

Curs 7
2017/2018

Dispozitive și circuite de microunde pentru radiocomunicații

Documentatie

- RF-OPTO
 - <http://rf-opto.eti.tuiasi.ro>
- Fotografie
 - de trimis prin email: ~~rdamian@etti.tuiasi.ro~~
 - necesara la laborator/curs

Software

- ADS ~~2016~~ 2017
- EmPro ~~2015~~ 2017
- pe baza de IP din exterior

Date:

Grupa	5601 (2017/2018)
Specializarea	Master Retele de Comunicatii
Marca	857

[Acceseaza ca acest student](#) | [Cere acces la licente](#)

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TMPAW	Tehnici moderne de proiectare a aplicatiilor web	N	29/05/2017	Nota finala	10	-

Nume
MOOROUN

Email

Cod de verificare
344bd9f

Trimite

Software

Advanced Design System
Premier High-Frequency and High Speed Design Platform
2016.01

KEYSIGHT TECHNOLOGIES

© Keysight Technologies 1985-2016

JW License Setup Wizard for Advanced Design System 2016.01

Specify Remote License Server
Enter the name of the network license server you wish to add or replace.

Advanced Design System 2016.01
Enter the ne

Network li Examining your license server...
(e.g. 27001)

What is a ne
How do I know which network license server to use?
How do I specify a network license server name?
Can I find out the network license server name from the license file?

Details < Back Next > Exit

Update Availability Legend: License available License in use or not available << Hide D

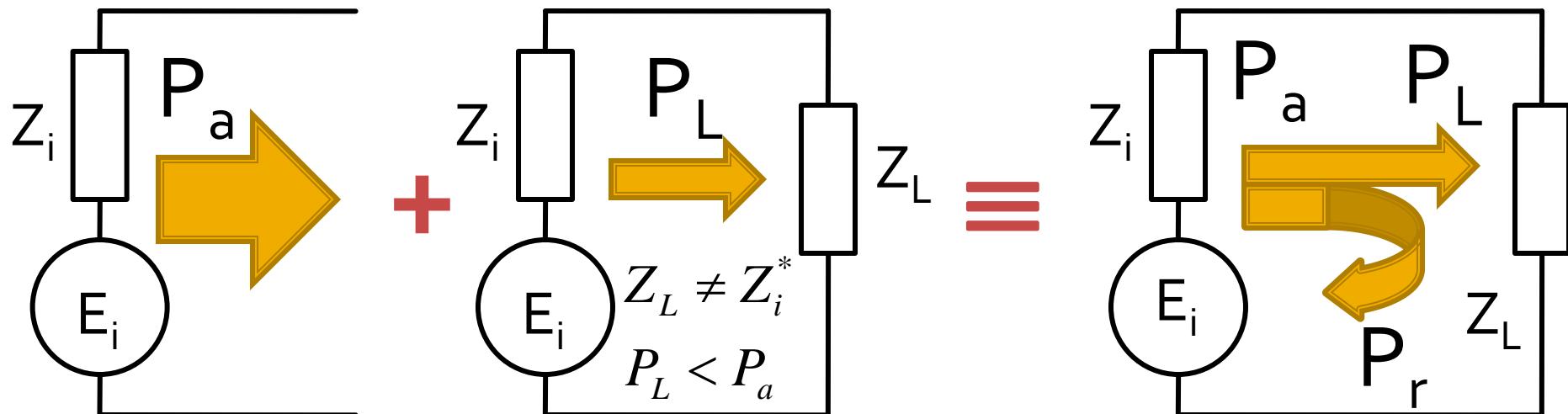
ADS Inclusive

License is available

Number of licenses: Used: Version: Expires:

b_ads_i

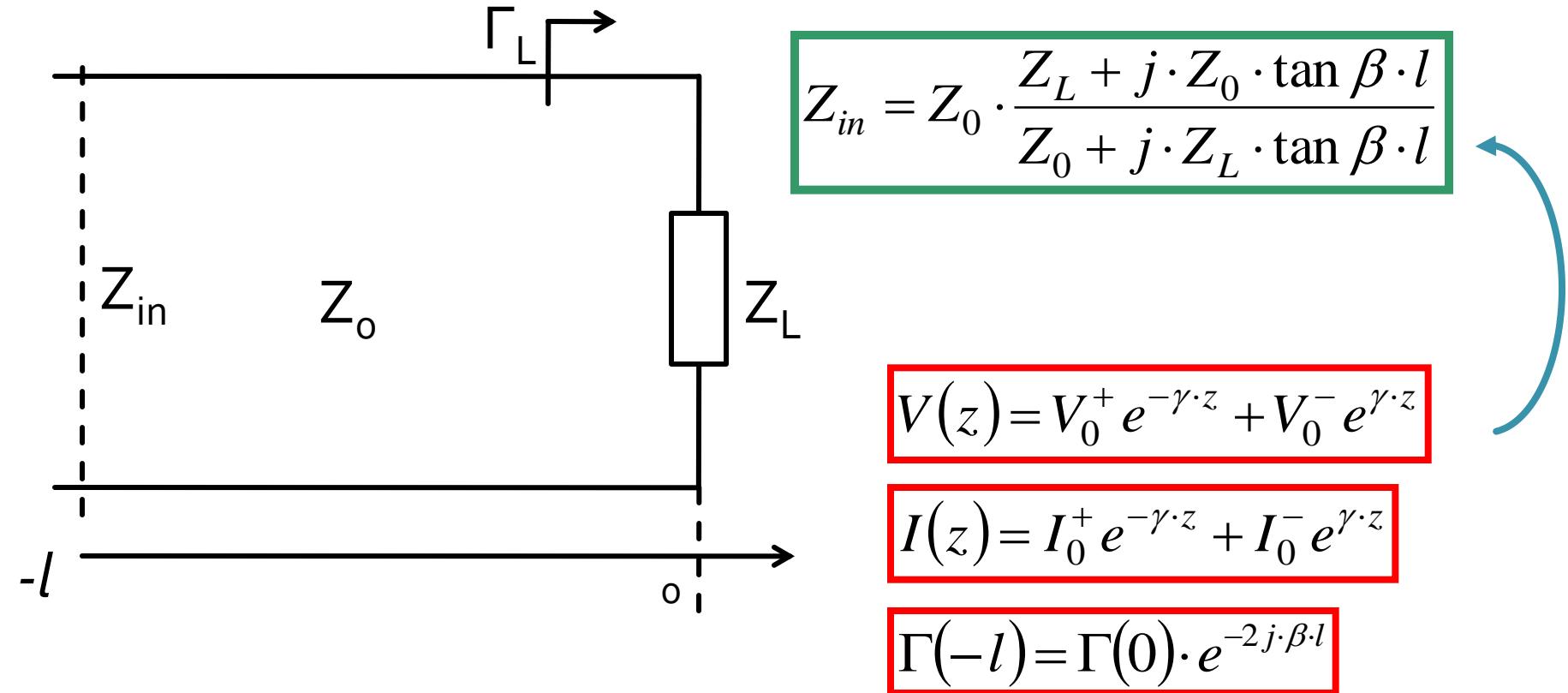
Reflexie de putere / Model



- Generatorul are posibilitatea de a oferi o anumita putere maxima de semnal P_a
- Pentru o sarcina oarecare, acesteia i se ofera o putere de semnal mai mica $P_L < P_a$
- Se intampla **“ca si cum”** (model) o parte din putere se reflecta $P_r = P_a - P_L$
- Puterea este o marime **scalara!**

Linii de transmisie in mod TEM

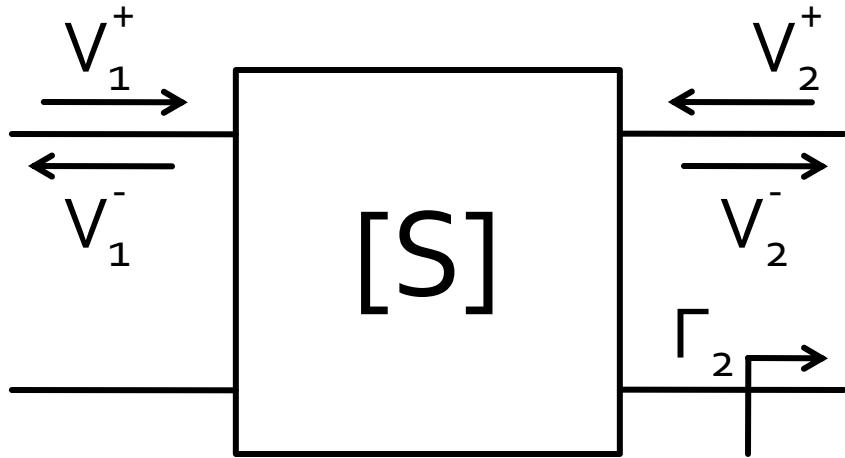
Linie fara pierderi +/-



**Analiza la nivel de rețea a
circuitelor de microunde**

Matricea S (repartitie)

- Scattering parameters



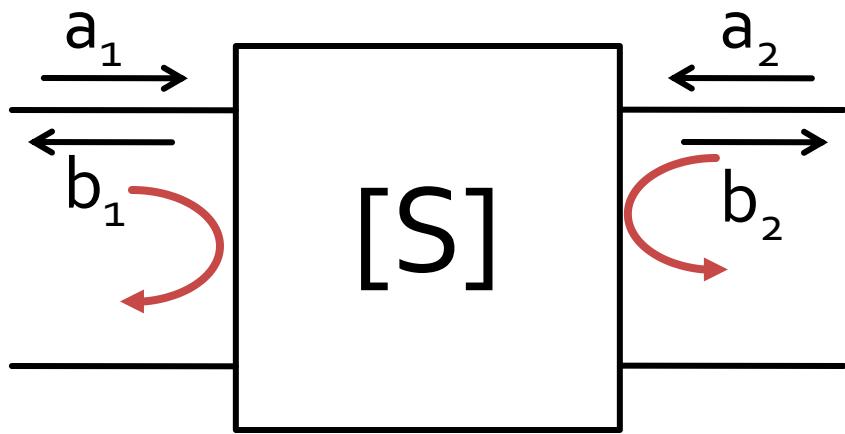
$$\begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

$$S_{11} = \frac{V_1^-}{V_1^+} \Big|_{V_1^+=0} \quad S_{21} = \frac{V_2^-}{V_1^+} \Big|_{V_2^+=0}$$

- $V_2^+ = 0$ are semnificatia: la portul 2 este conectata impedanta care realizeaza conditia de adaptare (complex conjugat)

$$\Gamma_2 = 0 \rightarrow V_2^+ = 0$$

Matricea S (repartitie)

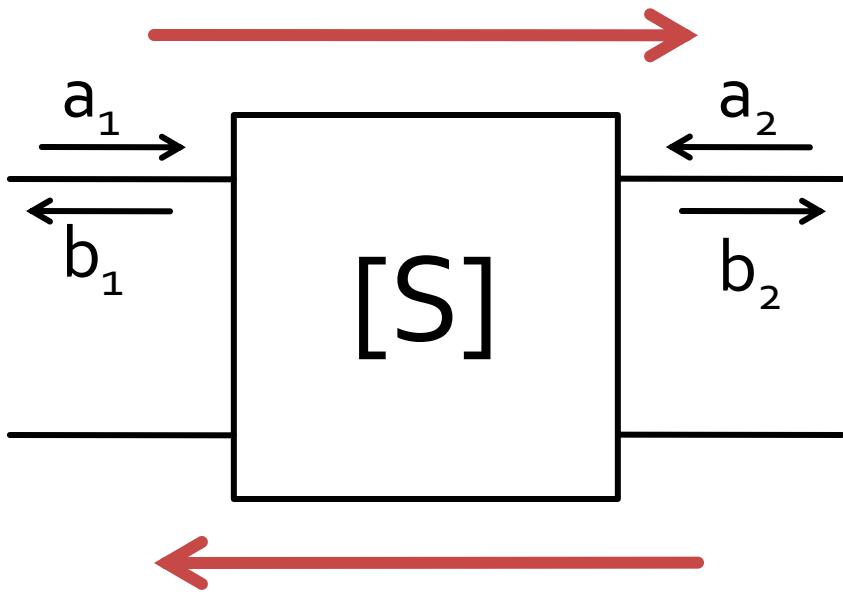


$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

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

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

Matricea S (repartitie)



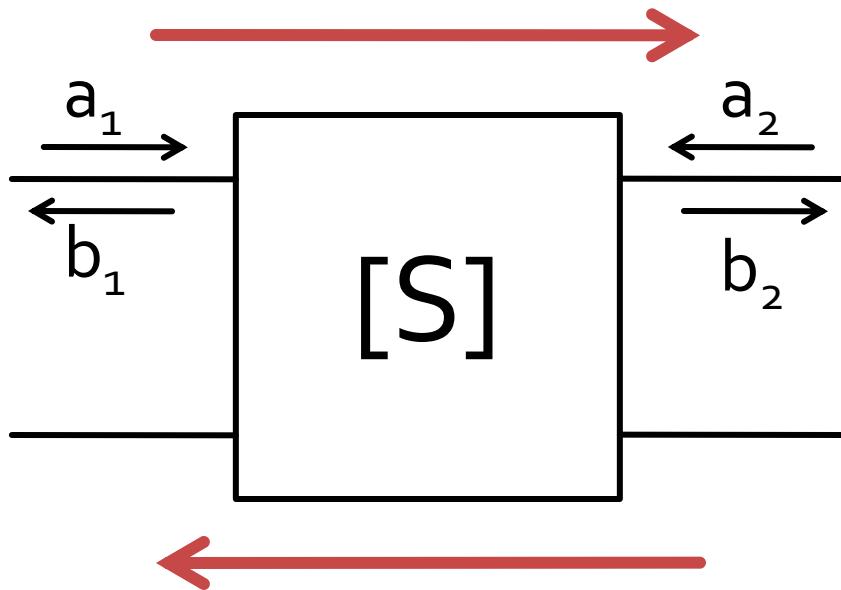
$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

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

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

- 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

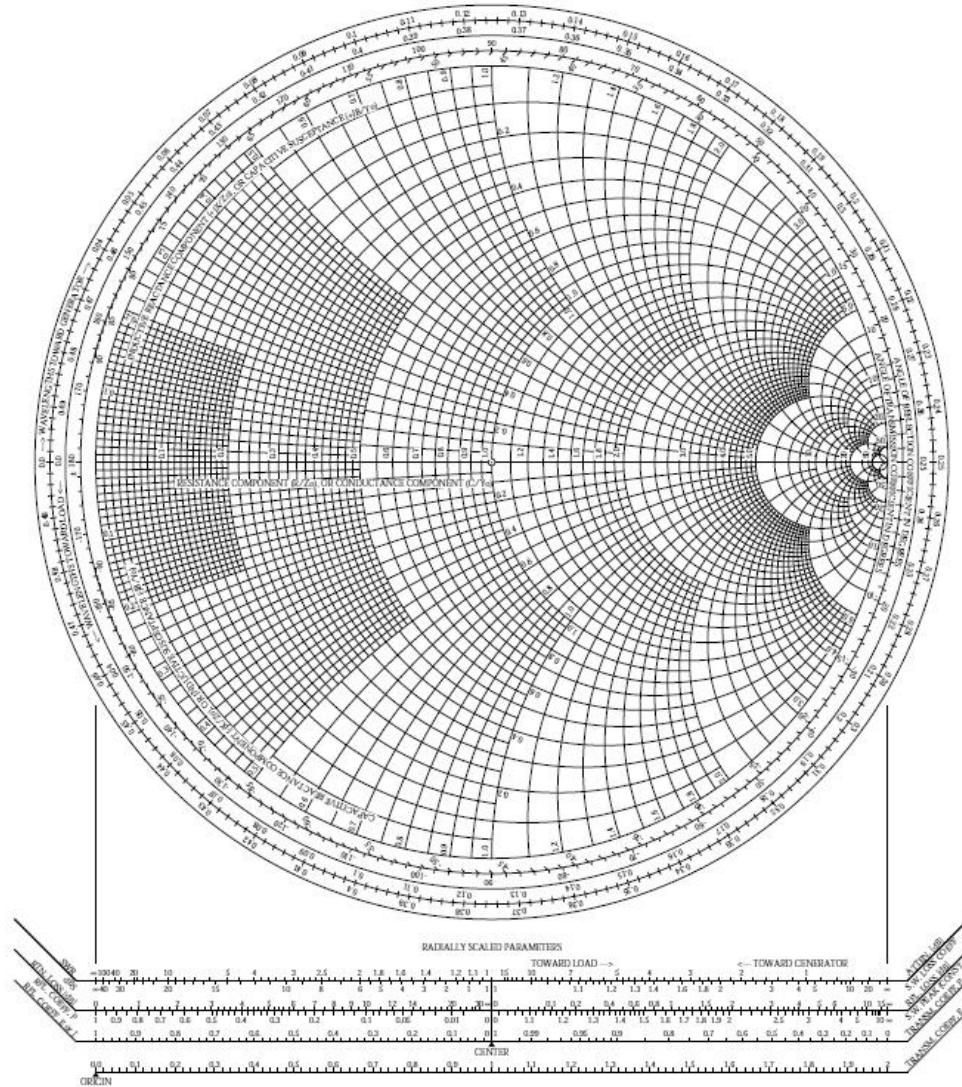
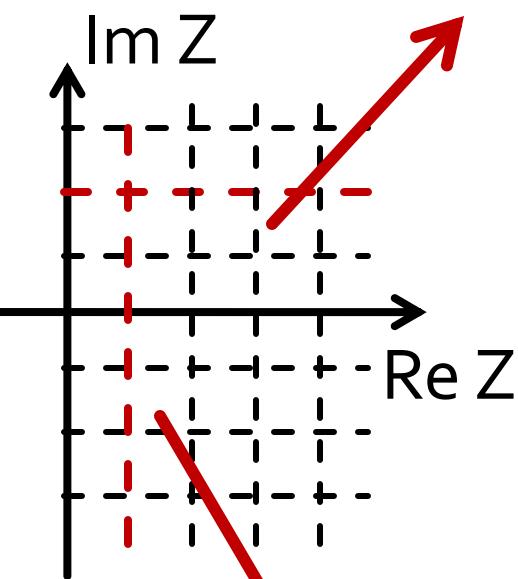


Diagrama Smith

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



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

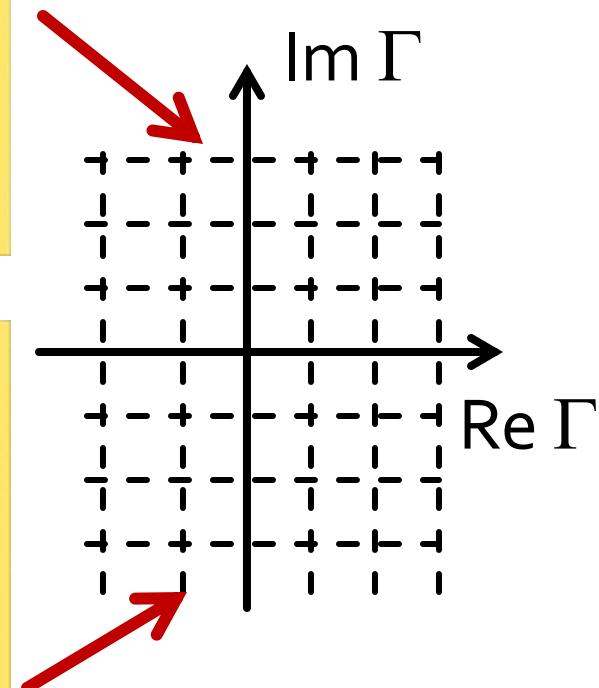
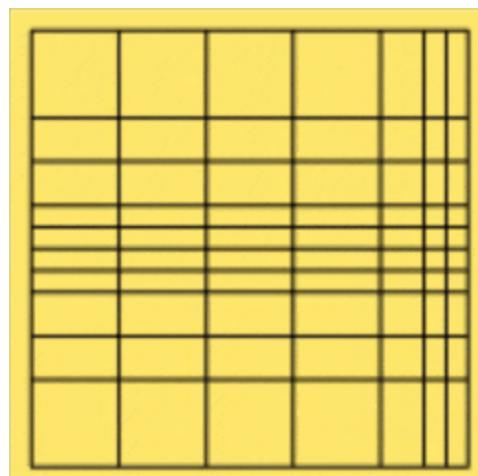
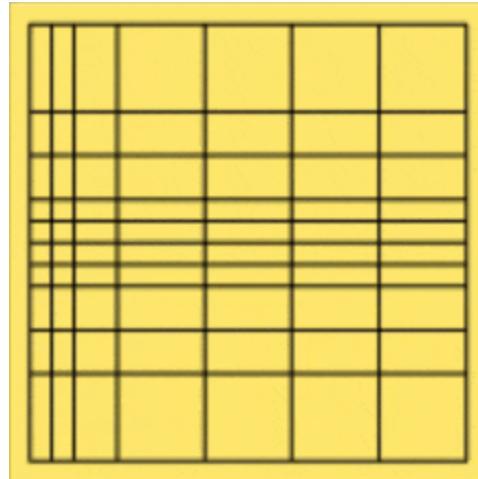
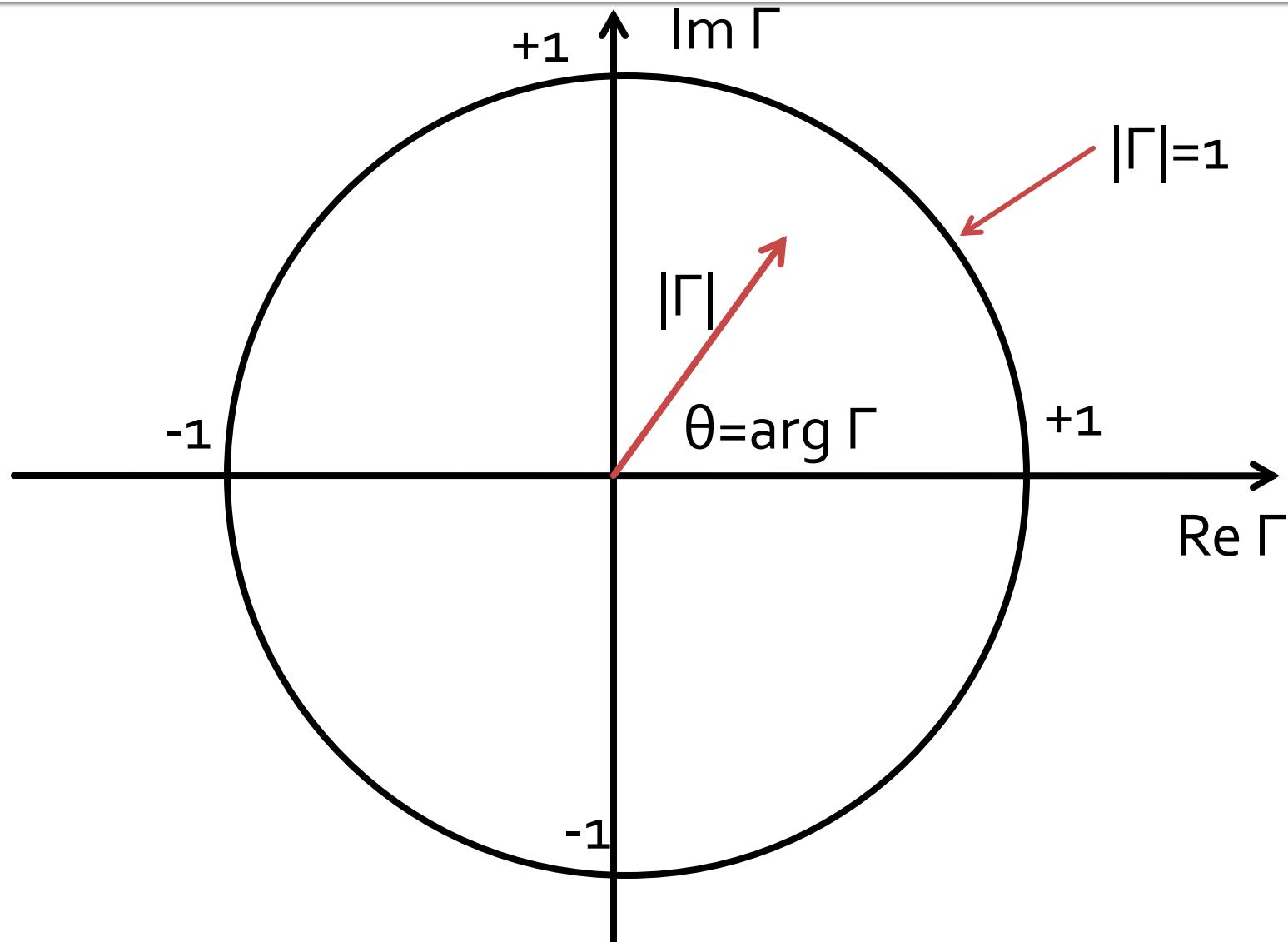


