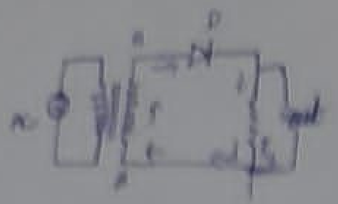
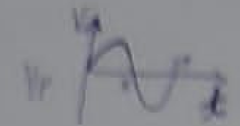
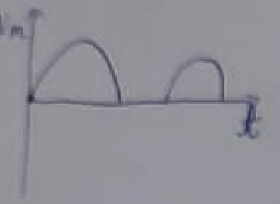
Half-wave rectifiers







Construction:

The rectifier circuit consist of AC supply, where the input is given to the transformer. The advantage of the transformer is it isolates the rectifier circuit from power line and we can stepdown and step up the Input supply. A diode D is connected to the transformer and a load R_L is connected between the ends A & B.

Working:

When the positive pulse from the AC supply enter the circuit, the end A becomes positive when compared with end B

$$P_{ac} = \frac{I_m^2}{4}(r_f + R_L)$$

$$\eta = \frac{\frac{I_m^2}{\pi^2}(R_L)}{\frac{I_m^2}{4}(r_f + R_L)}$$

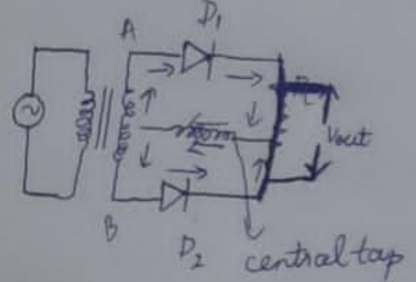
$$= \frac{4}{\pi^2} \frac{R_L}{r_f + R_L}$$

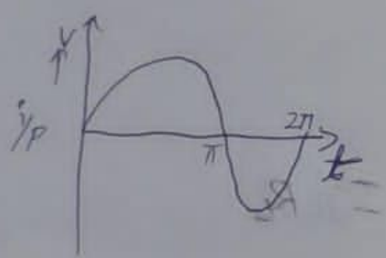
$$= \frac{4}{\pi^2} \frac{1}{\frac{r_f + R_L}{R_L}}$$

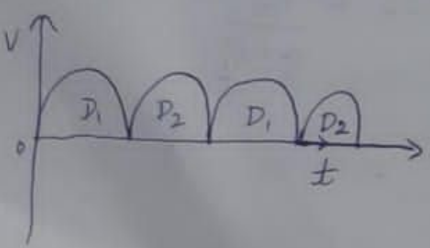
$$\eta = \frac{0.406}{1 + \frac{r_f}{R_L}} \approx 40\%$$

frequency → source dependent.
$[F_{input} = F_{output}]$

Fullwave rectifier:







The diode D will conduct and a positive DC supply appears across load R_L (output).

When the negative pulse enters the circuit, the end A becomes negative when compared with end B. Hence, the diode will be reverse bias and no current will flow across the load R_L. Hence, the output is pulsating and efficiency is only 50% that of the input.

Filter circuits are used to get a continuous output which will reduce the power of the output. Hence, this half-wave rectifier is not used to convert AC into DC.

$$\text{Efficiency } (\eta) = \frac{\text{Output power}}{\text{Input power}}$$

Output power:

$$P_{dc} = I_{dc}^2 R_L$$

$$I_{dc} = \frac{I_m}{\pi}, \quad V_{dc} = \frac{V_m}{\pi}, \quad I_m = \frac{V_m}{R_f + R_L}$$

$$P_{dc} = \frac{I_m^2}{\pi^2} R_L$$

Input power:

$$P_{AC} = I_{rms}^2 (\underbrace{r_f}_{\text{internal resistance of circuit}} + R_L)$$

$$I_{rms} = \frac{I_m}{2}$$

$$\eta = \frac{OP}{IP}$$

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

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

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

$$\text{Output } (P_{dc}) = I_{dc}^2 R_L$$

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

$$= \frac{4 I_m^2}{\pi^2} R_L$$

$$\eta = \frac{4 \cancel{I_m^2} R_L}{\pi^2} \times \frac{2}{\cancel{I_m^2} (R_L + r_f)}$$

