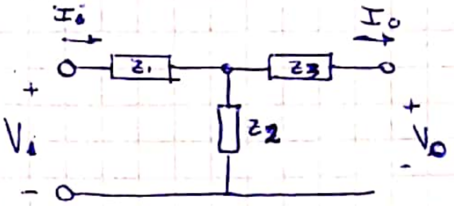
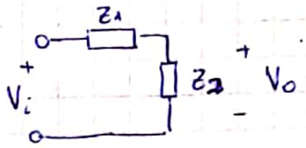
92) Econtrar parámetros [T] (ABCD) del sig. cuadripolo.

$Z_1 = 10\Omega$
$Z_2 = 5\Omega$
$Z_3 = 20\Omega$



$$V_i = A \cdot V_o + B \cdot I_o.$$
$$I_i = C \cdot V_o + D \cdot I_o.$$

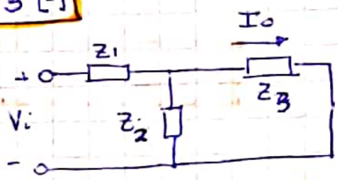
- $A = \left.\dfrac{V_i}{V_o}\right|_{I_o = 0}$



$$V_o = \frac{V_i}{Z_1 + Z_2} Z_2 \rightarrow \frac{V_i}{V_o} = A = \frac{Z_1 + Z_2}{Z_2} = \frac{10\Omega + 5\Omega}{5\Omega} = \frac{15}{5} = 3.$$

$$\boxed{A = 3\,[-]}$$

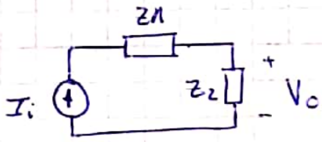
- $B = \left.\dfrac{V_i}{I_o}\right|_{V_o = 0}$



$$I_o = \frac{V_i}{Z_1 + Z_3 // Z_2} \cdot \frac{Z_3 // Z_2}{Z_3} \Rightarrow \frac{V_i}{I_o} = B = \frac{Z_3 (Z_1 + Z_3 // Z_2)}{Z_3 // Z_2} = \frac{20 (10 + 5 // 20)}{5 // 20}\,\Omega$$

$$B = \frac{20 (10 + 4)}{4}\,\Omega = 70\,\Omega \rightarrow \boxed{B = 70\,\Omega}$$

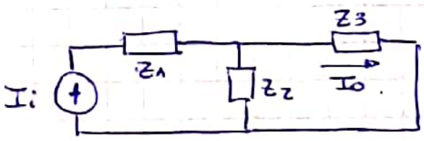
- $C = \left.\dfrac{I_i}{V_o}\right|_{I_o = 0}$



$$V_o = I_i \cdot Z_2$$

$$\frac{I_i}{V_o} = \frac{1}{Z_2} = \frac{1}{5\,\Omega} = C \rightarrow \boxed{C = 0{,}2\,℧}$$

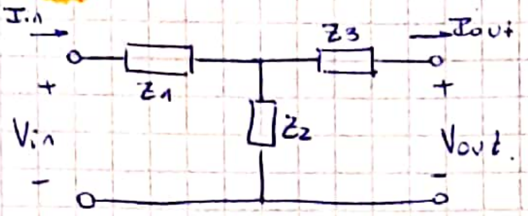
- $D = \left.\dfrac{I_i}{I_o}\right|_{V_o = 0}$



$$I_o = I_i \cdot \frac{Z_2 // Z_3}{Z_3} \rightarrow \frac{I_i}{I_o} = D = \frac{Z_3}{Z_2 // Z_3} = \frac{20\,\Omega}{20\,\Omega // 5\,\Omega} = \frac{20}{4} = 5$$

$$\boxed{D = 5\,[-]}$$

93) Encontrar ABCD del cuadripolo. $\left(\begin{array}{l} Z_1 = 40\Omega \\ Z_2 = 10\Omega \\ Z_3 = 50\Omega \end{array} \right)$



$$\text{ABCD} \begin{cases} V_{in} = A \cdot V_{out} + B \cdot I_{out} \\ I_{in} = C\, V_{out} + D\, I_{out} \end{cases}$$