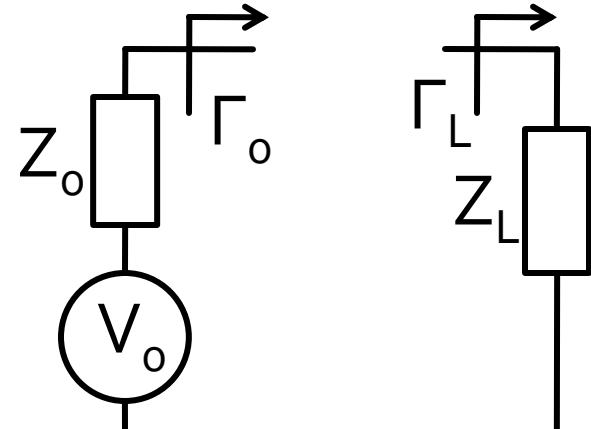
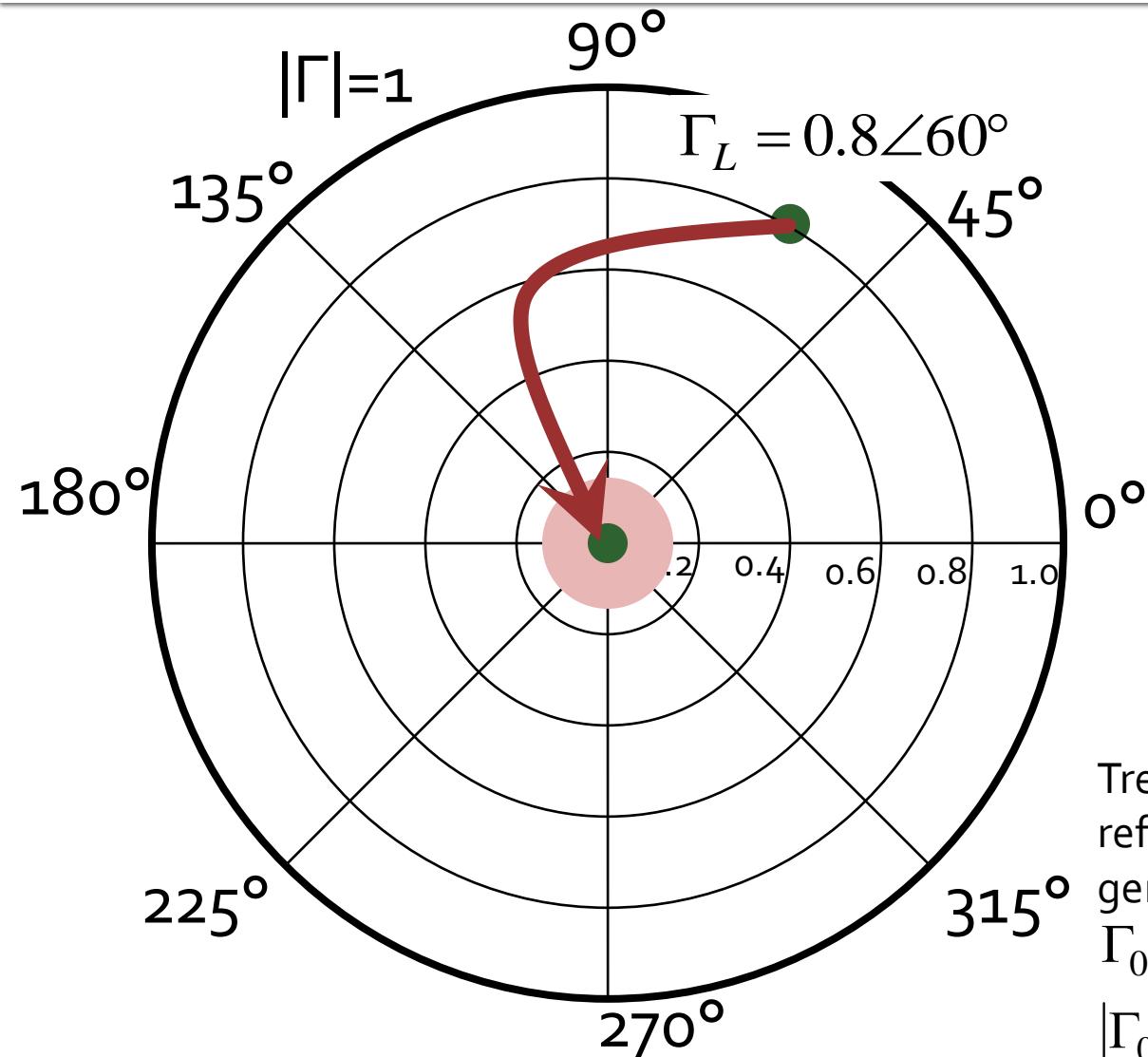
Diagrama Smith



Adaptarea cu elemente concentrate (Retele in L)

Adaptarea de impedanță

Diagrama Smith, adaptare



Adaptare Z_L la Z_0 . Se raporteaza Z_L la Z_0

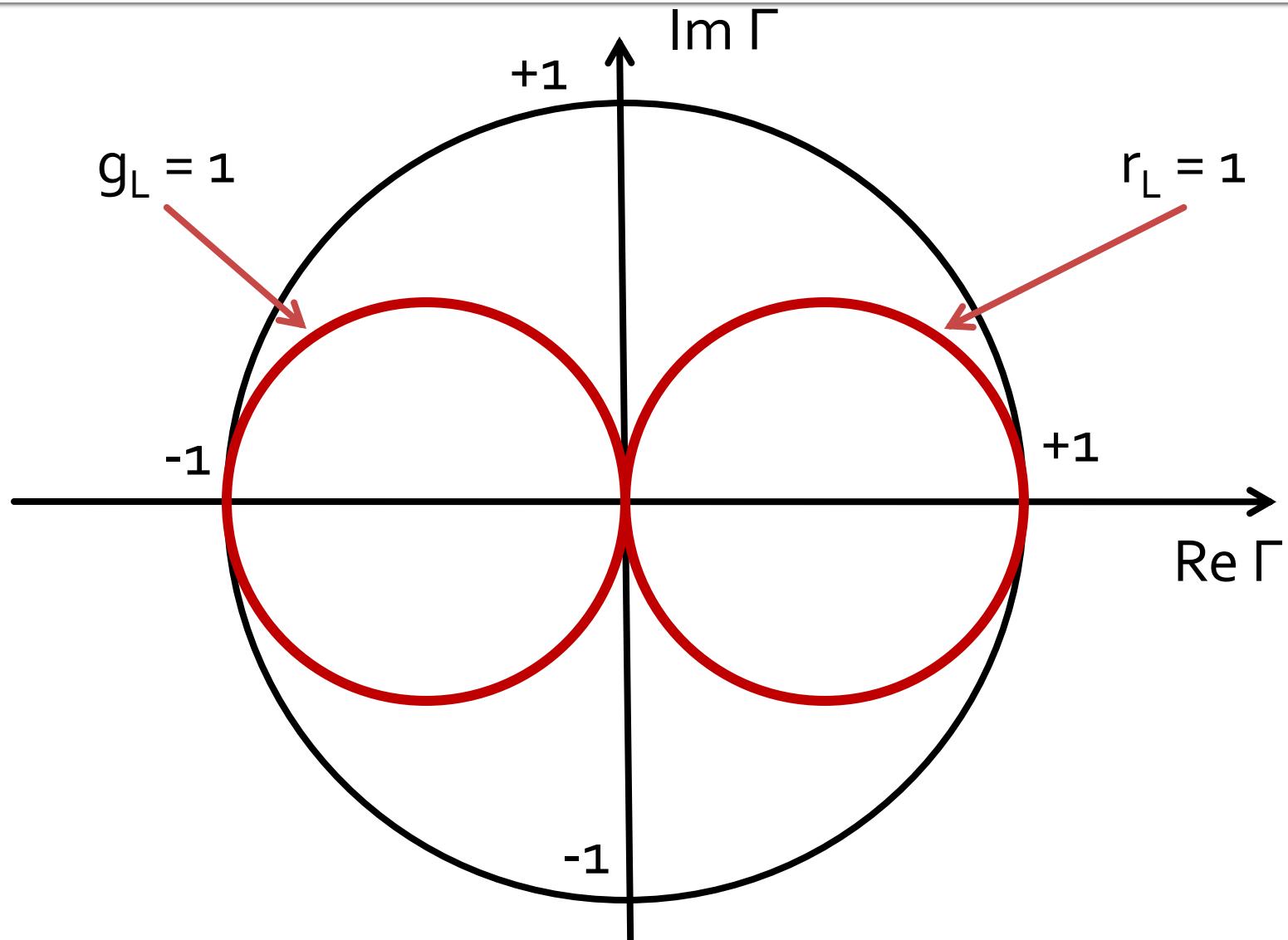
$$Z_L = 21.429\Omega + j \cdot 82.479\Omega$$
$$z_L = 0.429 + j \cdot 1.65$$
$$\Gamma_L = 0.8 \angle 60^\circ$$

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

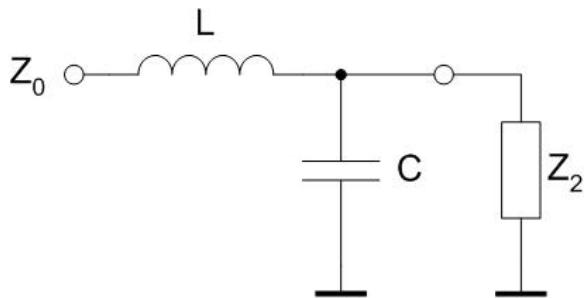
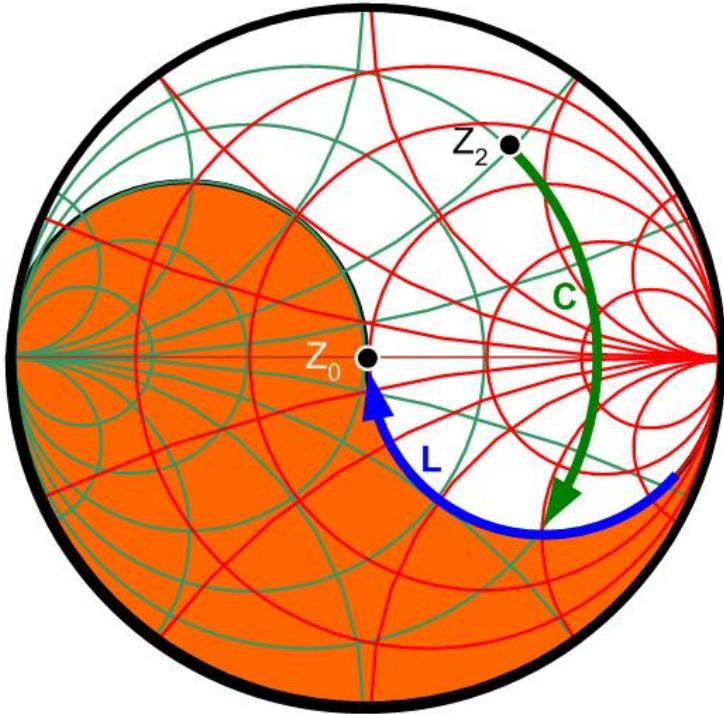
$\Gamma_0 = 0$ adaptare perfecta

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

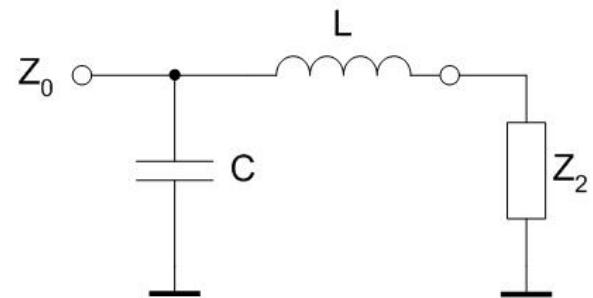
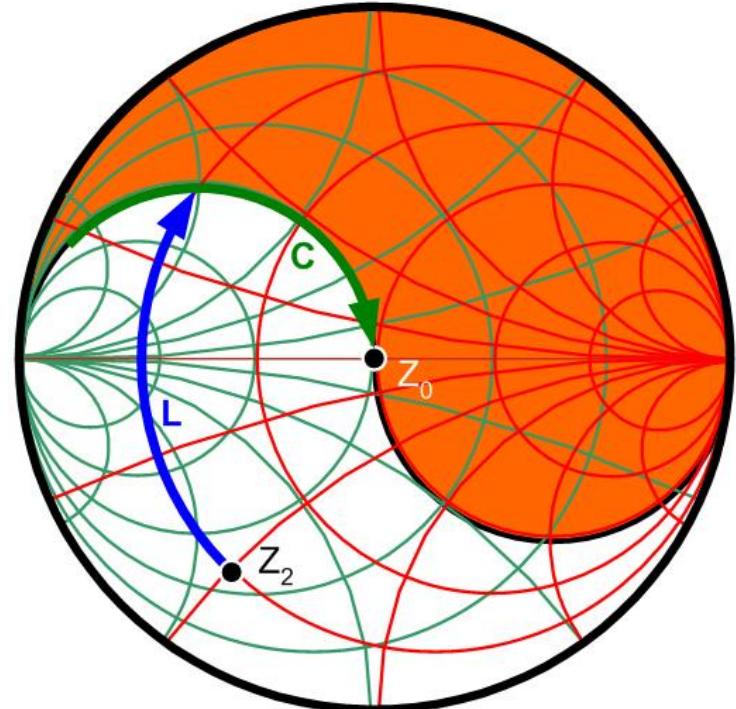
Diagrama Smith



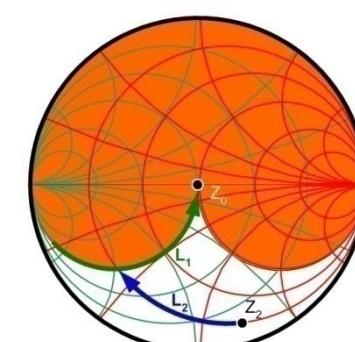
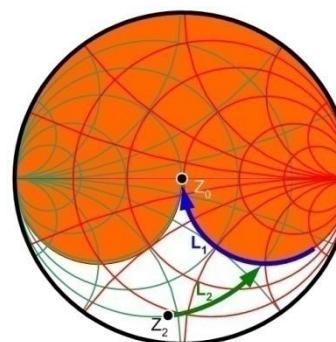
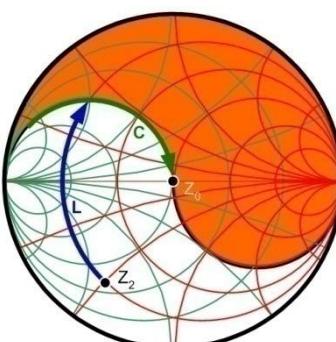
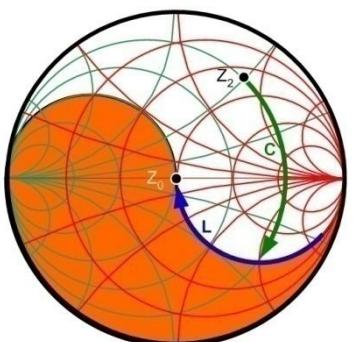
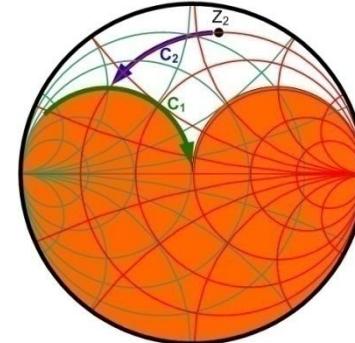
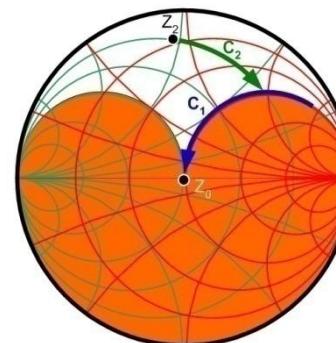
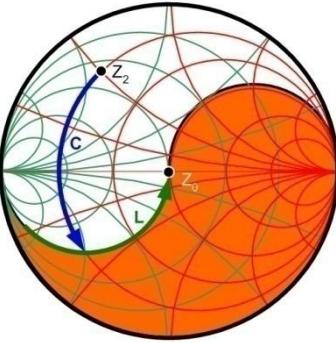
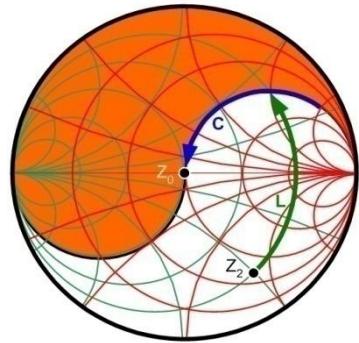
L serie, C paralel / C paralel, L serie



Zona interzisa cu
schema curenta



Adaptare cu două elemente reactive (retele in L)



Zona interzisa cu
schema curenta

Adaptarea cu sectiuni de linii (stub)

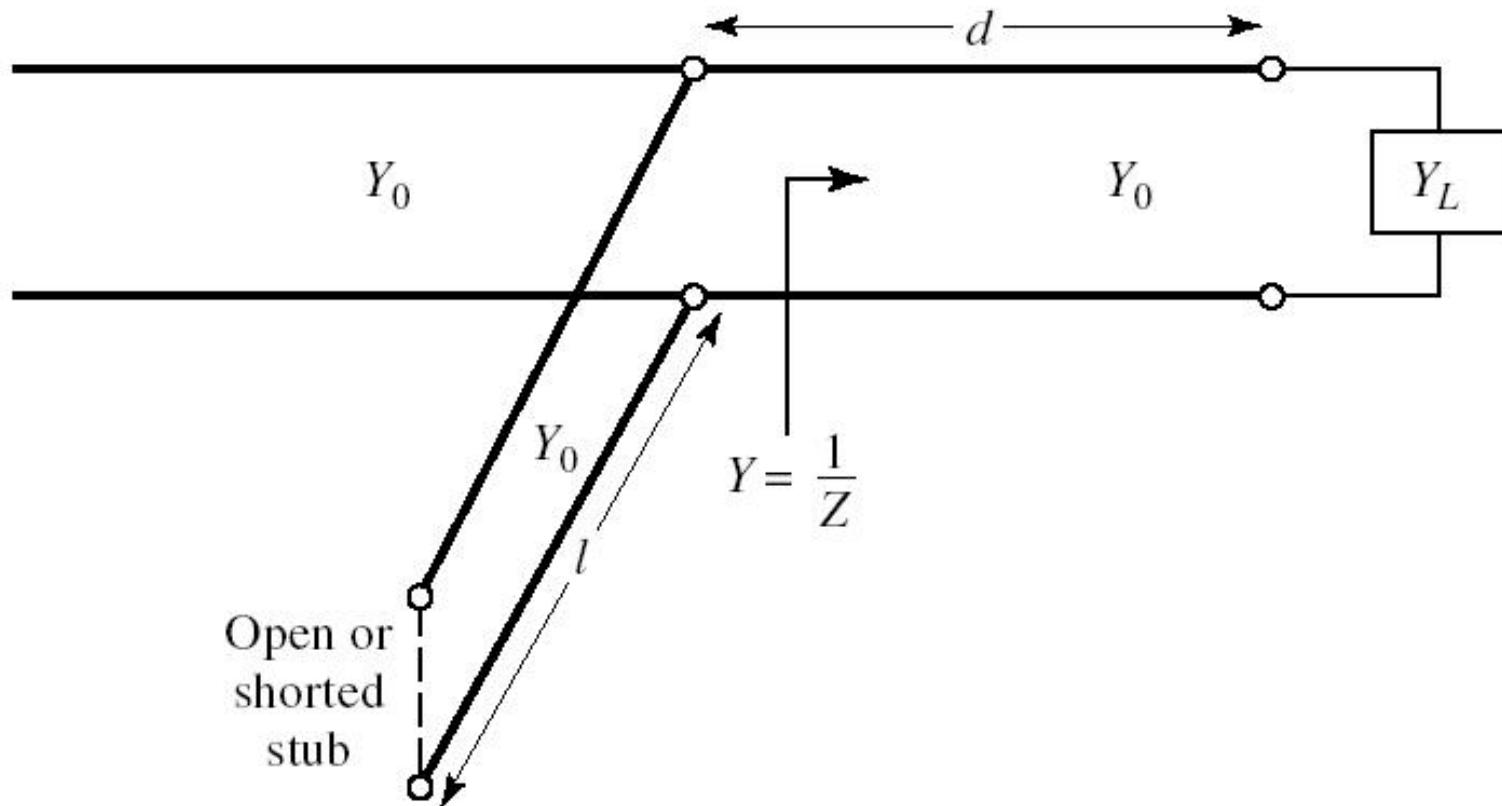
Adaptarea de impedanță

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

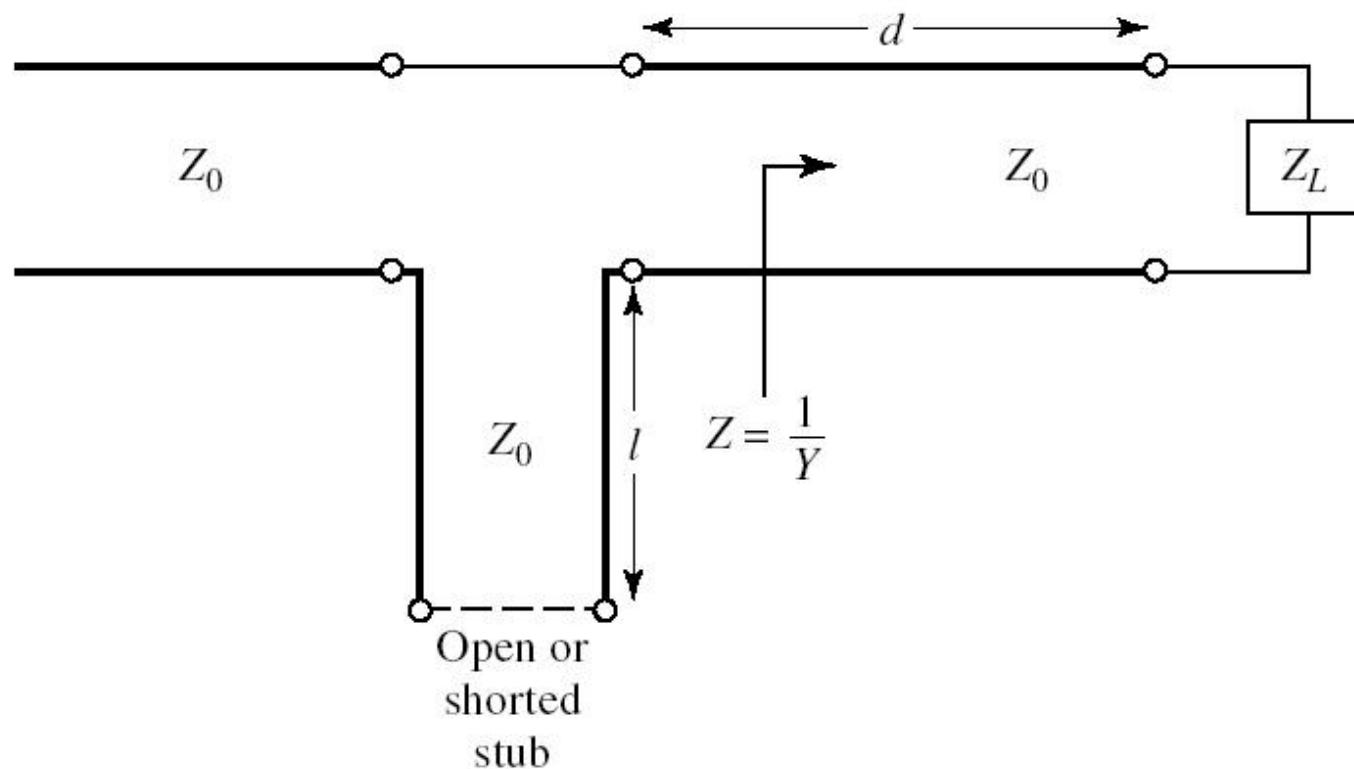
Single stub tuning

- Shunt Stub (secțiune de linie în paralel)

