

**Curs 8**

**2016/2017**

# **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 – 50% din nota
  - probleme + (2p prez. curs)
    - 3rez.=+0.5p
  - toate materialele permise
- Laborator – **sl. Radu Damian**
  - Joi 8-14 impar II.13
  - L – 25% din nota
  - P – 25% din nota

# Documentatie

■ <http://rf-opto.eti.tuiasi.ro>

The screenshot shows the homepage of the RF-OPTO website. At the top, there is a banner featuring the university's logo, a globe with 'ETI' and 'RF-OPTO' text, and a blue background with satellite dish icons. Below the banner, the URL 'http://rf-opto.eti.tuiasi.ro/optical\_comm.php' is visible in the address bar, along with other tabs like 'eti.tuiasi.ro' and 'ro.wikipedia.org'. The main menu includes 'Main', 'Courses' (which is underlined), 'Master', 'Staff', 'Research', and 'Students'. Under 'Courses', sub-options like 'Microwave CD', 'Optical Communications' (which is bolded), 'Optoelectronics', 'Internet', 'Practica', and 'Networks' are listed. The 'Optical Communications' section is expanded, showing course details for 'CO (2014-2015)'. It includes information about the course coordinator (Prof. Dr. Irinel Casian Botez), code (DOS410T), discipline type (DOS; Alternative, Specialty), credits (4), and enrollment year (Sem. 7). It also lists activities, evaluation methods (Colocviu), and grades. Other sections like 'Attendance' and 'Materials' are partially visible at the bottom.

http://rf-opto.eti.tuiasi.ro/optical\_comm.php eti.tuiasi.ro Laboratorul de Microunde s... ro.wikipedia.org

RF-OPTO

ETI

UNIVERSITATEA TEHNICA "DINISCU ROMANESCU" IASI

English | Romana

Main Courses Master Staff Research Students

Microwave CD Optical Communications Optoelectronics Internet Practica Networks

## Optical Communications

### Course: CO (2014-2015)

**Course Coordinator:** Prof. Dr. Irinel Casian Botez  
**Code:** DOS410T  
**Discipline Type:** DOS; Alternative, Specialty  
**Credits:** 4  
**Enrollment Year:** 4, Sem. 7

### Activities

**Course:** Instructor: Prof. Dr. Irinel Casian Botez, 3 Hours/Week, Specialization Section, Timetable:  
**Laboratory:** Instructor: Assist.P. Dr. Petre-Daniel Matasaru, 1 Hours/Week, Half Group, Timetable:

### Evaluation

Type: Colocviu

**A:** 70%, (Test/Colloquium)  
**B:** 30%, (Seminary/Laboratory/Project Activity)

### Grades

[Aggregate Results](#)

### Attendance

Not yet

### Materials

#### Course Slides

Raze de lumina slides (pdf, 232.99 KB, ro, )  
Fibre optice slides (pdf, 902.07 KB, ro, )  
LED (pdf, 664.51 KB, ro, )

# Documentatie

- RF-OPTO
  - <http://rf-opto.eti.tuiasi.ro>
- Fotografie
  - de trimis prin email: [rdamian@etti.tuiasi.ro](mailto:rdamian@etti.tuiasi.ro)
  - necesara la laborator/curs
    - ~~≤C<sub>3</sub>, +1p~~
    - ~~≤C<sub>5</sub>, +0.5p~~

# Fotografii

http://if-opto.eti.tuiasi.ro/presenza.php?act=153&nru=14&ext\_supliz=26 eti.tuiasi.ro Laboratorul de Microonde s... ro.wikipedia.org

Start Didactic Master Colectiv Cercetare Studenti Admin

Note Lista Studenti Fotografi Statistici

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>	<input type="checkbox"/> Prezent	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent
4	APOSTOL PAVEL-MANUEL	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent	5	BALASCA TUDIAN-PETRU	 <b>Fotografia nu există</b>	<input checked="" type="checkbox"/> Prezent	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent
7	BOTEZAT EMANUEL		<input type="checkbox"/> Prezent	8	BUTUNOI GEORGE-MADALIN	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent	 <b>Fotografia nu există</b>	<input type="checkbox"/> Prezent
10	CHIRITOIU ECATERINA		<input type="checkbox"/> Prezent	11	CODOC MARCUS		<input checked="" type="checkbox"/> Prezent		<input type="checkbox"/> Prezent
				12	COJOCARU ALINA-FLORINA				

Nr. Student

Prezent

2 ANTIGHIN  
FLORIN-RAZVAN

Prezent

Puncte: 0

Nota: 0

Obs:

**Fotografia nu există**

# Acces

## Personalizat



Date:

Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

[Acceseaza ca acest student](#)

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	Tehnologii Web					
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Colocviu Tehnologii Web 2013/2014	10	7.55	
	B	17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
	D	17/01/2014	Tema Tehnologii Web 2013/2014	9	-	

Nume

Email

Cod de verificare

Trimite

# Reprezentare logarithmică

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

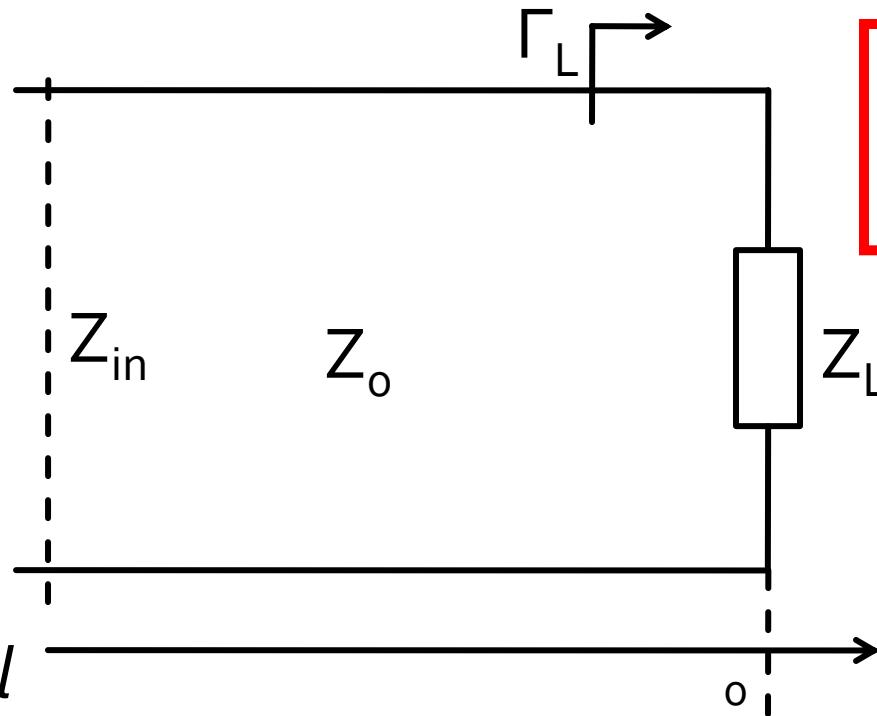
$$[\text{dBm}/\text{Hz}] + [\text{dB}] = [\text{dBm}/\text{Hz}]$$

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

# Recapitulare

# Linie fara pierderi

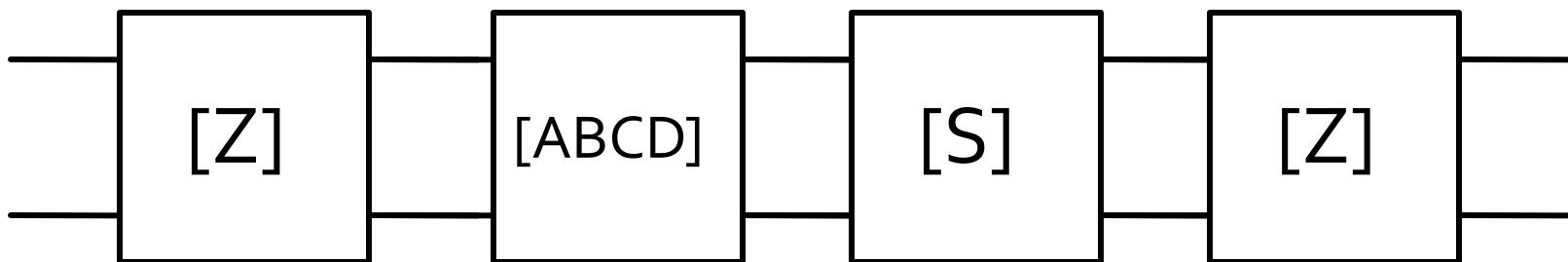
- impedanta la intrarea liniei de impedanta caracteristica  $Z_0$ , de lungime  $l$ , terminata cu impedanta  $Z_L$



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

# Analiza la nivel de bloc

- are ca scop separarea unui circuit complex în blocuri individuale
- acestea se analizează separat (decuplate de restul circuitului) și se caracterizează doar prin intermediul porturilor (**cutie neagră**)
- analiza la nivel de rețea permite cuplarea rezultatelor individuale și obținerea unui rezultat total pentru circuit



# Matricea S generalizata

- Definim undele de putere

$$a = \frac{V + Z_R \cdot I}{2 \cdot \sqrt{R_R}} \text{ unda incidenta de putere}$$

$$b = \frac{V - Z_R^* \cdot I}{2 \cdot \sqrt{R_R}} \text{ unda reflectata de putere}$$

$$Z_R = R_R + j \cdot X_R$$

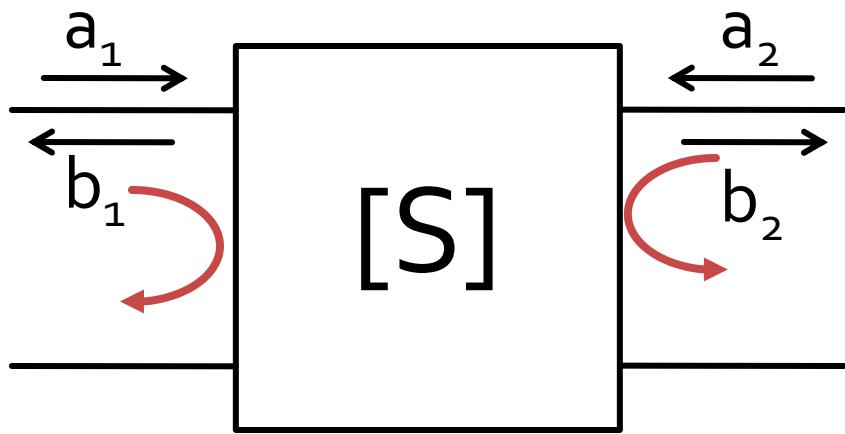
O impedanta de referinta  
oarecare, complexa

- Tensiuni si curenti

$$V = \frac{Z_R^* \cdot a + Z_R \cdot b}{\sqrt{R_R}}$$

$$I = \frac{a - b}{\sqrt{R_R}}$$

# Matricea S (repartitie)

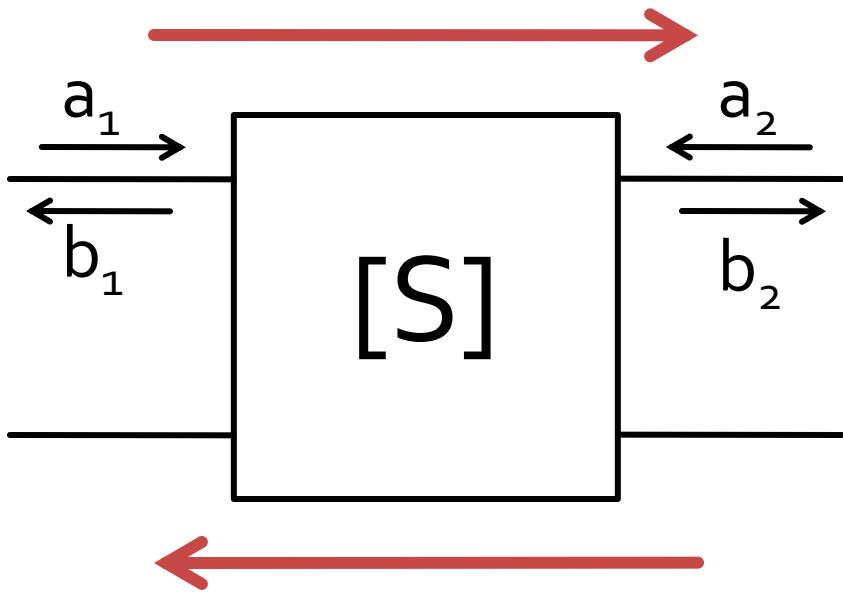


$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$S_{11} = \left. \frac{b_1}{a_1} \right|_{a_2=0} \quad S_{22} = \left. \frac{b_2}{a_2} \right|_{a_1=0}$$

- $S_{11}$  și  $S_{22}$  sunt coeficienti de reflexie la intrare si iesire cand celalalt port este adaptat

# Matricea S (repartitie)



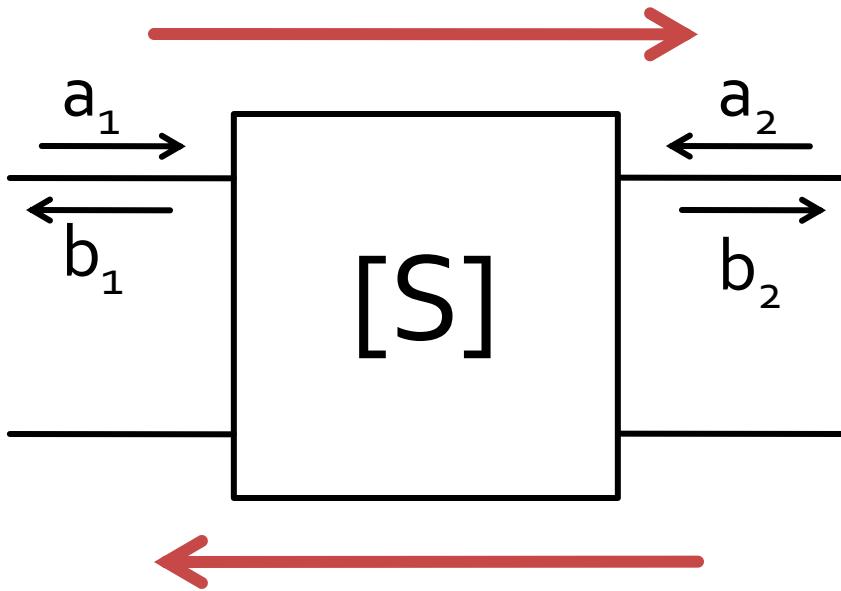
$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$S_{21} = \frac{b_2}{a_1} \Big|_{a_2=0}$$

$$S_{12} = \frac{b_1}{a_2} \Big|_{a_1=0}$$

- $S_{21}$  și  $S_{12}$  sunt amplificări de semnal cand celalalt port este adaptat

# Matricea S (repartitie)



$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$|S_{21}|^2 = \frac{\text{Putere sarcina } Z_0}{\text{Putere sursa } Z_0}$$

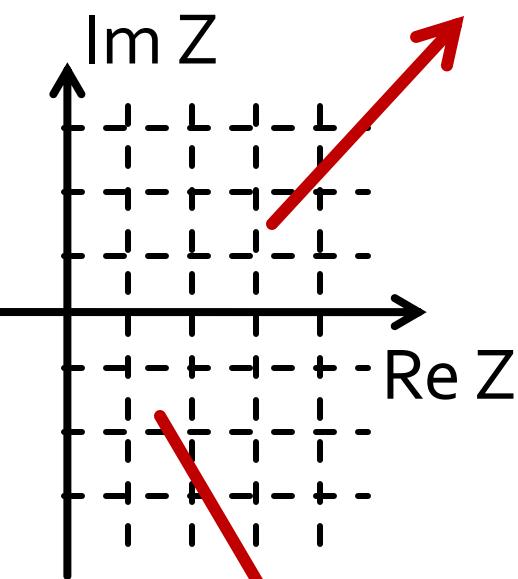
- a,b
  - informatia despre putere **SI** faza
- $S_{ij}$ 
  - influenta circuitului asupra puterii semnalului incluzand informatiile relativ la faza

Adaptarea de impedanță

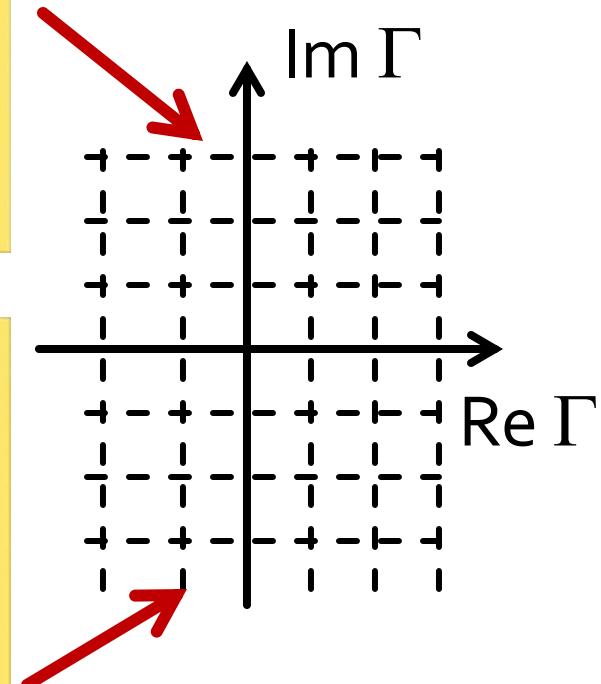
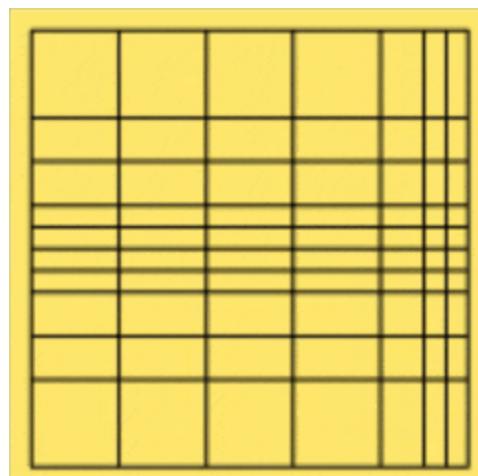
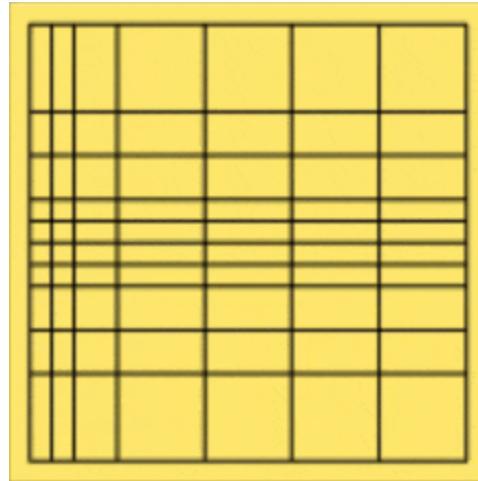
# Diagrama Smith

# Diagrama Smith

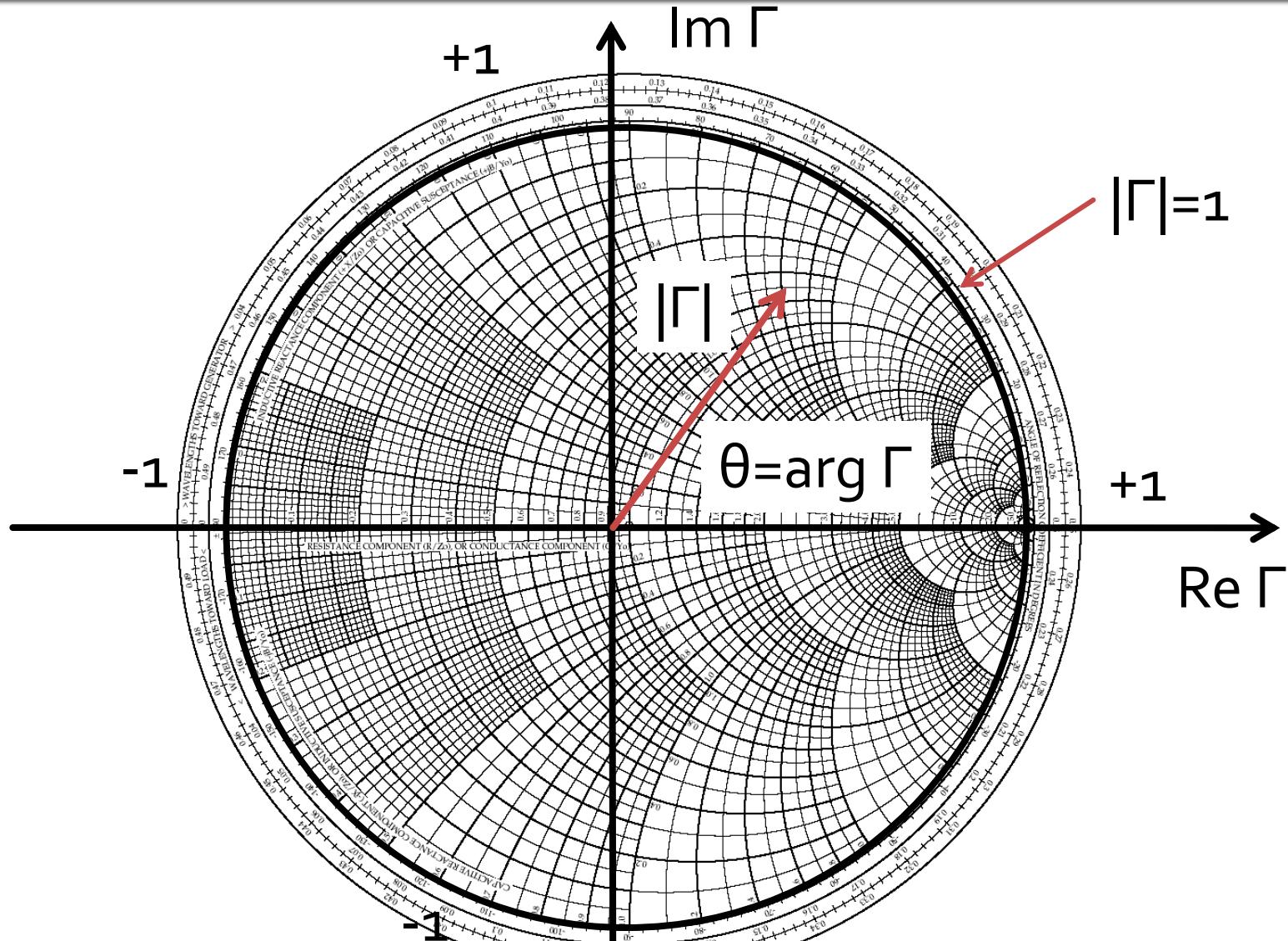
$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{z_L - 1}{z_L + 1}$$



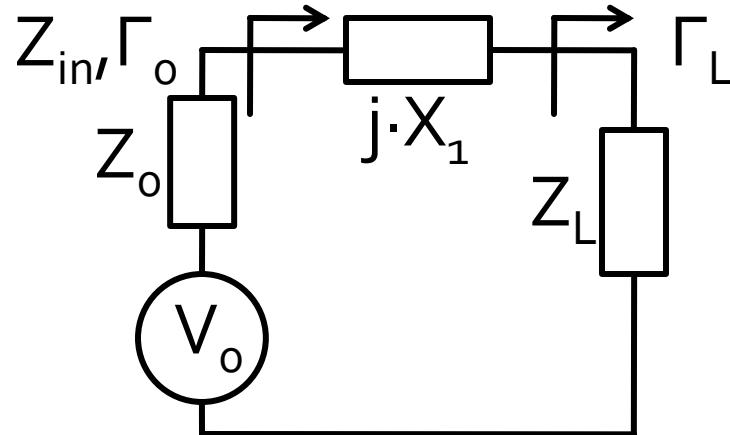
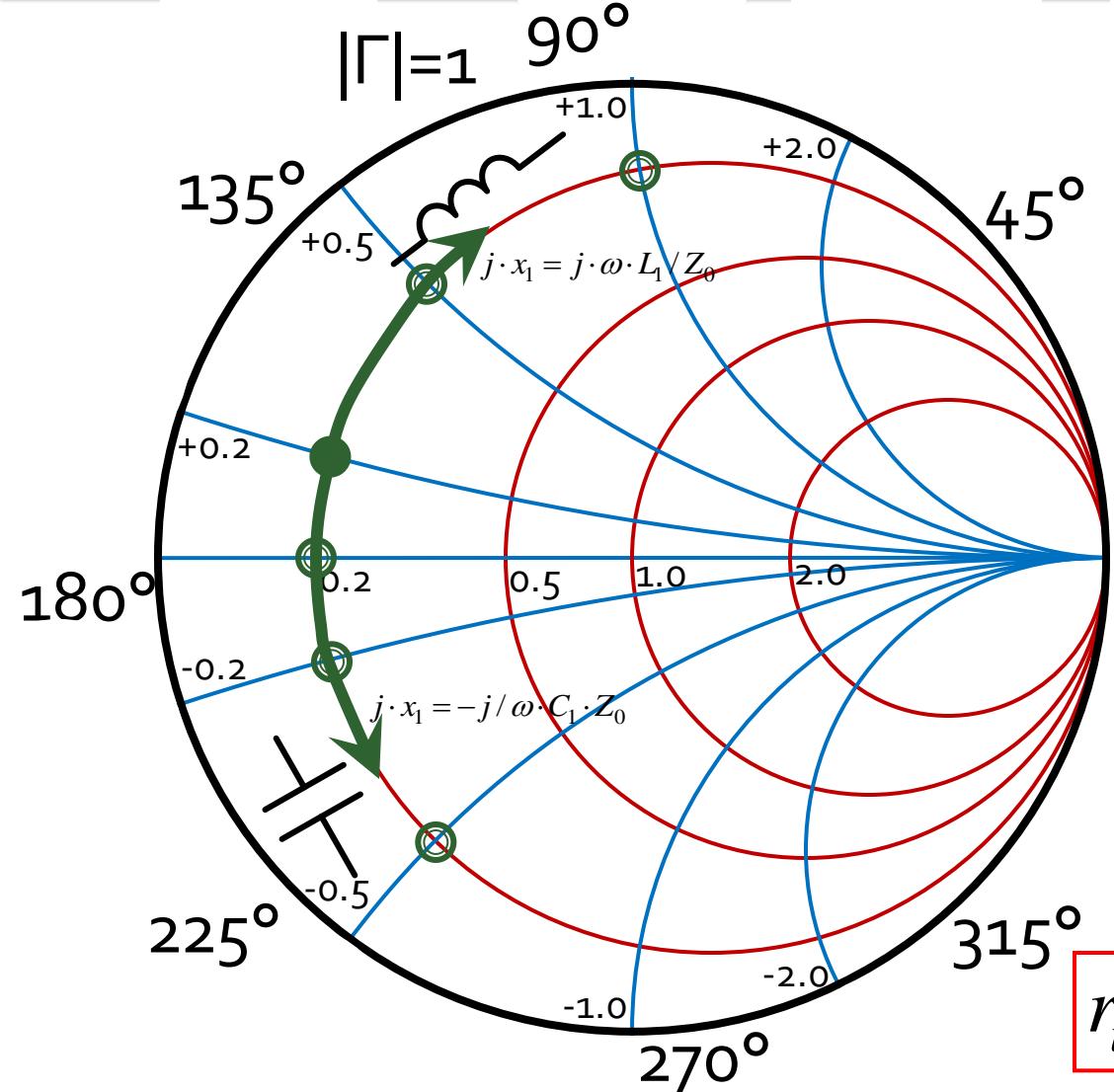
$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{Y_0 - Y_L}{Y_0 + Y_L} = \frac{1 - y_L}{1 + y_L}$$



# Diagrama Smith



# Diagrama Smith, coeficient de reflexie, reactanta in serie



$$Z_0 = 50\Omega$$

$$Z_L = R_L + j \cdot X_L = 10\Omega + j \cdot 10\Omega$$

$$z_L = r_L + j \cdot x_L = 0.2 + j \cdot 0.2$$

$$\Gamma_L = 0.678 \angle 156.5^\circ$$

$$Z_{in} = Z_L + j \cdot X_1 = R_L + j \cdot (X_L + X_1)$$

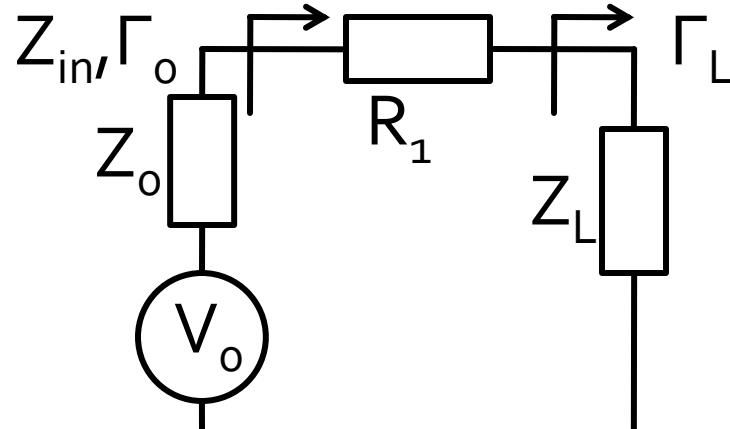
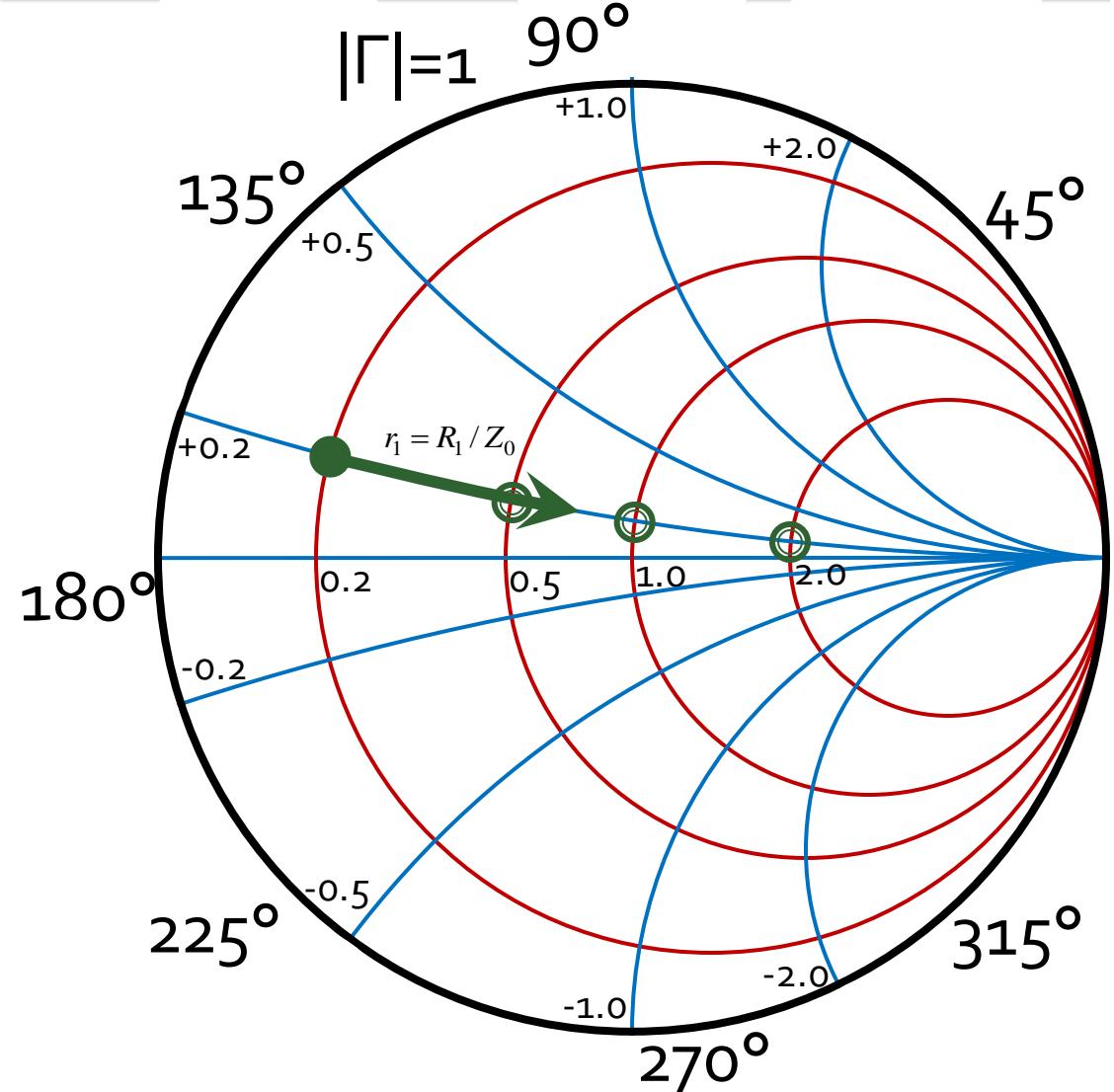
$$z_{in} = r_L + j \cdot (x_L + x_1)$$

$$r_{in} = r_L$$

$$j \cdot x_1 = j \cdot \omega \cdot L_1 / Z_0 > 0$$

$$j \cdot x_1 = -j/\omega \cdot C_1 \cdot Z_0 < 0$$

# Diagrama Smith, coeficient de reflexie, rezistenta in serie



$$Z_0 = 50\Omega$$

$$Z_L = R_L + j \cdot X_L = 10\Omega + j \cdot 10\Omega$$

$$z_L = r_L + j \cdot x_L = 0.2 + j \cdot 0.2$$

$$\Gamma_L = 0.678 \angle 156.5^\circ$$

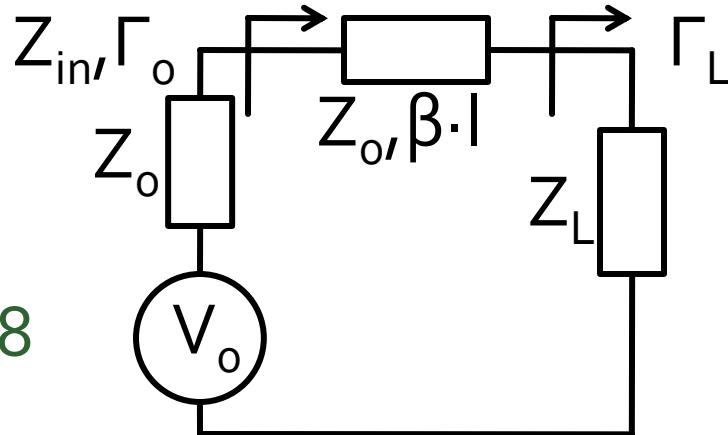
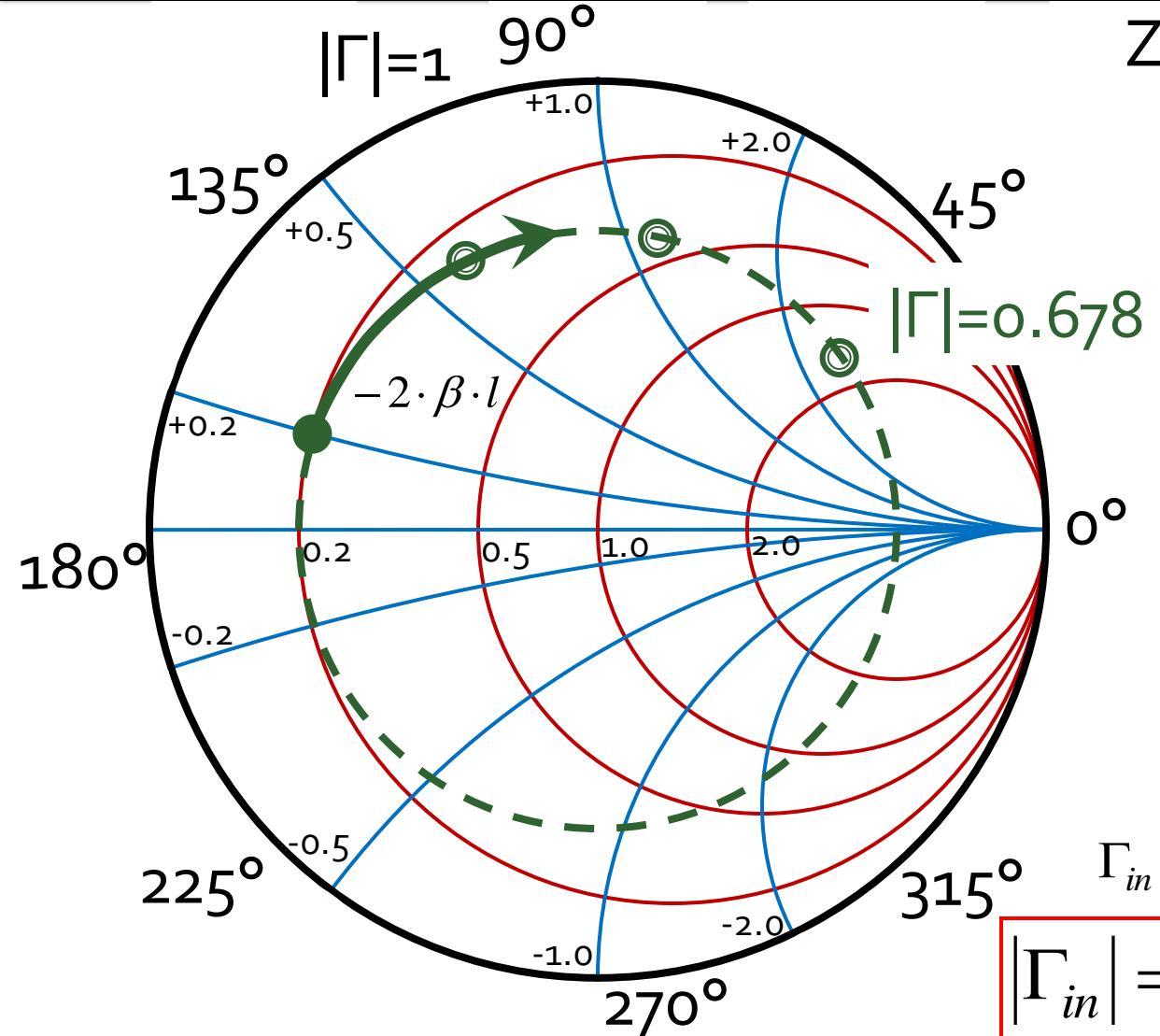
$$Z_{in} = Z_L + R_1 = (R_L + R_1) + j \cdot X_L$$

