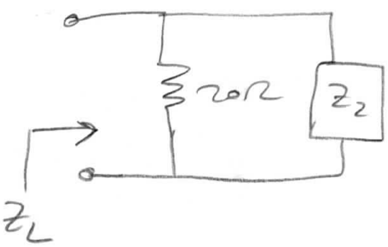
10-53:

(a) Goal: to achieve $Z_L(s) = \frac{s+5}{s+10}$ in the circuit:



by properly choosing Z_2.

Analysis: Given the circuit, we find Z_L:

$$Z_L = 20 \| Z_2 = \frac{20 Z_2}{Z_2 + 20}$$

then we equate it w/ the given eq'n for Z_L:

$$Z_L = \frac{20 Z_2}{Z_2 + 20} = \frac{s+5}{s+10}$$

where solving this eq'n for Z_2 we get:

$$\boxed{Z_2 = \frac{20s + 100}{19s + 195}}$$

(b) To realize Z_2, we first compute Y_L:

$$Y_L = \frac{1}{Z_L} = \frac{s+10}{s+5}$$

where we know from the circuit:

$$Y_L = \frac{s+10}{s+5} \equiv \frac{1}{20} + Y_2 = 0.05 + Y_2$$

$$\Downarrow$$

$$\frac{s+5+5}{s+5} = 1 + \frac{5}{s+5} = 0.05 + 0.95 + \frac{5}{s+5} \equiv 0.05 + Y_2$$

$$\Downarrow$$

$$\boxed{Y_2 = 0.95 + \frac{5}{s+5}} \quad (*)$$

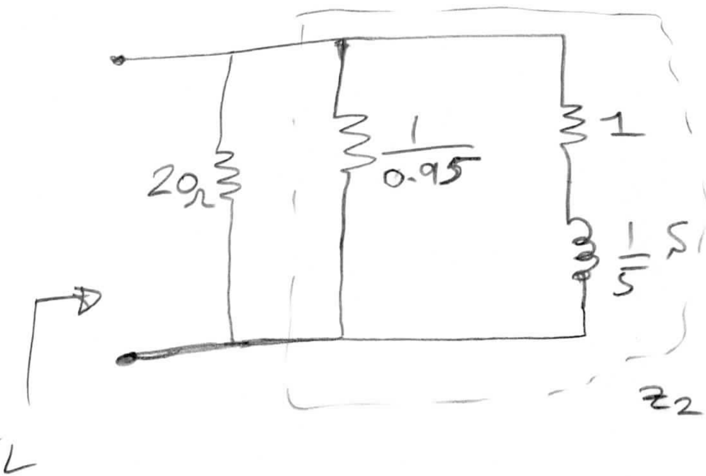
from eq'n (*), we can guess that the term $Y' = 0.95$ represents a resistance (P2)

in parallel w/ admittance $Y'' = \dfrac{5}{s+5}$, where the latter is also representing:

$$Y'' = \frac{5}{s+5} \Rightarrow Z'' = \frac{s+5}{5} = \underbrace{\frac{1}{5}s}_{\text{an inductor}} + \underbrace{1}_{\text{a resistance}}$$

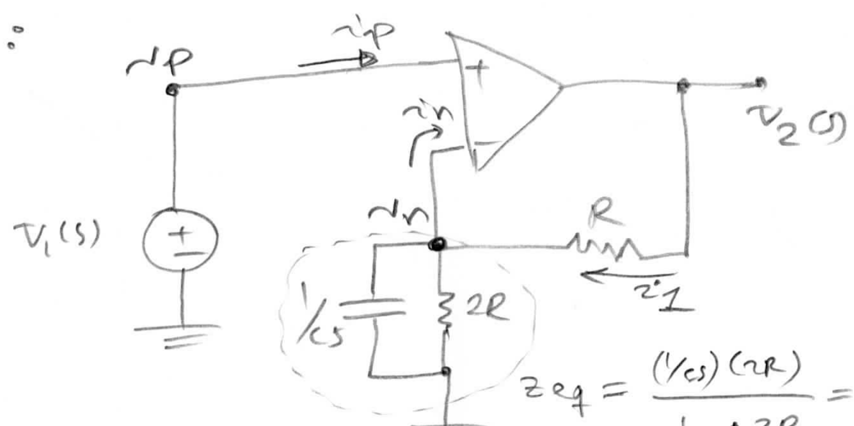
(because of summation, they are in series.)

Therefore, Z_2 can be realized in the following way:



12-4:

Given:



$$Z_{eq} = \frac{(1/cs)(2R)}{\frac{1}{cs} + 2R} = \frac{2R}{2RCs+1}$$

- from basic properties of op-amp: $i_p = 0 \Rightarrow$ Therefore, the driving-point impedance seen by $V_1(s)$ is ∞.

- also, from basic properties of op-amp: $v_n = v_p = V_1(s)$, so we find i_1:

$$i_1 = \frac{V_n - 0}{Z_{eq}} \Rightarrow i_1 = \frac{V_1(2RCs+1)}{2R}$$

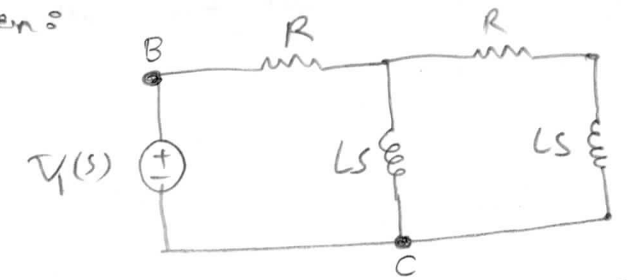
and so :

$$\frac{V_2 - V_n}{R} = i_1 \Rightarrow \frac{V_2 - V_1}{R} = \frac{V_1(2RCs+1)}{2R} \Rightarrow 2V_2 - 2V_1 = V_1(2RCs+1)$$

$$\Rightarrow \boxed{T_v(s) = \frac{V_2(s)}{V_1(s)} = \frac{2RCs+3}{2}}$$

11-6:

Given:

