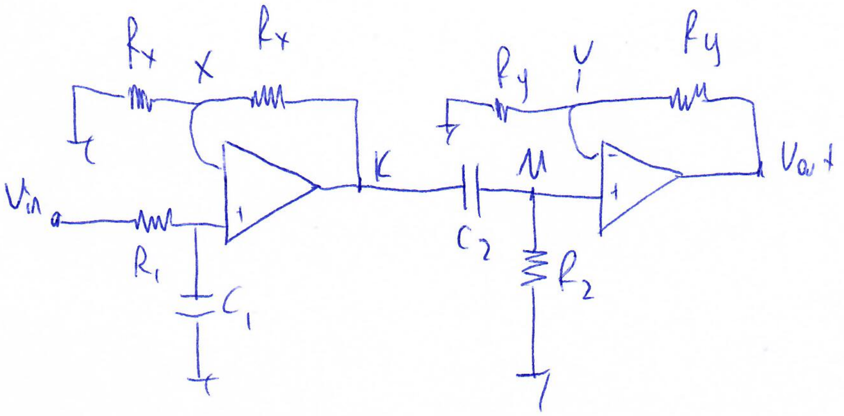
ME CE 347 Midterm 2017-2018 solutions

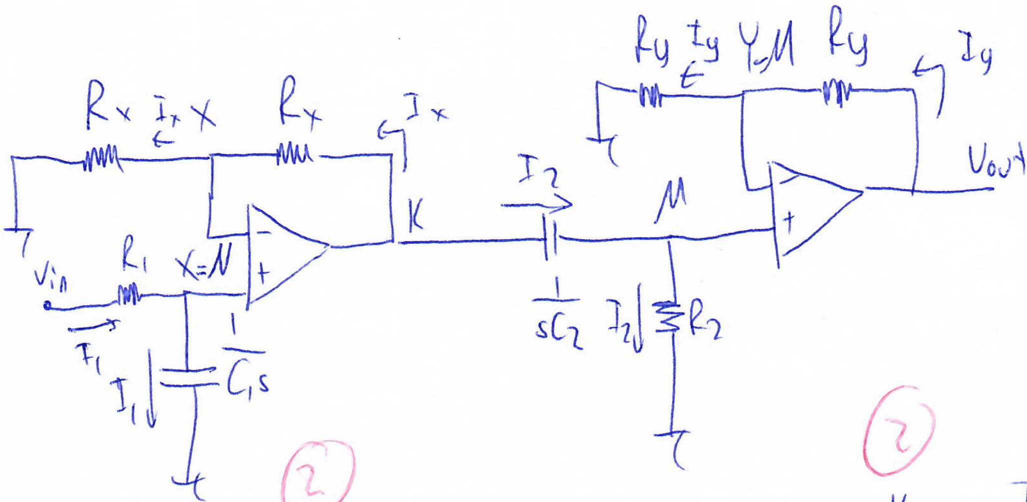
Q1

a)



↓

In Laplace (impedance values of circuit elements are shown)



(2)

$$I_x = \frac{K}{2R_x} = \frac{X}{R_x}$$

$$\boxed{X = \frac{K}{2}}$$

$$\boxed{N = X}$$

$$N = \frac{K}{2}$$

(2)

$$\frac{V_{out}}{2R_y} = \frac{Y}{R_y}$$

$$\boxed{Y = \frac{V_{out}}{2}}$$

$$\boxed{M = Y}$$

$$\boxed{M = \frac{V_{out}}{2}}$$

$$I_1 = \frac{V_{in} - N}{R_1} = \frac{N}{\frac{1}{sC_1}}$$

$$\boxed{V_{in} = N\left[1 + sC_1R_1\right]}$$

(3)

$$I_2 = \frac{K - M}{\frac{1}{sC_2}} = \frac{M}{R_2}$$

(3)

$$KsC_2 = M\left[\frac{1}{R_2} + sC_2\right]$$

$$KsC_2 = M\left[\frac{1 + sR_2C_2}{R_2}\right]$$

$$\boxed{\frac{K}{M} = \frac{1 + sR_2C_2}{sC_2R_2}}$$

$$V_{in} = \frac{K}{2}[1+sC_1R_1] \longrightarrow V_{in} = \frac{1}{2}\frac{M[1+sR_2C_2][1+sR_1C_1]}{sC_2R_2}$$