$$z_{in} = z_L + r_1 = (r_L + r_1) + j \cdot x_L$$

$$x_{in} = x_L$$

$$r_{in} = r_L + R_1 / Z_0$$

# Diagrama Smith, coeficient de reflexie, linie de transmisie in serie



$$Z_0 = 50\Omega$$

$$Z_L = R_L + j \cdot X_L = 10\Omega + j \cdot 10\Omega$$

$$z_L = r_L + j \cdot x_L = 0.2 + j \cdot 0.2$$

$$\Gamma_L = 0.678 \angle 156.5^\circ$$

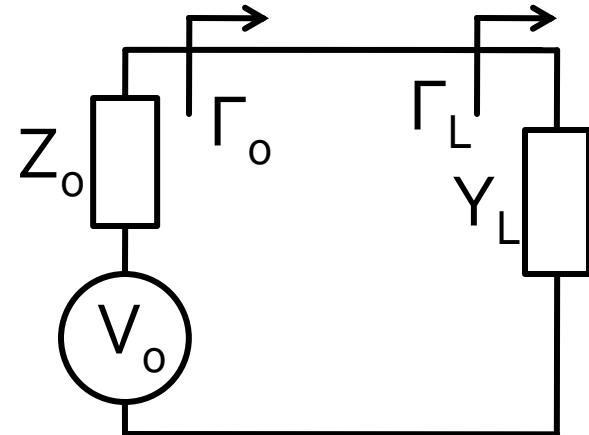
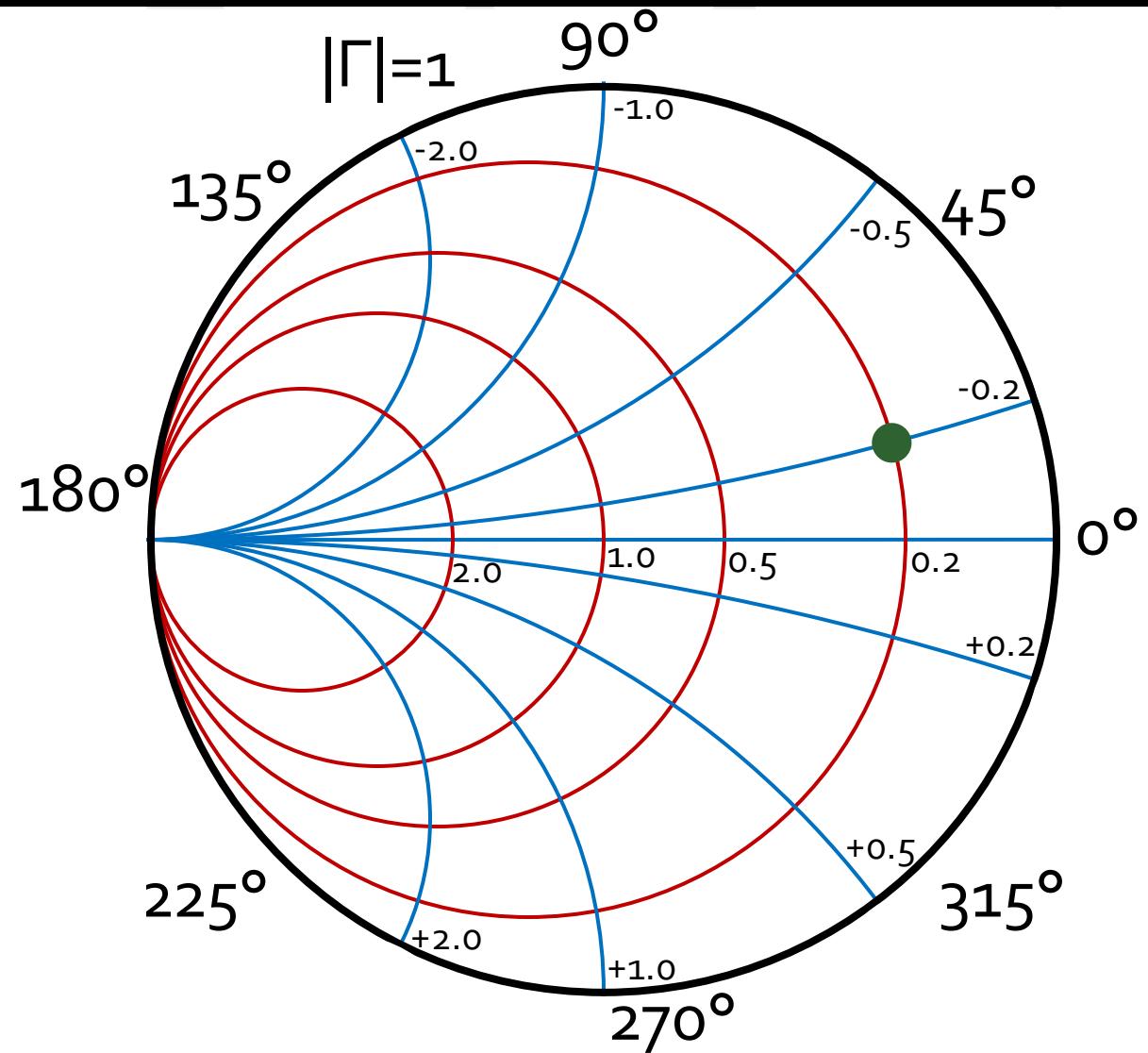
$$Z_{in} = Z_0 \cdot \frac{1 + \Gamma_L \cdot e^{-2j\beta l}}{1 - \Gamma_L \cdot e^{-2j\beta l}}$$

$$\Gamma_{in} = \Gamma_L \cdot e^{-2j\beta l}$$

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

$$\arg(\Gamma_{in}) = \arg(\Gamma_L) - 2 \cdot \beta l$$

# Diagrama Smith, coeficient de reflexie, admitanta



$$Z_0 = 50\Omega, Y_0 = 0.02S$$

$$Z_L = 125\Omega + j \cdot 125\Omega$$

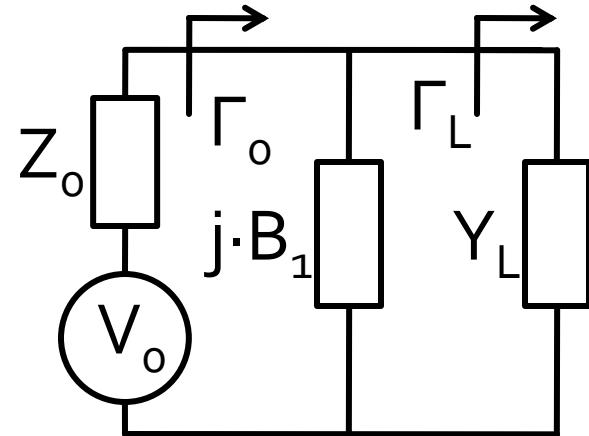
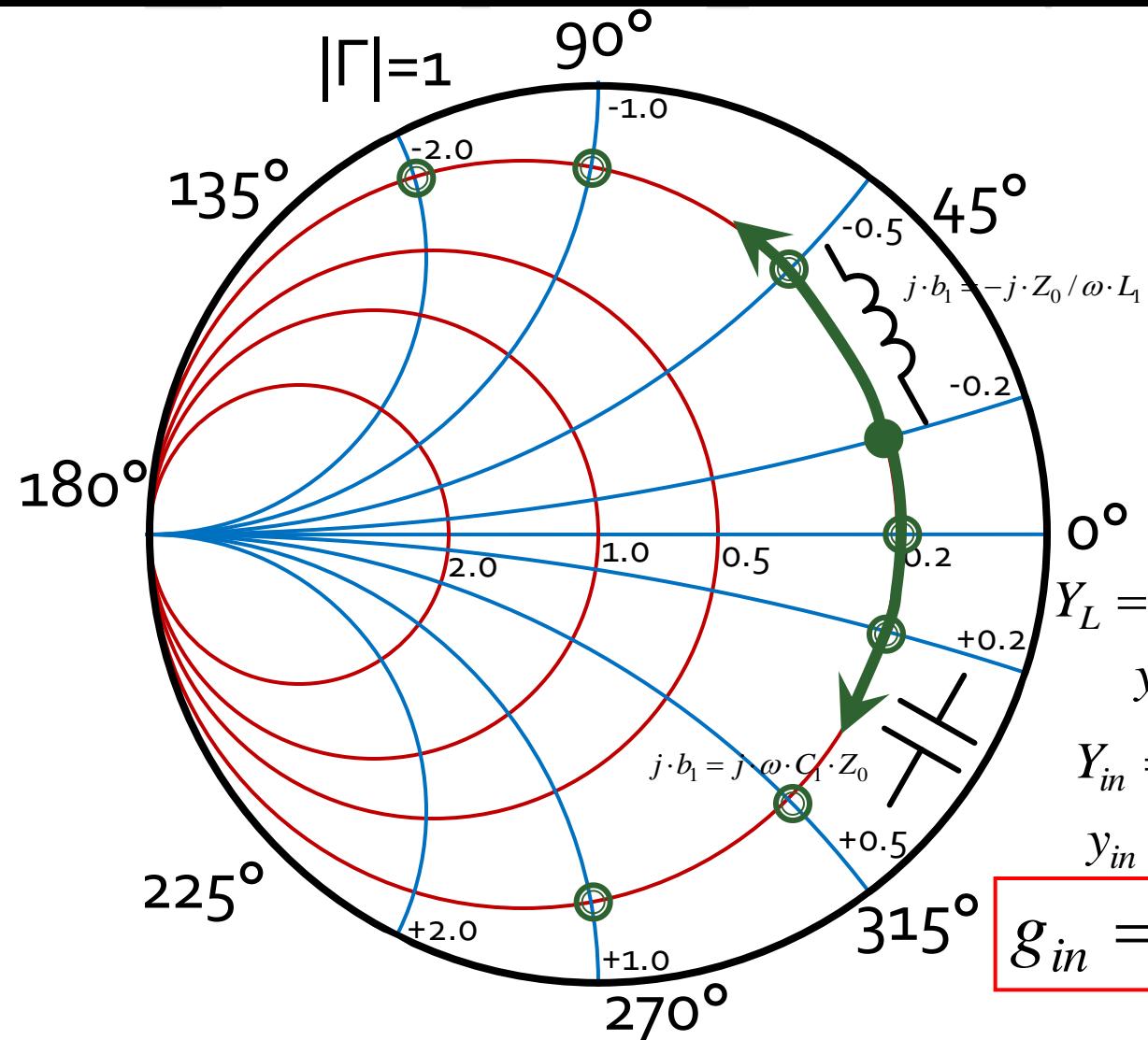
$$z_L = 2.5 + j \cdot 2.5$$

$$\Gamma_L = \Gamma_0 = 0.678 \angle 23.5^\circ$$

$$Y_L = \frac{1}{Z_L} = 0.004S - j \cdot 0.004S$$

$$y_L = \frac{1}{z_L} = \frac{Y_L}{Y_0} = 0.2 - j \cdot 0.2$$

# Diagrama Smith, coeficient de reflexie, susceptanta in paralel



$$Z_0 = 50\Omega, Y_0 = 0.02S$$

$$\Gamma_L = 0.678 \angle 23.5^\circ$$

$$Y_L = G_L + j \cdot B_L = 0.004S + j \cdot 0.004$$

$$y_L = g_L + j \cdot b_L = 0.2 - j \cdot 0.2$$

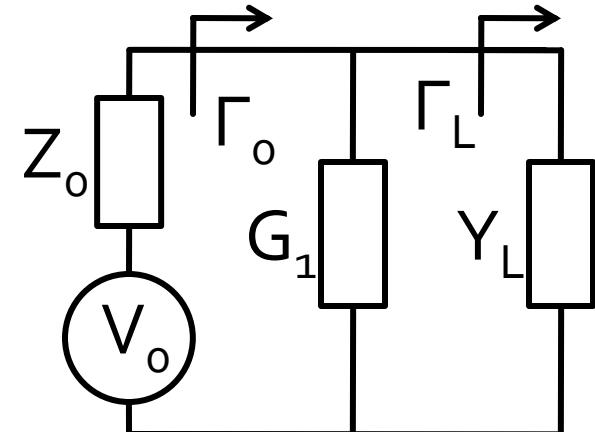
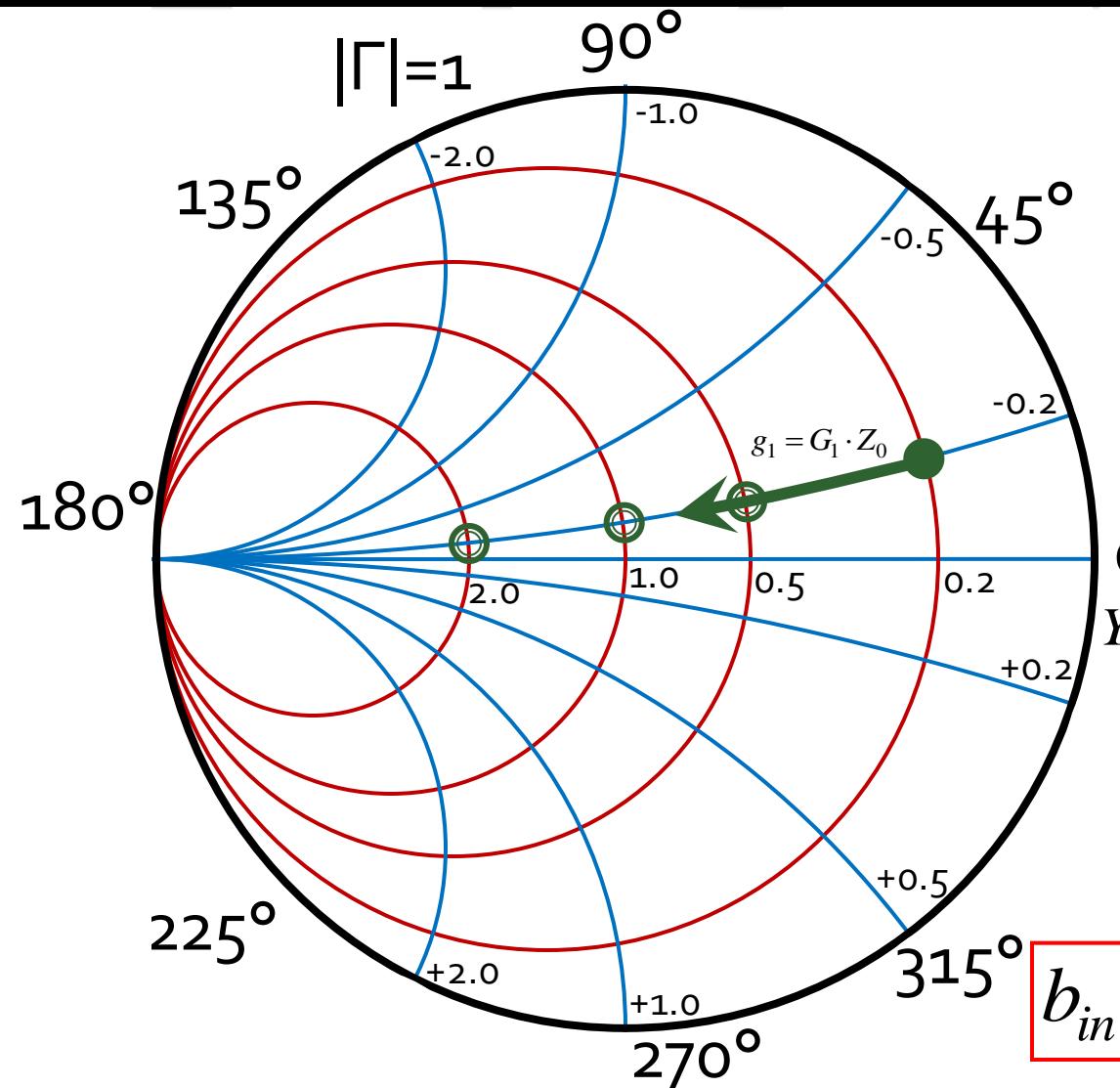
$$Y_{in} = Y_L + j \cdot B_1 = G_L + j \cdot (B_L + B_1)$$

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

$$g_{in} = g_L \quad j \cdot b_1 = j \cdot \omega \cdot C_1 \cdot Z_0 > 0$$

$$j \cdot b_1 = -j \cdot Z_0 / \omega \cdot L_1 < 0$$

# Diagrama Smith, coeficient de reflexie, conductanta in paralel



$$Z_0 = 50\Omega, Y_0 = 0.02S$$

$$\Gamma_L = 0.678 \angle 23.5^\circ$$

$$Y_L = G_L + j \cdot B_L = 0.004S + j \cdot 0.004$$

$$y_L = g_L + j \cdot b_L = 0.2 - j \cdot 0.2$$

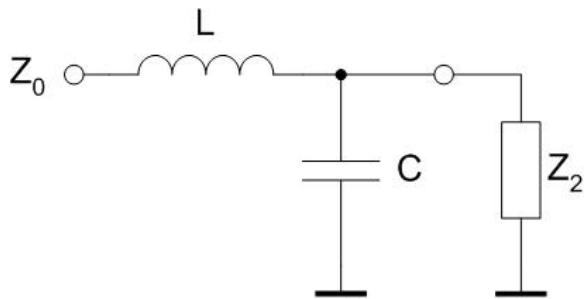
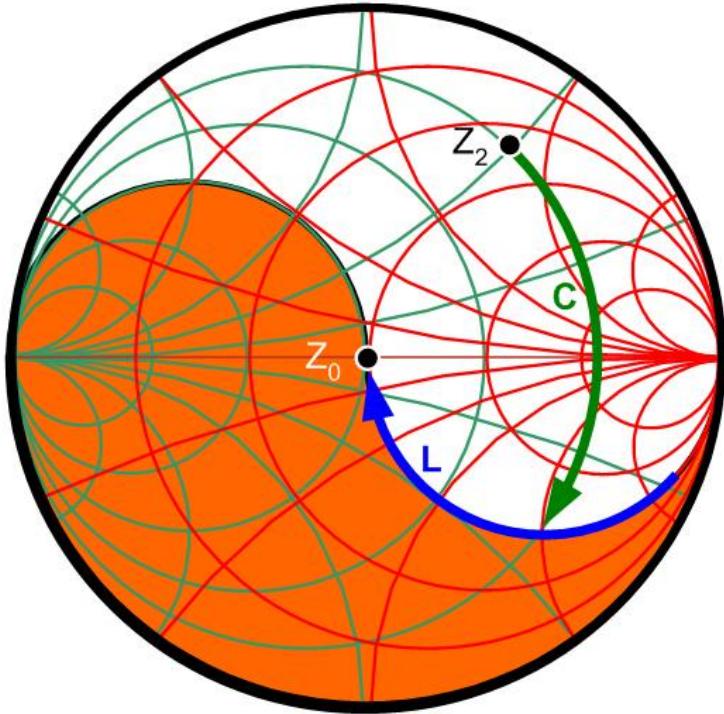
$$Y_{in} = Y_L + G_1 = (G_L + G_1) + j \cdot B_L$$

$$y_{in} = (g_L + g_1) + j \cdot b_L$$

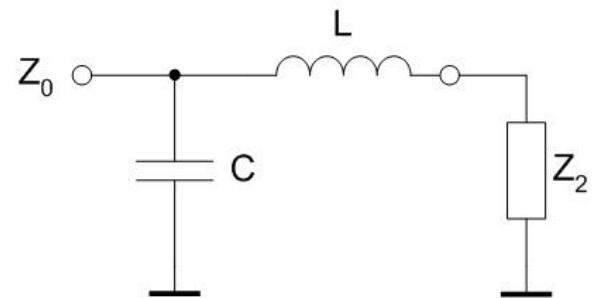
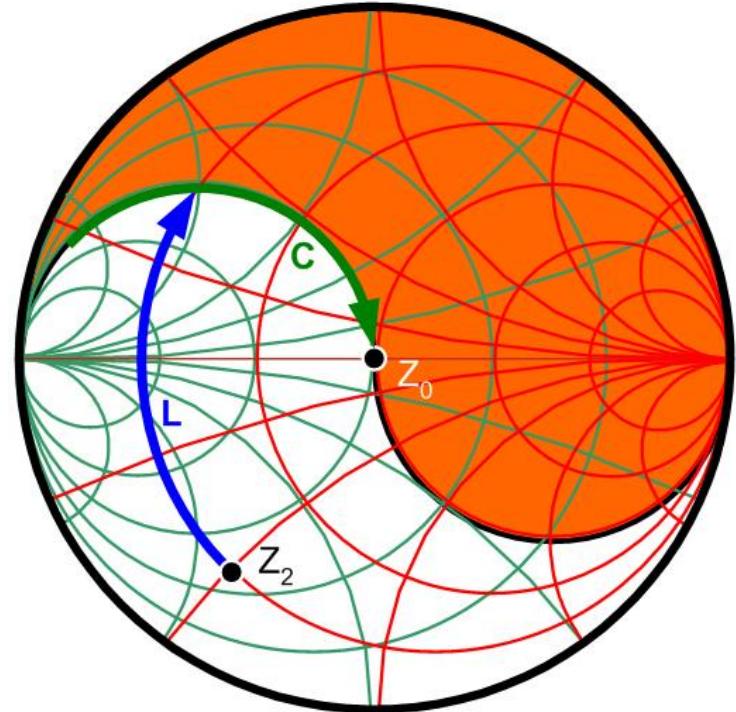
$$b_{in} = b_L$$

$$g_{in} = g_L + G_1 \cdot Z_0$$

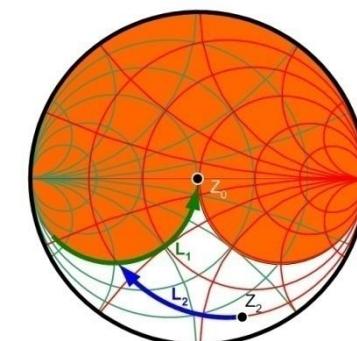
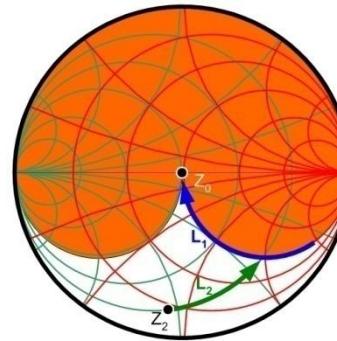
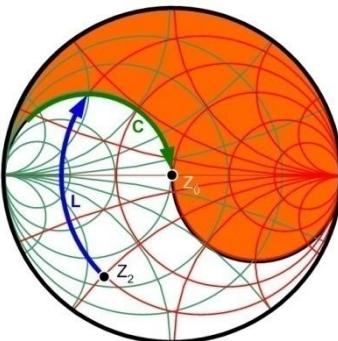
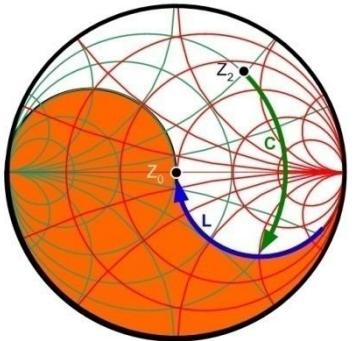
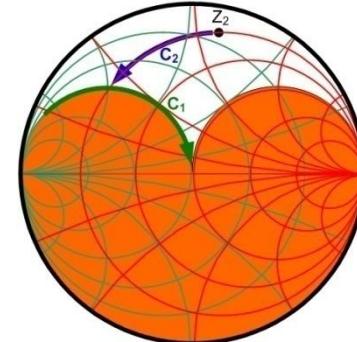
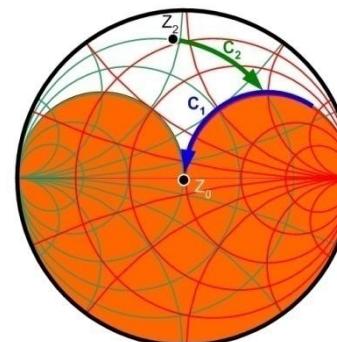
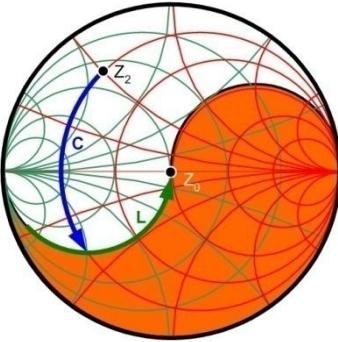
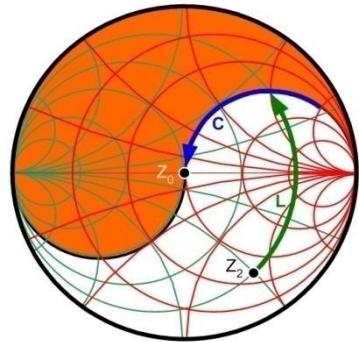
# L serie, C paralel / C paralel, L serie



Zona interzisa cu  
schema curenta



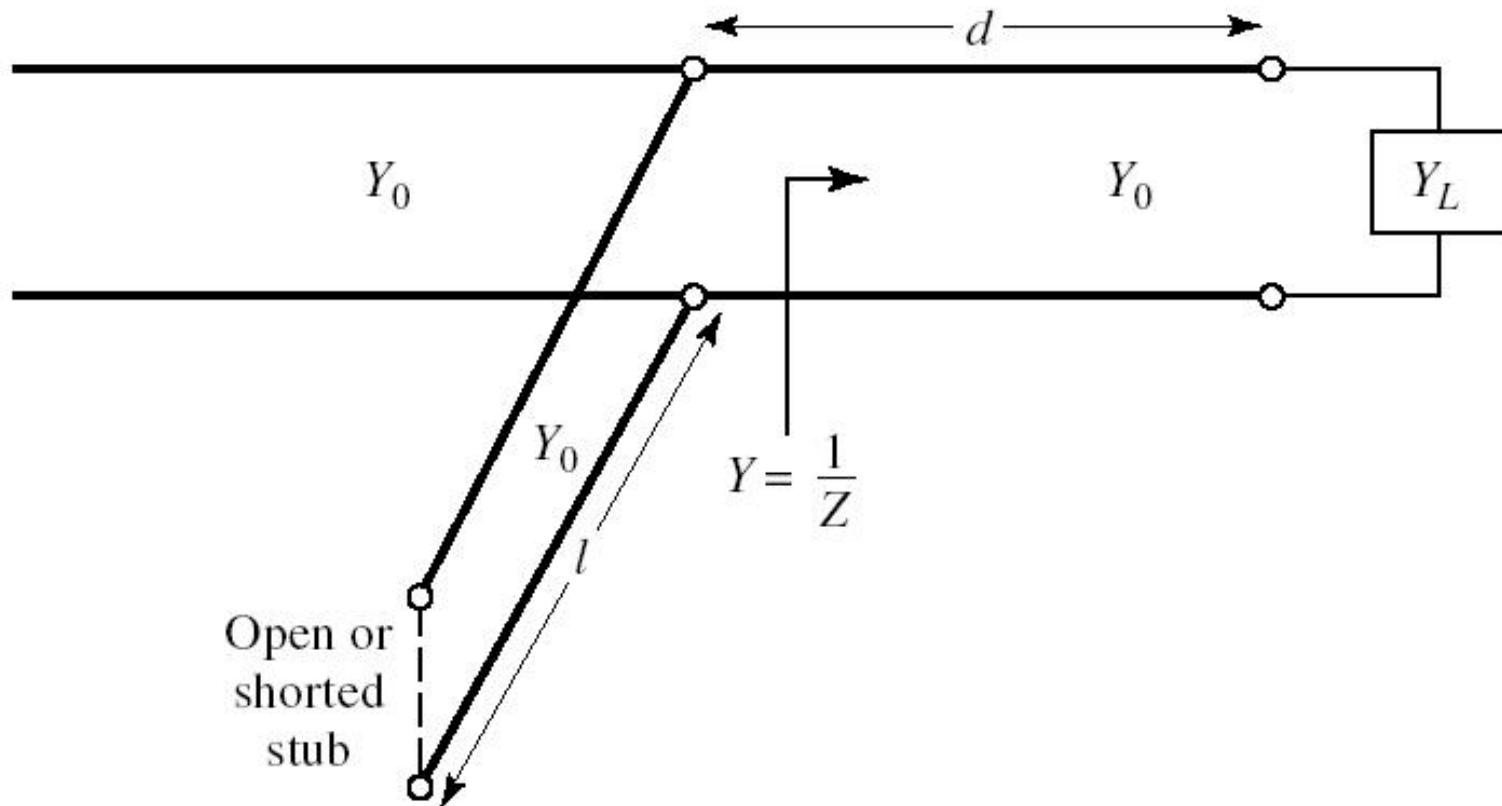
# Adaptare cu două elemente reactive (retele in L)



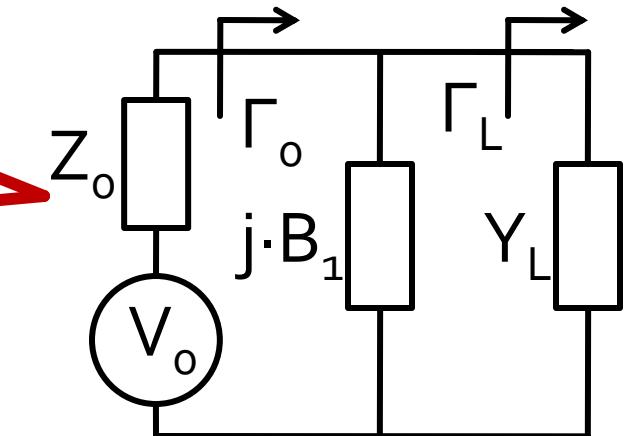
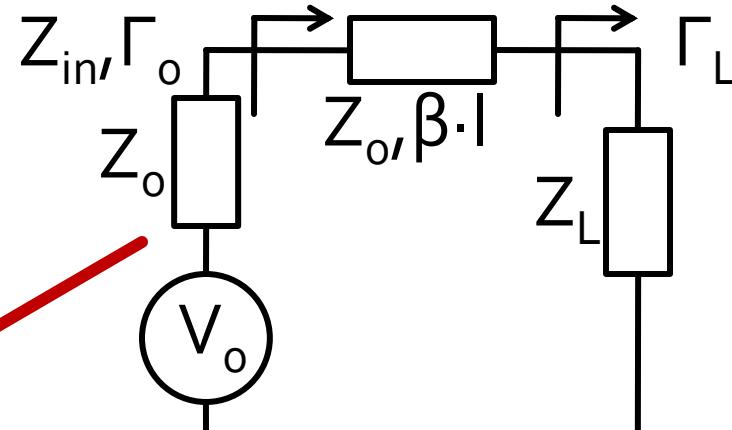
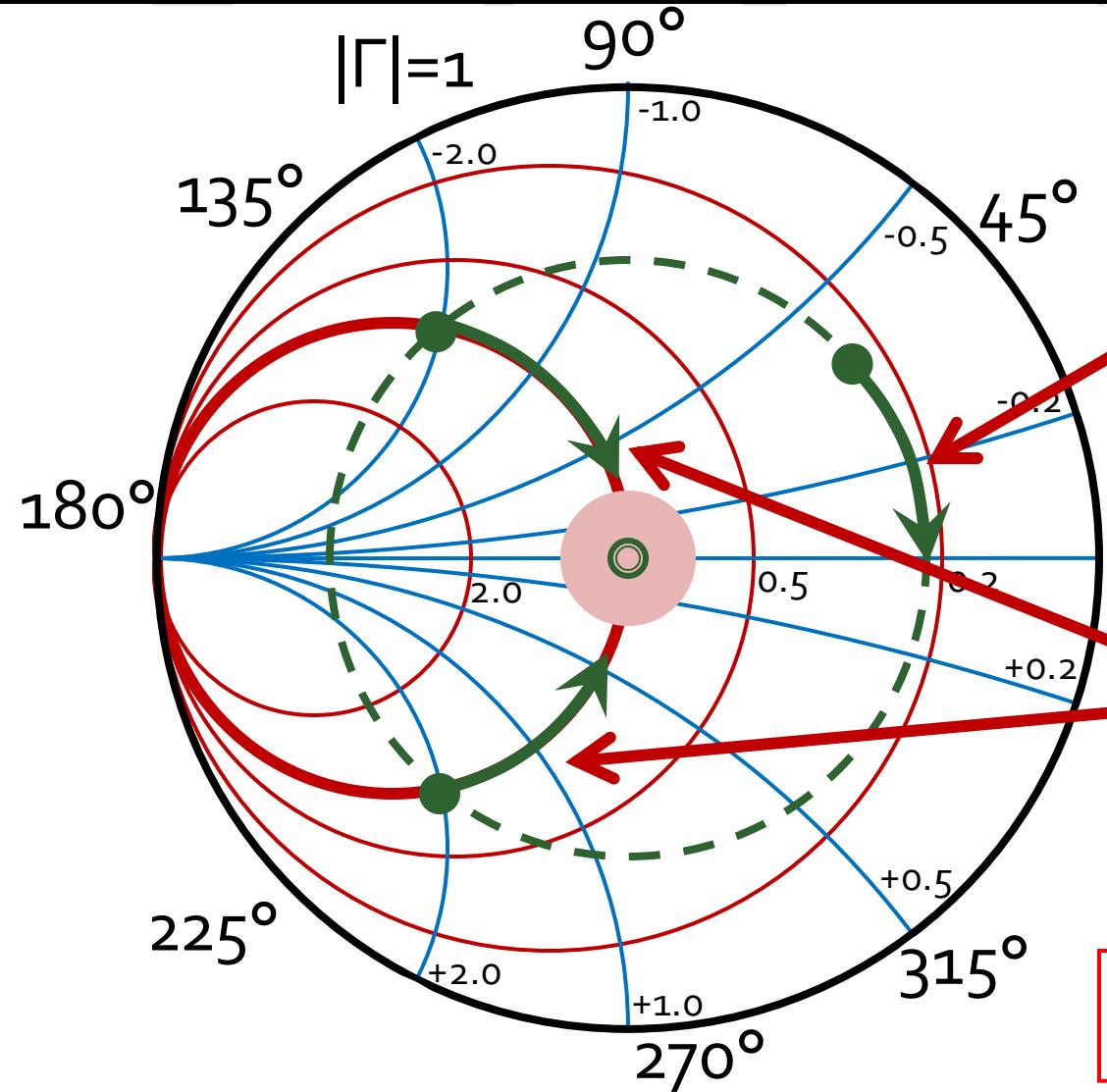
Zona interzisa cu  
schema curenta