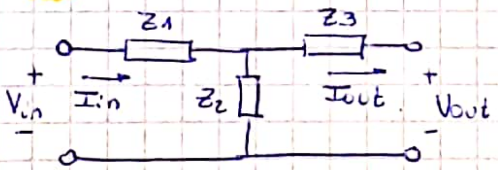
Resolviendo por conversión de parámetros Z a ABCD:

$$\left.\begin{array}{l} Z_{11} = Z_1 + Z_2 = 10\Omega + 40\Omega = 50\Omega \\ Z_{12} = Z_2 = Z_{21} = 10\Omega \\ Z_{22} = Z_2 + Z_3 = 10\Omega + 50\Omega = 60\Omega \end{array}\right\} [7] \begin{cases} V_{in} = Z_{11} I_{in} - Z_{12} I_{out} \\ V_{out} = Z_{21} I_{in} + Z_2 I_{out} \end{cases}$$

$$\Delta Z = Z_{11} \cdot Z_{22} - Z_{12}^2 = 50 \times 60 - 10^2 = 2900\,\Omega^2$$

- $A = \dfrac{Z_{11}}{Z_{21}} = \dfrac{50\Omega}{10\Omega} = \boxed{5 = A}$
- $B = \dfrac{\Delta Z}{Z_{21}} = \dfrac{2900\Omega^2}{10\Omega} = \boxed{290\Omega = B}$
- $C = \dfrac{1}{Z_{21}} = \dfrac{1}{10\Omega} = \boxed{0{,}1\ \mho = C}$
- $D = \dfrac{Z_{22}}{Z_{21}} = \dfrac{60\Omega}{10\Omega} = \boxed{6 = D}$

94) Encontrar ABCD del cuadripolo. $\left(\begin{array}{l} Z_1 = 10\Omega \\ Z_2 = 50\Omega \\ Z_3 = j5\Omega \end{array} \right)$

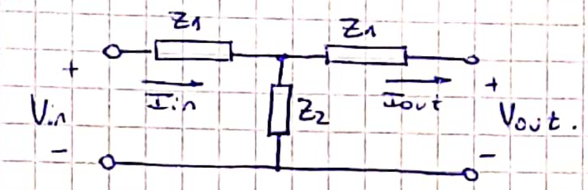


$$Z_{11} = Z_1 + Z_2 = 10\Omega + 50 = 60\Omega$$
$$Z_{12} = Z_{21} = Z_2 = 50\Omega$$
$$Z_{22} = Z_2 + Z_3 = 50 + j5\ [\Omega]$$

$$\Delta Z = Z_{11} \cdot Z_{22} - Z_{12}^2 = 500 + j300$$

- $A = \dfrac{Z_{11}}{Z_{21}} = \dfrac{60\Omega}{50\Omega} = \boxed{1{,}2\ [-] = A}$
- $B = \dfrac{\Delta Z}{Z_{21}} = \dfrac{500 + j300}{50} = \boxed{10 + j6_{\Omega} = B}$
- $C = \dfrac{1}{Z_{21}} = \dfrac{1}{50\Omega} = \boxed{0{,}02\ \mho = C}$
- $D = \dfrac{Z_{22}}{Z_{21}} = \dfrac{50 + j5}{50} = \boxed{1 + j0{,}1 = D}$

95) Encontrar ABCD del cuadripolo simétrico.



$Z_1 = j$

$Z_2 = -j0{,}5$

$Z_{11} = Z_1 + Z_2 = j0{,}5\ \Omega$

$Z_{12} = Z_{21} = Z_2 = -j0{,}5\ \Omega$

$Z_{22} = Z_1 + Z_2 = j0{,}5\ \Omega$

$\Delta Z = Z_{11} \cdot Z_{22} - Z_{12}^2 = (j0{,}5)^2 - (-j0{,}5)^2 = 0$

$\Delta Z = 0\ \Omega^2$.

