CUPLOARE

Proprietati de baza ale cuploarelor directionale

Circuite cu patru porti

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

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

$>$

$$[S] = \begin{bmatrix} 0 & S_{12} & S_{13} & S_{14} \\ S_{12} & 0 & S_{23} & S_{24} \\ S_{13} & S_{23} & 0 & S_{34} \\ S_{14} & S_{24} & S_{34} & 0 \end{bmatrix}$$

(11) $S_{14}^{*}\left(|S_{13}|^2 - |S_{24}|^2\right) = 0$

(13) $S_{23}\left(|S_{12}|^2 - |S_{34}|^2\right) = 0$

(14a) $|S_{12}|^2 + |S_{13}|^2 = 1$

(14b) $|S_{12}|^2 + |S_{24}|^2 = 1$

(14c) $|S_{13}|^2 + |S_{34}|^2 = 1$

(14d) $|S_{24}|^2 + |S_{34}|^2 = 1$

(15) $S_{12}^{*}S_{13} + S_{24}^{*}S_{34} = 0$

+

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

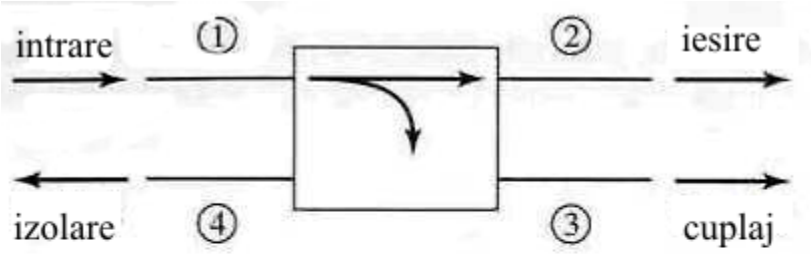
II

$<$ **10 ecuatii**

CONCLUZIE

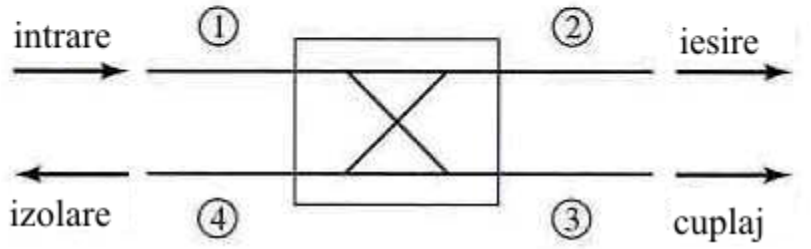
Orice circuit cu patru porti,
reciproc, fara pierderi si adaptat la toate portile
este un cuplor directional