# Single stub tuning

- Shunt Stub (secțiune de linie în paralel)



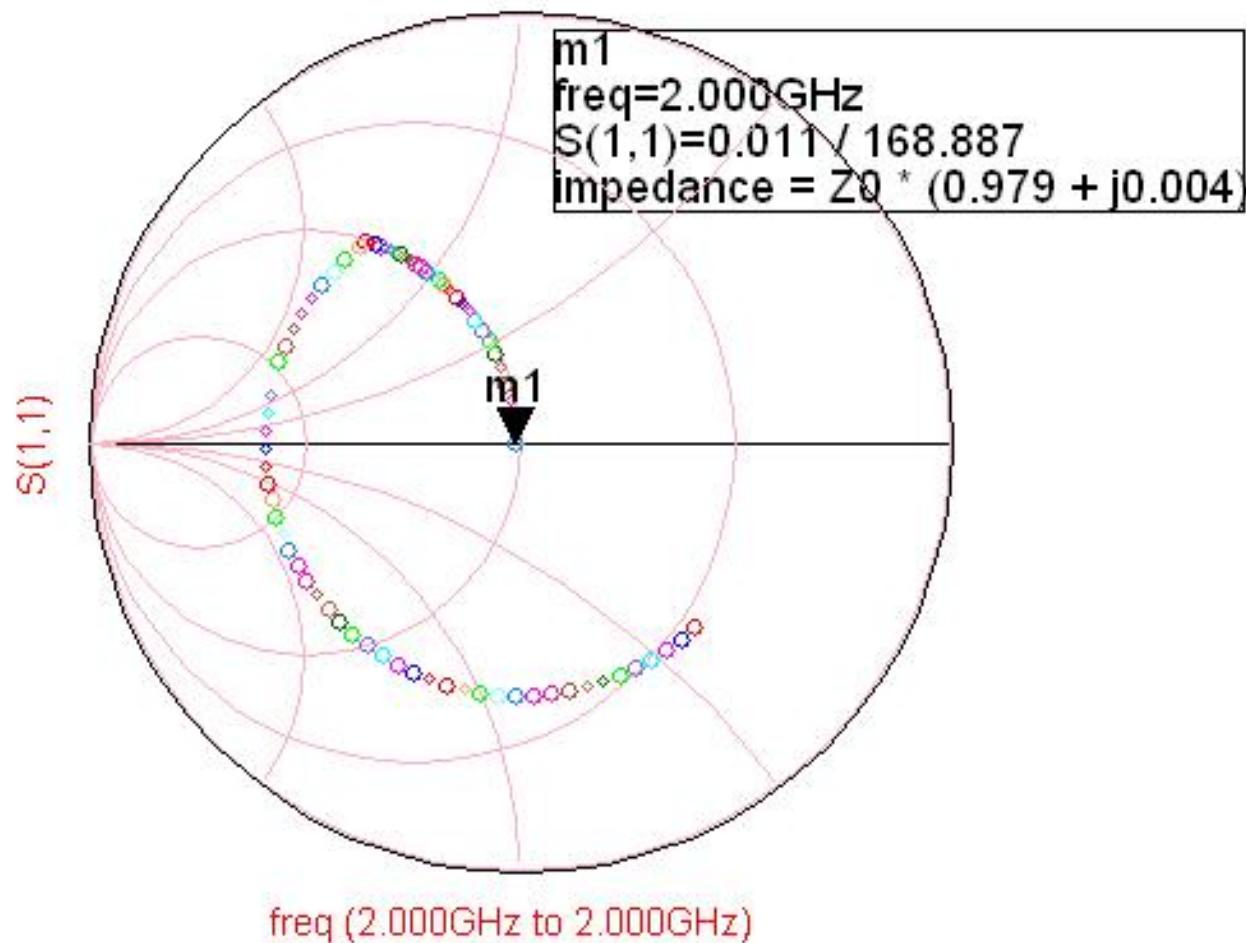
# Adaptare, linie serie + susceptanta in paralel



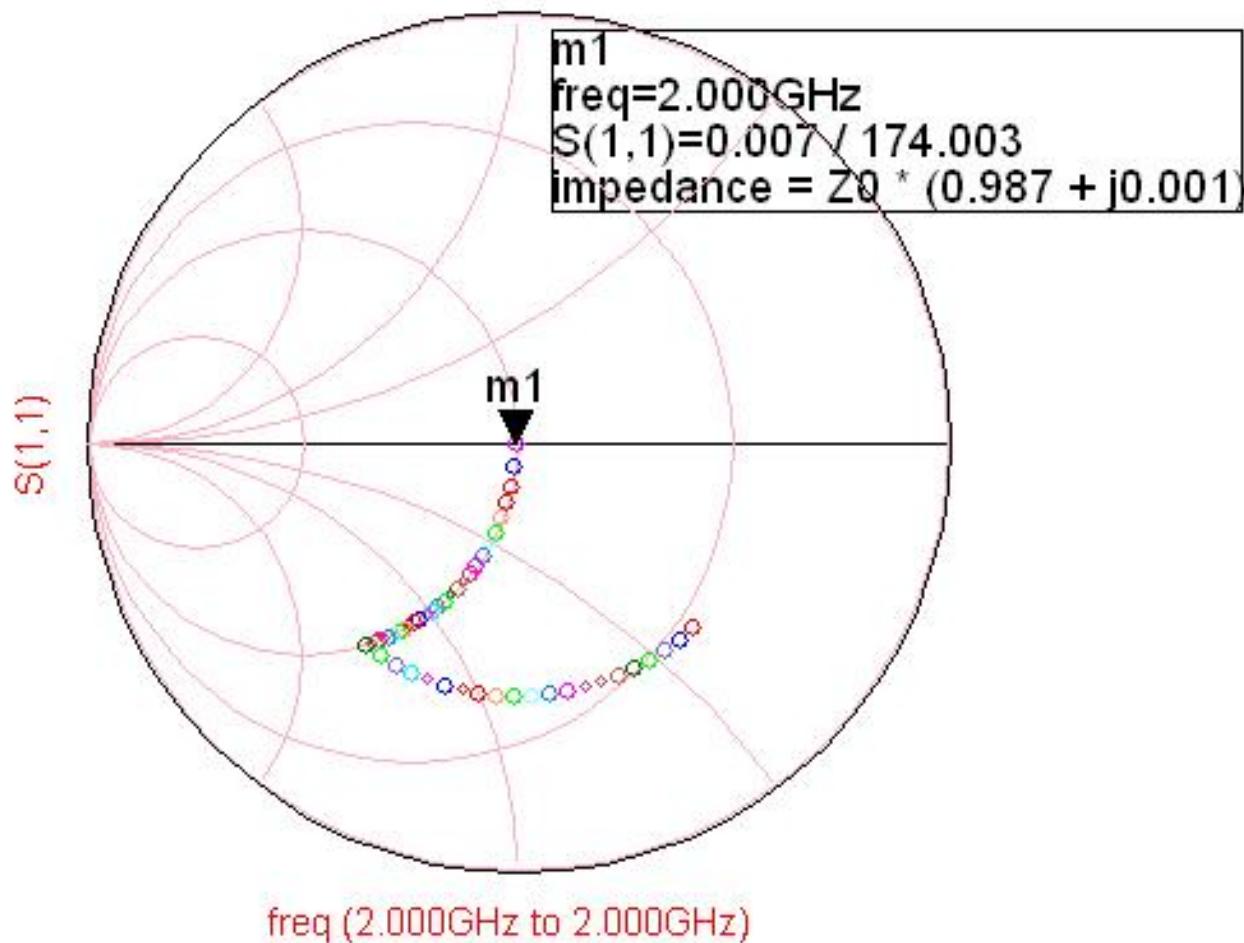
$$|\Gamma_{in}| = |\Gamma_L|$$

$$g_{in} = 1$$

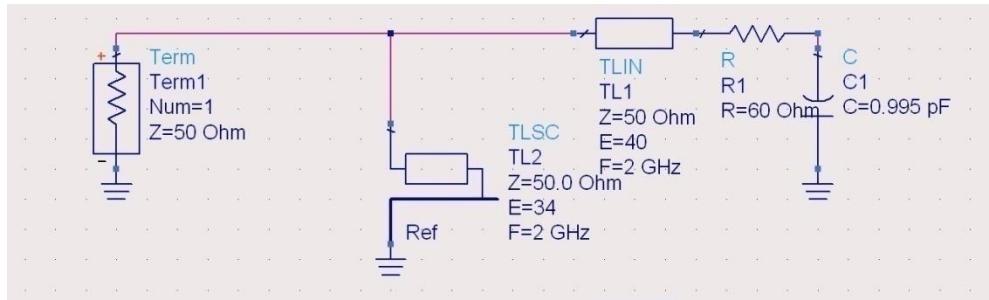
# Exemplu, Shunt Stub, sc



# Exemplu, Shunt Stub, sc



# Exemplu, Shunt Stub, sc

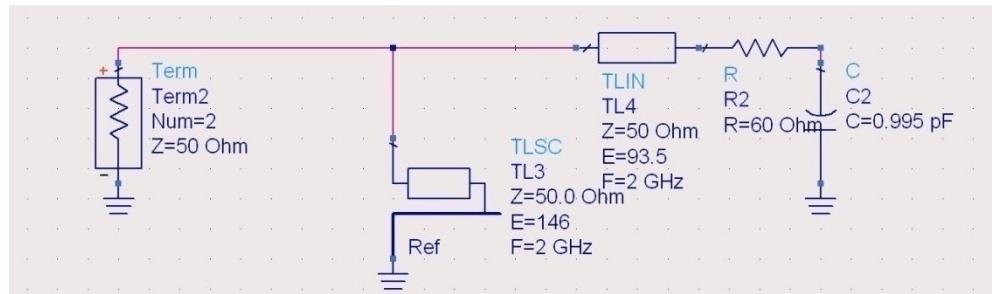


$$l_1 = \frac{40^\circ}{360^\circ} \cdot \lambda = 0.111 \cdot \lambda$$

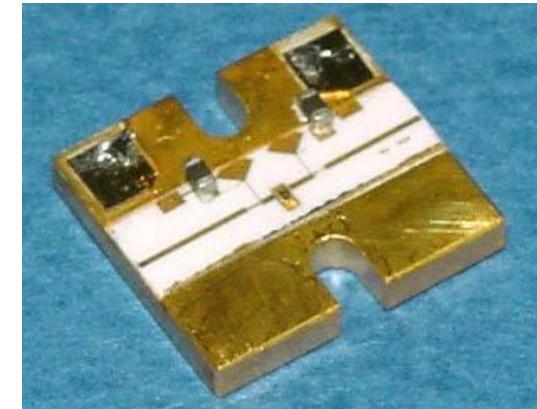
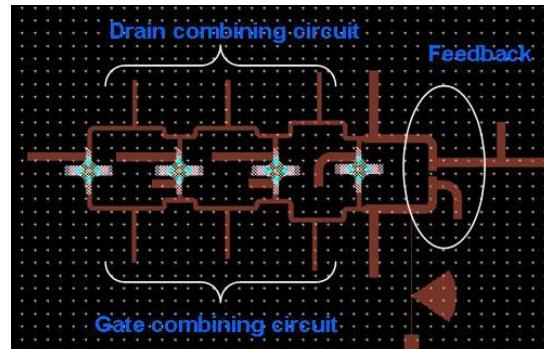
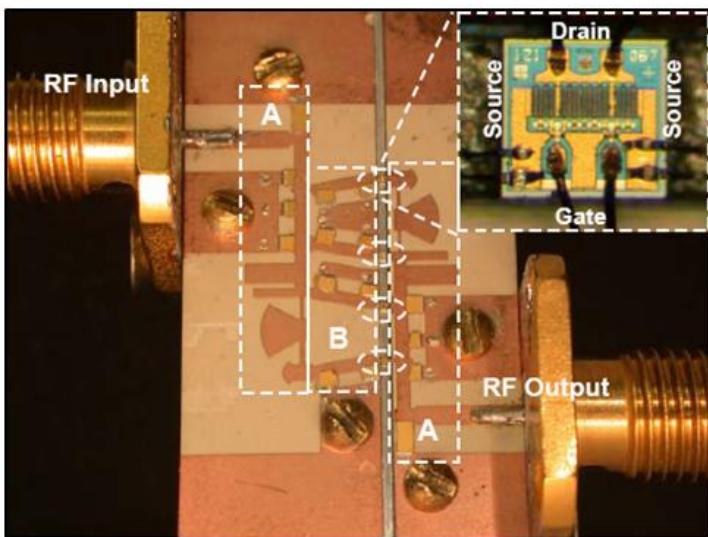
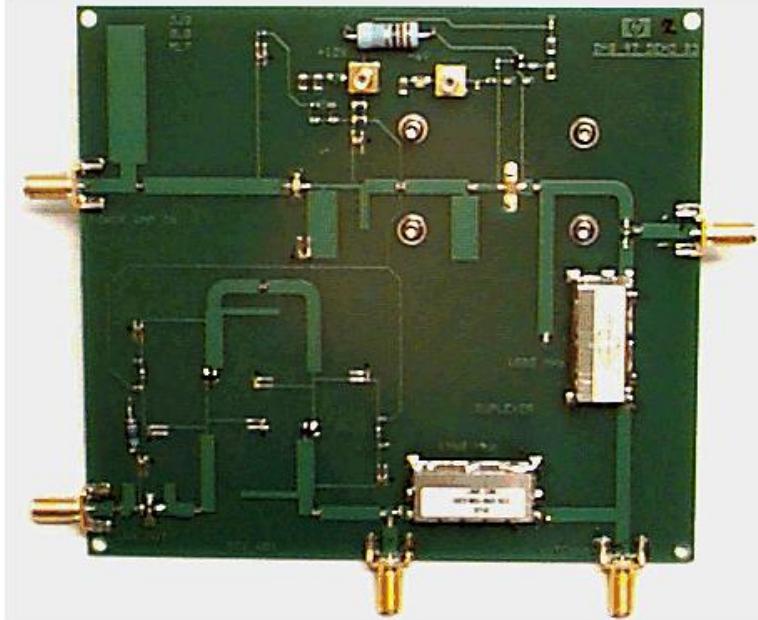
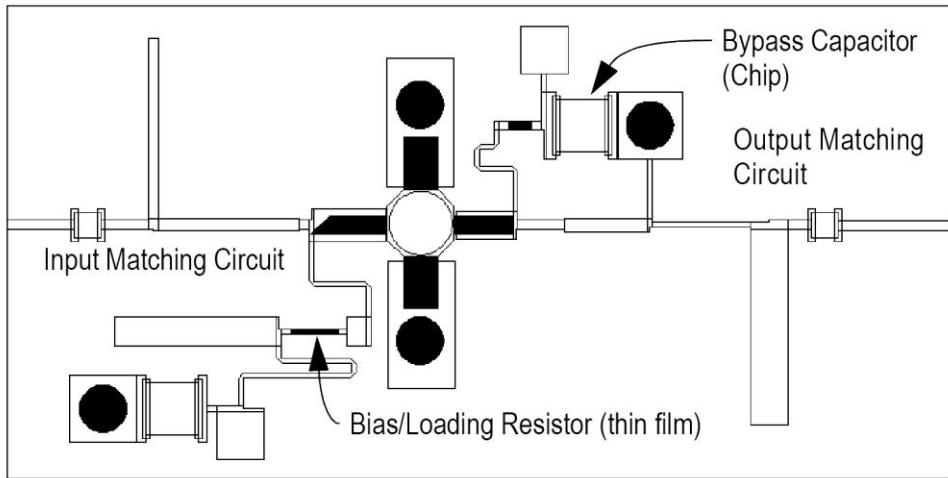
$$l_2 = \frac{34^\circ}{360^\circ} \cdot \lambda = 0.094 \cdot \lambda$$

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

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

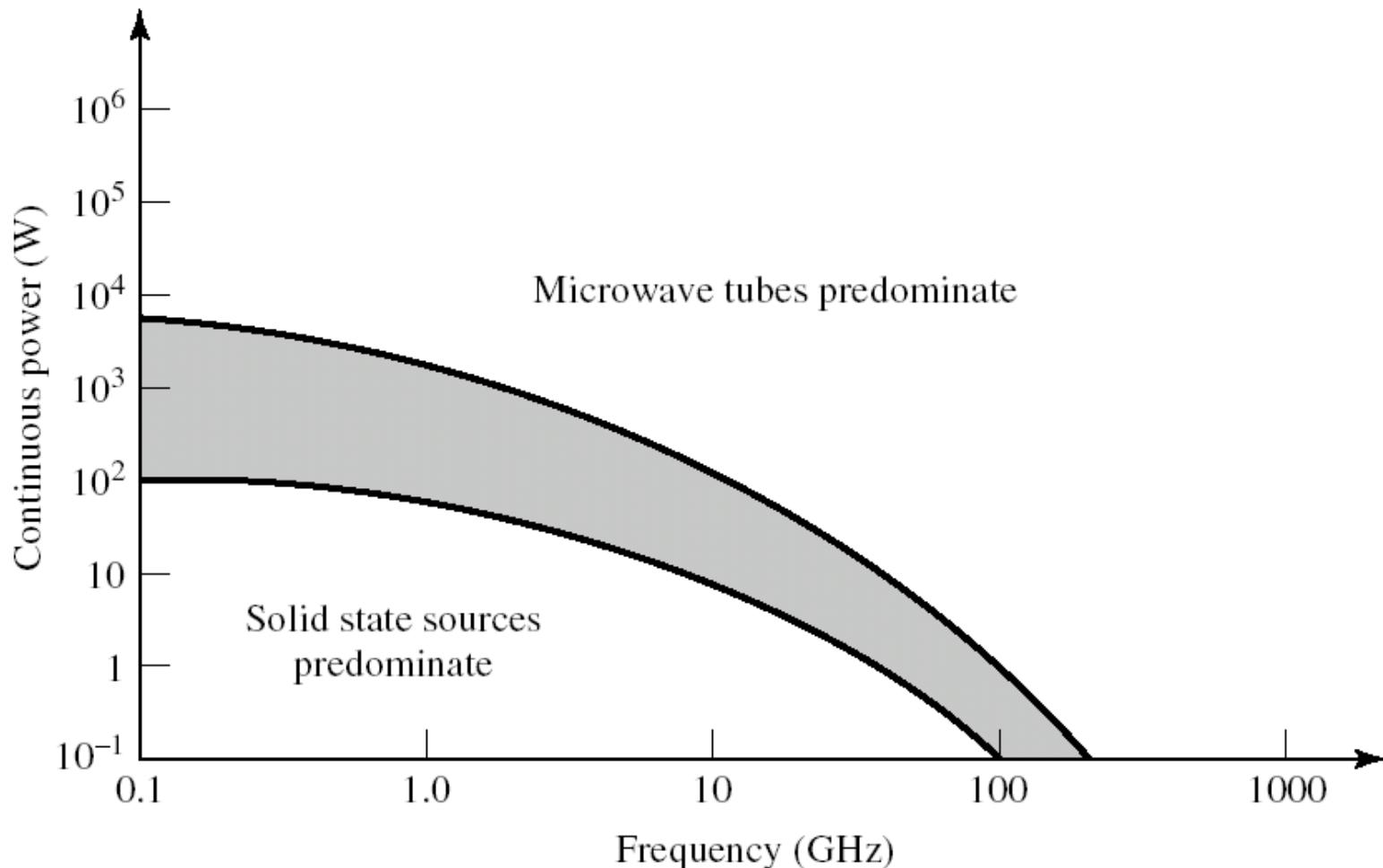


# Adaptarea cu sectiuni de linie

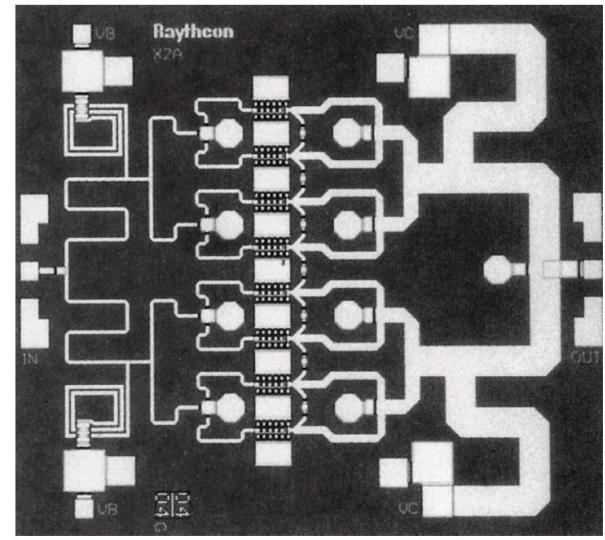
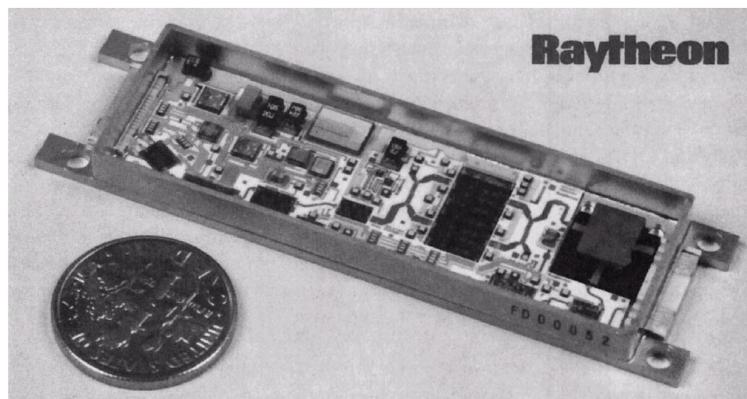
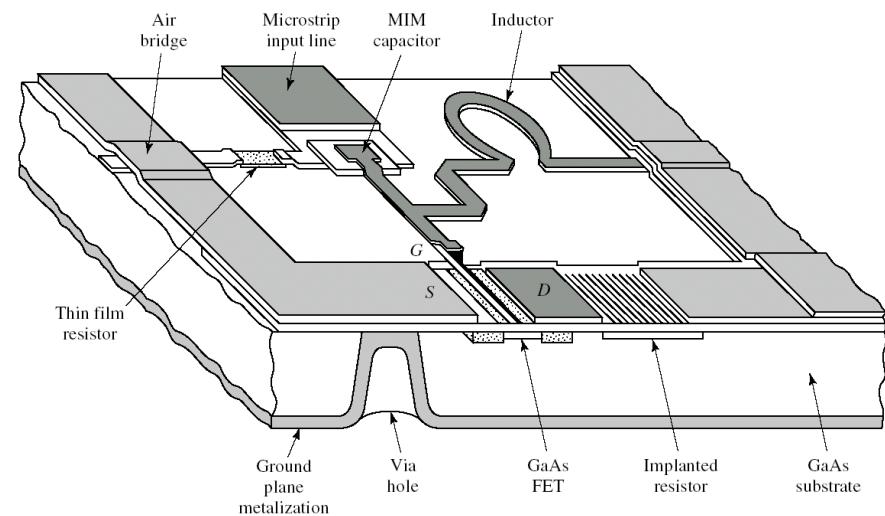
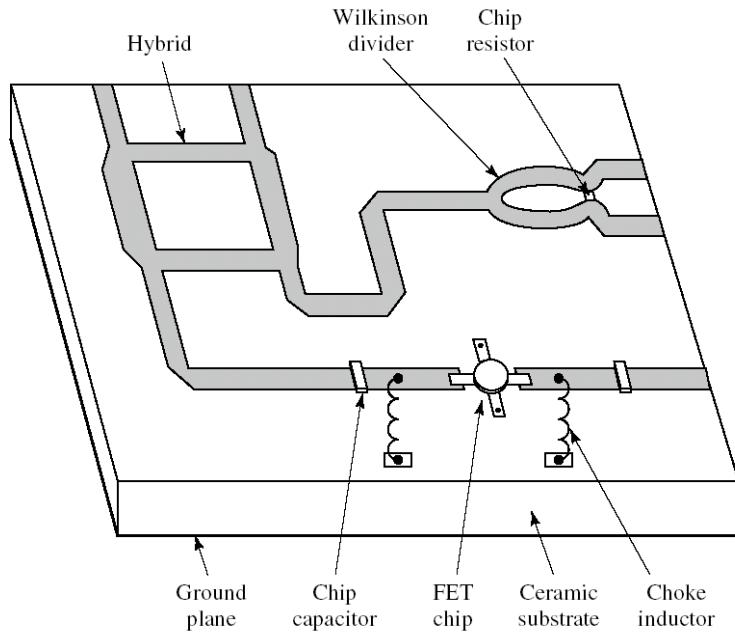


# **Amplificatoare de microunde**

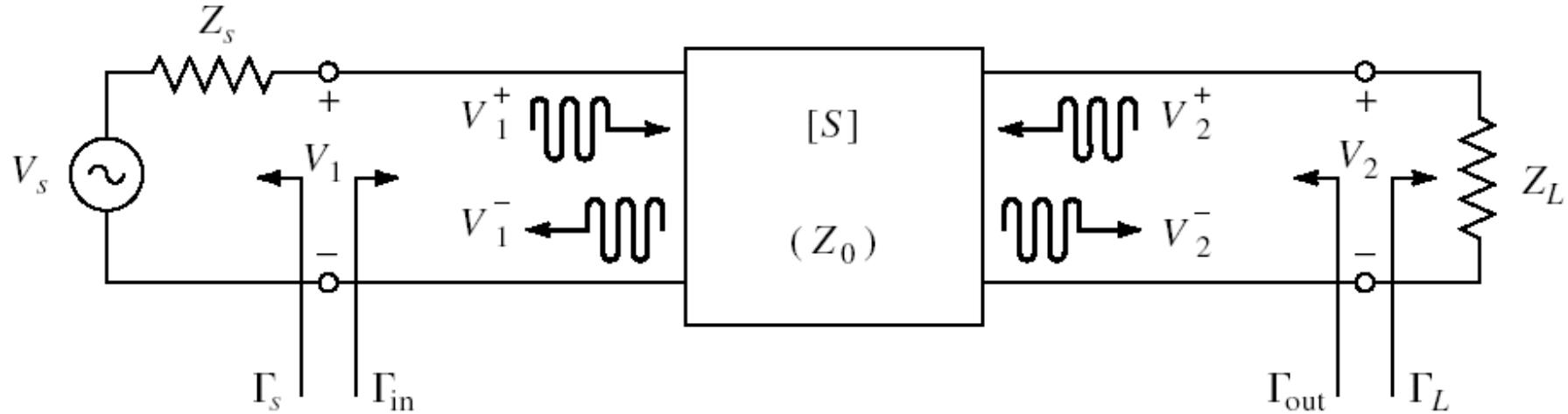
# Amplificatoare pentru microunde



# Circuite integrate pentru microunde



# Cuadripol Amplificator (diport)



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

# 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**

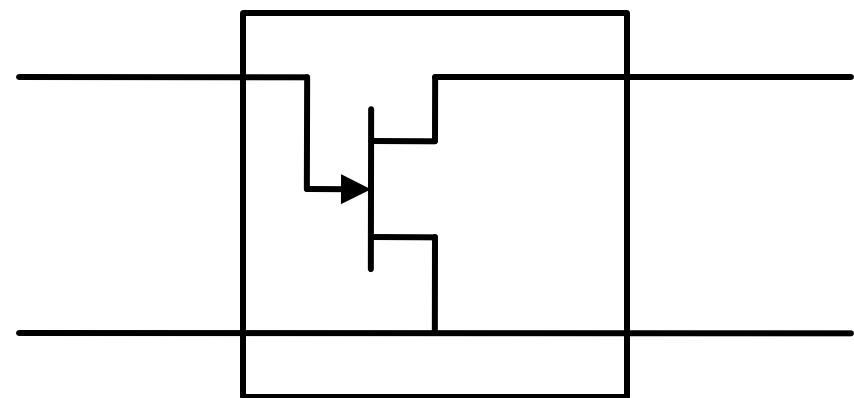
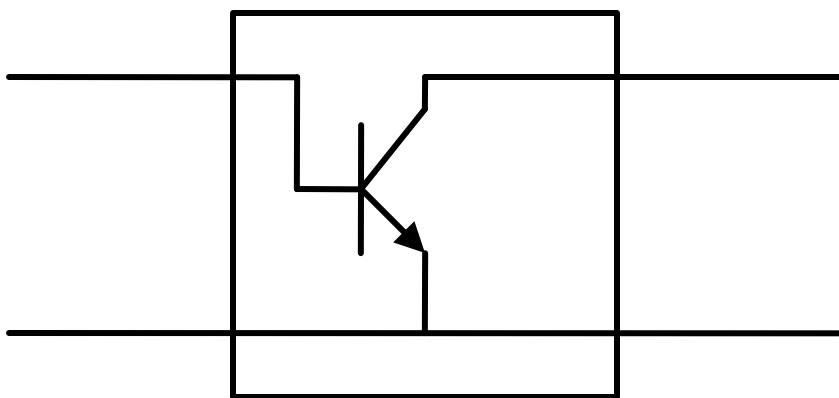
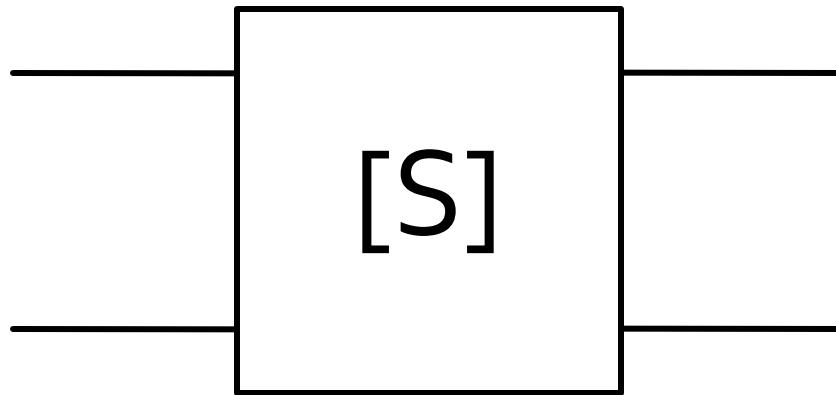
100	0.778	-144	27.669	111	0.027	35	0.523	-114	0.27	30.2
200	0.820	-164	14.559	97	0.029	29	0.445	-144	0.42	27.0
500	0.832	-179	5.885	84	0.035	38	0.435	-166	0.81	22.2
800	0.833	175	3.691	76	0.048	45	0.435	-173	0.95	18.8
1000	0.831	172	2.980	71	0.056	51	0.437	-176	1.05	16.0
1200	0.836	169	2.464	67	0.061	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