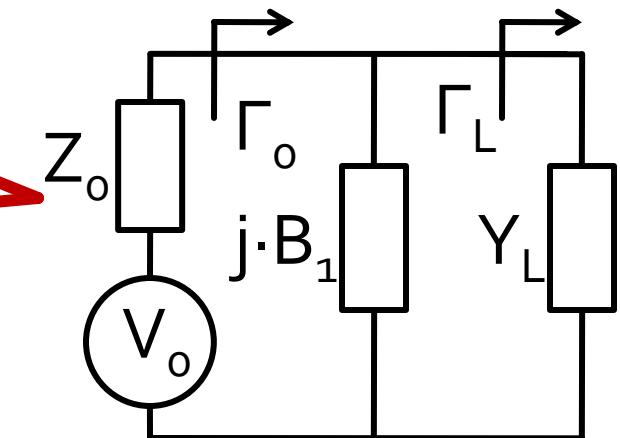
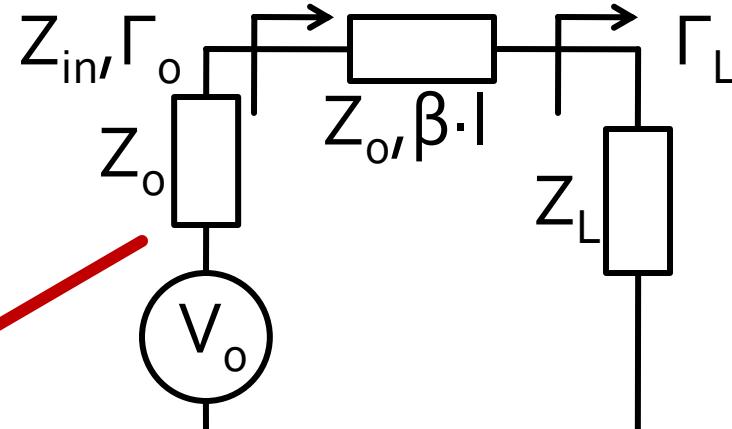
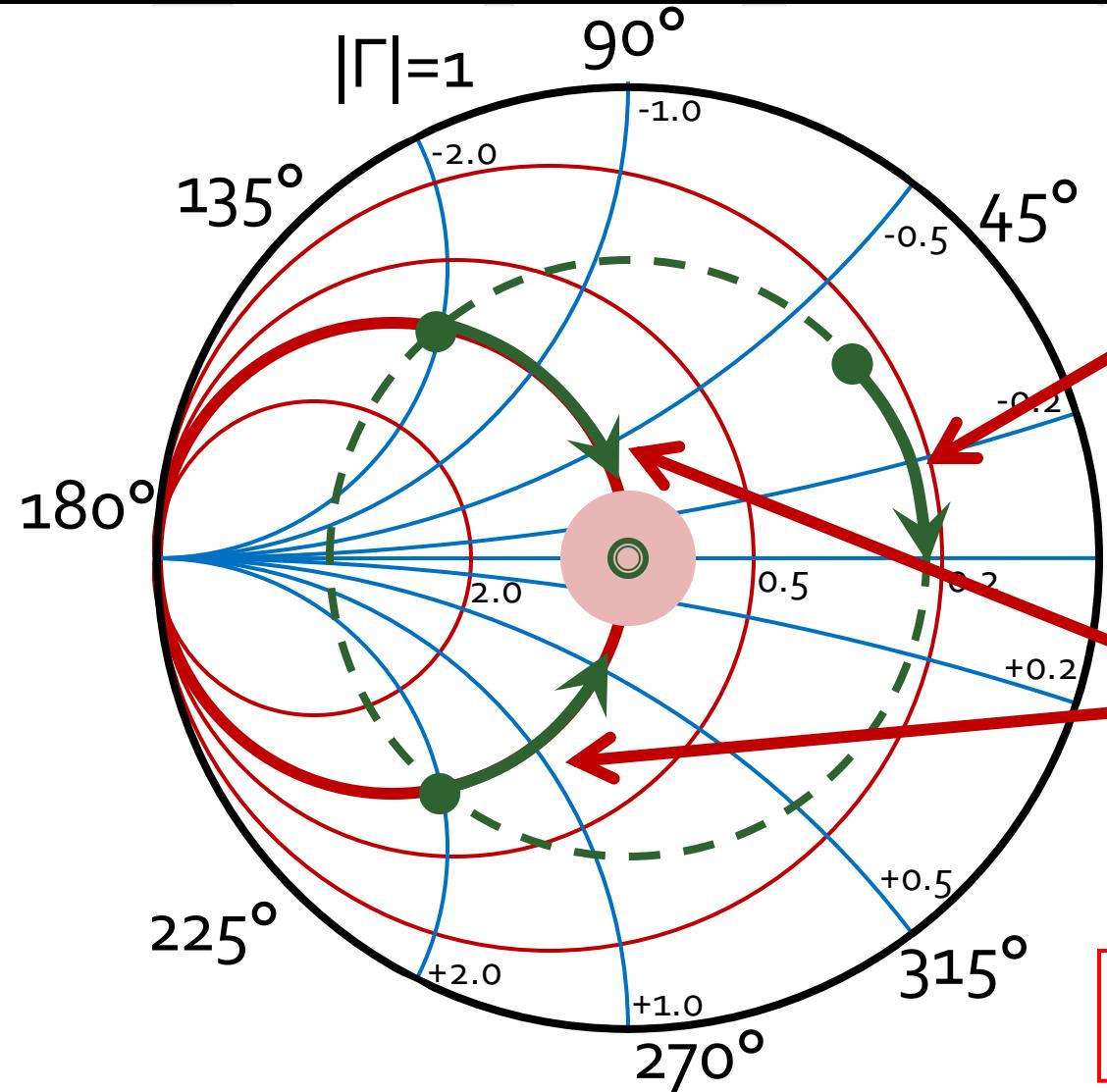


Single stub tuning

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



Adaptare, linie serie + susceptanta in paralel

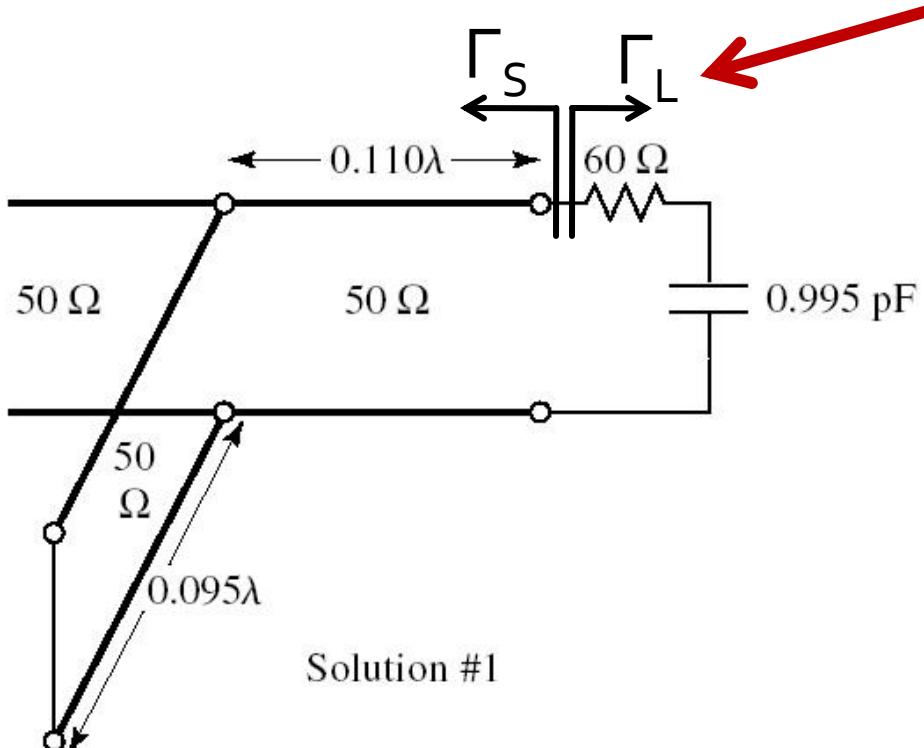


$$|\Gamma_{in}| = |\Gamma_L|$$

$$g_{in} = 1$$

Calcul analitic, coeficienti de reflexie

- sarcina: 60Ω serie 0.995 pF la 2GHz



$$Z_L = R_L + \frac{1}{j \cdot \omega \cdot C_L} = 60\Omega - j \cdot 79.977\Omega$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = 0.405 - j \cdot 0.432$$

$$Y_L = \frac{1}{Z_L} = 0.006S + j \cdot 0.008S$$

$$y_L = \frac{Y_L}{Y_0} = 0.3 + j \cdot 0.4$$

- adaptare necesita complex conjugat

$$\Gamma_s = \Gamma_L^* = 0.405 + j \cdot 0.432$$

$$\Gamma_s = 0.593 \angle 46.85^\circ$$

$$|\Gamma_s| = 0.593; \quad \varphi = 46.85^\circ$$

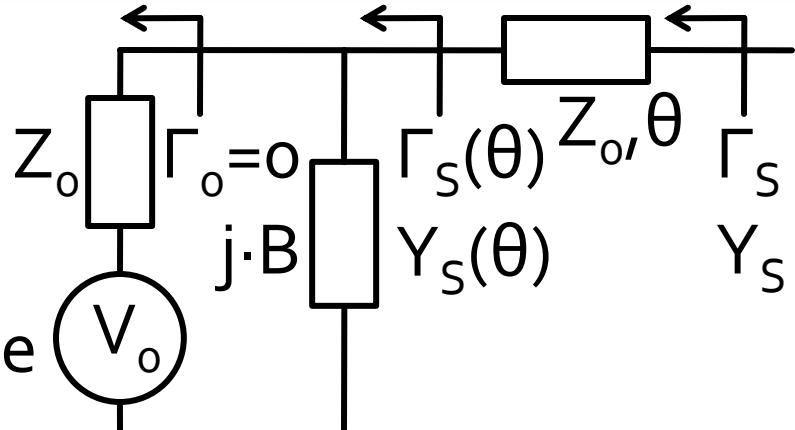
Calcul analitic, coeficienti de reflexie

■ linie serie

- lungime electrica $E = \beta \cdot l = \theta$
- mută coeficientul de reflexie pe cercul $g=1$

■ stub paralel:

- lungime electrica $E = \beta \cdot l_{sp} = \theta_{sp}$
- mută coeficientul de reflexie în centrul diagramei Smith ($\Gamma_o=0$)



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

$$y_s = \frac{1 - \Gamma_s}{1 + \Gamma_s} = 0.3 - j \cdot 0.4$$

$$\Gamma_s(\theta) = [\Gamma_L(\theta)]^* = [\Gamma_L \cdot e^{-2j\theta}]^*$$

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

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

Calcul analitic, linie serie (dem.)

- Dupa sectiunea de linie cu lungimea electrica θ

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

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

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

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

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

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

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

Calcul analitic, linie serie (calcul)

- Ecuatia pentru calcularea θ (linie serie)

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

$$\Gamma_s = |\Gamma_s| \cdot e^{j\varphi} \quad \Gamma_s = 0.593 \angle 46.85^\circ \quad |\Gamma_s| = 0.593; \quad \varphi = 46.85^\circ$$

- doua solutii posibile, normate la intervalul $0^\circ \div 180^\circ$
 - se adauga $\lambda/2$ (180°) dupa nevoie

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

$$\cos(\varphi + 2\theta) = -0.593 \Rightarrow (\varphi + 2\theta) = \pm 126.35^\circ \quad \forall k \in N$$

$$(46.85^\circ + 2\theta) = \begin{cases} +126.35^\circ \\ -126.35^\circ \end{cases}$$

$$\theta = \begin{cases} +39.7^\circ \\ -86.6^\circ + 180^\circ = +93.4^\circ \end{cases}$$

Calcul analitic, stub paralel (dem.)

- Ecuatia pentru calcularea stub-ului paralel θ_{sp}

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

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

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

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

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

Calcul analitic, stub paralel (dem.)

- 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

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

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

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

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

- Semnul** (+/-) solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

Calcul analitic, stub paralel (dem.)

- Se prefera (pentru microstrip) stub in gol

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

- Susceptanta raportata introdusa pentru adaptare
 - $Y(\theta)$ este admitanta vazuta **inspre** sursa, Z_0 in paralel cu $j \cdot B$

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

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

Calcul analitic (calcul efectiv)

$$(\varphi + 2\theta) = \begin{cases} +126.35^\circ \\ -126.35^\circ \end{cases} \quad \theta = \begin{cases} 39.7^\circ \\ 93.4^\circ \end{cases} \quad \text{Im}[y_s(\theta)] = \begin{cases} -1.472 \\ +1.472 \end{cases} \quad \theta_{sp} = \begin{cases} -55.8^\circ + 180^\circ = 124.2^\circ \\ +55.8^\circ \end{cases}$$

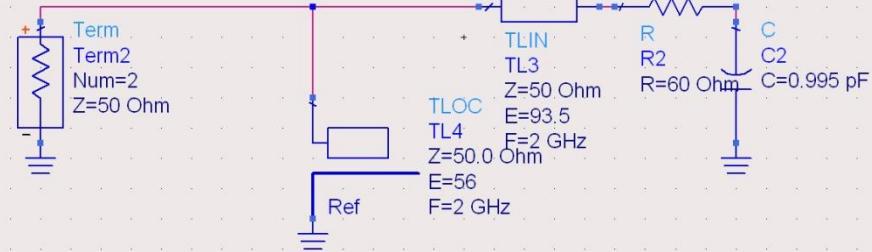
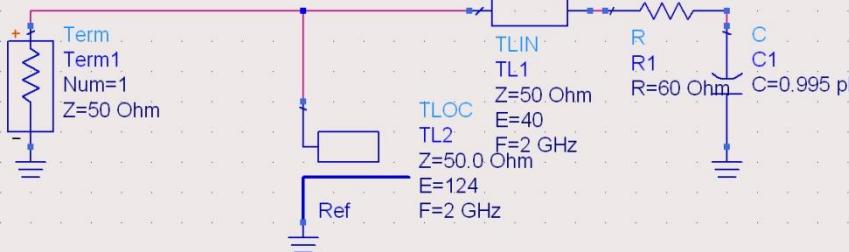
- Se alege **una** din cele doua solutii posibile
- **Semnul (+/-)** solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

$$l_1 = \frac{39.7^\circ}{360^\circ} \cdot \lambda = 0.110 \cdot \lambda$$

$$l_2 = \frac{124.2^\circ}{360^\circ} \cdot \lambda = 0.345 \cdot \lambda$$

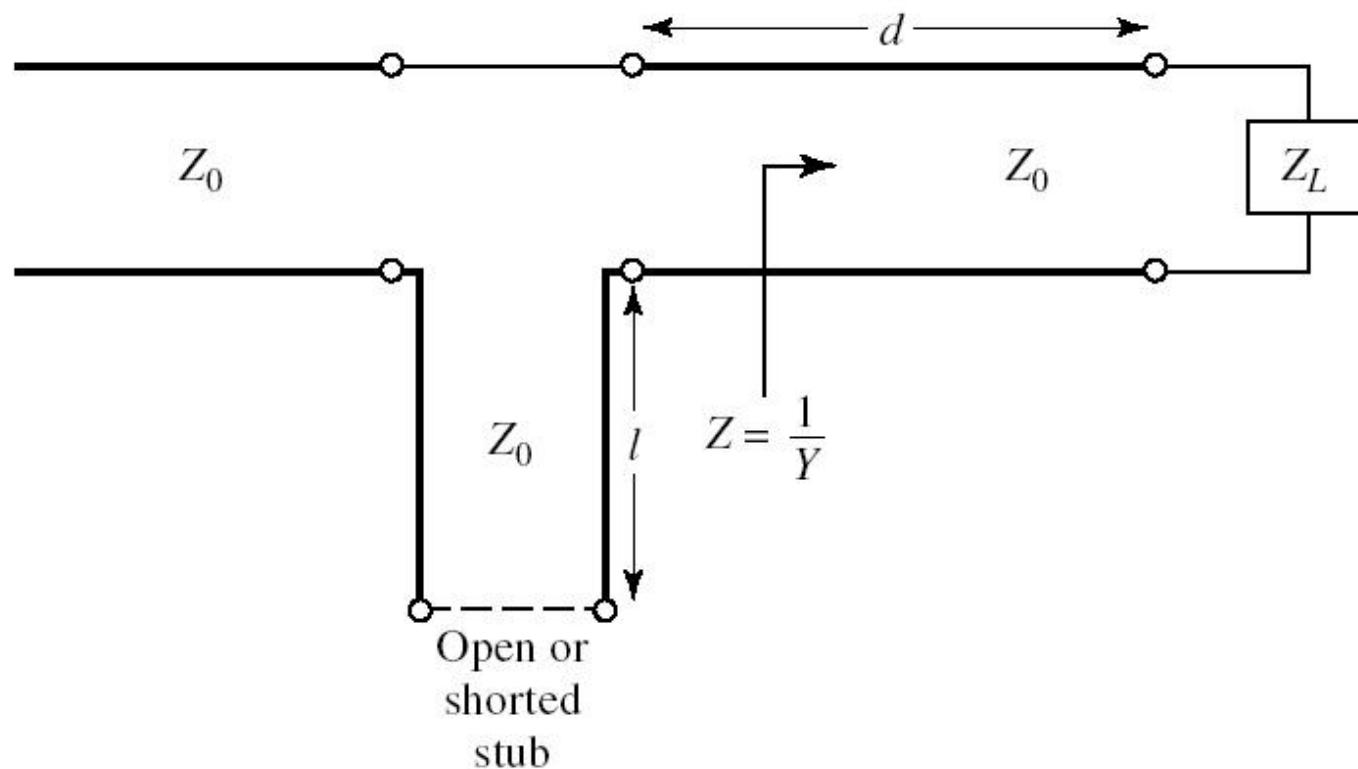
$$l_1 = \frac{93.4^\circ}{360^\circ} \cdot \lambda = 0.259 \cdot \lambda$$

