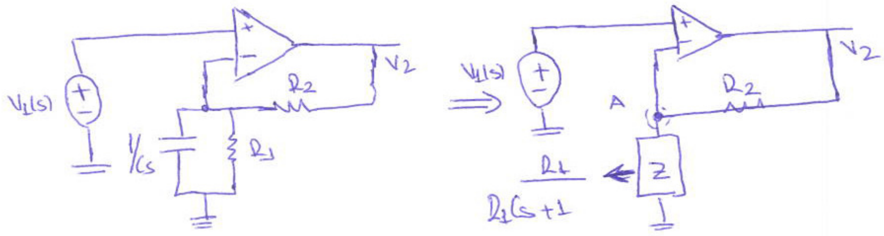
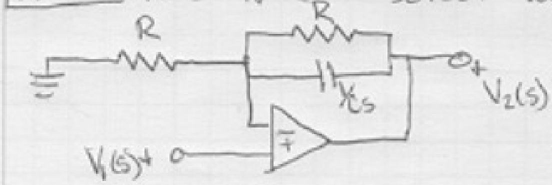
11.4) In Op-Amp $i_p = i_n = 0$, identically there is infinite Resistance, then we can conclude $Z_{eq} = \infty$



$$V_A = V_1(s) = \frac{\left(\frac{R_1}{R_1Cs+1}\right)}{R_2 + \frac{R_1}{R_1Cs+1}} V_2(s) = \frac{R_1}{R_1R_2Cs + R_2 + R_1} V_2(s) \quad \text{(current division)}$$

$$\Rightarrow T_V(s) = \frac{V_2}{V_1} = \frac{R_1R_2Cs + R_2 + R_1}{R_1}$$

$\boxed{\text{P.11.7}}$ find $T_V(s)$ & select values of R & C so there is a pole @ $s = -500 \frac{rad}{s}$



inverting amplifier

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

$$\boxed{T_V(s) = \frac{RCs+2}{RCs+1}}$$

any values of R & C such that

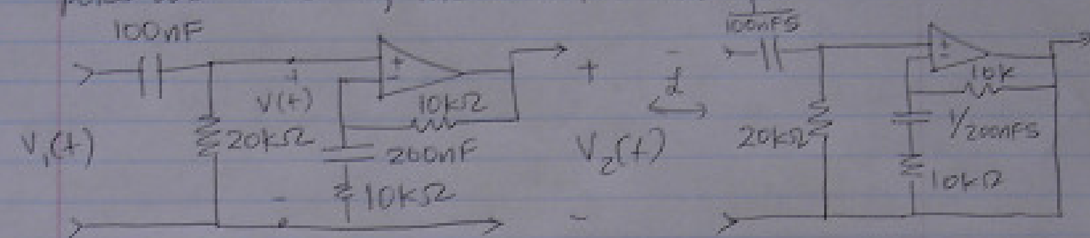
$$RC = \frac{1}{500}$$

ex.

$R = 1\,k\Omega$

$C = 2\,\mu F$

11.10) Find the voltage transfer function $T_V(s) = V_2(s)/V_1(s)$ of the cascade connection in the figure below. Locate the poles and zeros of the Transfer function



$$T_1(s) = \frac{V(s)}{V_1(s)} = \frac{20k}{20k + \frac{1}{100nFS}} = \frac{2000 \times 10^{-6} s}{2000 \times 10^{-6} s + 1}$$

$$T_2(s) = \frac{V_2(s)}{V(s)} = \frac{Z_1(s) + Z_2(s)}{Z_1(s)} = \frac{\left(10k + \frac{1}{200nFS}\right) + 10k}{10k + \frac{1}{200nFS}}$$

$$= \frac{20k(200nFS) + 1}{10k(200nFS) + 1}$$

$$= \frac{4000 \times 10^{-6} s + 1}{2000 \times 10^{-6} s + 1}$$

$$T_V(s) = T_1(s) \cdot T_2(s)$$

$$= \left(\frac{0.002s}{0.002s + 1}\right)\left(\frac{0.004s + 1}{0.002s + 1}\right)$$

