

Curs 8  
2015/2016

# Dispozitive și circuite de microunde pentru radiocomunicații

# Disciplina 2015/2016

- 2C/1L, DCMR (CDM)
- **Minim 7 prezente (curs+laborator)**
- Curs - **sl. Radu Damian**
  - Marti 18-20, P2
  - E – 60% din nota
  - probleme + (2p prez. curs)
    - 3p=+0.5p
  - **toate materialele permise**
- Laborator – **sl. Radu Damian**
  - Miercuri 8-14 impar (14.10.2015 – prez. obligatorie)
  - L – 25% din nota
  - P – 15% din nota

# Fotografii +0.5p

Grupa 5403																																							
Nr.	Student	Prezent	Nr.	Student	Prezent	Nr.	Student	Prezent																															
1	ANGHELUS IONUT-MARCUS		<input type="checkbox"/> Prezent	2	ANTIGHIN FLORIN-RAZVAN	 <b>Fotografia nu există</b>	3	ANTONICA BIANCA	 <b>Fotografia nu există</b>	4	APOSTOL PAVEL-MANUEL	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent	5	BALASCA TUDIAN-PETRU	 <b>Fotografia nu există</b>	6	BOSTAN ANDREI-PETRICA	 <b>Fotografia nu există</b>	7	BOTEZAT EMANUEL		<input type="checkbox"/> Prezent	8	BUTUNOI GEORGE-MADALIN	 <b>Fotografia nu există</b>	9	CHILEA SALUCA-MARIA	 <b>Fotografia nu există</b>	10	CHIRITOIU CATERINA		<input type="checkbox"/> Prezent	11	CODOC MARIUS		12	COJOCARU AURA-FLORINA	

Nr. Student

Prezent

2 ANTIGHIN  
FLORIN-RAZVAN

Prezent

Puncte: 0

Nota: 0

Obs:

**Fotografia nu există**

# Reprezentare logarithmică

$$\text{dB} = 10 \cdot \log_{10} (P_2 / P_1)$$

$$0 \text{ dB} = 1$$

$$+0.1 \text{ dB} = 1.023 (+2.3\%)$$

$$+3 \text{ dB} = 2$$

$$+5 \text{ dB} = 3$$

$$+10 \text{ dB} = 10$$

$$-3 \text{ dB} = 0.5$$

$$-10 \text{ dB} = 0.1$$

$$-20 \text{ dB} = 0.01$$

$$-30 \text{ dB} = 0.001$$

$$\text{dBm} = 10 \cdot \log_{10} (P / 1 \text{ mW})$$

$$0 \text{ dBm} = 1 \text{ mW}$$

$$3 \text{ dBm} = 2 \text{ mW}$$

$$5 \text{ dBm} = 3 \text{ mW}$$

$$10 \text{ dBm} = 10 \text{ mW}$$

$$20 \text{ dBm} = 100 \text{ mW}$$

$$-3 \text{ dBm} = 0.5 \text{ mW}$$

$$-10 \text{ dBm} = 100 \mu\text{W}$$

$$-20 \text{ dBm} = 1 \mu\text{W}$$

$$-30 \text{ dBm} = 1 \text{ nW}$$

$$[\text{dBm}] + [\text{dB}] = [\text{dBm}]$$

$$[\text{dBm}/\text{Hz}] + [\text{dB}] = [\text{dBm}/\text{Hz}]$$

$$[x] + [\text{dB}] = [x]$$

# Minitest C7

- 16 raspunsuri corecte
    - T<sub>1</sub> = 5, "REPI nu exista ca termen"
    - T<sub>2</sub> = 7, "Prostii/FAKE/Nu exista"
    - T<sub>3</sub> = 4, "Unda nu poate fi PI"
  - 16 X op
  - 1 X 0.25p
- 
- 16 X op? Dezbateră

# Dezbateră

■ Clientul nostru,  
stapanul nostru

# Dezbateră

- Interesul clientului 
- Voimța clientului 

# Dezbaterie

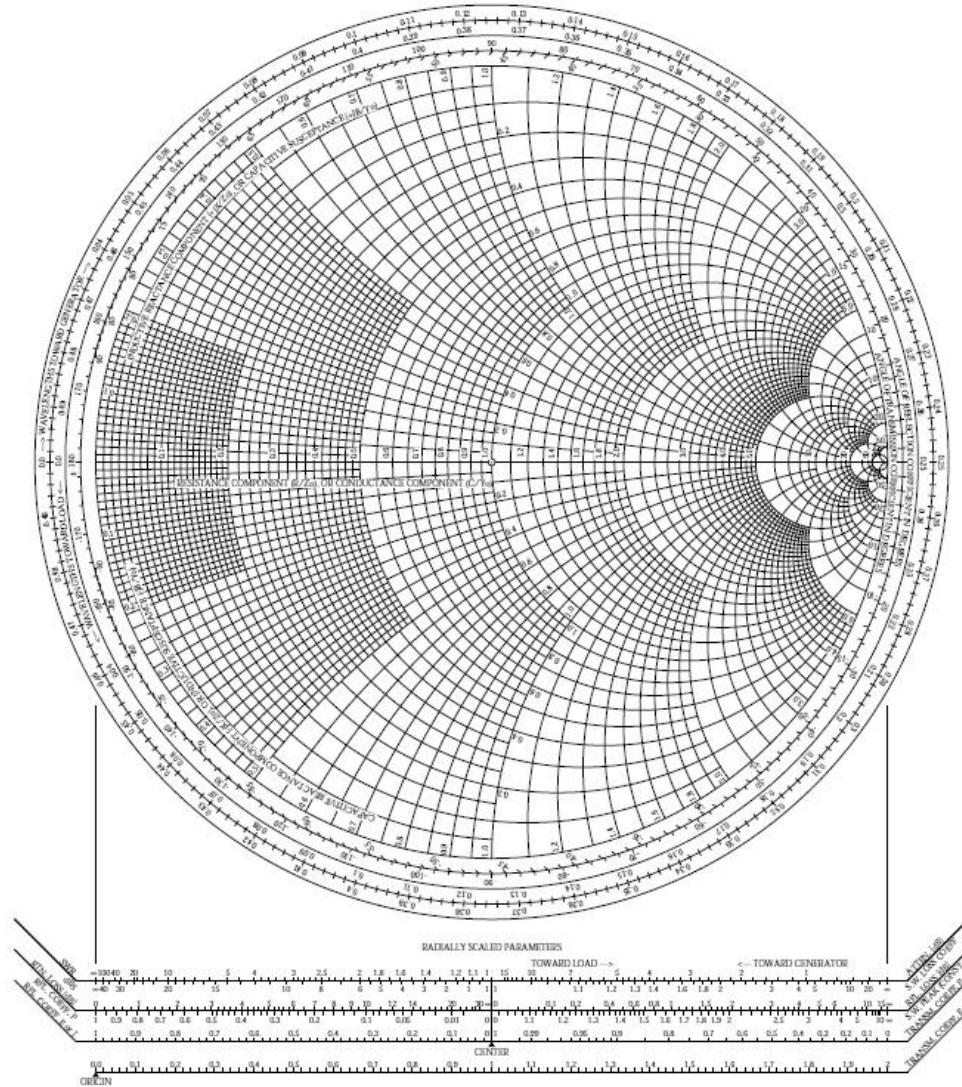
■ Client = ?

# Recapitulare

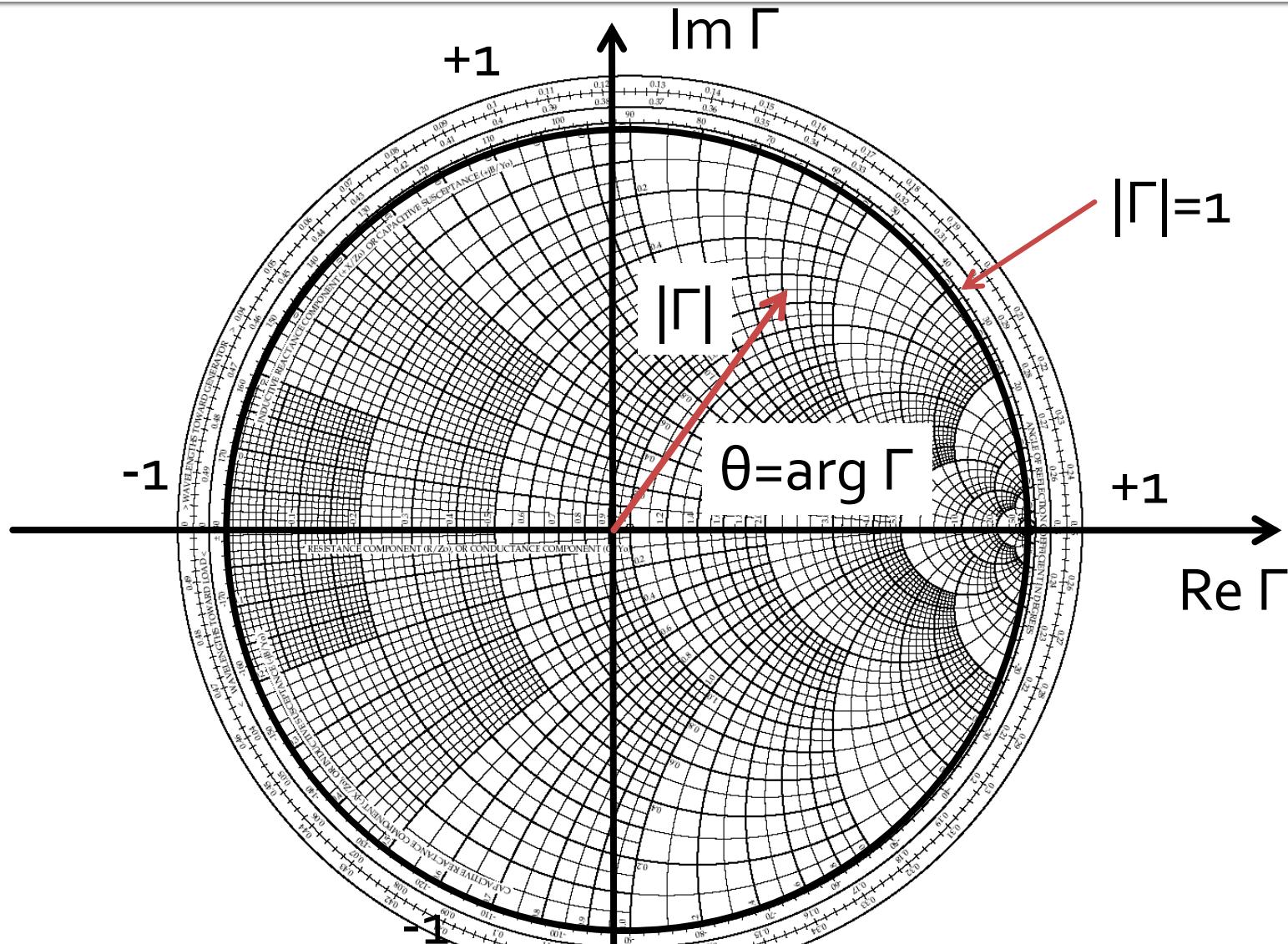
Adaptarea de impedanță

# Diagrama Smith

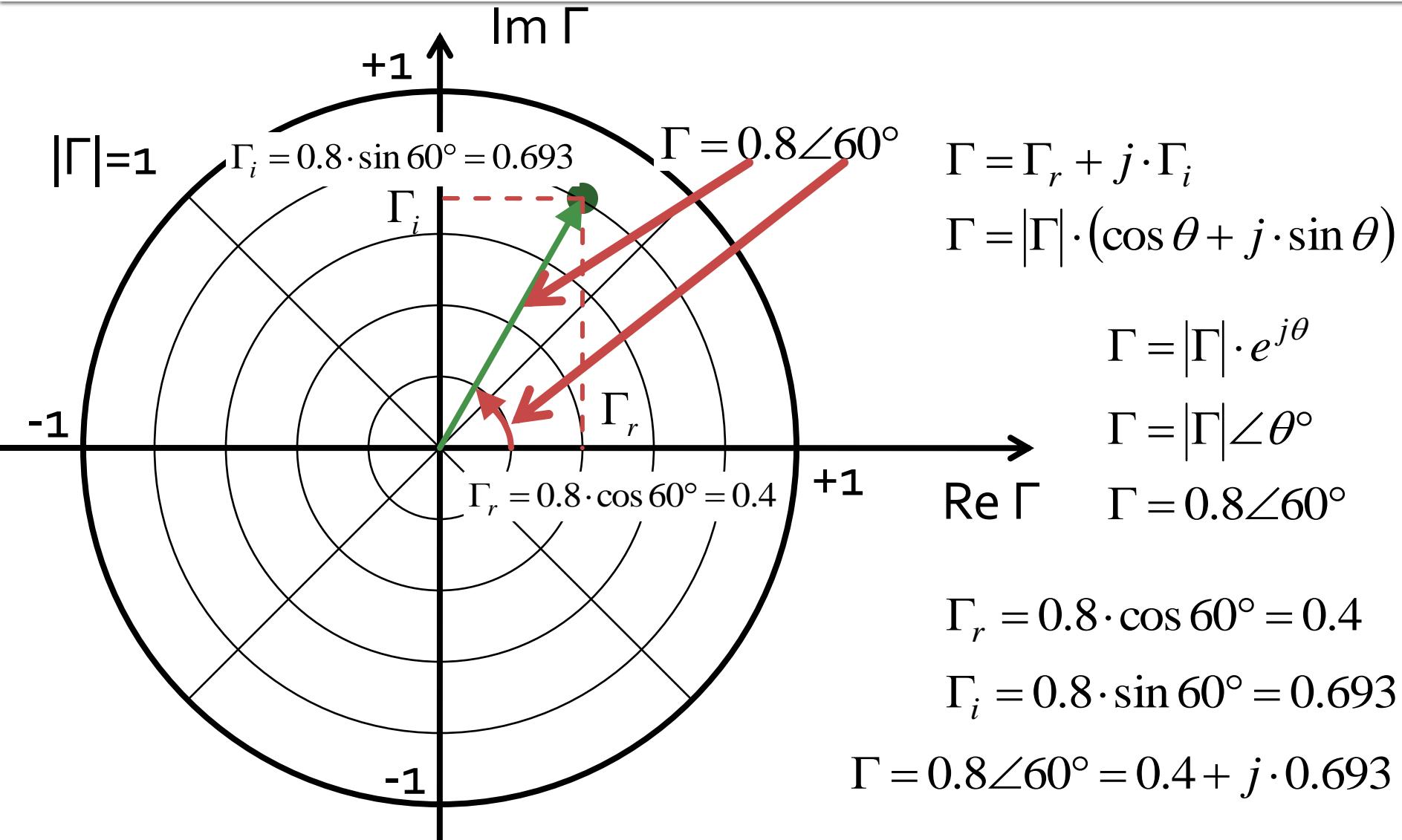
# Diagrama Smith



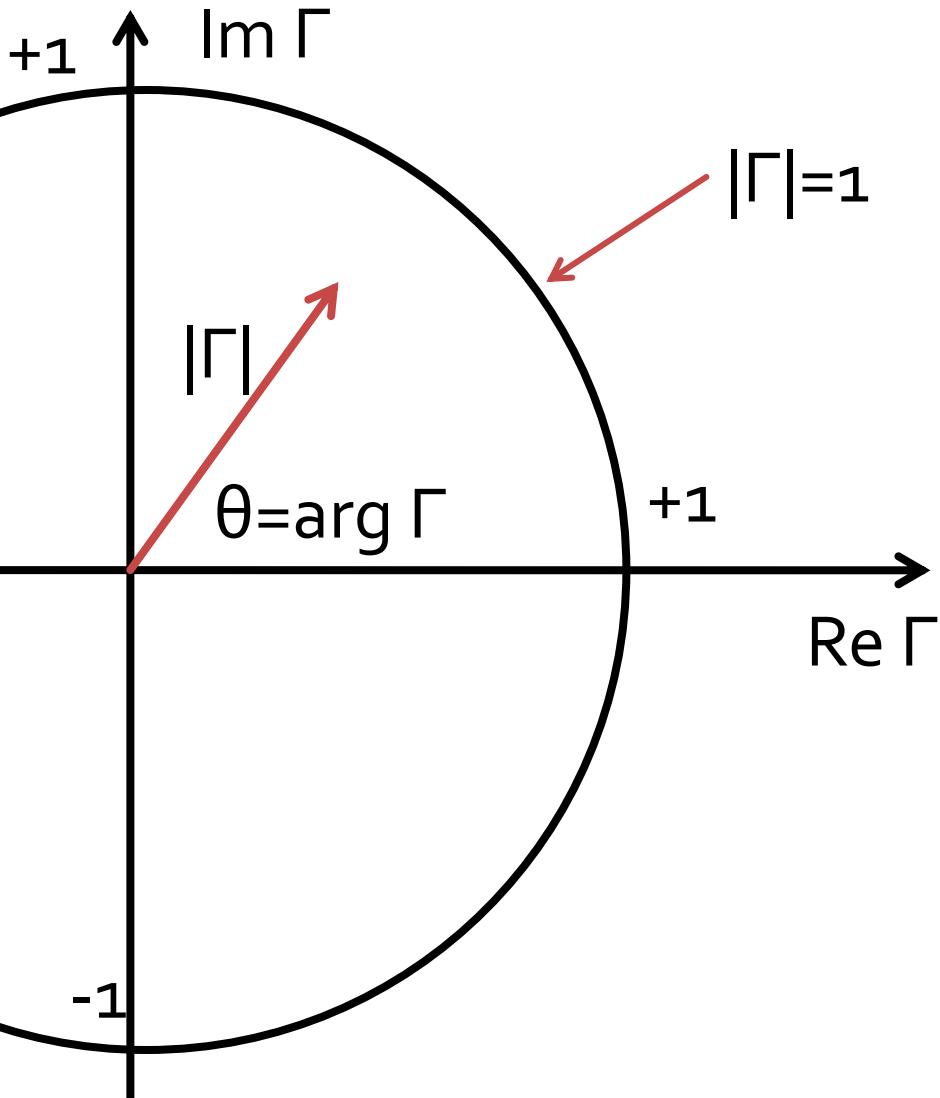
# Diagrama Smith



# Diagrama Smith, coeficient de reflexie, coordonate rectangulare



# Diagrama Smith



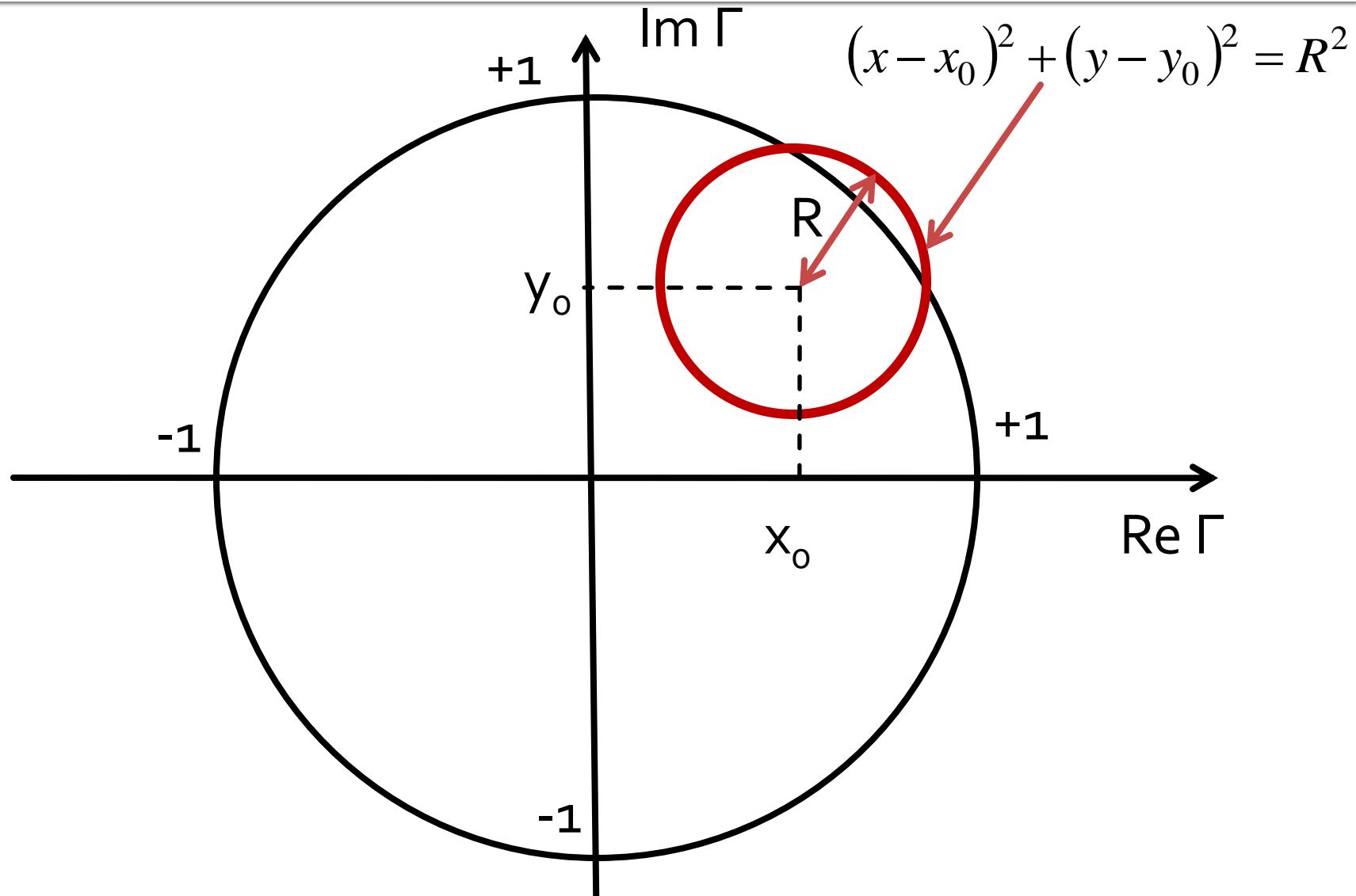
$$\left( \Gamma_r - \frac{r_L}{1+r_L} \right)^2 + \Gamma_i^2 = \left( \frac{1}{1+r_L} \right)^2$$

$$(\Gamma_r - 1)^2 + \left( \Gamma_i - \frac{1}{x_L} \right)^2 = \left( \frac{1}{x_L} \right)^2$$

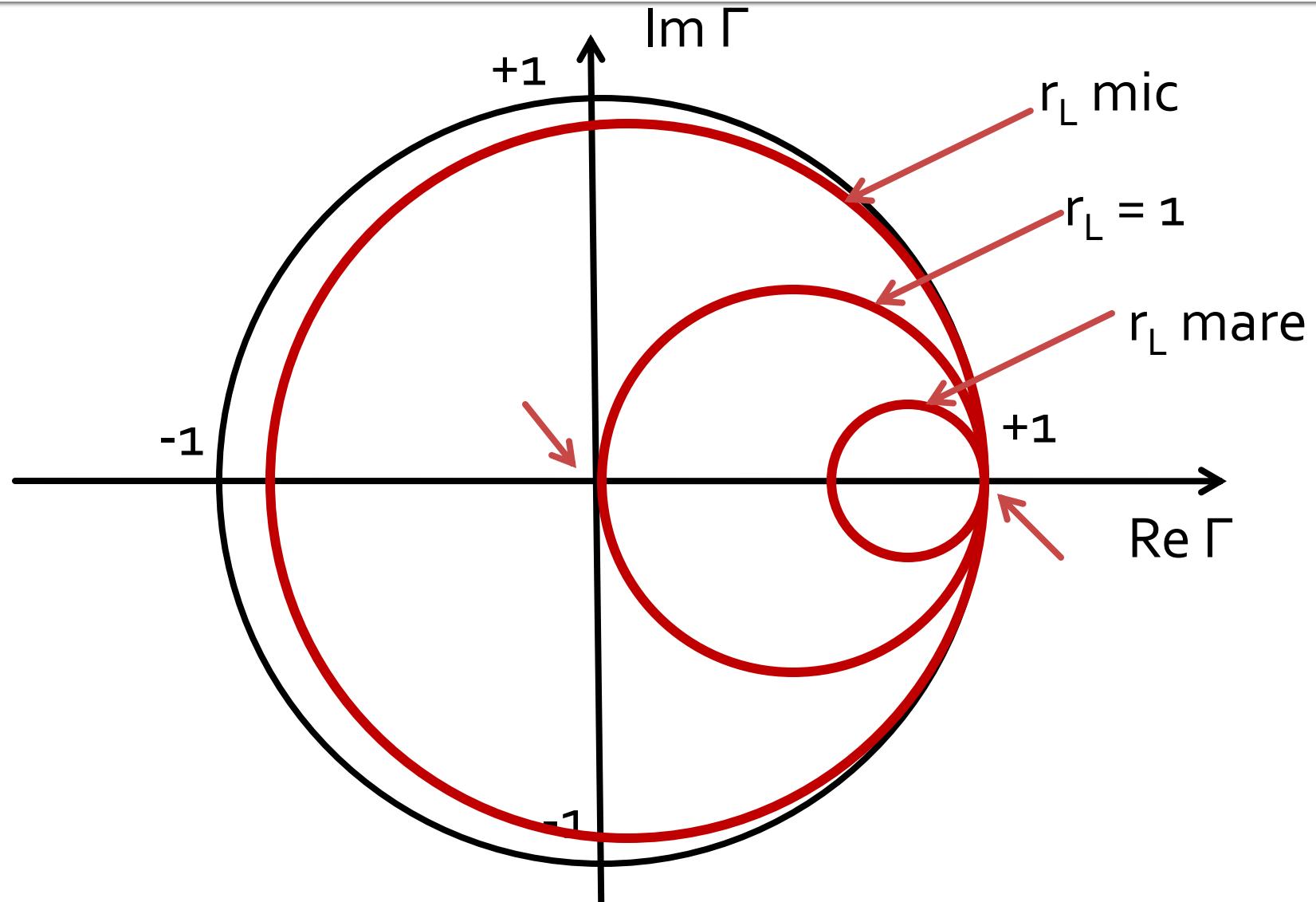
- Cercuri in planul complex

$$(x - x_0)^2 + (y - y_0)^2 = R^2$$

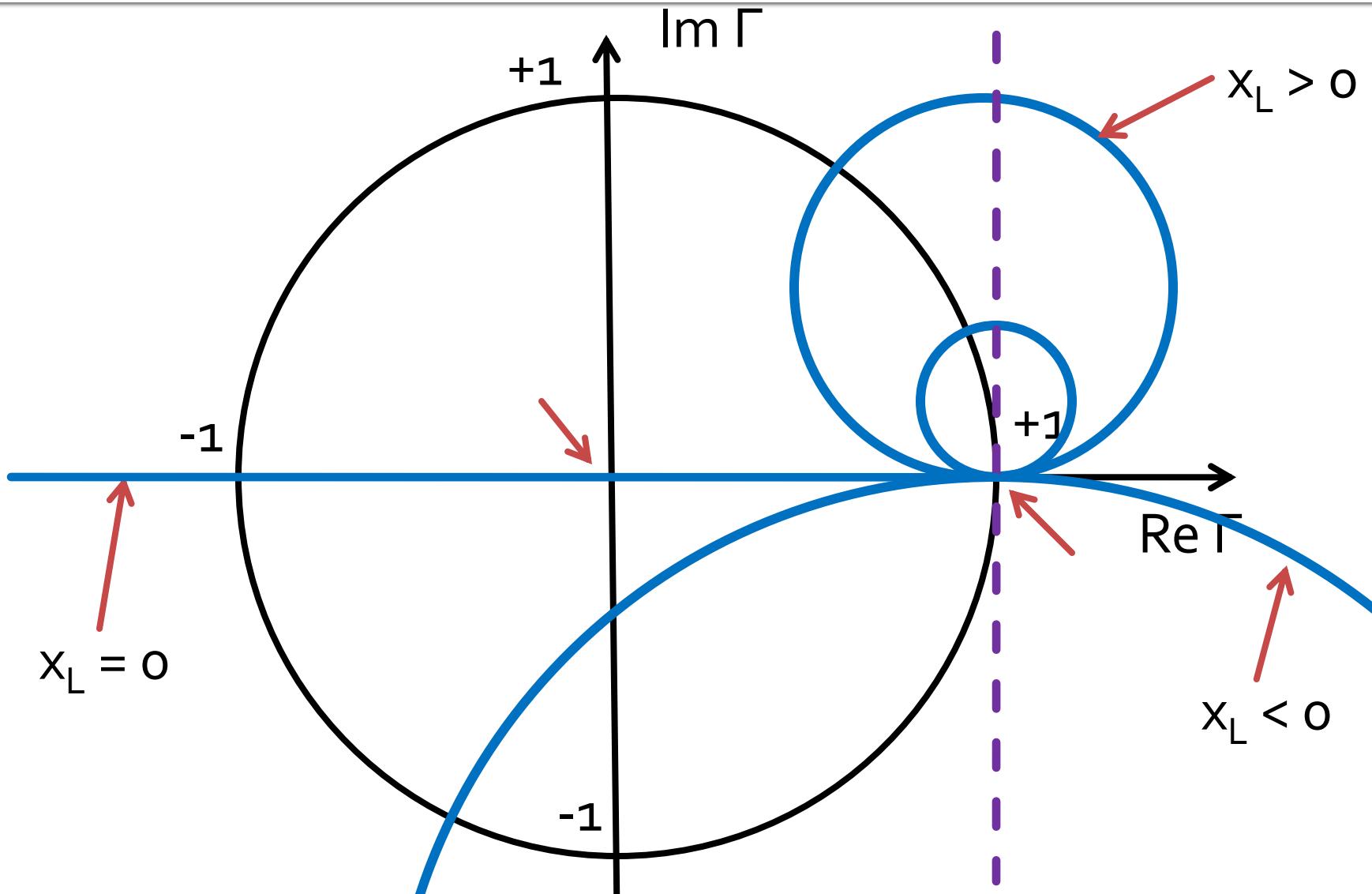
# Diagrama Smith



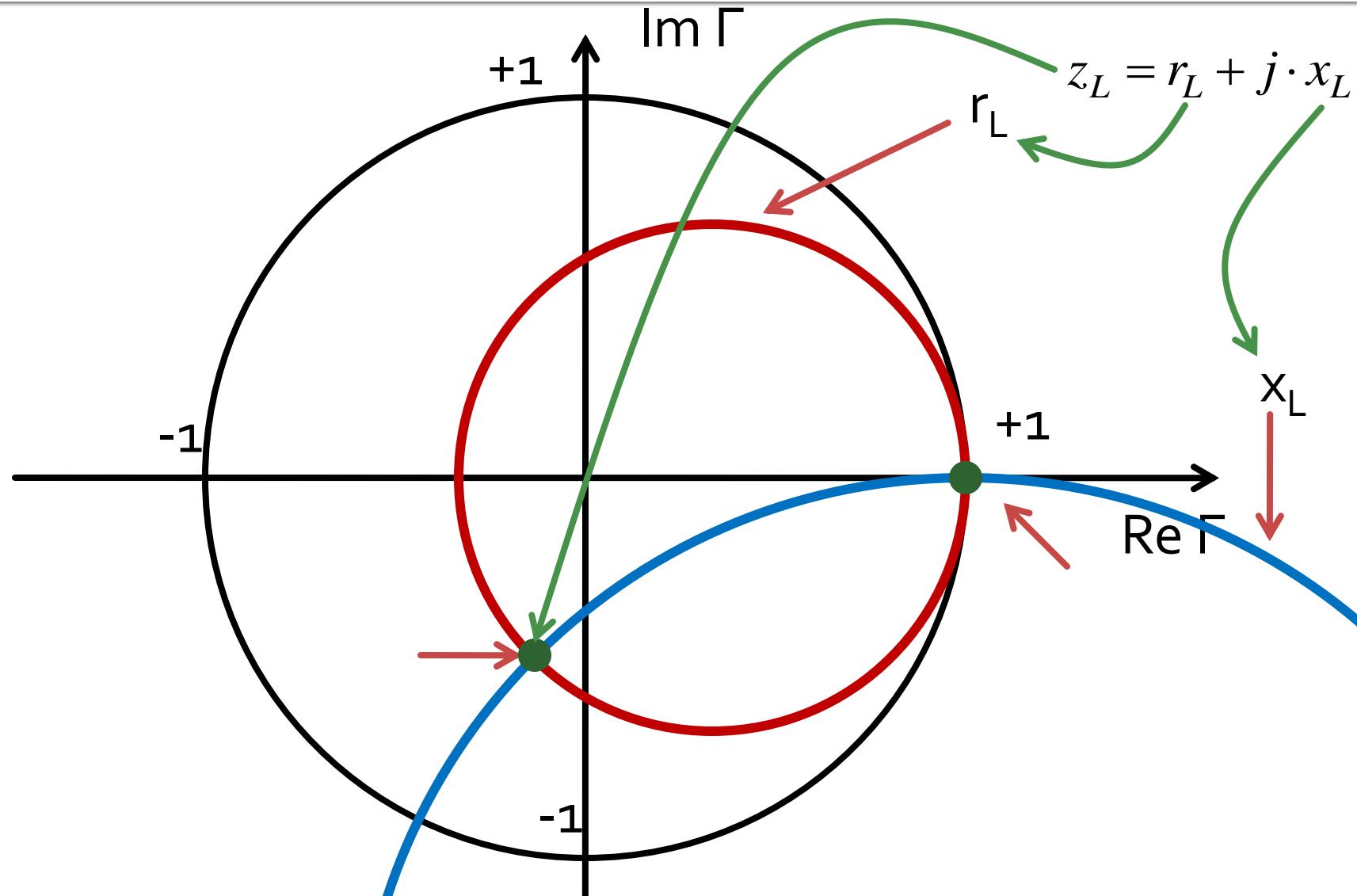
# Diagrama Smith, rezistenta



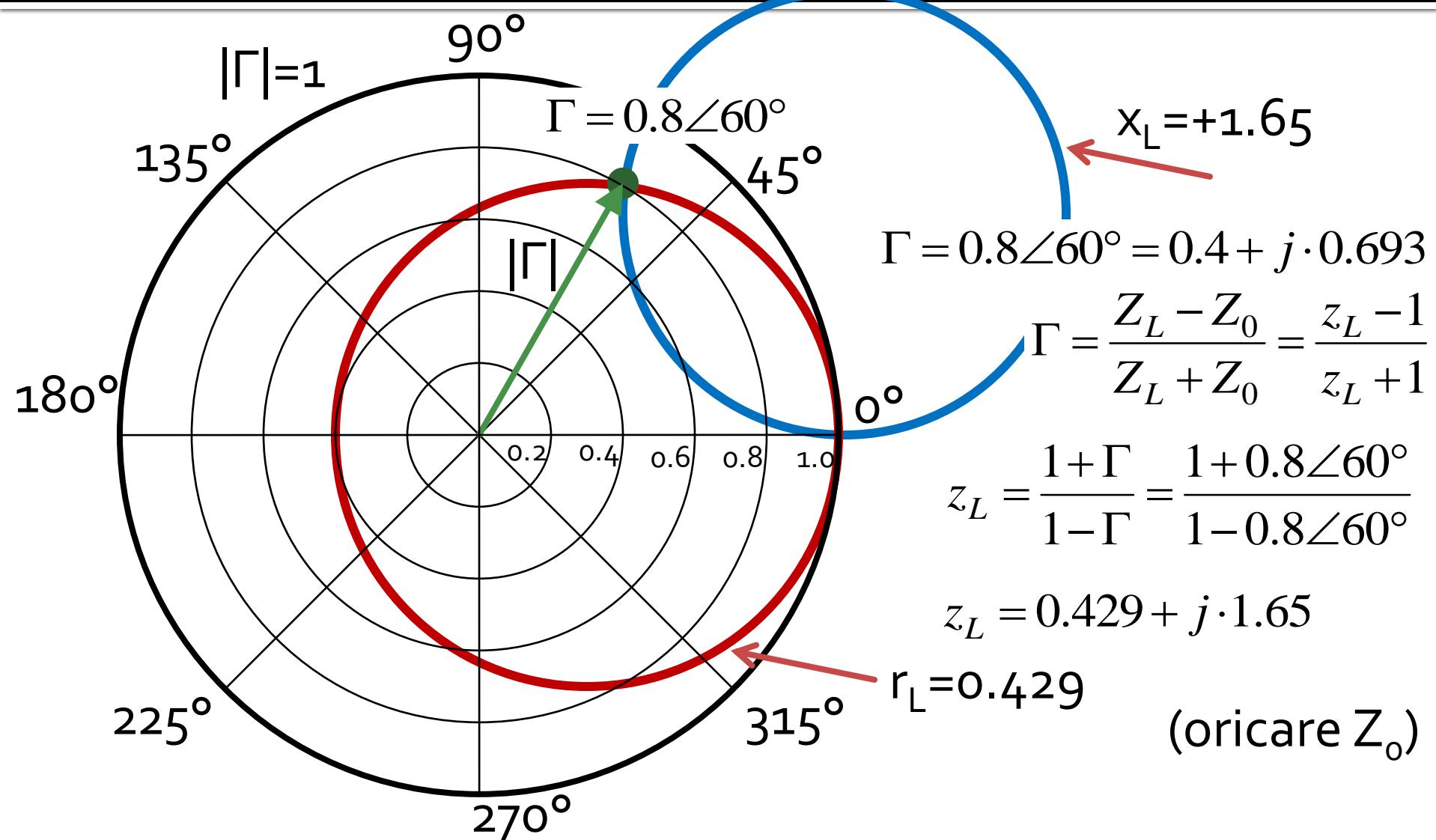
# Diagrama Smith, reactanta



# Diagrama Smith, impedanta



# Echivalenta coeficient de reflexie $\Leftrightarrow$ impedanta

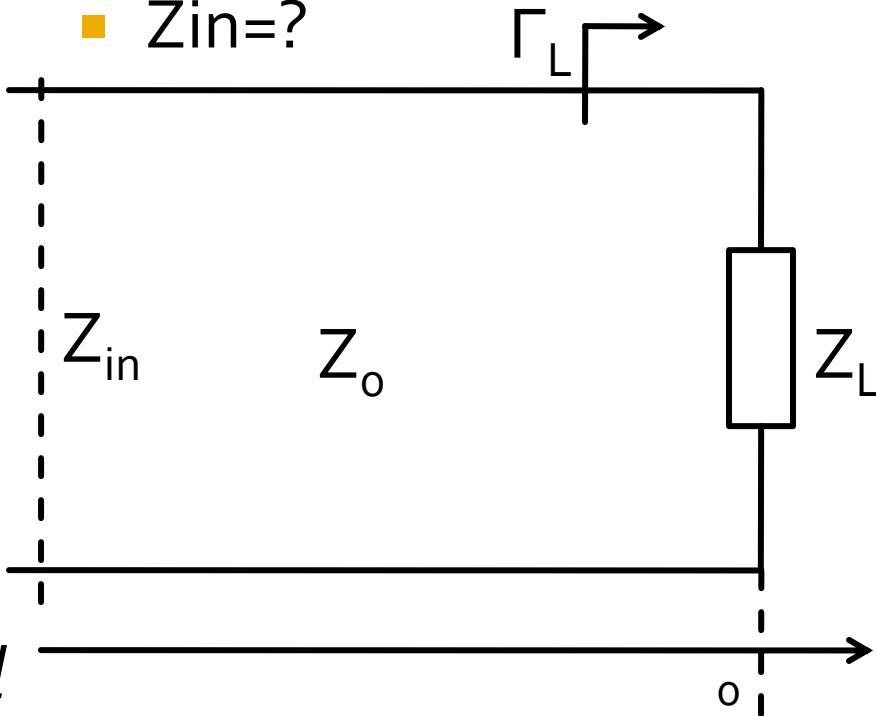


# Exemplu

- linie de transmisie

- $100\Omega$
- $0.3\lambda$  lungime
- $Z_L = 40\Omega + j \cdot 70\Omega$

- $Z_{in}=?$



$$Z_{in} = Z_0 \cdot \frac{Z_L + j \cdot Z_0 \cdot \tan \beta \cdot l}{Z_0 + j \cdot Z_L \cdot \tan \beta \cdot l}$$

$$Z_{in} = 36.5340\Omega - j \cdot 61.1190\Omega$$

# Exemplu

- linie de transmisie

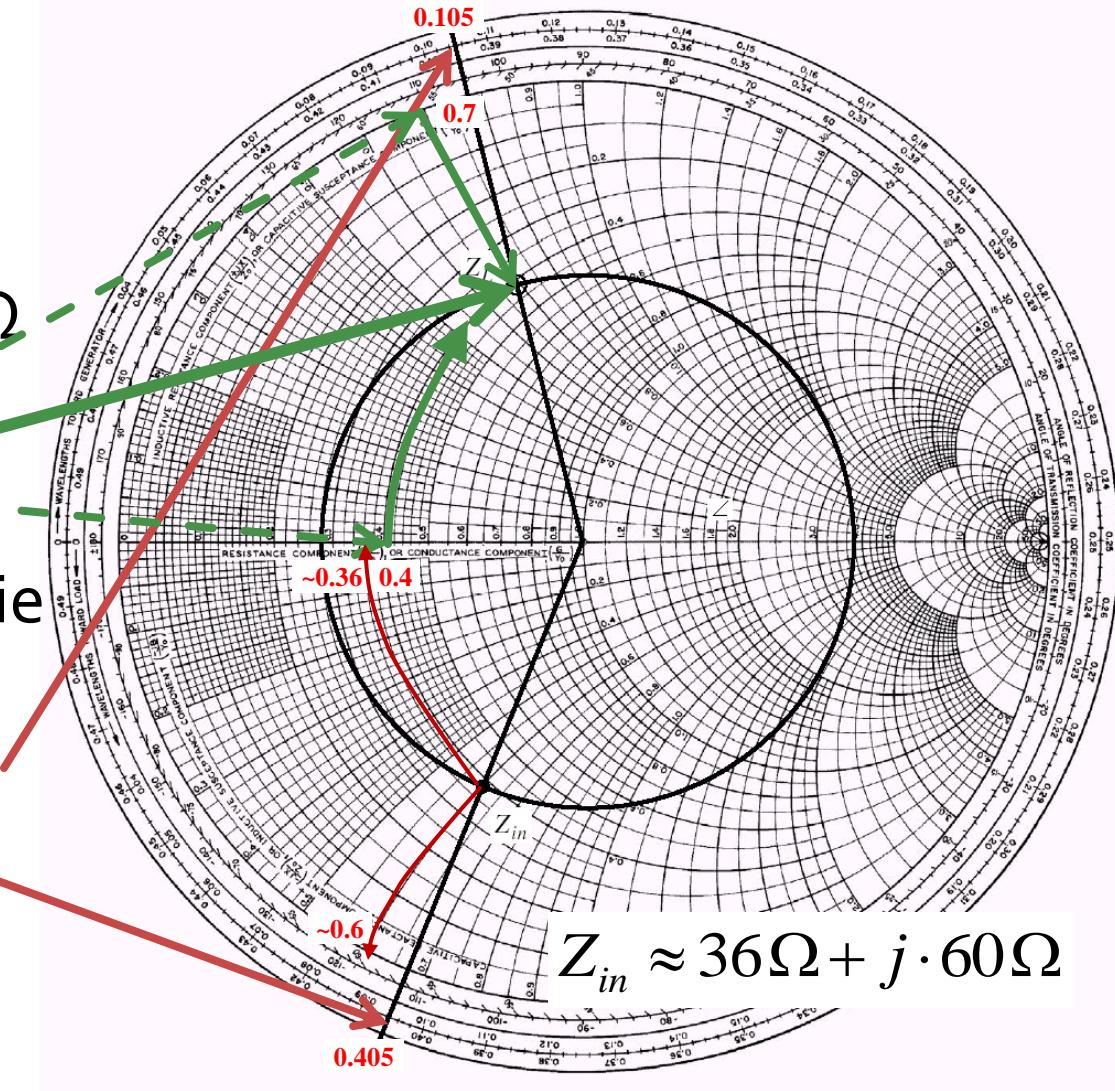
- $100\Omega$
- $0.3\lambda$  lungime
- $Z_L = 40\Omega + j \cdot 70\Omega$

$$z_L = \frac{Z_L}{Z_0} = 0.4 + j \cdot 0.7$$

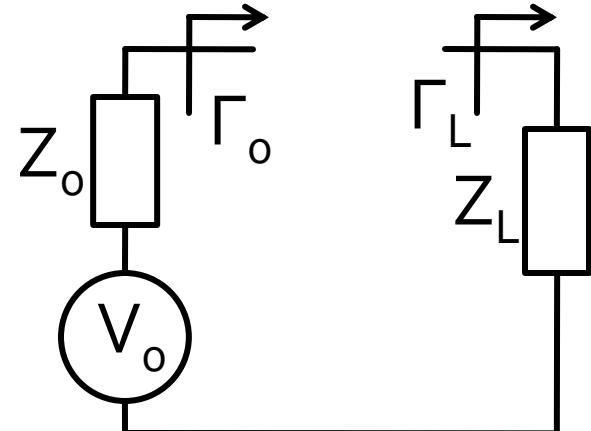
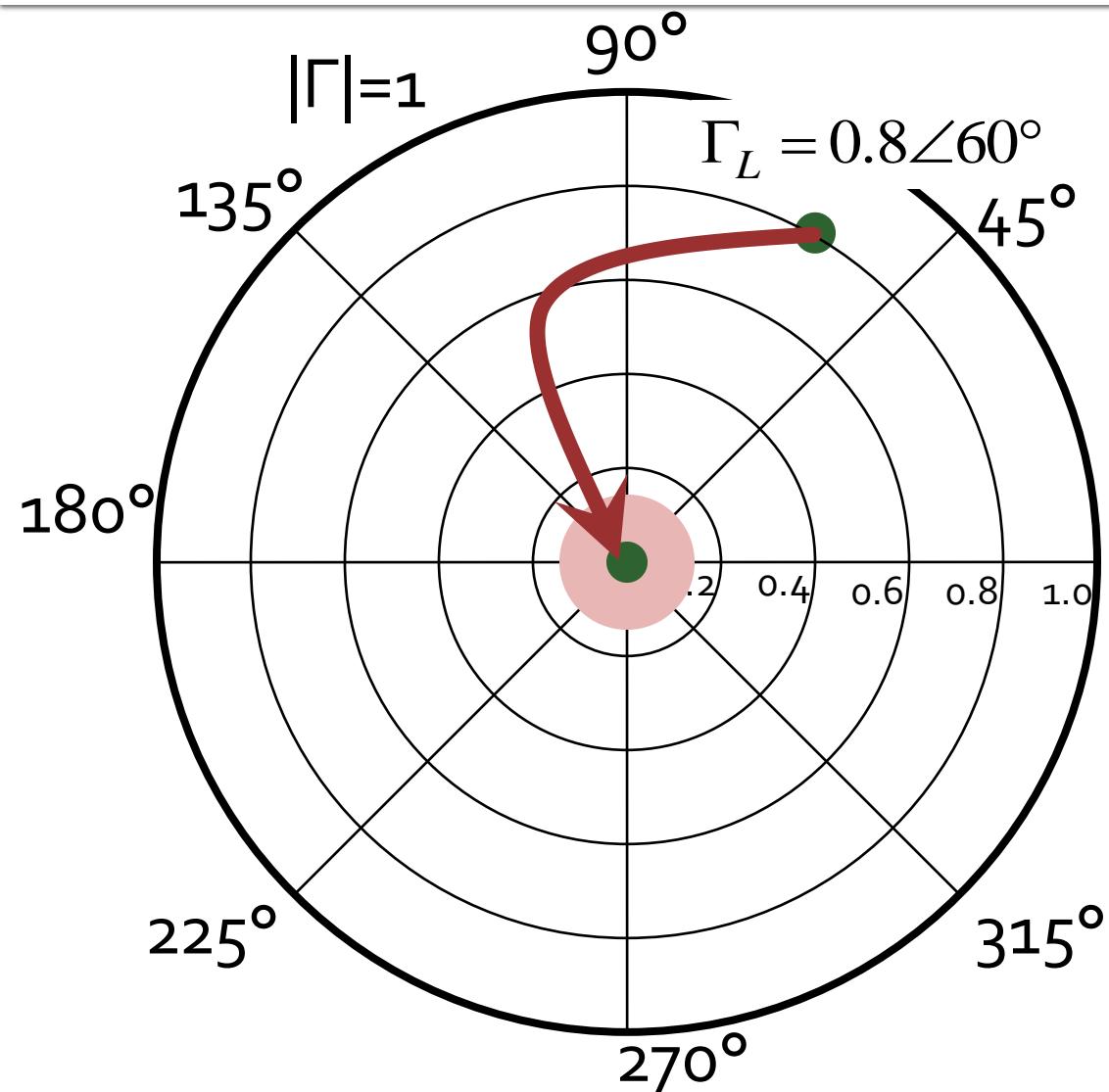
- deplasare  $0.3\lambda$  pe o linie cu  $Z_0 = 100\Omega$  (cerc)

- Plecand din  $z_L$  ( $0.105\lambda$ )
- Pana la  $z_{in}$  ( $0.405\lambda$ )

$$z_{in} \approx 0.36 + j \cdot 0.6 = \frac{Z_{in}}{Z_0}$$



# Diagrama Smith, adaptare



Adaptare  $Z_L$  la  $Z_0$ .