$$l_2 = \frac{55.8^\circ}{360^\circ} \cdot \lambda = 0.155 \cdot \lambda$$



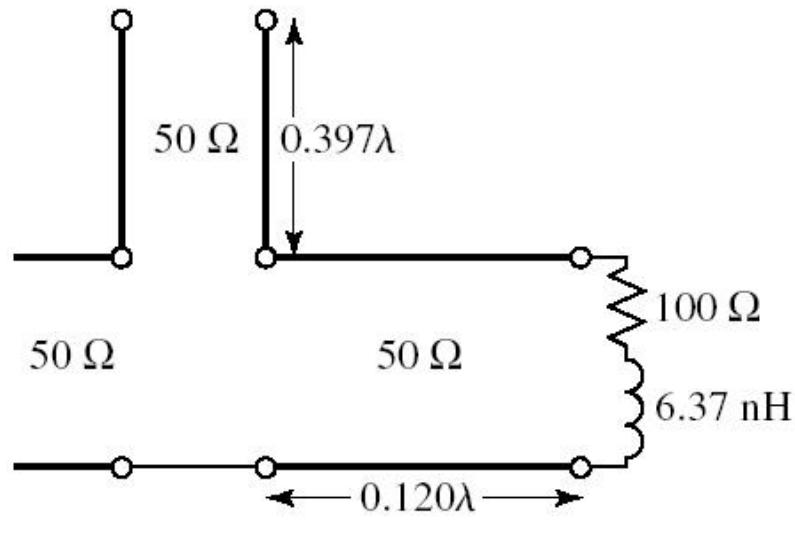
Caz 2, Series Stub

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

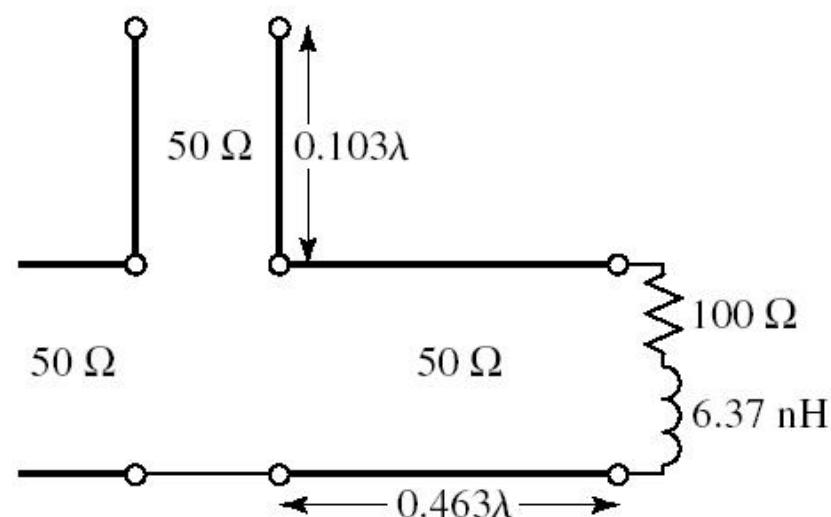


Exemplu, Series Stub, gol

- sarcina: 100Ω serie 6.37 nH la 2GHz
- doua solutii posibile

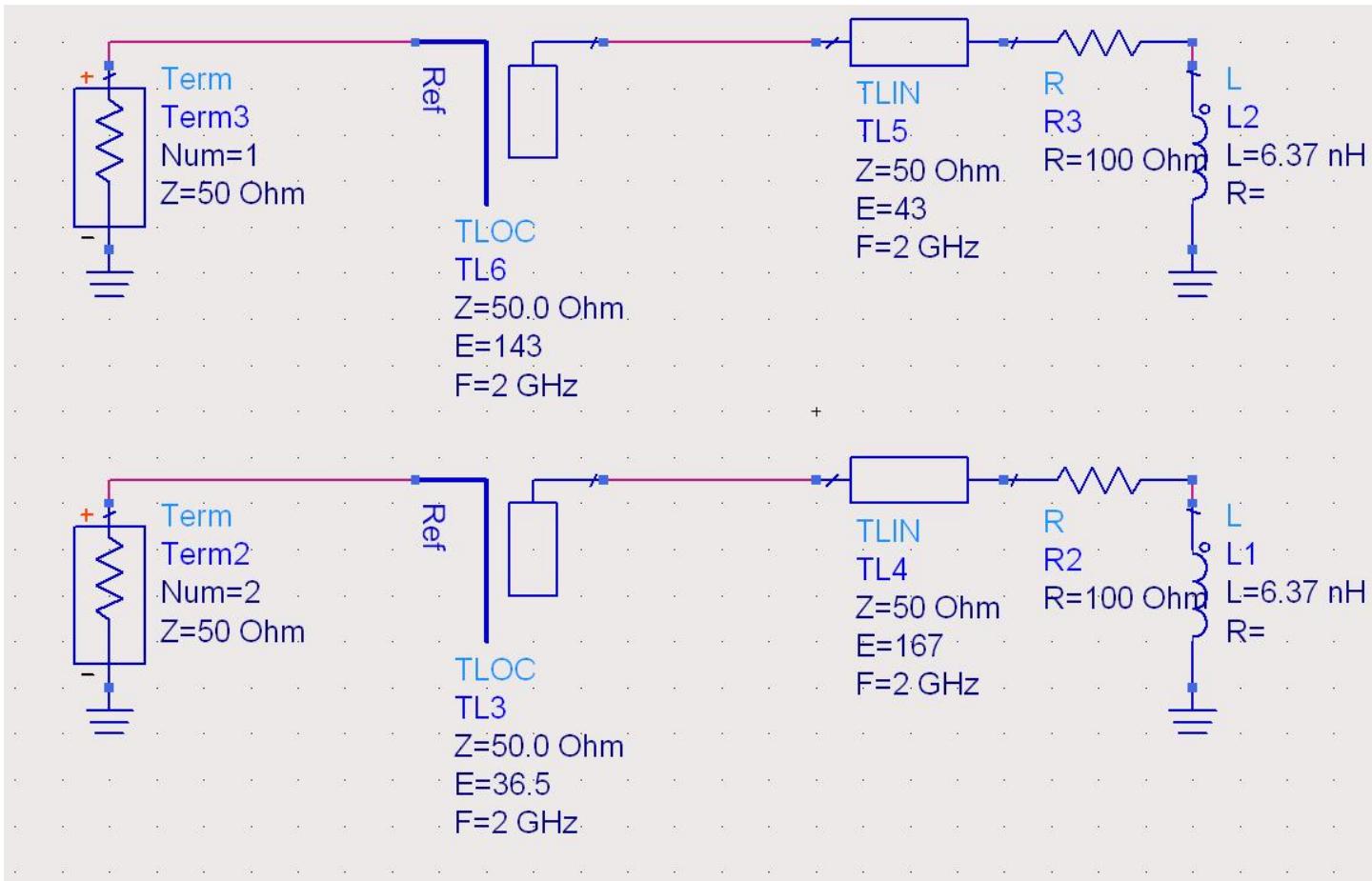


Solution 1

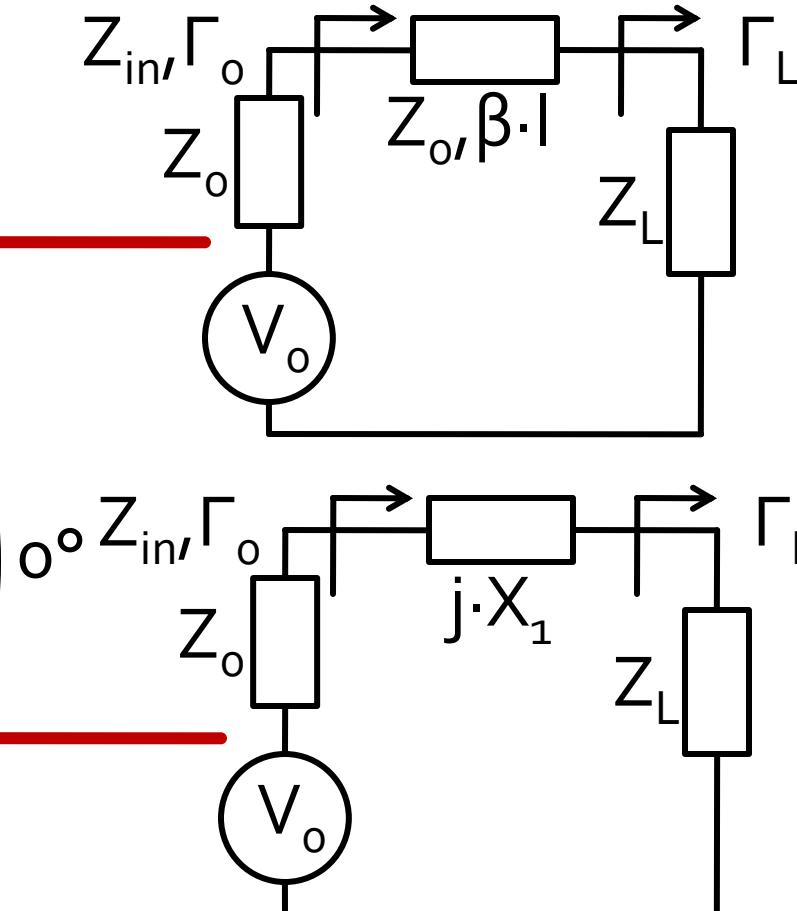
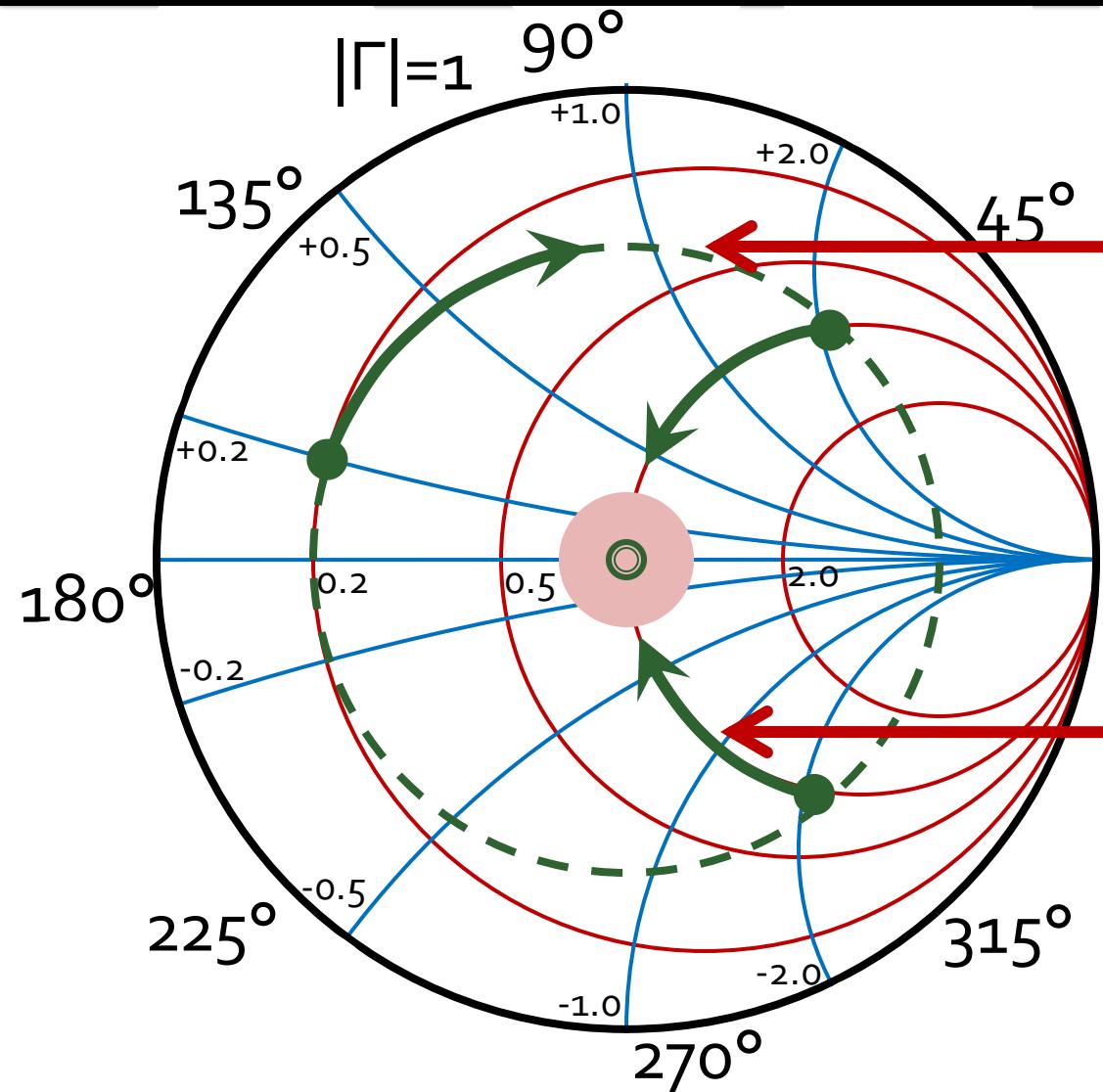


Solution 2

Exemplu, Series Stub, gol



Adaptare, linie serie + reactanta in serie

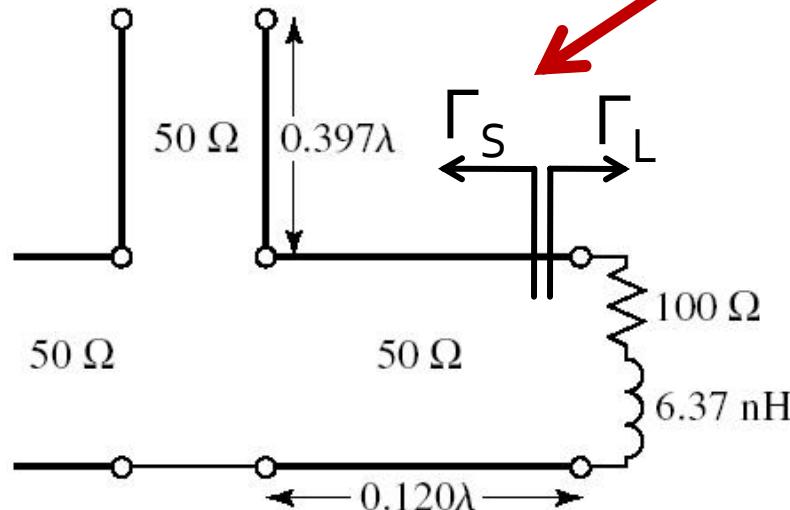


$$|\Gamma_{in}| = |\Gamma_L|$$

$$r_{in} = 1$$

Calcul analitic, coeficienti de reflexie

- sarcina: 100Ω serie 6.37 nH la 2GHz



Solution 1

$$Z_L = R_L + \frac{1}{j \cdot \omega \cdot C_L} = 100\Omega + j \cdot 80.05\Omega$$

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = 0.481 + j \cdot 0.277$$

$$z_L = \frac{Z_L}{Z_0} = 2 + j \cdot 1.6$$

- adaptare necesita Γ complex conjugat

$$\Gamma_s = \Gamma_L^* = 0.481 - j \cdot 0.277$$

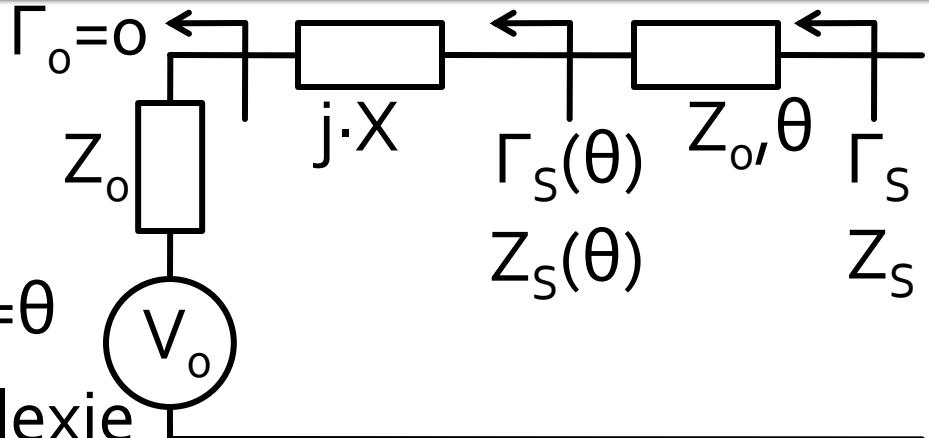
$$\Gamma_s = 0.555 \angle -29.92^\circ$$

$$|\Gamma_s| = 0.555; \quad \varphi = -29.92^\circ$$

Calcul analitic, coeficienti de reflexie

■ linie serie

- lungime electrica $E = \beta \cdot l = \theta$
- mută coeficientul de reflexie pe cercul $r=1$



■ stub serie

- lungime electrica $E = \beta \cdot l_{ss} = \theta_{ss}$
- mută coeficientul de reflexie în centrul diagramei Smith ($\Gamma_0 = 0$)

$$z_s = \frac{Z_s}{Z_0} = \frac{Z_s}{50\Omega}$$

$$z_s = \frac{1 + \Gamma_s}{1 - \Gamma_s} = 2 - j \cdot 1.6$$

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

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

Calcul analitic, linie serie (dem.)

- Dupa sectiunea de linie cu lungimea electrica θ :

$$\operatorname{Re}[z_s(\theta)] = 1 \quad \operatorname{Im}[z_s(\theta)] = X$$

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

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

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

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

Calcul analitic, linie serie (calcul)

- Ecuatia pentru calcularea θ (linie serie)

$$\operatorname{Re}[z_s(\theta)] = 1 \Rightarrow \cos(\varphi + 2\theta) = |\Gamma_s|$$

$$|\Gamma_s| = |\Gamma_s| \cdot e^{j\varphi} \quad \Gamma_s = 0.555 \angle -29.92^\circ \quad |\Gamma_s| = 0.555; \quad \varphi = -29.92^\circ$$

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

- se adauga $\lambda/2$ (180°) dupa nevoie

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

$$\cos(\varphi + 2\theta) = 0.555 \Rightarrow (\varphi + 2\theta) = \pm 56.28^\circ \quad \forall k \in N$$

$$(-29.92^\circ + 2\theta) = \begin{cases} +56.28^\circ \\ -56.28^\circ \end{cases} \quad \theta = \begin{cases} +43.1^\circ \\ -13.2^\circ + 180^\circ = +166.8^\circ \end{cases}$$

Calcul analitic, stub serie (dem.)

- Ecuatia pentru calcularea stub-ului serie θ_{ss} :

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

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

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

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

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

Calcul analitic, stub serie (dem.)

- Ecuatia pentru calcularea stub-ului serie θ_{ss} :

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

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

- doua situatii

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

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

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

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

- Semnul (+/-)** solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

Calcul analitic, stub serie (dem.)

- Se prefera (pentru microstrip) stub in gol

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

- Reactanta raportata introdusa pentru adaptare
 - $Z(\theta)$ este impedanta vazuta **inspre** sursa, Z_0 in serie cu $j \cdot X$

$$x = \operatorname{Im} \left[\frac{Z_{in,oc}}{Z_0} \right] = -\cot \beta \cdot l = \operatorname{Im}[z_s(\theta)]$$

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

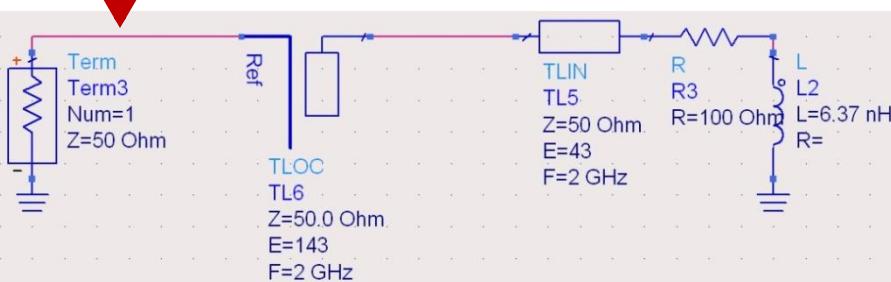
Calcul analitic (calcul efectiv)

$$(\varphi + 2\theta) = \begin{cases} +56.28^\circ \\ -56.28^\circ \end{cases} \quad \theta = \begin{cases} 43.1^\circ \\ 166.8^\circ \end{cases} \quad \text{Im}[z_s(\theta)] = \begin{cases} +1.335 \\ -1.335 \end{cases} \quad \theta_{ss} = \begin{cases} -36.8^\circ + 180^\circ = 143.2^\circ \\ +36.8^\circ \end{cases}$$

- Se alege **una** din cele doua solutii posibile
- **Semnul (+/-)** solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

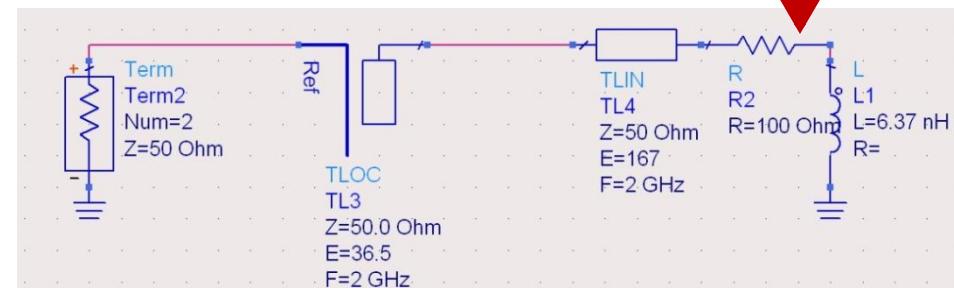
$$l_1 = \frac{43.1^\circ}{360^\circ} \cdot \lambda = 0.120 \cdot \lambda$$

$$l_2 = \frac{143.2^\circ}{360^\circ} \cdot \lambda = 0.398 \cdot \lambda$$



$$l_1 = \frac{166.8^\circ}{360^\circ} \cdot \lambda = 0.463 \cdot \lambda$$

$$l_2 = \frac{36.8^\circ}{360^\circ} \cdot \lambda = 0.102 \cdot \lambda$$

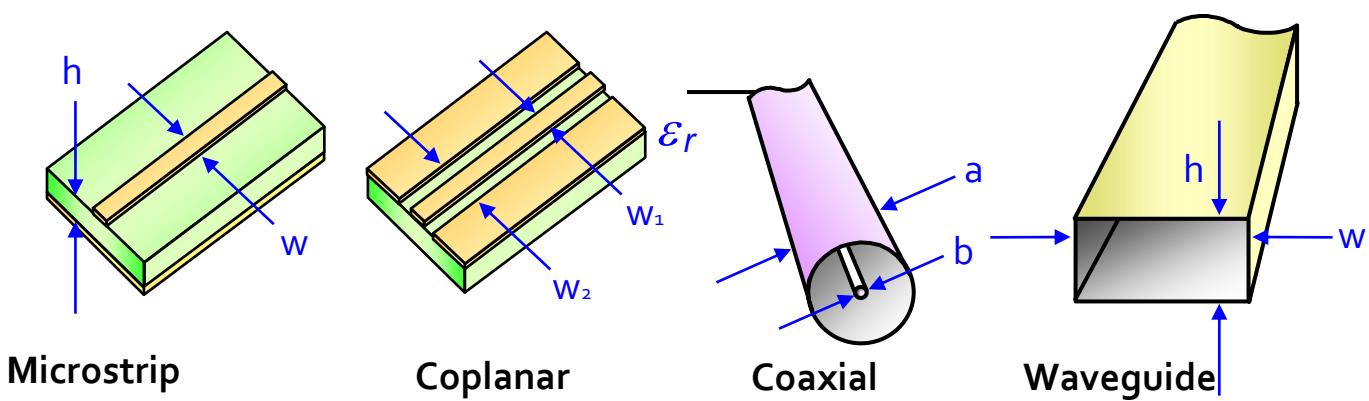


Adaptarea cu sectiuni de linii (stub)

- Se alege una din cele 8 solutii posibile convenabila tinand cont de:
 - dimensiuni fizice (suprafata ocupata pe chip/placa)
 - sensibilitatea adaptarii la variația parametrilor fizici ai liniilor ($\Delta\Gamma/\Delta E$, $\Delta\Gamma/\Delta I$)
 - caracteristica de frecvență convenabilă

Adaptarea cu sectiuni de linii (stub)

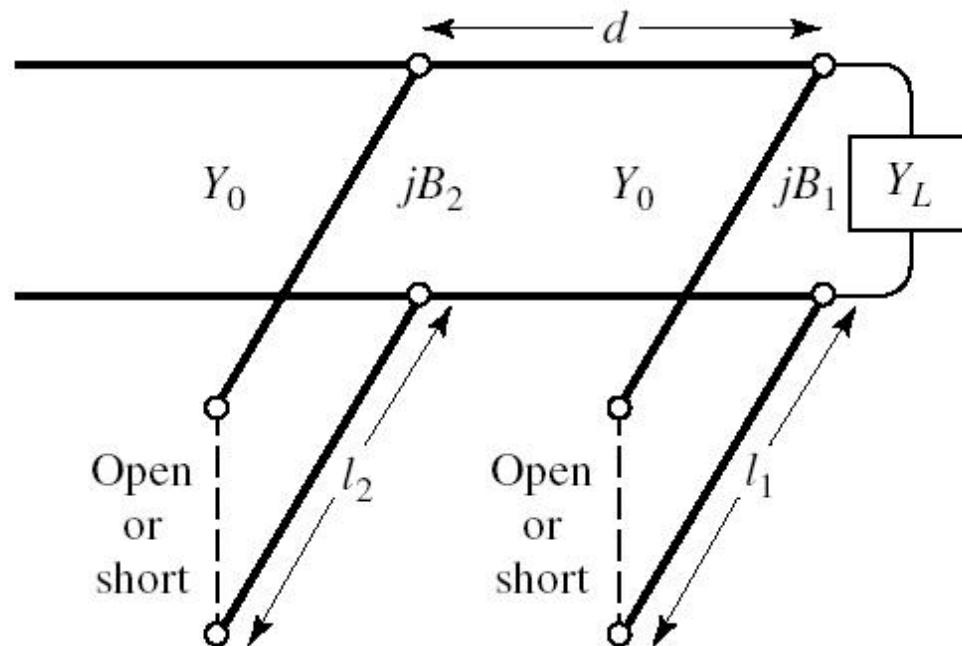
- Se alege una din cele 8 solutii posibile convenabila tinand cont de:
 - realizabilitate fizica (conform tehnologiei de linie utilizata)