Cuplor directional



$$|S_{12}|^2 = \alpha^2 = 1 - \beta^2$$

$$|S_{13}|^2 = \beta^2$$

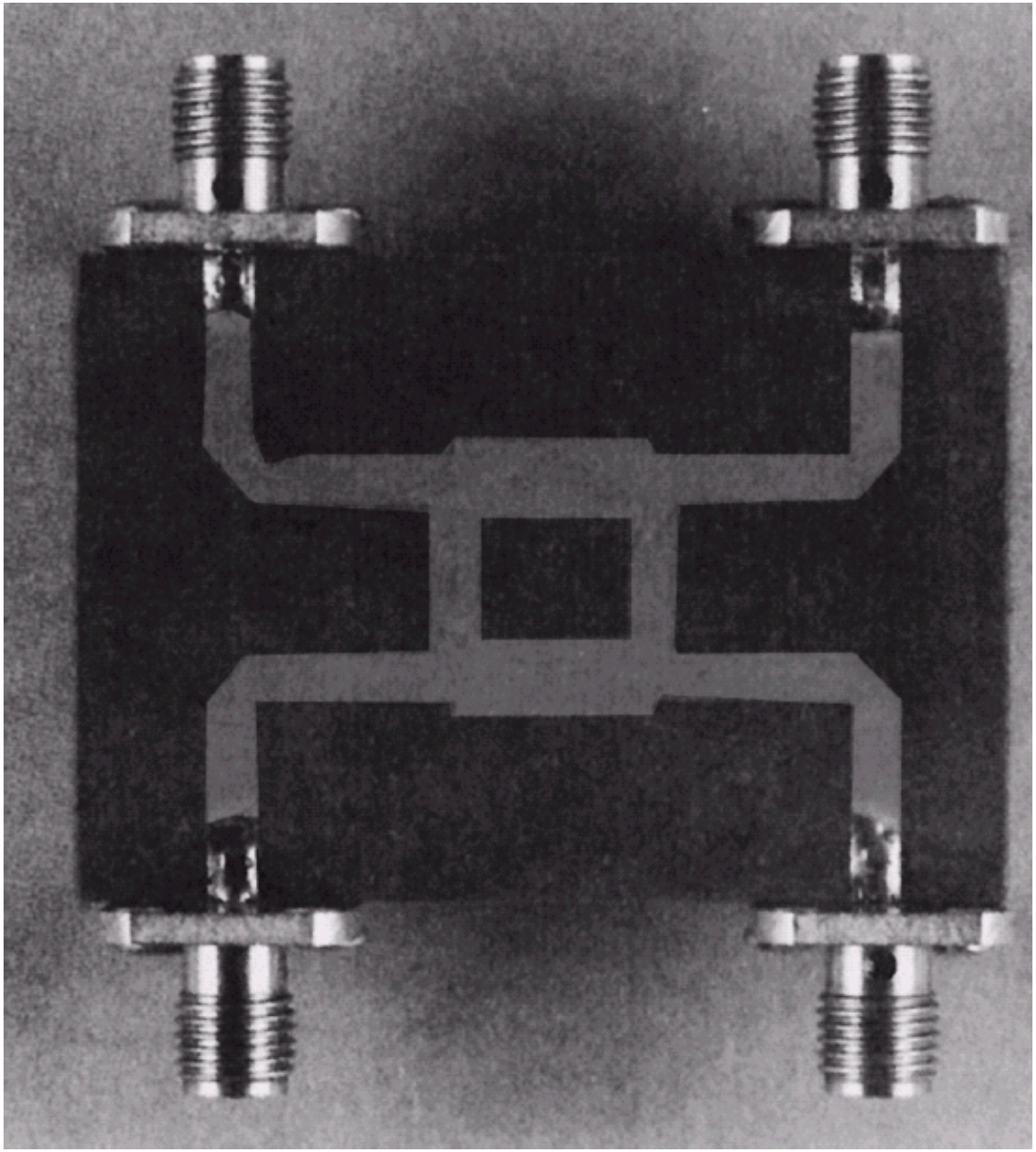


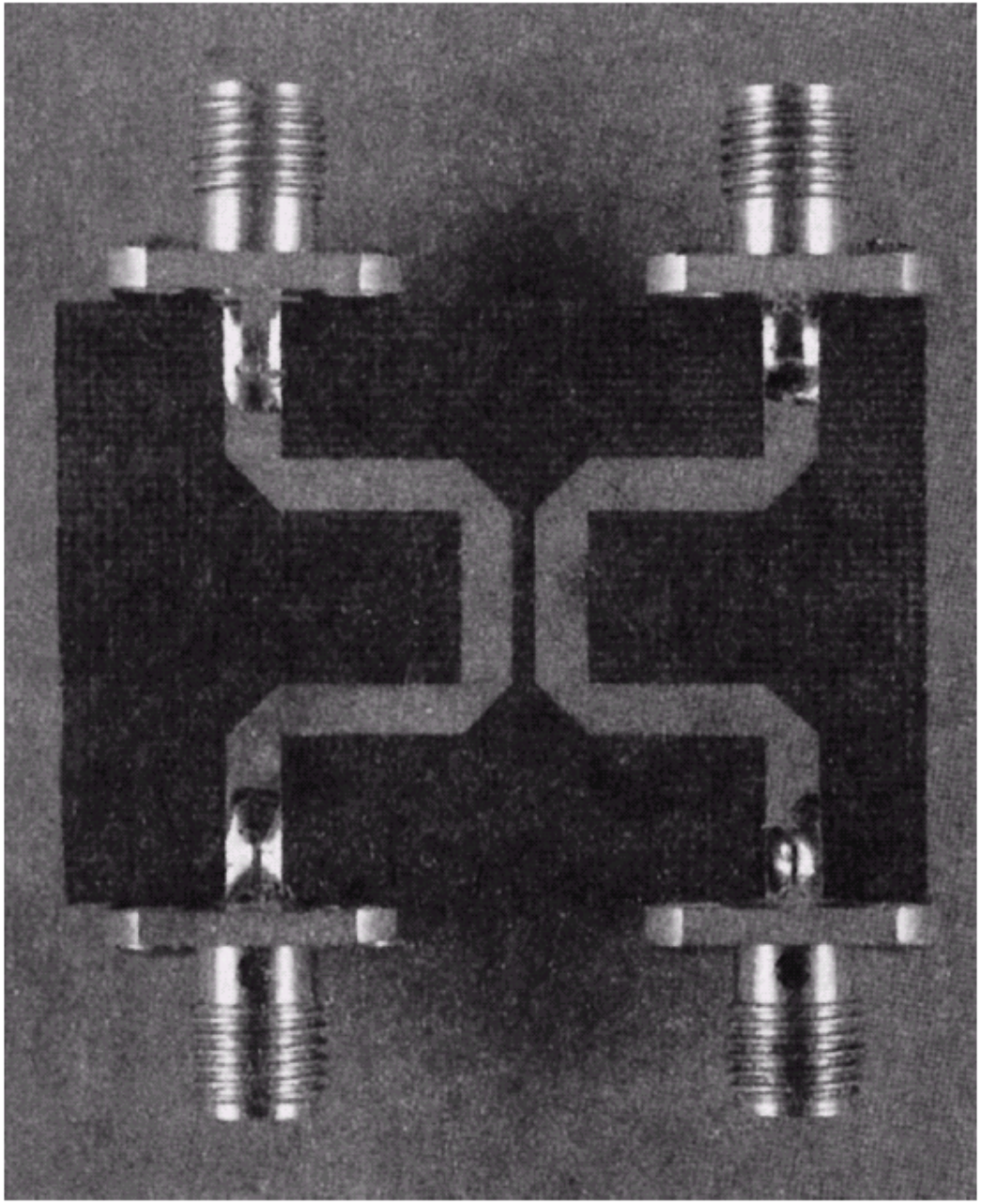
Cuplaj $= C = 10\log\frac{P_1}{P_3} = -20\log(\beta)\ dB$