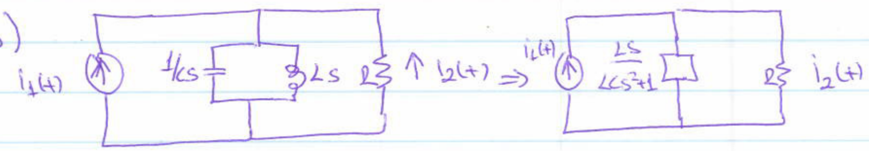
$$= \frac{8 \times 10^{-6} s^2 + 0.002s}{(0.002s + 1)(0.002s + 1)} = \frac{s(8 \times 10^{-6} s + 2 \times 10^{-3})}{(0.002s + 1)^2}$$

poles: $-1/2 \times 10^{-3}$, $\boxed{-500}$

zeros: 0 , $\frac{-2 \times 10^{-3}}{8 \times 10^{-6}} = -0.25 \times 10^{3}$

$\boxed{0, -250}$

11.29)



use two path current division

because of direction

$$i_2(s) = \frac{(-)\frac{Ls}{LCs^2+1}}{R+\frac{Ls}{LCs^2+1}}\, i_1(s) \Rightarrow T(s) = \frac{i_2(s)}{i_1(s)} = \frac{-s/RC}{s^2+s/RC+1/LC}$$

$$s = j\omega \Rightarrow |T(j\omega)| = \frac{\omega/RC}{\sqrt{\left(\frac{1}{LC}-\omega^2\right)^2+\left(\frac{\omega}{RC}\right)^2}}$$

$$\angle T(j\omega) = \underbrace{\angle(-j\omega/RC)}_{-\frac{\pi}{2}} - \underbrace{\angle\left(\frac{1}{LC}-\omega^2+j\,\omega/RC\right)}_{\tan^{-1}\left(\frac{\omega/RC}{\frac{1}{LC}-\omega^2}\right)}$$

for $i_1(t) = 5\cos(\underbrace{1000}_{\omega}t)$ and $R = 1000\,\Omega$

$L = 2\,H$ and $C = 500e^{-9}\,F$

$|T(1000j)| = 1 \quad \angle T(1000j) = -\pi$

Then $i_2 = 5 \times 1 \cos(1000t - \pi)$ mA

for $i_1(t) = 10\cos(2000t)$

$|T(2000j)| = 0.8 \quad \angle T(2000j) = -1.2\pi$

Then

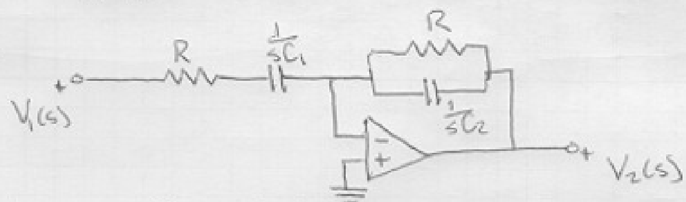
$$i_2(t) = 10 \times 0.8\cos(2000t - 1.2\pi)$$
$$= 8\cos(2000t - 1.2\pi)$$

$\boxed{P.11.53}$ Design a circuit to fit $T_v(s) = \pm \frac{1000s}{(s+500)(s+1000)}$

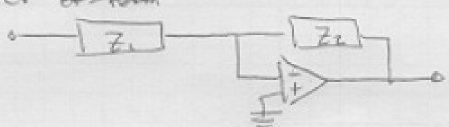
using only resistors, capacitors & not more than on OP-AMP
-scale it so that the final design uses only 20kΩ resistors

$$T_v(s) = \frac{k_1}{s+500} \quad \frac{k_2 s}{s+1000}$$

ex.



