For networks (a) and (b) on p.22, derive $f(s) = I_2/I_1$ and $k = \frac{V_1}{V_2}$, use your derivations to obtain equations (51) and (52)

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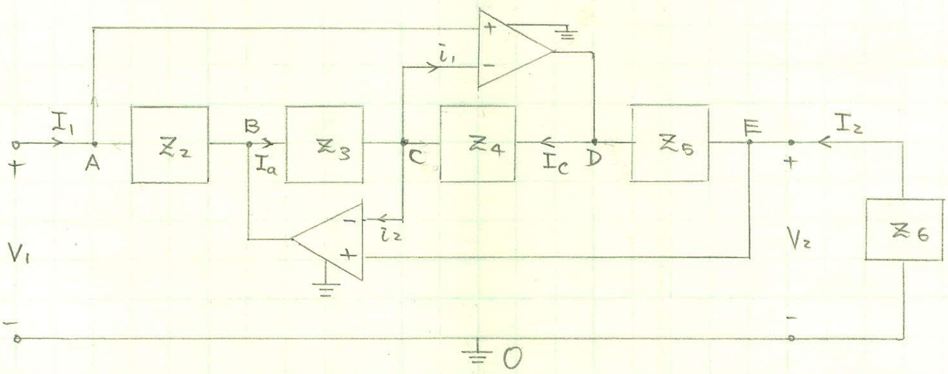
(a) Antoniou's GIC Circuit



$V_{AB} = I_1 Z_2$, $V_{ED} = I_2 Z_5$, $V_{CO} = V_{AO} = V_1$, $V_{CO} = V_{EO} = V_2$

$V_{BC} = V_{BO} - V_{OC} = V_{BA} - V_{AO} - V_{OC} = V_{BA}$

$V_{DC} = V_{DO} - V_{OC} = V_{DE} - V_{EO} - V_{OC} = V_{DE}$

$I_a = V_{BC}/Z_3 = V_{BA}/Z_3 = -V_{AB}/Z_3 = -I_1 Z_2/Z_3$

$I_c = V_{DC}/Z_4 = V_{DE}/Z_4 = -V_{ED}/Z_4 = -I_2 Z_5/Z_4$

$I_a = -I_c$ (Because $i_1 = i_2 = 0$) , so,

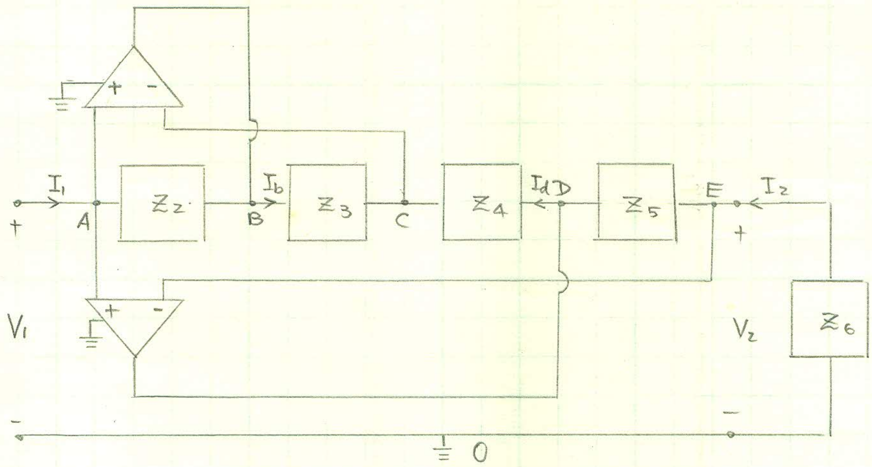
$-I_1 Z_2/Z_3 = +I_2 Z_5/Z_4$

$f(s) = \frac{I_2}{I_1} = \frac{-Z_2 \cdot Z_4}{Z_3 \cdot Z_5}$, $k = \frac{V_2}{V_1} = \frac{V_{CO}}{V_{CO}} = 1$

FROM THE EQUATION (50) ON P_{21}, WE HAVE

$$Z_{in} = k f(s) \cdot \frac{V_2}{I_2} = -\frac{Z_2 \cdot Z_4}{Z_3 Z_5} \cdot 1 \cdot (-Z_6) = \frac{Z_2 \cdot Z_4}{Z_3 \cdot Z_5} \cdot Z_6 \quad \underline{\text{QED}}$$

(b) Riordan's GIC Circuit



Apply the principle of virtual short circuit for both operational amplifiers.

$$V_{AO} = V_{CO} = V_{EO} = V_1 = V_2$$

$$I_d = V_{DC}/Z_4 = (V_{DO} - V_{OC})/Z_4 = (V_{DE} - V_{EO} - V_{OC})/Z_4$$

$$= (-V_{ED} - V_{EO} + V_{CO})/Z_4 = -\frac{V_{ED}}{Z_4} = -\frac{Z_5 \cdot I_2}{Z_4}$$

$$I_b = V_{BC}/Z_3 = (V_{BO} - V_{OC})/Z_3 = (V_{BA} - V_{AO} - V_{OC})/Z_3$$

$$= (-V_{AB} - V_{AO} + V_{CO})/Z_3 = -\frac{V_{AB}}{Z_3} = -\frac{Z_2}{Z_3} \cdot I_1$$

$$I_d = -I_b$$

$$-\frac{Z_5}{Z_4} I_2 = \frac{Z_2}{Z_3} \cdot I_1$$

$$f(s) = \frac{I_2}{I_1} = \frac{-Z_2 \cdot Z_4}{Z_3 \cdot Z_5},$$

$$K = V_1/V_2 = 1$$

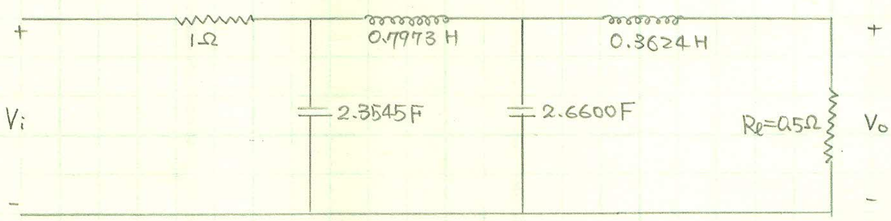
SO, $Z_{in} = kf(s) \cdot \frac{V_2}{I_1} = -\frac{Z_2 \cdot Z_4}{Z_3 \cdot Z_5} \cdot (-Z_6)$

$$= \frac{Z_2 \cdot Z_4}{Z_3 \cdot Z_5} \cdot Z_6$$ QED

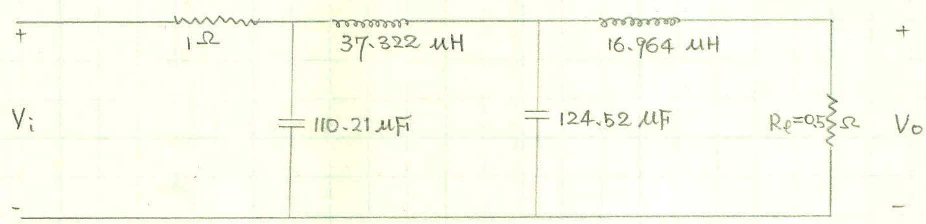
20/20

10-2. Find an active ladder circuit realization of an nth-order low-pass Chebyshev filter with 0.1 dB ripples, ripple bandwidth $f_r = 3.4$ KHz, and a terminating load resistor $R_\ell = 600\Omega$, where $n=4$ and use GIC.

