

Divizoare de Putere

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(a)



(b)

Proprietati de baza ale cuploarelor directionale

Circuite cu trei porti

$$(S_{ij} = S_{ji})$$

Reciproc

$$S_{ii} = 0$$

Adaptare simultana
la toate portile

$$\sum_k S_{ik} S_{kj}^* = \delta_{ij} \quad \text{Fara pierderi}$$



$$|S_{13}|^2 + |S_{23}|^2 = 1$$

$$|S_{12}|^2 + |S_{23}|^2 = 1$$

$$|S_{12}|^2 + |S_{13}|^2 = 1$$

$$S_{13}^* S_{23} = 0$$

$$S_{23}^* S_{12} = 0$$

$$S_{12}^* S_{13} = 0$$



Un circuit cu trei porti **NU** poate fi fara pierderi,
reciproc si adaptat simultan la toate portile

Circuitul fara pierderi si adaptat simultan la toate portile este nereciproc

$$[S] = \begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{21} & 0 & S_{23} \\ S_{31} & S_{32} & 0 \end{bmatrix}$$

$$S_{31}^* S_{32} = 0$$

$$S_{21}^* S_{23} = 0$$

$$S_{12}^* S_{13} = 0$$

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$$\sum_k S_{ik} S_{kj}^* = \delta_{ij}$$

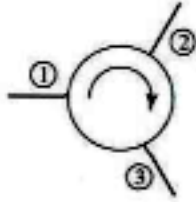
$$|S_{12}|^2 + |S_{13}|^2 = 1$$

$$|S_{21}|^2 + |S_{23}|^2 = 1$$

$$|S_{31}|^2 + |S_{32}|^2 = 1$$

$$1 \left\{ \begin{array}{l} S_{12} = S_{23} = S_{31} = 0 \\ |S_{21}| = |S_{32}| = |S_{13}| = 1 \end{array} \right.$$

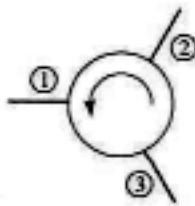
$$[S] = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$



CIRCULATOR

$$2 \left\{ \begin{array}{l} S_{21} = S_{32} = S_{13} = 0 \\ |S_{12}| = |S_{23}| = |S_{31}| = 1 \end{array} \right.$$

$$[S] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$$



Circuitul fara pierderi si reciproc poate fi adaptat doar la doua porti

$$S_{13}^* S_{23} = 0(a)$$

$$[S] = \begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{12} & 0 & S_{23} \\ S_{13} & S_{23} & S_{33} \end{bmatrix}$$

$$S_{12}^* S_{13} + S_{23}^* S_{33} = 0(b)$$

$$S_{23}^* S_{12} + S_{33}^* S_{13} = 0(c)$$

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$$|S_{12}|^2 + |S_{13}|^2 = 1(d)$$

$$|S_{12}|^2 + |S_{23}|^2 = 1(e)$$

$$|S_{13}|^2 + |S_{23}|^2 + |S_{33}|^2 = 1(f)$$

$$[S] = \begin{bmatrix} 0 & e^{j\theta} & 0 \\ e^{j\theta} & 0 & 0 \\ 0 & 0 & e^{j\phi} \end{bmatrix}$$