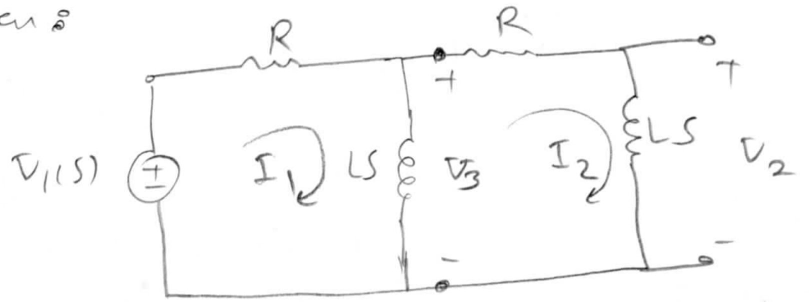


the driving-point impedance or the equivalent impedance seen from B-C ports:

$$Z_{BC} = (R+LS)\|(LS) + R = \frac{(R+LS)(LS)}{(R+LS)+LS} + R = \frac{L^2s^2+RLS}{2LS+R} + R$$

$$\Rightarrow \boxed{Z_{BC} = \frac{L^2s^2+3RLS+R^2}{2LS+R}}$$

Given:



we can have:

$$\begin{cases} V_2(s) = LsI_2(s) \\ LsI_2(s) + Ls(I_2 - I_1) + RI_2 = 0 \\ V_1(s) - RI_1 - Ls(I_1 - I_2) = 0 \end{cases}$$

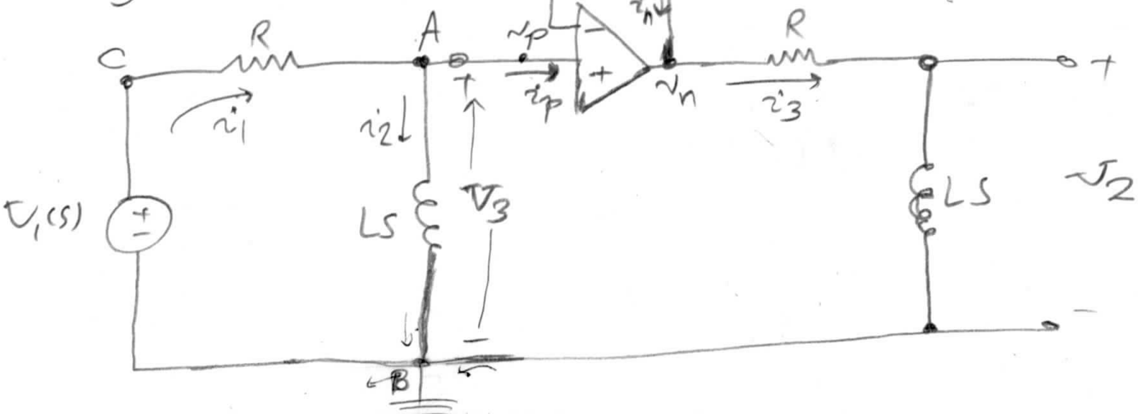
from these eq'ns we get:

$$\begin{cases} (2Ls+R)\frac{V_2}{Ls} = LsI_1 \Rightarrow I_1 = \frac{2Ls+R}{(Ls)^2}V_2 \\ V_1 = (R+Ls)I_1 - LsI_2 \\ I_2 = \frac{V_2}{Ls} \end{cases} \Rightarrow V_1 = (R+Ls)\left(\frac{2Ls+R}{(Ls)^2}\right)V_2 - Ls\frac{V_2}{Ls}$$

$$\Rightarrow V_1 = \frac{(R+Ls)(2Ls+R) - (Ls)^2}{(Ls)^2}V_2 \Rightarrow T_V(s) = \frac{V_2}{V_1} = \frac{(Ls)^2}{(R+Ls)(2Ls+R) - (Ls)^2}$$

$$\xrightarrow[\text{simplifications}]{\text{some}} \boxed{T_V(s) = \frac{L^2s^2}{L^2s^2 + 3RLs + R^2}}$$

By inserting a follower at point A, we get:



from basic properties of op-amp: $v_n = v_p$ where $v_p = v_A$ $\Rightarrow v_n = v_A$

moreover, $i_p = 0$ so there is no effect of loading & so we can apply the chain rule:

$$T_V = \frac{V_2}{V_1} = \frac{V_3}{V_1} \cdot \frac{V_2}{V_3}$$

where from voltage division we have:

$$\frac{V_3}{V_1} = \frac{LS}{R+LS} \quad \text{and} \quad \frac{V_2}{V_3} = \frac{LS}{R+LS}$$

therefore:

$$T_V = \left(\frac{LS}{R+LS}\right)\left(\frac{LS}{R+LS}\right) \Rightarrow \boxed{T_V(S) = \frac{L^2S^2}{L^2S^2 + 2RLS + R^2}}$$

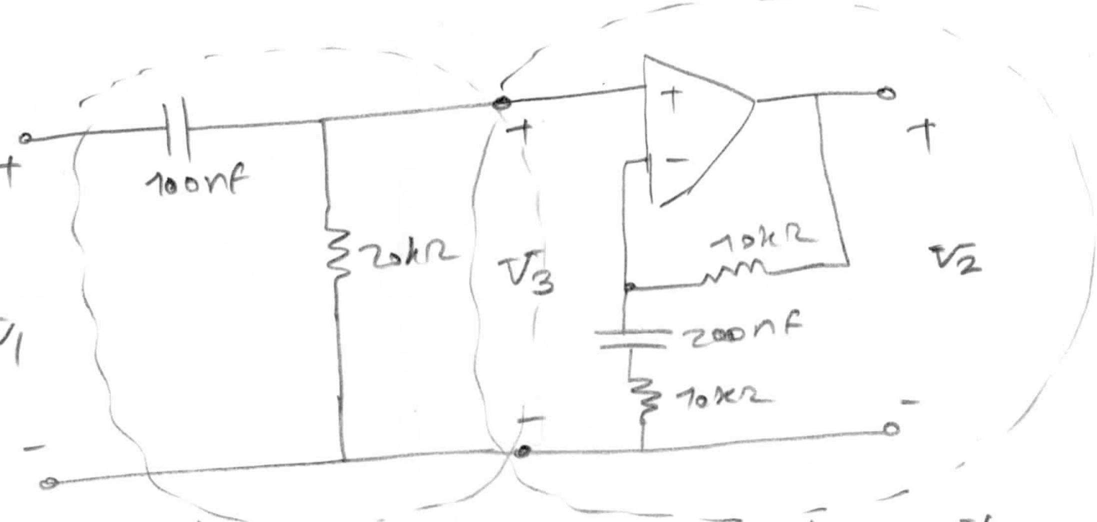
Moreover, $V_2 = V_3$ means that there is an ∞-impedance in parallel w/ LS,