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

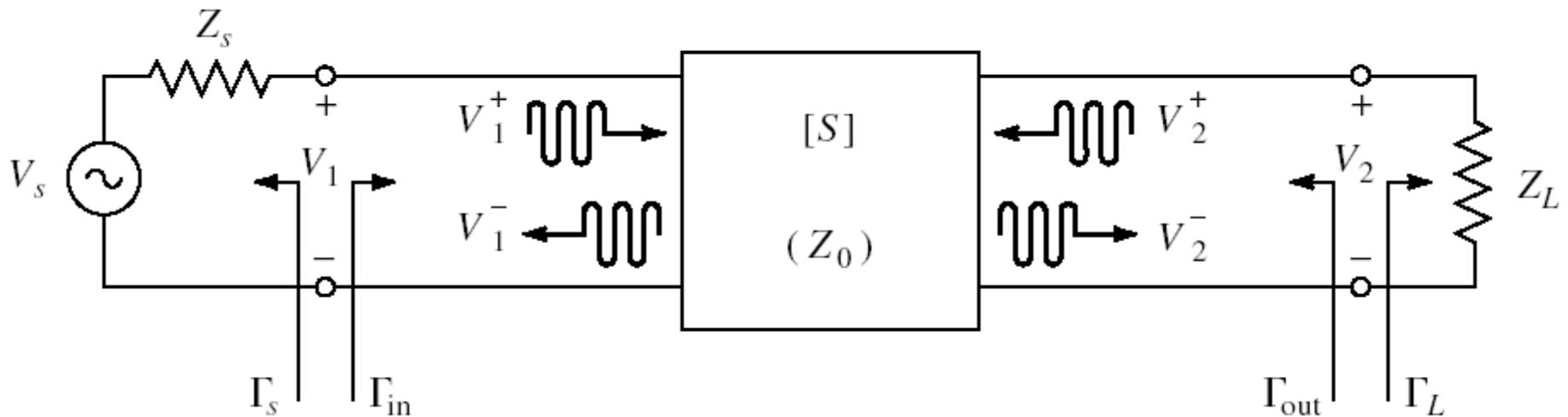
- Fisiere format Touchstone (\*.s2p)

```
! 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



# Dipole amplifier



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

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

# 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**

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

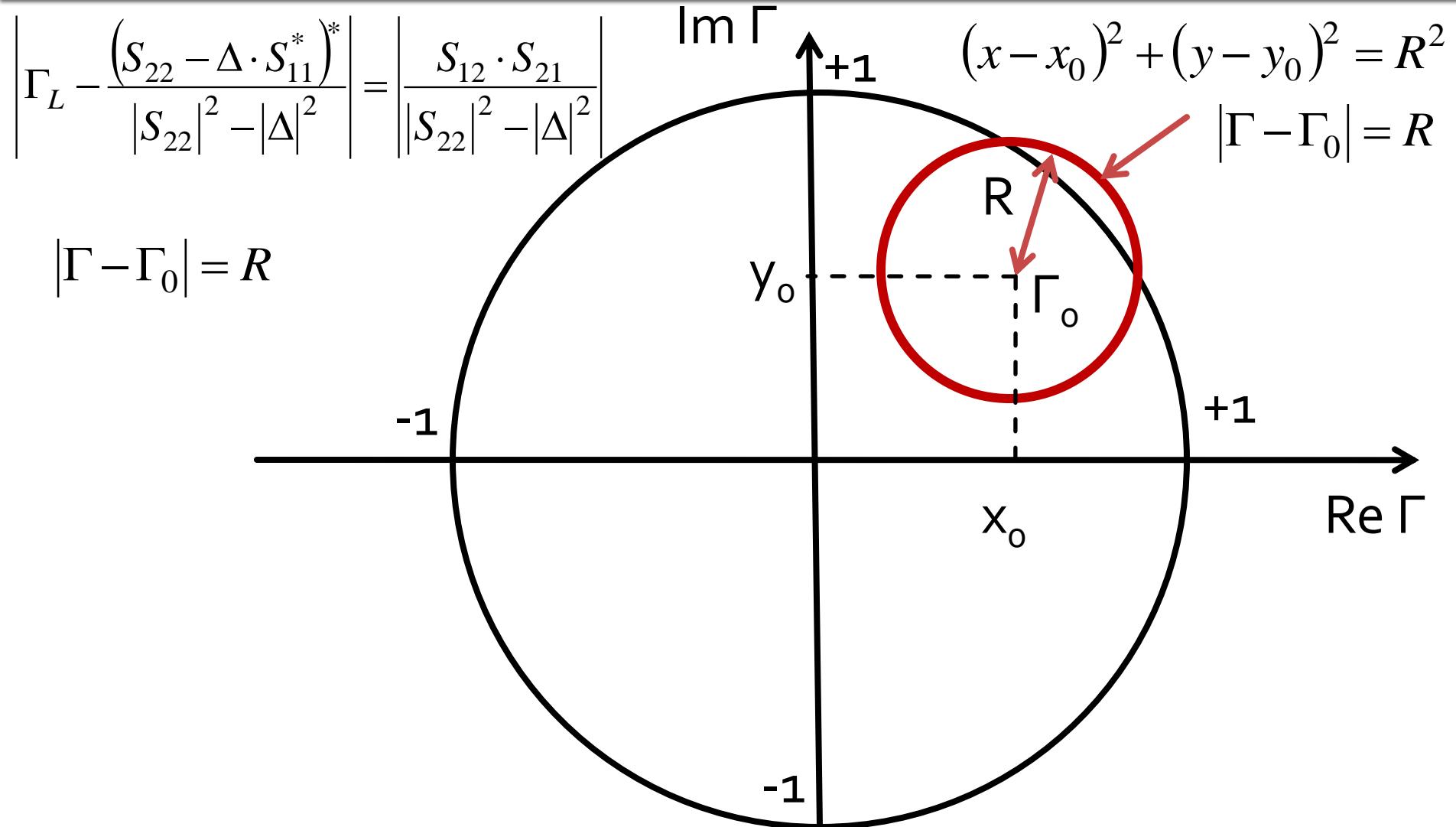
$$S_{12} \cong 0 \quad \Gamma_{in} = S_{11}$$

Permite tratarea separata  
a intrarii si iesirii

# Stabilitate

- C4       $\Gamma = \Gamma_r + j \cdot \Gamma_i$        $r_L = \frac{1 - \Gamma_r^2 - \Gamma_i^2}{(1 - \Gamma_r)^2 + \Gamma_i^2}$   
 $Z_{in}$        $\Gamma_{in} = \Gamma_r + j \cdot \Gamma_i$
- instabilitate  
 $\text{Re}\{Z_{in}\} < 0 \Leftrightarrow 1 - \Gamma_r^2 - \Gamma_i^2 < 0 \quad |\Gamma_{in}| > 1$
- 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)

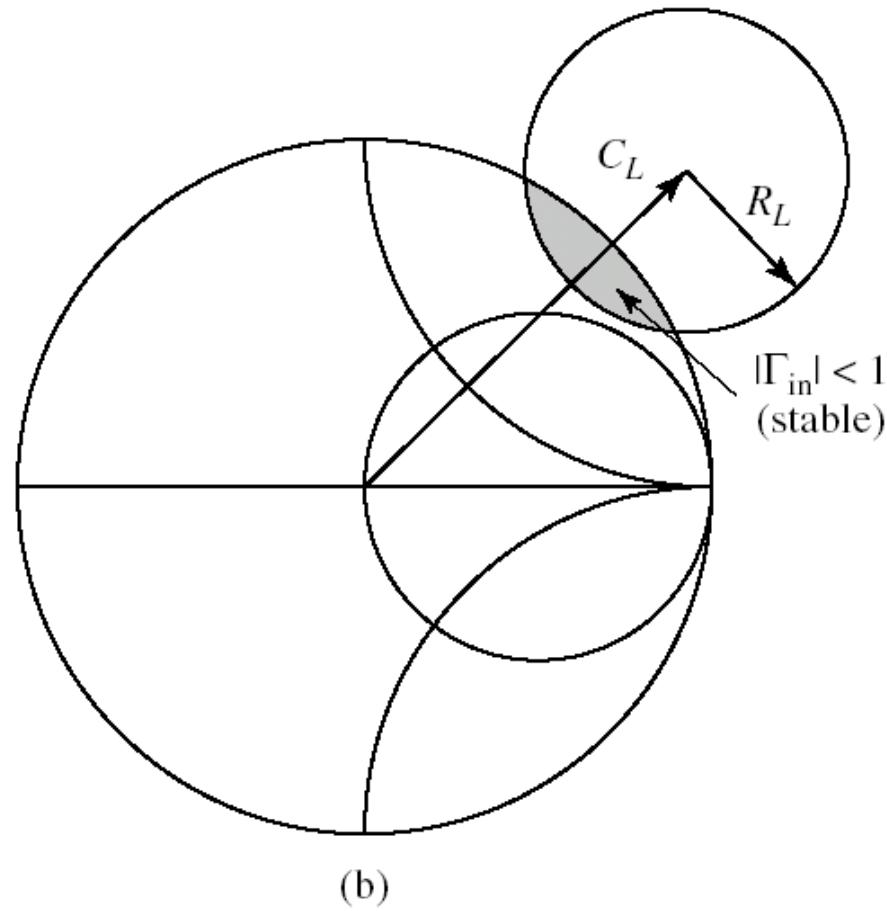
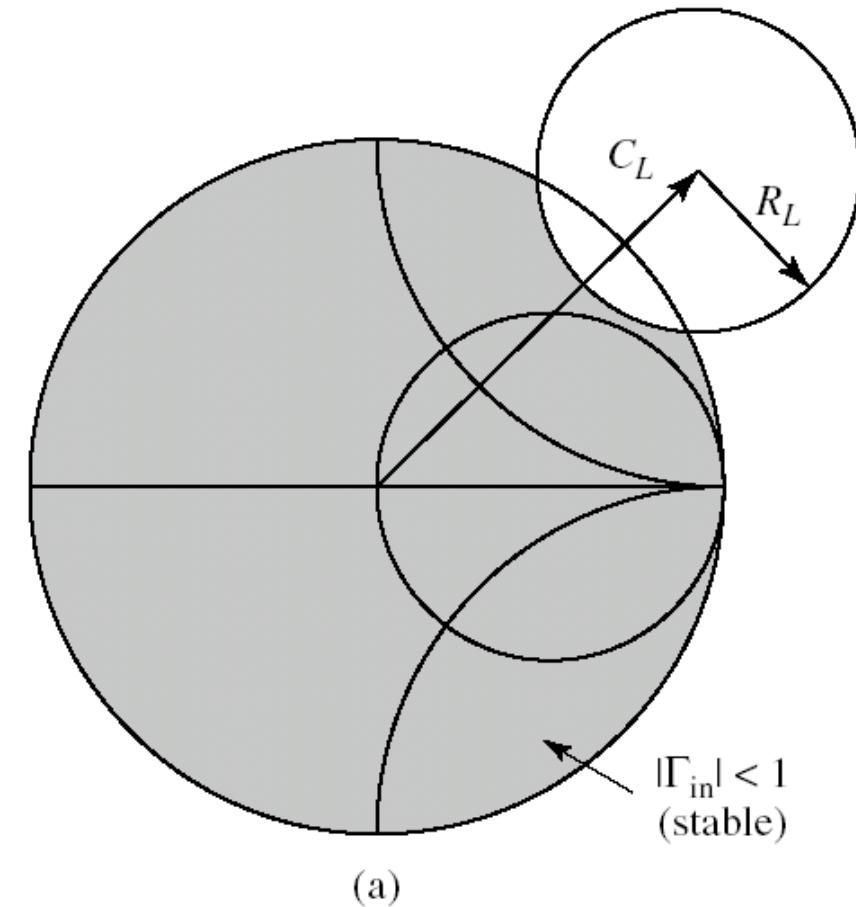
# Stabilitate



# Cerc de stabilitate la ieșire

- **Cercul de stabilitate la ieșire** reprezinta locul geometric al punctelor  $\Gamma_L$  pentru **limita** de stabilitate ( $|\Gamma_{in}|=1$ )
- Cercul imparte planul complex in doua suprafete, **interiorul** si **exteriorul** cercului
- Cele doua suprafete vor reprezenta zonele  $\Gamma_L$  de stabilitate ( $|\Gamma_{in}|<1$ ) / instabilitate ( $|\Gamma_{in}|>1$ )

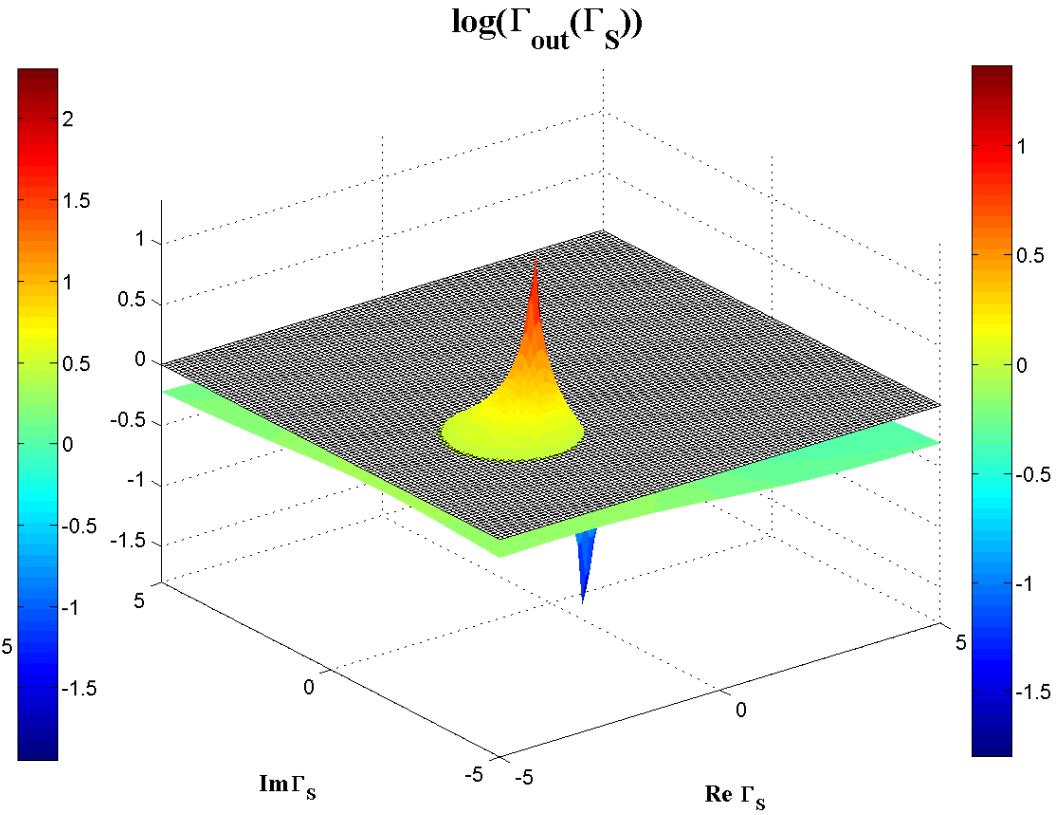
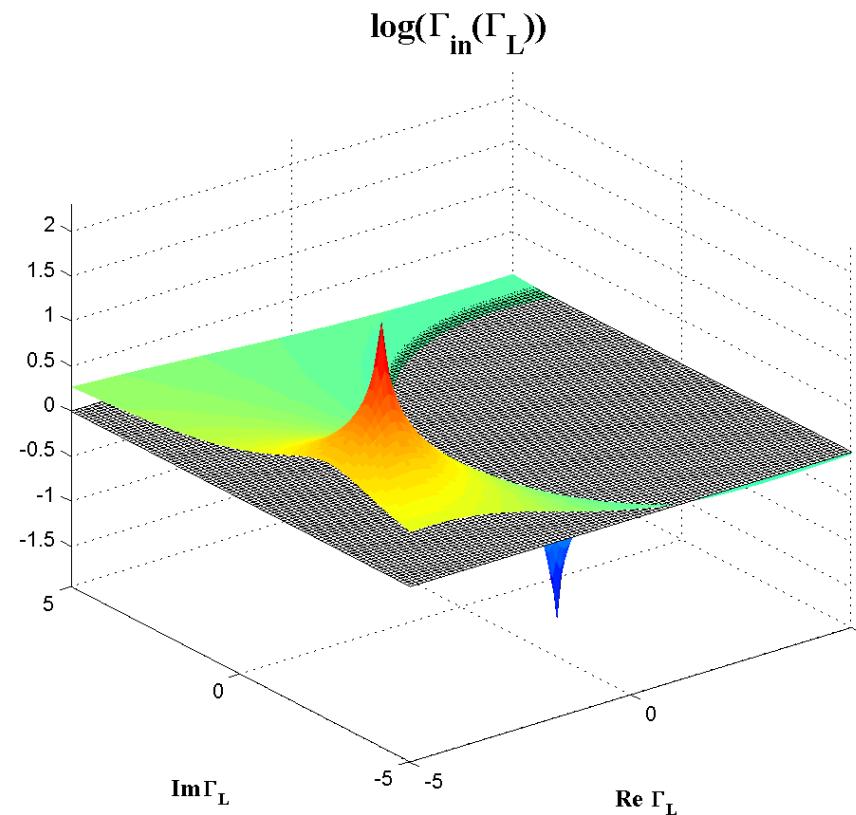
# Cerc de stabilitate la ieșire



- Doua cazuri: (a) exterior stabil / (b) interior stabil

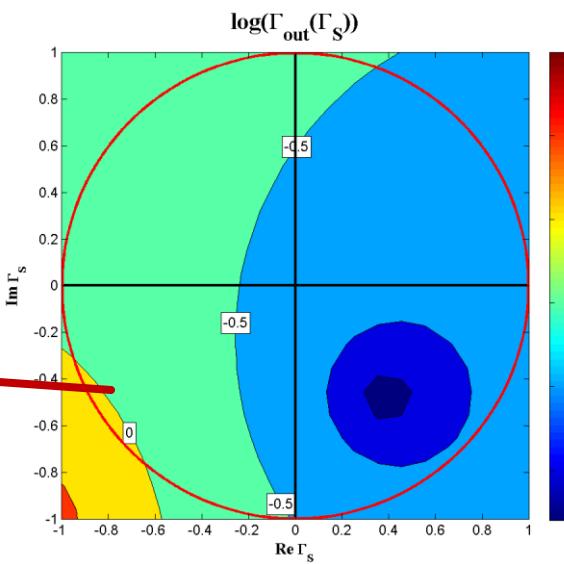
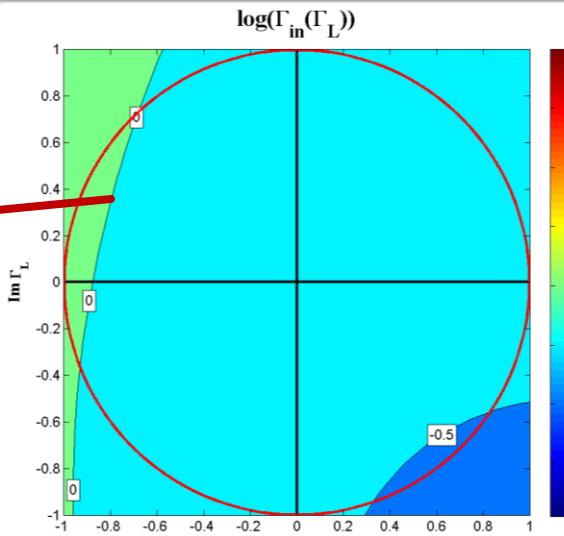
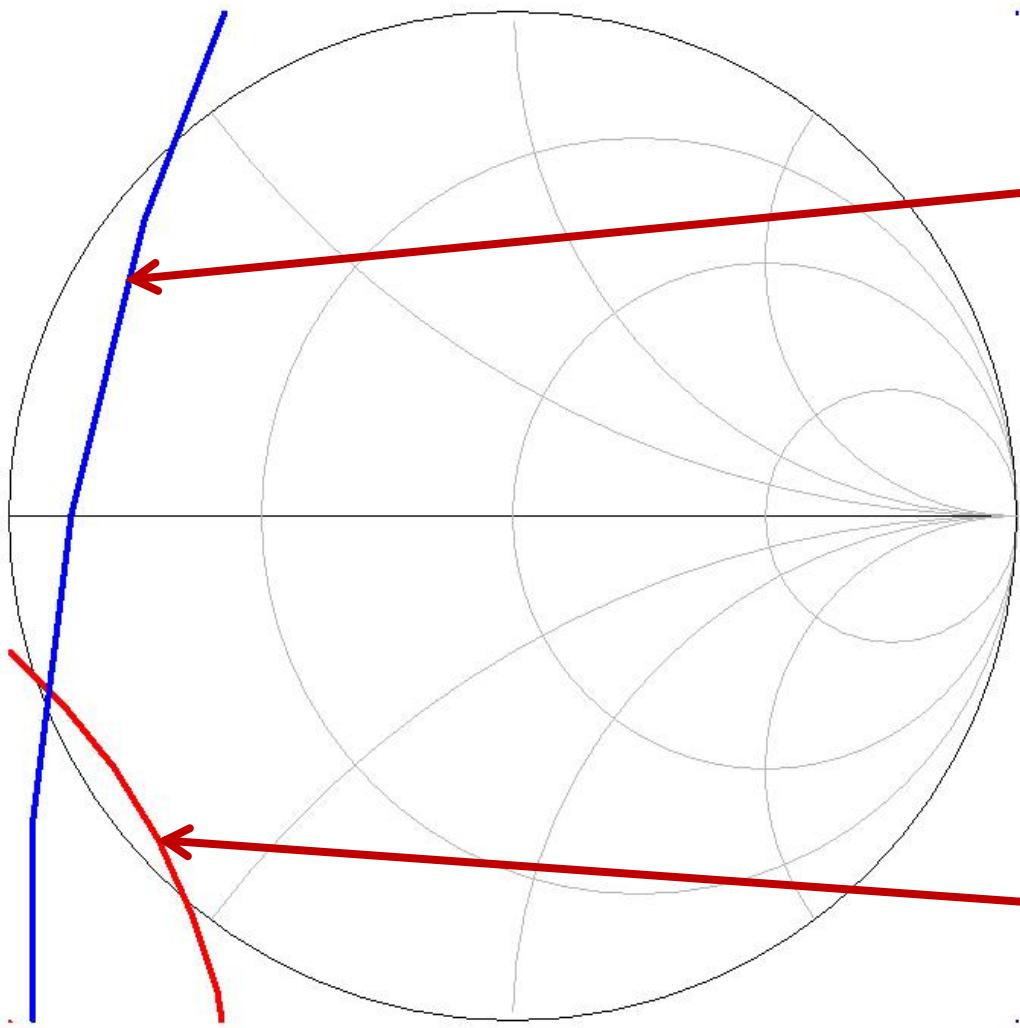
# Reprezentare 3D $|\Gamma_{\text{in}}|, |\Gamma_{\text{out}}|, |\Gamma|=1$

- $|\Gamma| = 1 \rightarrow \log_{10}|\Gamma| = 0$ , intersectia = cerc



# CSIN, CSOUT

CSOUT  
CSIN



**Continuare**

# Cerc de stabilitate la ieșire

- Identificarea zonelor de stabilitate / instabilitate
  - Centrul diagramei Smith: in coordonate polare corespunde lui  $\Gamma_L = 0$
  - Coeficientul de reflexie la intrare

$$\Gamma_{in} = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L} \quad \left. \Gamma_{in} \right|_{\Gamma_L=0} = S_{11} \quad \left| \Gamma_{in} \right|_{\Gamma_L=0} = |S_{11}|$$

- Decizia se poate lua in functie de valoarea pe care o are  $|S_{11}|$  si de pozitia centrului diagramei Smith fata de cercul de stabilitate

# Identificarea zonelor

- Cerc de stabilitate la iesire
  - $|S_{11}| < 1 \rightarrow$  centrul diagramei pe care se reprezinta  $\Gamma_L$  este punct **stabil**, se gaseste in zona stabila (cel mai des)
  - $|S_{11}| > 1 \rightarrow$  centrul diagramei pe care se reprezinta  $\Gamma_L$  este punct **instabil**, se gaseste in zona instabila
- Cerc de stabilitate la intrare
  - $|S_{22}| < 1 \rightarrow$  centrul diagramei pe care se reprezinta  $\Gamma_S$  este punct **stabil**, se gaseste in zona stabila (cel mai des)
  - $|S_{22}| > 1 \rightarrow$  centrul diagramei pe care se reprezinta  $\Gamma_S$  este punct **instabil**, se gaseste in zona instabila

# Exemplu

- ATF-34143 at  $V_{ds}=3V$   $I_d=20mA$ .

- @5GHz

- $S_{11} = 0.64 \angle 139^\circ$
- $S_{12} = 0.119 \angle -21^\circ$
- $S_{21} = 3.165 \angle 16^\circ$
- $S_{22} = 0.22 \angle 146^\circ$



```
!ATF-34143
IS-PARAMETERS at Vds=3V Id=20mA. LAST UPDATED 01-29-99
```

```
# ghz s ma r 50
```

```
2.0 0.75 -126 6.306 90 0.088 23 0.26 -120
2.5 0.72 -145 5.438 75 0.095 15 0.25 -140
3.0 0.69 -162 4.762 62 0.102 7 0.23 -156
4.0 0.65 166 3.806 38 0.111 -8 0.22 174
5.0 0.64 139 3.165 16 0.119 -21 0.22 146
6.0 0.65 114 2.706 -5 0.125 -35 0.23 118
7.0 0.66 89 2.326 -27 0.129 -49 0.25 91
8.0 0.69 67 2.017 -47 0.133 -62 0.29 67
9.0 0.72 48 1.758 -66 0.135 -75 0.34 46
```