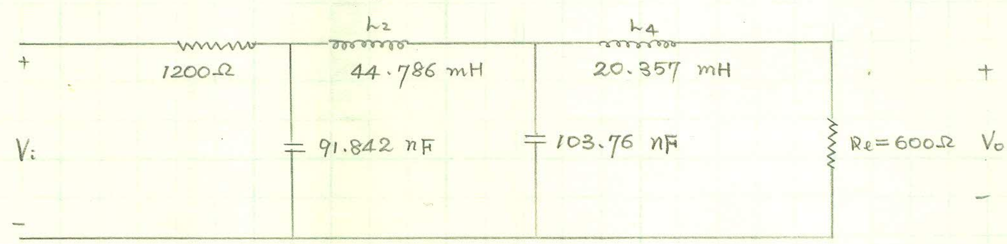
<u>Solution:</u> * From the circuit of Fig. 8-17 on page 261 and Table 8-2 on page 262 in text, we have the normalized Chebyshev low-pass filter with 0.1 dB ripple and ripple bandwidth $\omega_r = 1$ rad/s as well as $R_\ell = 0.5\Omega$:



* Scaling to the ripple bandwidth $f_r = 3.4$ KHz. $\omega_r = 2\pi f_r = 21362.83$ rad/s



* Impedance scaling by $600/0.5 = 1200$

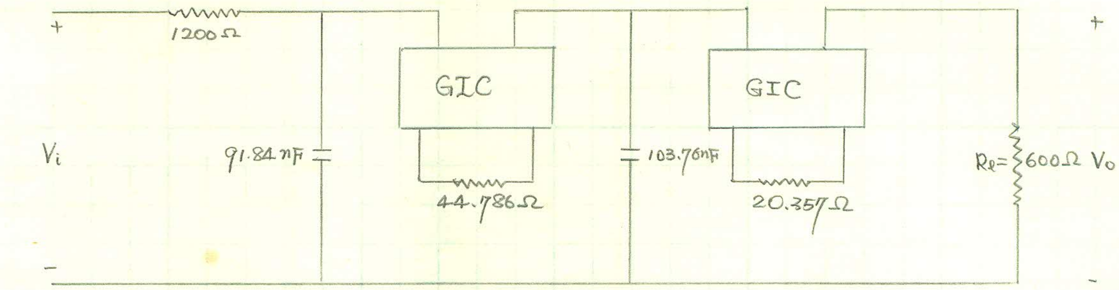


* Replace the inductors in the circuit with GIC

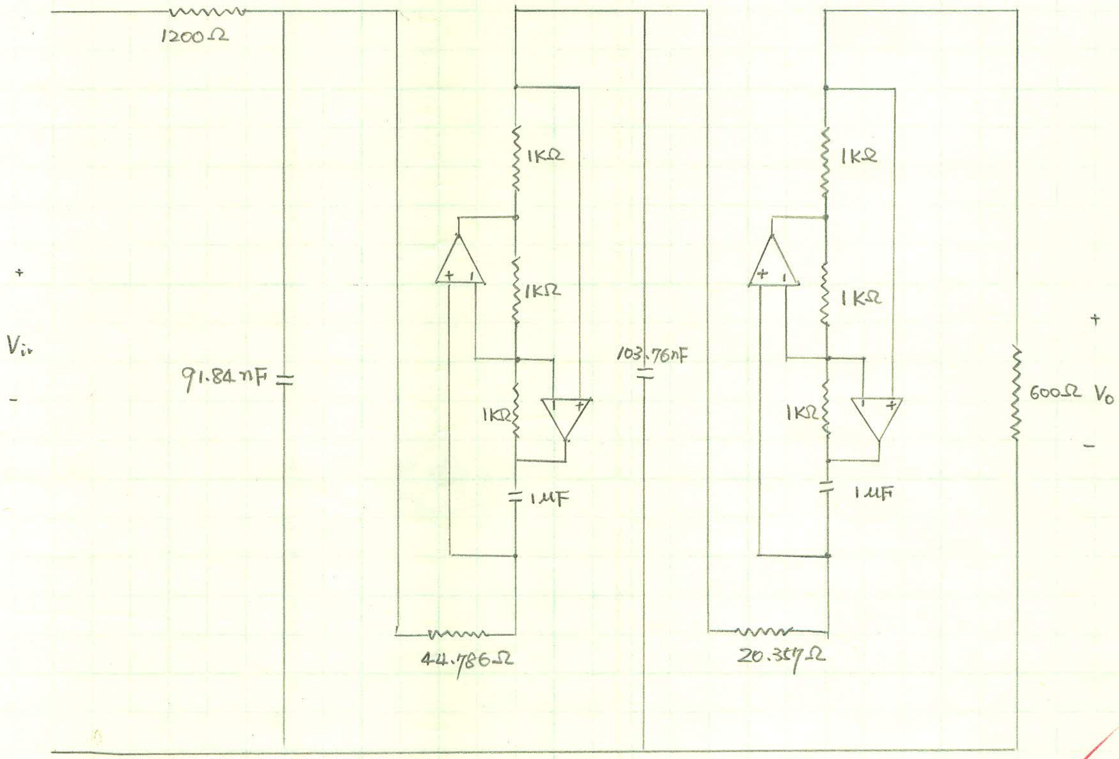
LET $R_2 = R_3 = R_4 = 1\,K\Omega$ and $C_5 = 1\,\mu F$

THUS FOR $L_2 = 44.786$ mH, $R_6' = 44.786\ \Omega$

FOR $L_4 = 20.357$ mH, $R_6'' = 20.357\ \Omega$

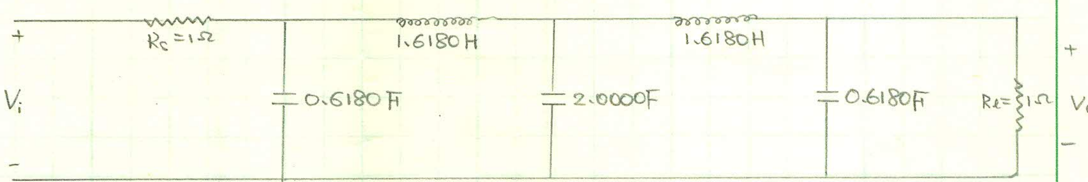

+
1200Ω
GIC
GIC
+
V_i
91.84 nF
44.786Ω
103.76nF
20.357Ω
R_ℓ= 600Ω V_o
–
–

OR:

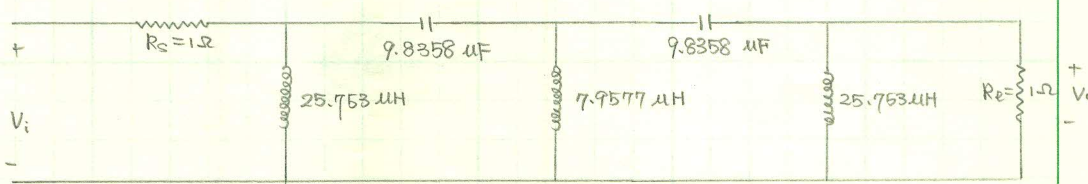

1200Ω
1KΩ
1KΩ
1KΩ
1KΩ
+
V_{in}
–
91.84 nF
103.76nF
1KΩ
1KΩ
+
600Ω V_o
–
1μF
1μF
44.786Ω
20.357Ω

10-3 Find an active ladder circuit realization of an nth-order high-pass Butterworth filter with the 3 dB cutoff frequency $f_c = 10$ KHz. and the terminating resistor $R_\ell = 600\Omega$, where $n = 5$ and use FDNR.

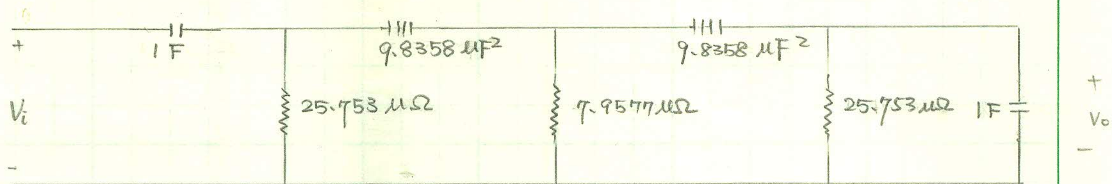
Solution: From the circuit at part c of Fig. 8-9 on page 237 and the Table 8-1 on page 238 in text, we can have the nonmalized Butterworth low-pass filter with the 3 dB cutoff freq. $\omega_0 = 1$ rad/s and the terminating resistors $R_\ell = R_s = 1\Omega$.



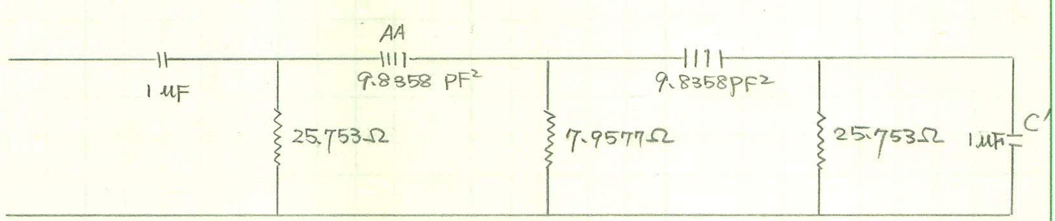
THEN THE HIGH-PASS FILTER WITH CUTOFF FREQ. $\omega_c = 2\pi f_c = 62832$ rad/s



