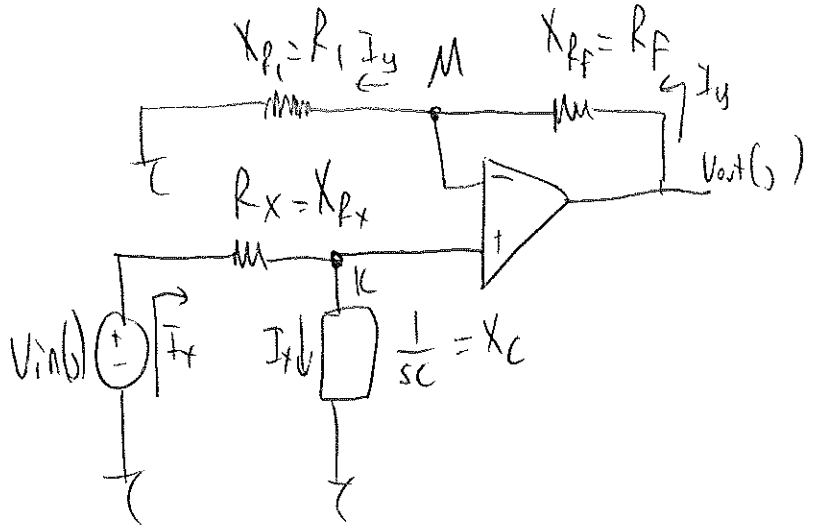
(Q1) In Laplace domain



$$\frac{V_{in} - K}{X_{R_x}} = \frac{K}{X_C} \qquad \frac{V_{in} - K}{R_x} = \frac{K}{\frac{1}{sC}} \qquad V_{in} = K[1 + sCR_x]$$

$$K = \frac{V_{in}}{1 + sCR_x} \quad \text{(pwm)}$$

$$\frac{V_{out} - M}{X_{R_f}} = \frac{M}{X_{R_1}} \qquad \frac{V_{out} - M}{R_f} = \frac{M}{R_1} \qquad V_{out} R_1 = M(R_1 + R_f)$$

$$M = \frac{V_{out} R_1}{R_1 + R_f}$$

(2 pwm)

$$M = K \Rightarrow \frac{V_{in}}{1 + sCR_x} = V_{out} \frac{R_1}{R_1 + R_f} \qquad \frac{V_{out}}{V_{in}} = \frac{R_1 + R_f}{R_1} \frac{1}{1 + sCR_x}$$

(5 pwm)

$$= \frac{V_{out}}{V_{in}} = \frac{R_1 + R_f}{R_1} \frac{\frac{1}{CR_x}}{s + \frac{1}{CR_x}} \qquad H(s) = \frac{V_{out}}{V_{in}} = \frac{R_1 + R_f}{R_1} \frac{1}{CR_x} \frac{1}{s + \frac{1}{CR_x}}$$

(1 pwm)

This is a low pass filter the maximum gain occurs when $\omega = 0$

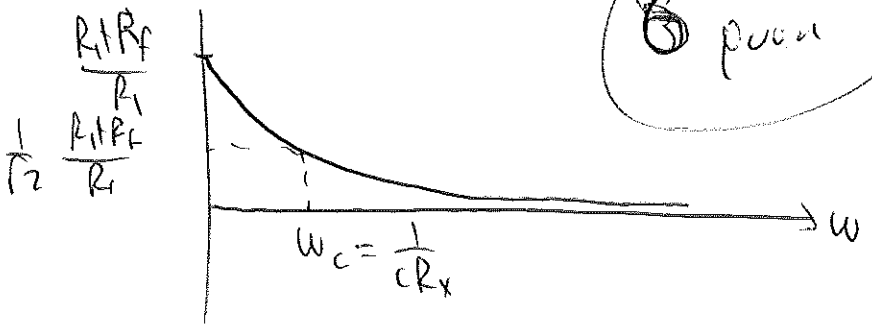
$$H(j\omega) = \frac{R_1 + R_f}{R_1} \frac{1}{CR_x} \frac{1}{j\omega + \frac{1}{CR_x}} \qquad |H(j\omega)| = \frac{R_1 + R_f}{R_1} \frac{1}{CR_x} \frac{1}{\sqrt{\omega^2 + \left[\frac{1}{CR_x}\right]^2}}$$