- Dezavantaj:
 - lungimea sectiunii de linie serie e variabila

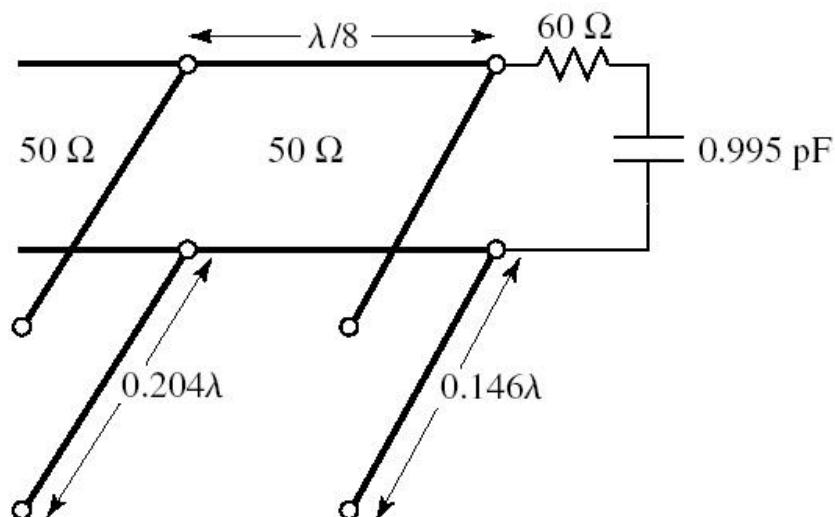
Adaptarea cu două secțiuni de linie

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

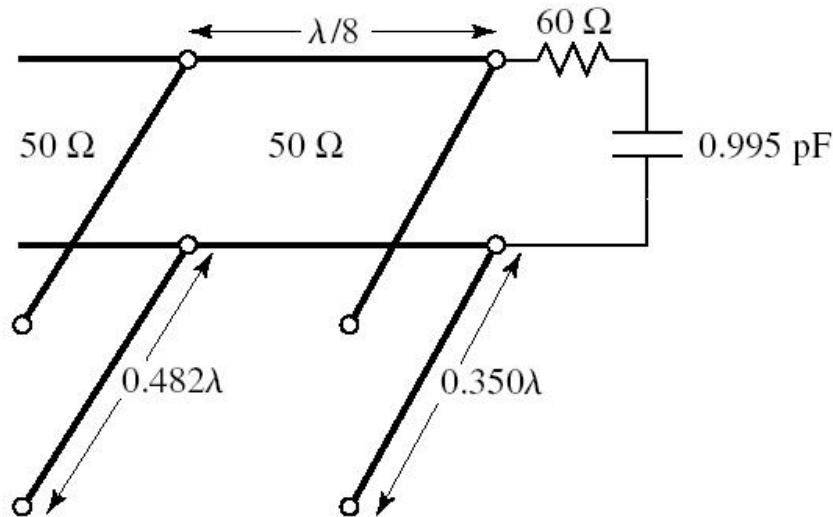


Adaptarea cu două secțiuni de linie

- Două soluții posibile



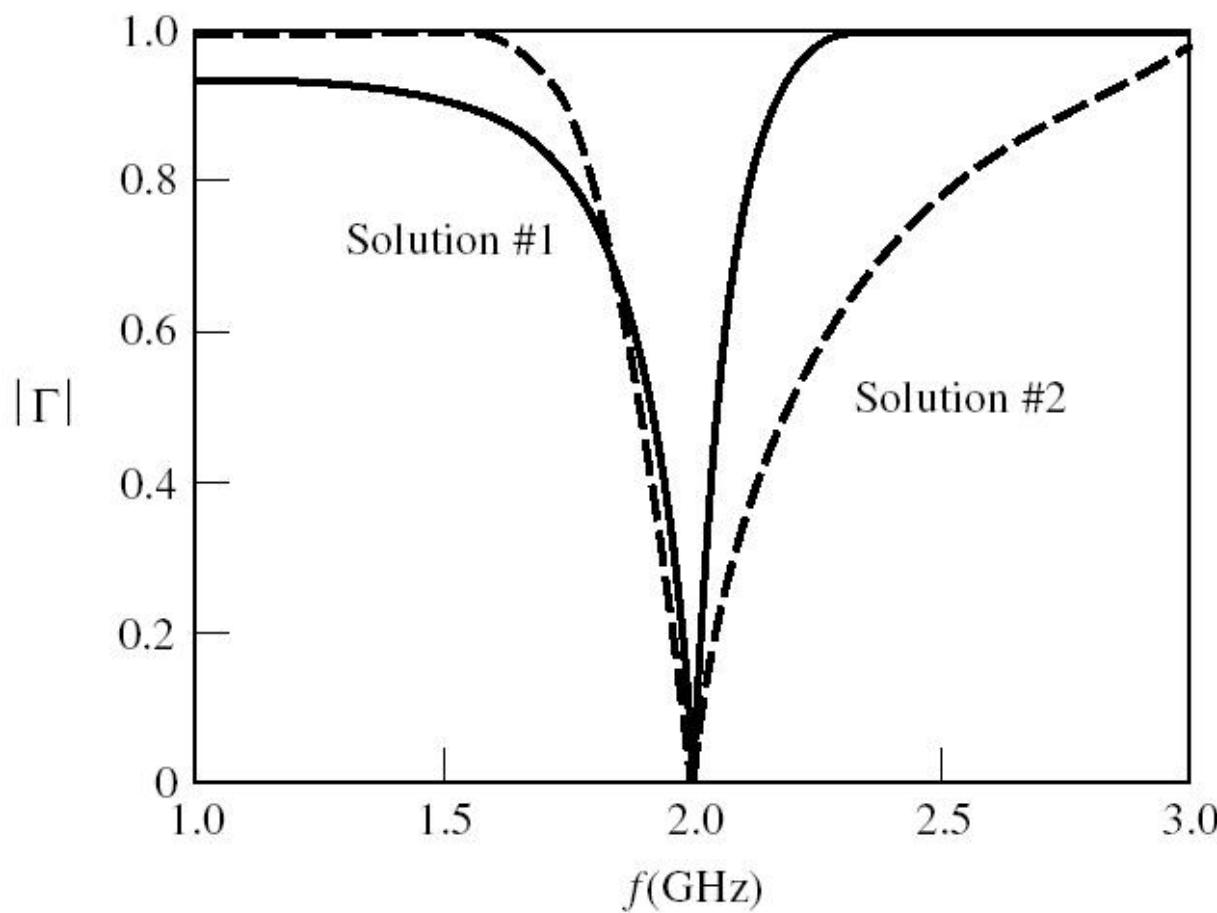
Solution 1



Solution 2

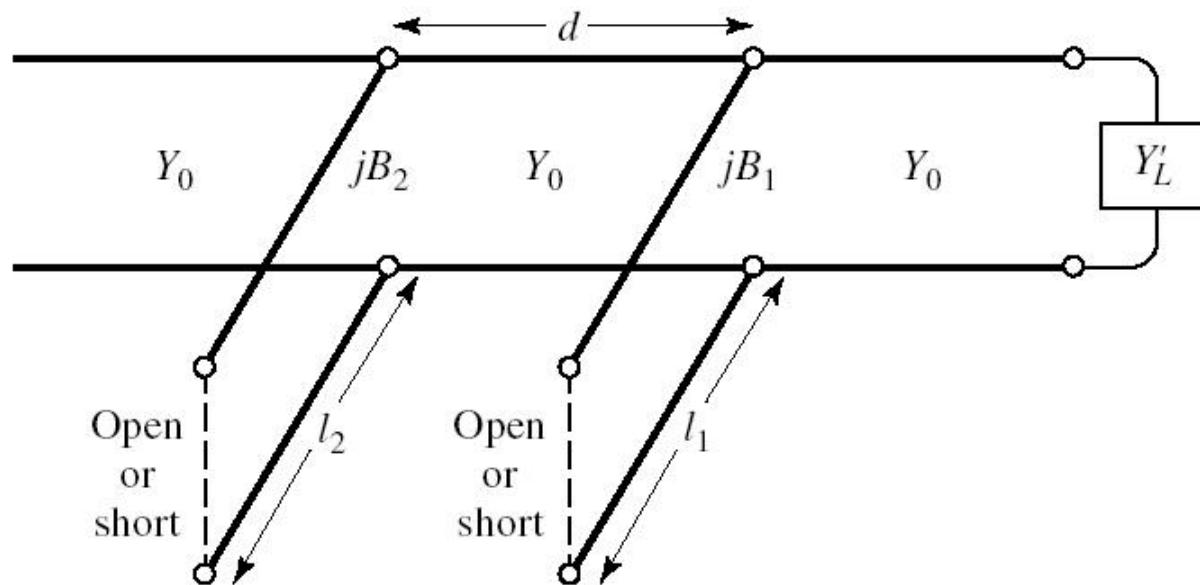
Adaptarea cu două secțiuni de linie

- Două soluții posibile

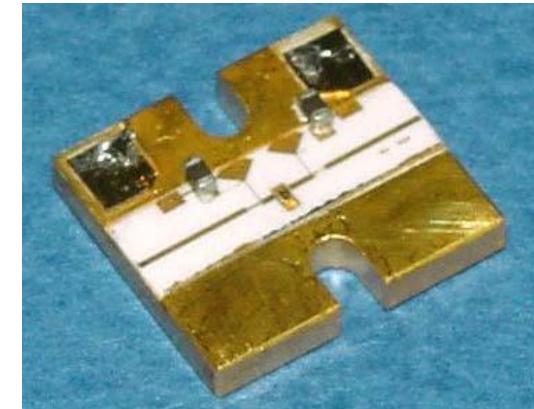
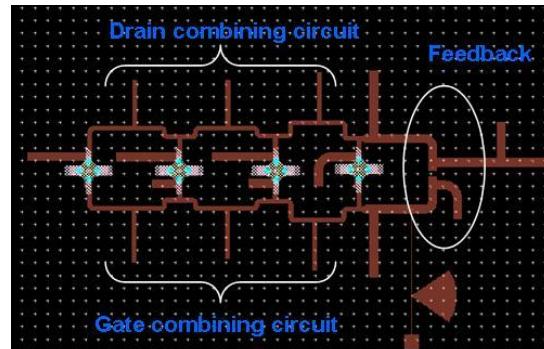
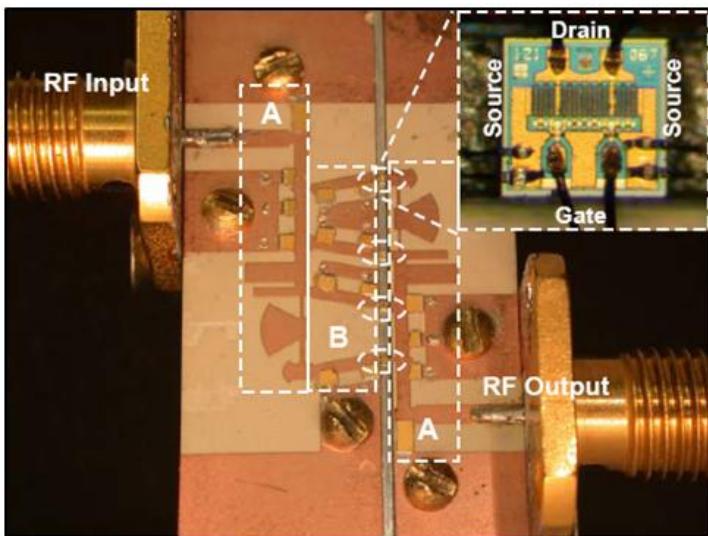
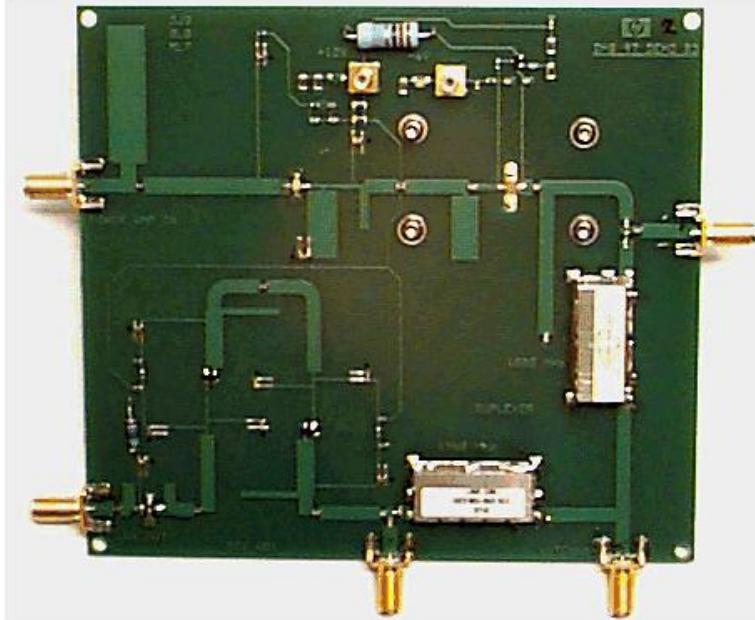
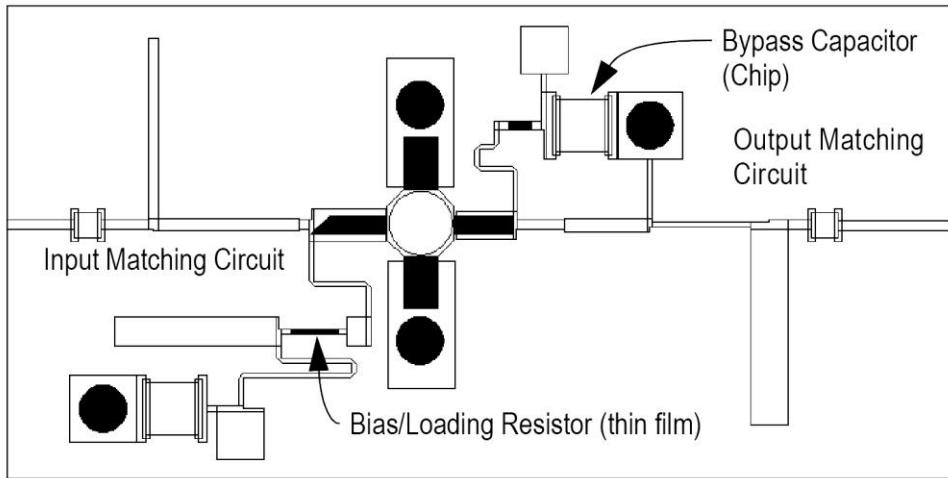


Adaptarea cu doua sectiuni de linie

- 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

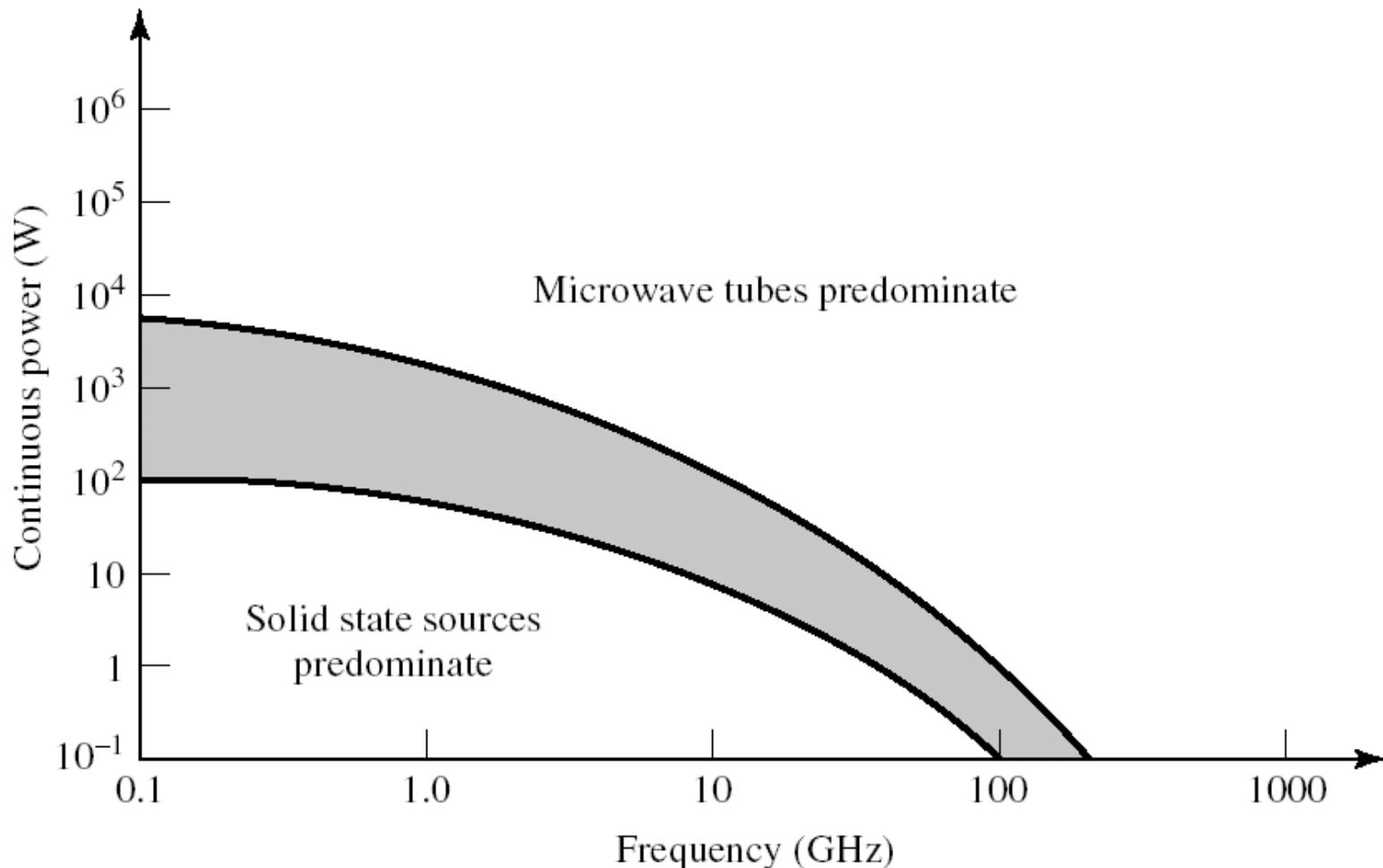


Adaptarea cu sectiuni de linie

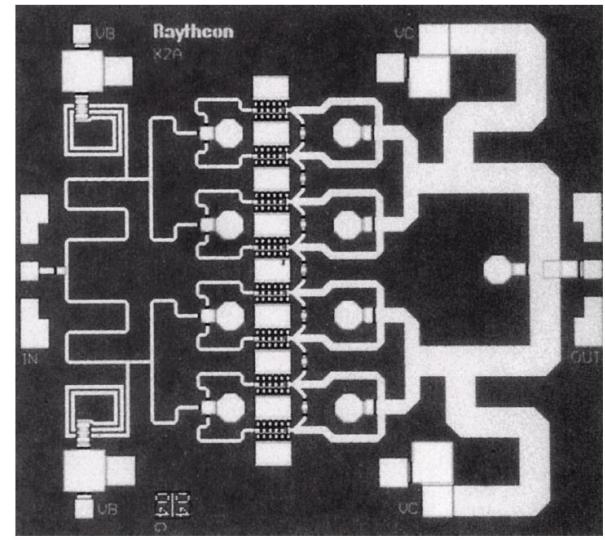
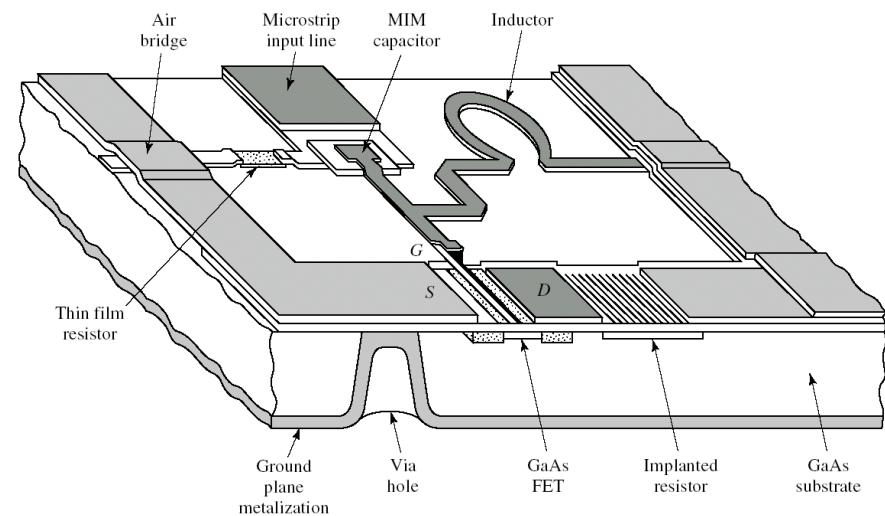
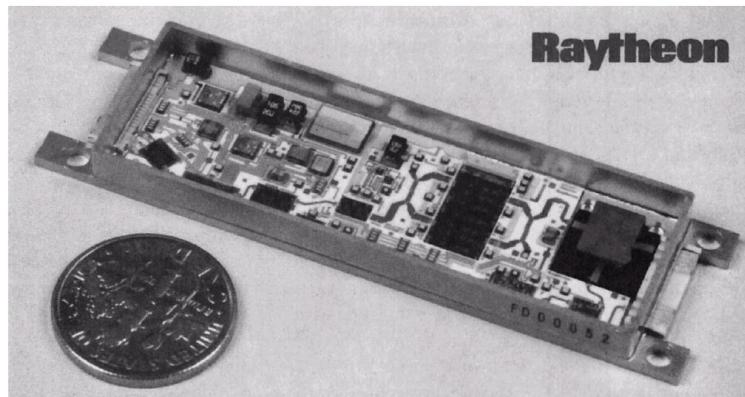
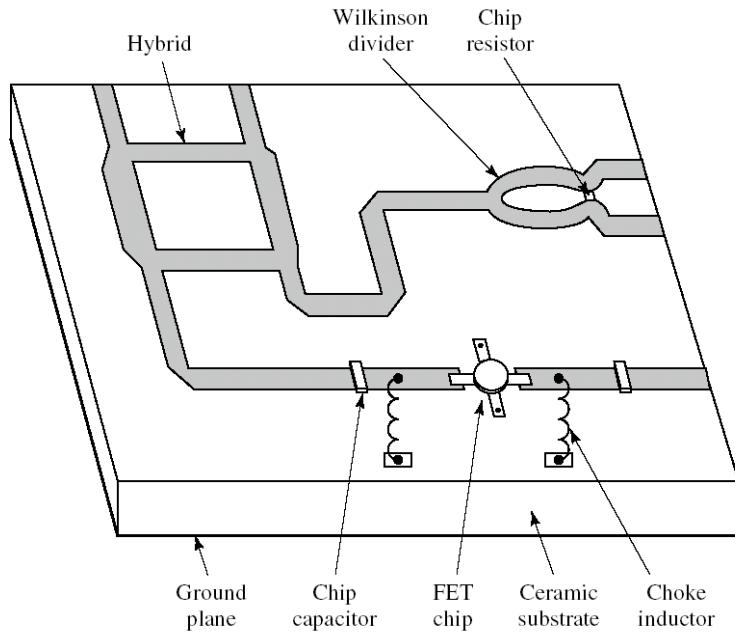


Amplificatoare de microunde

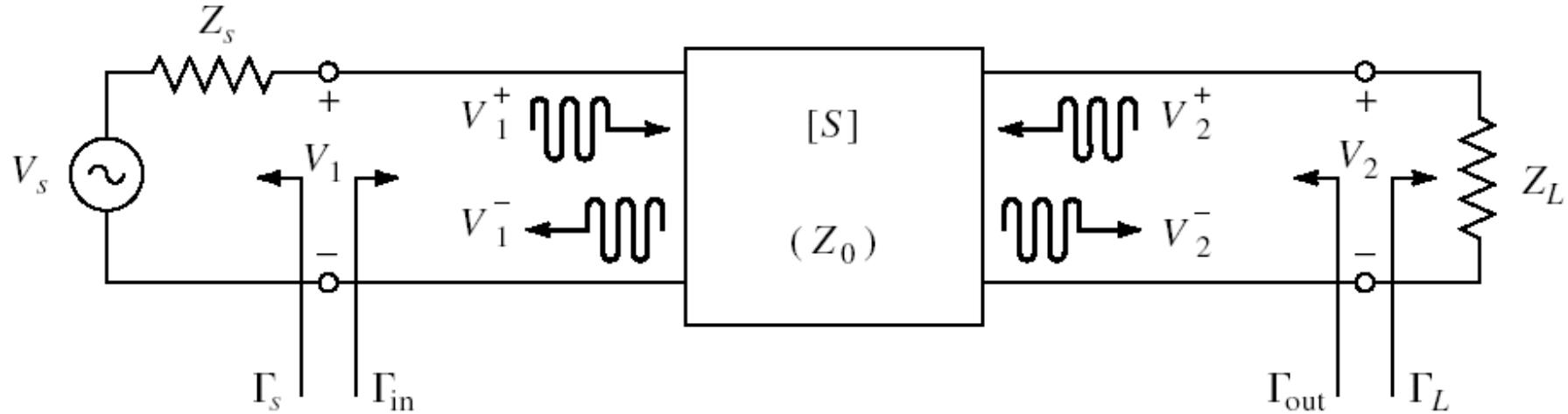
Amplificatoare pentru microunde



Circuite integrate pentru microunde



Cuadripol Amplificator (diport)



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

Catalogage

CEL

NE46100 / NE46134

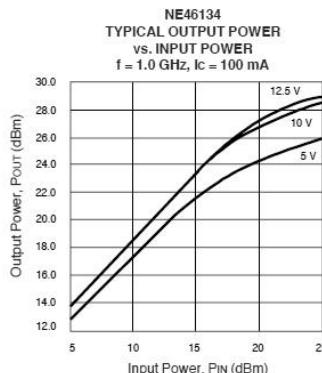
NPN MEDIUM POWER MICROWAVE TRANSISTOR

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 ³ 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 ² 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 ₁₁		S ₂₁		S ₁₂		S ₂₂		K	MAG ² (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

