Emitter Bias

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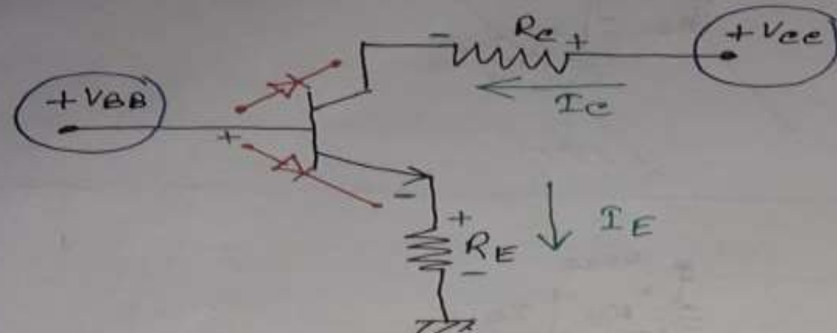
- To create the condition such that BJT can operate in the saturation region.
- To do the provisions for keeping I_{CQ} & V_{CEQ} independent of β.



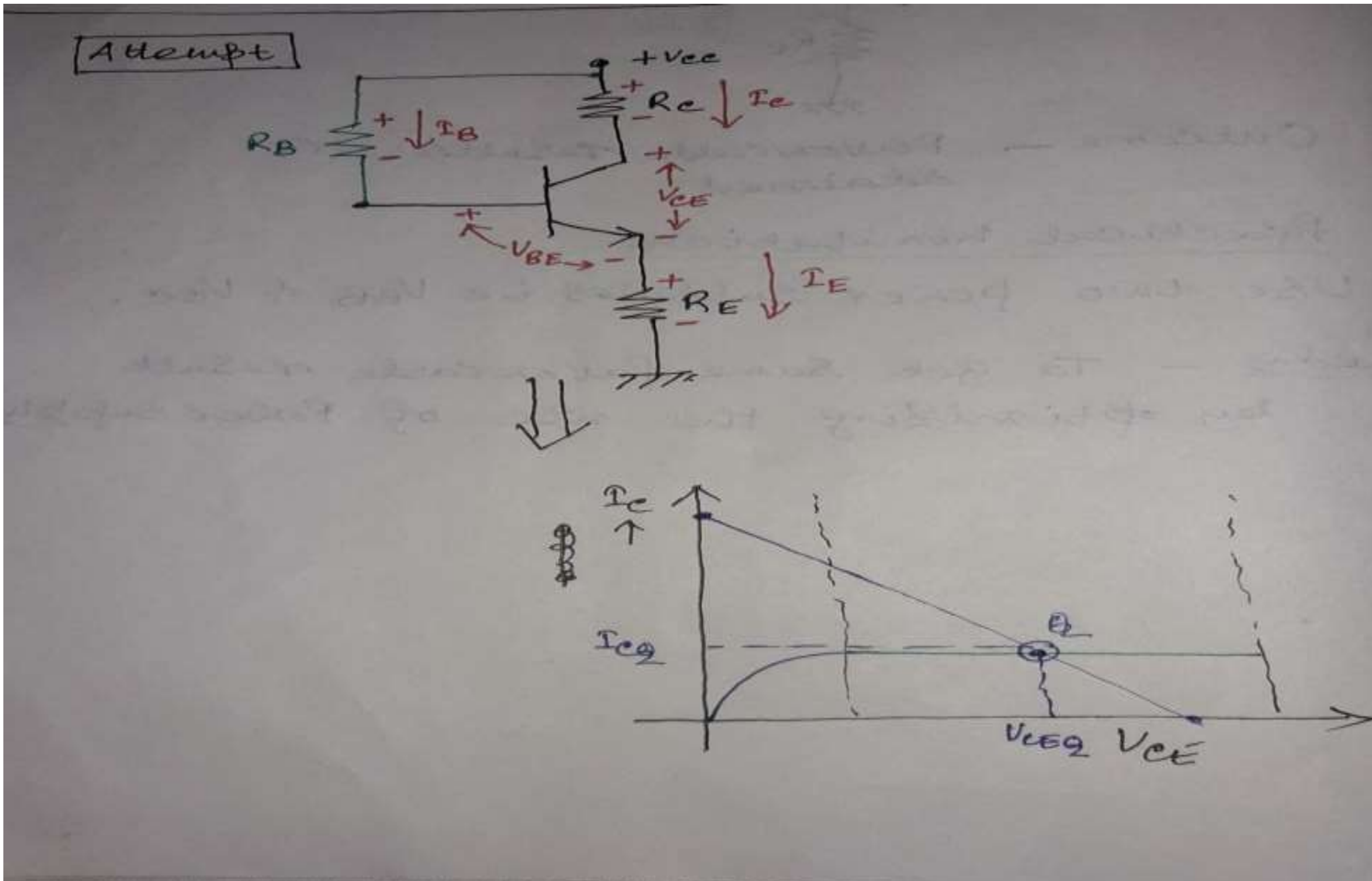
Outcome — Favourable results are obtained.

