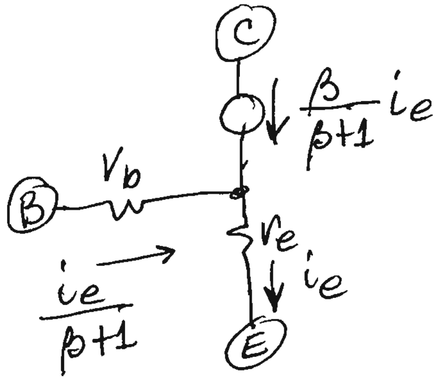
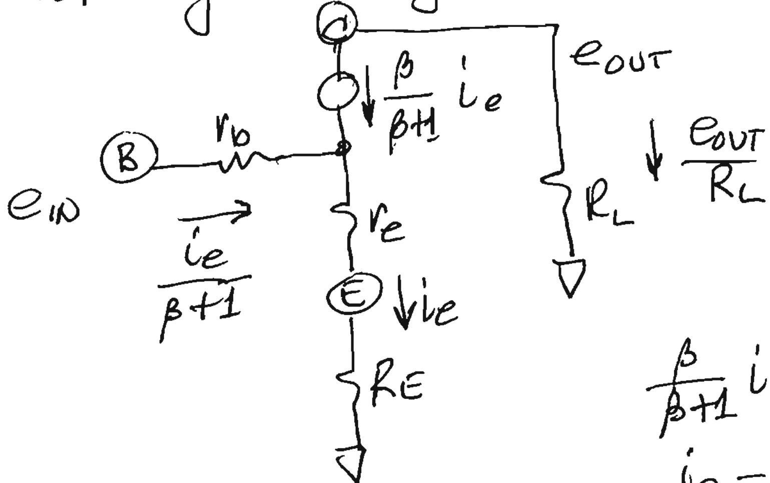
Simpler to use than hybrid-pi model
But just as good at audio frequencies:



$$r_e = \frac{kT}{qI_E}, \quad I_E = \text{DC emitter current}$$

$$r_e \approx \frac{26}{I_E}, \quad I_E \text{ IN mA}$$

So, for a gain stage:



$$\frac{\beta}{\beta+1} i_e = -\frac{e_{OUT}}{R_L}$$

$$i_e = -\frac{\beta+1}{\beta}\frac{e_{OUT}}{R_L}$$

$$e_{IN} = i_e\left(\frac{r_b}{\beta+1} + r_e + R_E\right) = -\frac{\beta+1}{\beta}\frac{e_{OUT}}{R_L}\left(\frac{r_b}{\beta+1} + r_e + R_E\right)$$

$$\text{GAIN} = \frac{e_{OUT}}{e_{IN}} = -\frac{\beta}{\beta+1}\cdot\frac{R_L}{\left(\frac{r_b}{\beta+1} + r_e + R_E\right)}$$

$$Z_{IN} = \frac{e_{IN}}{i_e}(\beta+1) = -\frac{e_{IN}\cancel{(\beta+1)}}{\cancel{(\beta+1)}}\cdot\frac{\beta R_L}{e_{OUT}} = -\frac{e_{IN}}{e_{OUT}}\cdot\beta R_L$$

$$Z_{IN} = \frac{\beta+1}{\cancel{\beta}}\cancel{\beta}\left(\frac{r_b}{\beta+1} + r_e + R_E\right) = (\beta+1)\cdot\left(\frac{r_b}{\beta+1} + r_e + R_E\right)$$

$$Z_{IN} = r_b + (\beta+1)\cdot(r_e + R_E)$$

—JT 10/10/2013