Chapter: 06

Ezaz Ahmed
C223009

Important Ques:

(i) principle of full wave rectifier and its efficiency (Centre Tap)

(ii) principle of full wave rectifier and its effiency. (Bridge Circuit)

Article:

6.1 – 6.15
6.18 – 6.19
6.25 – 6.27
6.10, 6.12

Math:

6.13 – 6.21
6.23 – 6.24

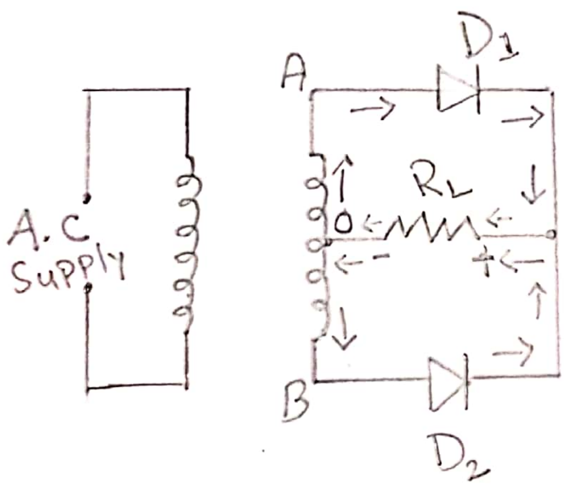
Book: Principles of Electronics (V.K Mehta)

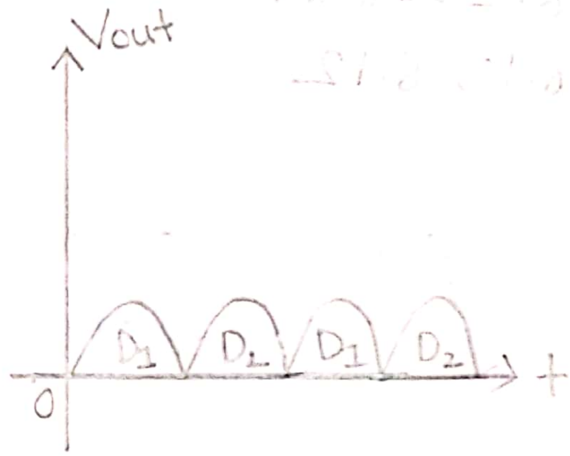
Ezaz Ahmed

1. Principle of full wave rectifier and its efficiency (Centere Tap)

Answer:

The circuit employs two diodes D_1 and D_2. A centre tapped secondary winding AB is used with two diodes connected so that each uses one half-cycle of input a.c voltage. In other words, diode D_1 utilises the a.c. voltage appearing across the upper half (OA) of secondary winding for rectification while diode D_2 uses the lower half winding OB.

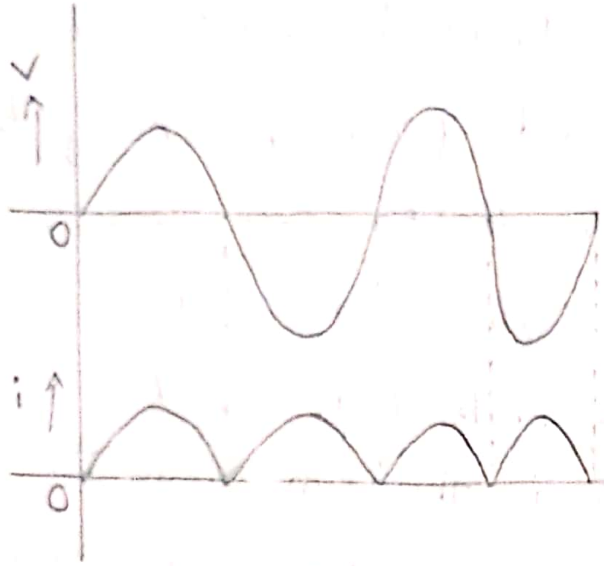




During the positive half-cycle of secondary voltage the end A of the secondary winding becomes positive and end B negative. This makes the diode D_1 forward biased and diode D_2 reverse biased. Therefore diode D_1 conducts while D_2 diode does not. The conventional current flow is through diode D_1, load resistor R_L and the upper half of secondary winding as shown by the dotted arrows. During the negative half-cycle, end A of the secondary winding becomes negative and end B positive. Therefore diode D_2 conducts while diode D_1. does not. The conventional current flow is through diode D_2, load R_L and lower half winding as shown by solid arrows. In the figure we can see that ~~s~~ current in the load R_L is in the same direction for both half-cycles of input a.c. voltage. Therefore, d.c. is obtained across the load R_L. Also, the polarities of the d.c. output across the load should be noted.

