Thévenin Base Circuit

Although the base is not an output terminal, the Thévenin equivalent circuit seen looking into the base is useful in calculating the base current. It consists of a voltage source $v_{b(oc)}$ in series with a resistor r_{ib} from the base node to signal ground. Fig. 1(a) shows the BJT symbol with a Thévenin source connected to its emitter. Fig. 1(b) shows the T model for calculating the open-circuit base voltage. Because $i_b = 0$, it follows that $i'_e = 0$. Thus there is no drop across r_x and r_e so that $v_{b(oc)}$ is given by

$$v_{b(oc)} = v_e = v_{te} \frac{r_0 + R_{tc}}{R_{te} + r_0 + R_{tc}} \tag{1}$$

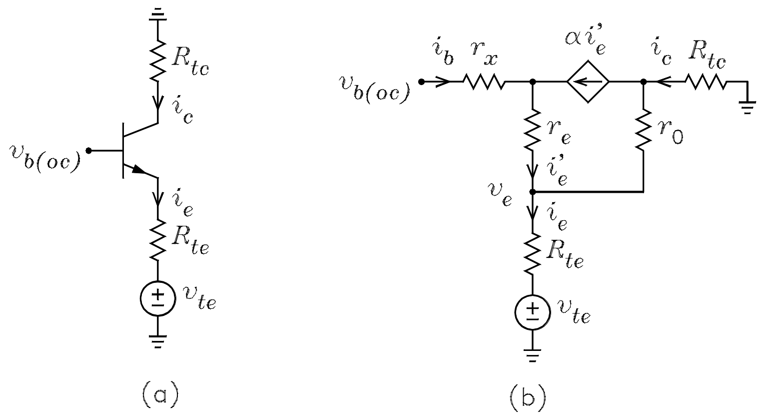

Figure 1: (a) BJT with Thevenin source connected to the emitter. (b) T model for calculating $v_{b(oc)}$.

The next step is to solve for the resistance seen looking into the base. It can be calculated by setting $v_{te} = 0$ and connecting a test current source i_t to the base. It is given by $r_{ib} = v_b / i_t$. Fig. 2(a) shows the T circuit for calculating v_b, where the current source βi_t has been divided into identical series sources with their common node grounded to simplify use of superposition. By superposition of i_t and the two βi_t sources, we can write

$$v_b = i_t r_x + (i_t + \beta i_t) \left[r_e + R_{te} \| (r_0 + R_{tc}) \right] - \beta i_t \frac{R_{tc} R_{te}}{R_{tc} + r_0 + R_{te}} \tag{2}$$

This can be solved for r_{ib} to obtain

$$\begin{aligned} r_{ib} &= \frac{v_b}{i_t} = r_x + (1+\beta) \left[r_e + R_{te} \| (r_0 + R_{tc}) \right] - \frac{\beta R_{tc} R_{te}}{R_{tc} + r_0 + R_{te}} \\ &= r_x + (1+\beta) r_e + R_{te} \frac{(1+\beta) r_0 + R_{tc}}{r_0 + + R_{te} + R_{tc}} = r_x + r_\pi + R_{te} \frac{(1+\beta) r_0 + R_{tc}}{r_0 + + R_{te} + R_{tc}} \end{aligned} \tag{3}$$

The Thévenin base circuit is shown in Fig. 2(b).

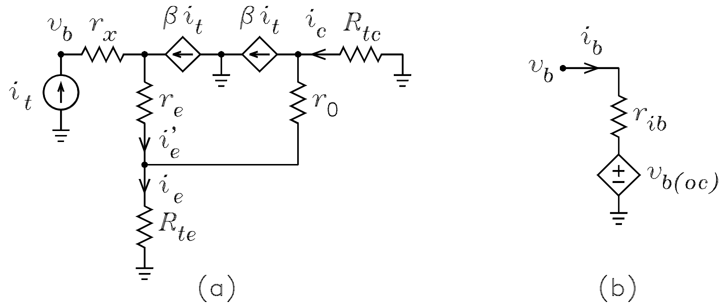

Figure 2: (a) Circuit for calculating v_b. (b) Thévenin base circuit.