Divizoare de Putere

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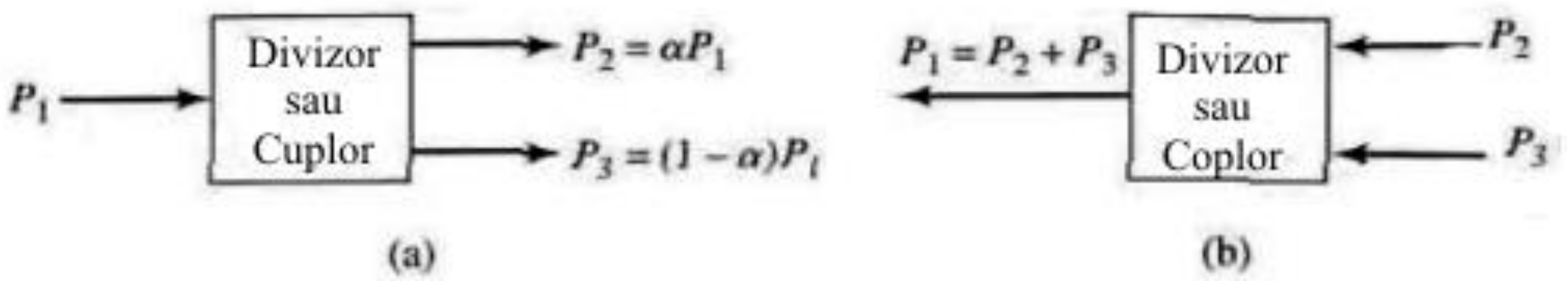

Proprietati de baza ale cuploarelor directionale

Circuite cu trei porti

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

$S_{ii} = 0$ Adaptare simultana la toate portile

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

$$>$$

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

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

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

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

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

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

$$\vee$$

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

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

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

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

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

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

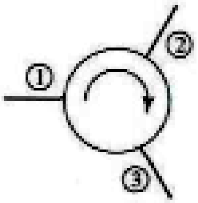
$$|S_{12}|^2 + |S_{13}|^2 = 1$$

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

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

$$1\begin{cases} S_{12} = S_{23} = S_{31} = 0 \\ |S_{21}| = |S_{32}| = |S_{13}| = 1 \end{cases}$$

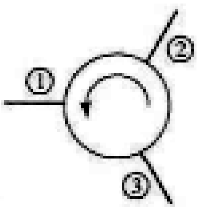
$$[S] = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$



CIRCULATOR

$$2\begin{cases} S_{21} = S_{32} = S_{13} = 0 \\ |S_{12}| = |S_{23}| = |S_{31}| = 1 \end{cases}$$

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



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

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

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

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

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

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

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

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

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

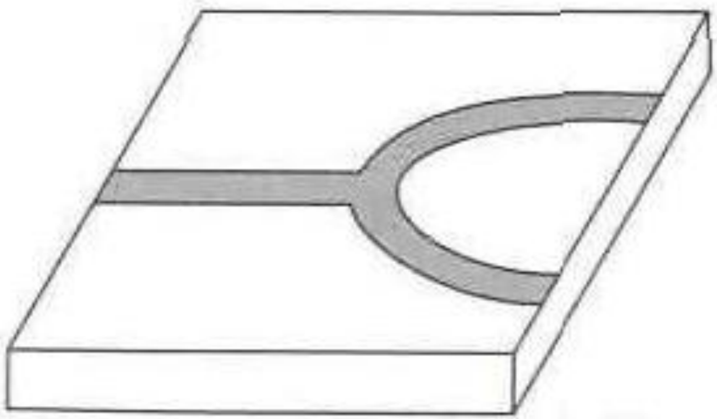
$$[S]=\begin{bmatrix} 0 & e^{j\theta} & 0 \\ e^{j\theta} & 0 & 0 \\ 0 & 0 & e^{j\phi} \end{bmatrix}$$

