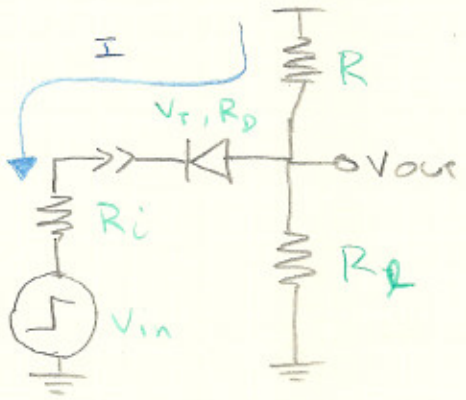


$$V - \frac{V - V_{in}^{\circ} - V_T}{R + R_D + R_i} \cdot R \leq V_{out}^{\circ}$$

$$\frac{V(R + R_D + R_i) - (V - V_{in} - V_T)R}{R + R_D + R_i} \leq V_{out}^{\circ}$$

$$\frac{VR + V(R_D + R_i) - VR + (V_{in} - V_T)R}{R + R_D + R_i} \leq V_{out}^{\circ}$$

$$V(R_D + R_i) - R(V_{in} - V_T) \leq V_{out}^{\circ} R + V_{out}^{\circ}(R_D + R_i)$$

$$-R(V_{in} - V_T - V_{out}^{\circ}) \leq V_{out}(R_D + R_i) - V(R_D + R_i)$$

$$\boxed{R \geq \frac{(V_{out} - V)(R_D + R_i)}{V_{in} - V_T - V_{out}^{\circ}}}$$

$$\boxed{V_{out} \geq V_{out}^{1}}$$

$$I = \frac{V}{R + R_l}$$

$$V_{out} = R_l I$$

$$V_{out} = \frac{R_\ell}{R + R_\ell} V \geq V_{out}'$$

$$R_\ell V \geq V_{out}' (R + R_\ell)$$

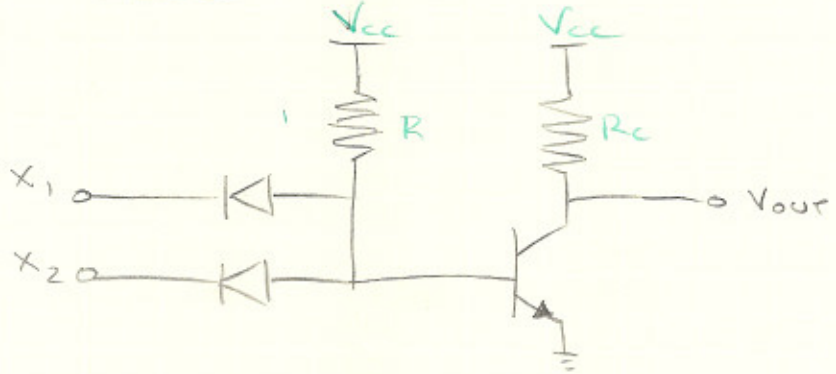
$$R_\ell (V - V_{out}') \geq V_{out}' R$$

$$\boxed{R_\ell \geq \frac{V_{out}'}{V - V_{out}'} R}$$

HW: Derive current driver to add to circuit.

NAND - DIODE TRANSISTOR LOGIC

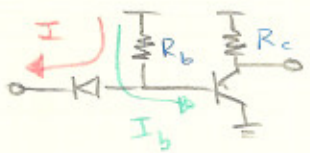
NAND



GIVEN: V_{cc}, $I_{C(SAT)}$, $V_{CE(SAT)}$, β, $V_{BE(T)}$, V_{in}^0, R_i

$(V_{CE} - V_{in}^!) < V_{TD}$

ANALYSIS: worst case senario



when T_1 is in saturation mode $(I_D = 0)$

$$R_C I_{SAT} + V_{CE(SAT)} = V_{cc}$$

$$R_C = \frac{V_{cc} - V_{CE(SAT)}}{I_{C(SAT)}}$$

$$V_{cc} = I_B R_B + V_{BE(T)}$$

$$I_B = \frac{V_{cc} - V_{BE(T)}}{R_B}$$

$$I_B \geq I'_B = \frac{I_{C(SAT)}}{\beta}$$

$$\frac{V_{cc} - V_{BE(T)}}{R_B} \geq \frac{I_{C(SAT)}}{\beta}$$

$$R_B \leq \frac{V_{cc} - V_{BE(T)}}{I_{C(SAT)}} \cdot \beta.$$

when transistor is in cut off mode.