So driving-point impedance:

$$Z_{BC} = R + (LS)\parallel\infty \Rightarrow \boxed{Z_{BC} = R + LS}$$

11-10

Given:



$\hookrightarrow T_{V_1} = \frac{V_3}{V_1}$ $\qquad$ $\hookrightarrow T_{V_3} = \frac{V_2}{V_3}$

As demonstrated on the circuit, we solve this problem using chain rule:

$$T_V = \frac{V_2}{V_1} = T_{V_1} \cdot T_{V_3}$$

where

$$T_{V_1} = \frac{20\,k\Omega}{20\,k\Omega + \frac{1}{100nF\,s}} \quad \text{(voltage-division)}$$

$$T_{V_3} = \frac{Z_1 + Z_2}{Z_1} \quad w/ \; Z_1 = 10\,k\Omega + \frac{1}{200nF\,s} \;\; \& \;\; Z_2 = 10\,k\Omega \quad \text{(non-inverting op-amp)}$$

Simplifying these transfer f'cns:

$$\boxed{T_{V_1} = \frac{2\times10^{-3}\,s}{2\times10^{-3}\,s + 1}}$$

&

$$T_{V_3} = \frac{10^4 + \frac{1}{2\times10^{-7}s} + 10^4}{10^4 + \frac{1}{2\times10^{-7}s}} \Rightarrow \boxed{T_{V_3} = \frac{4\times10^{-3}\,s + 1}{2\times10^{-3}\,s + 1}}$$

So, finally we get:

$$\Rightarrow T_V = T_{V_1} \cdot T_{V_3} = \left(\frac{2\times10^{-3}\,s}{2\times10^{-3}\,s + 1}\right)\left(\frac{4\times10^{-3}\,s + 1}{2\times10^{-3}\,s + 1}\right)$$

where by some simplification:

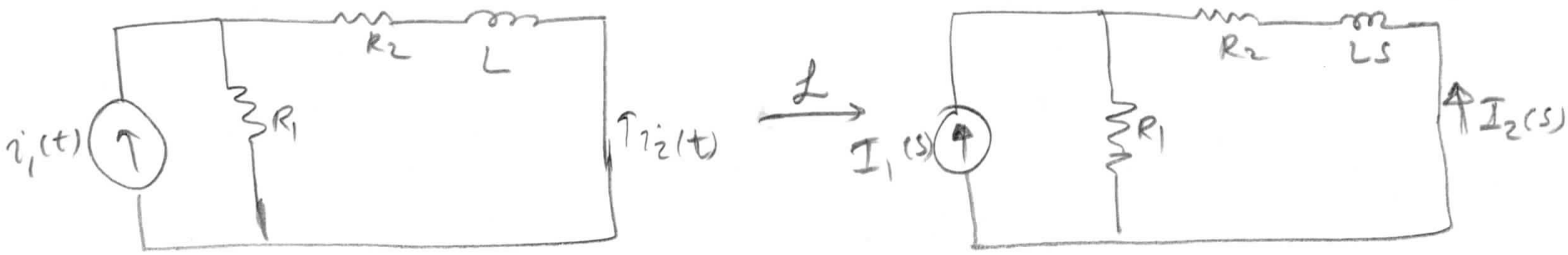
$$\boxed{T_V(s) = \frac{s(8\times10^{-6}\,s + 2\times10^{-3})}{(2\times10^{-3}\,s + 1)^2}}$$

the poles: $(2\times10^{-3}\,s + 1)^2 = 0 \Rightarrow$ $\boxed{\text{repeatitive pole at } p_{1,2} = -\frac{1}{2\times10^{-3}} = -500}$

the zeros: $s(8\times10^{-6}\,s + 2\times10^{-3}) = 0 \Rightarrow \boxed{z_1 = 0}$ & $z_2 = \frac{-2\times10^{-3}}{8\times10^{-6}} \Rightarrow \boxed{z_2 = -0.25\times10^{+3}}$

11-28:

Given:



We note that in general w/ input: $i_1(t) = A\cos(\omega t)$, the steady-state output is of the form: $i_{ss,2}(t) = A\,|T(j\omega)|\cos(\omega t + \theta)$, where $\theta = \angle T(j\omega)$ and $T(s)$ is mapping $I_1(s)$ to $I_2(s)$. Therefore, we compute $T(s)$:

(from current-division eq'n): $T(s) = \dfrac{I_2(s)}{I_1(s)} = \dfrac{\left(\frac{1}{R_2+Ls}\right)}{\frac{1}{R_1} + \frac{1}{R_2+Ls}} \Rightarrow \boxed{T(s) = \dfrac{R_1}{Ls + (R_1+R_2)}}$

Hence, given parameters: $R_1 = 100\Omega$, $R_2 = 400\Omega$, $L = 100\,mH$, we get:

$$T(s) = \frac{1000}{s+5000} \Rightarrow \boxed{T(j\omega) = \frac{1000}{j\omega + 5000}} \quad (*)$$

- For the first part: $i_1 = 10\cos(500t)\,mA$, so we compute $(*)$ at $\omega = 500$:

$$T(j\omega) = \frac{1000}{500j + 5000} \Rightarrow \begin{cases} |T(j\omega)| = \dfrac{1000}{\sqrt{500^2 + 5000^2}} = \dfrac{2}{\sqrt{101}} = 0.199 \\ \theta(j\omega) = \angle T(j\omega) = 0 - \tan^{-1}\left(\dfrac{500}{5000}\right) = -0.0997 \end{cases}$$

