UE25EC141A - Electronic Principles and Devices (4-0-0-4-4)

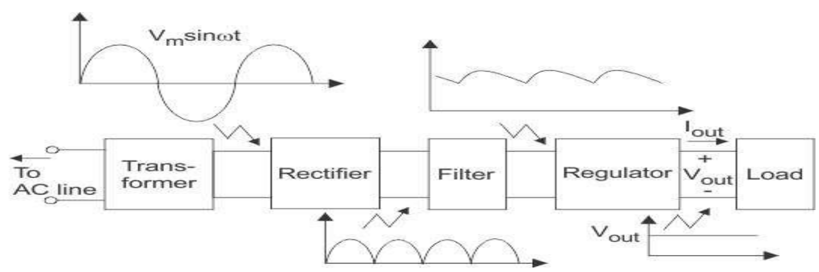
Session 2025-26

Unit-2: Semiconductor Diode Applications Question and Answer

1.	**Draw the block diagram of regulated power supply and explain the function of every block.**

Ans:

The basic power supply is constituted by four elements viz a transformer, a rectifier, a filter, and a regulator put together. The output of the dc power supply is used to provide a constant dc voltage across the load. Let us briefly outline the function of each of the elements of the dc power supply.



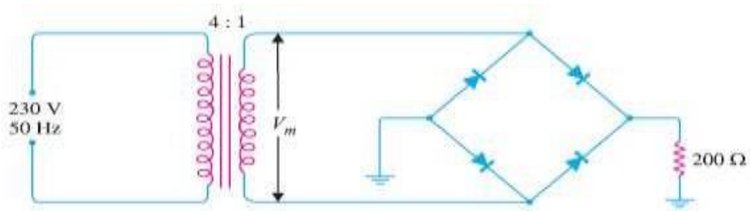
Components of typical linear power supply

Transformer is used to step-up or step-down (usually to step-down) the-supply voltage as per need of the solid-state electronic devices and circuits to be supplied by the dc power supply. It can provide isolation from the supply line-an important safety consideration. It may also include internal shielding to prevent unwanted electrical noise signal on the power line from getting into the power supply and possibly disturbing the load.

Rectifier is a device which converts the sinusoidal ac voltage into either positive or negative pulsating dc. P-N junction diode, which conducts when forward biased and prac-tically does not conduct when reverse biased, can be used for rectification i.e. for conver-sion of ac into dc.
The output voltage from a rectifier circuit has a pulsating character i.e., it contains unwanted ac components (components of supply frequency f and its harmonics) along with dc component. For most supply purposes, constant direct voltage is required than that furnished by a rectifier. To reduce ac components from the rectifier output voltage a filter circuit is required.

Thus filter is a device which passes dc component to the load and blocks I ac components of the rectifier output. Filter is typically constructed from reactive circuit I elements such as capacitors and/or inductors and resistors. The magnitude of output dc voltage may vary with the variation of either the input ac voltage or the magnitude of load current. So at the output of a rectifier filter combination a voltage regulator is required, to provide an almost constant dc voltage at the output of the regulator. The voltage regulator may be constructed from a Zener diode, and or discrete transistors, and/or integrated circuits (ICs). Its main function is to maintain a constant dc output voltage. However, it also rejects any ac ripple voltage that is not removed by the filter. The regulator may also include protective devices such as short-circuit protection, current limiting, thermal shutdown, or over-voltage protection.

2 **In the bridge type circuit shown below, the diodes are assumed to be ideal. Find: (i) d.c output voltage (ii) peak inverse voltage (iii) output frequency. Assume primary to secondary turns to be 4.**



Ans:

Primary/secondary turns, $N_1/N_2 = 4$

$$\text{R.M.S. primary voltage} = 230\text{ V}$$

$$\therefore \quad \text{R.M.S. secondary voltage} = 230\,(N_2/N_1) = 230 \times (1/4) = 57.5\text{ V}$$

Maximum voltage across secondary is

$$V_m = 57.5 \times \sqrt{2} = 81.3\text{ V}$$

(*i*) $$\text{Average current, } I_{dc} = \frac{2V_m}{\pi R_L} = \frac{2 \times 81.3}{\pi \times 200} = 0.26\text{ A}$$

$$\therefore \quad \text{d.c. output voltage, } V_{dc} = I_{dc} \times R_L = 0.26 \times 200 = \mathbf{52\ V}$$