Peak Inverse Voltage: Suppose V_m is the maximum voltage across the half secondary winding. The ~~ci~~ circuit at the instant secondary voltage reaches its maximum value in the positive direction. At this instant, diode D_1 is conducting while diode D_2 is non-conducting. Therefore whole of the secondary voltage appears across the non-conducting diode. The peak inverse voltage is twice the maximum voltage across the half secondary winding i.e. $PIV = 2V_m$

Efficiency of Full-Wave Rectifier:



Let $v = V_m \sin\theta$ be the a.c. voltage to be rectified. Let r_f and R_L be the diode resistance and load resistance respectively. Obviously, the rectifier will conduct current through the load in the same direction for both half-cycles of input a.c. voltage. The instantaneous current i is,

$$i = \frac{v}{r_f + R_L} = \frac{V_m \sin\theta}{r_f + R_L}$$

d.c. output power: The output current is pulsating direct current. So to find the d.c. power, average current has to be found out.

$$I_{dc} = \frac{2 I_m}{\pi}$$

$\therefore$ d.c. power output $P_{d.c} = I_{dc}^2 \times R_L = \left(\frac{2I_m}{\pi}\right)^2 \times R_L$

a.c. input power.

The a.c. input power is given by,

$$P_{ac} = I_{rms}^2 (r_f + R_L)$$

For a full wave rectified wave, we have,

$$I_{rms} = I_m/\sqrt{2}$$

$$P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)$$

∴ Full wave rectification efficiency is,

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{(2I_m/\pi)^2 R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)}$$

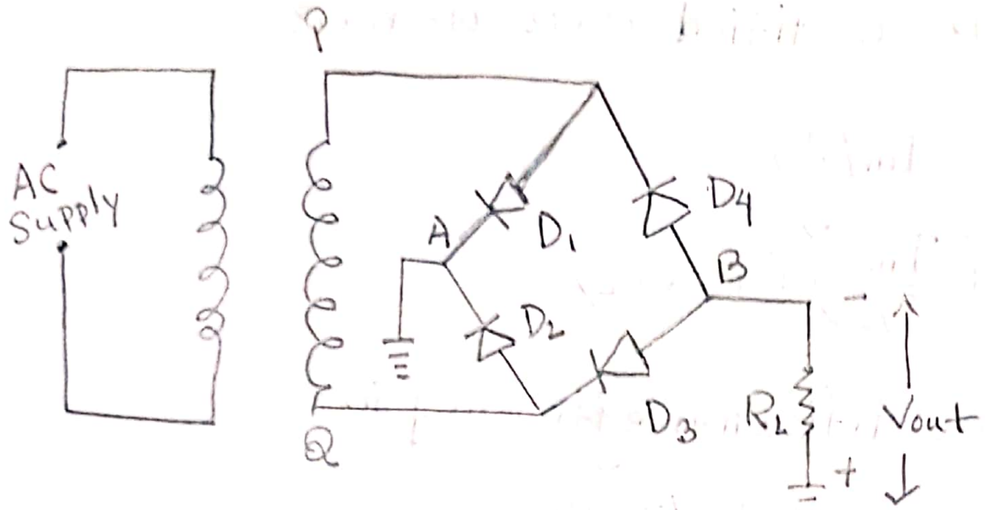
$$= \frac{8}{\pi^2} \times \frac{R_L}{r_f + R_L} = \frac{0.812 R_L}{r_f + R_L}$$