Directivitate $= D = 10\log\frac{P_3}{P_4} = 20\log\left(\frac{\beta}{|S_{14}|}\right) dB$

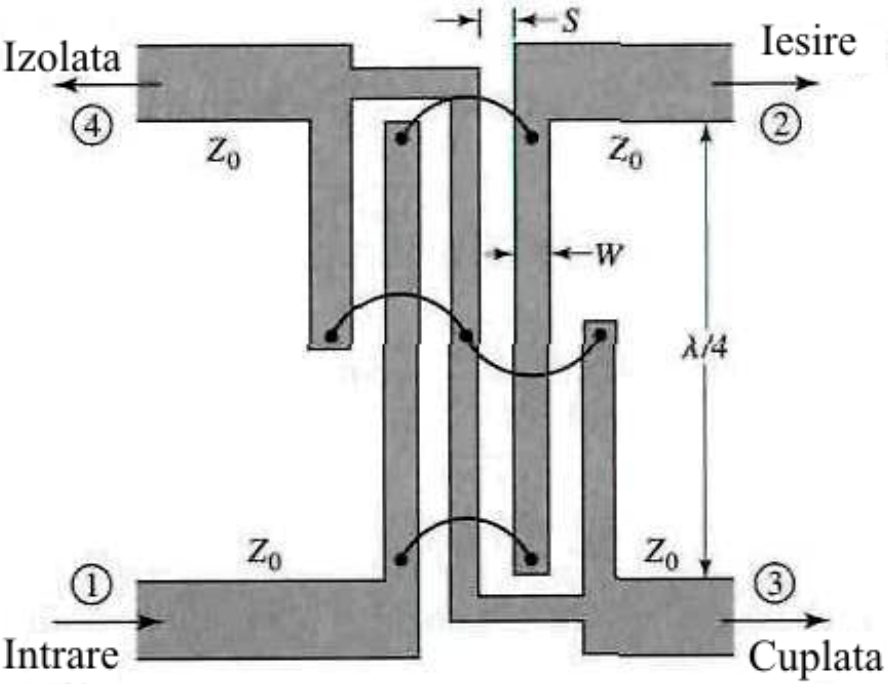
Izolare $= I = 10\log\left(\frac{P_1}{P_4}\right) = -20\log|S_{14}|\ dB$

