voltage 200sin(314t). Find all the parameter

Im=197.32,,,idc=125.617,,,vdc=126.87,,irms=139.526,,E=80.25,,,R=0.48

Question : Center Tapped FWR with ideal diode with Vrms 200V and load resistance 2K , **Find all the parameter**

Vm=282.8,,,im=141.4mA,,,idc=90.03mA,,vdc=180.06…Irms=0.099
Piv=565.6,,,r=0.483

Question : A diode with internal resistance 20 ohm is to supply power to a 1K load from 110V source of supply ,find all parameter (HWR)

Vm=110,,,im=107.16mA,,,irms=53.58mA,,,piv=110,,vdc=34.8

Question : A semi conductor diode having internal resistance 20 ohm is used HWR if applied voltage is 50sinwt and RL 800 ohm . Find all the parameter.

Im=0.06,,,idc=19mA,,,irms=30mA,,,,vdc=15.69,,,E=40.11

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UNIT-2: Class 32 to 34 –Zener diode Voltage Regulator – 3 cases

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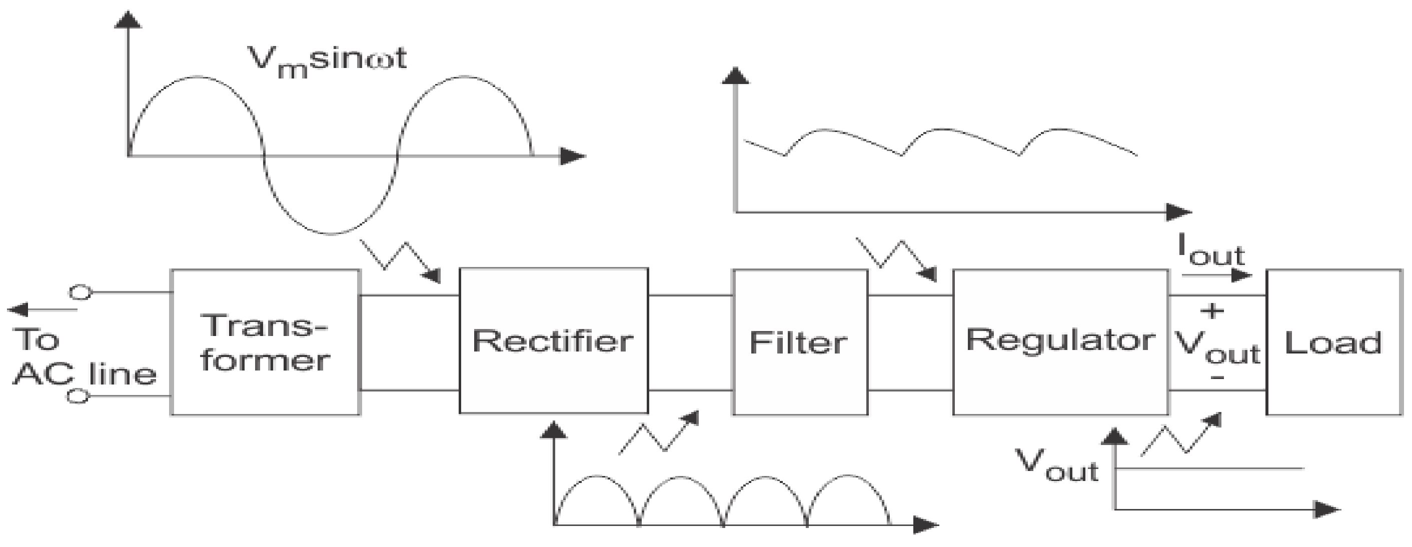
UNIT - II: Class 32 to 34 Voltage Regulator



Components of typical linear power supply

Filtered-Fluctuating signal to smooth constant DC signal is the output of Regulator Circuit

Voltage Regulating Device:

❖ Zener Diode

- Heavily Doped PN-Junction Device Specially Designed to operate under breakdown region

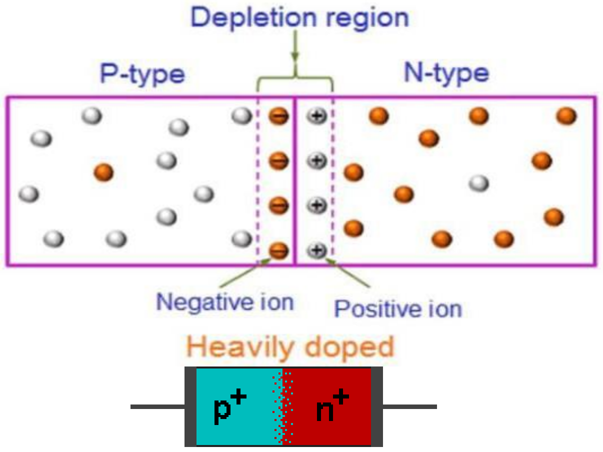
- Zener Diode under Forward Bias & Reverse Bias, its functioning is controlled by the current

