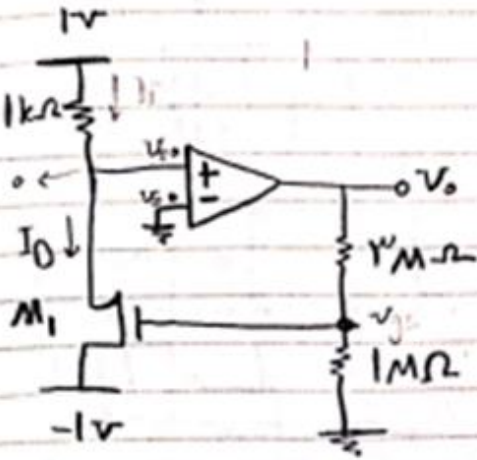


جواب سوالات 9 Homework

-۲



$$I_D = \frac{1-0}{1k} = 1m$$

$$I_D = \frac{k_p}{2} (V_{GS} - |V_t|)^2$$

در فرض اینکه به اشباع است

در فرض اول I_D برابر

حالت اشباع داریم:

$$1m = \frac{1m}{2} (V_{GS} - 2)^2$$

$$1 = (V_{GS} - 2)^2$$

$$1 = V_{GS} - 2$$

$$V_{GS} = 3$$

$$-1 = V_{GS} - 2$$

$$V_{GS} = +1$$

$$V_{GS} > |V_t| \rightarrow 3 > 2 \quad \checkmark$$

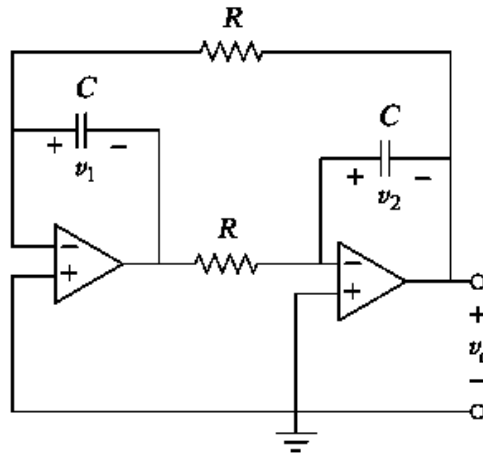
$$V_{DS} > V_{GS} - V_t \rightarrow 1 \geq 3 - 2 \quad \checkmark$$

$$V_{GS} = 3$$

$$V_G - V_S = 3$$

$$V_G = 2$$

$$kcl : \frac{V_o - 2}{3M} + \frac{0 - 2}{1M} = 0 \quad V_o - 2 - 4 = 0 \quad V_o = 8V$$



At the input of the first op amp,

$$(v_o - 0)/R = Cdv_1/dt \quad (1)$$

At the input of the second op amp,

$$(-v_1 - 0)/R = Cdv_2/dt \quad (2)$$

Let us now examine our constraints. Since the input terminals are essentially at ground, then we have the following,

$$v_o = -v_2 \text{ or } v_2 = -v_o \quad (3)$$

Combining (1), (2), and (3), eliminating v_1 and v_2 we get,

$$\frac{d^2 v_o}{dt^2} - \left(\frac{1}{R^2 C^2} \right) v_o = \frac{d^2 v_o}{dt^2} - 100 v_o = 0$$

$$\text{Which leads to } s^2 - 100 = 0$$

Clearly this produces roots of -10 and $+10$.

And, we obtain,

$$v_o(t) = (Ae^{+10t} + Be^{-10t})V$$

At $t = 0$, $v_o(0+) = -v_2(0+) = 0 = A + B$, thus $B = -A$

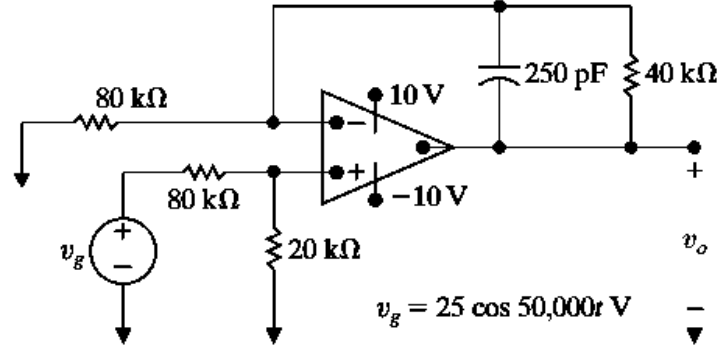
This leads to $v_o(t) = (Ae^{+10t} - Ae^{-10t})V$. Now we can use $v_1(0+) = 2V$.

