P.P.19.11

$$\mathbf{I}_1 = \frac{\mathbf{V}_1 - 0}{R_1} \longrightarrow \mathbf{V}_1 = \mathbf{I}_1 R_1$$

Also, $$\mathbf{I}_1 = \frac{0 - \mathbf{V}_2}{R_2} \longrightarrow \mathbf{V}_2 = \text{-}\mathbf{I}_1 R_2$$

Comparing these with

$$\mathbf{V}_1 = \mathbf{z}_{11}\,\mathbf{I}_1 + \mathbf{z}_{12}\,\mathbf{I}_2$$
$$\mathbf{V}_2 = \mathbf{z}_{21}\,\mathbf{I}_1 + \mathbf{z}_{22}\,\mathbf{I}_2$$

shows that

$$\mathbf{z}_{11} = R_1, \qquad \mathbf{z}_{21} = \text{-}R_2, \qquad \mathbf{z}_{12} = \mathbf{z}_{21} = 0$$

Hence,

$$[\mathbf{z}] = \begin{bmatrix} \mathbf{R_1} & \mathbf{0} \\ \mathbf{\text{-}R_2} & \mathbf{0} \end{bmatrix}$$

Since $\Delta_z = \mathbf{z}_{11}\,\mathbf{z}_{22} - \mathbf{z}_{12}\,\mathbf{z}_{21} = 0$, $\mathbf{[z]^{-1}}$ **does not exist**. Consequently, **[y] does not exist**.

P.P.19.12 This is a series connection of two two-ports.

For N_a, $\mathbf{z}_{12a} = \mathbf{z}_{21a} = 20$, $\mathbf{z}_{11a} = 20 - j15$, $\mathbf{z}_{22a} = 20 + j10$

For N_b, $\mathbf{z}_{12b} = \mathbf{z}_{21b} = 50$, $\mathbf{z}_{11b} = 50 + j40$, $\mathbf{z}_{22b} = 50 - j20$

Thus, $$[\mathbf{z}] = [\mathbf{z}_a] + [\mathbf{z}_b]$$

$$[\mathbf{z}] = \begin{bmatrix} 20 - j15 & 20 \\ 20 & 20 + j10 \end{bmatrix} + \begin{bmatrix} 50 + j40 & 50 \\ 50 & 50 - j20 \end{bmatrix}$$

$$[\mathbf{z}] = \begin{bmatrix} 70 + j25 & 70 \\ 70 & 70 - j10 \end{bmatrix}$$

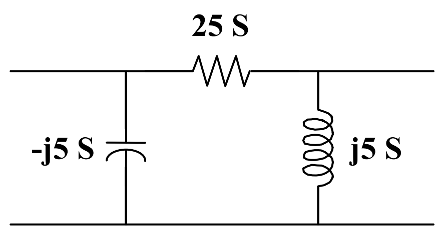
$$\frac{\mathbf{V}_2}{\mathbf{V}_s} = \frac{\mathbf{z}_{12}\,\mathbf{Z}_L}{(\mathbf{z}_{11} + \mathbf{Z}_s)(\mathbf{z}_{22} + \mathbf{Z}_L) - \mathbf{z}_{12}\,\mathbf{z}_{21}}$$

$$\frac{\mathbf{V}_2}{\mathbf{V}_s} = \frac{(70)(40)}{(70 + j25 + 5)(70 - j10 + 40) - 4900}$$

$$\frac{\mathbf{V}_2}{\mathbf{V}_s} = \frac{2800}{8250 - j750 + j2750 + 250 - 4900}$$

$$\frac{\mathbf{V}_2}{\mathbf{V}_s} = \frac{2800}{3600 + j2000} = \mathbf{0.6799\angle\text{-}29.05^\circ}$$

P.P.19.13 We convert the upper T network N_a to a Π network, as shown below.