- Zener Diode under forward Bias condition works like a normal semiconductor diode

- Zener Diode under reverse bias condition acts like Voltage regulator

UNIT - II: Class 32 to 34 - Zener Diode Characteristics

Structure of Zener Diode



Symbol of Zener Diode

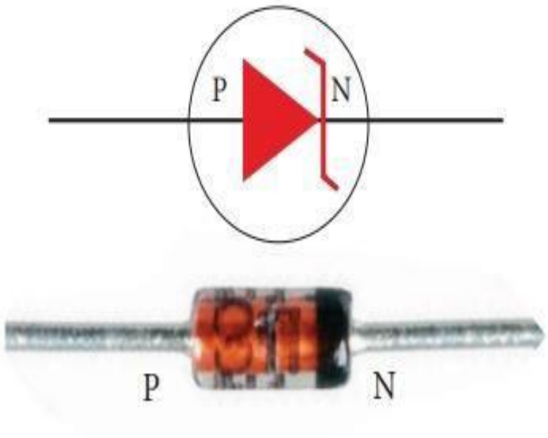


Figure (a) Zener diode and its symbol
(The black colour ring denotes the negative terminal of the Zener diode)

V-I Characteristics of Zener Diode

V-I Characteristics of Zener Diode in Forward Bias Condition

V-I Characteristics of Zener Diode in Reverse Bias Condition

UNIT - II: Class 32 to 34 - Zener Diode Characteristics

Forward Bias & Reverse Bias

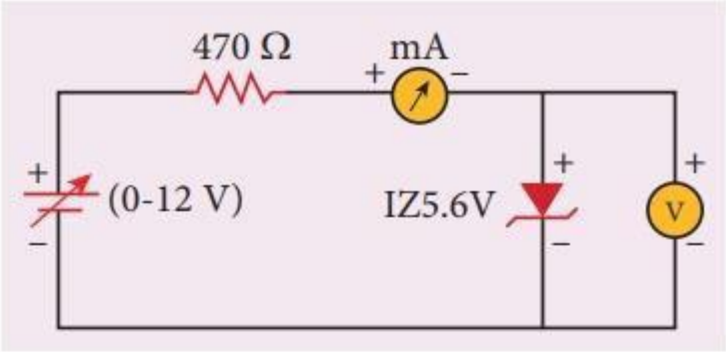


Figure (b) Zener diode in forward bias

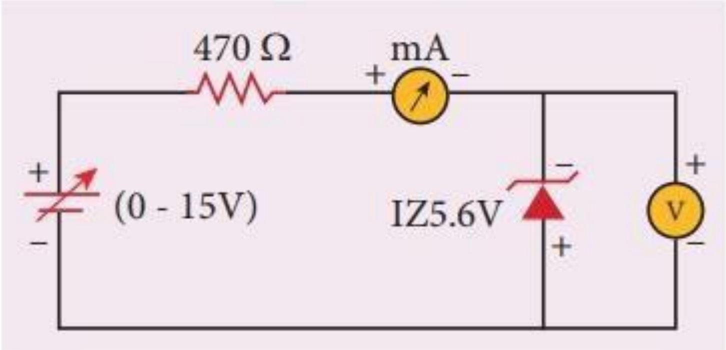
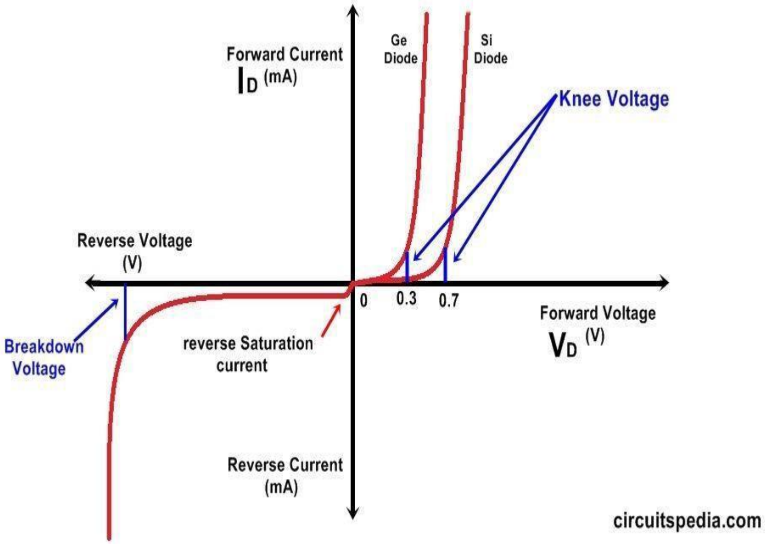