Therefore, for given: $i_1 = 10\cos(500t)\,mA$, the steady-state output is:

$$i_{ss,2} = -10 \times 0.199 \times \cos(500t - 0.0997)$$

$$\Downarrow$$

$$\boxed{i_{ss,2} = -1.99\cos(500t - 0.0997)\ mA}$$

- For the second part: $i_1 = 10\cos(5000t)\,mA$, so we compute $(*)$ at $\omega = 5000$:

$$T(j\omega) = \frac{1000}{5000j+5000} \Rightarrow \begin{cases} |T(j\omega)| = \dfrac{1000}{\sqrt{5000^2+5000^2}} = \dfrac{1}{5\sqrt{2}} = 0.141 \\ \theta = \measuredangle T(j\omega) = -\tan^{-1}\left(\dfrac{5000}{5000}\right) = -0.7854 \end{cases}$$

Therefore, w/ $i_1 = 10\cos(5000t)$ mA, we get:

$$i_{SS,2} = -10 \times 0.141 \times \cos(5000t - 0.7854)$$

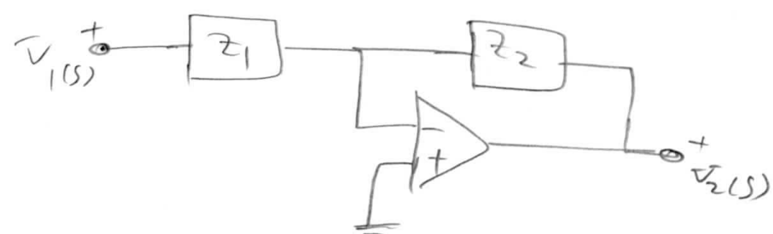
$$\Downarrow$$

$$\boxed{i_{SS,2} = -1.41\cos(5000t - 0.7854)\ \text{mA}}$$

11-53: [Difficult design, refer to page 10 for simpler design]

Goal: Design a circuit to realize: $T_V(s) = \pm \dfrac{1000s}{(s+500)(s+1000)}$

As an example, we can use inverting op-amp w/ the following set up:



where the transfer f'cn:

$$T_V(s) = \frac{V_2}{V_1} = -\frac{Z_2}{Z_1}$$

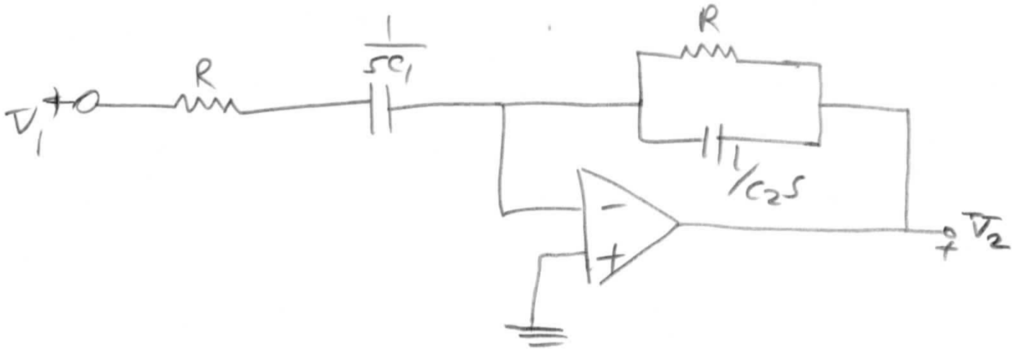
So, if we choose: $Z_2 = \dfrac{1}{\frac{1}{R}+sC_2}$ & $Z_1 = R + \dfrac{1}{sC_1}$, we get:

$$T_V(s) = -\frac{Z_2}{Z_1} = -\frac{R}{RC_2s+1} \cdot \frac{C_1 s}{RC_1 s+1} = -\frac{1}{RC_2} \cdot \frac{1}{s+\frac{1}{RC_2}} \cdot \frac{s}{s+\frac{1}{RC_1}}$$

and so, by picking: $\begin{cases} R = 20k\Omega \\ C_1 = 100nF \\ C_2 = 50nF \end{cases}$, we have:

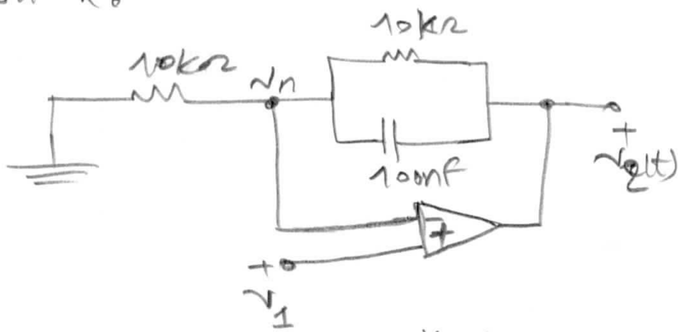
$$T_V(s) = -\frac{1000s}{(s+500)(s+1000)}$$ which satisfies our goal ✓

where the final realization of Z_1 & Z_2 is drawn below:

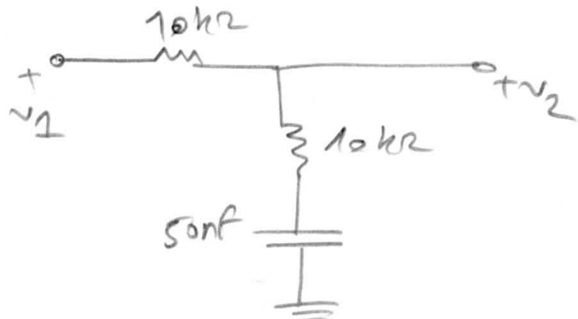


11-58:

Given:



circuit 1



Circuit 2

(a) For circuit 1:

$$v_n = v_p = v_1$$

where also we can find v_n from voltage-division:

$$v_1 = v_2 \left(\frac{10k}{10k + \dfrac{\frac{10k}{100nS}}{10k + \frac{1}{100nS}}} \right) \Rightarrow \text{by some simplifications:}$$

$$v_1 = v_2 \left(\frac{10S + 10^4}{10S + 2\times10^4} \right) (*)$$

we want: $T_V(S) = \frac{V_2}{V_1} \xrightarrow{(*)} \boxed{T_V(S) = \frac{S+2000}{S+1000}}$

For circuit 2:

It's simply a voltage-division:

$$V_2(s) = \frac{10k + \frac{1}{50ns}}{10k + 10k + \frac{1}{50ns}} V_1(s) \Rightarrow$$ by some simplification:

$$V_2(s) = \frac{5\times10^{-4}s+1}{10^{-3}s+1} V_1(s) \quad (**)$$

we want: $T_V(s) = \frac{V_2(s)}{V(s)} \xrightarrow{(**)} \boxed{T_V(s) = \frac{1}{2}\left(\frac{s+2000}{s+1000}\right)}$

(b) A 1kΩ load connected to the output $V_2(t)$ in the 2nd circuit produces loading which will then change its value to a new $V_2'(t)$. whereby, there is no change in the overall transfer f'cn when connecting a load to the output of an op-amp (recalling the basic properties of op-amps). Therefore, 1st circuit is preferred.