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

$$= \frac{8}{\pi^2} \times \frac{1}{1 + \frac{r_f}{R_L}}$$

$$\eta = \frac{0.811}{1 + \frac{r_f}{R_L}}$$

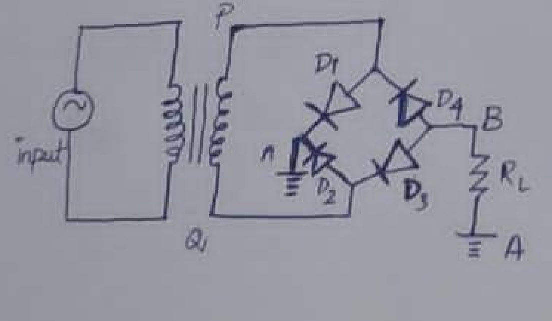
Construction:

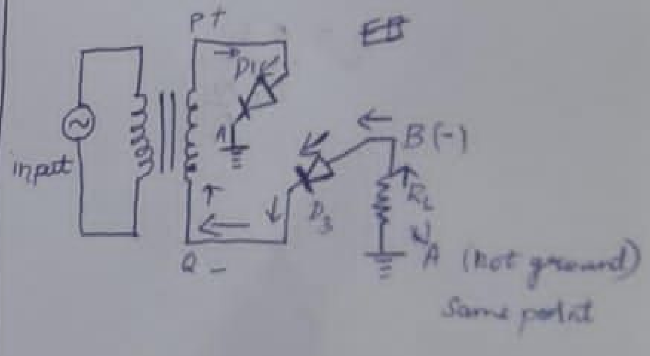
→ Full wave rectifier consist of two diodes D_1 and D_2. Similar to the half wave rectifier, the input is applied through the transformer. When the positive pulse enters a circuit, the diode D_1 will become forward biased and D_2 will become reverse biased, hence the positive pulse appears across the output. During the negative half cycle, the diode D_1 will become reverse bias and diode D_2 will become forward biased. Hence the positive pulse appears across the output.

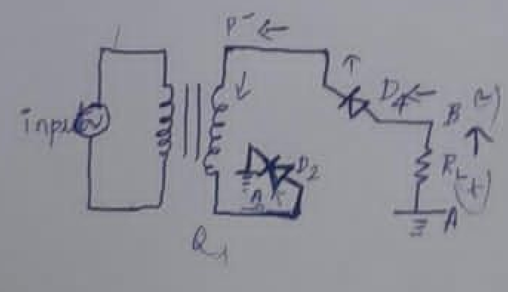
→ For both the half cycle, either D_1 or D_2 forward bias and a continuous output appears across the load.

→ This method is not used because the central tap doesnt match with the circuit, there are losses and hence we go for a method called bridge rectifier.

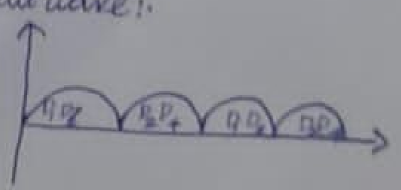
Full wave bridge rectifier:



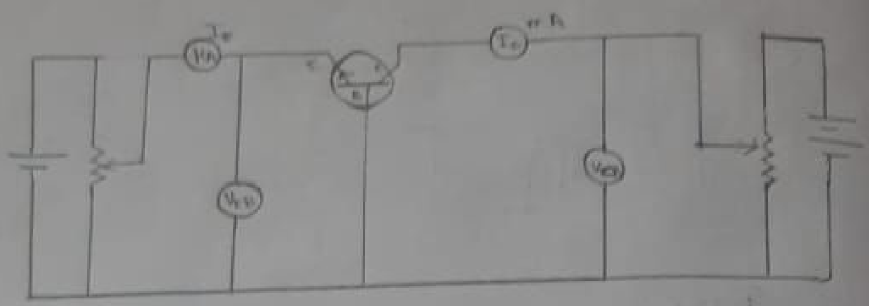




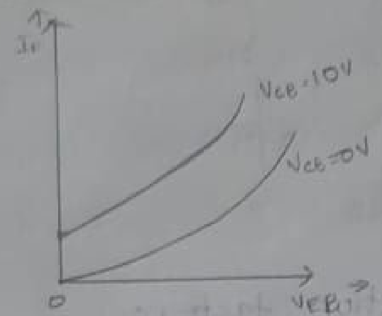
Output wave:



characteristics of BJT for common-Base:

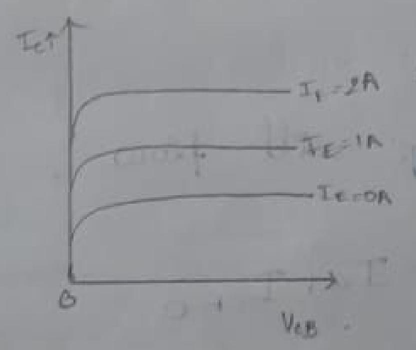


i) Input characteristics:



$\left(\frac{\Delta I_E}{\Delta V_{EB}}\right)$ at constant V_{CB}

ii) Output characteristics:



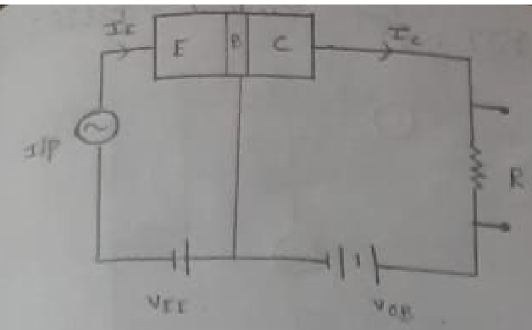
$\left(\frac{\Delta I_C}{\Delta V_{CB}}\right)$ at constant I_E

$\beta = \frac{\Delta I_C}{\Delta I_B}$

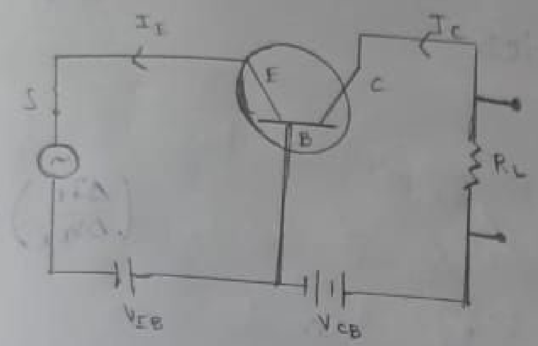
↓

Common-Emitter

Transistor as Amplifier.



common Base:



i) current amplification factor:

$$\alpha = \frac{\Delta I_c}{\Delta I_E} \text{ at constant } V_{CB}.$$

ii) collector current:

I_{CBO} - leakage will flow.

Total C current = $I_c + I_{CBO}$.

iii) Dc voltage output.

$$V_{dc} = \frac{V_m}{\pi} = \frac{50}{3.14} = 15.92 \text{ V}$$

iv) $$\eta = \frac{0.406}{(R_f + R_L)/R_L} = \frac{0.406}{(820)/800} = \frac{0.406 \times 800}{820} = \frac{0.406 \times 8}{82}$$

$$= 39.6\ \%$$

2. A full wave rectifier uses two diodes, the internal resistance of each is assumed constant at 20Ω. The transformer rms secondary voltage from centre tap to each end of secondary is 50V and load resistance is 980Ω find i) the mean load current. ii) the rms value of load current.

Soln:

Given:

i) $R_f = 20\Omega$

$R_L = 980\Omega$

i) $V_m = V\sqrt{2}$

$= 50 \times \sqrt{2}$

$= 50 \times 1.414$

$= 70.7$

70.7

0.07

$V_m = \frac{50}{\sqrt{2}}$

$= \frac{50}{1.414}$

$= 35.36$

$I_m = \frac{V_m}{1000}$

$= \frac{35.36}{1000}$

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

Problem:

A crystal diode having internal resistance $R_f = 20\Omega$. is used for half wave rectification. if Applied voltage is $V = 50 \sin(\omega t)$, $R_L = 800\Omega$, find i) I_m, I_{dc}, I_{RMS}, ii) Ac power input, dc power output iii) Dc output voltage iv) Efficiency of rectification.