```
!FREQ Fopt GAMMA OPT RN/Zo
!GHZ dB MAG ANG -
```

```
2.0 0.19 0.71 66 0.09
2.5 0.23 0.65 83 0.07
3.0 0.29 0.59 102 0.06
4.0 0.42 0.51 138 0.03
5.0 0.54 0.45 174 0.03
6.0 0.67 0.42 -151 0.05
7.0 0.79 0.42 -118 0.10
8.0 0.92 0.45 -88 0.18
9.0 1.04 0.51 -63 0.30
10.0 1.16 0.61 -43 0.46
```

# Calcul

## ■ Parametri S

- $S_{11} = -0.483 + 0.42 \cdot j$
- $S_{12} = 0.111 - 0.043 \cdot j$
- $S_{21} = 3.042 + 0.872 \cdot j$
- $S_{22} = -0.182 + 0.123 \cdot j$

$$C_L = \frac{(S_{22} - \Delta \cdot S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = 3.931 - 0.897 \cdot j$$

$$|C_L| = 4.032$$

$$R_L = \frac{|S_{12} \cdot S_{21}|}{|S_{22}|^2 - |\Delta|^2} = 4.891$$

$$C_S = \frac{(S_{11} - \Delta \cdot S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = -1.871 - 1.265 \cdot j$$

$$|S_{11}| < 1$$

$$|S_{22}| < 1$$

$$|C_L| < R_L \text{ o } \in CSOUT \quad |C_S| = 2.259$$

$$|C_S| > R_S \text{ o } \notin CSIN$$

$$R_S = \frac{|S_{12} \cdot S_{21}|}{|S_{11}|^2 - |\Delta|^2} = 1.325$$

# Stabilitate

- **Stabilitatea necondiționată:** circuitul este necondiționat stabil dacă  $|\Gamma_{in}| < 1$  și  $|\Gamma_{out}| < 1$  pentru **orice** impedanță pasivă a sarcinii și sursei
- **Stabilitatea condiționată:** circuitul este condiționat stabil dacă  $|\Gamma_{in}| < 1$  și  $|\Gamma_{out}| < 1$  doar pentru un anumit interval de valori pentru impedanța pasivă a sarcinii și sursei

# Stabilitate neconditionata

- Stabilitatea neconditionata se obtine daca:
  - Cercul de stabilitate este disjunct cu diagrama Smith (exterior) si zona stabila e exteriorul cercului
  - Cercul de stabilitate contine in intregime diagrama Smith si zona stabila e interiorul cercului
- O conditie obligatorie pentru obtinerea stabilitatii neconditionate este  $|S_{11}| < 1$  (CSOUT) sau  $|S_{22}| < 1$  (CSIN)
- Matematic:

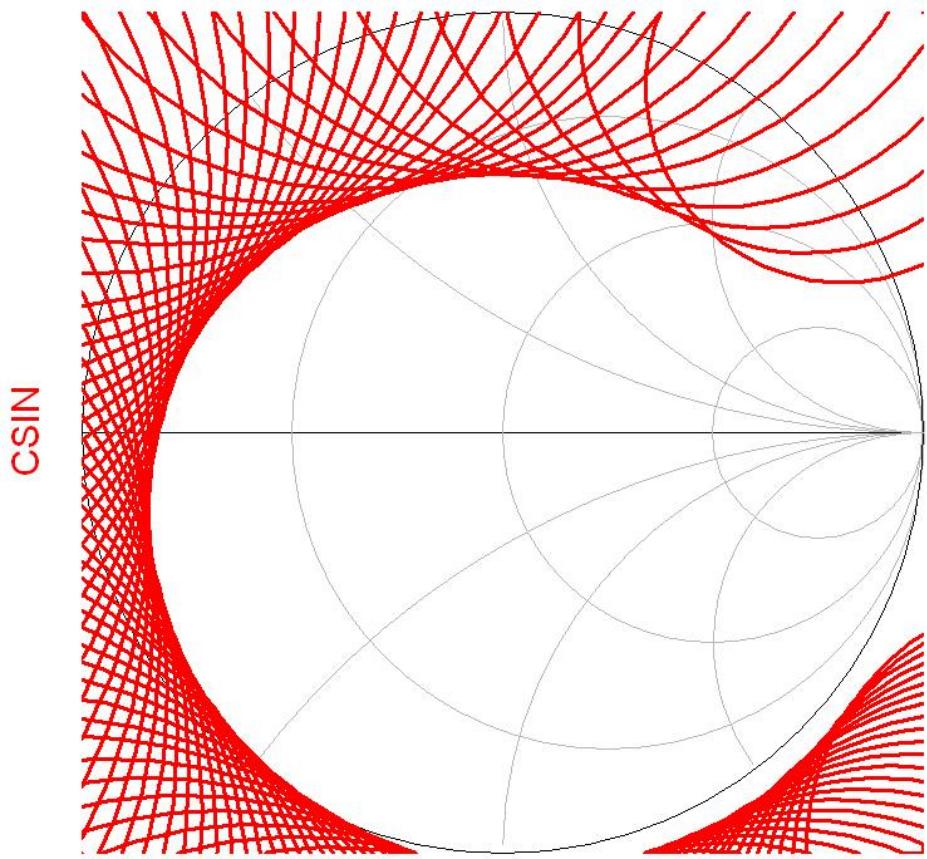
$$\begin{cases} |C_L - R_L| > 1 \\ |S_{11}| < 1 \end{cases}$$

$$\begin{cases} |C_S - R_S| > 1 \\ |S_{22}| < 1 \end{cases}$$

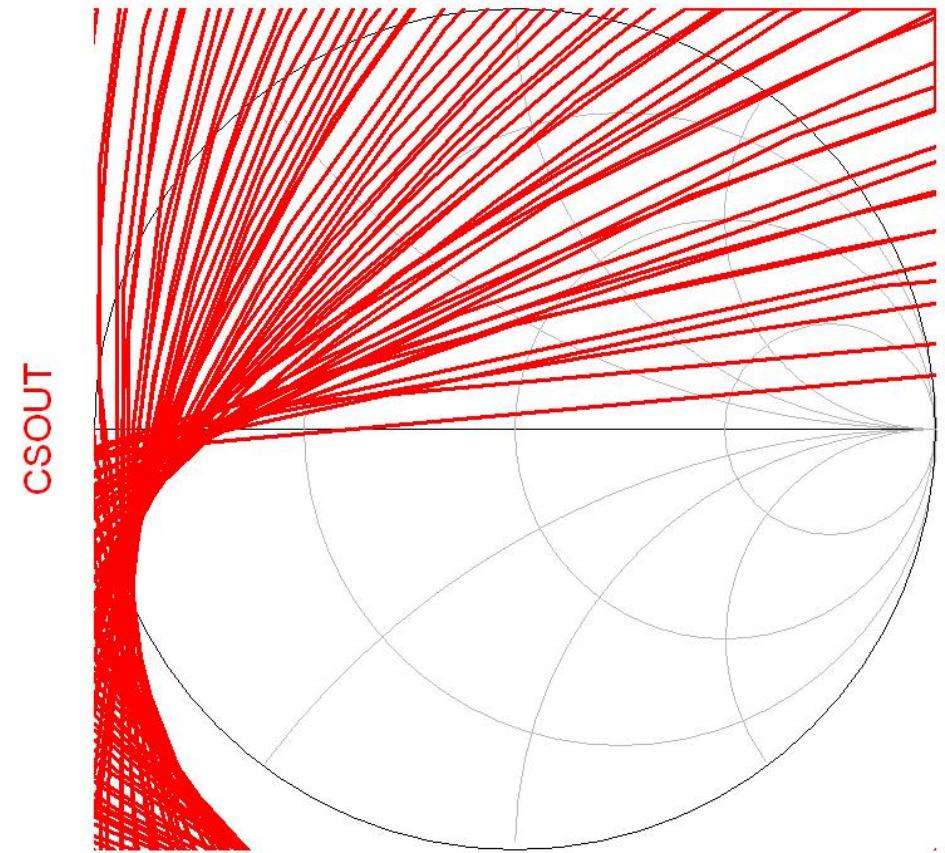
# Conditii analitice de stabilitate neconditionata

- Utile pentru analiza de banda larga
- Stabilitatea nu e suficient sa fie apreciata doar la frecventele de lucru
  - e necesar sa avem stabilitate pentru  $\Gamma_L$  si  $\Gamma_S$  alese la **orice** frecventa

# Cercuri in banda larga



indep(CSIN) (0.000 to 51.000)



indep(CSOUT) (0.000 to 51.000)

# Conditia Rollet

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 \cdot |S_{12} \cdot S_{21}|}$$
$$\Delta = S_{11} \cdot S_{22} - S_{12} \cdot S_{21}$$

- Diportul este **neconditionat stabil** daca:
  - Sunt indeplinite simultan conditiile
    - $K > 1$
    - $|\Delta| < 1$
  - Sunt valabile si conditiile implice
    - $|S_{11}| < 1$
    - $|S_{22}| < 1$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 \cdot |S_{12} \cdot S_{21}|} > 1$$
$$|\Delta| = |S_{11} \cdot S_{22} - S_{12} \cdot S_{21}| < 1$$

# Criteriul $\mu$

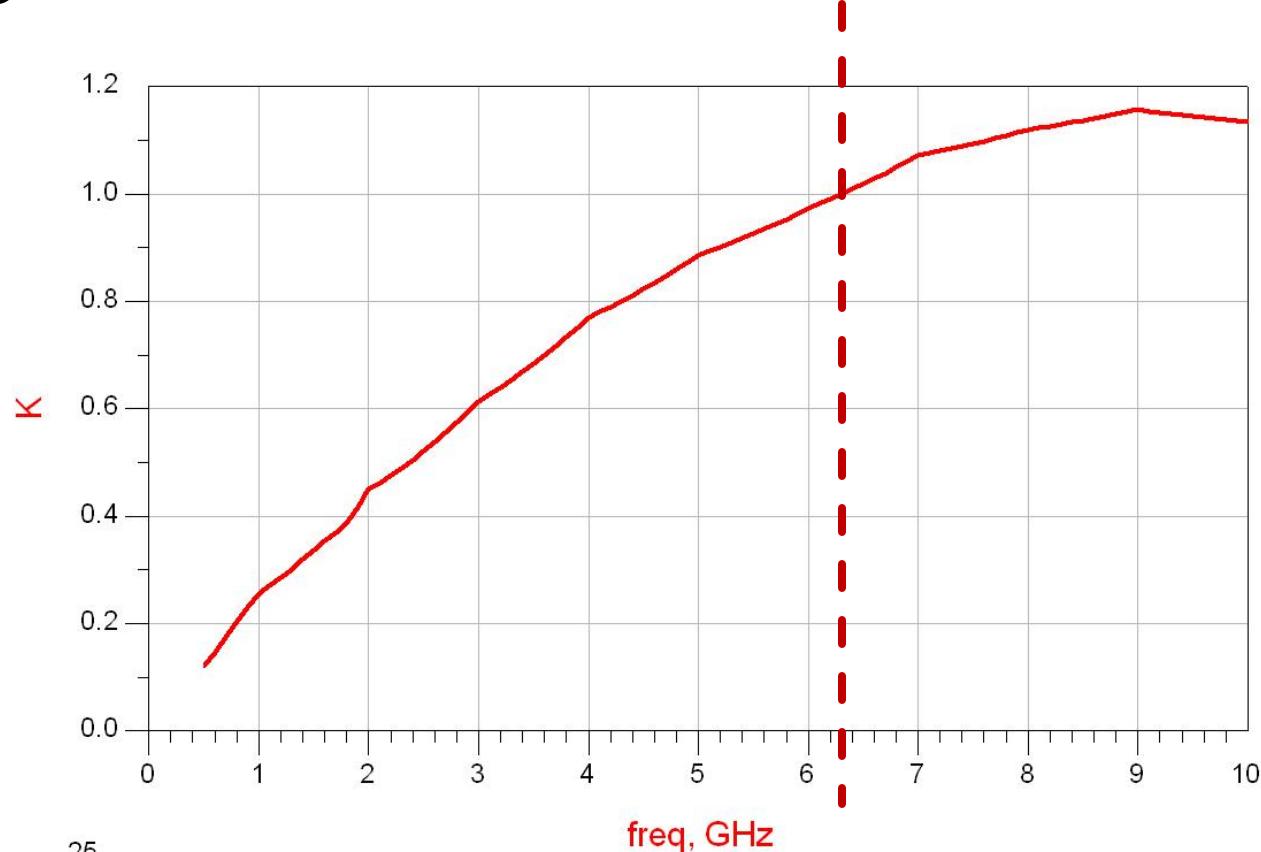
- Conditia Rollet depinde de doi parametri,  $K$  si  $\Delta$ , si nu poate fi utilizata pentru compararea stabilitatii a doua scheme

$$\mu = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta \cdot S_{11}^*| + |S_{12} \cdot S_{21}|} > 1$$

- Diportul este **neconditionat stabil** daca:
  - $\mu > 1$
- Sunt valabile si conditiile implicite
  - $|S_{11}| < 1$
  - $|S_{22}| < 1$
- In plus se poate spune ca daca  $\mu$  creste se obtine stabilitate mai buna

# Conditia Rollet

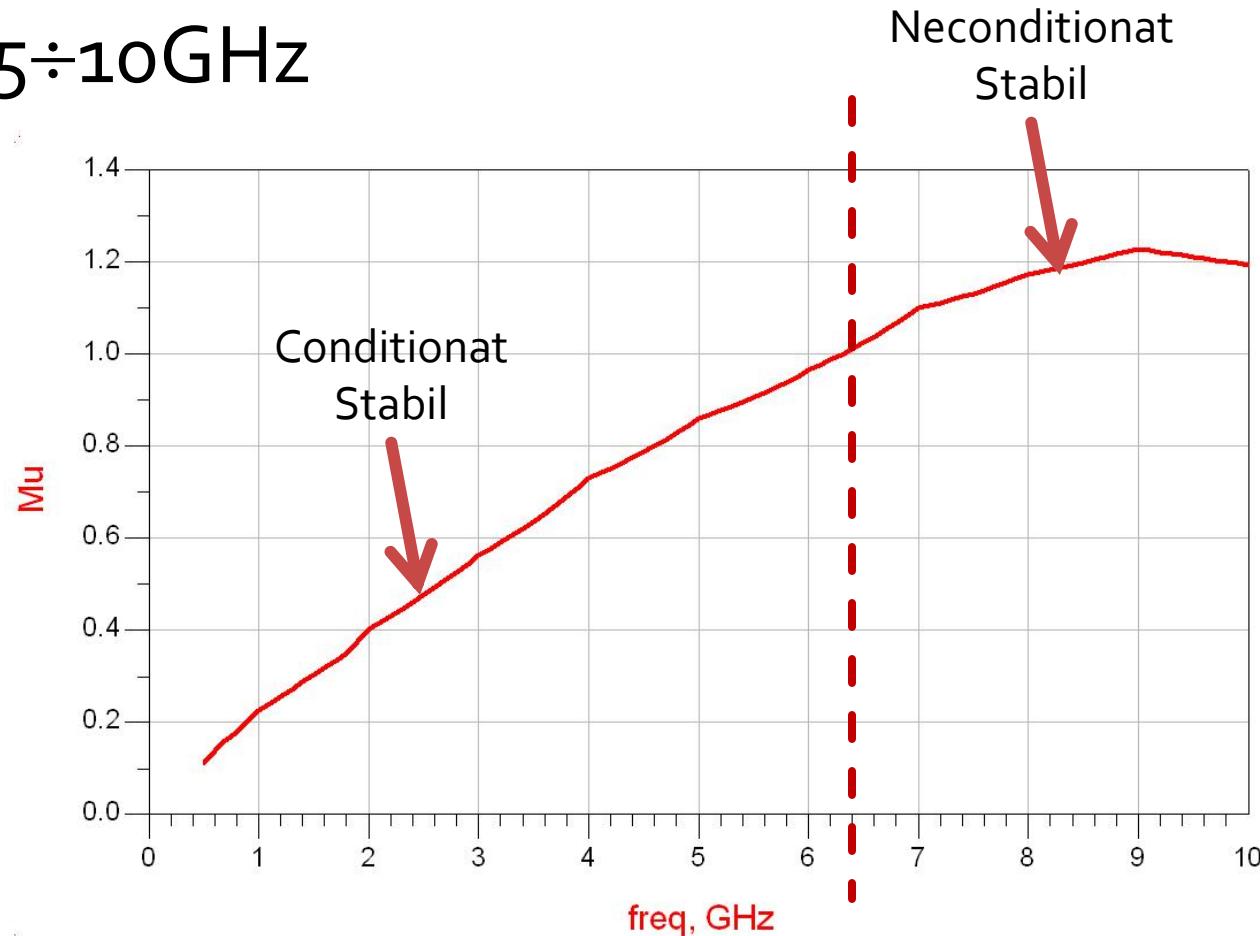
- ATF-34143 at  $V_{ds}=3V$   $I_d=20mA$ .
- @ $0.5 \div 10GHz$



# Criteriul $\mu$

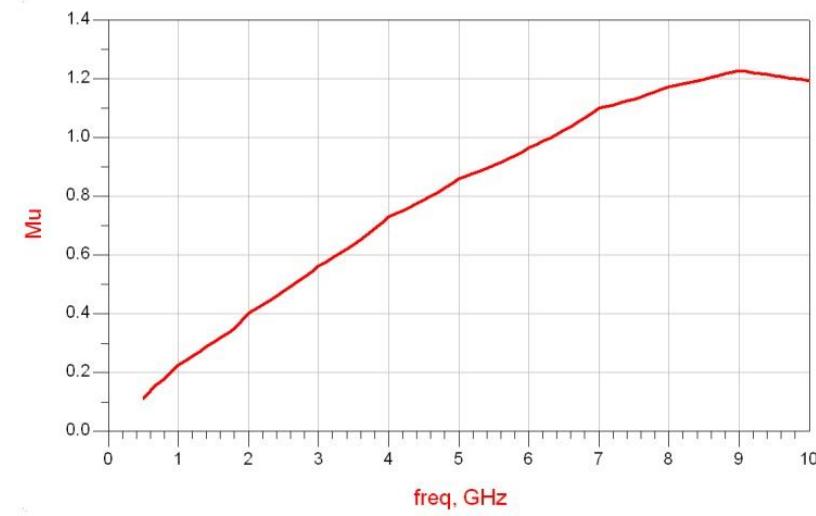
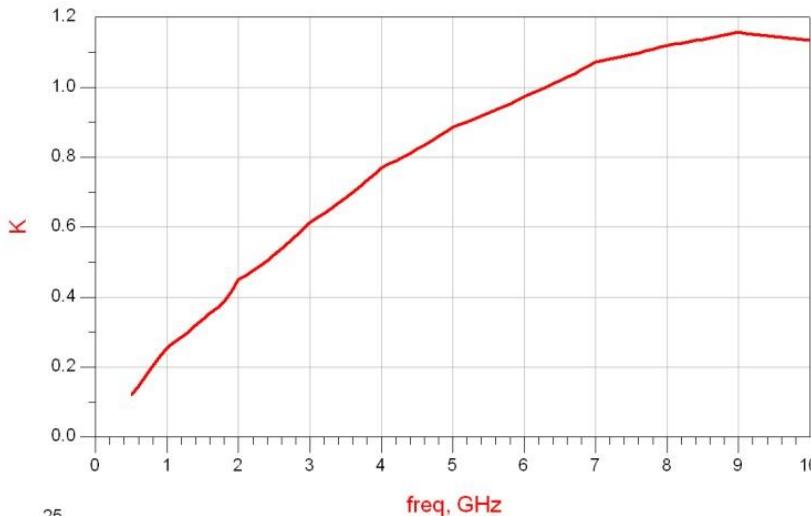
- ATF-34143 at  $V_{ds}=3V$   $I_d=20mA$ .

- @ $0.5 \div 10GHz$



# Stabilitate

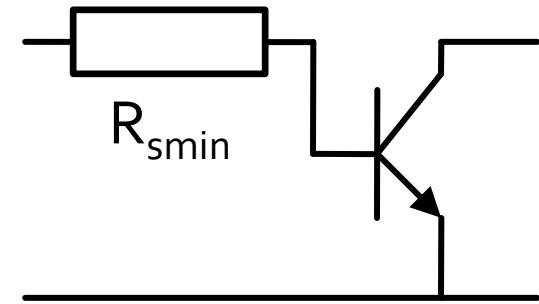
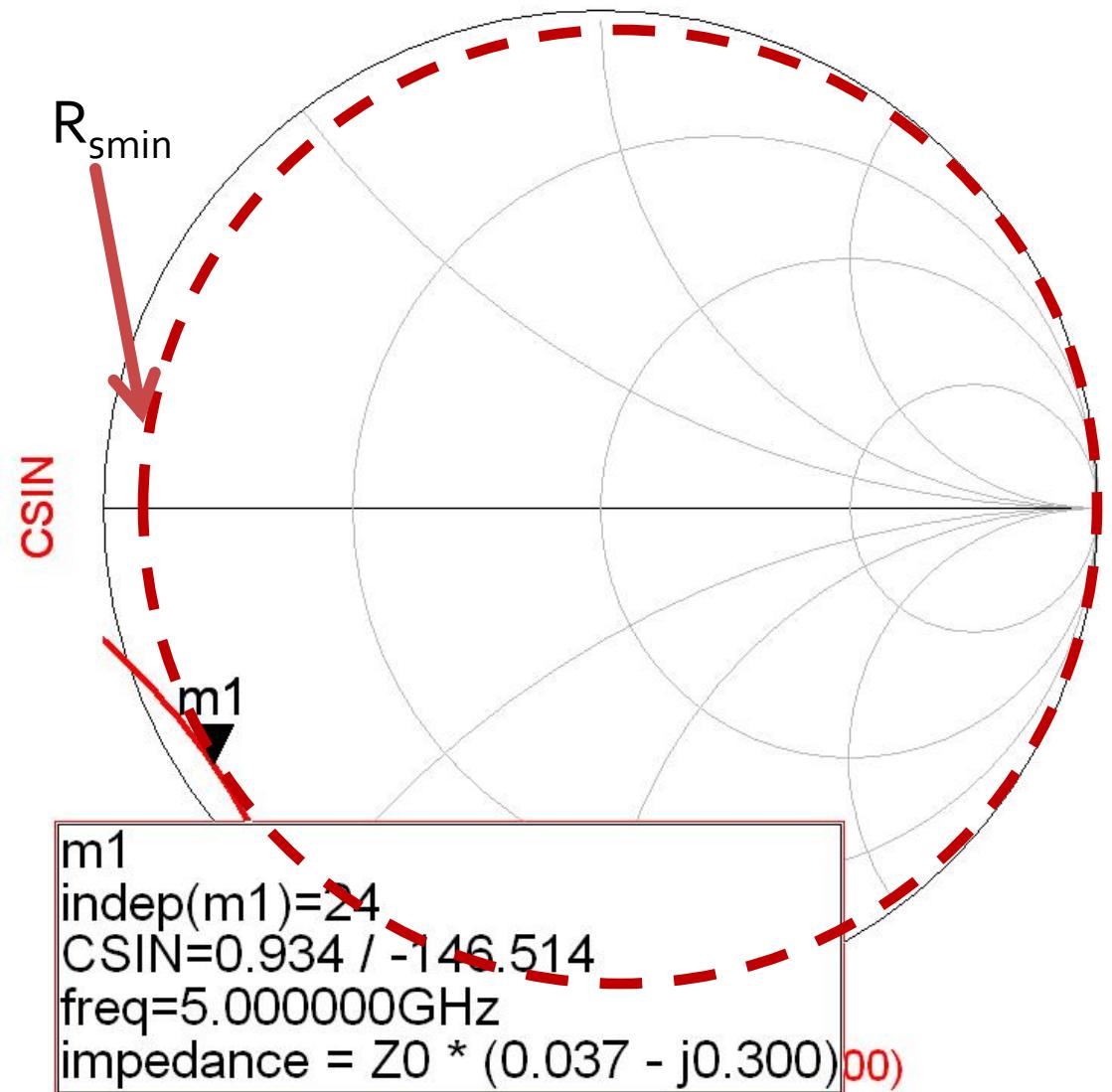
- ATF-34143 at  $V_{ds}=3V$   $I_d=20mA$ .
- @ $0.5 \div 10GHz$
- Neconditionat stabil pentru  $f > 6.31GHz$



# Stabilizarea unui dipozit

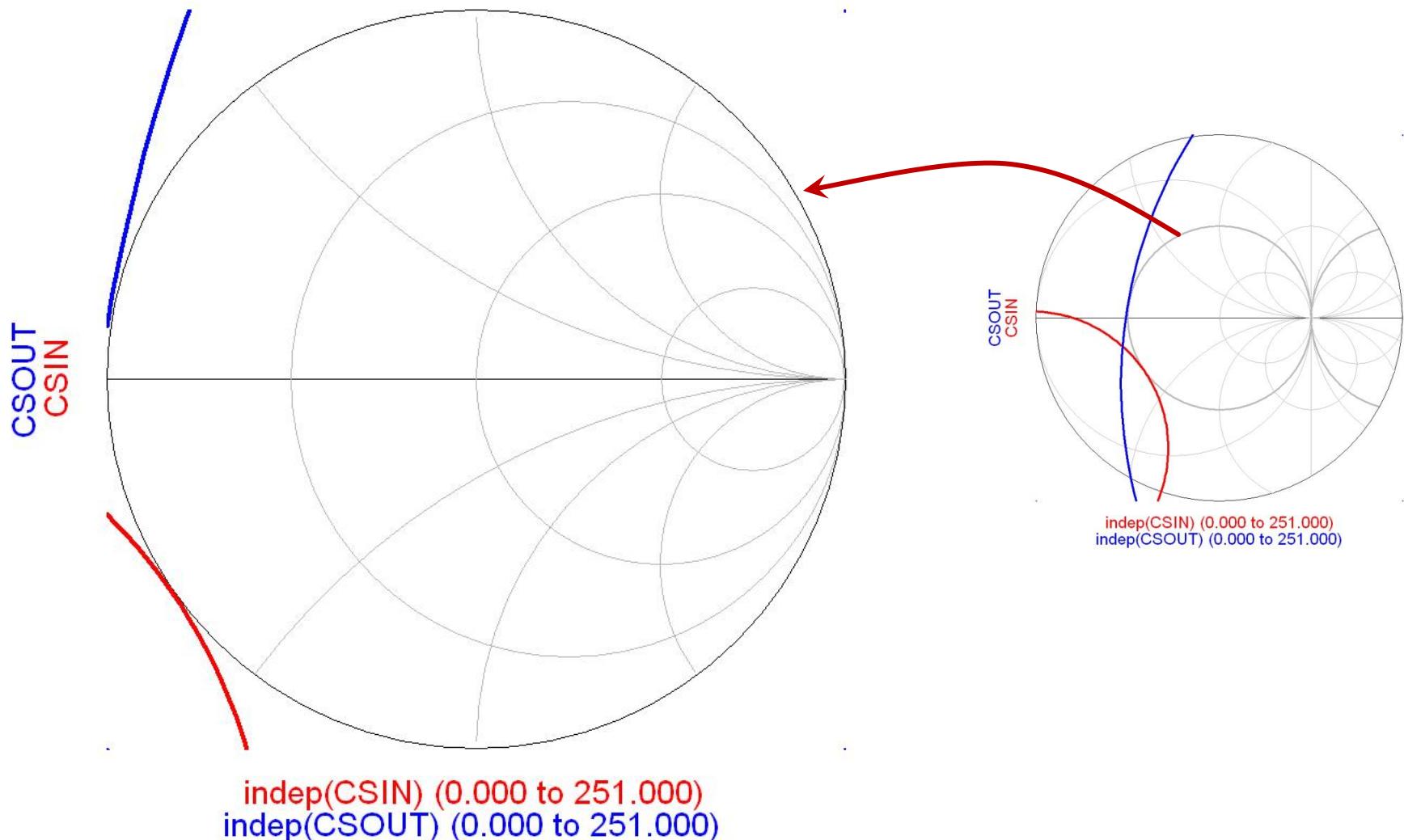
- Stabilitatea neconditionata pentru un interval larg de frecvente are avantaje importante
  - Ex: pot projecata cu ATF 34143 un amplificator stabil (conditionat) la 5GHz, dar acest lucru este inutil daca apar oscilatii la 500MHz ( $\mu \approx 0.1$ )
  - **Minimul necesar** in conditii de lucru cu stabilitate conditionata este **sa se verifice stabilitatea** la frecvente inafara benzii
- Stabilitatea neconditionata poate fi fortata prin introducerea de elemente rezistive in serie/paralel la intrare si/sau iesire

# Rezistenta serie la intrare

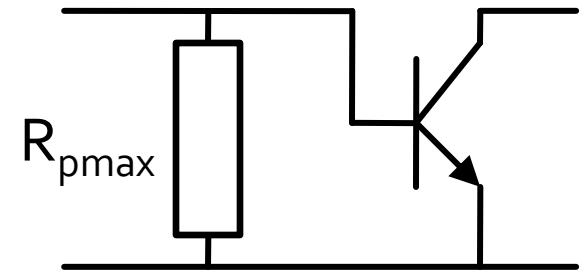
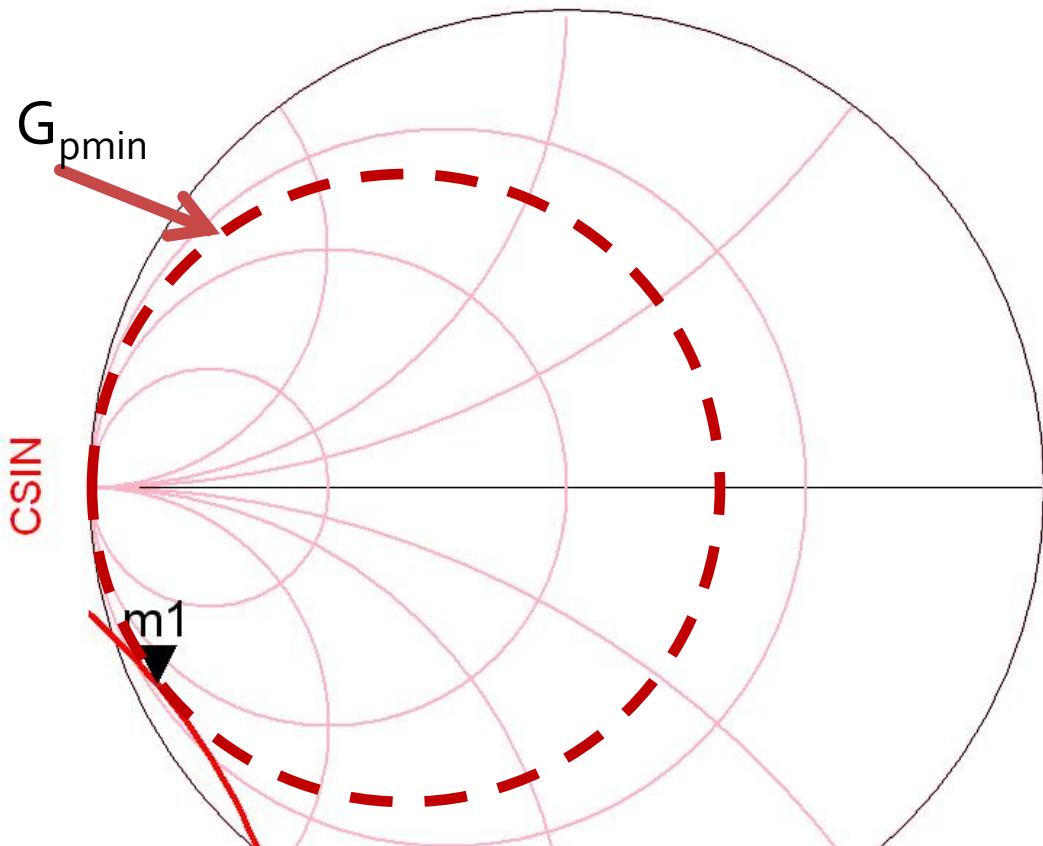


$$R_{smin} = 0.037 \cdot 50\Omega = 1.85\Omega$$

# ADS, $R_s = 2\Omega$



# Rezistenta paralel la intrare

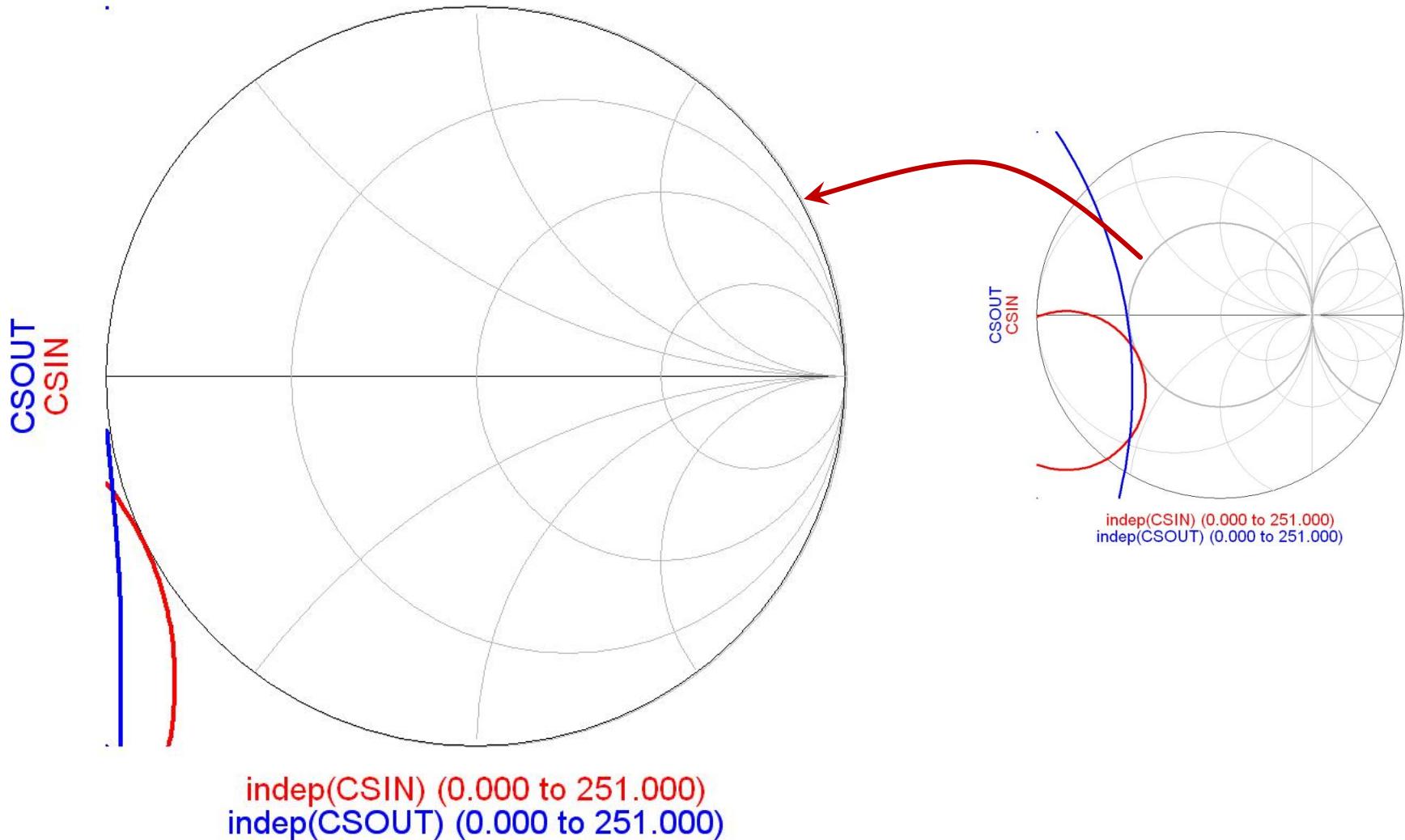


$$R_{p\max} = \frac{1}{G_{p\min}}$$

$$\frac{1}{0.026 - j \cdot 0.226} = 0.502 + j \cdot 4.367$$

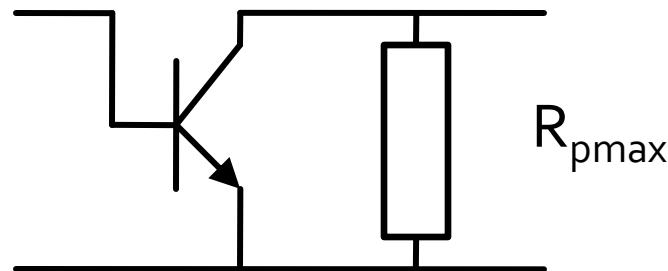
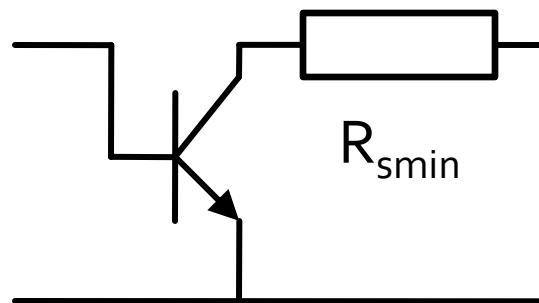
$$R_{p\max} = \frac{50\Omega}{0.502} = 99.6\Omega$$

# ADS, $R_p = 90\Omega$



# Rezistenta serie/paralel la iesire

- Procedura se poate aplica similar la iesire (plecand de la CSOUT)
- Din exemplele anterioare, incarcarea rezistiva la intrare are efect pozitiv si asupra stabilitatii la iesire si viceversa (incarcare la iesire efect asupra stabilitatii la intrare)

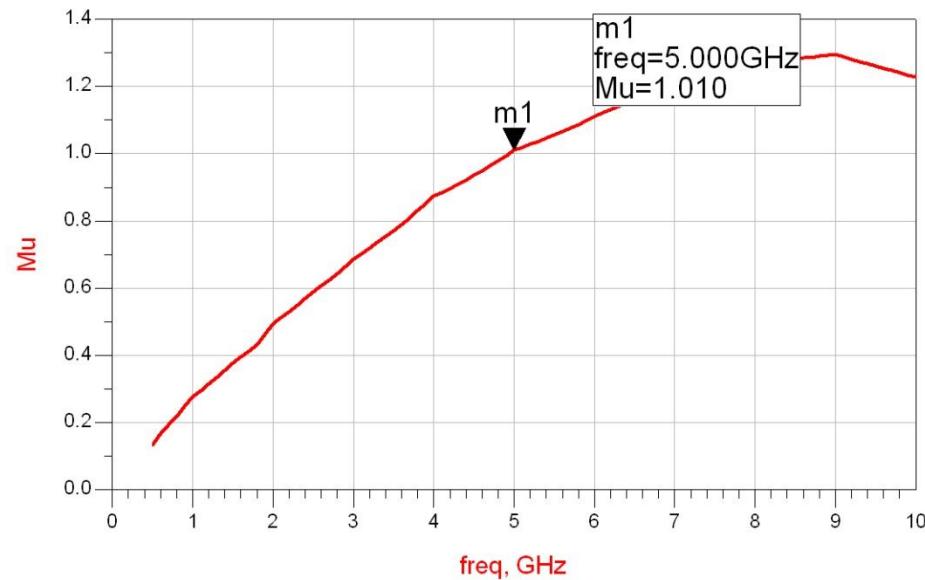
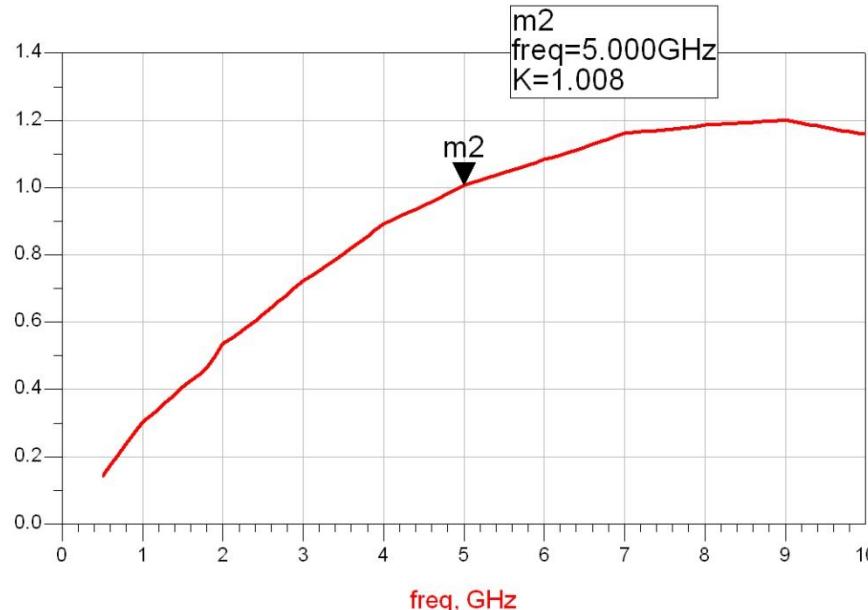


# Stabilizarea unui dipozit

- Efect negativ asupra castigului
  - trebuie urmarit MAG/MSG in timpul proiectarii
- Efect negativ asupra zgomotului (<sup>va urma</sup>)
- Se poate alege una din cele 4 variante care ofera performante mai bune (in functie de aplicatie)
- Se pot realiza cu elemente de pasivizare selective in frecventa
  - Ex: Circuite RL, RC sacrificia performanta doar unde este necesar sa se imbunatateasca stabilitatea fara afectarea frecventelor la care dispozitivul e deja stabil
- E posibil ca aceste efecte sa apară automat ca urmare a elementelor parazite ale circuitelor de polarizare (capacitati de decuplare, socruri de radiofrecventa)

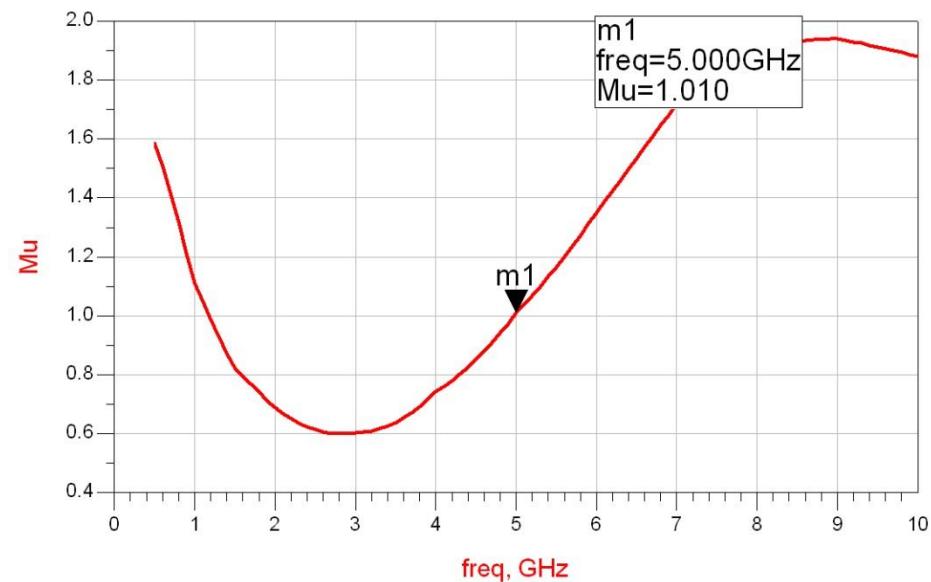
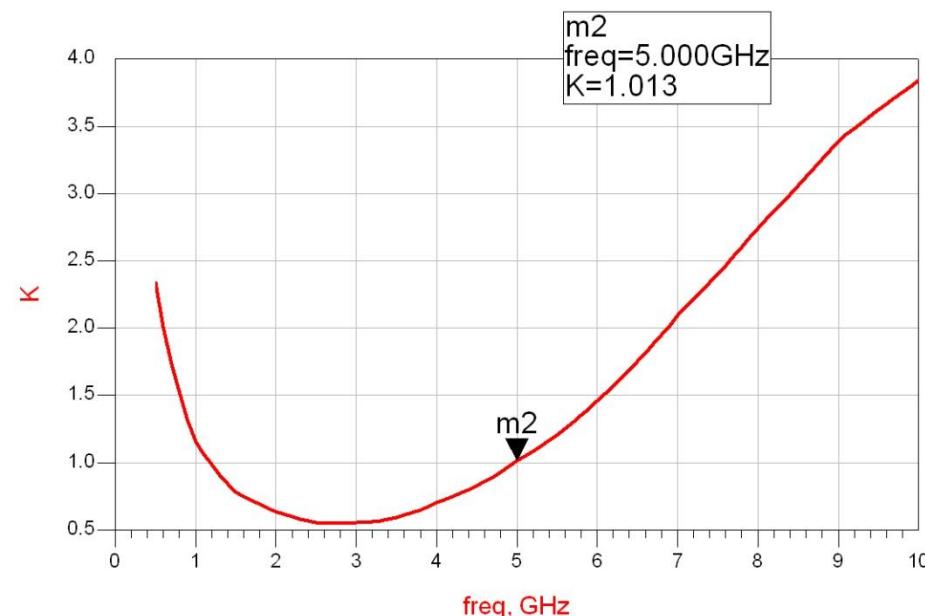
# Rezistenta serie la intrare

- $R_s = 2\Omega$
- $K = 1.008$ , MAG = 13.694dB @ 5GHz
  - fara stabilizare  $K = 0.886$ , MAG = 14.248dB @ 5GHz



# Rezistenta paralel la intrare

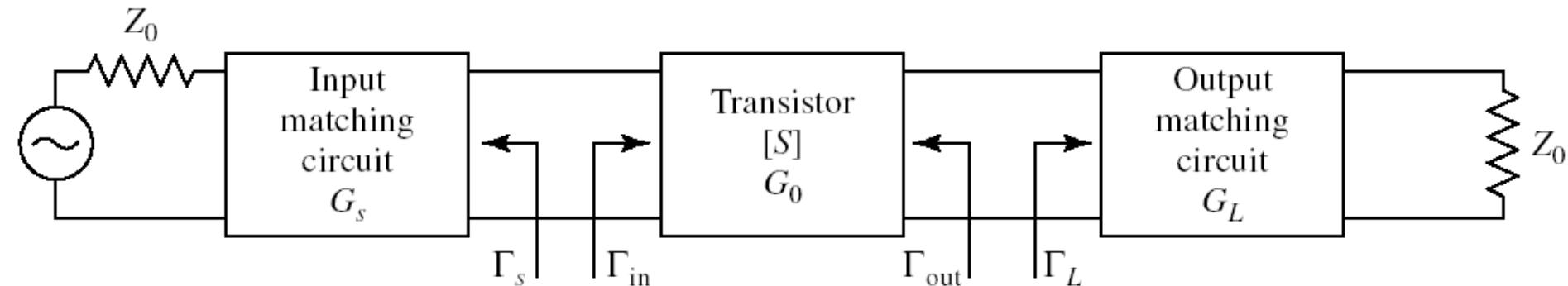
- $R_p = 90\Omega$
- $K = 1.013$ , MAG = 13.561dB @ 5GHz
  - fara stabilizare  $K = 0.886$ , MAG = 14.248dB @ 5GHz



Castigul amplificatoarelor de microunde

# **Amplificatoare de microunde**

# Proiectare pentru castig maxim



- Castig maxim de putere se obtine cand

$$\Gamma_{in} = \Gamma_s^* \quad \Gamma_{out} = \Gamma_L^*$$

- Pentru retelele de adaptare fara pierderi

$$G_{T\max} = \frac{|S_{21}|^2 \cdot (1 - |\Gamma_s|^2) \cdot (1 - |\Gamma_L|^2)}{|1 - \Gamma_s \cdot \Gamma_{in}|^2 \cdot |1 - S_{22} \cdot \Gamma_L|^2} \quad G_{T\max} = \frac{1}{1 - |\Gamma_s|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

- Pentru tranzistor bilateral ( $S_{12} \neq 0$ )  $\Gamma_{in}$  si  $\Gamma_{out}$  se influenteaza reciproc deci adaptarea trebuie sa fie simultana

# Adaptare simultana

$$\Gamma_{in} = \Gamma_S^*$$

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