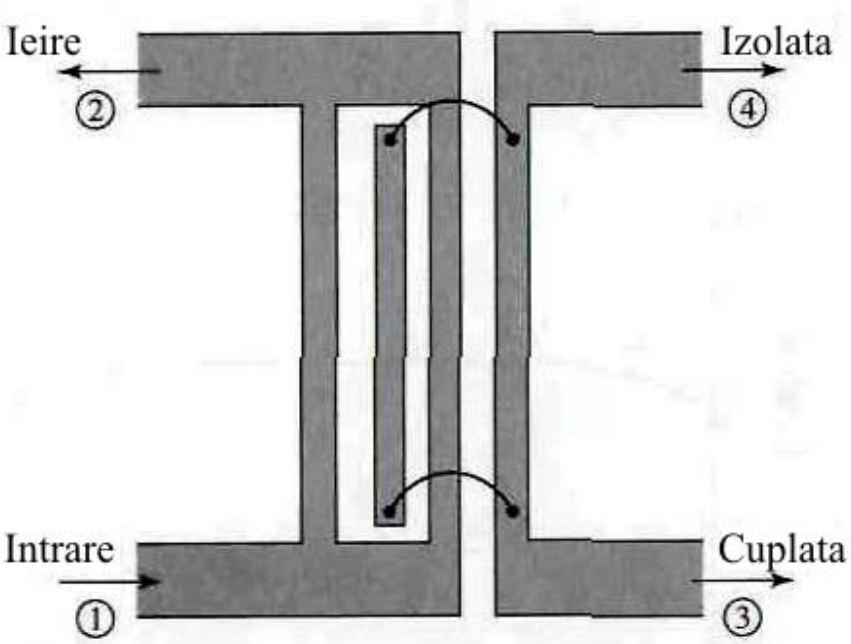
$$I = D + C,\ dB$$



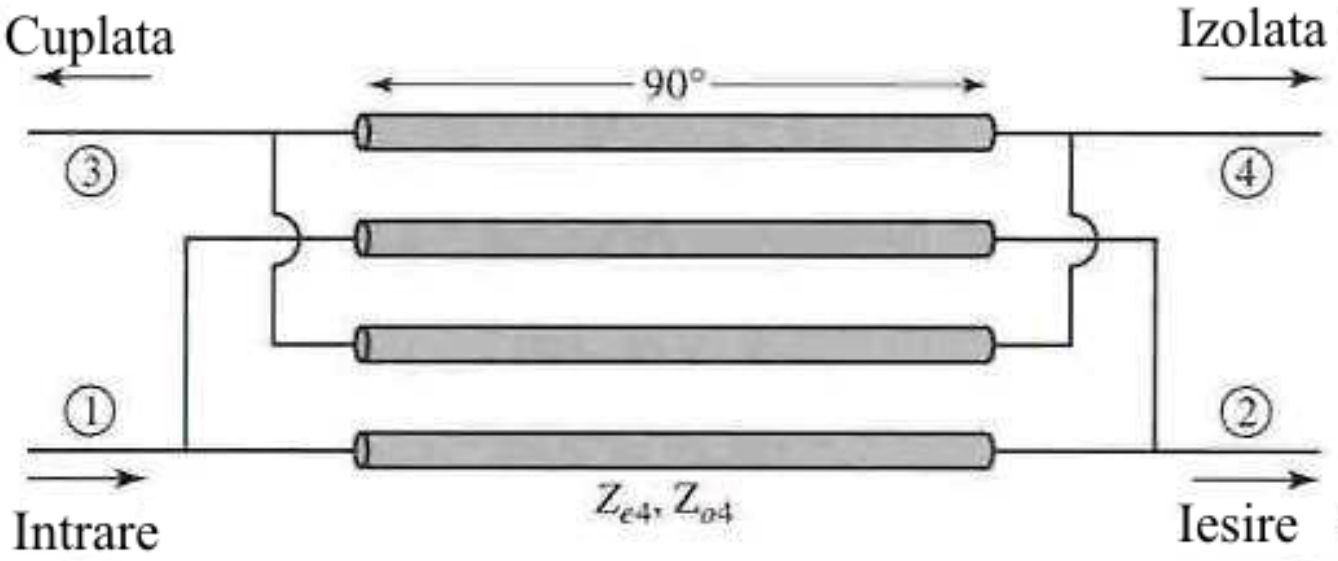


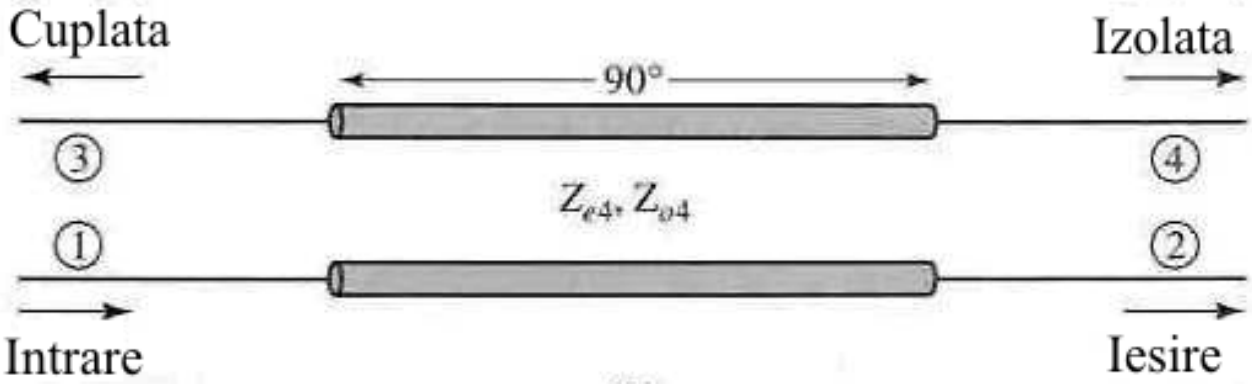
Cuplorul Lange



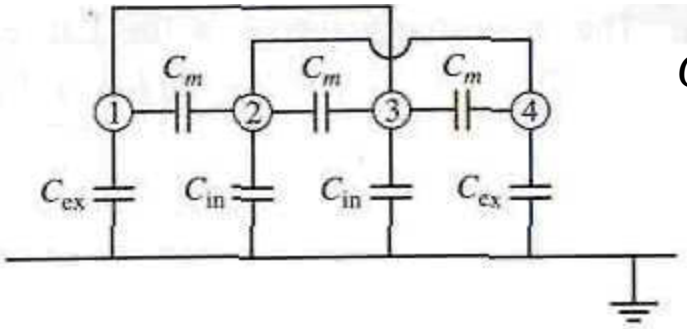


Cuplor Lange





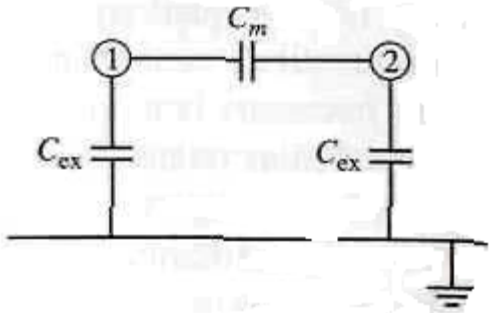
Modelul de circuit



$$C_{in} = C_{ex} - \frac{C_{ex}C_m}{C_{ex} + C_m}$$

$$C_{e4} = C_{ex} + C_{in}$$

$$C_{o4} = C_{ex} + C_{in} + 6C_m$$



$$C_e = C_{ex}$$

$$C_o = C_{ex} + 2C_m$$

$$Z_{e4} = \frac{1}{vC_{e4}}$$

$$Z_{o4} = \frac{1}{vC_{o4}}$$

$$Z_0 = \sqrt{Z_{e4}Z_{o4}} = \sqrt{\frac{Z_{0e}Z_{0o}(Z_{0o} + Z_{0e})^2}{(3Z_{0o} + Z_{0e})(3Z_{0e} + Z_{0o})}}$$

$$C = \frac{Z_{e4} - Z_{o4}}{Z_{e4} + Z_{o4}} = \frac{3\left(Z_{0e}^2 - Z_{0o}^2\right)}{3\left(Z_{0e}^2 + Z_{0o}^2\right) + 2Z_{0e}Z_{0o}}$$