Solm:

i) $I_m = \frac{V_m}{R_f + R_L} = \frac{50}{20+800} = \frac{50}{820} = \frac{5}{82} = 0.06A$

$I_{dc} = \frac{I_m}{\pi} = \frac{0.06}{3.14} = 0.019\,A$

$I_{RMS} = \frac{I_m}{2} = \frac{0.06}{2} = 0.03\,A$

ii) Ac power ~~out~~ Input:

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

$$= (0.03)^2 (20+800)$$

$$= 0.0009 (820)$$

$$= 0.738\,\omega$$

$$P_{dc} = \frac{I_m^2}{\pi^2} R_L$$

$$= \frac{(0.06)^2}{(3.14)^2} (800) = 0.292\text{ watts}$$

constant V_{CB}

tant

$r_f = 1\,\Omega$

$V_{rms} = 240V$

$R_L = 48\,\Omega$

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

$$V_m = 240 \times \sqrt{2} = 339.41 \qquad I_m = \frac{V_m}{2r_f + R_L} = \frac{339.4}{\cancel{49}\,50} = 6.78$$

$$I_{dc} = \frac{2I_m}{\pi} = \frac{2 \times \cancel{339.41}\ 6.78}{3.14} = 4.318\ (318)$$

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

$$\eta = \frac{0.811}{1 + \frac{2}{48}} = \frac{0.811 \times 48}{50} = \frac{38.93}{49} = 0.79 \times 100$$

$$= 79\%$$

$$P_{dis} = \cancel{P_{out} - P_{in}} = \frac{I_m}{2} = \frac{6.78}{2} = 3.39$$

(each)

Full wave $\rightarrow \left(\frac{I_m}{\sqrt{2}}\right)$

$$P = I^2 R_f = (3.39)^2 \times 1 = 11.49 = 11.5$$

Fullwave ↓ $\sqrt{2}$

Halfwave ↓ 2

each in full wave ↓ 2

Find the value of β if i) $\alpha = 0.9$

ii) $\alpha = 0.98$

iii) $\alpha = 0.99$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.9}{0.1} = 9$$

$$\beta = \frac{0.98}{1-0.98} = \frac{0.98}{0.02} = 49$$

$$\beta = \frac{0.99}{1-0.99} = \frac{0.99}{0.01} = 99$$

5. The base current in transistor is 0.01 mA and emitted current current is 1 mA. Calculate α & β.

$$\cancel{I_E = I_C + I_B = 1 + 0.01 = 1.01\,mA}$$

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{\Delta I_C}{\Delta I_E - \Delta I_C} = \cancel{\frac{\Delta I_C}{\Delta I_E} - 1}$$

$$\cancel{= \frac{0.09}{1} - 1}$$

$$I_C = I_E - I_B = 1 - 0.01 = 0.99\,mA$$

$$=$$

$$\beta = \frac{0.99}{\cancel{1-0.09}\ 0.01}$$

$$\beta = \frac{0.99}{0.01}$$

$$\beta = 99.$$

$$\alpha = \beta(1-\alpha)$$

$$\cancel{\beta = \frac{\alpha}{1+\alpha}} \qquad \alpha = \frac{\beta}{1+\beta} = \frac{99}{100} = 0.99.$$

$$\cancel{\alpha = \frac{I_C}{I_E}}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$\alpha = \frac{\beta}{1+\beta}$$

$$\alpha = \frac{I_C}{I_E}$$

$$\beta = \frac{I_C}{I_B}$$

i) A full wave rectifier uses 2 diodes. The r_f of each is constant at 20 Ω. The transformer rms secondary voltage from center tap to each end of secondary is 50 volts. $R_L = 980\,\Omega$. Find

i) Mean load current

ii) The Rms value of load current.

sol:

$r_f = 20\,\Omega$, $R_L = 980\,\Omega$

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

$$V_m = 50 \times \sqrt{2} = 70.7$$

$$I_m = \frac{V_m}{r_f + R_L} = \frac{70.7}{20+980} = \frac{70.7}{1000} = 0.0707$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{0.0707}{\sqrt{2}} = 0.049$$

$$I_{dc} = \frac{2I_m}{\pi} = \frac{2 \times 0.0707}{3.14} = 0.04503$$

) A four diodes used in bridge rectifier circuit hv ~~forward~~ resistance which may be considered constant at 1 Ω and infinite reverse resistance. The AC supply voltage is 240 V (rms) and resistant load is 48 Ω. Calculate

i) Mean load current

ii) Rectifier efficiency.

iii) Power dissipated in each diode.