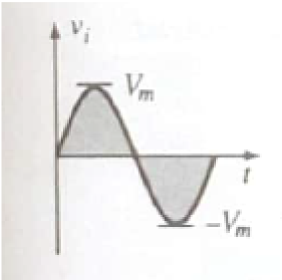
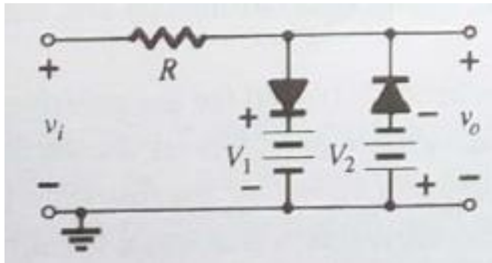
1a. Analyse the circuit and draw the pattern of the output(V_o) of the circuit shown in figure, Provided V_m=10V and V_1,V_2=5V.





During +ve half cycle

* Diode D_2 is always reverse bias & acts as open Ckt.

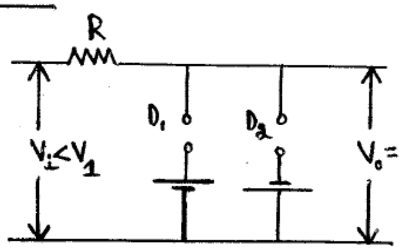
Case i: When $V_i < V_1$, diode D_1 is reverse bias & acts as open Ckt.

Thus o/p $\boxed{V_o = V_i}$

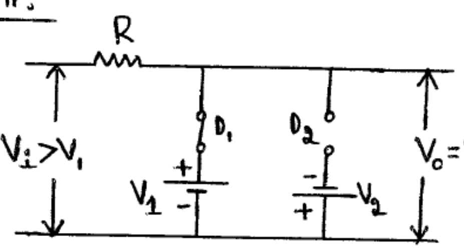
Case ii: When $V_i > V_1$, diode D_1 is forward bias & acts as Short Ckt.

Thus o/p $\boxed{V_o = V_1}$

Case i:



Case ii:



During -ve half cycle

* Diode D_1 is always reverse bias & acts as open Ckt.

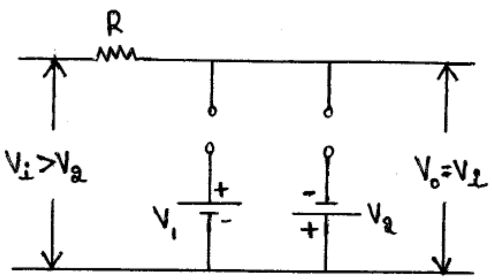
Case i: When $V_i > V_2$, diode D_2 is reverse bias & acts as open Ckt.

Thus o/p $\boxed{V_o = V_i}$

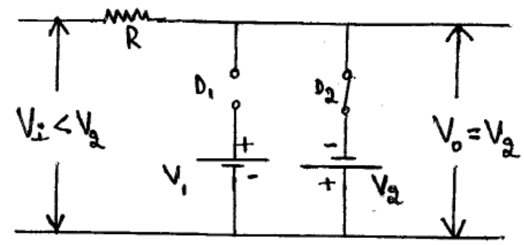
Case ii : When $V_i < V_2$, diode D_2 is forward bias & acts as short circuit.