$$= \frac{0.812}{1 + \frac{r_f}{R_L}}$$

The efficiency will be maximum if r_f is negligible as compared to R_L

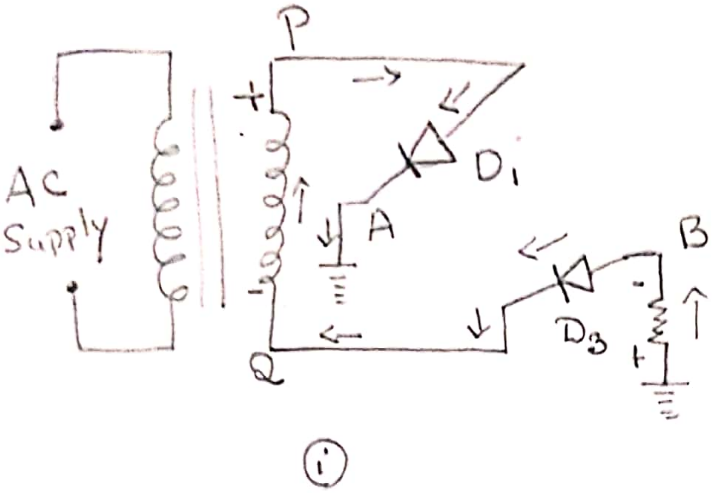
∴ Maximum efficiency = 81.2%.

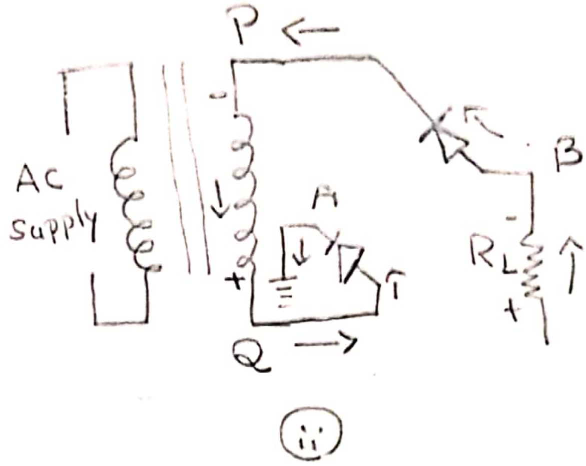
Principle of full wave rectifier and its efficiency
(Bridge Rectifier)



During the positive half-cycle of secondary voltage, the end P of the secondary winding becomes positive and end Q negative. This makes diodes D_1 and D_3 forward biased while diodes D_2 and D_4 are reverse biased. This D_1 and D_3 will be in series through the load R_L.

During the negative half-cycle of secondary voltage end P becomes negative and end Q becomes positive This makes diodes D_2 and D_4 forward biased whereas diodes D_1 and D_2 are reverse biased. D_2 and D_4 diode will be in series through the load R_L. Therefore d.c. output is obtained across load R_L.





Peak Inverse Voltage:

$$PIV = V_m$$

Math

Ex: 6.13

An a.c. supply of 230V 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.

Solution:

Primary to secondary turns is

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

R.M.S primary voltage $= 230\,V$

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

$$= \sqrt{2} \times 230 = 325.3\,V$$

Max secondary voltage is; $V_{sm} = V_{pm} \times \frac{N_2}{N_1} = 325.3 \times \frac{1}{10}$

$$= 32.53\,V$$

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

or, $V_{d.c} = \frac{I_m}{\pi} \times R_L = \frac{V_{sm}}{\pi} = \frac{32.53}{\pi} = 10.36\,V$

(ii) During the negative half-cycle of a.c. supply, the diode is reverse biased and hence conducts no current. Therefore the maximum secondary voltage appears across the diode

∴ Peak inverse voltage = 32.53 V

Example 6.14:

A crystal diode having internal resistance $r_f = 20\,\Omega$ is used for half-wave rectifier. If the applied voltage $v = 50 \sin\omega t$ and load resistance $R_L = 800\,\Omega$ find:

(i) I_m, I_{dc}, I_{rms} (ii) a.c. power input and d.c. power output.

(iii) d.c. output voltage (iv) efficiency of rectification.

Solution:

(i) $v = 50 \sin\omega t$

∴ Maximum voltage, $V_m = 50\text{ V}$

$$I_m = \frac{V_m}{r_f + R_L} = \frac{50}{20+800} = 0.061\text{ A} = 61\text{ mA}$$

$$I_{dc} = I_m/\pi = 61/\pi = 19.4\text{ mA}$$

$$I_{rms} = I_m/2 = 61/2 = 30.5\text{ mA}$$

(ii) a.c. power input $= (I_{rms})^2 \times (r_f + R_L)$

$$= \left(\frac{30.5}{1000}\right)^2 \times (20+800)$$

$$= 0.763\text{ watt}$$

d.c. power output $= I_{dc}^2 \times R_L$

$$= \left(\frac{19.4}{1000}\right)^2 \times 800 = 0.301 \text{ watt}$$

(iii) d.c. output voltage $= I_{dc} \times R_L = 19.4 \text{ mA} \times 800\,\Omega$

$$= 15.52 \text{ volts}$$

(iv) Efficiency of rectification $= \frac{0.301}{0.763} \times 100$

$$= 39.5\%.$$

Example 6.15:

A half-wave rectifier is used to supply 50V d.c. to a resistive load of 800Ω. The diode has a resistance of 25Ω. Calculate a.c. voltage required.