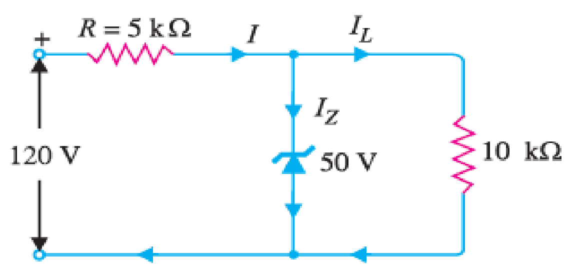
(*ii*) The peak inverse voltage is equal to the maximum secondary voltage *i.e.*

$$PIV = \mathbf{81.3\ V}$$

(*iii*) In full-wave rectification, there are two output pulses for each complete cycle of the input a.c. voltage. Therefore, the output frequency is twice that of the a.c. supply frequency *i.e.*

$$f_{out} = 2 \times f_{in} = 2 \times 50 = \mathbf{100\ Hz}$$

3. **For the circuit shown in figure. Find: (i) the output voltage (ii) the voltage drop across series resistance (iii) the current through Zener diode.**



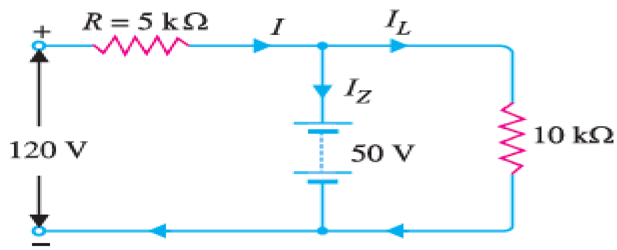
Ans:

Referring to above figure,

(i)

$$\text{Output voltage} = V_Z = \mathbf{50\ V}$$

(ii) $$\text{Voltage drop across } R = \text{Input voltage} - V_Z = 120 - 50 = \mathbf{70\ V}$$

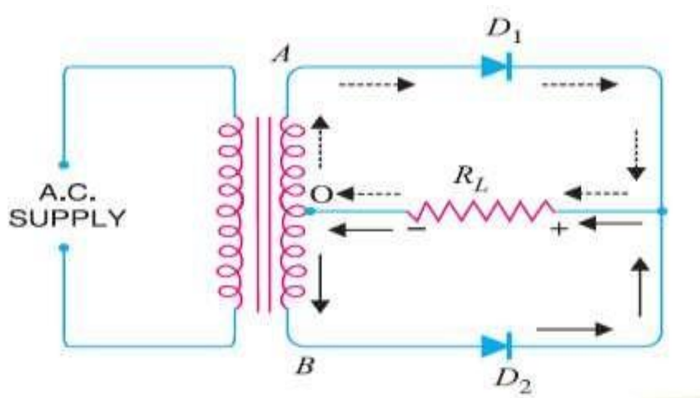
	Load current, $I_L = V_Z/R_L = 50\text{ V}/10\text{ k}\Omega = 5\text{ mA}$ Current through R, $I = \dfrac{70\text{ V}}{5\text{ k}\Omega} = 14\text{ mA}$ (iii) Applying Kirchhoff's first law, $I = I_L + I_Z$ $\therefore$ Zener current, $I_Z = I - I_L = 14 - 5 = 9\text{ mA}$ 
4.	**Derive the Idc and Vdc expression for Half Wave Rectifier.**
Ans:	**D.C. Power Output:** The output current is pulsating direct current. Iav = IDC $= \frac{1}{2\pi}\int_0^{\pi} i d\theta = \frac{1}{2\pi}\int_0^{\pi}\frac{V_m \sin\theta}{r_f + R_L} d\theta = \frac{V_m}{2\pi(r_f + R_L)}\int_0^{\pi}\sin\theta d\theta = \frac{V_m}{2\pi(r_f + R_L)}[-\cos\theta]_0^{\pi}$ $= \frac{V_m}{r_f + R_L} \times \frac{1}{\pi} = \frac{I_m}{\pi}$ **D.C. Power:** $P_{dc} = I_{dc}{}^2 R_L = \left(\frac{I_m}{\pi}\right)^2 \times R_L = \frac{I_m{}^2 R_L}{\pi^2}$
5.	**Show that in a half wave rectifier ripple content is more as compared to DC component.**
Ans:	In half-wave rectification, hence, $Ripple\ factor = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{I_m/2}{I_m/\pi}\right)^2 - 1} = 1.21$ Hence it is clear that AC component exceeds the DC component in the output of a half wave rectifier. It results more pulsation in the output. So, half wave rectifier is ineffective for conversion of AC into DC.