Devide all of elements by s, we have



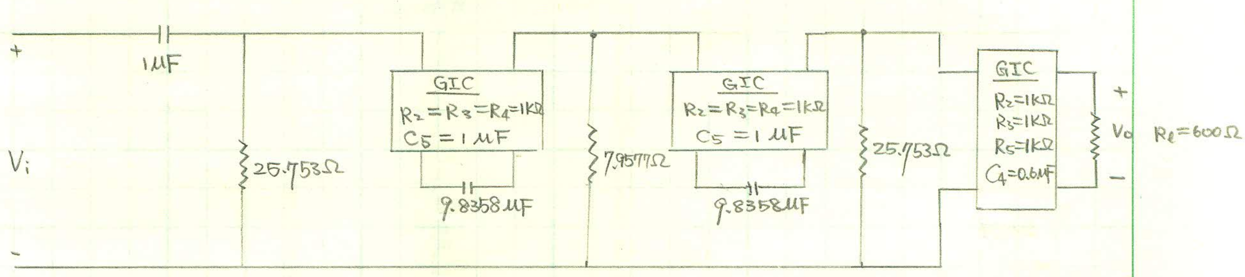
To obtain more reasonable values for the elements, we will scale impedance by 10^6



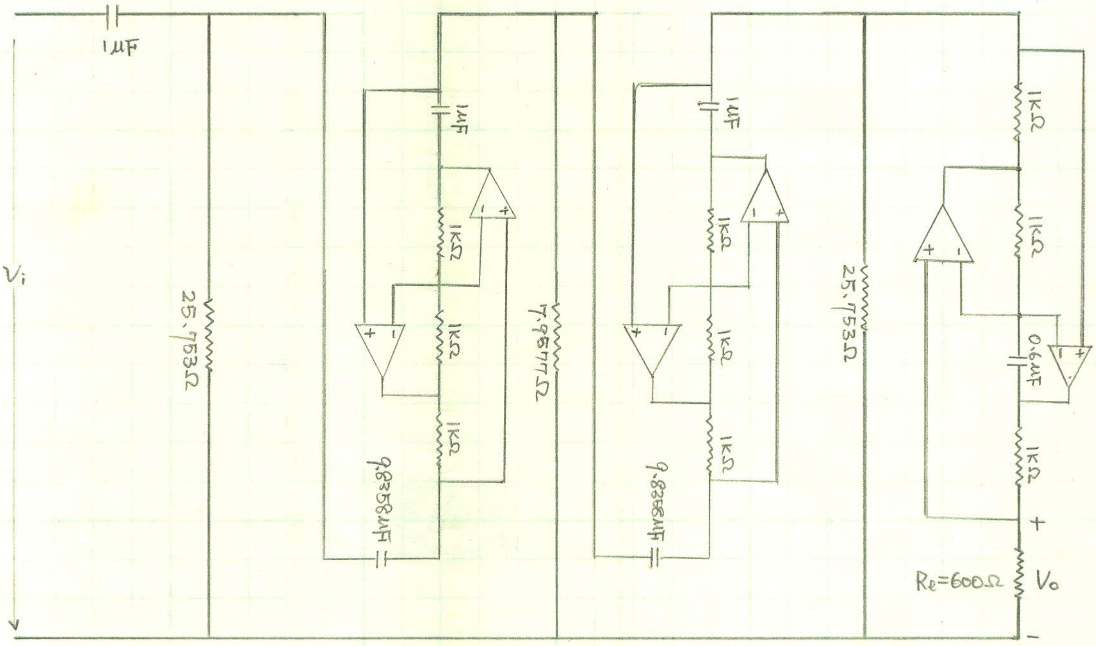
Using FDNR. with $R_2 = R_3 = R_4 = 1K\Omega$. $C_5 = 1\mu F$

FOR $AA = 9.8358\ pF^2 \longrightarrow C_1 = 9.8358\ nF$

And using the other FDNR with $R_2 = R_3 = R_5 = 1K\Omega$, $C_4 = 0.6\mu F$, $C' = 1\mu F \rightarrow R_6 = 600\Omega$


+
1μF
Vi
25.753Ω
GIC
R2=R3=R4=1kΩ
C5=1μF
9.8358μF
7.9577Ω
GIC
R2=R3=R4=1kΩ
C5=1μF
9.8358μF
25.753Ω
GIC
R2=1kΩ
R3=1kΩ
R5=1kΩ
C4=0.6μF
+
Vo
−
RL=600Ω
−

OR:


1μF
Vi
25.753Ω
1μF
1kΩ
1kΩ
1kΩ
9.8358μF
7.9577Ω
1μF
1kΩ
1kΩ
1kΩ
9.8358μF
25.753Ω
1kΩ
1kΩ
0.6μF
1kΩ
+
RL=600Ω
Vo
−

10/10

10-6. Realize the following filters with Kuh's configuration:

(c) A fourth-order bandpass Butterworth filter with center frequency $\omega_o = 8$ K rad/sec, bandwidth $B = 2$ K rad./sec., and a midband gain 1.

Solution: From chapter 8 in the text, we know a fourth-order bandpass can be obtained by transforming a normalized second-order low-pass. Look up TABLE A 8-1 from the text on page 301, we have the transfer function of normalized 2-nd order low-pass Butterworth filter:

$$H'(S) = \frac{1}{S^2 + 1.414213568 + 1}$$

Then, from TABLE 8-5, we have the bandpass transfer function.

$$H(S) = H'(S)\Big|_{S \Rightarrow \frac{S^2 + \omega_o^2}{BS}}$$

where, $\omega_o = 8000$ rad/sec. $B = 2000$ rad/s

$$H(S) = H'(S)\Big|_{S \Rightarrow \frac{S^2 + 64\times10^6}{4\times10^6 S}}$$

$$= \frac{1}{\left(\frac{S^2 + 64\times10^6}{2000S}\right)^2 + 1.41421356\cdot\left(\frac{S^2+64\times10^6}{2000S}\right) + 1}$$

$$= \frac{4\times10^6 S^2}{S^4 + 2828.427124 S^3 + 132\times10^6 S^2 + 1.8101933\times10^{11} S + 4096\times10^{12}}$$

Now, we are going to realize $H(S)$ by Kuh's configuration.

$B(S) = S^4 + 2828.427124 S^3 + 1.32\times10^8 S^2 + 1.8101933\times10^{11} S + 4096\times10^{12}$

LET $D(S) = (S+1000)(S+2000)(S+3000)$

THEN $y_{21} = -\frac{A(S)}{D(S)} = -\frac{4\times10^6 S^2}{D(S)}$

AND

$$y_{22} + Y_1 - \alpha Y_2 = \frac{B(S)}{D(S)} = \frac{S^4 + 2828.427124 S^3 + 1.32\times10^8 S^2 + 1.8101933\times10^{11} S + 4096\times10^{12}}{(S+1000)(S+2000)(S+3000)}$$

$$\frac{B(S)}{SD(S)} = \frac{S^4 + 2828.427124 S^3 + 1.32\times10^8 S^2 + 1.8101933\times10^{11} S + 4096\times10^{12}}{S^4 + 6000 S^3 + 11\times10^6 S^2 + 6\times10^9 S}$$

$$\frac{B(S)}{SD(S)} = 1-3171.57288 \times \frac{S^3-38151.41716S^2-55183764.21S-1.29147\times10^{12}}{S(S+1000)(S+2000)(S+3000)}$$

$$= 1+\frac{682665.2047}{S}-\frac{2022571.735}{S+1000}+\frac{2127662.575}{S+2000}-\frac{790927.6175}{S+3000}$$

SO, $y_{22}+Y_1-\alpha Y_2 = 682665.2047+S-\dfrac{2022571.735S}{S+1000}+\dfrac{2127662.575S}{S+2000}-\dfrac{790927.6175S}{S+3000}$

LET $y_{22} = 682665.2047+S+\dfrac{1000000S}{S+1000}+\dfrac{2127662.575S}{S+2000}+\dfrac{600000S}{S+3000}$

$$= \frac{S^4+3.91633\times10^6S^3+1.79176\times10^{10}S^2+2.00983\times10^{+13}S+4.09599\times10^{15}}{S^3+6000S^2+11\times10^6S+6\times10^9}$$

$$\begin{array}{r|l} & S \\ \hline S^3+6000S^2+11\times10^6S+6\times10^9 & S^4+3.91633\times10^6S^3+1.79176\times10^{10}S^2+2.00983\times10^{13}S+4.09599\times10^{15} \\ & S^3+6000S^3+11\times10^6S^2+6\times10^9S \\ \hline & 3.91033\times10^6S^3+1.79066\times10^{10}S^2+2.00923\times10^{13}S+4.09599\times10^{15} \end{array}$$

$$\begin{array}{r|l} & 2.55733\times10^{-7} \\ \hline 3.91033\times10^6S^3+1.79066\times10^{10}S^2+2.00923\times10^{13}S+4.09599\times10^{15} & S^3+6000S^2+11\times10^6S+6\times10^9 \\ & S^3+4579.31S^2+5.13826\times10^6S+1.04748\times10^9 \\ \hline & 1.42069\times10^3S^2+5.86174\times10^6S+4.95252\times10^9 \end{array}$$

$$\begin{array}{r|l} & 2.68203\times10^3S \\ \hline 1.42069\times10^3S^2+5.86174\times10^6S+4.95252\times10^9 & 3.91033\times10^6S^3+1.79066\times10^{10}S^2+2.00923\times10^{13}S+4.09599\times10^{15} \\ & 3.91033\times10^6S^3+1.57213\times10^{10}S^2+1.32828\times10^{13}S \\ \hline & 2.18525\times10^9S^2+6.80950\times10^{12}S+4.09599\times10^{15} \end{array}$$

