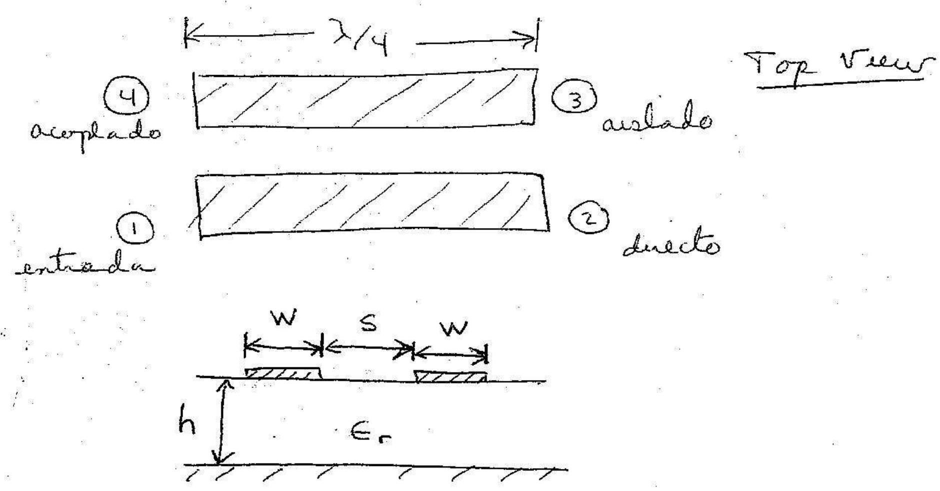
INEL 5306

- Resumen

  - Wilkinson Power Divider ⟹ 3 puertos
  - Branch Line Coupler ⟹ 4 puertos
  - Ambos operan en un ancho de banda estrecho.
  - El "branch line coupler" se usa para acoplamientos "fuertes" (2 - 9 dB)

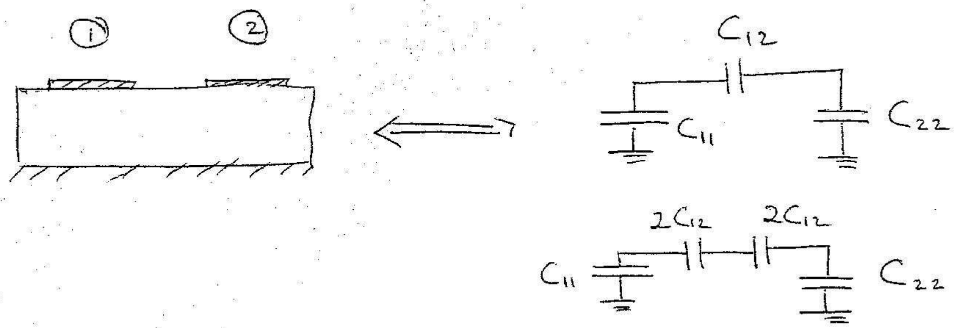
Otra estructura de 4-puertos que provee ancho de banda amplio es el "Coupled line coupler"



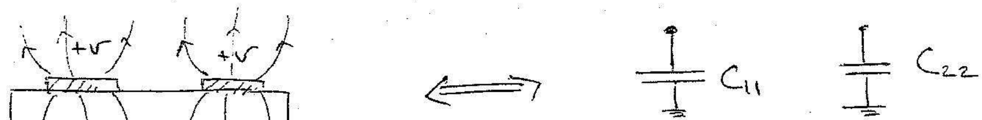
- principio de operación, interacción de campo EM entre líneas cercanas

- ancho de banda es amplio
- acople "débil" ($C_{max} = 8 \sim 9$ dB)

