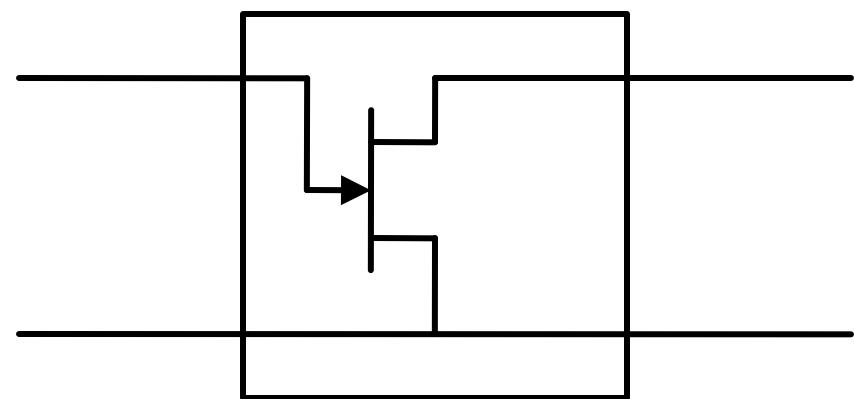
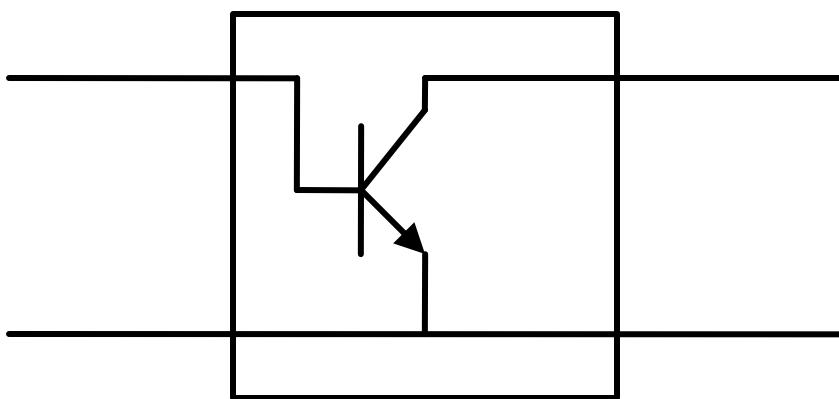
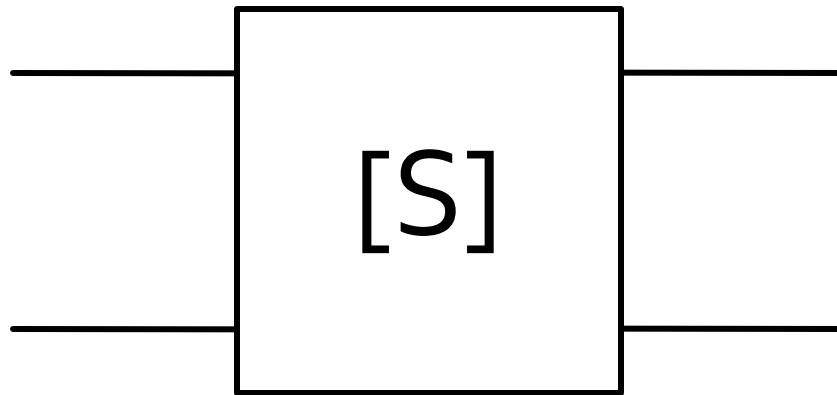


Laborator 3
2020/2021

Dispozitive și circuite de microunde pentru radiocomunicații

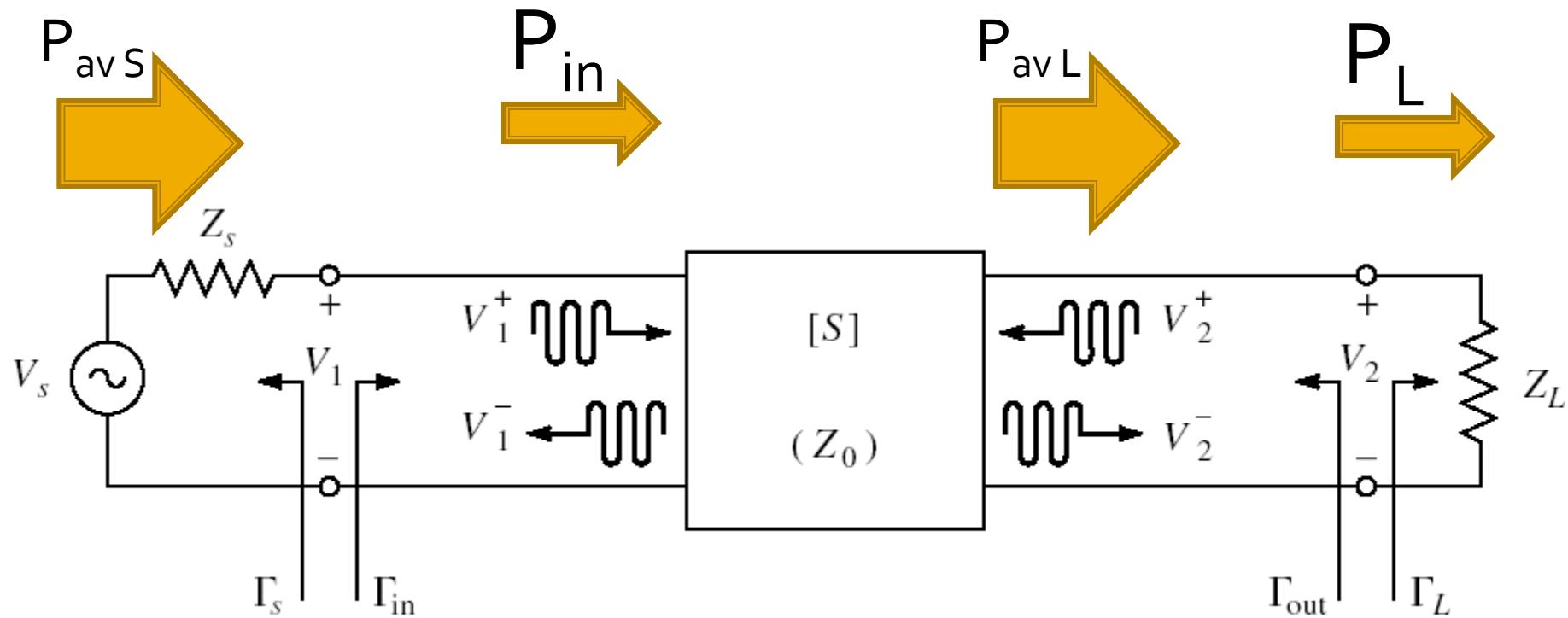
Scurta teorie

Parametri S

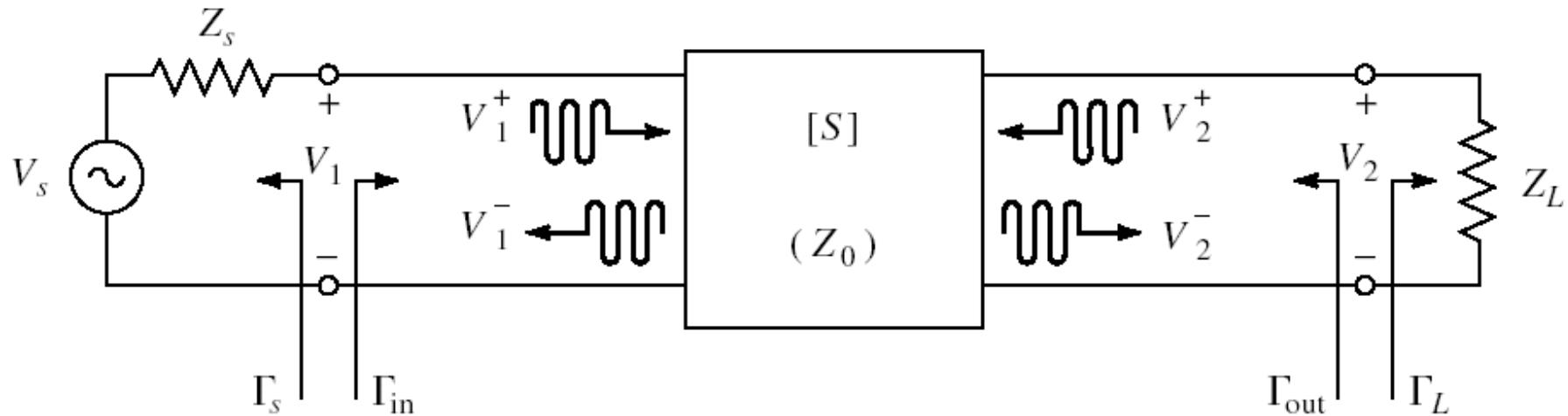


Puteri / Adaptare

- Doua porturi in care adaptarea influenteaza transferul de putere

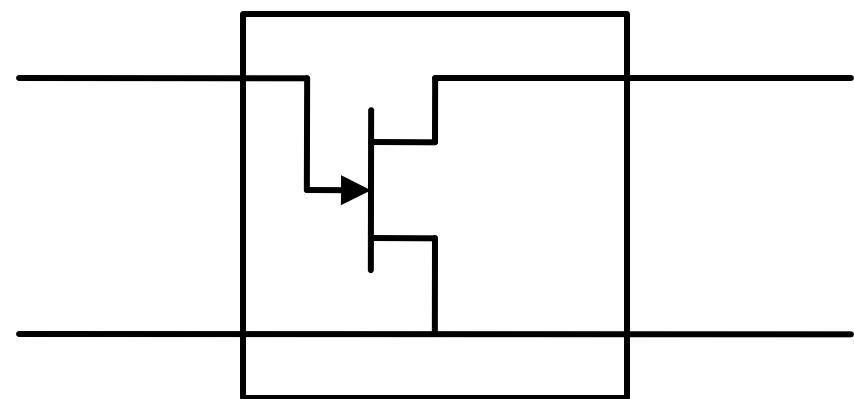
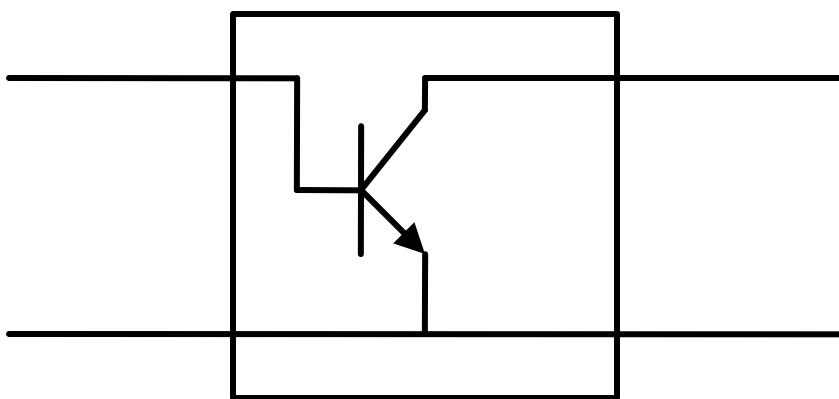
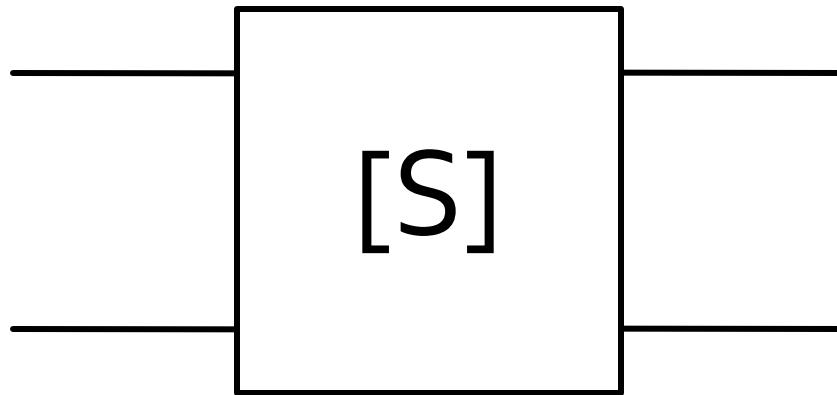


Cuadripol Amplificator (diport)



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

Parametri S



Stabilitate

$$|\Gamma_{in}| < 1$$

$$\left| S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L} \right| < 1$$

- Obtinem conditiile ce trebuie indeplinite de Γ_L pentru a obtine stabilitatea

$$|\Gamma_{out}| < 1$$

$$\left| S_{22} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_S}{1 - S_{11} \cdot \Gamma_S} \right| < 1$$

- Obtinem conditiile ce trebuie indeplinite de Γ_S pentru a obtine stabilitatea

Cerc de stabilitate la ieșire (CSOUT)

$$\left| \Gamma_L - \frac{(S_{22} - \Delta \cdot S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} \right| = \left| \frac{S_{12} \cdot S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| \quad |\Gamma_L - C_L| = R_L$$

- Ecuatia unui cerc, care reprezinta locul geometric al punctelor Γ_L pentru **limita** de stabilitate
- Cercul se numeste **cerc de stabilitate la ieșire** (Γ_L)

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

Cerc de stabilitate la intrare (CSIN)

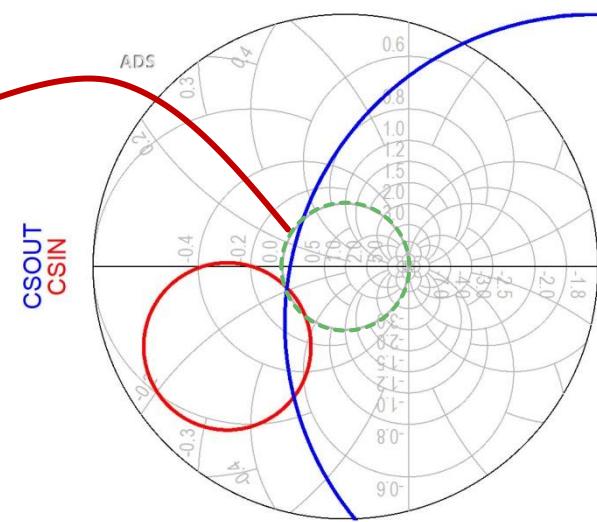
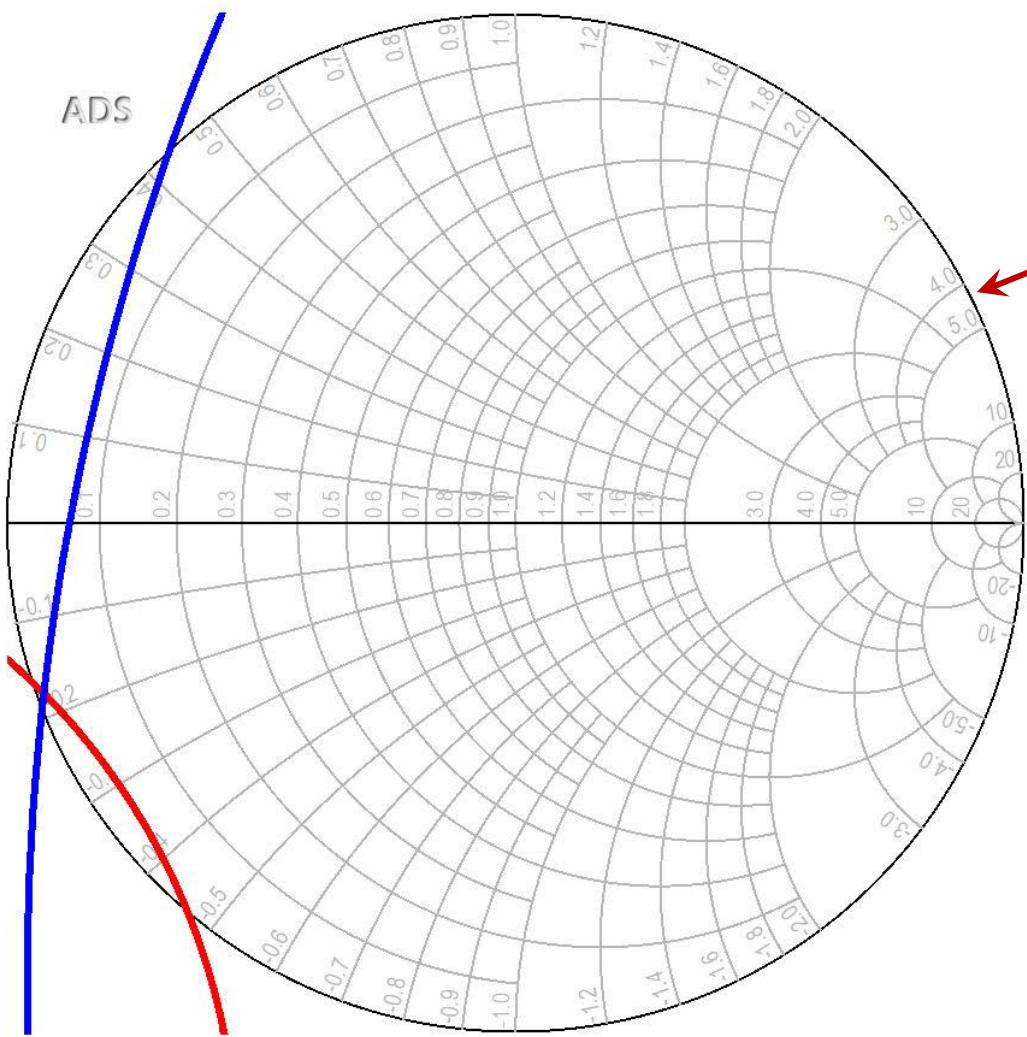
- Similar $|\Gamma_{out}| = 1$ $\left| S_{22} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_S}{1 - S_{11} \cdot \Gamma_S} \right| = 1$
- Ecuatia unui cerc, care reprezinta locul geometric al punctelor Γ_S pentru **limita** de stabilitate
- Cercul se numeste **cerc de stabilitate la intrare** (Γ_S)