SO THAT,

$$y_{22} = S+\cfrac{1}{2.55733\times10^{-7}+\cfrac{1}{2.68203\times10^3S+\cfrac{2.18525\times10^9S^2+6.80950\times10^{12}S+4.09599\times10^{15}}{1.42069\times10^3S^2+5.86174\times10^6S+4.95252\times10^9}}}$$

$$\begin{array}{r|l} & 8.27052\times10^5 \\ \hline 4.95252\times10^9+5.86174\times10^6S+1.42069\times10^3S^2 & 4.09599\times10^{15}+6.80950\times10^{12}S+2.18525\times10^9S^2 \\ & 4.09599\times10^5+4.84796\times10^{12}S+1.17498\times10^9S^2 \\ \hline & 1.96154\times10^{12}S+1.01027\times10^9S^2 \end{array}$$

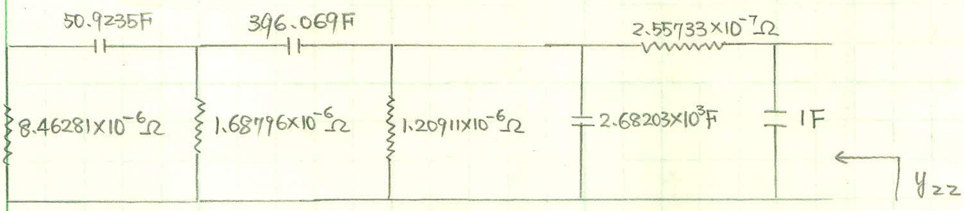
$$\begin{array}{r|l} & 2.52481\times10^{-3}/S \\ \hline 1.96154\times10^{12}S+1.01027\times10^9S^2 & 4.95252\times10^9+5.86174\times10^6S+1.42069\times10^3S^2 \\ & 4.95252\times10^9+2.55074\times10^6S \\ \hline & 3.31100\times10^6+1.42069\times10^3S \end{array}$$

$$\begin{array}{r|l} & 5.92432\times10^5 \\ \hline 3.31100\times10^6+1.42069\times10^3S & 1.96154\times10^{12}+1.01027\times10^9S \\ & 1.96154\times10^{12}+8.41662\times10^8S \\ \hline & 1.68608\times10^8S \end{array}$$

$$\begin{array}{r|l} & 1.96373\times10^{-2}/S \\ \hline 1.68608\times10^8S & 3.31100\times10^6+1.42069\times10^3S \\ & 3.31100\times10^6 \\ \hline & 1.42069\times10^3 \end{array}$$

$$\begin{array}{r|l} & 1.18164\times10^5 \\ \hline 1.42069\times10^3 & 1.68608\times10^8 \\ & 1.68608\times10^8 \\ \hline & 0 \end{array}$$

SO, WE HAVE THE CIRCUIT REALIZATION FOR y_{22}

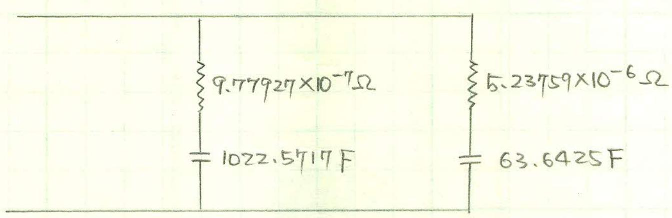


$$\alpha Y_2 - Y_1 = y_{22} - \frac{B(S)}{D(S)} = \frac{1022571.735\, S}{S + 1000} + \frac{190927.6175\, S}{S + 3000}$$

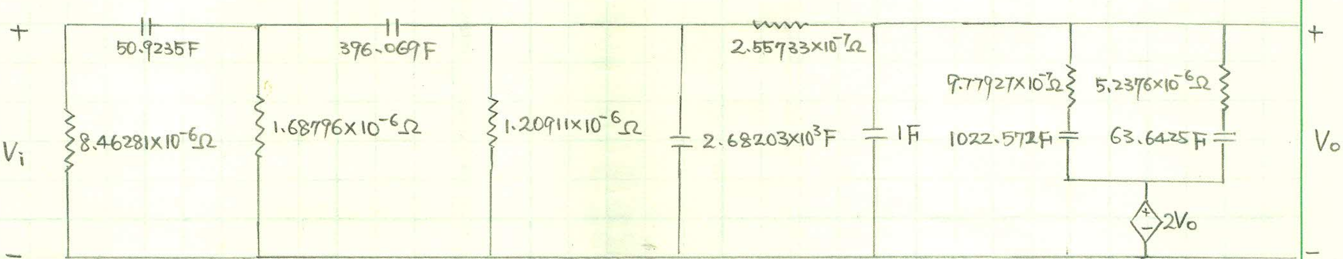
$$= \frac{1}{9.77927\times10^{-7} + 1/1022.5717355} + \frac{1}{5.23759\times10^{-6} + 1/63.6425\, S}$$

LET $Y_1 = 0$, $\alpha = 1$

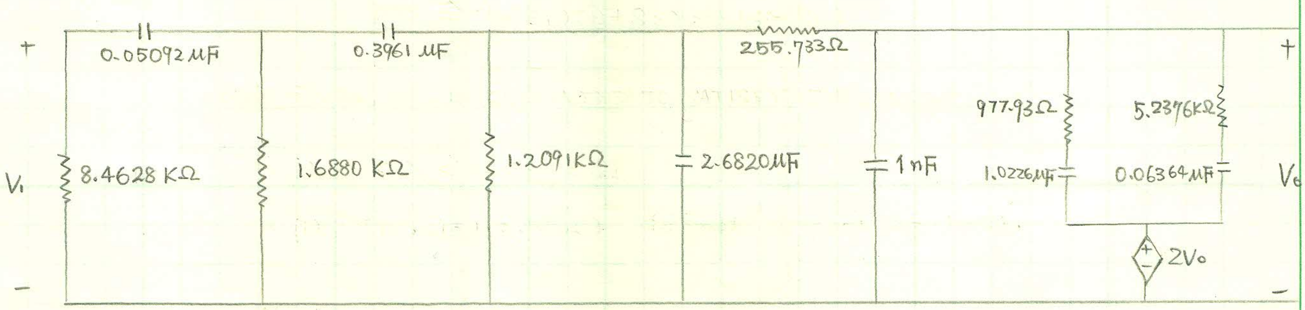
$$Y_2 = \frac{1}{9.77927\times10^{-7} + 1/1022.5717\, S} + \frac{1}{5.23759\times10^{-6} + 1/63.6425\, S}$$



SO, THE Kuh's configuration:



INPEDANCE SCALING BY 10^9, WE HAVE THE CIRCUIT REALIZATION:

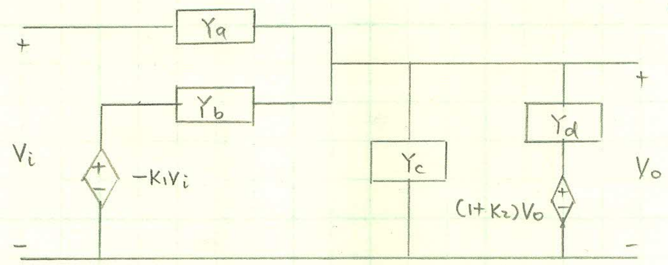


10-8. Realize the following transfer function by Yanagisawa's method:

$$H(s) = 1 / (\hat{s}+1)(\hat{s}^2+1) \quad \text{where } \hat{s}=s/1000$$

50/50

SOLUTION:



$$\frac{V_o}{V_i} = \frac{Y_a - k_1 Y_b}{Y_a + Y_b + Y_c - k_2 Y_d}$$

Now, the transfer function has a $\max(n_c, n_D) = 3$, so, we let $D(S) = (\hat{s}+1)(\hat{s}+2)$

$$H(S) = \frac{1}{(\hat{s}+1)(\hat{s}^2+1)} = \frac{\frac{1}{(\hat{s}+1)(\hat{s}+2)}}{\frac{(\hat{s}^2+1)}{\hat{s}+2}}$$

So, $\frac{A(S)}{D(S)} = \frac{1}{(s+1)(\hat{s}+2)}$; $\frac{B(S)}{D(S)} = \frac{\hat{s}^2+1}{\hat{s}+2}$