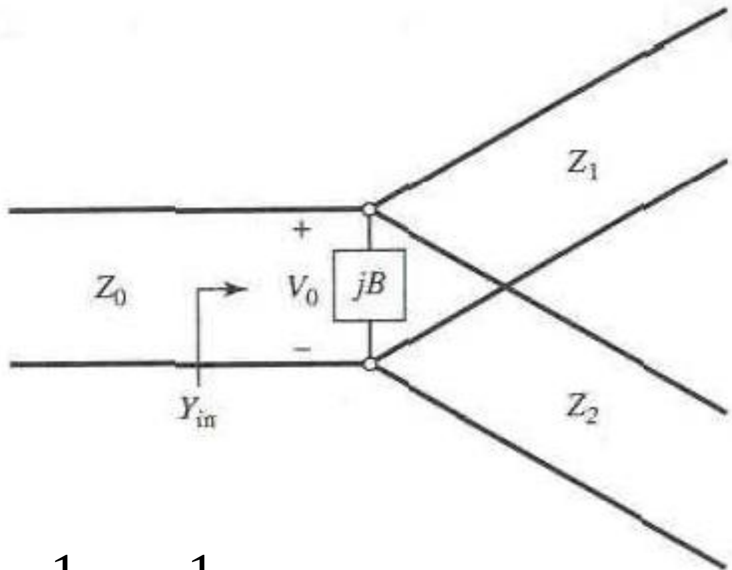
Linie fara pierderi adaptata
+
Poarta dezadaptata

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





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

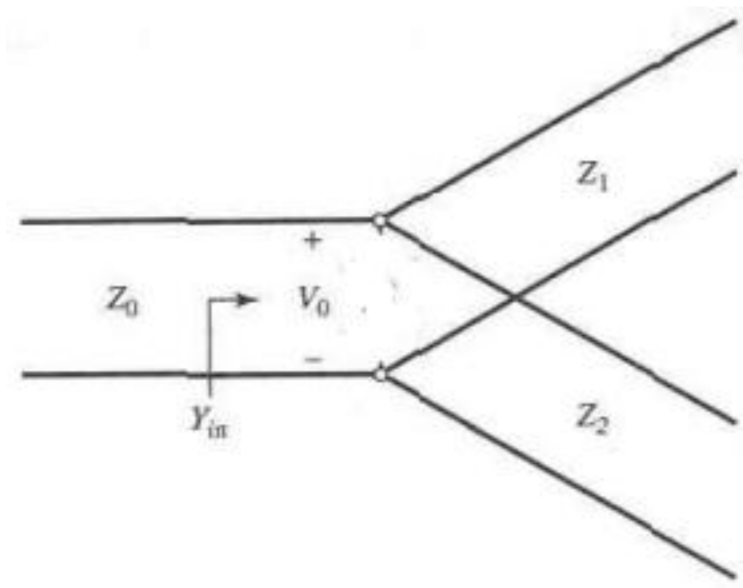
$$B = 0 \Rightarrow \quad \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{Z_0}$$

Exemplu

Un divizor de putere în T, fără pierderi, are o impedanţă a sursei de 50 Ω.
Calculaţi impedanţele caracteristice de ieşire astfel încît puterea de intrare sa fie impărţită în raportul 2:1.
Calculaţi coeficienţii de reflexie văzuţi privind în porţile de ieşire.