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

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

ADS

CSOUT
CSIN

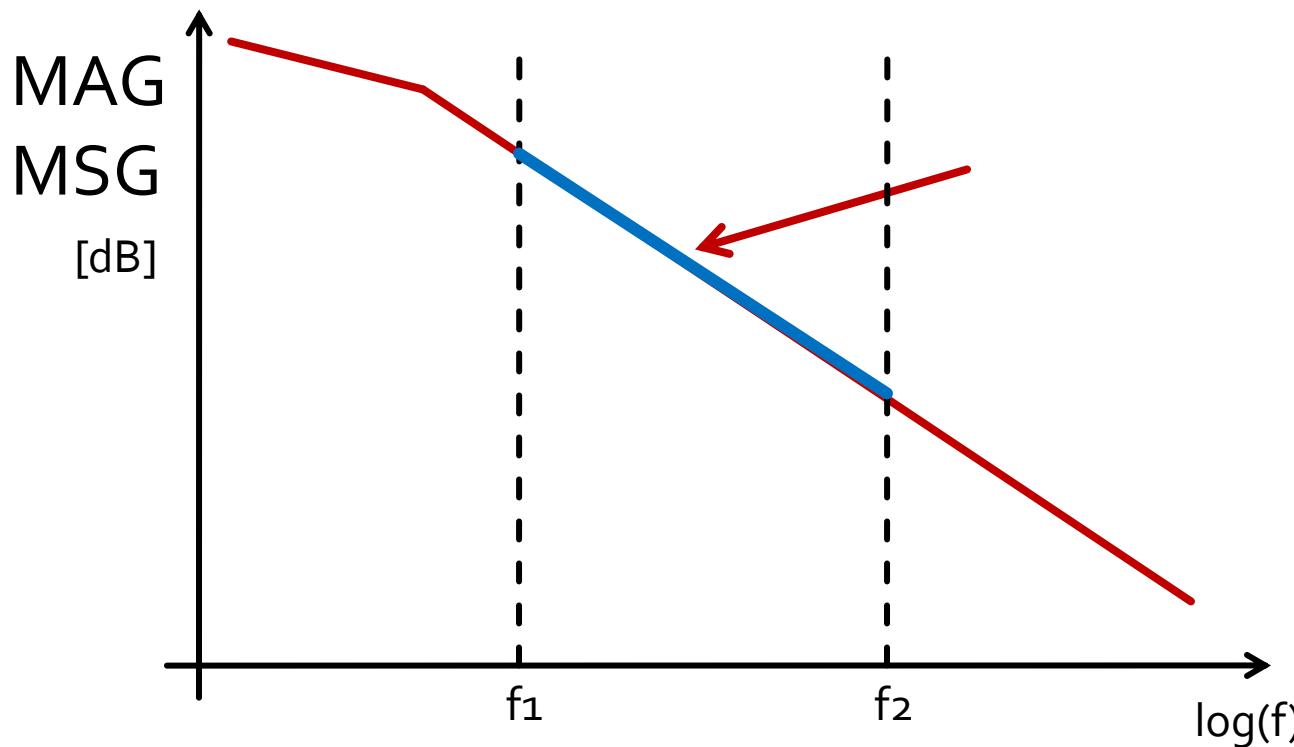


Proiectare pentru castig impus

- 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

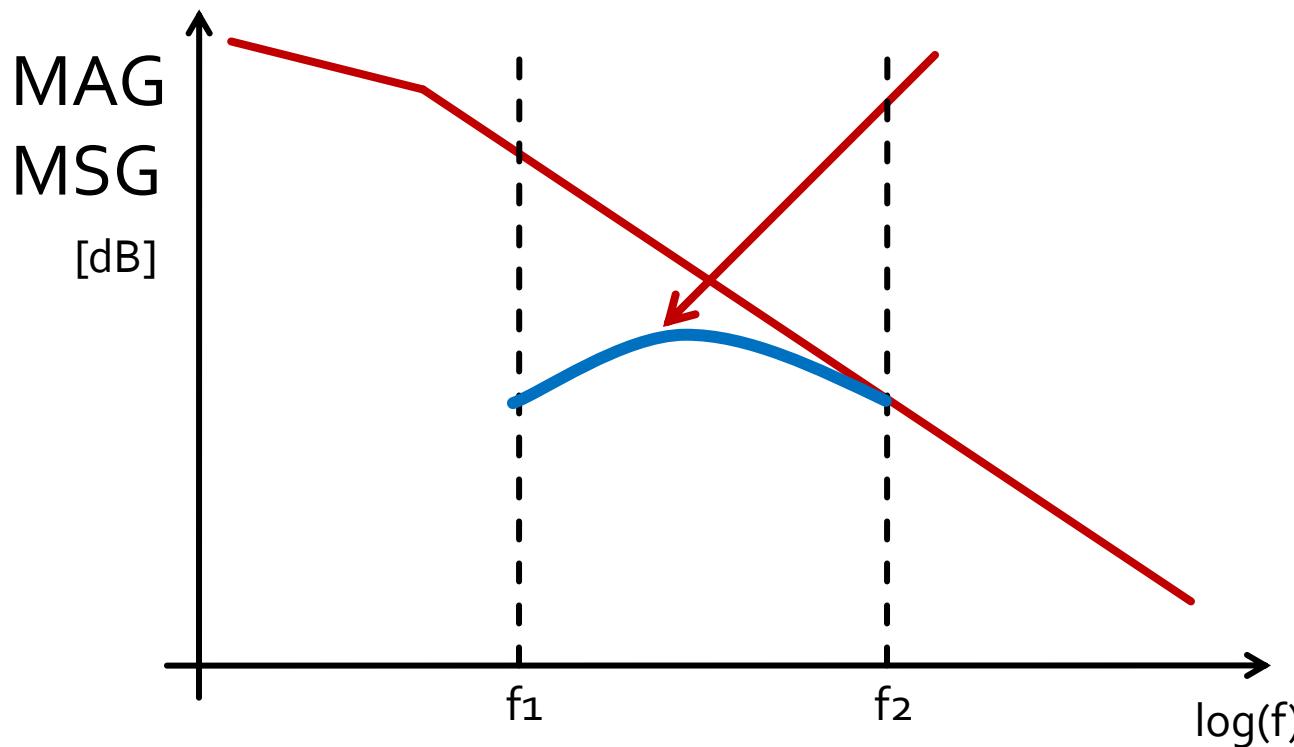
Amplificator de banda largă

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

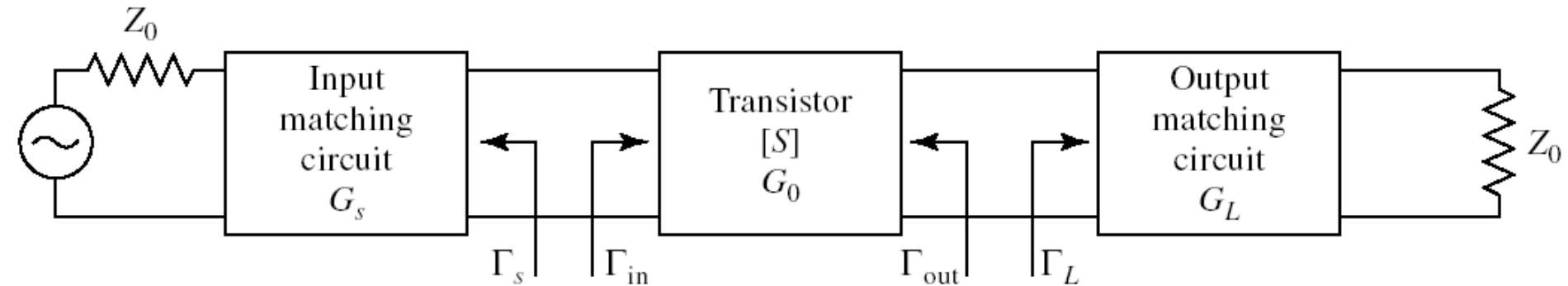


Amplificator de banda largă

- 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:

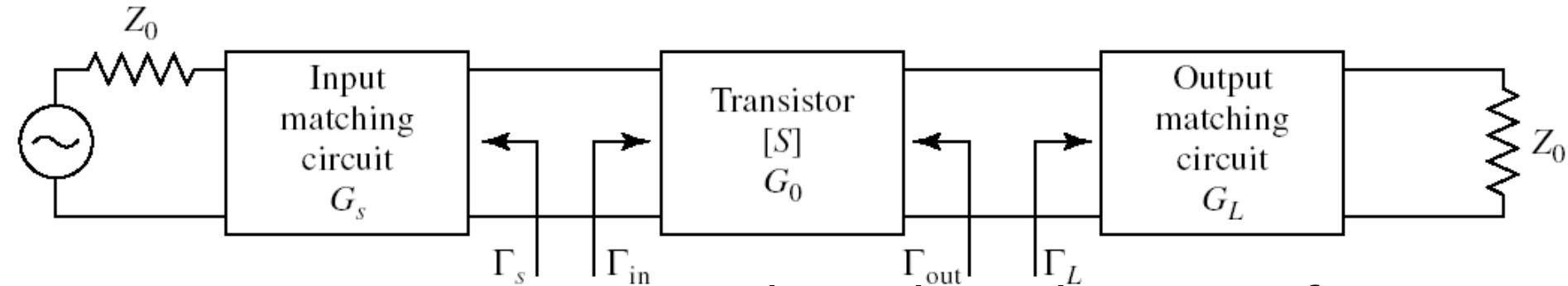
$$G_{TU} = |S_{21}|^2 \cdot \frac{1 - |\Gamma_s|^2}{|1 - S_{11} \cdot \Gamma_s|^2} \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

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

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

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

Proiectare pentru castig impus

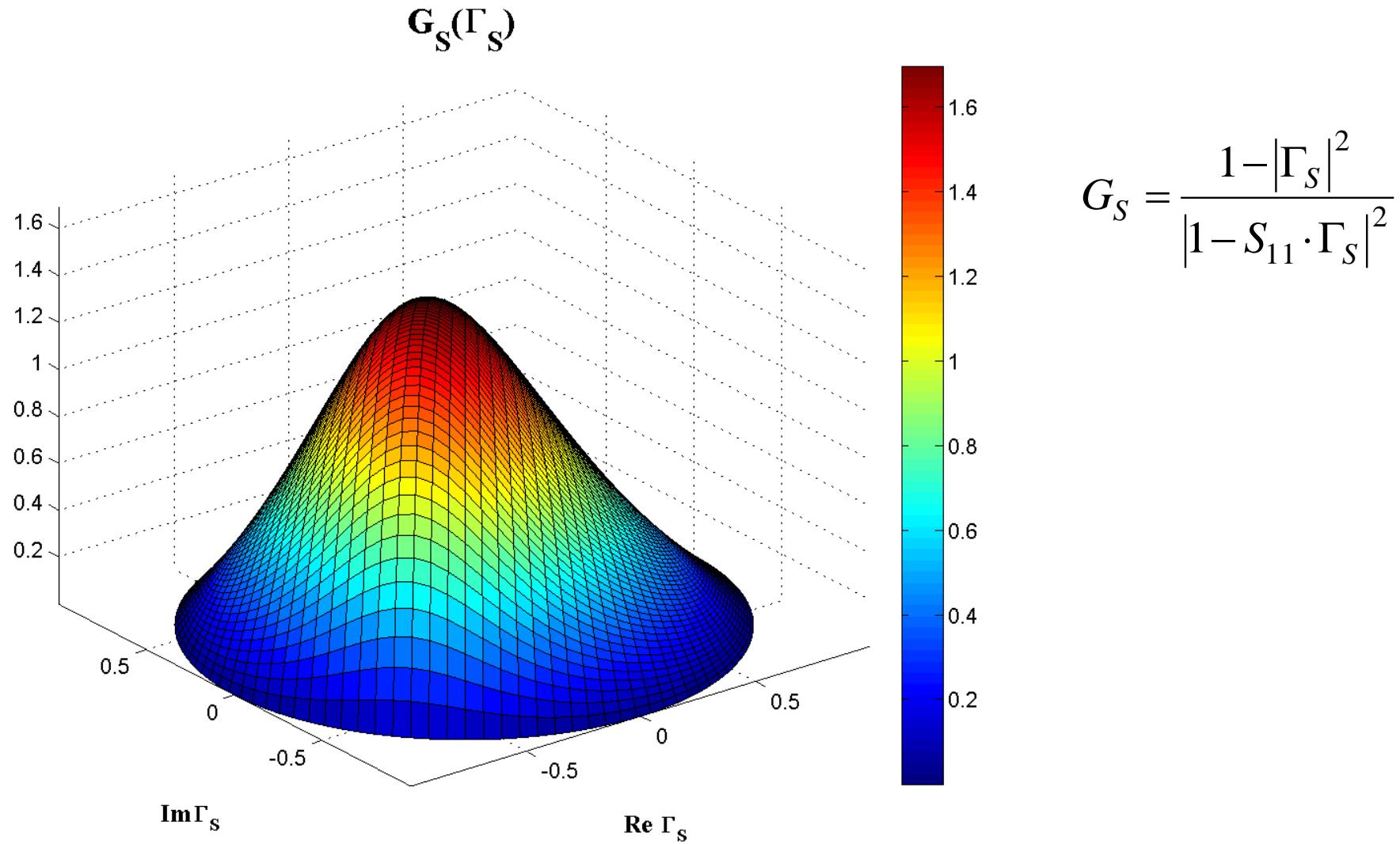


- Daca ipoteza tranzistorului unilateral este justificata:
 - castigul adaugat prin adaptare mai buna la intrare **nu** depinde de adaptarea la iesire
 - castigul adaugat prin adaptare mai buna la iesire **nu** depinde de adaptarea la intrare
- Adaptarile la intrare/iesire pot fi tratate independent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