(i) $$\frac{A(S)}{\hat{s}D(S)} = \frac{1}{\hat{s}(\hat{s}+1)(\hat{s}+2)} = \frac{1/2}{\hat{s}} + \frac{1/2}{\hat{s}+2} - \frac{1}{\hat{s}+1}$$

$$\frac{A(S)}{D(S)} = \frac{1}{2} + \frac{1}{2+\frac{1}{\frac{1}{4}\hat{s}}} - \frac{1}{1+\frac{1}{\frac{1}{2}\hat{s}}}$$

(ii) $$\frac{B(S)}{\hat{s}D(S)} = \frac{(\hat{s}^2+1)}{\hat{s}(\hat{s}+2)} = \frac{\hat{s}^2+2\hat{s}-2\hat{s}+1}{\hat{s}^2+2\hat{s}} = 1 - \frac{2\hat{s}-1}{\hat{s}(\hat{s}+2)} = 1 + \frac{1/2}{\hat{s}} - \frac{5/2}{\hat{s}+2}$$

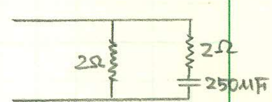
$$\frac{B(S)}{D(S)} = \hat{s} + \frac{1}{2} - \frac{1}{2/5 + \frac{1}{\frac{5}{4}\hat{s}}}$$

SO, WE HAVE $Y_{RC}^{(1)} = \frac{1}{2} + \frac{1}{2+\frac{1}{\frac{1}{4}\hat{s}}}$; $Y_{RC}^{(2)} = \frac{1}{1+\frac{1}{\frac{1}{2}\hat{s}}}$

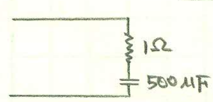
$Y_{RC}^{(3)} = \hat{s} + \frac{1}{2}$; $Y_{RC}^{(4)} = \frac{1}{2/5 + \frac{1}{\frac{5}{4}\hat{s}}}$

AND LET $k_1 = k_2 = 1$, WE HAVE ($\hat{s} = s/1000$)

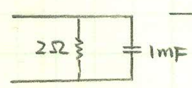
$$Y_a = Y_{RC}^{(1)} = \frac{1}{2} + \frac{1}{2+\frac{1}{\frac{1}{4}\hat{s}}} = \frac{1}{2} + \frac{1}{2+\frac{1}{\frac{1}{4000}s}} \Rightarrow$$



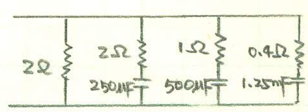
$$Y_b = Y_{RC}^{(2)} = \frac{1}{1+\frac{1}{\frac{1}{2}\hat{s}}} = \frac{1}{1+\frac{1}{\frac{1}{2000}s}} \Rightarrow$$



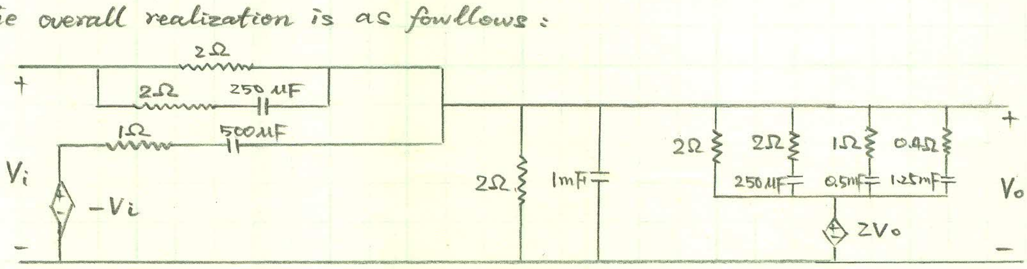
$$Y_c = Y_{RC}^{(3)} = \hat{s} + \frac{1}{2} = \frac{s}{1000} + \frac{1}{2} \Rightarrow$$



$$Y_d = Y_{RC}^{(1)} + Y_{RC}^{(2)} + Y_{RC}^{(4)} \Longrightarrow$$

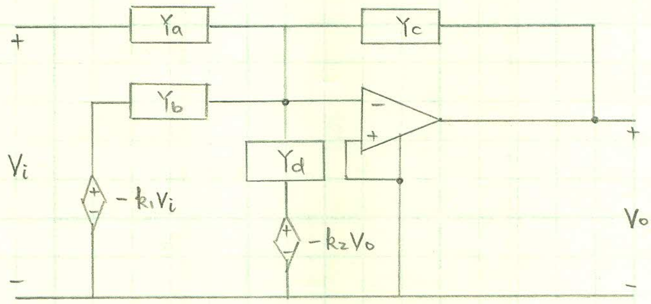


The overall realization is as fowllows:



10-9. Realize the following transfer function by Mathews-Seifert's METHOD: $H(s)=(s+1)^2/(s+2)(s^2+3)$

SOLUTION:



$$H(s)=\frac{V_o}{V_i}=\frac{k_1Y_b-Y_a}{Y_c-k_2Y_d}$$

LET $D(S)=(S+1)(S+2)$

$\therefore$ (i) $\frac{A(S)}{D(S)}=\frac{S+1}{S+2}$

$$\frac{A(S)}{SD(S)}=\frac{S+1}{S(S+2)}=\frac{1/2}{S}+\frac{1/2}{S+2}$$

$$\frac{A(S)}{D(S)}=\frac{1}{2}+\frac{1}{2+1/4S}=Y_a-k_1Y_b$$

(ii) $\frac{B(S)}{D(S)}=\frac{S^2+3}{S+1}$

$$\frac{B(S)}{SD(S)}=\frac{S^2+3}{S^2+S}=1+\frac{2}{S(S+1)}=1+\frac{2}{S}-\frac{2}{S+1}$$

$$\frac{B(S)}{D(S)}=S+2-\frac{1}{0.5+1/2S}=k_2Y_d-Y_c$$

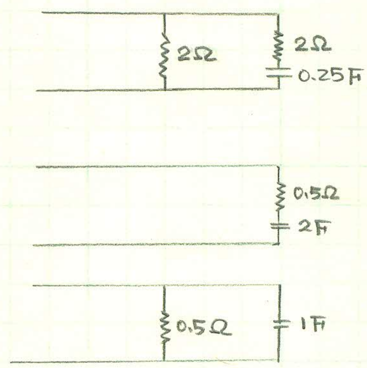
LET $k_1=0$, $k_2=1$; AND

$Y_a=\frac{1}{2}+\frac{1}{2+1/4S}$ $\Longrightarrow$

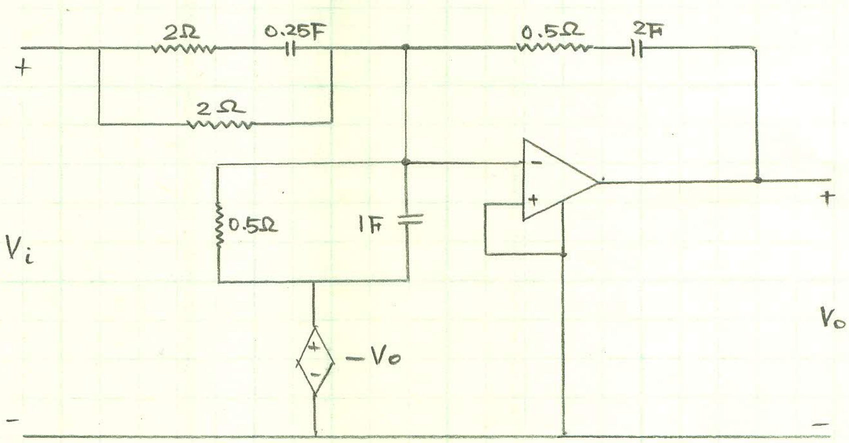
$Y_b=0$

$Y_c=\frac{1}{0.5+1/2S}$ $\Longrightarrow$

$Y_d=S+2$ $\Longrightarrow$



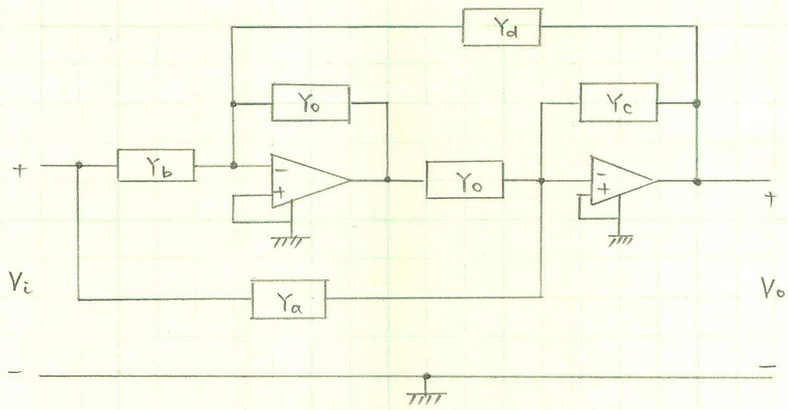
The following is the Mathews-Seifert's realization:



10-10. Realize the transfer function below by Lovering's method:

$$H(s) = (\hat{s}^2+1)/(\hat{s}+1)(\hat{s}^2+3\hat{s}+3) \quad \text{where } \hat{s}=s/4000$$

SOLUTION:



$$H(s) = \frac{V_o}{V_i} = \frac{Y_a - Y_b}{Y_d - Y_c}$$

LET $D(s) = (\hat{s}+1)(\hat{s}+2)$

(i) $$\frac{A(s)}{D(s)\cdot\hat{s}} = \frac{\hat{s}^2+1}{\hat{s}(\hat{s}+1)(\hat{s}+2)} = \frac{1/2}{\hat{s}} + \frac{5/2}{\hat{s}+2} - \frac{2}{\hat{s}+1}$$

$$\frac{A(s)}{D(s)} = \frac{1}{2} + \frac{1}{\frac{2}{5} + 1/\frac{5}{4}\hat{s}} - \frac{1}{\frac{1}{2} + 1/2\hat{s}} = Y_a - Y_b$$

(ii) $$\frac{B(s)}{\hat{s}\cdot D(s)} = \frac{\hat{s}^2+3\hat{s}+3}{\hat{s}^2+2\hat{s}} = 1 + \frac{\hat{s}+3}{\hat{s}(\hat{s}+2)} = 1 + \frac{3/2}{\hat{s}} - \frac{1/2}{\hat{s}+2}$$

$$\frac{B(s)}{D(s)} = \hat{s} + \frac{3}{2} - \frac{1}{2 + 1/\frac{1}{4}\hat{s}} = Y_d - Y_c$$

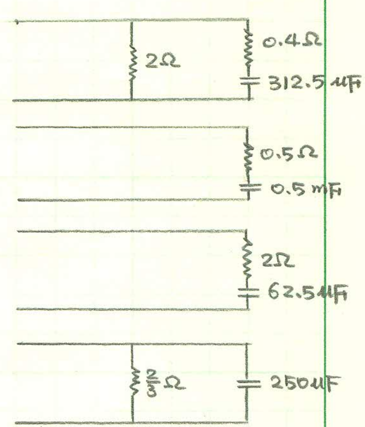
THEN, LET

$$Y_a = \frac{1}{2} + \frac{1}{\frac{2}{5} + 1/\frac{5}{4}\hat{s}} = \frac{1}{2} + \frac{1}{\frac{2}{5} + 1/\frac{5}{4000\times 4}s} \Rightarrow$$

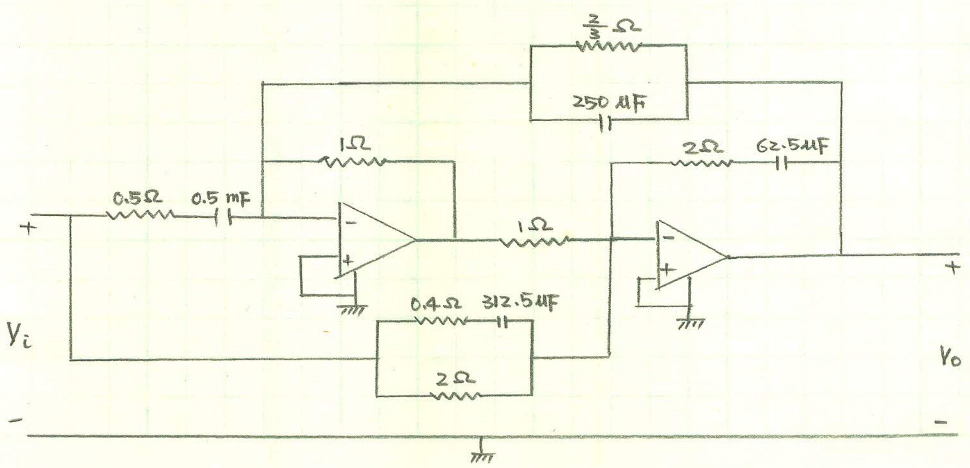
$$Y_b = \frac{1}{\frac{1}{2} + 1/2\hat{s}} = \frac{1}{0.5 + 1/\frac{1}{2000}s} \Rightarrow$$

$$Y_c = \frac{1}{2 + 1/\frac{1}{4}\hat{s}} = \frac{1}{2 + 1/\frac{1}{16000}s}$$

$$Y_d = \hat{s} + \frac{3}{2} = \frac{1}{4000}s + \frac{3}{2} \Rightarrow$$



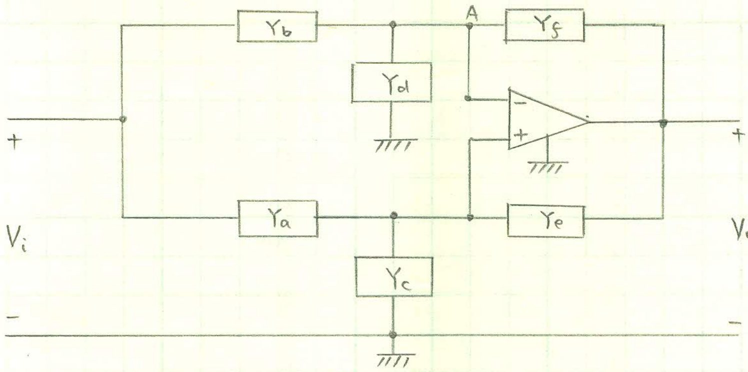
The overall realization is as follows: Choose $Y_o = 1\,℧$



10-11. Realize the following function by Mitra's method:

$$H(s)=(-s^3+2s^2-2s+4)/(s^3+2s^2+2s+4)$$

SOLUTION:



$$H(s)=\frac{Y_a(Y_b+Y_d+Y_f)-Y_b(Y_a+Y_c+Y_e)}{Y_f(Y_a+Y_c+Y_e)-Y_e(Y_b+Y_d+Y_f)}$$

$$H(S)=\frac{-S^3+2S^2-2S+4}{S^3+2S^2+2S+4}=\frac{-(S-2)(S^2+2)}{(S+2)(S^2+2)}=\frac{-S+2}{S+2}$$

LET $D(S)=1$

(i) $\frac{A(S)}{S\,D(S)}=\frac{-S+2}{S}=-1+\frac{2}{S}$

$\frac{A(S)}{D(S)}=2-S$

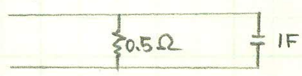
(ii) $\frac{B(S)}{S\,D(S)}=\frac{S+2}{S}=1+\frac{2}{S}$

$\frac{B(S)}{D(S)}=S+2$

LET $Y_b=Y_{RC}^{(1)}=2 \Longrightarrow$

$Y_a=Y_{RC}^{(2)}=S$

$Y_f=0$; $Y_e=Y_{RC}^{(3)}=S+2 \Longrightarrow$

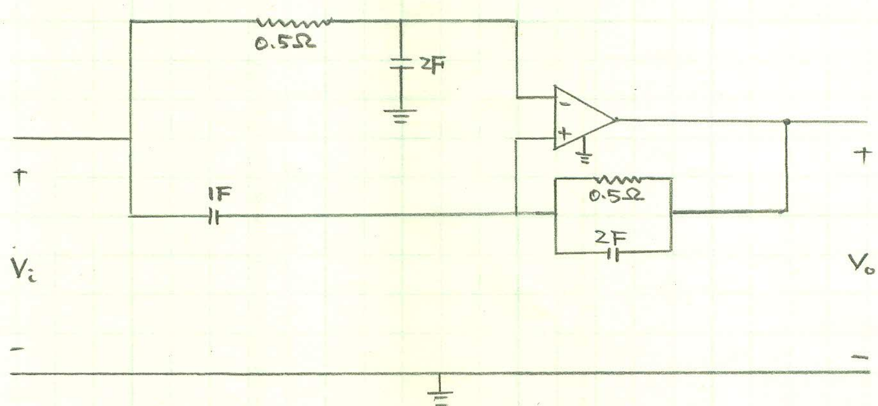


SO, $Y_c-Y_d=Y_f+Y_b-Y_e-Y_a$

$=2-S-2-S=-2S.$

$Y_c=0$; $Y_d=2S \Longrightarrow$

The following is the Mitra's realization:



10-13. Realize the following transfer function via the state-variable technique: $H(s)= 2\hat{s}^2/(\hat{s}+2)(\hat{s}^2+1)$ where $\hat{s}=s/10000$.