inverting amplifier ~~of form~~



$$\text{Gain} = -\frac{Z_2}{Z_1}$$

in example $\quad Z_2 = \frac{1}{\frac{1}{R}+sC_2} = \frac{R}{RC_2 s+1}$

$$Z_1 = R + \frac{1}{sC_1} = \frac{RC_1 s+1}{C_1 s}$$

$$T_v(s) = -\frac{Z_2}{Z_1} = -\frac{R}{RC_2 s+1} \quad \frac{C_1 s}{RC_1 s+1}$$

$$= -\frac{1}{RC_2} \quad \frac{1}{s+\frac{1}{RC_2}} \quad \frac{s}{s+1/RC_1}$$

if $R = 20k\Omega$

$C_1 = 100nF$

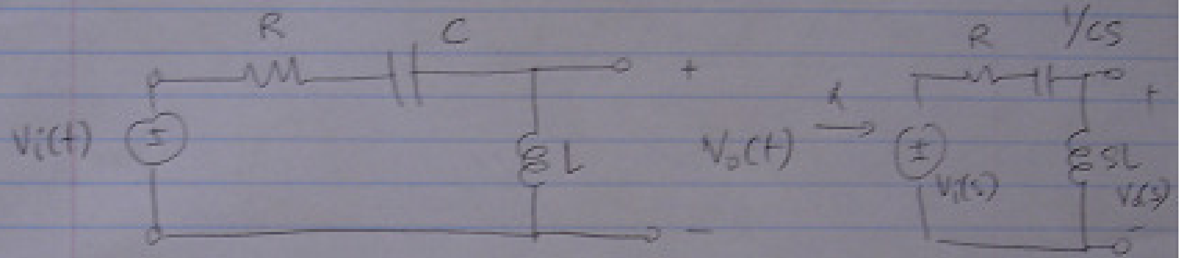
$C_2 = 50nF$

$$T_v(s) = -\frac{1000s}{(s+500)(s+1000)}$$

11-54) Design a circuit to realize the TF below using only resistors, capacitors, and inductors (no op-Amps allowed). Scale the circuit so that all inductors are 50mH or less.

$$T_V(s) = \frac{s^2}{(s+2000)(s+4000)}$$

$$T_V(s) = \frac{s^2}{s^2 + 6000s + 8\times10^6} = \cancel{\left(\frac{1/2}{s+2000}\right)\left(\frac{\ }{s+4000}\right)}$$



$$\frac{V_o(s)}{V_i(s)} = \frac{Z_2(s)}{Z_1(s) + Z_2(s)} = \frac{sL}{R + \frac{1}{Cs} + sL}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{LCs^2}{RCs + 1 + LCs^2}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{s^2}{s^2 + \frac{R}{L}s + \frac{1}{LC}} = \frac{s^2}{s^2 + 6000s + 8\times10^6}$$

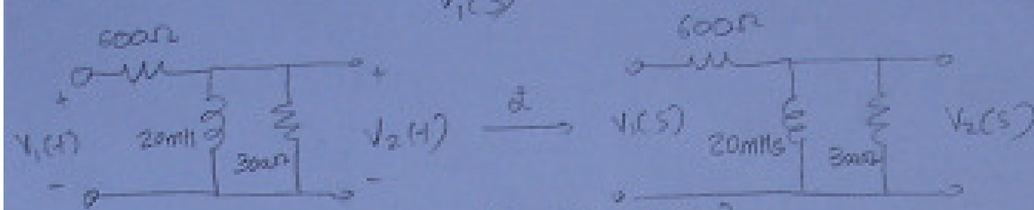
$$\frac{R}{L} = 6000 \qquad \frac{1}{LC} = 8\times10^6$$

$$\boxed{L = 50\times10^{-3}\,H}$$

$$\Rightarrow R = 6000 \times 5\times10^{-2} = 30000\times10^{-2} = \boxed{300\,\Omega}$$

$$C = \frac{1}{5\times10^{-2}\times 8\times10^{6}} = \frac{10^{-4}}{40} = \boxed{3\,\mu F}$$

