Curs 9
2025/2026

Dispozitive şi circuite de microunde pentru radiocomunicații

Disciplina 2025/2026

- 2C/1L (+1), **DCMR (CDM)**

- **Minim 7 prezente (curs+laborator)**

- Curs - **conf. Radu Damian**
  - Vineri 10-12/**Video (istoric)**, C1, corp C
  - E – **50%** din nota
  - **probleme** + (2p prez. curs) + (3 teste) + (bonus activitate)
    - primul test L1: ~01.10.2025 (t2 si t3 neanuntate la **curs**)
    - 3pz (C) ≈ +0.5p (**2p** max)
  - **toate materialele permise**

Disciplina 2025/2026

- 2C/1L, **DCMR (CDM)**
- Laborator – **conf. Radu Damian**
  - L – **25%** din nota
    - ADS, 4 sedinte aplicatii
    - prezenta + **rezultate personale!**
  - P – **25%** din nota
    - ADS, 3 sedinte aplicatii (-1? 21-22.12.2022)
    - tema personala

Programare examen

- **NU** ultimul examen din sesiune
- Toate grupele: P2 sau P6 (~~C1~~)
- **Termen**: 10.12

Documentatie

- https://rf-opto.etti.tuiasi.ro

Microwave and Optoelectronics Laboratory
Faculty of Electronics, Telecommunications and Information Technology
Gheorghe Asachi Technical University of Iaşi

Main | **Courses** ▾ | Master ▾ | Staff ▾ | Research ▾ | Students ▾ | ▾

English
Romana

Microwave Devices and Circuits for Radiocommunicati

Course: DCMR (2024-2025)

Course Coordinator: Assoc.P. Dr. Radu-Florin Damian
Code: DOS412T
Discipline Type: DOS; Alternative, Specialty
Credits: 4
Enrollment Year: 4, **Sem.** 7

Activities

Course: Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:
Laboratory: Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

Evaluation

Type: **Exam**

A: 50%, (Test/Colloquium)
B: 25%, (Seminary/Laboratory/Project Activity)
D: 25%, (Homework/Specialty papers)

Grades

Aggregate Results

Bibliografie

- https://rf-opto.etti.tuiasi.ro
- Irinel Casian-Botez: "Microunde vol. 1: Proiectarea de circuit", Ed. TEHNOPRES, 2008
- David Pozar, Microwave Engineering, Wiley; 4th edition , 2011, ISBN : 978-1-118-29813-8 (E), ISBN : 978-0-470-63155-3 (P)

Examen: Reprezentare logaritmică

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

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

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
-3 dB	= 0.5
-10 dB	= 0.1
-20 dB	= 0.01
-30 dB	= 0.001

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
-3 dBm	= 0.5 mW
-10 dBm	= 100 μW
-30 dBm	= 1 μW
-60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

[x] + [dB] = [x]

Examen: Reprezentare logaritmică

- $P_0 = 1\text{mW}$
  - $P[\text{dBm}] = 10 \cdot log\left(\frac{P}{P_0}\right)$
  - $P = P_0 \cdot 10^{\frac{P[\text{dBm}]}{10}}$
- Cu unitati de masura
  - $P[\text{mW}] = 1[\text{mW}] \cdot 10^{\frac{P[\text{dBm}]}{10}} = 10^{\frac{P[\text{dBm}]}{10}}$
  - $P[\mu\text{W}] = 1000[\mu\text{W}] \cdot 10^{\frac{P[\text{dBm}]}{10}} = 10^3 \cdot 10^{\frac{P[\text{dBm}]}{10}}$
  - $P[\mu\text{W}] = 10^{\frac{30+P[\text{dBm}]}{10}}$

Examen: Reprezentare logaritmică

- Relatii empirice
  - $\lambda[\mu\text{m}] = \frac{1.240}{E_g[\text{eV}]}$
  - uneori cu corespondenta fizica $E_g = h\nu; \lambda = \frac{hc}{E_g}$
- Puteri
  - $1\text{mW} = 10^3\mu\text{W}; 1\mu\text{W} = 10^{-3}\text{mW}$
- Empiric
  - $P[\mu W] = 10^3 \cdot P[mW]$**!!**
  - Ex: P = **1.2**mW = **1200**µW

Examen

- Operatii cu numere complexe!
- $z = a + j \cdot b$; $\mathbf{j^2 = -1}$

Adaptarea de impedanța

Diagrama Smith

Cuprins

- Linii de transmisie
- Adaptarea de impedanța
- Cuploare direcționale
- Divizoare de putere
- Amplificatoare de microunde
- Filtre de microunde
- Oscilatoare de microunde ?

Diagrama Smith

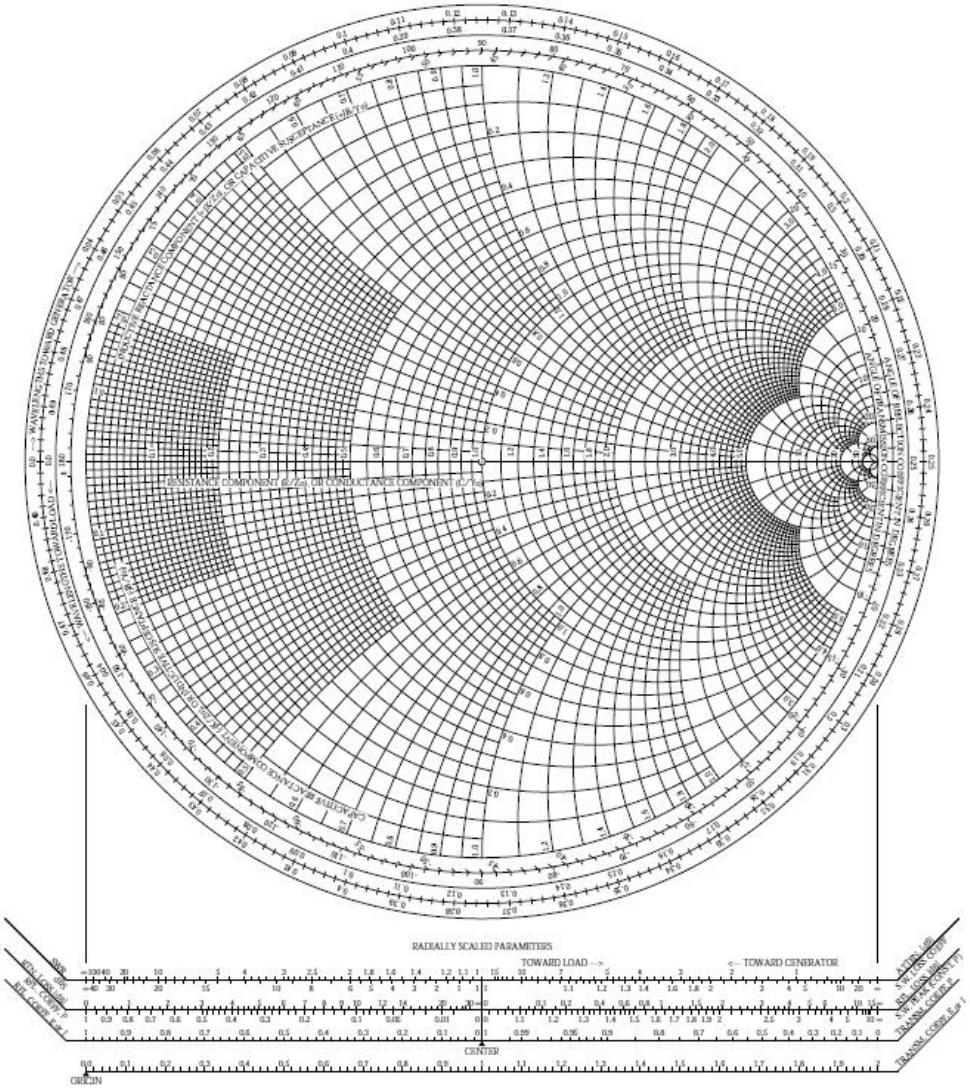
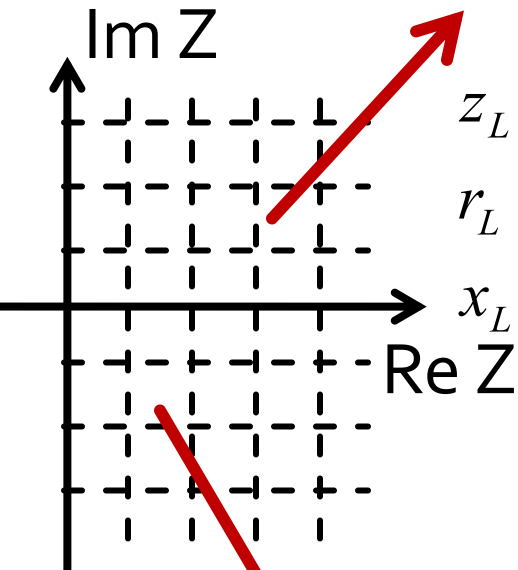


Diagrama Smith

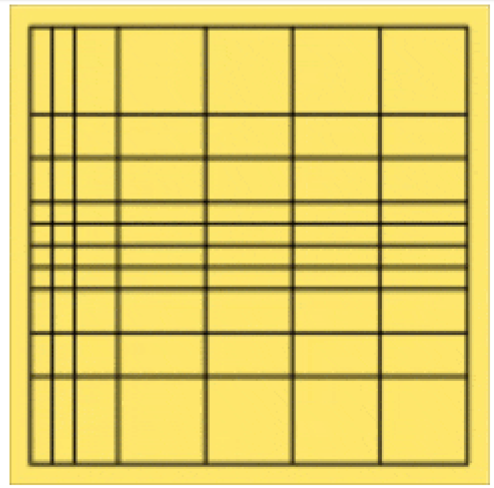
$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{z_L - 1}{z_L + 1}$$