SOLUTION:

$$H(s) = \frac{2\hat{s}^2}{(\hat{s}+2)(\hat{s}^2+1)}$$

$$= \frac{2\hat{s}^2}{\hat{s}^3+2\hat{s}^2+\hat{s}+2}$$

$$= \frac{2(S/10000)^2}{(S/10000)^3+2(S/10000)^2+(S/10000)+2}$$

$$= \frac{2\times10^4\, S^2}{S^3+2\times10^4 S^2+10^8 s+2\times10^{12}} \quad \cdots\cdots (1)$$

From the equation (71) on page 105 in notes, we have the state-variable realization given as

$$H(S) = \frac{G_0(RC)^{-1}\, S^2}{S^3+\frac{G_1}{RC}S^2+\frac{G_2}{(RC)^2}s+\frac{G_3}{(RC)^3}} = \frac{V_1}{V_3} \cdots\cdots (2)$$

Compare the equations (1) and (2) above, we have

(i) $G_0 = 2\times10^4\, RC$
(ii) $G_1 = 2\times10^4\, RC$
(iii) $G_2 = 10^8\,(RC)^2$
(iv) $G_3 = 2\times10^{12}\,(RC)^3$

We let all the G's within the range of $10^{-6} < G < 10^{-1}$ ∴

Range of RC:

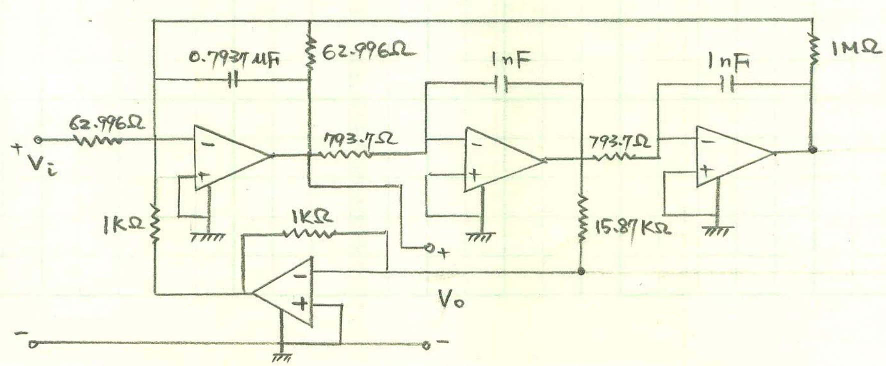
(i)	5×10^{-11}	to	5×10^{-6}
(ii)	5×10^{-11}	to	5×10^{-6}
(iii)	1×10^{-7}	to	3.1623×10^{-5}
(iv)	7.937×10^{-7}	to	3.684×10^{-5}

SO, LET $RC = 7.937\times10^{-7}$; $C = 1nF$ and $R = 793.7\Omega$

$G_0 = 1.5874\times10^{-2} \Rightarrow R_0 = 62.996\ \Omega$; $G_1 = 1.5874\times10^{-2} \Rightarrow R_1 = 62.996\ \Omega$

$G_2 = 6.2996\times10^{-5} \Rightarrow R_3 = 15.874\ k\Omega$; $G_3 = 10^{-6} \Rightarrow R_3 = 1M\Omega$

The state-variable realization is as follows:



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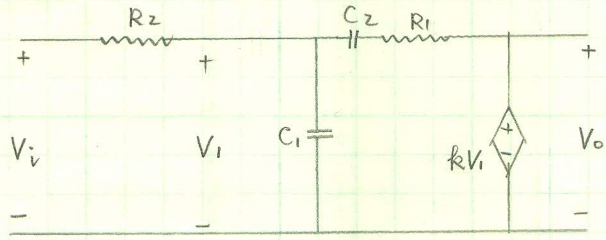
10-14. Realize the following second-order transfer functions via Table 10-1

50/50

(l) $H(S) = \dfrac{\hat{S}^2 + 1}{\hat{S}^2 + 0.1\hat{S} + 1}$ where $\hat{S} = S/10^4$

According to the Table 10-1, A4 (b)



And the equations

$R_1C_1R_2C_2 = 1$ ... (1)

$R_2C_2 = 1/a = 1$ ... (2)

$R_1C_1 + R_2C_2 + R_1C_2(1-k) = 0.1$ ... (3)

$kR_2C_2 = G_1 = 1$ ... (4)

$R_1C_1 = 1$

$R_2C_2 = 1$

$R_1C_2(1-k) = -1.9$

$G_1 = kR_2C_2$

LET $R_1 = R_2 = 1\,\Omega$; $C_1 = C_2 = 1\,F$.

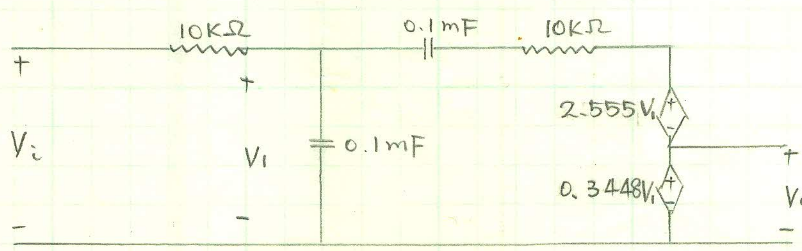
$K = 2.9$ $\therefore G_1 = 2.9$; $\beta = 0.34483$

$$H(s) = 0.34483 \cdot \frac{2.9(\hat{S}^2 + 1)}{\hat{S}^2 + 0.1\hat{S} + 1} = \beta H_1(s)$$

SCALING FREQUENCY BY 10^4

$R_1 = R_2 = 10\,K\Omega$; $C_1 = C_2 = 0.1\,mF$

THE FOLLOWING IS THE CIRCUIT REALIZATION:



10.-19. Realize the following transfer functions by Friend's circuit configuration of Fig. 10-26:

$$(b)\qquad H(S) = \frac{S^2 - 100S + 10^6}{S^2 + 100S + 10^6}$$

$$= \frac{\left(\frac{S}{1000}\right)^2 - 0.1\times\left(\frac{S}{1000}\right) + 1}{\left(\frac{S}{1000}\right)^2 + 0.1\times\left(\frac{S}{1000}\right) + 1}$$

$$\triangleq \frac{\hat{S}^2 - 0.1\hat{S} + 1}{\hat{S}^2 + 0.1\hat{S} + 1} \qquad \text{WHERE } \hat{S} = S/10^3$$

WITH $a_2 = 1$, $a_1 = -0.1$, $a_0 = 1$, $b_1 = 0.1$ $b_0 = 1$

$$G_1 = \frac{C_2 G_a}{2G_b}\left[-0.1 + \sqrt{0.01 + 4\left(1 + \frac{C_1}{C_2}\right)\frac{G_b}{G_a}}\,\right]$$

$$G_4 = \frac{G_1 G_a}{G_a + G_b}\left[1 + \left(1 + \frac{C_1}{C_2}\right)\cdot\frac{C_2^2}{G_1^2} + \frac{0.1 C_2}{G_1}\right]$$

CHOOSE $C_1 = C_2 = 1\,F$, $G_a = G_b = 1$ mho.

WE HAVE $G_1 = 0.95125$ $\quad G_4 = 1.576877$

LET $\beta = G_1/G_4 = 0.6$

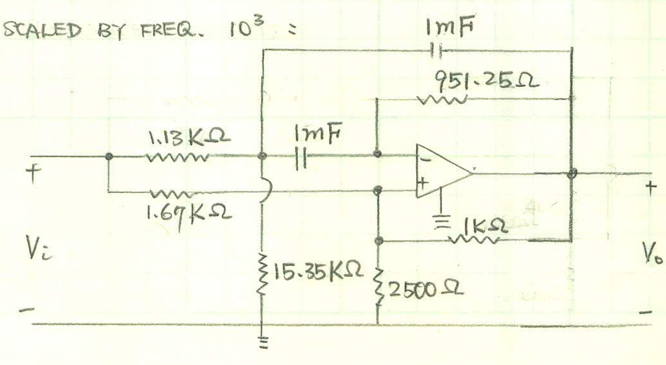
$$\therefore\quad \beta H(S) = \frac{0.6\hat{S}^2 - 0.06\hat{S} + 0.6}{\hat{S}^2 + 0.1\hat{S} + 1}$$

LET $C_1 = C_2 = 1F$, $G_a = G_b = 1\,\mho$, $\alpha = 0$

WE HAVE

$$\begin{cases} G_1 = 0.95125 = \dfrac{1}{1.05125} \\ G_4 = 0.88612 = 1/1.12852 \\ G_3 = 0 \\ G_2 = 1.05125 = 1/0.95125 \\ G_5 = 0.06513 = 1/15.3589 \\ G_6 = G_7 = 0 \\ G_c = 0.6 = 1/1.666667 \\ G_d = 0.4 = 1/2.5 \end{cases}$$