Trebuie sa deplasez coeficientul de reflexie in zona in care pentru generator cu  $Z_0$  am:

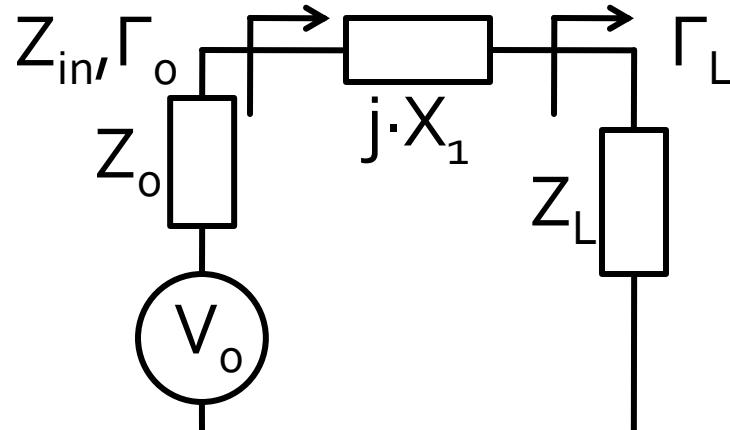
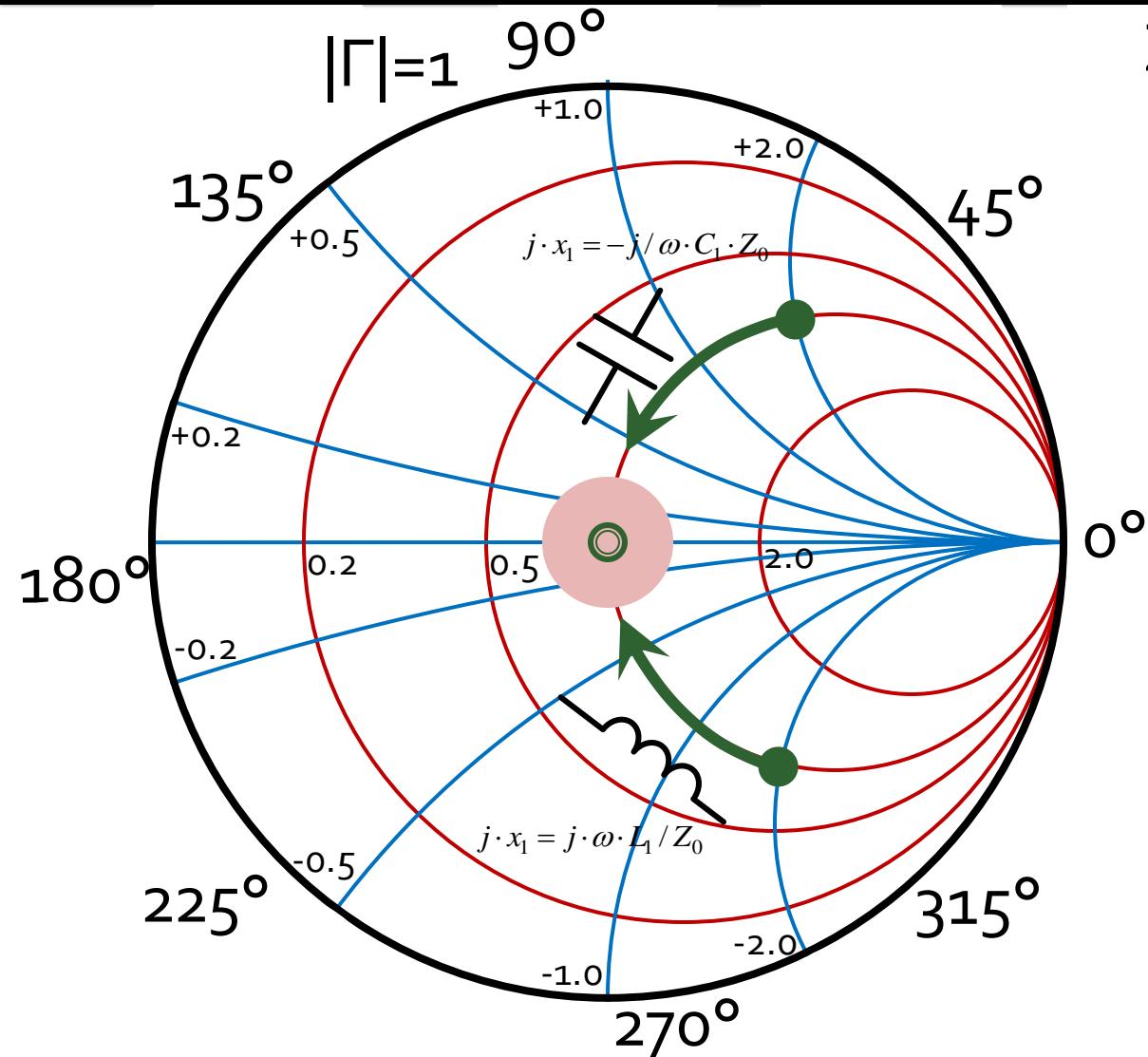
$\Gamma_0 = 0$  adaptare perfecta ●

$|\Gamma_0| \leq \Gamma_m$  adaptare "suficienta" ●

Adaptarea cu elemente concentrate (Retele in L)

# **Adaptarea de impedanță**

# Adaptare, reactanta in serie



$$z_L = r_L + j \cdot x_L$$

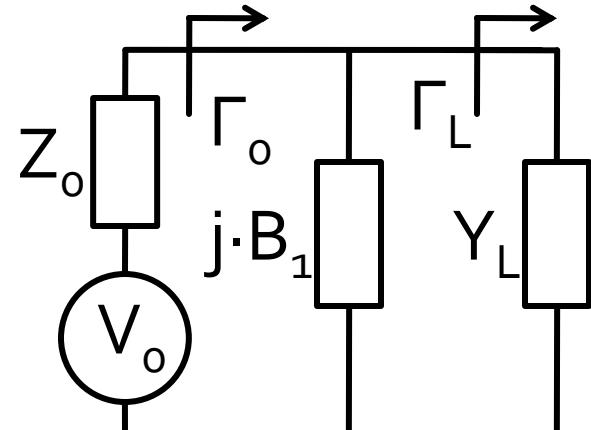
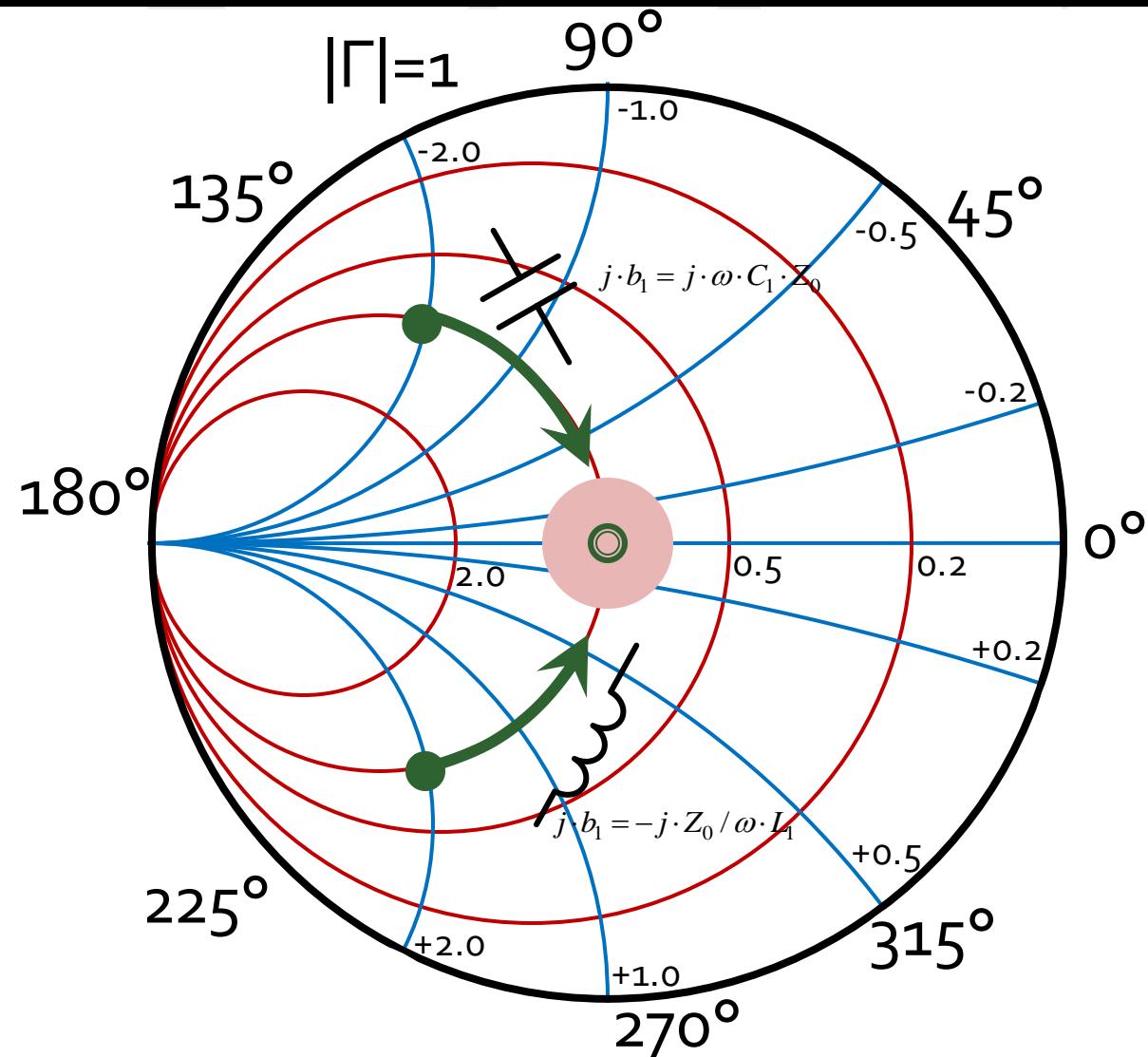
$$z_{in} = r_L + j \cdot (x_L + x_1)$$

$$r_{in} = r_L$$

- Adaptarea se poate realiza numai daca  $r_L = 1$
- se realizeaza compensarea partii reactive a sarcinii

$$j \cdot x_1 = -j \cdot x_L$$

# Adaptare, susceptanta in paralel



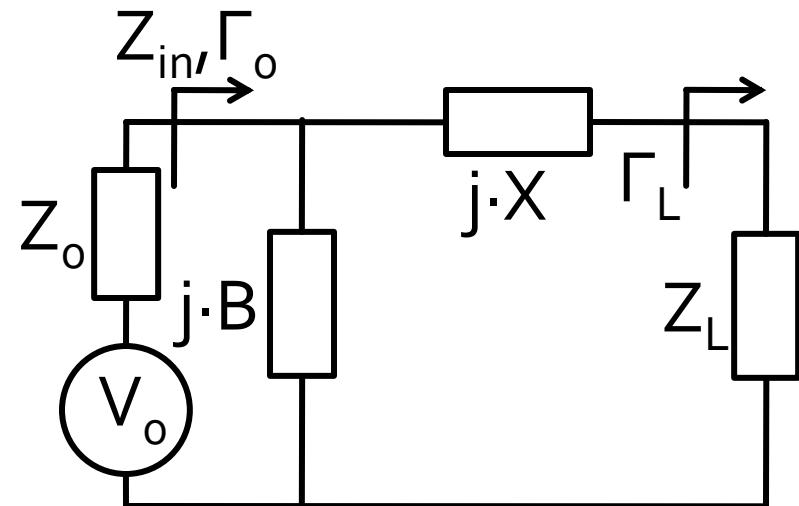
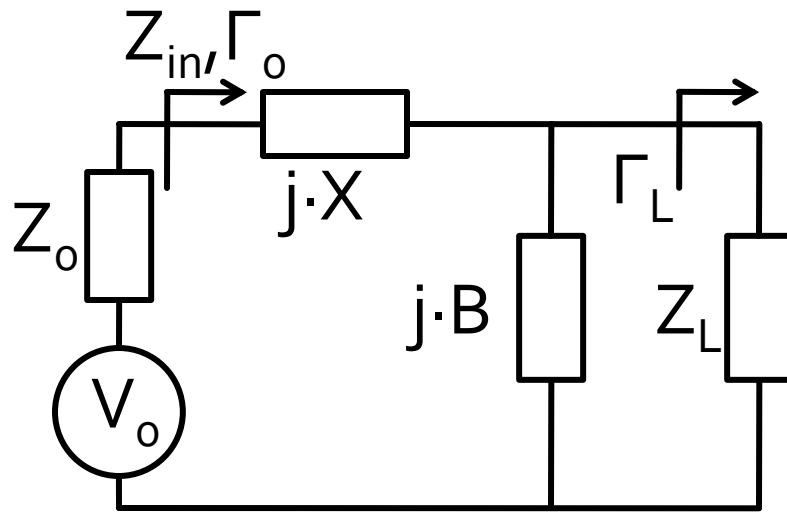
$$y_L = g_L + j \cdot b_L$$

$$y_{in} = g_L + j \cdot (b_L + b_1)$$

$$g_{in} = g_L$$

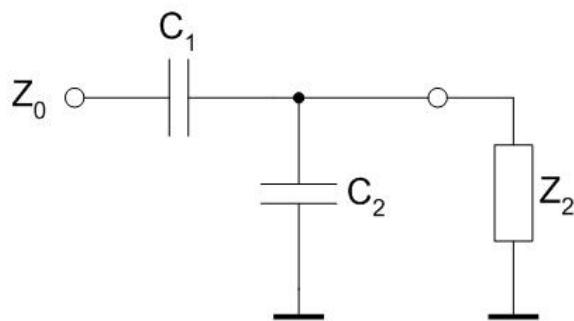
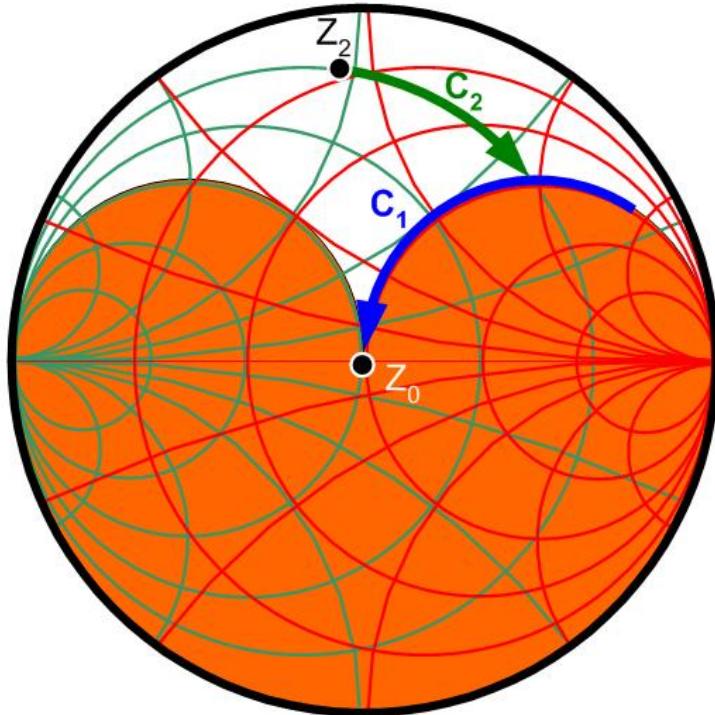
- Adaptarea se poate realiza numai daca  $g_L = 1$
  - se realizeaza compensarea partii reactive a sarcinii
- $$j \cdot b_1 = -j \cdot b_L$$

# Adaptare cu două elemente reactive (retele in L)

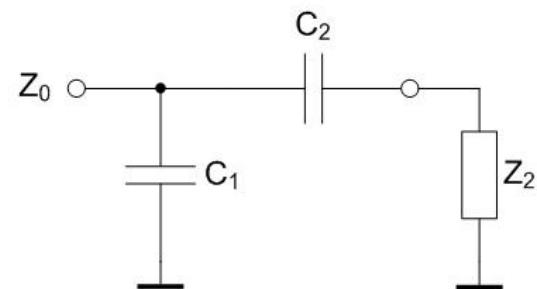
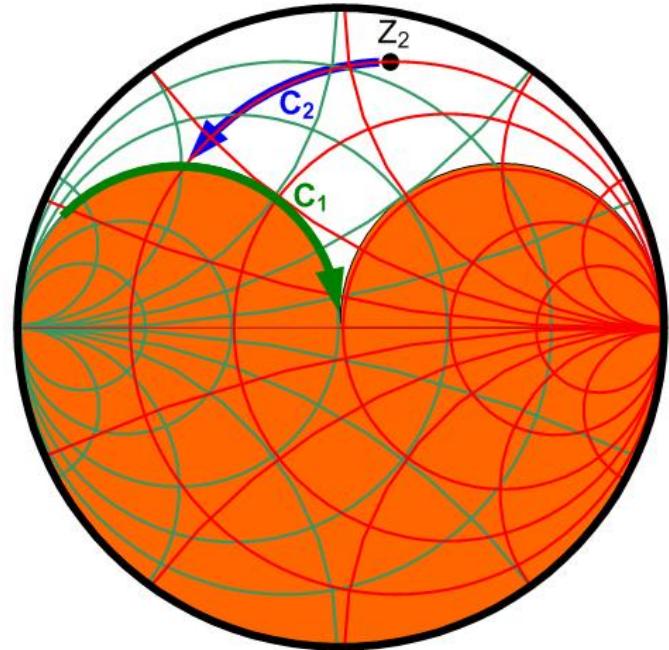


- Adaptare in doi pasi
  - un prim element muta coeficientul de reflexie pe cercul  $r_L = 1/g_L = 1$
  - al doilea element realizeaza adaptarea

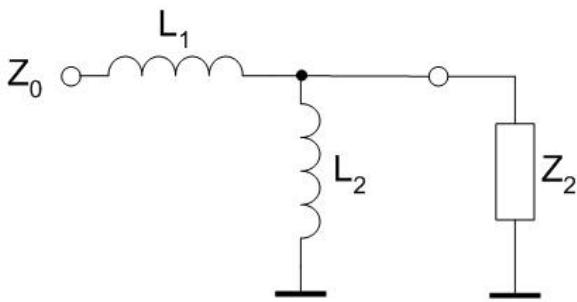
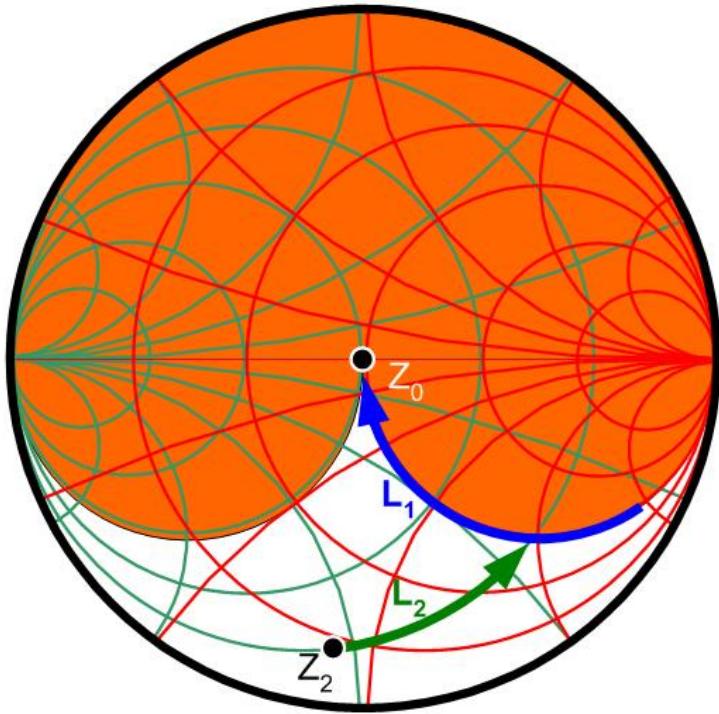
# C serie, C paralel / C paralel, C serie



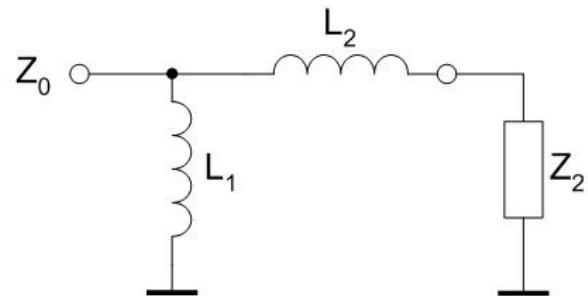
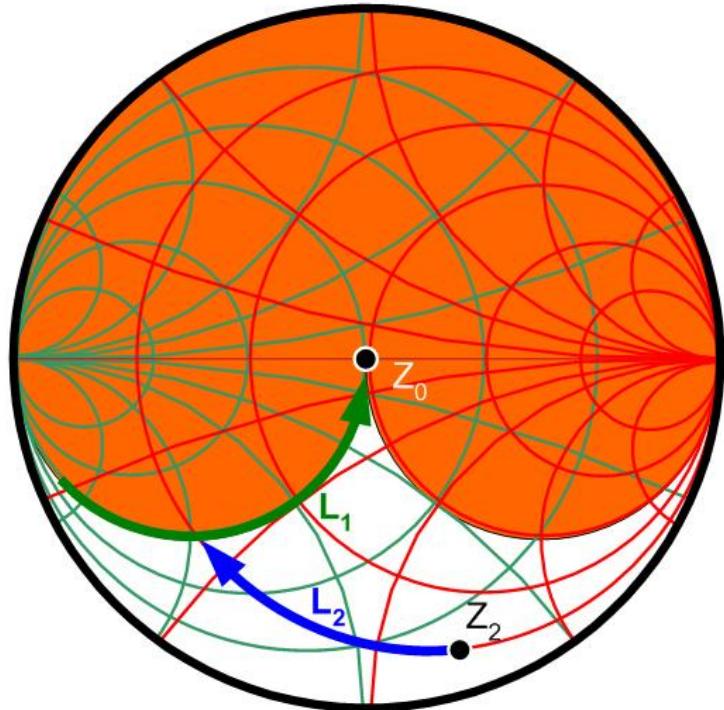
Zona interzisa cu  
schema curenta



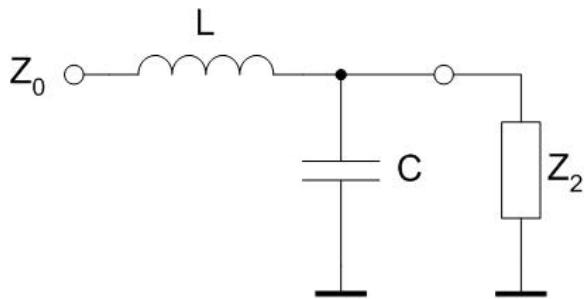
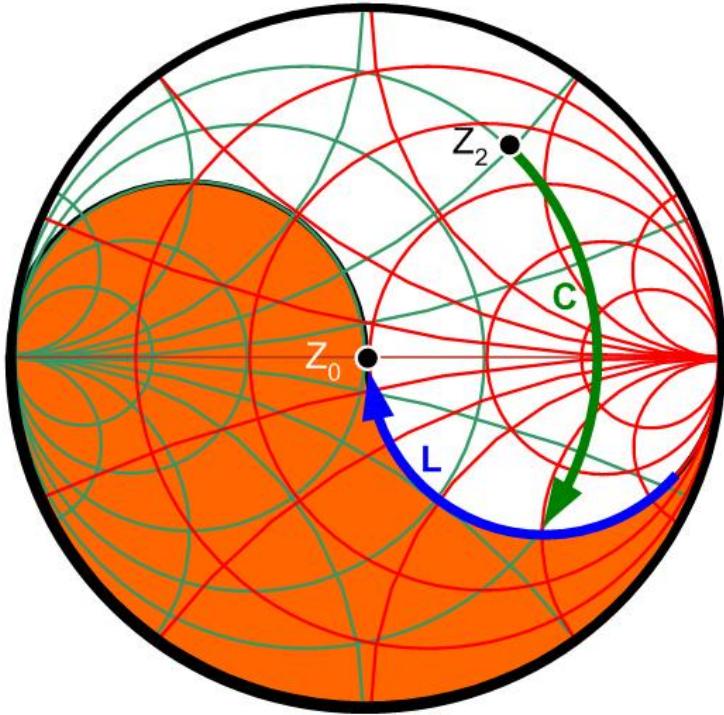
# L serie, L paralel / L paralel, L serie



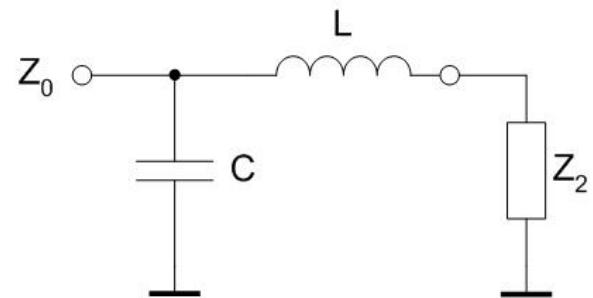
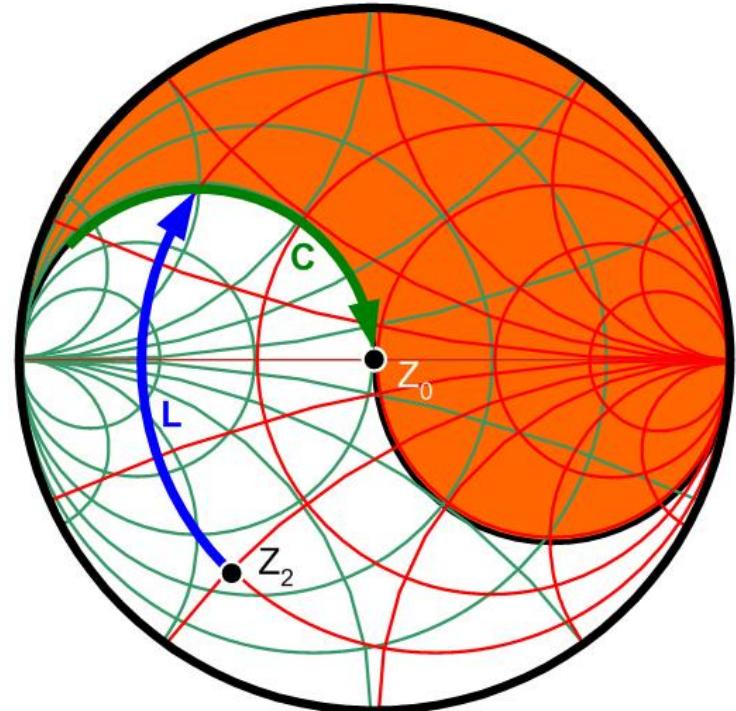
Zona interzisa cu  
schema curenta



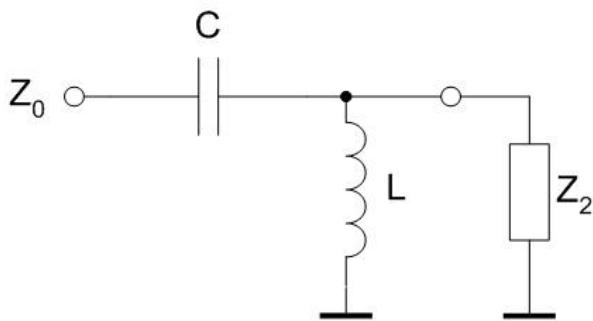
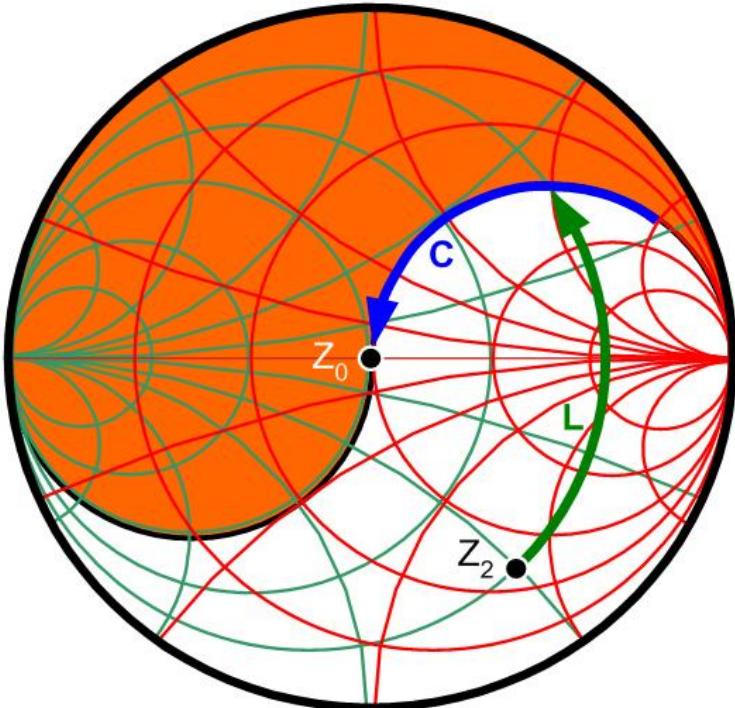
# L serie, C paralel / C paralel, L serie



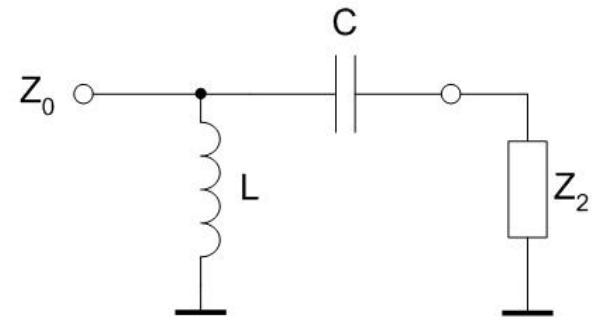
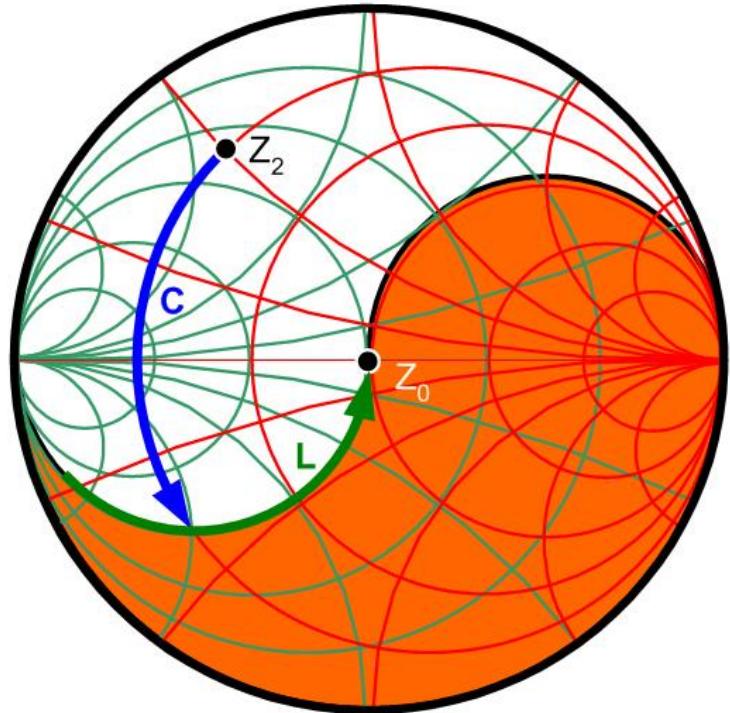
Zona interzisa cu  
schema curenta



# C serie, L paralel / L paralel, C serie



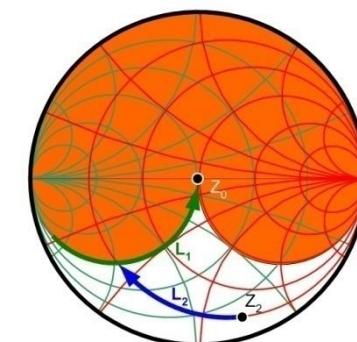
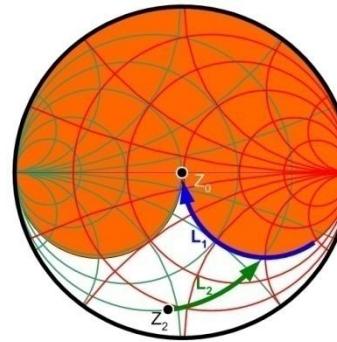
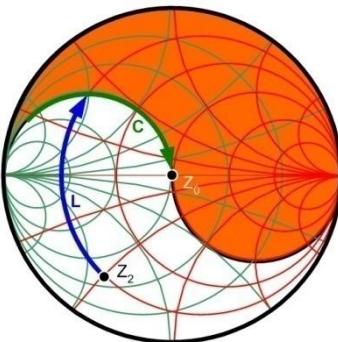
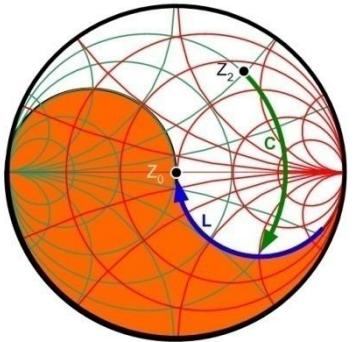
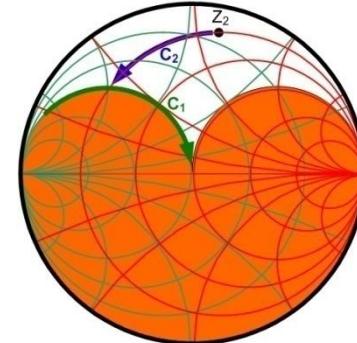
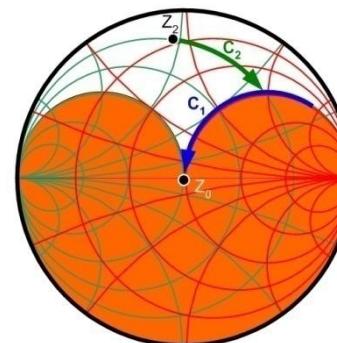
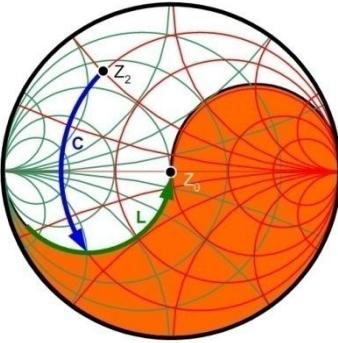
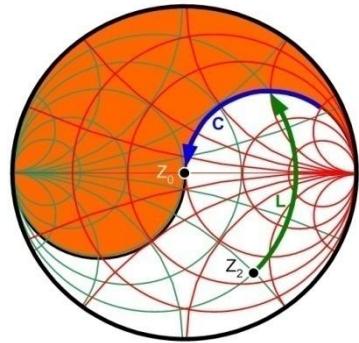
Zona interzisa cu  
schema curenta



# Adaptare cu doua elemente reactive (retele in L)

- Pentru orice  $\Gamma_L$  exista cel putin 2 retele in L de adaptare posibile (L+C)
- Pentru anumite zone de start de pe diagrama Smith exista 4 posibilitati (+2 retele C+C/L+L)
- Se alege reteaua care necesita componente de valori realizabile
- Prin adaugarea elementelor rezistive se pot suplimenta retelele posibile cu **pierdere de putere (nerecomandat)**

# Adaptare cu două elemente reactive (retele in L)



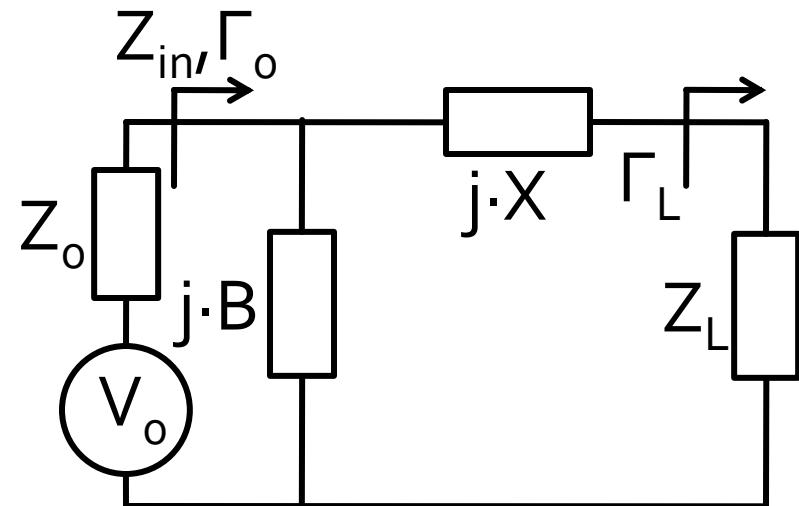
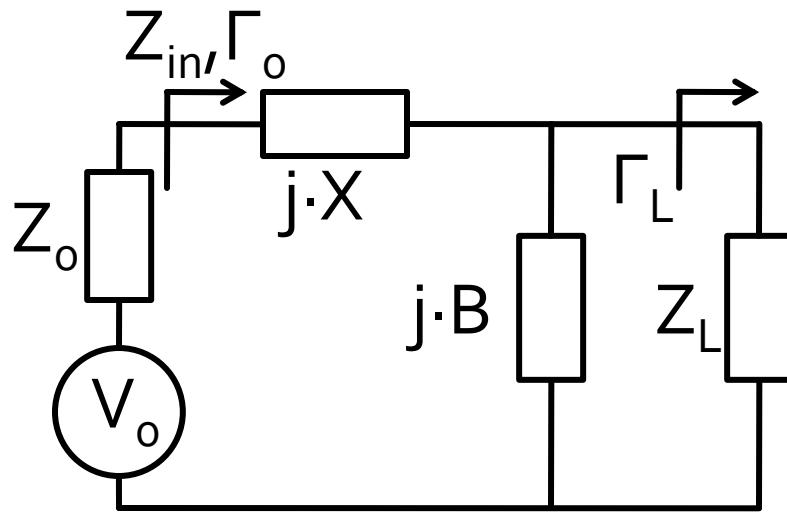
Zona interzisa cu  
schema curenta