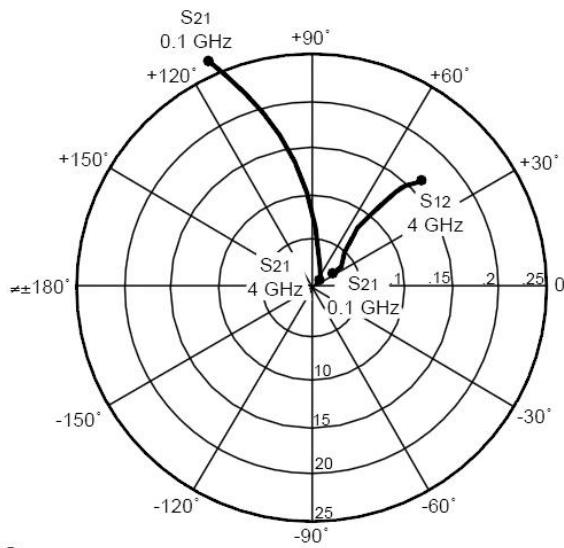
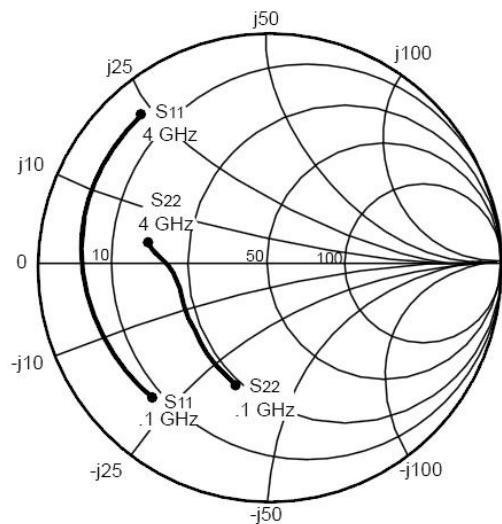
VCE = 5 V, Ic = 100 mA

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 PARAMETERS¹ ($T_A = 25^\circ\text{C}$)



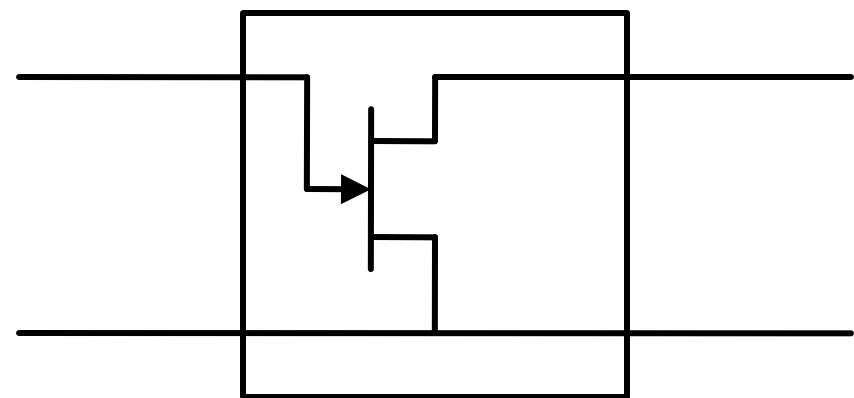
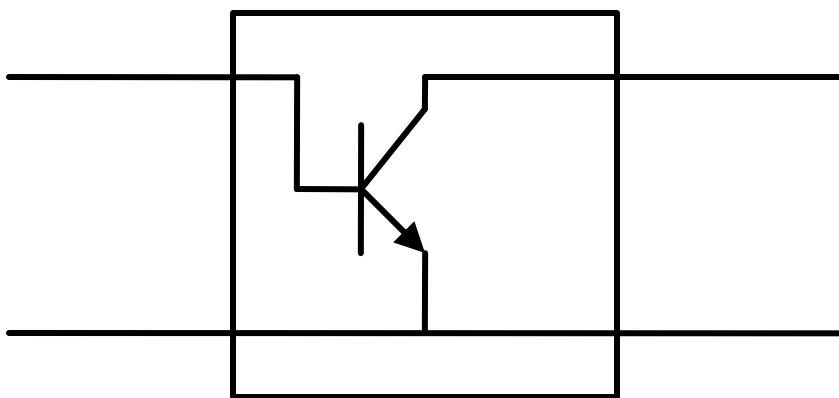
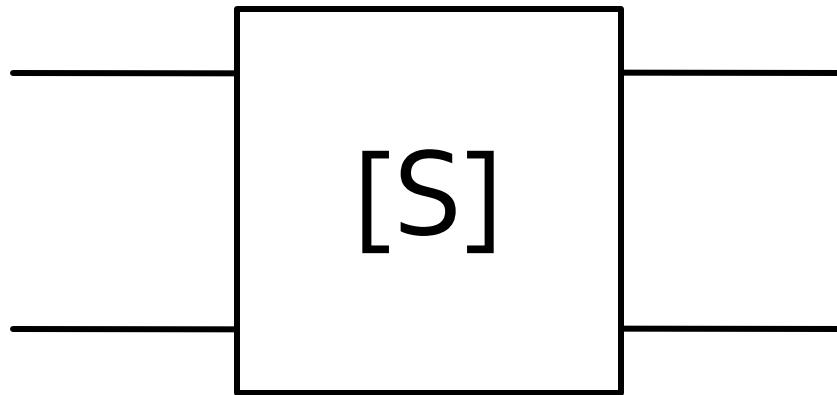
Coordinates in Ohms
Frequency in GHz
 $V_{CE} = 5 \text{ V}, I_C = 50 \text{ mA}$