(c) Both circuits can be chosen if the load is of 50 Ω. The reason is that 50 Ω << 10 kΩ which satisfies the rule $Z_{out} \ll Z_{in}$ to prevent loading in circuit 2. whereby, Circuit 1 is a non-inverting op-amp so any load can be connected to V_1 w/o changing the overall transfer f'cn, so circuit 1 is preferred.

(d) the claim is true, because the op-amp used is non-inverting op-amp.

11-53 [alternative & simpler design]:

Given:

$$T_v(s) = \frac{10k\,s}{(s+1k)(s+5k)}$$, we will design a 3-stage ckt:

$$T_v(s) = \underbrace{\left(\frac{k_1}{s+1k}\right)}_{1^{st}\text{ stage}} \underbrace{(k_2)}_{2^{nd}\text{ stage}} \underbrace{\left(\frac{k_3 s}{s+5k}\right)}_{3^{rd}\text{ stage}} \quad (*)$$

1st stage can be realized by using RC divider realization:

$$\frac{k_1}{s+1k} = \frac{k_1/s}{1+1k/s} \equiv \frac{Z_2(s)}{Z_1(s)+Z_2(s)}$$

where we obtain: (equating numerator & denominators)

$$Z_2(s) = k_1/s$$

$$Z_1(s) = 1 + 1k/s - Z_2(s) = 1 + 1k/s - k_1/s \Rightarrow Z_1(s) = 1 + (1000 - k_1)/s$$

thus, for simplicity we pick: $\underline{k_1 = 1000} \Rightarrow \begin{cases} Z_1 = 1 \Rightarrow \underline{R_1 = 1\,\Omega} \\ Z_2 = \frac{1000}{s} \Rightarrow \underline{C_2 = \frac{1}{1000}\,F} \end{cases}$

3rd stage can be realized by using RC divider realization as well:

$$\frac{k_3 s}{s+5k} = \frac{k_3}{1+5k/s} = \frac{Z_4(s)}{Z_3(s)+Z_4(s)}$$

where we obtain:

$$Z_4(s) = k_3$$

$$Z_3(s) = 1 + 5k/s - Z_4(s) = 1 - k_3 + 5k/s$$

thus, for simplicity we pick: $\underline{k_3 = 1} \Rightarrow \begin{cases} Z_4 = 1\,\Omega \Rightarrow \underline{R_4 = 1\,\Omega} \\ Z_3 = 5k/s \Rightarrow \underline{C_3 = \frac{1}{5000}\,F} \end{cases}$

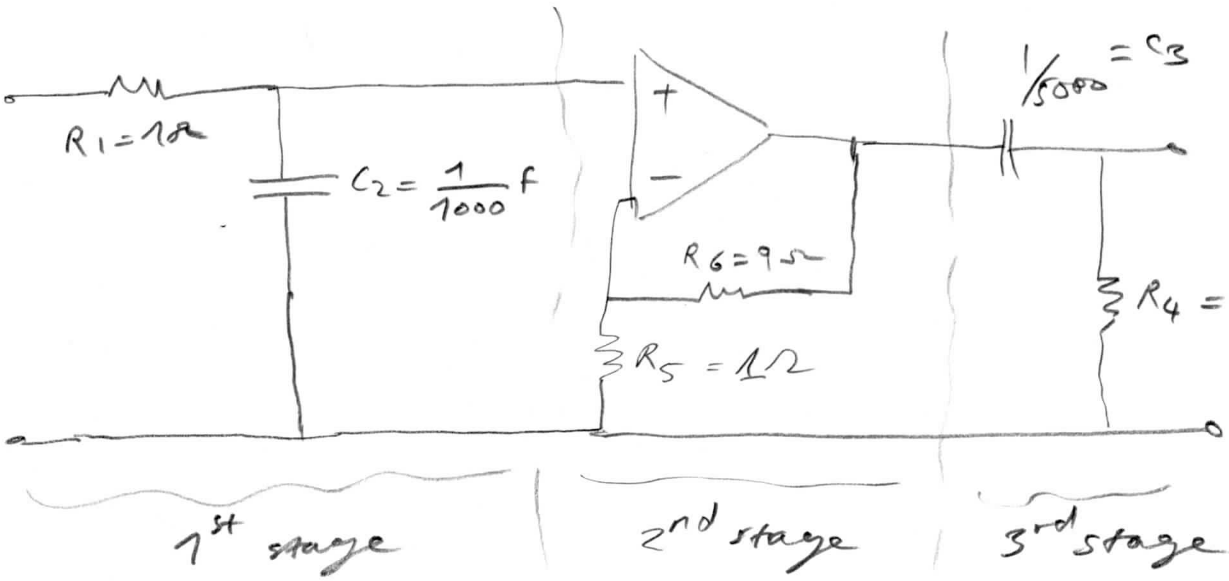
recalling (*) & our given transfer f'cn, we get the constraint:

$$\left.\begin{array}{l} k_1 k_2 k_3 = 10k \\ \text{where we have already chosen: } \begin{array}{l} k_1 = 1000 \\ k_3 = 1 \end{array} \end{array}\right\} \Rightarrow \underline{k_2 = 10}$$