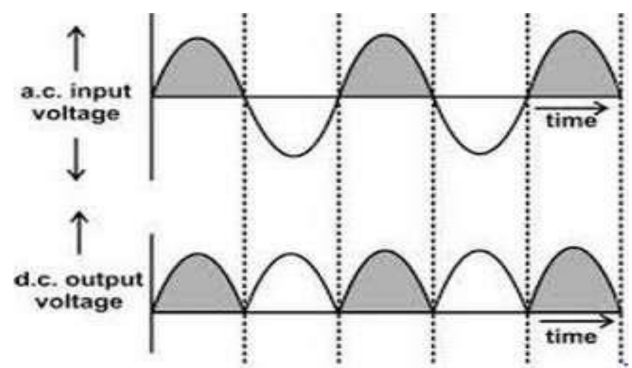
6. **Discuss the Construction and Working of Centre Tapped Full Wave Rectifier.**

Ans:

The circuits uses two diodes D1 and D2. A centre-tap secondary winding AB is connected with the two diodes such that each diode uses one half-cycle of input a.c. voltage. That means diode D1 utilises the the upper half of secondary winding for rectification and diode D2 uses the lower half. Fig. 3 shows the circuit diagram of a Centre-tap full wave rectifier and Fig. 4 shows the input and output waveform of a centre-tap full wave rectifier.

Operation: During the positive half cycle of secondary voltage, the end A of the secondary winding becomes positive and end B negative. So diode D1 is forward biased and diode D2 is reverse biased. Hence, diode D1 conducts and diode D2 does not. The current flows through diode D1, load resistance R_L and the upper half of the secondary winding OA. This is shown by the dotted arrows.
During the negative half cycle of secondary voltage, the end A of the secondary winding becomes negative and end B positive. So diode D2 is forward biased and D1 is reverse biased. Hence D2 conducts while D1 does not. The conventional current flows through diode D2, load resistance R_L and the lower half of through secondary winding OB as shown by the solid arrows. As we can see that current in the load R_L flows in the same direction for both the half cycles of input supply voltage. So DC is obtained across R_L.

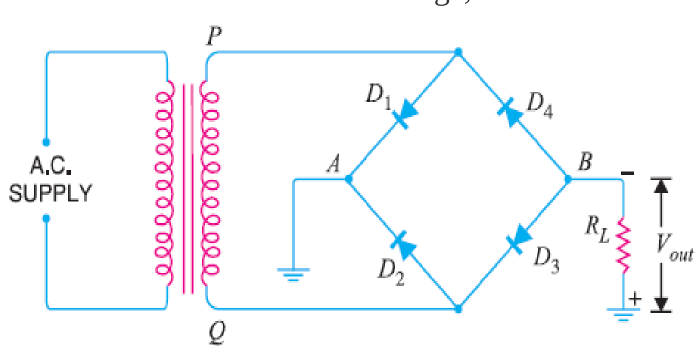


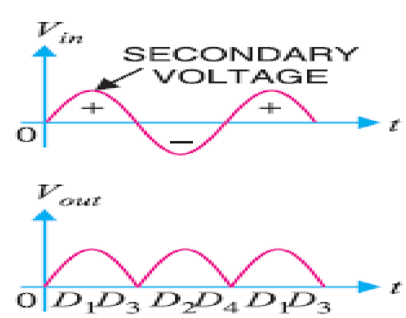


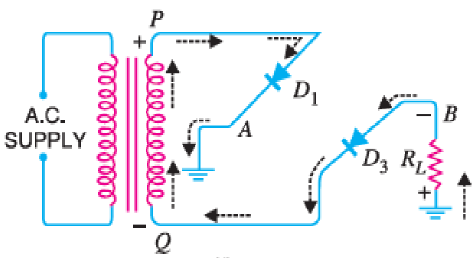
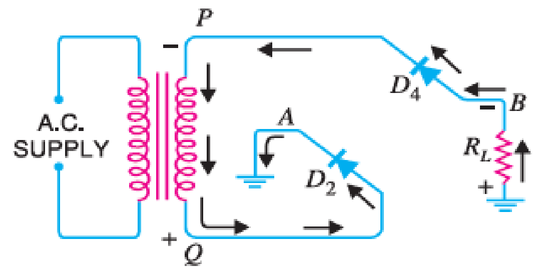
7. **Discuss the Construction and Working of Bridge Rectifier.**

Ans:

The full wave bridge rectifier circuit contains four diodes D1, D2, D3 and D4, connected to form a bridge as shown in below figures shows the input and output waveform of full-wave bridge rectifier. The AC supply to be rectified is applied to the diagonally opposite ends of the bridge through the transformer. Between other two ends of the bridge, the load resistance R_L is connected.





