TEMPERATURE COMPENSATION

Ref : BJT Biasing Circuit

Transistor Biasing

Facts reflected about Transistor Biasing

<1> Basic Ground rules are followed to bias the BJT properly.

<2> Identified Base Bias & Emitter Bias ckt. & corresponding transistor applications are mapped.

<3> Transistor Switch is discussed and studied applications of it.

<4> Emitter Bias ckt. is modified keeping in view to elliminate the effect of change β. Such that BJT can work as current source and amplifier effectively [By targetting fixed Q pt.]

Parameters affect Q point

The parameters which may affect the transistor operation in the active region –

$$I_{CQ} = I_{CQ}(\beta, V_{BE}, I_{CBO})$$

I_{CBO} → Change is very very small.

V_{BE} → $\Delta V_{BE} = -K \Delta T$ → 2mV/°c

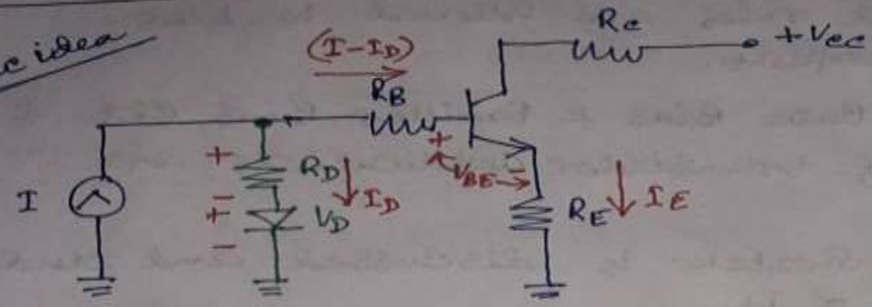
[Taken care by temperature Compensation circuit]

β → Taken suitable measure so as to get I_{CQ} & V_{CEQ} independent of β

Basic Concept

Temperature Compensation Circuit

The Basic idea



$$V_D + I_D R_D = (I - I_D) R_B + V_{BE} + I_E R_E$$

$$\therefore V_D + I_D R_D = I R_B - I_D R_B + V_{BE} + I_{CQ} R_E$$

$$\therefore I_{CQ} = \frac{(V_D - V_{BE}) + I_D (R_B + R_D) + I R_B}{R_E}$$

$$\therefore \frac{\Delta I_{CQ}}{\Delta T} = \frac{1}{R_E}\left[\frac{\Delta V_D}{\Delta T} - \frac{\Delta V_{BE}}{\Delta T}\right]$$

As $\dfrac{\Delta V_D}{\Delta T} = \dfrac{\Delta V_{BE}}{\Delta T} = -K$

So $\dfrac{\Delta I_{CQ}}{\Delta T} = 0$ [desired result is obtained]

→ So the suggested circuit may act as TEMPERATURE COMPENSATION CIRCUIT.

Outcome

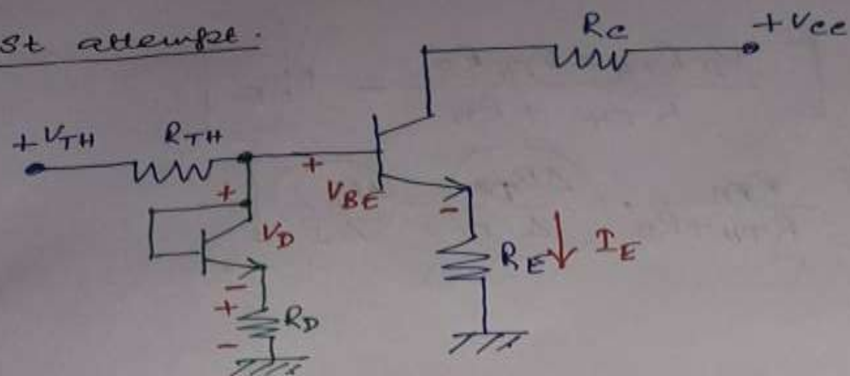
<u>Analysis of the Result</u>

<1> The suggested Temp. Compensation circuit has to be used in actual biasing circuit & subsequently we have to check whether same result is obtained or not.