Hence, for the 2^{nd} stage, we could use non inverting opamp realization as follows:

$$\left.\begin{array}{l} k_2 = \dfrac{R_5 + R_6}{R_5} = 10 \\ \text{for simplicity, we pick: } \underline{R_5 = 1\Omega} \end{array}\right\} \Rightarrow \underline{R_6 = 9\Omega}$$

Aggregating our analysis so far, the circuit looks like:



We note that this is a "prototype" i.e., the values for resistances & capacitors are not realistic, we use "Magnitude scaling" concept to scale these values & get the realistic values:

Regarding 1^{st} stage:

$$\left.\begin{array}{l} R_{1after} = k_m R_{1before} = k_m \times 1 \\ C_{2after} = \dfrac{C_{2before}}{k_m} = \dfrac{10^{-3}}{k_m} \end{array}\right\} \xrightarrow[k_m = 10^6]{\text{pick}} \left\{\begin{array}{l} R_{1after} = 1M\Omega \ \checkmark \\ C_{2after} = 1pF \ \checkmark \end{array}\right.$$

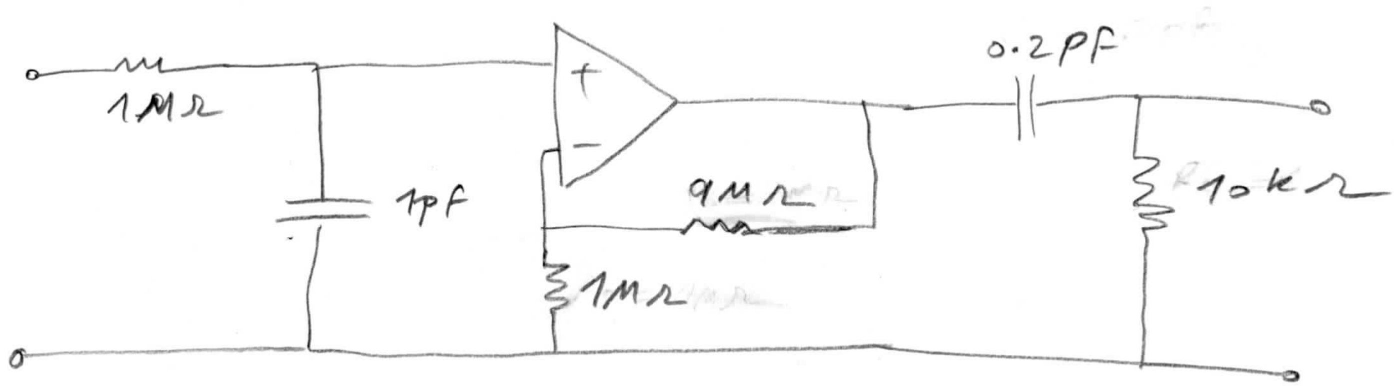
Regarding 2nd stage:

$$\left.\begin{aligned} R_{5after} &= k_m R_{5before} = k_m \times 1 \\ R_{6after} &= k_m R_{6before} = k_m \times 9 \end{aligned}\right\} \xrightarrow[k_m = 10^6]{pick} \left\{\begin{aligned} R_{5after} &= 1M\Omega \checkmark \\ R_{6after} &= 9M\Omega \checkmark \end{aligned}\right.$$

Regarding 3rd stage:

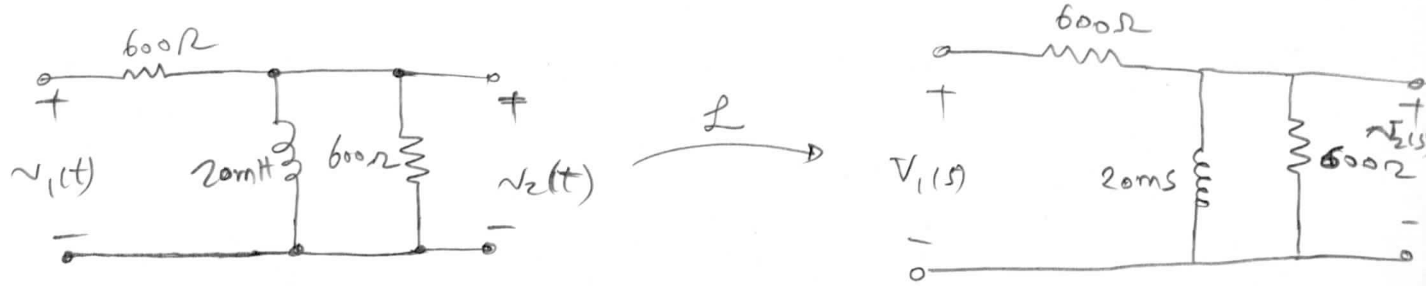
$$\left.\begin{aligned} C_{3after} &= \frac{C_{3before}}{k_m} = \frac{2\times10^{-4}}{k_m} \\ R_{4after} &= k_m R_{4before} = k_m \times 1 \end{aligned}\right\} \xrightarrow[k_m = 10^4]{pick} \left\{\begin{aligned} C_{3after} &= 0.2pF \checkmark \\ R_{4after} &= 10k\Omega \checkmark \end{aligned}\right.$$

So, the final realistic design will be:



12-2:

Given:



using voltage division we get:

$$V_2 = V_1 \frac{\left(\dfrac{2\times10^{-2}s\times6\times10^{2}}{2\times10^{-2}s+6\times10^{2}}\right)}{600+\dfrac{2\times10^{-2}s\times6\times10^{2}}{2\times10^{-2}s+6\times10^{2}}} \Rightarrow V_2 = V_1\left(\frac{s}{2s+30000}\right)$$

$$\Rightarrow \boxed{T_V(s) = \frac{V_2(s)}{V_1(s)} = \frac{s}{2s+3\times10^{4}}}$$

(a)