Solution:

Output d.c. voltage, $V_{dc} = 50V$

Diode resistance, $r_f = 25\,\Omega$

Load resistance, $R_L = 800\,\Omega$

Let V_m be the maximum value of a.c. voltage required.

$\therefore V_{dc} = I_{dc} \times R_L$

$$= \frac{I_m}{\pi} \times R_L = \frac{V_m}{\pi(r_f + R_L)} \times R_L \quad \left[\because I_m = \frac{V_m}{r_f + R_L}\right]$$

or, $50 = \frac{V_m}{\pi(25+800)} \times 800$

or, $V_m = \frac{\pi \times 825 \times 50}{800}$

$\therefore V_m = 162 V$

So a.c. voltage of maximum 162 V is required.

Example 6.16:

A full wave rectifier uses two diodes, the internal resistance of each diode may be assumed constant at 20Ω. The transformer r.m.s secondary voltage from center tap to each end of secondary is 50 V and load resistance is 980Ω. (i) the mean load current (ii) the r.m.s value of load current.

Solution:

(i) Here $r_f = 20 \Omega$, $R_L = 980 \Omega$

Max a.c. voltage, $V_m = 50 \times \sqrt{2} = 70.7 V$

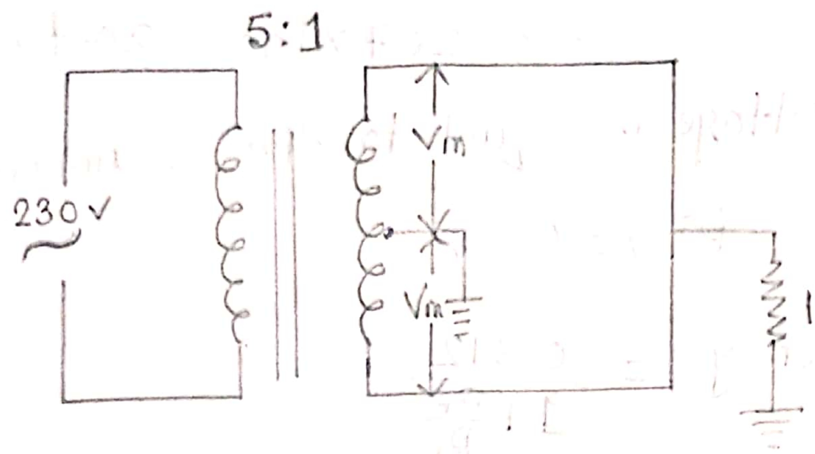
Max load current $I_m = \frac{V_m}{r_f + R_L} = \frac{70.7}{20+980} = 70.7 mA$

Mean load current, $I_{dc} = \frac{2 I_m}{\pi} = \frac{2 \times 70.7}{\pi} = 45 mA$

(ii) R.M.S value of load current, $I_{rms} = \frac{I_m}{\sqrt{2}}$

$$= \frac{70.7}{\sqrt{2}} = 50\,mA$$

Example 6.17:



Diodes are assumed to be ideal i.e. having zero internal resistance.

(i) d.c. output voltage (ii) peak inverse voltage (iii) rectification efficiency

Solution:

Primary to secondary turns $\frac{N_1}{N_2} = 5$

R.M.S primary voltage = 230 V

∴ R.M.S secondary voltage $= \left(230 \times \frac{1}{5}\right) V = 46 V$

Maximum voltage across secondary $= (46 \times \sqrt{2}) = 65 V$

Maximum voltage across half secondary winding is,
$V_m = 65/2\ V = 32.5\ V$

(i) Average current, $I_{dc} = \frac{2V_m}{\pi R_L} = \frac{2 \times 32.5}{\pi \times 100}$

$= 0.207\,A$

$\therefore$ d.c. output voltage $V_{dc} = I_{dc} \times R_L$

$= 0.207 \times 100 = 20.7V$

(ii) The peak inverse voltage is equal to the maximum secondary voltage i.e. $PIV = 65\,V$