From (2), $v_1 = -RCdv_2/dt = 0.1dv_o/dt = 0.1(10Ae^{+10t} + 10Ae^{-10t})$

$$v_1(0+) = 2 = 0.1(20A) = 2A \text{ or } A = 1$$

$$\text{Thus, } v_o(t) = \underline{(e^{+10t} - e^{-10t})V}$$

It should be noted that this circuit is unstable (clearly one of the poles lies in the right-half-plane).



[a] $V_g = 25/\underline{0^\circ}$ V

$$V_p = \frac{20}{100} V_g = 5/\underline{0^\circ}; \quad V_n = V_p = 5/\underline{0^\circ} \text{ V}$$

$$\frac{5}{80,000} + \frac{5 - V_o}{Z_p} = 0$$

$$Z_p = -j80,000 \parallel 40,000 = 32,000 - j16,000 \Omega$$

$$V_o = \frac{5Z_p}{80,000} + 5 = 7 - j = 7.07/\underline{-8.13^\circ}$$

$$v_o = 7.07 \cos(50,000t - 8.13^\circ) \text{ V}$$

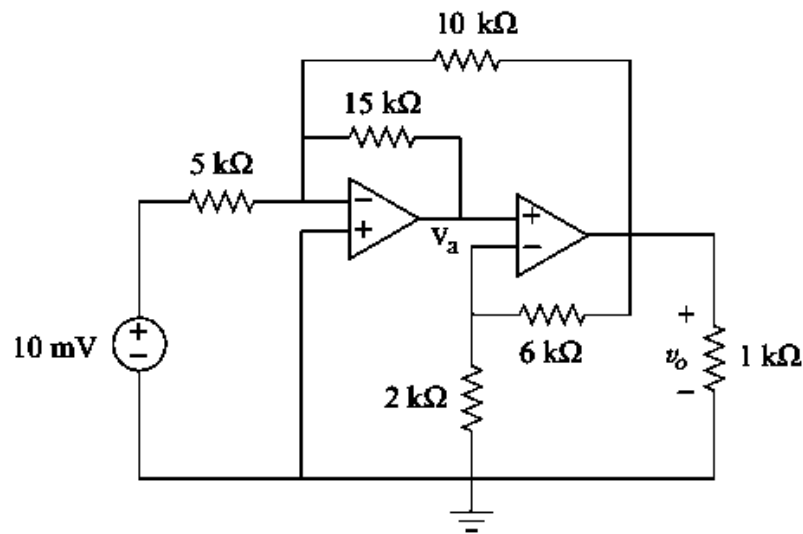
[b] $V_p = 0.2V_m/\underline{0^\circ}; \quad V_n = V_p = 0.2V_m/\underline{0^\circ}$

$$\frac{0.2V_m}{80,000} + \frac{0.2V_m - V_o}{32,000 - j16,000} = 0$$

$$\therefore V_o = 0.2V_m + \frac{32,000 - j16,000}{80,000} V_m (0.2) = V_m (0.28 - j0.04)$$

$$\therefore |V_m (0.28 - j0.04)| \leq 10$$

$$\therefore V_m \leq 35.36 \text{ V}$$



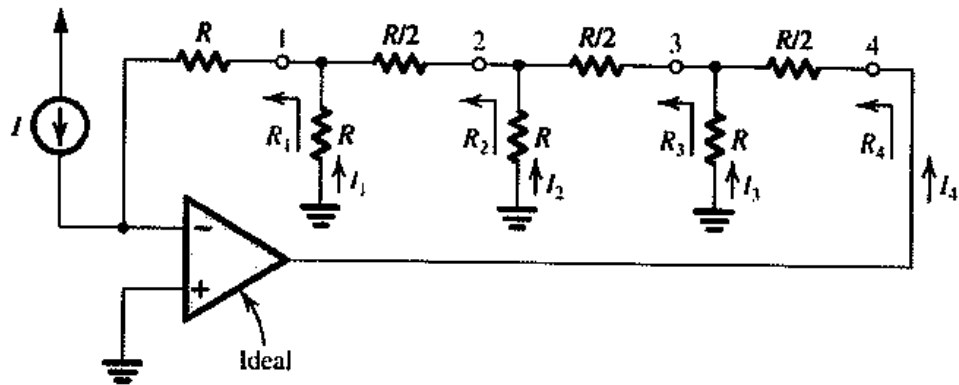
In this case, the first stage is a summer