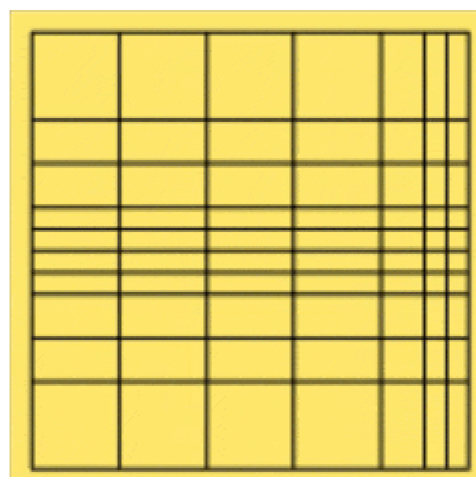


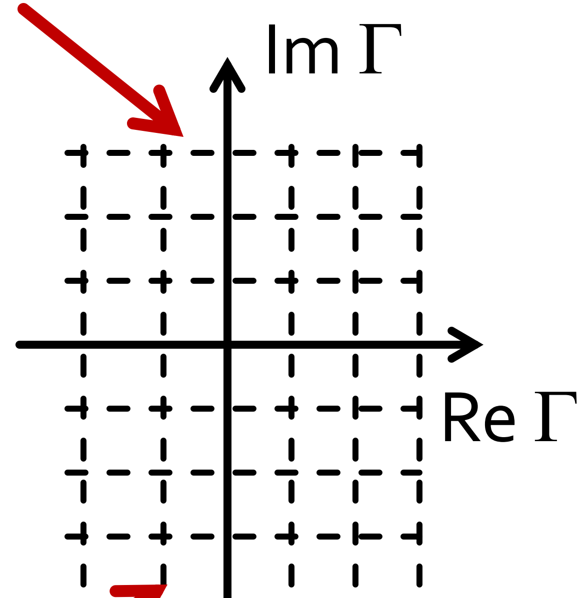
$$z_L = r_L + j \cdot x_L$$

$$r_L = ct.$$

$$x_L = ct.$$







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

Diagrama Smith

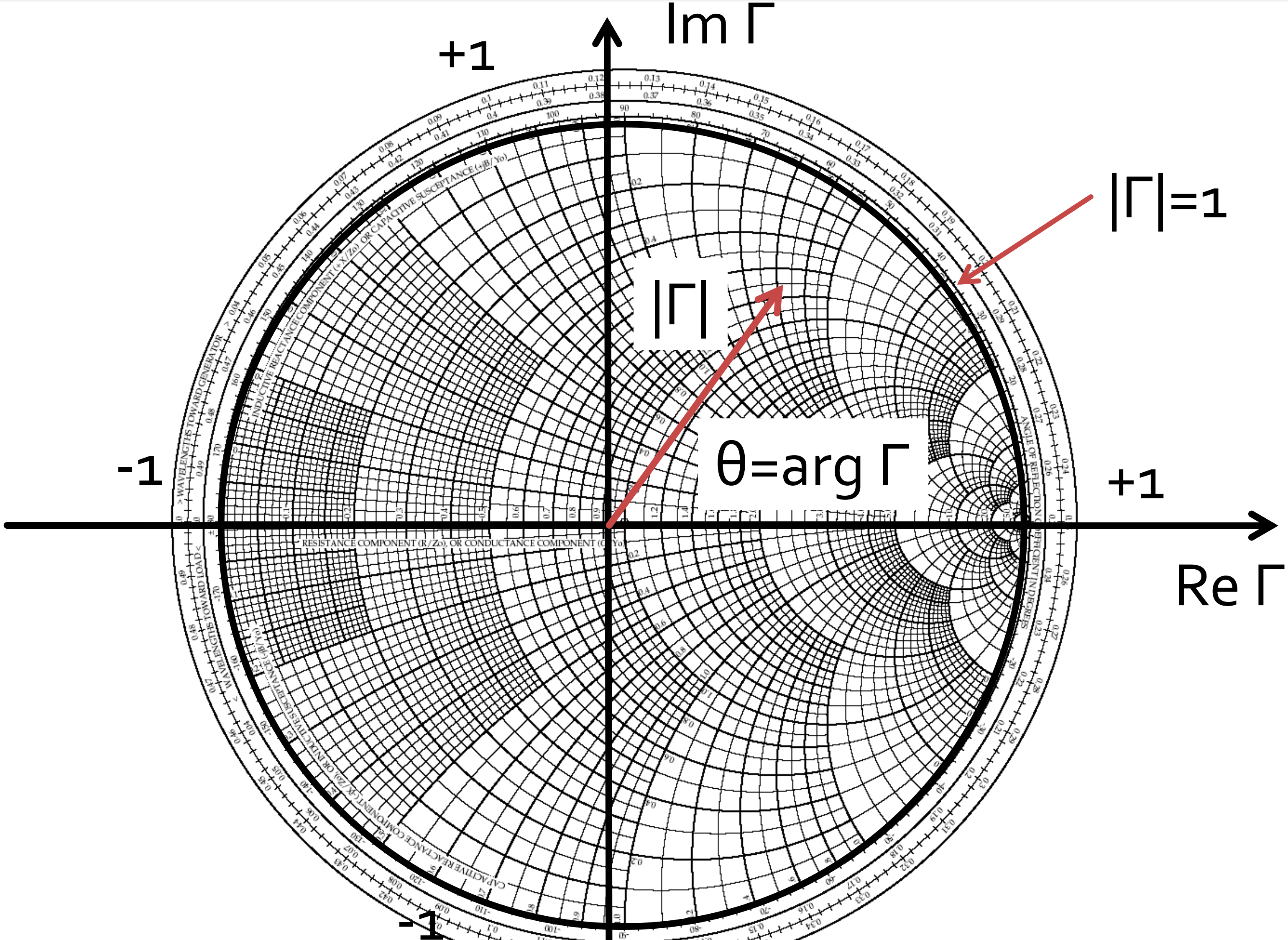


Diagrama Smith

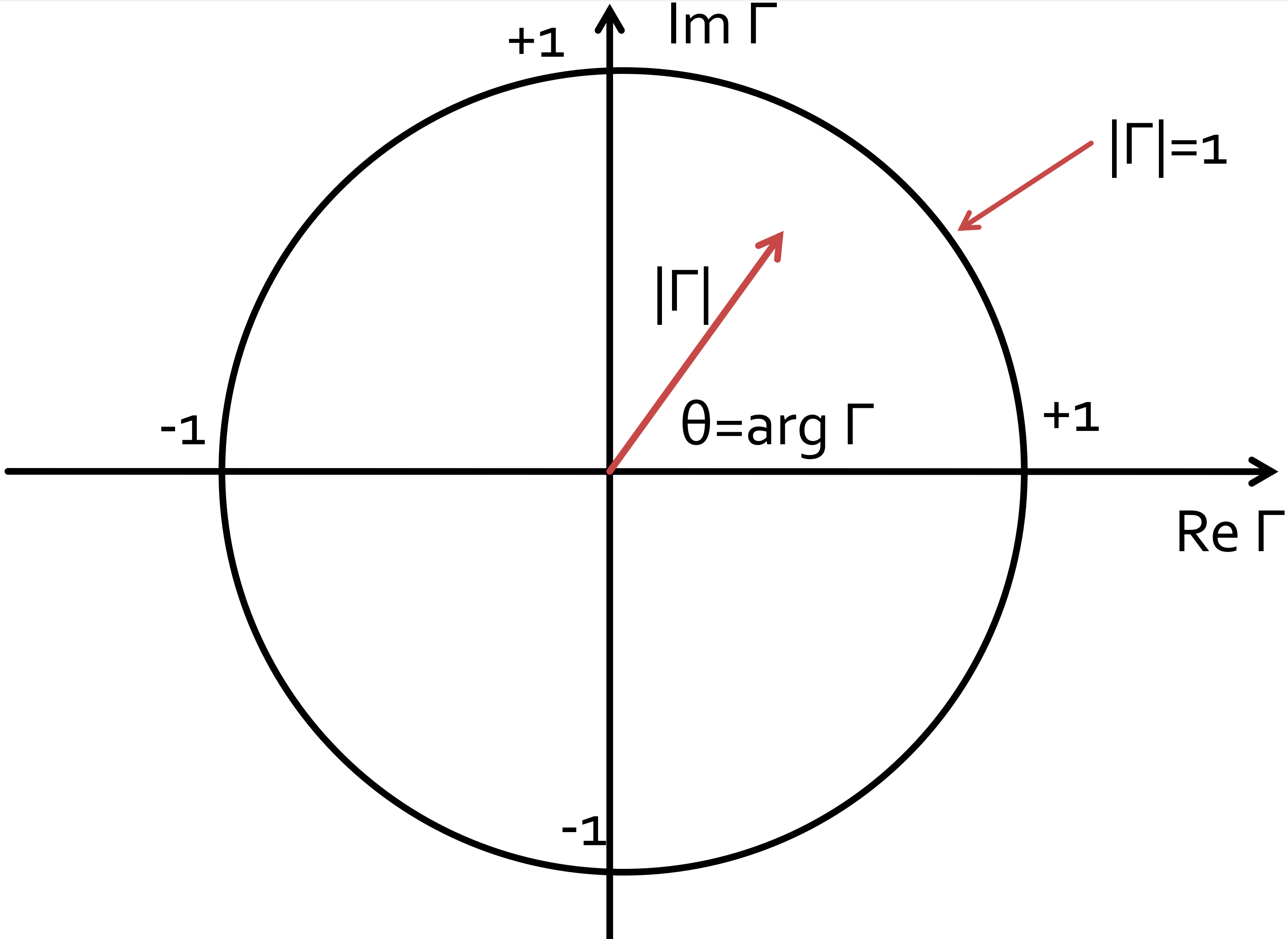


Diagrama Smith, rezistenta

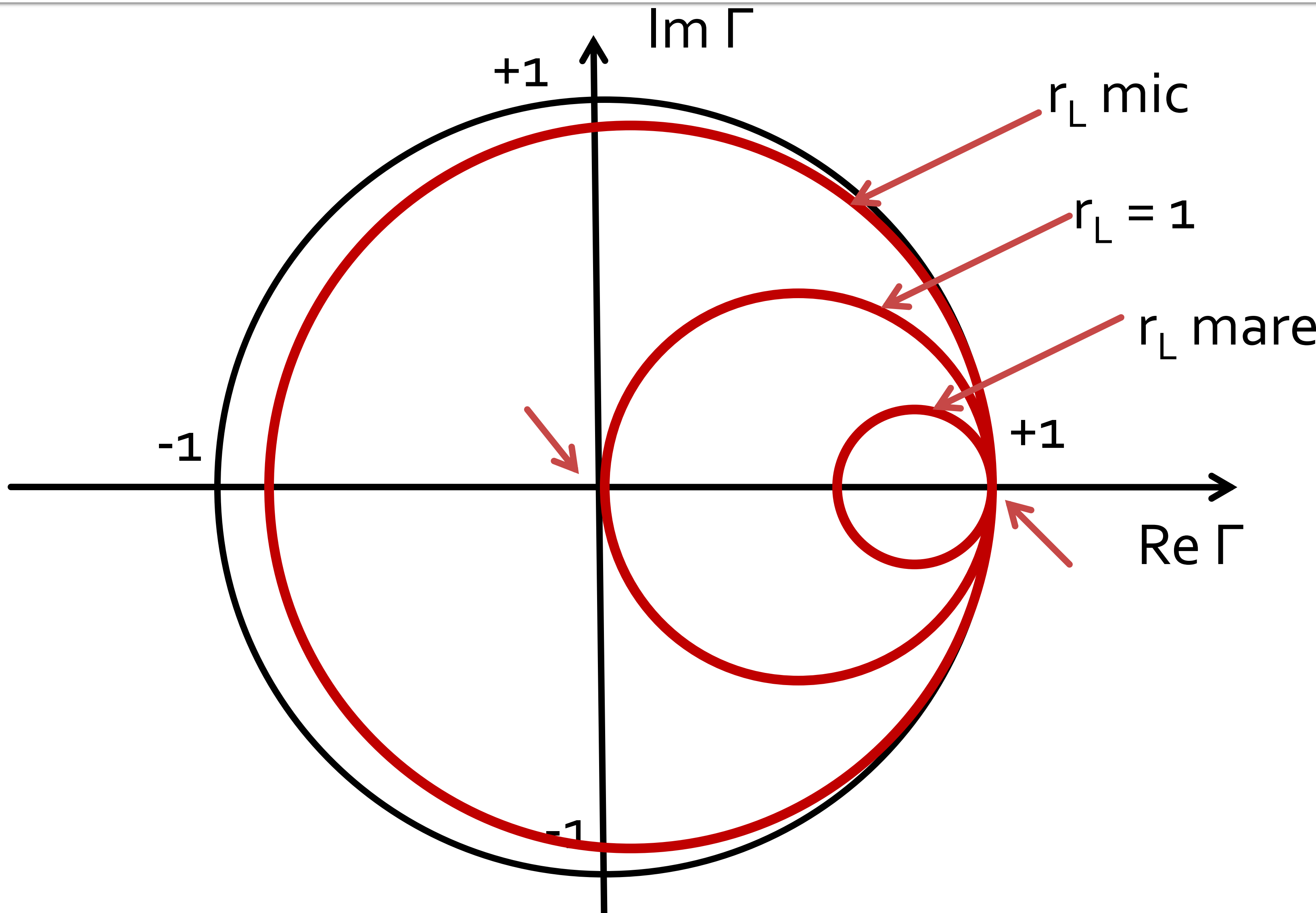
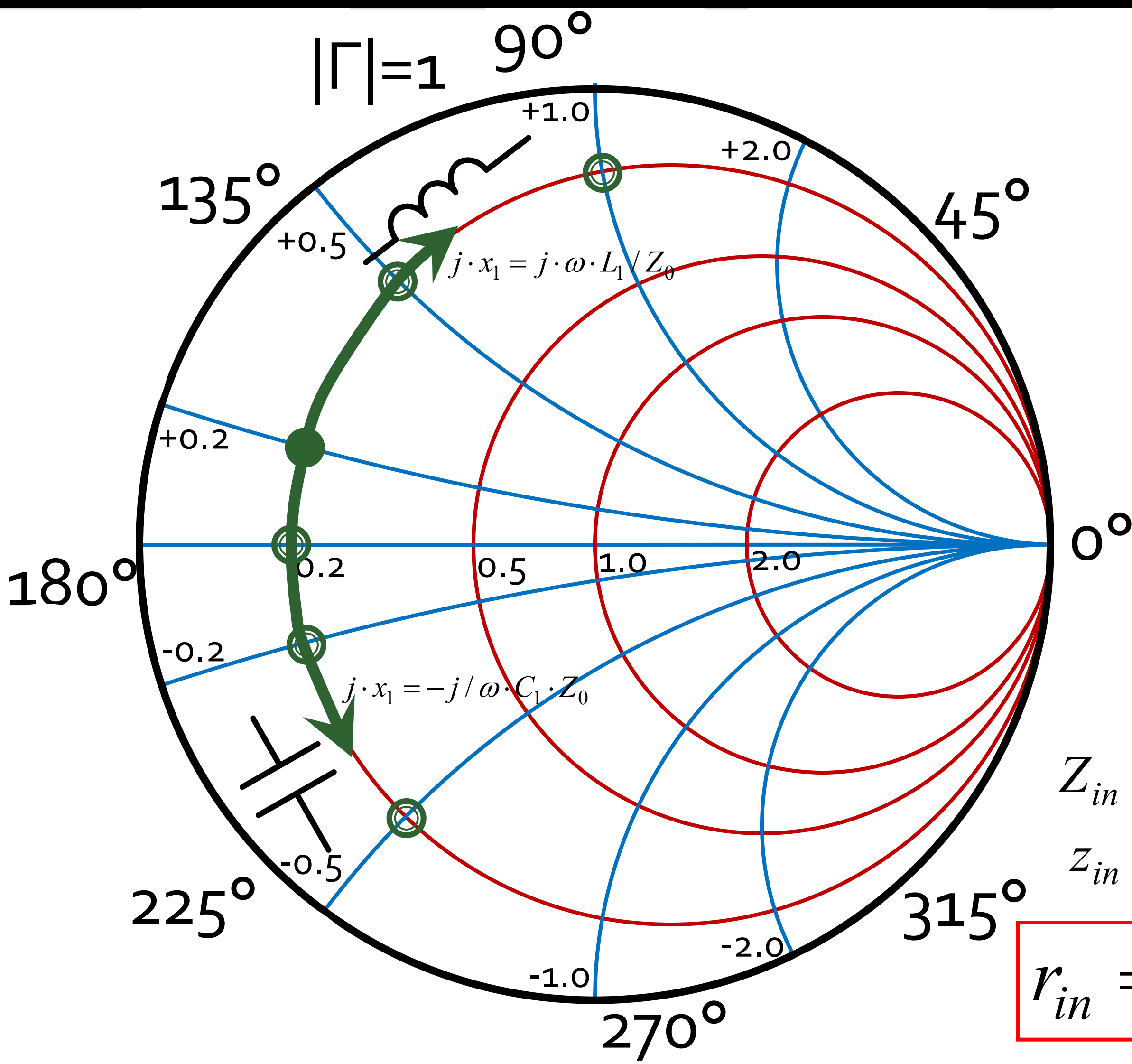
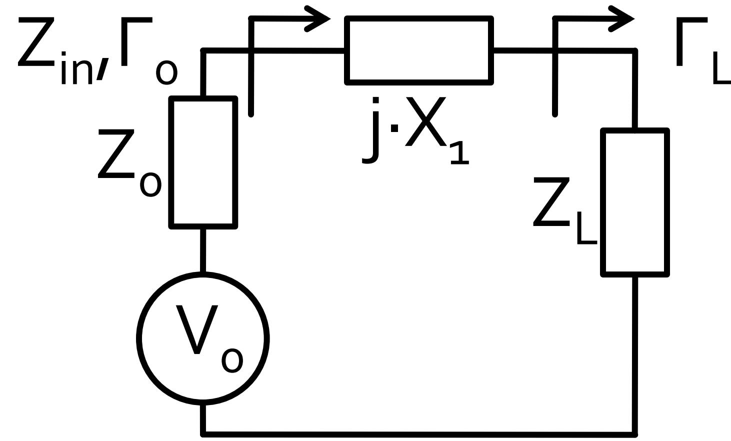