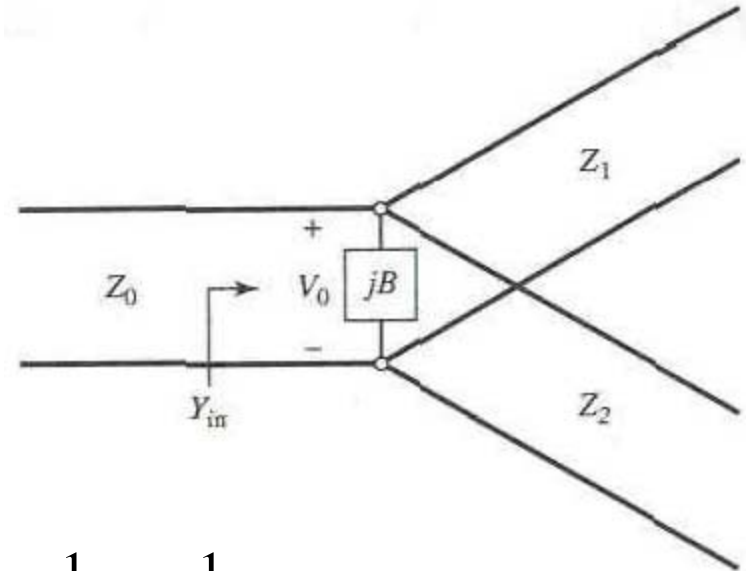
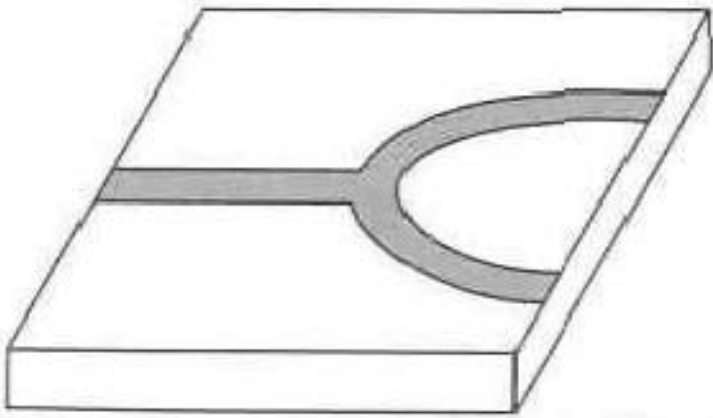
**Linie fara pierderi adaptata
+
Poarta dezadaptata**

$$\sum_k S_{ik} S_{kj}^* = \delta_{ij}$$

Circuit reciproc si adaptat la toate portile trebuie sa fie cu pierderi

Divizorul de putere cu izolare intre portile de iesire

Divizorul de Putere in T



$$Y_{\text{in}} = jB + \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{Z_0}$$

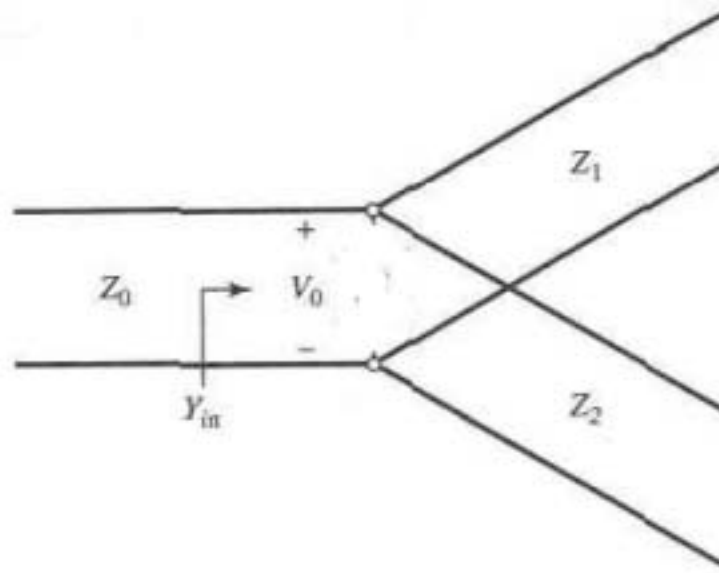
$$B = 0 \Rightarrow \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{Z_0}$$

Exemplu

Un divizor de putere în T, fără pierderi, are o impedanță a sursei de 50Ω .
Calculați impedanțele caracteristice de ieșire astfel încât puterea de intrare sa fie împărțită în raportul 2:1.
Calculați coeficienții de reflexie văzuți privind în porțile de ieșire.