$$C_{e4} = \frac{C_e(3C_e + C_o)}{C_e + C_o}$$

$$C_{o4} = \frac{C_o(3C_o + C_e)}{C_e + C_o}$$

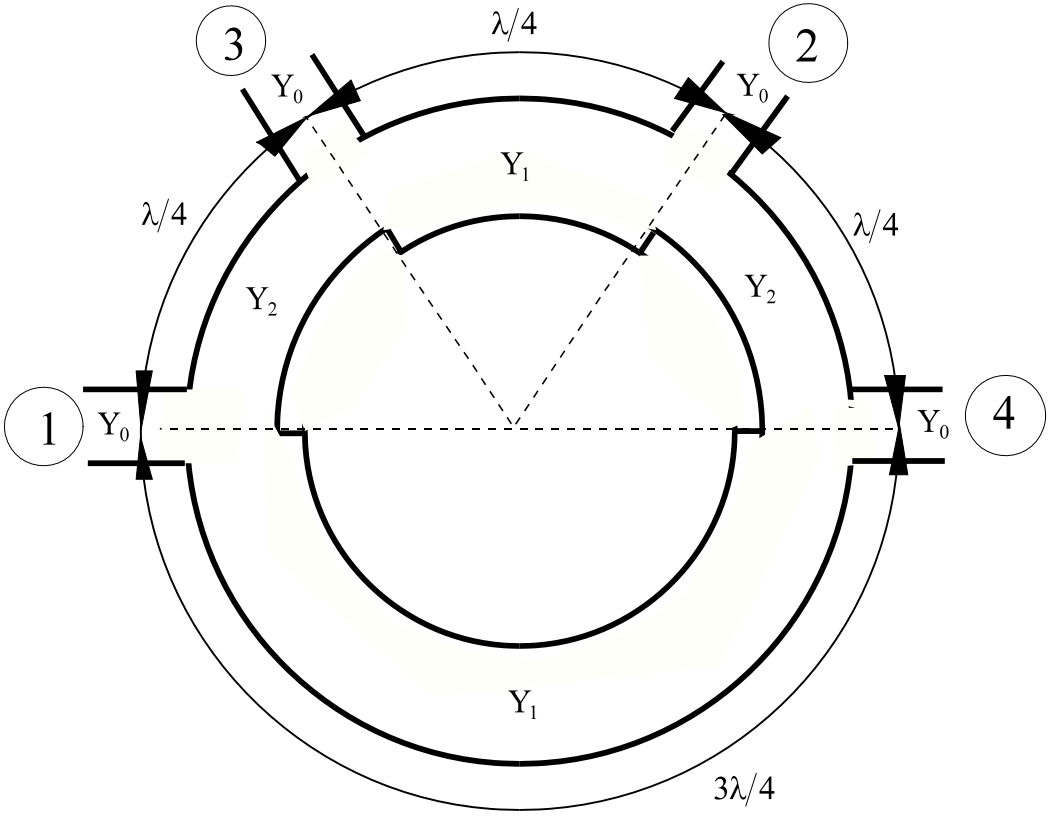
$$Z_{e4} = Z_{0e}\frac{Z_{0e} + Z_{0o}}{3Z_{0o} + Z_{0e}}$$

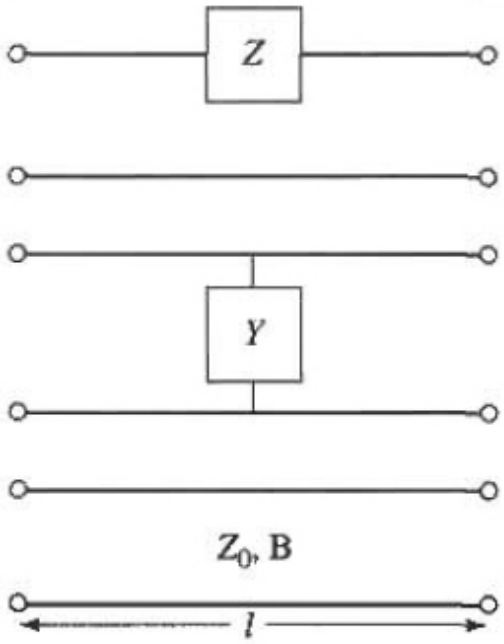
$$Z_{o4} = Z_{0o}\frac{Z_{0e} + Z_{0o}}{3Z_{0e} + Z_{0o}}$$

$$Z_{0e} = \frac{4C - 3 + \sqrt{9 - 8C^2}}{2C\sqrt{(1-C)/(1+C)}}Z_0$$

$$Z_{0o} = \frac{4C + 3 - \sqrt{9 - 8C^2}}{2C\sqrt{(1+C)/(1-C)}}Z_0$$

Cuplorul in inel



Circuit	*ABCD* Parameters	
	$A = 1$ $C = 0$	$B = Z$ $D = 1$
	$A = 1$ $C = Y$	$B = 0$ $D = 1$
	$A = \cos \beta\ell$ $C = jY_0 \sin \beta\ell$	$B = jZ_0 \sin \beta\ell$ $D = \cos \beta\ell$