SCALED BY FREQ. 10^3 :



$$H(S) = \frac{0.6\,(S^2 - 100S + 10^6)}{S^2 + 100S + 10^6}$$

10-20 . (a) Realize the transfer function by Friend's circuit configuration.

$$H(s) = \frac{s^2 + 10^4}{s^2 + 100s + 10^6}$$

SOLUTION:

$$H(s) = \frac{(s/1000)^2 + 0.01}{(s/1000)^2 + 0.1(s/1000) + 1} \triangleq \frac{\hat{s}^2 + 0.01}{\hat{s}^2 + 0.1\hat{s} + 1} \quad ; \hat{s} = s/10^3$$

$a_2 = 1$, $a_1 = 0$, $a_0 = 0.01$, $b_1 = 0.1$, $b_0 = 1$

LET $C_1 = C_2 = 1F$; $G_a = G_b = 1℧$ $\alpha = 1$, $\beta = 0.9$

$G_1 = 0.95125 = 1/1.05125$ $G_4 = 0.43662 = 1/2.29032$

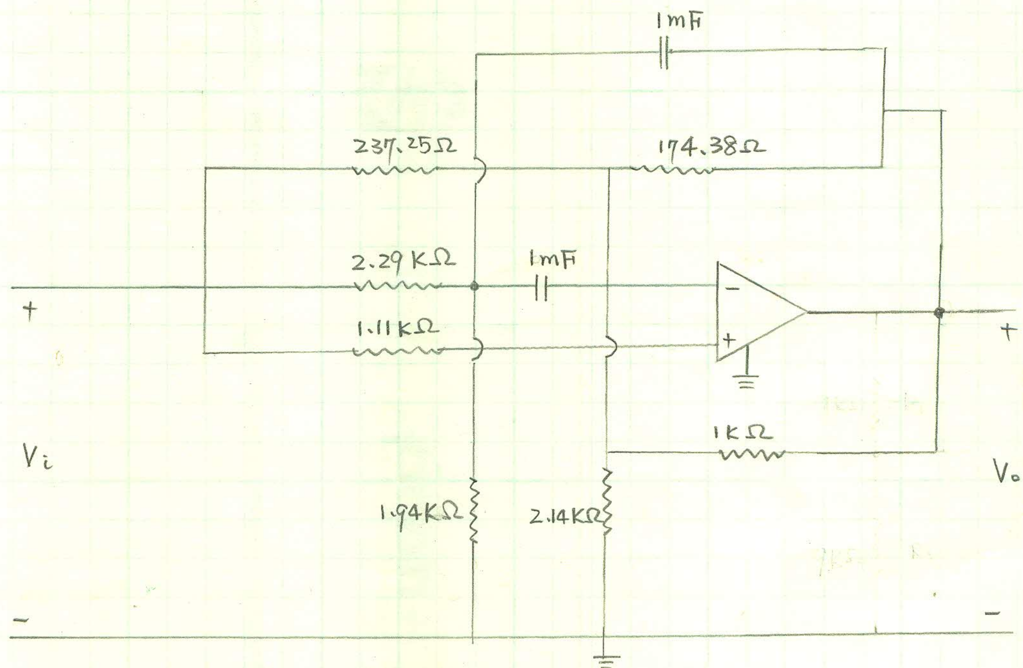
$G_3 = 4.68332 = 1/0.21352$ $G_2 = 5.73457 = 1/0.17438$

$G_5 = 0.51463 = 1/1.94315$ $G_6 = 4.21499 = 1/0.23725$

$G_7 = 0.46833 = 1/2.13524$ $G_e = 0.9 = 1/1.11111$

$G_d = 0.1 = 1/10$

THE FOLLOWING IS THE FRIEND'S CIRCUIT CONFIGURATION: (SCALED FREQ. BY 10^3)



$$H(s) = 0.9\,\frac{s^2 + 10^4}{s^2 + 100s + 10^6}$$

10-21. *Realize the following transfer functions via the multiple amplifier biquads of Fig. 10-29.*

(b) $$H(S) = \frac{1}{\hat{S}^2 + \sqrt{2}\,\hat{S} + 1}, \quad \text{WHERE} \quad \hat{S} = S/10^4$$

FROM EQ. (10-133a) IN TEXT,

$$\frac{V_3}{V_i} = \frac{R_2(R+R_3)}{R_3(R_1+R_2)} \cdot \frac{1}{C_1C_2R_8R_9S^2 + \frac{R_1(R+R_3)}{(R_1+R_2)R_3}R_9C_2S + \frac{R}{R_3}}$$

LET $C_1 = C_2 = 1\,F$ $R_1 = R_2 = R_3 = 1\Omega$

$\therefore$ $R = R_3 = 1\Omega$ and

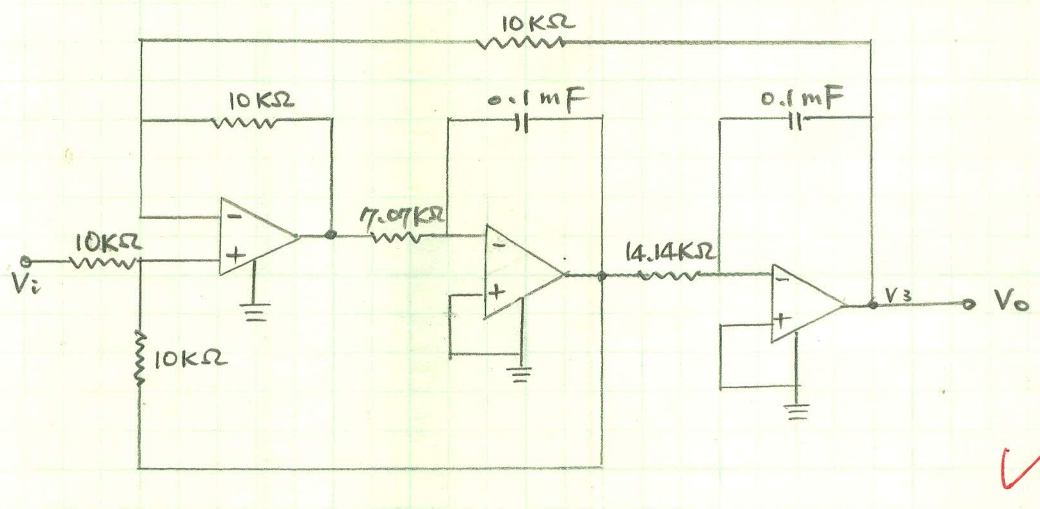
$$\frac{2}{2} \cdot R_9 \cdot 1 = \sqrt{2} \Rightarrow R_9 = \sqrt{2}\,\Omega$$

$R_8 = \sqrt{2}/2\ \Omega$ and $k = 1$

FREQ. SCALING BY 10^4, WE HAVE

$C_1 = C_2 = 0.1\ mF$, $R_1 = R_2 = R_3 = R = 10K\Omega$, $R_8 = 7.07K\Omega$ $R_9 = 14.14K\Omega$

THEN CIRCUIT GIVEN BELOW:



(j) $$H(S) = \frac{S^2 + \sqrt{2}S + 1}{S^2 + 3S + 3}$$

Solution: $a_1 = \sqrt{2}$, $a_0 = 1$; $b_1 = 3$, $b_0 = 3$

$$\frac{R_6(R_4+R_5)}{C_1R_8R_5(R_6+R_7)} = a_1 = \sqrt{2}$$

$$\frac{R_4}{C_1R_8C_2R_9R_5} = a_0 = 1$$

$$\frac{R_1(R+R_3)}{C_1R_8R_3(R_1+R_2)} = b_1 = 3$$

$$\frac{R}{C_1R_8C_2R_9R_3} = b_0 = 3$$

$$k = \frac{R_2R_5(R+R_3)(R_6+R_7)}{R_3R_7(R_1+R_2)(R_4+R_5)} = 1$$

LET $R_1=R_2=R_3=R_4=R_5=1\Omega$; $C_1=C_2=1F$

$$\therefore \left\{ \begin{aligned} & 2\frac{R_6}{R_8(R_6+R_7)} = \sqrt{2} \\ & \frac{1}{R_8R_9} = 1 \\ & \frac{R+1}{2R_8} = 3 \\ & \frac{(R+1)(R_6+R_7)}{4R_7} = 1 \end{aligned} \right. \quad \text{and} \quad \frac{R}{R_8R_9} = 3$$

$\therefore$ $R = 3\Omega$; $R_8 = 0.667\Omega$; $R_9 = 1.5\Omega$; $R_6 = 0$, $R_7 = 2.121\Omega$