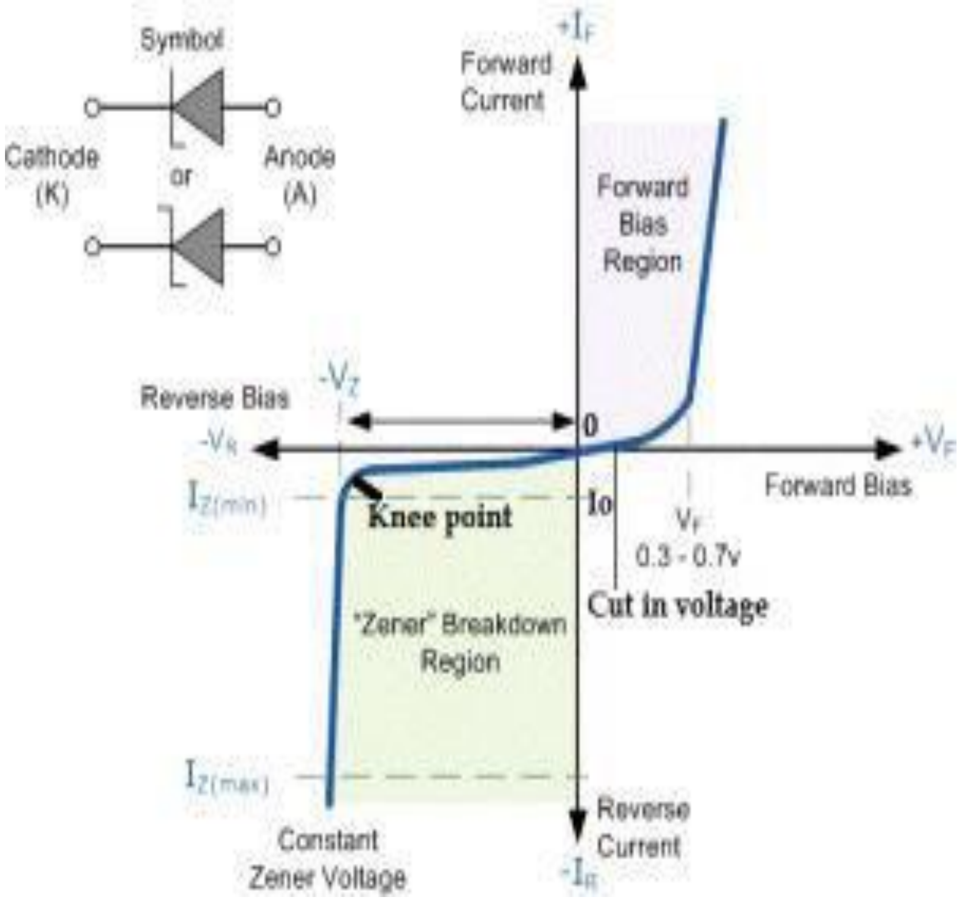
Figure (c) Zener diode in reverse bias

V-I Characteristics of Semiconductor Diode



P-N Junction Diode V-I Characteristics

Forward Bias & Reverse Bias Curves



Zener Diode Parameters

- Knee Voltage
- Forward Current Rating
- Forward Resistance
- Izmin
- Izmax
- Zener Breakdown Voltage (Vz)
- Maximum Power Rating

i.e Pzmax = (Vz). (Izmax)

UNIT - II: Class 32 to 34 - Zener Diode Applications

- It is normally used as voltage reference
- Zener diodes are used in voltage stabilizers or shunt regulators
- Zener diodes are used in switching operations
- Zener diodes are used in clipping and clamping circuits
- Zener diodes are used in various protection circuits

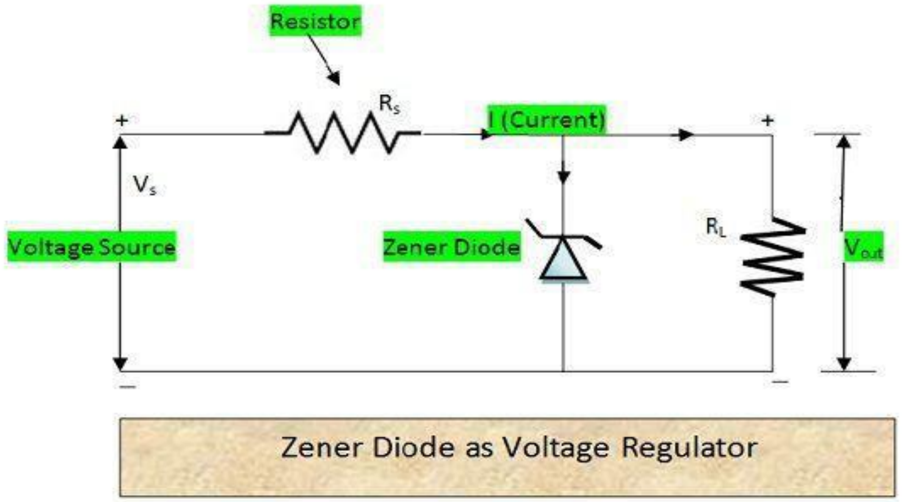
Regulator is an electronic circuit maintains one of the output electrical parameter to be constant