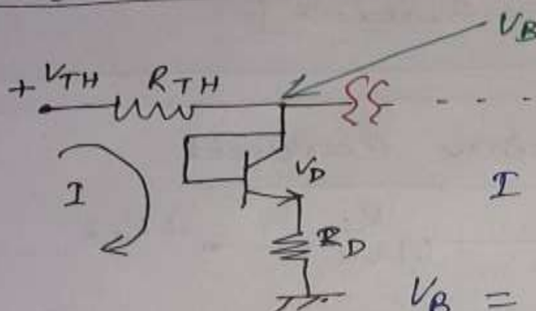
<2> Temperature characteristics of the diode junction may not be same as the junction ch. of BJT. So it is recommended to use transistor instead and use it as a diode.

Temperature Compensation

1st attempt:



Simplification.



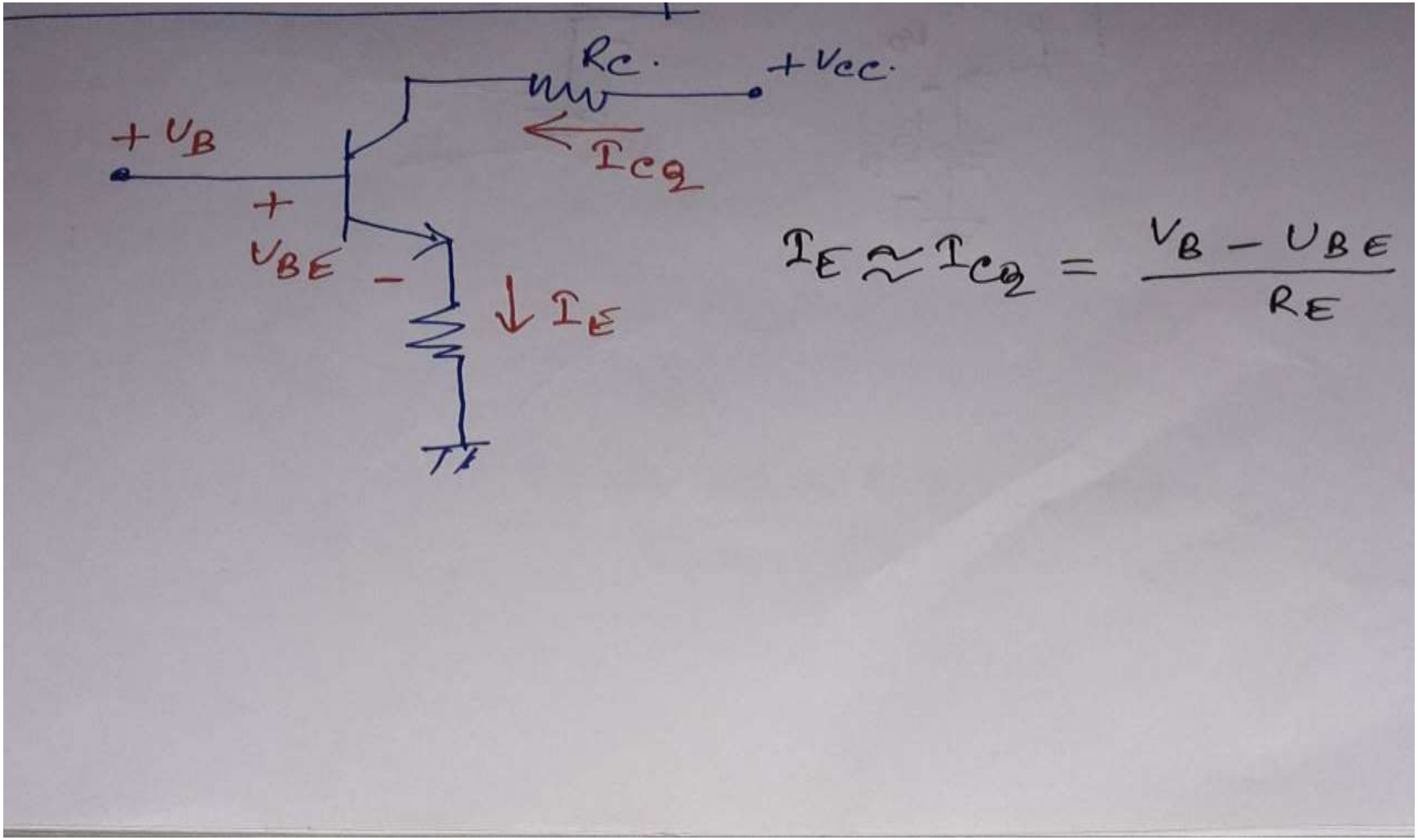
$$I = \frac{V_{TH} - V_D}{R_{TH} + R_D}.$$

