4.7.1 Diode Compensation for V_{BE} :

The voltage divider bias circuit with diode compensation is as shown in Fig. 4.7.1. The additional power supply V_{DD} is connected in order to forward bias the diode D. The diode is of same material and type as the transistor. The voltage V_F across the diode has the same temperature coefficient (-2.5 mV/ °C) as that of the base to emitter voltage V_{BE}.

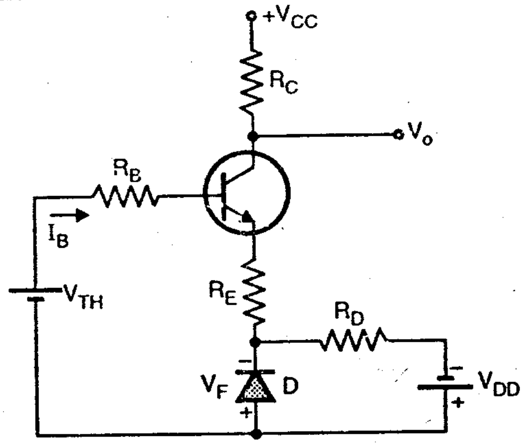

Fig. 4.7.1 : Diode compensation for V_{BE}

How does the compensation take place ?

From Fig. 4.7.1 the KVL for the base circuit gives :

$$V_{TH} = I_B R_B + V_{BE} + (I_B + I_C) R_E - V_F \qquad ...(4.7.1)$$

But, $$I_C = \beta_{dc} I_B + (1 + \beta_{dc}) I_{CBO} \qquad ...(4.7.2)$$

$$\therefore \quad V_{TH} = I_B (R_B + R_E) + V_{BE} + I_C R_E - V_F \qquad ...(4.7.3)$$

From Equation (4.7.2) $$I_B = \frac{I_C}{\beta_{dc}} - \frac{(1 + \beta_{dc}) I_{CBO}}{\beta_{dc}}$$

Substituting this value in Equation (4.7.3) we get,

$$V_{TH} = \frac{I_C}{\beta_{dc}} (R_B + R_E) - \frac{(1 + \beta_{dc})(R_B + R_E)}{\beta_{dc}} I_{CBO} + V_{BE} + I_C R_E - V_F$$

$$\therefore V_{TH} = V_{BE} - V_F + \frac{R_B + R_E (1 + \beta_{dc})}{\beta_{dc}} I_C - \frac{(R_B + R_E)}{\beta_{dc}} (1 + \beta_{dc}) I_{CBO} \qquad ...(4.7.4)$$

As the diode is made of same material as that of the transistor and has the same temperature coefficient, the change in voltage across the diode (V_F) will be equal to change in V_{BE} due to temperature. In Equation (4.7.4) these terms have opposite sign. Hence the change ... ected by change in V.. and I.. will become insensitive to variations in ...

4.7.2 Diode Compensation for I_{CO} :

For the germanium transistors, changes in I_{CO} due to change in temperature is more important than changes in V_{BE} due to temperature. The diode compensation circuit shown in Fig. 4.7.2 offers the stabilization against variation in I_{CO}.

How is the compensation provided ?

(i) The diode and the transistor are of same type and material. Therefore the reverse saturation current of the diode i.e. I_O will increase with temperature at the same rate as the current I_{CO}.

(ii) Referring to Fig. 4.7.2. We can write that,

$$I = \frac{V_{CC} - V_{BE}}{R_1} \approx \frac{V_{CC}}{R_1} = \text{constant}.$$

(iii) The base current $I_B = I - I_O$. Now substitute this value of I_B in the following equation :

$$I_C = \beta_{dc} I_B + (1 + \beta_{dc}) I_{CO}$$

$$= \beta_{dc}(I - I_O) + (1 + \beta_{dc}) I_{CO}$$

$$\therefore \quad I_C = \beta_{dc} I - \beta_{dc} I_O + (1 + \beta_{dc}) I_{CO} \quad ...(4.7.5)$$

(iv) Looking at the last two terms of Equation (4.7.5), we conclude that if $\beta >> 1$ and if I_O of D and I_{CO} of the transistor track each other over the desired temperature range then I_C will remain constant. Thus compensation is provided.

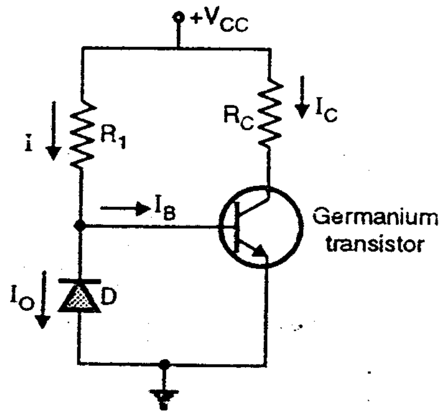

Fig. 4.7.2 : Diode compensation for I_{CO}

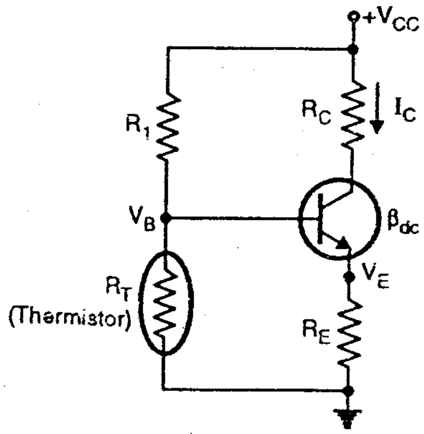

Fig. 4.7.3 : Bias compensation using a thermistor

4.7.3 Bias Compensation using Thermistor :

In the two previous circuits we have seen how to use a diode for compensation. Now let us see how a thermistor can be used for compensation. Thermistor is a resistor the resistance of which is temperature dependent. It's resistance decreases exponentially with increase in temperature. He said to have a negative temperature coefficient of resistivity.

The use of thermistor for bias compensation is demonstrated in Fig. 4.7.3.

Operation of the circuit :

As we have seen earlier with increase in temperature, the collector current I_C tends to increase. Now let us see how this increased I_C is reduced.

(i) As the temperature increases, resistance R_T of the thermistor decreases.

(ii) Due to decrease in R_T voltage drop across R_T also decreases.

(iii) This reduces V_B and therefore V_{BE} of the transistor.

(iv) Due to reduction in V_{BE}, the base current I_B decreases which in turn will reduce the increased collector current I_C. Thus the compensation is achieved.

4.7.4 Bias Compensation using Sensistor :

The bias compensation circuit using a sensistor is shown in Fig. 4.7.4. Sensistor is a temperature dependent resistance, the resistance of which increases with increase in temperature. Thus it has a positive temperature coefficient of resistivity.

Operation of the circuit :

(i) As the temperature increases, R_T increases.

(ii) As R_T increases, voltage drop across R_2 i.e. V_B will decrease.

(iii) As V_B decreases, V_{BE} also will decrease. Due to reduction in V_{BE}, base current I_B will decrease.

(iv) This will reduce the increased I_C due to increase in I_{CBO} with temperature. Thus the compensation is achieved.

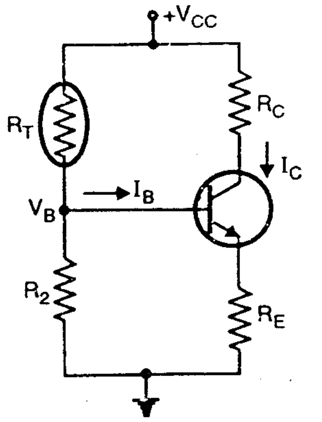

Fig. 4.7.4 : Bias compensation using a sensistor