20405124 2008 (1)

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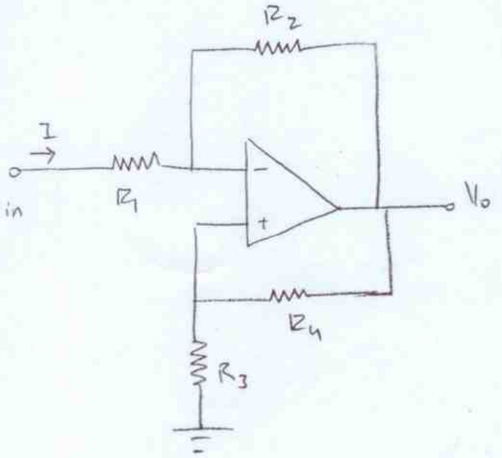

$$V_+ = \frac{R_3}{R_3+R_4} V_o \qquad (1)$$

$$\frac{V_{in} - V_-}{R_1} = \frac{V_- - V_o}{R_2}$$

$$\Rightarrow V_- = \frac{R_2}{R_1+R_2} V_{in} + \frac{R_1}{R_1+R_2} V_o \qquad (2)$$

$$I = \frac{1}{R_1+R_2} (V_{in} - V_o) \qquad (3)$$

— o —

Define : $\beta := \frac{R_3}{R_3+R_4}$, $\gamma := \frac{R_1}{R_1+R_2}$ Note that both $0<\beta<1$ & $0<\gamma<1$

— o —

Linear region: $V_+ = V_-$ & $-E_s \le V_o \le E_s$

from (1) & (2) $\Rightarrow \beta V_o = \gamma V_o + (1-\gamma) V_{in}$

$$\Rightarrow \boxed{V_o = \frac{1-\gamma}{\beta-\gamma} \cdot V_{in}}$$

Define $\bar{V} := \left|\frac{\beta-\gamma}{1-\gamma}\right| E_s$ $\Rightarrow$ In linear region $-\bar{V} \le V_{in} \le \bar{V}$

from (3) $\Rightarrow I = \frac{1}{R_1+R_2}\left(1 - \frac{V_o}{V_{in}}\right) V_{in}$

$$\Rightarrow I = \frac{1}{R_1+R_2}\left(1 - \frac{1-\gamma}{\beta-\gamma}\right) V_{in} = \frac{1}{R_1+R_2} \frac{\beta-1}{\beta-\gamma} V_{in}$$

$$\Rightarrow \boxed{I = \frac{1}{R_1+R_2} \frac{\beta-1}{\beta-\gamma} V_{in}}$$

– Define $G := \left| \frac{1}{R_1+R_2} \cdot \frac{\beta-1}{\beta-\gamma} \right|$

+ sat region : $V_+ > V_-$ & $V_o = E_s$

from (1) & (2) $\Rightarrow$ $\beta V_o > \gamma V_o + (1-\gamma) V_{in}$

$$\Rightarrow \beta E_s > \gamma E_s + (1-\gamma) V_{in} \Rightarrow \boxed{V_{in} < \frac{\beta-\gamma}{1-\gamma} E_s}$$

from (3) $\Rightarrow$ $\boxed{I = \frac{1}{R_1+R_2}(V_{in} - E_s)}$

− sat region : $V_+ < V_-$ & $V_o = -E_s$

from (1) & (2) $\Rightarrow$ $\beta V_o < \gamma V_o + (1-\gamma) V_{in}$

$$\Rightarrow -\beta E_s < -\gamma E_s + (1-\gamma) V_{in} \Rightarrow \boxed{V_{in} > -\frac{\beta-\gamma}{1-\gamma} E_s}$$

from (3) $\Rightarrow$ $\boxed{I = \frac{1}{R_1+R_2}(V_{in} + E_s)}$

— o —

Cases : $\beta > \gamma$ $\qquad$ $\beta < \gamma$ $\qquad$ $\beta = \gamma$