Modelo Capacitores



Modo Par

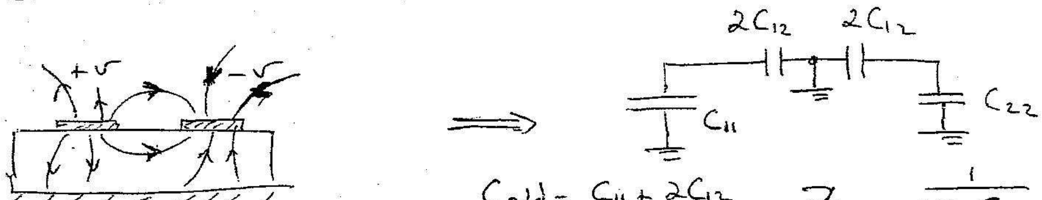


$$C_{even} = C_{11} = C_{22}$$

$$Z_o = \sqrt{\frac{L}{C}} = \frac{\sqrt{LC}}{C} = \frac{1}{Cv}$$

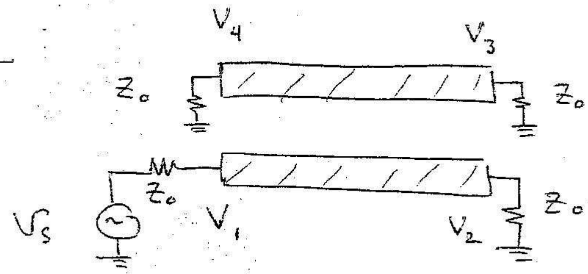
$$Z_{oe} = \frac{1}{v_e C_e}$$

Modo Impar

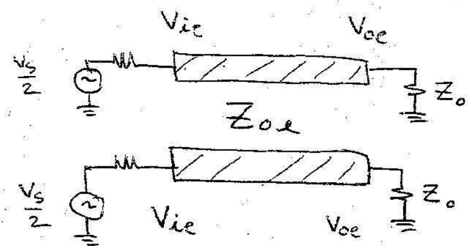


$$C_{odd} = C_{11} + 2C_{12} \qquad Z_{odd} = \frac{1}{v_p C_{odd}}$$

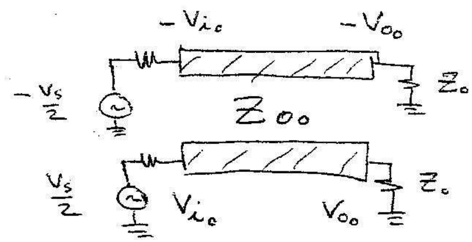
Diseño



Modo Par



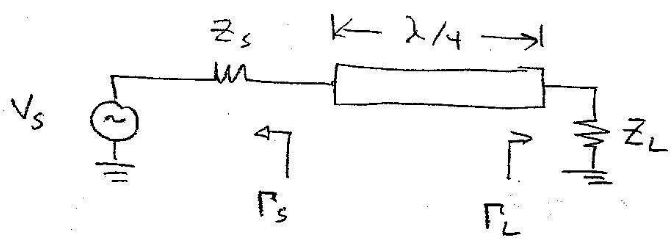
Modo Impar



$V_1 = V_{ie} + V_{io}$ $\qquad$ $V_2 = V_{oe} + V_{oo}$

$V_3 = V_{oe} - V_{oo}$ $\qquad$ $V_4 = V_{ie} - V_{io}$

Analizar una línea de transmisión.



Si $Z_s = Z_L$

$\therefore \Gamma_s = \Gamma_L = \Gamma$

$$V_{in} = \frac{V_s}{2}\left(1 - \frac{2\Gamma}{1+\Gamma^2}\right)$$

$$V_{out} = \frac{V_s}{2}\left(\frac{(1-\Gamma^2)\, e^{-j90^\circ}}{1+\Gamma^2}\right)$$

Voltajes en términos de Γ

Podemos decir que:

$$V_{ie} = \frac{V_s}{4}\left(1 - \frac{2\Gamma_e}{1+\Gamma_e^2}\right) \qquad \Gamma_e = \frac{Z_0 - Z_{0e}}{Z_0 + Z_{0e}}$$

$$V_{oe} = \frac{V_s}{4}\left(\frac{(1-\Gamma_e^2)\,e^{-j90}}{1+\Gamma_e^2}\right)$$

$$V_{io} = \frac{V_s}{4}\left(1 - \frac{2\Gamma_o}{1+\Gamma_o^2}\right)$$

$$V_{oo} = \frac{V_s}{4}\left(\frac{(1-\Gamma_o^2)\,e^{-j90}}{1+\Gamma_o^2}\right) \qquad \Gamma_o = \frac{Z_0 - Z_{00}}{Z_0 + Z_{00}}$$

Analizar cada voltaje en puertos ①, ② ....

a) $$V_1 = \frac{V_s}{4}\left(2 - \frac{2\Gamma_e}{1+\Gamma_e^2} - \frac{2\Gamma_o}{1+\Gamma_o^2}\right) = V_{ie} + V_{io}$$

Si quiero ① acoplado $V_1 = \frac{V_s}{2}$

Esto lo logro si $\Gamma_e = -\Gamma_o$

Lo cual implica $\boxed{Z_0 = \sqrt{Z_{0e} Z_{00}}}$

b) $$V_4 = \frac{V_s}{4}\left(1 - \frac{2\Gamma_e}{1+\Gamma_e^2}\right) - \frac{V_s}{4}\left(1 - \frac{2\Gamma_o}{1+\Gamma_o^2}\right)$$

$$= -\frac{V_s}{4}\left(2\left(\frac{2\Gamma_e}{1+\Gamma_e^2}\right)\right) = \frac{V_s}{2}\left(\frac{-2\Gamma_e}{1+\Gamma_e^2}\right)$$

$$= \frac{V_s}{2}\left(\frac{Z_{0e} - Z_{00}}{Z_{0e} + Z_{00}}\right) = \frac{V_s}{2}\,C$$