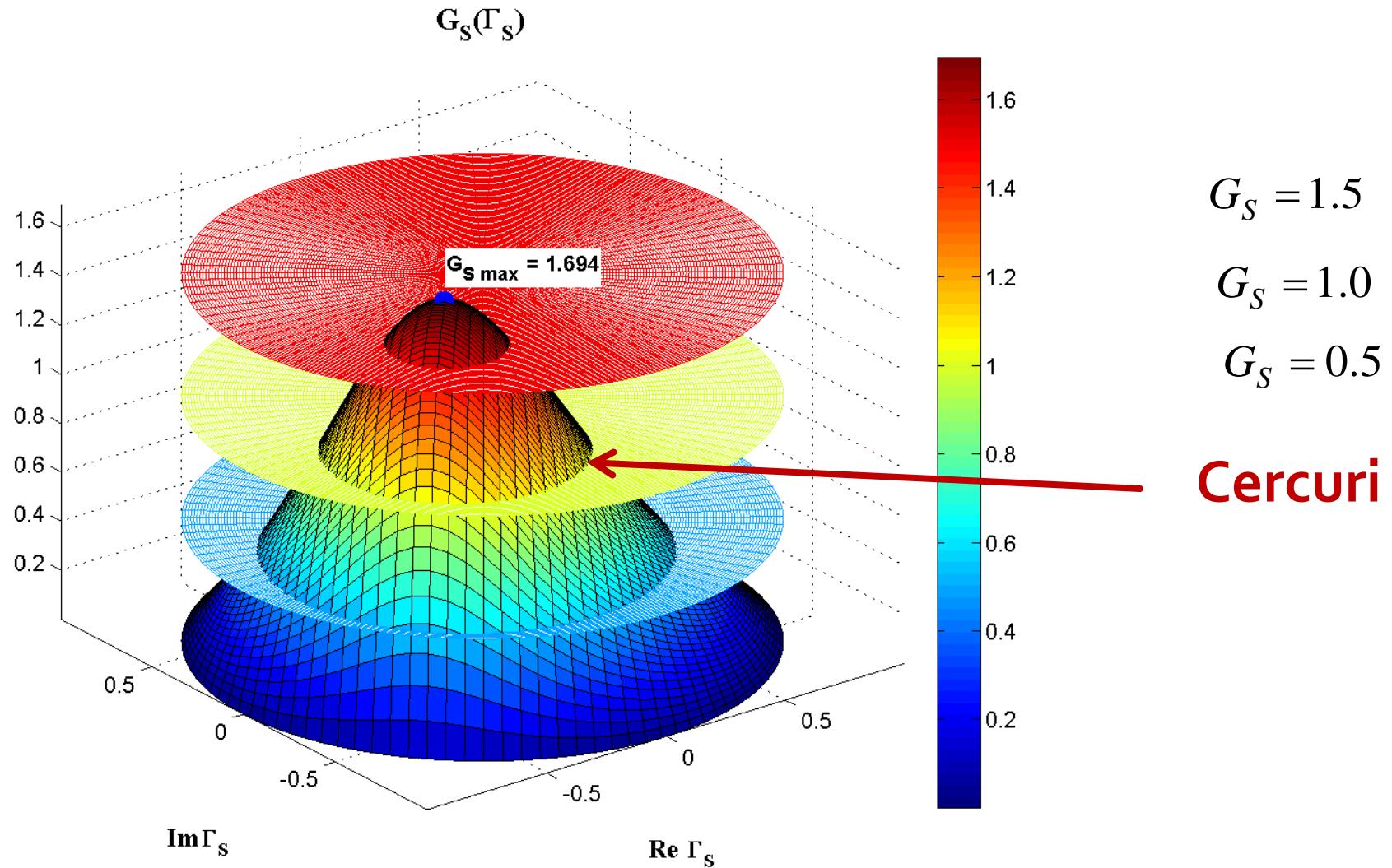
$$G_T = G_s \cdot G_0 \cdot G_L$$

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

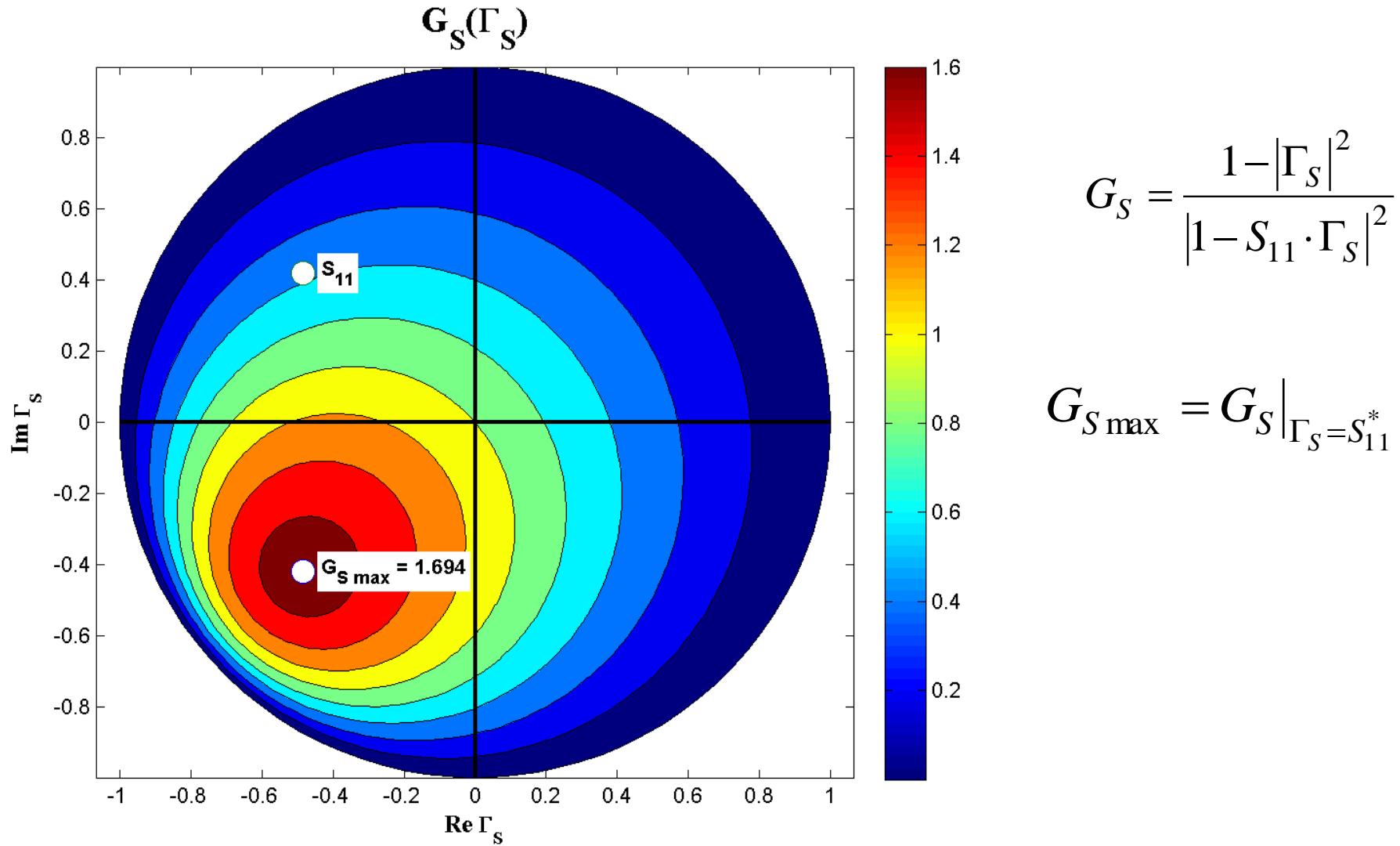
$\mathbf{G}_S(\Gamma_S)$



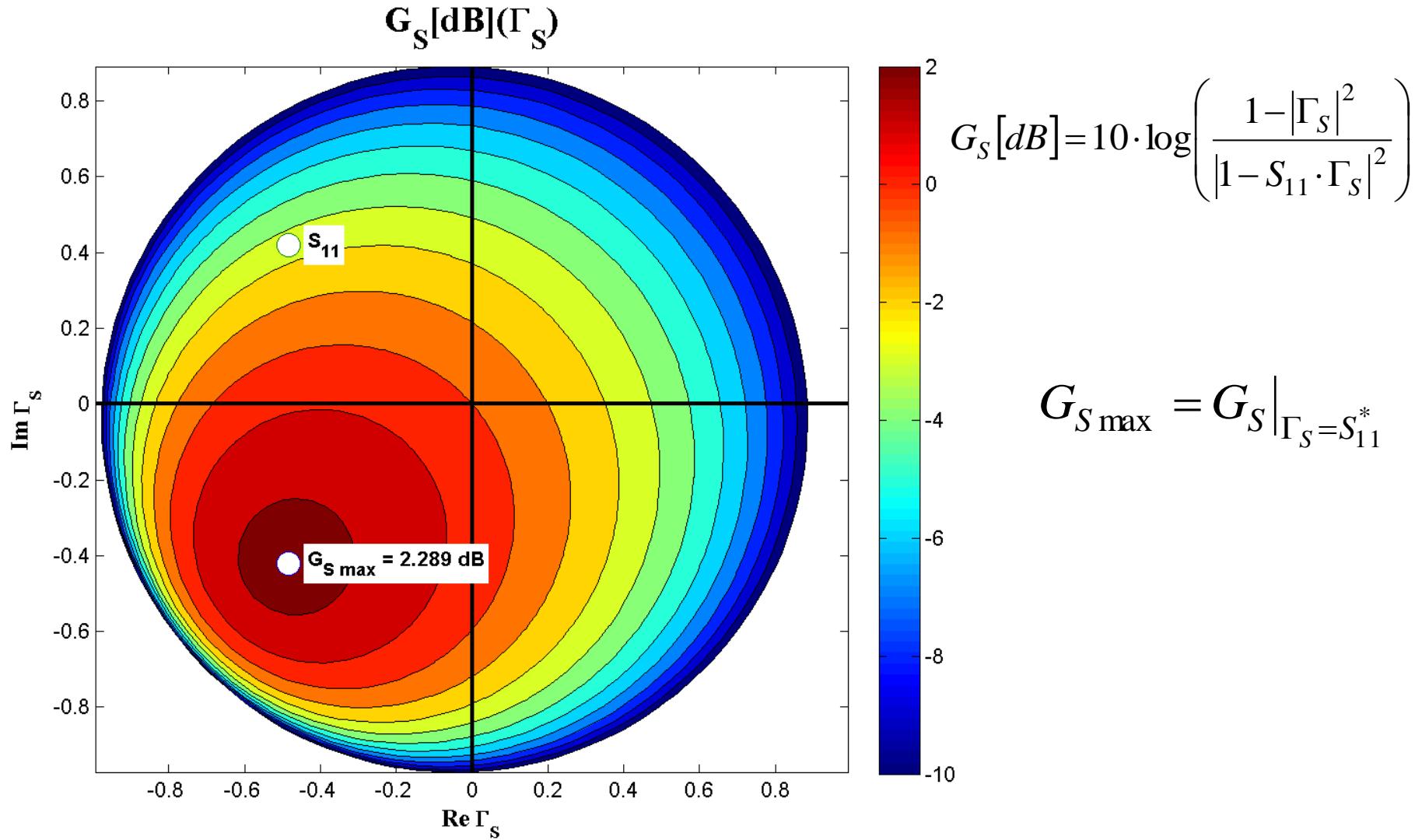
$G_S(\Gamma_S)$, nivel constant



$G_S(\Gamma_S)$, diagrama de nível



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

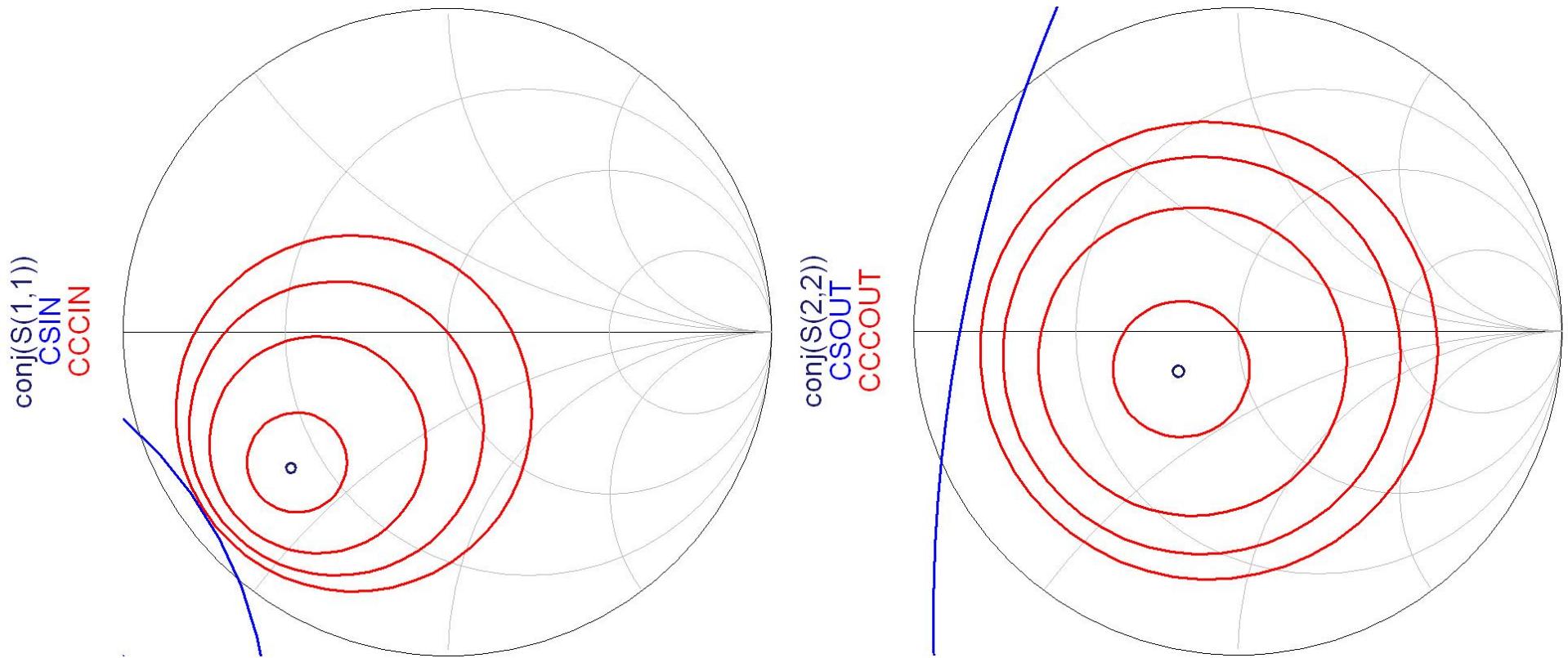


Cercuri de castig constant la intrare

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

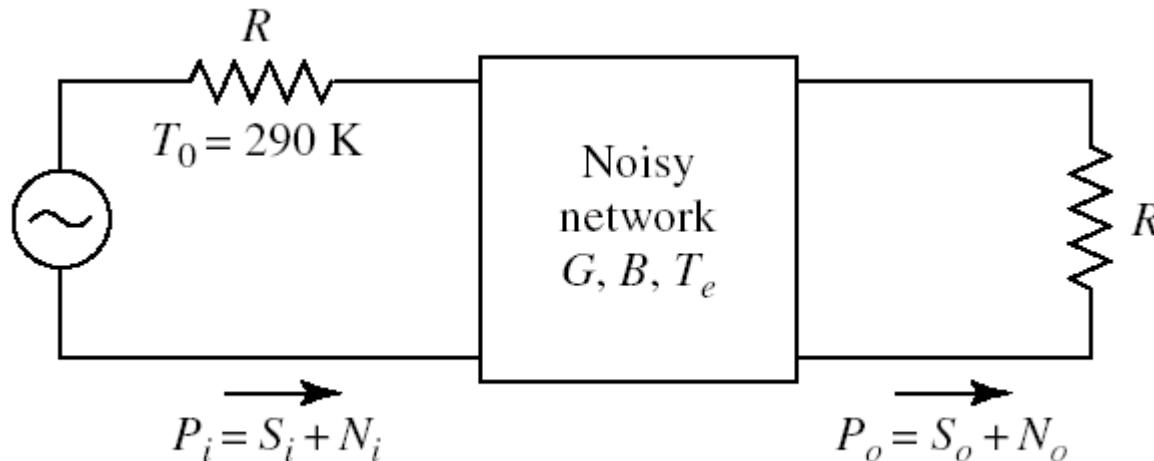
- Ecuatia unui cerc in planul complex in care reprezintă Γ_S
- **Interpretare:** Orice punct Γ_S care reprezentă în planul complex se gaseste **pe** cercul desenat pentru $g_{\text{cerc}} = G_{\text{cerc}} / G_{\text{Smax}}$ va conduce la obținerea castigului $G_S = G_{\text{cerc}}$
 - Orice punct **in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

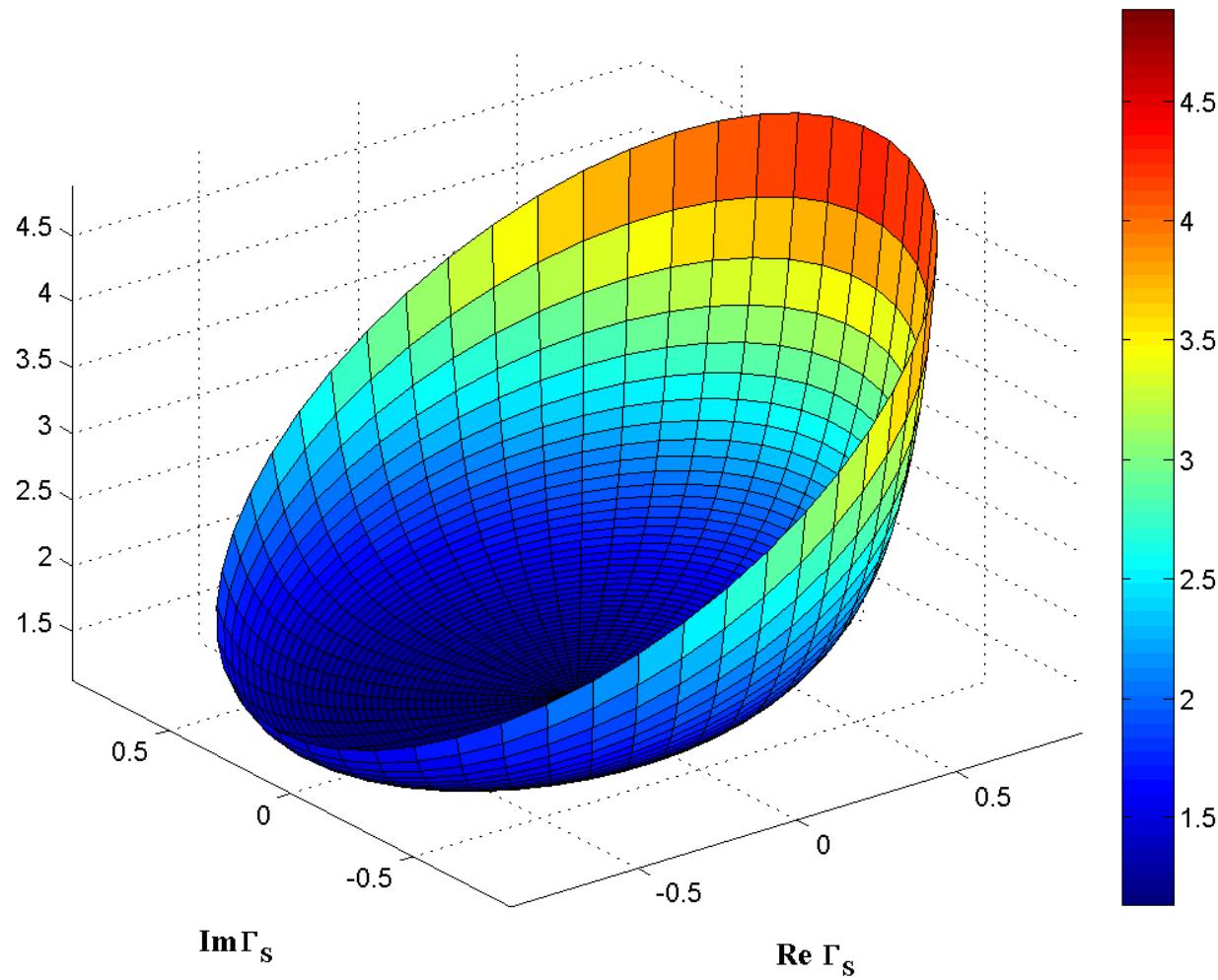


- Factorul de zgomot F caracterizeaza degradarea raportului semnal/zgomot intre intrarea si iesirea unei componente