Solutie

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



$$P_1 = \frac{1}{2}\frac{V_0^2}{Z_1} \overset{n}{=} \frac{1}{3}P_{in}$$

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

$$P_2 = \frac{1}{2}\frac{V_0^2}{Z_2} \overset{n}{=} \frac{2}{3}P_{in}$$

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

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

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

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

Divizorul Rezistiv

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

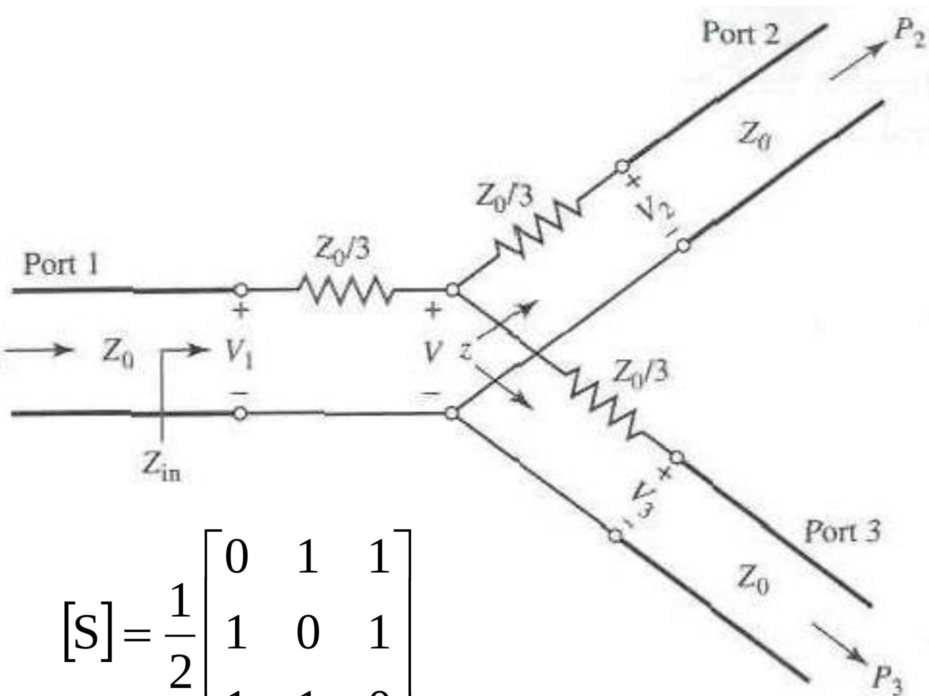
$$Z = \frac{Z_0}{3} + Z_0 = \frac{4Z_0}{3}$$

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

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

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

$$P_{in} = \frac{1}{2}\frac{V_1^2}{Z_0}$$



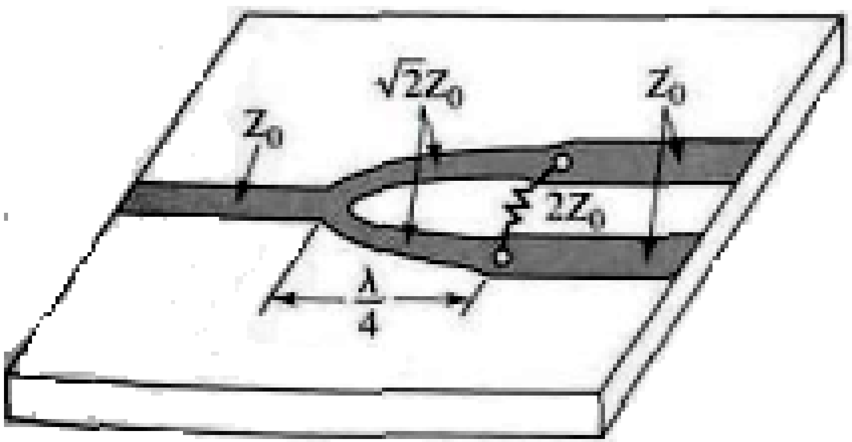
$$V_2 = V_3 = V\frac{Z_0}{Z_0/3 + Z_0} = \frac{3}{4}V = \frac{1}{2}V_1$$