# Adaptare cu elemente rezistive

- Circuitele active lucreaza in zona frecventei unitare
- Orice "risipa" de putere este **nerecomandata**
- Exista situatii in care este **necesara** o astfel de actiune pentru asigurarea stabilitatii



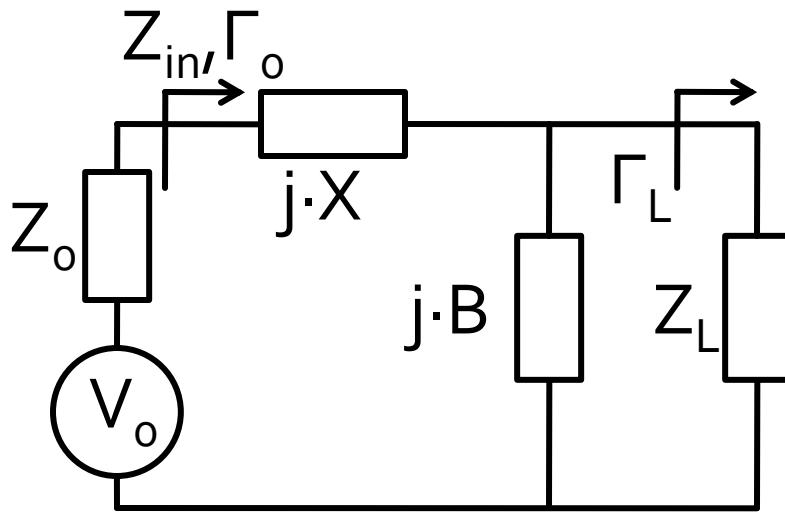
# Adaptare cu doua elemente reactive (retele in L)



## ■ Adaptare in doi pasi

- pentru elementele situate in interiorul cercului  $r_L = 1$  se utilizeaza prima schema
- pentru elementele situate in exteriorul cercului  $r_L = 1$  se utilizeaza a doua schema

# Adaptare cu două elemente reactive (retele în L)



$$Z_L = R_L + j \cdot X_L \quad R_L > Z_0 \quad Z_{in} = Z_0$$

$$Z_0 = j \cdot X + \frac{1}{j \cdot B + 1/(R_L + j \cdot X_L)}$$

$$\begin{cases} B \cdot (X \cdot R_L - X_L \cdot Z_0) = R_L - Z_0 \\ X \cdot (1 - B \cdot X_L) = B \cdot Z_0 \cdot R_L - X_L \end{cases}$$

$$B = \frac{X_L \pm \sqrt{R_L/Z_0} \cdot \sqrt{R_L^2 + X_L^2 - Z_0 \cdot R_L}}{R_L^2 + X_L^2}$$

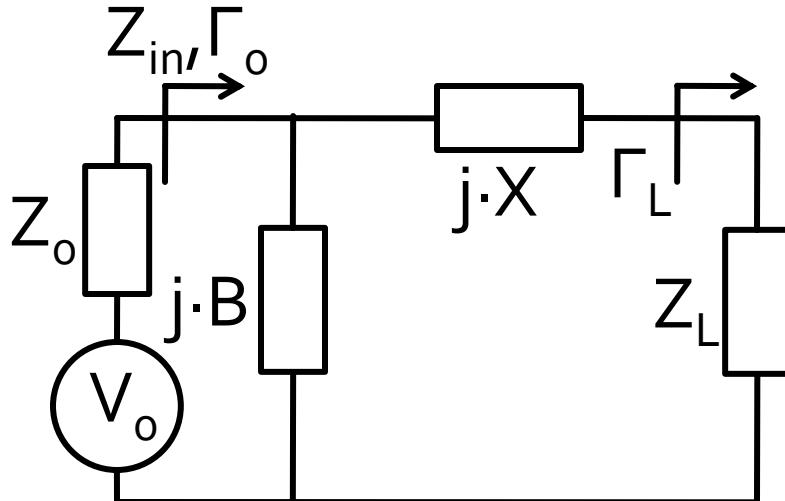
$$X = \frac{1}{B} + \frac{X_L \cdot Z_0}{R_L} - \frac{Z_0}{B \cdot R_L}$$

- valoarea de sub radical e intotdeauna pozitiva pentru

$$R_L > Z_0$$

- se obtin doua solutii realizabile

# Adaptare cu doua elemente reactive (retele in L)



$$Z_L = R_L + j \cdot X_L \quad R_L < Z_0 \quad Y_{in} = Y_0 = \frac{1}{Z_0}$$

$$\frac{1}{Z_0} = j \cdot B + \frac{1}{R_L + j \cdot (X + j \cdot X_L)}$$

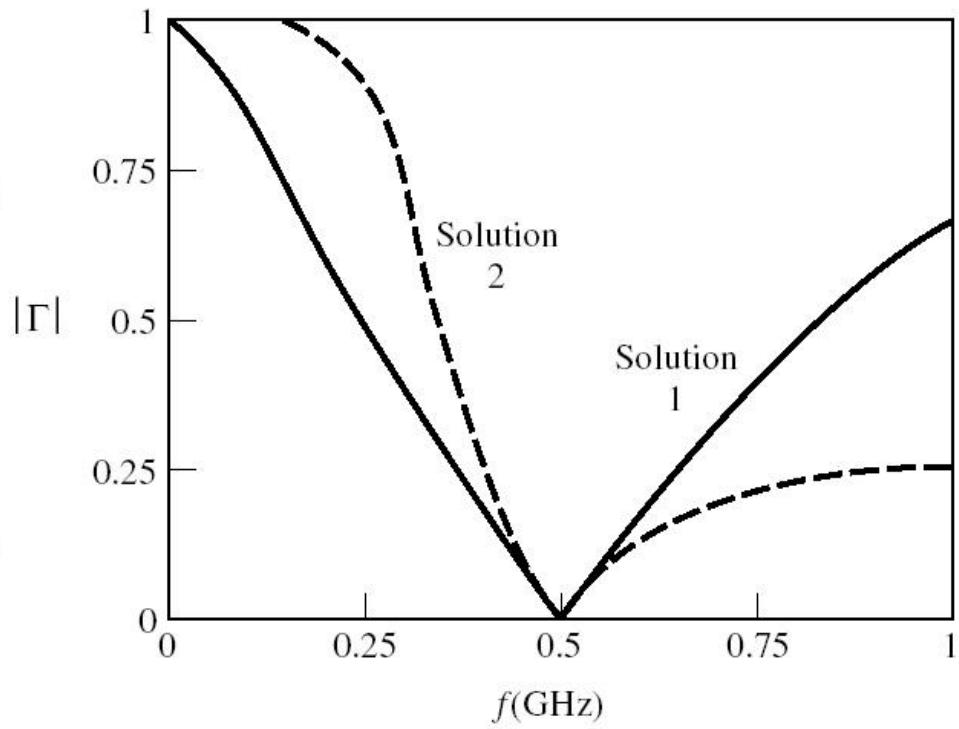
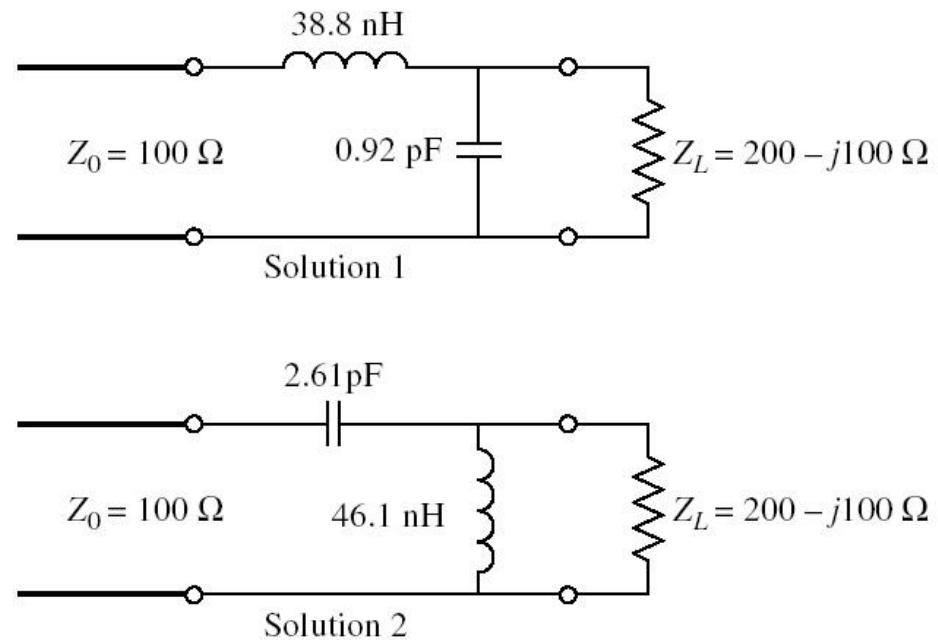
$$\begin{cases} B \cdot Z_0 \cdot (X + X_L) = Z_0 - R_L \\ (X + X_L) = B \cdot Z_0 \cdot R_L \end{cases}$$

$$X = \pm \sqrt{R_L \cdot (Z_0 - R_L)} - X_L$$

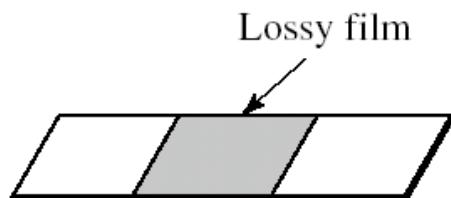
$$B = \pm \frac{\sqrt{(Z_0 - R_L)/R_L}}{Z_0}$$

- valoarea de sub radical e intotdeauna pozitiva pentru  $R_L < Z_0$
- se obtin doua solutii realizabile

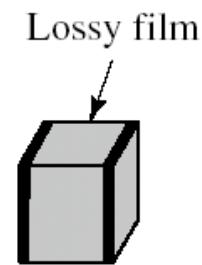
# Exemplu



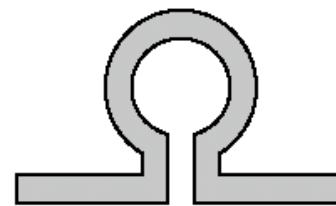
# Realizare elemente concentrate



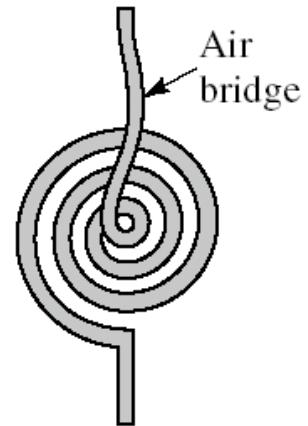
Planar resistor



Chip resistor



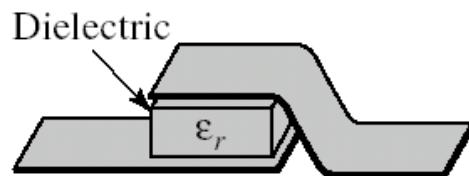
Loop inductor



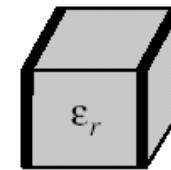
Spiral inductor



Interdigital  
gap capacitor



Metal-insulator-  
metal capacitor



Chip capacitor

Adaptarea cu sectiuni de linii (stub)

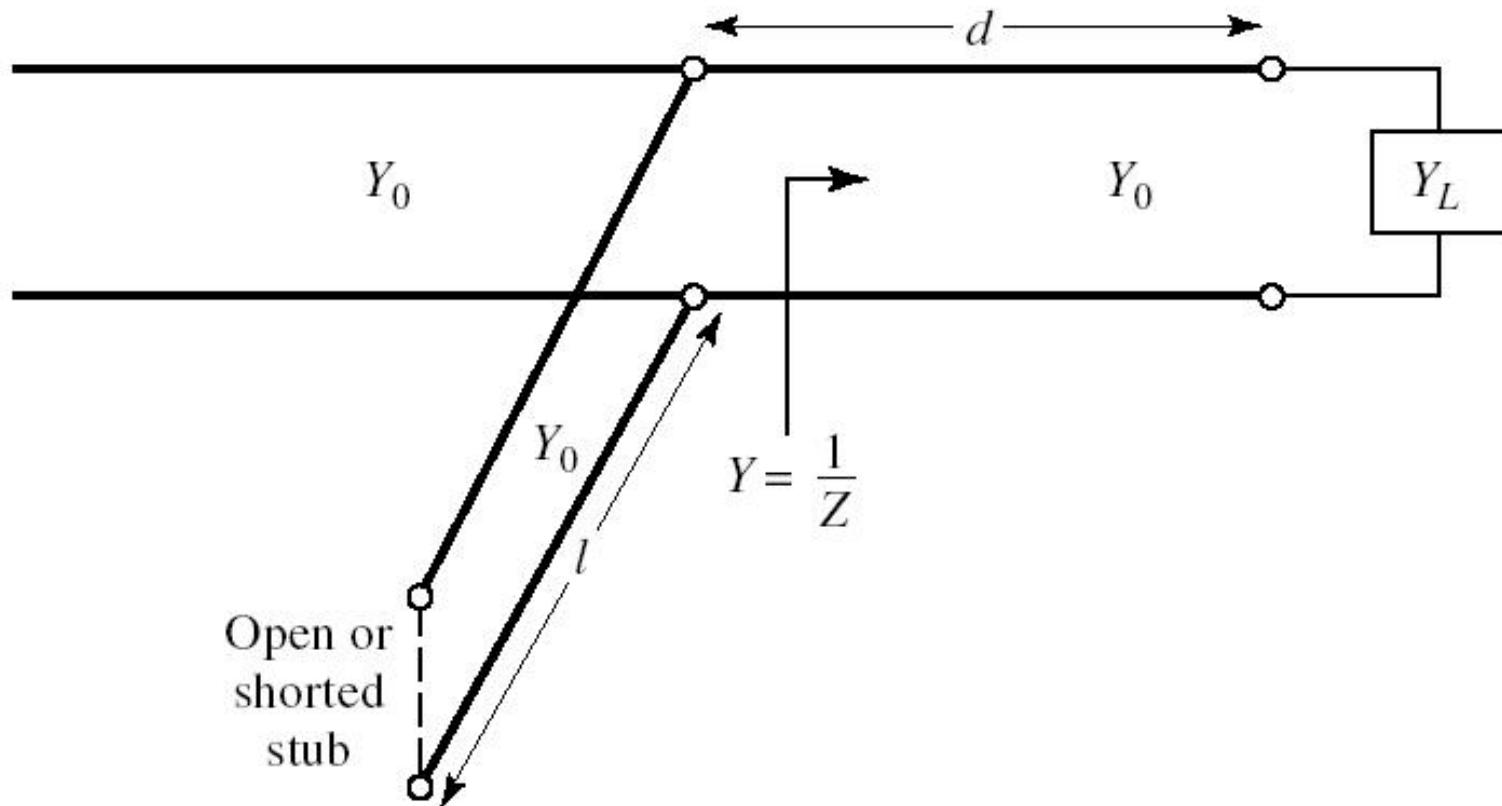
# **Adaptarea de impedanță**

# Stub

- stub=rest, ciot, cotor, capăt
- Se evita utilizarea elementelor concentrate
- Se realizeaza (foarte precis) utilizând liniile de transmisie uzuale ale circuitului
- Se utilizeaza sectiuni de linie (stub-uri) in serie sau paralel care pot fi:
  - in gol
  - scurtcircuitate
- De obicei liniile in gol sunt mai usor de implementat si sunt preferate

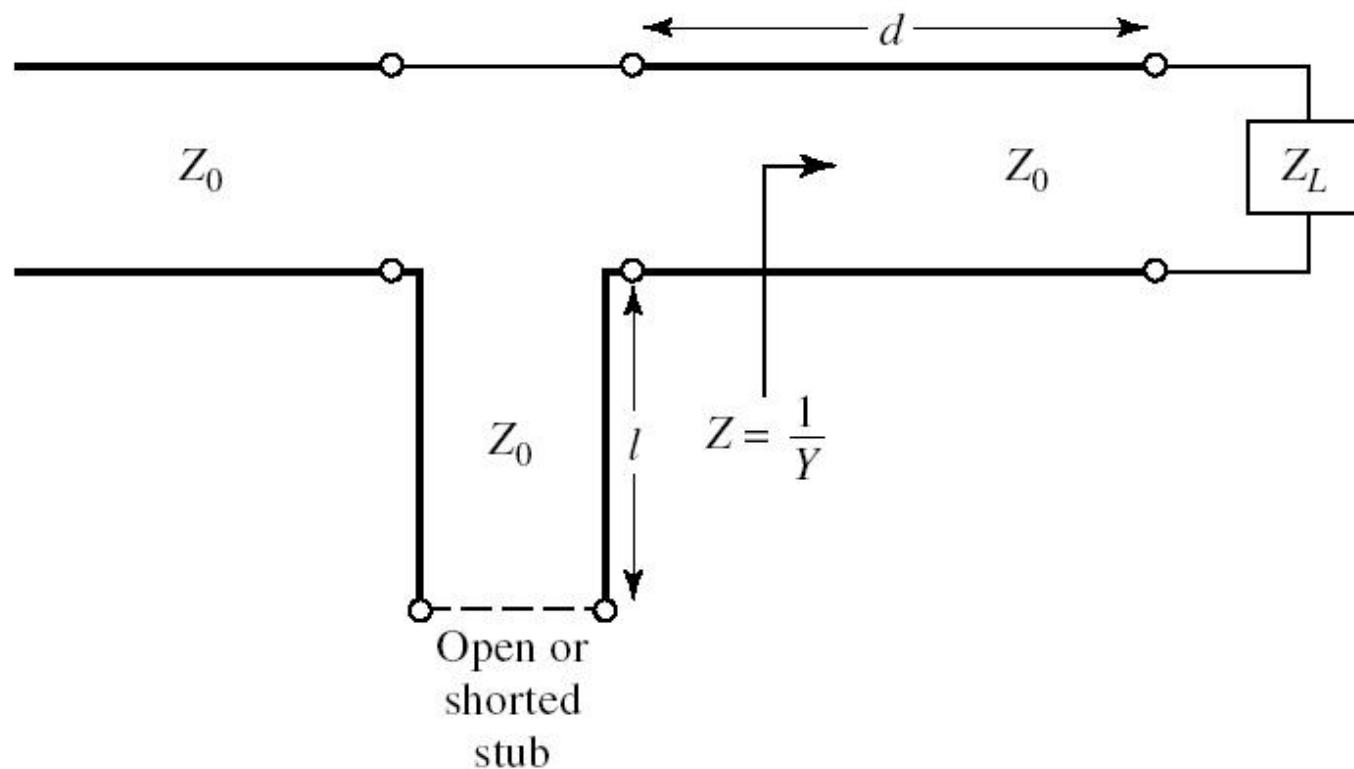
# Single stub tuning

- Shunt Stub (secțiune de linie în paralel)

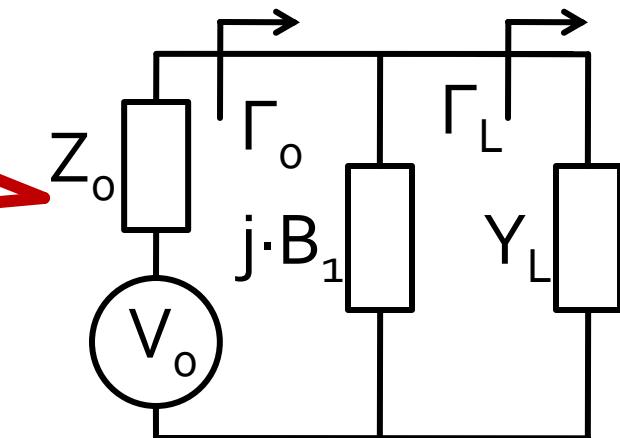
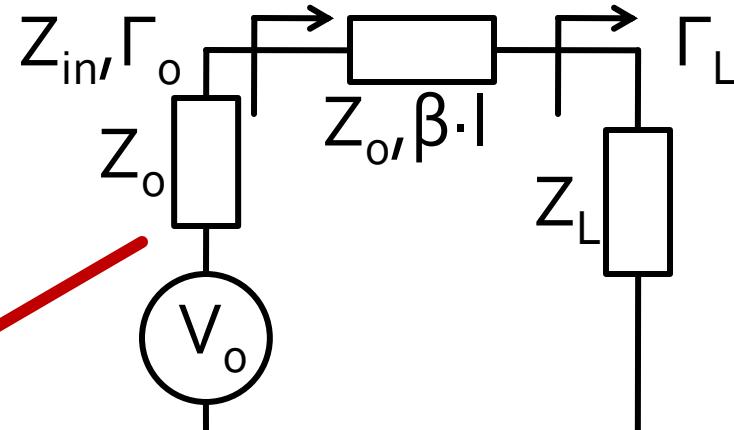
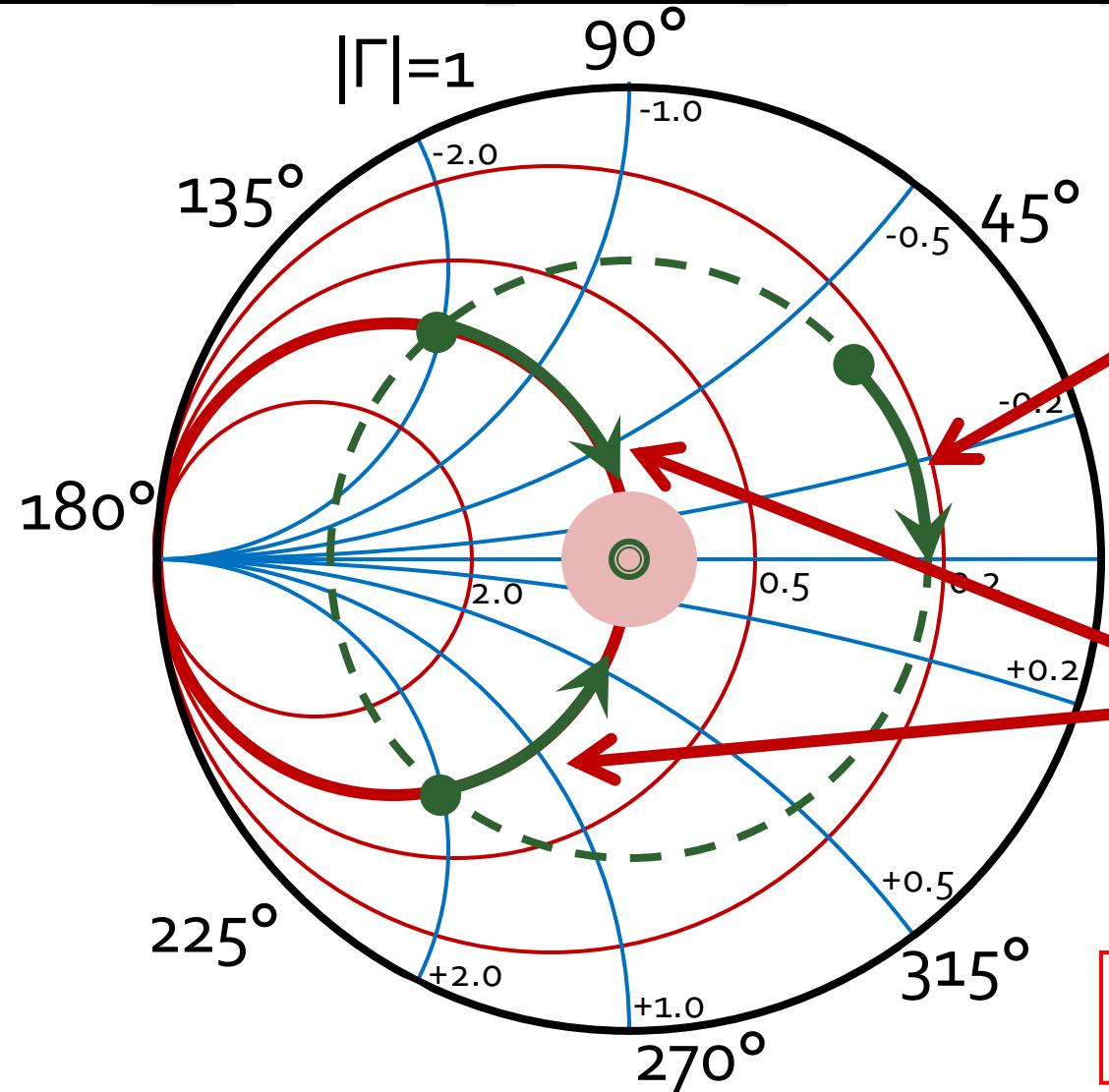


# Single stub tuning

- Series Stub (secțiune de linie în serie)
- tehnologic mai dificil de realizat la liniile monofilare (microstrip)



# Adaptare, linie serie + susceptanta in paralel

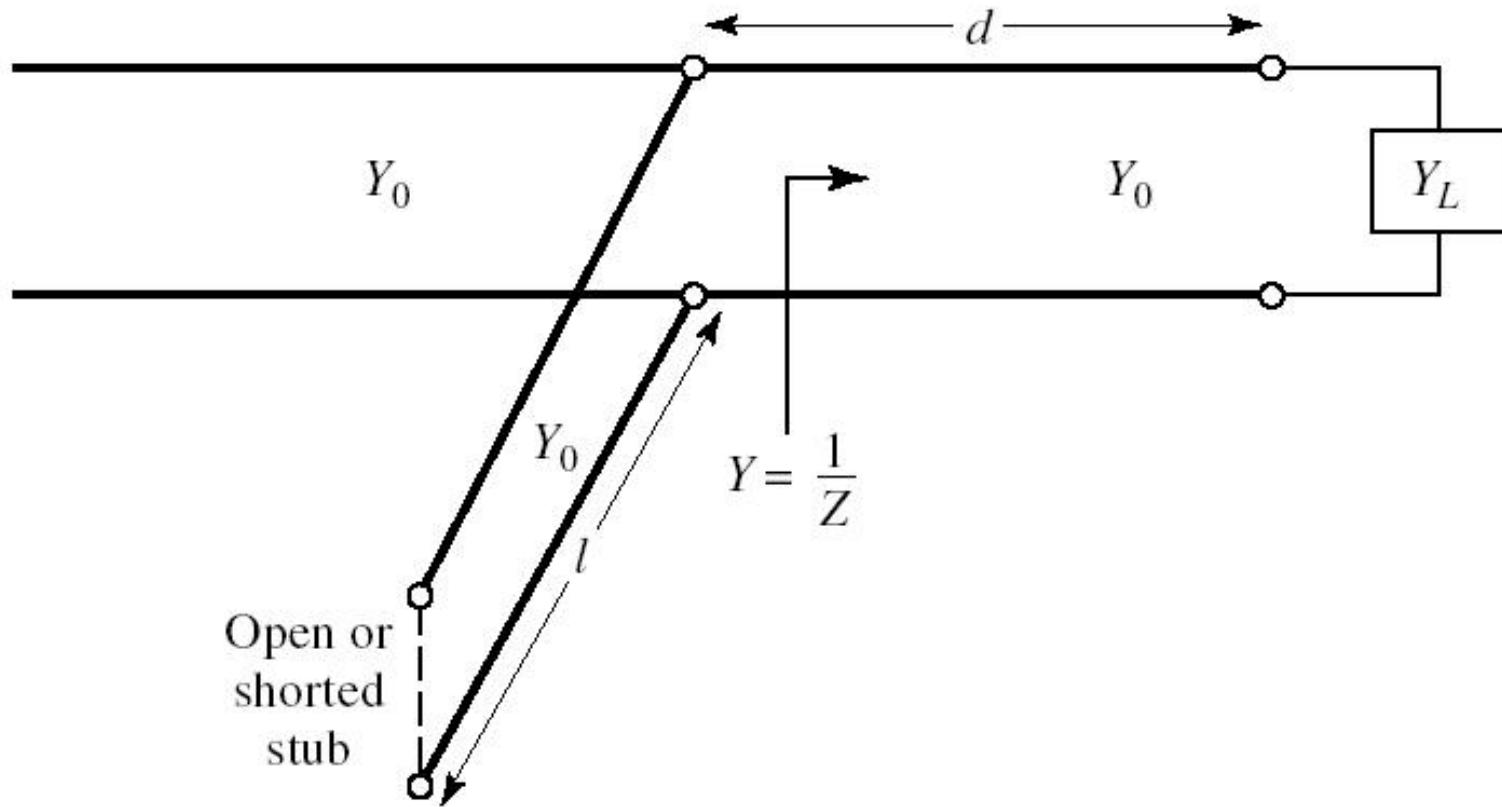


$$| \Gamma_{in} | = | \Gamma_L |$$

$$g_{in} = 1$$

# Caz 1, Shunt Stub

- Shunt Stub (secțiune de linie în paralel)



# Caz 1, Shunt Stub

- Se utilizeaza o linie de transmisie serie pentru a muta coeficientul de reflexie pe cercul  $g_L = 1$
- Se introduce o reactanta in paralel pentru a realiza adaptarea
- Aceasta reactanta se realizeaza cu o linie de transmisie care poate fi dupa nevoie:
  - in gol
  - in scurtcircuit

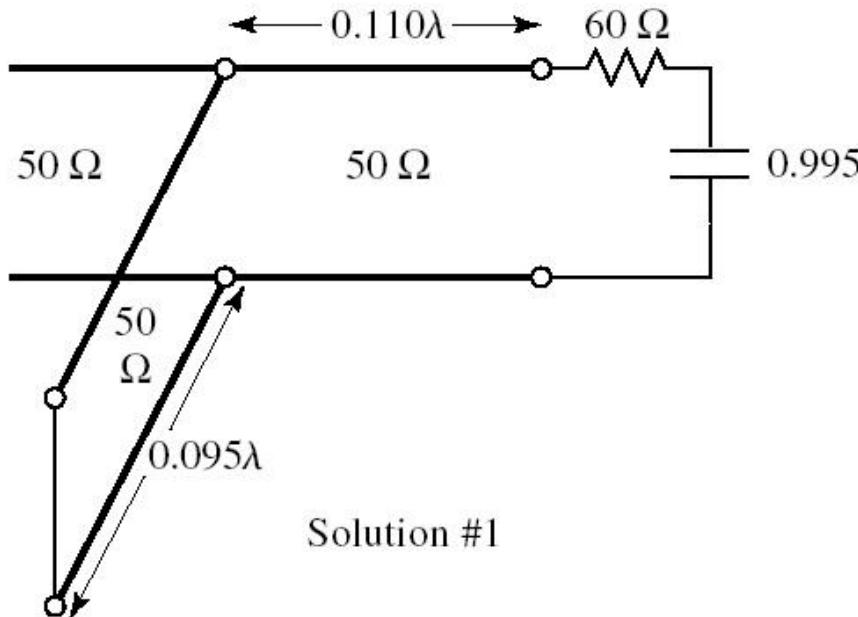
$$Z_{in} = Z_0 \cdot \frac{Z_L + j \cdot Z_0 \cdot \tan \beta \cdot l}{Z_0 + j \cdot Z_L \cdot \tan \beta \cdot l}$$

$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l$$

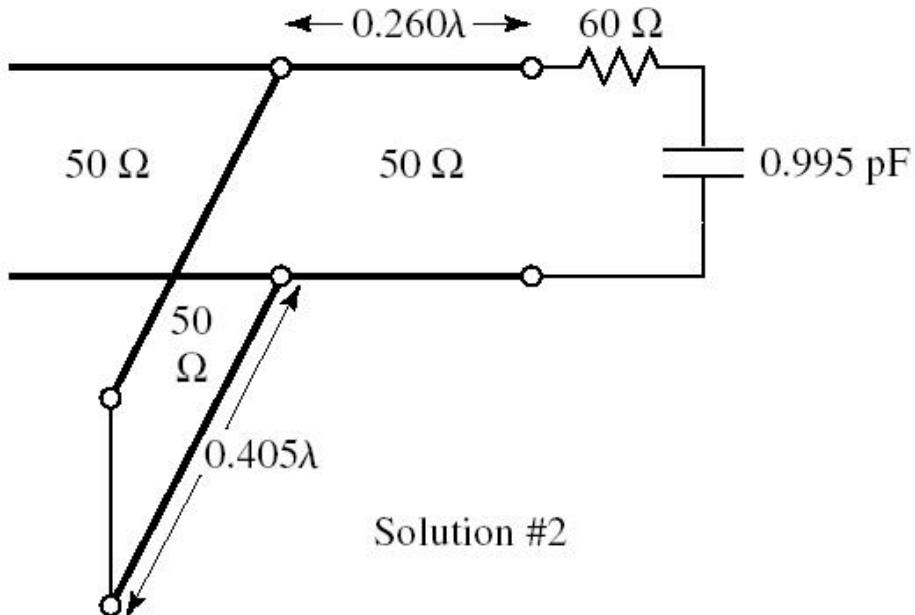
$$Z_{in,g} = -j \cdot Z_0 \cdot \cot \beta \cdot l$$