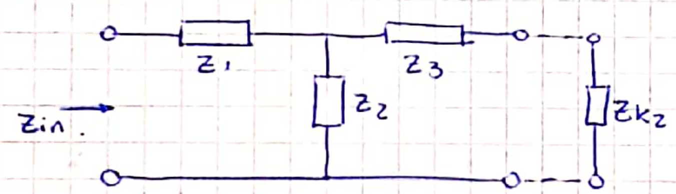
• $A = \dfrac{Z_{11}}{Z_{12}} = \dfrac{j0{,}5}{-j0{,}5} = \boxed{-1 = A}$

• $C = \dfrac{1}{Z_{21}} = \dfrac{1}{-j0{,}5} = \boxed{j2\ \mho = C}$

• $B = \dfrac{\Delta Z}{Z_{21}} = \dfrac{0}{-j0{,}5} = \boxed{0 = B}$

• $D = \dfrac{Z_{22}}{Z_{21}} = \dfrac{j0{,}5}{-j0{,}5} = \boxed{-1 = D}$

96) Determinar el valor de impedancia iterativa de salida (Z_{k2}). Encontrar el valor de impedancia de entrada (Z_{in}) con el cuadripolo cargado con Z_{k2}.



$Z_1 = 10\ \Omega$

$Z_2 = 5\ \Omega$

$Z_3 = 20\ \Omega$

$$Z_{k2} = -\left(\frac{D-A}{2C}\right) \pm \sqrt{\left(\frac{D-A}{2C}\right)^2 + \frac{B}{C}}$$

Primero hallamos los valores ABCD = (método $[Z] \rightarrow [T]$)

$Z_{11} = Z_1 + Z_2 = 15\ \Omega$

$Z_{12} = Z_{21} = Z_2 = 5\ \Omega$

$Z_{22} = Z_2 + Z_3 = 25\ \Omega$

$\Delta Z = Z_{11} \cdot Z_{22} - Z_{12}^2 = 15 \cdot 25 - 5^2 = 350\ \Omega^2$

• $A = \dfrac{Z_{11}}{Z_{21}} = \dfrac{15}{5} = 3$

• $C = \dfrac{1}{Z_{21}} = \dfrac{1}{5} = 0{,}2\ \mho$

• $B = \dfrac{\Delta Z}{Z_{21}} = \dfrac{350\ \Omega^2}{5\ \Omega} = 70\ \Omega$

• $D = \dfrac{Z_{22}}{Z_{21}} = \dfrac{25}{5} = 5$

$$Zk_2 = -\left(\frac{D-A}{2C}\right) \pm \sqrt{\left(\frac{D-A}{2C}\right)^2 + \frac{B}{C}} \quad ; \quad \begin{matrix} A = 3 \\ B = 70 \\ C = 0{,}2 \\ D = 5 \end{matrix}$$

$$Zk_2 = -\left(\frac{5-3}{2 \cdot 0{,}2}\right) \pm \sqrt{\left(\frac{5-3}{2 \cdot 0{,}2}\right)^2 + \frac{70}{0{,}2}}$$

$$Zk_2 = -5 \pm 19{,}36$$

$$\boxed{Zk_2 = 14{,}36\,\Omega}$$

Impedancia de entrada:

$$Zin = Z_1 + Z_2 \parallel (Z_3 + Zk_2) = 10 + 5 \parallel (20 + 14{,}36) = 10 + 5 \parallel 34{,}36$$

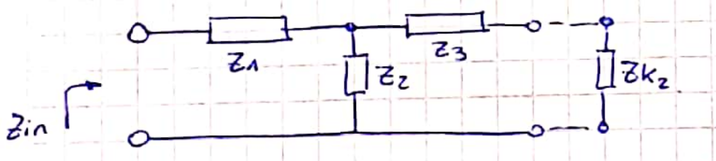
$$Zin = 10 + 4{,}36$$

$$\boxed{Zin = 14{,}36\,\Omega}$$

También:

$$Zin = \frac{A + \frac{B}{Zout}}{C + \frac{D}{Zout}} = \frac{3 + \frac{70}{14{,}36}}{0{,}2 + \frac{5}{14{,}36}} = 14{,}36\,\Omega$$

97) Determinar Zk_2 y encontrar el valor de Zin con Zk_2 como carga.



