MAE140 Win12 HW8 Solutions

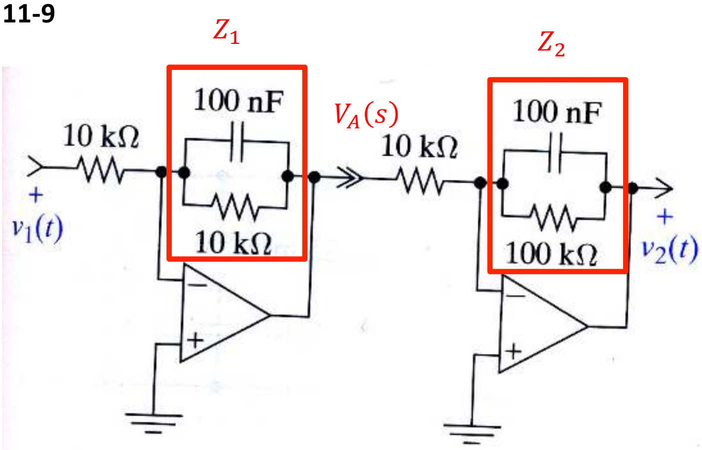
T R & T, 11.8, 11.9, 11.10, 11.11, 11.26, 11.28, 11.52, 11.64, 12.14, 12.56

11-8

$$T_1(s) = \frac{I_2(s)}{I_1(s)} = \frac{R}{3R + Ls}$$

Pole at $s = -3R/L$. Choosing $R = 500\ \Omega$, $L = 3H$, we can get the pole at s=-500 rad/s. The answer is not unique.

11-9



Transfer the circuit into s-domain and using the properties of inverting Amps. We can get

$$\frac{V_A}{V_1} = -\frac{Z_1}{10k\Omega}; \frac{V_2}{V_A} = -\frac{Z_2}{10k\Omega}$$

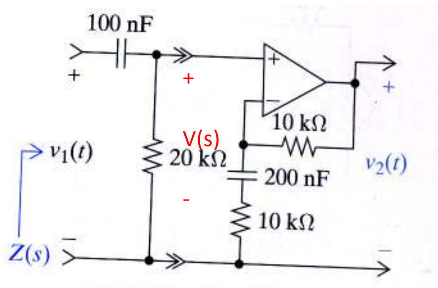
Where $Z_1 = \frac{10k\Omega \cdot \frac{1}{100nF \cdot s}}{10k\Omega + \frac{1}{100nF \cdot s}}$, $Z_2 = \frac{100k\Omega \cdot \frac{1}{100nF \cdot s}}{100k\Omega + \frac{1}{100nF \cdot s}}$

So we can obtain:

$$T_V(s) = \frac{V_2}{V_1} = \frac{Z_1 Z_2}{(10k\Omega)^2} = \frac{10^6}{(s + 100)(s + 1000)}$$

Poles as s=-100, s=-1000.

11-10



Transform the circuit into s-domain and get the transfer function.

$$T_1(s) = \frac{V(s)}{V_1(s)} = \frac{20k\Omega}{\frac{1}{s\cdot 100nF} + 20k\Omega}, T_2 = \frac{V_2(s)}{V(s)} = \frac{10k\Omega + \frac{1}{s\cdot 200nF} + 10k\Omega}{10k\Omega + \frac{1}{s\cdot 200nF}}$$

$$T_V(s) = T_1(s)T_2(s) = \frac{s(8\times 10^{-6}s + 2\times 10^{-3})}{(2\times 10^{-3}s + 1)^2}$$

Poles: double pole at s=-500, Zeros at s=0 and s=-250

11-11

$$Z(s) = 20k\Omega + \frac{1}{s\cdot 100nF} = \frac{2\times 10^4 s + 10^{-7}}{s}$$

11-26

$$\frac{V_2(s)}{V_1(s)} = \frac{1+s^2LC}{1+sRC+s^2LC}$$

where $R = 100\Omega, C = 20\mu F, L = 25mH$.

$$T(j\omega) = \frac{V_2(j\omega)}{V_1(j\omega)} = \frac{1 + (j\omega)^2 LC}{1 + j\omega RC + (j\omega)^2 LC}$$

(a) $\omega = 225.08 rad/s$, $\frac{V_2(j\omega)}{V_1(j\omega)} = 0.9079e^{-j24.79^O}$, $v_2(t) = 4.54\cos(225.08t - 24.79^O)$.