C ← "coupling factor"

$$V_3 = V_{oe} - V_{oo} = 0 \quad (\Gamma_e = -\Gamma_o)$$

$$V_2 = -j \frac{V_s}{2} \sqrt{1-c^2}$$

Para acoplador de 3dB ("hybrid coupler")

$V_s = 2V \quad c = .707$ notar que:

$V_1 = \frac{V_s}{2} = 1 \qquad V_4 = .707 \qquad V_3 = 0 \qquad V_2 = -j\,.707$

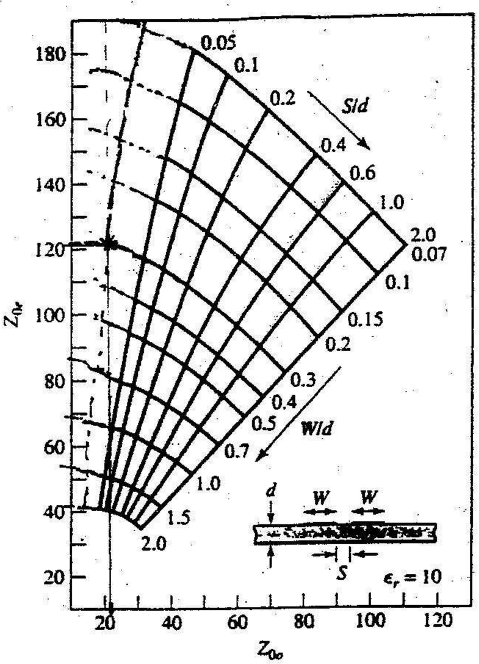
Para ecuaciones de diseño, debo relacionar Z_{oe} y Z_{oo} a dimensiones del acoplador W y S.

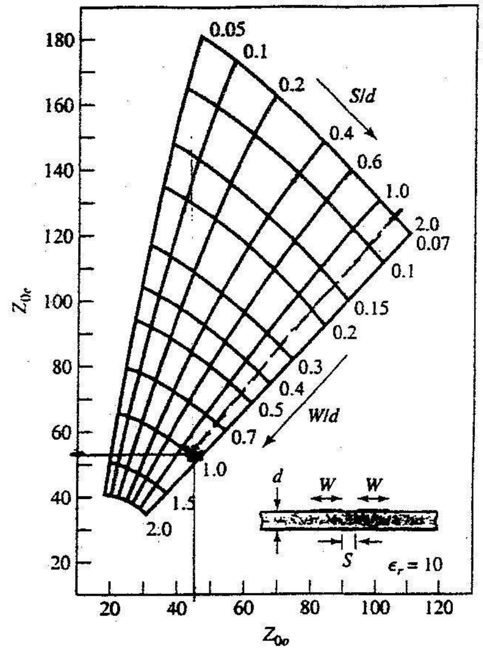
Tenemos que: $C = \frac{Z_{oe} - Z_{oo}}{Z_{oe} + Z_{oo}}$ y $Z_o = \sqrt{Z_{oe} Z_{oo}}$

$$Z_{oe} = Z_o \sqrt{\frac{1+C}{1-C}}$$

$$Z_{oo} = Z_o \sqrt{\frac{1-C}{1+C}}$$

↙ pg. 340 ↘





$Z_o = 50\Omega \quad C = .707$

$Z_{oe} = 50\sqrt{\frac{1+.707}{1-.707}} = 121\Omega$

$Z_{oo} = 50\sqrt{\frac{1-.707}{1+.707}} = 20.7\Omega$

S is very small

→ $C_{dB} = 20$ dB

$Z_o = 50\Omega \quad C = 0.1$

$Z_{oe} = 53.3\Omega \quad Z_{oo} = 45.2\Omega$

$S/d = 1.5 \quad \frac{W}{d} = 1$

for 42 mil substrate $\epsilon_r = 10.0$

$S = (1.5)(42) = 63$ mils

$W = (1)(42) = 42$ mils

Notar que Z_{oo} tiende a ser pequeña para acoplamiento fuerte. ∴ C_o es grande. Si tenemos expresión donde Z_{oo} sea mas grande para $C = .707$, entonces podemos fabricar el acoplador.

EE 5306 Homework

Design a 3 dB quadrature hybrid with a center frequency of 3 GHz. Go to Rogers Corporation web page (www.rogers-corp.com) or Taconics and select a suitable material for your design. Keep the same substrate material for ALL your designs.

Design the hybrid for each of the cases below:

a) Wilkinson Power Divider
b) Branch Line Coupler
c) Coupled Line Coupler
d) Lange Coupler

Show your calculations and verify the results using ADS. Hand in your plots, the circuit schematics, and the layout plot (generated by ADS or by hand). Discuss the advantages and disadvantages of each structure. Show the results in dB and verify that the phase differnce between the output ports is 90^0. Plot results from 0.5 to 5 GHz.