	Operation: During the positive half-cycle of secondary voltage, the end P of the secondary winding becomes positive and end Q negative. This makes diodes D1 and D3 forward biased while D2 and D4 are reverse biased. Hence only diodes D1 and D3 conduct. These two diodes will be in series through the load R_L as shown in Fig. 7. The conventional current flows through load RL is shown by the dotted arrows. It may be seen that current flows from A to B through the load R_L.   During the negative half cycle of secondary voltage, end P becomes negative and end Q positive. This makes diodes D2 and D4 forward biased and diodes D1 and D3 are reverse biased. Hence only diodes D2 and D4 conduct. These two diodes will be in series through the load RL as shown in Fig. 8. The conventional current flow through load RL is shown by the solid arrows. It may be seen that again the current flows from A to B through the load i.e. in the same direction as for the positive half-cycle. Therefore, DC output is obtained across load R_L.
8.	**Define Ripple Factor & show that for a full wave rectifier the ripple factor is less than one.**
Ans:	**Ripple Factor:** The output of a rectifier consists of a DC component and an AC component, which is also known as ripple. The AC component is undesirable and accounts for the pulsations in the rectifier output. The effectiveness of a rectifier depends upon the magnitude of AC component in the output. i.e., the smaller this component, the more effective is the rectifier. The ratio of r.m.s. value of AC component to the d.c. component in the rectifier output is known as ripple factor i.e. Ripple factor = r.m.s. value of AC component/value of d.c. component = Iac /Idc In full-wave rectification, $I_{dc} = \frac{2I_m}{\pi}$ $\quad I_{rms} = \frac{I_m}{\sqrt{2}}$ $\quad Ripple\,factor = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1} = 0.48$ It is clear that d.c. component exceeds the AC component in the output of a full wave rectifier .This results in lesser pulsation in the output of a full wave rectifier as compared to a half wave rectifier . Therefore, full-wave rectification is invariably used for conversion rectification.
9.	**Explain the construction & working of the shunt capacitor filter for half wave rectifier.**

Ans: An electronic circuit which passes desired electrical component & blocks/reduces unwanted is called as filter. The capacitor allows the ac component and blocks the dc component. The inductor allows the dc component and blocks the ac component.

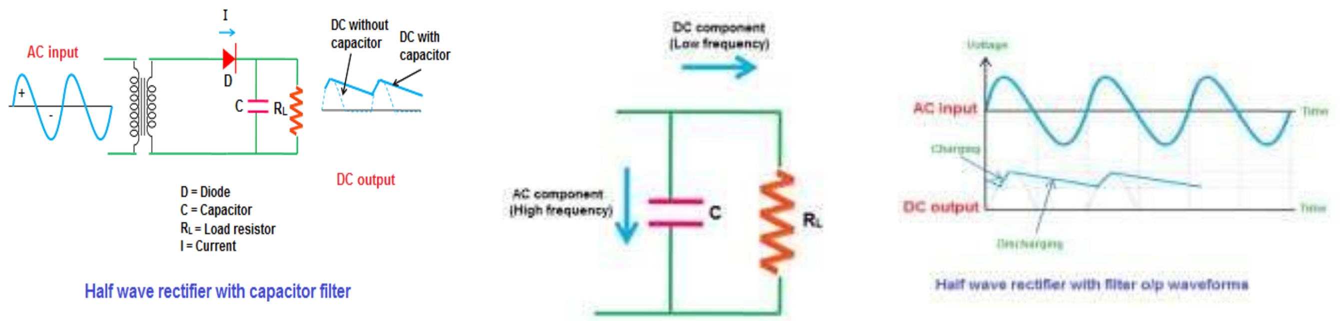
SHUNT CAPACITOR FILTER:

In the below circuit diagram, the capacitor C is connected in shunt with load resistor (R_L).

When AC voltage is applied, during the positive half cycle, the diode D is forward biased and allows electric current through it. As we already know that, the capacitor provides high resistive path to dc components (low-frequency signal) and low resistive path to ac components (high-frequency signal).

Electric current always prefers to flow through a low resistance path. So when the electric current reaches the filter, the dc components experience a high resistance from the capacitor and ac components experience a low resistance from the capacitor.

The dc components do not like to flow through the capacitor (high resistance path). So they find an alternative path (low resistance path) and flows to the load resistor (R_L) through that path.



On the other hand, the ac components experience a low resistance from the capacitor. So the ac components easily pass through the capacitor. Only a small part of the ac components passes through the load resistor (RL) producing a small ripple voltage at the output. The passage of ac components through the capacitor is nothing but charging of the capacitor.

In simple words, the ac components are nothing but an excess current that flows through the capacitor and charges it. This prevents any sudden change in the voltage at the output.