$$\mathbf{y}_a = \frac{\mathbf{y}_1\mathbf{y}_2 + \mathbf{y}_2\mathbf{y}_3 + \mathbf{y}_3\mathbf{y}_1}{\mathbf{y}_2} = \frac{(\text{-j5})(\text{j5}) + (\text{j5})(1) + (1)(\text{-j5})}{\text{j5}} = \text{-j5}$$

$$\mathbf{y}_b = 5, \qquad \mathbf{y}_c = 25$$

For N_a,

$$\mathbf{y}_{12a} = \text{-}25 = \mathbf{y}_{21a}, \qquad \mathbf{y}_{11a} = 25 - \text{j5}, \qquad \mathbf{y}_{22a} = 25 + \text{j5}$$

$$[\mathbf{y}_a] = \begin{bmatrix} 25 - \text{j5} & \text{-}25 \\ \text{-}25 & 25 + \text{j5} \end{bmatrix}$$

For N_b,

$$\mathbf{y}_{12b} = \text{j10} = \mathbf{y}_{21b}, \qquad \mathbf{y}_{11b} = 2 - \text{j10} = \mathbf{y}_{22b}$$

$$[\mathbf{y}_b] = \begin{bmatrix} 2 - \text{j10} & \text{j10} \\ \text{j10} & 2 - \text{j10} \end{bmatrix}$$

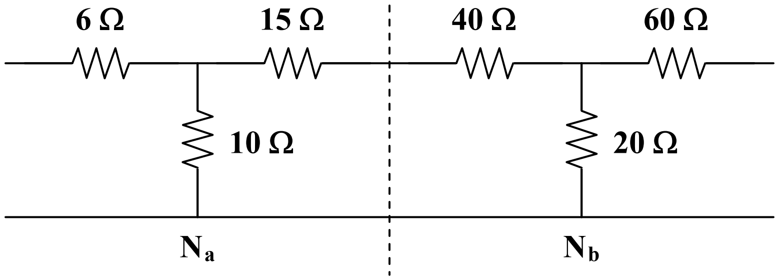
Since N_a and N_b are in parallel, $[\mathbf{y}] = [\mathbf{y}_a] + [\mathbf{y}_b]$

$$[\mathbf{y}] = \begin{bmatrix} \mathbf{27 - j15} & \mathbf{-25 + j10} \\ \mathbf{-25 + j10} & \mathbf{27 - j5} \end{bmatrix} \mathbf{S}$$

P.P.19.14 Convert the left Π network to a T network.

$$R_1 = \frac{(20)(30)}{20 + 30 + 50} = 6, \qquad R_2 = \frac{(20)(50)}{100} = 10, \qquad R_3 = \frac{(30)(50)}{100} = 15$$

Putting this network into the given network produces the network shown below. This may be regarded as a cascaded connection of T two-port networks.



For N_a ,

$$\mathbf{A}_a = 1 + \frac{6}{10} = 1.6, \qquad \mathbf{B}_a = 15 + \left(\frac{6}{10}\right)(25) = 30$$

$$\mathbf{C}_a = \frac{1}{10} = 0.1 , \qquad \mathbf{D}_a = 1 + \frac{15}{10} = 2.5$$

$$[\mathbf{T}_a] = \begin{bmatrix} 1.6 & 30 \\ 0.1 & 2.5 \end{bmatrix}$$

For N_b ,

$$\mathbf{A}_b = 1 + \frac{40}{20} = 3, \qquad \mathbf{B}_b = 60 + \left(\frac{40}{20}\right)(80) = 220$$

$$\mathbf{C}_b = \frac{1}{20} = 0.05, \qquad \mathbf{D}_b = 1 + \frac{60}{20} = 4$$

$$[\mathbf{T}_b] = \begin{bmatrix} 3 & 220 \\ 0.05 & 4 \end{bmatrix}$$

Hence,

$$[\mathbf{T}] = [\mathbf{T}_a][\mathbf{T}_b] = \begin{bmatrix} 1.6 & 30 \\ 0.1 & 2.5 \end{bmatrix}\begin{bmatrix} 3 & 220 \\ 0.05 & 4 \end{bmatrix}$$

