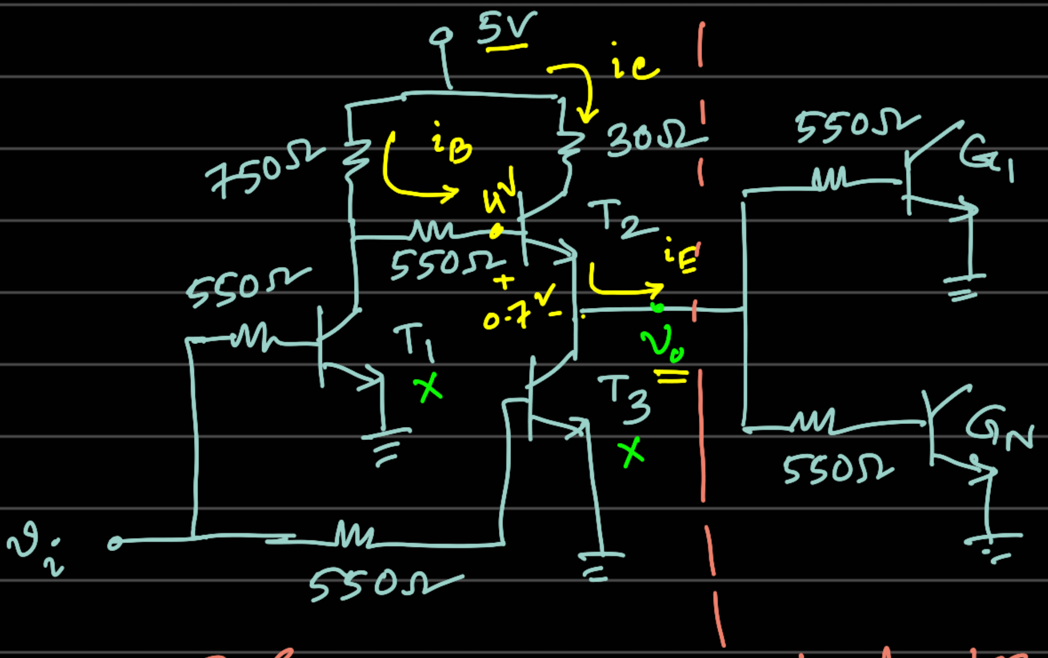
Quiz 1 Solution:



Buffer inverter   Load gates.

$V_{OH} = 3.3V$

$V_{OL} = 0.2V$

$V_{BE}(sat) = 0.8V$

$V_{CE}(sat) = 0.2V$

$V_\gamma = 0.5V$

$\beta_F = 30$

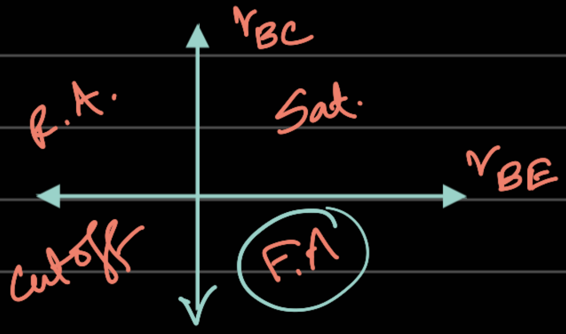
@ Maximum fanout calculation:

Case 1.: $v_i = 5V$. $T_3 \rightarrow$ saturation. $v_o \rightarrow 0.2V$. $G_1 \ldots G_N$ $\rightarrow$ cutoff mode. Demand current $= 0$. supply current $= 0$

fanout $= \infty$.

Case 2: $v_i = 0.2V$. $T_1, T_3 \rightarrow$ cutoff. $T_2 \Rightarrow$ forward active.

Because collector terminal is connected to 5V with very small resistance compared to the base terminal of T_2 transistor. Thus $V_B < V_C \Rightarrow V_{BC} < 0$.