Diagrama Smith, coeficient de reflexie, reactanta in serie





$$Z_0 = 50\Omega$$

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

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

$$\Gamma_L = 0.678\angle 156.5°$$

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

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

$$\boxed{r_{in} = r_L}$$

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

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

Diagrama Smith, reactanta

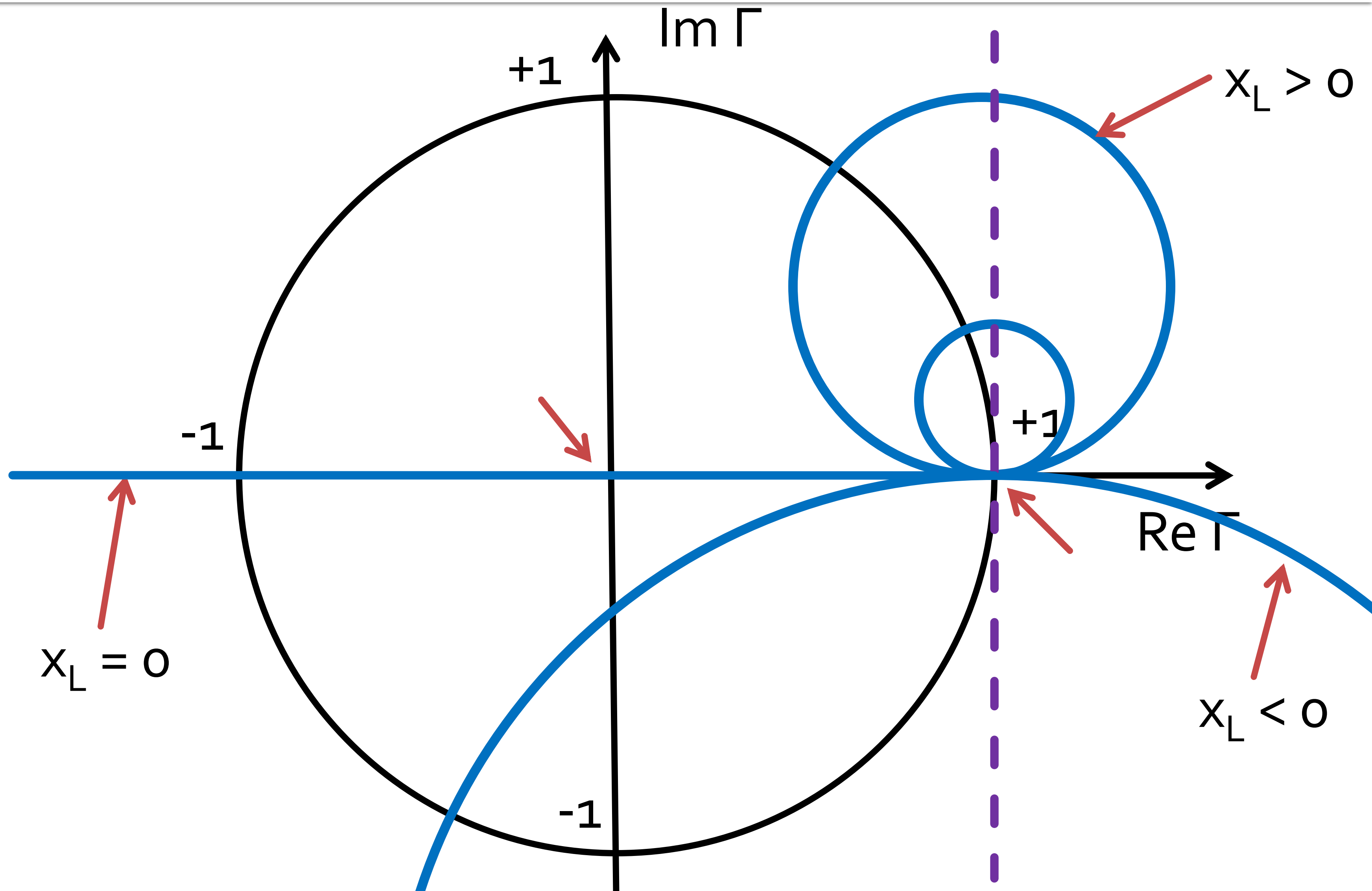
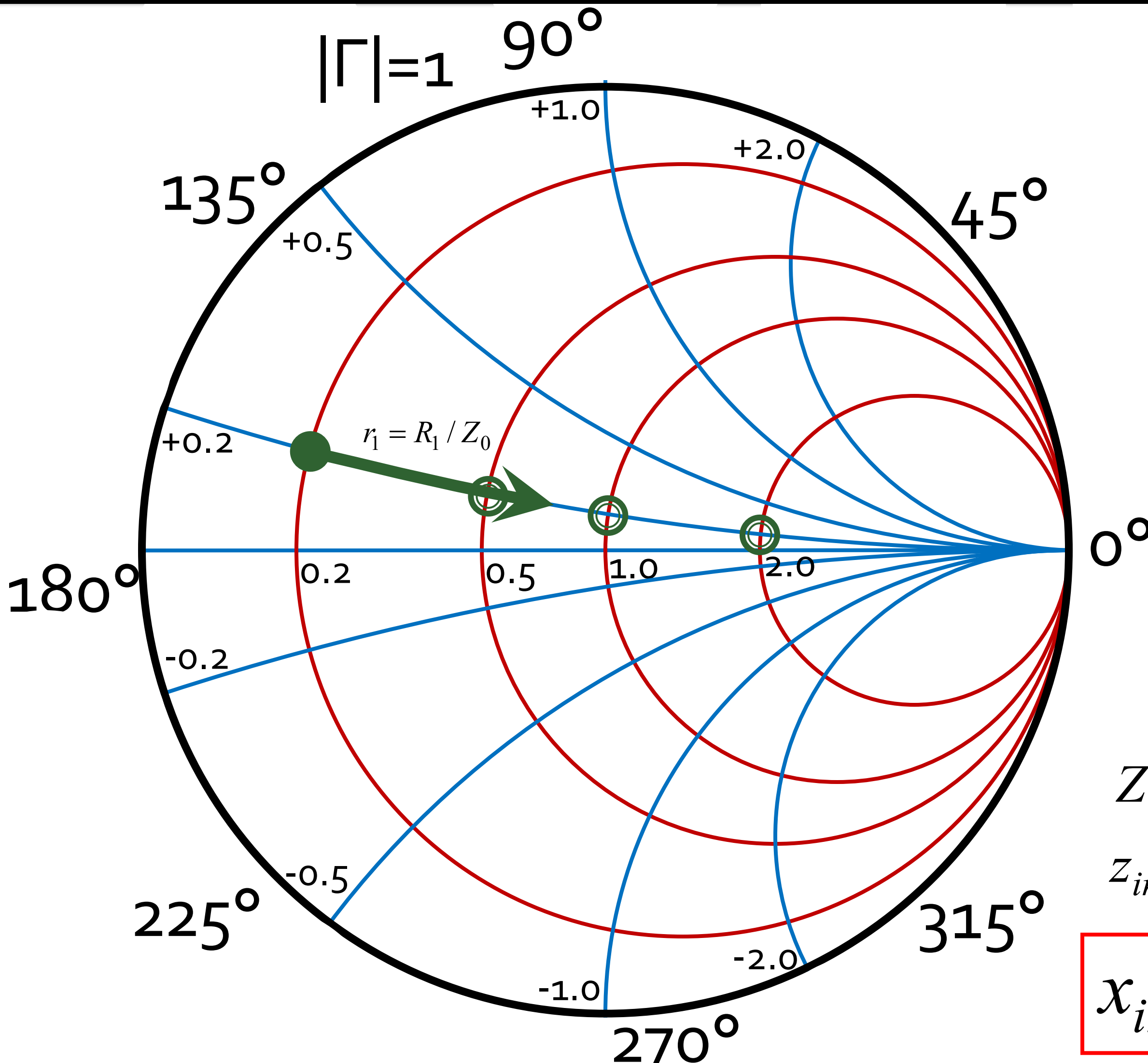
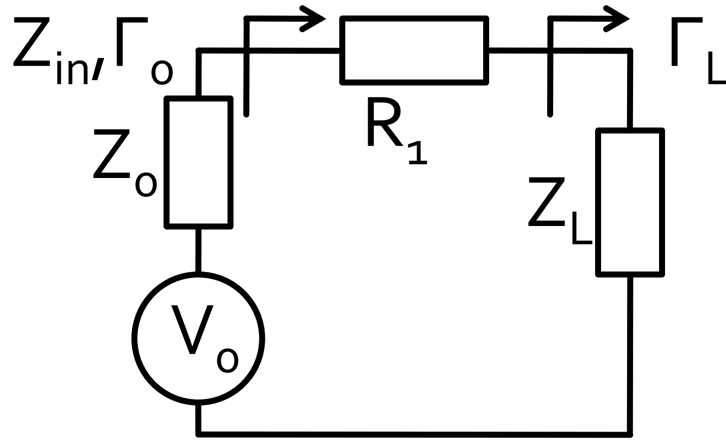


Diagrama Smith, coeficient de reflexie, rezistenta in serie





$$Z_0 = 50\Omega$$

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

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

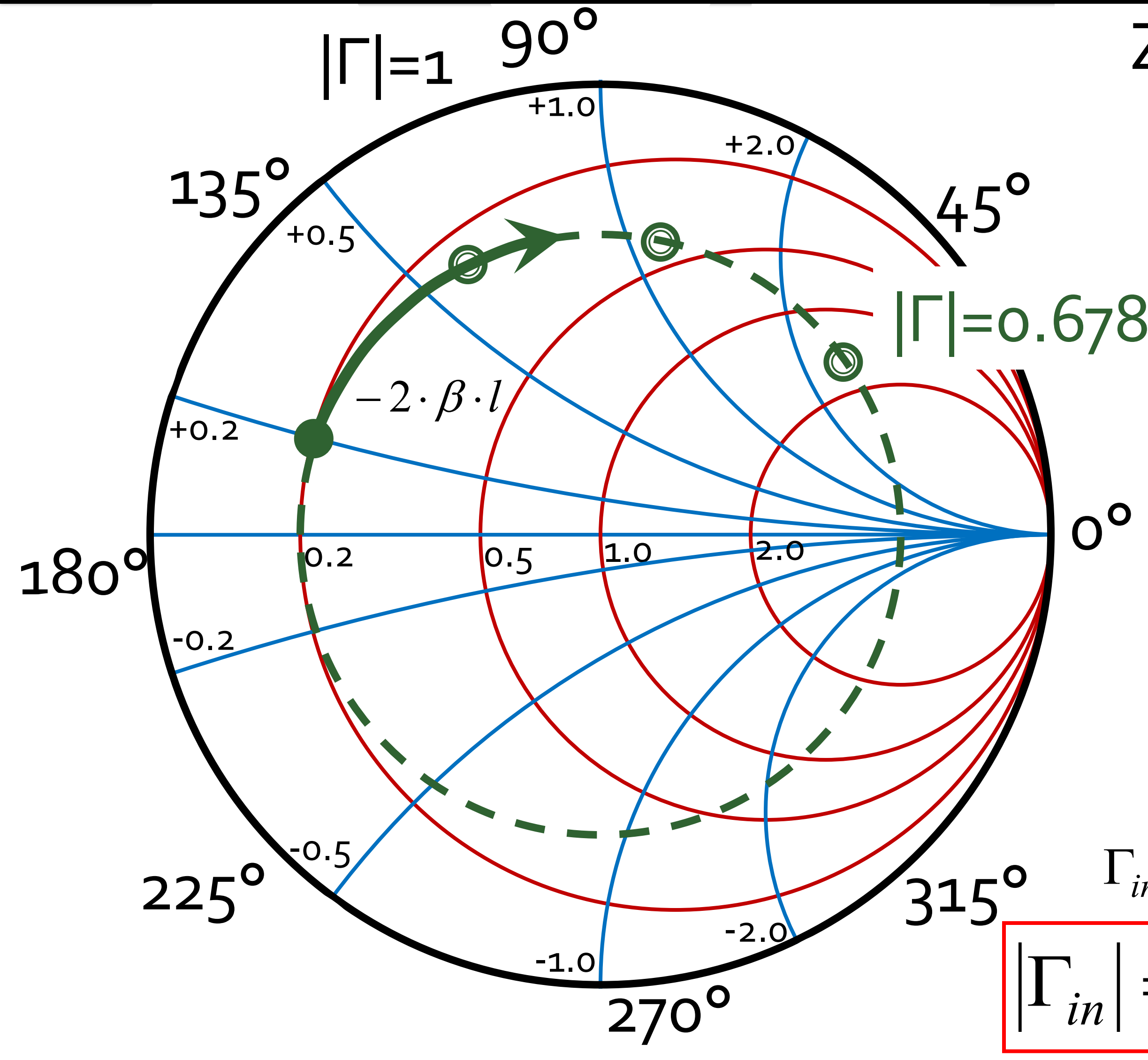
$$\Gamma_L = 0.678\angle 156.5°$$

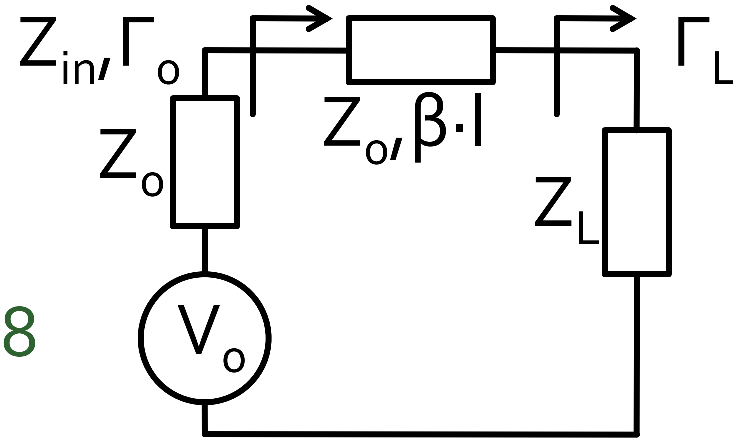
$$Z_{in} = Z_L + R_1 = (R_L + R_1) + j \cdot X_L$$