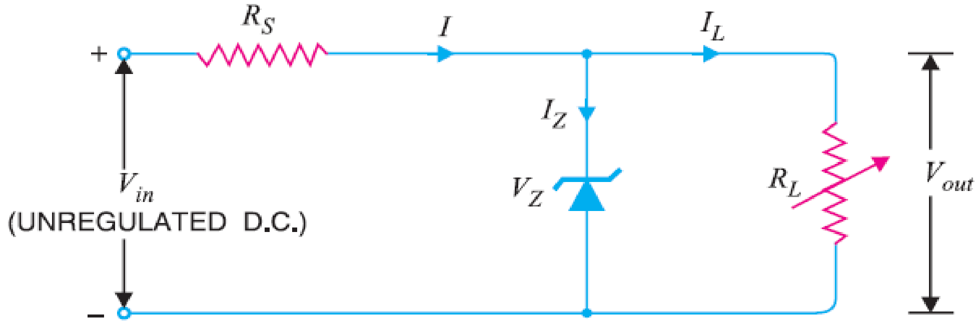
During the conduction period, the capacitor charges to the maximum value of the supply voltage. When the voltage between the plates of the capacitor is equal to the supply voltage, the capacitor is said to be fully charged.

When the capacitor is fully charged, it holds the charge until the input AC supply to the rectifier reaches the negative half cycle.

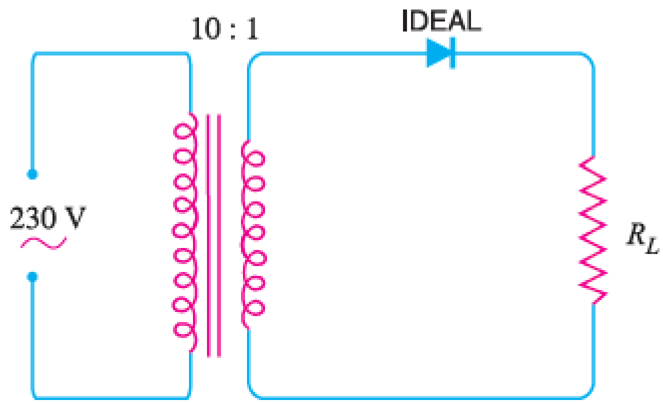
When the negative half cycle is reached, the diode D gets reverse biased and stops allowing electric current through it. During this non-conduction period, the input voltage is less than that of the capacitor voltage. So the capacitor discharges all the stored charges through the load resistor RL. This prevents the output load voltage from falling to zero. The capacitor discharges until the input supply voltage is less than the capacitor voltage. When the input supply voltage is greater than the capacitor voltage, the capacitor again starts charging. When the positive half cycle is reached again, the diode D is forward biased and allows electric current. This makes capacitor to charge again.

The capacitor filter with a large discharge time constant will produce a very smooth DC voltage. Thus, a smooth and steady DC voltage is obtained by using the filter.

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

10.	**Prove the property of voltage regulation by Zener Diode.**
Ans:	An electronic Circuit which has ability to maintain output voltage to be constant, even there is variation of input voltage or output current known as Voltage regulator. **Zener Diode as Voltage Regulator:** A Zener diode can be used as a voltage regulator or voltage stabilizer, to provide a constant voltage from a source whose voltage may vary over a particular range.  The Zener diode of Zener voltage V_Z is connected reversely across the load resistance R_L across which constant output voltage V_{OUT} is required. The series resistance R is used to absorb the output voltage fluctuations, so as to maintain constant output voltage across R_L. When the circuit is properly designed, the output voltage V_{OUT} remains constant even though the input voltage Ei and load resistance R_L may vary over a wide range. **Case 1: V_{IN} Variable and R_L constant:** Suppose the input voltage V_{IN} increases, since the Zener is in the breakdown region, the Zener diode is equivalent to a battery of voltage VZ as shown in Fig.2 and the output voltage remains constant at V_Z ($V_{OUT} = V_Z$). The excess voltage is dropped across R. This will cause an increase in the value of total current I. The Zener will conduct the increase of current in I, while the load current remains constant. Hence the output voltage remains constant irrespective of the change in input voltage V_{IN} Summary (Case 1): Suppose V_{IN} increases Since Zener is in breakdown region, V_Z remains constant $V_O = V_Z$ So V_O remains constant Excess voltage drops across R So I increases, since I_L remains constant, I_Z increases $\uparrow I = \uparrow I_Z + I_L$ (constant) Excess current is conducted by the Zener diode and V_{OUT} remains constant irrespective of the change in E_I **Case 2: V_I Constant and R_L Variable**: Now suppose the input voltage V_I is constant but R_L decreases Since the Zener diode is in breakdown region, voltage across it will remain constant at V_Z. As the output voltage V_{OUT} is equal to the Zener voltage, So V_{OUT} will also remain constant at V_Z. When R_L decreases, in order to maintain EO constant, current through the load resistance I_L will increase. Since V_I is constant, total current I is also constant. So the increase in load current I_L will come from a decrease in Zener current I_Z. $I(\text{constant}) = \uparrow I_L + \downarrow I_Z$ Voltage drop across R = $V_I - V_O$; Current through R, $I = I_Z + I_L$