<u>Practical limitation</u>

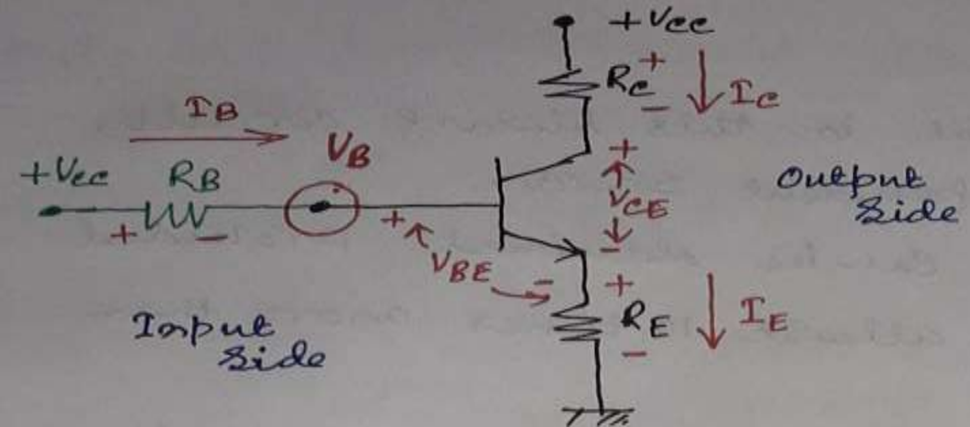
Use two power supplies i.e V_{BB} & V_{CC}.

<u>Remedy</u> — To get same favourable result by optimizing the use of power supply.

1st Attempt



Analysis



Input Side

$$V_{cc} - I_B R_B - V_{BE} - I_E R_E = 0$$

$$\therefore \quad V_{cc} - \frac{I_E}{\beta+1} \cdot R_B - V_{BE} - I_E R_E = 0.$$

$$\therefore \quad I_E \left(R_E + \frac{R_B}{\beta+1} \right) = V_{cc} - V_{BE}$$

$$\therefore \quad \boxed{I_E = \frac{V_{cc} - V_{BE}}{R_E + \left(\frac{R_B}{\beta+1}\right)}} \approx I_c \rightarrow \text{Not independent of } \beta.$$

Analysis

If $R_E \gg \frac{R_B}{\beta+1}$, $I_E \approx \frac{V_{CC}-V_{BE}}{R_E} \approx I_C$ (Independent of β)

<u>Practical Consideration.</u>

If $R_E = \frac{10 R_B}{\beta+1}$, $\boxed{I_E = \frac{V_{CC}-V_{BE}}{R_E+(.1)R_E} = \frac{V_{CC}-V_{BE}}{1.1 R_E} = I_{CQ}}$

[Satisfactory]

<u>Output side</u>

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$$

$$\therefore V_{CC} - V_{CE} - I_C (R_C + R_E) = 0 \quad [I_C \approx I_E]$$

$$\therefore V_{CE} = V_{CC} - I_C (R_C + R_E)$$

$$= V_{CC} - \frac{V_{CC}-V_{BE}}{1.1 R_E} \cdot (R_C + R_E)$$

$$\boxed{V_{CE} = V_{CC} - (0.9)(V_{CC} - V_{BE})\left(1 + \frac{R_C}{R_E}\right)} = V_{CEQ}$$

Inference

Observations

<1> In general in this biasing circuit, V_B is a dependent source.