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

$$\boxed{x_{in} = x_L} \qquad r_{in} = r_L + R_1 / Z_0$$

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





$$Z_0 = 50\Omega$$

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

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

$$\Gamma_L = 0.678\angle 156.5°$$

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

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

$$\boxed{\left|\Gamma_{in}\right| = \left|\Gamma_L\right|}$$

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

Diagrama Smith, conductanta

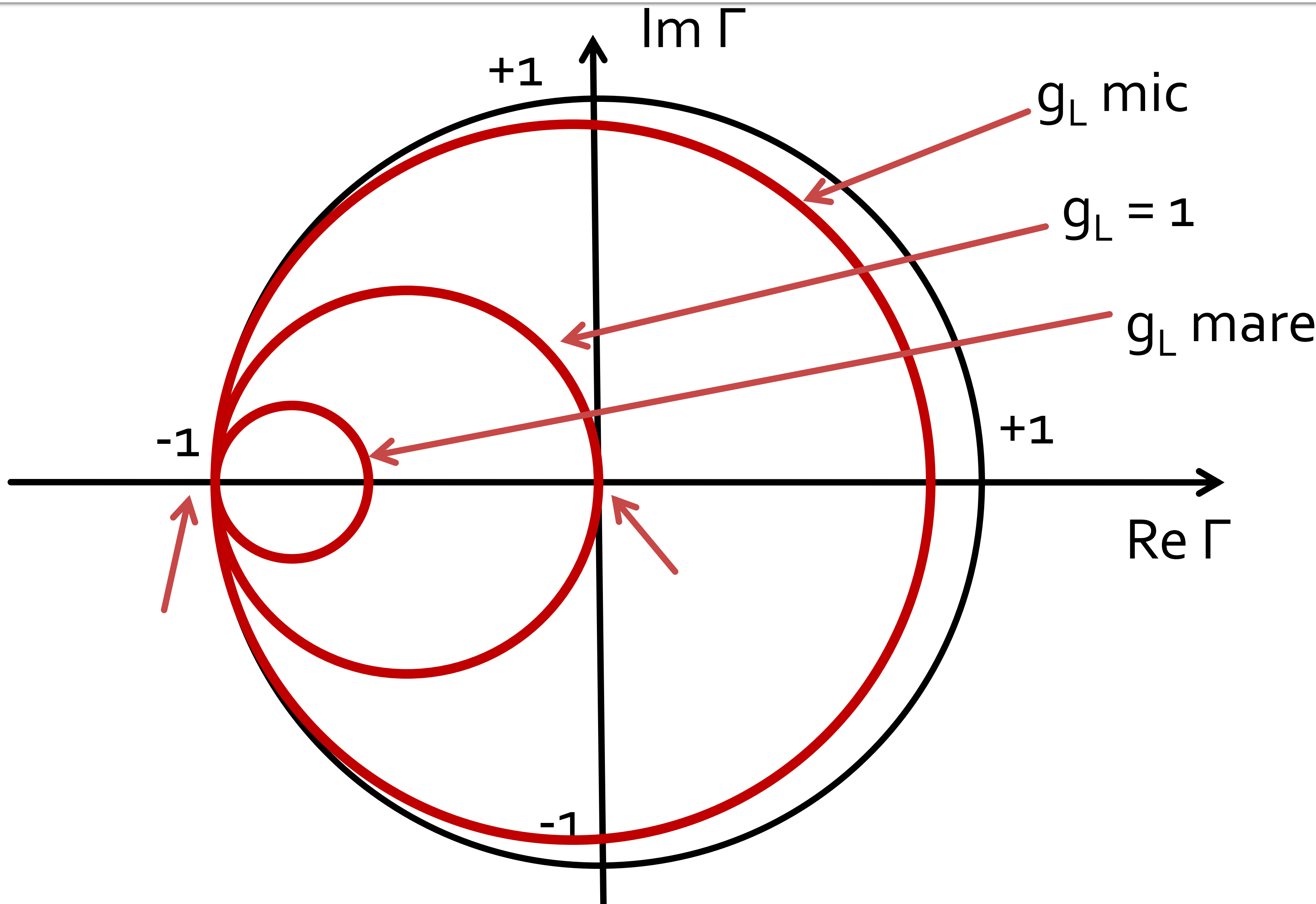
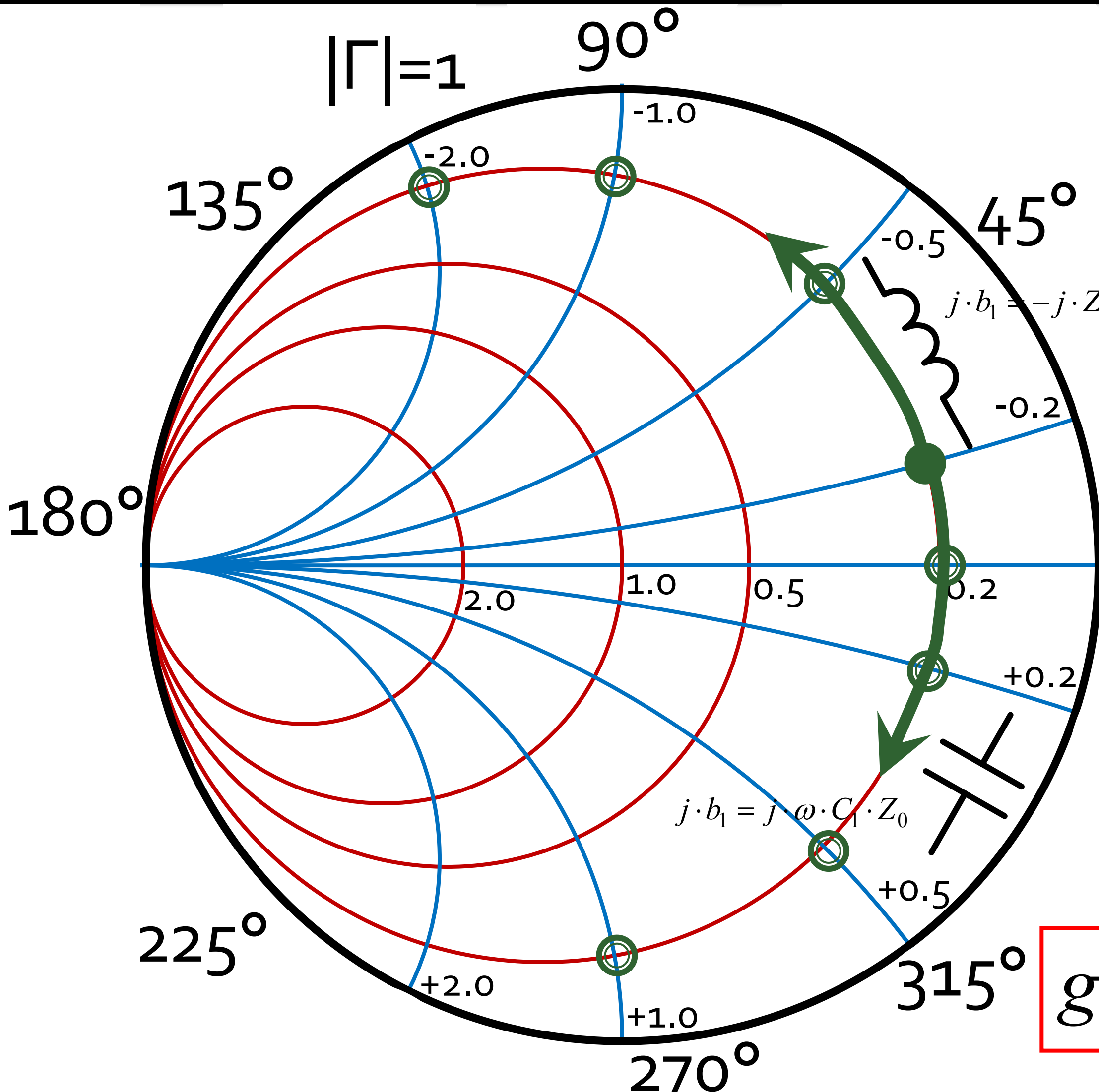
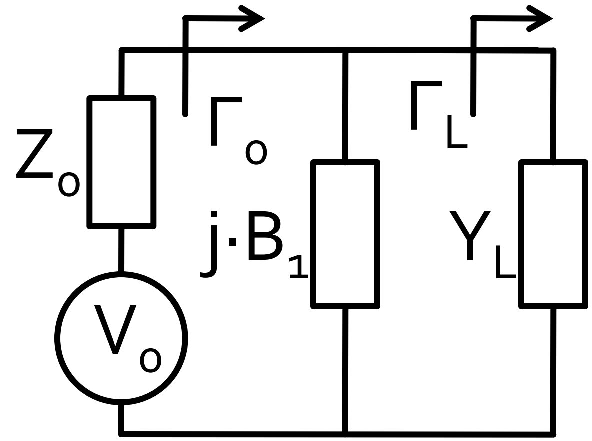


Diagrama Smith, coeficient de reflexie, susceptanta in paralel





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

$$\Gamma_L = 0.678\angle 23.5°$$

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

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

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

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

$$\boxed{g_{in} = g_L}$$

$$j \cdot b_1 = j \cdot \omega \cdot C_1 \cdot Z_0 > 0$$

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

Diagrama Smith, susceptanta

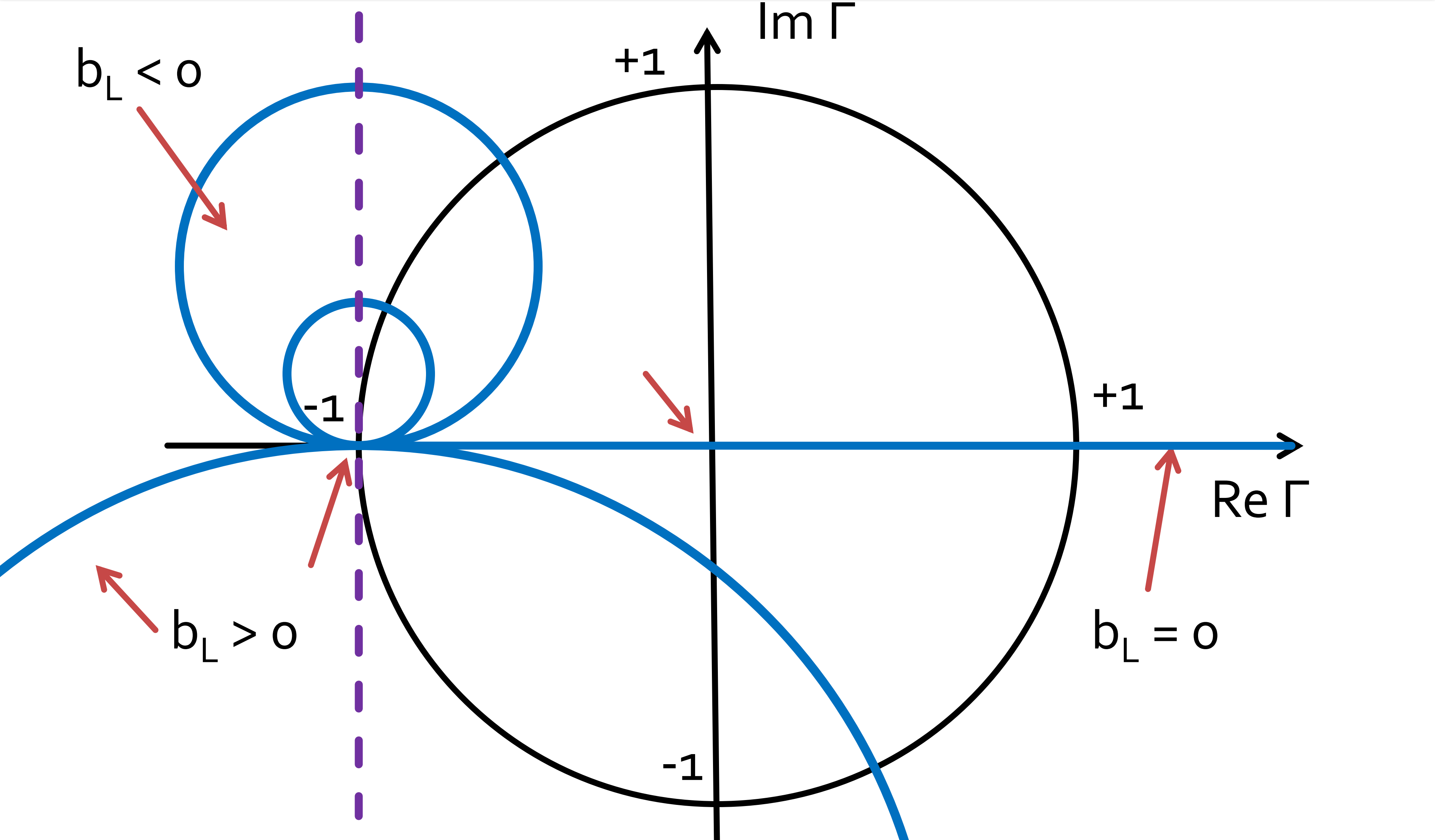
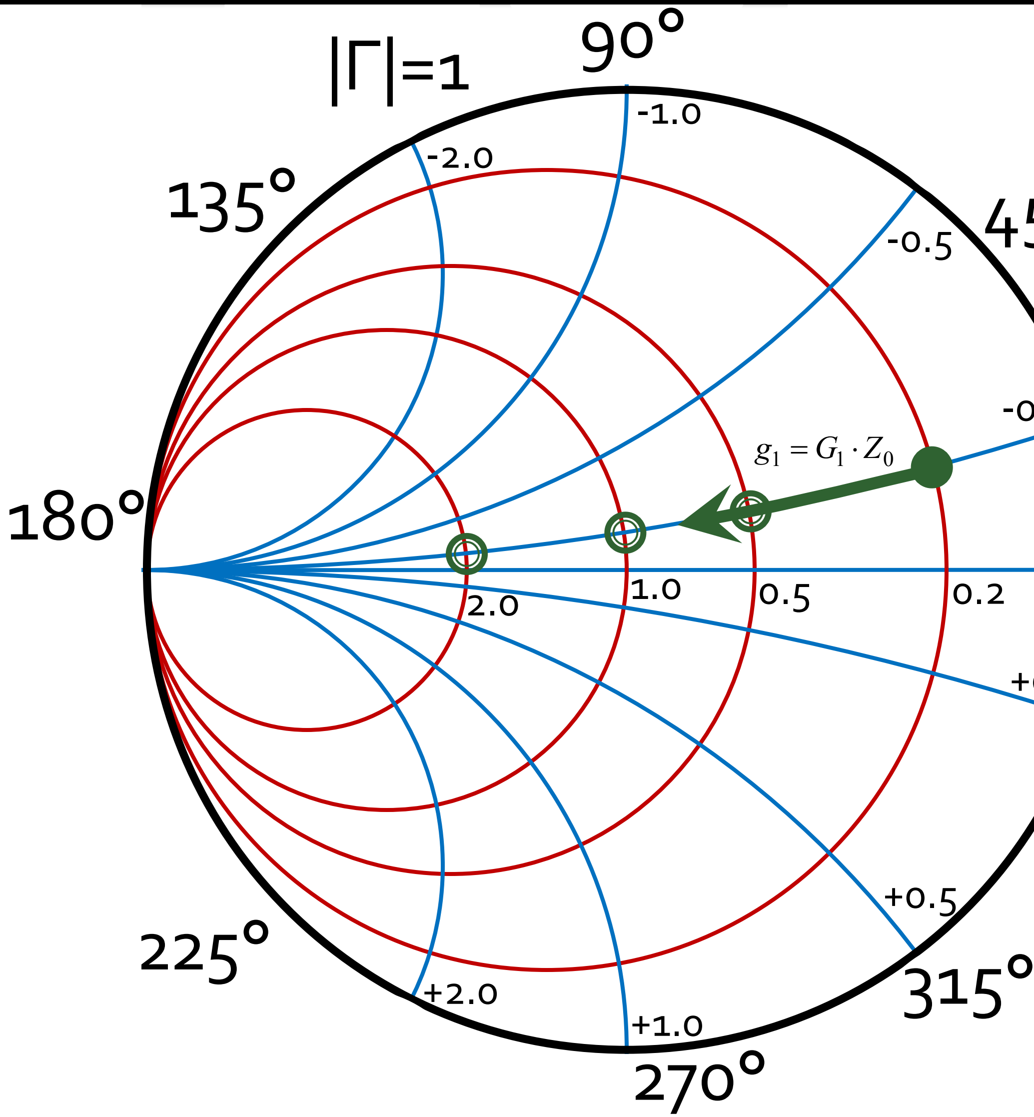
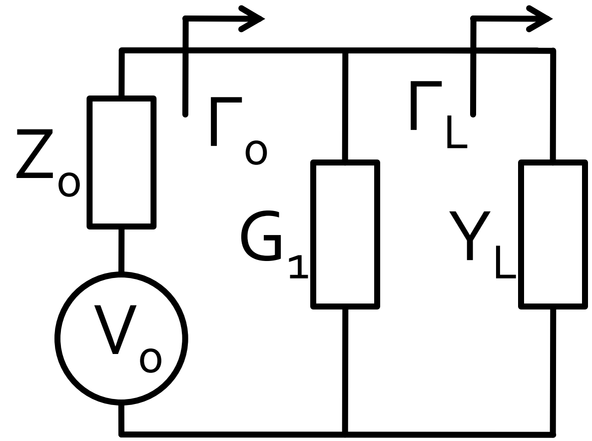