$$\Gamma_S^* = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L}$$

$$\Gamma_{out} = \Gamma_L^*$$

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

$$\Gamma_L^* = S_{22} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_S}{1 - S_{11} \cdot \Gamma_S}$$

- Aflam  $\Gamma_S$

$$\Gamma_S = S_{11}^* + \frac{S_{12}^* \cdot S_{21}^*}{1/\Gamma_L^* - S_{22}^*}$$

$$\Gamma_L^* = \frac{S_{22} - \Delta \cdot \Gamma_S}{1 - S_{11} \cdot \Gamma_S}$$

$$\Gamma_S \cdot (1 - |S_{22}|^2) + \Gamma_S^2 \cdot (\Delta \cdot S_{22}^* - S_{11}) = \Gamma_S \cdot (\Delta \cdot S_{11}^* \cdot S_{22}^* - |S_{22}|^2 - \Delta \cdot S_{12}^* \cdot S_{21}^*) + S_{11}^* \cdot (1 - |S_{22}|^2) + S_{12}^* \cdot S_{21}^* \cdot S_{22}$$

# Adaptare simultana

$$\Delta \cdot (S_{11}^* \cdot S_{22}^* - S_{12}^* \cdot S_{21}^*) = |\Delta|^2$$

$$\Gamma_S^2 \cdot (S_{11} - \Delta \cdot S_{22}^*) + \Gamma_S \cdot (|\Delta|^2 - |S_{11}|^2 + |S_{22}|^2 - 1) + (S_{11}^* - \Delta^* \cdot S_{22}) = 0$$

- Ecuatie de gradul 2

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4 \cdot |C_1|^2}}{2 \cdot C_1}$$

- Similar

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4 \cdot |C_2|^2}}{2 \cdot C_2}$$

- Cu variabilele

$$\begin{cases} B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \\ C_1 = S_{11} - \Delta \cdot S_{22}^* \end{cases}$$

$$\begin{cases} B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 \\ C_2 = S_{22} - \Delta \cdot S_{11}^* \end{cases}$$

# Adaptare simultana

- Este posibila daca

$$B_1^2 - 4 \cdot |C_1|^2 > 0 \quad B_2^2 - 4 \cdot |C_2|^2 > 0$$

$$\Delta \cdot (S_{11}^* \cdot S_{22}^* - S_{12}^* \cdot S_{21}^*) = |\Delta|^2$$

$$|C_1|^2 = |S_{11} - \Delta \cdot S_{22}^*|^2 = |S_{12}|^2 \cdot |S_{21}|^2 + (1 - |S_{22}|^2) \cdot (|S_{11}|^2 - |\Delta|^2)$$

$$\begin{aligned} B_1^2 - 4 \cdot |C_1|^2 &= (1 + |S_{11}|^2)^2 + (|S_{22}|^2 + |\Delta|^2)^2 - \\ &\quad - 2 \cdot (1 + |S_{11}|^2) \cdot (|S_{22}|^2 + |\Delta|^2) - 4 \cdot |S_{12} \cdot S_{21}|^2 - 4 \cdot (1 - |S_{22}|^2) \cdot (|S_{22}|^2 - |\Delta|^2) \end{aligned}$$

$$\begin{aligned} B_1^2 - 4 \cdot |C_1|^2 &= (1 + |S_{11}|^2)^2 + (|S_{22}|^2 + |\Delta|^2)^2 - \\ &\quad - 4 \cdot |S_{11}|^2 - 4 \cdot |S_{22}|^2 \cdot |\Delta|^2 - 2 \cdot (1 - |S_{11}|^2) \cdot (|S_{22}|^2 - |\Delta|^2) - 4 \cdot |S_{12} \cdot S_{21}|^2 \end{aligned}$$

# Adaptare simultana

$$B_1^2 - 4 \cdot |C_1|^2 = \left(1 + |S_{11}|^2\right)^2 + \left(|S_{22}|^2 + |\Delta|^2\right)^2 - \\ - 4 \cdot |S_{11}|^2 - 4 \cdot |S_{22}|^2 \cdot |\Delta|^2 - 2 \cdot \left(1 - |S_{11}|^2\right) \cdot \left(|S_{22}|^2 - |\Delta|^2\right) - 4 \cdot |S_{12} \cdot S_{21}|^2$$

$$B_1^2 - 4 \cdot |C_1|^2 = \left(1 - |S_{11}|^2\right)^2 + \left(|S_{22}|^2 - |\Delta|^2\right)^2 - 2 \cdot \left(1 - |S_{11}|^2\right) \cdot \left(|S_{22}|^2 - |\Delta|^2\right) - 4 \cdot |S_{12} \cdot S_{21}|^2$$

$$B_1^2 - 4 \cdot |C_1|^2 = \left(1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2\right)^2 - 4 \cdot |S_{12} \cdot S_{21}|^2$$

$$B_1^2 - 4 \cdot |C_1|^2 = \left(K \cdot 2 \cdot |S_{12} \cdot S_{21}|\right)^2 - 4 \cdot |S_{12} \cdot S_{21}|^2$$

$$B_1^2 - 4 \cdot |C_1|^2 = 4 \cdot |S_{12}|^2 \cdot |S_{21}|^2 \cdot \left(K^2 - 1\right)$$

## ■ Similar

$$B_2^2 - 4 \cdot |C_2|^2 = 4 \cdot |S_{12}|^2 \cdot |S_{21}|^2 \cdot \left(K^2 - 1\right)$$

# Adaptare simultana

$$\Gamma_S = \frac{B_1 \pm \sqrt{B_1^2 - 4 \cdot |C_1|^2}}{2 \cdot C_1}$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4 \cdot |C_2|^2}}{2 \cdot C_2}$$

## ■ Necesar pentru solutii

$$|\Gamma_S| < 1 \quad |\Gamma_L| < 1$$

$$|\Delta| = |S_{11} \cdot S_{22} - S_{12} \cdot S_{21}| < 1 \quad \begin{cases} B_1 > 0 \\ B_2 > 0 \end{cases}$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 \cdot |S_{12} \cdot S_{21}|} > 1 \quad \begin{cases} B_1^2 - 4 \cdot |C_1|^2 = 4 \cdot |S_{12}|^2 \cdot |S_{21}|^2 \cdot (K^2 - 1) > 0 \\ B_2^2 - 4 \cdot |C_2|^2 = 4 \cdot |S_{12}|^2 \cdot |S_{21}|^2 \cdot (K^2 - 1) > 0 \end{cases}$$

# Adaptare simultana

- Adaptarea simultana se poate realiza **numai** pentru amplificatoarele **neconditionat stabile** la frecventa de lucru, si solutia cu  $|\Gamma| < 1$  se obtine cu semnul “-”

$$\Gamma_S = \frac{B_1 - \sqrt{B_1^2 - 4 \cdot |C_1|^2}}{2 \cdot C_1}$$

$$\begin{cases} B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \\ C_1 = S_{11} - \Delta \cdot S_{22}^* \end{cases}$$

$$\Gamma_L = \frac{B_2 - \sqrt{B_2^2 - 4 \cdot |C_2|^2}}{2 \cdot C_2}$$

$$\begin{cases} B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 \\ C_2 = S_{22} - \Delta \cdot S_{11}^* \end{cases}$$

# Adaptare simultana

- În condițiile adaptării simultane se obține castigul de transfer maxim pentru tranzistorul bilateral

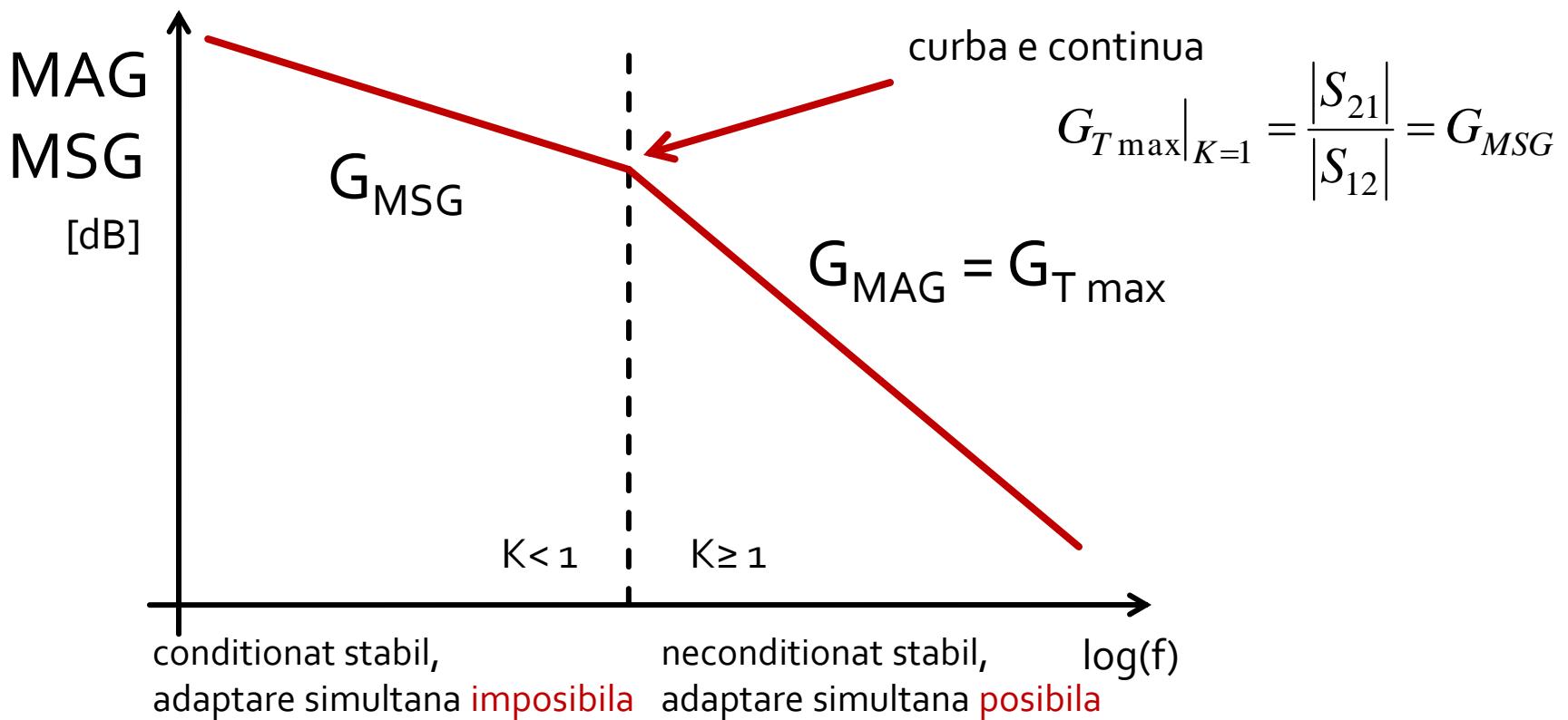
$$G_{T\max} = \frac{|S_{21}|}{|S_{12}|} \cdot \left( K - \sqrt{K^2 - 1} \right)$$

- Dacă dispozitivul **nu** este **neconditionat stabil** se poate folosi ca o indicatie a capacitatii de amplificare castigul maxim stabil (Maximum Stable Gain)

$$G_{MSG} = \frac{|S_{21}|}{|S_{12}|}$$

# Maximum Available Gain

- Indicator in intreaga gama de frecventa a capacitatii de a obtine castig



# Adaptare simultana, tranzistor unilateral

- Daca amplificatorul/tranzistorul este **unilateral** ( $S_{12} = 0$ ) adaptarea simultana implica:

$$\Gamma_{in} = S_{11}$$

$$\Gamma_{out} = S_{22}$$

$$\Gamma_S = S_{11}^*$$

$$\Gamma_L = S_{22}^*$$

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

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

# Exemplu

- ATF-34143 **at  $V_{ds}=3V$   $I_d=20mA$ .**
  - fara stabilizare  $K = 0.886$ , MAG = 14.248dB @ 5GHz
  - nu poate fi folosit in aceasta polarizare
- ATF-34143 **at  $V_{ds}=4V$   $I_d=40mA$** 
  - fara stabilizare  $K = 1.031$ , MAG = 12.9dB @ 5GHz
  - utilizam aceasta polarizare pentru a implementa un amplificator

# Exemplu

- ATF-34143 at  $V_{ds}=4V$   $I_d=40mA$ .
- @5GHz
  - $S_{11} = 0.64 \angle 111^\circ$
  - $S_{12} = 0.117 \angle -27^\circ$
  - $S_{21} = 2.923 \angle -6^\circ$
  - $S_{22} = 0.21 \angle 111^\circ$

# Calcul

## ■ Parametri S

- $S_{11} = -0.229 + 0.597 \cdot j$
- $S_{12} = 0.104 - 0.053 \cdot j$
- $S_{21} = 2.907 - 0.306 \cdot j$
- $S_{22} = -0.075 + 0.196 \cdot j$

$$G_{T\max} = \frac{|S_{21}|}{|S_{12}|} \cdot \left( K - \sqrt{K^2 - 1} \right) = 19.497 = 12.9 \text{ dB}$$

$$G_{TU\max} = \frac{1}{1 - |S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1}{1 - |S_{22}|^2} = 15.139 = 11.8 \text{ dB}$$

# Calcul

$$\begin{cases} B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \\ C_1 = S_{11} - \Delta \cdot S_{22}^* \end{cases}$$

$$\begin{cases} B_1 = 1.207 \\ C_1 = -0.277 + j \cdot 0.529 \end{cases}$$

$$\Gamma_S = \frac{B_1 - \sqrt{B_1^2 - 4 \cdot |C_1|^2}}{2 \cdot C_1}$$

$$\Gamma_S = -0.403 - j \cdot 0.768$$

$$|\Gamma_S| = 0.867 < 1$$

$$\begin{cases} B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 \\ C_2 = S_{22} - \Delta \cdot S_{11}^* \end{cases}$$

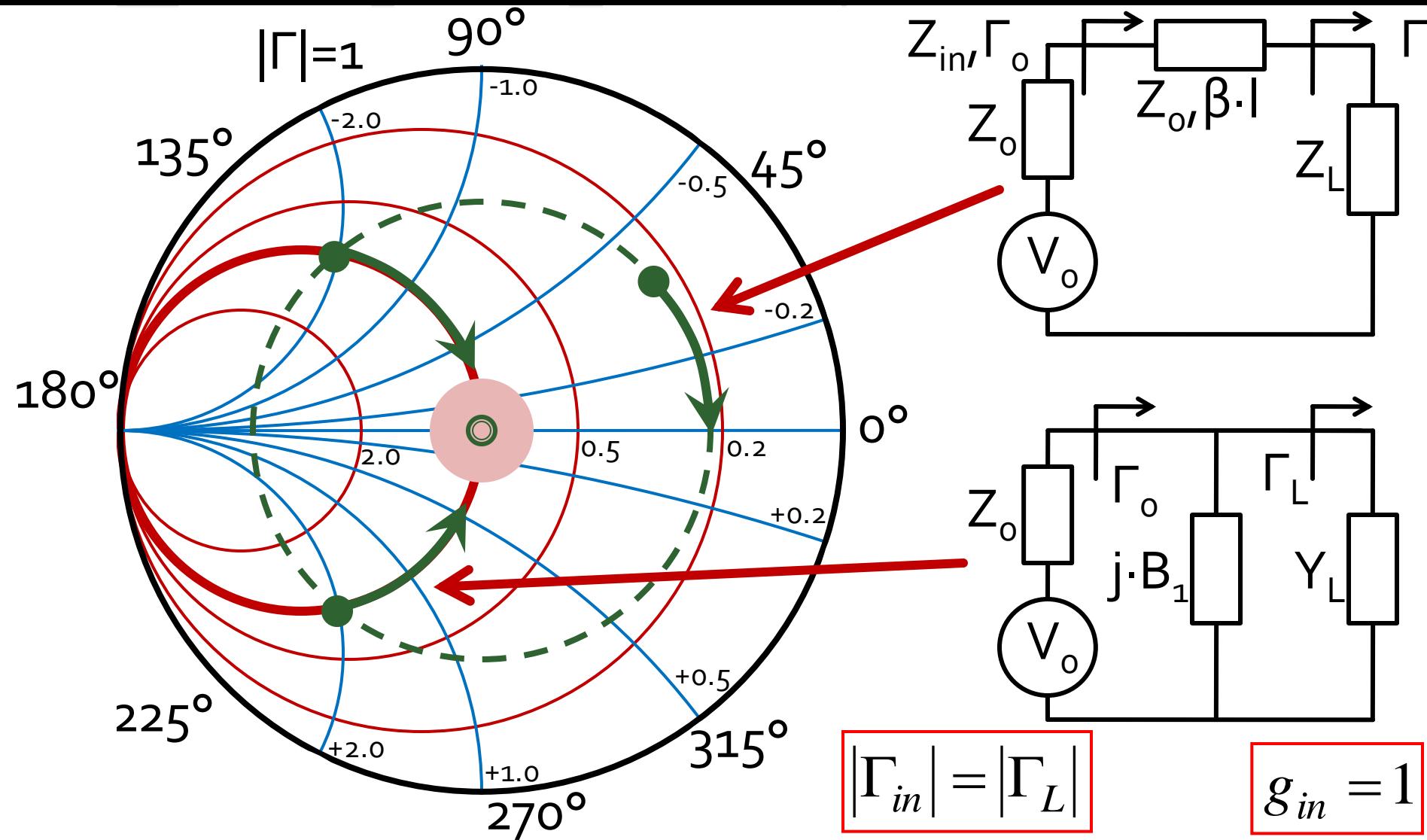
$$\begin{cases} B_2 = 0.476 \\ C_2 = -0.222 - j \cdot 0.013 \end{cases}$$

$$\Gamma_L = \frac{B_2 - \sqrt{B_2^2 - 4 \cdot |C_2|^2}}{2 \cdot C_2}$$

$$\Gamma_L = -0.685 + j \cdot 0.04$$

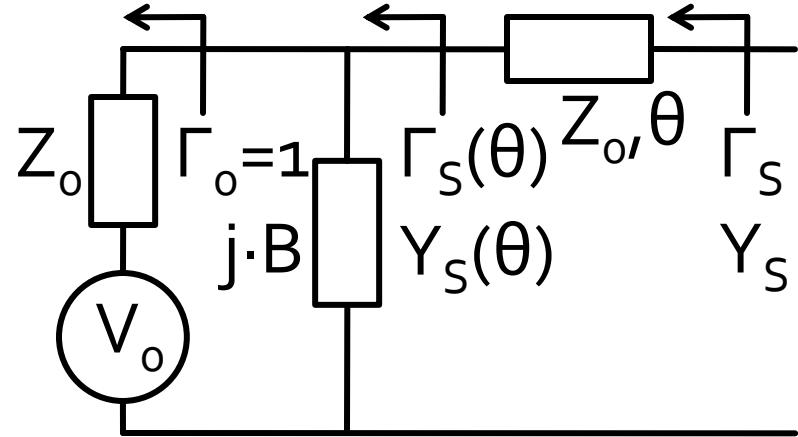
$$|\Gamma_L| = 0.686 < 1$$

# Adaptare cu stub-uri, C6-7



# Calcul analitic, coeficienti de reflexie

- linie serie
  - lungime electrică  $E = \beta \cdot l = \theta$