$$V_{in} = \frac{1}{2}\frac{V_{out}}{2}\frac{[1+sR_2C_2][1+sR_1C_1]}{sC_2R_2}$$

Birleştirme 2

$$\frac{V_{out}}{V_{in}} = \frac{4sC_2R_2}{[1+sR_2C_2][1+sR_1C_1]}$$

$R_2 = 10^6\,\Omega$

$R_1 = 10^6\,\Omega$

$C_1 = 10^{-6}\,F$

$C_2 = \frac{1}{16}\times 10^{-6}\,F$

Gidiş 4

$$\frac{V_{out}}{V_{in}} = \frac{4s\left(\frac{1}{16}\times 10^{-6}\right)10^6}{[1+10^6\times\frac{1}{16}\times 10^{-6}s][1+s\,10^6\times 10^{-6}]}$$

$$= \frac{1}{4}\frac{s}{[1+\frac{s}{16}][1+s]} = \frac{4s}{[s+16][s+1]}$$

Sonuç 4

(d) $20\log\left(\frac{4\omega}{(\omega^2+16^2)^{\frac{1}{2}}(\omega^2+1^2)^{\frac{1}{2}}}\right) = |H(j\omega)|_{dB}$

$|H(j\omega)|_{dB} = 20\log 4 + 20\log\omega - 20\log(\omega^2+16^2)^{\frac{1}{2}} - 20\log(\omega^2+1^2)$

$0 < \omega < 1$

$|H(j\omega)|_{dB} \simeq 20\log 4 + 20\log\omega - 20\log\sqrt{16^2} - 20\log\sqrt{1^2}$

$= 20\log 4 - 20\log 16 + 20\log\omega = 20\log\frac{1}{4} + 20\log\omega$

$1 < \omega < 16$

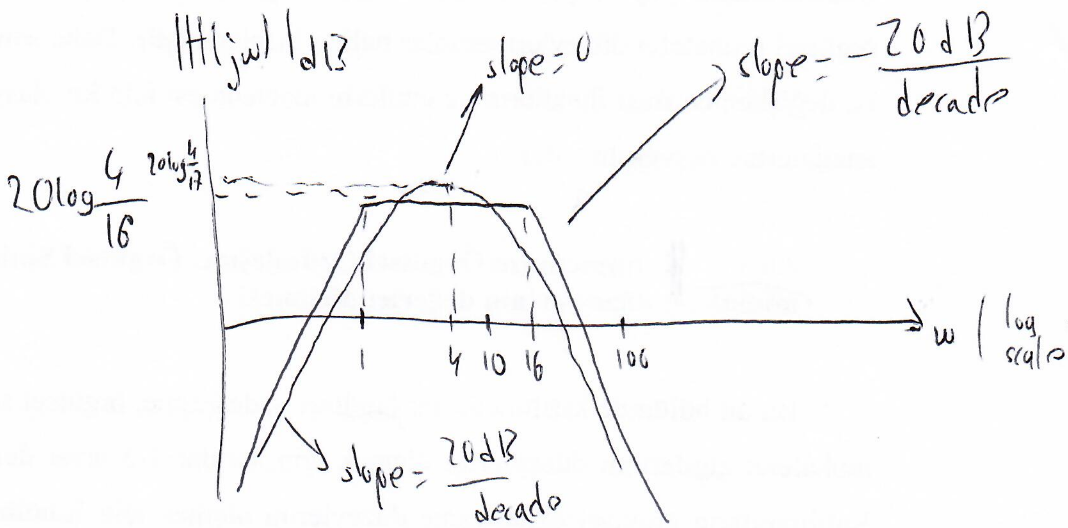
$|H(j\omega)|_{dB} \simeq 20\log 4 + 20\log\omega - 20\log\sqrt{16^2} - 20\log\sqrt{\omega^2}$