Solutie

$$P_{in} = \frac{1}{2} \frac{V_0^2}{Z_0}$$



$$P_1 = \frac{1}{2} \frac{V_1^2}{Z_1} = \frac{1}{3} P_{in}$$

$$\Gamma_1 = \frac{30 - 150}{30 + 150} = -0.666$$

$$P_2 = \frac{1}{2} \frac{V_2^2}{Z_2} = \frac{2}{3} P_{in}$$

$$\Gamma_2 = \frac{37.5 - 75}{37.5 + 75} = -0.333$$

$$Z_1 = 3Z_0 = 150\Omega$$

$$Z_2 = 3Z_0/2 = 75\Omega$$

$$Z_{in} = 75 \parallel 150 = 50\Omega$$

Divizorul Rezistiv

$$Z = \frac{Z_0}{3} + Z_0 = \frac{4Z_0}{3}$$

$$Z_{in} = \frac{Z_0}{3} + \frac{2Z_0}{3} = Z_0$$

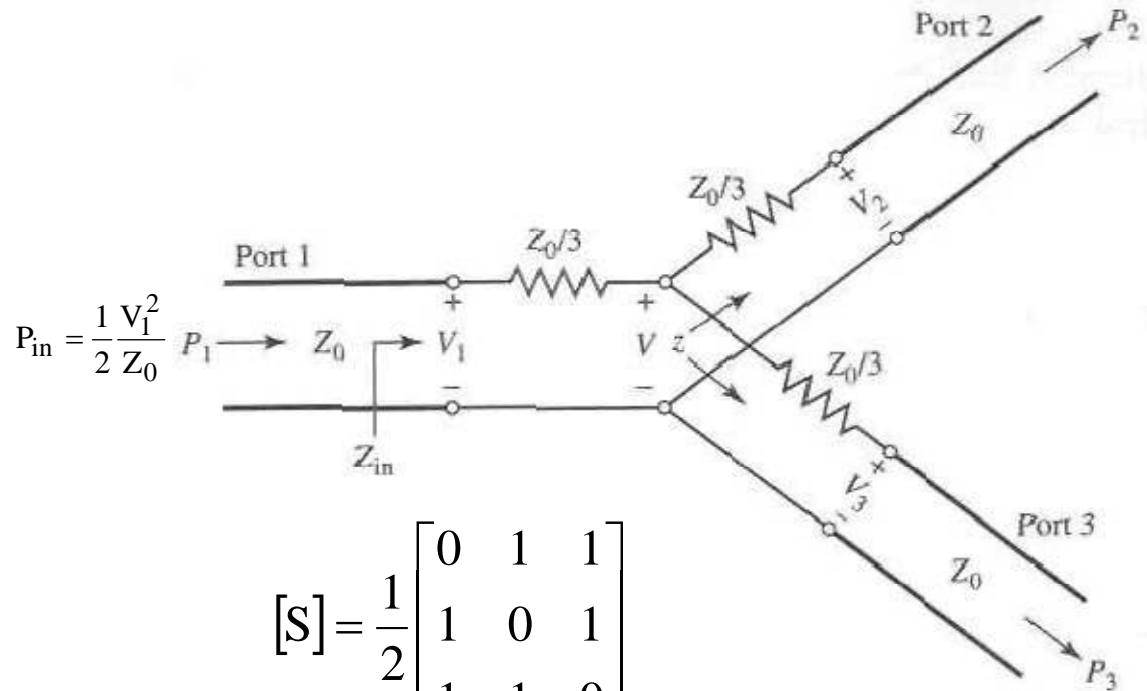
$$S_{11} = S_{22} = S_{33} = 0$$