Diagrama Smith, coeficient de reflexie, conductanta in paralel





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

$$\Gamma_L = 0.678\angle 23.5°$$

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

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

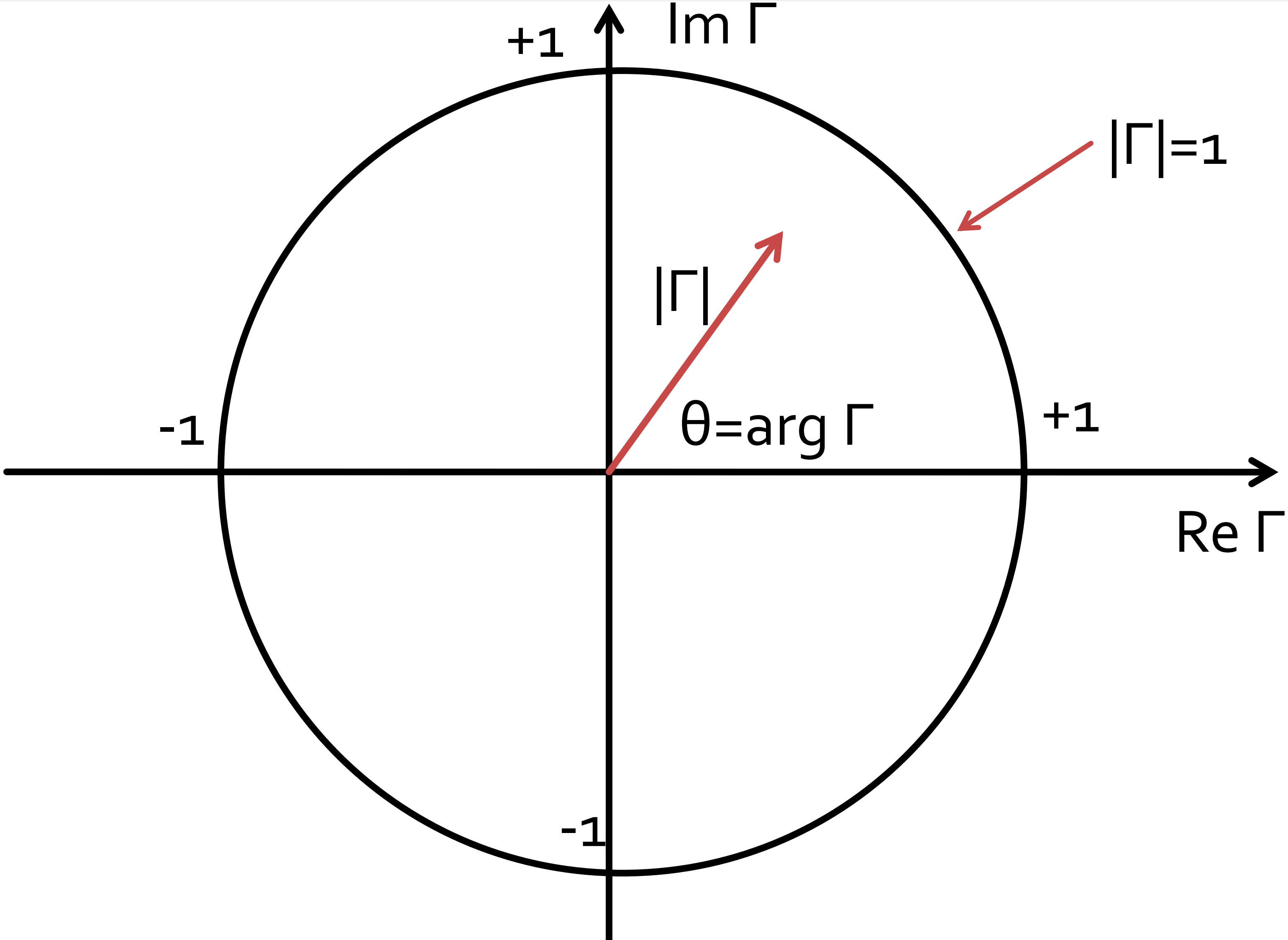
$$Y_{in} = Y_L + G_1 = (G_L + G_1) + j \cdot B_L$$

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

$$\boxed{b_{in} = b_L}$$

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

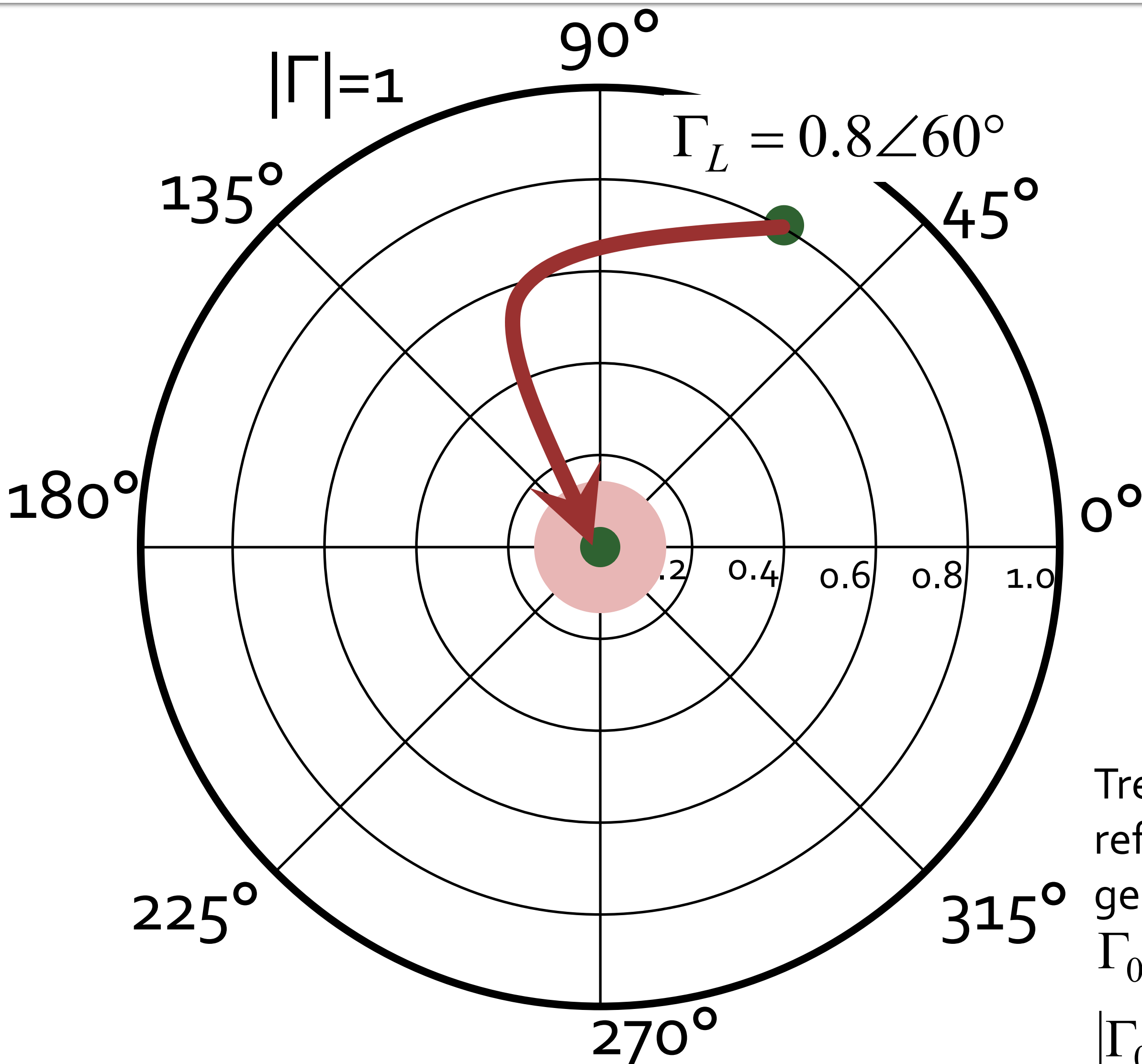
Diagrama Smith

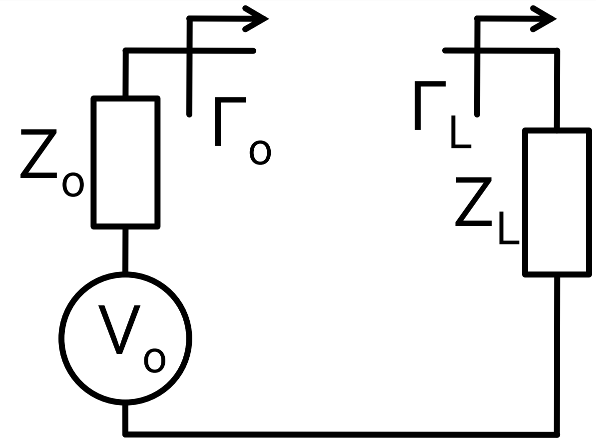


Adaptarea de impedanța

Adaptarea cu elemente concentrate (Retele in L)

Diagrama Smith, adaptare





Adaptare Z_L la Z_o. Se raporteaza Z_L la Z_o

$$Z_L = 21.429\Omega + j \cdot 82.479\Omega$$

$$z_L = 0.429 + j \cdot 1.65$$

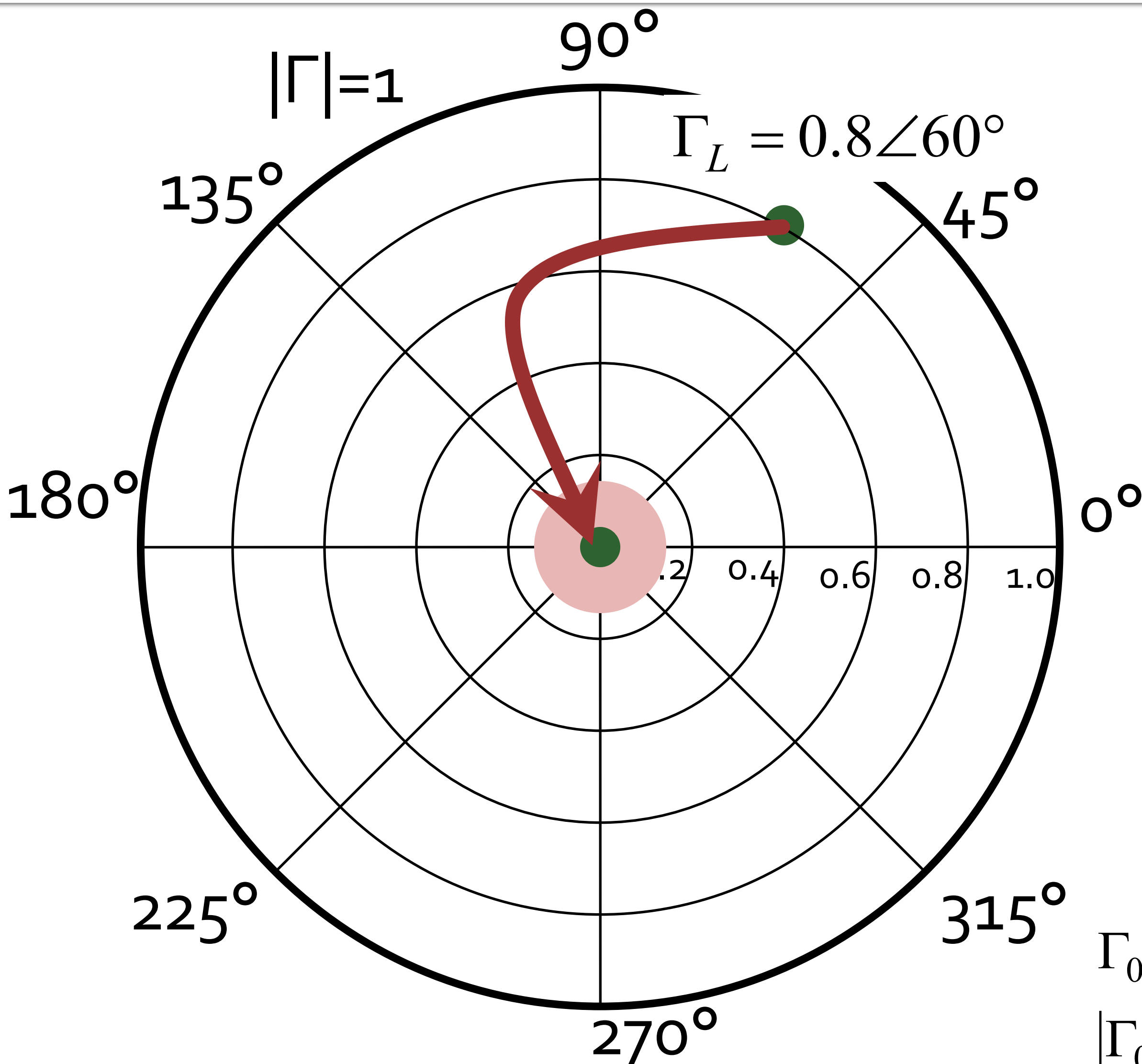
$$\Gamma_L = 0.8\angle 60°$$

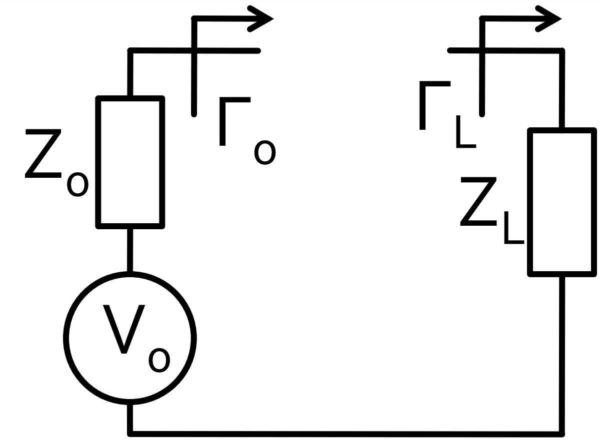
Trebuie sa deplasez coeficientul de reflexie in zona in care pentru generator cu Z_o am:

$\Gamma_0 = 0$ adaptare perfecta

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

Adaptare de impedanța



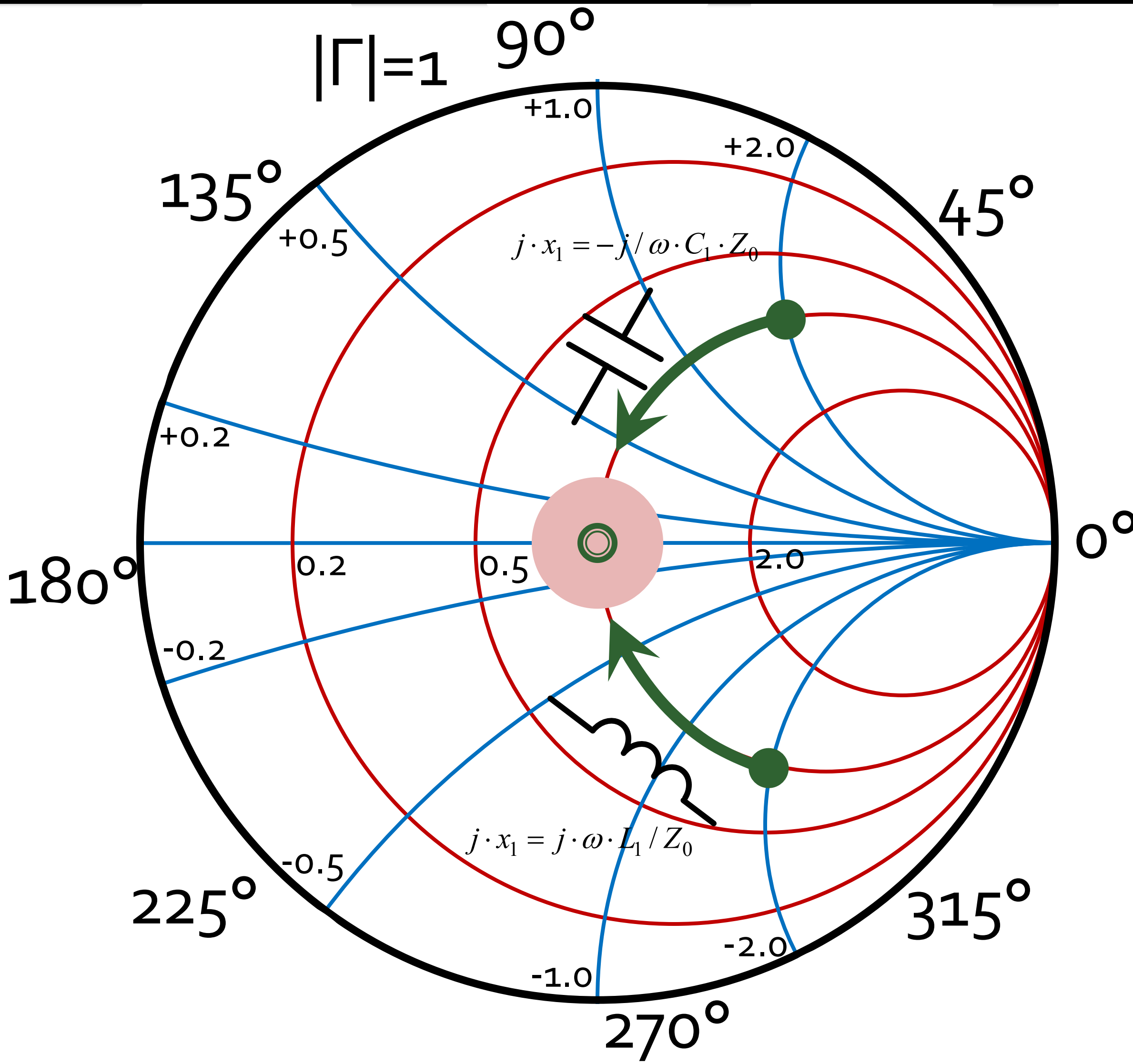


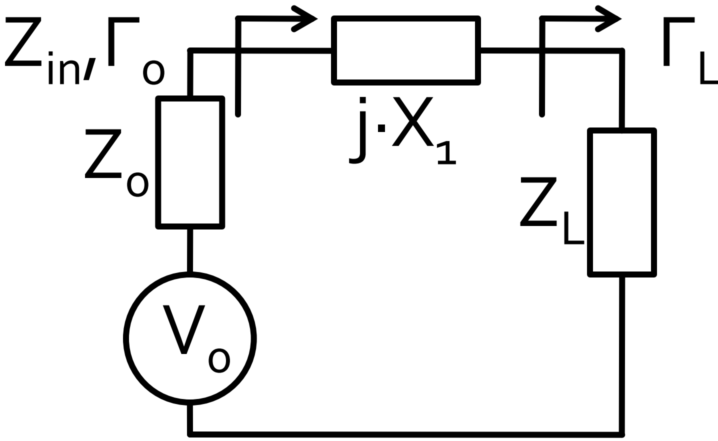
Cum?