12.2 Find the $T_V(s) = \frac{V_2(s)}{V_1(s)}$



$$T_V(s) = \frac{Z_2}{Z_1 + Z_2} = \frac{\frac{(300)(200mHs)}{300 + 200mS}}{600\Omega + \frac{60S}{300 + 0.2S}}$$

$$= \frac{60S}{600(300+0.2S) + 60S} = \frac{60S}{180S + 18000}$$

$$T_V(s) = \frac{\frac{1}{3}S}{S + 100}$$

a.) DC gain $|k|$ $(|T(j\omega)| \to T_{max})$

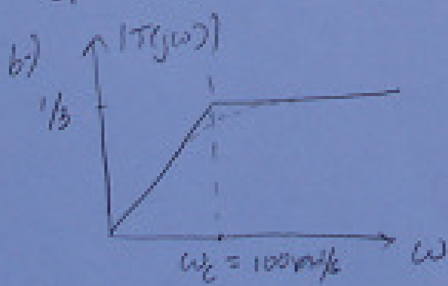
$$|k| = \frac{1}{3}$$

$$|T(j\infty)| = \frac{\frac{1}{3}\infty}{\infty + 100} = \frac{\frac{1}{3}}{1 + \frac{100}{\infty}} = \frac{1}{3}$$ Infinite frequency gain

cutoff frequency $\omega_c = 100$ rad/s

Type of gain response: I order High Pass

b.)



c.) i) $|T(j0.5\omega_c)| = |T(j50)|$

$$|T(j\omega)| = \frac{1/3\ \omega}{\sqrt{\omega^2 + 100^2}}$$

$$|T(j50)| = \frac{1/3(50)}{\sqrt{50^2 + 100^2}} = 0.149$$

ii) $\omega = \omega_c = 100$ rad/s

$$|T(j100)| = \frac{1/3(100)}{\sqrt{100^2 + 100^2}} = 0.2357$$

iii) $\omega = 2\omega_c = 200$ rad/s

$$|T(j200)| = \frac{1/3(200)}{\sqrt{200^2 + 100^2}} = 0.298$$

$\boxed{P.12.10}$ a) Identify the gain response, cutoff frequency & passband gain for $T(s) = \dfrac{10/s}{100/s + 1/20}$

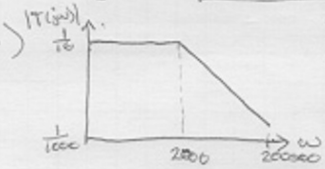
b) Sketch straight line gain response & estimate the gain for $0.5\omega_c$, ω_c, $2\omega_c$

a) $|T(0)| \to 1/10$ $\boxed{\text{Low - Pass}}$
$|T(\infty)| \to 0$

$\boxed{\omega_c = 2000 \ \frac{rad}{s}}$

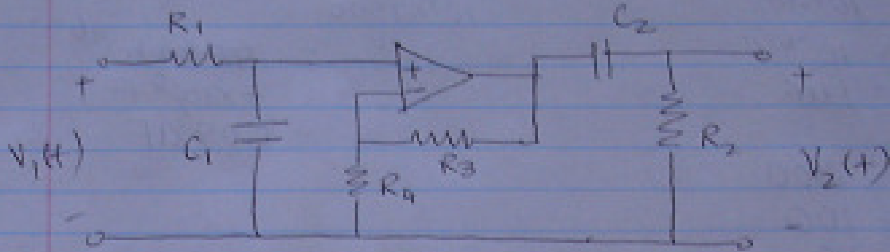
passband gain $\boxed{|T(0)| = \frac{1}{10}}$

b)

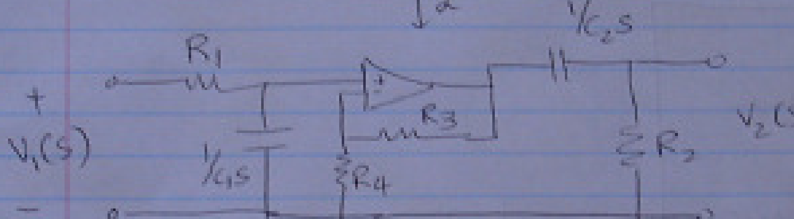


$|T(j0.5\omega_c)| \approx 1/10$
$|T(j\omega_c)| \simeq \frac{1}{10\sqrt{2}}$
$|T(j2\omega_c)| \simeq 1/50$