$$V_B = V_D + \frac{V_{TH} - V_D}{R_{TH} + R_D} \cdot R_D.$$

$$V_B = \frac{V_D R_{TH} + \cancel{V_D R_D} + V_{TH} R_D - \cancel{V_D R_D}}{R_{TH} + R_D}$$

$$\boxed{V_B = \frac{V_D R_{TH} + V_{TH} R_D}{R_{TH} + R_D}}$$

Single Diode Compensation



Outcome

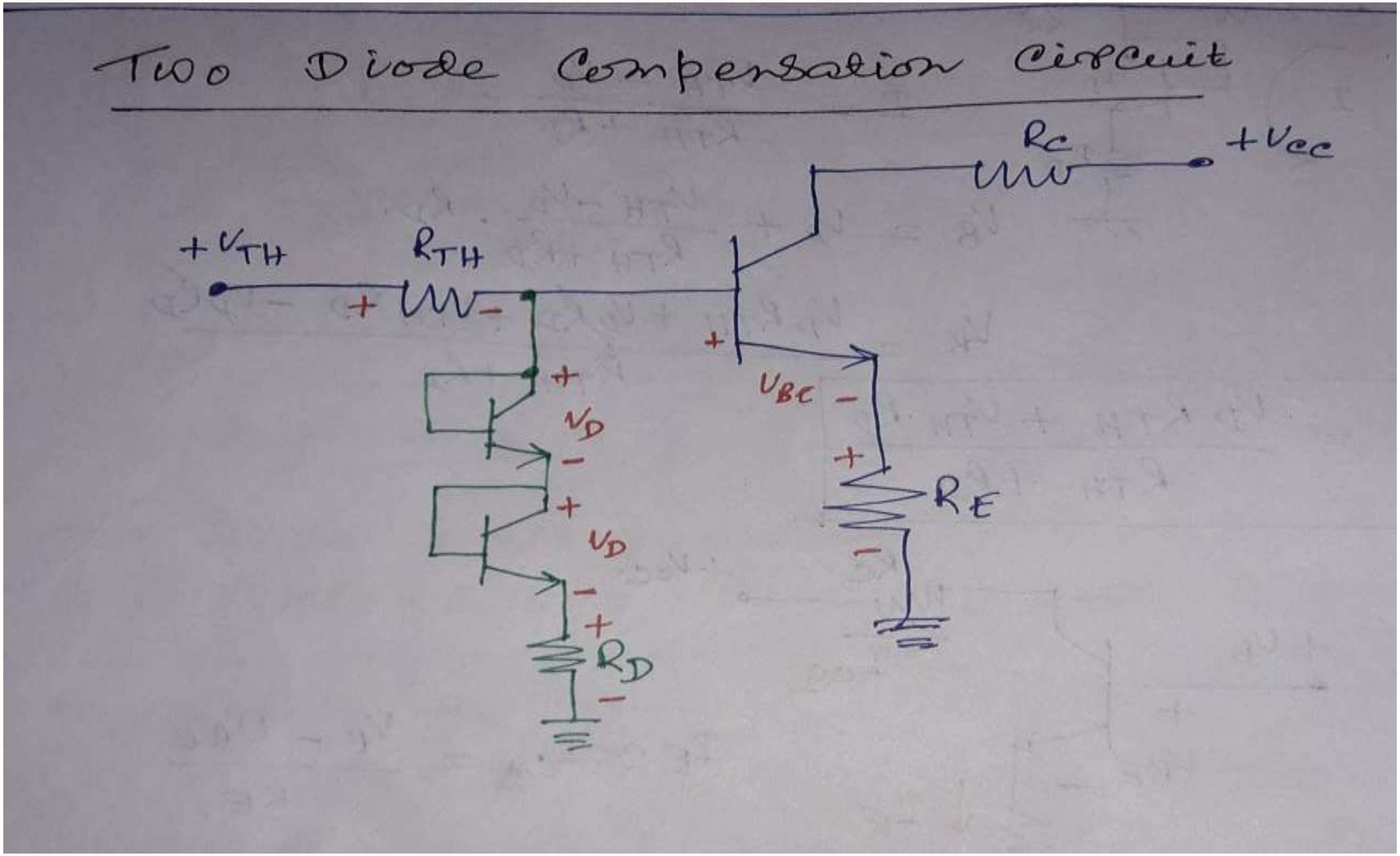
$$I_{CQ_2} = \frac{1}{R_E}\left[\frac{V_D R_{TH} + V_{TH} R_D}{R_{TH} + R_D} - V_{BE}\right]$$

