Equations imposed by external Circuit

\[
\begin{align*}
\text{KVL 1 (Left)} & \quad V_{BB} = R_B i_B + v_{BE} + R_E i_E \\
\text{KVL 2 (Right)} & \quad V_{CC} = R_C i_C + v_{CE} + R_E i_E \\
\text{KCL (BJT)} & \quad i_E = i_C + i_B
\end{align*}
\]

Consider a Simple BJT

If BJT is in Forward Active Region:

Then \( i_C = \beta i_B \)

Hence \( i_E = (\beta + 1)i_B = \left(\frac{\beta + 1}{\beta}\right)i_C \)

Then KVL 1

\[
KVL 2 \Rightarrow i_C = \frac{V_{CC} - v_{CE}}{R_B + \left(\frac{\beta + 1}{\beta}\right)R_E}
\]

\[
\Rightarrow i_B = \frac{V_{BB} - v_{BE}}{R_B + (\beta + 1)R_E}
\]

load line in \( i_B \) vs \( v_{BE} \) plot

\[
\Rightarrow i_C = -\frac{1}{R_{DC}} v_{CE} + \frac{1}{R_{DC}} V_{CC}
\]

load line in \( i_C \) vs \( v_{CE} \) plot

\[
R_{DC} = R_B + \left(\frac{\beta + 1}{\beta}\right)R_E
\]