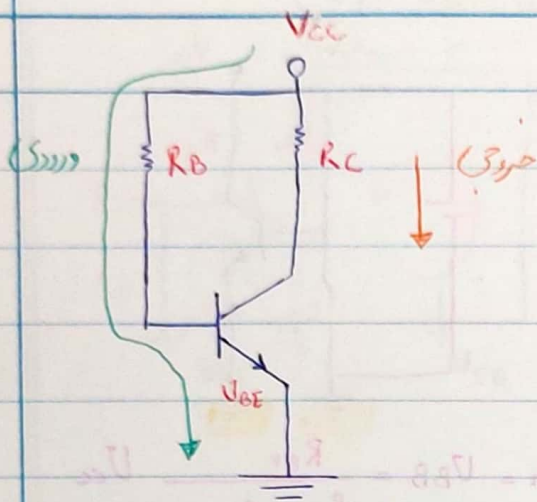


mode 1:



$$-V_{cc} + I_B R_B + V_{BE} = 0$$

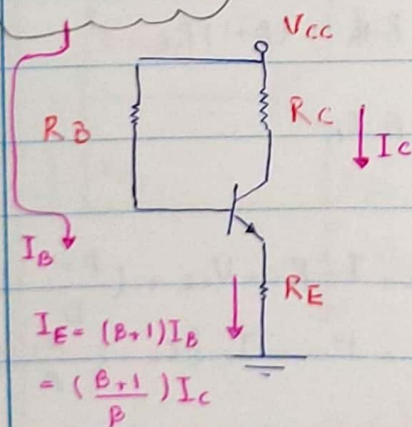
$$I_B = \frac{V_{cc} - V_{BE}}{R_B}$$

$$I_C = \beta I_B \quad \text{در صورت فرض فعال}$$

$$* -V_{cc} + I_C R_C + V_{CE} = 0$$

$$V_{CE} = V_{cc} - I_C R_C$$

mode 3:



$$I_E = (\beta + 1) I_B = \left(\frac{\beta + 1}{\beta} \right) I_C$$

$$* -V_{cc} + I_B R_B + V_{BE} + (\beta + 1) I_B R_E = 0$$

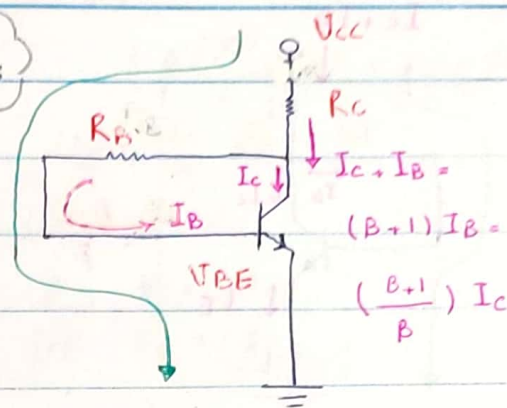
$$I_B = \frac{V_{cc} - V_{BE}}{R_B + (\beta + 1) R_E}$$

$$I_C = \beta I_B$$

$$* -V_{cc} + I_C R_C + V_{CE} + \left(\frac{\beta + 1}{\beta} \right) I_C R_E = 0$$

$$V_{CE} = V_{cc} - I_C \left[R_C + \left(\frac{\beta + 1}{\beta} \right) R_E \right]$$

mode 2:



$$\text{در صورت فرض فعال} \rightarrow \beta I_B$$

$$* -V_{cc} + (I_C + I_B) R_C + V_{CE} = 0$$

$$I_C R_C + V_{CE} = 0$$

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

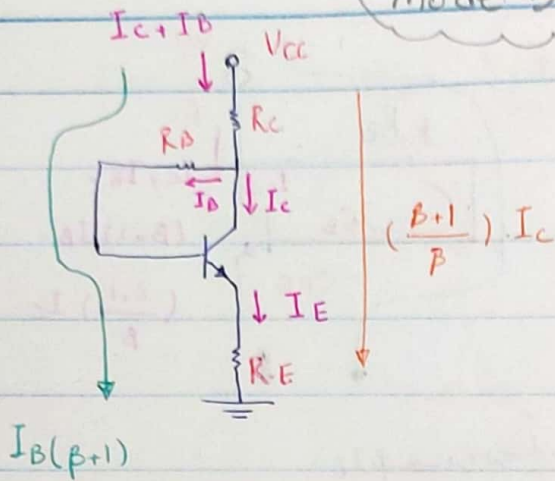
$$I_C = \beta I_B$$

$$* -V_{cc} + \left(\frac{\beta + 1}{\beta} \right) I_C R_C + V_{CE} = 0$$

$$V_{CE} = V_{cc} - \left(\frac{\beta + 1}{\beta} \right) R_C I_C$$

مدار خروجی برحسب I_C نوشته و در مدار ورودی برحسب I_B نوشته می شود.

mode 5:



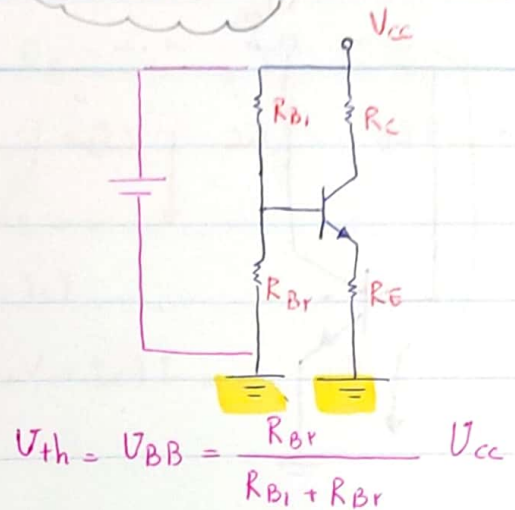
$$\begin{aligned}
 & * -V_{CC} + (\beta + 1) I_B R_C + I_B R_B \\
 & + V_{BE} + (\beta + 1) I_B R_E = 0 \\
 & I_B = \frac{V_{CC} - V_{BE}}{R_B + ((\beta + 1)(R_C + R_E))}
 \end{aligned}$$

$$I_C = \beta I_B$$

$$\begin{aligned}
 & * -V_{CC} + \left(\frac{\beta + 1}{\beta} \right) I_C R_C + V_{CE} \\
 & + \left(\frac{\beta + 1}{\beta} \right) I_C R_E
 \end{aligned}$$

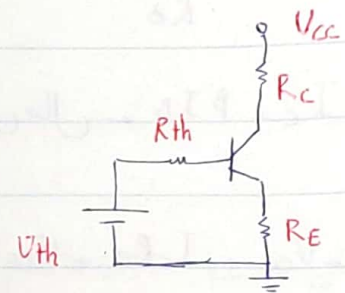
$$V_{CE} = V_{CC} - \left(\frac{\beta + 1}{\beta} \right) (R_C + R_E) I_C$$

mode 4:



$$R_{th} = \frac{R_{B1} R_{B2}}{R_{B1} + R_{B2}} = R_B$$

↓



$$\begin{aligned}
 & -V_{th} + I_B R_{th} + V_{BE} + (\beta + 1) I_B R_E = 0 \\
 & I_B = \frac{V_{th} - V_{BE}}{R_{th} + (\beta + 1) R_E}
 \end{aligned}$$

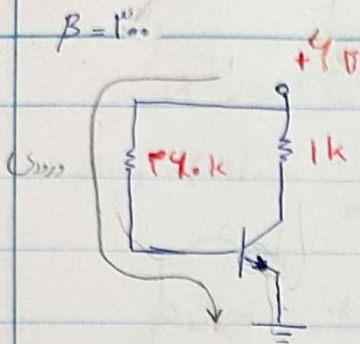
$$I_C = \beta I_B$$

$$\begin{aligned}
 & -V_{CC} + I_C R_C + V_{CE} + \left(\frac{\beta + 1}{\beta} \right) I_C R_E = 0 \\
 & V_{CE} = V_{CC} - I_C \left[R_C + \left(\frac{\beta + 1}{\beta} \right) R_E \right]
 \end{aligned}$$

Ex:

$$\text{ورودی: } 4 - 240 I_B - 0.1V = 0 \rightarrow I_B = 0.012$$

$$I_C = \beta I_B = 4.11$$



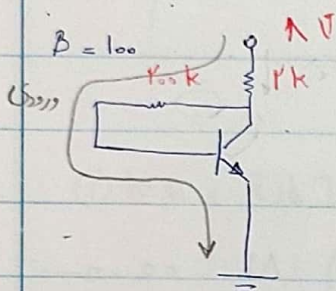
خروجی = $4 - 4.11 \times 2 = -0.11 < 0.2$ (منفی، حال باطل)

$$\text{ورودی: } 4 - 240 I_B - 0.1V = 0 \rightarrow I_B = 0.012$$

$$\text{خروجی: } 4 - I_C - 0.2 = 0 \rightarrow I_C = 3.8$$

$$\left. \begin{array}{l} \rightarrow I_{B(\min) \text{ Sat}} \\ = \\ \frac{I_C}{\beta_{FE}} = 0.019 \end{array} \right\}$$

$\rightarrow I_{B(\min) \text{ Sat}} < I_B \rightarrow$ (اشباع)



ورودی: $4 - (\beta + 1) I_B \times 2 - 200 I_B - 0.1V = 0$

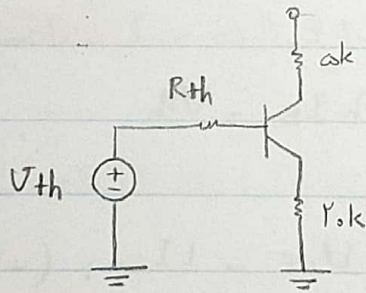
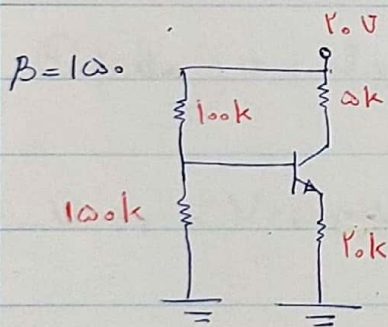
$$4 - 2.2 I_B - 200 I_B - 0.1V = 0$$

$$V_{BE} = 0.7V \rightarrow I_B = 0.014$$

$$I_C = 1.96$$

خروجی: $4 - \frac{1.96}{1} \times 2 - V_{CE} = 0 \rightarrow V_{CE} = 0.08 > 0.2$

(فعال)



$$V_{th} = \frac{100k}{100k + 100k} \times 4 = 2V$$

$$R_{th} = \frac{100k \times 100k}{100k + 100k} = 50k$$

حالت ورودی: $12 - 40 I_B - 0.1V - 100 I_B \times 2 = 0 \rightarrow I_B = 0.003$

$$I_C = 100 \times 0.003 = 0.3$$

حالت خروجی: $2 - 0.3 \times 2 - V_{CE} - \frac{100}{100} \times 0.3 \times 2 = 0$

$$V_{CE} = 1.4 > 0.2$$

(فعال)