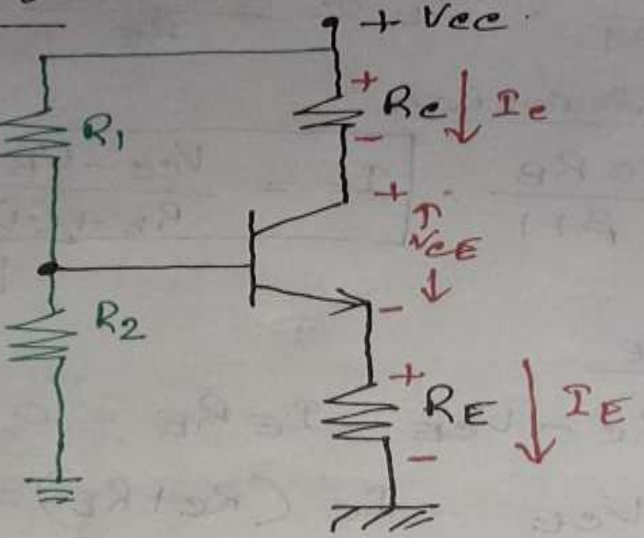
<2> I_{CQ}, V_{CEQ} can be obtained provided R_E is atleast 10 times more than $R_B/(\beta+1)$

<3> If V_B is fixed then Q pt will be obtained. But getting fixed V_B is solely dependent on resistance R_B. Since resistances are available in discrete values, so getting a Q pt. finally is a challenge.

<4> This biasing ckt. is also known as ~~Self bias~~ Emitter Bias with a base resistance of Fixed Bias.

2nd Attempt

Another Attempt.

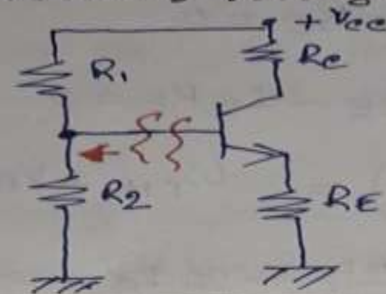


I/p side of this circuit has to be simplified.

Simplification

Simplify this biasing circuit by using Thevenin's Theorem.

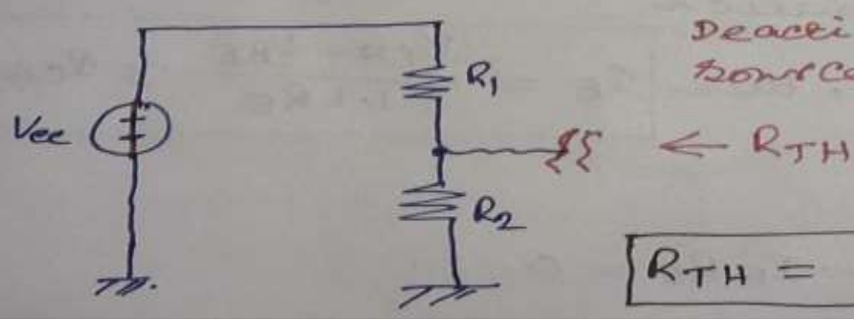
① To get Thevenin's Voltage V_{TH}



Load is removed, then subsequently voltage has to be measured as indicated.