$$V = V_1 \frac{2Z_0/3}{Z_0/3 + 2Z_0/3} = \frac{2}{3} V_1$$

$$V_2 = V_3 = V \frac{Z_0}{Z_0/3 + Z_0} = \frac{3}{4} V = \frac{1}{2} V_1$$

$$S_{21} = S_{31} = S_{23} = 1/2$$

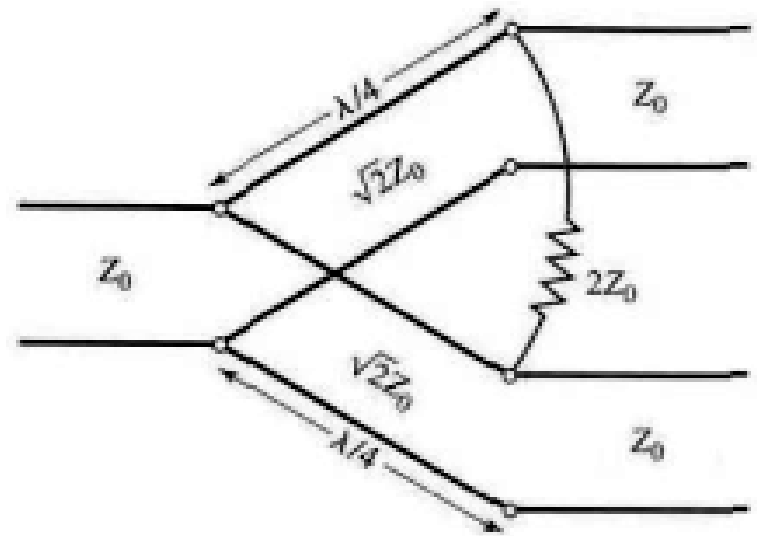
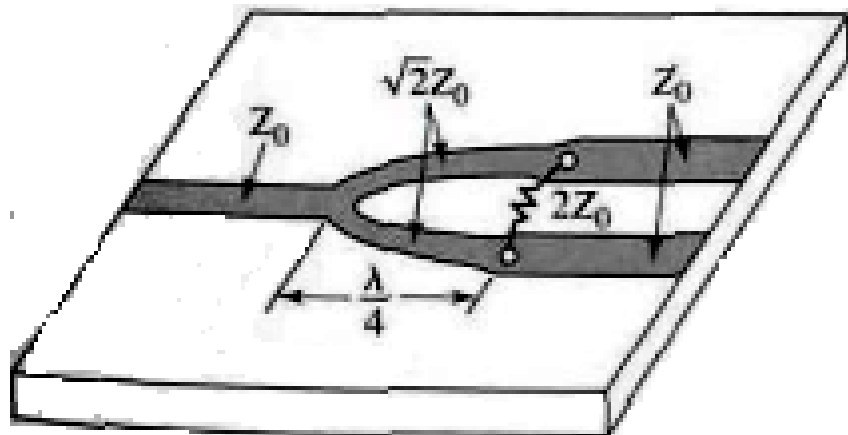
$$P_2 = P_3 = \frac{1}{2} \frac{(1/2 V_1)^2}{Z_0} = \frac{1}{8} \frac{V_1^2}{Z_0} = \frac{1}{4} P_{in}$$



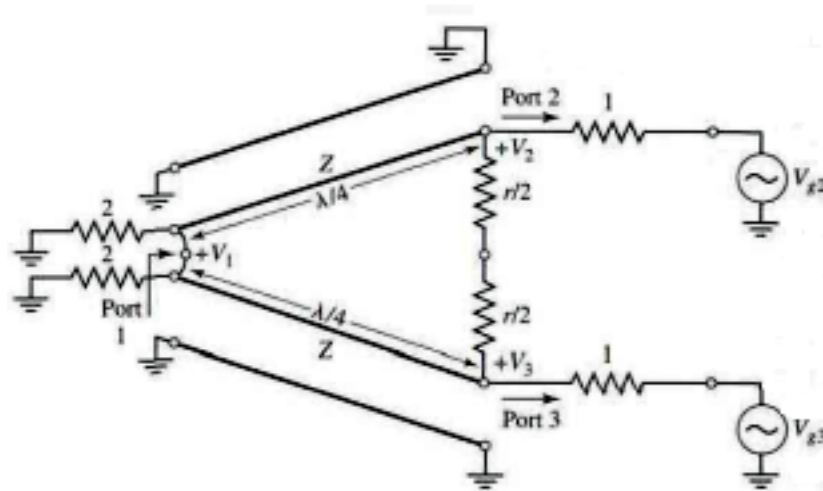
$$[S] = \frac{1}{2} \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

$$P_2 = P_3 = \frac{1}{2} \frac{(1/2 V_1)^2}{Z_0} = \frac{1}{8} \frac{V_1^2}{Z_0} = \frac{1}{4} P_{in}$$