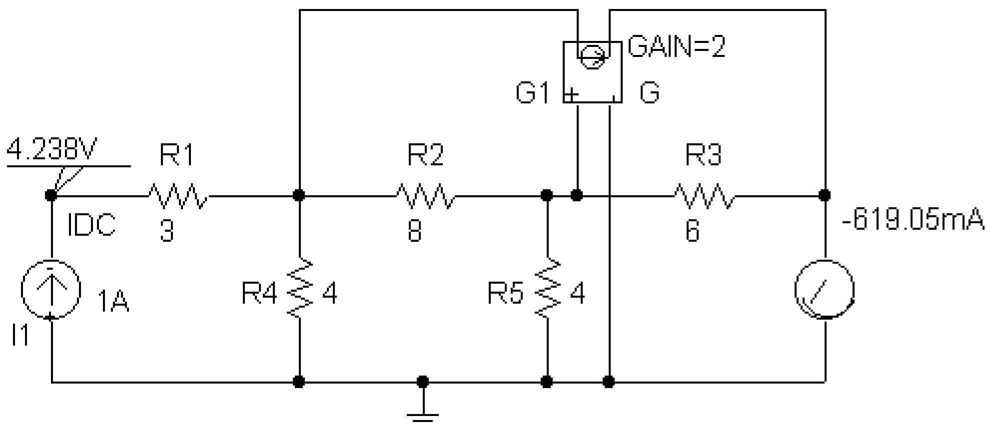
We can now use MATLAB to obtain T.

```
>> Ta=[1.6,30;0.1,2.5]
Ta =
   1.6000   30.0000
   0.1000    2.5000
>> Tb=[3,220;0.05,4]
Tb =
   3.0000  220.0000
```

0.0500   4.0000
>> T=Ta*Tb
T =
6.3000 472.0000
0.4250   32.0000

$$[\mathbf{T}] = \begin{bmatrix} \mathbf{6.3} & \mathbf{472\ \Omega} \\ \mathbf{0.425\ S} & \mathbf{32} \end{bmatrix}$$

P.P.19.15 To obtain $\mathbf{h}_{11}$ and $\mathbf{h}_{21}$, simulate the schematic in Fig. (a) using PSpice.



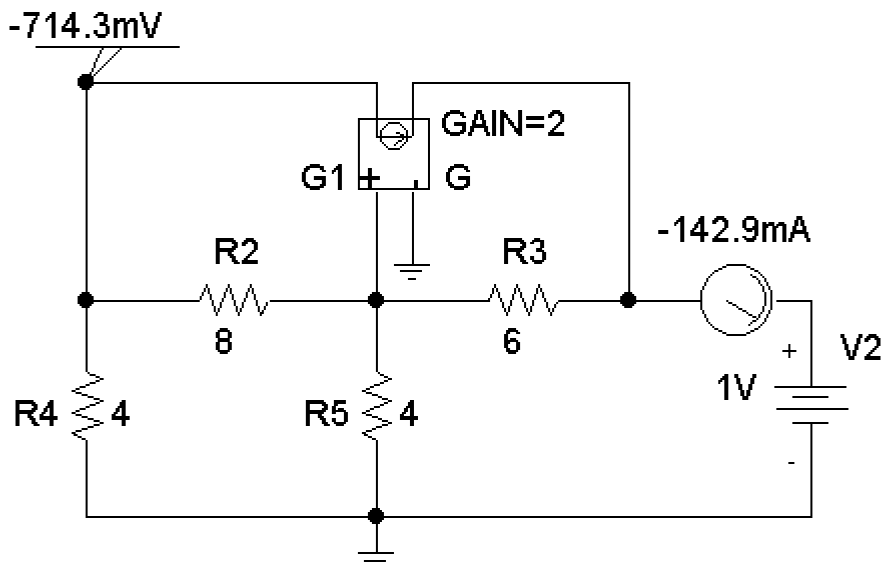
(a)