$= 20\log\frac{4}{16}$ //

$16 < \omega$

$|H(j\omega)|_{dB} = 20\log 4 + 20\log\omega - 20\log\omega - 20\log\omega$

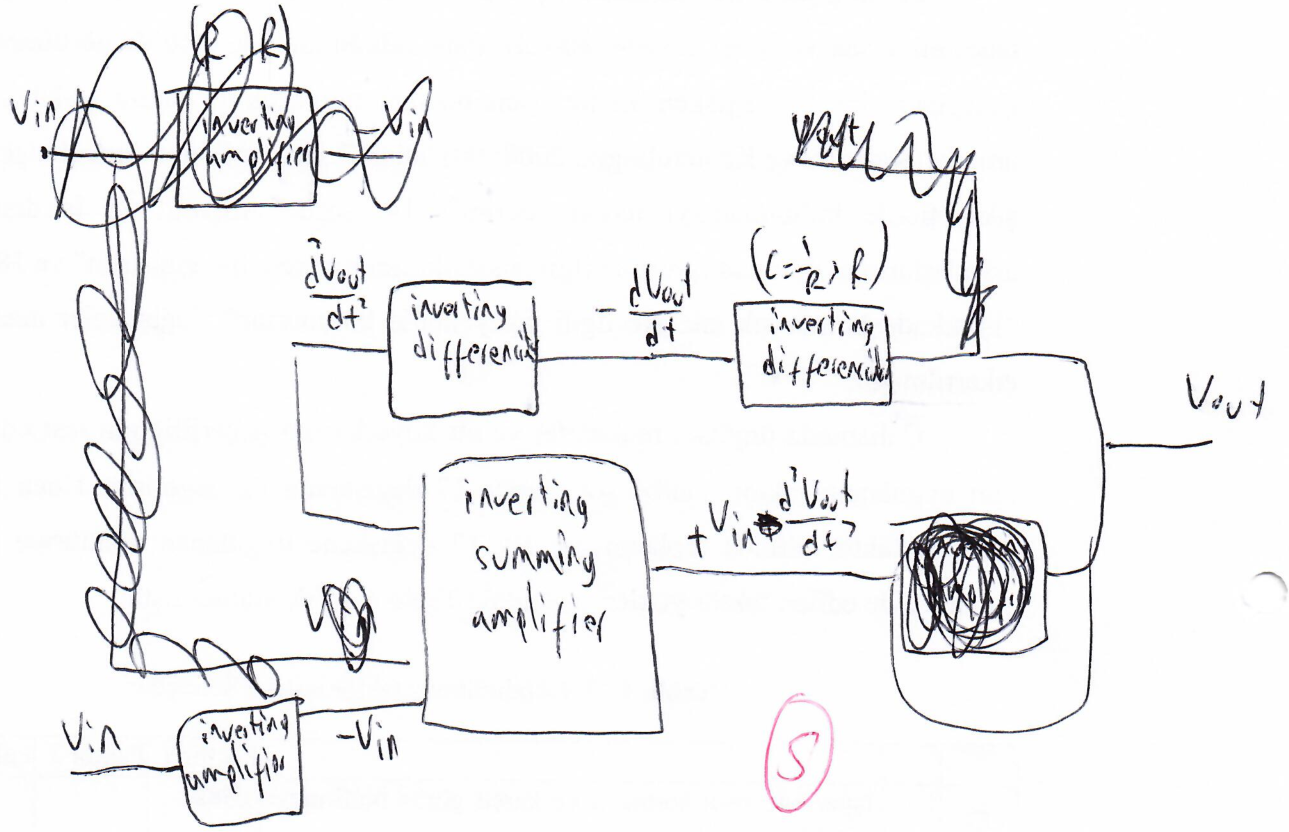
$= 20\log 4 - 20\log\omega$

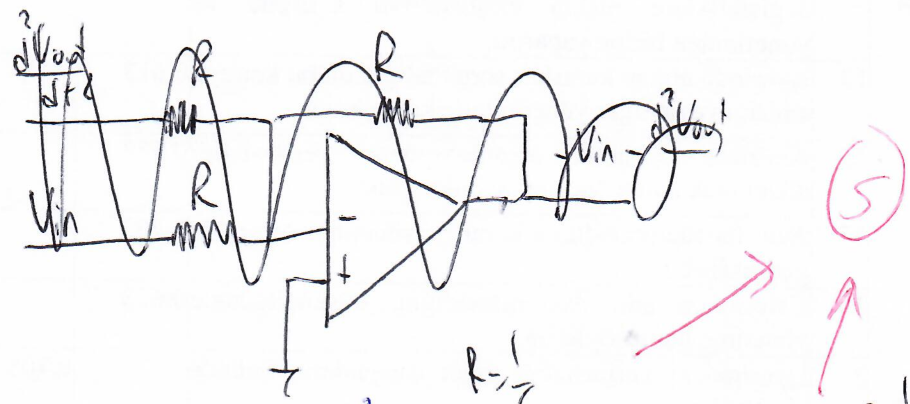


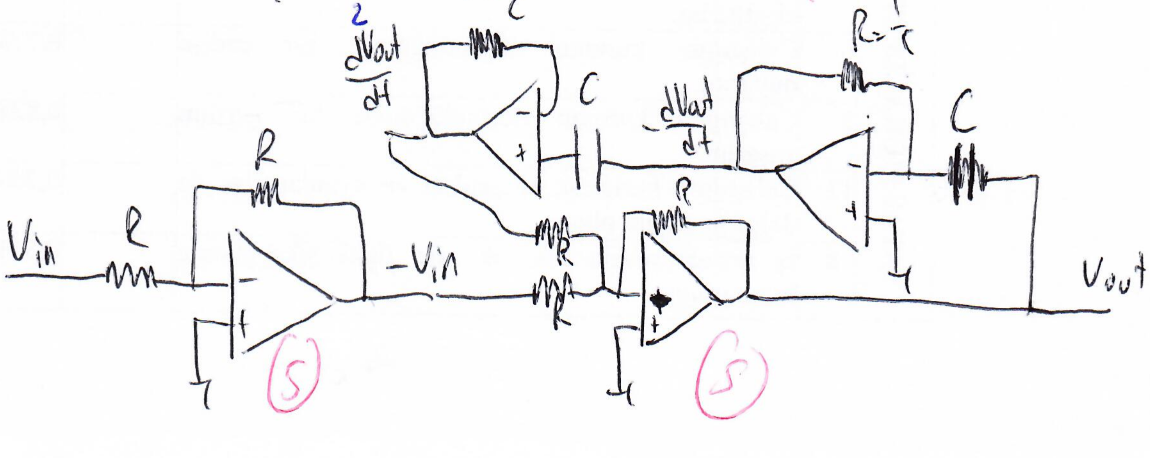
Exact value if $\omega = 4$ $|H(j\omega)|_{dB} = 20\log\frac{4}{17}$

Q2