  - mută coeficientul de reflexie pe cercul  $g=1$
- stub paralel mută coeficientul de reflexie în centrul diagramei Smith



$$y_s = \frac{Y_s}{Y_0} = Y_s \cdot Z_0 = Y_s \cdot 50\Omega$$

$$y_s = \frac{1 - \Gamma_s}{1 + \Gamma_s} = 0.263 + j \cdot 1.622$$

$$\Gamma_s(\theta) = \Gamma_s \cdot e^{2j\theta}$$

$$y_s(\theta) = \frac{1 - \Gamma_s(\theta)}{1 + \Gamma_s(\theta)} = \frac{1 - \Gamma_s \cdot e^{2j\theta}}{1 + \Gamma_s \cdot e^{2j\theta}}$$

# Calcul analitic, stub

- Dupa sectiunea de linie cu lungimea electrica  $\theta$

$$\operatorname{Re}[y_S(\theta)] = 1$$

$$\operatorname{Im}[y_S(\theta)] = B$$

$$\operatorname{Re}[y_S(\theta)] = \frac{1}{2} \cdot [y_S(\theta) + y_S^*(\theta)]$$

$$\operatorname{Im}[y_S(\theta)] = \frac{1}{2j} \cdot [y_S(\theta) - y_S^*(\theta)]$$

$$\operatorname{Re}[y_S(\theta)] = \frac{1}{2} \cdot \left[ \frac{1 - \Gamma_S \cdot e^{2j\theta}}{1 + \Gamma_S \cdot e^{2j\theta}} + \frac{1 - \Gamma_S^* \cdot e^{-2j\theta}}{1 + \Gamma_S^* \cdot e^{-2j\theta}} \right] \quad \Gamma_S = |\Gamma_S| \cdot e^{j\varphi}$$

$$\operatorname{Re}[y_S(\theta)] = \frac{1}{2} \cdot \left[ \frac{(1 - |\Gamma_S| \cdot e^{j(\varphi+2\theta)}) \cdot (1 + |\Gamma_S| \cdot e^{-j(\varphi+2\theta)}) + (1 - |\Gamma_S| \cdot e^{-j(\varphi+2\theta)}) \cdot (1 + |\Gamma_S| \cdot e^{j(\varphi+2\theta)})}{(1 + |\Gamma_S| \cdot e^{-j(\varphi+2\theta)}) \cdot (1 + |\Gamma_S| \cdot e^{j(\varphi+2\theta)})} \right]$$

$$\operatorname{Re}[y_S(\theta)] = \frac{1}{2} \cdot \left[ \frac{2 - 2 \cdot |\Gamma_S|^2}{1 + |\Gamma_S|^2 + 2 \cdot |\Gamma_S| \cdot \cos(\varphi + 2\theta)} \right]$$

$$\operatorname{Re}[y_S(\theta)] = 1$$

$$\cos(\varphi + 2\theta) = -|\Gamma_S|$$

# Calcul analitic, stub

- Ecuatia pentru calcularea  $\theta$

$$\operatorname{Re}[y_S(\theta)] = 1 \Rightarrow \cos(\varphi + 2\theta) = -|\Gamma_S|$$

$$\Gamma_S = |\Gamma_S| \cdot e^{j\varphi} \quad \Gamma_S = 0.867 \angle -117.7^\circ \quad |\Gamma_S| = 0.867; \quad \varphi = -117.7^\circ$$

- doua solutii posibile, normate la intervalul  $0^\circ \div 180^\circ$

$$\theta = \frac{1}{2} \cdot [\pm \cos^{-1}(-|\Gamma_S|) - \varphi + k \cdot 360^\circ] = \frac{1}{2} \cdot [\pm \cos^{-1}(-|\Gamma_S|) - \varphi] + k \cdot 180^\circ$$

$$\forall k \in N$$

$$\cos(\varphi + 2\theta) = -0.867 \Rightarrow (\varphi + 2\theta) = \pm 150.1^\circ$$

$$(-117.7^\circ + 2\theta) = \begin{cases} +150.1^\circ \\ -150.1^\circ \end{cases} \quad \theta = \begin{cases} +133.9^\circ \\ -16.2^\circ + 180^\circ = +163.8^\circ \end{cases}$$

# Calcul analitic, stub paralel

- Ecuatia pentru calcularea stub-ului paralel

$$\operatorname{Re}[y_s(\theta)] = 1 \quad \cos(\varphi + 2\theta) = -|\Gamma_s|$$

$$\operatorname{Im}[y_s(\theta)] = \frac{1}{2j} \cdot \left[ \frac{1 - \Gamma_s \cdot e^{2j\theta}}{1 + \Gamma_s \cdot e^{2j\theta}} - \frac{1 - \Gamma_s^* \cdot e^{-2j\theta}}{1 + \Gamma_s^* \cdot e^{-2j\theta}} \right] \quad \Gamma_s = |\Gamma_s| \cdot e^{j\varphi}$$

$$\operatorname{Im}[y_s(\theta)] = \frac{1}{2j} \cdot \left[ \frac{(1 - |\Gamma_s| \cdot e^{j(\varphi+2\theta)}) \cdot (1 + |\Gamma_s| \cdot e^{-j(\varphi+2\theta)}) - (1 - |\Gamma_s| \cdot e^{-j(\varphi+2\theta)}) \cdot (1 + |\Gamma_s| \cdot e^{j(\varphi+2\theta)})}{(1 + |\Gamma_s| \cdot e^{-j(\varphi+2\theta)}) \cdot (1 + |\Gamma_s| \cdot e^{j(\varphi+2\theta)})} \right]$$

$$\operatorname{Im}[y_s(\theta)] = \frac{1}{2j} \cdot \left[ \frac{2 \cdot |\Gamma_s| \cdot e^{-j(\varphi+2\theta)} - 2 \cdot |\Gamma_s| \cdot e^{+j(\varphi+2\theta)}}{1 + |\Gamma_s|^2 + 2 \cdot |\Gamma_s| \cdot \cos(\varphi + 2\theta)} \right] = \frac{-2 \cdot |\Gamma_s| \cdot \sin(\varphi + 2\theta)}{1 + |\Gamma_s|^2 + 2 \cdot |\Gamma_s| \cdot \cos(\varphi + 2\theta)}$$

$$\cos(\varphi + 2\theta) = -|\Gamma_s| \Rightarrow \operatorname{Im}[y_s(\theta)] = \frac{-2 \cdot |\Gamma_s| \cdot \sin(\varphi + 2\theta)}{1 - |\Gamma_s|^2}$$

# Calcul analitic, stub paralel

## Ecuatia pentru calcularea stub-ului paralel

$$\cos(\varphi + 2\theta) = -|\Gamma_s| \Rightarrow \sin(\varphi + 2\theta) = \pm \sqrt{1 - |\Gamma_s|^2}$$

$$\text{Im}[y_s(\theta)] = \frac{-2 \cdot |\Gamma_s| \cdot \sin(\varphi + 2\theta)}{1 - |\Gamma_s|^2} \Rightarrow \text{Im}[y_s(\theta)] = \frac{\mp 2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}}$$

## doua situatii

$$\varphi + 2\theta \in [0^\circ, 180^\circ] \Rightarrow \sin(\varphi + 2\theta) \geq 0$$

$$\begin{cases} \sin(\varphi + 2\theta) = \sqrt{1 - |\Gamma_s|^2} \\ \text{Im}[y_s(\theta)] = \frac{-2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}} \end{cases}$$

$$\varphi + 2\theta \in (-180^\circ, 0^\circ) \Rightarrow \sin(\varphi + 2\theta) < 0$$

$$\begin{cases} \sin(\varphi + 2\theta) = -\sqrt{1 - |\Gamma_s|^2} \\ \text{Im}[y_s(\theta)] = \frac{2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}} \end{cases}$$

# Calcul analitic, stub paralel

- Se preferă (pentru microstrip) stub în gol

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

- Susceptanța raportată introdusă pentru adaptare

$$b = \operatorname{Im} \left[ \frac{Y_{in,g}}{Y_0} \right] = \operatorname{Im} \left[ \frac{Z_0}{Z_{in,g}} \right] = \tan \beta \cdot l = \operatorname{Im} [y_s(\theta)]$$

$$\theta_{sp} = \beta \cdot l = \tan^{-1} \frac{\mp 2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}}$$

# Calcul analitic

$$(\varphi + 2\theta) = \begin{cases} +150.1^\circ \\ -150.1^\circ \end{cases} \quad \theta = \begin{cases} 133.9^\circ \\ 163.8^\circ \end{cases} \quad \text{Im}[y_S(\theta)] = \begin{cases} -3.477 \\ +3.477 \end{cases} \quad \theta_{sp} = \begin{cases} -74^\circ + 180^\circ = 106^\circ \\ +74^\circ \end{cases}$$

- Se alege **una** din cele două solutii posibile
- Similar pentru adaptarea la ieșire

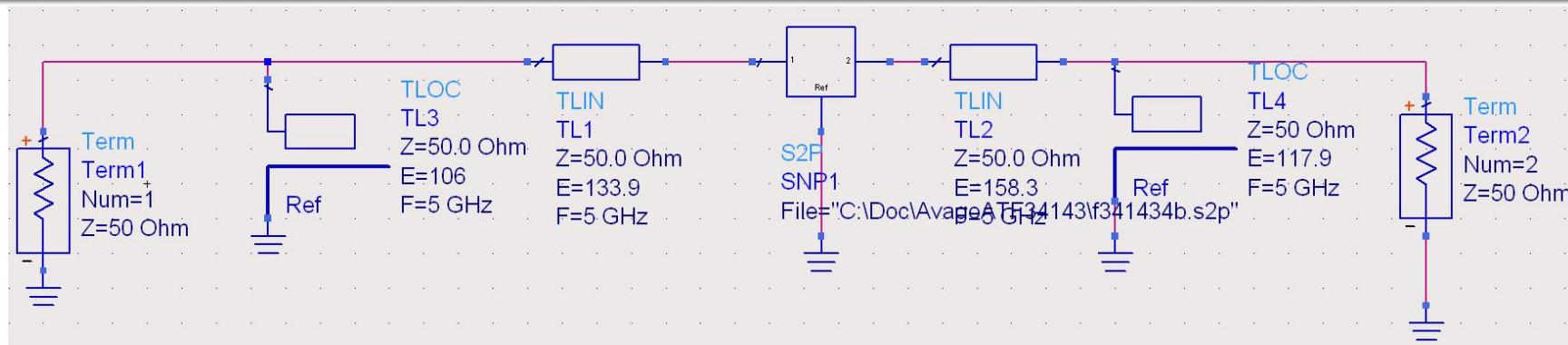
$$\Gamma_L = 0.686 \angle 176.7^\circ \quad \text{Re}[y_L(\theta)] = 1 \Rightarrow \cos(\varphi + 2\theta) = -|\Gamma_L|$$

$$(176.7^\circ + 2\theta) = \begin{cases} +133.3^\circ \\ -133.3^\circ \end{cases} \quad \theta = \begin{cases} -21.7^\circ + 180^\circ = +158.3^\circ \\ -155^\circ + 180^\circ = +25^\circ \end{cases}$$

$$\text{Im}[y_L(\theta)] = \frac{-2 \cdot |\Gamma_L|}{\sqrt{1 - |\Gamma_L|^2}} = -1.885 \quad \theta_{sp} = \begin{cases} -62.1^\circ + 180^\circ = 117.9^\circ \\ +62.1^\circ \end{cases}$$

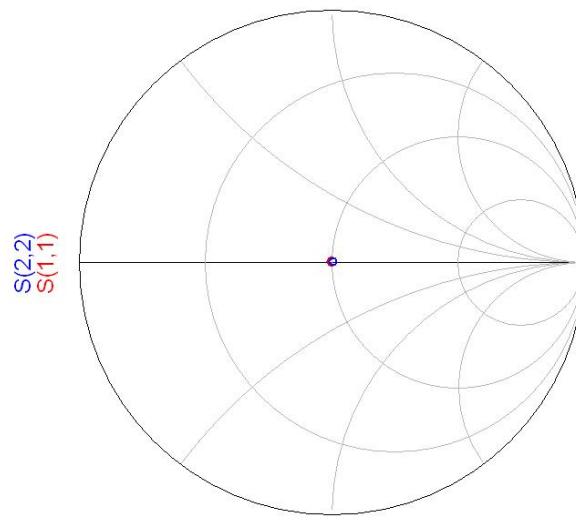
$$(\varphi + 2\theta) = \begin{cases} +133.3^\circ \\ -133.3^\circ \end{cases} \quad \theta = \begin{cases} 158.3^\circ \\ 25.0^\circ \end{cases} \quad \text{Im}[y_S(\theta)] = \begin{cases} -1.885 \\ +1.885 \end{cases} \quad \theta_{sp} = \begin{cases} 117.9^\circ \\ 62.1^\circ \end{cases}$$

# ADS

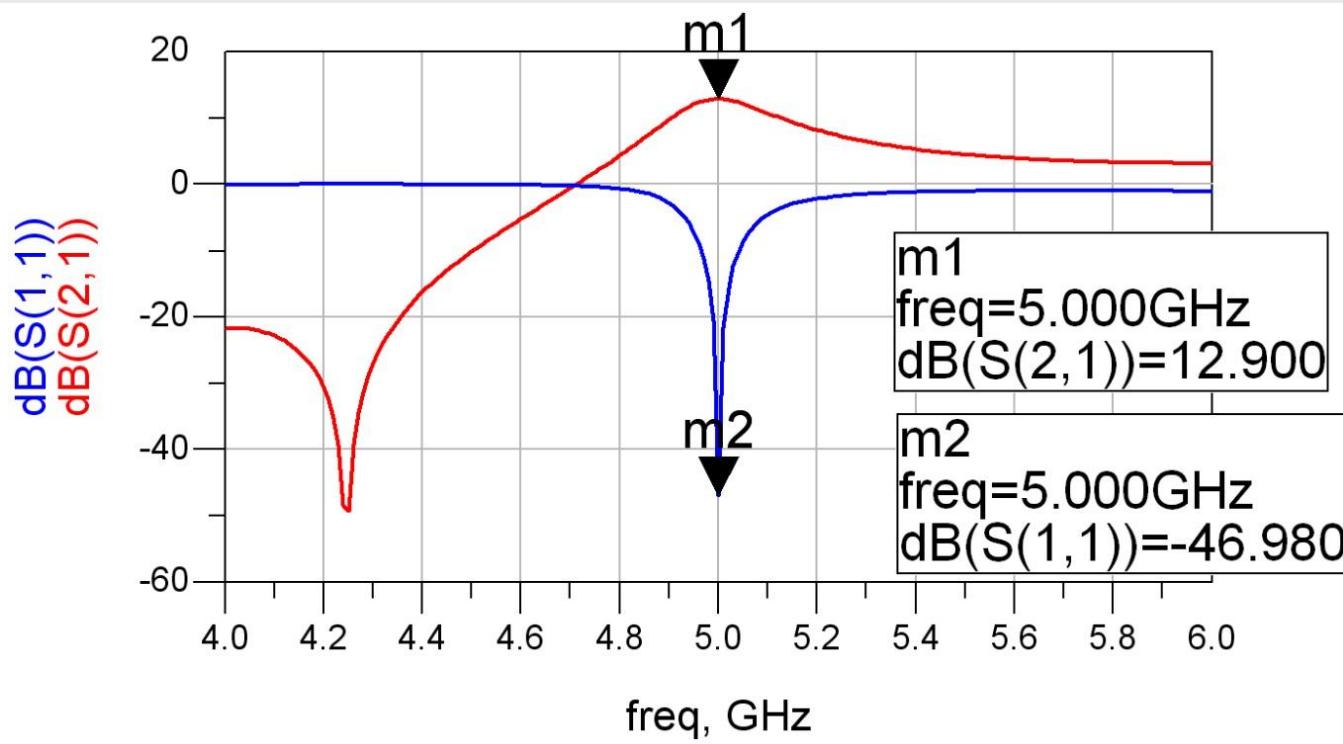
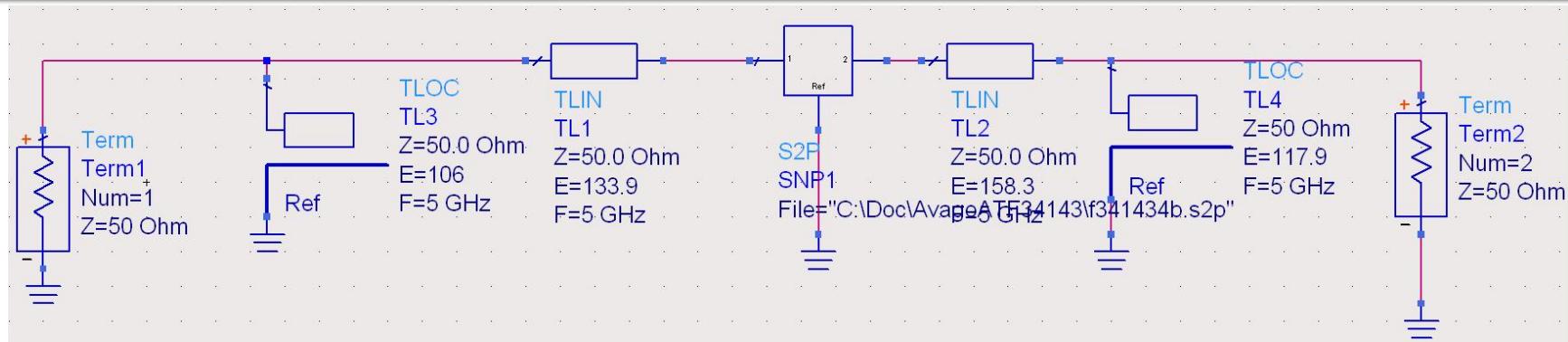


$$\text{Eqn } GT = 10 * \log(\text{mag}(S(2,1))^{\star 2})$$

freq	S(2,1)	GT	S(1,1)	S(2,2)
5.000GHz	4.415 / 157....	12.900	0.004 / 86.088	0.004 / 37.766



# ADS



Proiectare pentru castig impus

# **Amplificatoare de microunde**

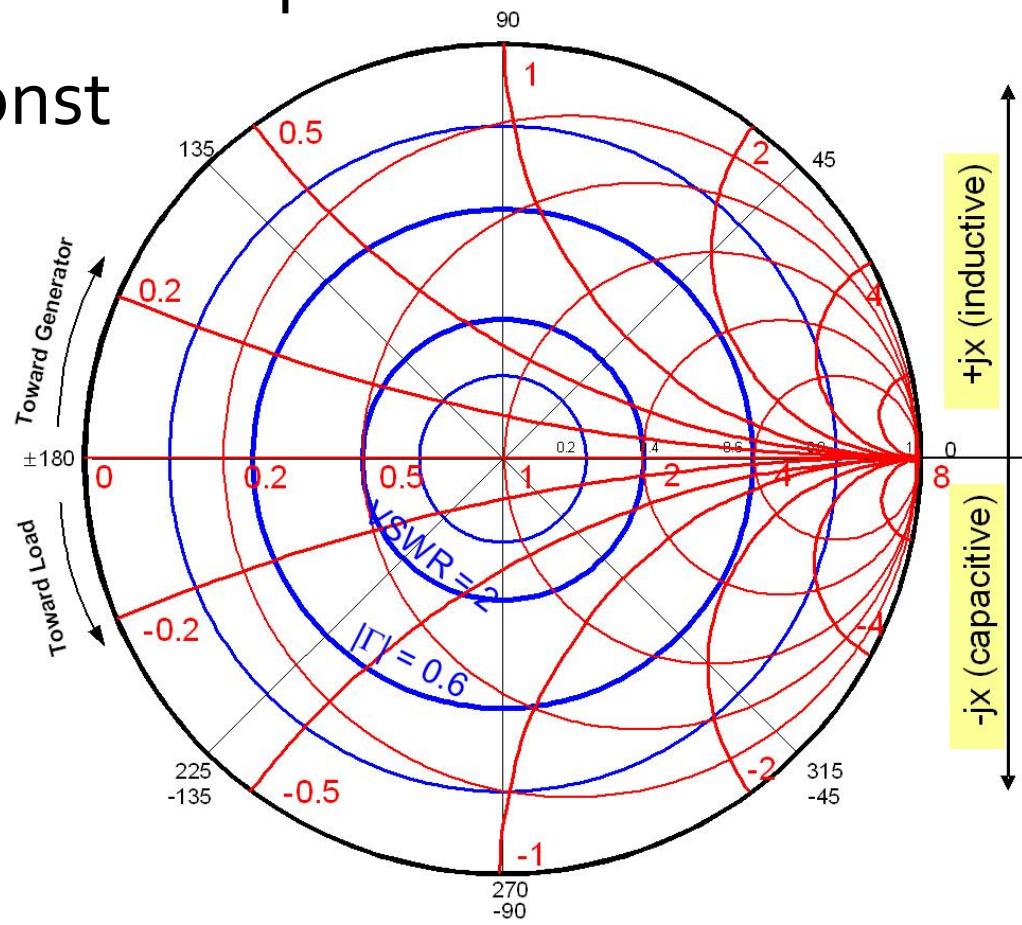
# Proiectare pentru castig impus

- 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 ( $L_3 + C_9$ )
  - conditii de stabilitate mai bune
  - obtinerea unui VSWR mai mic
  - controlul performantelor la mai multe frecvente
  - banda de functionare a amplificatorului

# VSWR

- Anumite aplicatii pot impune un raport intre tensiunile maxime/minime pe linii