Insert a 1-A dc current source to account for $\mathbf{I}_1 = 1\ \text{A}$. Also, include pseudocomponents VIEWPOINT and IPROBE to display $\mathbf{V}_1$ and $\mathbf{I}_2$ respectively. When the circuit is saved and run, the values of $\mathbf{V}_1$ and $\mathbf{I}_2$ are displayed on the pseudocomponents as shown in Fig. (a). Thus,

$$\mathbf{h}_{11} = \frac{\mathbf{V}_1}{1} = 4.238\ \Omega, \qquad \mathbf{h}_{21} = \frac{\mathbf{I}_2}{1} = \text{-0.6190}$$

To obtain $\mathbf{h}_{12}$ and $\mathbf{h}_{22}$, insert a 1-V dc voltage source at the output port to account for $\mathbf{V}_2 = 1\ \text{V}$. The pseudocomponents VIEWPOINT and IPROBE are included to display $\mathbf{V}_1$ and $\mathbf{I}_2$ respectively. After simulation, the schematic displays the results as shown in Fig. (b).

$$\mathbf{h}_{12} = \frac{\mathbf{V}_1}{1} = \text{-0.7143}, \qquad \mathbf{h}_{22} = \frac{\mathbf{I}_2}{1} = \text{-0.1429 S}$$

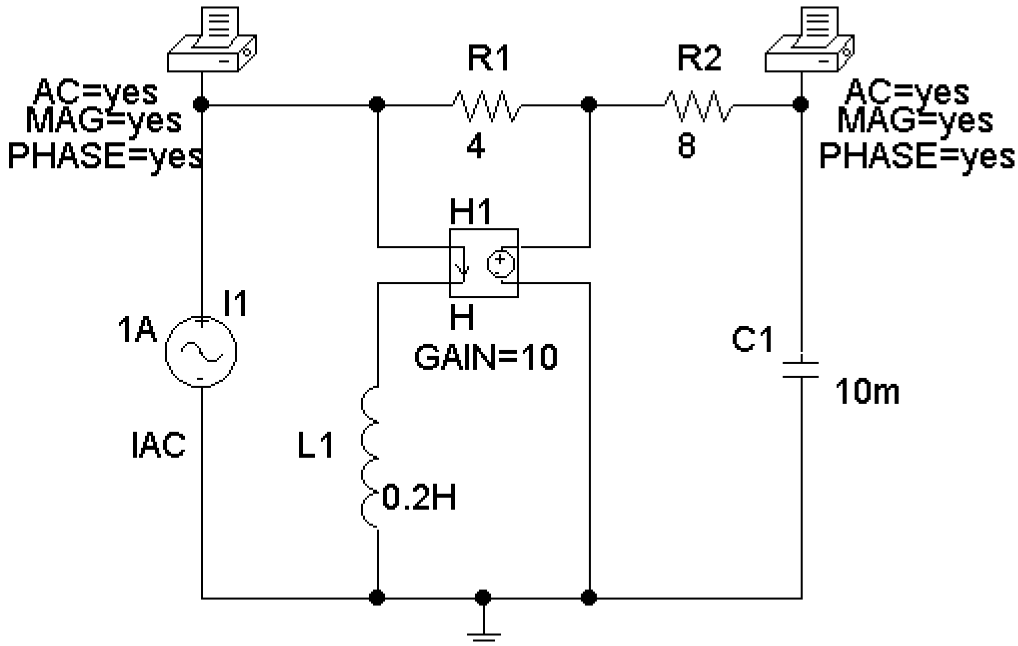


(b)

Thus,

$$[\mathbf{h}] = \begin{bmatrix} \mathbf{4.238\,\Omega} & \mathbf{-0.7143} \\ \mathbf{-0.6190} & \mathbf{-0.1429\,S} \end{bmatrix}$$

P.P.19.16 Insert a 1-A ac current source at the output terminals to account for $\mathbf{I}_1 = 1\text{ A}$. Include two VPRINT1 pseudocomponents to output $\mathbf{V}_1$ and $\mathbf{V}_2$. For each VPRINT1, set the attributes to AC = yes, PHASE = yes, and MAG = yes. In the AC Sweep and Noise Analysis dialog box, set Total pt : 1, Start Freq : 60, and End Freq : 60. The schematic is shown in Fig. (a).