11	An a.c. supply of 230 V is applied to a half-wave rectifier circuit through a transformer of turn ratio 10 : 1. Find (i) the output d.c. voltage and (ii) the peak inverse voltage. Assume the diode to be ideal.



$$\frac{N_1}{N_2} = 10$$

R.M.S. primary voltage

$$= 230 \text{ V}$$

$\therefore$ Max. primary voltage is

$$V_{pm} = (\sqrt{2}) \times \text{r.m.s. primary voltage}$$

$$= (\sqrt{2}) \times 230 = 325.3 \text{ V}$$

$$V_{sm} = V_{pm} \times \frac{N_2}{N_1} = 325.3 \times \frac{1}{10} = 32.53 \text{ V}$$

$$I_{d.c.} = \frac{I_m}{\pi}$$

$$V_{dc} = \frac{I_m}{\pi} \times R_L = \frac{V_{sm}}{\pi} = \frac{32.53}{\pi} = \mathbf{10.36\ V}$$

$\therefore$ Peak inverse voltage = **32.53 V**

Over what range of input voltage will the zener in a voltage regulator in circuit maintain 30 V across

12 **2000 Ω load, assuming that series resistance R = 200 Ω and zener current rating is 25 mA ?**

Sol. : The circuit is shown in the Fig. 1.24.4.

$V_Z = 30$ V , $I_{Z\,max} = 25$ mA

Let $I_{Z\,min} = 2.5$ mA

$$I_L = \frac{V_o}{R_L} = \frac{V_Z}{R_L} = \frac{30}{2\times10^3} = 15 \text{ mA constant}$$

For $V_{in(min)}$, $I_Z = I_{Z\,min} = 2.5$ mA

$\therefore \quad I = I_{Z\,min} + I_L = 2.5 + 15 = 17.5$ mA

But $\quad I = \dfrac{V_{in(min)} - V_Z}{R}$

i.e. $\quad 17.5\times10^{-3} = \dfrac{V_{in(min)} - 30}{200}$

$\therefore \quad V_{in(min)} = 33.5$ V

For $V_{in(max)}$, $I_Z = I_{Z\,max} = 25$ mA

$\therefore \quad I = I_{Z\,max} + I_L = 25 + 15 = 40$ mA

$\therefore \quad V_{in(max)} = 40\times10^{-3}\times200+30 = 38$ V

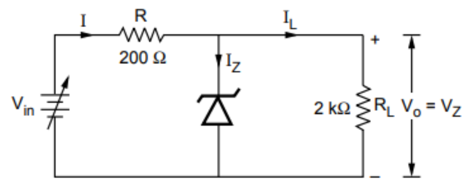


Fig. 1.24.4

Thus, the range of input voltage is 33.5 V to 38 V for which the circuit will work as regulator.

Design a Zener regulator for the following specifications

13 **Output voltage, Vo = 5 V, Input voltage, = Vt = 12 ± 3, IZmin = 10 mA**

Load current, IL = 20 mA, Zener wattage, PZ = 500 mW

Sol-:

Sol. : $V_{in(min)} = 12 - 3 = 9$ V, $V_{in(max)} = 12 + 3 = 15$ V

$I_L = 20$ mA constant, $V_o = V_Z = 5$ V, $P_Z = 500$ mW

Step 1 : The maximum power dissipation is corresponding to I_{Zmax}.

$\therefore \quad P_Z(\text{given}) = V_Z\, I_{Zmax} \quad$ i.e. $\quad 500\times10^{-3} = 5\, I_{Zmax}$

$\therefore \quad I_{Zmax} = \mathbf{100\ mA}$

Step 2 : I_L is constant

For $V_{in(max)}$, $I_Z = I_{Zmax}$

$\therefore \quad I = I_L + I_{Zmax} = 20 + 100 = 120$ mA

$\therefore \quad V_{in(max)} = V_Z + I\, R_{min} \quad$ i.e. $\quad R_{min} = \dfrac{15-5}{120\times10^{-3}} = \mathbf{83.33\ \Omega}$

When R = Rmin, for the current I will be at its maximum i.e. IZ will be at its maximum.