$$\boxed{V_{TH} = \frac{V_{cc}}{R_1 + R_2} \cdot R_2}$$

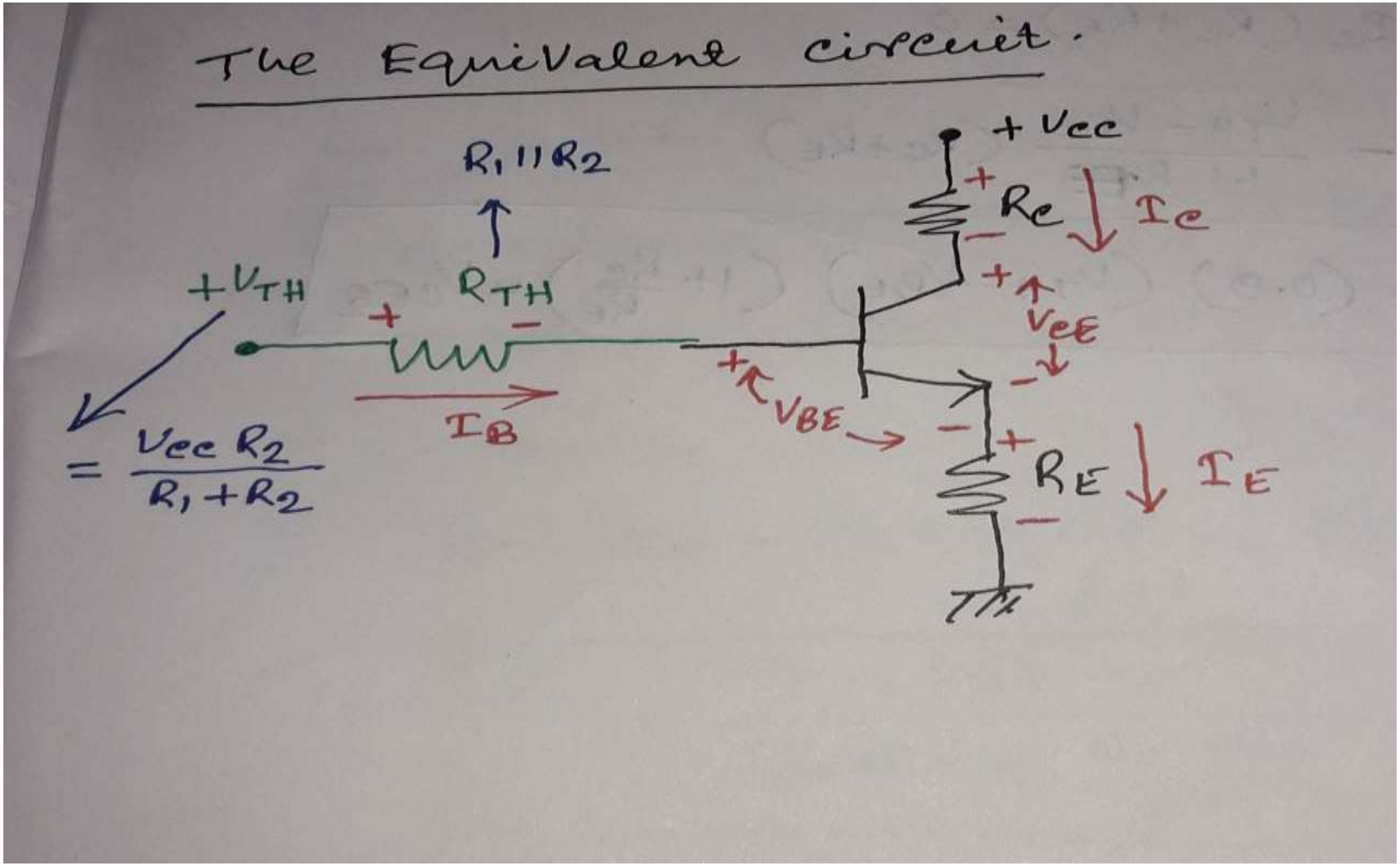
② To get Thevenin's Resistance. R_{TH}



Deactivated the voltage source.

$$\boxed{R_{TH} = R_1 \parallel R_2}$$

Equivalent Circuit



Analysis

Analysis of the circuit.

For I/P side.