# Exemplu, Shunt Stub, sc

- sarcina:  $60 \Omega$  serie  $0.995 \text{ pF}$
- doua solutii posibile

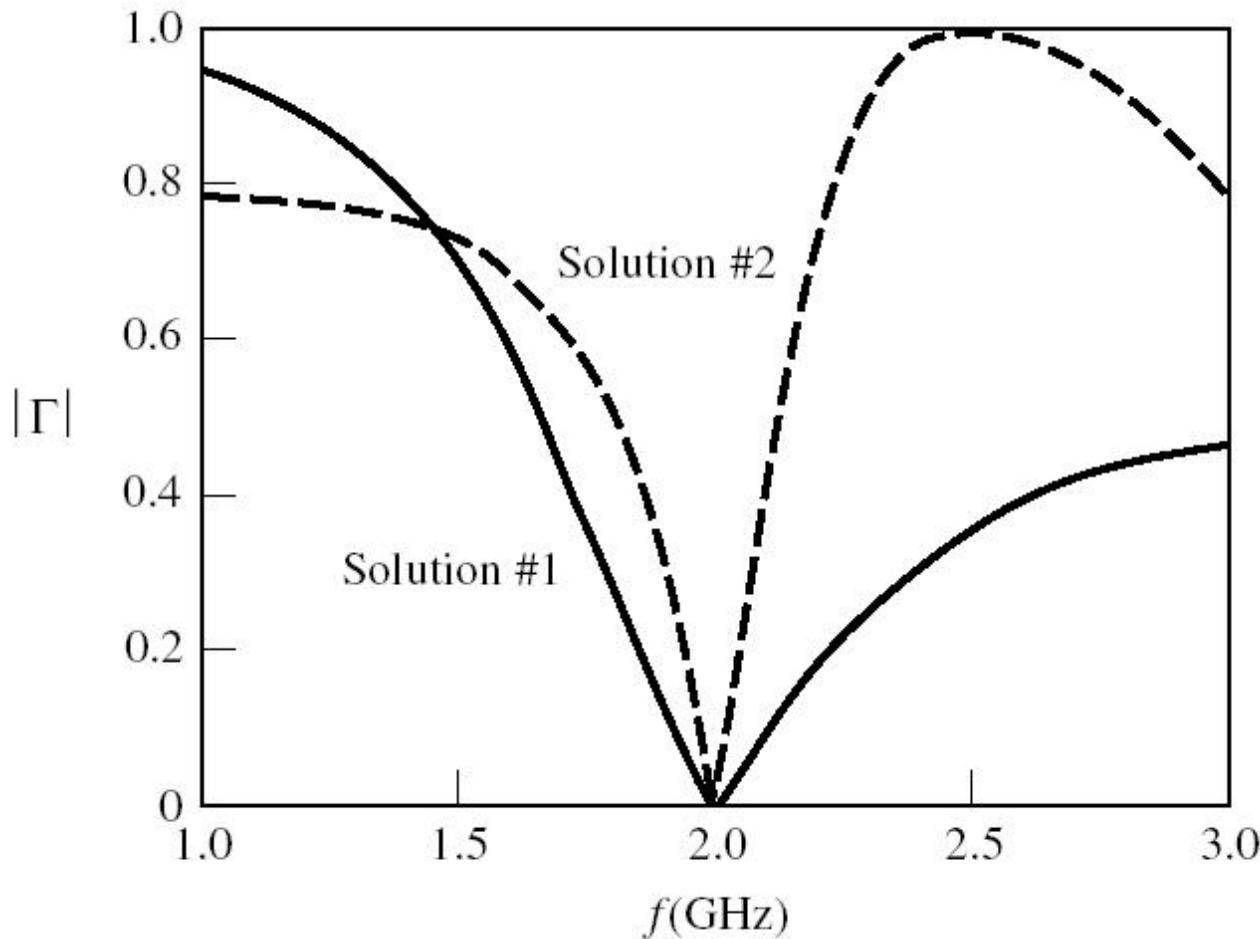


Solution #1

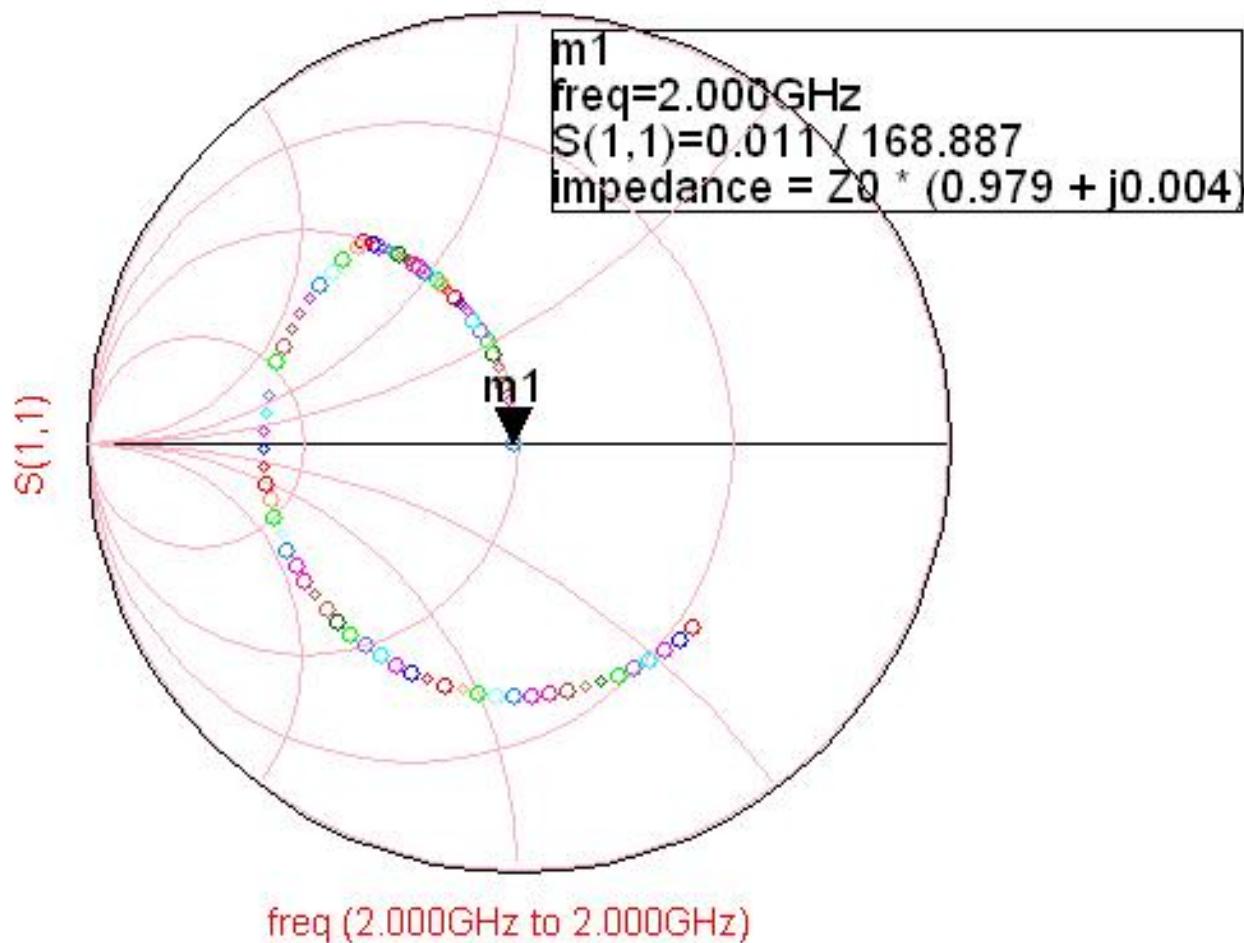


Solution #2

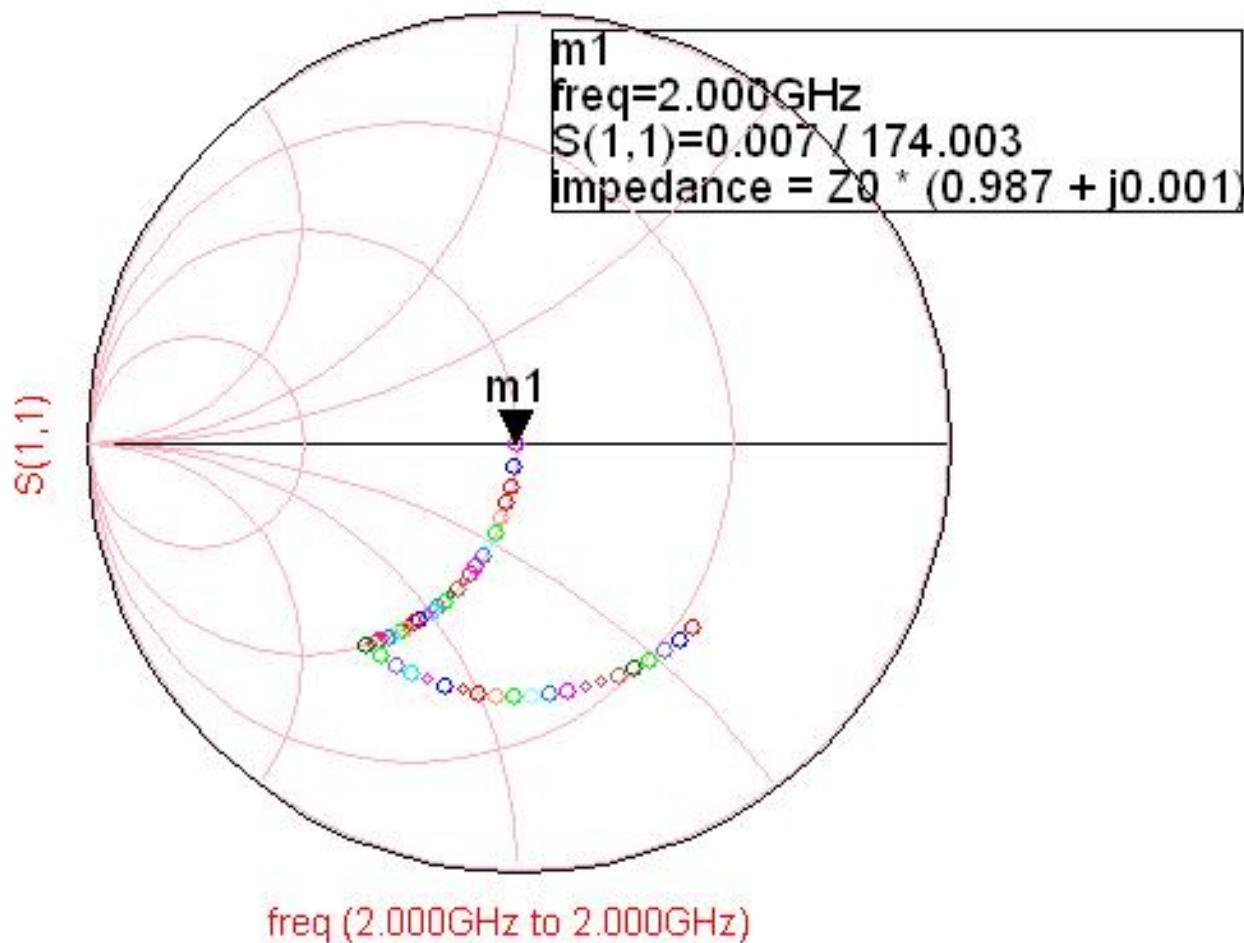
# Exemplu, Shunt Stub, sc



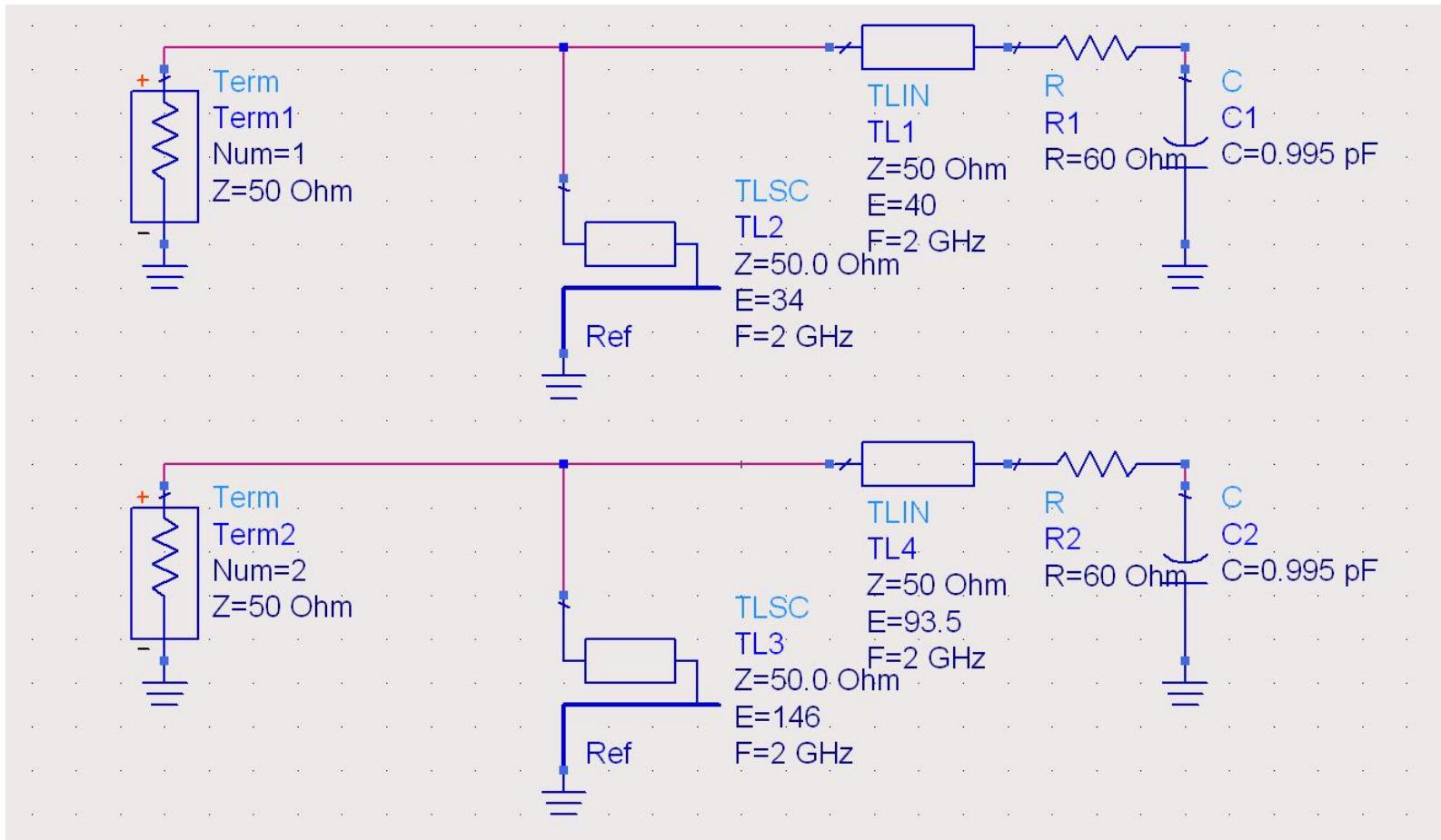
# Exemplu, Shunt Stub, sc



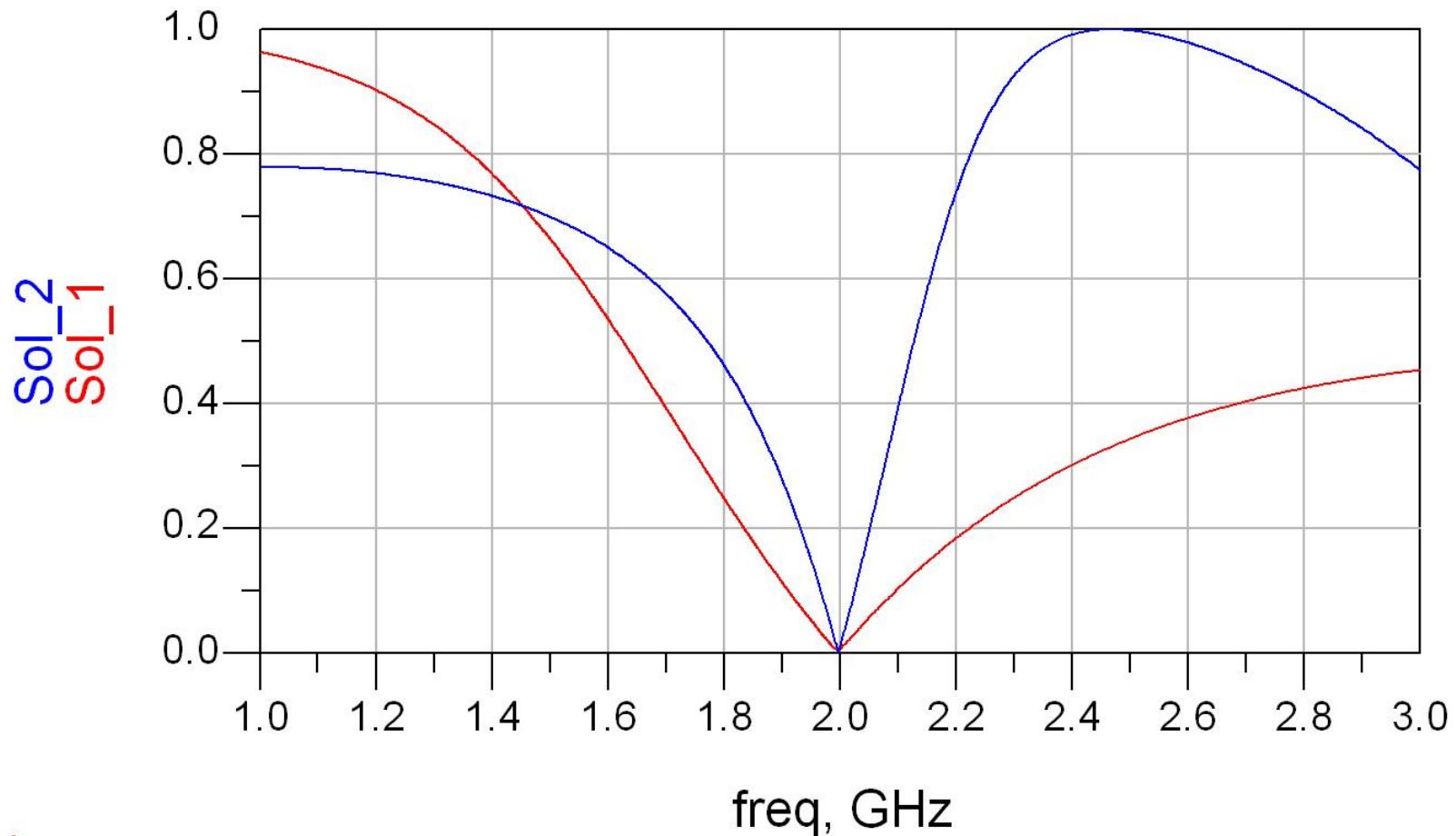
# Exemplu, Shunt Stub, sc



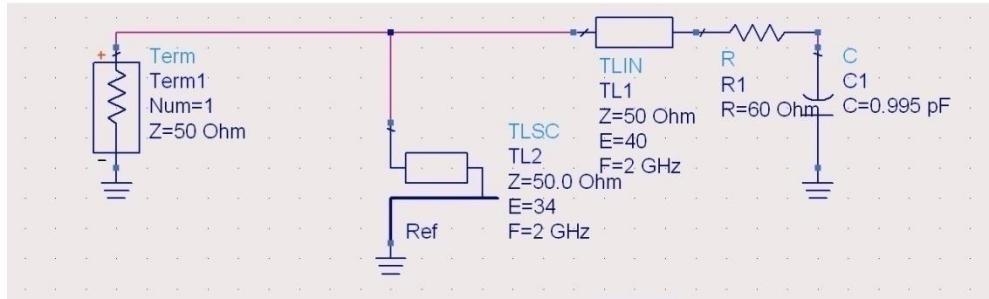
# Exemplu, Shunt Stub, sc



# Exemplu, Shunt Stub, sc



# Exemplu, Shunt Stub, sc

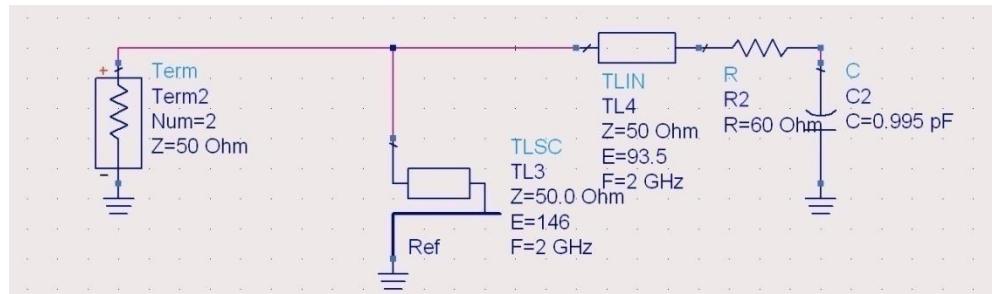


$$l_1 = \frac{40^\circ}{360^\circ} \cdot \lambda = 0.111 \cdot \lambda$$

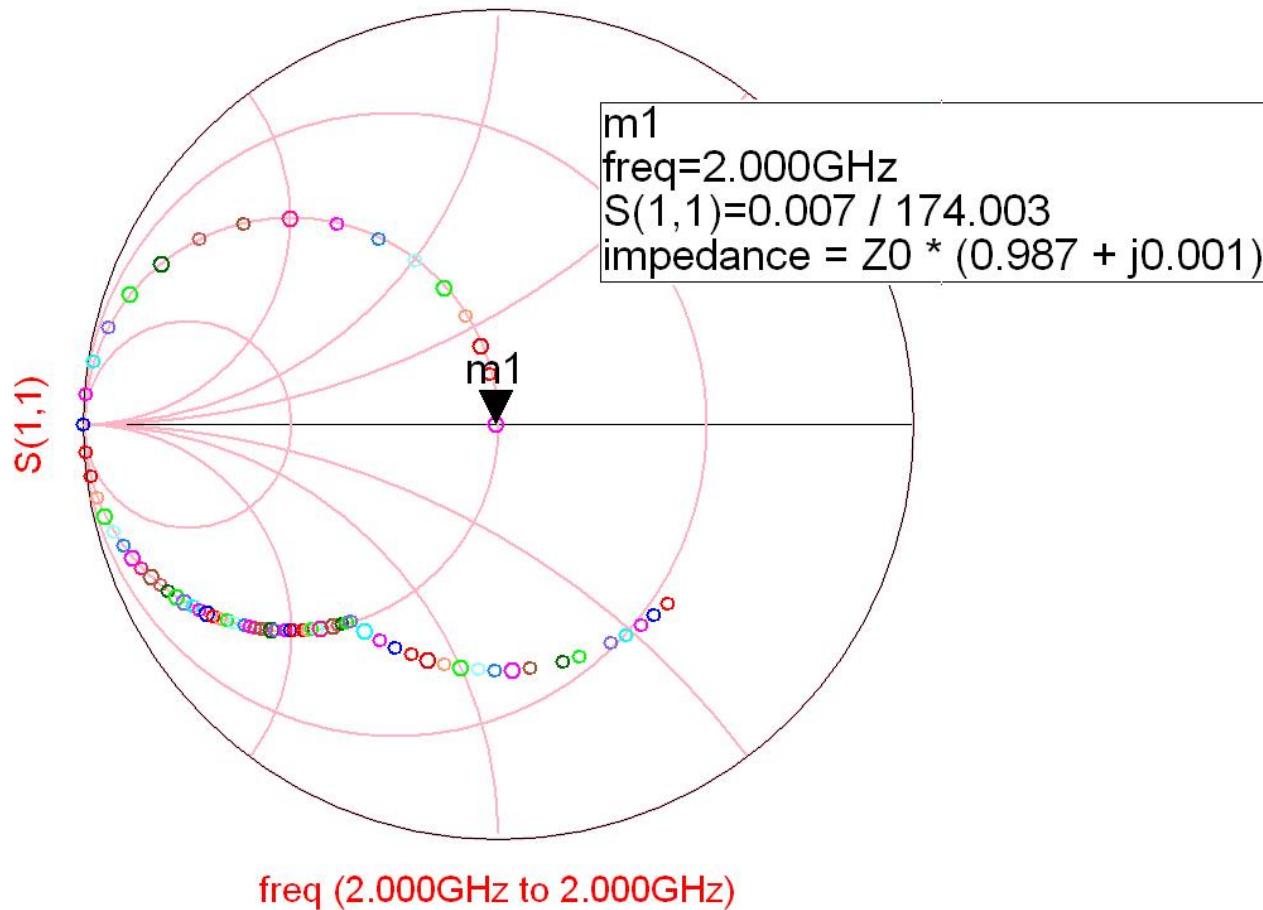
$$l_2 = \frac{34^\circ}{360^\circ} \cdot \lambda = 0.094 \cdot \lambda$$

$$l_1 = \frac{93.5^\circ}{360^\circ} \cdot \lambda = 0.260 \cdot \lambda$$

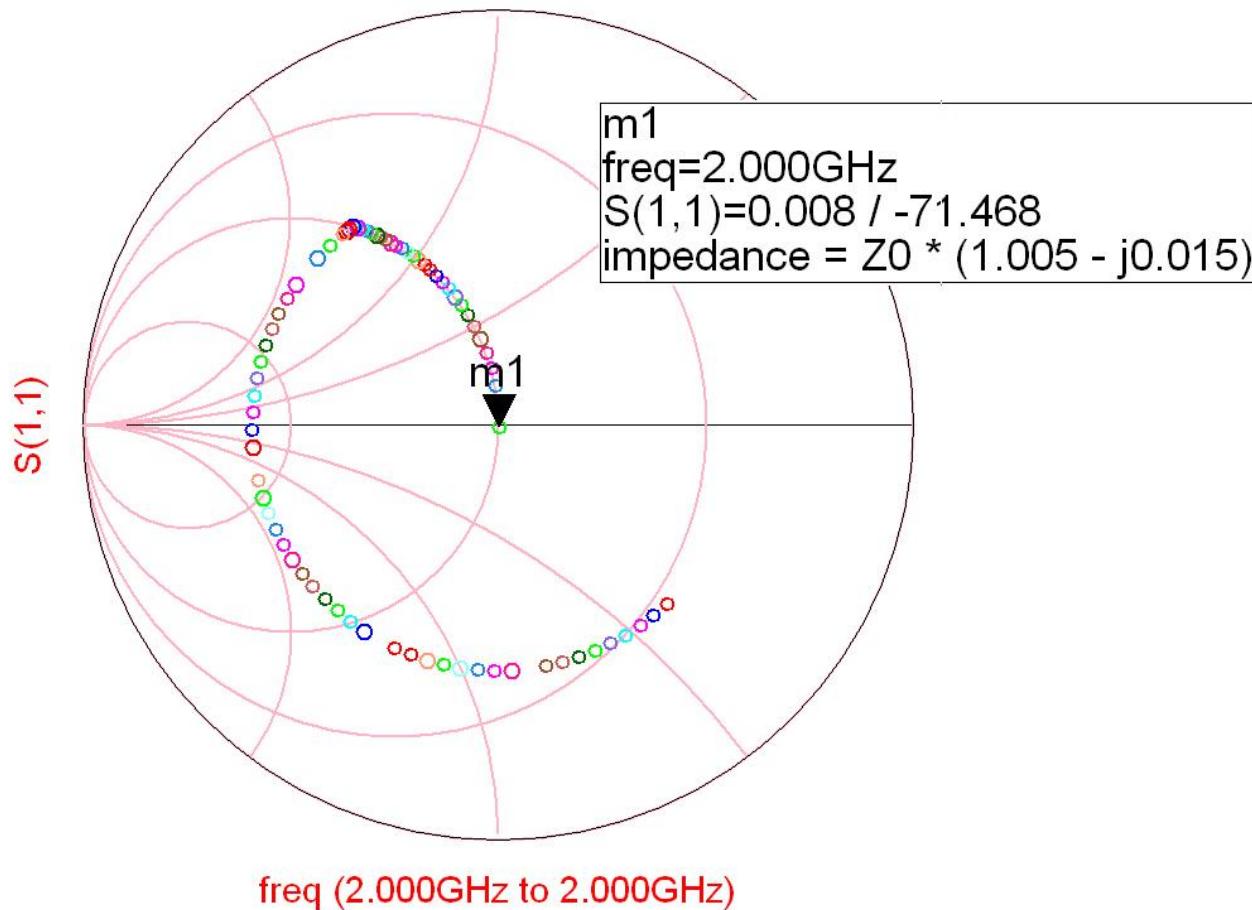
$$l_2 = \frac{146^\circ}{360^\circ} \cdot \lambda = 0.406 \cdot \lambda$$



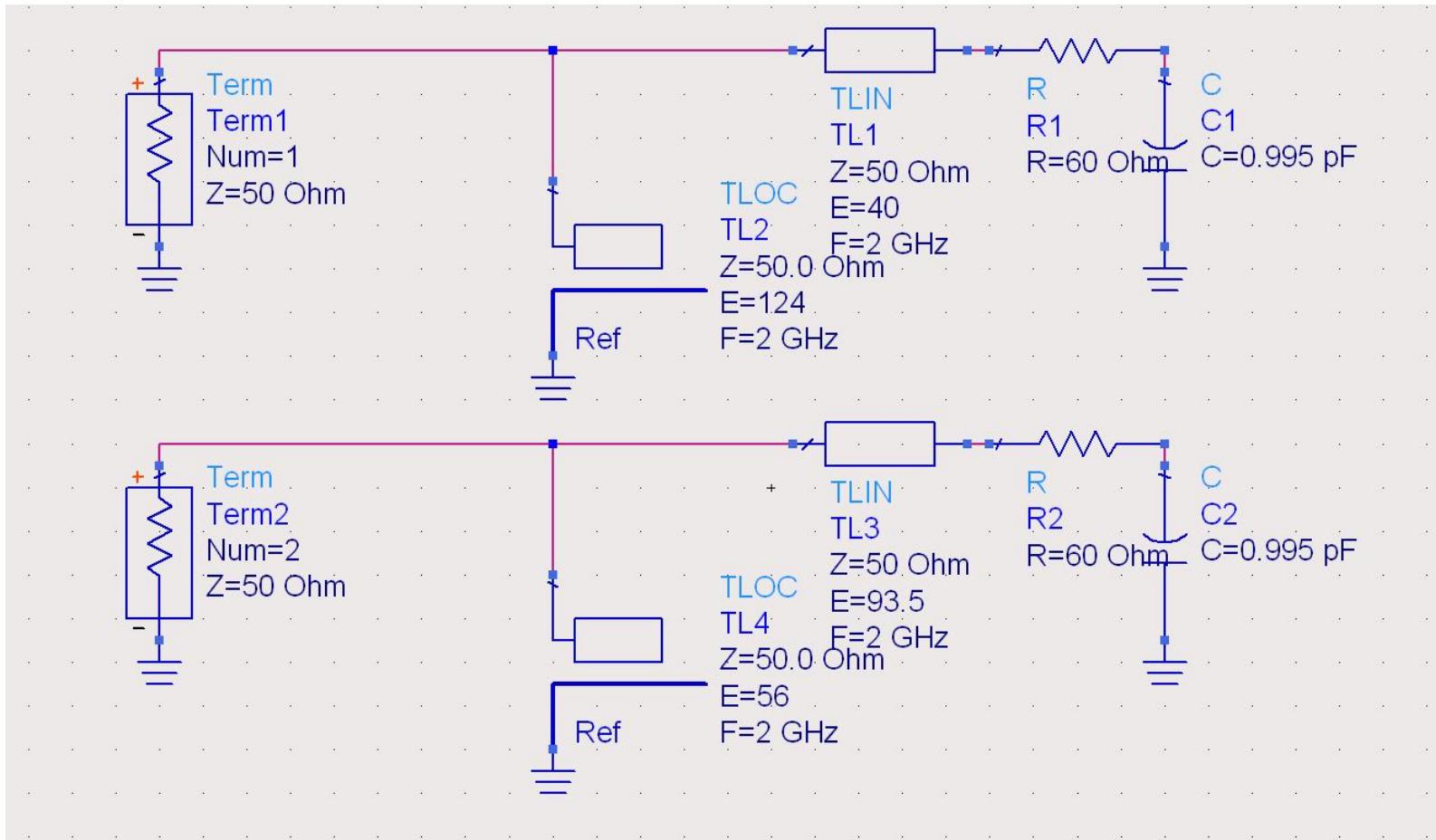
# Exemplu, Shunt Stub, gol



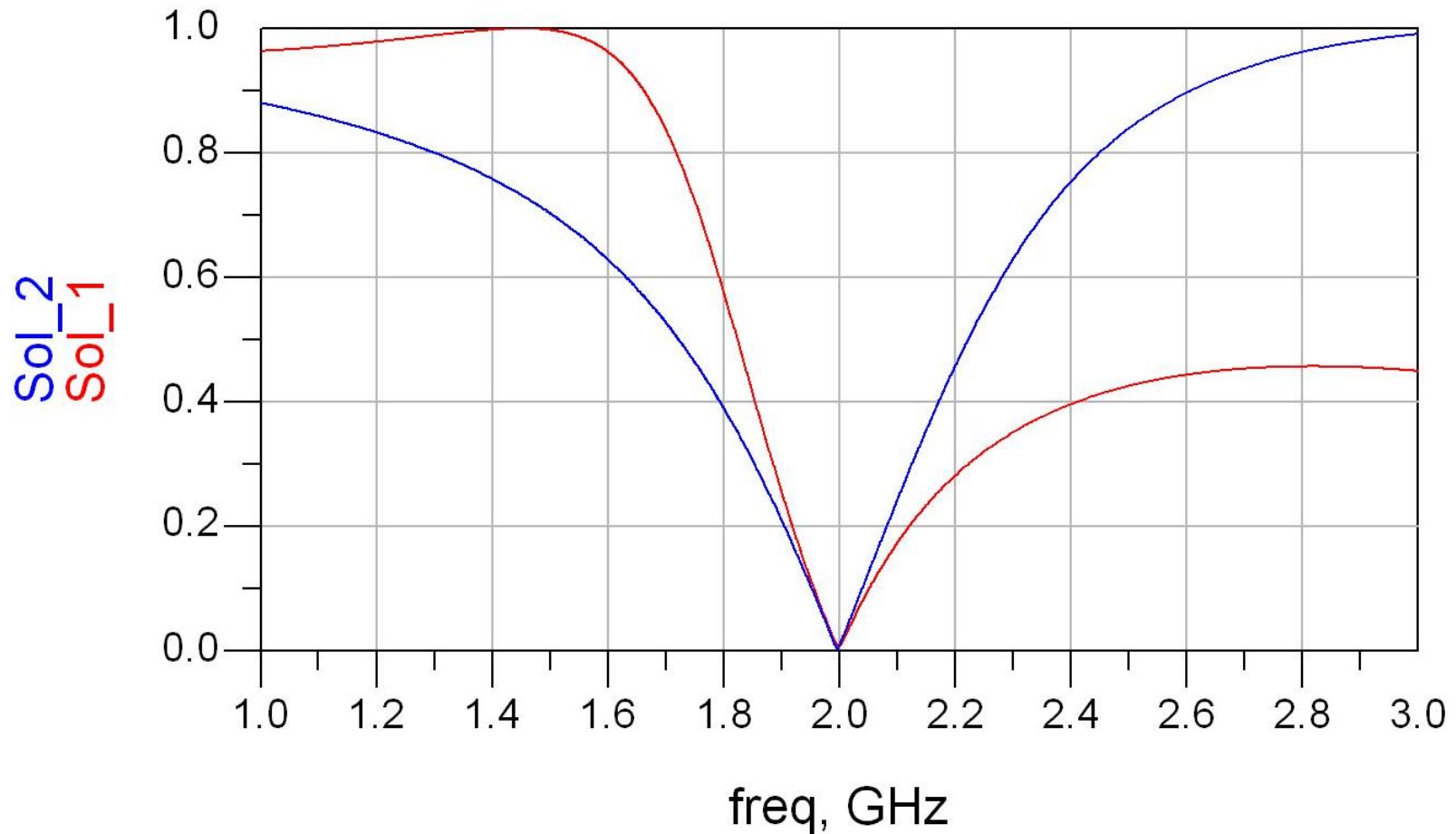
# Exemplu, Shunt Stub, gol



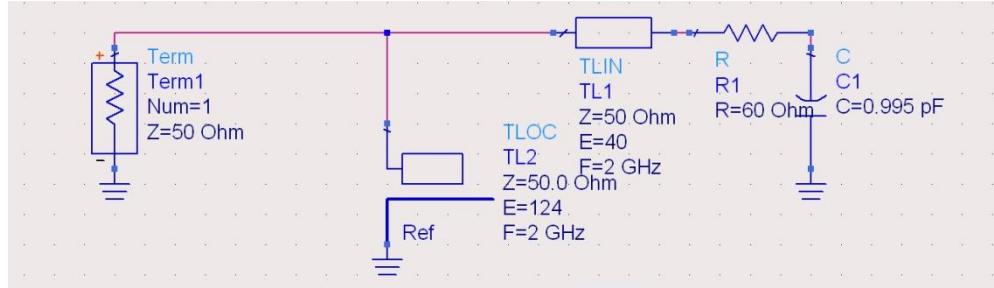
# Exemplu, Shunt Stub, gol



# Exemplu, Shunt Stub, gol



# Exemplu, Shunt Stub, gol

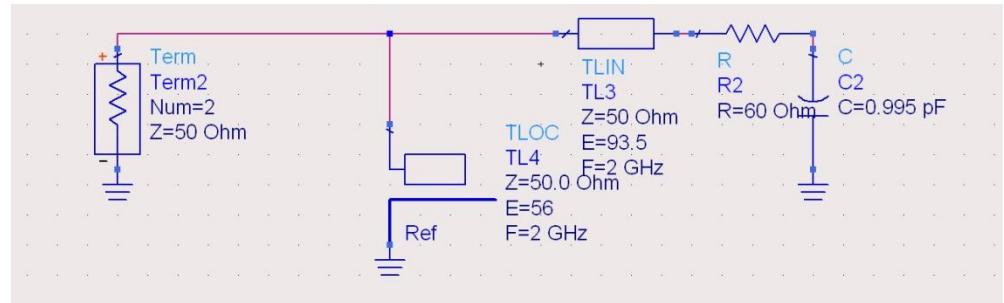


$$l_1 = \frac{40^\circ}{360^\circ} \cdot \lambda = 0.111 \cdot \lambda$$

↓

$$l_2 = \frac{124^\circ}{360^\circ} \cdot \lambda = 0.344 \cdot \lambda = 0.094 \cdot \lambda + \frac{\lambda}{4}$$

$$l_1 = \frac{93.5^\circ}{360^\circ} \cdot \lambda = 0.260 \cdot \lambda$$



$$l_2 = \frac{56^\circ}{360^\circ} \cdot \lambda = 0.156 \cdot \lambda = 0.406 \cdot \lambda - \frac{\lambda}{4}$$

←

# Stub, observatii

- functiile care ofera impedanta de intrare intr-un stub sunt periodice in functie de lungime ( $l$ ), functii tip tg/ctg

$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l$$

$$Z_{in,g} = -j \cdot Z_0 \cdot \cot \beta \cdot l$$

- adunarea si scadere

$$E = \beta \cdot l = \pi = 180^\circ \quad l = k \cdot \frac{\lambda}{2}, \forall k \in \mathbf{N}$$

nu schimba rezultatul (rotatie completa in jurul diagramei – de aici provine gradatia 0.5 lungimi de unda a circumferintei diagramei)

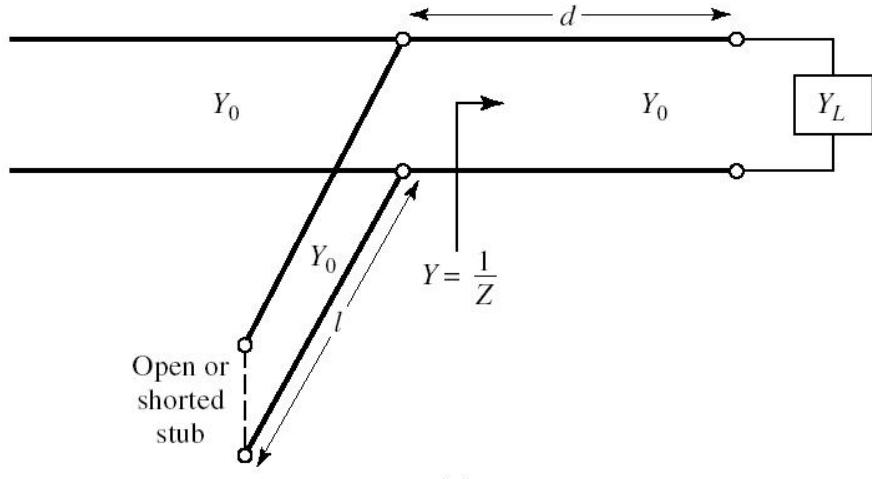
# Stub, observatii

- pentru reglaj in vederea adaptarii este preferabila pornirea din punctul neutru (valoarea lungimii liniei care nu influenteaza circuitul)
  - linia in serie:  $E = \beta \cdot l = 0$
  - stub:  $Z_{in} \rightarrow \infty$ ,  $\tan \beta \cdot l / \cot \beta \cdot l \rightarrow \infty$ ,  $E = 90^\circ / 0^\circ$
- o adaugare sau scadere de sfert de lungime de unda transforma impedanta:

$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l \quad Z_{in,g} = -j \cdot Z_0 \cdot \cot \beta \cdot l$$

$$\tan \beta \cdot \left( l + \frac{\lambda}{4} \right) = \tan \left( \beta \cdot l + \frac{\pi}{2} \right) = \frac{\sin(\beta \cdot l + \pi/2)}{\cos(\beta \cdot l + \pi/2)} = \frac{\cos \beta \cdot l}{-\sin \beta \cdot l} = -\cot \beta \cdot l$$

# Solutie analitica



$$G = \frac{R_L \cdot (1 + t^2)}{R_L^2 + (X_L + Z_0 \cdot t)^2}$$

$$Z_L = \frac{1}{Y_L} = R_L + j \cdot X_L$$

$$Z = Z_0 \cdot \frac{(R_L + j \cdot X_L) + j \cdot Z_0 \cdot t}{Z_0 + j \cdot (R_L + j \cdot X_L) \cdot t}$$

$$t = \tan \beta \cdot d \quad Y = G + j \cdot B = \frac{1}{Z}$$

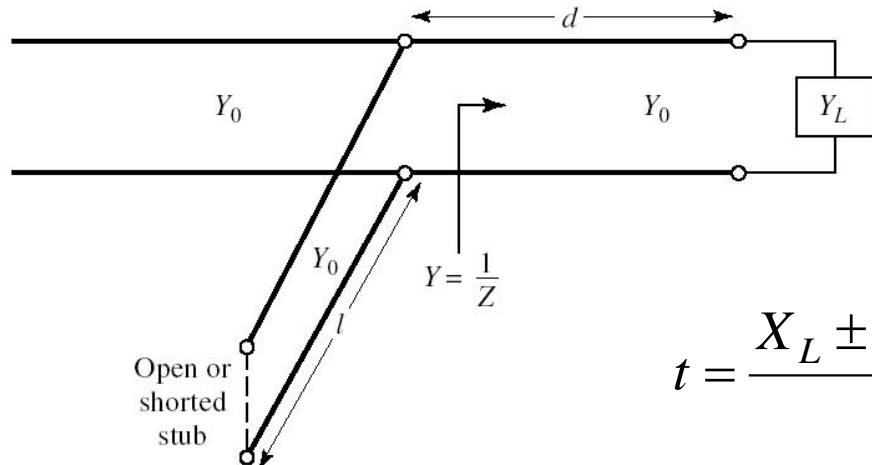
$$B = \frac{R_L^2 \cdot t - (Z_0 - X_L \cdot t) \cdot (X_L + Z_0 \cdot t)}{Z_0 \cdot [R_L^2 + (X_L + Z_0 \cdot t)^2]}$$

$$G = Y_0 = \frac{1}{Z_0}$$

$$Z_0 \cdot (R_L - Z_0) \cdot t^2 - 2 \cdot X_L \cdot Z_0 \cdot t + (R_L \cdot Z_0 - R_L^2 - X_L^2) = 0$$

- $d$  este ales astfel incat

# Solutie analitica



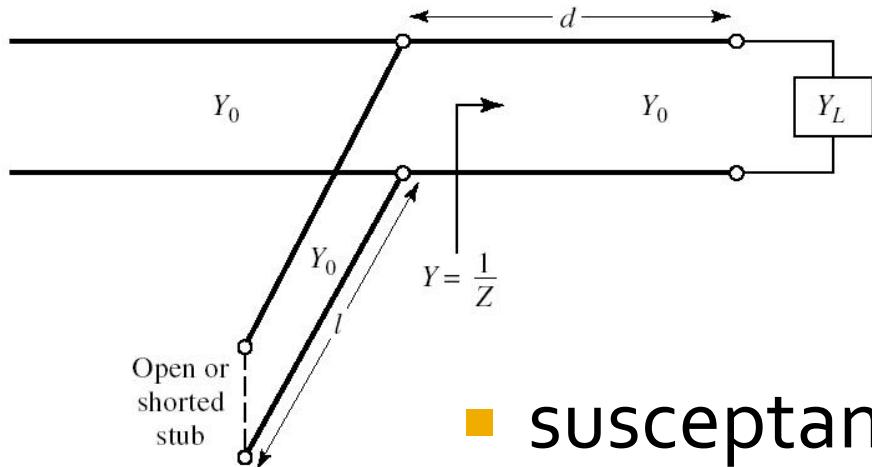
$$t = -\frac{X_L}{2 \cdot Z_0}, \quad R_L = Z_0$$

$$t = \frac{X_L \pm \sqrt{R_L \cdot [(Z_0 - R_L)^2 + X_L^2] / Z_0}}{R_L - Z_0} \quad R_L \neq Z_0$$

- ecuatie de gradul 2, 2 solutii posibile
- $d$  este ales astfel incat

$$\frac{d}{\lambda} = \begin{cases} \frac{1}{2\pi} \cdot \arctan t & t \geq 0 \\ \frac{1}{2\pi} \cdot (\pi + \arctan t) & t < 0 \end{cases}$$

# Solutie analitica



$$B_S = -B$$

$$B = \frac{R_L^2 \cdot t - (Z_0 - X_L \cdot t) \cdot (X_L + Z_0 \cdot t)}{Z_0 \cdot [R_L^2 + (X_L + Z_0 \cdot t)^2]}$$

■ susceptanta de anulare se obtine

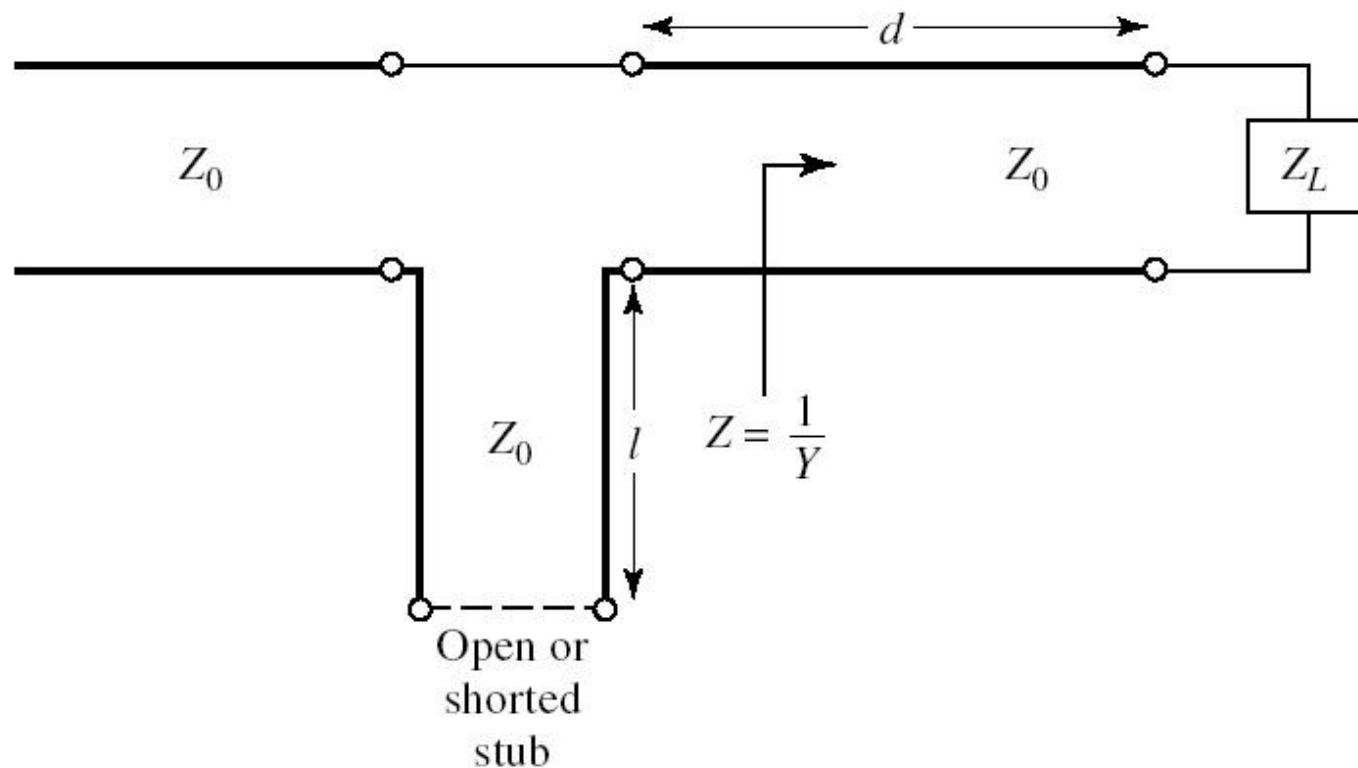
$$\frac{l_{gol}}{\lambda} = \frac{1}{2\pi} \cdot \arctan \left( \frac{B_S}{Y_0} \right) = \frac{-1}{2\pi} \cdot \arctan \left( \frac{B}{Y_0} \right)$$

$$\frac{l_{sc}}{\lambda} = \frac{-1}{2\pi} \cdot \arctan \left( \frac{Y_0}{B_S} \right) = \frac{1}{2\pi} \cdot \arctan \left( \frac{Y_0}{B} \right)$$

■ pentru lungimi negative se adauga  $\lambda/2$

# Caz 2, Series Stub

- Series Stub (secțiune de linie în serie)
- tehnologic mai dificil de realizat la liniile monofilare (microstrip)