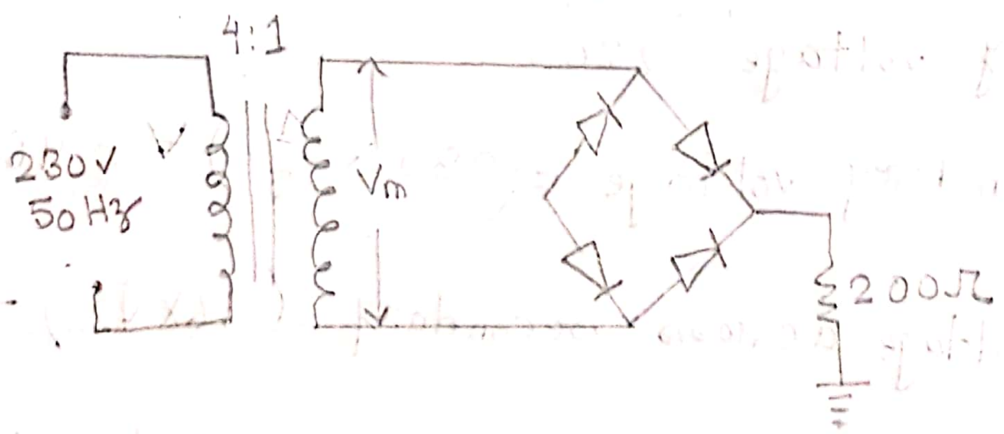
(iii) Rectification efficiency $= \frac{0.812}{1 + \frac{r_f}{R_L}}$

Since $r_f = 0$

$\therefore$ Rectification efficiency $= 81.2\%$

Example 6.18:

(i) d.c. output voltage (ii) peak inverse voltage (iii) output frequency
Assume primary to secondary turns to be 4.



$N_1/N_2 = 4$

R.M.S primary voltage = 230 V

R.M.S secondary voltage $= 230 \times \frac{1}{4} = 57.5V$

Maximum ~~se~~ voltage across secondary $V_m = 57.5 \times \sqrt{2}$
$= 81.3V$

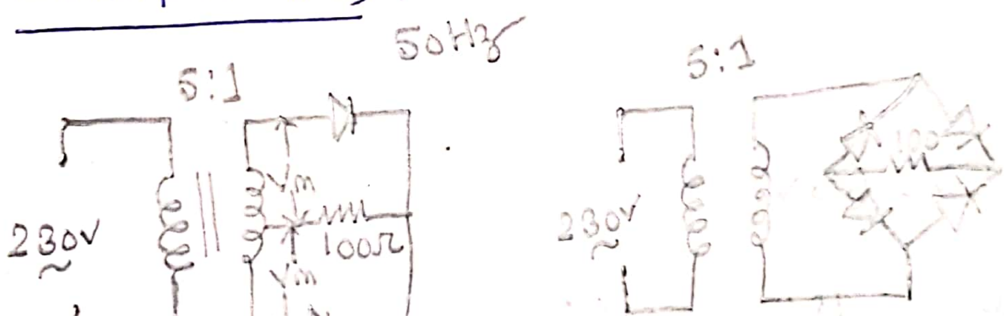
(i) Average current, $I_{dc} = \frac{2V_m}{\pi R_L} = \frac{2 \times 81.3}{\pi \times 200} = 0.26A$

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

(ii) $PIV = V_m = 81.3V$

(iii) $f_{out} = 2 f_{in} = 2 \times 50 = 100$ Hz

Example : 6.19 :



(i) DC. output voltage,

Centre- tap circuit:

R.M.S secondary voltage $= 230 \times \frac{1}{5} = 46V$

Max voltage across secondary ~~Vm~~ $= 46 \times \sqrt{2} = 65V$

Scanned with CamScanner

Max voltage appearing across half secondary winding

is $V_m = 65/2 = 32.5V$

Average current $I_{dc} = \frac{2V_m}{\pi R_L}$

D.C. output voltage $V_{dc} = \frac{2V_m}{\pi R_L} \times R_L = \frac{2V_m}{\pi} = \frac{2 \times 32.5}{\pi}$

$= 20.7V$

Bridge Circuit:

Max voltage across secondary $V_m = 65V$

D.C. output voltage $V_{d.c} = \frac{2V_m}{R_L} \times R_L = 41.4V$

(ii) PIV for same d.c. output voltage:

$V_m = 32.5V$

$PIV = 2 \times 32.5V = 65V$

In Bridge Circuit $N_1/N_2 = 10$

∴ R.M.S secondary voltage $= 230 \times 1/10 = 23V$

$V_m = 23 \times \sqrt{2} = 32.5V$

∴ $PIV = V_m = 32.5V$

Example: 6.20

Max a.c. voltage, $V_m = 240 \times \sqrt{2}$ V

(i) Max load current, $I_m = \frac{V_m}{2R_f + R_L} = \frac{240 \times \sqrt{2}}{2 \times 1 + 480} = 0.7$ A

Mean load current, $I_{dc} = \frac{2 I_m}{\pi} = \frac{2 \times 0.7}{\pi} = 0.45$ A

(ii) $I_{r.m.s} = \frac{I_m}{2} = 0.35$

Power dissipated in each diode $= I_{r.m.s}^2 \times R_f$

$= (0.35)^2 \times 1$

$= 0.123$ W

Example: 6.21

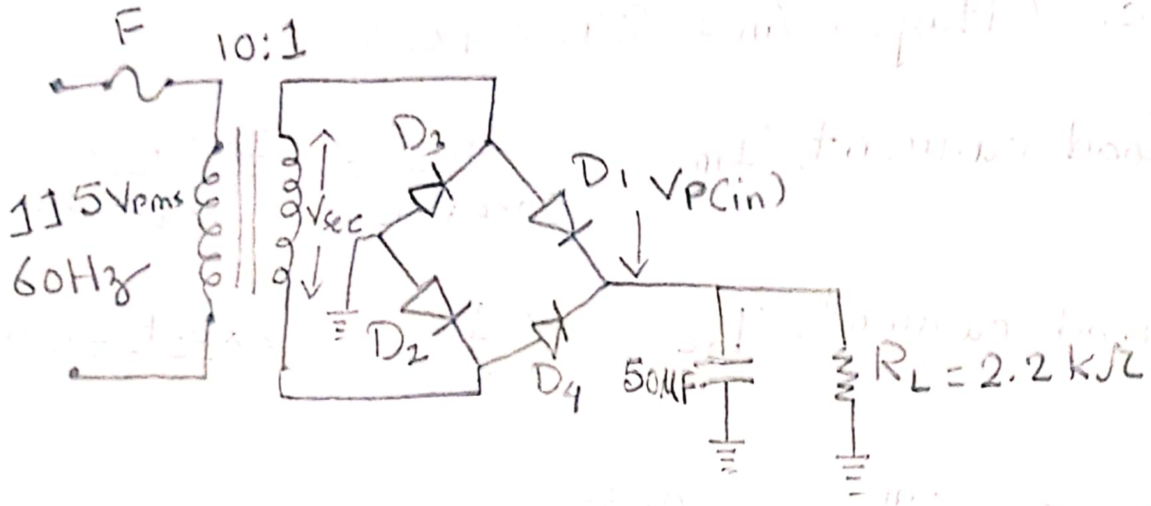
Peak secondary voltage $V_{s(PK)} = 12 \times \sqrt{2} = 16.97$ V

(i) $V_{out}(PK) = 16.97 - 2(0.7) = 15.57$ V

$V_{av} = V_{dc} = \frac{2 V_{out(PK)}}{\pi} = \frac{2 \times 15.57}{\pi} = 9.91$ V

(ii) $I_{av} = \frac{V_{av}}{R_L} = \frac{9.91 V}{12 K\Omega} = 825.8\ \mu A$

Ex 6.23



$$V_{dc} = V_{P(in)}\left(1 - \frac{1}{2fR_LC}\right)$$

Here,

$V_{P(in)}$ = Peak rectified full-wave voltage applied to the filter.

f = output frequency

Peak primary voltage $V_{P(prim)} = \sqrt{2} \times 115 = 163V$

" Secondary " $V_{P(sec)} = \frac{1}{10} \times 163 = 16.3V$

$V_{P(in)} = V_{P(sec)} - 2 \times 0.7 = 14.9V$

$f_{out} = 2f_{in} = 2 \times 60 = 120Hz$

Now,

$$V_{dc} = V_{P(in)}\left(1 - \frac{1}{2fR_LC}\right)$$

$$= 14.9\left(1 - \frac{1}{2\times120\times2.2\times10^{3}\times50\times10^{-6}}\right)$$