(a)

Once the schematic is saved and run, the output results include :

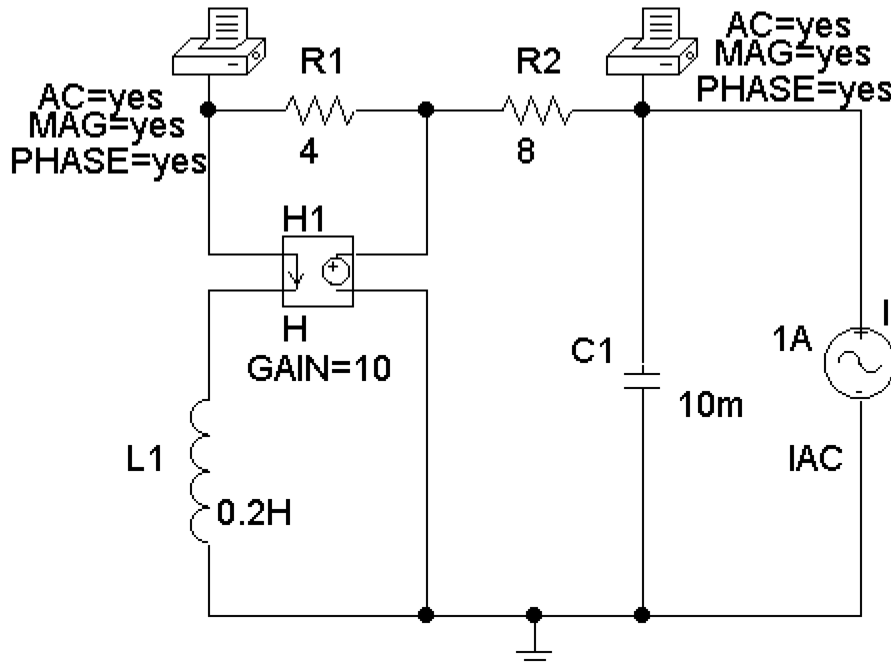
FREQ	VM($N_0002)	VP($N_0002)
6.000E+01	3.987E+00	1.755E+02

FREQ	VM($N_0003)	VP($N_0003)
6.000E+01	1.752E-02	-2.651E+00

From this table,

$$\mathbf{z}_{11} = \frac{\mathbf{V}_1}{1} = 3.987\angle 175.5°, \qquad \mathbf{z}_{21} = 0.0175\angle -2.65°$$

Similarly, insert a 1-A ac source at the output port with the two pseudocomponents in place as in Fig. (a). The result is the schematic in Fig. (b).



(b)

When the schematic is saved and run, the output results include :

FREQ	VM($N_0002)	VP($N_0002)
6.000E+01	1.000E-30	0.000E+00

FREQ	VM($N_0003)	VP($N_0003)
6.000E+01	2.651E-01	9.190E+01

From this table,

$$\mathbf{z}_{12} = \frac{\mathbf{V}_1}{1} \cong 0 \qquad \mathbf{z}_{22} = 0.265\angle 91.9°$$

Thus,

$$[\mathbf{z}] = \begin{bmatrix} \mathbf{3.987\angle 175.5°} & \mathbf{0} \\ \mathbf{0.0175\angle -2.65°} & \mathbf{0.2651\angle 91.9°} \end{bmatrix} \Omega$$

P.P.19.17 In this case, $R_s = 150\ k\Omega$, $R_L = 3.75\ k\Omega$.

$$h_{ie} h_{oe} - h_{re} h_{fe} = (6\times10^3)(8\times10^{-6}) - (1.5\times10^{-4})(200) = 18\times10^{-3}$$

The gain for the transistor is given as,

$$A_V = \frac{-(200)(3750)}{6000 + (18\times10^{-3})(3.75\times10^3)} = V_o/V_b = \mathbf{-123.61}$$

To calculate the gain of the circuit we need to use,

$-V_s + 150kI_b + V_b = 0$ or $0.002 = 150k(0.002/156k) - V_c/123.61$

$V_c = -9.506$ mV which leads to the gain = –9.506/2 = **–4.753**

$$A_i = \frac{200}{1 + (8\times10^{-6})(3.75\times10^3)} = \mathbf{194.17}$$

The input resistance for the transistor is equal to h_{ie} = **6 kΩ**.