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

$$\therefore V_{TH} - \frac{I_E}{\beta+1} \cdot R_{TH} - V_{BE} - I_E R_E = 0$$

$$\therefore \quad I_E \left(R_E + \frac{R_{TH}}{\beta+1} \right) = V_{TH} - V_{BE}$$

$$\therefore I_E = \frac{V_{TH} - V_{BE}}{R_E + \frac{R_{TH}}{\beta+1}} \simeq I_C \rightarrow \text{not independent of } \beta$$

If $\quad R_E >> \frac{R_{TH}}{\beta+1}$, then $I_E \simeq \frac{V_{TH} - V_{BE}}{R_E}$

Analysis

<u>Practical consideration</u>

If $R_E = \frac{10 R_{TH}}{\beta + 1}$, then $\boxed{I_E = \frac{V_{TH} - V_{BE}}{1.1 R_E} \simeq I_{CQ}}$

<u>For o/p side</u>

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0$$

$$\therefore V_{CC} - V_{CE} - I_C (R_C + R_E) = 0$$

$$\therefore V_{CE} = V_{CC} - \frac{V_{TH} - V_{BE}}{1.1 R_E} (R_C + R_E)$$

$$\boxed{V_{CE} = V_{CC} - (0.9)(V_{TH} - V_{BE})\left(1 + \frac{R_C}{R_E}\right) = V_{CEQ}}$$

Observations

Observations

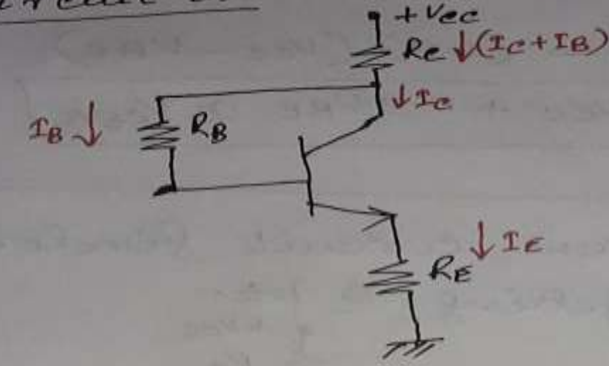
<1> I_{CQ} & V_{CEQ} can be obtained if R_E is atleast 10 times more than $\frac{R_{TH}}{\beta+1}$

<2> Getting Q pt. is much better way because $R_{TH} = R_1 \parallel R_2$ (nonstandard values can be obtained)

<3> This biasing circuit is known as Voltage Divider Bias Circuit.

A new type-analysis

The given circuit is



For I/P side

$$V_{cc} - R_c(I_c+I_B) - I_B R_B - I_E R_E - V_{BE} = 0$$

$$\therefore\ V_{cc} - V_{BE} - R_c I_B - I_B R_B - R_c I_c - I_E R_E = 0$$

$$\therefore\ V_{cc} - V_{BE} - (R_c+R_B) I_B - I_E (R_c+R_E) = 0$$

$$\therefore\ V_{cc} - V_{BE} - \frac{(R_c+R_B) I_E}{\beta+1} - I_E (R_c+R_E) = 0$$

$$\therefore\ \boxed{I_E = \frac{V_{cc} - V_{BE}}{(R_c+R_E) + \frac{R_c+R_B}{\beta+1}} \simeq I_c}$$

Not independent of β.