if $\omega \nearrow$ $|H(j\omega)| \searrow$

$$|H(j\omega)|\Big|_{\omega=0} = \frac{R_1R_f}{R_1} = \text{Max gain}$$

$|H(j\omega)|$

6 puan



5 puan

Hence Max gain $\frac{R_1R_f}{R_1} = 10$ $R_f = 9R_1$ should be found

Let $R_1 = 1M\Omega$ $R_f = 9M\Omega$ 2 puan

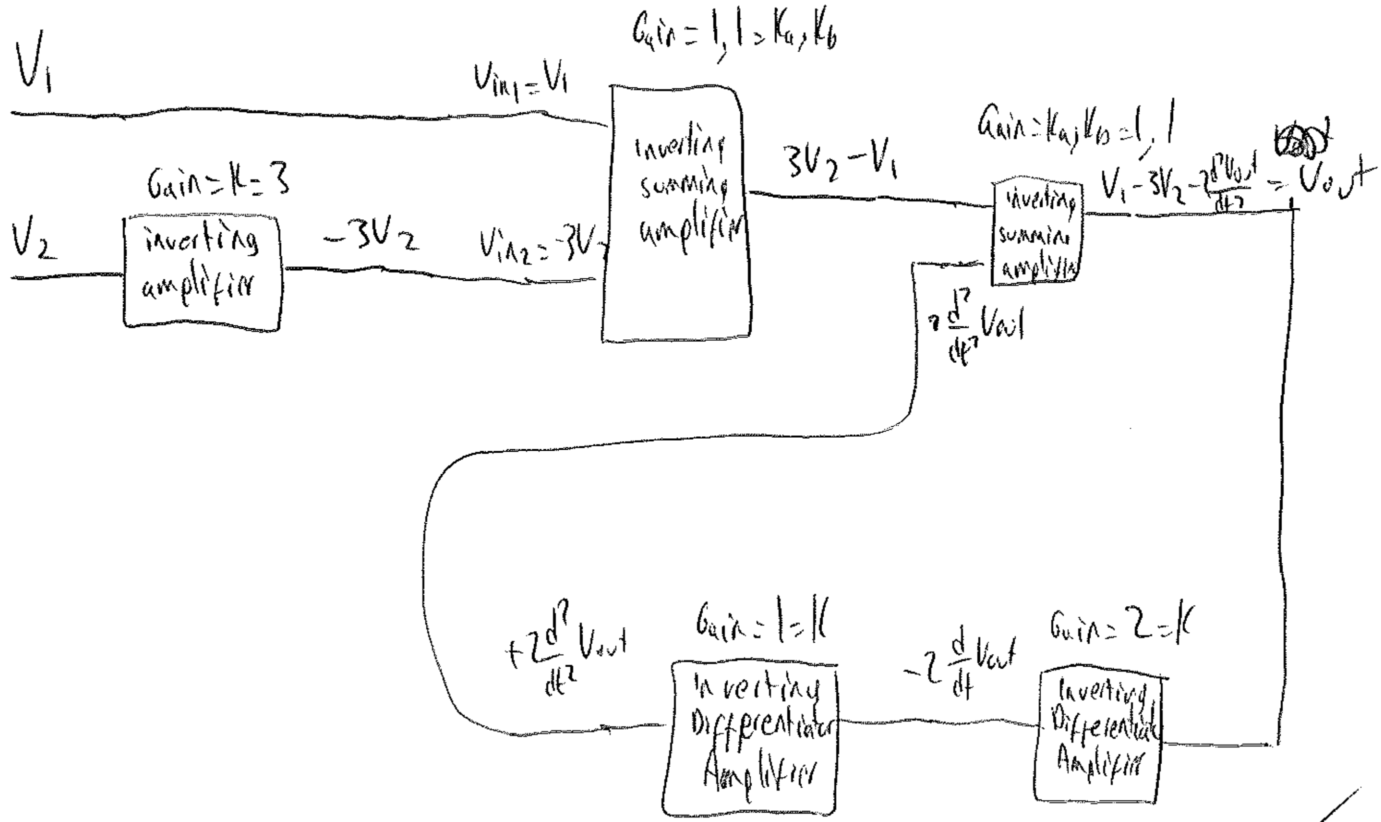
Cut off frequency $= \omega_c = \frac{1}{CR_x}$ at $|H(j\omega)|\Big|_{\omega=\omega_c} = \frac{R_1R_f}{R_1}\frac{1}{\sqrt{2}} = \frac{\text{Gain-max}}{\sqrt{2}}$

4 puan

hence $\frac{1}{CR_x} = 10000 \frac{rad}{sec}$ Let $R_x = 1000\Omega \Rightarrow C = 10^{-7}$ F