Thus o/p $\boxed{V_o = V_2}$

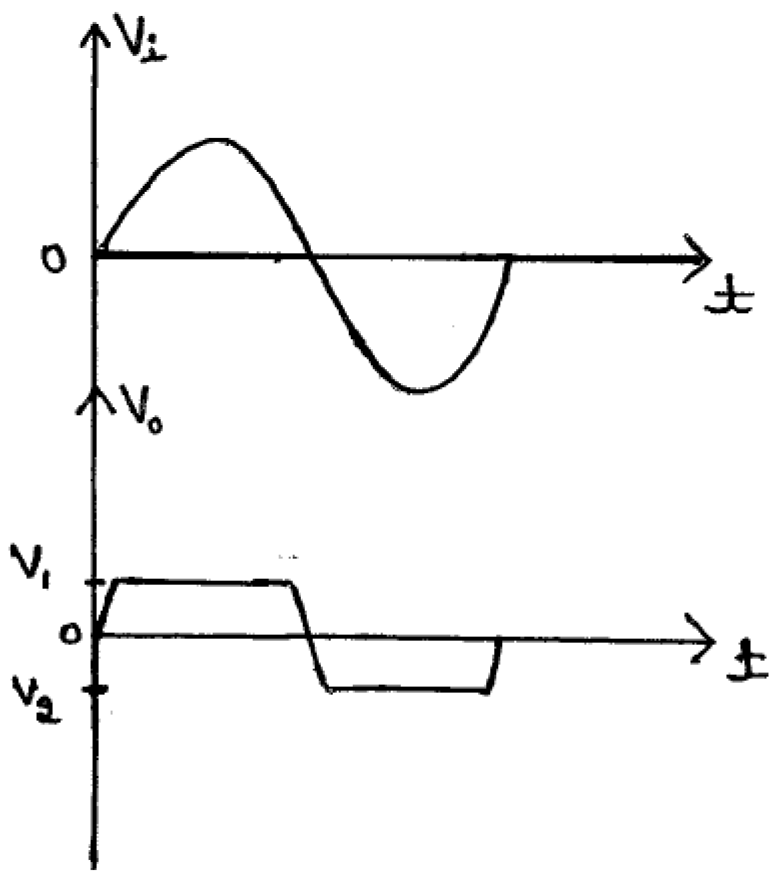
Case i:



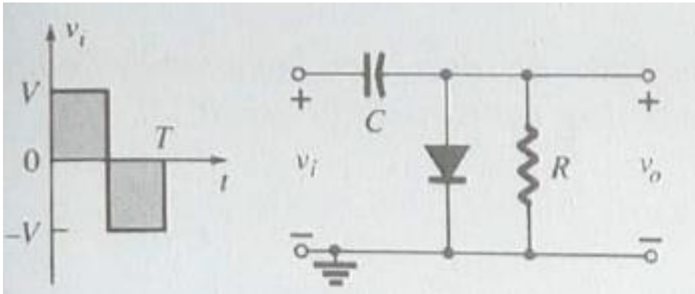
Case ii :



I/O Waveforms:



1b. Analyse the circuit and draw the pattern of the output (V_o)of the circuit shown in figure .



2. What are the different biasing circuits? Find the expression for stability factor S(I_{CBO}) of each biasing circuit?

1) Fixed - Bias circuit :-

> For fixed-bias ckt, the base current is given by

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} \rightarrow (1).$$

Differentiating eq 1 w.r.to I_C, we get

$$\frac{dI_B}{dI_C} = 0 \rightarrow (2).$$

Sub eq (2) in stability factor equation

$$S = \frac{(1+\beta)}{1 - \beta\left(\frac{dI_B}{dI_C}\right)} = \frac{(1+\beta)}{1-\beta(0)} = \frac{1+\beta}{1}$$

$$\boxed{S = 1+\beta}$$

Emitter stabilized bias :-

i) $S = S_{(I_{CBO})} = \frac{dI_B}{dI_C}$

From emitter stabilized bias ckt we have.

$$V_{CC} = I_B R_B + V_{BE} + I_E R_E \rightarrow (1).$$

W.K.T

$I_E = I_C + I_B$.

$$V_{CC} = I_B R_B + V_{BE} + (I_C + I_B) R_E$$

$$V_{CC} = \underline{I_B R_B} + V_{BE} + I_C R_E + \underline{I_B R_E}$$

$$V_{CC} = I_B (R_B + R_E) + I_C R_E + V_{BE} \rightarrow (2).$$

$$(I_B (R_B + R_E) = V_{CC} - I_C R_E - V_{BE})$$

diff eq (2) w.r. to I_C

$$0 = \frac{dI_B}{dI_C}(R_B + R_E) + \frac{dI_C}{dI_C}(R_E) + 0.$$

$$\frac{dI_B}{dI_C}(R_B + R_E) = -R_E$$

$$\therefore \frac{dI_B}{dI_C} = \frac{-R_E}{R_B + R_E}.$$

$$\therefore S_{ICO} = \frac{1+\beta}{1 - \beta\left(-\frac{R_E}{R_B + R_E}\right)}$$

$$\boxed{S_{ICO} = \frac{1+\beta}{1+\beta\left[\frac{R_E}{R_B + R_E}\right]}}$$

Voltage divider bias :-

$$S(I_{CBO}) = \frac{dI_B}{dI_C}$$

From voltage divider bias circuit, we have.