Current Regulator: Output Current to be constant even though input current or output voltage is changing

Voltage Regulator: Output Voltage to be constant even though input voltage or output current is changing

Zener Diode Exhibit the Property of Voltage regulator

Zener Diode as Voltage regulator, it operates as Line Regulator & Load Regulator



Line Regulator: Vin is Varying But Iout is constant; circuit should maintain Vout to be Constant

Load Regulator: Iout is Varying But Vin is constant; circuit should maintain Vout to be Constant

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UNIT-2: Class 32 to 34 – Zener diode voltage regulator

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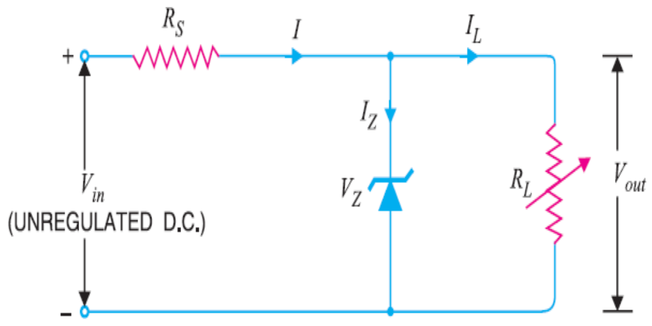
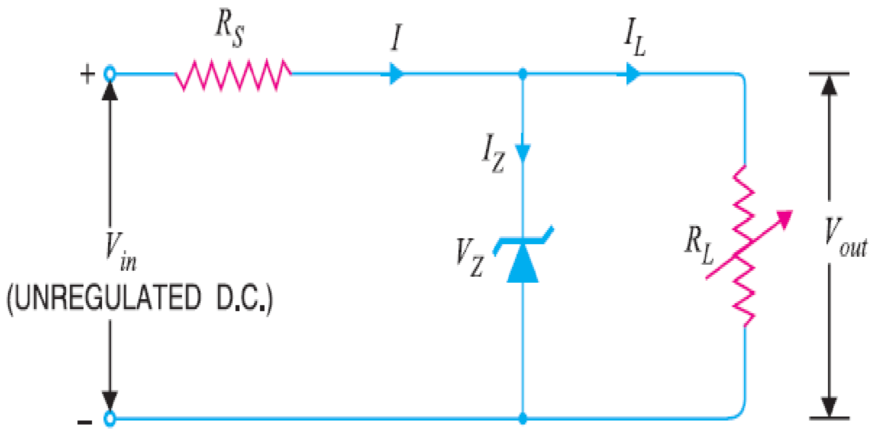
Conditions required to operate Zener Diode as Voltage Regulator



- Zener Diode should be in Reverse Biased Condition
- Vin should be Greater than Vz
- Iz should be greater than Izmin
- Iz should be less than or equal to Izmax
- RL should be Greater than RLmin

The Property of Voltage regulator to maintain output voltage to be constant even though there is variation in input voltage but output/load current is constant

i.e. Vin is varying but IL or Iout is constant



From KVL we have,

$V_{in} = I.R_s + V_z$----- 1

Where V_z=V_{out} (zener diode & R_L are in parallel Combination)

From KCL we have,

$I = I_z + I_L$----- 2

Part -1: Vin is Increasing; Iout/IL is Constant;

From Equation- 1 We have, Vin $\uparrow$ = I.Rs $\uparrow$ + Vz

From Equation – 2 We have, I $\uparrow$ = Iz $\uparrow$ + IL

Constant

Therefore Vout is constant

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Part -2: Vin is Decreasing; Iout/IL is Constant;

From Equation- 1 We have, Vin ↓ = I.Rs ↓ + Vz

From Equation – 2 We have, I ↓ = Iz ↓ + IL ↑

Constant

Therefore Vout is constant

UNIT - II: Class 32 to 34 - Modes of Zener diode as Voltage Regulator

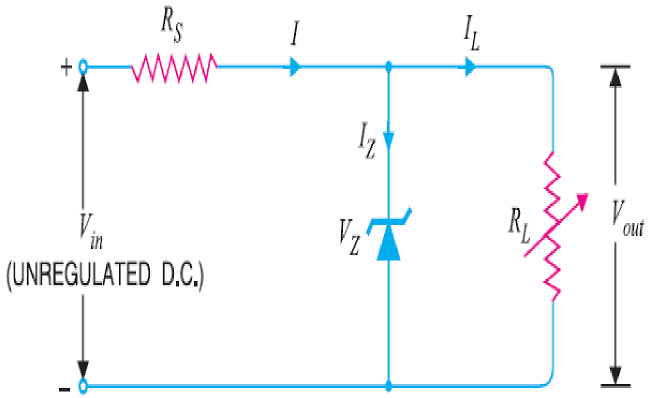
It can be operated as Voltage Regulator by Keeping Vin & Iout both to be constant i.e. Fixed Vi and fixed RL