# Caz 2, Series Stub

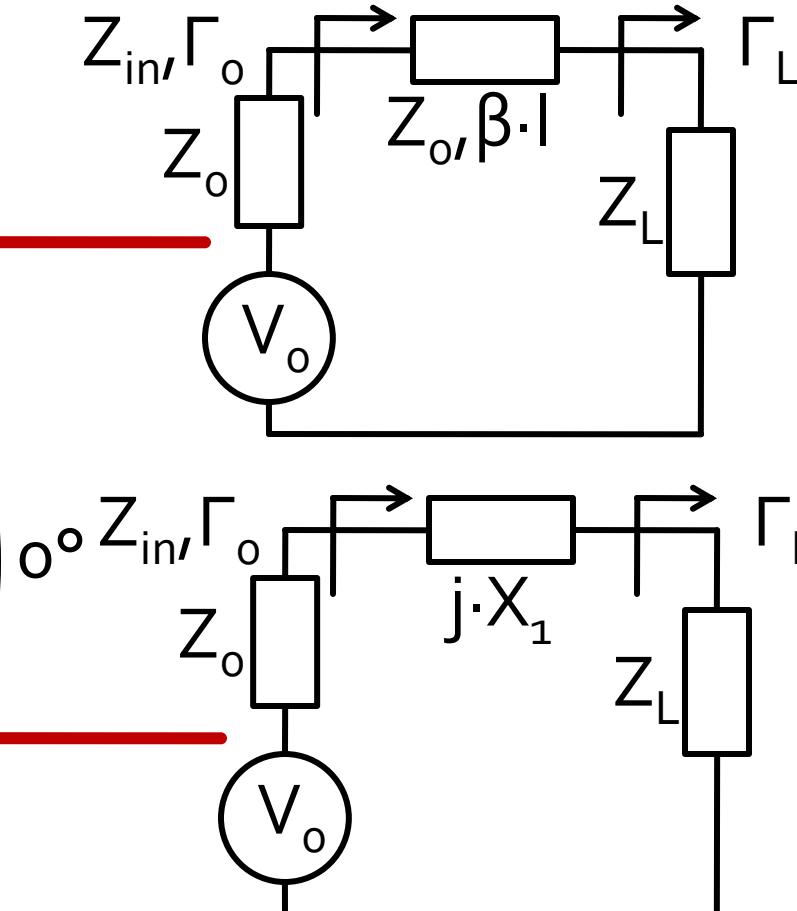
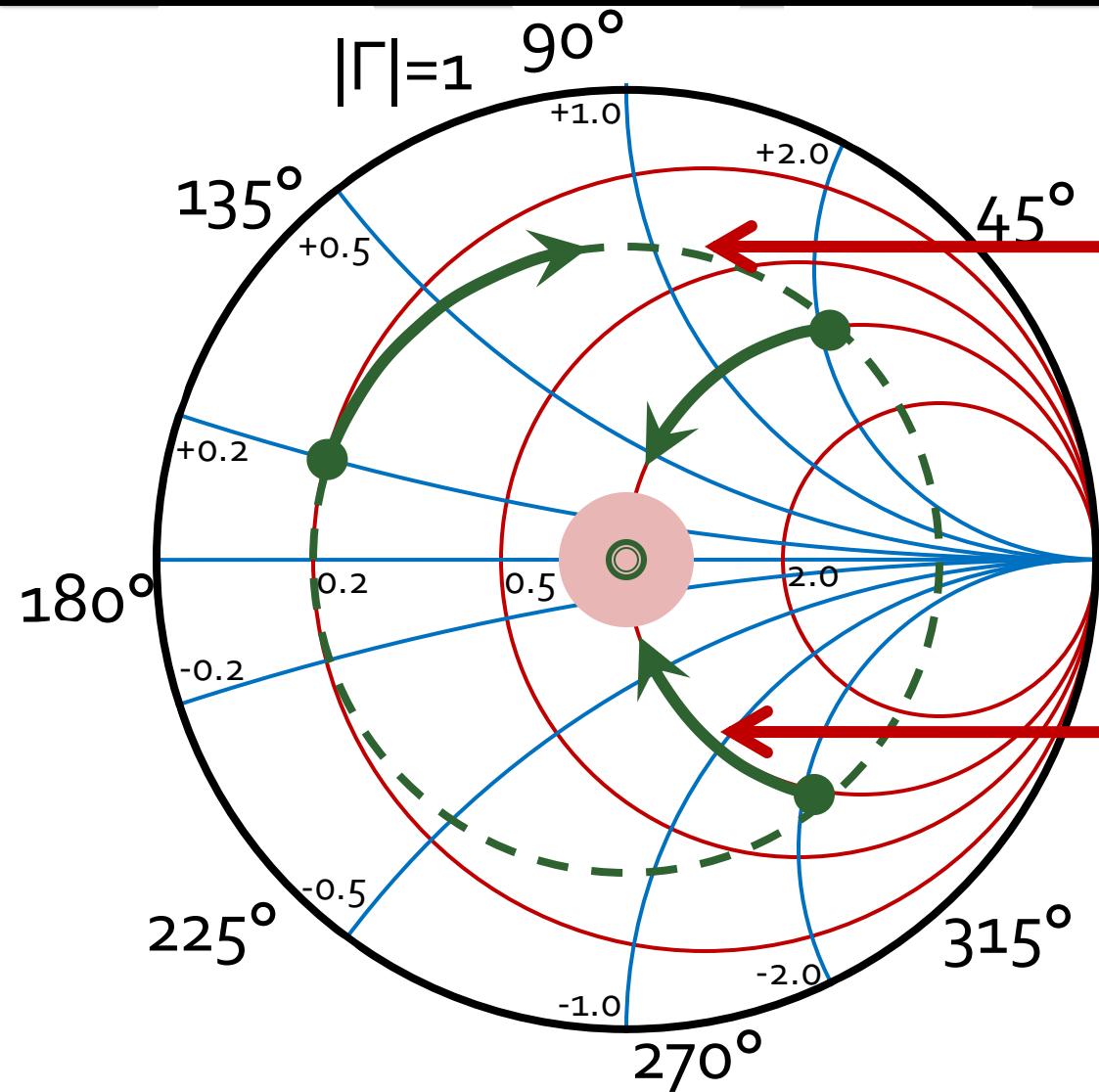
- Se utilizeaza o linie de transmisie serie pentru a muta coeficientul de reflexie pe cercul  $g_L = 1$
- Se introduce o reactanta in serie pentru a realiza adaptarea
- Aceasta reactanta se realizeaza cu o linie de transmisie care poate fi dupa nevoie:
  - in gol
  - in scurtcircuit

$$Z_{in} = Z_0 \cdot \frac{Z_L + j \cdot Z_0 \cdot \tan \beta \cdot l}{Z_0 + j \cdot Z_L \cdot \tan \beta \cdot l}$$

$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l$$

$$Z_{in,g} = -j \cdot Z_0 \cdot \cot \beta \cdot l$$

# Adaptare, linie serie + reactanta in serie

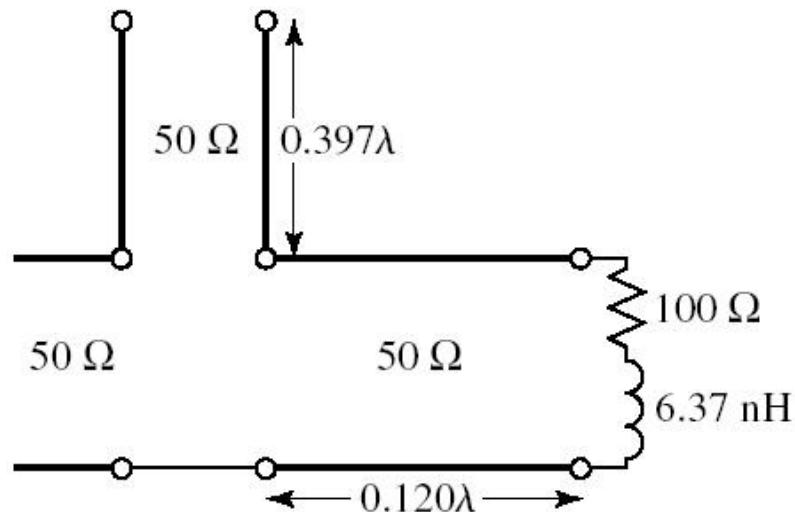


$$|\Gamma_{in}| = |\Gamma_L|$$

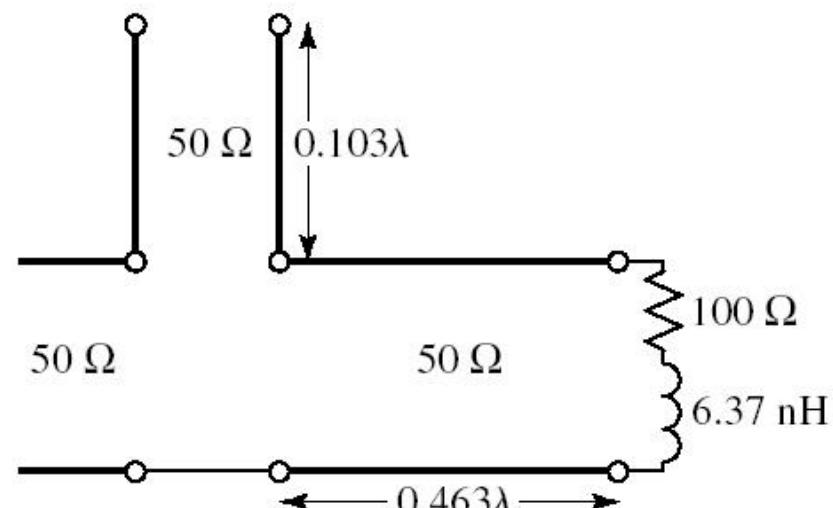
$$r_{in} = 1$$

# Exemplu, Series Stub, gol

- sarcina:  $100 \Omega$  serie  $6.37 \text{ nH}$
- doua solutii posibile

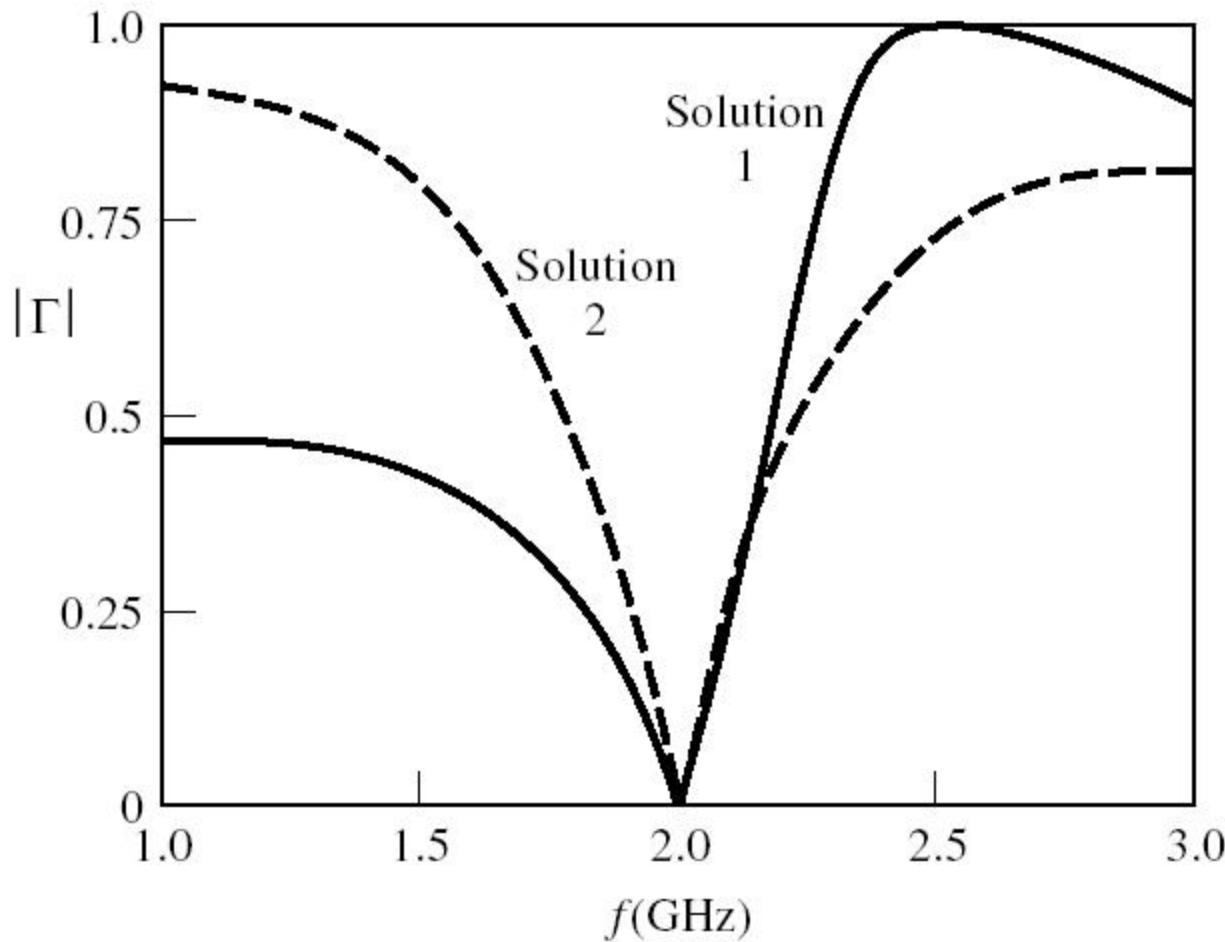


Solution 1

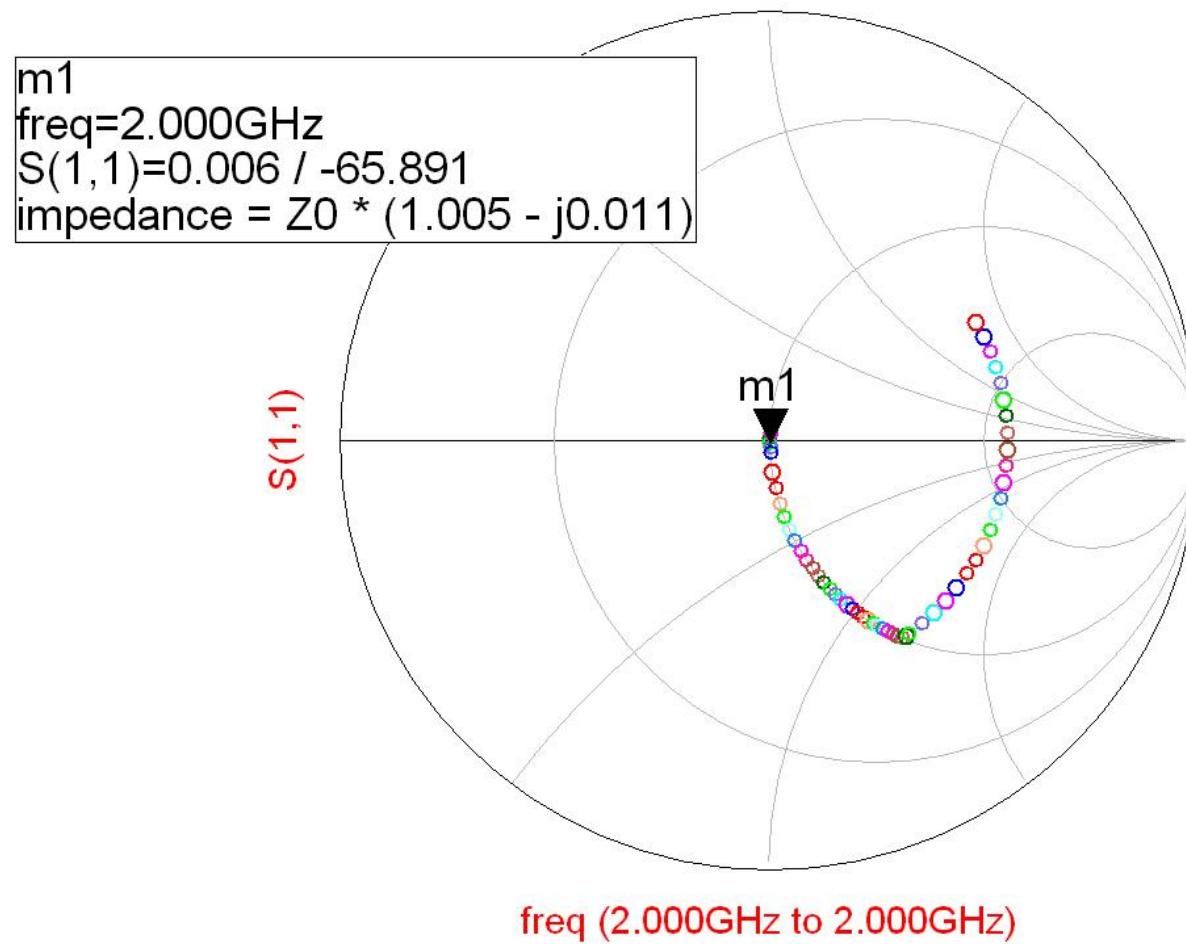


Solution 2

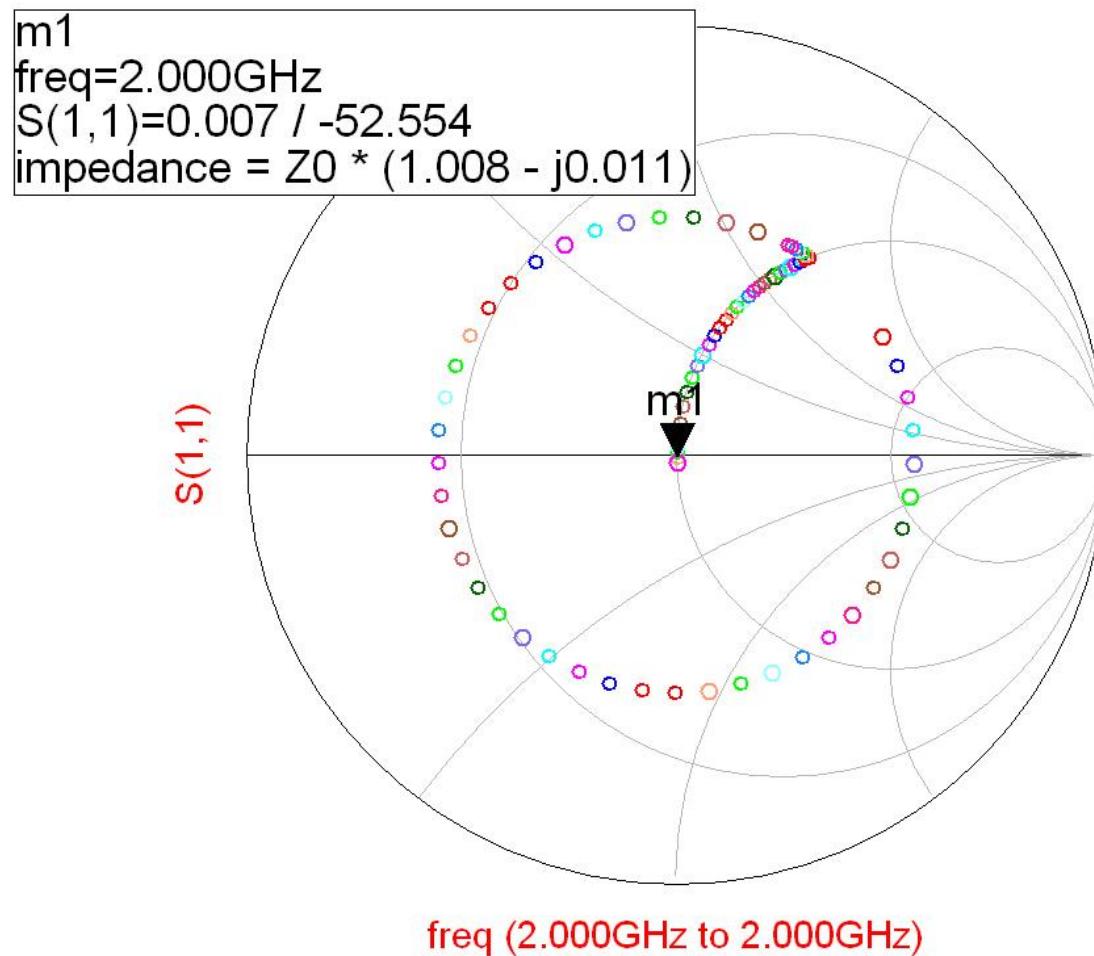
# Exemplu, Series Stub, gol



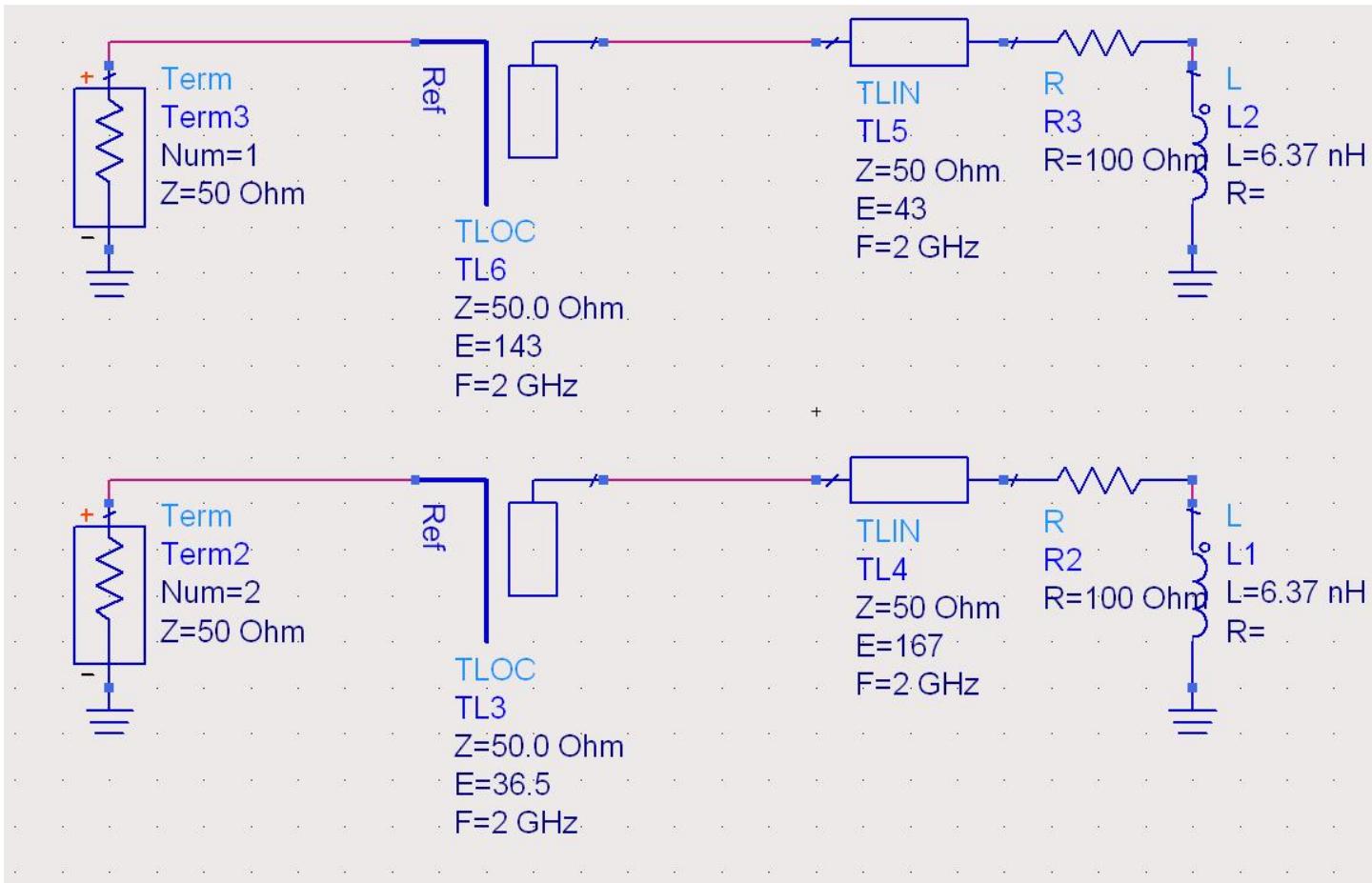
# Exemplu, Series Stub, gol



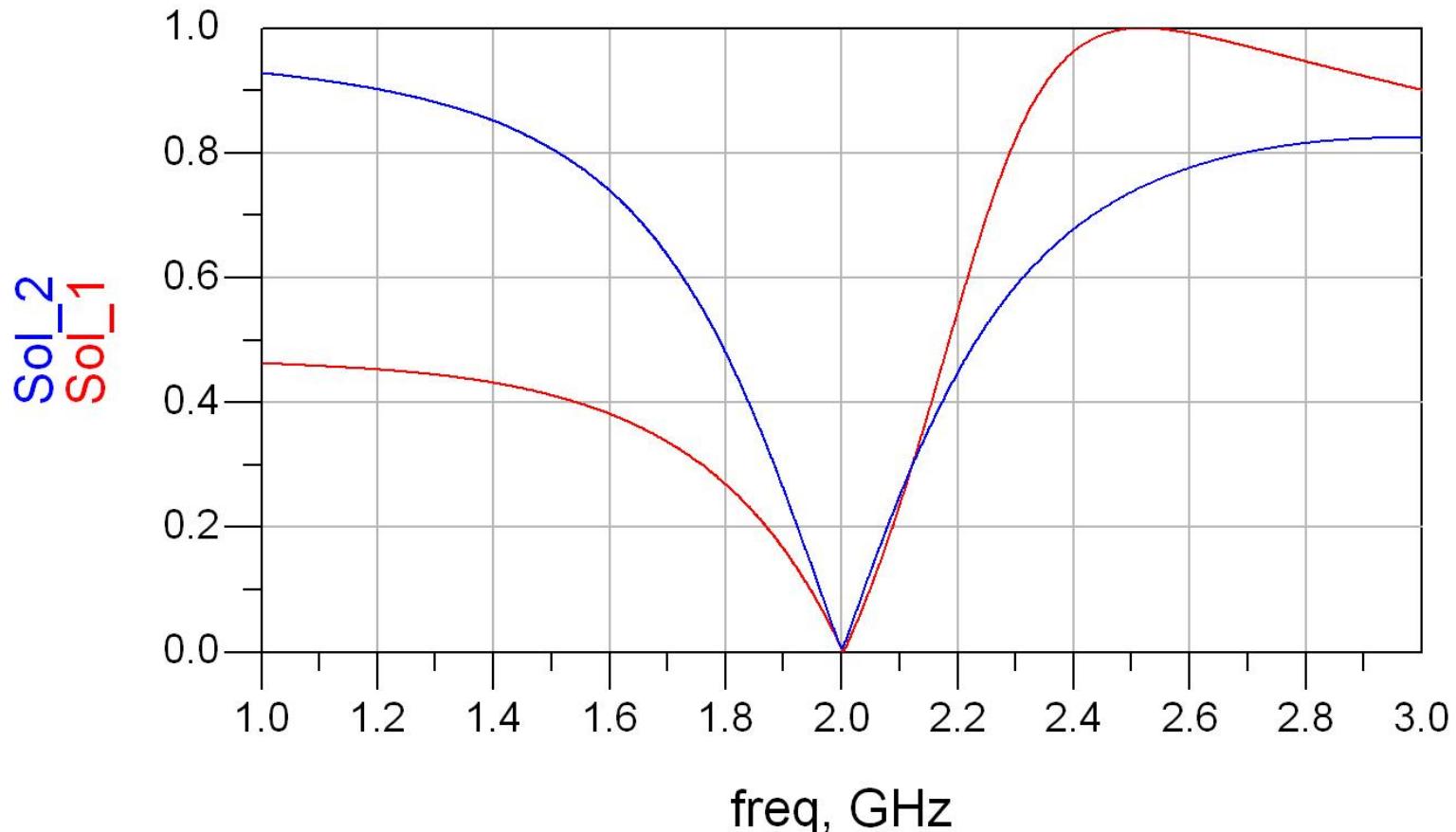
# Exemplu, Series Stub, gol



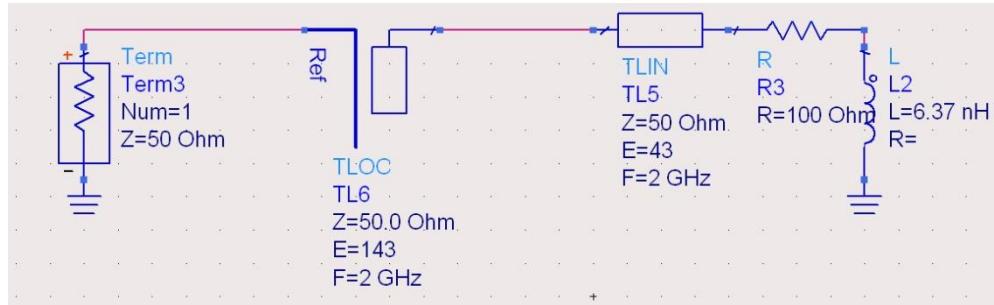
# Exemplu, Series Stub, gol



# Exemplu, Series Stub, gol



# Exemplu, Series Stub, gol

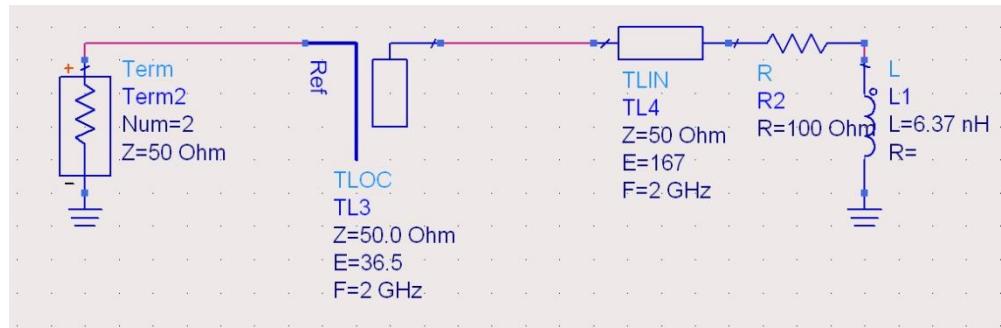


$$l_1 = \frac{43^\circ}{360^\circ} \cdot \lambda = 0.119 \cdot \lambda$$

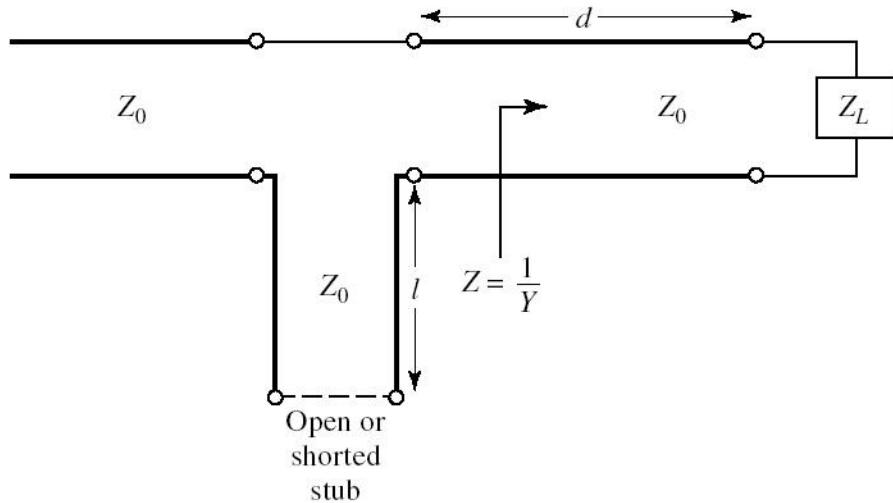
$$l_2 = \frac{143^\circ}{360^\circ} \cdot \lambda = 0.397 \cdot \lambda$$

$$l_1 = \frac{93.5^\circ}{360^\circ} \cdot \lambda = 0.464 \cdot \lambda$$

$$l_2 = \frac{146^\circ}{360^\circ} \cdot \lambda = 0.101 \cdot \lambda$$



# Solutie analitica



$$R = \frac{G_L \cdot (1 + t^2)}{G_L^2 + (G_L + Y_0 \cdot t)^2}$$

$$Y_L = \frac{1}{Z_L} = G_L + j \cdot B_L$$

$$Y = Y_0 \cdot \frac{(G_L + j \cdot B_L) + j \cdot Y_0 \cdot t}{Y_0 + j \cdot (G_L + j \cdot B_L) \cdot t}$$

$$t \stackrel{\text{not}}{=} \tan \beta \cdot d \quad Z = R + j \cdot X = \frac{1}{Y}$$

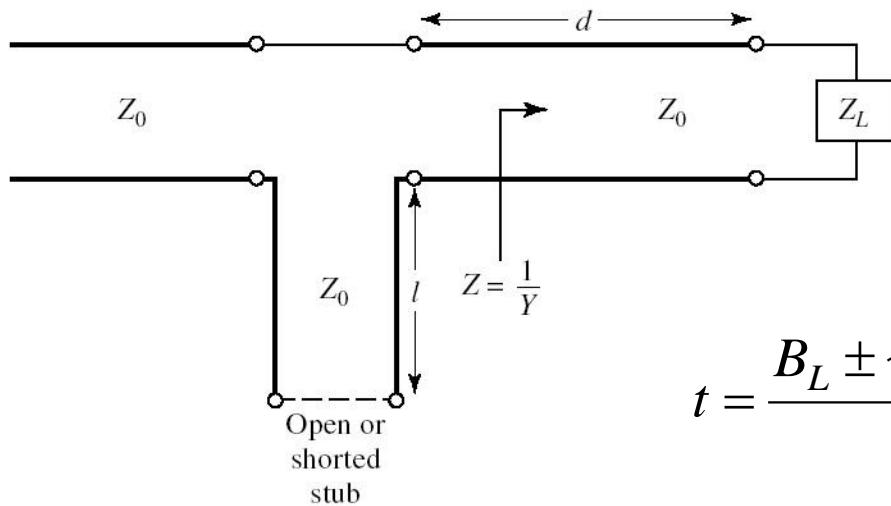
$$X = \frac{G_L^2 \cdot t - (Y_0 - B_L \cdot t) \cdot (B_L + Y_0 \cdot t)}{Y_0 \cdot [G_L^2 + (B_L + Y_0 \cdot t)^2]}$$

$$R = Z_0 = \frac{1}{Y_0}$$

$$Y_0 \cdot (G_L - Y_0) \cdot t^2 - 2 \cdot B_L \cdot Y_0 \cdot t + (G_L \cdot Y_0 - G_L^2 - B_L^2) = 0$$

- $d$  este ales astfel incat

# Solutie analitica



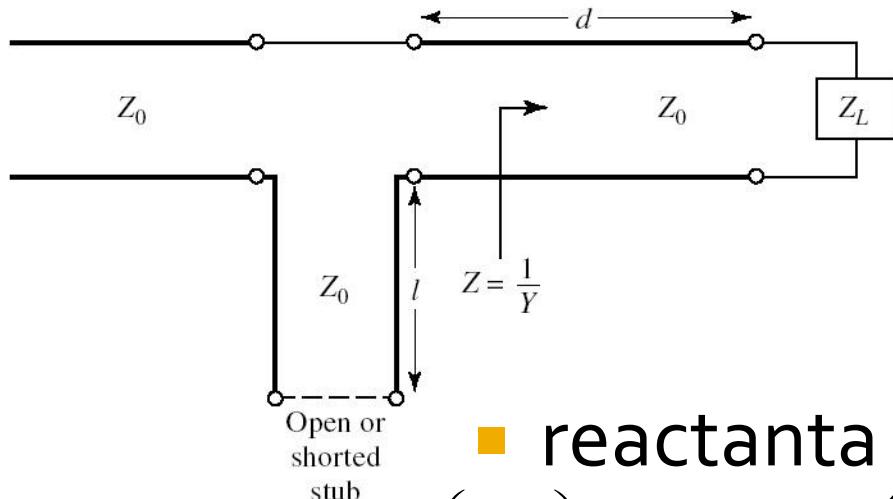
$$t = \frac{-B_L}{2 \cdot Y_0}, \quad G_L = Y_0$$

$$t = \frac{B_L \pm \sqrt{G_L \cdot [(Y_0 - G_L)^2 + B_L^2] / Y_0}}{G_L - Y_0} \quad G_L \neq Y_0$$

- ecuatie de gradul 2, 2 solutii posibile
- $d$  este ales astfel incat

$$\frac{d}{\lambda} = \begin{cases} \frac{1}{2\pi} \cdot \arctan t & t \geq 0 \\ \frac{1}{2\pi} \cdot (\pi + \arctan t) & t < 0 \end{cases}$$

# Solutie analitica



$$X_S = -X$$

$$X = \frac{G_L^2 \cdot t - (Y_0 - B_L \cdot t) \cdot (B_L + Y_0 \cdot t)}{Y_0 \cdot [G_L^2 + (B_L + Y_0 \cdot t)^2]}$$

■ reactanta de anulare se obtine cu:

$$\frac{l_{sc}}{\lambda} = \frac{1}{2\pi} \cdot \arctan \left( \frac{X_S}{Z_0} \right) = \frac{-1}{2\pi} \cdot \arctan \left( \frac{X}{Z_0} \right)$$

$$\frac{l_{gol}}{\lambda} = \frac{-1}{2\pi} \cdot \arctan \left( \frac{Z_0}{X_S} \right) = \frac{1}{2\pi} \cdot \arctan \left( \frac{Z_0}{X} \right)$$

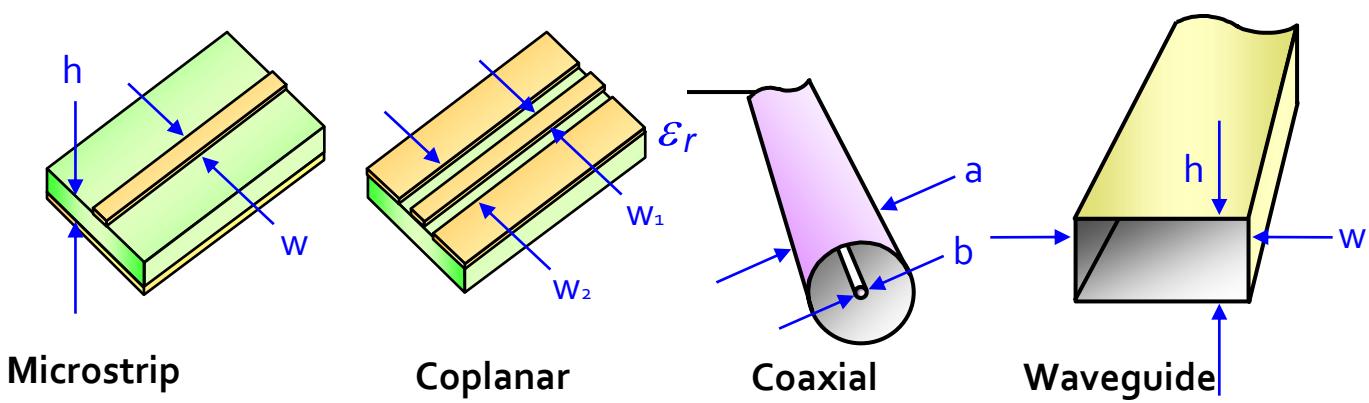
■ pentru lungimi negative se adauga  $\lambda/2$

# Adaptarea cu sectiuni de linii (stub)

- Se alege una din cele 8 solutii posibile convenabila tinand cont de:
  - dimensiuni fizice (suprafata ocupata pe chip/placa)
  - sensibilitatea la variatia parametrilor ( $\Delta\Gamma/\Delta E$ ,  $\Delta\Gamma/\Delta I$ )
  - caracteristica de frecventa convenabila

# Adaptarea cu sectiuni de linii (stub)

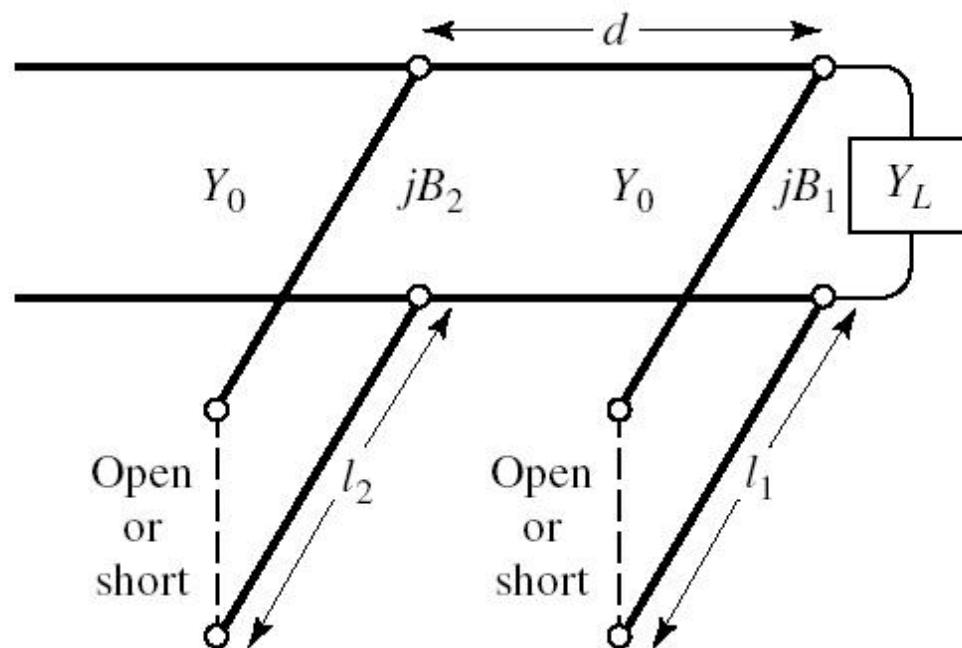
- Se alege una din cele 8 solutii posibile convenabila tinand cont de:
  - realizabilitate fizica (conform tehnologiei de linie utilizata)



- Dezavantaj:
  - lungimea sectiunii de linie serie e variabila

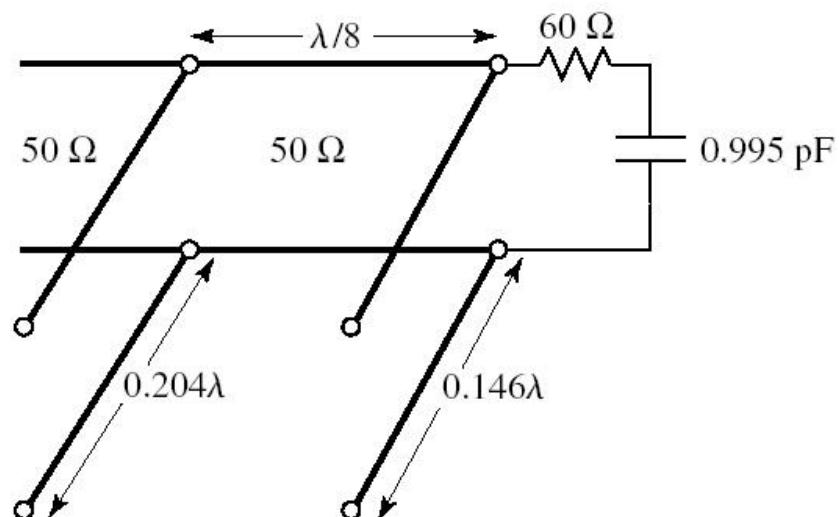
# Adaptarea cu două secțiuni de linie

- Double stub tuning
- Se foloseste o lungime constantă de linie intre 2 stub-uri