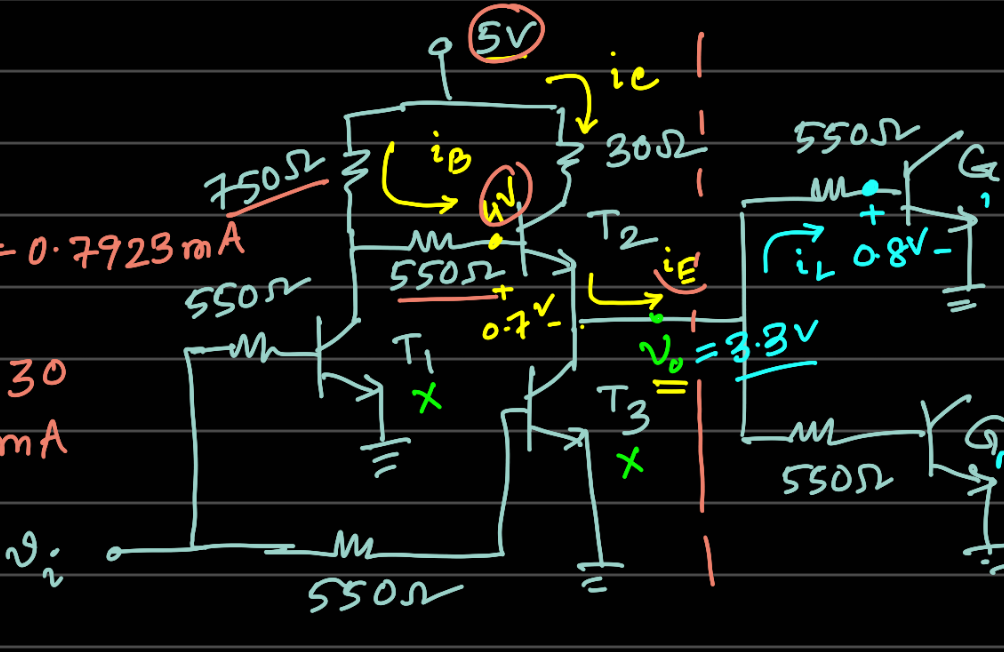


Allowed value of $v_o = V_{OH} = 3.3V$

$$i_B = \frac{5-4}{.75+.55} = \frac{1}{1.3} = 0.7923\,mA$$

$$i_C = \beta_F i_B = 0.7923 \times 30$$
$$= 23.077\,mA$$

$$i_E = i_C + i_B$$
$$= 23.846\,mA$$



$G_1, G_2, \ldots G_N$ are in saturation mode.

$$\text{individual demand current} = \frac{3.3-0.8}{0.55} = 4.5454\ \text{mA}$$

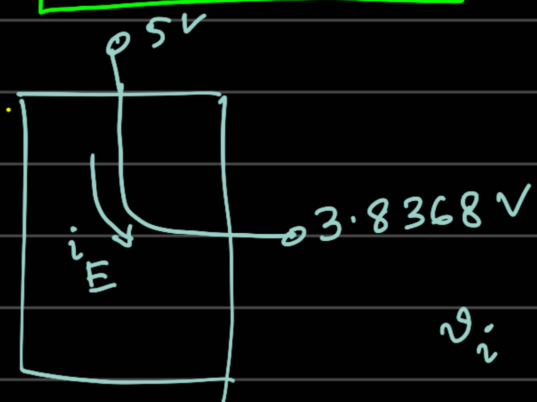
$$\underline{\text{Max. fanout}} = \left\lfloor \frac{\text{supply current}}{\text{demand current}} \right\rfloor = \left\lfloor \frac{23.846}{4.5454} \right\rfloor = \boxed{5}$$