Linie de transmisie cu impedanta de terminatie

$$Z_{in} = Z_0 \frac{(Z_L + Z_0)e^{j\beta\ell} + (Z_L - Z_0)e^{-j\beta\ell}}{(Z_L + Z_0)e^{j\beta\ell} - (Z_L - Z_0)e^{-j\beta\ell}}$$

$$= Z_0 \frac{Z_L \cos \beta\ell + jZ_0 \sin \beta\ell}{Z_0 \cos \beta\ell + jZ_L \sin \beta\ell}$$

$$= Z_0 \frac{Z_L + jZ_0 \tan \beta\ell}{Z_0 + jZ_L \tan \beta\ell}.$$

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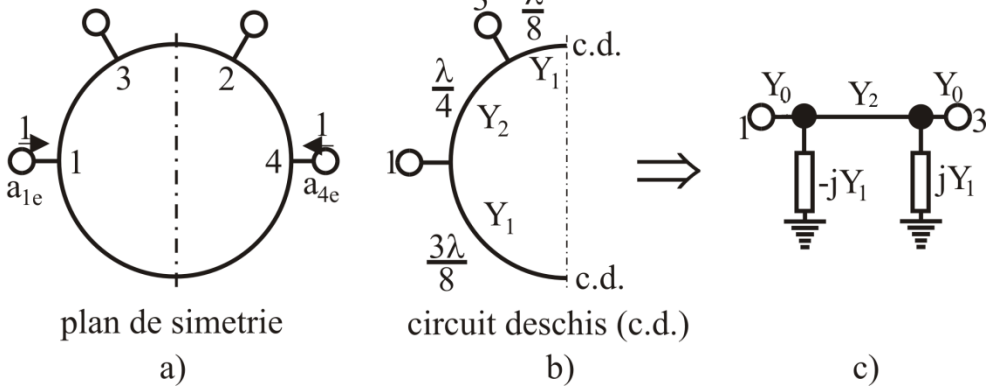
$$Z_{in} = jZ_0 \tan \beta\ell,$$

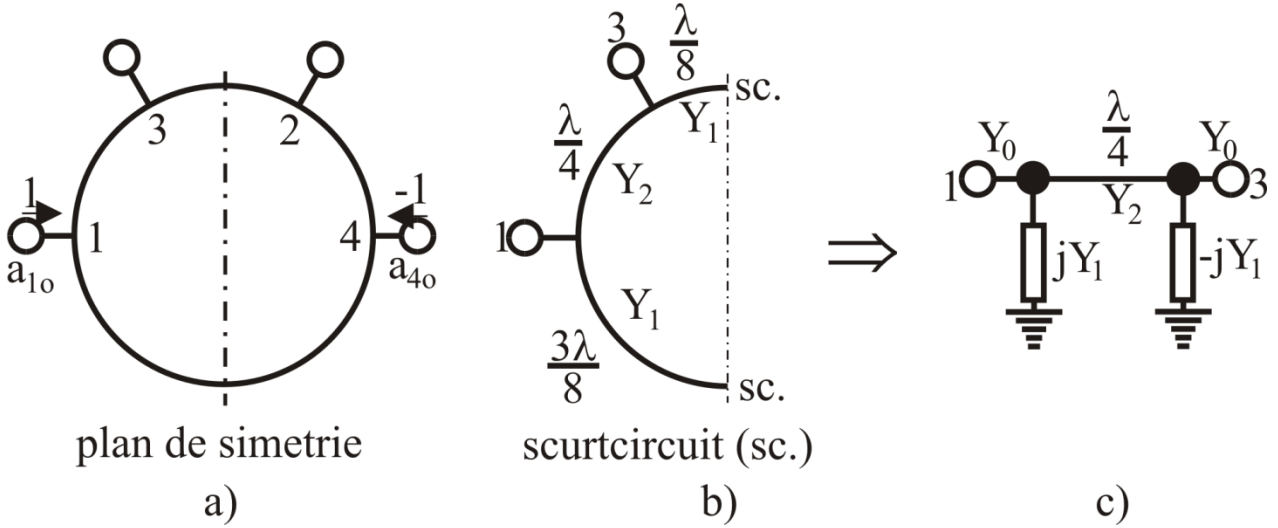
gol

$$Z_{in} = -jZ_0 \cot \beta\ell,$$

Analiza cuplorului in inel



Modul par

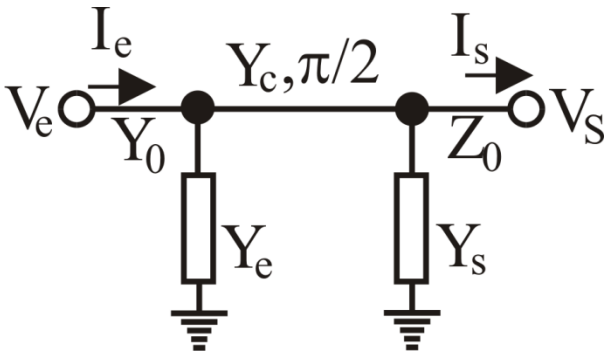


Modul impar

Analiza cuplorului in inel

$$S_{11} = \frac{jz_2y_s + jz_2 - j(y_2 + y_e y_s z_2) - jy_e z_2}{jz_2y_s + jz_2 + j(y_2 + y_e y_s z_2) + jy_e z_2}$$