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

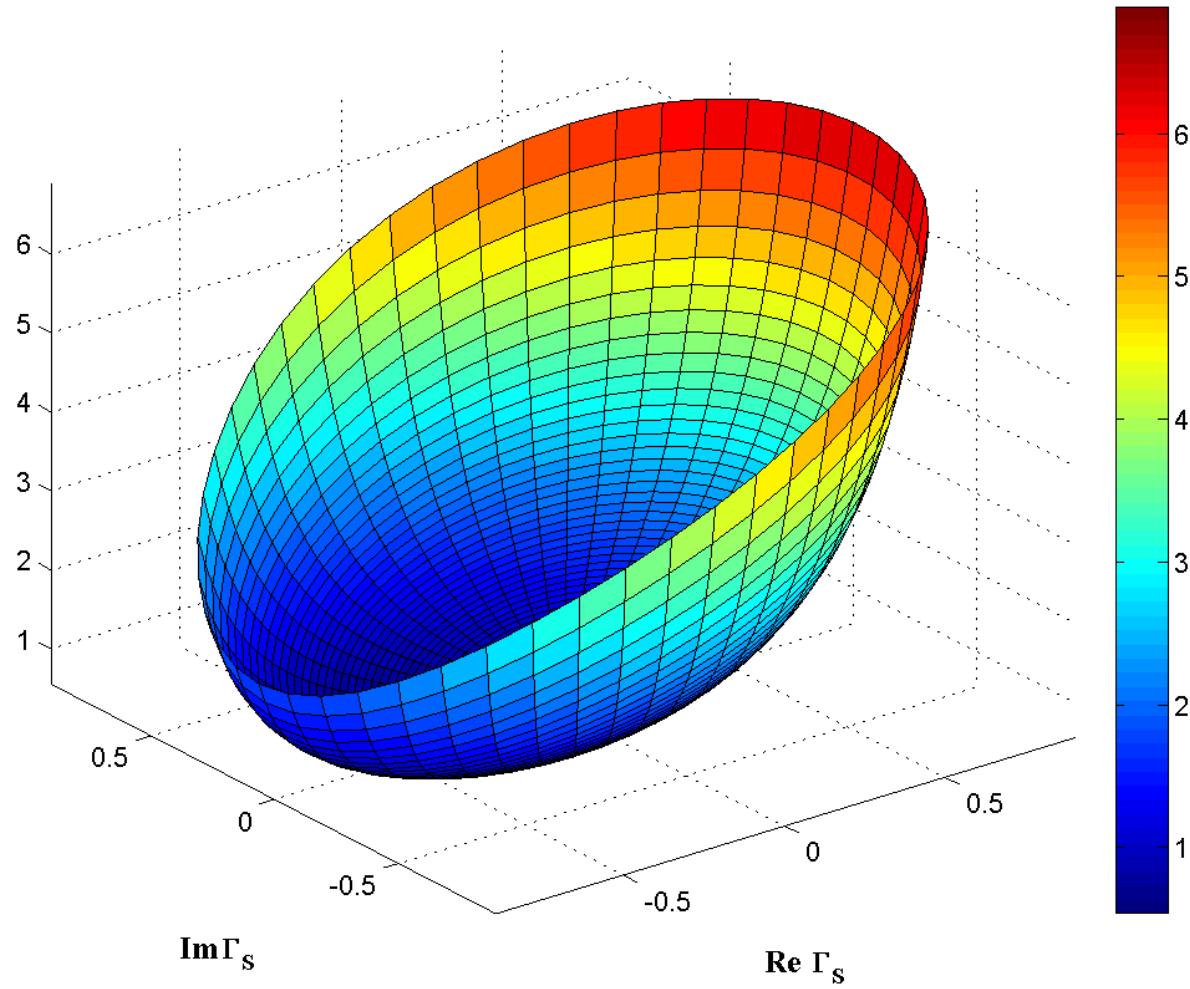
$F(\Gamma_s)$

$F(\Gamma_s)$

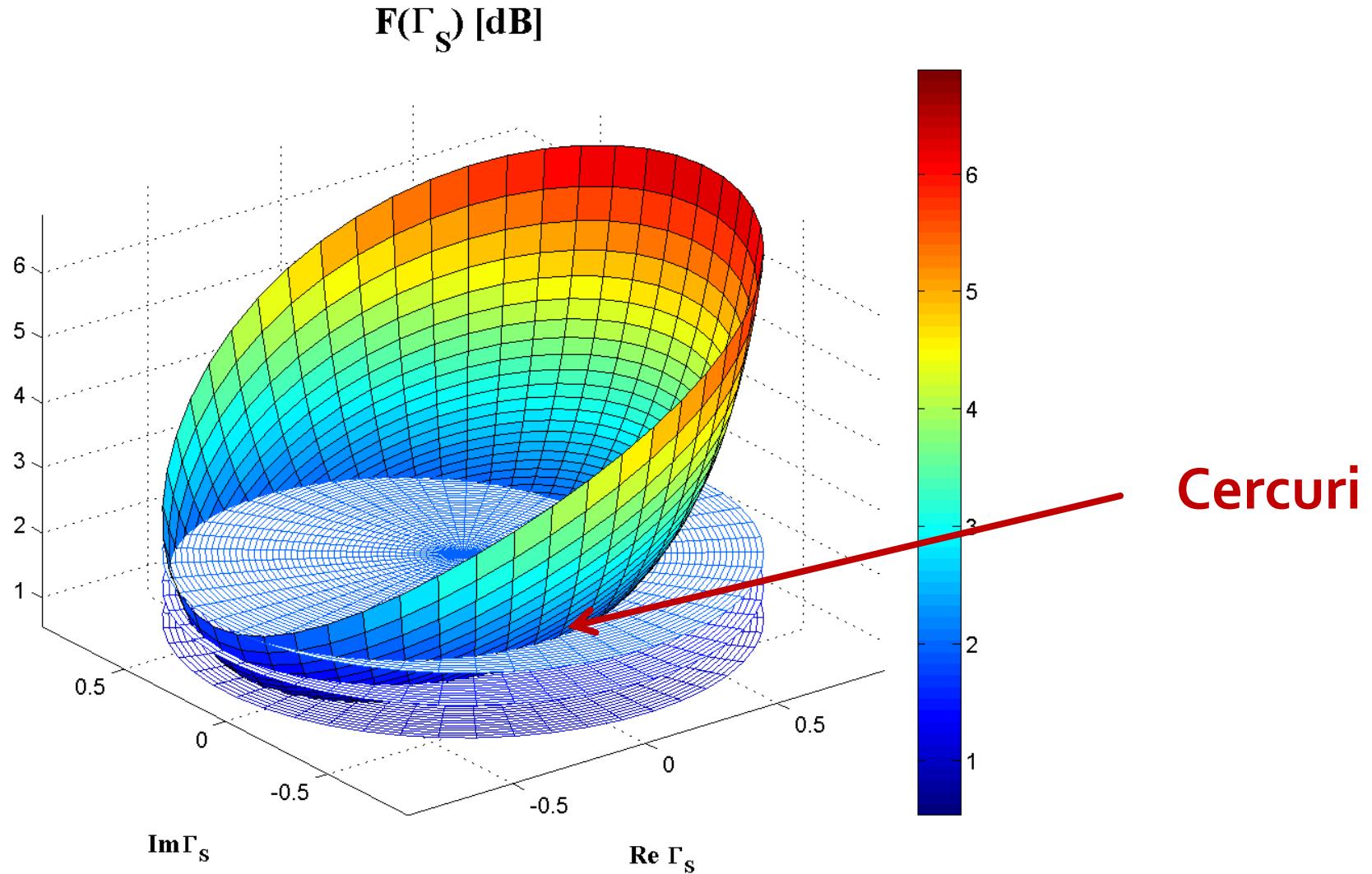


$F[dB](\Gamma_S)$

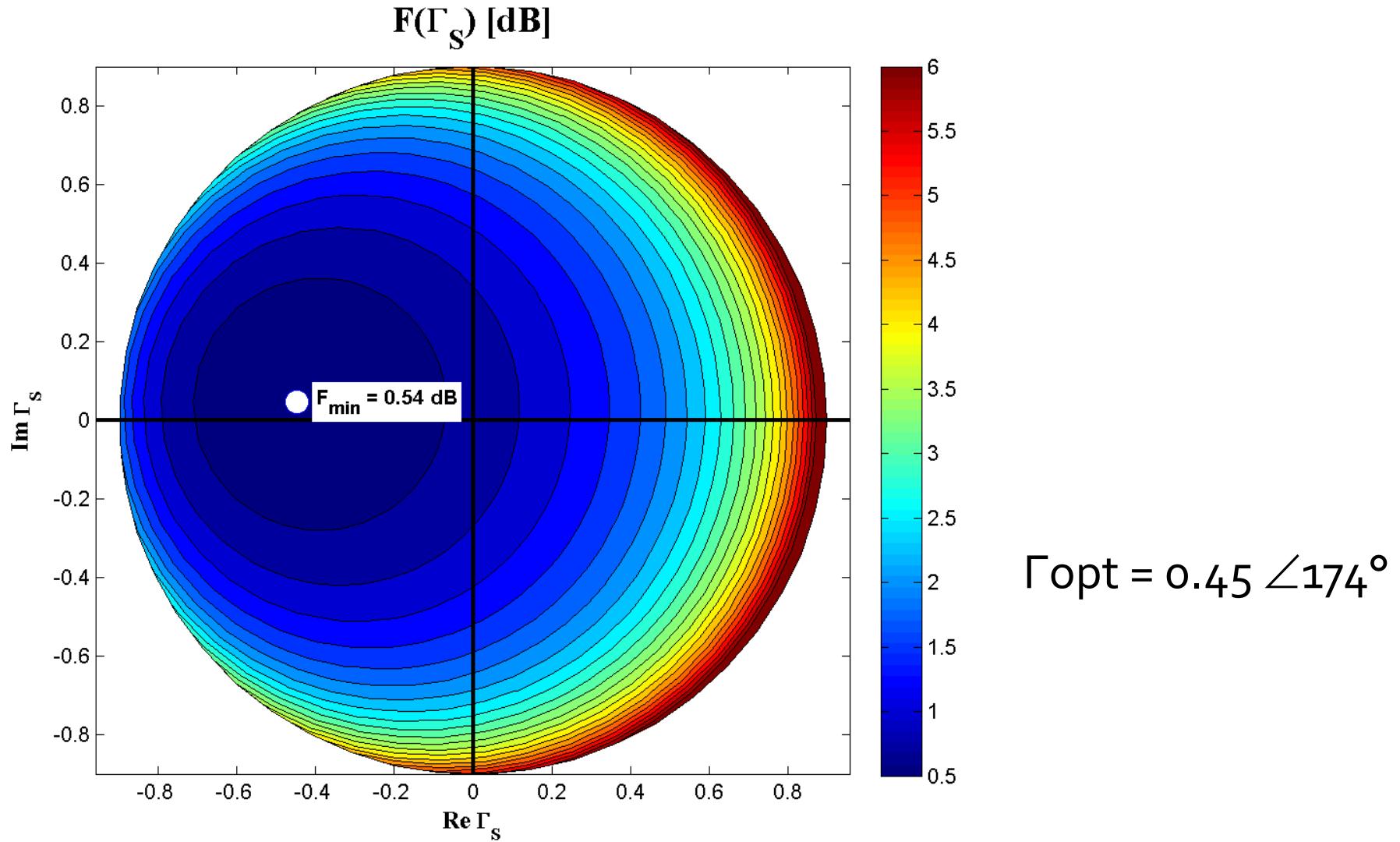
$F(\Gamma_S) [dB]$



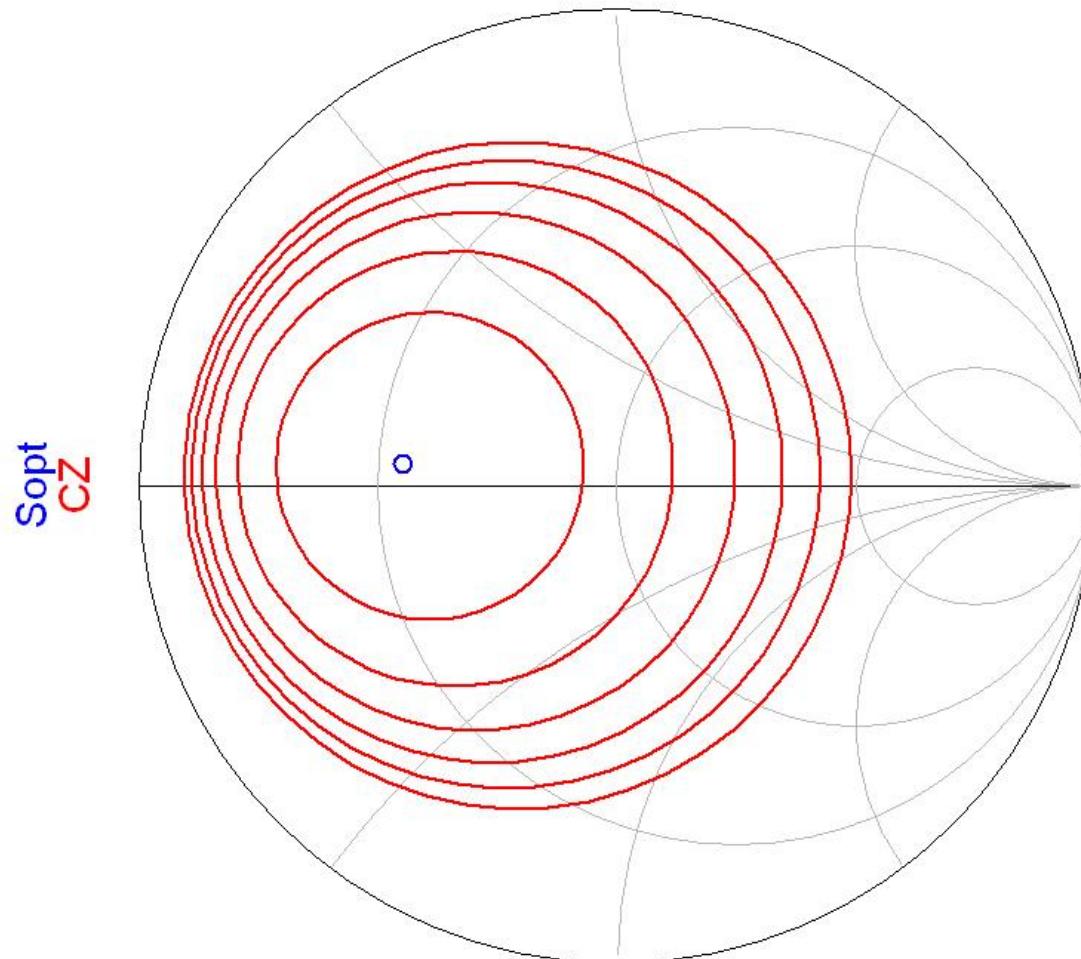
$F[dB](\Gamma_s)$, diagrama de nivel



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



CZ – numai la intrare !

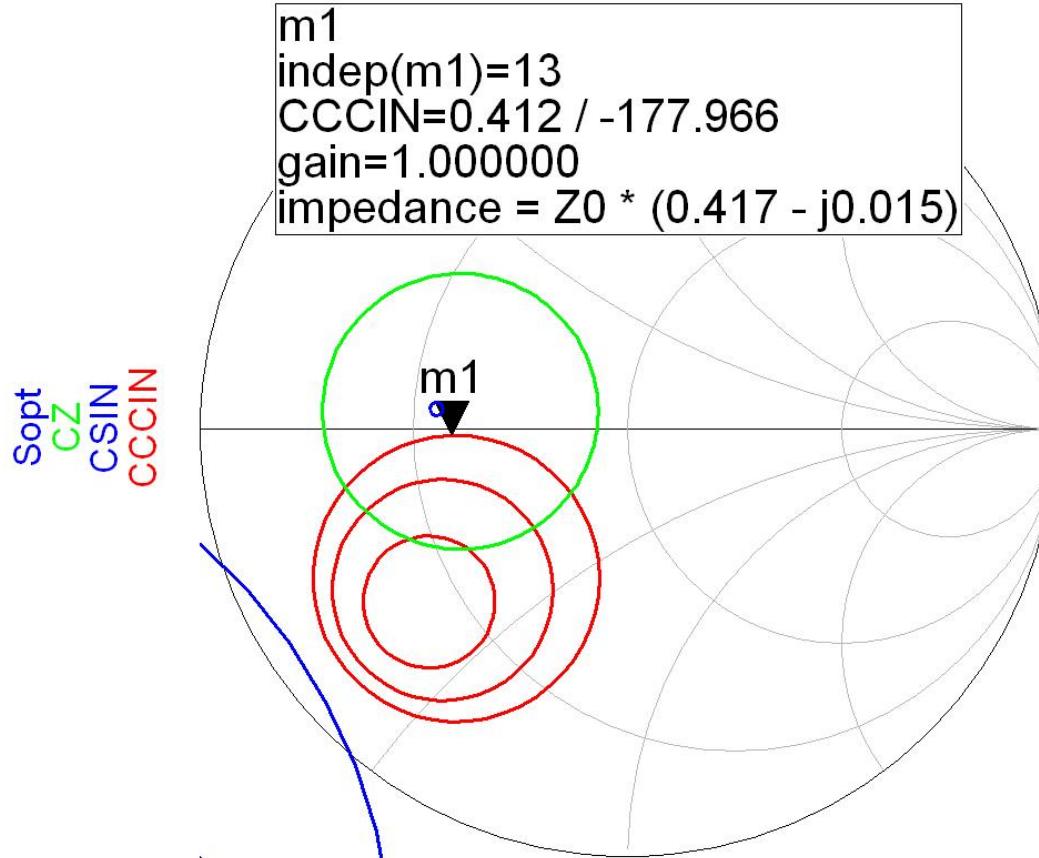


cir_pts (0.000 to 51.000)
freq (5.000GHz to 5.000GHz)

