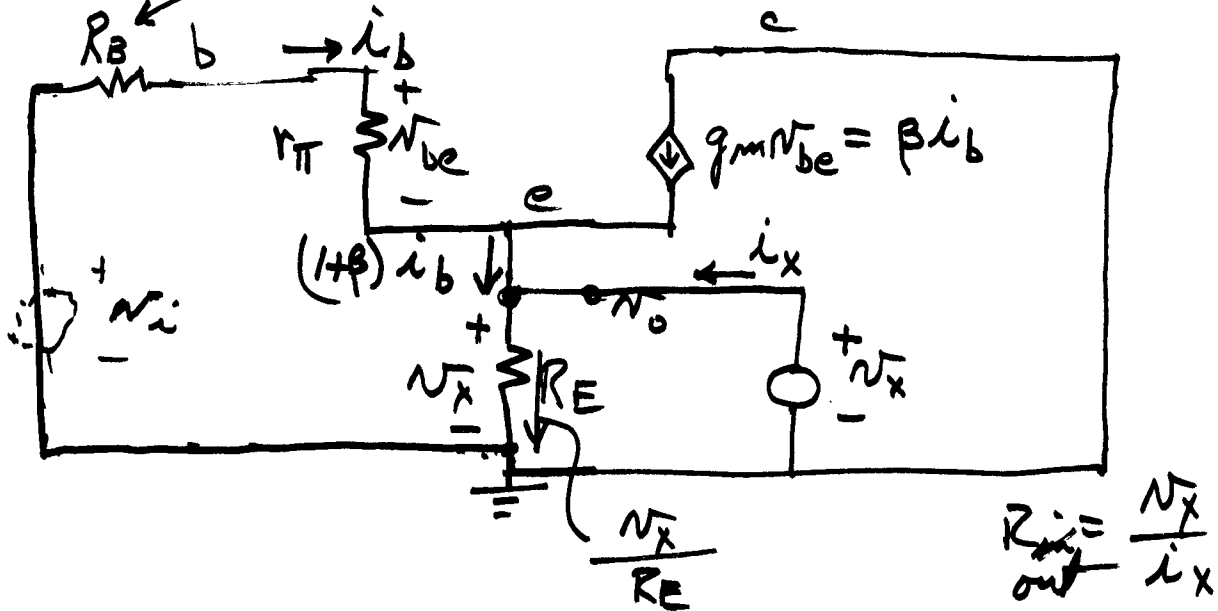
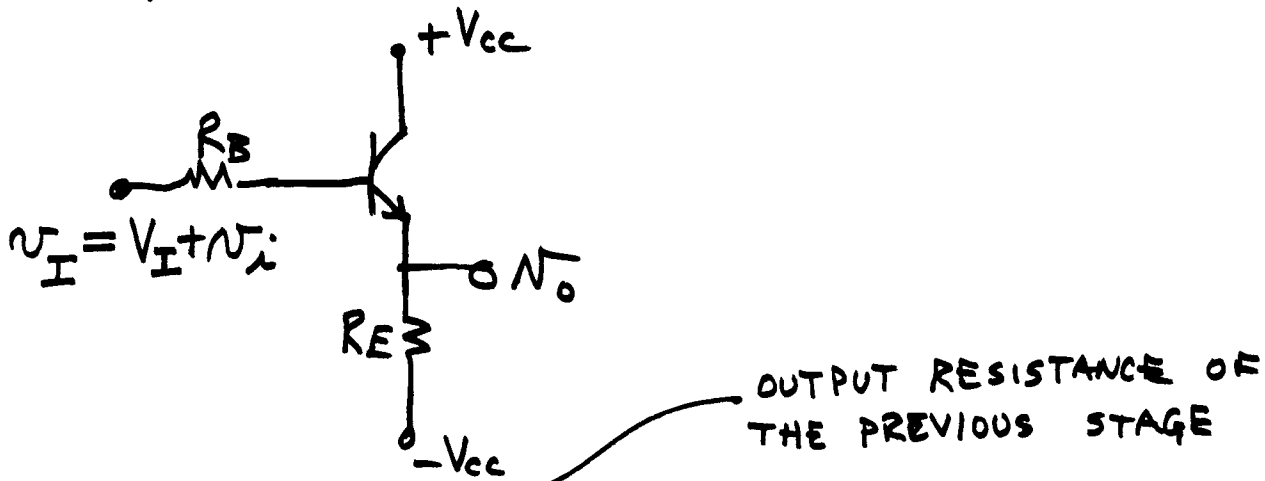


LOW OUTPUT RESISTANCE

EMITTER FOLLOWER



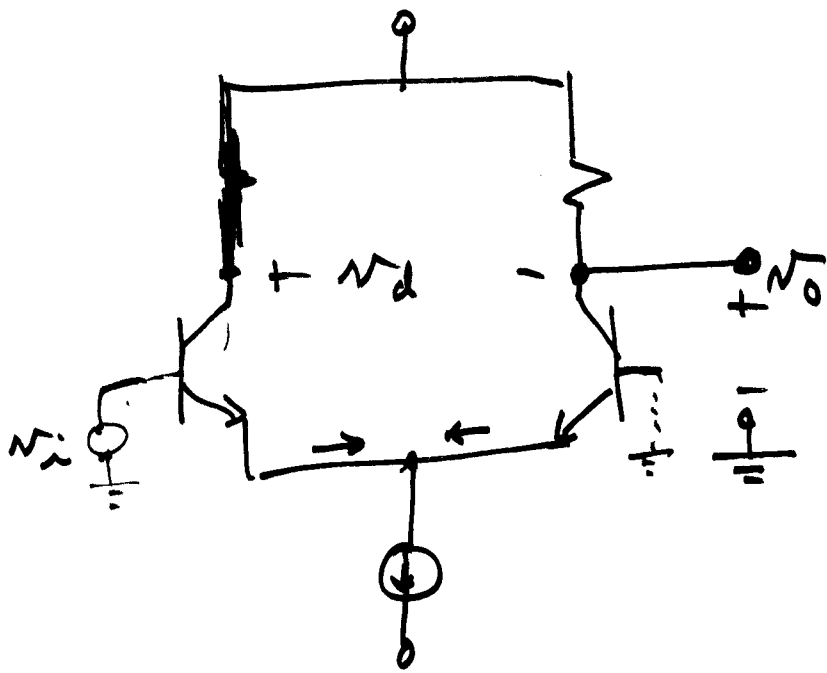
$$\text{KCL: } i_x = \frac{N_x}{R_E} - (1+\beta) i_b$$

$$i_b = -\frac{N_x}{r_{\pi} + R_E}$$

$$i_x = N_x \left[\frac{1}{R_E} + \frac{1+\beta}{r_{\pi} + R_E} \right]$$

$$\frac{i_x}{N_x} = \frac{1}{R_E} + \frac{1}{(r_{\pi} + R_E)/(1+\beta)} = \frac{1}{R_{out}}$$

$$R_{out} = R_E \parallel \frac{r_{\pi} + R_E}{1+\beta}$$



single-ended output

$$\frac{v_d}{v_{id}} = - \frac{I_{EE} R_c}{V_T}$$

$$\frac{v_o}{v_{id}} = + \frac{I_{EE} R_c}{2V_T}$$

LEVEL SHIFTER