$$\frac{d^2 V_{out}}{dt^2} + V_{out} = V_{in} \qquad V_{out} = V_{in} - \frac{d^2 V_{out}}{dt}$$







(Q3) $R_{in} = \frac{V_{in}}{I_1}$

$I_{in} = I_1 + I_2$ (1)

$$\frac{V_{in}}{Z_{in}} = \frac{V_{in}}{R_{in}} + \frac{V_{in} - V_{out}}{X_C}$$

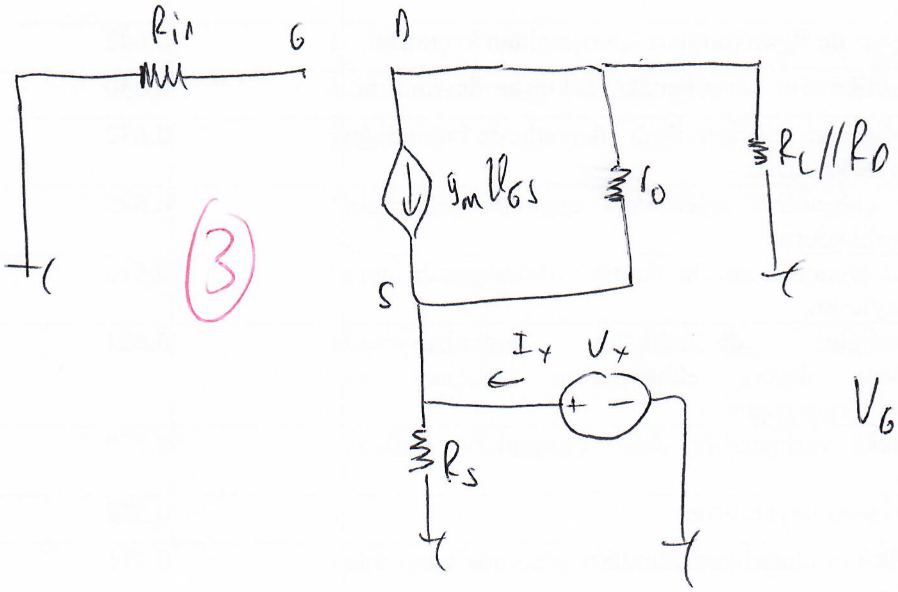
$$\frac{1}{Z_{in}} = \frac{1}{R_{in}} + \frac{1 - \frac{V_{out}}{V_{in}}}{X_C}$$ (7)