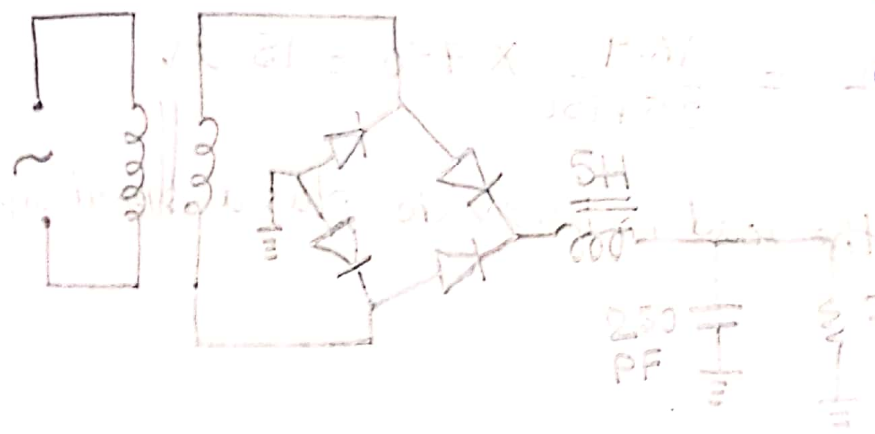
$$= \cancel{0.02}\ 14.3V$$

$\therefore V_{dc} = 14.3V$

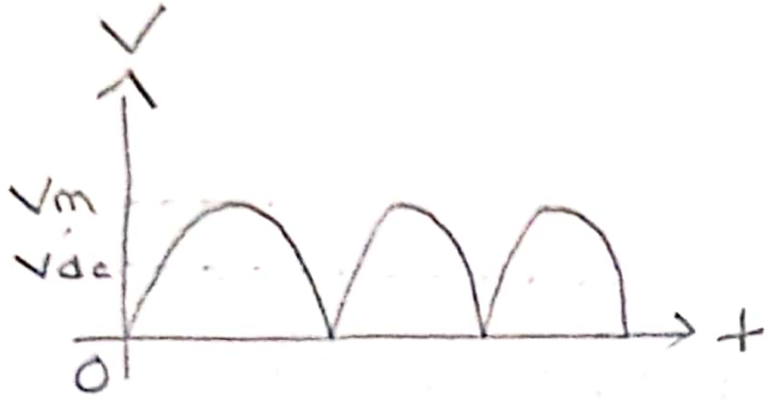
Ex: 6.24:

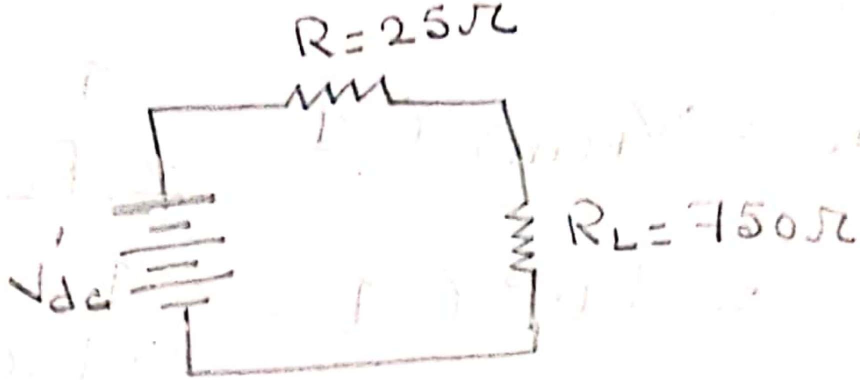
$V_m = 25.7V$

d.c resistance $R = 25\Omega$



The output of a full wave rectifier has a dc. component and an a.c component. Due to the presence of a.c component, the rectifier has a pulsating character. The maximum value of the pulsating output is V_m and d.c component is $V_{dc}' = 2V_m/\pi$





Voltage across load $V_{dc} = \frac{V'_{dc}}{R+R_L} \times R_L$

$$V'_{dc} = \frac{2V_m}{\pi} = \frac{2 \times 25.7}{\pi} = 16.4V$$

$$V_{dc} = \frac{V'_{dc}}{R+R_L} \times R_L = \frac{16.4}{25+750} \times 750 = 15.9V$$

The voltage across the load is 15.9V dc plus a small ripple.