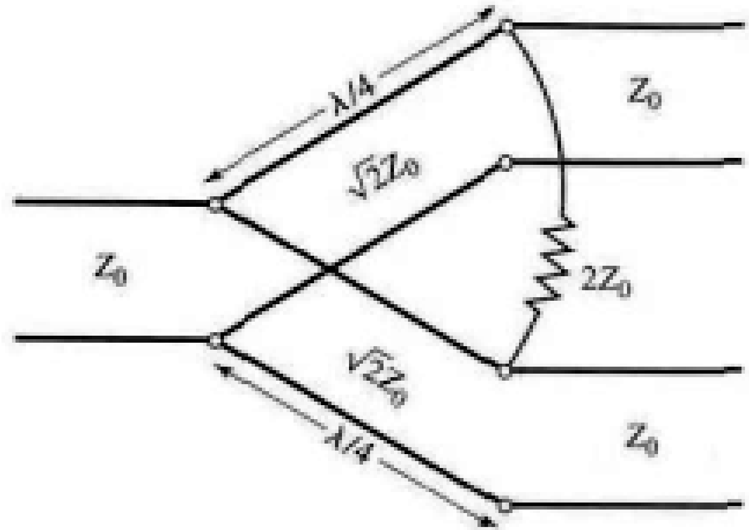
$$S_{21} = S_{31} = S_{23} = 1/2$$

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

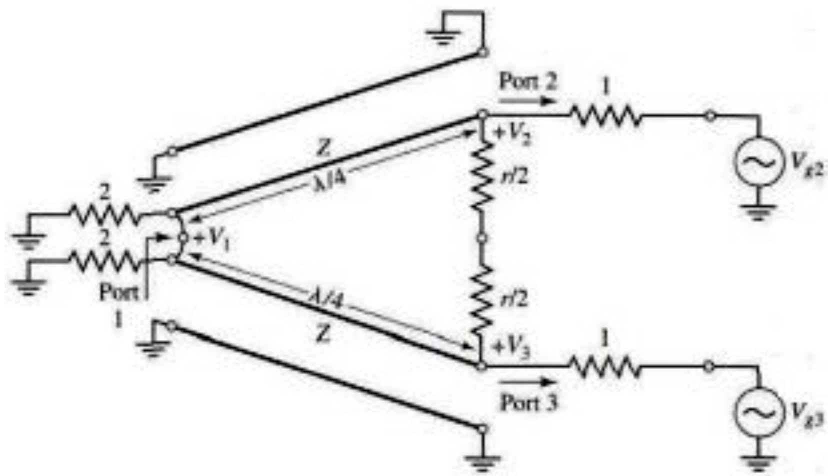
$$P_2 = P_3 = \frac{1}{2}\frac{\left(1/2 V_1\right)^2}{Z_0} = \frac{1}{8}\frac{V_1^2}{Z_0} = \frac{1}{4}P_{in}$$