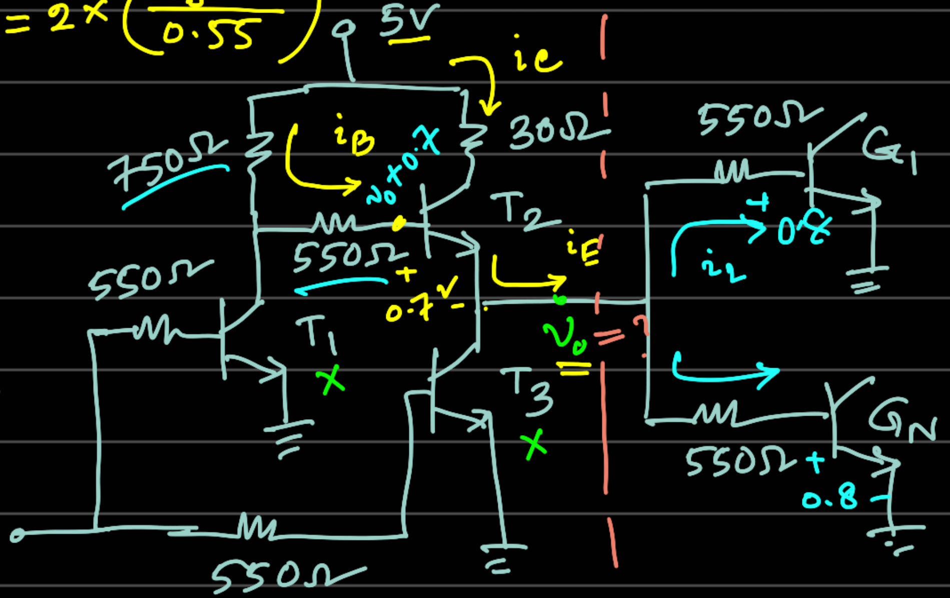
(b) $i_B = \dfrac{(5-(v_o+0.7))}{1.3}$, $[i_E = (\beta+1) i_B] \rightarrow$ supply

$\left[i_L = \dfrac{v_o - 0.8}{0.55}\right] \rightarrow$ individual demand.

$$(30+1)\left(\frac{5-(v_o+0.7)}{1.3}\right) = 2\times\left(\frac{v_o-0.8}{0.55}\right)$$

$$\Rightarrow \boxed{v_o = 3.8368\,V}$$





$$i_E = 31\times\left(\frac{5-3.8368-0.7}{1.3}\right) = 1.1043\,\text{mA}$$

$$\text{Power dissipation} = (5-3.8368)\times 1.1043 = \boxed{12.84\,\text{mW}}$$

Quiz 2 solution:

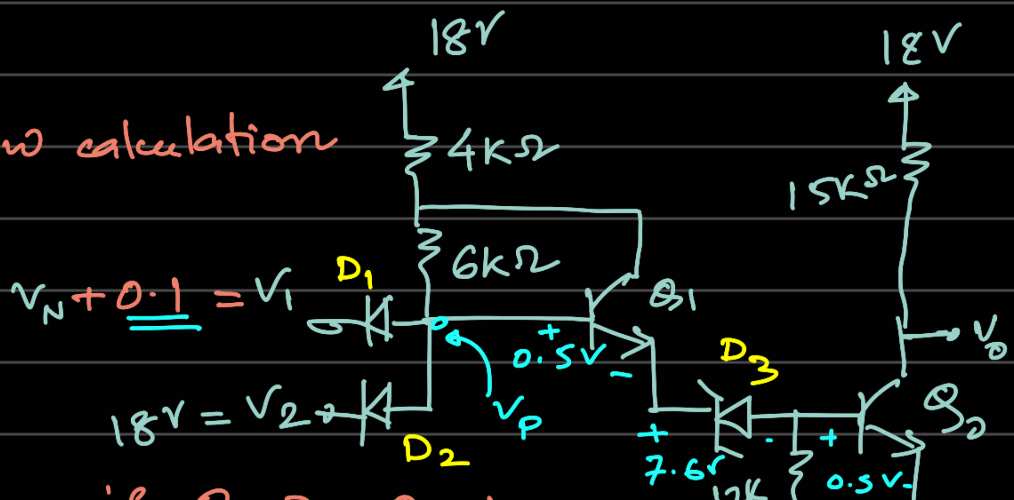
(a) Noise margin low calculation

Normal operation:

$v_1 = 0.1V$, $v_2 = 18V$

$D_1 \rightarrow ON$, $D_2 \rightarrow OFF$.