$$V_{Th} = I_B R_{Th} + V_{BE} + I_E R_E \rightarrow (1)$$

W.K.T

$$\boxed{I_E = I_B + I_C}$$

$$V_{Th} = I_B R_{Th} + V_{BE} + I_B R_E + I_C R_E$$

$$V_{Th} = V_{BE} + I_B (R_{Th} + R_E) + I_C R_E \rightarrow (2)$$

diff eq (2) w.r.to I_C.

$$0 = 0 + \frac{dI_B}{dI_C}(R_{Th} + R_E) + \frac{dI_C}{dI_C} R_E$$

$$\frac{dI_B}{dI_C}(R_{Th} + R_E) = -R_E$$

$$\boxed{\frac{dI_B}{dI_C} = -\frac{R_E}{R_{Th} + R_E}}$$

$$\therefore S(I_{CBO}) = \frac{1+\beta}{1-\beta\left(\frac{dI_B}{dI_C}\right)}$$

$$\boxed{S(I_{CBO}) = \frac{1+\beta}{1+\beta\left[\frac{R_E}{R_{Th}+R_E}\right]}}$$

where, $R_{Th} = R_1 \parallel R_2$.

3. Draw the circuit of voltage divider bias circuit. The circuit parameters are,

$V_{cc} = 10V$, $R_2 = 17\ k\Omega$, $R_1 = 83\ k\Omega$, $R_c = 2\ k\Omega$, $R_E = 0.5\ k\Omega$, find Q-point and terminal voltages. The transistor has $\beta = 100$ and $V_{BE} = 0.7V$

4a. Explain the reasons for instability of Operating point.

Reasons for Instability of the operating point :-

1. **Variation of leakage current 'I_{CO}' with temperature:-**

   The reverse saturation current 'I_{CO}' doubles for every 10^0C increase in temperature.

2. **Variation of base-emitter voltage 'V_{BE}' with temperature :-**

   V_{BE} decreases by 2.5mv for every 1^0C rise in temperature.

3. **Variation of current gain 'β' with temperature :-**

   β increases with rise in the temperature.

4b. Describe procedure to find the Q-point of a BJT circuit.

5a. Mention the applications of clippers and clampers.

Clippers find several applications, such as

- They are frequently used for the separation of synchronizing signals from the composite picture signals.
- The excessive noise spikes above a certain level can be limited or clipped in FM transmitters by using the series clippers.
- For the generation of new waveforms or shaping the existing waveform, clippers are used.
- The typical application of diode clipper is for the protection of transistor from transients, as a freewheeling diode connected in parallel across the inductive load.
- Frequently used half wave rectifier in power supply kits is a typical example of a clipper. It clips either positive or negative half wave of the input.
- Clippers can be used as voltage limiters and amplitude selectors.

Clampers can be used in applications

- The complex transmitter and receiver circuitry of television clamper is used as a base line stabilizer to define sections of the luminance signals to preset levels.
- Clampers are also called as direct current restorers as they clamp the wave forms to a fixed DC potential.
- These are frequently used in test equipment, sonar and radar systems.
- For the protection of the amplifiers from large errant signals clampers are used.
- Clampers can be used for removing the distortions
- For improving the overdrive recovery time clampers are used.
- Clampers can be used as voltage doublers or voltage multipliers.

5b. Design emitter bias circuit using the following specifications:
$I_{c(sat)}$= 10mA, I_{CQ} = 0.5 $I_{c(sat)}$, V_c= 20V, V_{cc}=30V.Assume silicon transistor with
β =100

Calculation of R_C

$$I_{CQ} = I_C = \frac{1}{2} I_{C\,(sat)} = 5\text{ mA}$$

$$R_C = \frac{V_{CC} - V_C}{I_C} = \frac{30\text{ V} - 20\text{ V}}{5\text{ mA}} = 2\text{ k}\Omega$$

Calculation of R_E

$$I_{C\,(sat)} = \frac{V_{CC}}{R_C + R_E}$$

$$R_C + R_E = \frac{V_{CC}}{I_{C(sat)}} = \frac{30\text{ V}}{10\text{ mA}} = 3\text{ k}\Omega$$

$$R_E = 3\text{ k}\Omega - R_C = 1\text{ k}\Omega$$

Calculation of R_B

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta)R_E}$$

$$I_B = \frac{I_C}{\beta} = \frac{5\text{ mA}}{100} = 50\ \mu\text{A}$$

Using this value in Equation (A) we have,

$$50\ \mu\text{A} = \frac{30\text{ V} - 0.7\text{ V}}{R_B + (101)(1\text{ k}\Omega)}$$