The input resistance for the circuit is equal to,

$$Z_{in} = 150{,}000 + 6000 - (1.5\times10^{-4})(194.17) \cong \mathbf{156\ k\Omega}$$

$$Z_{out} = \frac{150\times10^3 + 6\times10^3}{(150\times10^3)(8\times10^{-6}) - (1.5\times10^{-4})(200)}$$

$$= \frac{156}{1.248 - 0.03}\ k\Omega = \mathbf{128.08\ k\Omega}$$

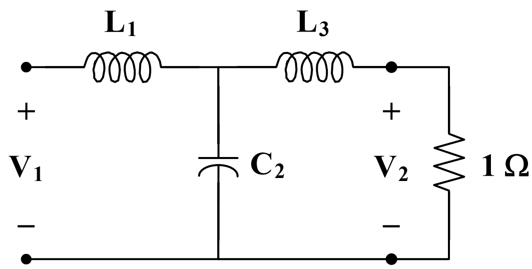
P.P.19.18 Let $\mathbf{D}(s) = (s^3 + 4s) + (s^2 + 2)$

Dividing both numerator and denominator by $s^3 + 4s$ gives

$$\mathbf{H}(s) = \frac{\dfrac{2}{s^3 + 4s}}{1 + \dfrac{s^2 + 2}{s^3 + 4s}}$$

i.e. $\mathbf{y}_{21} = \dfrac{-2}{s^3 + 4s}$ $\mathbf{y}_{22} = \dfrac{s^2 + 2}{s^3 + 4s}$

As a third order function, we can realize $\mathbf{H}(s)$ by the **LC network shown in Fig. (a)**.

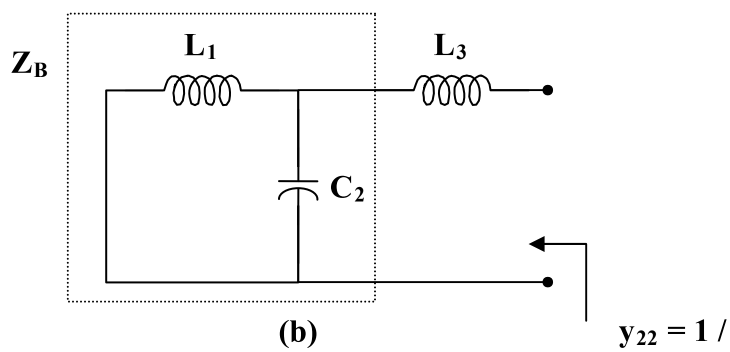


(a)

$$\mathbf{Z}_A = \frac{1}{\mathbf{y}_{22}} = \frac{s^3 + 4s}{s^2 + 2} = s + \frac{2s}{s^2 + 2} = s L_3 + \mathbf{Z}_B$$

$$L_3 = 1\,\text{H}$$

$$\mathbf{Z}_B = \frac{2s}{s^2 + 2}$$



(b)

$$\mathbf{Y}_B = \frac{1}{\mathbf{Z}_B} = \frac{s^2 + 2}{2s} = 0.5s + \frac{1}{s} = s C_2 + \frac{1}{\mathbf{Y}_C}$$

$$C_2 = 0.5\,\text{F}$$

$$\mathbf{Y}_C = \frac{1}{s L_1} = \frac{1}{s} \longrightarrow L_1 = 1\,\text{H}$$

Hence,

L_1 = **1 H**, C_2 = **500 mF**, L_3 = **1 H**.