$Q_1, D_3, Q_o \rightarrow OFF$



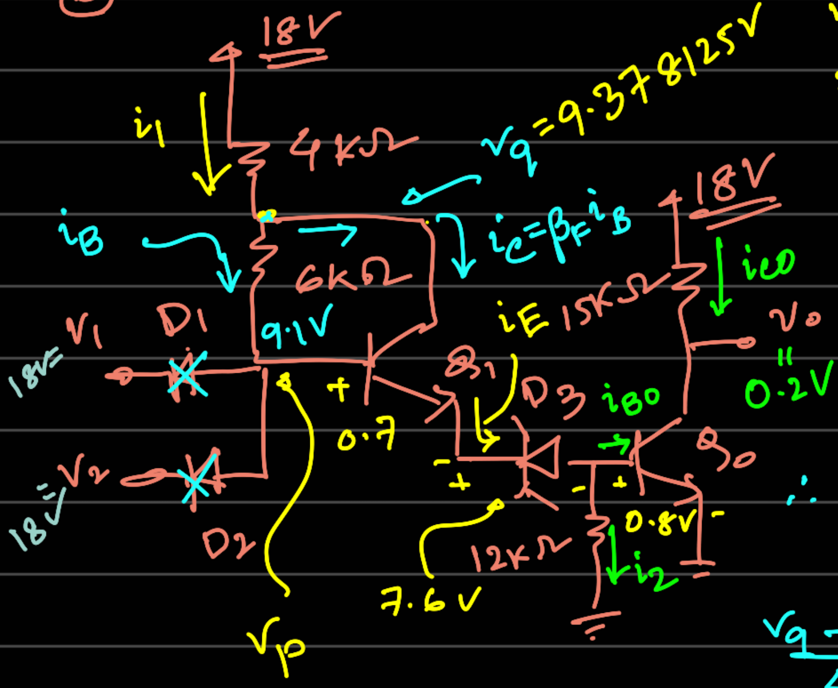
Malfunction will occur if Q_1, D_3, Q_o turns on.

$V_P = 0.5 + 7.6 + 0.5 = 8.6V$ in order turn on Q_o, Q_1, D_3.

However, without noise v_p has voltage. $0.1+0.7=0.8V$

$$0.8+v_N = 8.6V \Rightarrow v_N = 8.6-0.8 = \boxed{7.8V}$$

(b)



$v_1 = v_2 = 18V.$

$D_1, D_2 \rightarrow$ OFF.

Q_1, D_3 and Q_o are ON.

For Q_1. $v_C > v_B \Rightarrow v_{BC} < 0$

$\therefore Q_1$ is in forward active mode.

Q_o is in saturation mode.

$$\therefore v_p = 0.8+0.7+7.6V = 9.1V$$

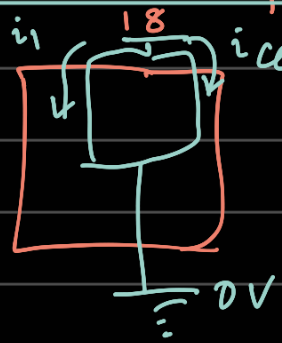
$$\frac{v_q-18}{4} + \frac{v_q-9.1}{4} + 30\times\frac{v_q-9.1}{4} = 0$$

$$\Rightarrow v_q = 9.378125V$$

$$i_1 = i_C + i_B = i_E = \left(\frac{18-9.378125}{4K}\right) = 1.437\,mA, \quad i_2 = \frac{0.8-0}{12K} = 0.0333\,mA$$

$$\therefore i_{BO} = i_1 - i_2 = 1.4036\,mA, \quad i_{CO} = \frac{18-0.2}{15K} = 1.18667\,mA.$$

(i) Power dissipation calulation:



$$P = (18-0)\times(i_1+i_{CO})$$

$$= 18\times(1.437+1.18667)$$

$$\boxed{P = 47.226\,mW}$$

(ii) minimum value of β. $\beta_{min} = \beta_{forced}$

$$\boxed{\beta_{min} = \frac{i_{CO}}{i_{BO}} = 0.84544}$$