$$V_{BE} < V_{BE(T)}$$

$$I R_B + I R_D + I R_i + V_{TD} + V_{in}^{\circ} = V_{cc}$$

$$I = \frac{V_{cc} - V_{in}^{\circ} - V_{TD}}{R_B + R_D + R_i}$$

$$V_{BE} = V_{cc} - I R_B.$$

$$V_{cc} - I R_B < V_{BE(T)}$$

$$V_{cc} - \frac{V_{cc} - V_{TD} - V_{in}^{\circ}}{R_B + R_D + R_i} R_B < V_{BE(T)}$$

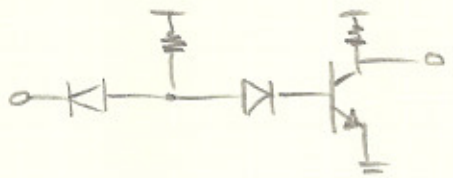
$$V_{cc} - V_{BE(T)} < \frac{V_{cc} - V_{TD} - V_{in}^{\circ}}{R_B + R_D + R_i} R_B$$

$$R_i (V_{cc} - V_{BE(T)}) + (R_B + R_D)(V_{cc} - V_{BE(T)}) < (V_{cc} - V_{TD} - V_{in}^{\circ}) R_B$$

$$R_i (V_{cc} - V_{BE(T)}) < (V_{cc} - V_{TD} - V_{in}^{\circ}) R_B - (R_B + R_D)(V_{cc} - V_{BE(T)})$$

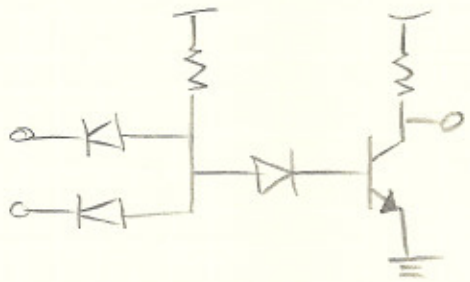
$$R_i < \frac{(V_{cc} - V_{TD} - V_{in}^{\circ}) R_B - (R_B + R_D)(V_{cc} - V_{BE(T)})}{V_{cc} - V_{BE(T)}}$$

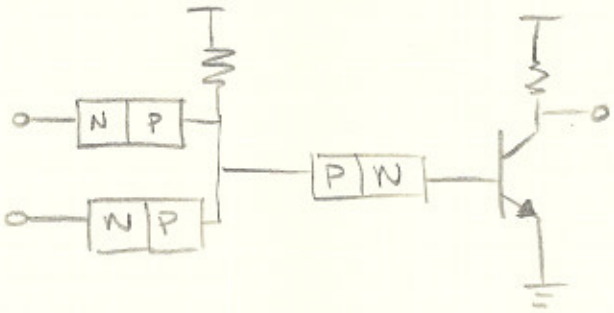
Solution

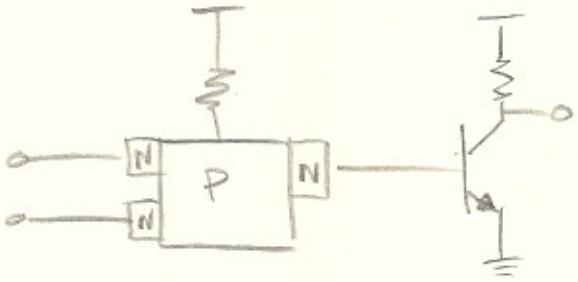


$$V_{BE(T)} = V_{BE(T)} + V_{TD}'$$

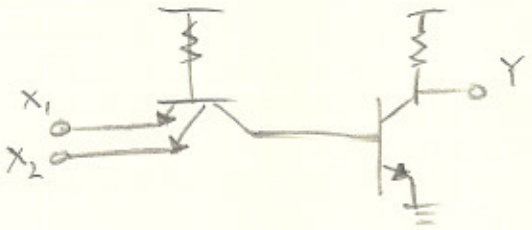
HW: Redirive, and derive for current driver.







$$w_p < l_n$$



$$Y = \overline{X_1 \cdot X_2}$$