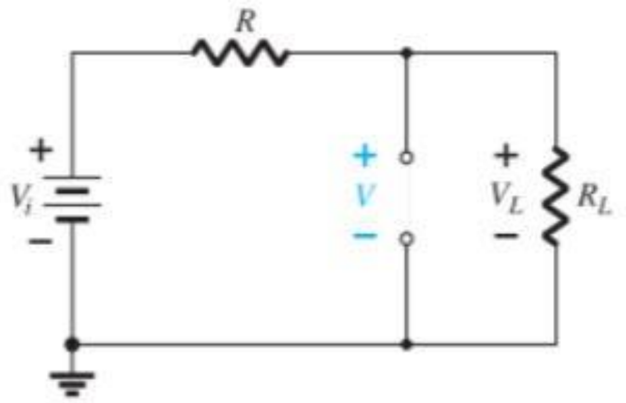
It can be operated as Voltage Regulator by Keeping Vin variable & Iout to be constant i.e. Changing Vi and fixed RL

It can be operated as Voltage Regulator by Keeping Vin constant & Iout to be variable i.e. Fixed Vi and Changing RL

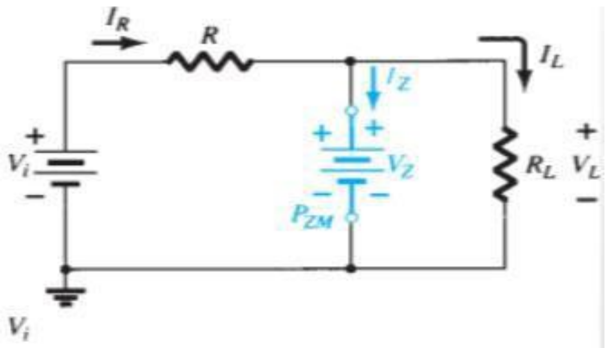
It can be operated as Voltage Regulator by Keeping Vin variable & Iout both to be constant i.e. Changing Vi and Changing RL

CASE-1: Fixed Vi and fixed R Voltage Regulator





Determining the state of the Zener diode.



Substituting the Zener equivalent for the "on" situation.

CASE-1: Fixed Vi and fixed R Voltage Regulator

1. Determine the state of the Zener diode by removing it from the network and calculating the voltage across the resulting open circuit.

$$\boxed{V = V_L = \frac{R_L V_i}{R + R_L}}$$

2. Substitute the appropriate equivalent circuit and solve for the desired unknowns.

$$\boxed{V_L = V_Z}$$

$$I_R = I_Z + I_L$$

$$\boxed{I_Z = I_R - I_L}$$

$$I_L = \frac{V_L}{R_L} \qquad I_R = \frac{V_R}{R} = \frac{V_i - V_L}{R}$$

$$\boxed{P_Z = V_Z I_Z}$$

CASE-2: Fixed Vin and Variable RL Voltage Regulator

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

$$\boxed{R_{L_{\min}} = \frac{R V_Z}{V_i - V_Z}}$$

$$\boxed{I_{L_{\max}} = \frac{V_L}{R_L} = \frac{V_Z}{R_{L_{\min}}}}$$

$$\boxed{V_R = V_i - V_Z}$$

$$\boxed{I_R = \frac{V_R}{R}}$$

$$\boxed{I_Z = I_R - I_L}$$

$$\boxed{I_{L_{\min}} = I_R - I_{ZM}}$$

$$\boxed{R_{L_{\max}} = \frac{V_Z}{I_{L_{\min}}}}$$

CASE-3: Variable Vin and Fixed RL Voltage Regulator

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

$$\boxed{V_{i_{\min}} = \frac{(R_L + R)V_Z}{R_L}}$$

$$\boxed{I_{R_{\max}} = I_{ZM} + I_L}$$

$$V_{i_{\max}} = V_{R_{\max}} + V_Z$$

$$\boxed{V_{i_{\max}} = I_{R_{\max}} R + V_Z}$$

CASE-4: Variable Vin and Variable RL Voltage Regulator

$$R_{smin} = \frac{V_{imax} - V_z}{I_{zmax} - I_{Lmin}}$$

$$R_{smax} = \frac{V_{imin} - V_z}{I_{zmin} - I_{Lmax}}$$

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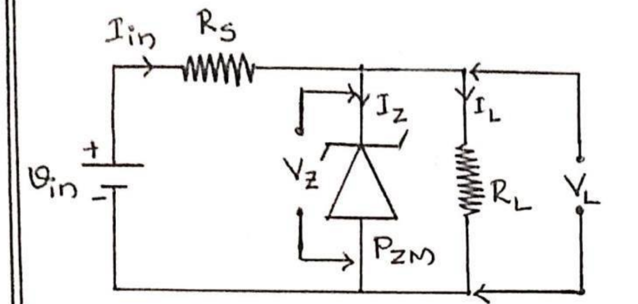
UNIT-2: Semiconductor Diode and Applications