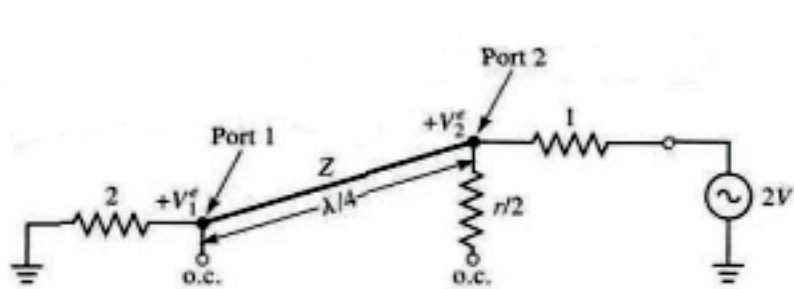
Divizorul Wilkinson



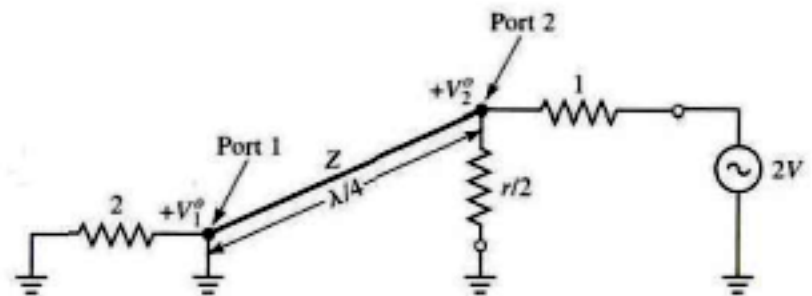
Analiza pe modul par-impair



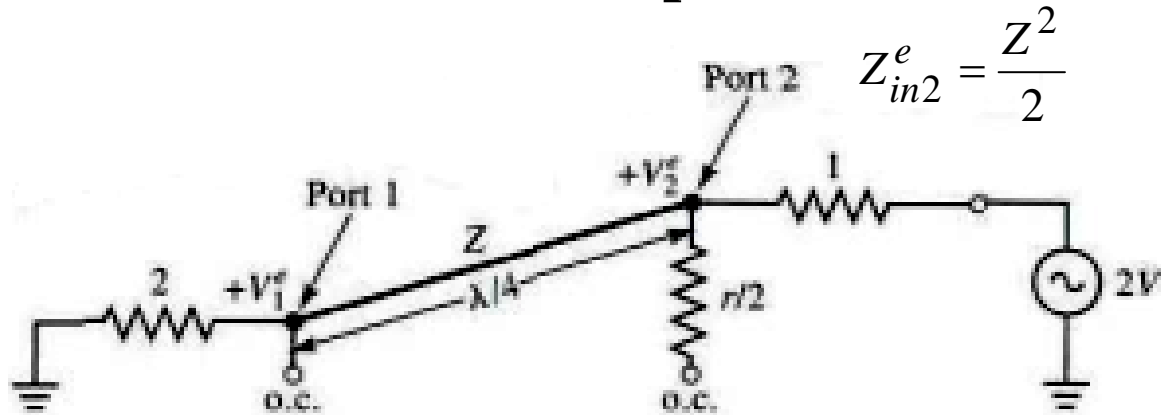
Modul par



Modul impar



Modul par



$$V(x) = V^+ \left(e^{-j\beta x} + \Gamma e^{j\beta x} \right)$$