$Z_1 = 40\,\Omega$
$Z_2 = 10\,\Omega$
$Z_3 = 50\,\Omega$

El cuadripolo es el mismo del ej. 93, los parámetros ABCD son $\begin{cases} A = 5 \\ B = 290\,\Omega \\ C = 0{,}1\,\mho \\ D = 6 \end{cases}$

$$Zk_2 = -\left(\frac{D-A}{2C}\right) \pm \sqrt{\left(\frac{D-A}{2C}\right)^2 + \frac{B}{C}} = -\left(\frac{6-5}{2 \cdot 0{,}1}\right) \pm \sqrt{\left(\frac{6-5}{2 \times 0{,}1}\right)^2 + \frac{290}{0{,}1}}$$

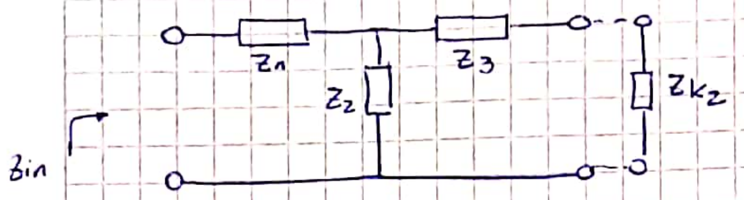
$$Zk_2 = -5 \pm 54{,}08 \longrightarrow \boxed{Zk_2 = 49{,}08\,\Omega}$$

$$Zin = Z_1 + Z_2 \parallel (Z_3 + Zk_2) = 40 + 10 \parallel (50 + 49{,}08) = 40 + 10 \parallel 99{,}08$$

$$Zin = 40 + 9{,}08$$

$$\boxed{Zin = 49{,}08\,\Omega}$$

98) Determinar Zk_2 y encontrar Zin con Zk_2 como carga.



$Z_1 = 10\ \Omega$
$Z_2 = 50\ \Omega$
$Z_3 = j5\ \Omega$

El cuadripolo es el mismo del ejercicio 94 $\begin{cases} A = 1,2 \\ B = 10 + j6\ \Omega \\ C = 0,02\ \mho \\ D = 1 + j0,1 \end{cases}$.

$$Zk_2 = -\left(\frac{D-A}{2C}\right) \pm \sqrt{\left(\frac{D-A}{2C}\right)^2 + \frac{B}{C}}$$

$$Zk_2 = -\left(\frac{1 + j0,1 - 1,2}{2 \cdot 0,02}\right) \pm \sqrt{\left(\frac{1 + j0,1 - 1,2}{2 \cdot 0,02}\right)^2 + \frac{10 + j6}{0,02}}$$

$$Zk_2 = (5 - j2,5) \pm \sqrt{(-5 + j2,5)^2 + 500 + j300}$$

$$Zk_2 = (5 - j2,5) \pm \sqrt{518,75 + j275} = 5 - j2,5 \pm \sqrt{587,13 \angle 27,93}$$

$$Zk_2 = 5 - j2,5 \pm \left(\sqrt{587,13} \angle \frac{27,93}{2}\right) = 5 - j2,5 \pm (24,23 \angle 13,96)$$