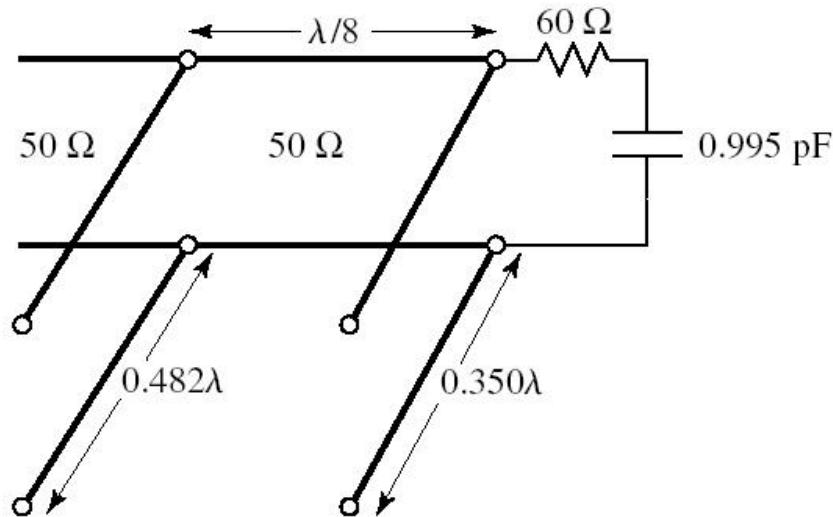


# Adaptarea cu două secțiuni de linie

- Două soluții posibile



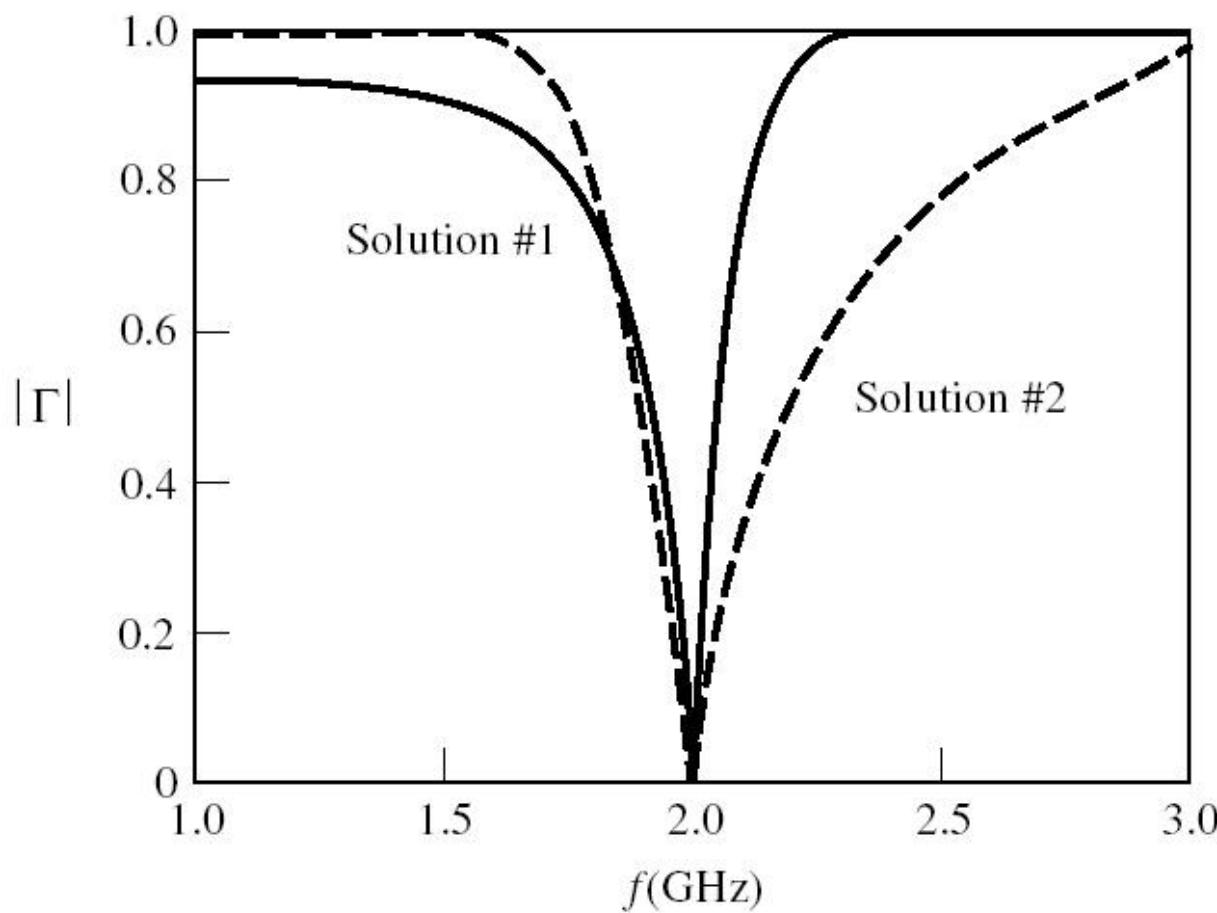
Solution 1



Solution 2

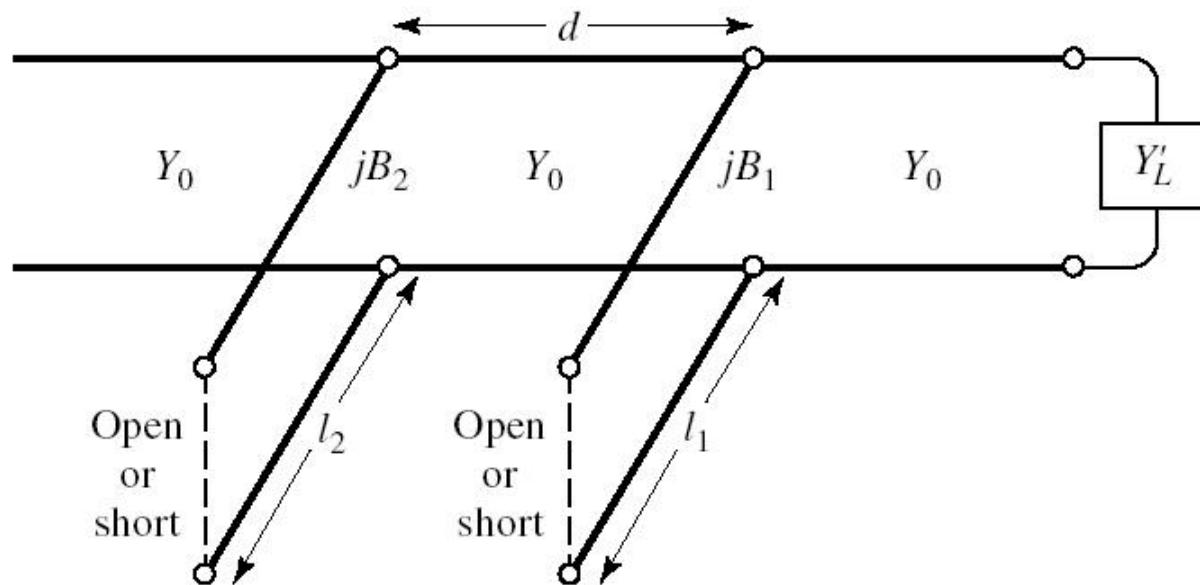
# Adaptarea cu două secțiuni de linie

- Două soluții posibile

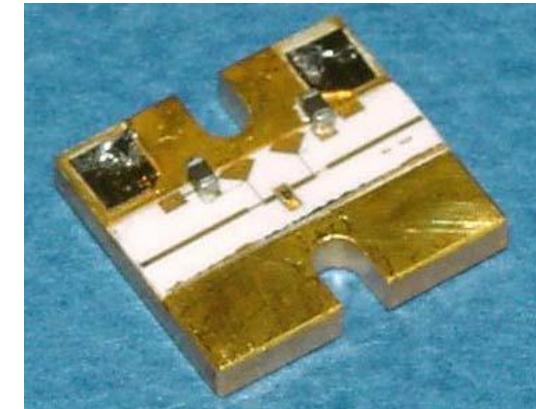
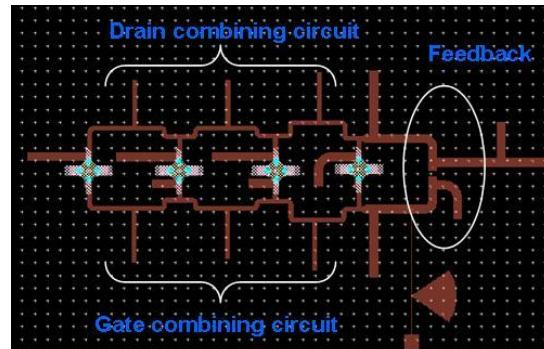
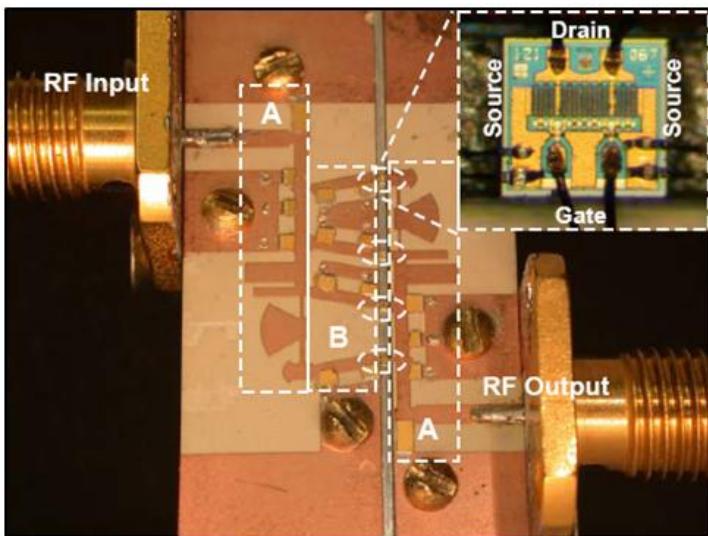
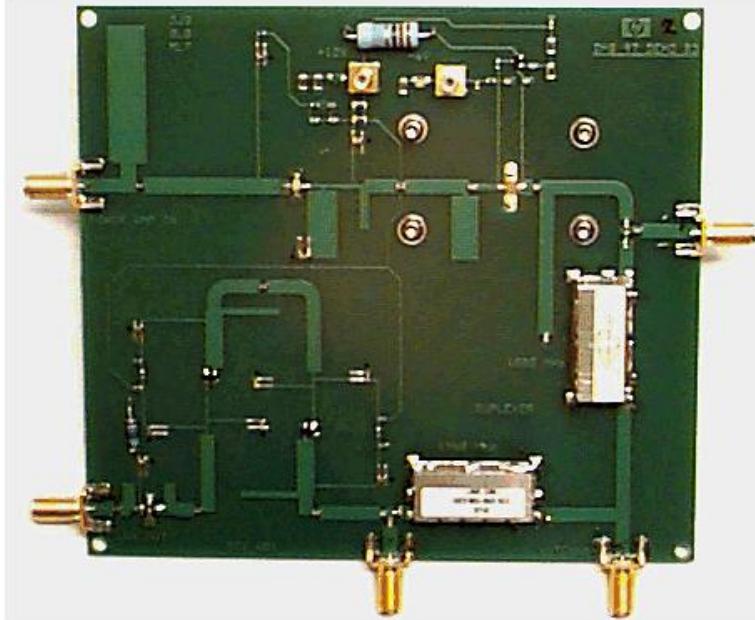
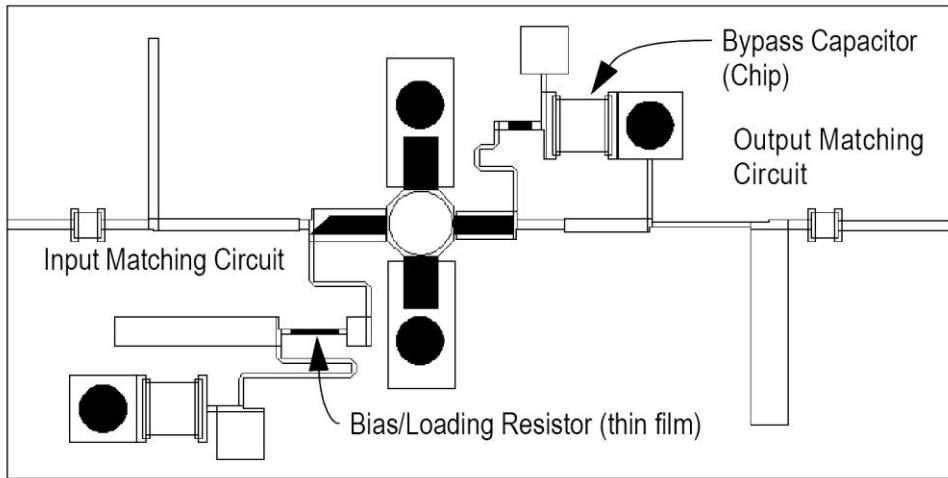


# Adaptarea cu doua sectiuni de linie

- Tipic  $d=\lambda/8$  sau  $d=3\lambda/8$
- **Nu** pentru orice sarcina este posibila
  - decat daca se poate introduce o sectiune de linie pana la sarcina



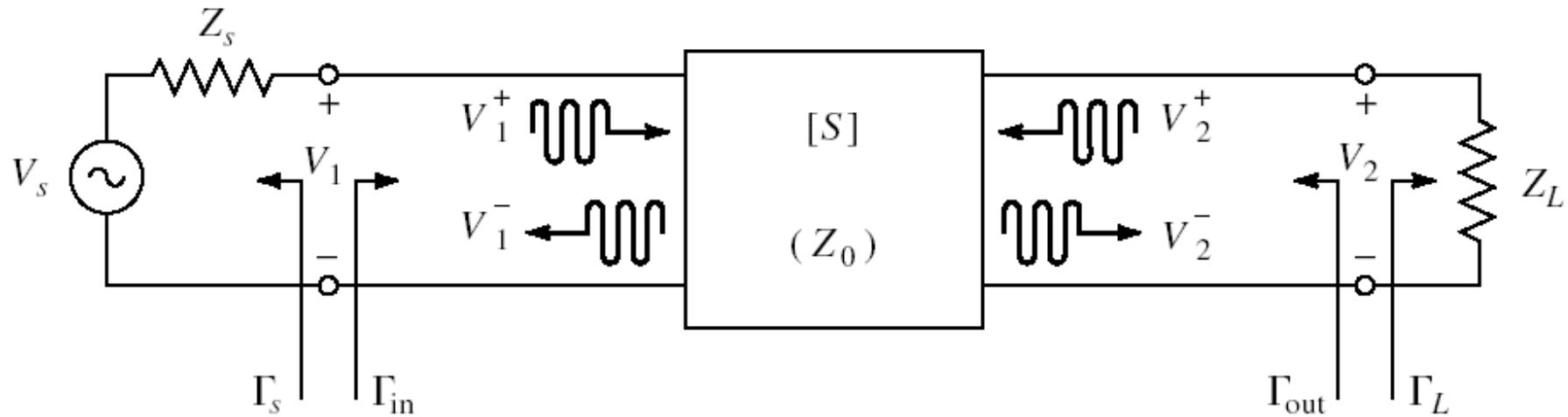
# Adaptarea cu sectiuni de linie



Preview (pentru laborator 3-4)

# **Amplificatoare de microunde**

# Cuadripol Amplificator (diport)



- Caracterizare cu parametri S
- Normalizati la  $Z_0$  (implicit  $50\Omega$ )
- Catalogage: parametri S pentru anumite polarizari

# Catalogage

CEL

## NE46100 / NE46134

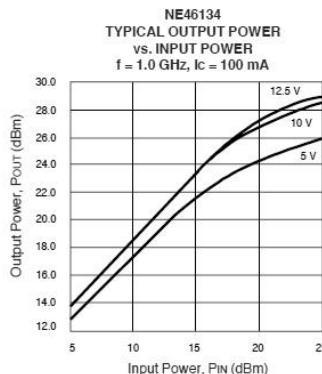
### NPN MEDIUM POWER MICROWAVE TRANSISTOR

#### FEATURES

- HIGH DYNAMIC RANGE
- LOW IM DISTORTION: -40 dBc
- HIGH OUTPUT POWER : 27.5 dBm at TYP
- LOW NOISE: 1.5 dB TYP at 500 MHz
- LOW COST

#### DESCRIPTION

The NE461 series of NPN silicon epitaxial bipolar transistors is designed for medium power applications requiring high dynamic range. This device exhibits an outstanding combination of high gain and low intermodulation distortion, as well as low noise figure. The NE461 series offers excellent performance and reliability at low cost through titanium, platinum, gold metallization system and direct nitride passivation of the surface of the chip. Devices are available in a low cost surface mount package (SOT-89) as well as in chip form.



#### ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ )

SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	NE46100			NE46134		
			MIN	TYP	MAX	MIN	TYP	MAX
$f_T$	Gain Bandwidth Product at $V_{CE} = 10 \text{ V}$ , $I_C = 100 \text{ mA}$	GHz	5.5		5.5			
$NF_{MIN}$	Minimum Noise Figure <sup>3</sup> at $V_{CE} = 10 \text{ V}$ , $I_C = 50 \text{ mA}$ , 500 MHz $V_{CE} = 10 \text{ V}$ , $I_C = 50 \text{ mA}$ , 1 GHz	dB	1.5		1.5			
$G_L$	Linear Gain, $V_{CE} = 12.5 \text{ V}$ , $I_C = 100 \text{ mA}$ , 2.0 GHz $V_{CE} = 12.5 \text{ V}$ , $I_C = 100 \text{ mA}$ , 1.0 GHz	dB	9.0			8.0		
$IS_{21E1^2}$	Insertion Power Gain at 10 V, 50 mA, $f = 1.0 \text{ GHz}$	dB	10.0		5.5	7.0		
$h_{FE}$	DC Current Gain <sup>2</sup> at $V_{CE} = 10 \text{ V}$ , $I_C = 50 \text{ mA}$		40	200	40		200	
$I_{CBO}$	Collector Cutoff Current at $V_{CB} = 20 \text{ V}$ , $I_E = 0 \text{ mA}$	mA		5.0		5.0		
$I_{EBO}$	Emitter Cutoff Current at $V_{EB} = 2 \text{ V}$ , $I_C = 0 \text{ mA}$	mA		5.0		5.0		
$P_{1dB}$	Output Power at 1 dB Compression, $V_{CE} = 12.5 \text{ V}$ , $I_C = 100 \text{ mA}$ , 2.0 GHz $V_{CE} = 12.5 \text{ V}$ , $I_C = 100 \text{ mA}$ , 1.0 GHz	dBm	27.0			27.5		
$IM_3$	Intermodulation Distortion, 10 V, 100 mA, $F_1 = 1.0 \text{ GHz}$ , $F_2 = 0.99 \text{ GHz}$							

# Catalogage

**NE46100**

**VCE = 5 V, Ic = 50 mA**

FREQUENCY (MHz)	S <sub>11</sub>		S <sub>21</sub>		S <sub>12</sub>		S <sub>22</sub>		K	MAG <sup>2</sup> (dB)
	MAG	ANG	MAG	ANG	MAG	ANG	MAG	ANG		
100	0.778	-137	26.776	114	0.028	30	0.555	-102	0.16	29.8
200	0.815	-159	14.407	100	0.035	29	0.434	-135	0.36	26.2
500	0.826	-177	5.855	84	0.040	38	0.400	-162	0.75	21.7
800	0.827	176	3.682	76	0.052	43	0.402	-169	0.91	18.5
1000	0.826	173	2.963	71	0.058	47	0.405	-172	1.02	16.3
1200	0.825	170	2.441	66	0.064	47	0.412	-174	1.08	14.0
1400	0.820	167	2.111	61	0.069	47	0.413	-176	1.17	12.4
1600	0.828	165	1.863	57	0.078	54	0.426	-177	1.15	11.4
1800	0.827	162	1.671	53	0.087	50	0.432	-178	1.14	10.6
2000	0.828	159	1.484	49	0.093	50	0.431	-180	1.17	9.5
2500	0.822	153	1.218	39	0.11	48	0.462	177	1.18	7.8
3000	0.818	148	1.010	30	0.135	46	0.490	174	1.16	6.3
3500	0.824	142	0.876	21	0.147	44	0.507	170	1.16	5.3
4000	0.812	137	0.762	13	0.168	38	0.535	167	1.14	4.3

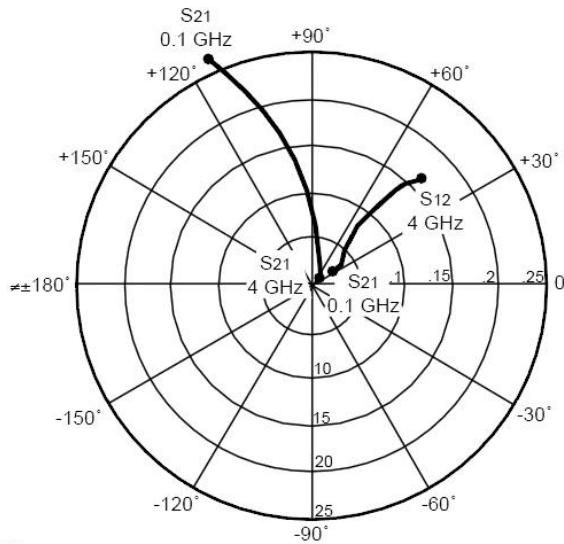
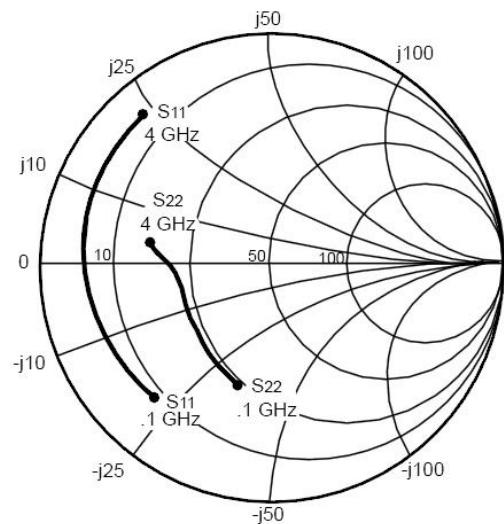
**VCE = 5 V, Ic = 100 mA**

100	0.778	-144	27.669	111	0.027	35	0.523	-114	0.27	30.2
200	0.820	-164	14.559	97	0.029	29	0.445	-144	0.42	27.0
500	0.832	-179	5.885	84	0.035	38	0.435	-166	0.81	22.2
800	0.833	175	3.691	76	0.048	45	0.435	-173	0.95	18.8
1000	0.831	172	2.980	71	0.056	51	0.437	-176	1.05	16.0
1200	0.836	169	2.464	67	0.061	52	0.432	-178	1.11	14.0
1400	0.829	166	2.121	61	0.072	53	0.447	-180	1.12	12.6
1600	0.831	164	1.867	58	0.080	54	0.445	179	1.14	11.4

# Catalogage

NE46100, NE46134

## TYPICAL COMMON EMITTER SCATTERING PARAMETERS<sup>1</sup> ( $T_A = 25^\circ\text{C}$ )



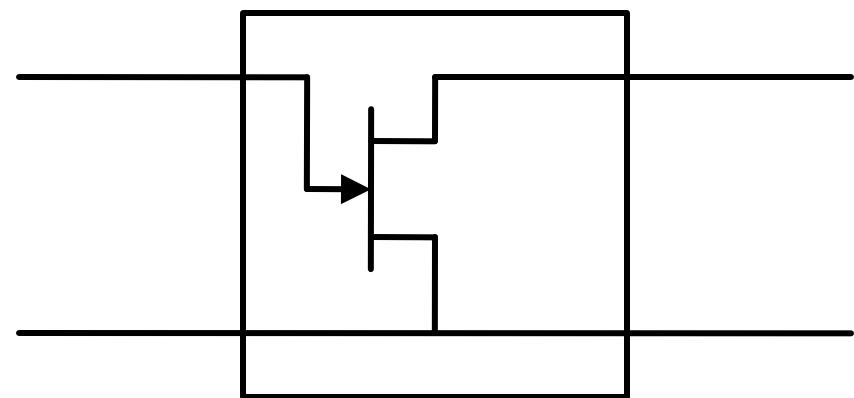
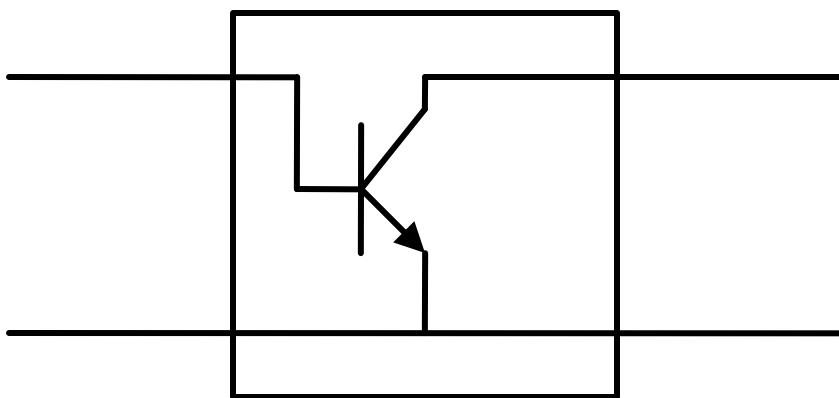
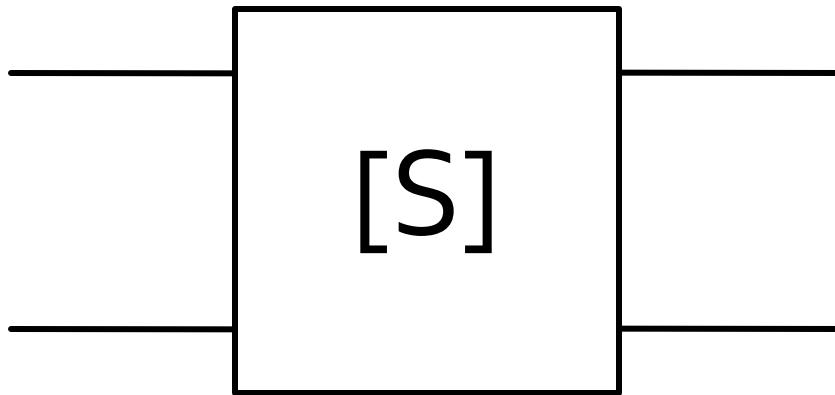
Coordinates in Ohms  
Frequency in GHz  
 $V_{CE} = 5 \text{ V}, I_C = 50 \text{ mA}$

# S<sub>2</sub>P - Touchstone

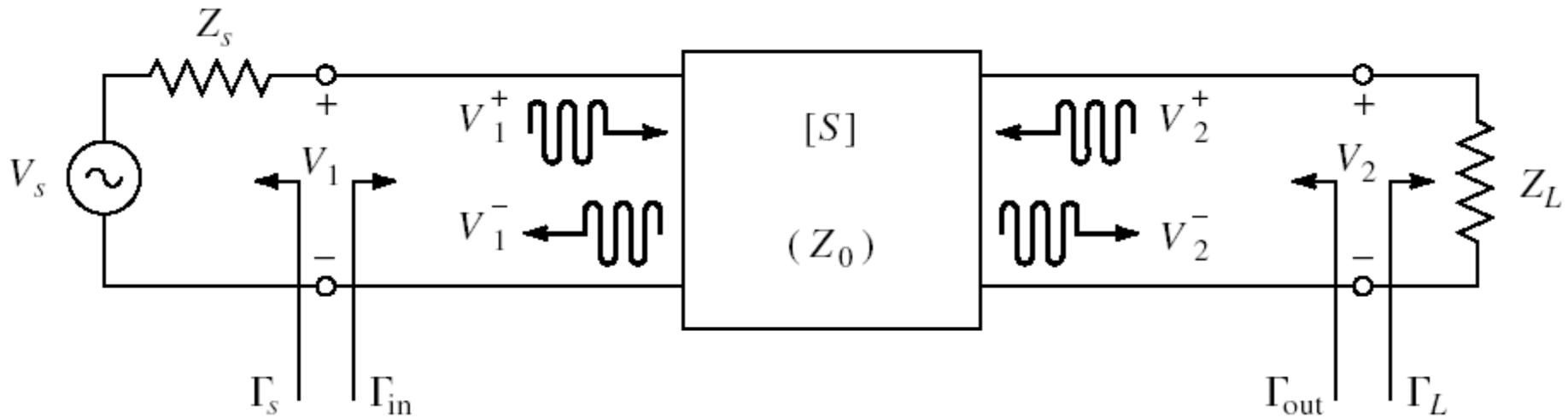
- Fisiere format Touchstone (\*.s2p)

```
! SIEMENS Small Signal Semiconductors
! VDS = 3.5 V  ID = 15 mA
# GHz S MA R 50
! f    S11      S21      S12      S22
! GHz  MAG  ANG  MAG  ANG  MAG  ANG  MAG  ANG
1.000 0.9800 -18.0  2.230 157.0  0.0240  74.0  0.6900 -15.0
2.000 0.9500 -39.0  2.220 136.0  0.0450  57.0  0.6600 -30.0
3.000 0.8900 -64.0  2.210 110.0  0.0680  40.0  0.6100 -45.0
4.000 0.8200 -89.0  2.230  86.0  0.0850  23.0  0.5600 -62.0
5.000 0.7400 -115.0 2.190  61.0  0.0990  7.0   0.4900 -80.0
6.000 0.6500 -142.0 2.110  36.0  0.1070 -10.0  0.4100 -98.0
!
! f    Fmin  Gammaopt rn/50
! GHz  dB   MAG  ANG  -
2.000 1.00 0.72 27 0.84
4.000 1.40 0.64 61 0.58
```

# Parametri S



# Diport amplifier



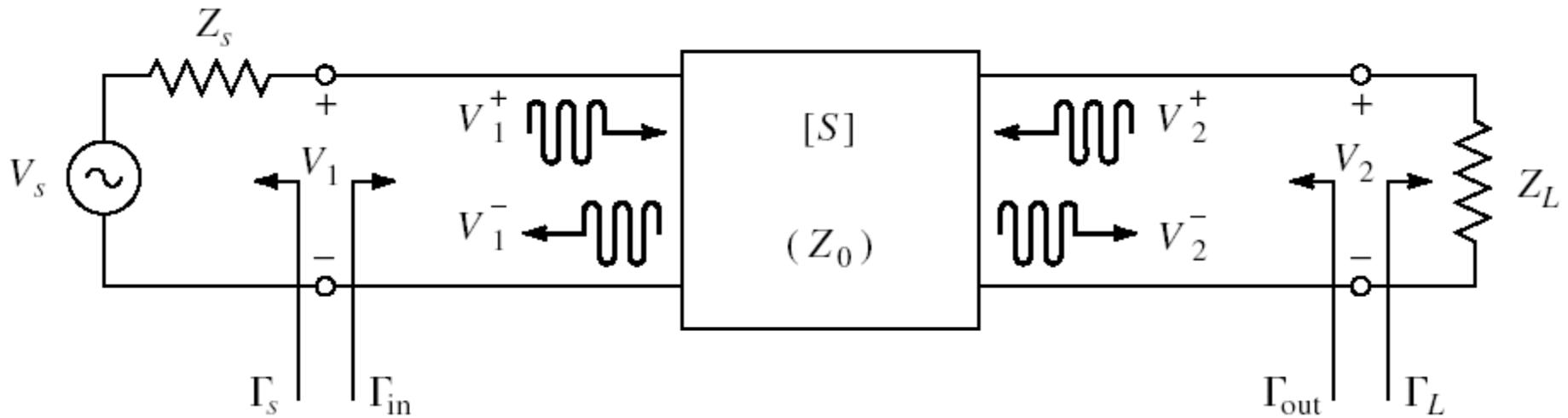
$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} \quad \Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0} \quad \begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

$$\Gamma_L = \frac{V_2^+}{V_2^-}$$

$$V_1^- = S_{11} \cdot V_1^+ + S_{12} \cdot V_2^+ = S_{11} \cdot V_1^+ + S_{12} \cdot \Gamma_L \cdot V_2^-$$

$$V_2^- = S_{21} \cdot V_1^+ + S_{22} \cdot V_2^+ = S_{21} \cdot V_1^+ + S_{22} \cdot \Gamma_L \cdot V_2^-$$

# Dipole amplifier



$$V_1^- = S_{11} \cdot V_1^+ + S_{12} \cdot V_2^+ = S_{11} \cdot V_1^+ + S_{12} \cdot \Gamma_L \cdot V_2^-$$

$$V_2^- = S_{21} \cdot V_1^+ + S_{22} \cdot V_2^+ = S_{21} \cdot V_1^+ + S_{22} \cdot \Gamma_L \cdot V_2^-$$

■ similar

$$\Gamma_{in} = \frac{V_1^-}{V_1^+} = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L}$$

$$\Gamma_{out} = \frac{V_2^-}{V_2^+} = S_{22} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_S}{1 - S_{11} \cdot \Gamma_S}$$

# Puteri

$$\Gamma_{in} = \frac{V_1^-}{V_1^+} = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L}$$

$$V_1 = \frac{V_S \cdot Z_{in}}{Z_S + Z_{in}} = V_1^+ + V_1^- = V_1^+ \cdot (1 + \Gamma_{in})$$

■ **C2**       $P_{in} = \frac{1}{2 \cdot Z_0} \cdot |V_1^+|^2 \cdot (1 - |\Gamma_{in}|^2)$

$$P_{in} = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S \cdot \Gamma_{in}|^2} (1 - |\Gamma_{in}|^2)$$

$$V_2^- = S_{21} \cdot V_1^+ + S_{22} \cdot V_2^+ = S_{21} \cdot V_1^+ + S_{22} \cdot \Gamma_L \cdot V_2^-$$

$$P_L = \frac{|V_1^+|^2}{2 \cdot Z_0} \cdot \frac{|S_{21}|^2}{|1 - S_{22} \cdot \Gamma_L|^2} (1 - |\Gamma_L|^2)$$

$$\Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

$$V_1^+ = \frac{V_S}{2} \frac{(1 - \Gamma_S)}{(1 - \Gamma_S \cdot \Gamma_{in})}$$

$$P_L = \frac{1}{2 \cdot Z_0} \cdot |V_2^-|^2 \cdot (1 - |\Gamma_L|^2)$$

$$V_2^- = \frac{S_{21} \cdot V_1^+}{1 - S_{22} \cdot \Gamma_L}$$

$$P_L = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|S_{21}|^2 \cdot (1 - |\Gamma_L|^2)}{|1 - S_{22} \cdot \Gamma_L|^2} \cdot \frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S \cdot \Gamma_{in}|^2}$$

# Puteri

## ■ Puteri

$$P_{in} = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S \cdot \Gamma_{in}|^2} \left(1 - |\Gamma_{in}|^2\right)$$

$$P_L = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|S_{21}|^2 \cdot (1 - |\Gamma_L|^2)}{|1 - S_{22} \cdot \Gamma_L|^2} \cdot \frac{|1 - \Gamma_S|^2}{|1 - \Gamma_S \cdot \Gamma_{in}|^2}$$

## ■ Puterea disponibila de la sursa

$$P_{av\ S} = P_{in} \Big|_{\Gamma_{in}=\Gamma_S^*} = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|1 - \Gamma_S|^2}{\left(1 - |\Gamma_S|^2\right)}$$

## ■ Puterea disponibila la sarcina

$$P_{av\ L} = P_L \Big|_{\Gamma_L=\Gamma_{out}^*} = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|S_{21}|^2 \cdot |1 - \Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2 \cdot \left(1 - |\Gamma_{out}|^2\right)}$$

# Castig de putere

## ■ Castigul de putere

$$G = \frac{P_L}{P_{in}} = \frac{|S_{21}|^2 \cdot (1 - |\Gamma_L|^2)}{(1 - |\Gamma_{in}|^2) \cdot |1 - S_{22} \cdot \Gamma_L|^2}$$

$$P_{in} = P_{in}(\Gamma_S, \Gamma_{in}(\Gamma_L), S)$$

$$P_L = P_L(\Gamma_S, \Gamma_{in}(\Gamma_L), S)$$

- Castigul **introdus** efectiv de amplificator este mai putin important deoarece un castig mai mare poate fi insotit de o **scadere** a puterii de intrare (absorbita efectiv de la sursa)
- Se prefera caracterizarea efectului amplificatorului prin analiza puterii **efectiv obtinuta pe sarcina** in raport cu puterea **disponibila de la sursa** (constanta)

# Castig de putere

## ■ Castigul de putere **disponibil**

$$G_A = \frac{P_{av L}}{P_{av S}} = \frac{|S_{21}|^2 \cdot (1 - |\Gamma_S|^2)}{|1 - S_{22} \cdot \Gamma_L|^2 \cdot (1 - |\Gamma_{out}|^2)}$$

## ■ Castigul de putere de **transfer** (transducer power gain)

$$G_T = \frac{P_L}{P_{av S}} = \frac{|S_{21}|^2 \cdot (1 - |\Gamma_S|^2) \cdot (1 - |\Gamma_L|^2)}{|1 - \Gamma_S \cdot \Gamma_{in}|^2 \cdot |1 - S_{22} \cdot \Gamma_L|^2}$$

$$\Gamma_{in} = \Gamma_{in}(\Gamma_L)$$

## ■ Castigul de putere de **transfer unilateral**

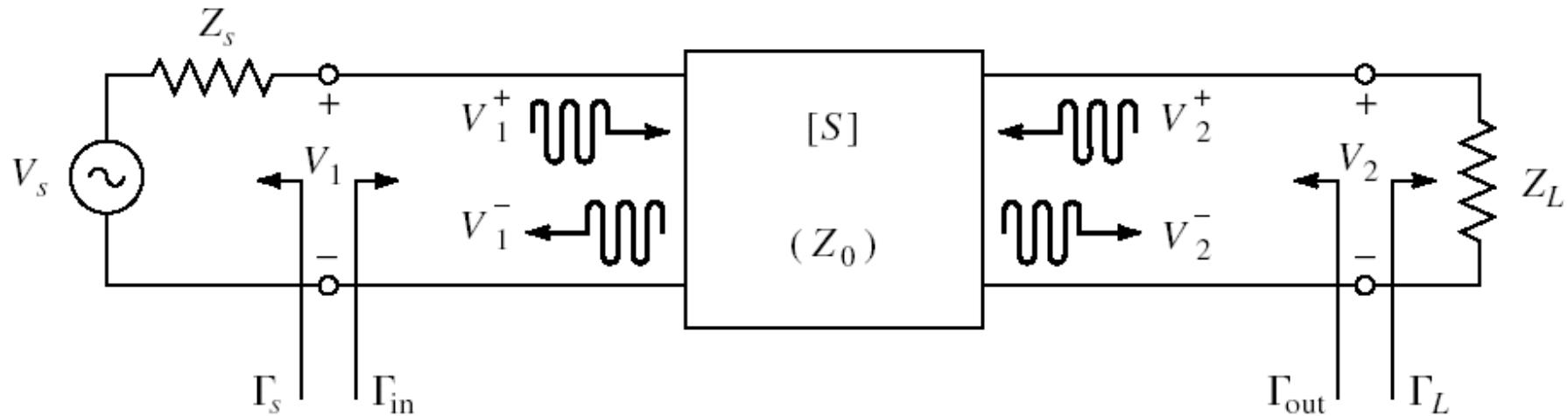
$$G_{TU} = |S_{21}|^2 \cdot \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2} \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$



$$S_{12} \cong 0 \quad \Gamma_{in} = S_{11}$$

Permite tratarea separata  
a intrarii si iesirii

# Cuadripol Amplificator



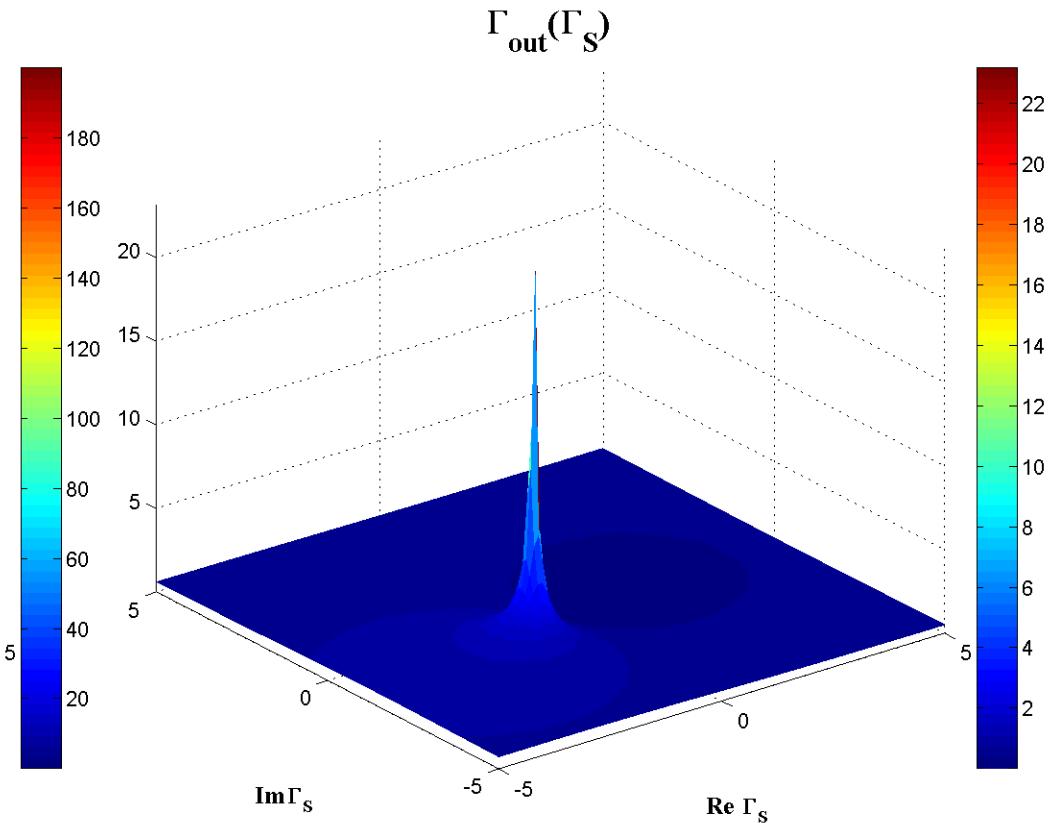
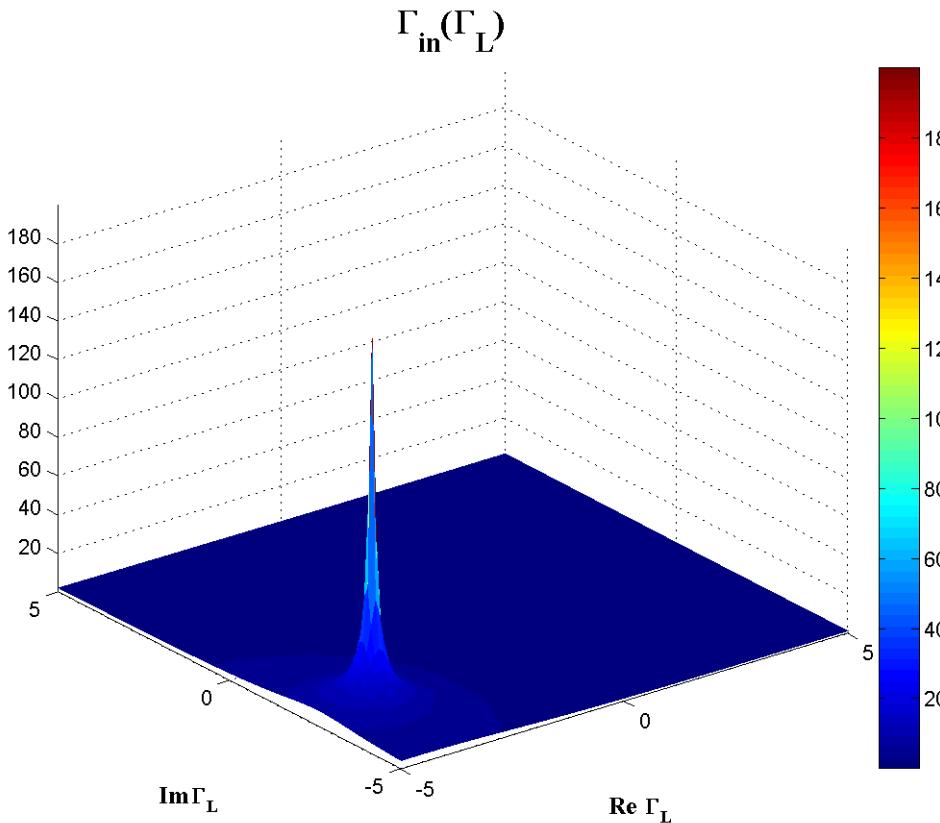
- marimi care intereseaza:
  - stabilitate
  - castig de putere
  - zgomot (uneori – semnal mic)
  - liniaritate (uneori – semnal mare)

# Stabilitate

- C7       $\Gamma = \Gamma_r + j \cdot \Gamma_i$        $r_L = \frac{1 - \Gamma_r^2 - \Gamma_i^2}{(1 - \Gamma_r)^2 + \Gamma_i^2}$   
 $Z_{in}$        $\Gamma_{in} = \Gamma_r + j \cdot \Gamma_i$
- instabilitate  
 $\operatorname{Re}\{Z_{in}\} < 0 \Leftrightarrow 1 - \Gamma_r^2 - \Gamma_i^2 < 0 \quad |\Gamma_{in}| > 1$
- stabilitate,  $Z_{in}$ 
  - conditii ce trebuie indeplinite de  $\Gamma_L$  pentru a obtine stabilitatea (la intrare)  
 $|\Gamma_{in}| < 1 \quad \left| S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L} \right| < 1$
- similar  $Z_{out}$ 
  - conditii ce trebuie indeplinite de  $\Gamma_S$  pentru a obtine stabilitatea (la iesire)