DC-gain $= T_V(j0) = 0$

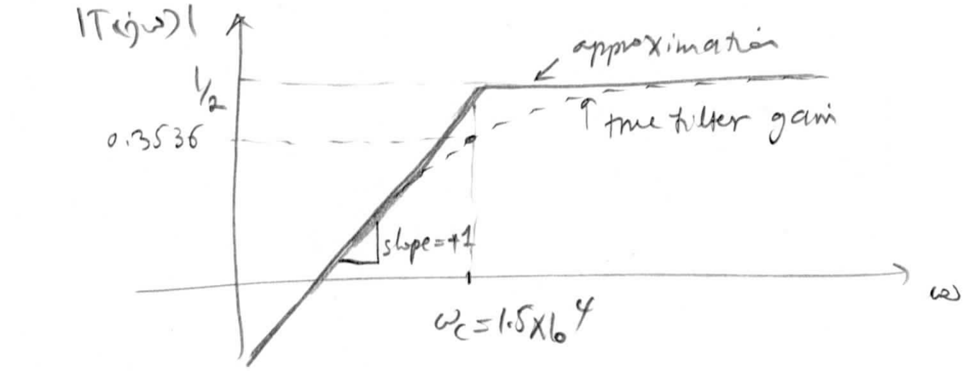
Infinite-freq gain $= \lim_{\omega\to\infty} T_V(j\omega) = 1/2$

Cut-off frequency $= 3\times10^4/2 = 1.5\times10^4$ rad/sec

It is a first order HIGH pass filter.

(b) Straight-line approximation of the gain:

$$|T(j\omega_c)| = |T(j\times1.5\times10^4)| = \left|\frac{j\times1.5\times10^4}{2j\times1.5\times10^4+3\times10^4}\right| = \left|\frac{j}{2j+2}\right| = 0.3536$$



(c) Having computed $\omega_c = 1.5 \times 10^4$ rad/sec, we get:

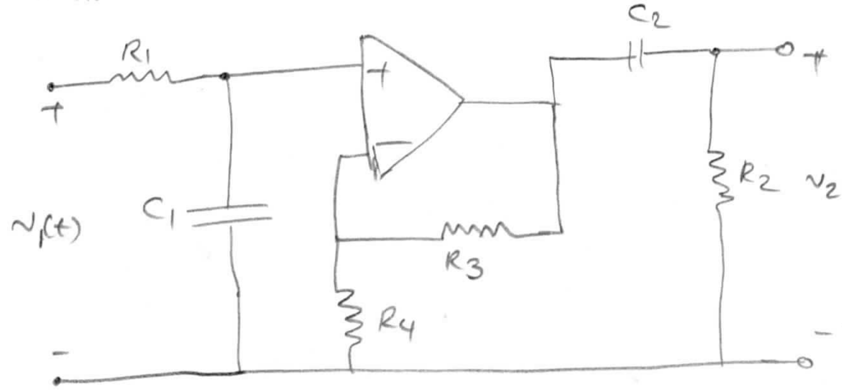
$$|T(j0.5\omega_c)| = |T(j7500)| = \left| \frac{7500j}{2 \times 7500j + 3\times10^4} \right| = \left| \frac{j}{2j+4} \right| = 0.2236$$

$$|T(j\omega_c)| = 0.3536 \quad \text{(Computed previously)}$$

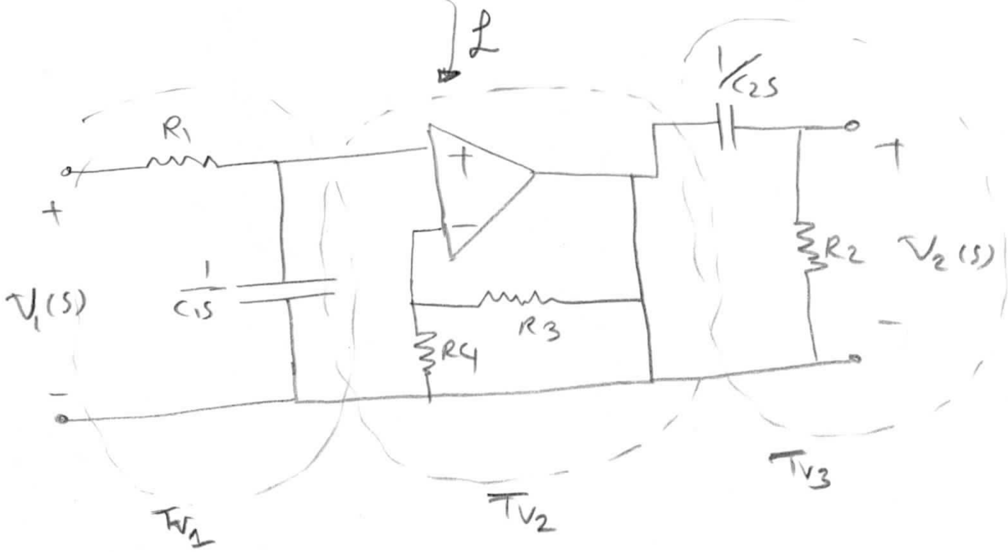
$$|T(j2\omega_c)| = |T(j3\times10^4)| = \left| \frac{3\times10^4 j}{2\times3\times10^4 j + 3\times10^4} \right| = \left| \frac{j}{2j+1} \right| = 0.4472$$

12-14

Given:



$\downarrow \mathcal{L}$



Chain rule: $T_V = \underbrace{T_{V_1}}_{\text{voltage division}} \cdot \underbrace{T_{V_2}}_{\text{non-inverting op-amp}} \cdot \underbrace{T_{V_3}}_{\text{voltage-division}}$

So, we compute these 3 transfer fns:

$$T_{V_1}(s) = \frac{1/C_1 s}{R_1 + 1/C_1 s} = \frac{1}{R_1 C_1 s + 1}$$

$$T_{V_2}(s) = \frac{R_4+R_3}{R_4}$$

$$T_{V_3}(s) = \frac{R_2}{R_2 + 1/C_2 s} = \frac{R_2 C_2 s}{R_2 C_2 s+1}$$

and so, we get:

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

Therefore, the two cut-off frequencies are:

$$\boxed{\alpha_2 = \frac{1}{R_1 C_1} \; ; \; \alpha_1 = \frac{1}{R_2 C_2}}$$: cutoff frequencies

So, R_1, C_1 ; R_2, C_2 are controlling the cutoff frequencies.