$\Gamma_0 = 0$ adaptare perfecta

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

Adaptare, reactanta in serie





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

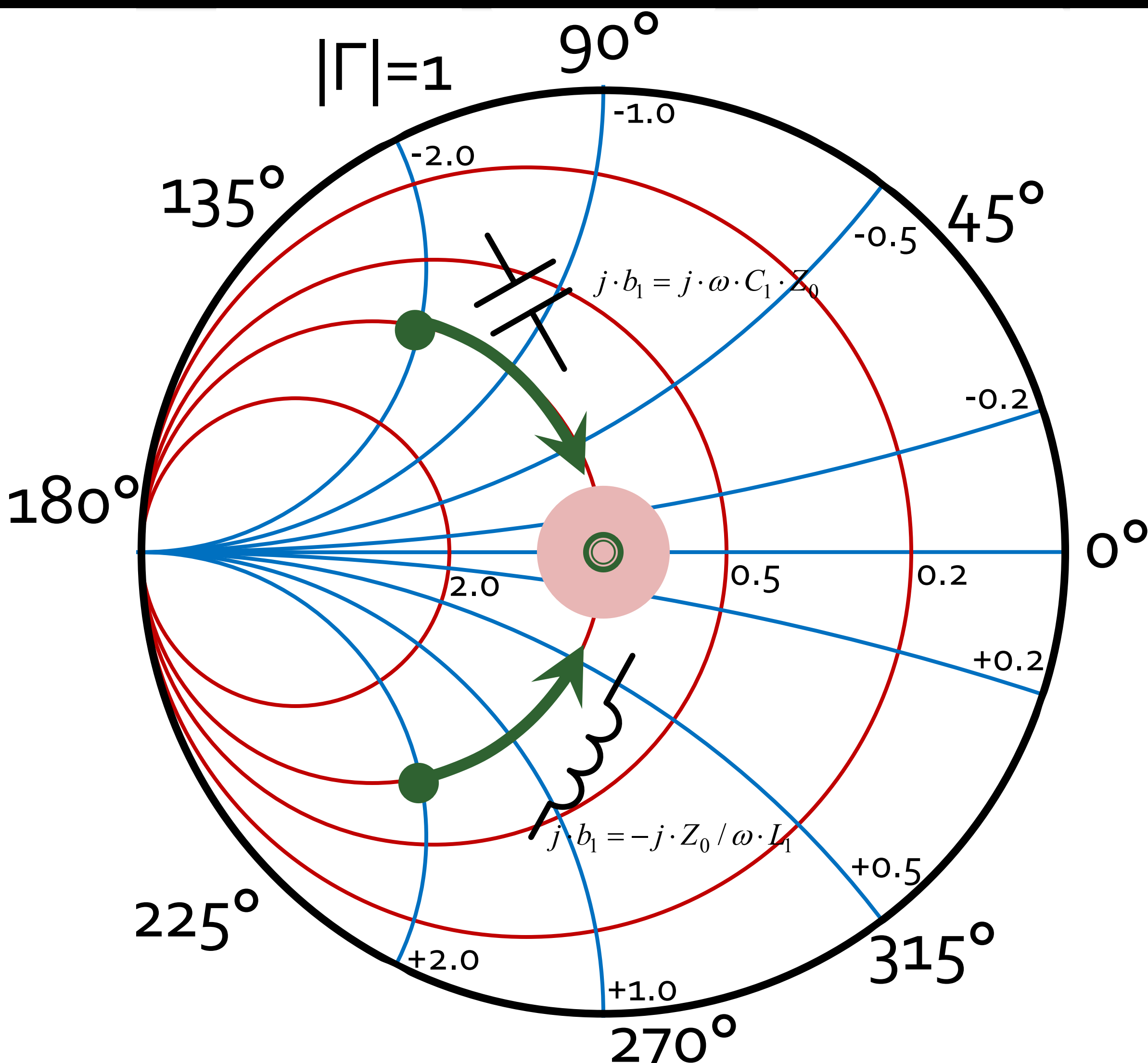
$$z_{in} = r_L + j \cdot (x_L + x_1)$$

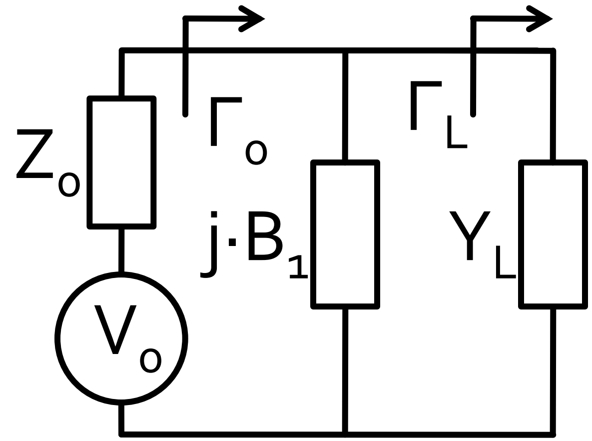
$$\boxed{r_{in} = r_L}$$

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

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

Adaptare, susceptanta in paralel





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

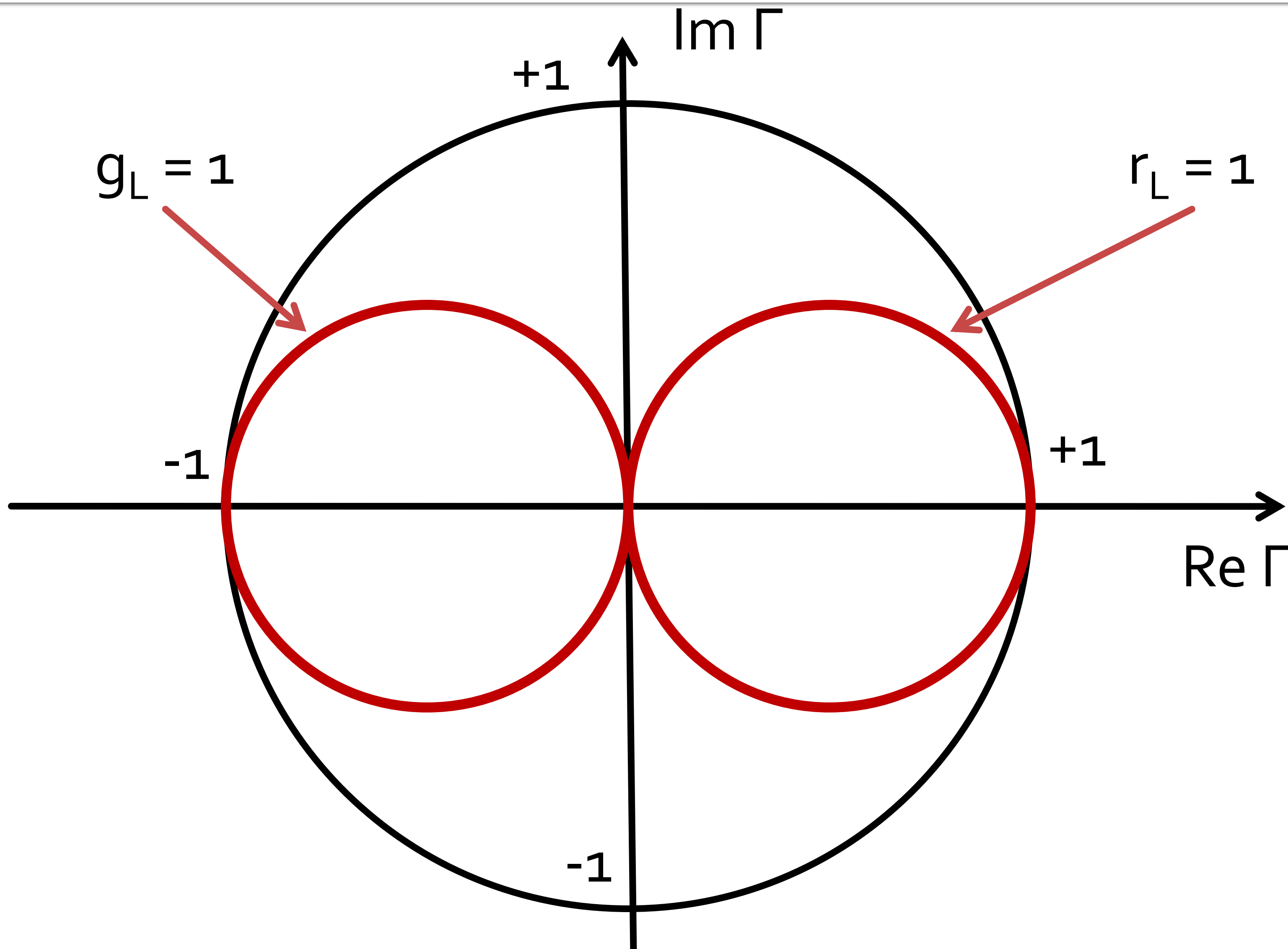
$$y_{in} = g_L + j\cdot(b_L + b_1)$$

$$\boxed{g_{in} = g_L}$$

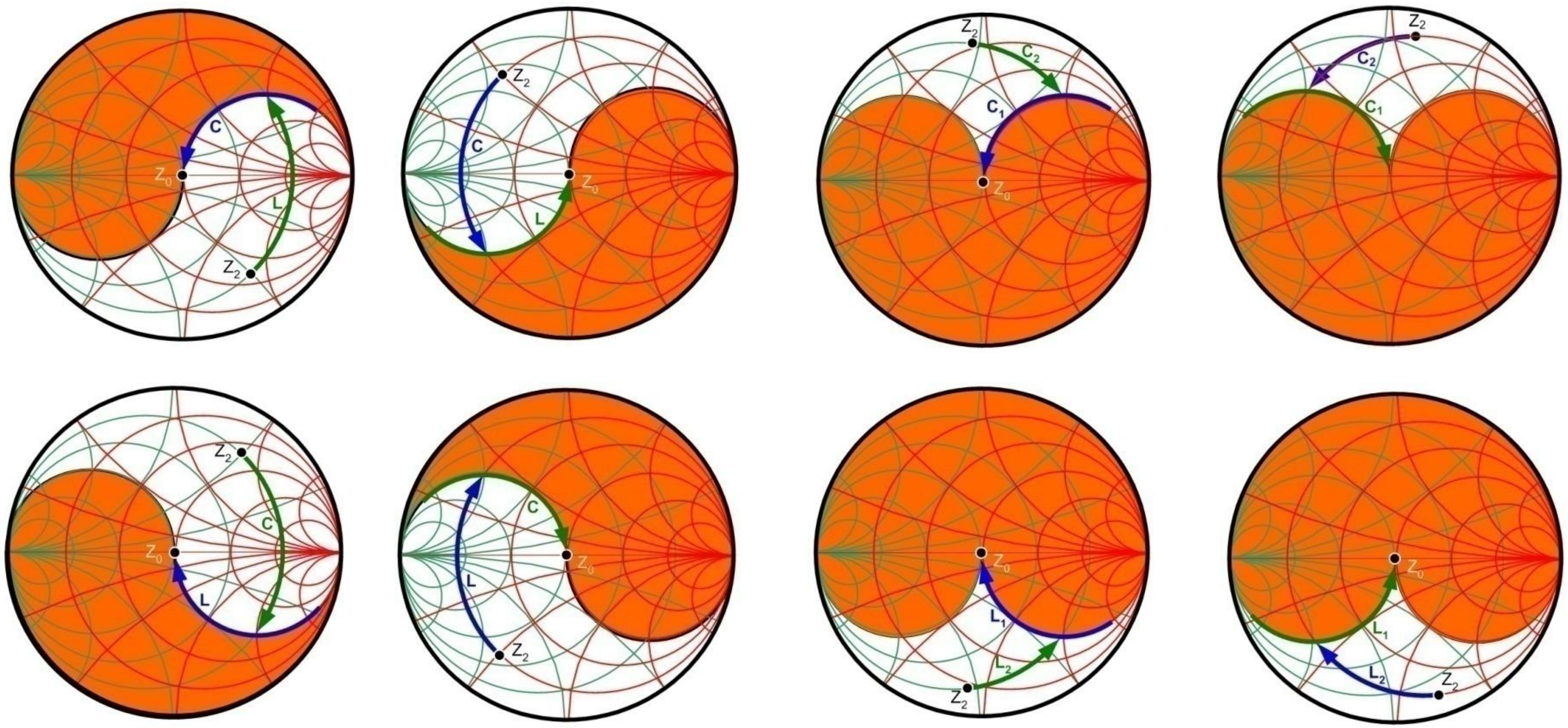
- Adaptarea se poate realiza **numai daca** $g_L = 1$
- se realizeaza compensarea partii reactive a sarcinii

$$j\cdot b_1 = -j\cdot b_L$$

Diagrama Smith, r=1 si g=1

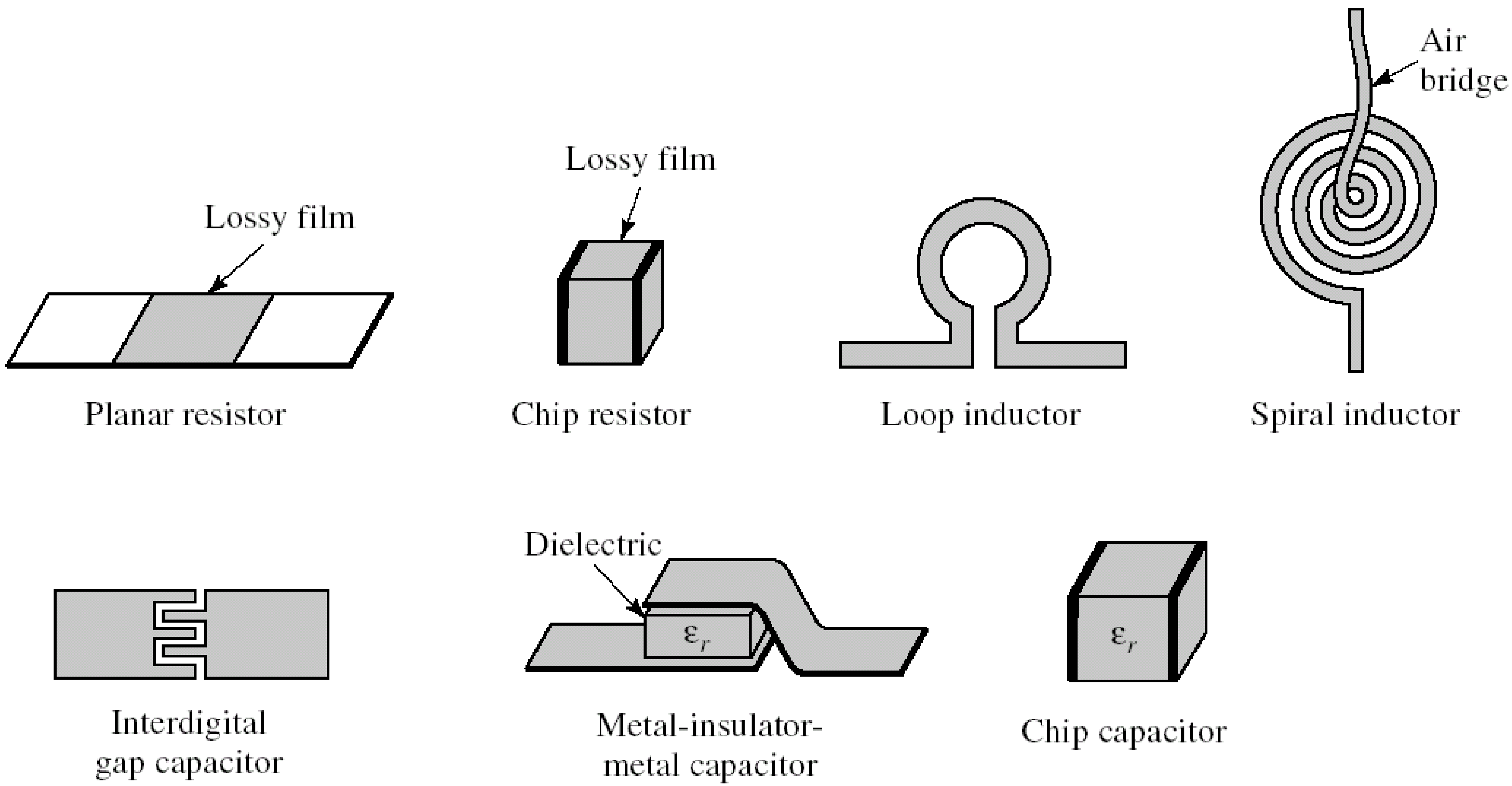


Adaptare cu doua elemente reactive (retele in L)



Zona interzisa cu schema curenta

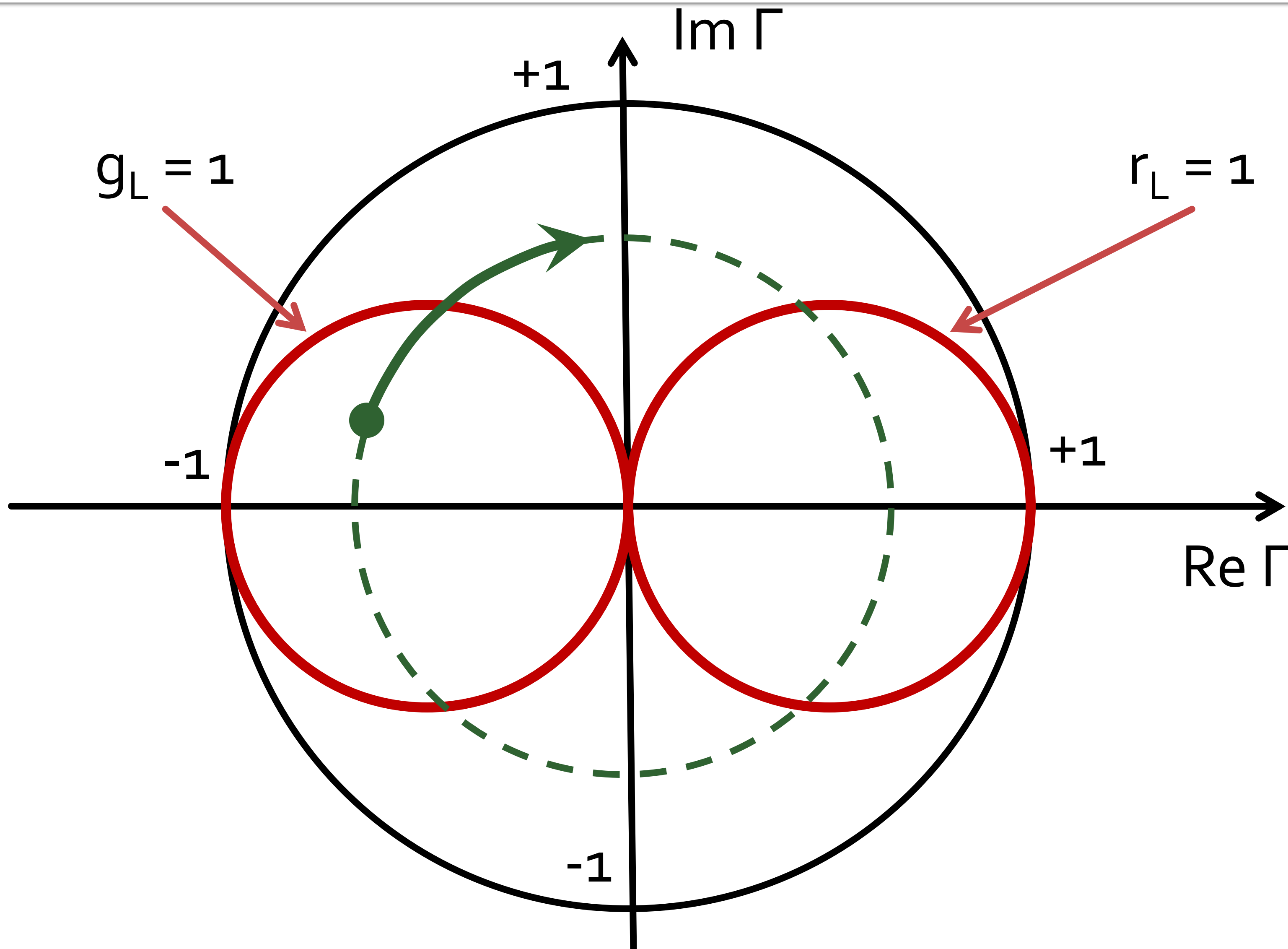
Realizare elemente concentrate



Adaptarea cu sectiuni de linii (stub)