$$Zk_2 = 5 - j2,5 \pm (23,51 + j5,84)$$

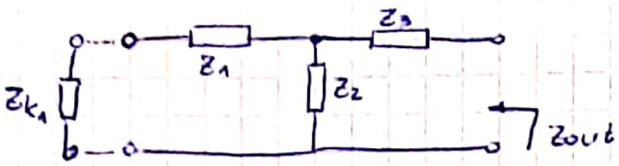
$$\boxed{Zk_2 = 28,51 + j3,34\ \Omega}$$

$$Zin = Z_1 + Z_2 // (Z_3 + Zk_2) = 10 + 50 // (j5 + 28,51 + j3,34)$$

$$Zin = 10 + 50 // (28,51 + j8,34) = 10 + 18,51 + j3,34$$

$$\boxed{Zin = 28,51 + j3,34}$$

99) Determinar Z_{k1} y encontrar Z_{out} con Z_{k1} como Z_{in}.



$Z_1 = 10\,\Omega$
$Z_2 = 5\,\Omega$
$Z_3 = 20\,\Omega$.

El cuadripolo es el mismo del ej. 92. $\begin{cases} A = 3 \\ B = 70\,\Omega \\ C = 0{,}2\ \mho \\ D = 5. \end{cases}$

$$Z_{k1} = -\left(\frac{A-D}{2C}\right) \pm \sqrt{\left(\frac{A-D}{2C}\right)^2 + \frac{B}{C}}$$

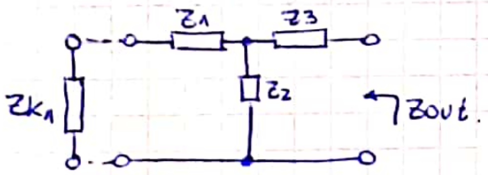
$$Z_{k1} = -\left(\frac{3-5}{2\cdot 0{,}2}\right) \pm \sqrt{\left(\frac{3-5}{2\cdot 0{,}2}\right)^2 + \frac{70}{0{,}2}} = -(-5) \pm \sqrt{5^2 + 350} = 5 \pm 19{,}36$$

$$\boxed{Z_{k1} = 24{,}36\,\Omega}$$

$$Z_{out} = Z_3 + Z_2 /\!/ (Z_1 + Z_{k1}) = 20 + 5 /\!/ (10 + 24{,}36) = 20 + 5 /\!/ 34{,}36$$

$$Z_{out} = 20 + 4{,}36 = \boxed{24{,}36 = Z_{out}}$$

100) Determinar Z_{k1} y encontrar Z_{out} con Z_{k1} como Z_{in}.



$Z_1 = 40\,\Omega$
$Z_2 = 10\,\Omega$
$Z_3 = 50\,\Omega$

Cuadripolo del ej. 93 $\begin{cases} A = 5 \\ B = 290\,\Omega \\ C = 0{,}1\ \mho \\ D = 6 \end{cases}$

$$Z_{k1} = -\left(\frac{A-D}{2C}\right) \pm \sqrt{\left(\frac{A-D}{2C}\right)^2 + \frac{B}{C}} = -\left(\frac{5-6}{2\cdot 0{,}1}\right) \pm \sqrt{\left(\frac{5-6}{2\cdot 0{,}1}\right)^2 + \frac{290}{0{,}1}}$$

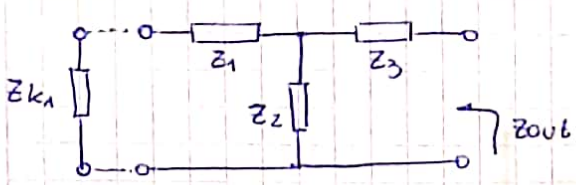
$$Z_{k1} = -(-5) \pm 54{,}08 \rightarrow \boxed{Z_{k1} = 59{,}08\,\Omega}$$

$$Z_{out} = Z_3 + Z_2 /\!/ (Z_1 + Z_{k1}) = 50 + 10 /\!/ (40 + 59{,}08) = 50 + 10 /\!/ 99{,}08.$$

$$Z_{out} = 50 + 9{,}08$$

$$\boxed{Z_{out} = 59{,}08\,\Omega}.$$

101) Determinar Zk_1 y encontrar Z_{out} con Zk_1 como Z_{in}.



