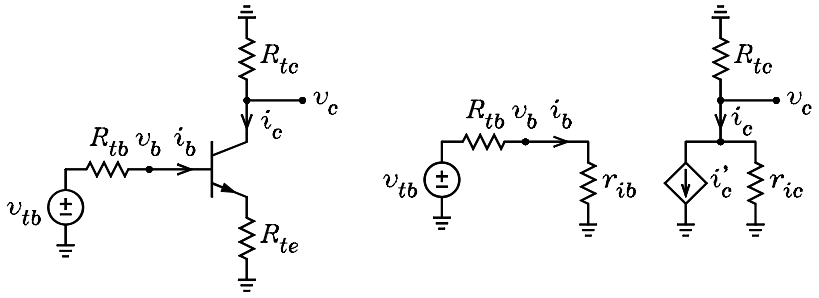
BJT Amplifier Small-Signal Equivalent Circuits
ECE 3050 – Analog Electronics

The BJT Common-Emitter Amplifier



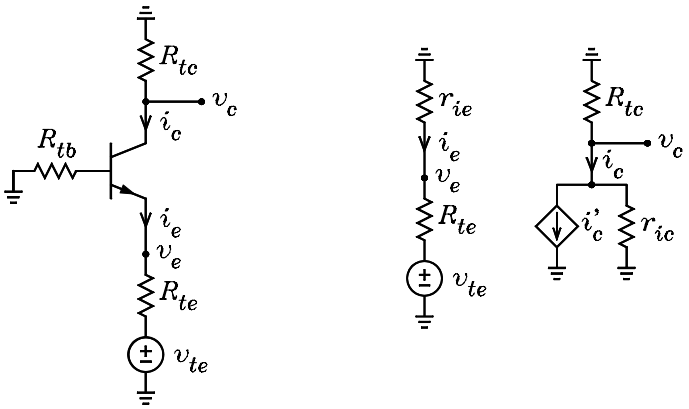
$$r_e = \frac{V_T}{I_E} \qquad r_e' = \frac{R_{tb} + r_x}{1+\beta} + r_e \qquad r_0 = \frac{V_A + V_{CE}}{I_C}$$

$$r_{ib} = r_x + (1+\beta)\, r_e + R_{te}\frac{(1+\beta)\, r_0 + R_{tc}}{r_0 + R_{te} + R_{tc}} \qquad r_{ic} = \frac{r_0 + r_e' \| R_{te}}{1 - \dfrac{\alpha R_{te}}{r_e' + R_{te}}}$$

$$i_b = \frac{v_{tb}}{R_{tb} + r_{ib}} \qquad v_b = \frac{r_{ib}}{R_{tb} + r_{ib}} v_{tb}$$

$$i_c' = \frac{\alpha}{r_e' + R_{te} \| r_0} \frac{r_0 - R_{te}/\beta}{r_0 + R_{te}} v_{tb} \qquad i_c = \frac{r_{ic}}{r_{ic} + R_{tc}} i_c' \qquad v_c = -i_c' \left(r_{ic} \| R_{tc}\right)$$

The BJT Common-Base Amplifier



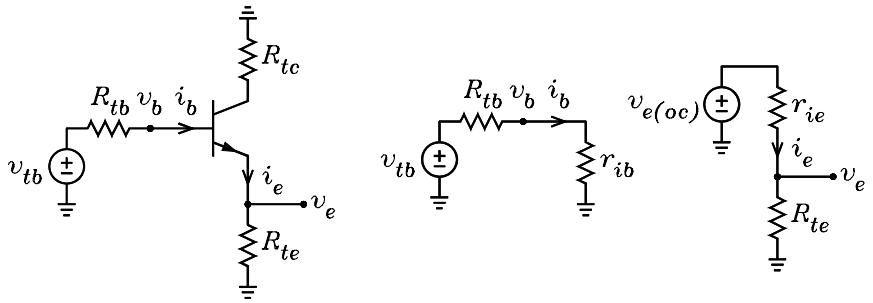
$$r_e = \frac{V_T}{I_E} \qquad r_e' = \frac{R_{tb} + r_x}{1+\beta} + r_e \qquad r_0 = \frac{V_A + V_{CE}}{I_C}$$

$$r_{ie} = \frac{r_e' \| \left(r_0 + R_{tc}\right)}{1 - \dfrac{\alpha R_{tc}}{r_e' + r_0 + R_{tc}}} \qquad r_{ic} = \frac{r_0 + r_e' \| R_{te}}{1 - \dfrac{\alpha R_{te}}{r_e' + R_{te}}}$$

$$i_e = -\frac{v_{te}}{R_{te} + r_{ie}} \qquad v_e = \frac{r_{ie}}{R_{te} + r_{ie}} v_{te}$$

$$i'_c = -\frac{1}{R_{te} + r'_e \| r_0} \frac{\alpha r_0 + r'_e}{r_0 + r'_e} v_{te} \qquad i_c = \frac{r_{ic}}{r_{ic} + R_{tc}} i'_c \qquad v_c = -i'_c \left(r_{ic} \| R_{tc}\right)$$

The BJT Common-Collector Amplifier



$$r_e = \frac{V_T}{I_E} \qquad r'_e = \frac{R_{tb} + r_x}{1 + \beta} + r_e \qquad r_0 = \frac{V_A + V_{CE}}{I_C}$$

$$r_{ib} = r_x + (1 + \beta) r_e + R_{te} \frac{(1 + \beta) r_0 + R_{tc}}{r_0 + R_{te} + R_{tc}} \qquad r_{ie} = \frac{r'_e \| (r_0 + R_{tc})}{1 - \dfrac{\alpha R_{tc}}{r'_e + r_0 + R_{tc}}}$$

$$i_b = \frac{v_{tb}}{R_{tb} + r_{ib}} \qquad v_b = \frac{r_{ib}}{R_{tb} + r_{ib}} v_{tb}$$

$$v_{e(\mathrm{oc})} = \frac{v_{tb}}{1 + \dfrac{r'_e}{r_0 + R_{tc} / (1 + \beta)}} \qquad i_e = \frac{v_{e(\mathrm{oc})}}{r_{ie} + R_{te}} \qquad v_e = \frac{R_{te}}{r_{ie} + R_{te}} v_{e(\mathrm{oc})}$$