S2P - Touchstone

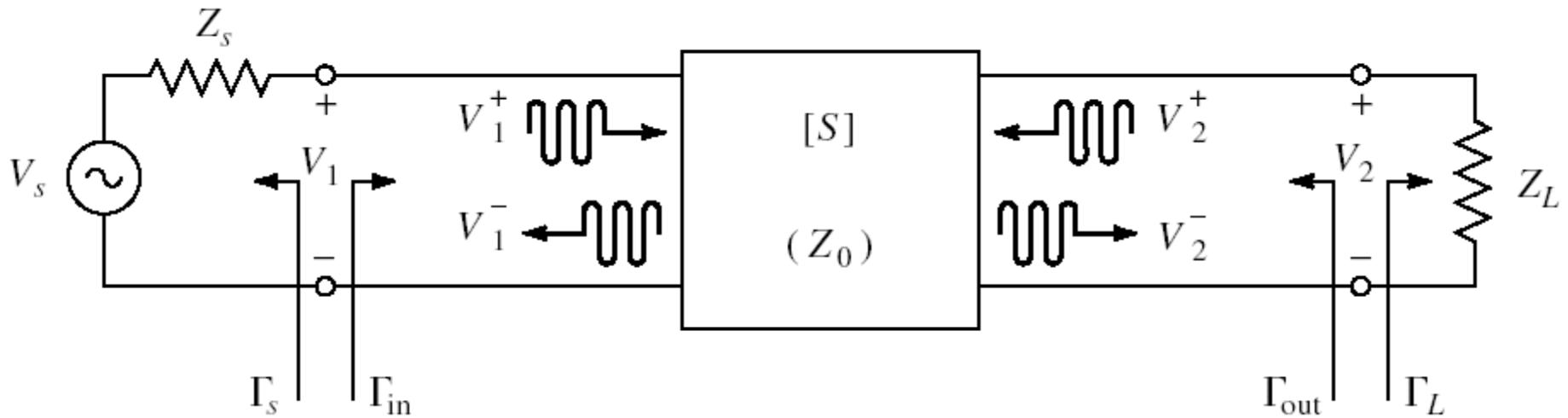
■ Fisiere format Touchstone (*.s2p)

```
! 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



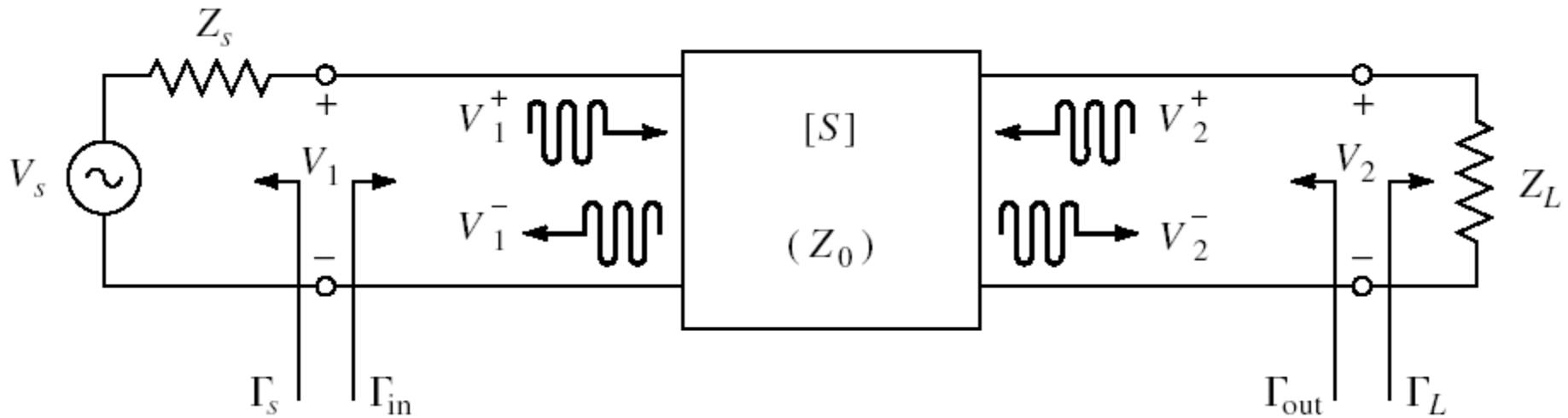
$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} \quad \Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0} \quad \begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

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

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

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

Diport amplifier



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

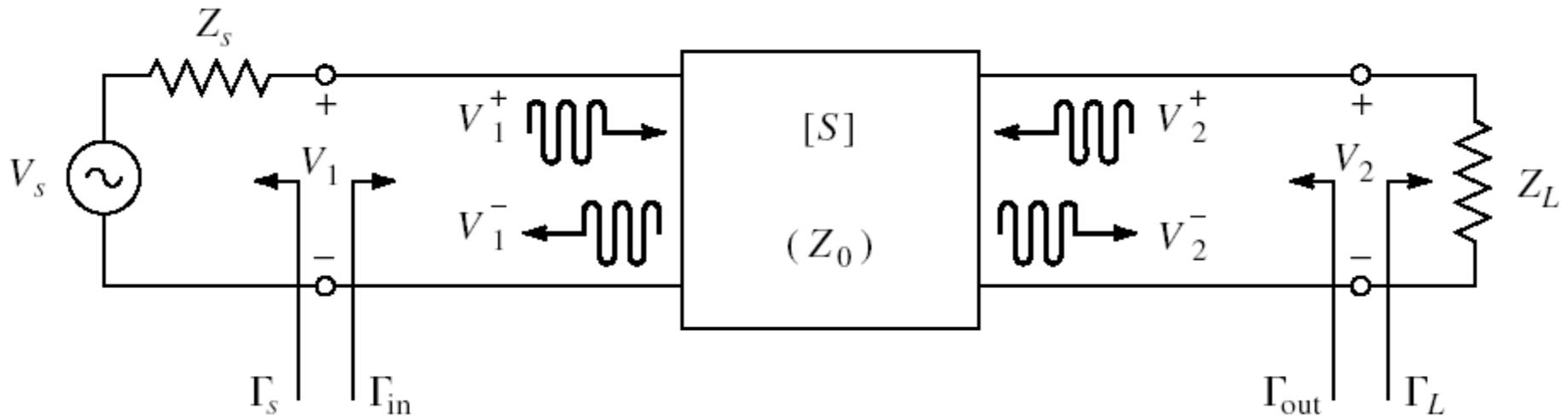
$$V_2^- = S_{21} \cdot V_1^+ + S_{22} \cdot V_2^+ = S_{21} \cdot V_1^+ + S_{22} \cdot \Gamma_L \cdot V_2^-$$

■ similar

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

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

Diport amplifier



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

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

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**

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

$$S_{12} \cong 0$$

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

Permite tratarea separata
a intrarii si iesirii

Preview (pentru laborator 3-4)

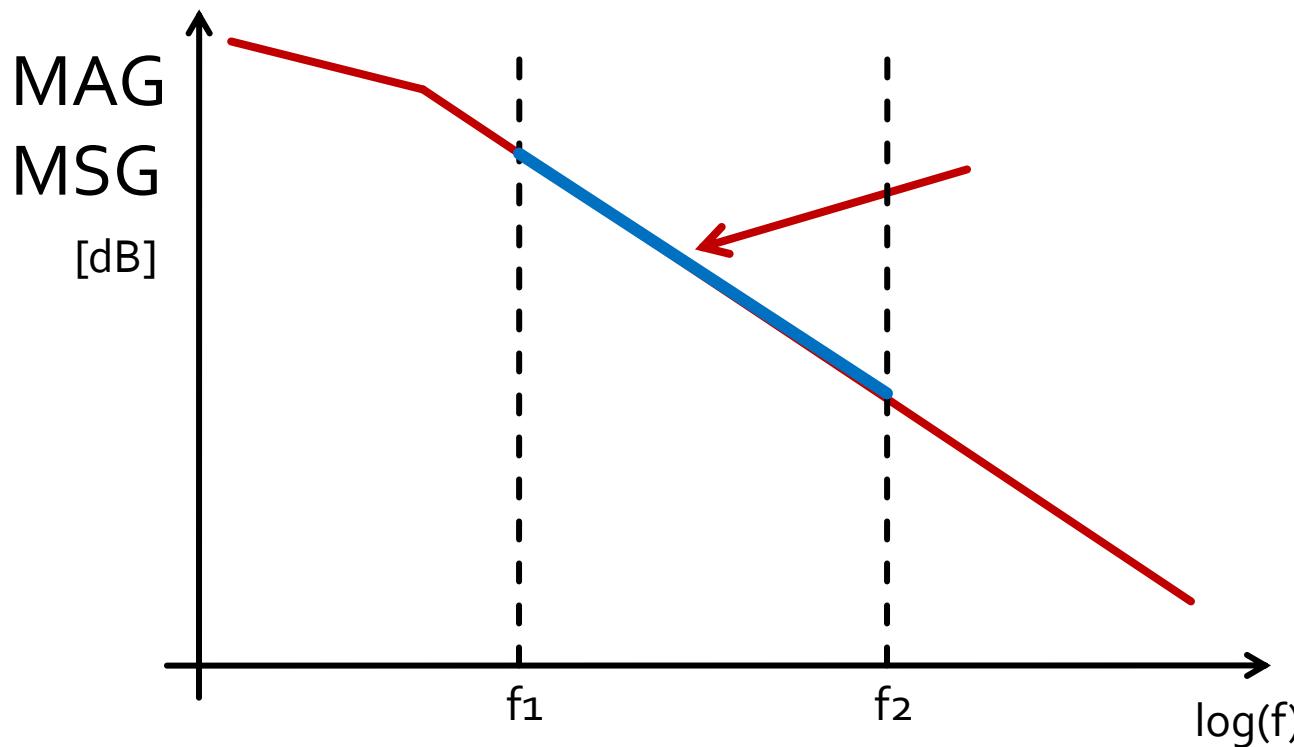
Amplificatoare de microunde

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

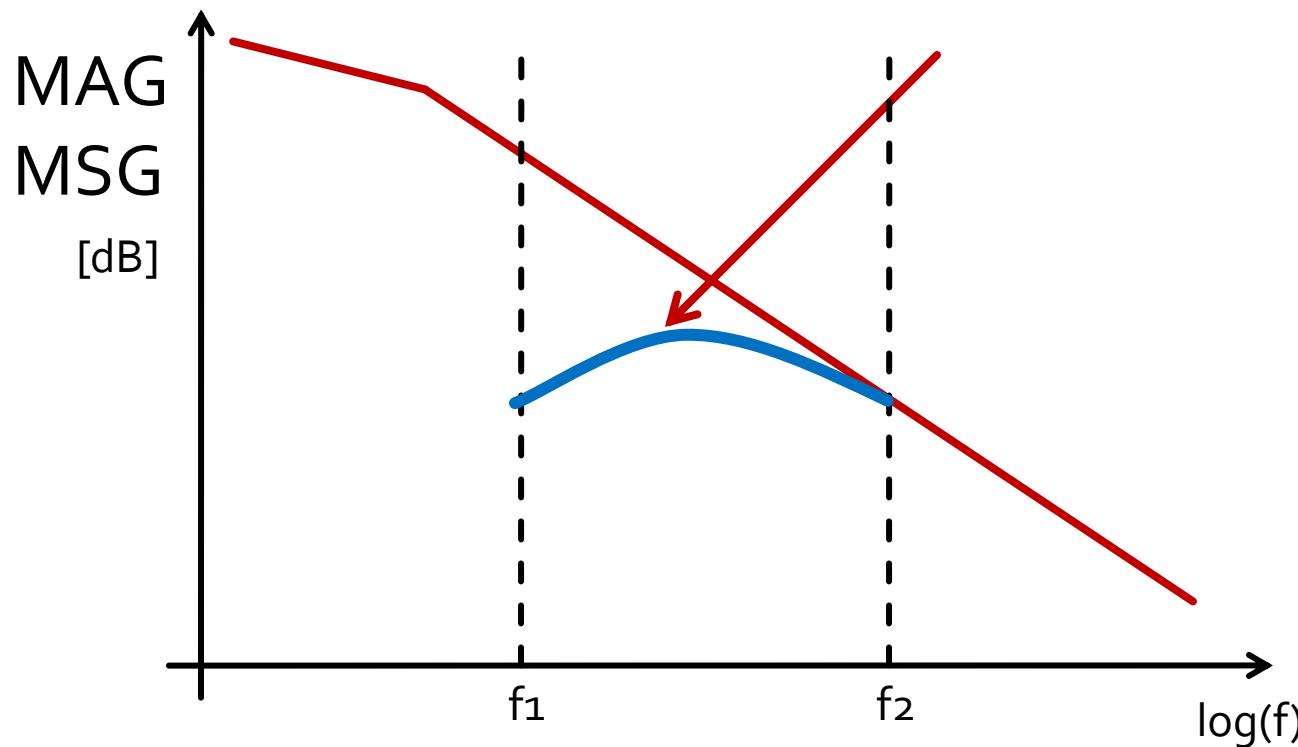
Amplificator de banda largă

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

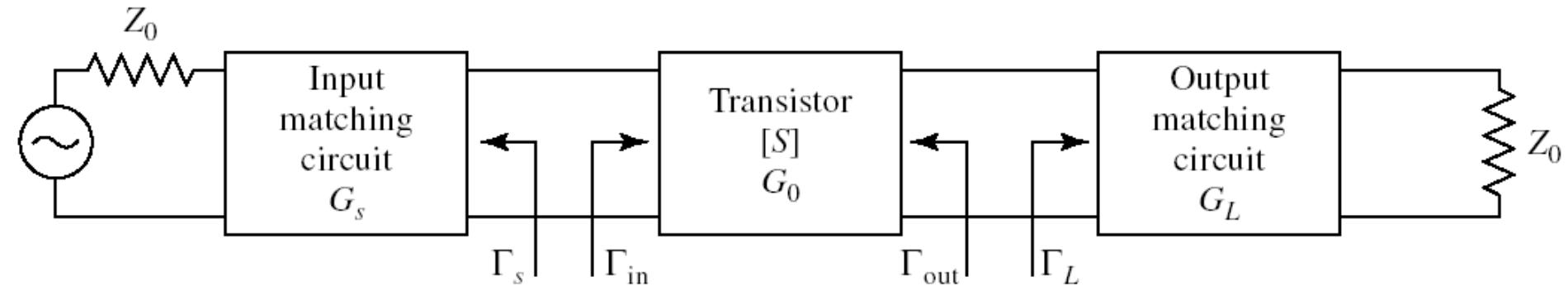


Amplificator de banda largă

- 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:

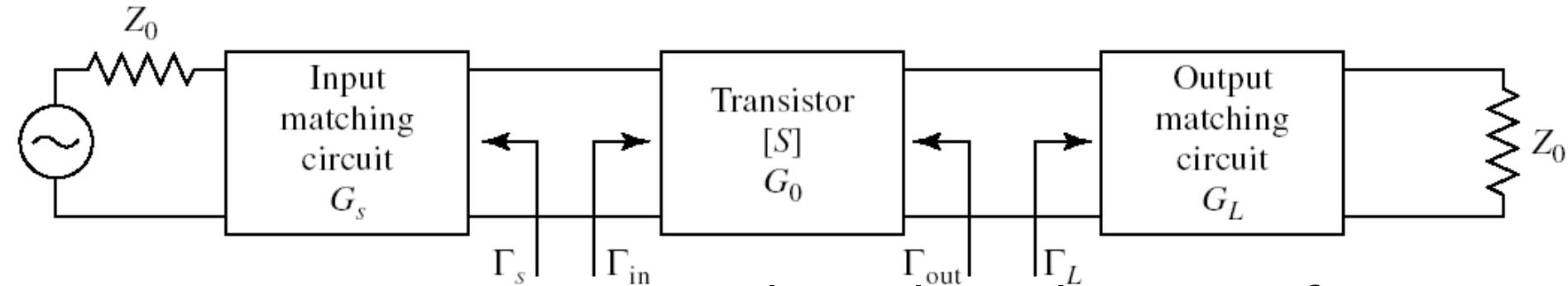
$$G_{TU} = |S_{21}|^2 \cdot \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2} \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

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

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

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

Proiectare pentru castig impus

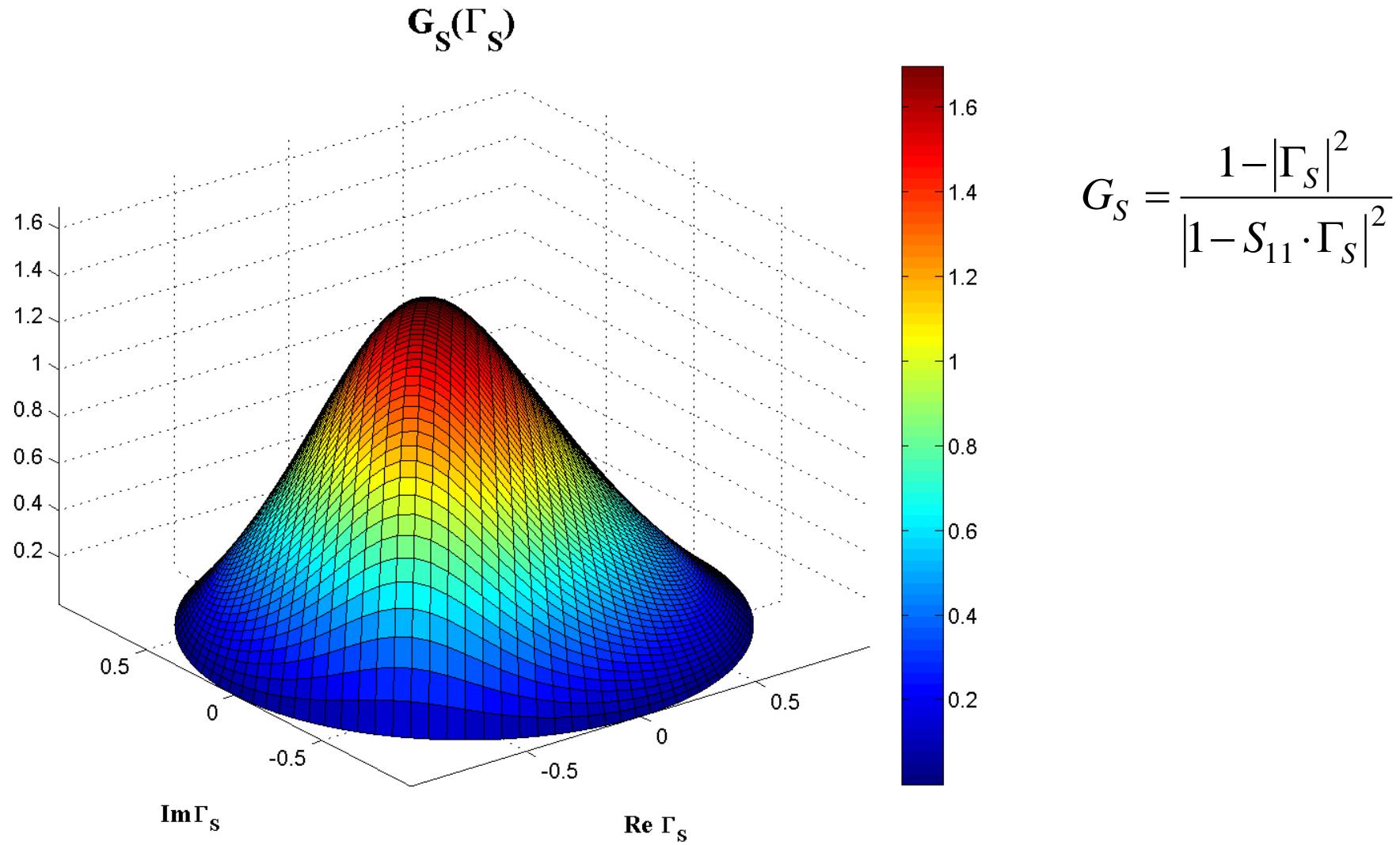


- Daca ipoteza tranzistorului unilateral este justificata:
 - castigul adaugat prin adaptare mai buna la intrare **nu** depinde de adaptarea la iesire
 - castigul adaugat prin adaptare mai buna la iesire **nu** depinde de adaptarea la intrare