Department of Electronics and Communication Engineering

List of Formulae for CASE-1: V_{in} & R_L are fixed

①

#] ZENER DIODE AS VOLTAGE REGULATOR



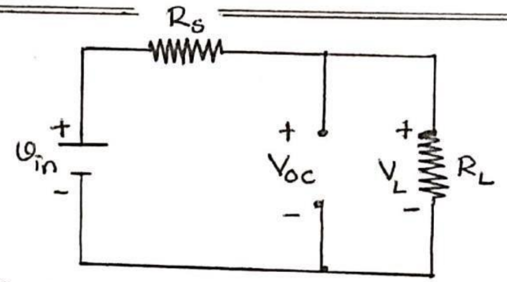
Circuit diagram of Zener Diode as Voltage Regulator

CASE I: V_{in} & R_L are fixed

Step 1: Determine the state of zener diode [ON/OFF] by removing it from the circuit & Calculating the voltage across the resulting open circuit.

i.e

⇓



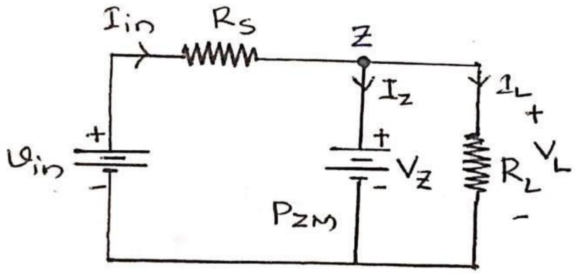
∴ Voltage drop across open circuit is nothing but Voltage drop across "R_L".

Hence - $\boxed{V_{OC} = V_L = \dfrac{V_{in} R_L}{R_S + R_L}} \rightarrow (1)$

If $V_{OC} = V_L > V_Z$ then Zener diode is in "ON" state ; $V_{OC} < V_Z$ then Zener-off

List of Formulae for CASE-1: V_{in} & R_L are fixed; Continues…

– Step 2: If Zener diode is in ON state [Confirmed from eqn (1)] then equate V_L to V_Z or $\boxed{V_L = V_Z}$



Replacing ON state Zener diode by equivalent battery 'V_Z'

Apply KCL at node "Z" we get $\boxed{I_{in} = I_Z + I_L}$

where $\boxed{I_L = \dfrac{V_L}{R_L}}$

IIIly from circuit we get

$$v_{in} = I_{in} R_S + V_Z$$

$$I_{in} R_S = v_{in} - V_Z \quad \therefore \quad \boxed{I_{in} = \frac{v_{in} - V_Z}{R_S}}$$

Power dissipated in Zener diode is $\boxed{P_Z = V_Z I_Z}$

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List of Formulae for CASE-2: V_{in} fixed & R_L Variable

②

CASE ii: V_{in} is fixed but R_L is variable:

- Too small value of R_L will result in a Voltage V_L across the load resistor less than V_Z and the zener diod will be in OFF state. [Minimum Load Resistor should be used]

W.K.T $V_L = V_Z = \dfrac{R_L V_{in}}{R_S + R_L} \Rightarrow V_Z[R_S + R_L] = R_L V_{in}$

or $V_Z R_S + V_Z R_L = R_L V_{in}$

$R_L V_{in} - V_Z R_L = V_Z R_S \quad \therefore \boxed{R_{Lmin} = \dfrac{V_Z R_S}{V_{in} - V_Z}}$

- When $R_L = R_{Lmin}$ then $I_L \rightarrow I_{Lmax}$ & it given by $\boxed{I_{Lmax} = \dfrac{V_Z}{R_{Lmin}}}$

- Determine I_{in} i.e $\boxed{I_{in} = \dfrac{V_{in} - V_Z}{R_S}}$

- If I_{ZM} is mentioned as part of data then

$\boxed{I_{Lmin} = I_{in} - I_{ZM}}$ where $I_{ZM} \rightarrow$ Zener Maximum Current

Then $\boxed{R_{Lmax} = \dfrac{V_Z}{I_{Lmin}}}$

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List of Formulae for CASE-3: V_{in} Variable & R_L fixed

CASE iii : V_{in} is variable but R_L is fixed :