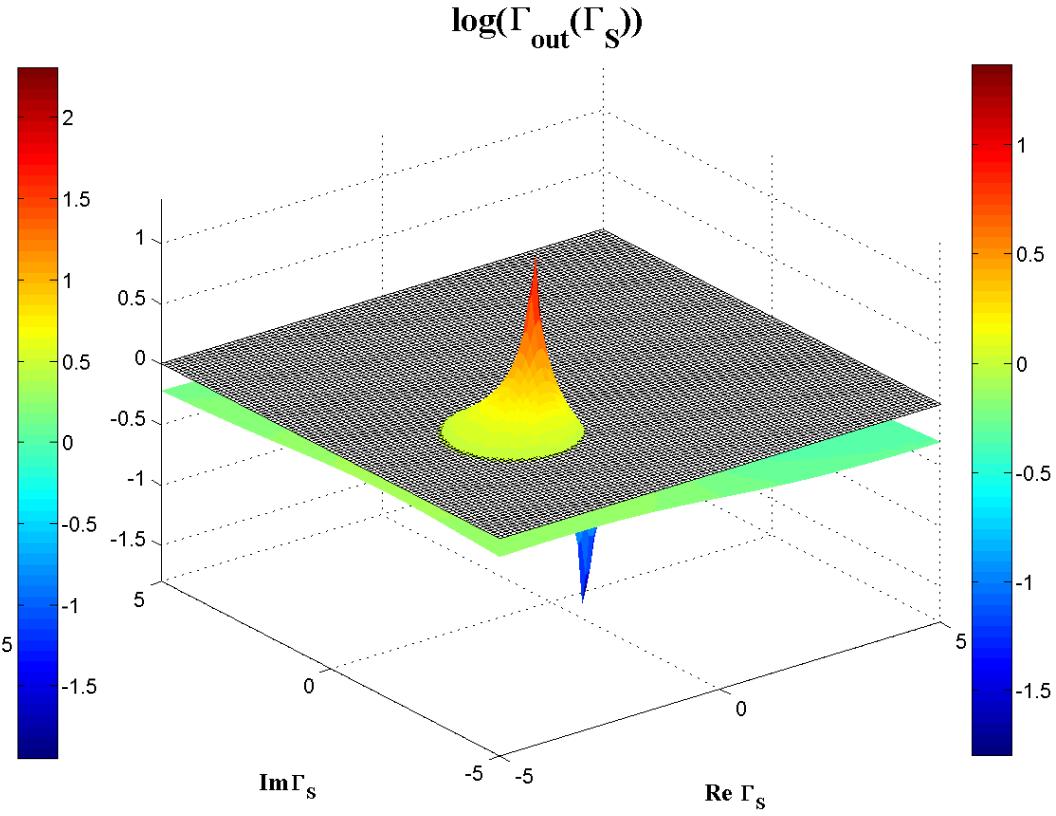
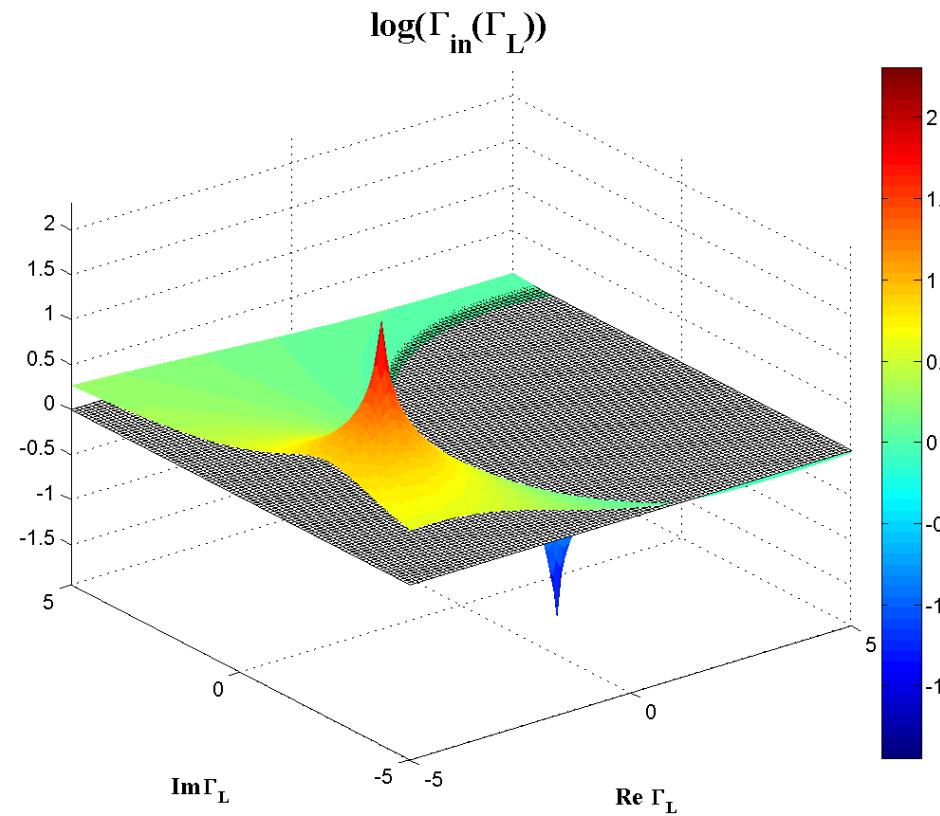
# Reprezentare 3D $|\Gamma_{\text{in}}|, |\Gamma_{\text{out}}|$

- Variatii foarte mari  $\rightarrow$  logaritmic



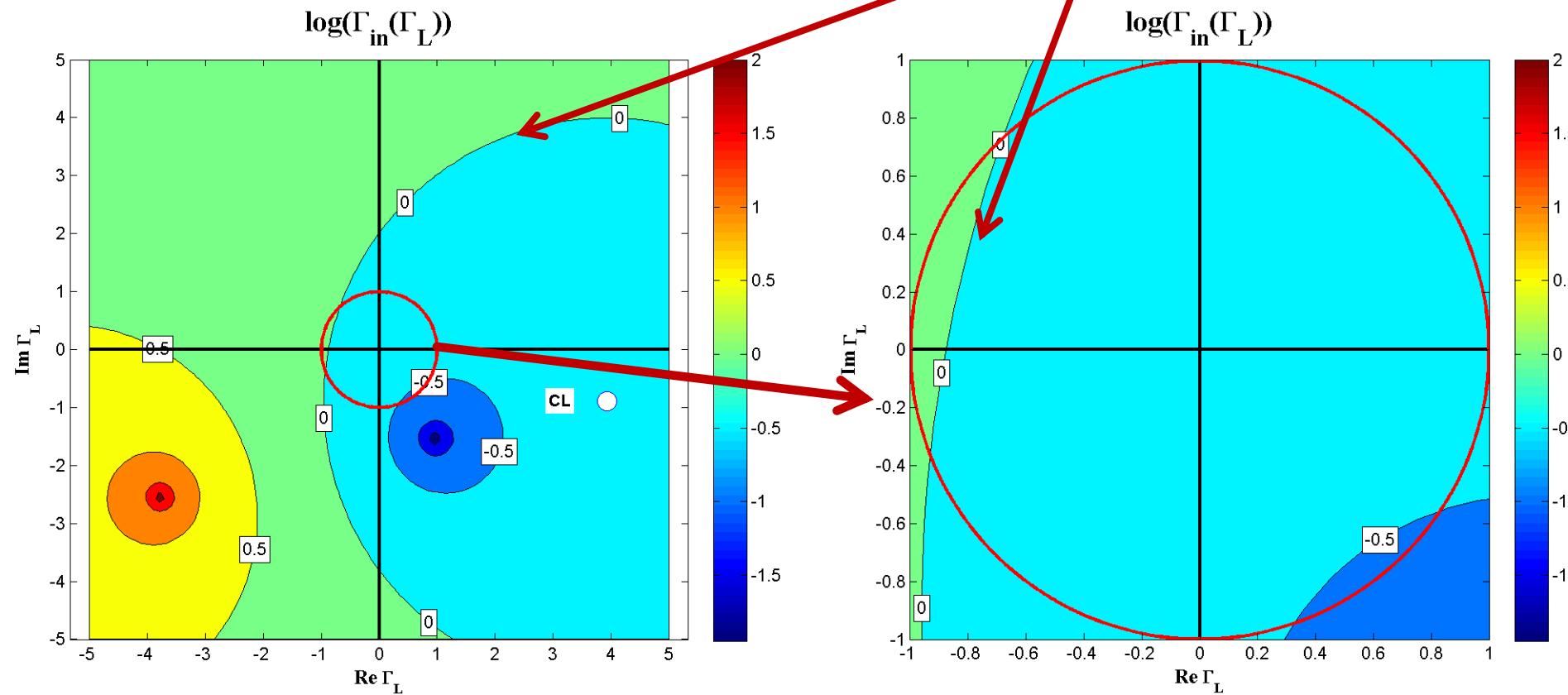
# Reprezentare 3D $|\Gamma_{\text{in}}|, |\Gamma_{\text{out}}|, |\Gamma|=1$

- $|\Gamma| = 1 \rightarrow \log_{10}|\Gamma| = 0$ , intersectia = cerc, limita de stabilitate (intrare+iesire)



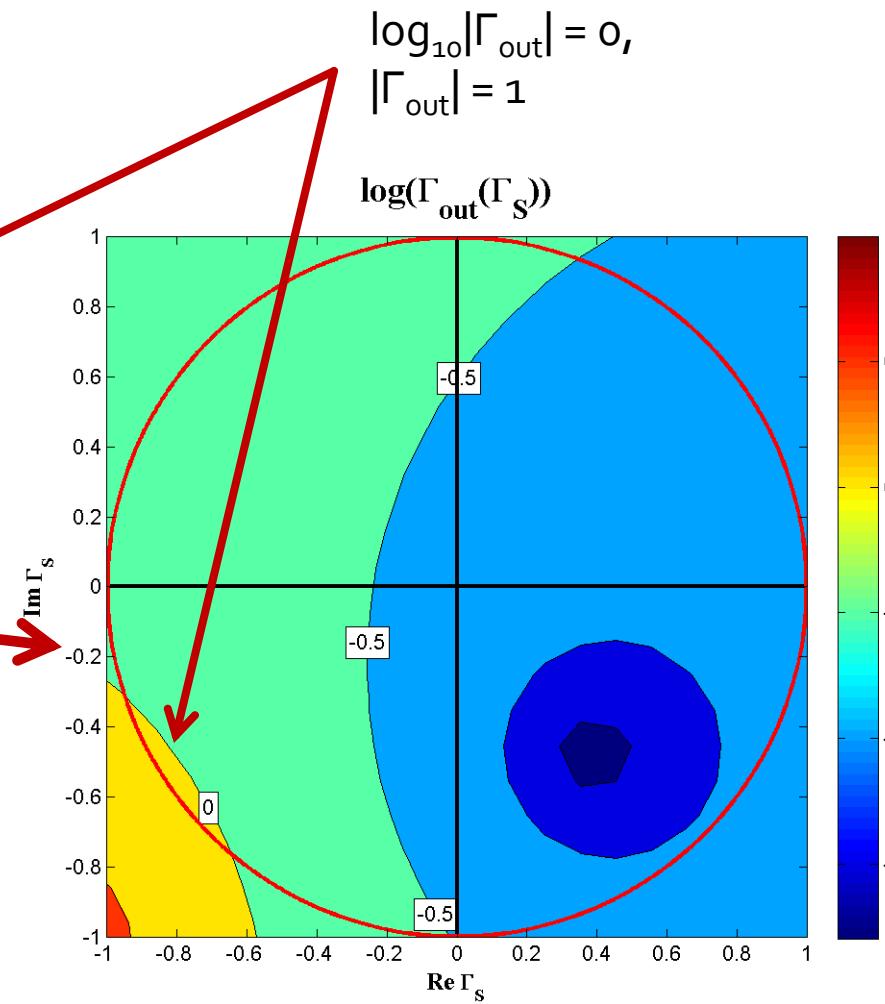
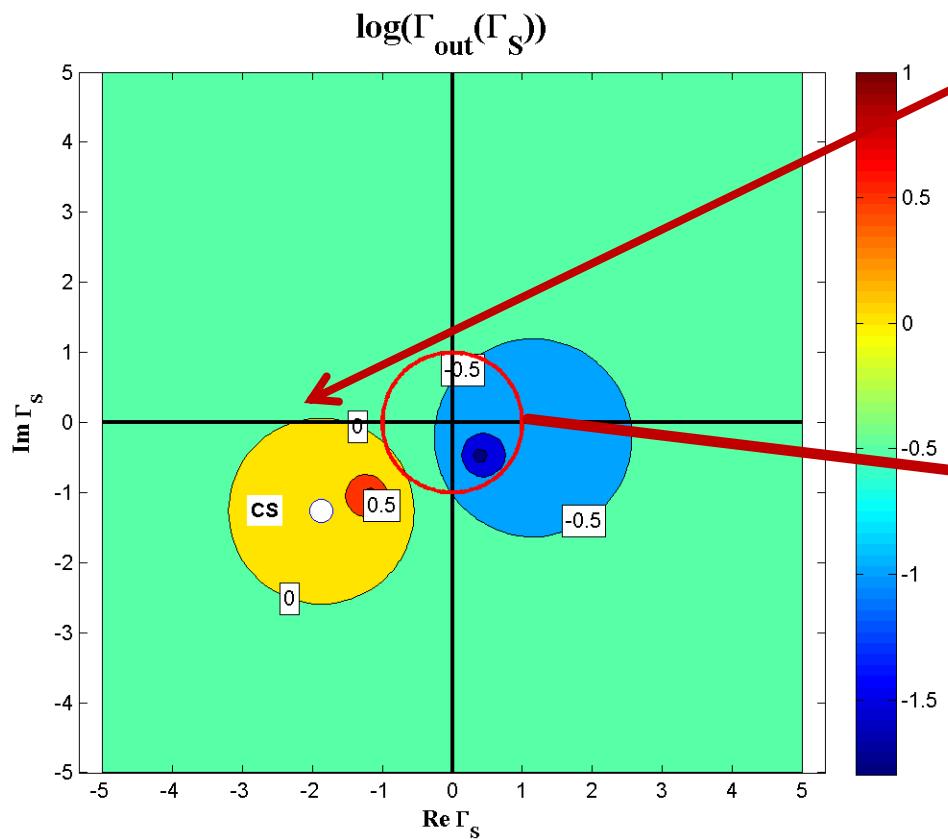
# Reprezentare 3D $|\Gamma_{\text{in}}|, |\Gamma_{\text{out}}|$

- $\log_{10}|\Gamma_{\text{in}}| = 0, \Gamma_L, \text{CSOUT}$



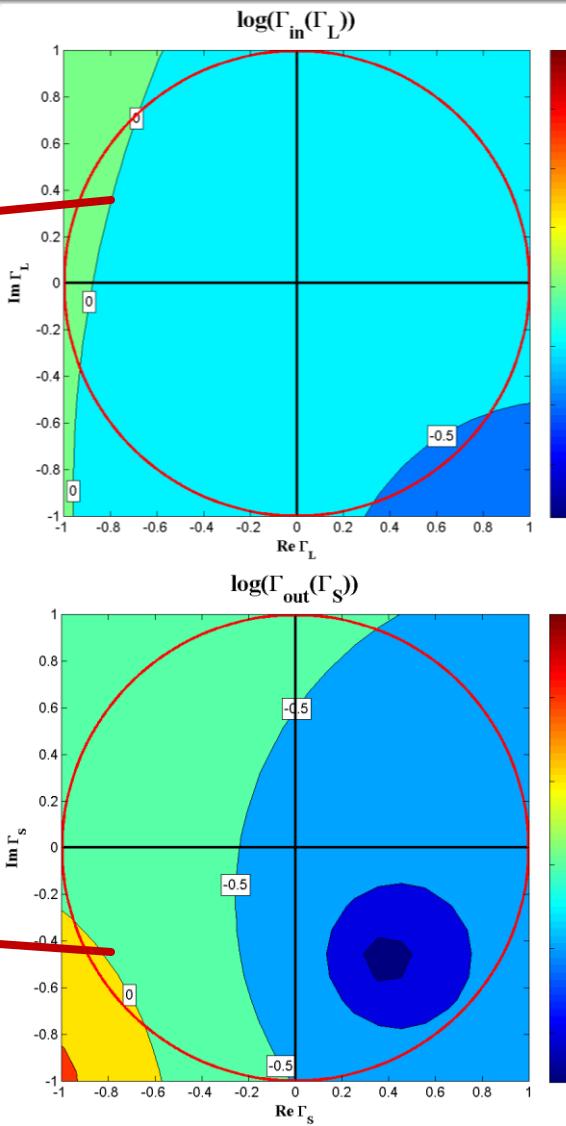
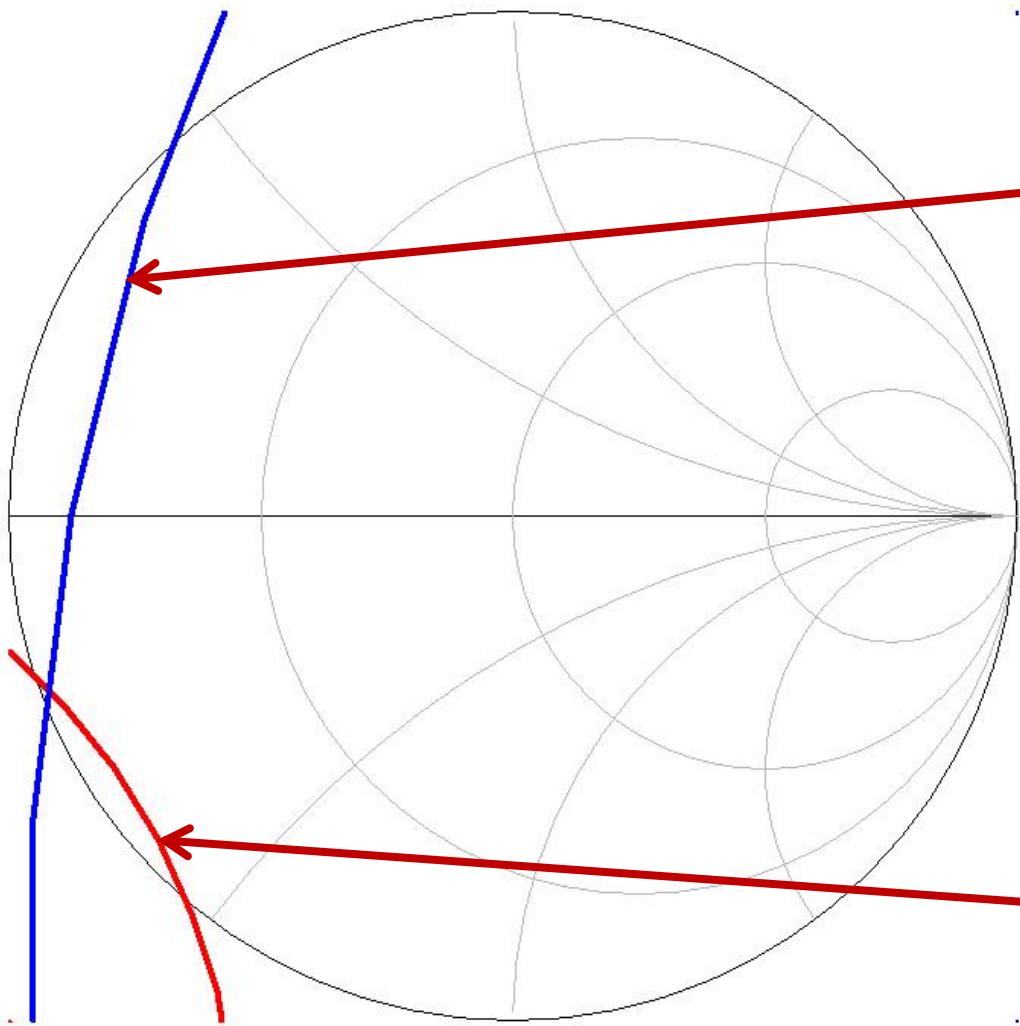
# Reprezentare 3D $|\Gamma_{\text{in}}|, |\Gamma_{\text{out}}|$

- $\log_{10}|\Gamma_{\text{out}}| = 0, \Gamma_S, \text{CSIN}$

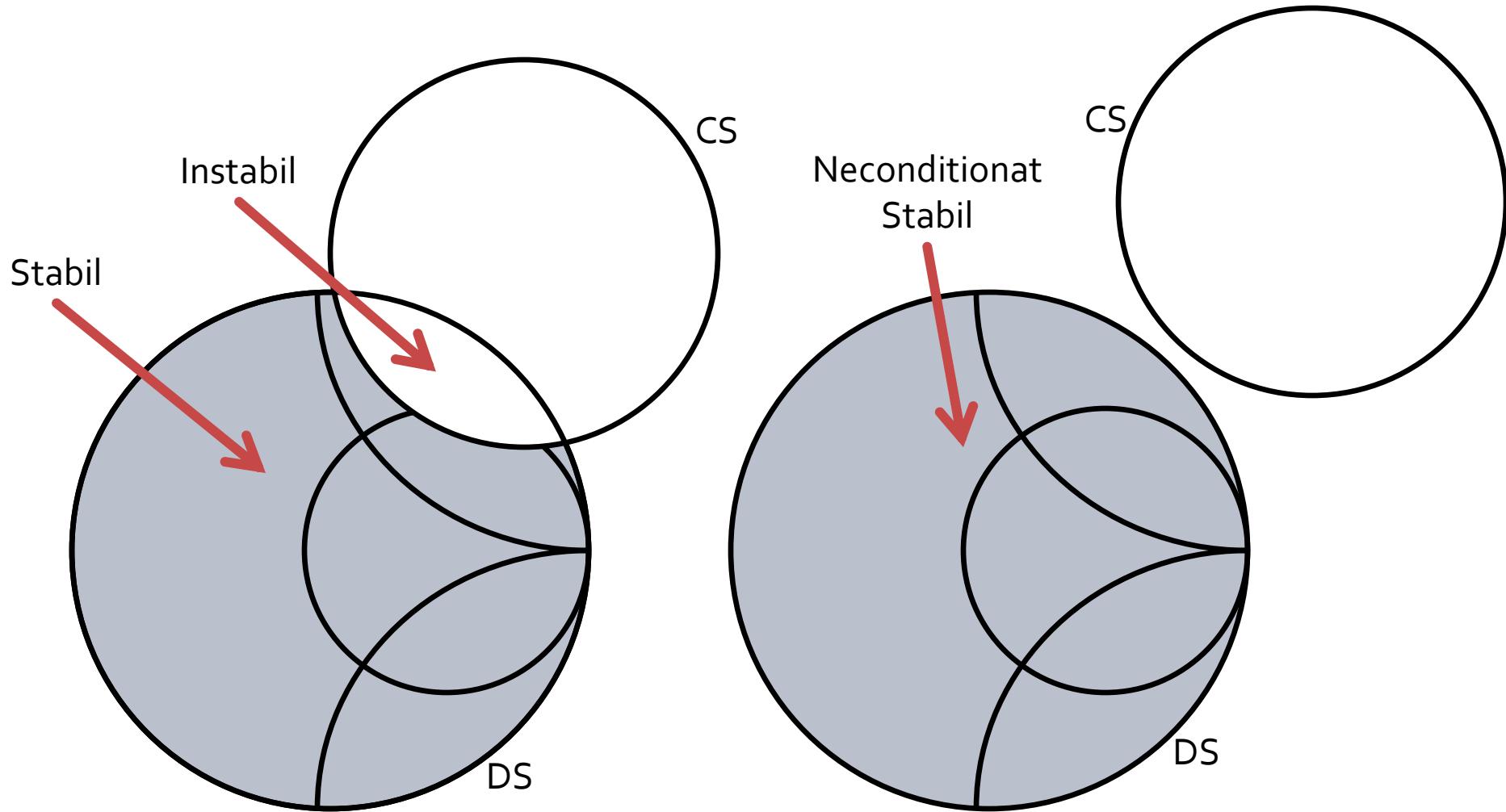


# CSIN, CSOUT

CSOUT  
CSIN



# Mai multe pozitionari posibile

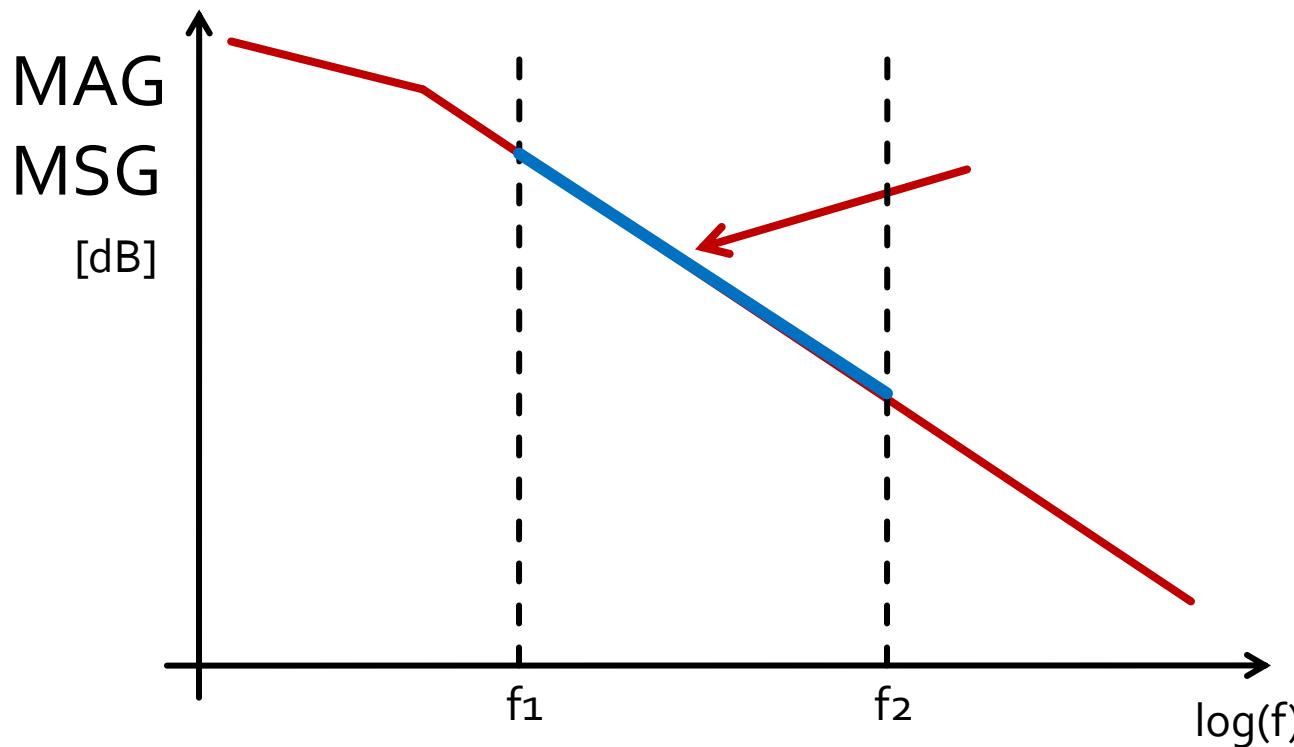


# Proiectare pentru castig impus

- Deseori este necesara o alta abordare decat "forta bruta" si se prefera obtinerea unui **castig mai mic** decat cel maxim posibil pentru:
  - conditii de zgomot avantajoase ( $L_3$ )
  - conditii de stabilitate mai bune
  - obtinerea unui VSWR mai mic
  - controlul performantelor la mai multe frecvente
  - banda de functionare a amplificatorului

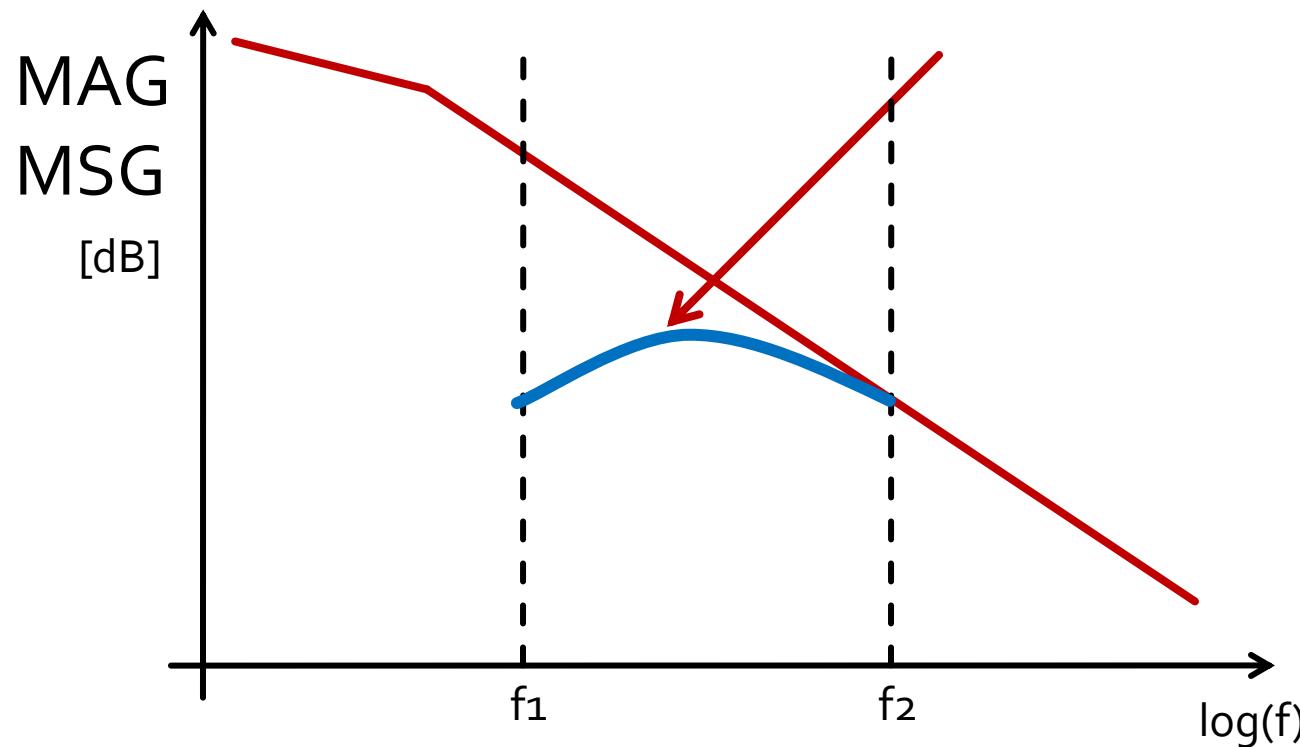
# Amplificator de banda largă

- Adaptarea pentru castig maxim la doua frecvente genereaza o comportare dezechilibrata

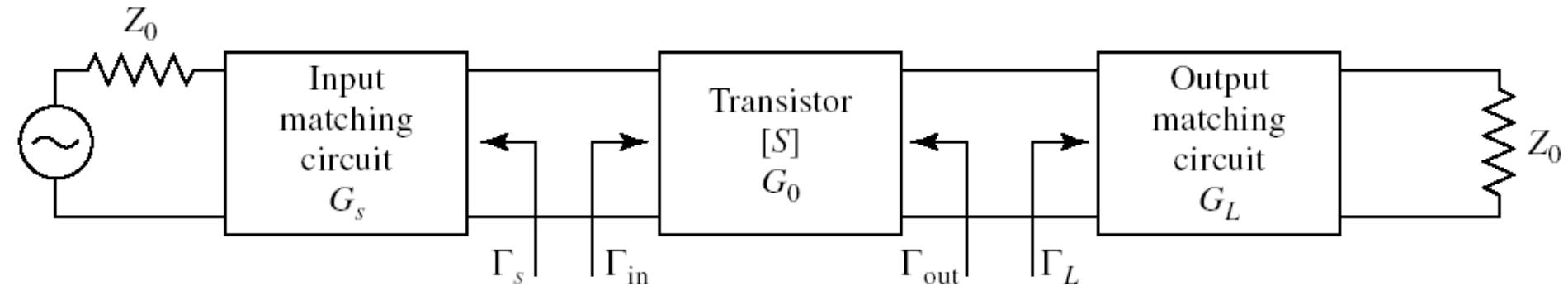


# Amplificator de banda largă

- Adaptare pentru castig maxim la frecventa maxima
- Dezadaptare controlata la frecventa minima
  - eventual la mai multe frecvente din banda



# Proiectare pentru castig impus



- Daca ipoteza tranzistorului unilateral este justificata:

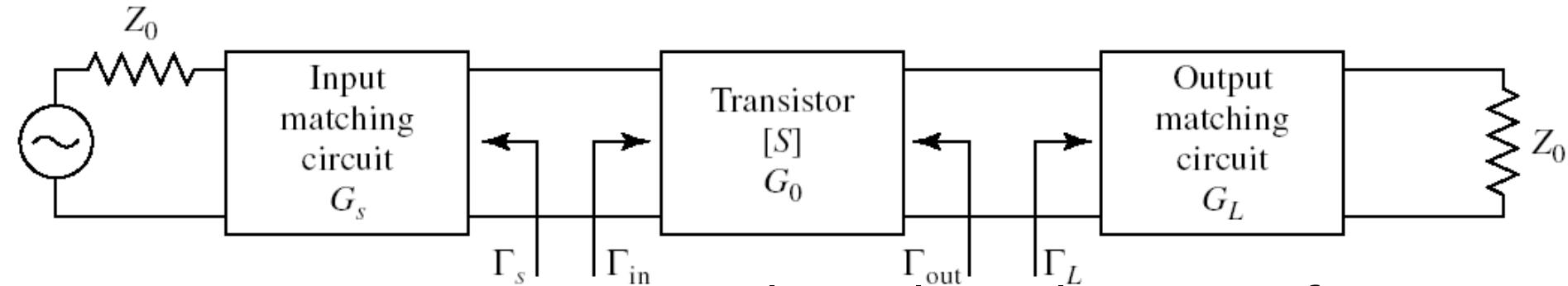
$$G_{TU} = |S_{21}|^2 \cdot \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2} \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

$$G_S = \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2}$$

$$G_0 = |S_{21}|^2$$

$$G_L = \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

# Proiectare pentru castig impus

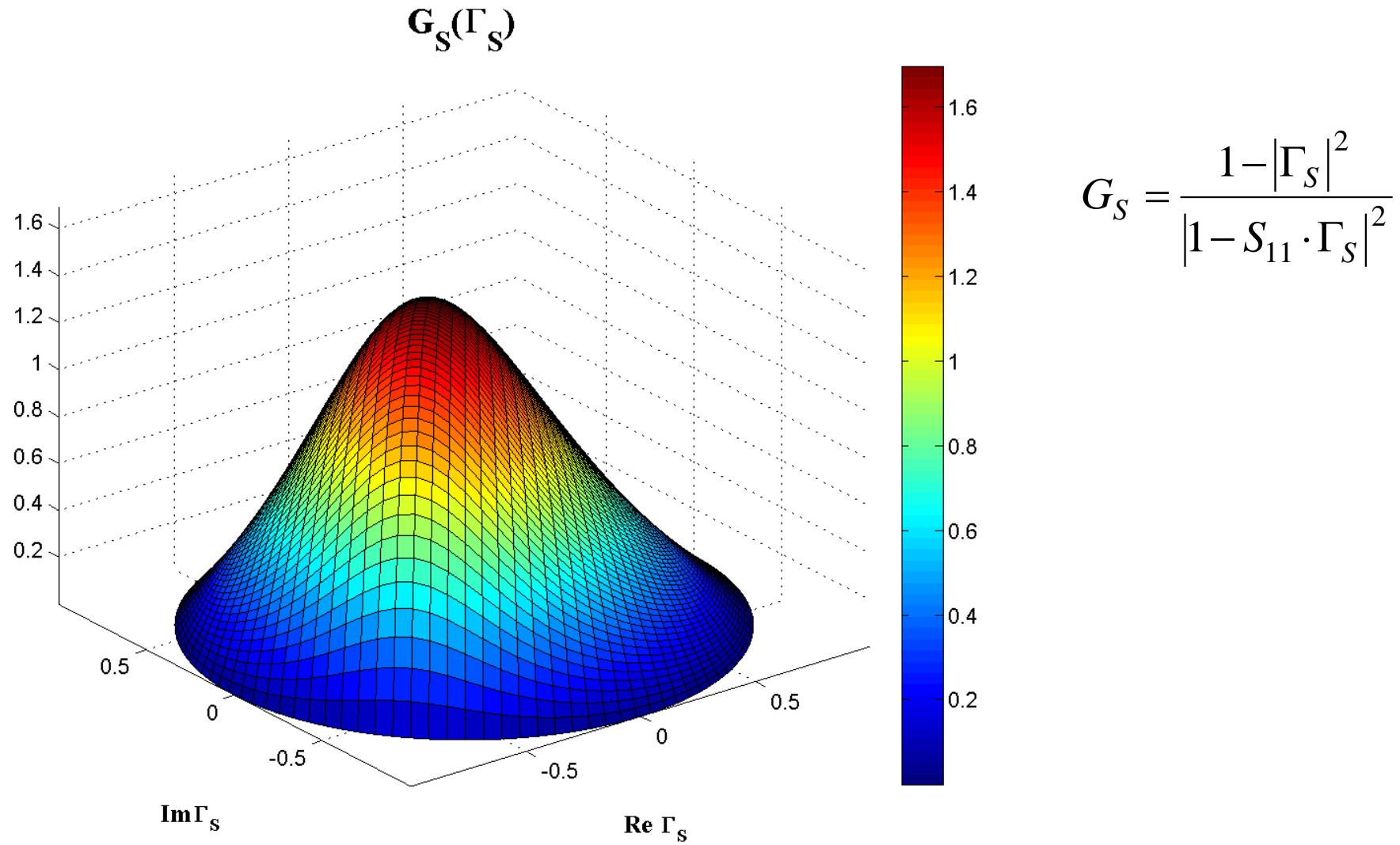


- Daca ipoteza tranzistorului unilateral este justificata:
  - castigul adaugat prin adaptare mai buna la intrare **nu** depinde de adaptarea la iesire
  - castigul adaugat prin adaptare mai buna la iesire **nu** depinde de adaptarea la intrare
- Adaptarile la intrare/iesire pot fi tratate independent
  - Se pot impune cerinte diferite intrare/iesire
  - se tine cont de compunerea castigurilor generate