- Adaptarile la intrare/iesire pot fi tratate independent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

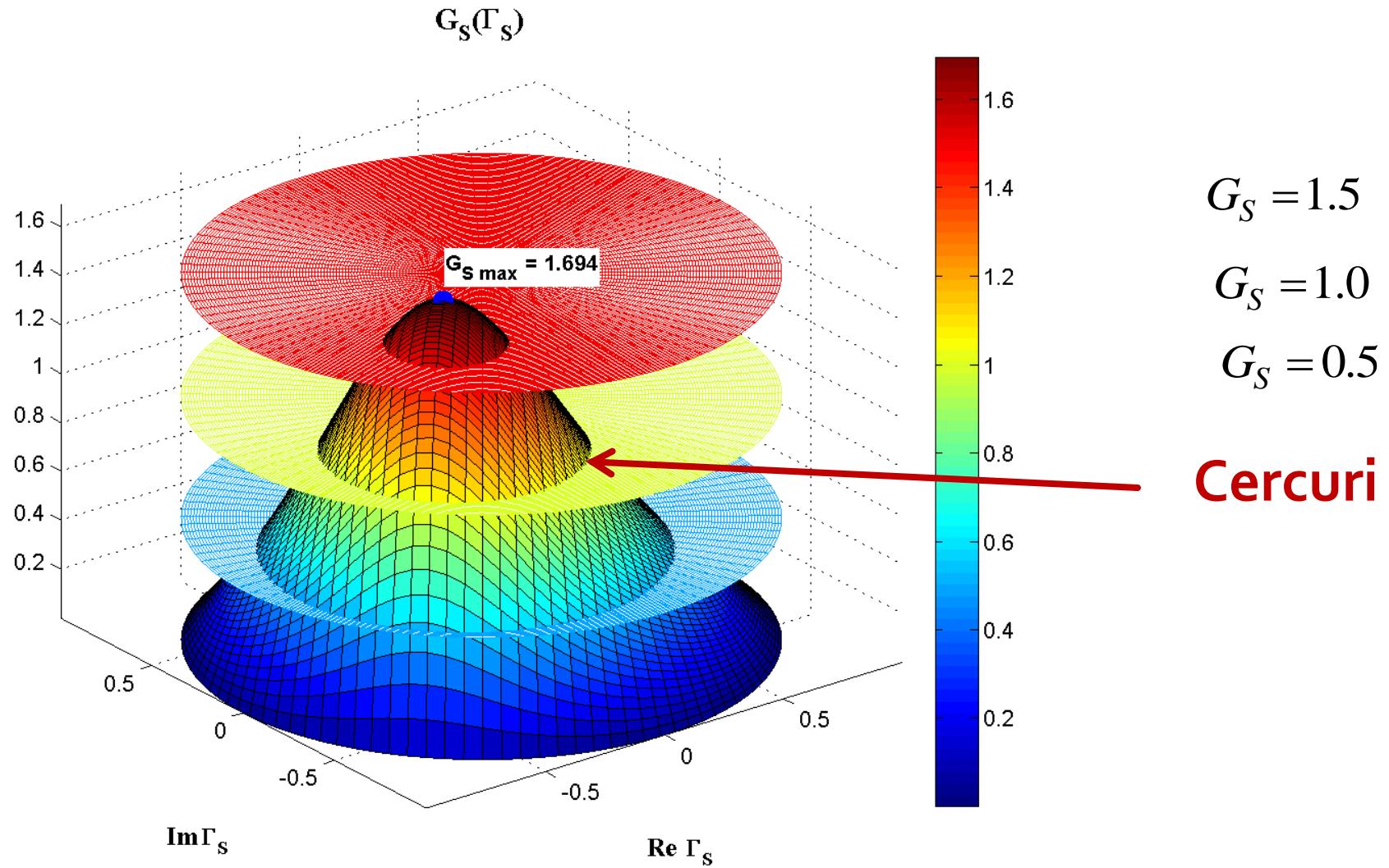
$$G_T = G_S \cdot G_0 \cdot G_L$$

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

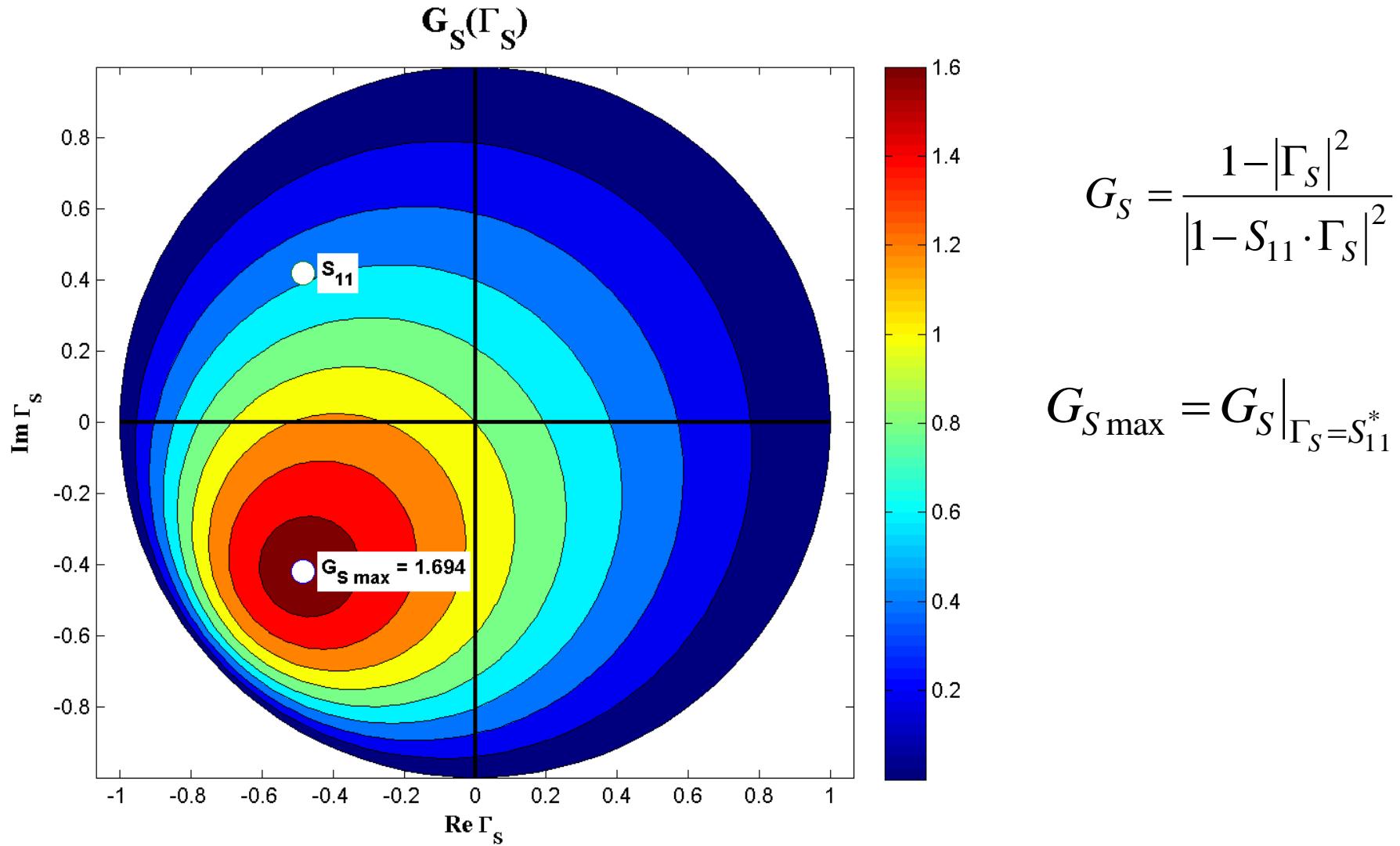
$\mathbf{G}_S(\Gamma_S)$



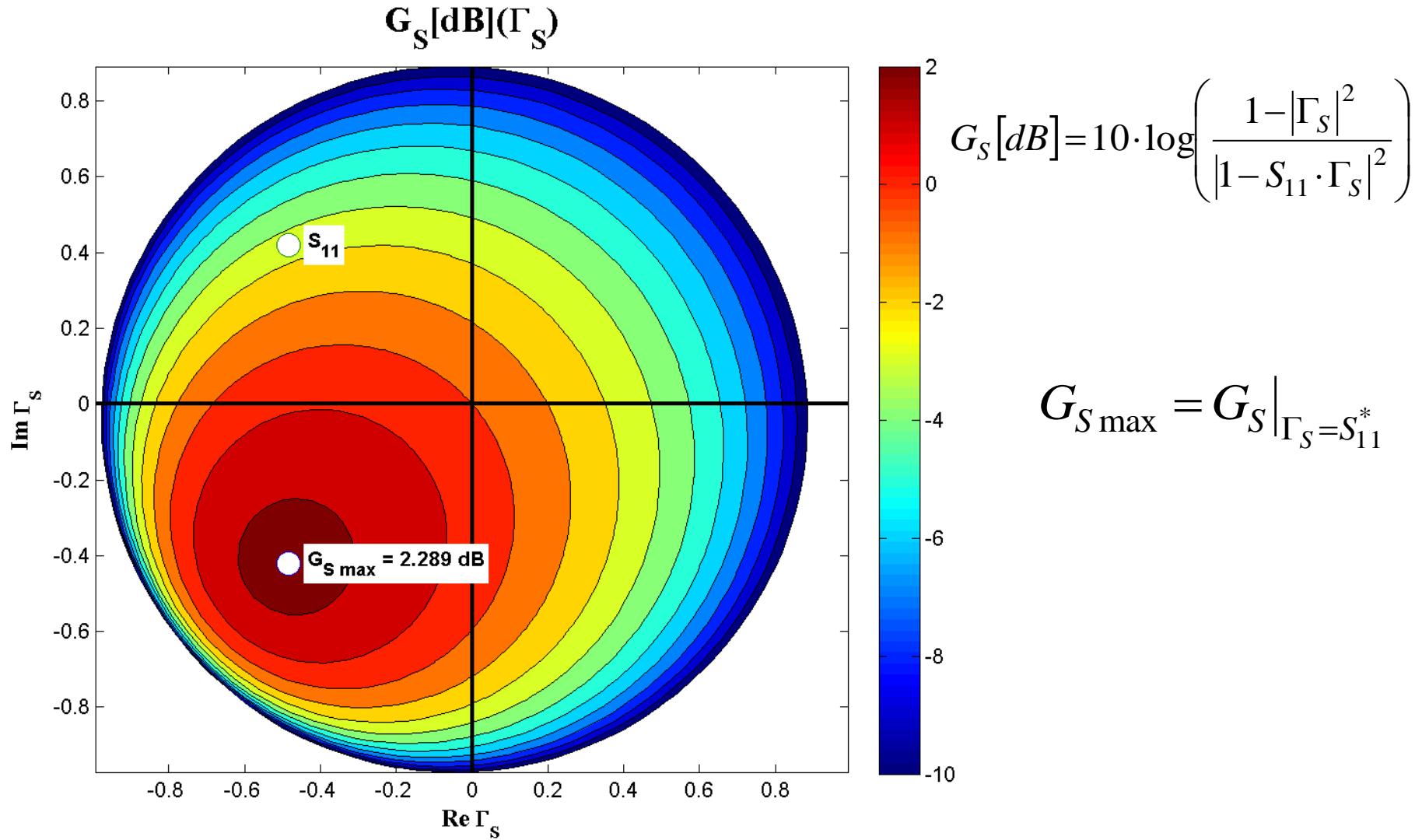
$G_S(\Gamma_S)$, nivel constant



$G_S(\Gamma_S)$, diagrama de nível



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

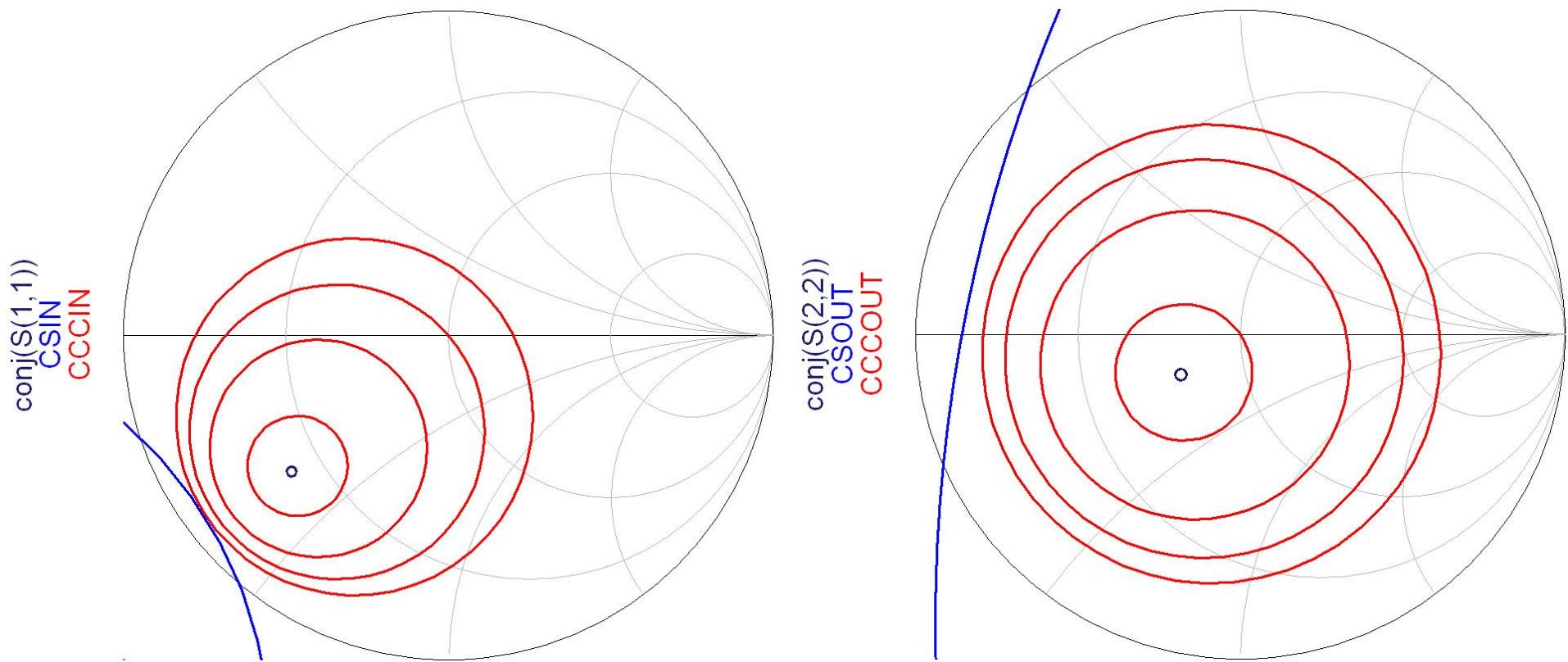


Cercuri de castig constant la intrare

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

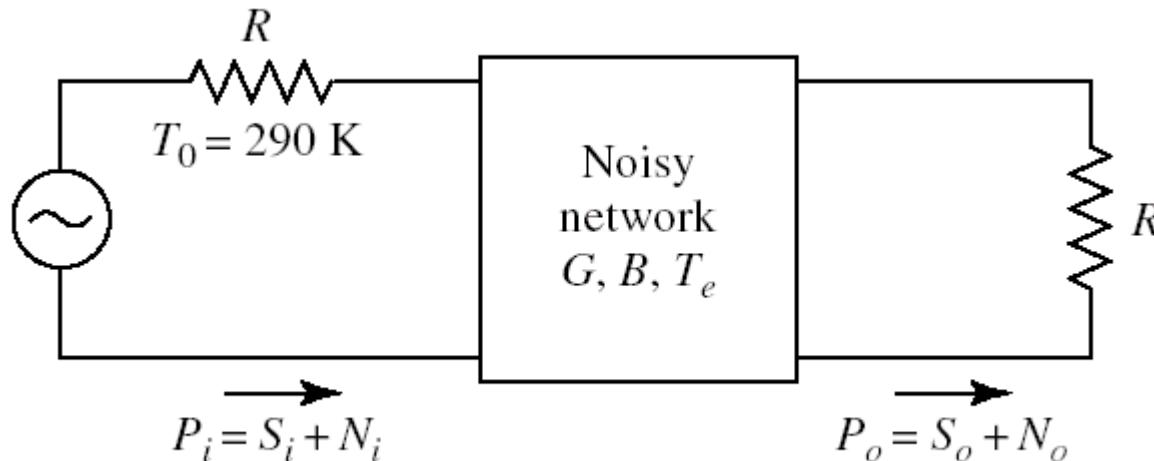
- Ecuatia unui cerc in planul complex in care reprezint Γ_S
- **Interpretare:** Orice punct Γ_S care reprezentat in planul complex se gaseste **pe** cercul desenat pentru $g_{\text{cerc}} = G_{\text{cerc}} / G_{\text{Smax}}$ va conduce la obtinerea castigului $G_S = G_{\text{cerc}}$
 - Orice punct **in 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

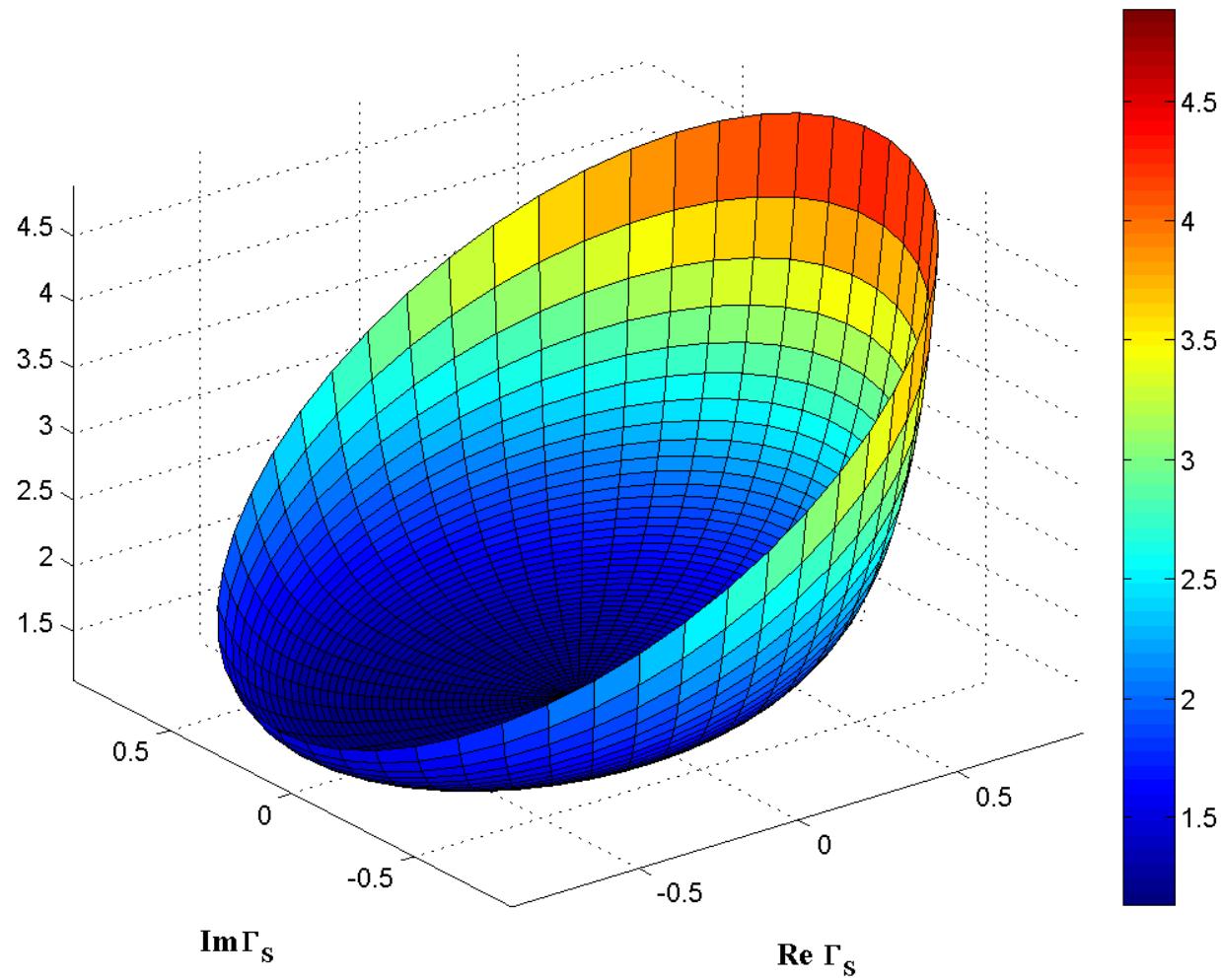


- Factorul de zgomot F caracterizeaza degradarea raportului semnal/zgomot intre intrarea si iesirea unei componente

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

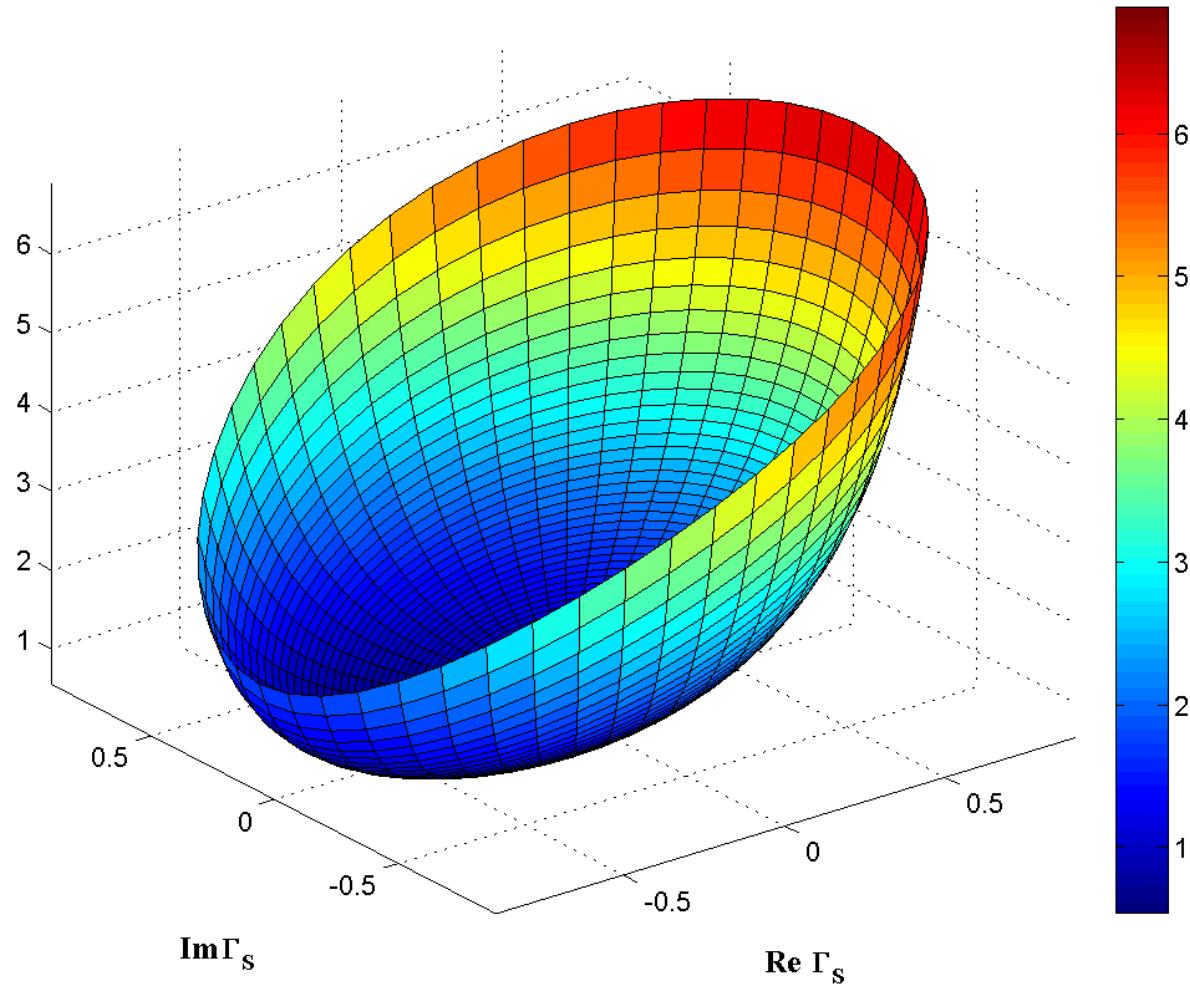
$F(\Gamma_s)$

$F(\Gamma_s)$

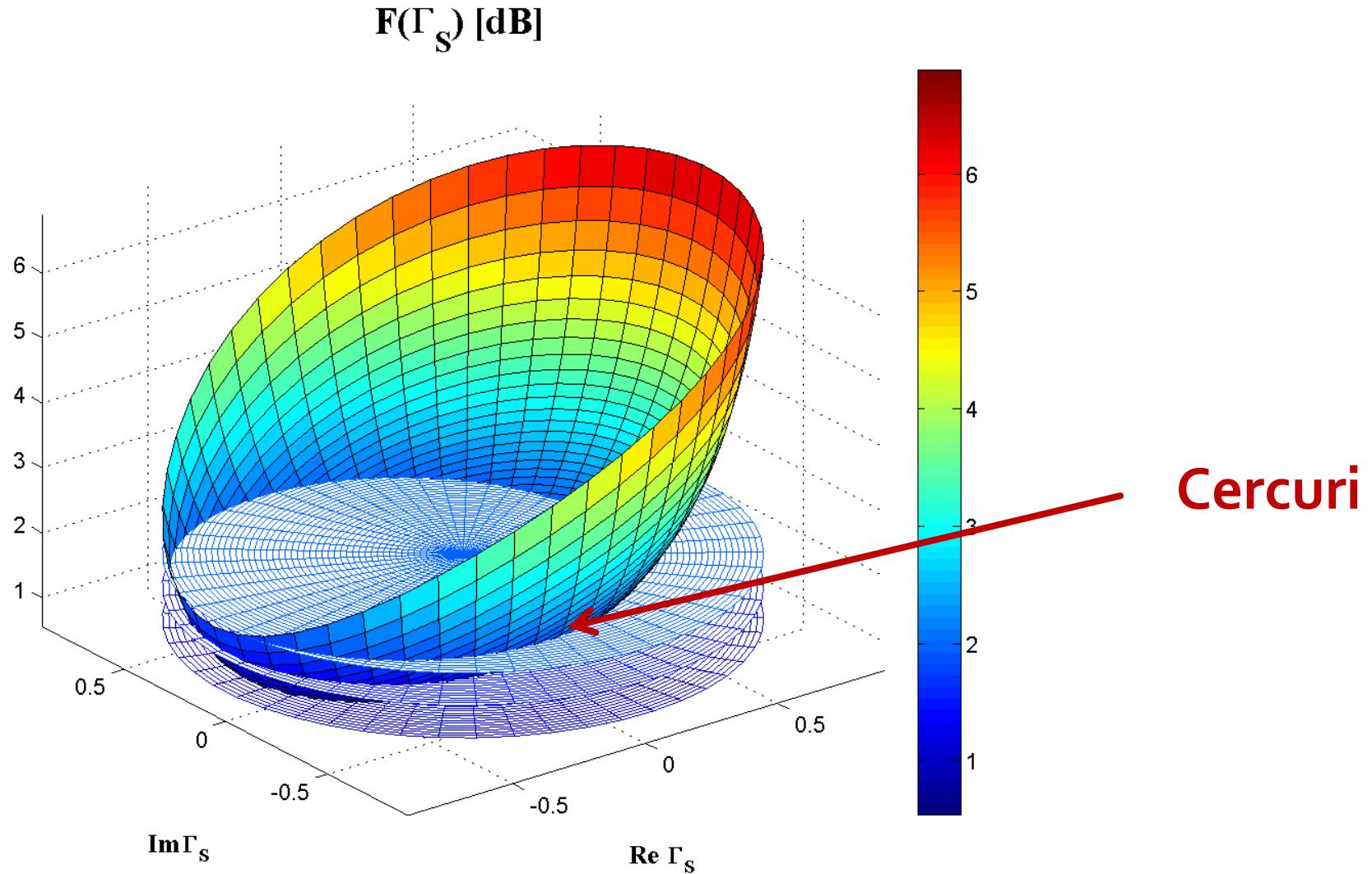


$F[dB](\Gamma_S)$

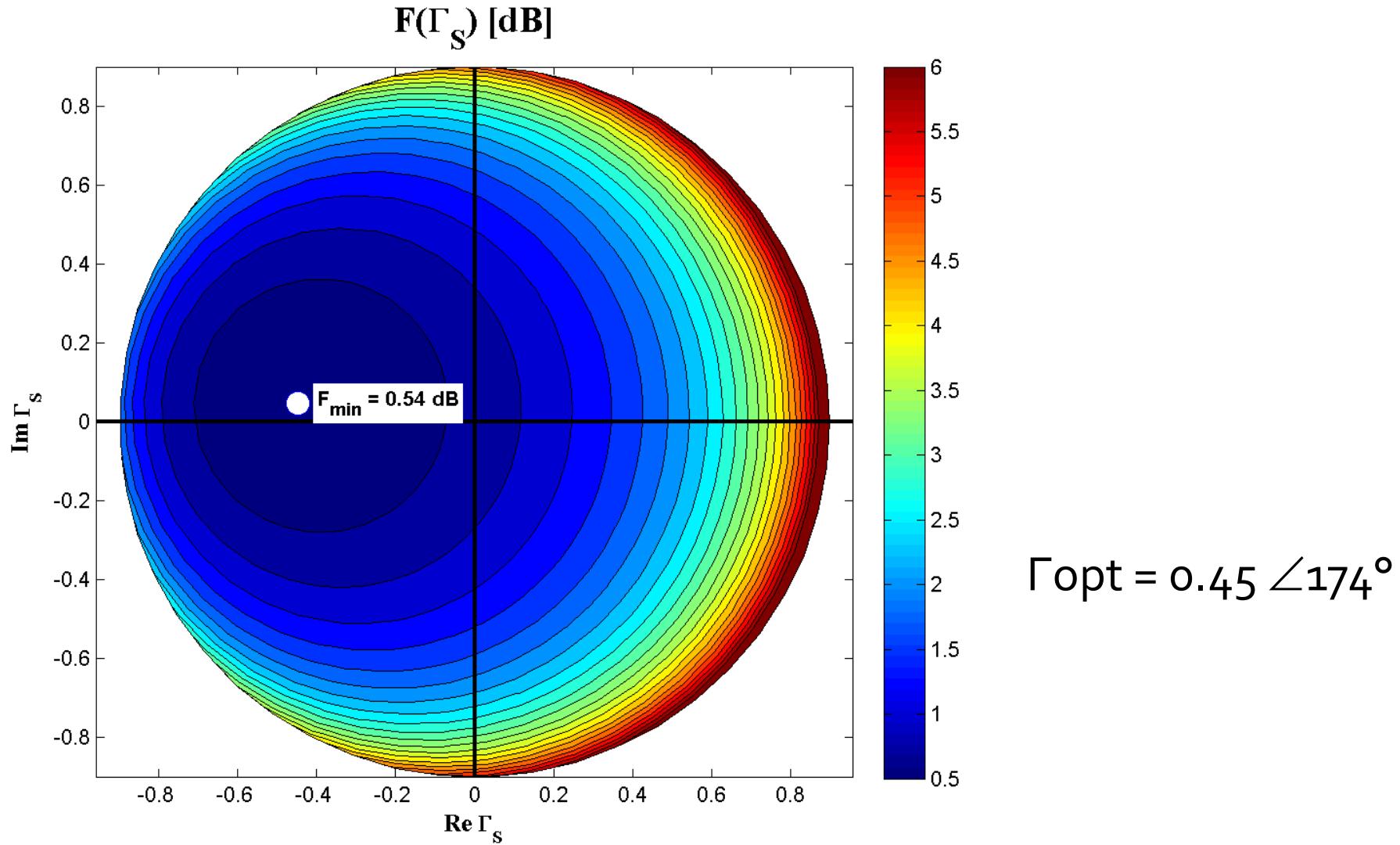
$F(\Gamma_S) [dB]$



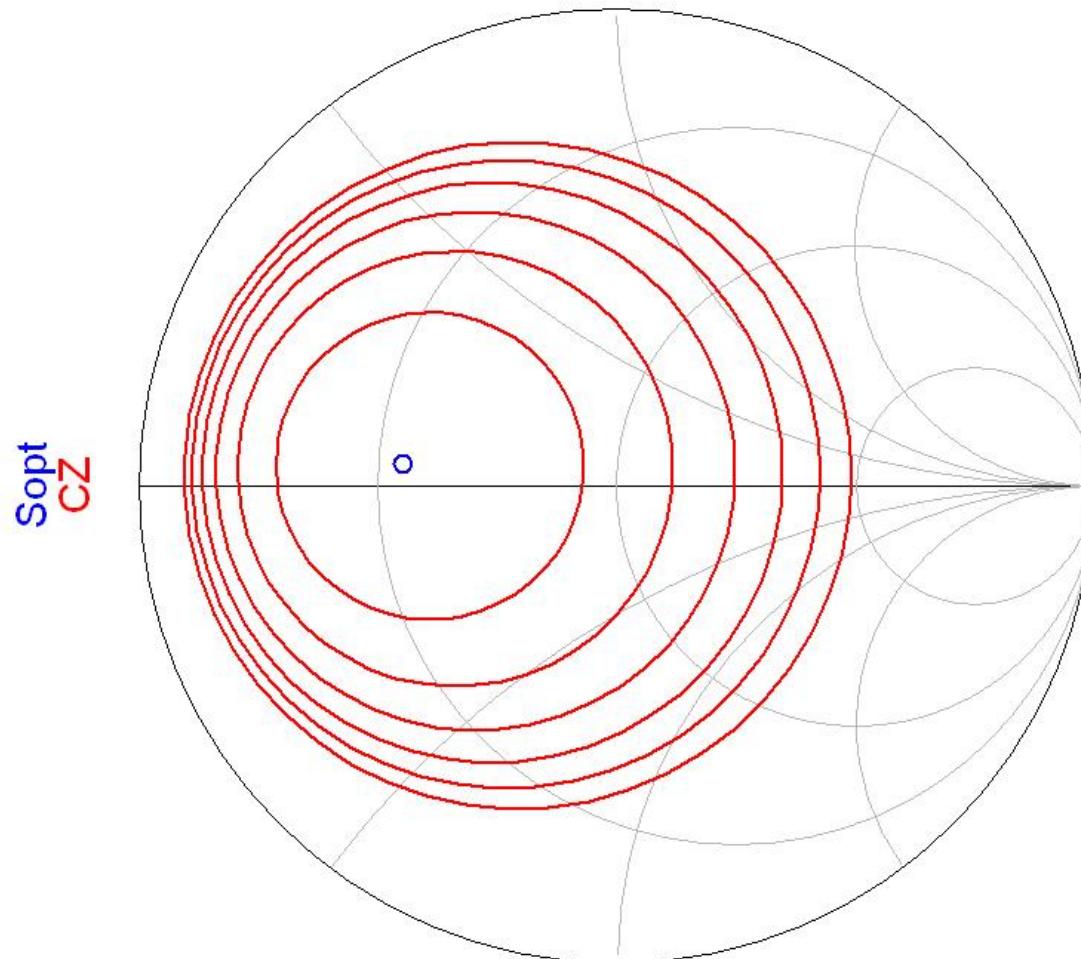
$F[dB](\Gamma_s)$, diagrama de nivel



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



CZ – numai la intrare !



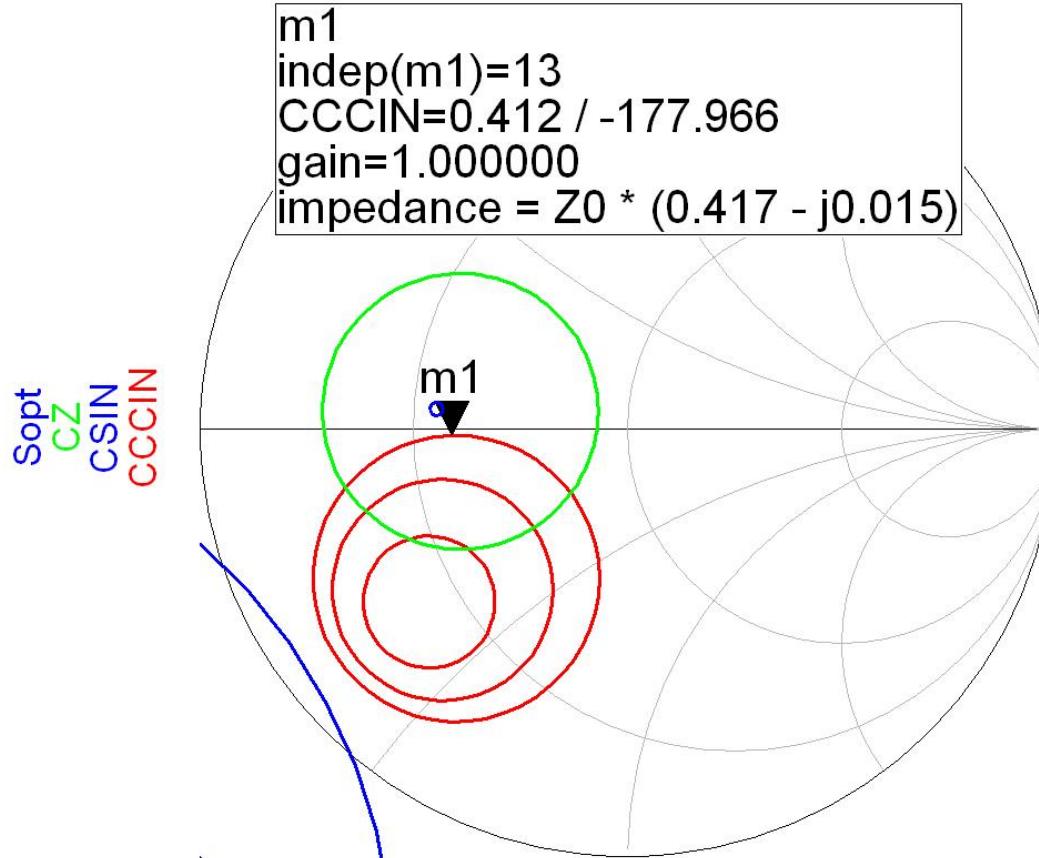
S_{CZ}^{opt}

cir_pts (0.000 to 51.000)
freq (5.000GHz to 5.000GHz)

Exemplu, LNA @ 5 GHz

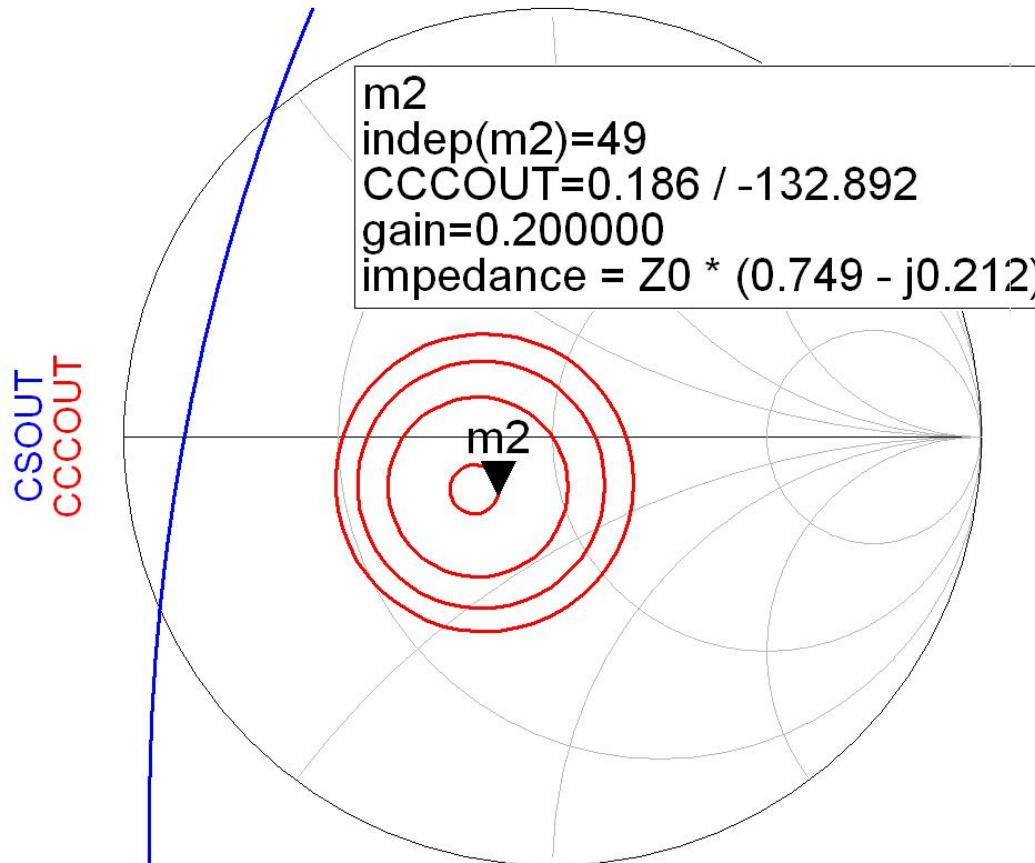
- Amplificator de zgomot redus
- La intrare e necesar un compromis intre
 - zgomot (cerc de zgomot constant ~~la intrare~~)
 - castig (cerc de castig constant la intrare)
 - stabilitate (cerc de stabilitate la intrare)
- La iesire zgomotul **nu intervine** (nu exista influenta). Compromis intre:
 - castig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

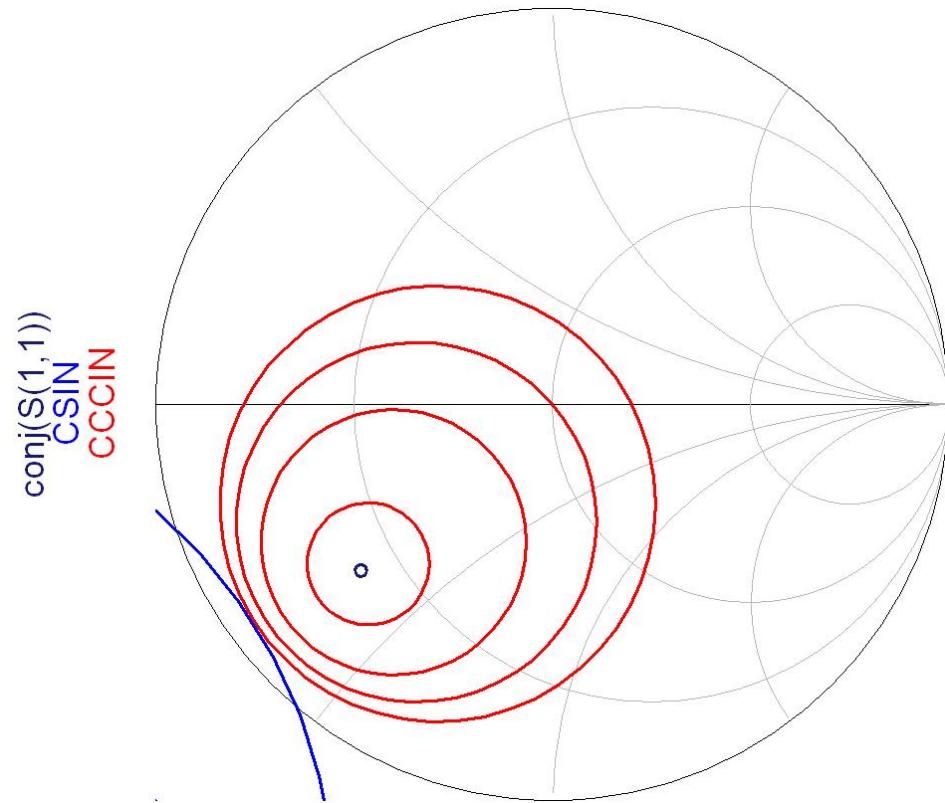
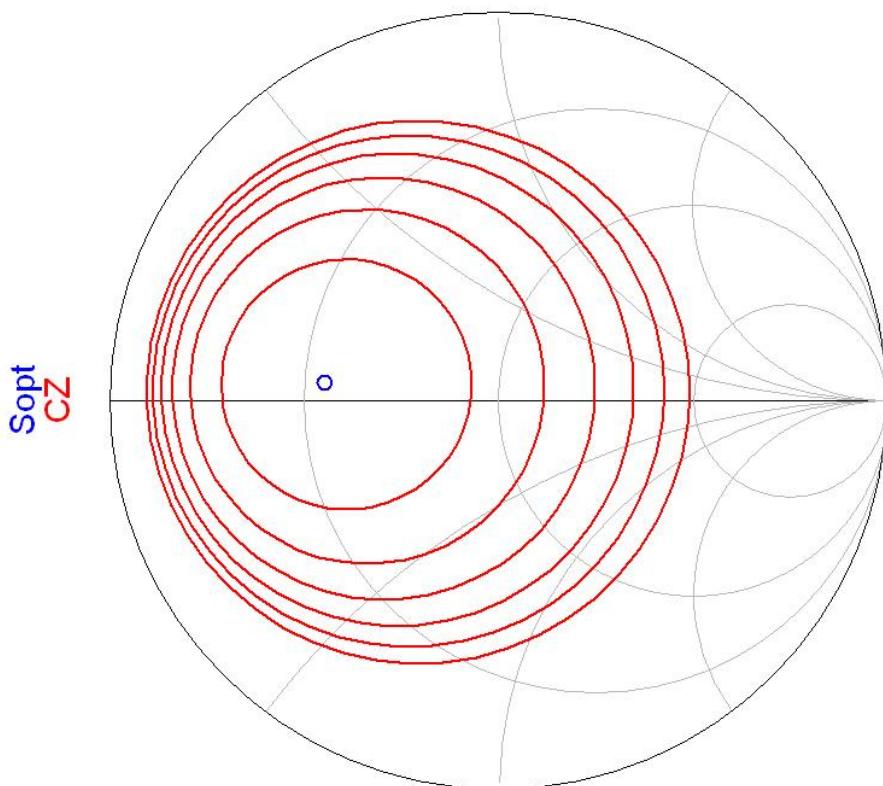
Adaptare la ieșire



- 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 Γ_s



Contact

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- rdamian@etti.tuiasi.ro