- V_{in} should be sufficiently large to turn ON the Zener diode

∴ The minimum turn-ON voltage required is

$$\boxed{V_{in[min]} = \frac{[R_L + R_S]\, V_Z}{R_L}} \quad \left[\because V_Z = V_L = \frac{V_{in} R_L}{R_S + R_L}\right]$$

- The Maximum value of V_{in} is limited by Zener maximum Current i.e I_{Zmax} or I_{ZM}

∴ $I_{in[max]} = I_{Zmax} + I_L$ [where I_L is fixed because R_L is constant]

Hence

$$\boxed{V_{in[max]} = I_{in[max]} R_S + V_Z}$$

List of Formulae for CASE-4: V_{in} & R_L both are Variable

③

CASE iv : BOTH V_{in} & R_L varying :

Let V_{in} varies between $V_{in[min]}$ to $V_{in[max]}$ & R_L between $R_{L min}$ to $R_{L max}$; the one need to design the zener diode as voltage regulator with the constant output voltage by choosing the appropriate value of R_S & also maintaining the I_Z range within $I_{Z min}$ to $I_{Z max}$.

- Condition for $R_{S min}$ is

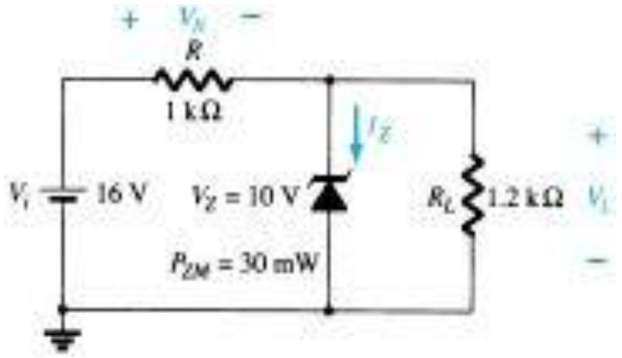
$$\boxed{R_{S min} = \frac{V_{in(max)} - V_Z}{I_{Z max} + I_{L min}}}$$

- Condition for $R_{S max}$ is

$$\boxed{R_{S max} = \frac{V_{in(min)} - V_Z}{I_{Z min} + I_{L max}}}$$

UNIT - II: Numerical on Zener diode as Voltage Regulator

Question No. 1: For the following Zener diode network, determine VL, VR, IZ, and PZ.



Solution:

$$V = \frac{R_L V_i}{R + R_L} = \frac{1.2\ \text{k}\Omega(16\ \text{V})}{1\ \text{k}\Omega + 1.2\ \text{k}\Omega} = 8.73\ \text{V}$$

Since VL is less than VZ, the diode is in the "off" state.

Substituting the open-circuit equivalent will result in;

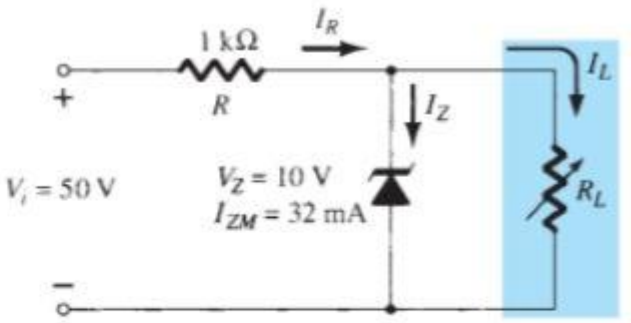
$$V_L = V = \mathbf{8.73\ V}$$

$$V_R = V_i - V_L = 16\ V - 8.73\ \text{V} = \mathbf{7.27\ V}$$

$$I_Z = \mathbf{0\ A}$$

$$P_Z = V_Z I_Z = V_Z(0\ \text{A}) = \mathbf{0\ W}$$

Question No. 2: Find the range of load resistance and the maximum power rating for the circuit?



Solution:

a) To determine the value of *RL that will turn the Zener diode on*

$$R_{L_{\min}} = \frac{RV_Z}{V_i - V_Z} = \frac{(1\ \text{k}\Omega)(10\ \text{V})}{50\ \text{V} - 10\ \text{V}} = \frac{10\ \text{k}\Omega}{40} = \mathbf{250\ \Omega}$$

The voltage across the resistor *R*

$$V_R = V_i - V_Z = 50\ \text{V} - 10\ \text{V} = \mathbf{40\ V}$$

$$I_R = \frac{V_R}{R} = \frac{40\ \text{V}}{1\ \text{k}\Omega} = \mathbf{40\ mA}$$