$Z_1 = 10\,\Omega$
$Z_2 = 50\,\Omega$
$Z_3 = j5\,\Omega$

Cuadripolo Ej. 94 $\begin{cases} A = 1,2 \\ B = 10 + j6\ [\Omega] \\ C = 0,02\ \mho \\ D = 1 + j0,1 \end{cases}$

$$Zk_1 = -\left(\frac{A-D}{2C}\right) \pm \sqrt{\left(\frac{A-D}{2C}\right)^2 + \frac{B}{C}} = -\left(\frac{1,2-1-j0,1}{2\cdot 0,02}\right) \pm \sqrt{\left(\frac{1,2-1-j0,1}{2\cdot 0,02}\right)^2 + \frac{10+j6}{2\,0,02}}$$

$$Zk_1 = -(5 - j\,2,5) \pm \sqrt{(5-j\,2,5)^2 + 250 + j150} = (-5 + j\,2,5) \pm \left(\sqrt{587,13}\ \underline{|27,93/2}\right)$$

$$Zk_1 = (-5 + j\,2,5) \pm (24,23\ \underline{|13,96^\circ}) = (-5 + j\,2,5) \pm (23,51 + j\,5,84)$$

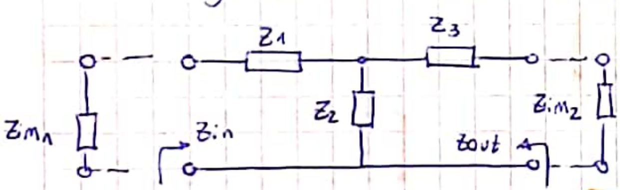
$$\boxed{Zk_1 = 18,51 + j\,8,34}$$

$$Z_{out} = Z_3 + Z_2 \,//\, (Z_1 + Zk_1) = j5 + 50 \,//\, (10 + 18,51 + j\,8,34)$$

$$Z_{out} = j5 + 50 \,//\, (28,51 + j\,8,34) = j5 + 18,51 + j\,3,34$$

$$\boxed{Z_{out} = 18,51 + j\,8,34}$$

102) Determinar Z_{im_1} y Z_{im_2}. Encontrar Z_{in} y Z_{out} con los cuad. cargados con las Z_{im} correspondiente.



$Z_1 = 10\,\Omega$
$Z_2 = 5\,\Omega$
$Z_3 = 20\,\Omega$

Cuad. Ej. 92 $\begin{cases} A = 3 \\ B = 70\,\Omega \\ C = 0,2\ \mho \\ D = 5\ [-] \end{cases}$

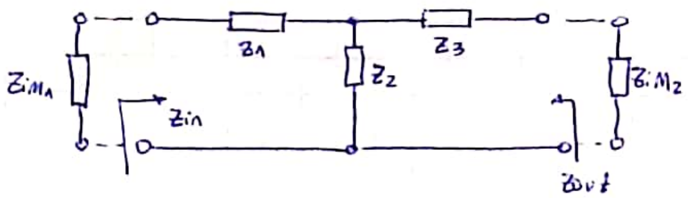
- $Z_{im_1} = \sqrt{\dfrac{A\,B}{C\,D}} = \sqrt{\dfrac{3 \times 70}{0,2 \times 5}} = \boxed{14,49\,\Omega = Z_{im_1}}$

- $Z_{im_2} = \sqrt{\dfrac{B\cdot D}{A\cdot C}} = \sqrt{\dfrac{70\cdot 5}{3\ 0,2}} = \boxed{24,15\,\Omega = Z_{im_2}}$

- $Z_{in} = Z_1 + Z_2 \,//\, (Z_3 + Z_{im_2}) = 10 + 5 \,//\, (20 + 24,15) = \boxed{14,49\,\Omega = Z_{in}}$

- $Z_{out} = Z_3 + Z_2 \,//\, (Z_1 + Z_{im_1}) = 20 + 5 \,//\, (10 + 14,49) = \boxed{24,15\,\Omega = Z_{out}}$

103) Determinar Z_{im_1} y Z_{im_2}. Calcular Z_{in} y Z_{out} con el cuad. cargado c/ Z_{im}s.