Divizorul Wilkinson

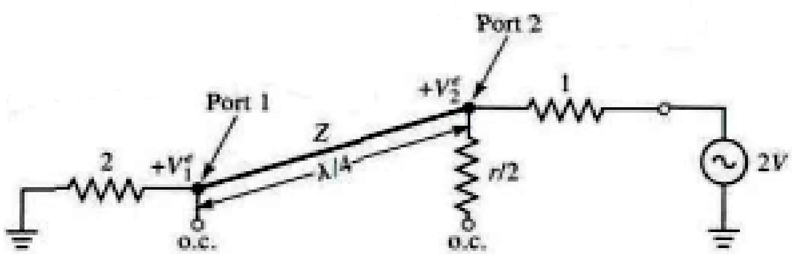




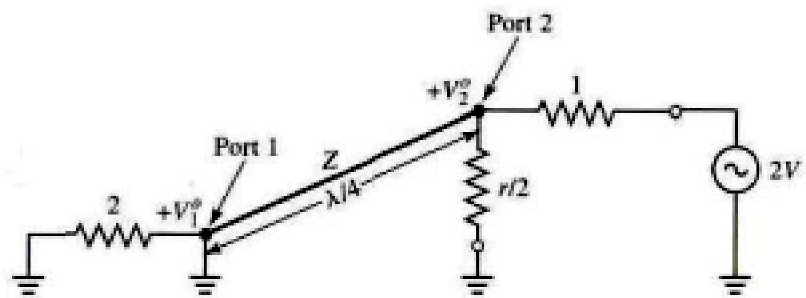
Analiza pe modul par-impar



Modul par

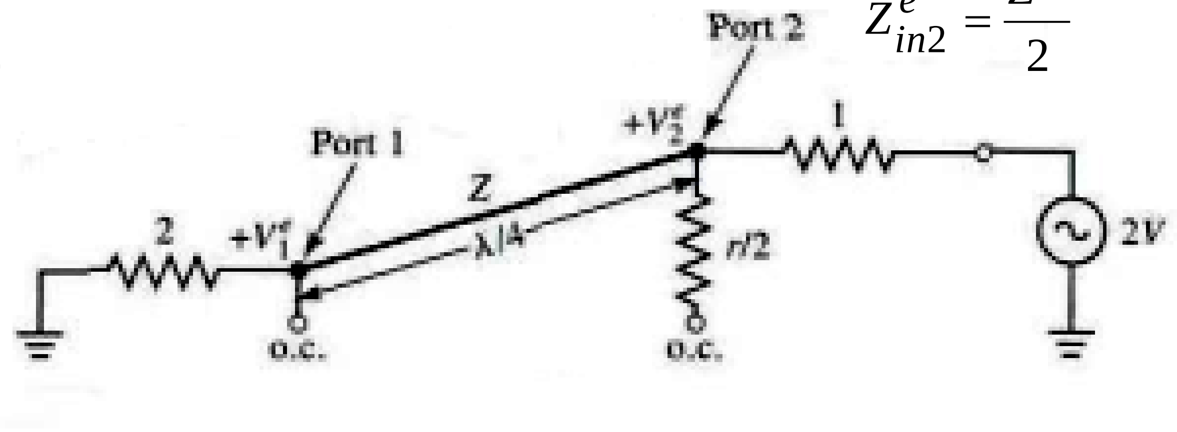


Modul impar



Modul par

$$Z_{in2}^{e} = \frac{Z^2}{2}$$



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

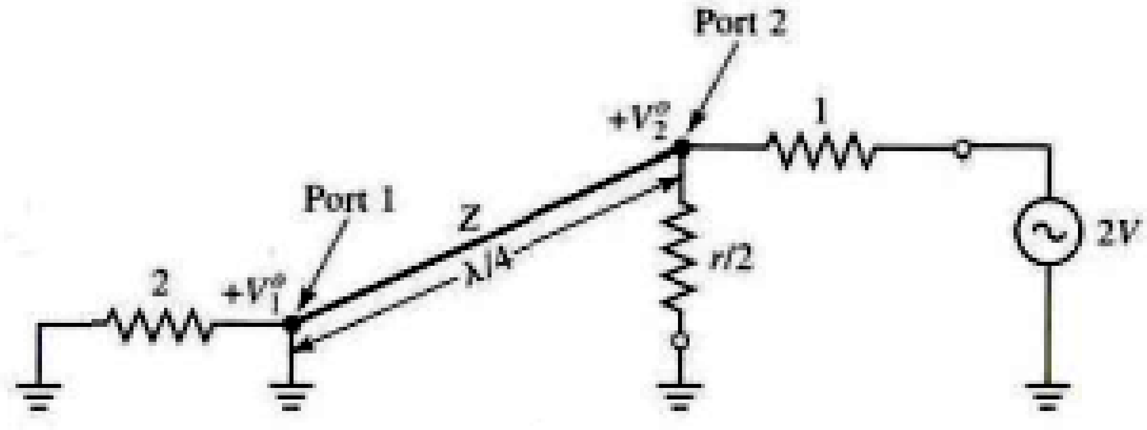
$$V_2^e = V(-\lambda/4) = jV^{+}(1-\Gamma) = 1$$

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

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

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

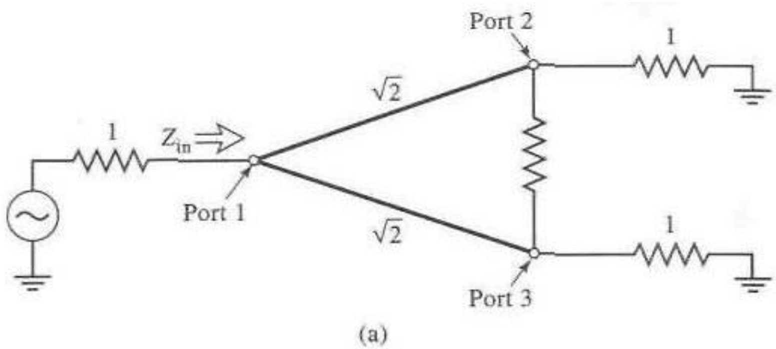
Modul impar

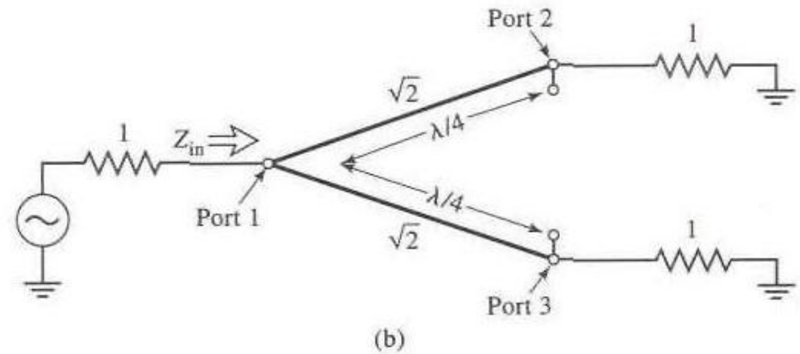


$$V_1^o = 0$$

$$V_2^o = 1$$

Calculul lui S11





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

$$S_{11} = 0$$

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

$$S_{12} = S_{21} = \frac{V_1^e + V_1^o}{V_2^e + V_2^o} = \frac{-j\sqrt{2} + 0}{1+1} = -j\,\frac{\sqrt{2}}{2}$$

