The Thévenin equivalent circuit seen looking into the emitter is useful in calculating the response of common-collector stages. It consists of a voltage source $v_{e(oc)}$ in series with a resistor $r_{ie}$ from the emitter node to signal ground. Fig. 1(a) shows the BJT symbol with a Thévenin source connected to the base. The resistor $R_{tc}$ represents the external load resistance in series with the collector. With the emitter open circuited, we denote the emitter voltage by $v_{e(oc)}$. The voltage source in the Thévenin emitter circuit has this value. To solve for it, we use the simplified T model in Fig. 1(b).

Figure 1: (a) BJT with Thévenin source connected to the base. (b) Simplified T model circuit for calculating $v_{e(oc)}$.

The current $i_e'$ can be solved for by superposition of the sources $v_{tb}$ and $\alpha i_e'$. It is given by

$$i_e' = \frac{v_{tb}}{r_e' + r_0 + R_{tc}} + \alpha i_e' \frac{R_{tc}}{r_e' + r_0 + R_{tc}} \quad (1)$$

This can be solved for $i_e'$ to obtain

$$i_e' = \frac{v_{tb}}{r_e' + r_0 + (1 - \alpha) R_{tc}} = \frac{v_{tb}}{r_e' + r_0 + R_{tc} / (1 + \beta)} \quad (2)$$

The open-circuit emitter voltage is given by

$$v_{e(oc)} = v_{tb} - i_e' r_e' = v_{tb} \frac{r_0 + R_{tc} / (1 + \beta)}{r_e' + r_0 + R_{tc} / (1 + \beta)} \quad (3)$$

We next solve for the resistance seen looking into the emitter node. It can be solved for as the ratio of the open-circuit emitter voltage $v_{e(oc)}$ to the short-circuit emitter current. The circuit for calculating the short-circuit current is shown in Fig. 2(a). By superposition of $i_e'$ and $\alpha i_e'$, we can write

$$i_{e(sc)} = i_e' - \alpha i_e' = \frac{R_{tc}}{r_0 + R_{tc}} = \frac{v_{tb}}{r_e' + r_0 + R_{tc}} \quad (4)$$

The resistance seen looking into the emitter is given by

$$r_{ie} = \frac{v_{e(oc)}}{i_{e(sc)}} = \frac{r_0 + R_{tc}}{r_e' + r_0 + R_{tc} / (1 + \beta)} \quad (5)$$

The Thévenin equivalent circuit seen looking into the emitter is shown in Fig. 2(b).
Figure 2: (a) Circuit for calculating $i_e(\text{sc})$. (b) Thévenin emitter circuit.