Exemplu, LNA @ 5 GHz

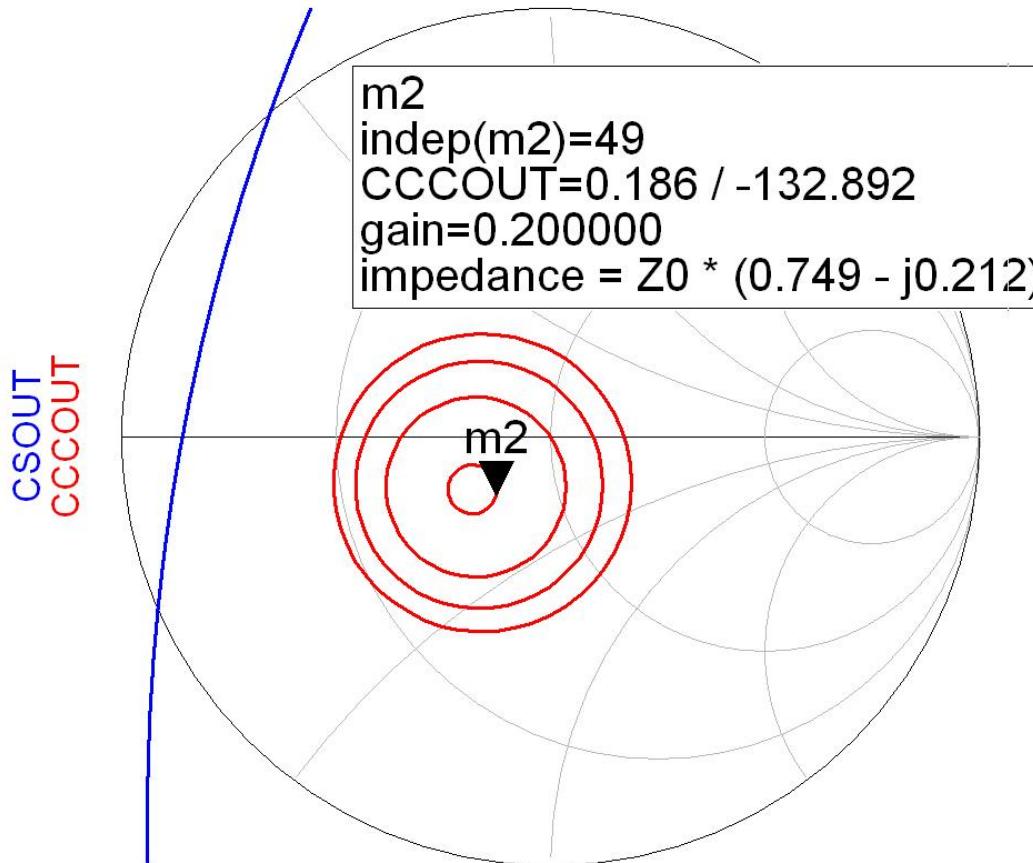
- Amplificator de zgomot redus
- La intrare e necesar un compromis intre
 - zgomot (cerc de zgomot constant ~~la intrare~~)
 - castig (cerc de castig constant la intrare)
 - stabilitate (cerc de stabilitate la intrare)
- La iesire zgomotul **nu intervine** (nu exista influenta). Compromis intre:
 - castig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

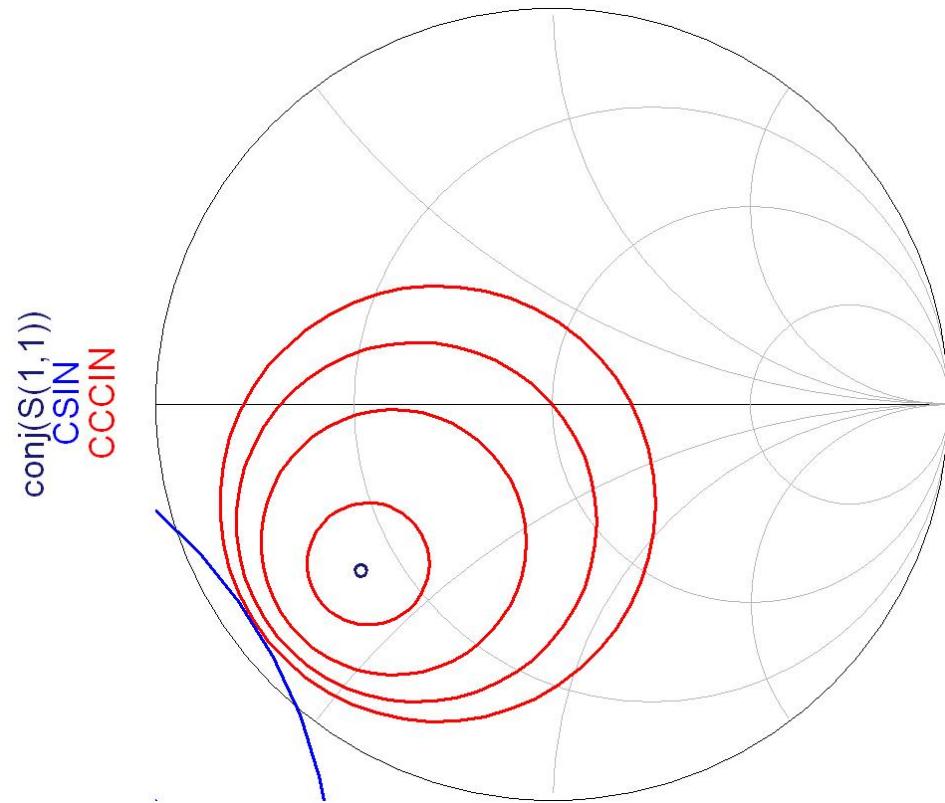
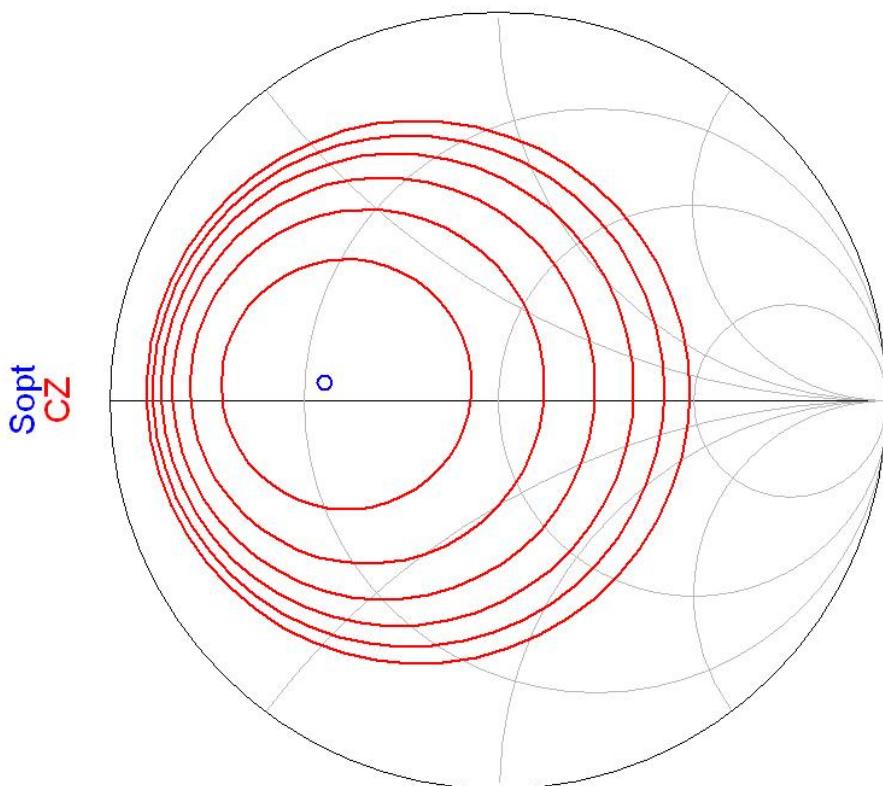
Adaptare la ieșire



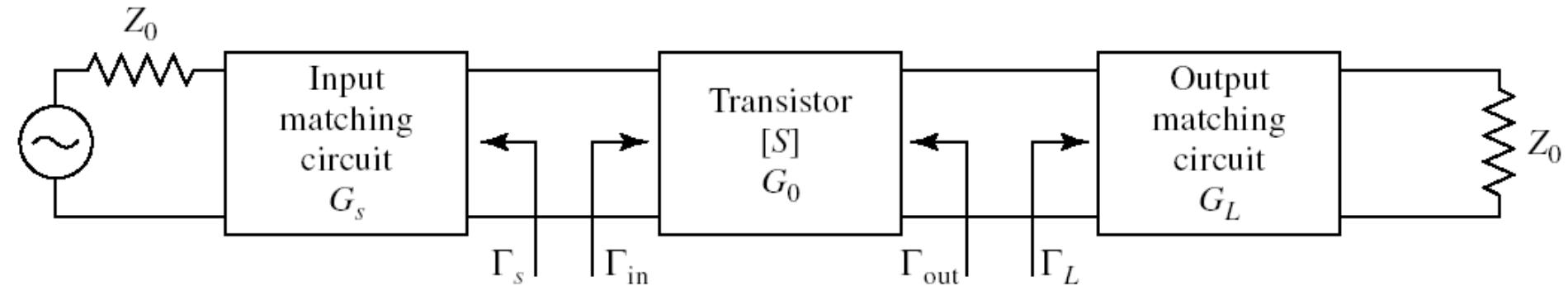
- CCCOUT: -0.4dB, -0.2dB, 0dB, +0.2dB
- Lipsa conditiilor privitoare la zgomot ofera posibilitatea obtinerii unui castig mai mare (spre maxim)

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



Proiectare pentru castig impus



- Daca ipoteza tranzistorului unilateral este justificata:

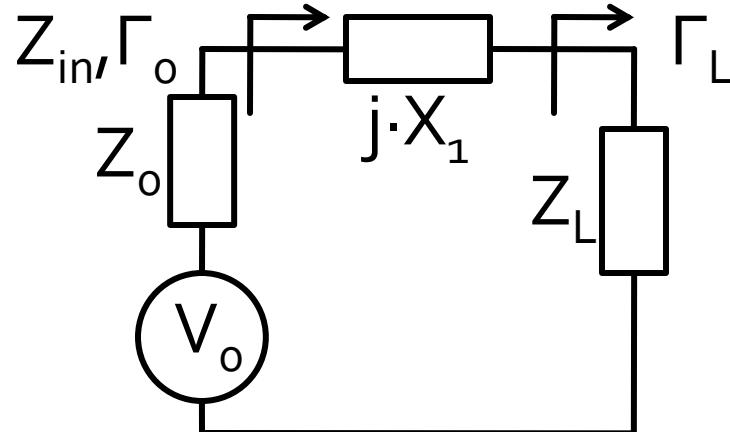
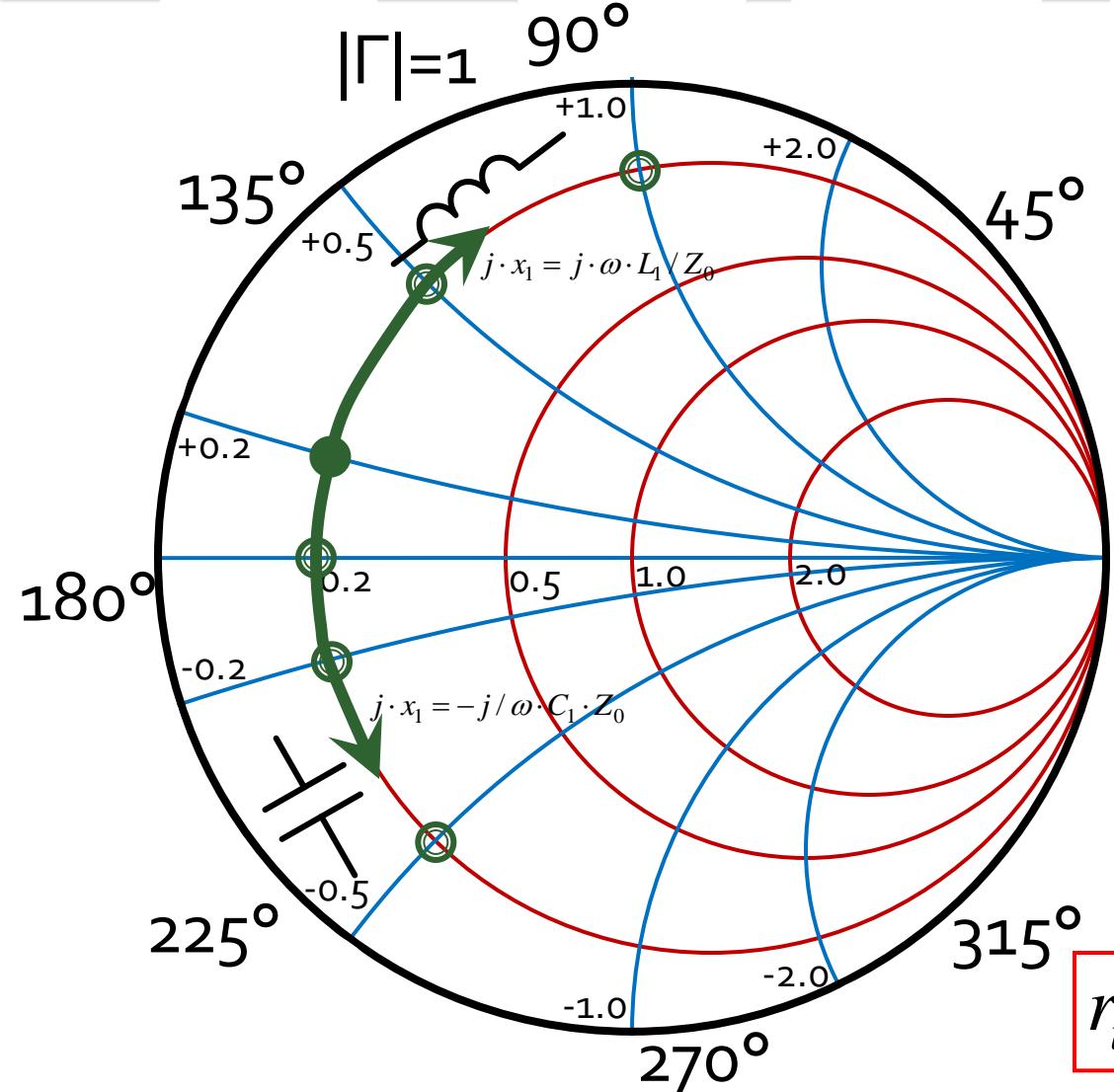
$$G_{TU} = |S_{21}|^2 \cdot \frac{1 - |\Gamma_S|^2}{|1 - S_{11} \cdot \Gamma_S|^2} \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22} \cdot \Gamma_L|^2}$$

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

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

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

Diagrama Smith, coeficient de reflexie, reactanta in serie



$$Z_0 = 50\Omega$$

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

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

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

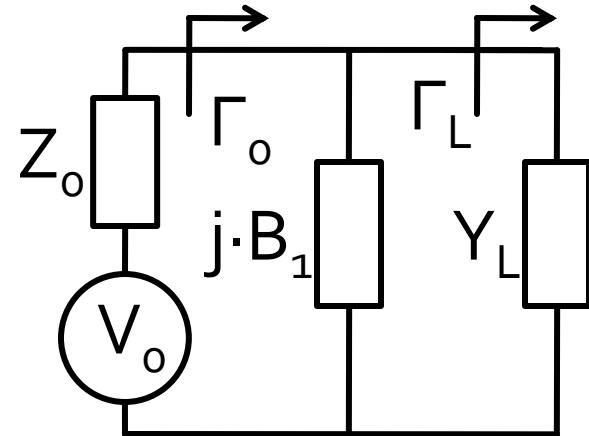
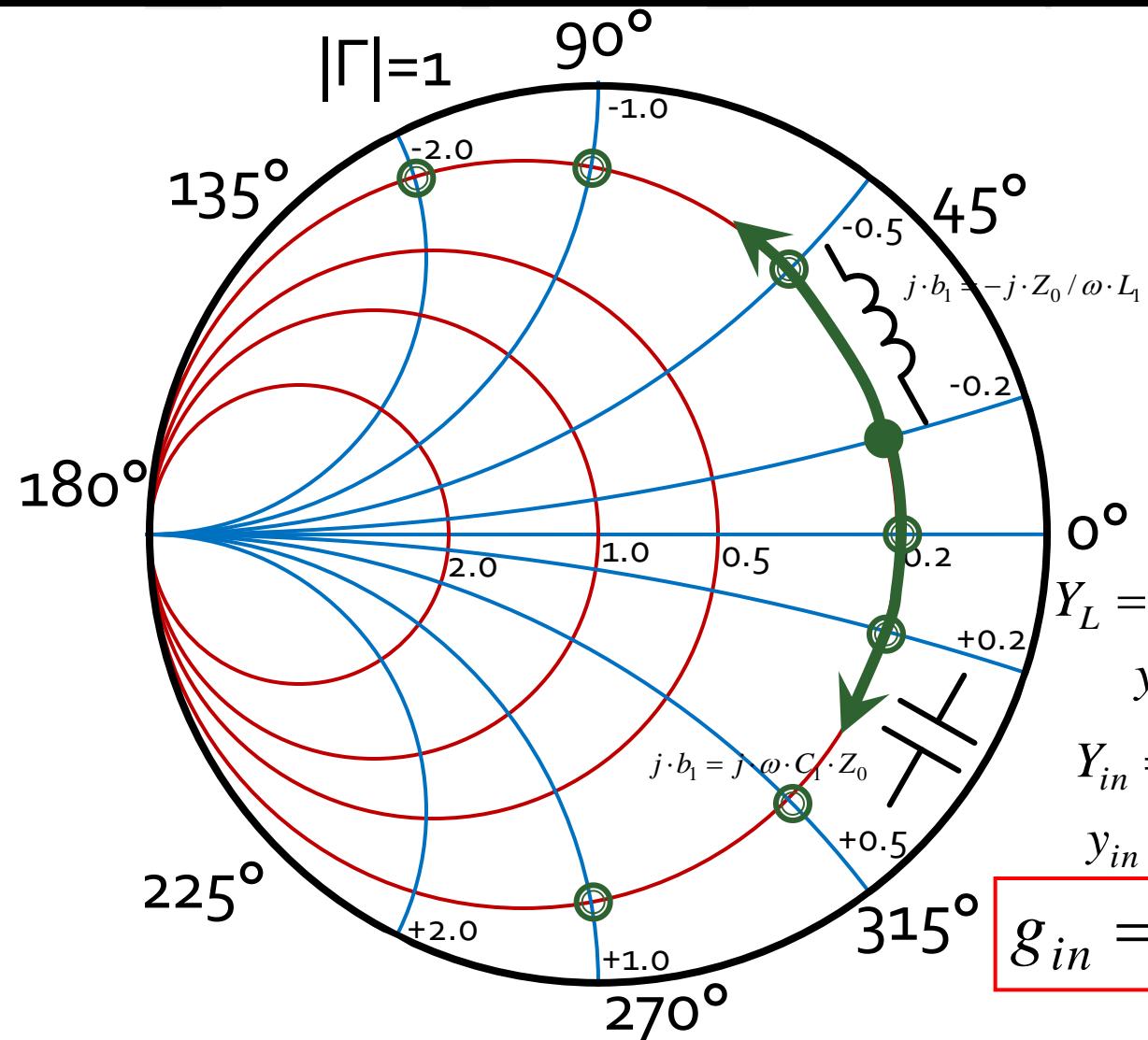
$$Z_{in} = Z_L + j \cdot X_1 = R_L + j \cdot (X_L + X_1)$$