$Z_1 = 40\,\Omega$, $Z_2 = 10\,\Omega$, $Z_3 = 50\,\Omega$ } Cuad. Ej. 93 { $A = 5$, $B = 290\,\Omega$, $C = 0{,}1\,℧$, $D = 6$.

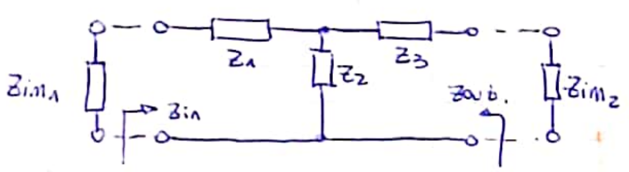
$$Z_{im_1} = \sqrt{\frac{AB}{CD}} = \sqrt{\frac{5 \cdot 290}{0{,}1 \cdot 6}} = \boxed{49{,}16\,\Omega = Z_{im_1}}$$

$$Z_{im_2} = \sqrt{\frac{D\,B}{A \cdot C}} = \sqrt{\frac{6 \cdot 290}{5 \cdot 0{,}1}} = \boxed{58{,}99\,\Omega = Z_{im_2}}$$

$$Z_{in} = Z_1 + Z_2 /\!/ (Z_3 + Z_{im_2}) = 40 + 10 /\!/ (50 + 58{,}99) = \boxed{49{,}16\,\Omega = Z_{in}}$$

$$Z_{out} = Z_3 + Z_2 /\!/ (Z_1 + Z_{im_1}) = 50 + 10 /\!/ (40 + 49{,}16) = \boxed{58{,}99\,\Omega = Z_{out}}$$

104) Determinar Z_{im_1} y Z_{im_2}. Calcular Z_{in} y Z_{out} con el cuad. cargado con Z_{im}s.



$Z_1 = 10\,\Omega$, $Z_2 = 50\,\Omega$, $Z_3 = j5\,\Omega$ } Cuad. Ej. 94. { $A = 1{,}2$, $B = 10 + j6$ $[\Omega]$, $C = 0{,}02\,℧$, $D = 1 + j0{,}1$

- $$Z_{im_1} = \sqrt{\frac{A\,B}{C\,D}} = \sqrt{\frac{1{,}2\,(10+j6)}{0{,}02 \cdot (1+j0{,}1)}} = \sqrt{696{,}4 \angle 25{,}25} = 26{,}39 \angle 12{,}62^\circ = 25{,}8 + j\,5{,}78\,[\Omega] =$$

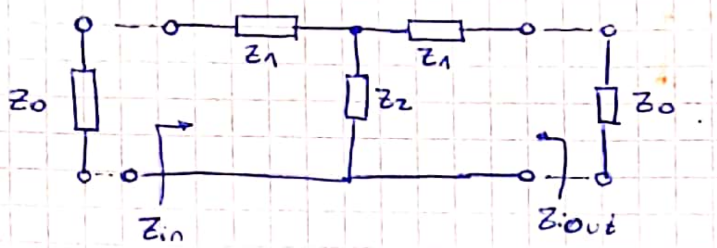
$$\boxed{Z_{im_1} = 25{,}8 + j\,5{,}78\ [\Omega]}$$

- $$Z_{im_2} = \sqrt{\frac{D\,B}{CA}} = \sqrt{\frac{(1+j0{,}1)(10+j6)}{1{,}2 \times 0{,}02}} = \sqrt{488{,}34} \angle \frac{36{,}67}{2} = \boxed{20{,}96 + j\,6{,}95\ [\Omega] = Z_{im_2}}$$