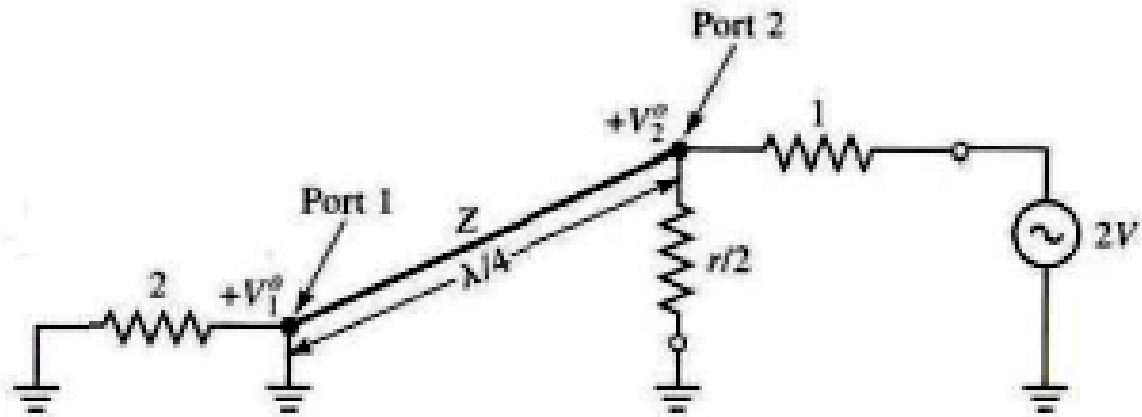
$$V_2^e = V(-\lambda/4) = jV^+(1 - \Gamma) = V$$

$$V_1^e = V(0) = V^+(1 + \Gamma) = jV \frac{\Gamma + 1}{\Gamma - 1}$$

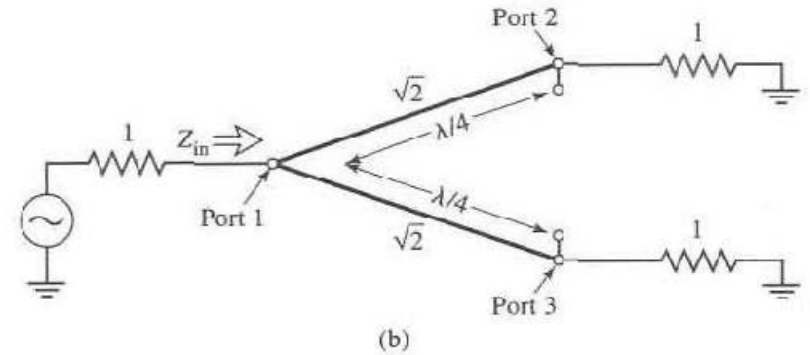
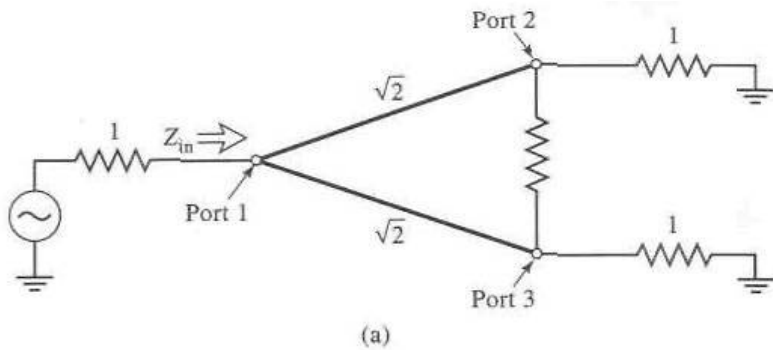
$$\Gamma = \frac{2 - \sqrt{2}}{2 + \sqrt{2}}$$