Moreover, the gains are obtained as follows:

$$\boxed{K_1 = \frac{R_4+R_3}{R_4} \; ; \; K_2 = \frac{1}{R_1 C_1}}$$: high pass & low pass gains

which will match the pattern:

$$T_v(s) = \left(\frac{K_2}{s+\alpha_2}\right)\left(\frac{K_1 s}{s+\alpha_1}\right) = \left(\frac{1/R_1C_1}{s+1/R_1C_1}\right)\left(\frac{\left(\frac{R_4+R_3}{R_4}\right) s}{s+\frac{1}{R_2C_2}}\right)$$

and so, the passband gain is:

$$\boxed{K_{pb} = \frac{|K_1 K_2|}{\alpha_2} = \frac{\left(\frac{R_4+R_3}{R_4}\right)\left(\frac{1}{R_1C_1}\right)}{\frac{1}{R_1C_1}} = \frac{R_4+R_3}{R_4}}$$: passband gain

We would like to have:

$$K_{pb} = 30 = \frac{R_4+R_3}{R_4}$$

$$\alpha_1 = \frac{1}{R_2 C_2} = 100 \text{ rad/sec}$$

$$\alpha_2 = \frac{1}{R_1 C_1} = 2500 \text{ rad/sec}$$

Subject to $R \geq 10 k\Omega$, $C \leq 1 \mu F$

So, one set of parameters are:

$R_1 = 10\,k\Omega$

$R_2 = 10\,k\Omega$

$R_3 = 100\,k$

$R_4 = 11.11\,k$

$C_1 = 0.04\,\mu F$

$C_2 = 1\,\mu F$

(They need not be unique).

12-56:

Design requirements:

(1) low-pass filter

(2) pass band gain: $9 \pm 10\%$

(3) Cut off freq: $90 \pm 10\%$ krad/sec

(4) Sensor driven the input w/ a 1kΩ resistance & open-circuit voltage: ±1.6V

Evaluation criteria:

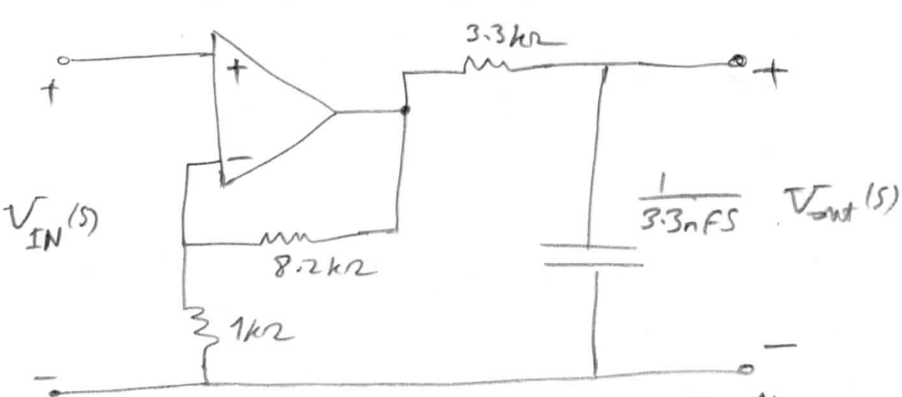
(5) Filter performance

(6) parts count

(7) use of standard parts

(8) Cost.

"First-order filter company" design: (already transformed into s-domain)



we use chain rule to get the overall transfer fcn:

non inverting op amp:

$$T_{V_1} = \frac{Z_1 + Z_2}{Z_1}, \quad Z_1 = 1k\Omega, \quad Z_2 = 8.2\,k\Omega \quad \Rightarrow T_{V_1} = 9.2$$

voltage division:

$$T_{V_2} = \frac{\frac{1}{3.3\times10^{-9}s}}{3.3\times10^3 + \frac{1}{3.3\times10^{-9}s}} = \frac{1}{(3.3)^2\times10^{-6}s + 1}$$

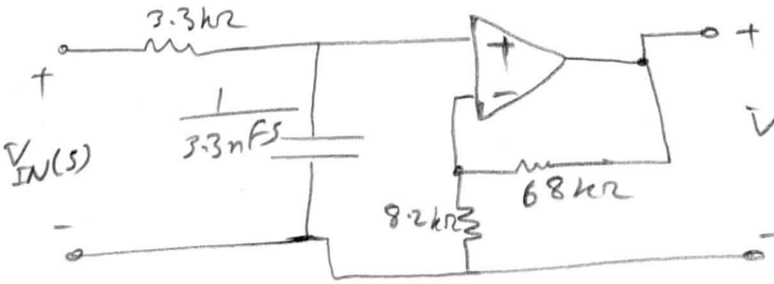
(P17)

$$\Rightarrow T_V(S) = T_{V_1} \times T_{V_2} \Rightarrow \boxed{T_V(S) = \frac{9.2\times10^6/(3.3)^2}{S + \frac{10^6}{(3.3)^2}}}$$

So, it is a low pass filter w/ { cutoff freq = 91.83 krad/sec ; passband gain = 9.2 }

So, it satisfies design requirements (1) – (3).

"Simply filters" design: (already transformed into s-domain)



In an analogous way to the previous circuit analysis:

$$T_{V_1} = \frac{\frac{1}{3.3\times10^{-9}S}}{3.3\times10^3 + \frac{1}{3.3\times10^{-9}S}} = \frac{1}{(3.3)^2\times10^{-6}S+1}$$

$$T_{V_2} = \frac{z_1+z_2}{z_1} = \frac{68+8.2}{8.2} = 9.29$$

$$\Rightarrow \boxed{T_V = \frac{9.29\times10^6/(3.3)^2}{S + \frac{10^6}{(3.3)^2}}}$$

So, it is a low-pass filter w/ { cutoff freq = 91.83 krad/sec ; passband gain = 9.29 }

So, it satisfies design requirements (1) – (3)

Evaluation statement:

→ they both have the same parts count
→ they both use standard elements
→ The "Simply Filters, Ltd." design does not meet the specifications, the

reason is that there is a source resistance of $1k\Omega$, which is connected in series w/ $3.3\ k\Omega$ resistance which will change the transfer f'cn, where as it is not the case for "First_order filter company", because source resistance of $1k\Omega$ is in series w/ op-amp.

Moreover, in "First-order filter company" the input ~~vol~~ voltage will not Saturate as it is in $\pm 1.6\ V$ range.