(b) $\omega = 10krad/s$, $\frac{V_2(j\omega)}{V_1(j\omega)} = 0.9258e^{j22.20^O}$ $v_2(t) = 4.54\cos(10kt + 22.20^O)$.

(c) $\omega = 0$, $v_2(t) = 5$.

11-28

$$\frac{I_2(s)}{I_1(s)} = -\frac{R_1}{R_1 + R_2 + sL}.$$

When $\omega = 500 rad/s$, $\frac{I_2(j\omega)}{I_1(j\omega)} = -0.199e^{-j5.71^O}$, $i_2(t) = 1.99\cos(500t - 5.71^O)$

When $\omega = 5000 rad/s$, $\frac{I_2(j\omega)}{I_1(j\omega)} = -0.1414e^{-j45^O}$ and $i_2(t) = 1.414\cos(5000t - 45^O)$.

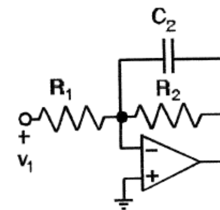
11-52

$$T_V(s) = \pm\frac{100(s+1000)}{(s+100)(s+10{,}000)} = \mp T_1(s)\cdot T_2(s) = \mp\left(-\frac{100}{s+100}\right)\left(\frac{s+1000}{s+10{,}000}\right)$$

Use a two-stage design.

$T_1(s) = -\frac{100}{s+100} = -\frac{\frac{1}{R_1}}{\frac{1}{R_2}+C_2\cdot s}$

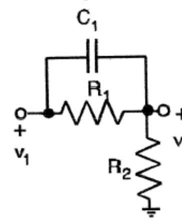
$k_m \coloneqq 10^{10}, R_1 = R_2 = \frac{k_m}{100} = 1\times10^8,\ C_2 = \frac{1}{k_m} = 1\times10^{-10}$



Stage #1

$T_2(s) = \frac{s+1000}{s+10{,}000} = -\frac{\frac{1}{R_1}+C_1 s}{\frac{1}{R_1}+\frac{1}{R_2}+C_1\cdot s}$

$k_m \coloneqq 10^{10}, R_1 = \frac{k_m}{1000} = 1\times10^7,\ R_2 = \frac{k_m}{10{,}000-1000} = \frac{1}{9}\times10^7, C_1 = \frac{1}{k_m} = 1\times10^{-10}$



Stage #2

11-64

(a) No.

(b) 1st stage: $T_1(s) = -\frac{R}{R+\frac{1}{Cs}}$, 2nd stage: $T_2(s) = -\frac{R\cdot\frac{1}{Cs}}{R+\frac{1}{Cs}}$

$$T_V(s) = \frac{sRC}{1+sRC} + \frac{1}{1+sRC} = 1$$

(c) Whatever the input, the output is the same as the input.

(d) It can be used as a voltage-follower. The output is the same as the input, and the input is not influenced by the loading.

12-14

$$T_V(s) = \left(\frac{\frac{1}{C_1 s}}{R_1+\frac{1}{C_1 s}}\right)\left(\frac{R_4+R_3}{R_4}\right)\left(\frac{R_2}{R_2+\frac{1}{C_2 s}}\right) = \left(\frac{1/R_1C_1}{s+\ 1/R_1C_1}\right)\left(\frac{R_4+R_3}{R_4}\right)\left(\frac{s}{s+1/R_2C_2}\right)$$

It can be seen that the two RC-constants $R_1C_1$and R_2C_2determine the cutoff frequencies.

We have $\omega_1 = \frac{1}{R_1C_1} = 2500 rad/s, \omega_2 = \frac{1}{R_2C_2} = 100 rad/s$

Since the gain is 30, we have $\frac{R_4+R_3}{R_4} = 30$

Then choose the value of each item.

12-56

First-Order Filter Company:

$$T_V(s) = 9.2 \cdot \frac{1}{s \cdot 3.3k\Omega \cdot 3.3\ nF + 1}$$

Simply Filters, Ltd:

$$T_V(s) = \frac{68 + 8.2}{8.2} \frac{1}{s \cdot 3.3k\Omega \cdot 3.3\ nF + 1} = 9.3 \frac{1}{s \cdot 3.3k\Omega \cdot 3.3\ nF + 1}$$

The two circuits have the same transfer function. But the sensor drives the filter input with a 1kΩ source resistance. So we choose the first circuit.