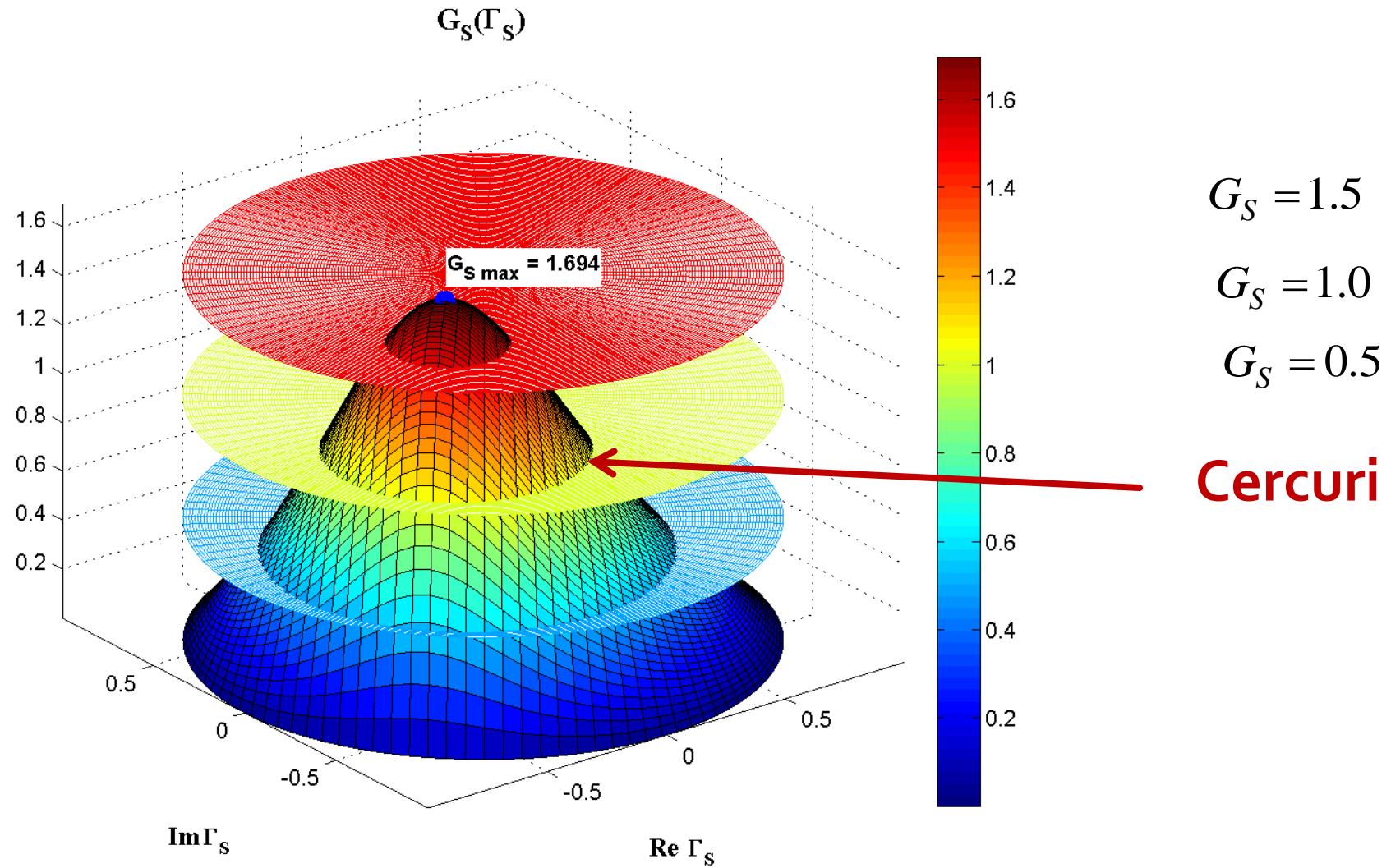
$$G_T = G_S \cdot G_0 \cdot G_L$$

$$G_T [dB] = G_S [dB] + G_0 [dB] + G_L [dB]$$

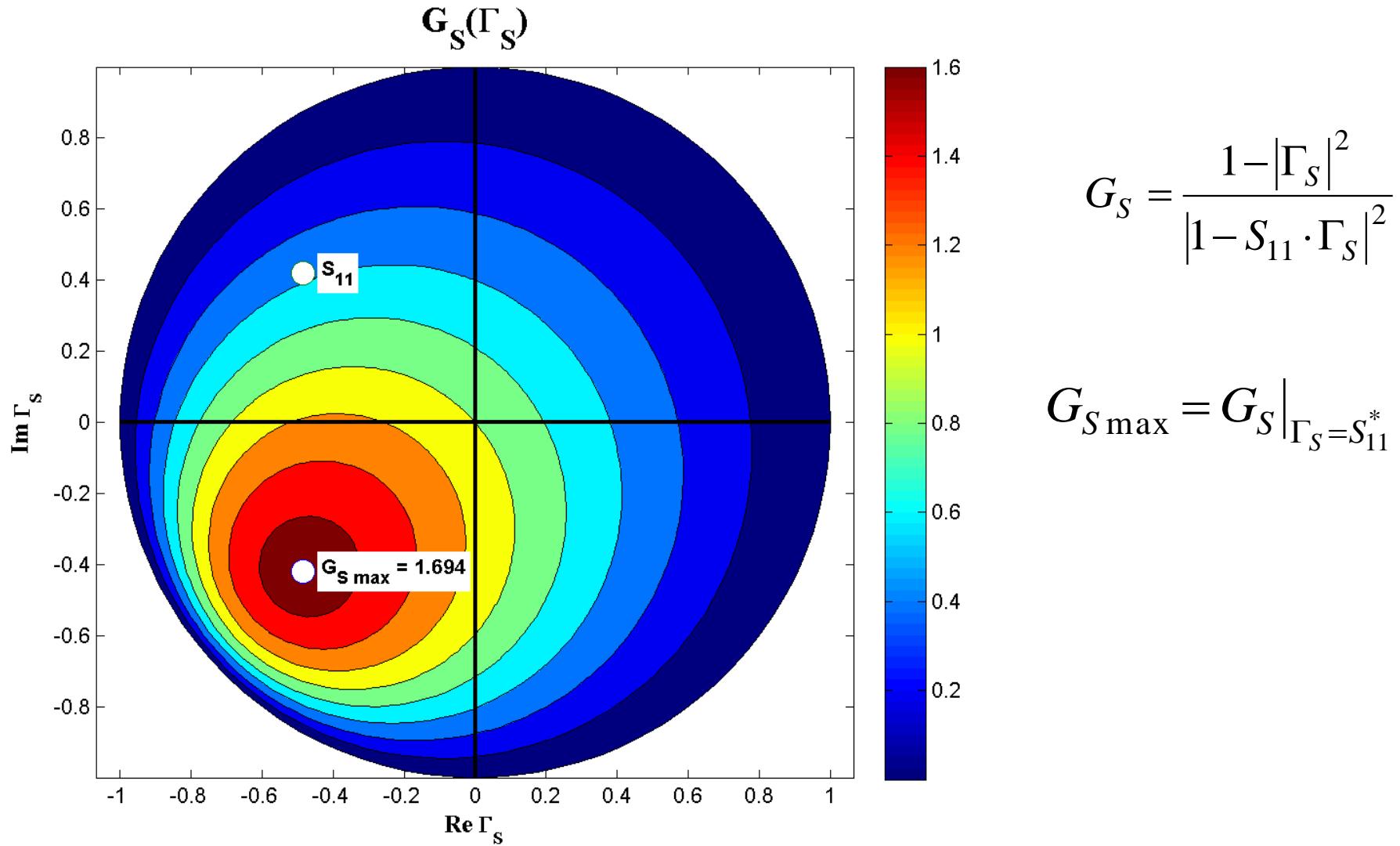
# $\mathbf{G}_S(\Gamma_S)$



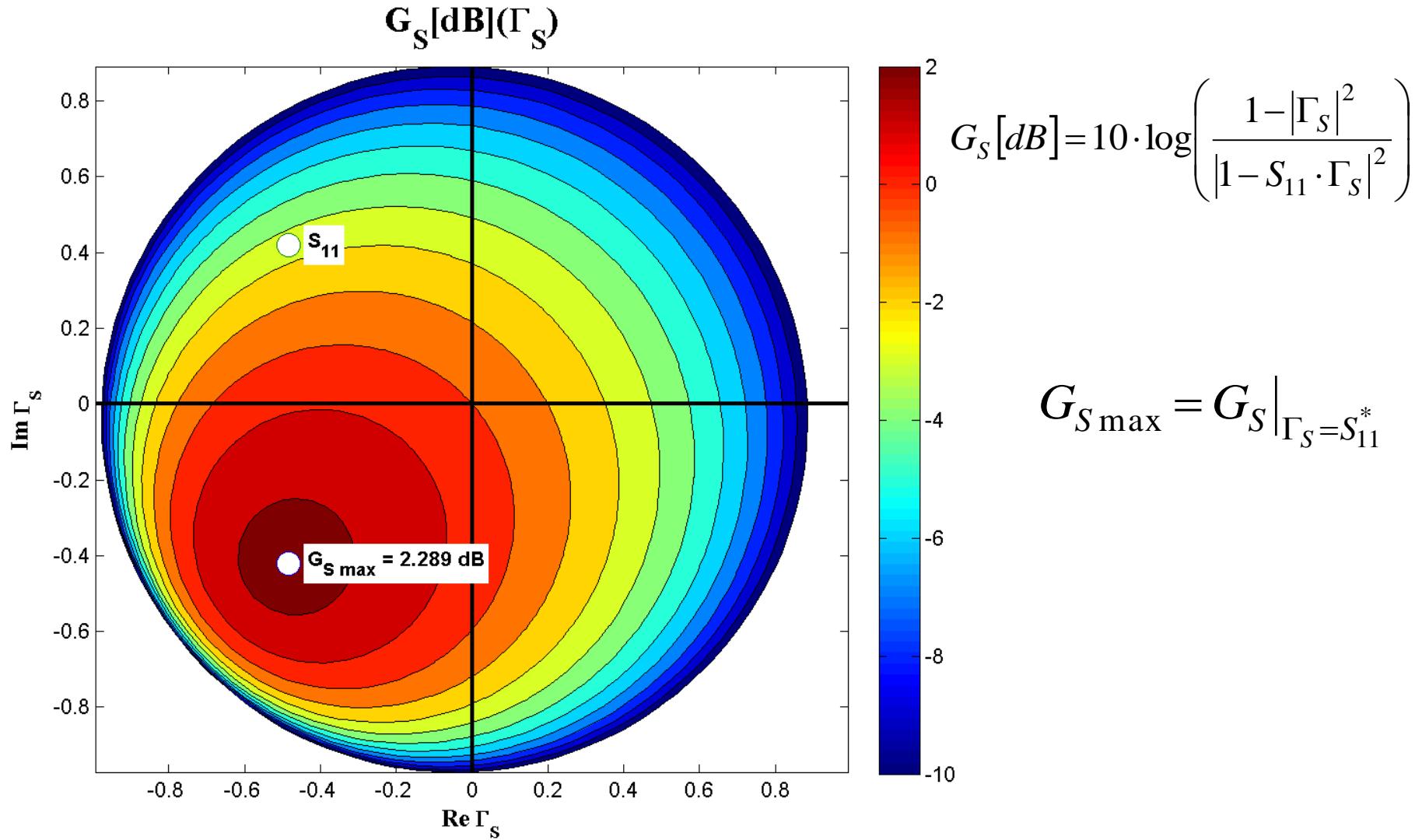
# $G_S(\Gamma_S)$ , nivel constant



# $G_S(\Gamma_S)$ , diagrama de nível



# $G_S[\text{dB}](\Gamma_S)$ , diagrama de nível

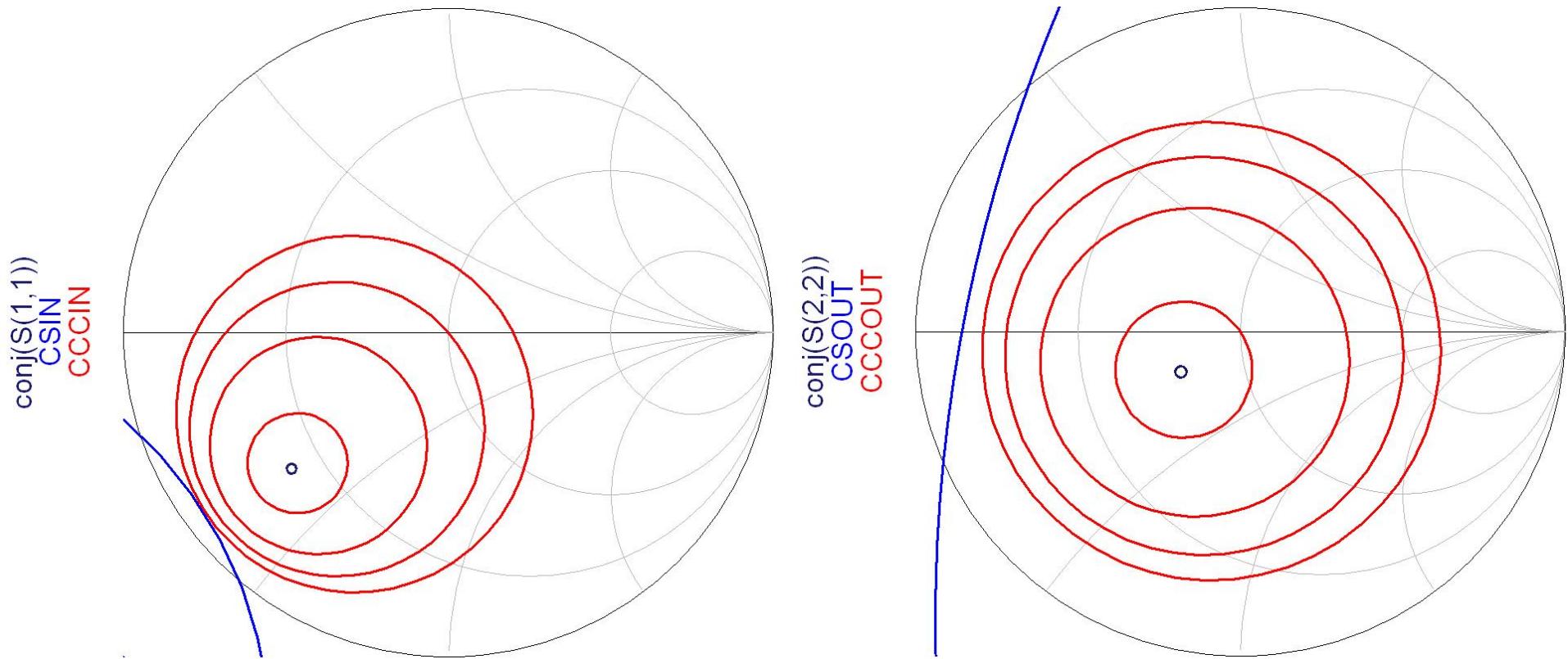


# Cercuri de castig constant la intrare

$$\left| \Gamma_S - \frac{g_S \cdot S_{11}^*}{1 - (1 - g_S) \cdot |S_{11}|^2} \right| = \frac{\sqrt{1 - g_S} \cdot (1 - |S_{11}|^2)}{1 - (1 - g_S) \cdot |S_{11}|^2} \quad |\Gamma_S - C_S| = R_S$$
$$C_S = \frac{g_S \cdot S_{11}^*}{1 - (1 - g_S) \cdot |S_{11}|^2} \quad R_S = \frac{\sqrt{1 - g_S} \cdot (1 - |S_{11}|^2)}{1 - (1 - g_S) \cdot |S_{11}|^2}$$

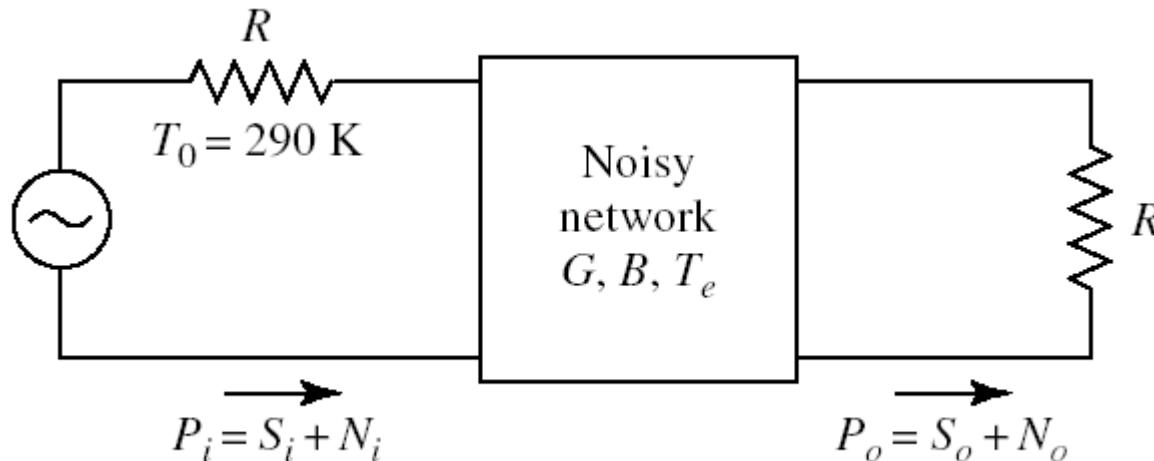
- Ecuatia unui cerc in planul complex in care reprezint  $\Gamma_S$
- **Interpretare:** Orice punct  $\Gamma_S$  care reprezentat in planul complex se gaseste **pe** cercul desenat pentru  $g_{\text{cerc}} = G_{\text{cerc}} / G_{S\text{max}}$  va conduce la obtinerea castigului  $G_S = G_{\text{cerc}}$ 
  - Orice punct **in exteriorul** acestui cerc va genera un castig  $G_S < G_{\text{cerc}}$
  - Orice punct **in interiorul** acestui cerc va genera un castig  $G_S > G_{\text{cerc}}$
- Discutie similara la iesire **CCCIN, CCCOUT**

# CCCIN, CCCOUT



- Cerculile se reprezinta pentru valorile cerute in dB
- Este utila calcularea  $G_{S_{max}}$  si  $G_{L_{max}}$  anterior

# Factor de zgomot

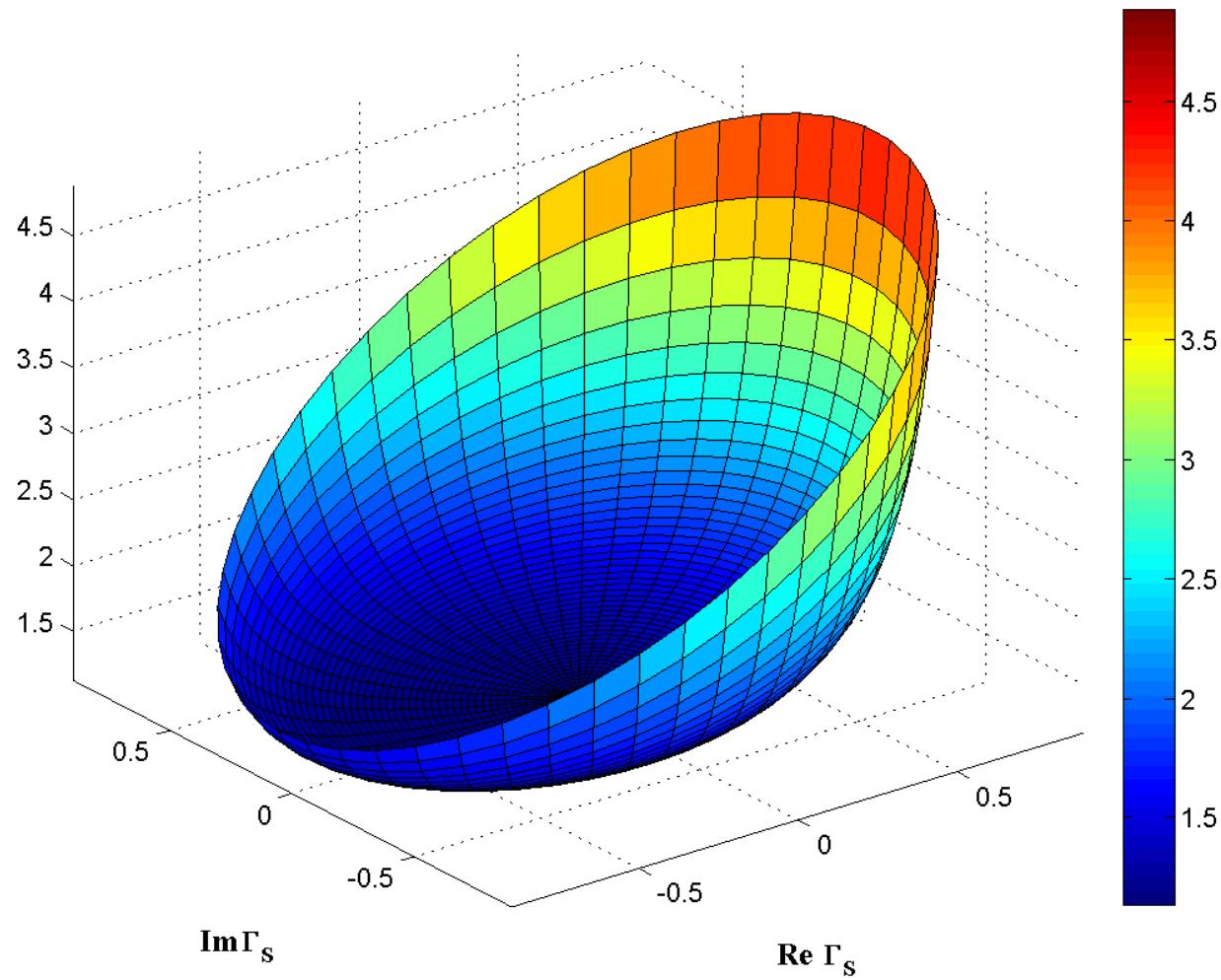


- Factorul de zgomot  $F$  caracterizeaza degradarea raportului semnal/zgomot intre intrarea si iesirea unei componente

$$F = \frac{S_i/N_i}{S_o/N_o}$$

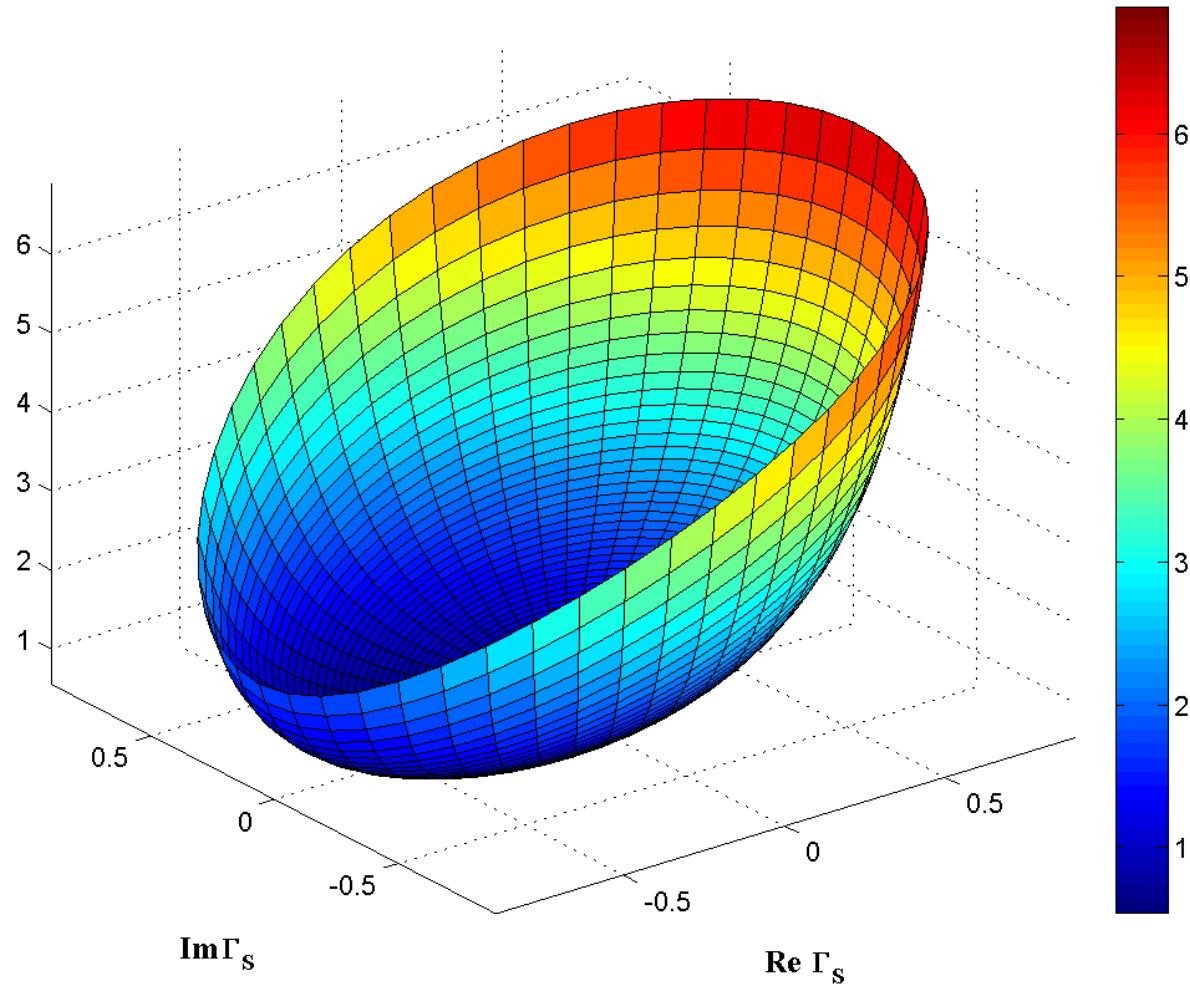
# $F(\Gamma_s)$

$F(\Gamma_s)$

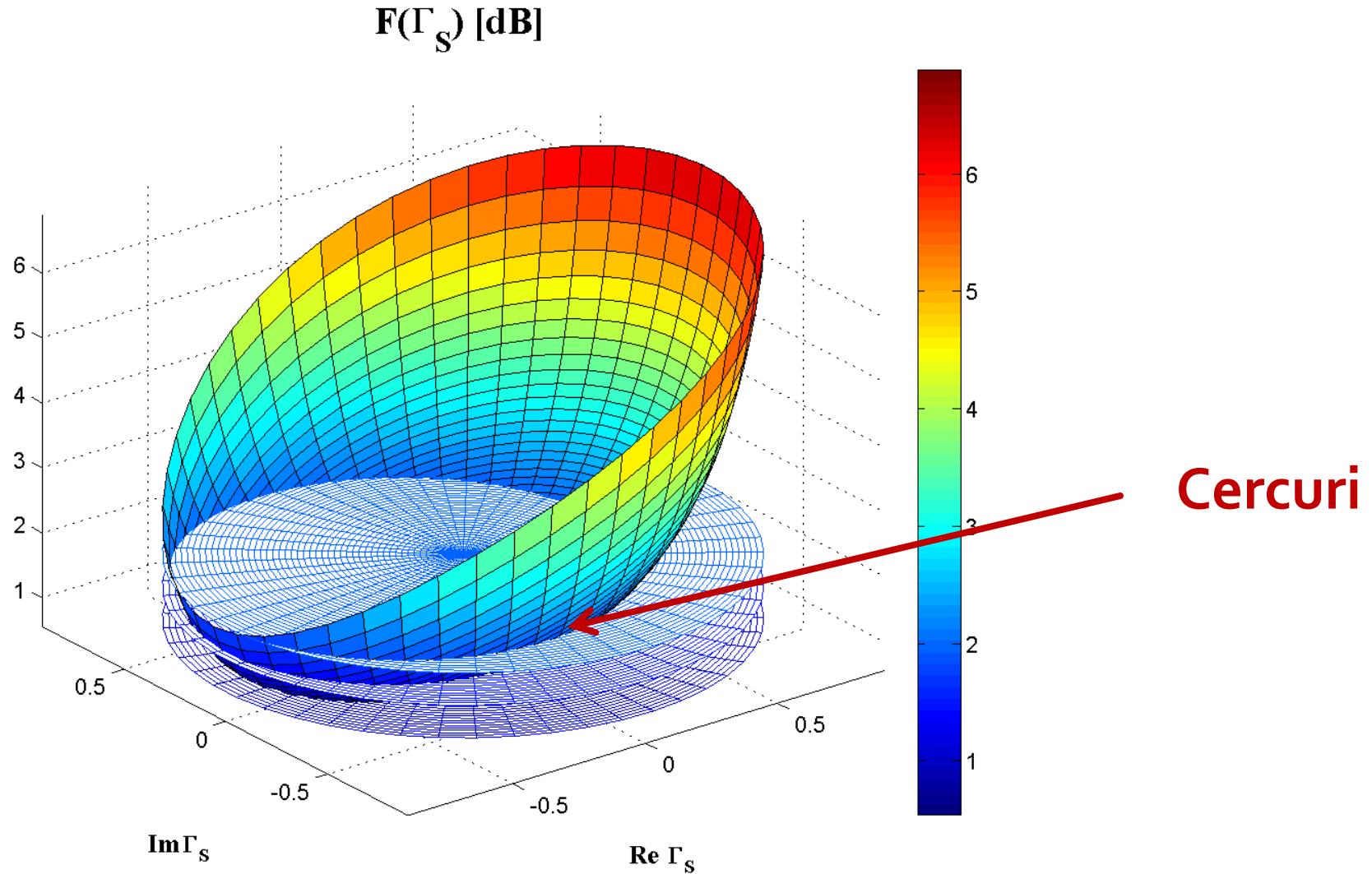


# $F[dB](\Gamma_S)$

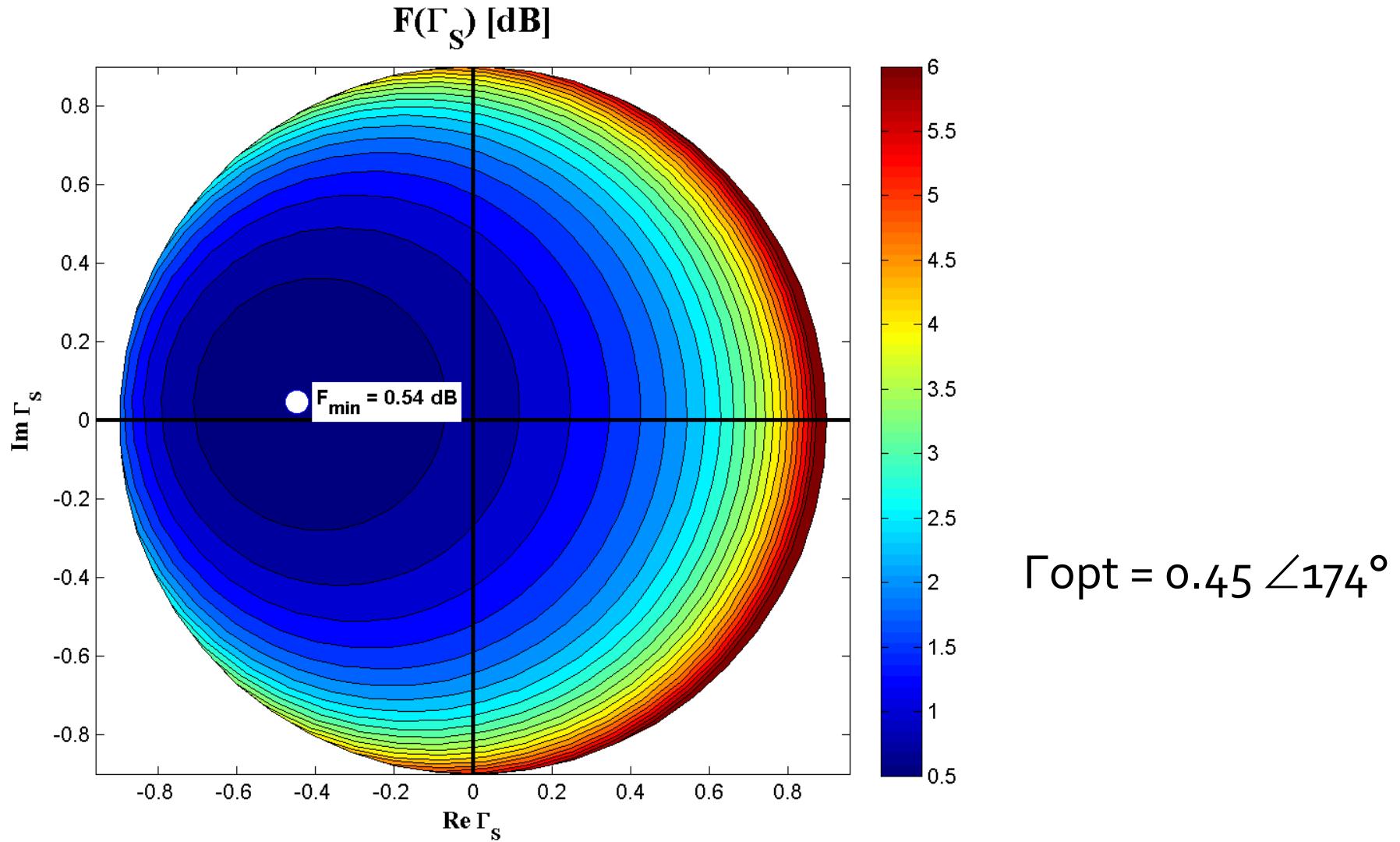
$F(\Gamma_S) [dB]$



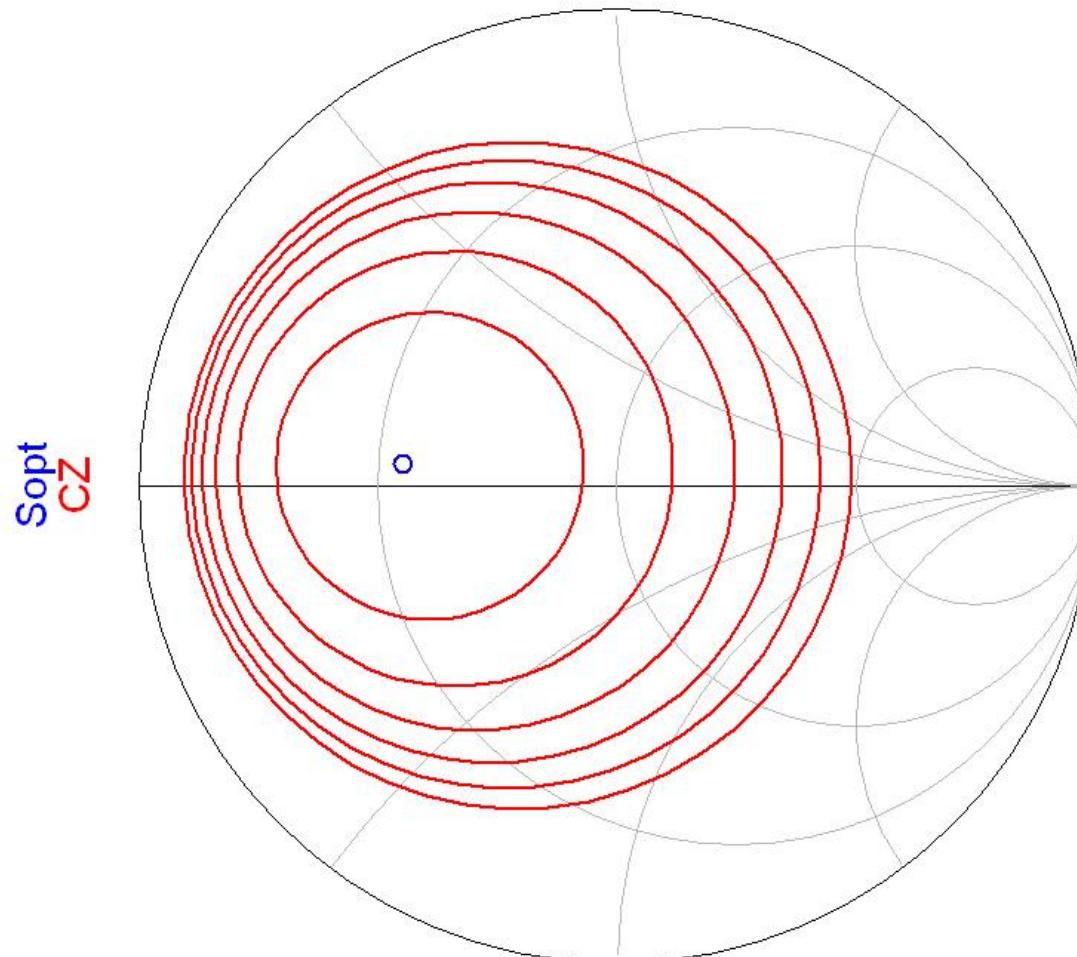
# $F[dB](\Gamma_s)$ , diagrama de nivel



# $G_S[\text{dB}](\Gamma_S)$ , diagrama de nível



# CZ – numai la intrare !



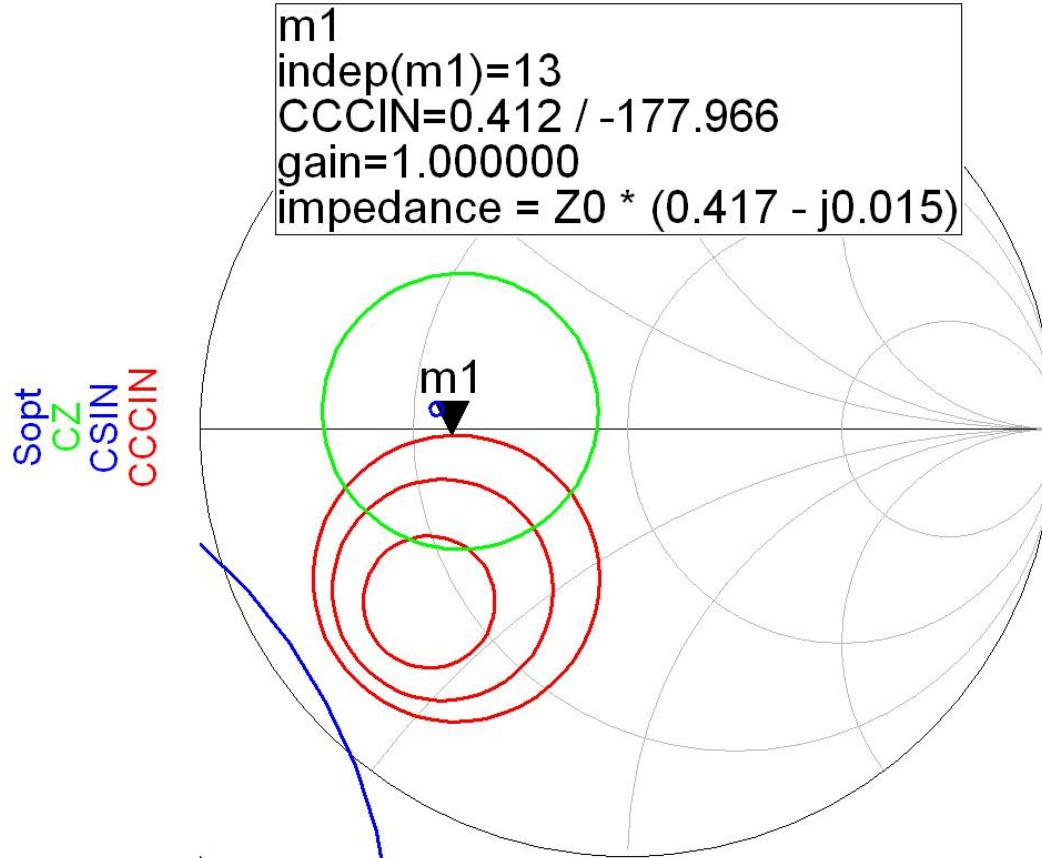
$S_{CZ}^{opt}$

cir\_pts (0.000 to 51.000)  
freq (5.000GHz to 5.000GHz)

# Exemplu, LNA @ 5 GHz

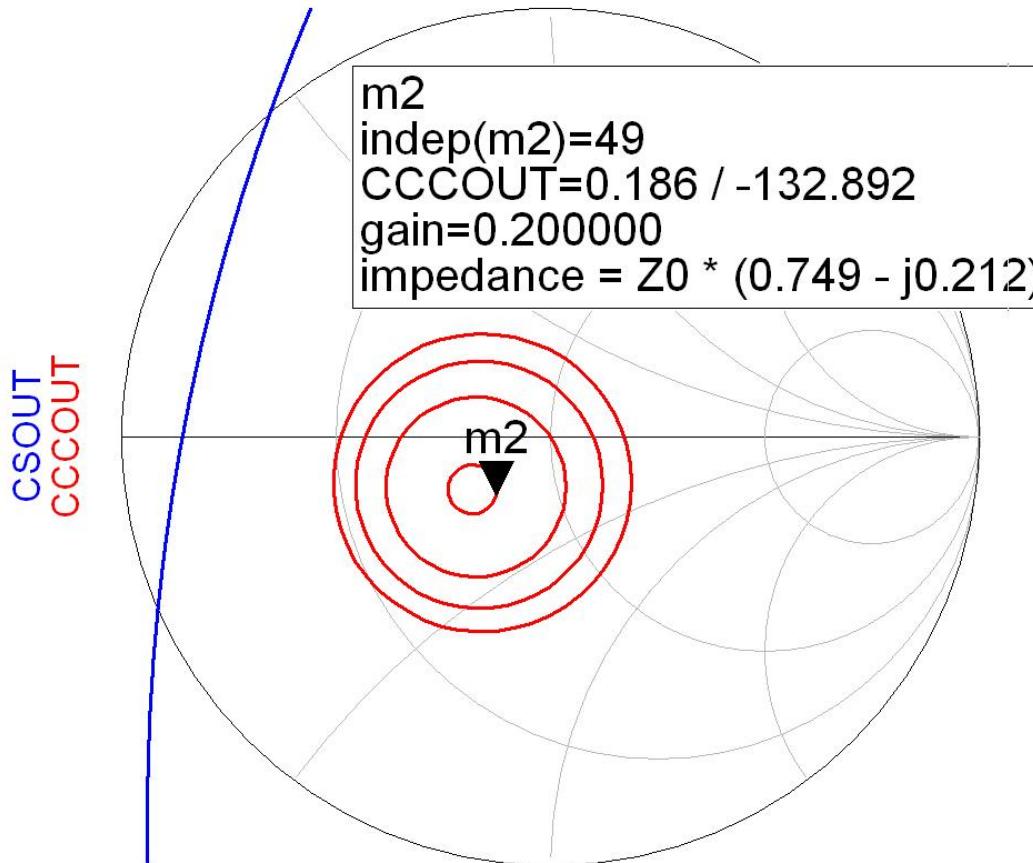
- Amplificator de zgomot redus
- La intrare e necesar un compromis intre
  - zgomot (cerc de zgomot constant ~~la intrare~~)
  - castig (cerc de castig constant la intrare)
  - stabilitate (cerc de stabilitate la intrare)
- La iesire zgomotul **nu intervine** (nu exista influenta). Compromis intre:
  - castig (cerc de castig constant la iesire)
  - stabilitate (cerc de stabilitate la iesire)

# Adaptare la intrare



- Daca se sacrifică 1.2dB castig la intrare pentru conditii convenabile F,Q (Gs = 1 dB)
- Se prefera obtinerea unui zgomot mai mic

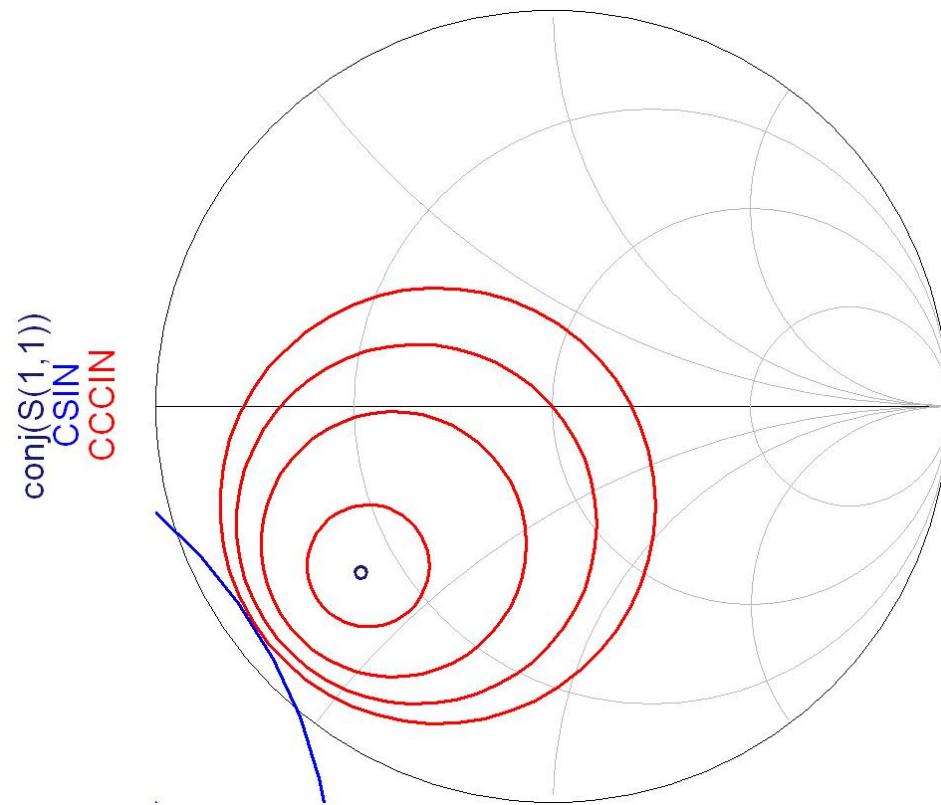
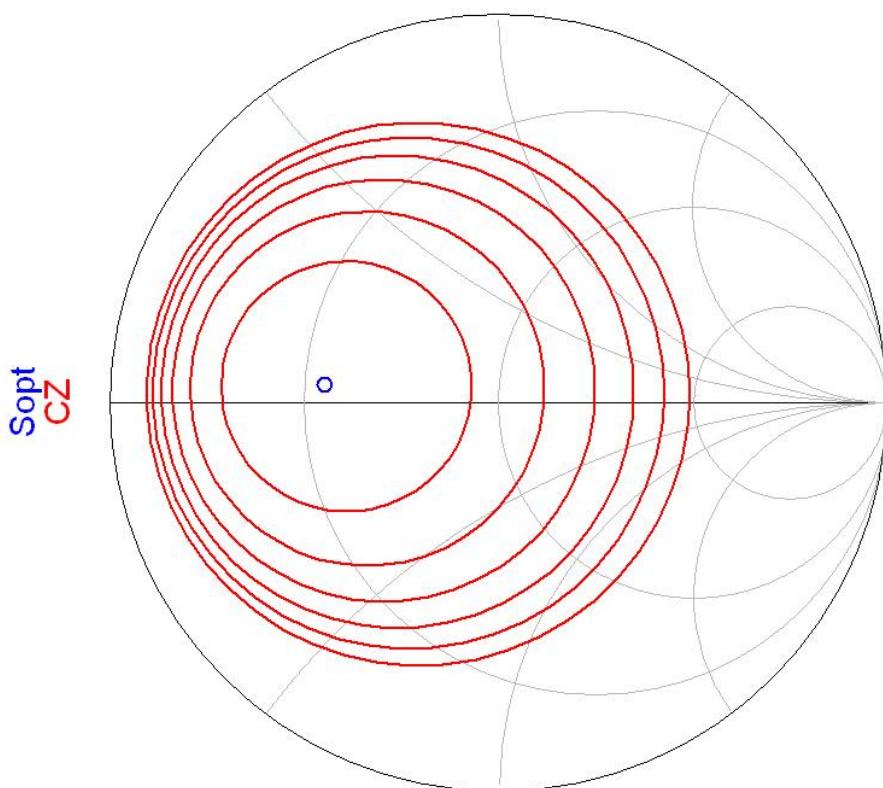
# Adaptare la ieșire



- CCCOUT: -0.4dB, -0.2dB, 0dB, +0.2dB
- Lipsa conditiilor privitoare la zgomot ofera posibilitatea obtinerii unui castig mai mare (spre maxim)

# LNA

- De obicei un tranzistor potrivit pentru implementarea unui LNA la o anumita frecventa va avea cercurile de castig la intrare si cercurile de zgomot in aceeasi zona pentru  $\Gamma_s$



# Contact

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