12.14 Identify the elements that control the two cutoff frequencies. Select the element values so that the passband gain is 10, and the cutoff frequencies are 100 rad/s and 2500 rad/s. Use practical element values with $R \geq 10k\Omega$ and $C \leq 1\mu F$



$\downarrow \mathcal{L}$



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

$$= \left(\frac{1}{R_1 C_1 S + 1}\right)\left(\frac{R_4 + R_3}{R_4}\right)\left(\frac{R_2 C_2 S}{R_2 C_2 S + 1}\right)$$

$$T_V(j\omega) = \left(\frac{|K_1|}{\sqrt{\omega^2 + \left(\frac{1}{R_1 C_1}\right)^2}}\right)(K_3)\left(\frac{|K_2|\,\omega}{\sqrt{\omega^2 + \left(\frac{1}{R_2 C_2}\right)^2}}\right)$$

$\omega_1 = \frac{1}{R_2 C_2}$ $\quad K_1 = 1/R_1 C_1 \quad K_2 = 1/R_2 C_2$

$\omega_2 = \frac{1}{R_1 C_1}$ $\quad K_3 = 10$

$R_4 + R_3 = 10 R_4$ $\quad$ If $R_3 = 100k$

$9R_4 = R_3$ $\quad R_4 = \frac{100k}{9} = 11.11\,k\Omega$

$100 = \frac{1}{R_2 C_2}$ $2500 = \frac{1}{R_1 C_1}$

if $R_2 = 10k$

$C_2 = \frac{1}{10^4 . 10^2}$

$= 10^{-6} F$

$= 1 \mu F$

if $R_1 = 10k$

$C_1 = \frac{1}{10^4 \times 2500}$

$= \frac{10^{-6}}{25} = \cancel{400 \times 10^{-6}}$

$= 4 \times 10^{-8} F$

$= 0.04 \mu F$

$K_1 = 2500$

$K_2 = 100$

$K_3 = 10$

$R_1 = 10k$

$R_2 = 10k$

$R_3 = 100k$

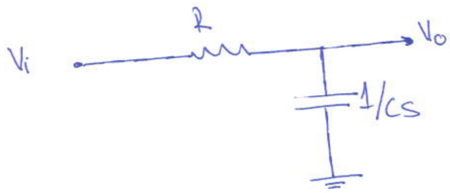
$R_4 = 11.11k$

$C_1 = 0.04 \mu F$

$C_2 = 1 \mu F$

9 3:26

12.54) This is basically low-pass filter.



$$V_o = \frac{1/cs}{R + 1/cs} V_i$$

$$V_o = \frac{1}{RCs+1} V_i \Rightarrow T(s) = \frac{1}{RCs+1}$$

The magnitude of the transffer function is

$$|T(j\omega)| = \left| \frac{1}{1+jRC\omega} \right| = \frac{1}{\sqrt{R^2C^2\omega^2+1}}$$

units are given as dB then

$$|T(j\omega)|_{dB} = 20\log_{10}(|T(j\omega)|)$$

the frequency of RF noise = 3.2 MHz = $3.2 \times 10^6 \times 2\pi$ rad/sec

" " " signal data = 1.1 MHz = $1.1 \times 10^6 \times 2\pi$ rad/sec

for RF noise $|T(j\omega)|_{dB} \leq -7dB$

for signal data $|T(j\omega)|_{dB} \geq -2dB$

We need to try the values which are given in Table 12.54. and observe which value is best for that purpose.

for 2AEN46 ($R = 470\Omega$ and $C = 1000pF$)

$$|T(j(\text{signaldata})|_{dB} \cong -1.06$$

$$|T(j(\text{RF noise})|_{dB} \cong -7.00$$