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

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

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

Diagrama Smith, coeficient de reflexie, susceptanta in paralel



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

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

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

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

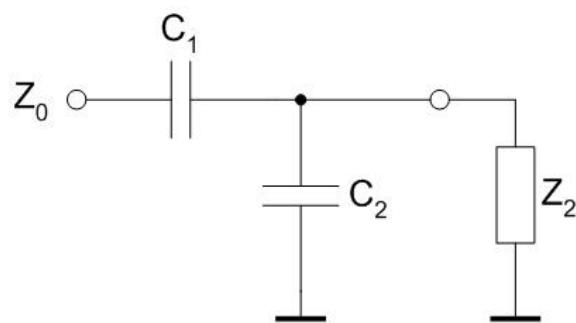
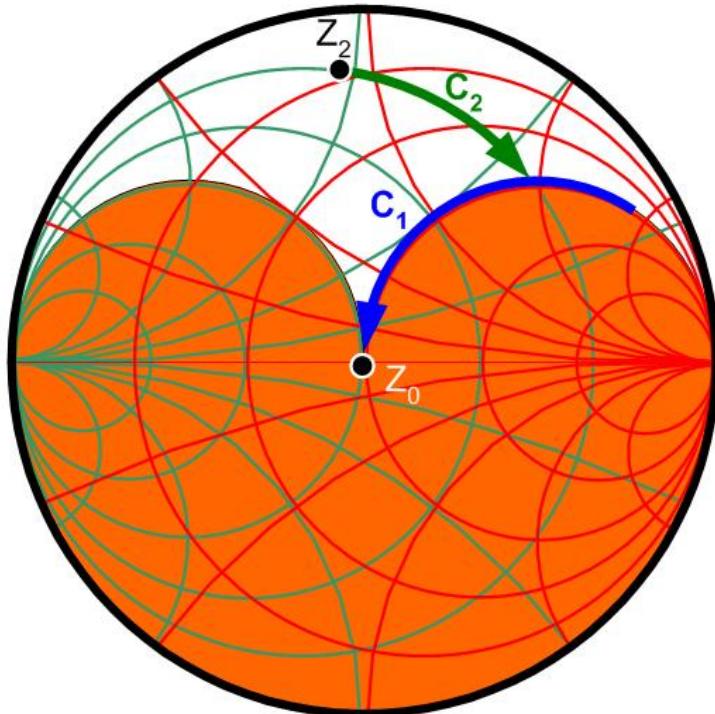
$$Y_{in} = Y_L + j \cdot B_1 = G_L + j \cdot (B_L + B_1)$$

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

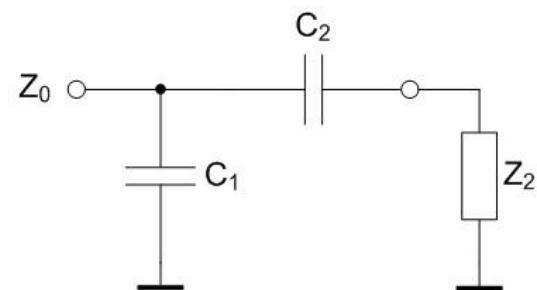
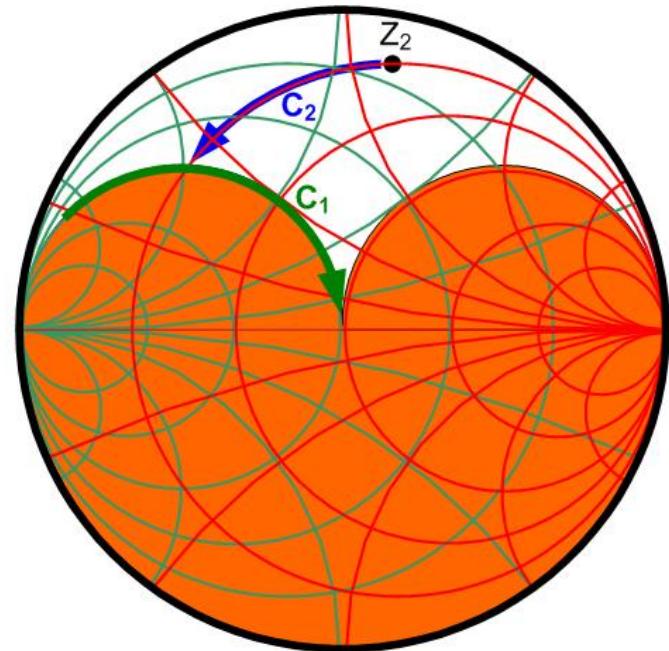
$$g_{in} = g_L \quad j \cdot b_1 = j \cdot \omega \cdot C_1 \cdot Z_0 > 0$$

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

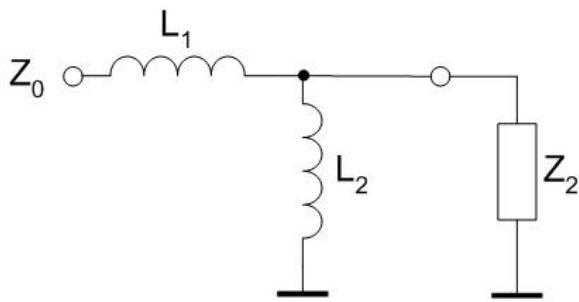
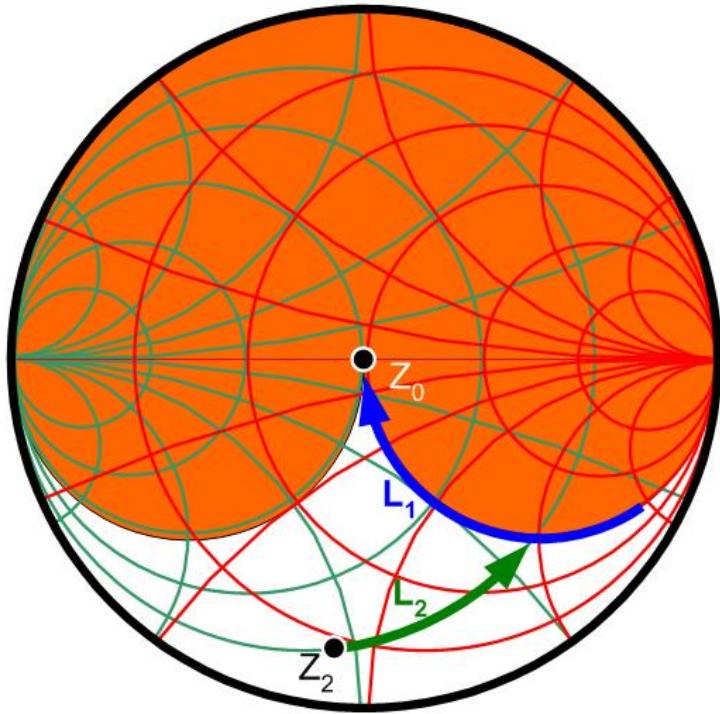
C serie, C paralel / C paralel, C serie



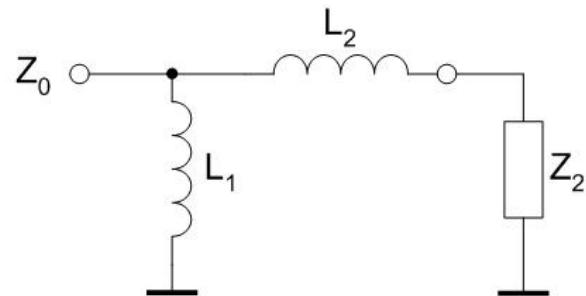
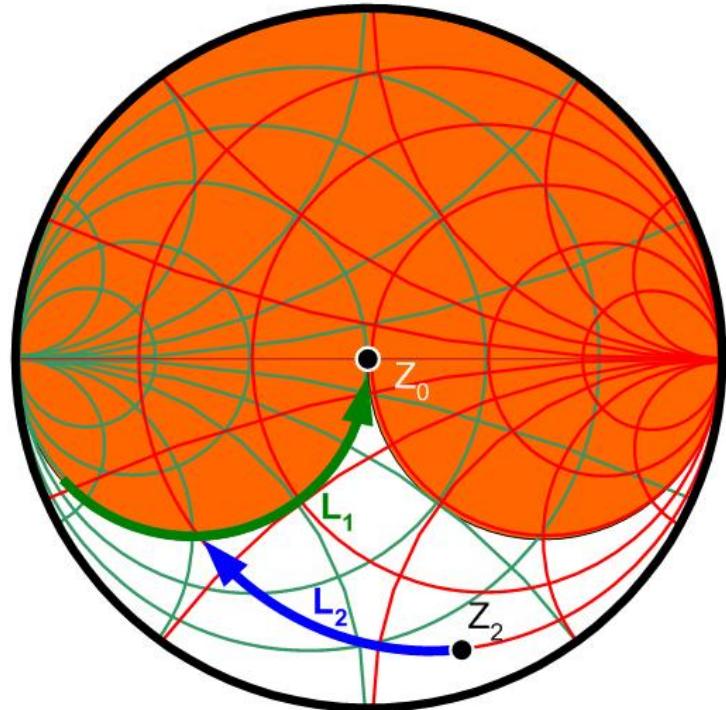
Zona interzisa cu
schema curenta



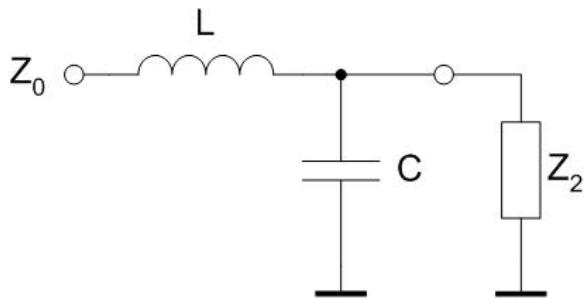
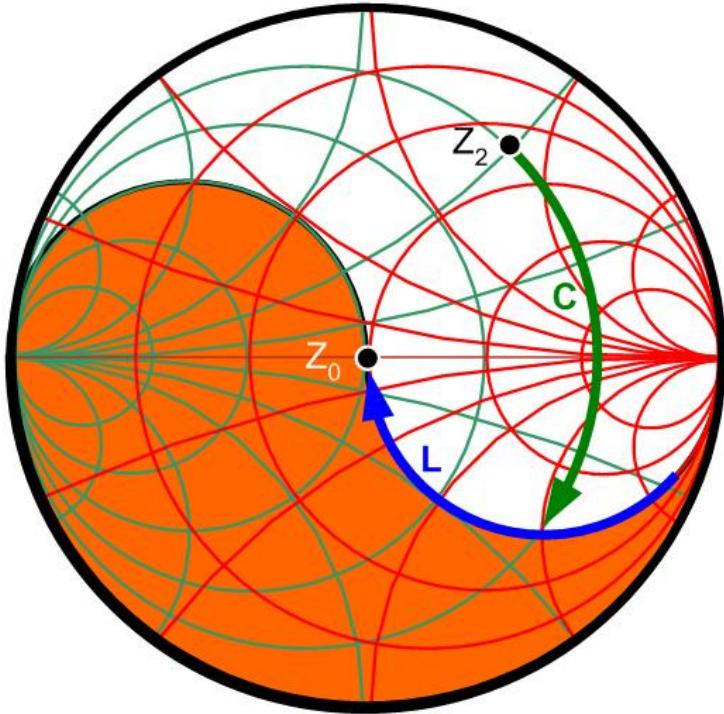
L serie, L paralel / L paralel, L serie



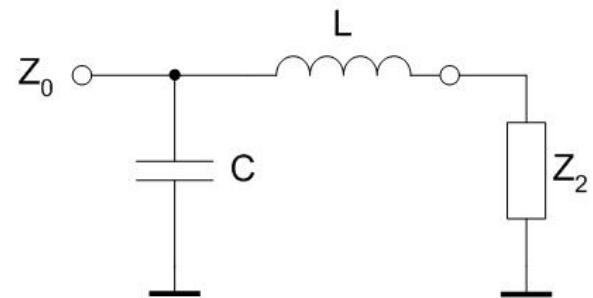
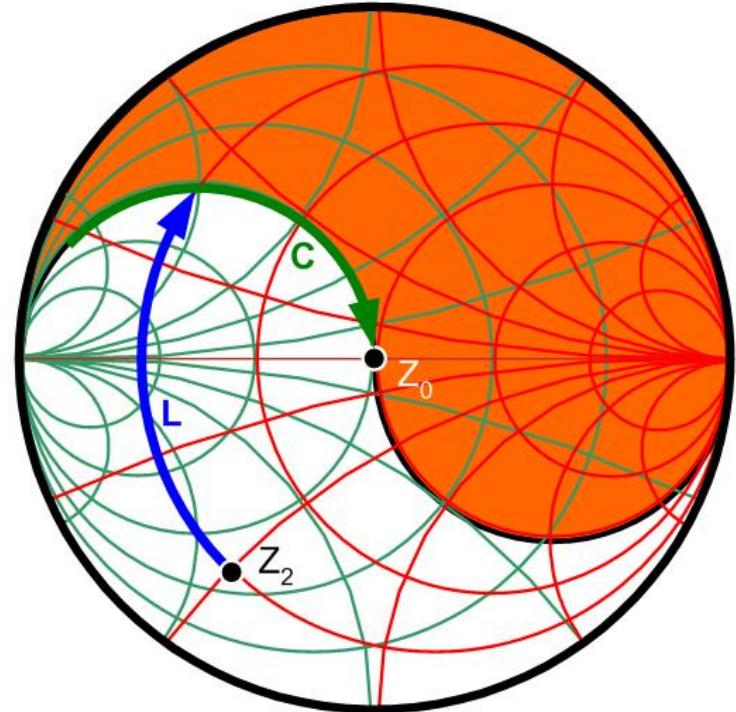
Zona interzisa cu
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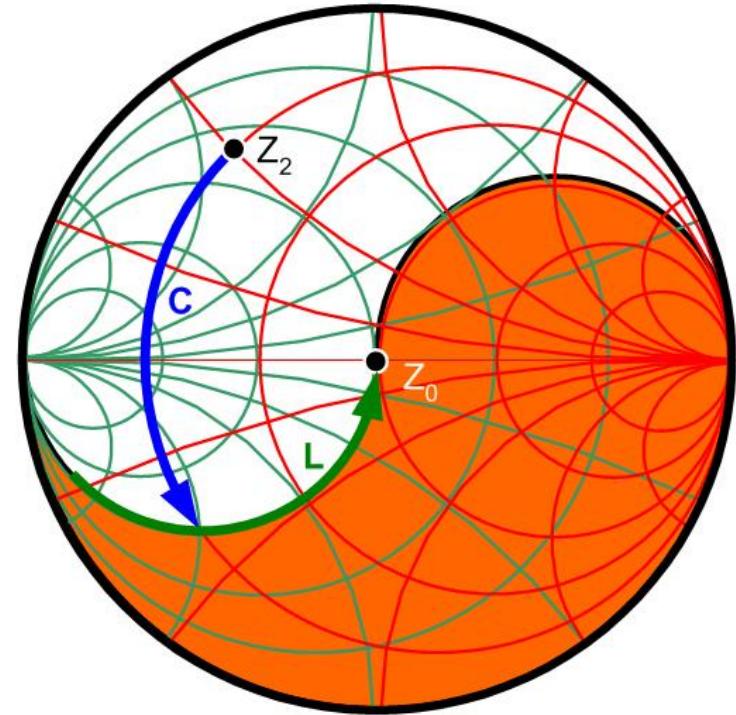
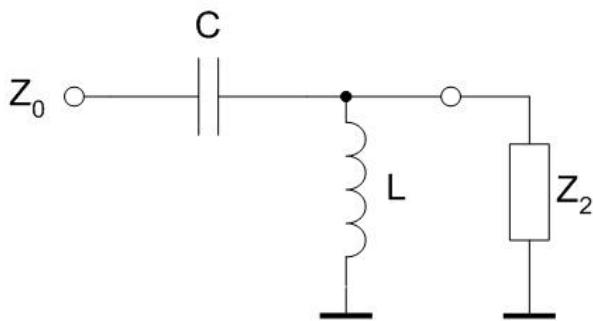
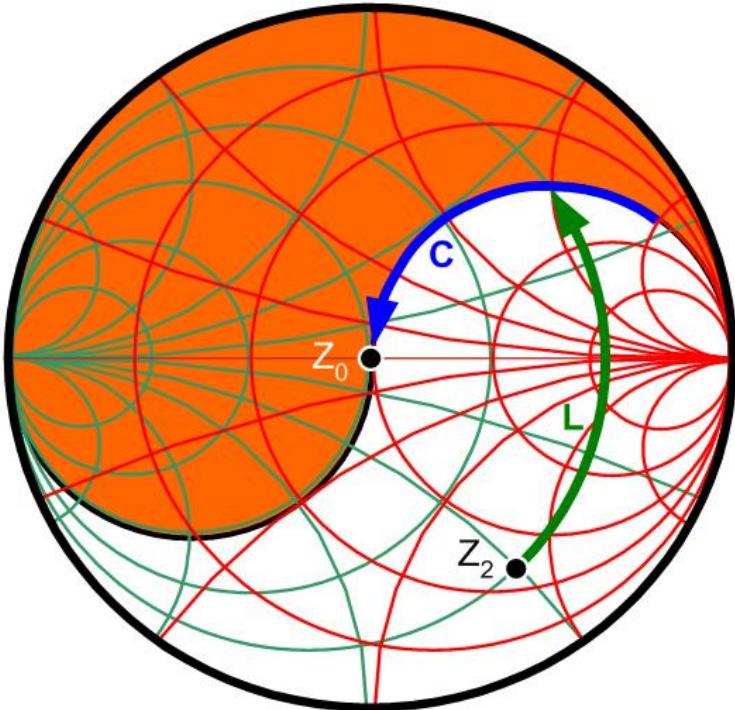
L serie, C paralel / C paralel, L serie