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

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

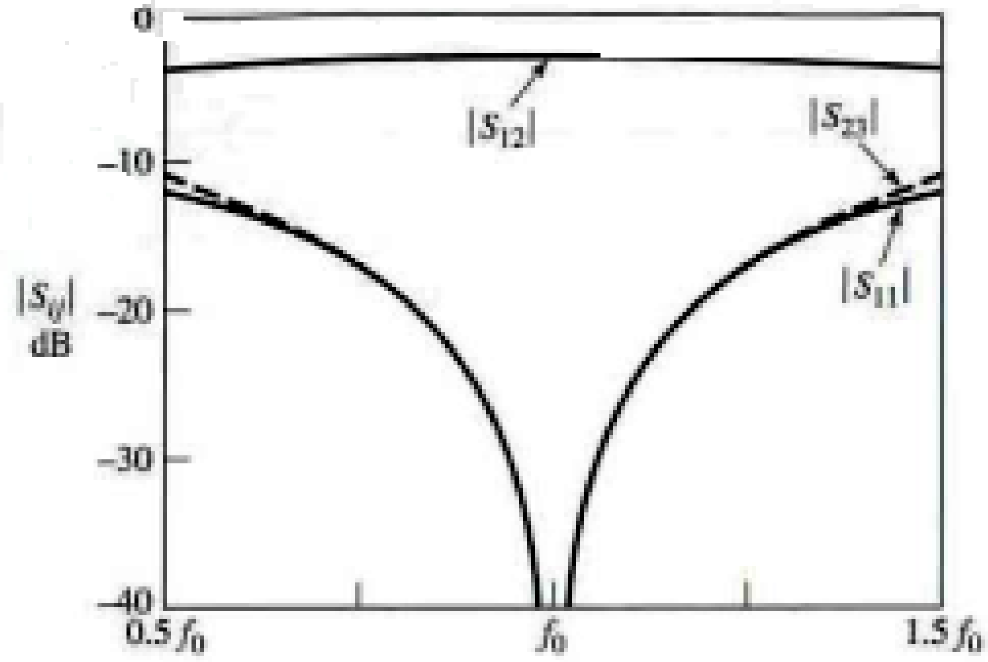
Exemplu

- Proiectaţi un divizor de putere Wilkinson de 3 dB, pe 50Ω, la frecvenţa f_0 şi reprezentaţi grafic pierderile de întoarcere (S_{11}), pierderile de inserţie $(S_{21} = S_{31})$ şi izolarea în funcţie de frecventă.

Solutie

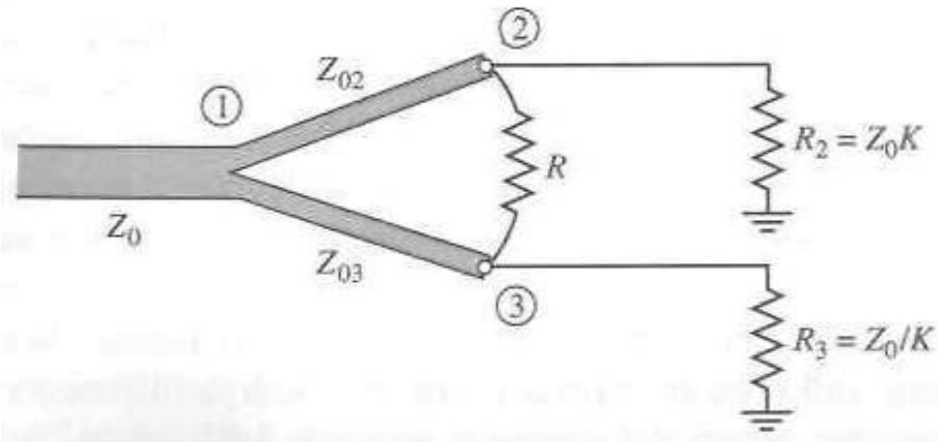
$$Z = \sqrt{2}Z_0 = 70.7\Omega$$

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



Divizorul Wilkinson cu puteri inegale

$$K^2 = P_3/P_2$$



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

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

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

Divizorul Wilkinson cu N cai