$$V_1^e = -jV\sqrt{2}$$

Modul impar



Calculul lui S11



$$Z_{in} = \frac{1}{2}(\sqrt{2})^2 = 1$$

$$S_{11} = 0$$

$$S_{22} = S_{33} = 0$$

$$S_{12} = S_{21} = \frac{V_1^e + V_1^o}{V_2^e + V_2^o} = -j\sqrt{2}$$

$$S_{13} = S_{31} = -j\sqrt{2}$$

$$S_{23} = S_{32} = 0$$

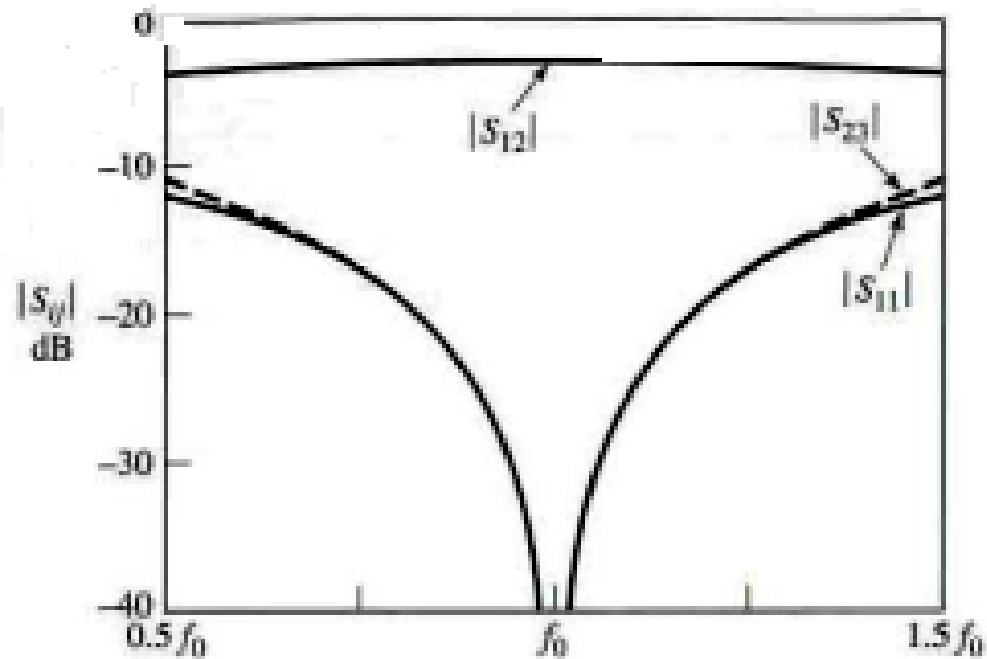
Exemplu

- Proiectați un divizor de putere Wilkinson de 3 dB, pe 50Ω , la frecvența f_0 și reprezentați grafic pierderile de întoarcere (S_{11}), pierderile de inserție ($S_{21} = S_{31}$) și izolarea ($S_{23} = S_{32}$) în funcție de frecvență.

Solutie

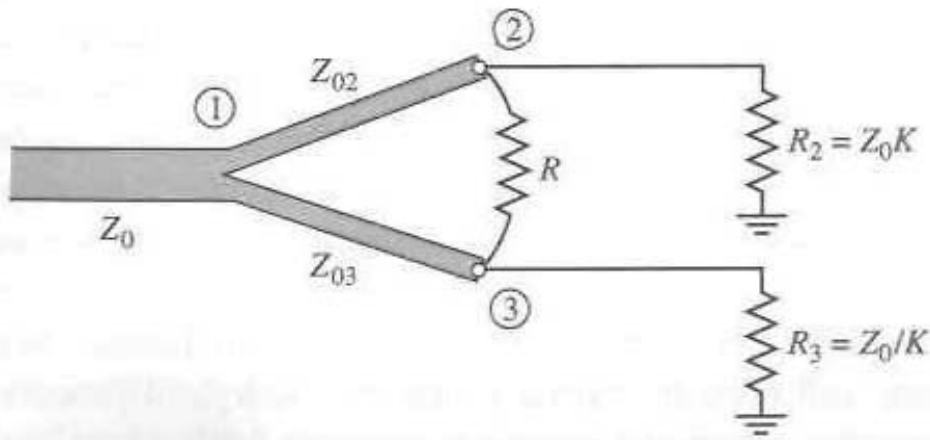
$$Z = \sqrt{2}Z_0 = 70.7\Omega$$

$$R = 2Z_0 = 100\Omega$$



Divizorul Wilkinson cu puteri inegale

$$K^2 = P_3/P_2$$



$$Z_{03} = Z_0 \sqrt{\frac{1 + K^2}{K^3}}$$

$$Z_{02} = K^2 Z_{03} = Z_0 \sqrt{K(1 + K^2)}$$

$$R = Z_0 \left(K + \frac{1}{K} \right)$$

Divizorul Wilkinson cu N cai

