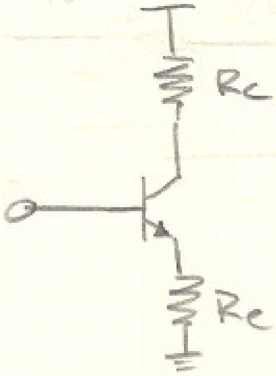
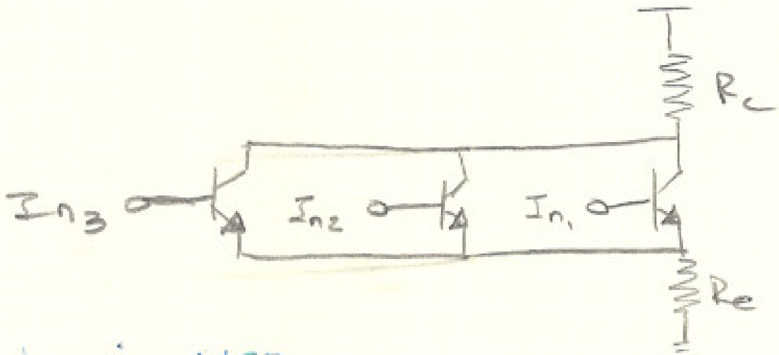
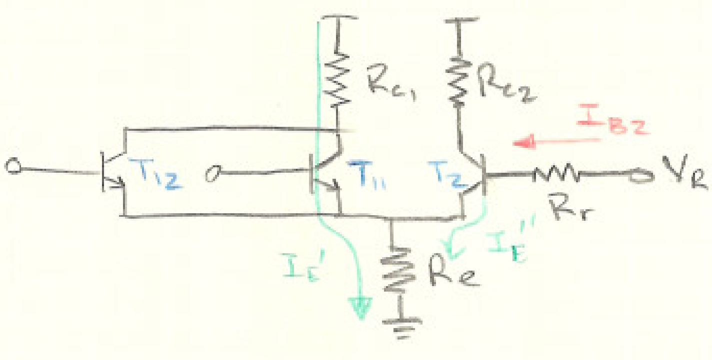


note: negative feedback reduces electron cloud, it virtually does not occur.



this is NOR

$Y = \overline{x_1 + x_2 + \ldots}$



to design, we should consider only one branch.

GIVEN: $V_{cc}, V_{OUT}^1, V_{in}^0, V_{in}^1, R_L, V_r, R_r$
$V_{BE(T)1}, V_{BE(T)2}, \beta_1, \beta_2$.

FIND: R_{C1}, R_{C2}, R_e.

ANALYSIS:

$$V_{in}^0 < V_{BET1} + V_e$$

$$V_e > V_{in}^0 - V_{BET1}$$

$$\beta_2 I_{B2} = I_{C2}$$

$$I_{C2} + I_{B2} = I_{E2}$$

$$\boxed{I_{B2} = \frac{I_{E2}}{1+\beta_2}}$$

$$I_{B2}R_r + V_{BET2} + I_{e2}R_e = V_r$$

$$\frac{I_{E2}}{1+\beta_2}R_r + V_{BET2} + I_{E2}R_e = V_r$$

$$I_{E2}R_e = V_r - V_{BET2} - \frac{I_{E2}}{1+\beta_2}R_r = V_{e2}$$

$$V_{in}^0 - V_{BET1} < V_r - V_{BET2} - \frac{I_{E2}}{1+\beta_2}R_r$$

$$\frac{I_{E2}}{1+\beta_2} \cdot R_r < V_r + V_{BET1} - V_{BET2} - V_{in}^0$$

$$0 < \boxed{I_{E2} < \frac{V_r + V_{BET1} - V_{BET2} - V_{in}^0}{R_r}(1+\beta_2)}$$

$$V_{e2} = R_e I_{e2}$$

$$V_{e2} = R_e \frac{V_r + V_{BET1} - V_{BET2} - V_{in}^0}{R_r}(1+\beta_2)$$

$$V_{in}' > V_{BE1} + V_{e2}$$

$$V_{in}' > V_{BE1} + R_e \frac{V_r + V_{BET1} - V_{BET2} - V_{in}^{\circ}}{R_r}(1+\beta_2)$$

$$R_e' = R_e < \frac{V_{in}' - V_{BET2}}{V_r - V_{BET2} + V_{BET1} - V_{in}^{\circ}} \cdot \frac{R_r}{1+\beta_2}$$

now determing R_{c1}

$$I_{B1} R_i + V_{BET1} + I_{E1} R_e' = V_{in}'$$

$$I_{c1} + I_{B1} = I_{E1}$$

$$\frac{I_{c1}}{\beta_1} = I_{B1}$$

$$I_c \left(1 + \frac{1}{\beta_1}\right) = I_{E1} \Rightarrow I_{c1} = \frac{\beta_1 I_{E1}}{1+\beta_1}$$

$$\frac{I_{c1}}{\beta_1} R_i + V_{BET1} + \frac{1+\beta_1}{\beta_1} I_{c1} R_e' = V_{in}'$$

$$I_{c1}\left(\frac{R_i}{\beta_1} + \frac{1+\beta_1}{\beta_1} R_e'\right) = V_{in}' - V_{BET1}$$

$$I_{c1} = \frac{\beta_1 (V_{in}' - V_{BET1})}{R_i + (1+\beta_1) R_e'}$$

$$V_{out}^{\circ} = V_{cc} - R_{c1} I_{c1}$$

$$R_{c1} = \frac{V_{cc} - V_{out}^{\circ}}{I_{c1}} = \frac{(V_{cc} - V_{out}^{\circ})(R_i + (1+\beta_1)R_e')}{\beta_1 (V_{in}' - V_{BET1})}$$

$$I_{B2} R_r + V_{BET2} + R_e' \cdot I_{E2} = V_r$$

$$\frac{I_{c2}}{\beta_2} R_r + V_{BET2} + R_e' \frac{1+\beta_2}{\beta_2} I_{c2} = V_r$$

$$I_{C2} = \frac{(V_r - V_{BET2})(B_2)}{R_r + (1+B_2)R_e'}$$

$$V_{C2} + R_{C2} I_{C2} = V_{CC}$$

$$R_C = \frac{V_{CC} - V_{C2}}{I_{C2}} = \frac{(V_{CC} - V_{C2})(R_r + (1+B_2)R_e')}{(V_r - V_{BET2})B_2}$$