$$R_B + 101\text{ k}\Omega = 586\text{ k}\Omega$$

$$R_B = 586\text{ k}\Omega - 101\text{ k}\Omega = 485\text{ k}\Omega$$

6. Design a voltage divider bias circuit with V_{cc} = 10V, R_c = 1.5 kΩ,

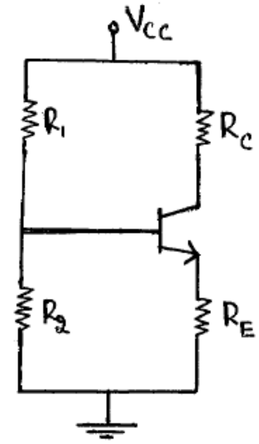
I_c= 2mA,V_{CE}=5V, β =50.Assume silicon transistor and stability factor = 5

Given :

$V_{CC} = 10V$, $R_C = 1.5\,k\Omega$, $I_C = 2mA$, $V_{CE} = 5V$, $V_{BE} = 0.7V$

$\beta = 50$ & $S = 5$.

$R_1 = ?$, $R_2 = ?$ & $R_E = ?$



Sol :-

$* \; I_B = \dfrac{I_C}{\beta} = \dfrac{2mA}{50} = 40\,\mu A$

$* \; I_E = I_B + I_C = 40\,\mu A + 2mA = 2.04mA$

$* \; R_E = \dfrac{V_{CC} - V_{CE} - I_C R_C}{I_E} = \dfrac{10V - 5V - [2mA \times 1.5\,k\Omega]}{2.04\,mA} = 980.39\,\Omega$

$* \; V_E = I_E R_E = 2.04mA \times 980.39\,\Omega = 1.999V$

$* \; S = 1 + \dfrac{R_{Th}}{R_E}$

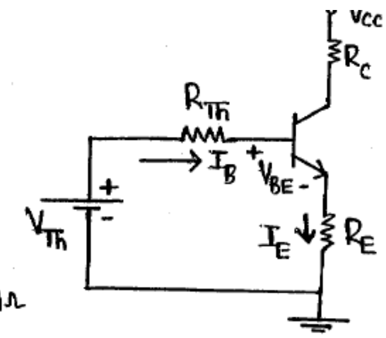
$5 = 1 + \dfrac{R_{Th}}{R_E}$

$4 = \dfrac{R_{Th}}{R_E}$

$R_{Th} = 4R_E = 4 \times 980.39\,\Omega$

$\boxed{R_{Th} = 3.92\,k\Omega}$

* Applying KVL to the ckt, we get



$$V_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$$

$$V_{Th} = I_B R_{Th} + V_{BE} + I_E R_E$$

$$= 40\,\mu A \times 3.92\,k\Omega + 0.7V + 2.04\,mA \times 980.39\,\Omega$$

$$\boxed{V_{Th} = 2.856V}$$

* WKT

$$V_{Th} = \frac{R_2}{R_1+R_2} V_{cc}$$

$$\frac{R_2}{R_1+R_2} = \frac{V_{Th}}{V_{cc}}$$

$$\frac{R_2}{R_1+R_2} = \frac{2.856V}{10V}$$

$$\boxed{\frac{R_2}{R_1+R_2} = 0.2856V} \longrightarrow ①$$

* WKT $R_{Th} = \frac{R_1 R_2}{R_1+R_2} \longrightarrow ②$

Substituting eq ① in eq ②, we get

$$R_{Th} = R_1 \times 0.2856$$

$$R_1 = \frac{R_{Th}}{0.2856} = \frac{3.92k\Omega}{0.2856}$$

$$\boxed{R_1 = 13.72k\Omega}$$

Substituting 'R_1' value in eq ①, we get

i.e. $\frac{R_2}{R_1+R_2} = 0.2856V \longleftarrow ①$

$$\frac{R_1 + R_2}{R_2} = \frac{1}{0.28568}$$

$$\frac{R_1}{R_2} + \frac{R_2}{R_2} = 3.50042$$

$$\frac{R_1}{R_2} + 1 = 3.50042$$

$$\frac{R_1}{R_2} = 3.50042 - 1$$

$$\frac{R_1}{R_2} = 2.50042$$

$$R_2 = \frac{R_1}{2.50042} = \frac{13.72\,k\Omega}{2.50042}$$

$$\boxed{R_2 = 5.48\,k\Omega}$$