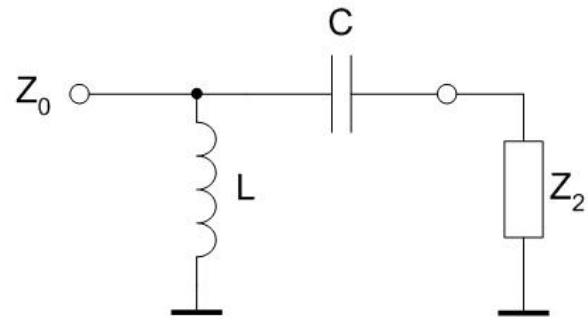
Zona interzisa cu
schema curenta



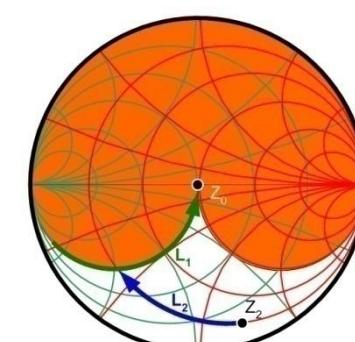
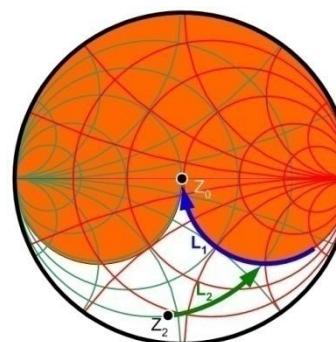
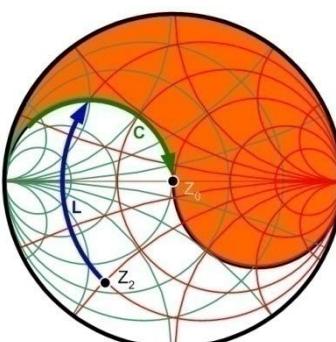
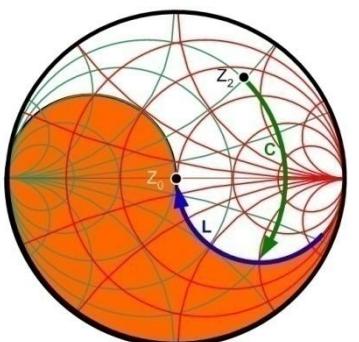
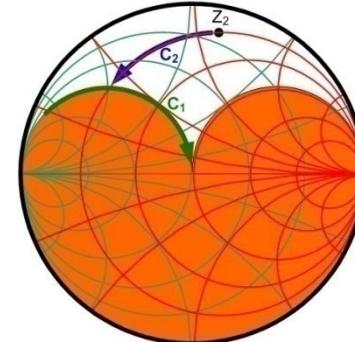
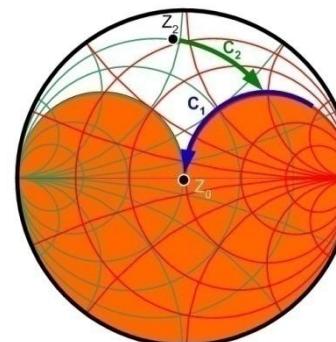
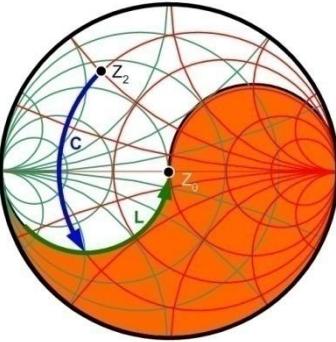
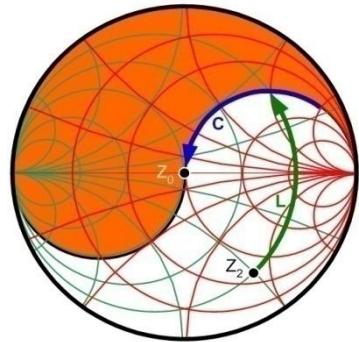
C serie, L paralel / L paralel, C serie



 Zona interzisa cu schema curenta



Adaptare cu două elemente reactive (retele in L)



Zona interzisa cu
schema curenta

Adaptare cu doua elemente reactive (retele in L)

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

Mod de lucru

Pas 0

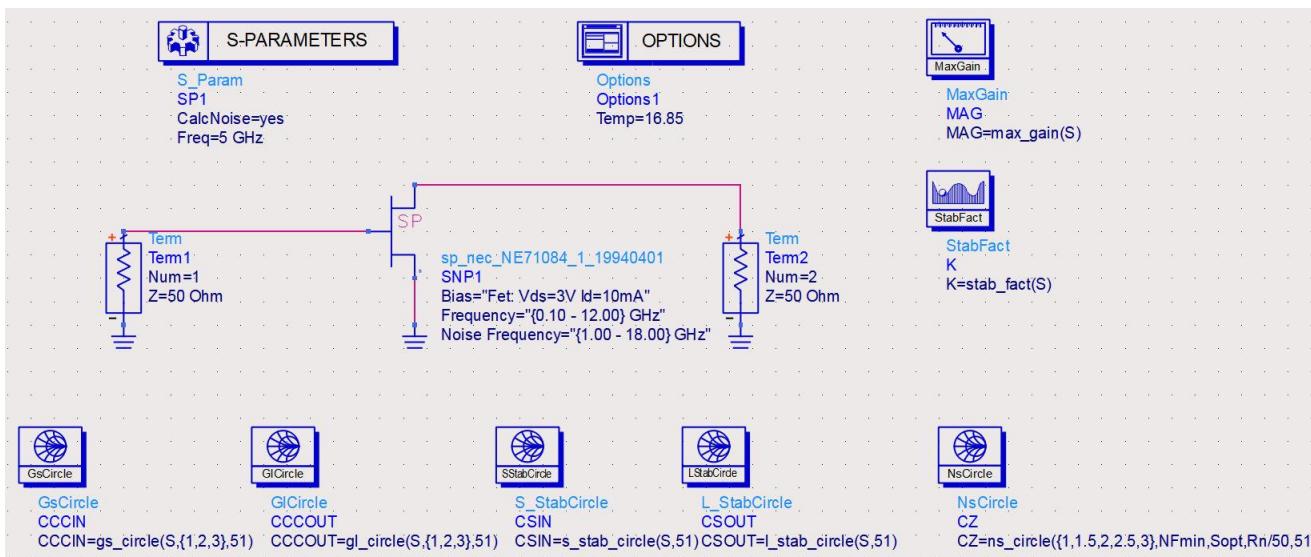
- Se scrie de mana de 100 de ori pe o foaie de hartie:
- **Promit solemn sa citesc SI textul si sa nu sar din poza in poza**
- 

Pas 1

- Lucrarea 3-4 se desfasoara in doi pasi:
 - lucrarea 3: se lucreaza cu datele din referat (comune) cu scopul de a obtine cele **4 scheme** (corecte) intr-un singur proiect
 - lucrarea 4: se porneste de la cele 4 scheme (stiente corecte!) pentru a implementa tema personala
- Atentie! cele 4 scheme trebuie salvate in directorul “networks” din directorul proiect ADS pentru a face parte din acest proiect (si sa poata fi simulate)

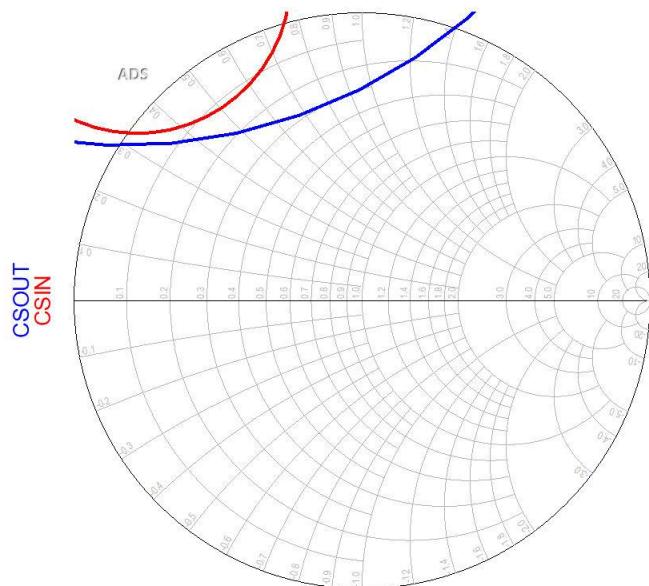
Schema 1

- permite investigarea tranzistorului la frecventa aleasa

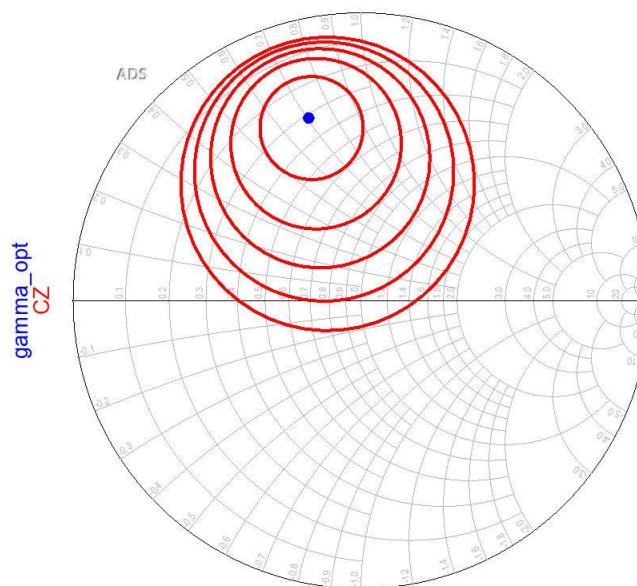


Schema 1

- se reprezinta **familii de cercuri** si se calculeaza anumite valori necesare



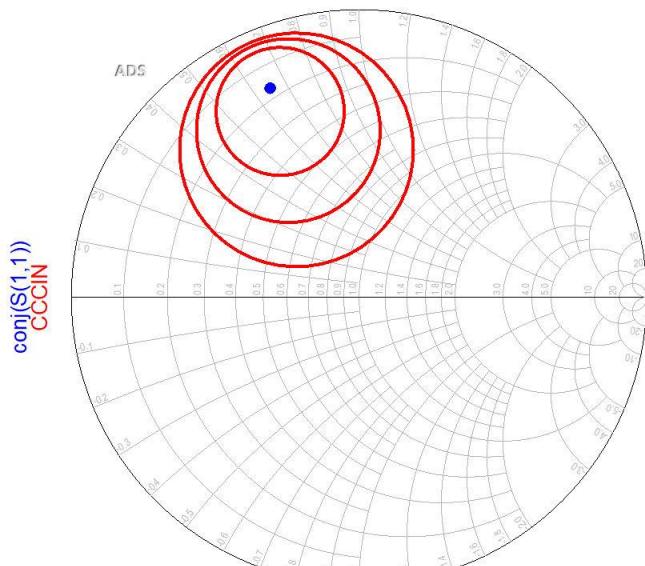
indep(CSIN) (0.000 to 51.000)
indep(CSOUT) (0.000 to 51.000)



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

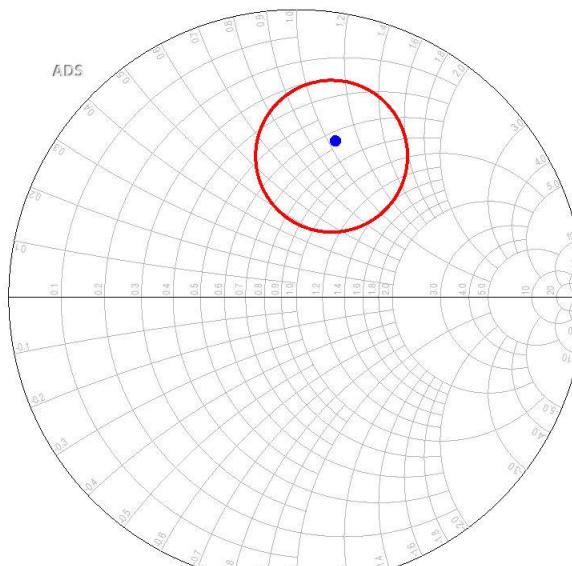
Schema 1

- se reprezinta **familii de cercuri** si se calculeaza anumite valori necesare



$$\text{Eqn} \gamma_{\text{opt}} = S_{\text{opt}}$$

$\text{conj}(S(2,2))$
 $CCCOUT$



$$\text{Eqn} G_0 = 10 * \log(\text{mag}(S(2,1))^2)$$

$$\text{Eqn} GS_{\text{max}} = 10 * \log(1/(1 - \text{mag}(S(1,1))^2))$$

$$\text{Eqn} GL_{\text{max}} = 10 * \log(1/(1 - \text{mag}(S(2,2))^2))$$

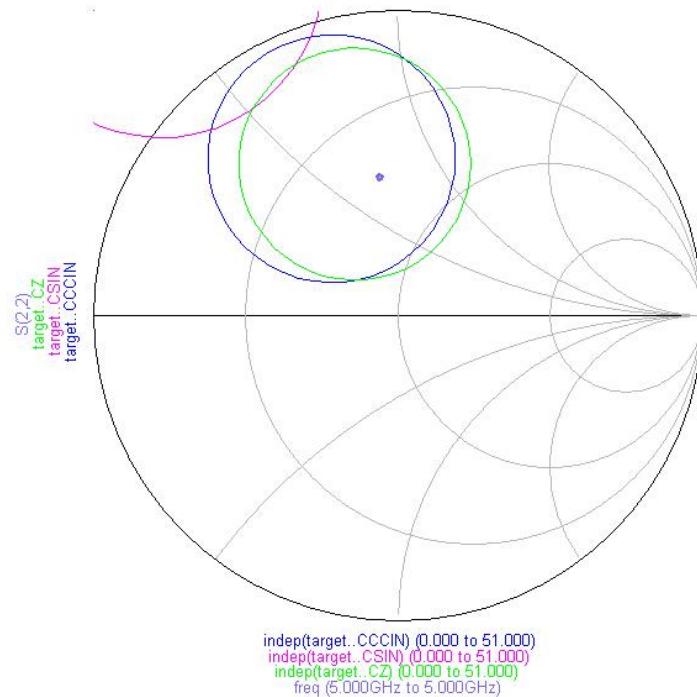
freq	K	MAG	NFmin	Sopt	Rn	G0	GLmax	GSmax
5.000 GHz	0.533	15.296	0.700	0.660 / 106....	19.500	8.974	1.634	4.249

Schema 2

- Similară în mare parte cu schema 1
- Analizând rezultatele din **schema 1** se alege căte **un singur cerc** tinta:
 - stabilitate
 - castig
 - zgomot (intrare)
- Afisarea cerurilor nu e necesara
 - cercurile vor fi utilizate efectiv în **schema 3**

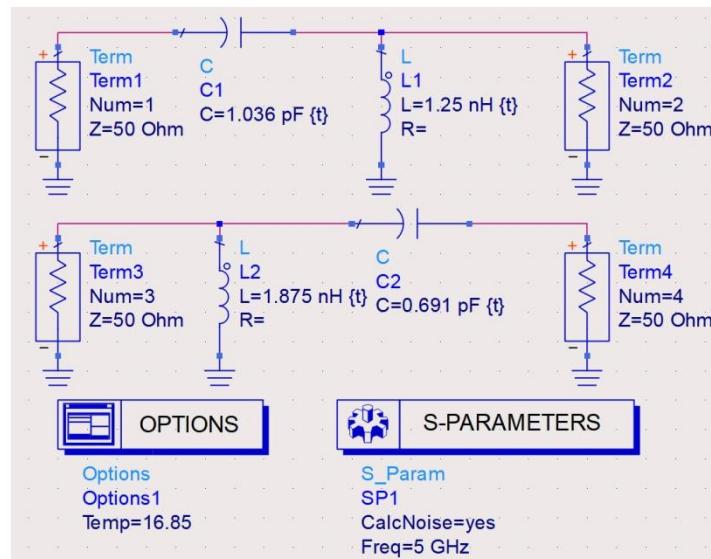
Schema 2

- Chiar daca nu sunt afisate, schema 2 **calculeaza** cercurile (pentru tranzistor)