Analysis

If $(R_C + R_E) = 10 \cdot \dfrac{R_C + R_B}{\beta + 1}$

then $\boxed{I_E = \dfrac{V_{CC} - V_{BE}}{1.1\,(R_C + R_E)}} \approx I_{CQ}$

For o/p side

$$V_{CC} - I_C R_C - I_E R_E - V_{CE} = 0.$$

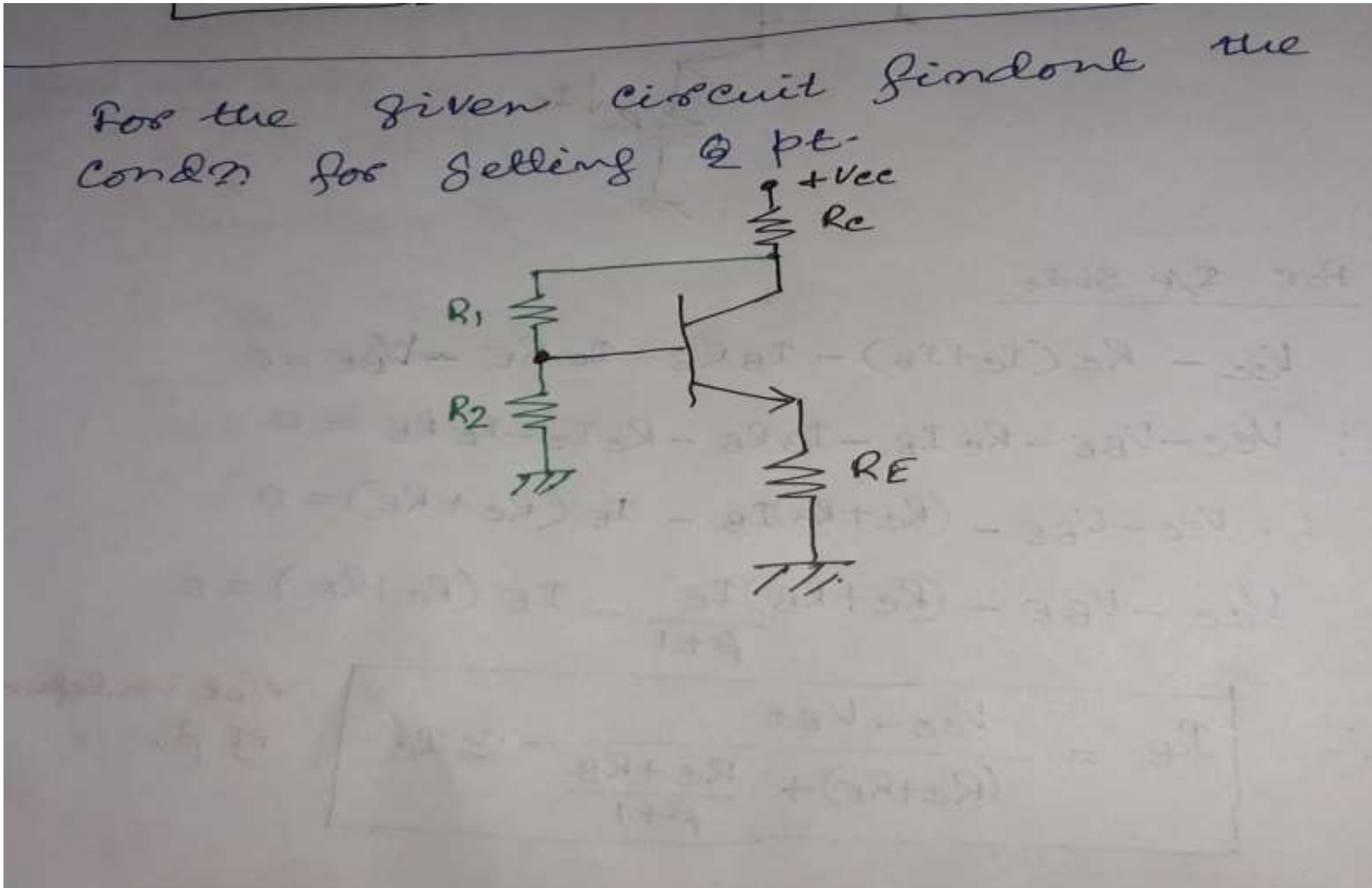
$$\therefore V_{CE} = V_{CC} - I_C (R_C + R_E)$$

$$= V_{CC} - \frac{V_{CC} - V_{BE}}{1.1\,(R_C + R_E)} \cdot (R_C + R_E)$$

$$V_{CE} = V_{CC} - (0.9)(V_{CC} - V_{BE})$$

$$\boxed{V_{CE} = 0.1\, V_{CC} + 0.9\, V_{BE} \approx V_{CEQ}}$$

Assignment


For the given circuit findout the
condn. for setting Q pt.
+Vcc
Rc
R1
R2
RE