Step 3 : To calculate Rmax, I must be minimum i.e. IZ must be minimum i.e. 10 mA.

$$\therefore \quad I = I_L + I_{Zmin} = 20 + 10 = 30 \text{ mA}$$

$$\therefore \quad V_{in(min)} = V_Z + I\,R_{max} \quad \text{i.e.} \quad R_{max} = \frac{9-5}{30\times10^{-3}} = \mathbf{133.33\ \Omega}$$

Thus R must be greater than 83.33 Ω and less than 133.33 Ω for proper regulating action.

14 **Determine the minimum and the maximum load currents for which the zener diode in Fig . 1.24.6 will maintain regulation. What is the minimum RL that can be used? VZ = 10 V, IZmin = Assume rZ = 0 Ω**

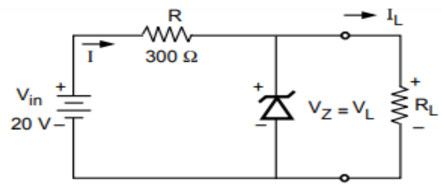


Fig. 1.24.6

Sol. : $V_Z = 10$ V, $I_{Zmin} = 5$ mA, $I_{Zmax} = 25$ mA, $V_{in} = 20$ V

$$I = \frac{V_{in} - V_Z}{R} = \frac{20-10}{300} = 33.33 \text{ mA}$$

Now $\quad I = I_L + I_Z = \text{Constant}$

For $I_{L(min)}$, $\quad I_Z = I_{Zmax}$

$$\therefore \quad I_{L(min)} = I - I_{Zmax} = 33.33 - 25 = 8.33 \text{ mA}$$

For $I_{L(max)}$, $\quad I_Z = I_{Zmin}$

$$\therefore \quad I_{L(max)} = I - I_{Zmin} = 33.33 - 5 = 28.33 \text{ mA}$$

So load current can vary from 8.33 mA to 28.33 mA for which output will be constant.

The minimum R_L means maximum I_L hence,

$$R_{L(min)} = \frac{V_Z}{I_{L(max)}} = \frac{10}{28.33\times10^{-3}} = \mathbf{352.982\ \Omega}$$

For the following circuit, find the maximum and minimum values of Zener diode current.

Sol. :

Sol. : $V_Z = 50$ V, $R_L = 10$ kΩ

$\therefore \quad I_L = \frac{V_Z}{R_L} = \frac{50}{10 \times 10^3}$

$= 5$ mA (constant)

i) $V_{in} = 80$ V

$\therefore \quad I_{min} = \frac{V_{in} - V_Z}{R} = \frac{80-50}{5 \times 10^3}$

$= 6$ mA

$\therefore \quad I_{Z(min)} = I_{min} - I_L$

$= 6 - 5 = \mathbf{1\ mA}$

ii) $V_{in(max)} = 120$ V

$\therefore \quad I_{max} = \frac{V_{in(max)} - V_Z}{R} = \frac{120-50}{5 \times 10^3}$

$= 14$ mA

$\therefore \quad I_{Z(max)} = I_{max} - I_L$

$= 14 - 5 = \mathbf{9\ mA}$

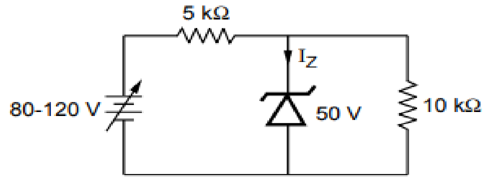


Fig. 1.24.7

Thus minimum and maximum valves of zener diode current are 1 mA and 9 mA respectively.

15 A 50 load resistance is connected across a half wave rectifier. The input supply voltage is 230V (rms) at 50 Hz. Determine the DC output (average) voltage, peak-to-peak ripple in the output voltage (Vp-p), and the output ripple frequency (fr).