$$v_a = -\frac{15}{5}(10) - \frac{15}{10}v_o = -30 - 1.5v_o$$

For the second stage,

$$v_o = \left(1 + \frac{6}{2}\right)v_a = 4v_a = 4(-30 - 1.5v_o)$$

$$7v_o = -120 \longrightarrow v_o = -\frac{120}{7} = \underline{\underline{-17.143\text{mV}}}$$

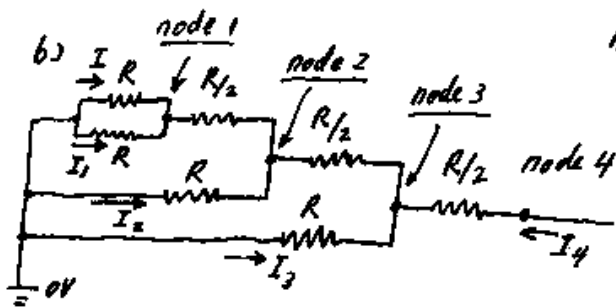


a) looking into node 1: $R_1 = R$

$$\text{node 2: } R_2 = (R \parallel R) + \frac{R}{2} = R$$

$$\text{node 3: } R_3 = (R_2 \parallel R) + \frac{R}{2} = R$$

$$\text{node 4: } R_4 = (R_3 \parallel R) + \frac{R}{2} = R$$



$$I_1 = I$$

based on current division,

$$I_2 = 2I$$

$$I_3 = 4I$$

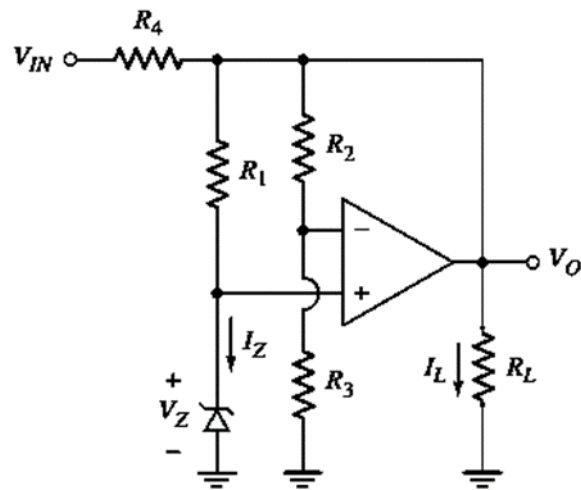
$$I_4 = -8I$$

$$c) \quad V_1 = 0 - IR = -IR$$

$$V_2 = -I_2 R = -2IR$$

$$V_3 = -I_3 R = -4IR$$

$$V_4 = V_3 + \frac{R}{2}(I_4) = -4IR + \frac{R}{2}(-8I) = -8IR$$



$$R_1 = \frac{V_O - V_Z}{I_Z} = \frac{12 - 5.6}{2} = 3.2 \text{ k}\Omega$$

$$\frac{V_O}{V_Z} = \left(1 + \frac{R_2}{R_3}\right) = \frac{12}{5.6} \Rightarrow \frac{R_2}{R_3} = 1.143$$

$$\text{Let } I_R = 2 \text{ mA}, \Rightarrow R_2 + R_3 = \frac{V_O}{I_R} = \frac{12}{2} = 6 \text{ k}\Omega$$

$$\text{Then } 1.143R_3 + R_3 = 6, \Rightarrow R_3 = 2.8 \text{ k}\Omega \text{ and } R_2 = 3.2 \text{ k}\Omega$$

$$\text{Let } I_{R4} = 4 \text{ mA}, R_4 = \frac{V_{IN} - V_O}{I_{R4}} = \frac{15 - 12}{4} = 0.75 \text{ k}\Omega$$