$$\frac{\Delta I_{CQ_2}}{\Delta T} = \frac{1}{R_E}\left[\frac{R_{TH}}{R_{TH} + R_D} \cdot \underset{\simeq -k}{\frac{\Delta V_D}{\Delta T}} - \underset{\simeq -k}{\frac{\Delta V_{BE}}{\Delta T}}\right]$$

$$\neq 0$$

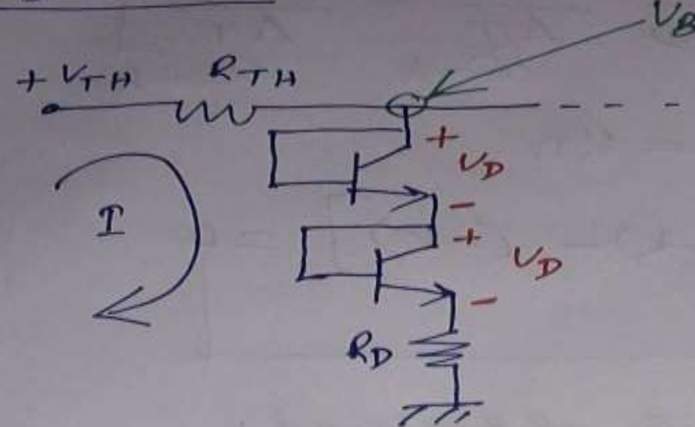
So this circuit failed all as compensation ckt. [Single Diode Compensation]

Two Diode Compensation



Two Diode Compensation

Simplification



$$I = \frac{V_{TH} - 2V_D}{R_{TH} + R_D}$$

$$V_B = 2V_D + I R_D$$

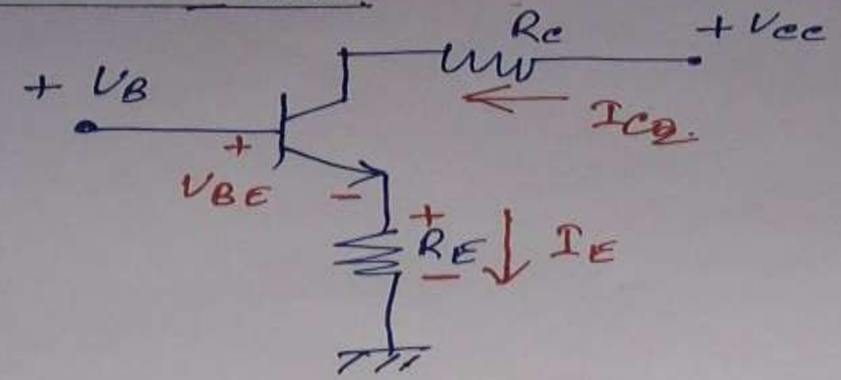
$$= 2V_D + \frac{V_{TH} - 2V_D}{R_{TH} + R_D} \cdot R_D$$

$$= \frac{2V_D R_{TH} + \cancel{2V_D R_D} + V_{TH} R_D - \cancel{2V_D R_D}}{R_{TH} + R_D}$$

$$\boxed{V_B = \frac{V_{TH} R_D + 2V_D R_{TH}}{R_{TH} + R_D}}$$

Two Diode Compensation

Equivalent ckt.



$$I_E \simeq I_{CQ} = \frac{V_B - V_{BE}}{R_E}$$

$$= \frac{1}{R_E}\left[\frac{V_{TH} R_D + 2V_D R_{TH}}{R_{TH} + R_D} - V_{BE}\right]$$

Outcome

$$\frac{\Delta I_{CQ}}{\Delta T} = \frac{1}{R_E}\left[\frac{2R_{TH}}{R_{TH}+R_D}\underbrace{\frac{\Delta V_D}{\Delta T}}_{\simeq -k} - \underbrace{\frac{\Delta V_{BE}}{\Delta T}}_{\simeq -k}\right]$$

Select $R_{TH} = R_D$.

$$\frac{\Delta I_{CQ}}{\Delta T} = \frac{1}{R_E}\left[\frac{2}{2}(-k) - (-k)\right] = 0$$

So desired result is obtained.