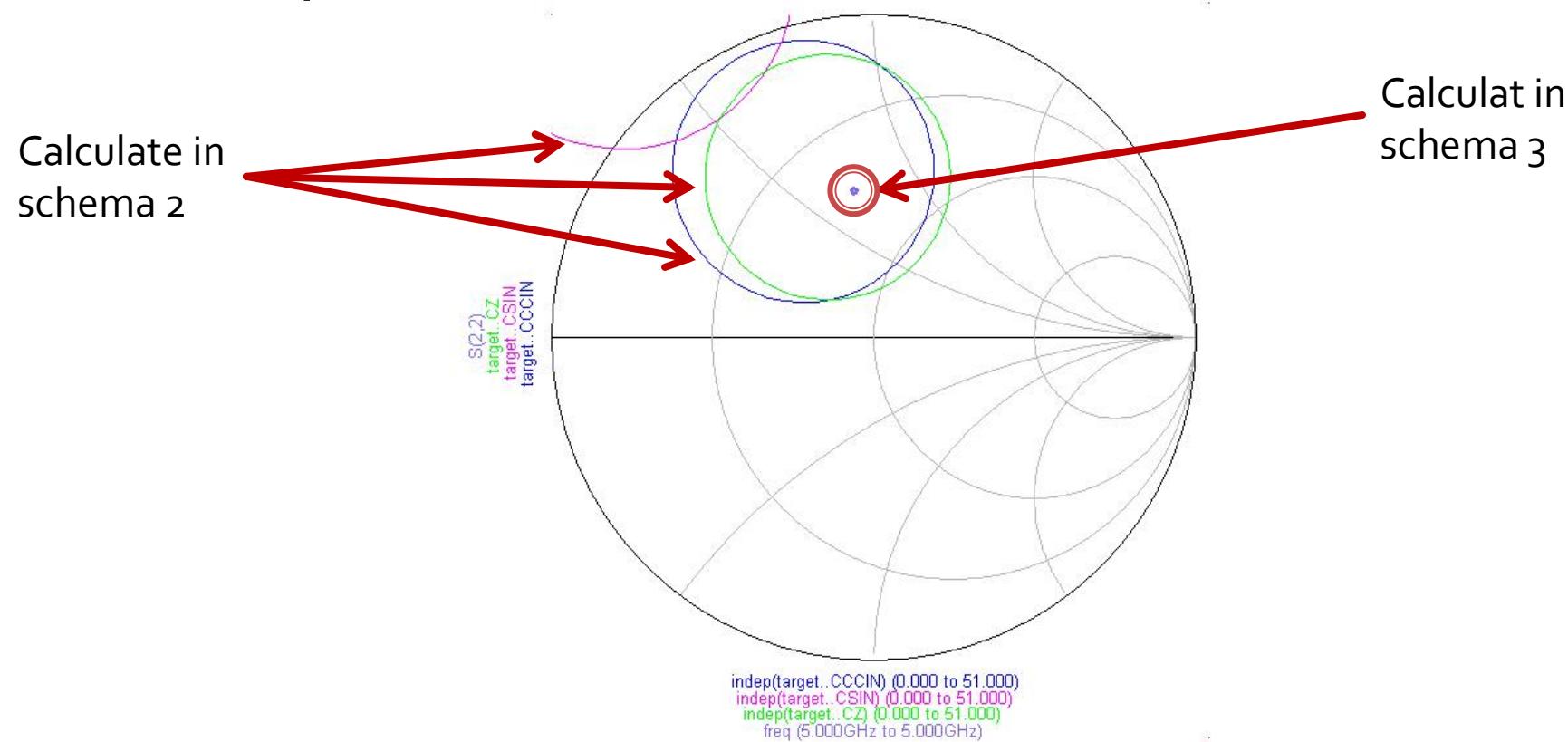
Schema 3

- Se utilizeaza cercurile calculate in **schema 2** ca “tinta”/indicator
- Se **regleaza** elementele din retelele de adaptare pentru atingerea punctelor dorite



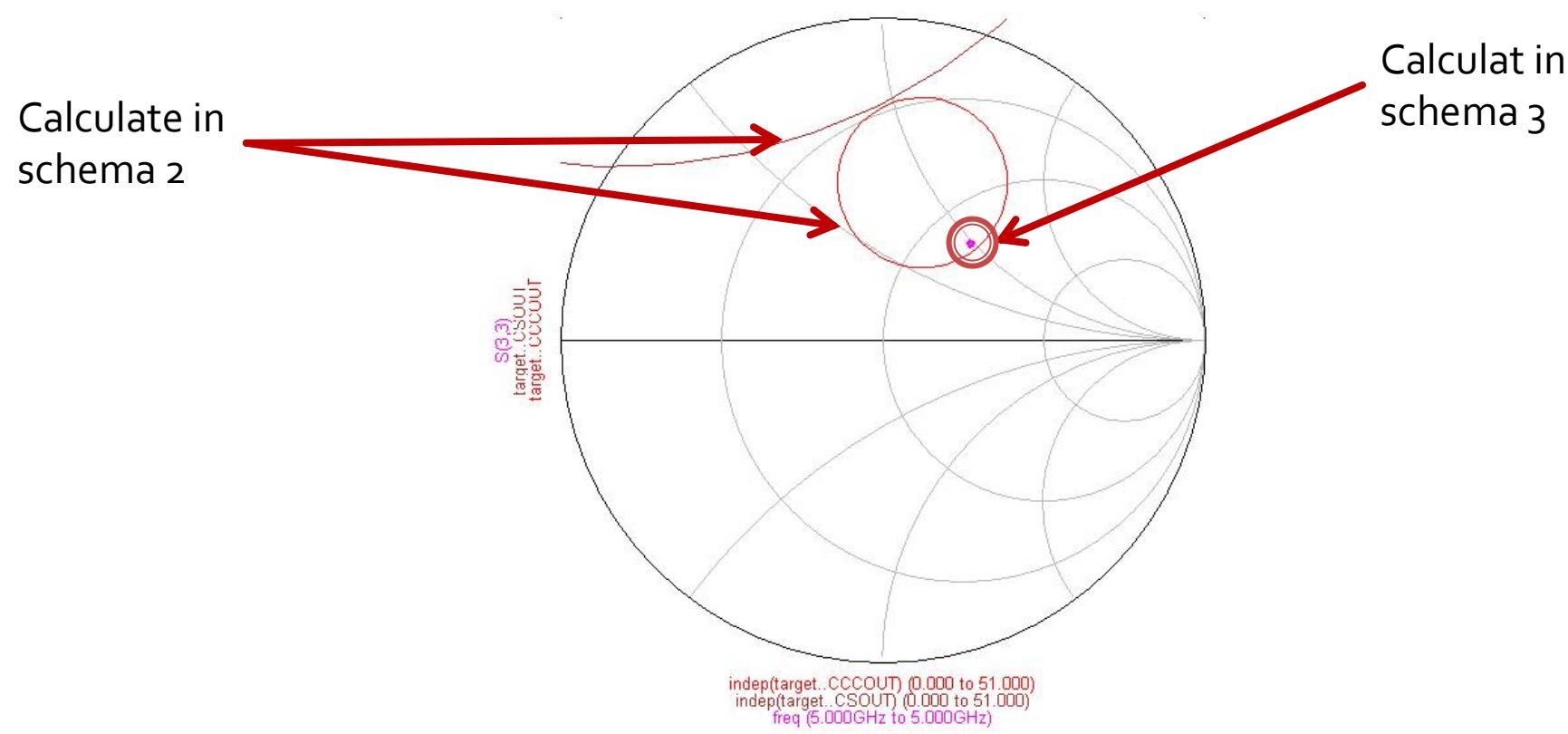
Schema 3

- Se regleaza elementele din retelele de adaptare pentru atingerea punctelor dorite



Schema 3

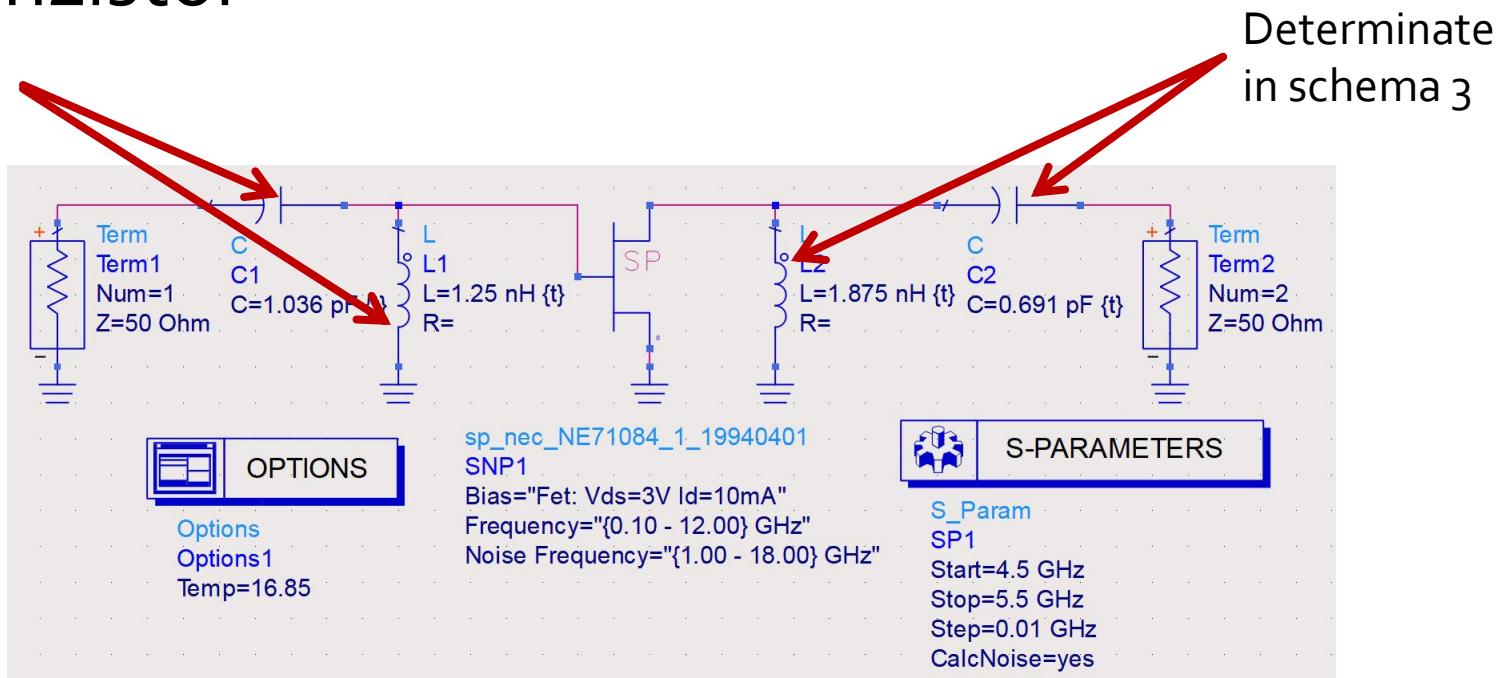
- Se regleaza elementele din retelele de adaptare pentru atingerea punctelor dorite



Schema 4

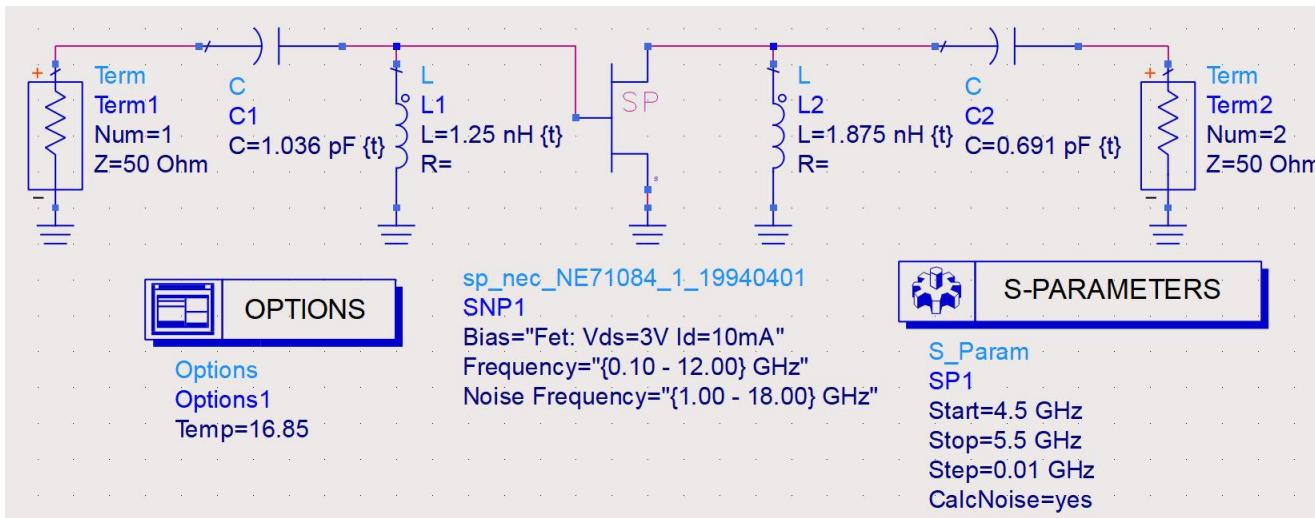
- Se introduc componentele gasite in **schema 3** ca retele de adaptare la intrare/iesire pentru tranzistor

Determinate
in schema 3



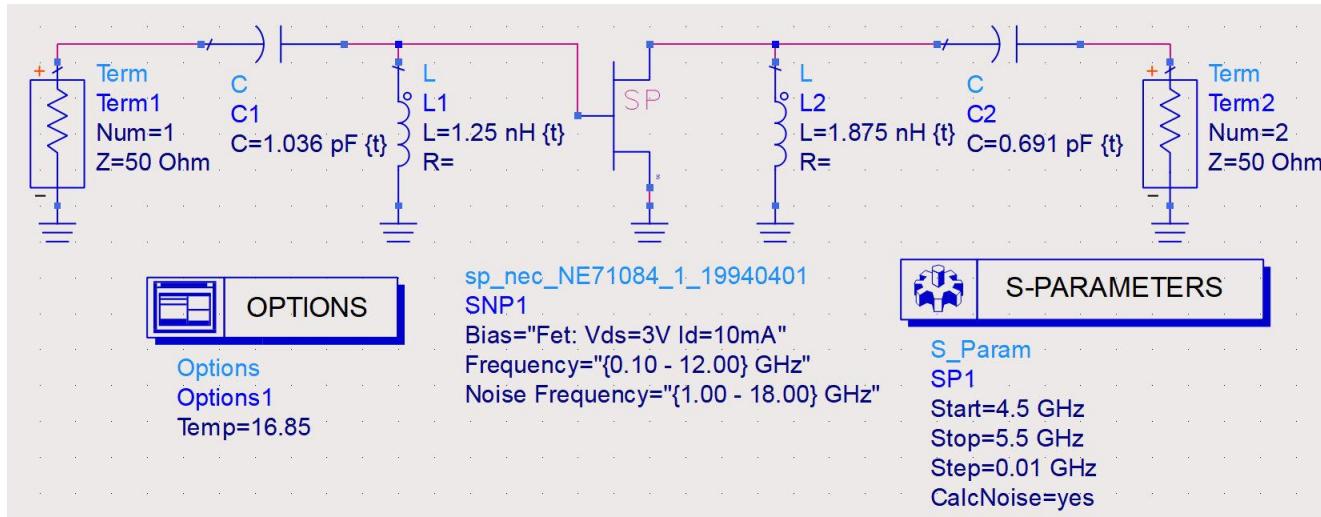
Schema 4

- Se **regleaza** elementele din retelele de adaptare pentru o caracteristica mai convenabila



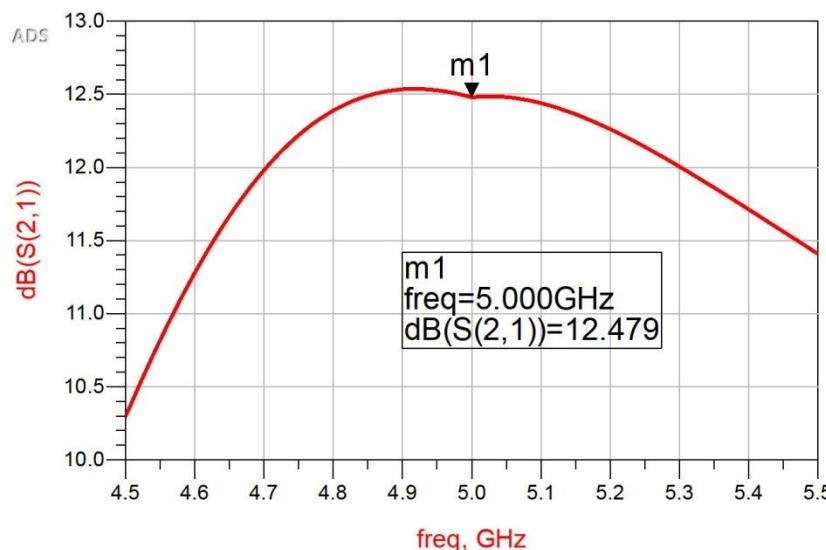
Schema 4

- Reglajul direct in schema finala (fara parcurgerea celorlalte 3 scheme) are sanse **nule** de reusita



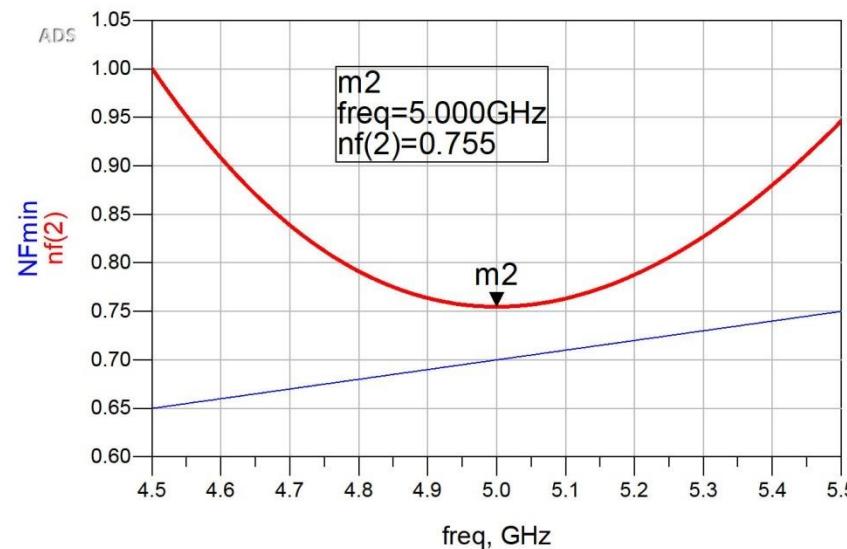
Schema 4

- Se obtine comportamentul schemei finale cu verificarea indeplinirii temei:
 - Castig (de putere)



Schema 4

- Se obtine comportamentul schemei finale cu verificarea indeplinirii temei:
 - Factor de zgomot



Contact

- Laboratorul de microunde si optoelectronica
- <http://rf-opto.etti.tuiasi.ro>
- rdamian@etti.tuiasi.ro