3 puan

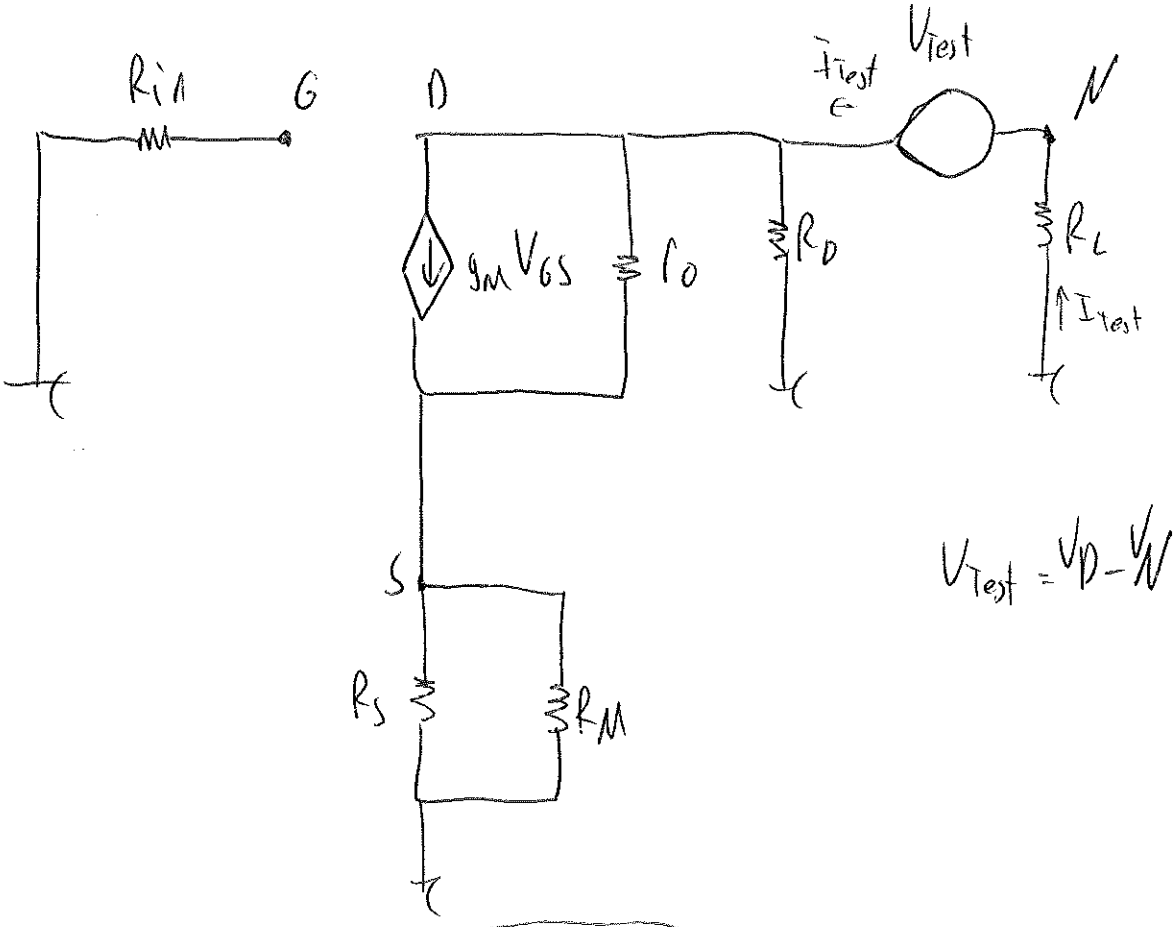
(Q2) $V_{out} = -2\frac{d^2}{dt^2}V_{out} + V_1 - 3V_2$



Sıkıllar 13
Kazançlar 20

(Q3)

When procedure is applied



$V_{Test} = V_D - V_N$

$V_G = 0$

$$I_{Test} = \frac{V_D}{R_D} + \frac{V_D - V_S}{r_o} + g_m V_{GS}$$

$$I_{Test} = \frac{V_D}{1000} + \frac{V_D - V_S}{1000} + \frac{1}{1000}(V_G - V_S)$$

$$I_{Test} = V_D\left[\frac{2}{1000}\right] - \frac{V_S}{1000} - \frac{V_S}{1000}$$

$$I_{Test} = V_D\left[\frac{2}{1000}\right] - V_S\left[\frac{2}{1000}\right]$$

$$g_m V_{GS} + \frac{V_D - V_S}{r_O} = \frac{V_S}{R_S} + \frac{V_S}{R_M}$$

$V_G = 0$

Sayfa 5

$$\frac{1}{1000}\left[V_G - V_S\right] + \frac{V_D - V_S}{1000} = \frac{V_S}{1000} + \frac{V_S}{1000}$$

$$\frac{V_D}{1000} = 4\frac{V_S}{1000}$$

$$\boxed{V_D = 4V_S} \Rightarrow \boxed{V_S = \frac{V_D}{4}}$$

$$I_{Test} = V_D\left[\frac{2}{1000}\right] - \frac{V_D}{4}\left(\frac{2}{1000}\right)$$

$$\boxed{I_{Test} = \frac{3V_D}{4}\left[\frac{2}{1000}\right]}$$

$$V_D = \frac{4000}{6} I_{Test}$$

$$I_{Test} = \frac{0 - V_N}{R_L} \qquad I_{Test} \times 1000 = -V_N \qquad V_N = -1000\, I_{Test}$$

$$V_D - V_N = V_{Test} = \frac{4000}{6} I_{Test} - (-1000) I_{Test}$$

$$= \frac{10000}{6} I_{Test}$$

$$R_{ds} = \frac{V_{Test}}{I_{Test}} = \frac{10000}{6}\ \Omega$$

$$f_{cut\text{-}of\text{-}C_d} = \frac{1}{2\pi C_d R_{ds}} = \frac{1}{2\pi \times 10^{-6} F \times \frac{10000}{6}\Omega} = \frac{6 \times 10^6}{2\pi \times 10000} = \frac{600}{2\pi}\ Hertz$$