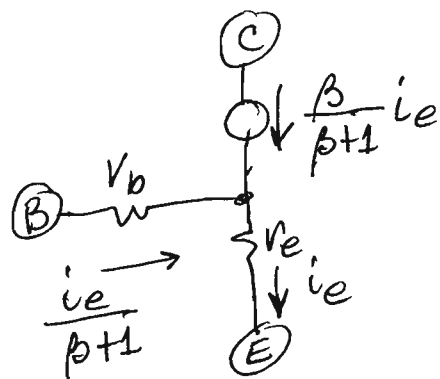


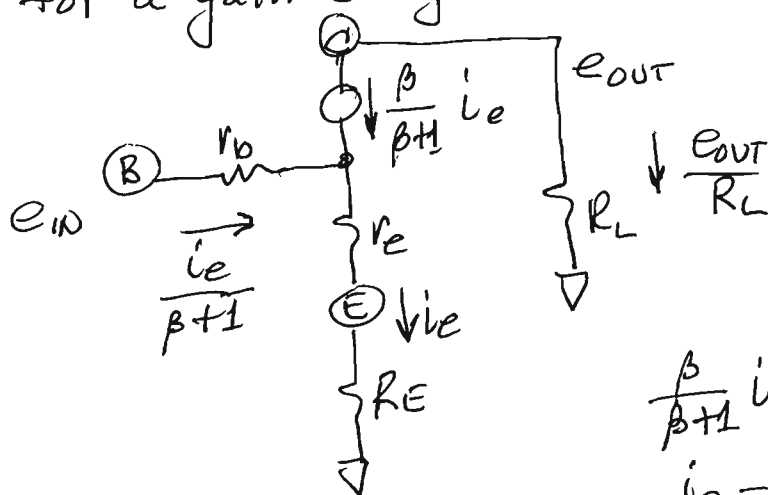
Simpler to use than hybrid- π model
 But just as good at audio frequencies:



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

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

So, for a gain stage:



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

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

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

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

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

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

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