- $$Z_{in} = Z_1 + Z_2 /\!/ (Z_3 + Z_{im_2}) = 10 + 50 /\!/ (j5 + 20{,}96 + j\,6{,}95) = \boxed{25{,}8 + j\,5{,}78\ [\Omega] = Z_{in}}$$

- $$Z_{out} = Z_3 + Z_2 /\!/ (Z_1 + Z_{im_1}) = j5 + 50 /\!/ (10 + 25{,}8 + j\,5{,}78) = \boxed{20{,}96 + j6{,}95\ [\Omega] = Z_{out}}$$

105) Determinar la impedancia característica (Z_0) del sig. cuad. simétrico.



$Z_1 = 10\,\Omega$.
$Z_2 = 120\,\Omega$.

$$Z_0 = \sqrt{\frac{B}{C}}$$

[Z]:

$$\left.\begin{aligned} Z_{11} &= Z_1 + Z_2 = 130\,\Omega = Z_{22} \\ Z_{12} &= Z_{21} = Z_2 = 120\,\Omega \end{aligned}\right\} \Delta Z = Z_{11}^2 - Z_{12}^2 = 130^2 - 120^2 = 2500\,\Omega^2$$

- $B = \dfrac{\Delta Z}{Z_{21}} = \dfrac{2500\,\Omega^2}{120\,\Omega} = 20{,}833\,\Omega$

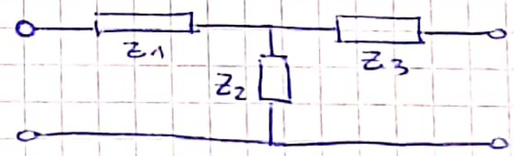
- $C = \dfrac{1}{Z_{21}} = \dfrac{1}{120\,\Omega} = 8{,}33 \times 10^{-3}\ \mho$

- $Z_0 = \sqrt{\dfrac{B}{C}} = \sqrt{\dfrac{20{,}833}{8{,}33\times 10^{-3}}} = 50\,\Omega \longrightarrow \boxed{Z_0 = 50\,\Omega}$

$$\boxed{Z_{in} = Z_{out} = Z_0 = 50\,\Omega}$$

106) Determinar Z_1 y Z_3 para conformar un cuadripolo simétrico con $Z_0 = 50\,\Omega$

$Z_2 = 20\,\Omega$.



$\boxed{Z_1 = Z_3}$

$$Z_0 = \sqrt{\frac{B}{C}} = \sqrt{\frac{\frac{\Delta Z}{Z_{21}}}{\frac{1}{Z_{21}}}} = \sqrt{\frac{\Delta Z \cdot Z_{21}}{Z_{21}}} = \sqrt{\Delta Z} = \sqrt{Z_{11}^2 - Z_{12}^2}$$

$$Z_{11} = Z_1 + Z_2 . \longrightarrow Z_{11}^2 = Z_1^2 + 2 Z_1 Z_2 + Z_2^2$$
$$Z_{12} = Z_2 . \longrightarrow Z_{12}^2 = Z_2^2$$

$$Z_0 = \sqrt{Z_1^2 + 2Z_1Z_2 + \cancel{Z_2^2} - \cancel{Z_2^2}} = \sqrt{Z_1^2 + 2Z_1Z_2}$$

$$Z_0^2 = Z_1^2 + 2Z_2 \cdot Z_1 \longrightarrow Z_1^2 + 2Z_2Z_1 - Z_0^2 = 0$$

$$Z_1^2 + 2 \cdot 20 \cdot Z_1 - 50^2 = 0$$

$$Z_1^2 + 40 Z_1 - 2500 = 0 \quad \begin{cases} (Z_1)_1 = 33,851 \ \Omega \\ \cancel{(Z_1)_2 = -73,851} \ \Omega \end{cases}$$

$$\boxed{Z_1 = Z_3 = 33,851 \ \Omega}$$