$$\frac{1}{Z_{in}} = \frac{1}{R_{in}} + \frac{1 - A_V}{X_C}$$

$$\frac{1}{Z_{in}} = \frac{X_C + (1 - A_V) R_{in}}{R_{in} X_C}$$ (2)

$$Z_{in} = \frac{R_{in} X_C}{X_C + (1 - A_V) R_{in}}$$

(Q4) Let C_g and C_d shorted, V_{in} short circuit put a test source instead of C_S (V_x) and calculate current I_x



$V_G = 0$

$V_S = V_x$

$V_{GS} = V_G - V_S$

$= -V_S = -V_x$

$$g_m V_{GS} + I_x = \frac{V_S}{R_S} + \frac{V_S - V_D}{r_o}$$

$$g_m [0 - V_x] + I_x = \frac{V_x}{R_S} + \frac{V_x - V_D}{r_o}$$

$$I_x = \left[g_m + \frac{1}{R_S} + \frac{1}{r_o}\right] V_x - \frac{V_D}{r_o}$$

$$g_m V_{GS} + \frac{V_D - V_S}{r_o} + \frac{V_D}{R_L} + \frac{V_D}{R_D} = 0$$

$$-g_m V_x - \frac{V_x}{r_o} + V_D \left[\frac{1}{r_o} + \frac{1}{R_L} + \frac{1}{R_D}\right] = 0$$

$$\left[g_m + \frac{1}{r_o}\right] V_x = V_D \left[\frac{1}{r_o} + \frac{1}{R_L} + \frac{1}{R_D}\right]$$

$$\frac{V_D}{V_x} = \frac{g_m + \frac{1}{r_o}}{\frac{1}{r_o} + \frac{1}{R_L} + \frac{1}{R_D}}$$

$$\frac{I_x}{V_x} = \frac{1}{R_{slow}} = \left[g_m + \frac{1}{R_s} + \frac{1}{r_o}\right] - \frac{1}{r_o}\frac{V_D}{V_x}$$

$$\frac{1}{R_{slow}} = \left[g_m + \frac{1}{R_s} + \frac{1}{r_o}\right] - \frac{1}{r_o}\,\frac{g_m + \frac{1}{r_o}}{\frac{1}{r_o} + \frac{1}{R_L} + \frac{1}{R_D}}$$

$$R_{slow} = \frac{1}{\left[g_m + \frac{1}{R_s} + \frac{1}{r_d}\right] - \frac{1}{r_o}\,\frac{g_m + \frac{1}{r_o}}{\frac{1}{r_o} + \frac{1}{R_L} + \frac{1}{R_D}}}$$

$C_S = 1\,\mu F$

$R_S = 1000\,\Omega$

$r_o = 1000\,\Omega$

$R_D = 1000\,\Omega$

$R_L = 1000\,\Omega$

$g_m = 10^{-3}$

$$R_{slow} = \frac{1}{\left[10^{-3} + 10^{-3} + 10^{-3}\right] - \frac{1}{1000}\,\frac{10^{-3} + 10^{-3}}{3\times10^{-3}}}$$

$$R_{slow} = \frac{1}{3\times10^{-3} - 10^{-3}\,\frac{2}{3}} = \frac{10^3}{\left(\frac{9-2}{3}\right)} = \frac{3\times10^3}{7}$$

$$f_{R_{slow}} = \frac{1}{2\pi C_s R_{slow}} = \frac{1}{2\pi\times10^{-6}\times\frac{3\times10^3}{7}} = \frac{7\times10^6}{6\times\pi\times10^3} = \frac{7\times10^3}{6\times\pi}$$