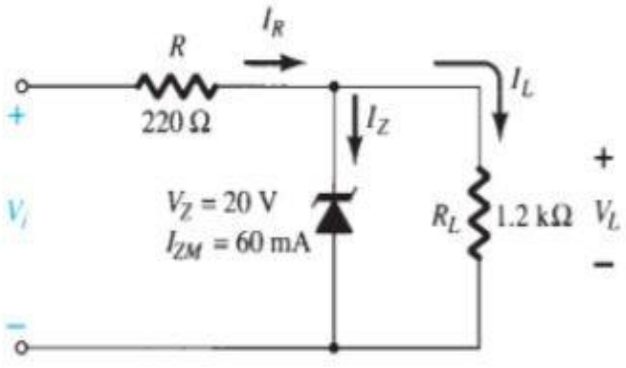
Solution: Continues

$$I_{L_{\min}} = I_R - I_{ZM} = 40\text{ mA} - 32\text{ mA} = \mathbf{8\ mA}$$

$$R_{L_{\max}} = \frac{V_Z}{I_{L_{\min}}} = \frac{10\text{ V}}{8\text{ mA}} = \mathbf{1.25\ k\Omega}$$

(b) $$P_{\max} = V_Z I_{ZM} = (10\text{ V})(32\text{ mA}) = \mathbf{320\ mW}$$

Question No. 3: Determine the range of values of Vi that will maintain Zener diode in the “on” state?



Solution: **from problem statement, R=220Ω, RL=1.2KΩ, Vz=20V, IzM=60mA**

$$V_L = V_Z = \frac{R_L V_i}{R_L + R}$$

$$\boxed{V_{i_{\min}} = \frac{(R_L + R)V_Z}{R_L}}$$

$$\boxed{I_{R_{\max}} = I_{ZM} + I_L}$$

$$V_{i_{\max}} = V_{R_{\max}} + V_Z$$

$$\boxed{V_{i_{\max}} = I_{R_{\max}} R + V_Z}$$

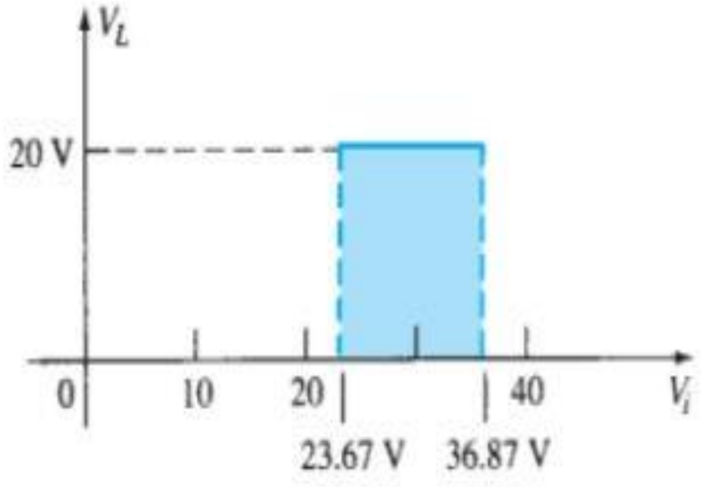
Solution: **Continues**

$$V_{i_{min}} = \frac{(R_L + R)V_Z}{R_L} = \frac{(1200\ \Omega + 220\ \Omega)(20\ \text{V})}{1200\ \Omega} = \mathbf{23.67\ V}$$

$$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L} = \frac{20\ \text{V}}{1.2\ \text{k}\Omega} = 16.67\ \text{mA}$$

$$I_{R_{max}} = I_{ZM} + I_L = 60\ \text{mA} + 16.67\ \text{mA}$$
$$= 76.67\ \text{mA}$$

$$V_{i_{max}} = I_{R_{max}}R + V_Z$$
$$= (76.67\ \text{mA})(0.22\ \text{k}\Omega) + 20\ \text{V}$$
$$= 16.87\ \text{V} + 20\ \text{V}$$
$$= \mathbf{36.87\ V}$$



UNIT - II: Numerical on Zener diode as Voltage Regulator

Question No. 4: Design a Zener diode regulator that maintains output voltage at 10V for an input voltage variation 20V±10% and a load current variation of 30mA±20% .Given Izmin=2mA and Pzmax=0.5W

Solution: **It is a case of both input voltage and output current varying Voltage regulator**

$$R_{smin} = \frac{V_{imax} - V_z}{I_{zmax} + I_{Lmin}} \qquad R_{smax} = \frac{V_{imin} - V_z}{I_{zmin} + I_{Lmax}}$$

Solution: Continues

$$V_i = 20 \pm 2,\ V_{i\min} = 18V, V_{i\max} = 22V$$

$$I_L = 30 \pm 6,\ I_{L\min} = 24mA, I_{L\max} = 36mA,\quad V_z = 10V$$

$$I_{z\min} = 2mA, I_{z\max} = \frac{P_{Z\max}}{V_z} = 50mA, substituting\ the values$$

$$R_{s\min} = 162\Omega,\quad R_{s\max} = 210\Omega$$

NOTE: In every design problem circuit should be drawn

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