Sol: Vp =1.414 * 230 = 325.3 V

Vav = (Vp- 0.7)/□ = 103.32V

Ripple Voltage = (Vorms^2- Vav^2)^0.5 = 125.67V

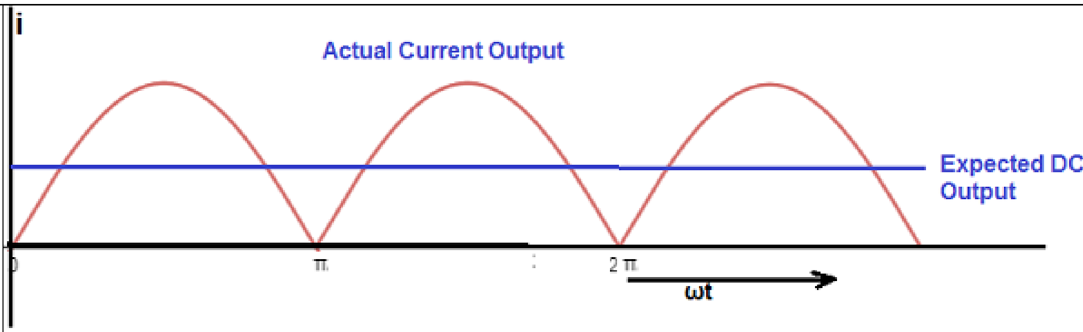
Ripple Percentage = (Vrrms/Vav) = 122%

Fr = 50 Hz

16 **What is Ripple? Why Ripple is Present?**

Ripple is the fluctuating AC component present in rectified DC output. The output of a rectifier may either be DC current or voltage. In view of this, AC fluctuating component present in DC output voltage is called voltage ripple and that in DC current output is called current ripple.

Ripple is always present in the rectifier output. This is because of the behavior of circuit elements like diode or thyristor. Let us consider an example of single phase full wave rectifier to better understand the reason for presence of ripple. The output current waveform of single phase full wave rectifier is shown below.



Ripple = Im Sinωt - I_{avg}

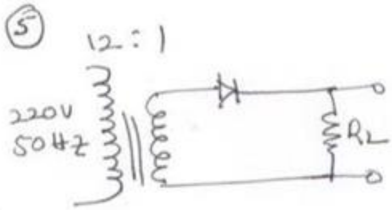
The expected output from full wave rectifier should be a pure DC but actually the output current is different. Since the average value of output current is the pure, therefore the ripple present is equal to the difference of output current or load current minus average current.

17 Differentiate between Bridge Full Wave Rectifier and Centre Tap Full Wave Rectifier

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

18	***A half wave rectifier with R_L = 10k Ω*** **is given an input of 10V peak from step down Transformer. Calculate D.C voltage and load current for ideal and silicon diode**
	Case i) Ideal diode Cut in voltage $V_\gamma = 0\text{ V}, R_f = 0\ \Omega$ $\therefore \quad E_{DC} = \frac{V_m}{\pi} = \frac{10}{\pi} = \mathbf{3.18\ V}$ $\therefore \quad I_{DC} = \frac{E_{DC}}{R_L} = \frac{3.18}{1 \times 10^3} = \mathbf{3.18\ mA}$ **Case ii) Silicon diode** Cut in voltage $V_\gamma = 0.7\text{ V}$ $\therefore \quad E_{DC} = \frac{V_m - V_\gamma}{\pi} = \frac{10-0.7}{\pi} = \mathbf{2.96\ V}$ $\therefore \quad I_{DC} = \frac{E_{DC}}{R_L} = \mathbf{2.96\ mA}$
19	Given: vin(RMS) = 110 V (60 HZ) is given as input to a step down transformer of Turns Ratio 10:1. Find vin(Peak), vout(Peak), vDiode, Vout(DC Effective). vin(Peak) = 1.414 vin(RMS) = 1.414 x 110 = 155.5 V vout(Peak) = 1/10 vin(Peak) = 1/10 x 155.5 = 15.6 V vDiode = 15.6 - 0.7 = 14.9 V Vout(DC Effective) = 0.318 vDiode = 0.318 x 14.9 ≈ 4.7 VDC
20	The primary to secondary turns ratio of a transformer used in a HWR is 12:1. The primary is connected to the power mains: 220V, 50Hz. Assuming the diode resistance in forward bias to be zero, calculate the D.C voltage across the load resistor. What is the PIV of the diode?

(5)



Calculate o/p D.C voltage and PIV of the diode.

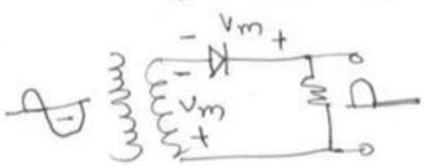
$$\frac{220}{E_2} = \frac{12}{1} \Rightarrow E_2 = \frac{220}{12}$$

$$E_2 = 18.33\ V\ (rms)$$

$$V_m = \sqrt{2} \times 18.33 = 25.92\ V$$

$$V_{dc} = \frac{V_m}{\pi} = \frac{25.92}{\pi} = 8.25\ V$$

PIV of diode in HWR is V_m. PIV is the maximum voltage which appears across the diode in reverse bias.



The diode is in reverse bias during negative half cycle. During -ve half cycle the maximum secondary voltage is V_m and the output voltage is zero. Therefore the maximum voltage which appears across the diode is $V_m = 25.92\ V$