- $VSWR = \text{const} \rightarrow \Gamma = \text{const}$

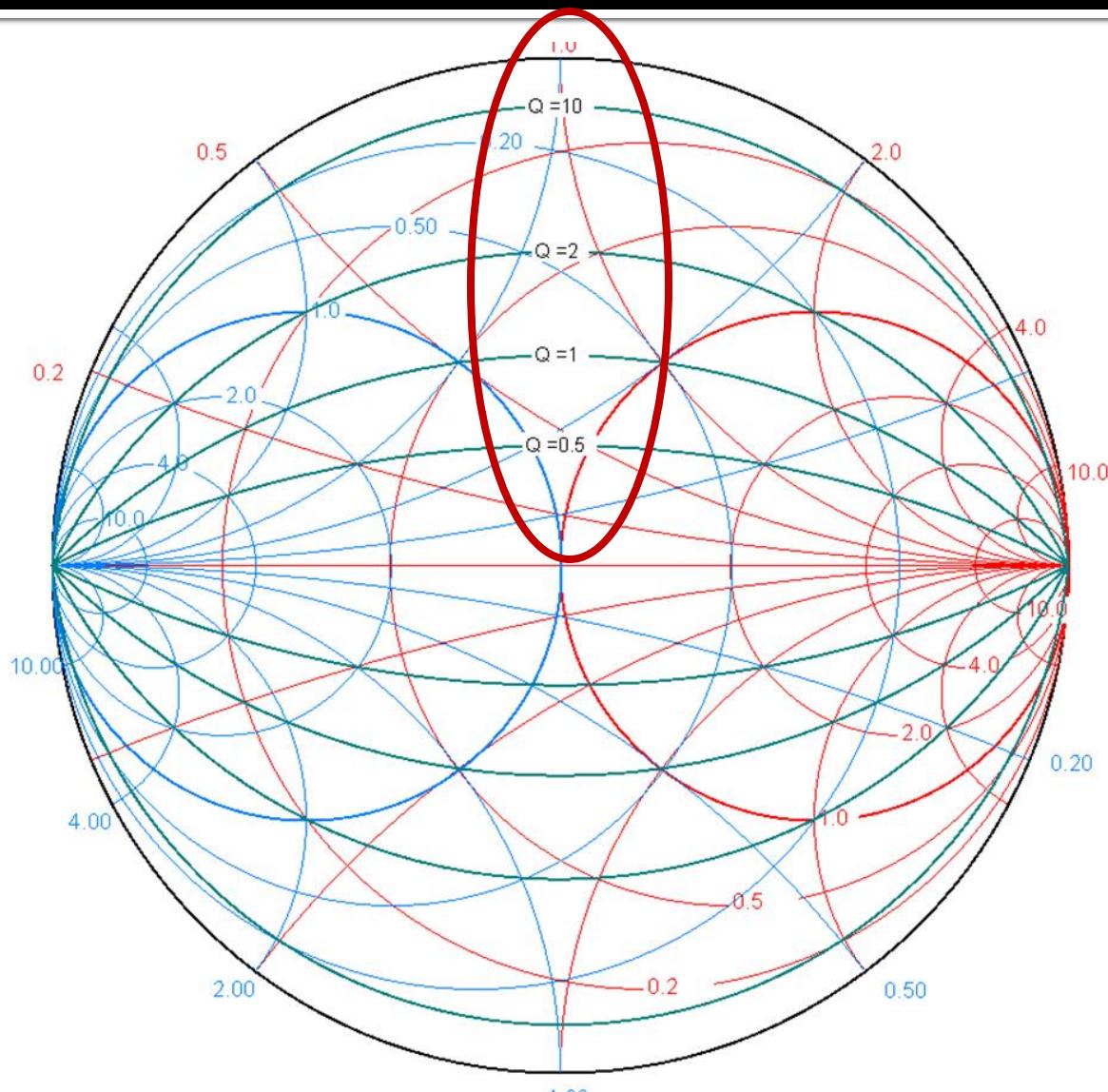
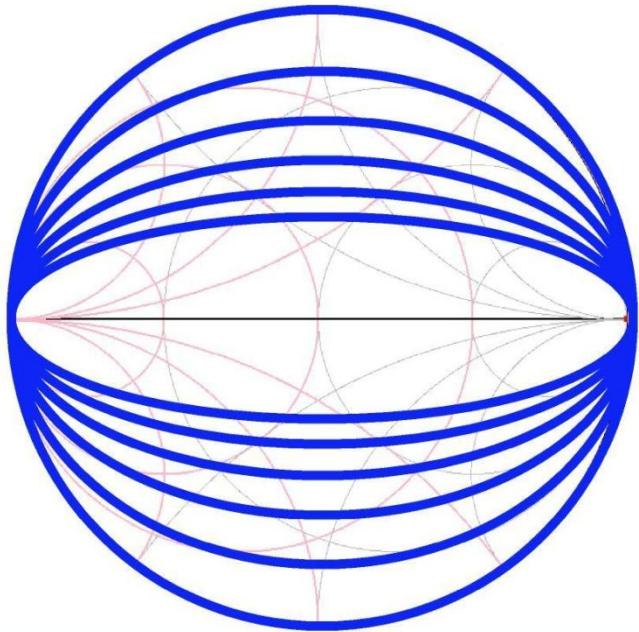
$$VSWR = \frac{V_{\max}}{V_{\min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$



# Cercuri de factor de calitate constant

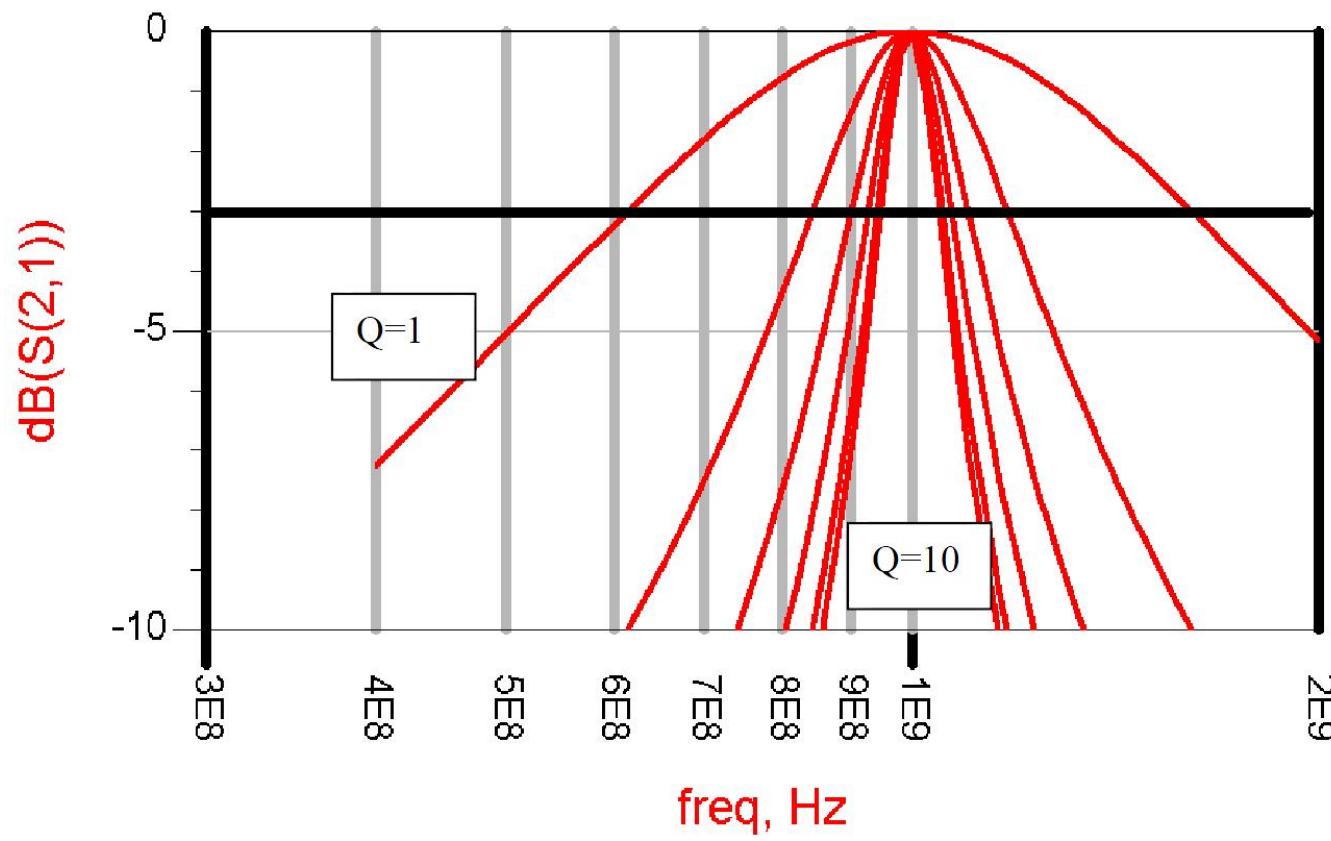
- Diagrama Smith

$$Q = \frac{X}{R} = \frac{G}{B} = const$$

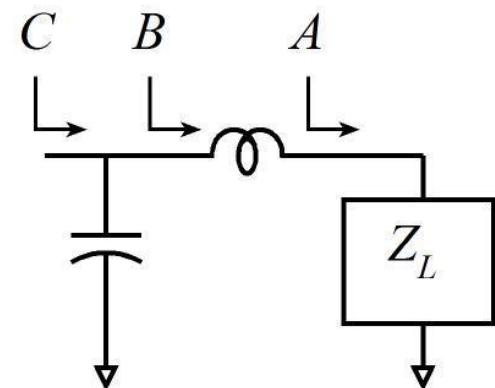
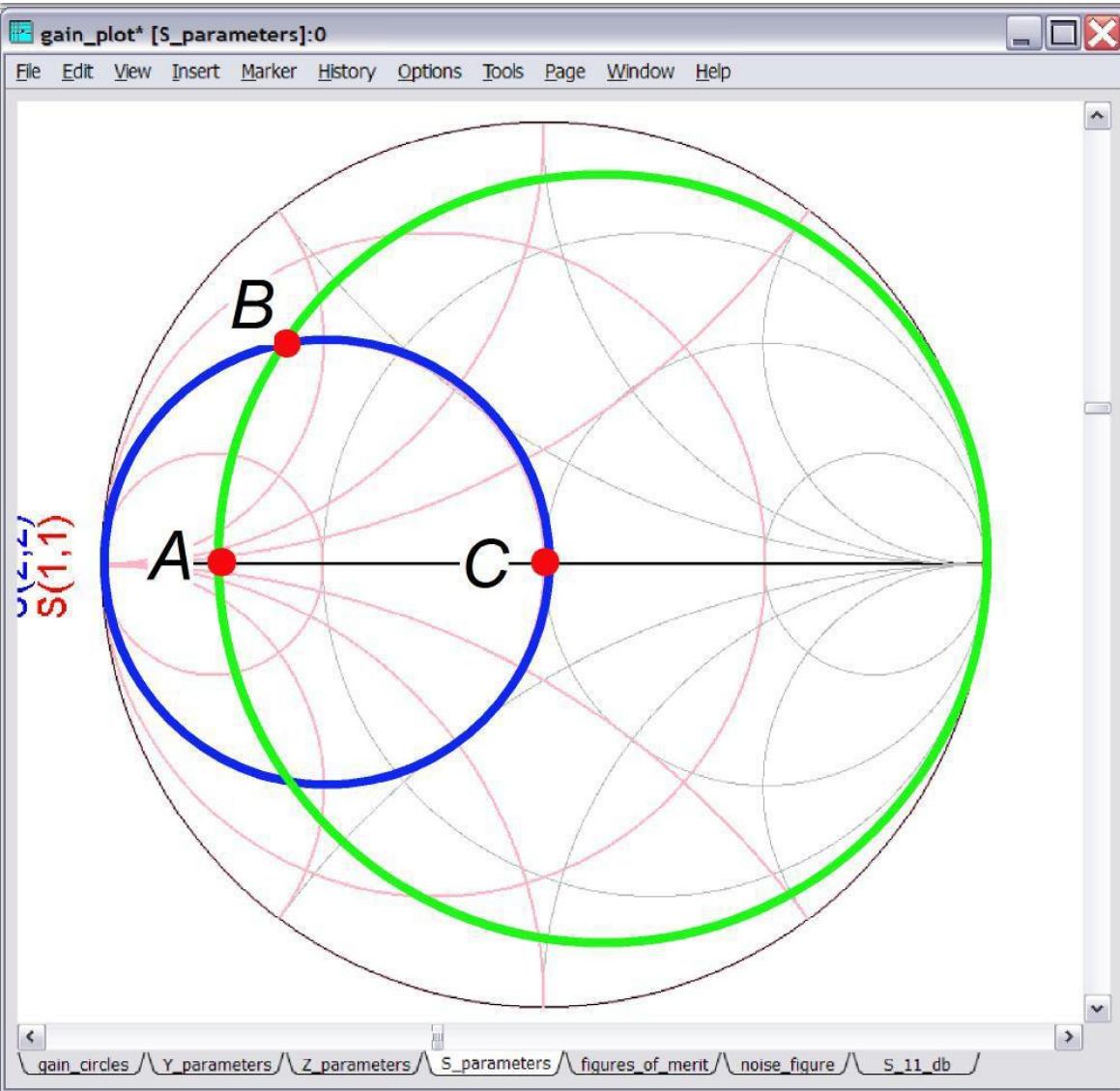


# Factor de calitate - banda

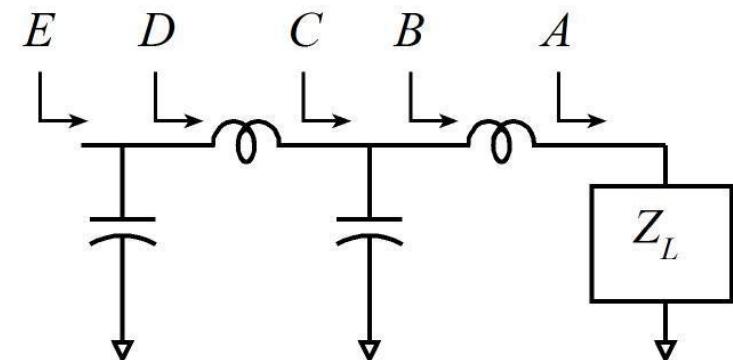
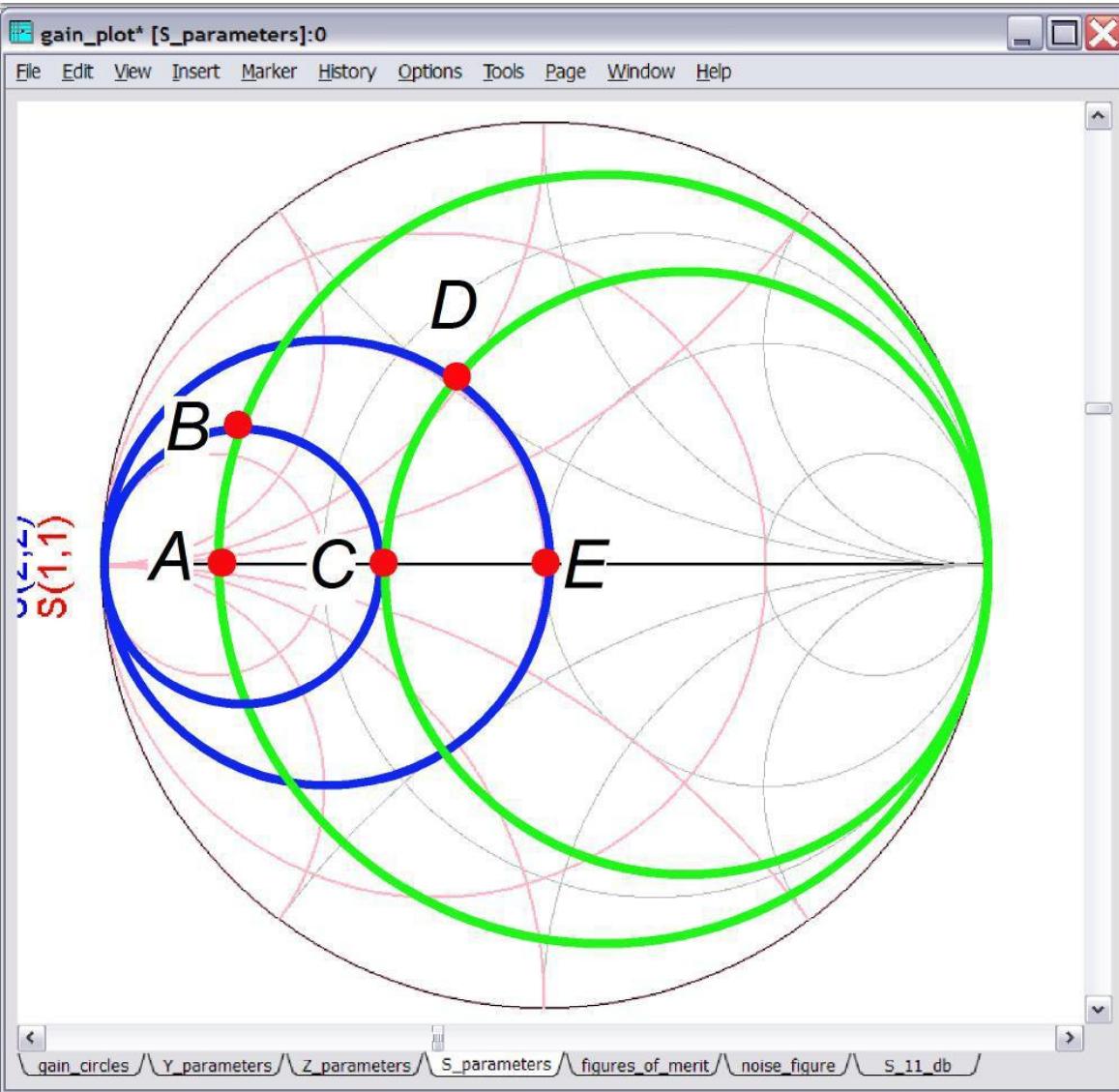
- Factor de calitate ridicat echivalent cu banda ingusta



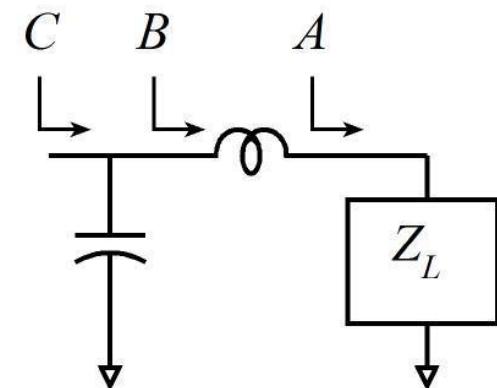
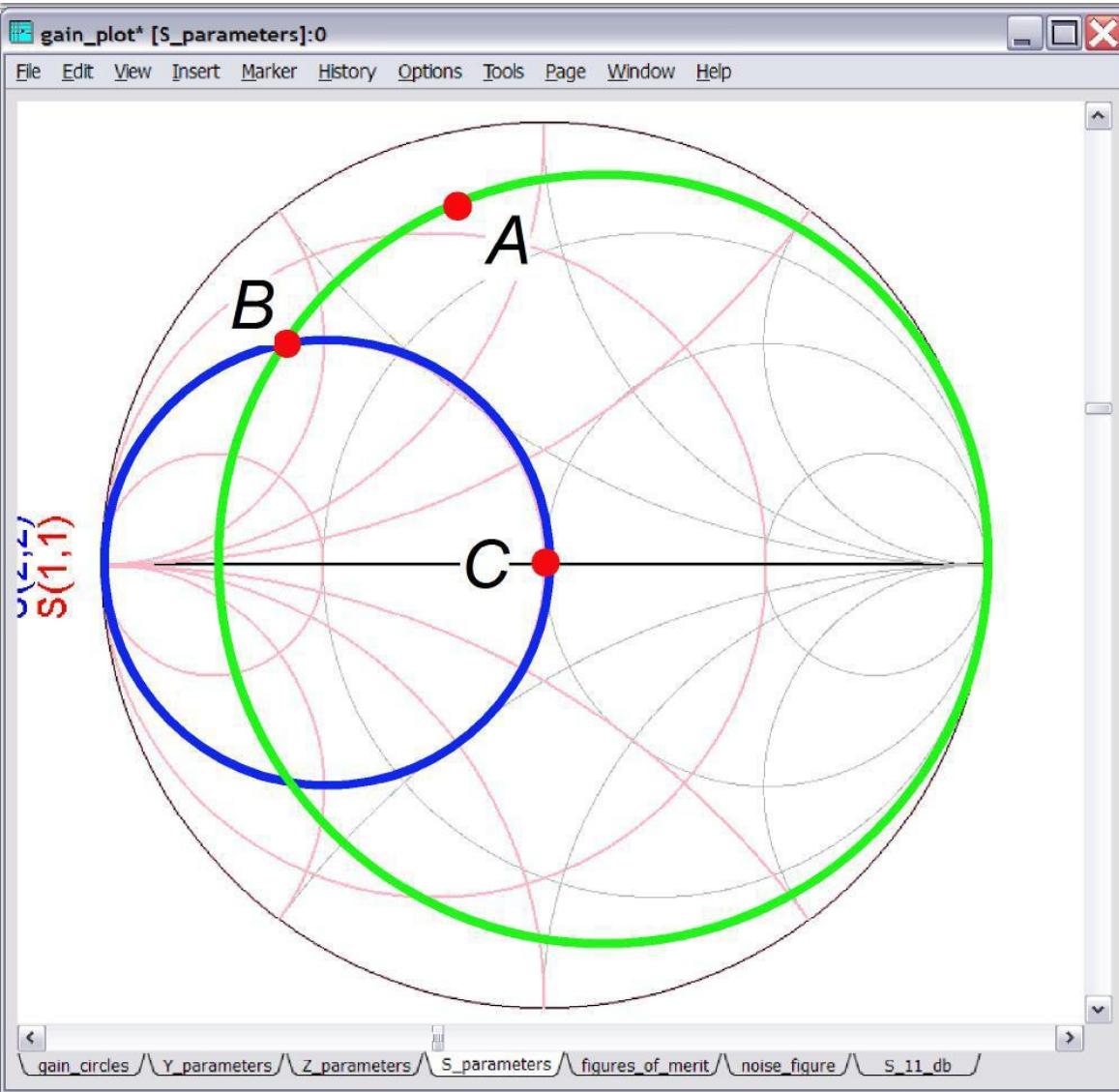
# Adaptare - banda



# Adaptare - banda

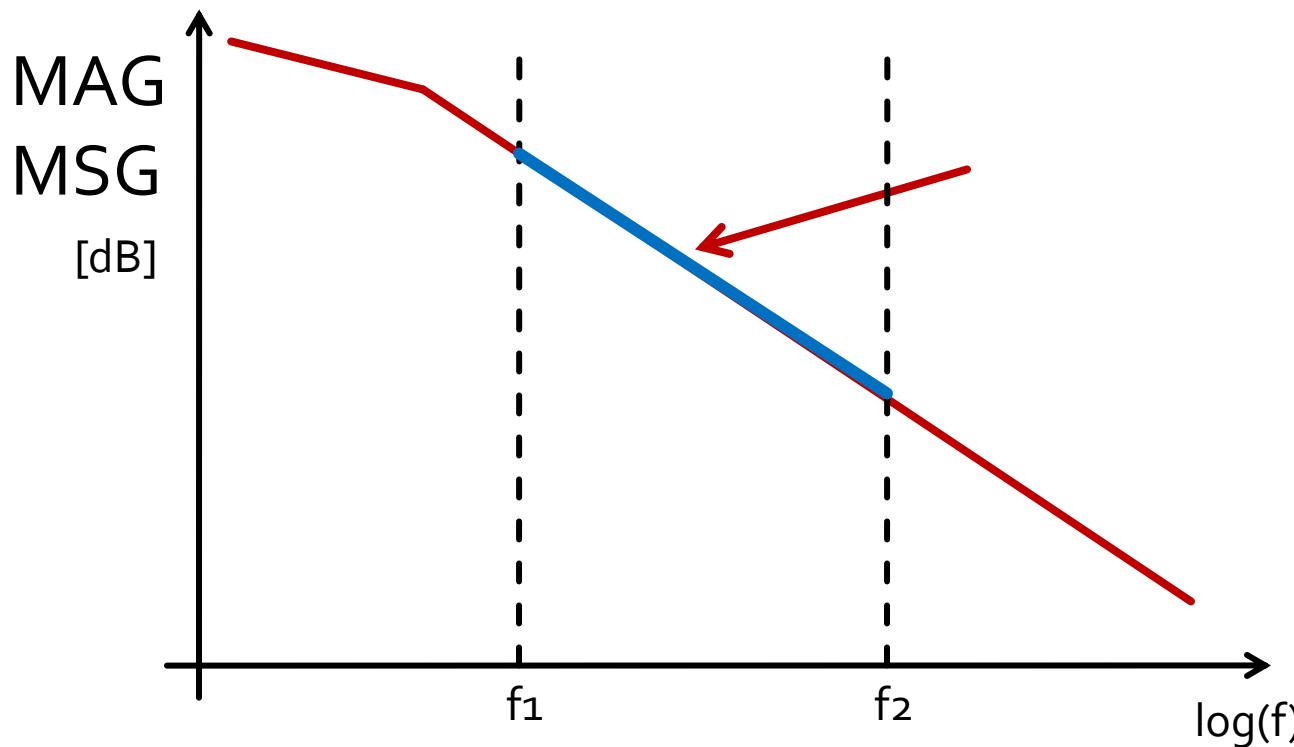


# Adaptare - banda



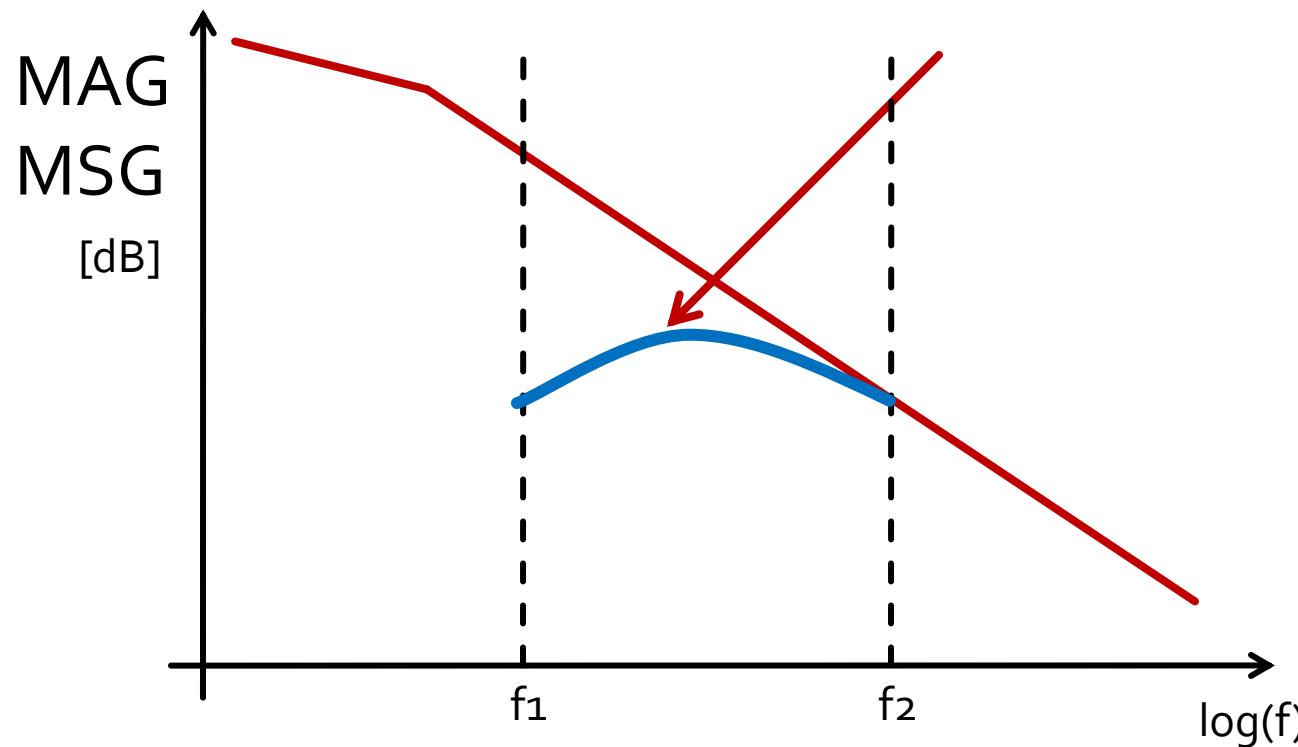
# Amplificator de banda largă

- 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

- Se realizeaza cu asumarea unilaterală a amplificatorului



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

Permite tratarea separată  
a intrării și ieșirii

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

- Castig maxim

$$\Gamma_S = S_{11}^*$$

$$\Gamma_L = S_{22}^*$$

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

# Factor de merit unilateral

- Permite estimarea erorii induse de ipoteza tranzistorului unilateral

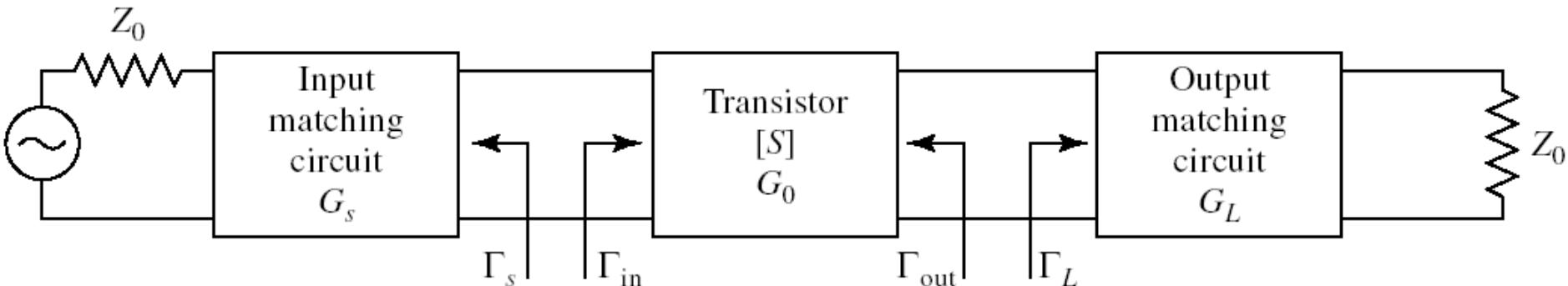
$$\frac{1}{(1+U)^2} < \frac{G_T}{G_{TU}} < \frac{1}{(1-U)^2}$$

$$U = \frac{|S_{12}| \cdot |S_{21}| \cdot |S_{11}| \cdot |S_{22}|}{\left(1 - |S_{11}|^2\right) \cdot \left(1 - |S_{22}|^2\right)}$$

- Se calculeaza U si abaterea maxima si minima a lui GTU fata de GT
  - aceasta abatere trebuie prevazuta in proiectare ca rezerva pentru castigul maxim

$$-20 \cdot \log(1+U) < G_T [dB] - G_{TU} [dB] < -20 \cdot \log(1-U)$$

# Proiectare pentru castig impus



- Daca ipoteza tranzistorului unilateral este justificata:

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

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

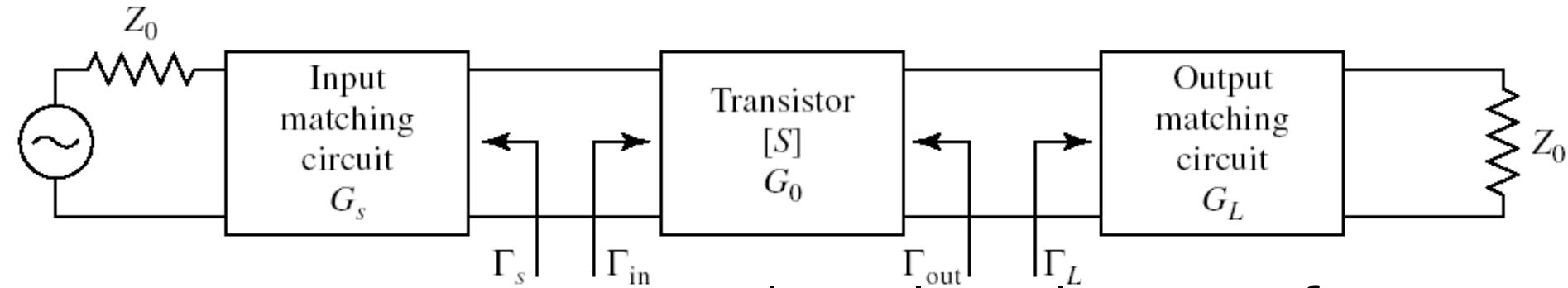
$$G_S = G_S(\Gamma_S)$$

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

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

$$G_L = G_L(\Gamma_L)$$

# Proiectare pentru castig impus

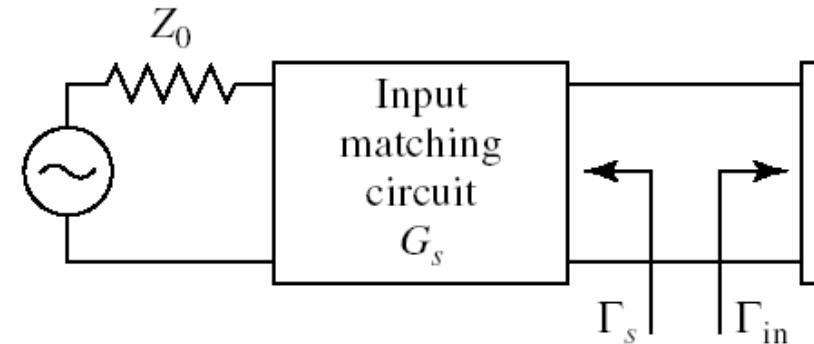


- Daca ipoteza tranzistorului unilateral este justificata:
  - castigul adaugat prin adaptare mai buna la intrare **nu** depinde de adaptarea la iesire  $G_s = G_s(\Gamma_s)$
  - castigul adaugat prin adaptare mai buna la iesire **nu** depinde de adaptarea la intrare  $G_L = G_L(\Gamma_L)$
- Adaptarile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

$$G_T = G_s \cdot G_0 \cdot G_L$$

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

# Adaptarea la intrare



$$G_s = \frac{1 - |\Gamma_s|^2}{|1 - S_{11} \cdot \Gamma_s|^2}$$

- Castig maxim pentru adaptare complex conjugata (putere) la intrare

$$\Gamma_s = S_{11}^* \Rightarrow G_{s\max} = \frac{1}{1 - |S_{11}|^2}$$

- Pentru oricare alta retea de adaptare

$$G_s = \frac{1 - |\Gamma_s|^2}{|1 - S_{11} \cdot \Gamma_s|^2} < G_{s\max} = \frac{1}{1 - |S_{11}|^2}$$

# Exemplu

- ATF-34143 at  $V_{ds}=3V$   $I_d=20mA$ .

- @5GHz

- $S_{11} = 0.64 \angle 139^\circ$
- $S_{12} = 0.119 \angle -21^\circ$
- $S_{21} = 3.165 \angle 16^\circ$
- $S_{22} = 0.22 \angle 146^\circ$

$$U = \frac{|S_{12}| \cdot |S_{21}| \cdot |S_{11}| \cdot |S_{22}|}{\left(1 - |S_{11}|^2\right) \cdot \left(1 - |S_{22}|^2\right)} = 0.094$$

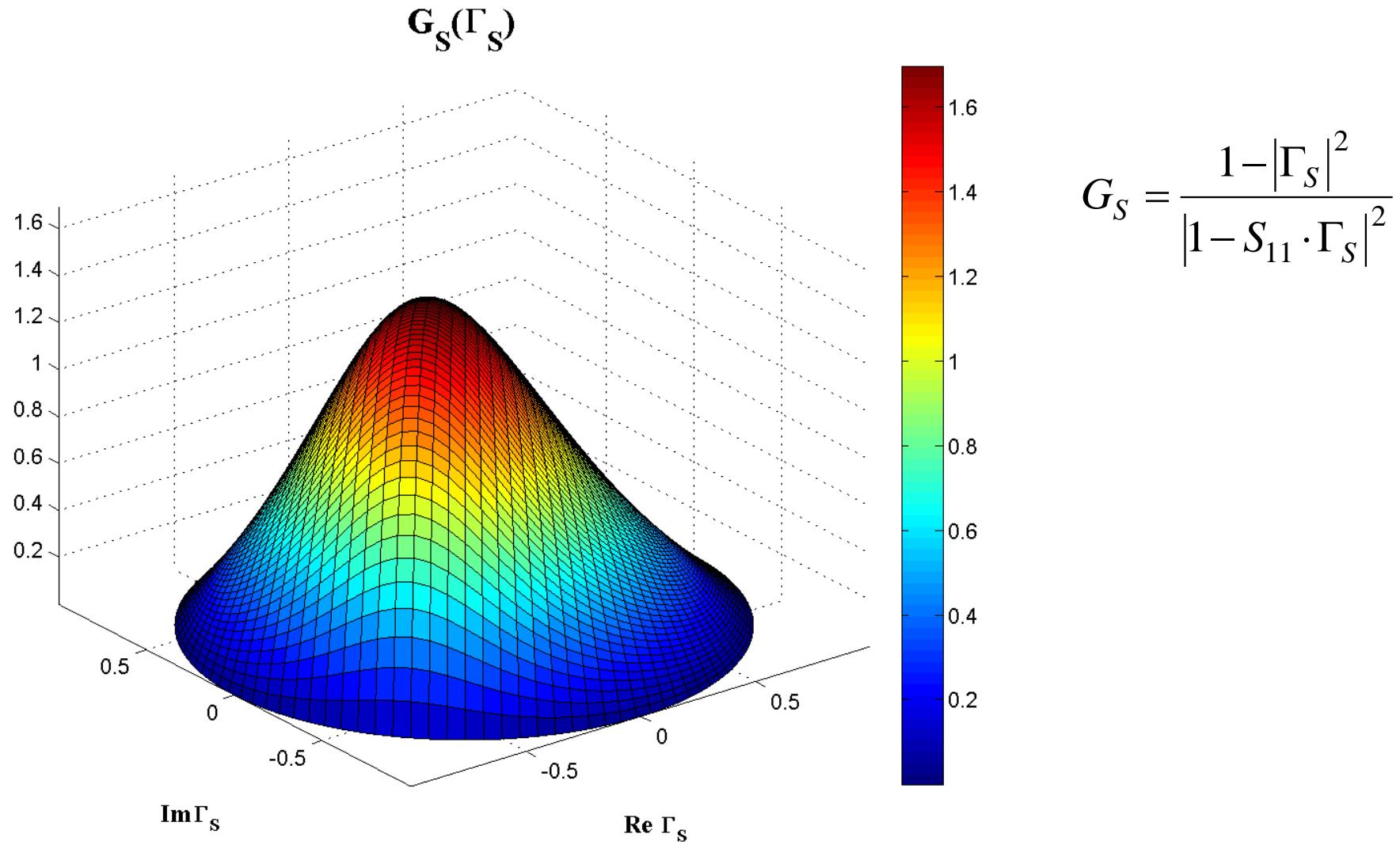
$$-0.783 \text{ dB} < G_T[\text{dB}] - G_{TU}[\text{dB}] < 0.861 \text{ dB}$$

$$G_{TU \max} = \frac{1}{1 - |S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1}{1 - |S_{22}|^2} = 17.83$$

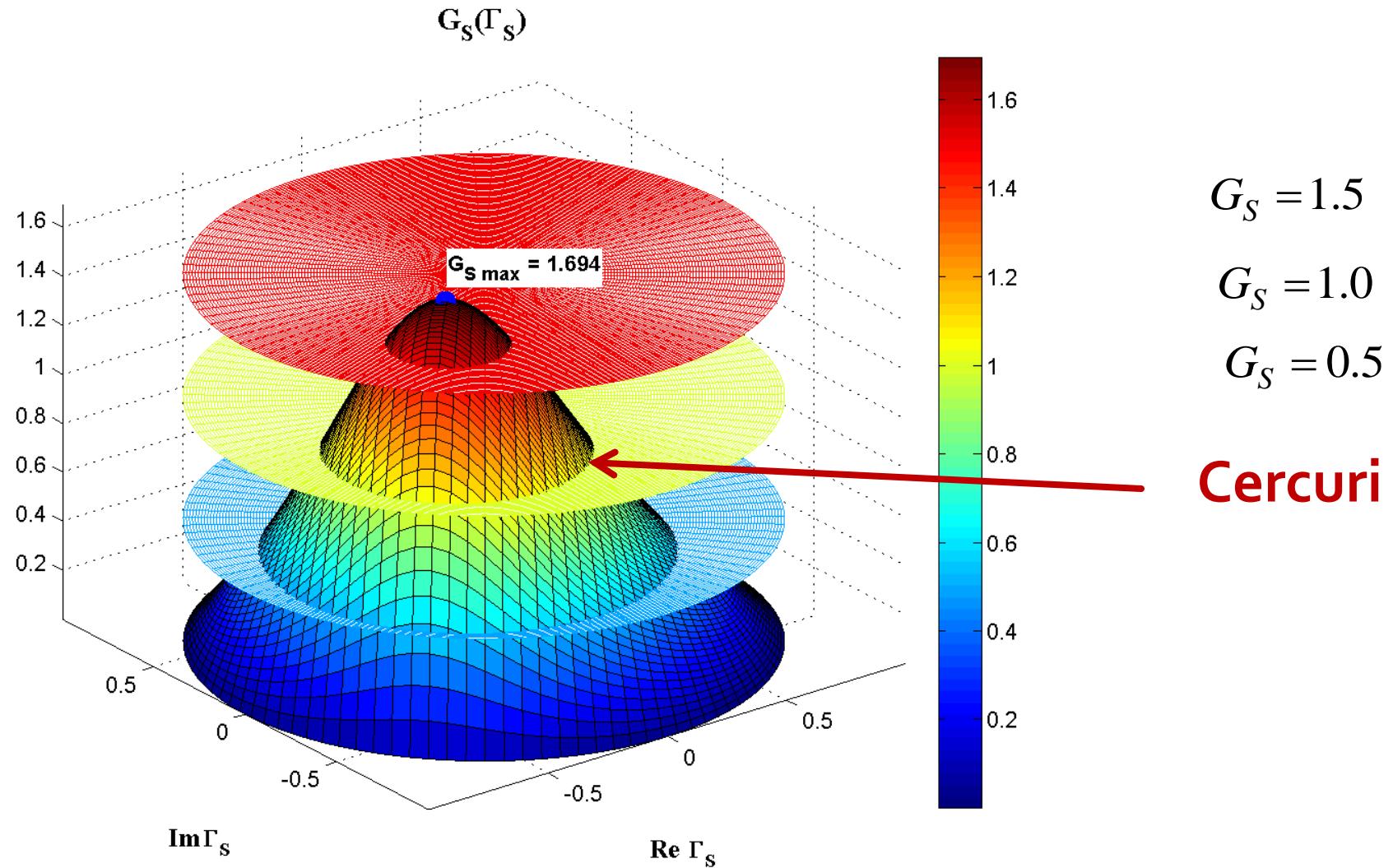
$$G_{TU \max}[\text{dB}] = 12.511 \text{ dB}$$

$$G_{S \max} = \frac{1}{1 - |S_{11}|^2} = 1.694 = 2.289 \text{ dB}$$

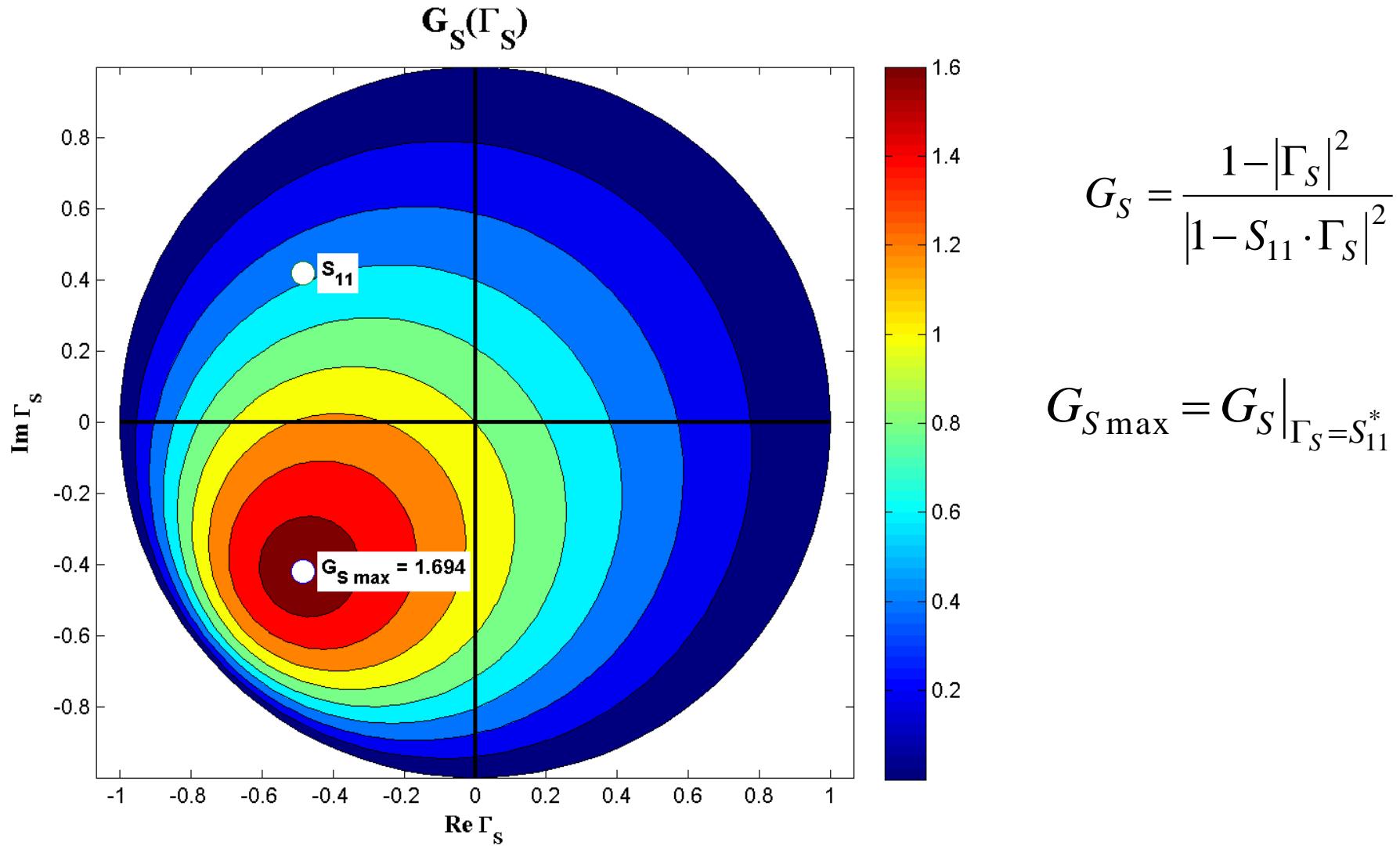
# $\mathbf{G}_S(\Gamma_S)$



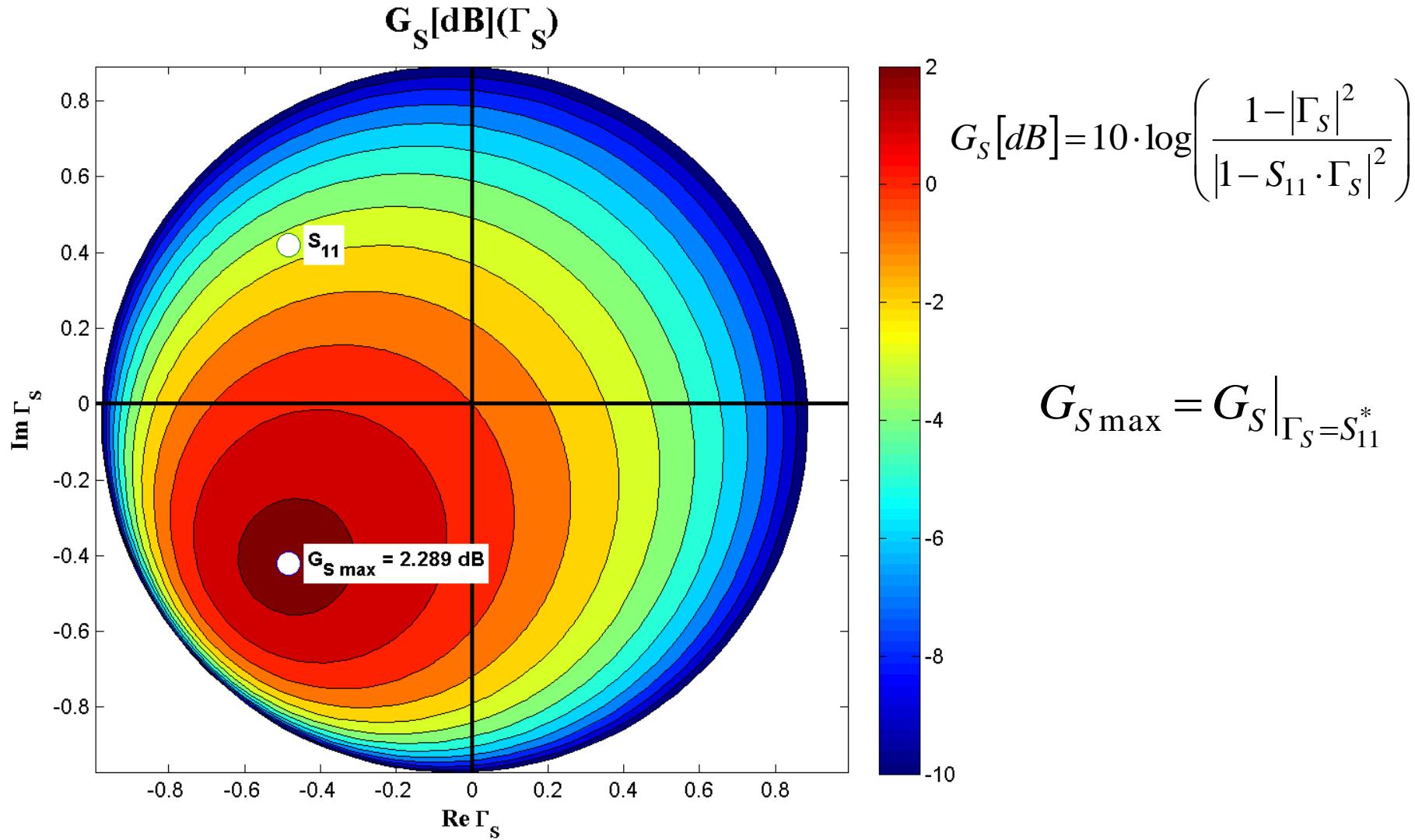
# $G_S(\Gamma_S)$ , nivel constant



# $G_S(\Gamma_S)$ , diagrama de nível



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



# Cercuri de castig constant la intrare

- Castig normat (coordonate liniare)

$$g_S = \frac{G_S}{G_{S\max}} = \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2} \cdot (1 - |S_{11}|^2) < 1$$

- Punctele de nivel constant, pentru un  $g_s < 1$  fixat

$$\begin{aligned} g_S \cdot |1 - S_{11} \cdot \Gamma_S|^2 &= (1 - |\Gamma_S|^2) \cdot (1 - |S_{11}|^2) \\ (g_S \cdot |S_{11}|^2 + 1 - |S_{11}|^2) \cdot |\Gamma_S|^2 - g_S \cdot (S_{11} \cdot \Gamma_S + S_{11}^* \cdot \Gamma_S^*) &= 1 - |S_{11}|^2 - g_S \\ \Gamma_S \cdot \Gamma_S^* - \frac{g_S \cdot (S_{11} \cdot \Gamma_S + S_{11}^* \cdot \Gamma_S^*)}{1 - (1 - g_S) \cdot |S_{11}|^2} &= \frac{1 - |S_{11}|^2 - g_S}{1 - (1 - g_S) \cdot |S_{11}|^2} \quad \leftarrow + \frac{g_S^2 \cdot |S_{11}|^2}{[1 - (1 - g_S) \cdot |S_{11}|^2]^2} \end{aligned}$$

# 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  $g_{\text{cerc}} = G_{\text{cerc}}/G_{S\max}$  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  $G_S > G_{\text{cerc}}$

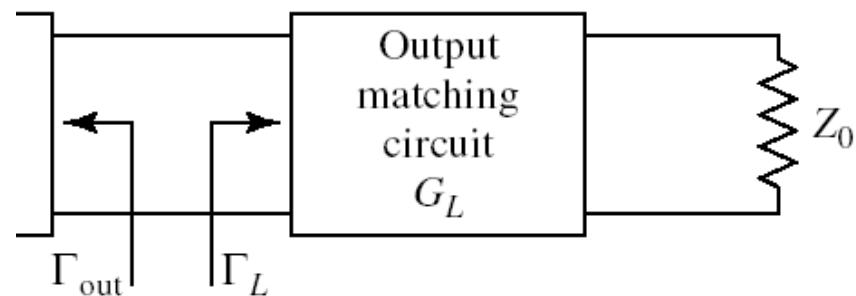
# Cercuri de castig constant la intrare

$$C_S = \frac{g_S \cdot S_{11}^*}{1 - (1 - g_S) \cdot |S_{11}|^2}$$

$$R_S = \frac{\sqrt{1 - g_S} \cdot (1 - |S_{11}|^2)}{1 - (1 - g_S) \cdot |S_{11}|^2}$$

- Centrele cercurilor se gasesc pe segmentul care unește  $\Gamma_S = S_{11}^*$  cu centrul diagramei Smith
- Cercurile se traseaza (traditional, CAD) in **coordonate logaritmice** ([dB])
  - relatiile de calcul sunt in coordonate **liniare** !
- Cercul corespunzator lui  $g_S = 0$  dB trece prin origine

# Cercuri de castig constant la iesire



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

- Castig maxim  $\Gamma_L = S_{22}^* \Rightarrow G_{L\max} = \frac{1}{1 - |S_{22}|^2}$

$$g_L = \frac{G_L}{G_{L\max}} = \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2} \cdot (1 - |S_{22}|^2) < 1$$

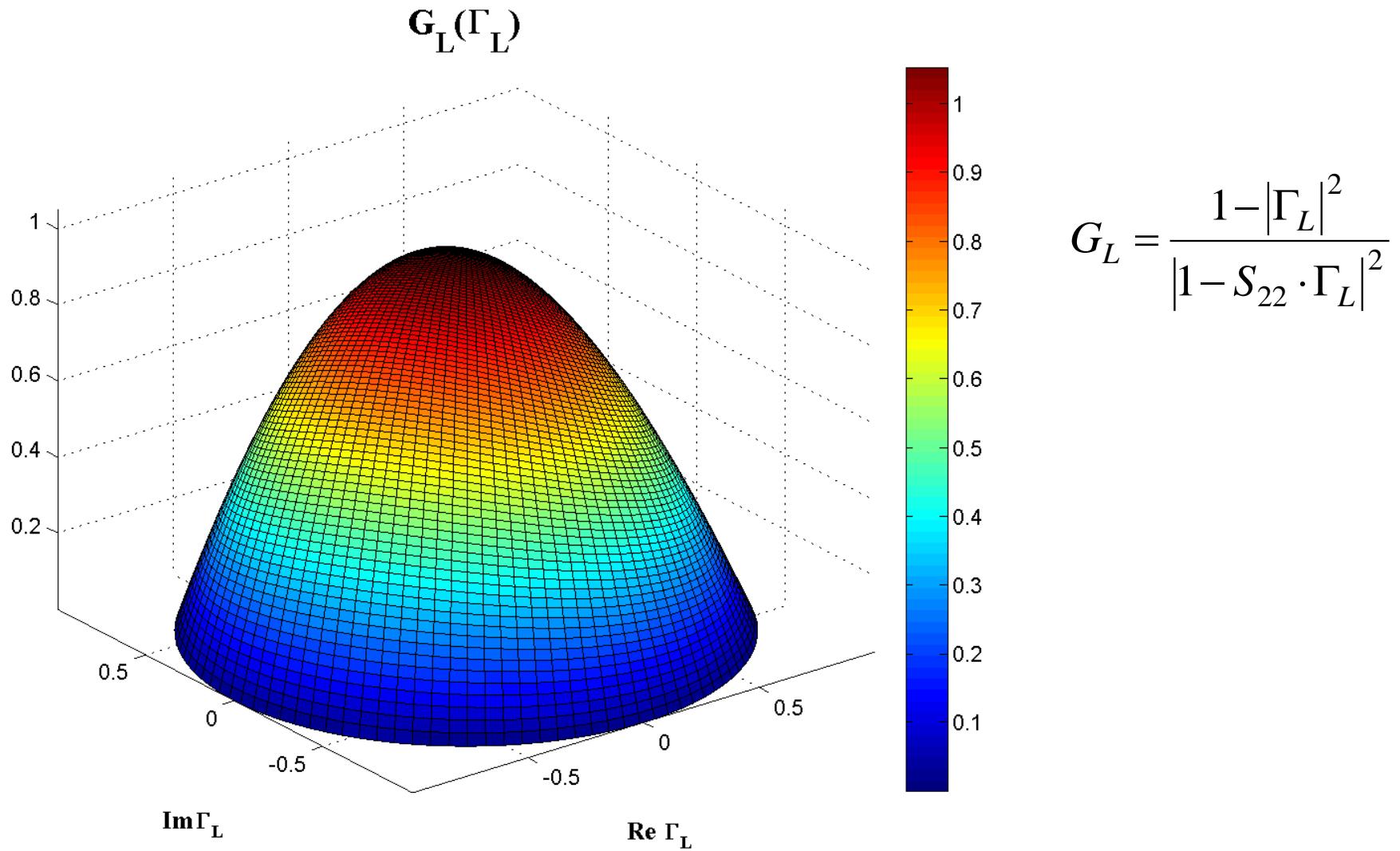
- Calcul similar

$$C_L = \frac{g_L \cdot S_{22}^*}{1 - (1 - g_L) \cdot |S_{22}|^2}$$

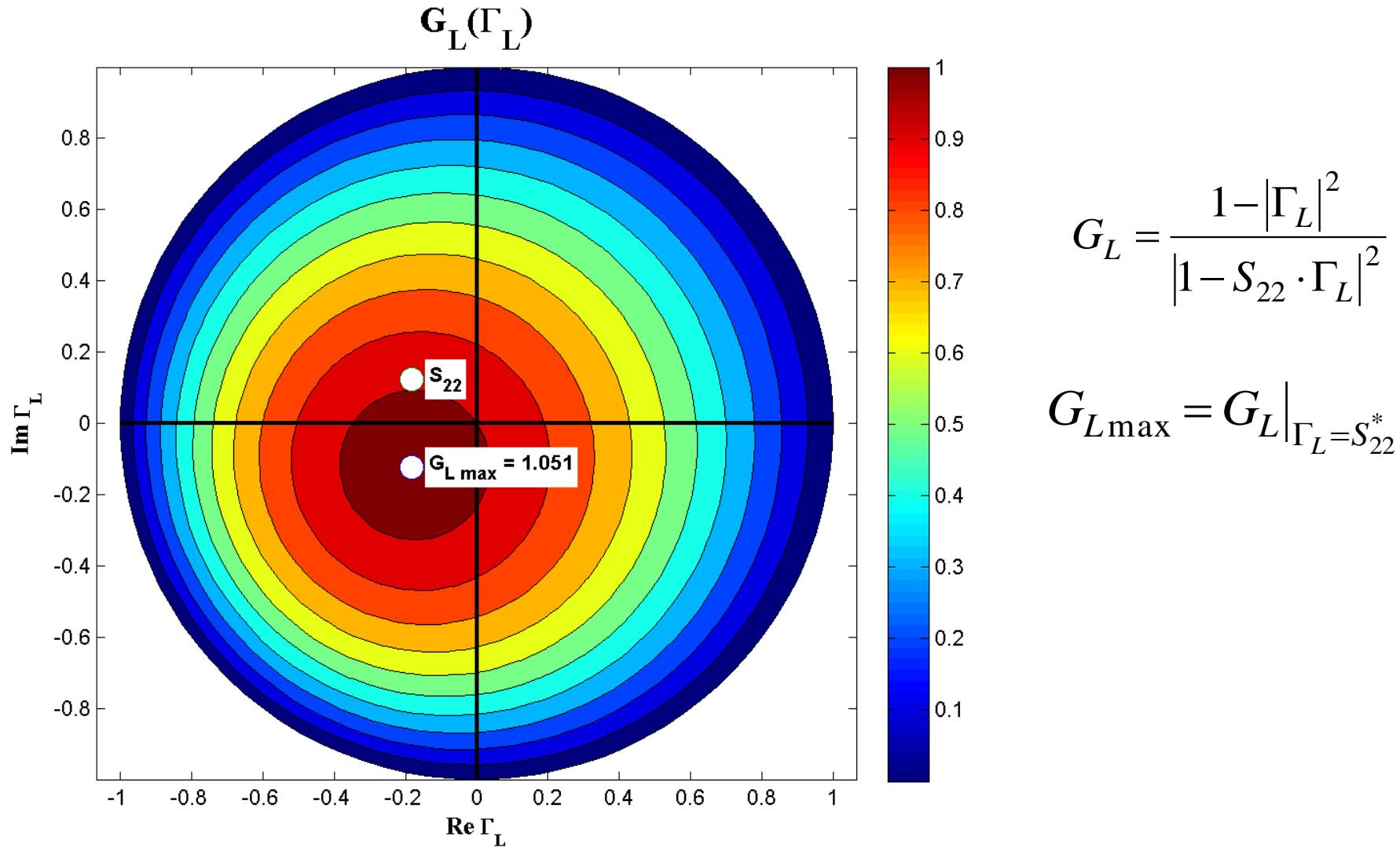
$$R_L = \frac{\sqrt{1 - g_L} \cdot (1 - |S_{22}|^2)}{1 - (1 - g_L) \cdot |S_{22}|^2}$$

- Exemplu  $G_{L\max} = \frac{1}{1 - |S_{22}|^2} = 1.051 = 0.215 \text{ dB}$

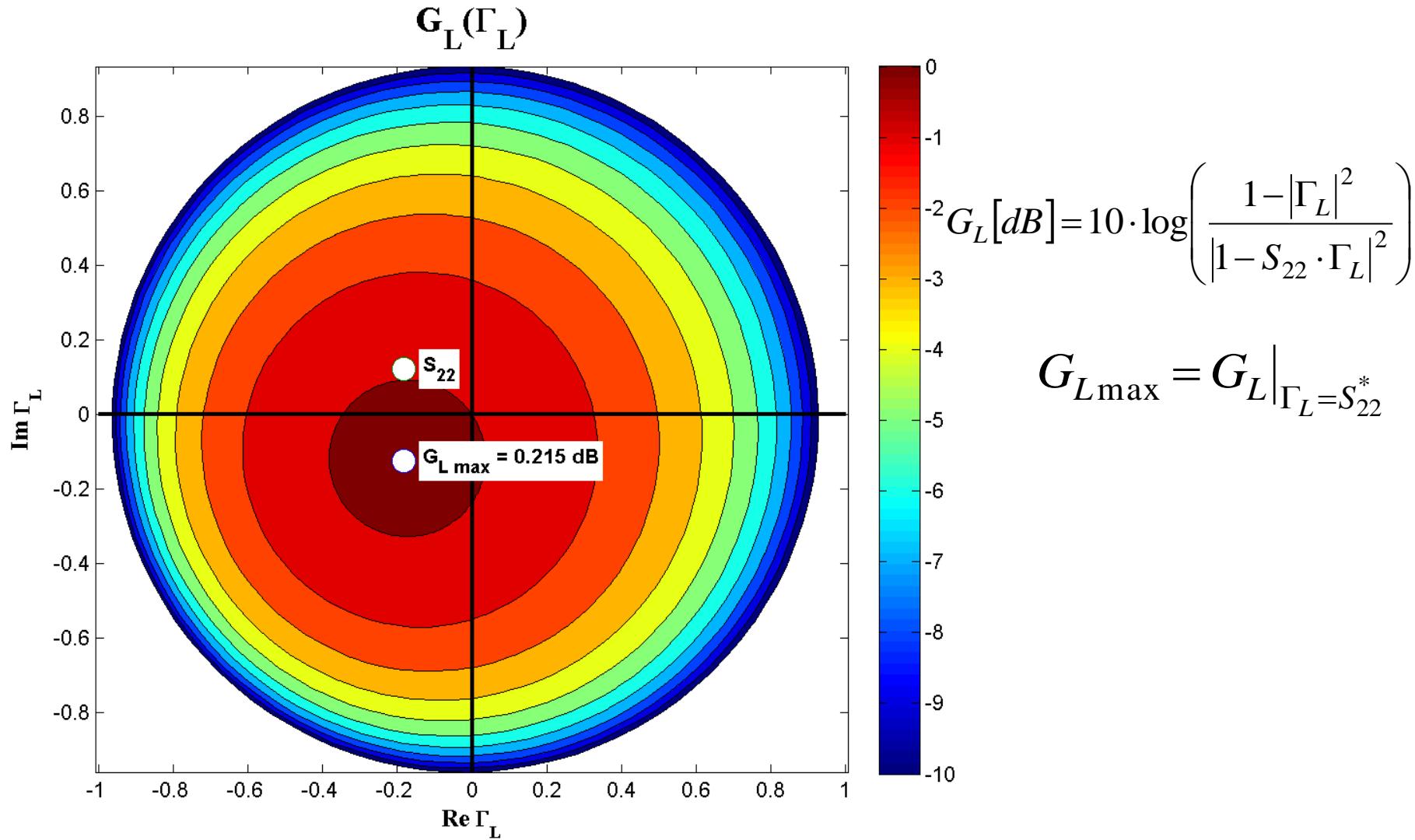
# $\mathbf{G}_L(\Gamma_L)$



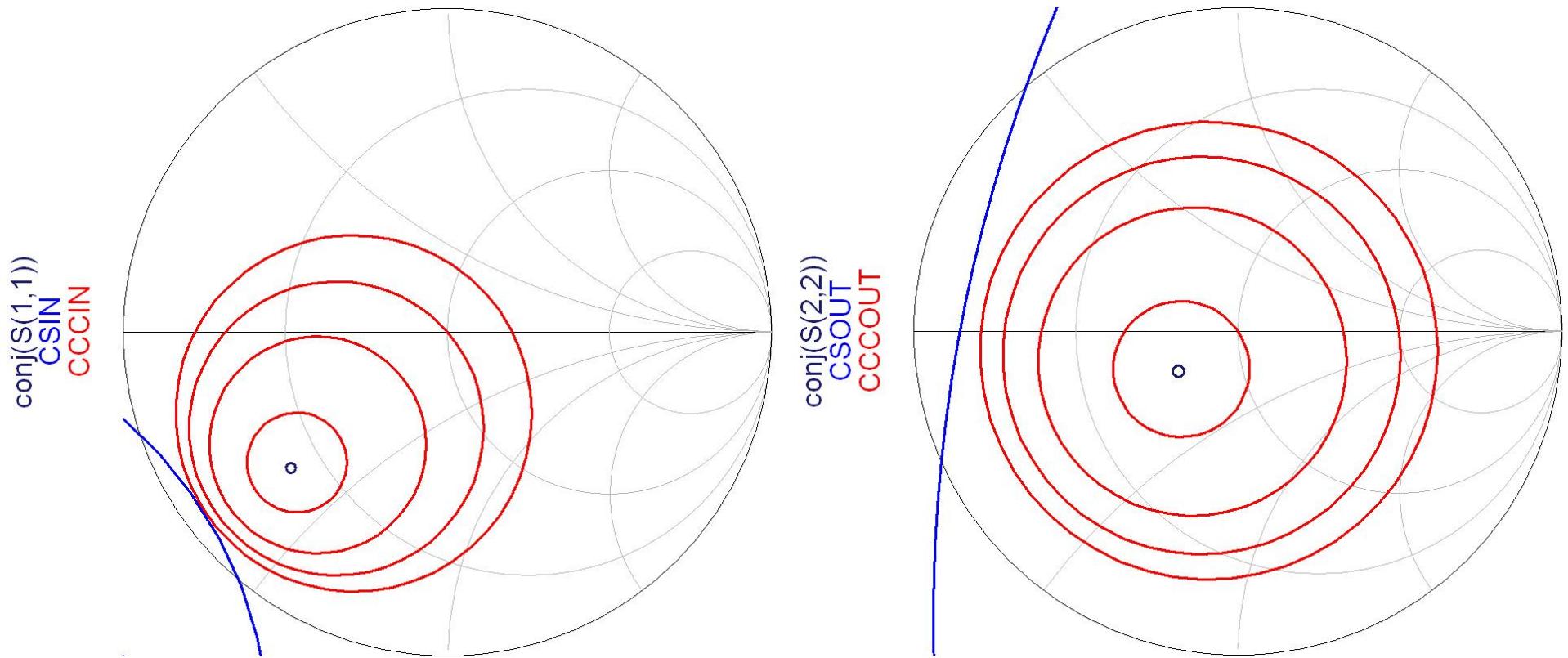
# $G_L(\Gamma_L)$ , diagrama de nível



# $G_L[\text{dB}](\Gamma_L)$ , diagrama de nível



# ADS



- Cerculile se reprezinta pentru valorile cerute in dB
- Este utila calcularea  $G_{S\max}$  si  $G_{L\max}$  anterior

# Proiectare pentru castig impus

- Se calculeaza  $G_o$ ,  $G_{S_{max}}$ ,  $G_{L_{max}}$
- Pentru obtinerea castigului impus se **aleg** valorile suplimentare necesare (suplimentar la  $G_o$ )
  - se tine cont de abaterea caracterizata de factorul de merit U

$$G_{dorit} [dB] = G_{S\_dor} [dB] + G_0 [dB] + G_{L\_dor} [dB]$$

- Se reprezinta cercurile de castig pentru valorile alese  $G_{S\_dor}$ ,  $G_{L\_dor}$
- Se proiecteaza retelele de adaptare care muta coeficientul de reflexie **pe** sau **in interiorul** cercurilor dorite (in functie de aplicatie)

# Contact

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