$$S_{12} = \frac{2}{jz_2y_s + jz_2 + j(y_2 + y_e y_s z_2) + jy_e z_2}$$



$$S_{21} = \frac{2}{jz_2y_s + jz_2 + j(y_2 + y_e y_s z_2) + jy_e z_2}$$

$$S_{22} = \frac{-jz_2y_s + jz_2 - j(y_2 + y_e y_s z_2) + jy_e z_2}{jz_2y_s + jz_2 + j(y_2 + y_e y_s z_2) + jy_e z_2}$$

Pentru modul par:

$y_e = -jy_1$

$y_s = jy_1$

Conditia de adaptare

$$y_1^2 + y_2^2 = 1$$

$$[S] = \begin{bmatrix} 0 & 0 & -jy_2 & jy_1 \\ 0 & 0 & -jy_1 & -jy_2 \\ -jy_2 & -jy_1 & 0 & 0 \\ jy_1 & -jy_2 & 0 & 0 \end{bmatrix}$$

Pe modul impar:

$y_e = jy_1$

$y_s = -jy_1$

$$S_{11o} = \frac{z_2 - y_2 - y_1^2 z_2 - 2jz_2y_1}{z_2 + y_2 + y_1^2 z_2}$$

$$S_{12o} = S_{21o} = \frac{-2j}{z_2 + y_2 + y_1^2 z_2}$$

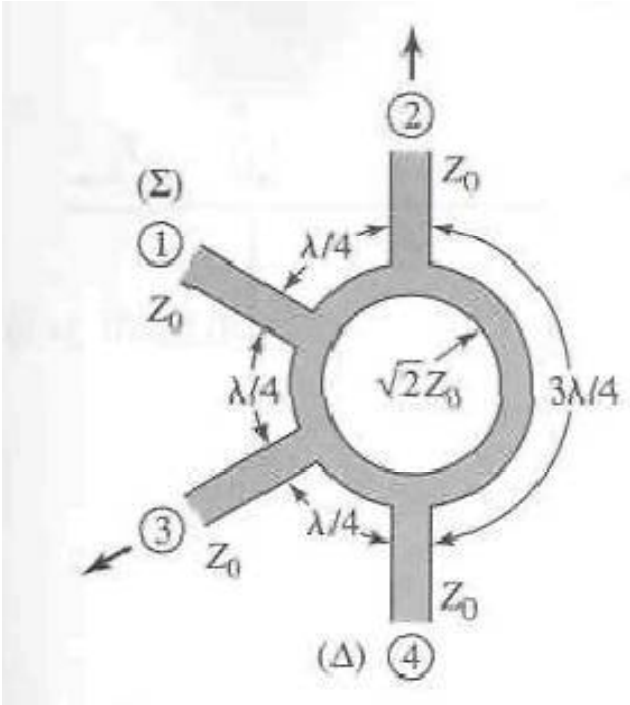
$$S_{22o} = \frac{z_2 - y_2 - y_1^2 z_2 + 2jz_2y_1}{z_2 + y_2 + y_1^2 z_2}$$

$$S_{11e} = \frac{z_2 - y_2 - y_1^2 z_2 + 2jz_2y_1}{z_2 + y_2 + y_1^2 z_2}$$

$$S_{12e} = S_{21e} = \frac{-2j}{z_2 + y_2 + y_1^2 z_2}$$

$$S_{22e} = \frac{z_2 - y_2 - y_1^2 z_2 - 2jz_2y_1}{z_2 + y_2 + y_1^2 z_2}$$

Cuplorul in inel



$$[S]=\begin{bmatrix} 0 & -jy_2 & -jy_1 & 0 \\ -jy_2 & 0 & 0 & jy_1 \\ -jy_1 & 0 & 0 & -jy_2 \\ 0 & jy_1 & -jy_2 & 0 \end{bmatrix} = -j\begin{bmatrix} 0 & \alpha & \beta & 0 \\ \alpha & 0 & 0 & -\beta \\ \beta & 0 & 0 & \alpha \\ 0 & -\beta & \alpha & 0 \end{bmatrix}$$

$$C(dB) = -20\log(\beta) = -20\log(y_1)$$

Proiectarea şi performanța unui cuplor în inel

Proiectați un cuplor în inel pe impedanța de 50 Ω şi reprezentati mărimea parametrilor S între 0.5 si 1.5 din frecventa centrala.

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