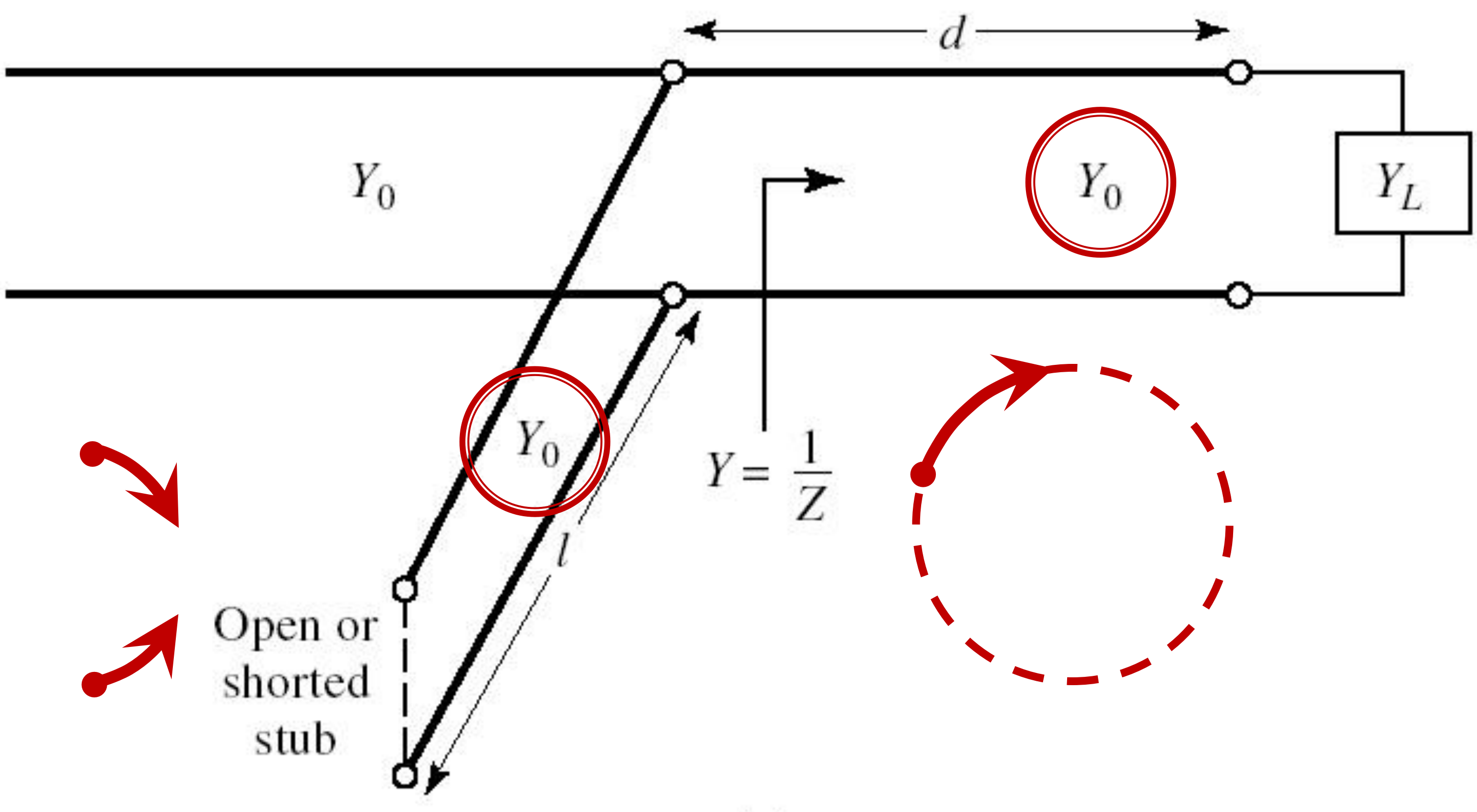
Adaptarea de impedanța

Diagrama Smith, r=1 si g=1



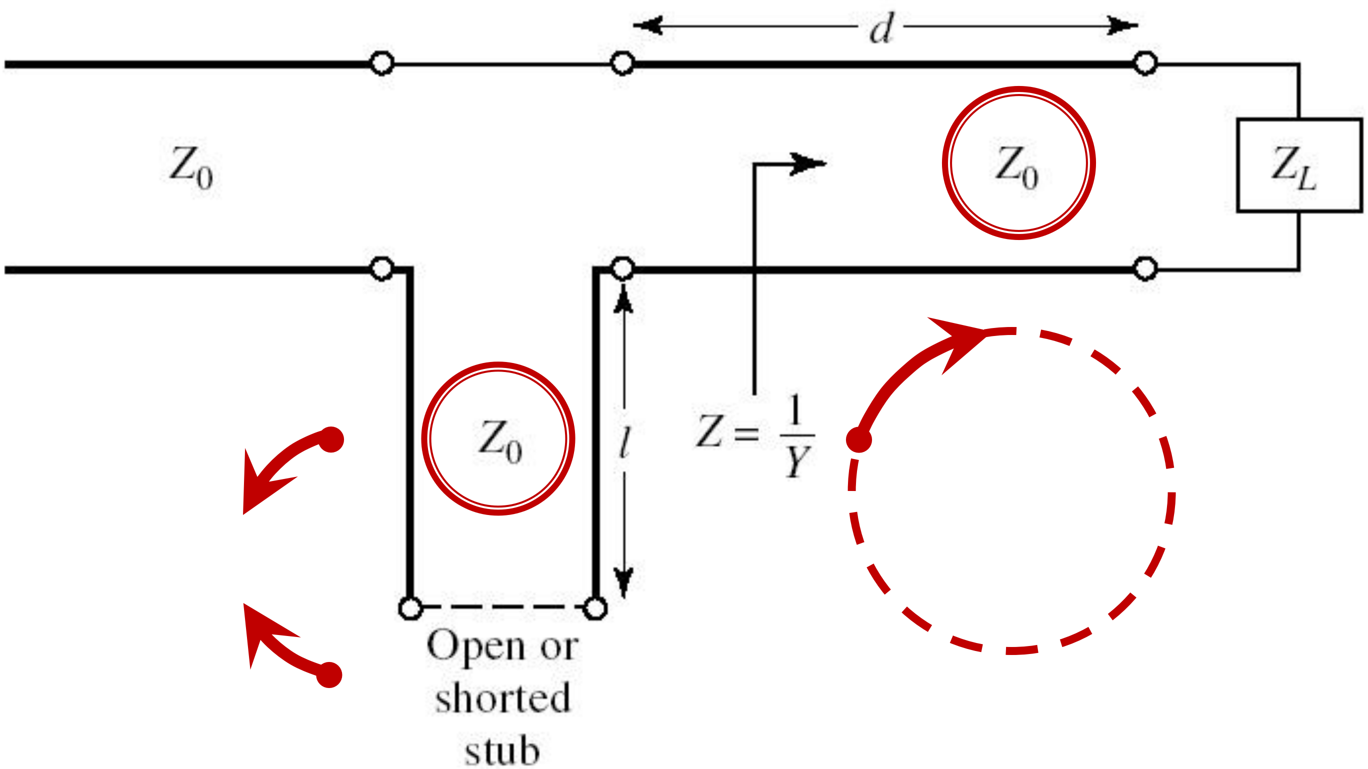
Single stub tuning

- Shunt Stub (sectiune de linie in paralel)



Single stub tuning

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

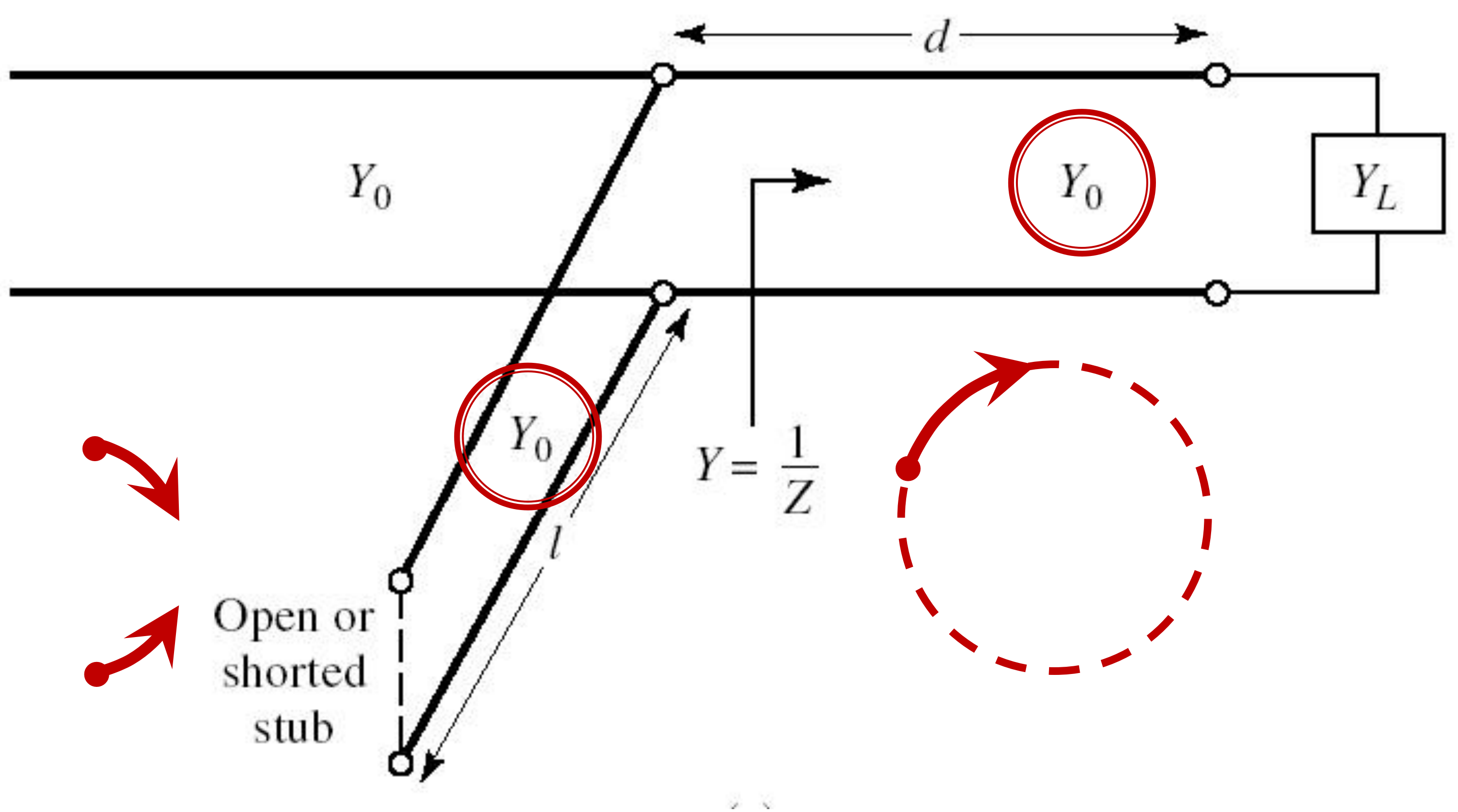


Solutii analitice

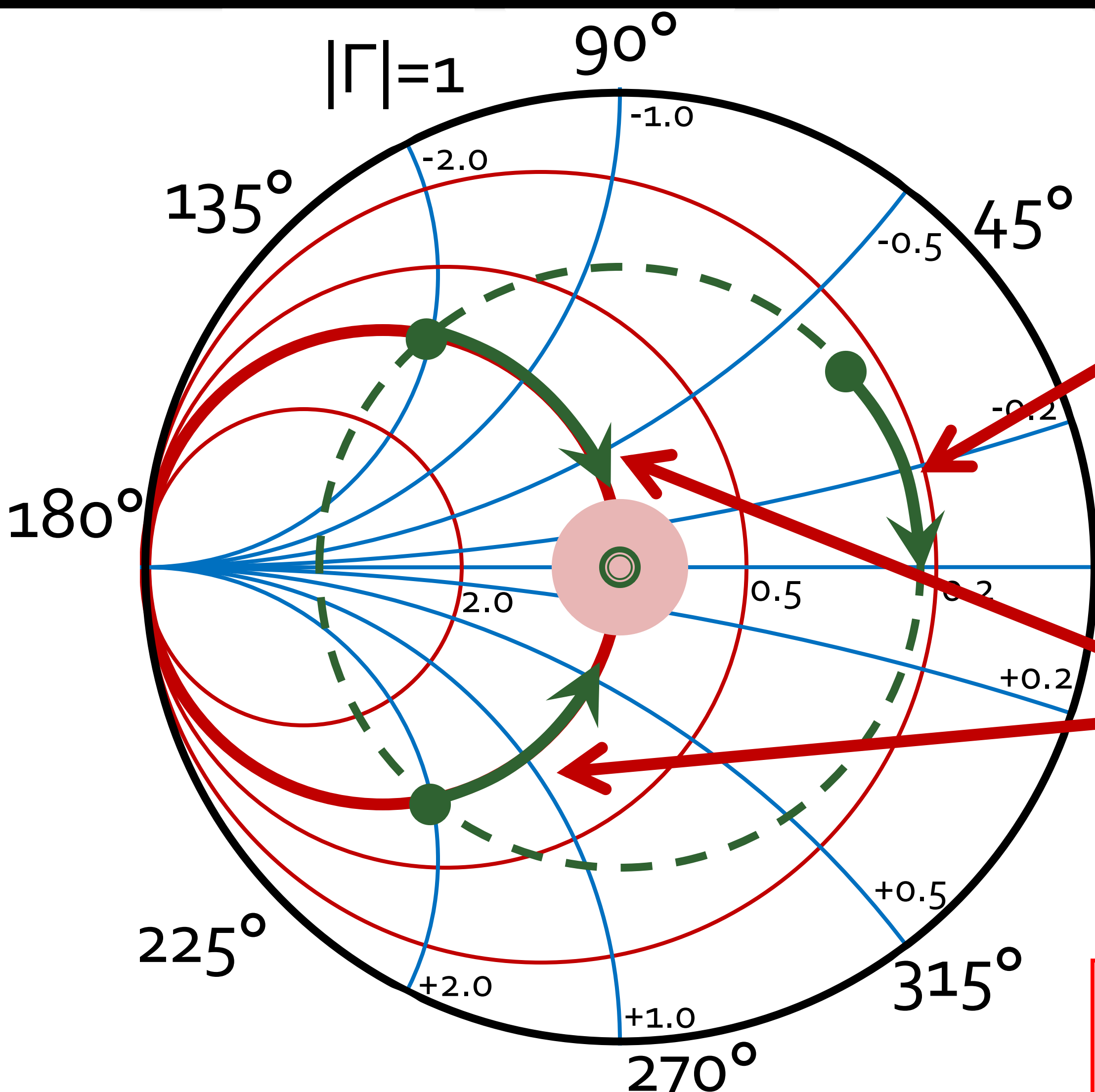
Examen / Proiect

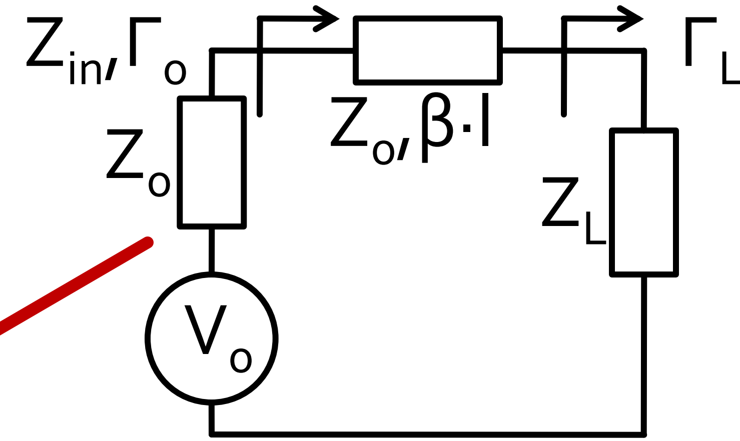
Caz 1, Shunt Stub

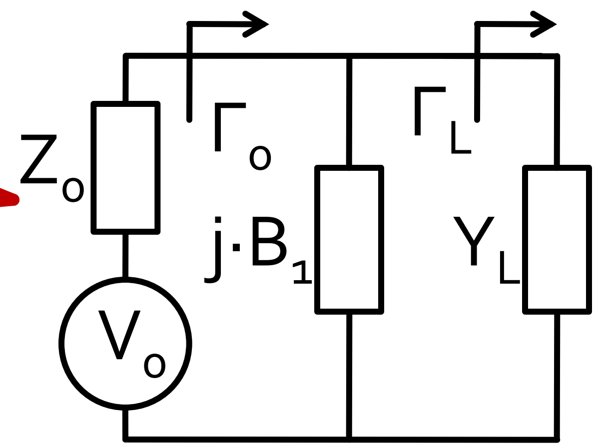
- Shunt Stub (sectiune de linie in paralel)



Adaptare, linie serie + susceptanta in paralel







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

$$g_{in} = 1$$

Calcul analitic (calcul efectiv)

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

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

$$\Gamma_S = 0.593 \angle 46.85°$$

$$|\Gamma_S| = 0.593; \quad \varphi = 46.85° \qquad \cos(\varphi + 2\theta) = -0.593 \Rightarrow (\varphi + 2\theta) = \pm 126.35°$$

- **Semnul** (+/-) solutiei alese la ecuatia **liniei serie** impune **semnul** solutiei utilizate la ecuatia **stub-ului paralel**
  - **solutia "cu +"**

$$(46.85° + 2\theta) = +126.35° \qquad \theta = +39.7° \qquad \operatorname{Im} y_S = \frac{-2 \cdot |\Gamma_S|}{\sqrt{1 - |\Gamma_S|^2}} = -1.472$$

$$\theta_{sp} = \tan^{-1}(\operatorname{Im} y_S) = -55.8° \underline{(+180°)} \rightarrow \theta_{sp} = 124.2°$$

  - **solutia "cu -"**

$$(46.85° + 2\theta) = -126.35° \qquad \theta = -86.6° \underline{(+180°)} \rightarrow \theta = 93.4°$$

$$\operatorname{Im} y_S = \frac{+2 \cdot |\Gamma_S|}{\sqrt{1 - |\Gamma_S|^2}} = +1.472 \qquad \theta_{sp} = \tan^{-1}(\operatorname{Im} y_S) = 55.8°$$

Calcul analitic (calcul efectiv)

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

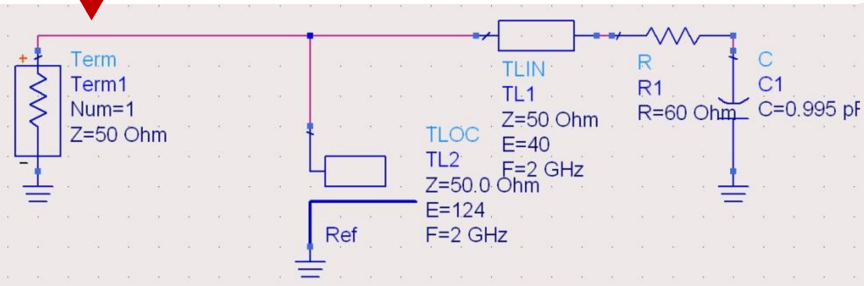
- Se alege **una** din cele doua solutii posibile
- **Semnul** (+/-) solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

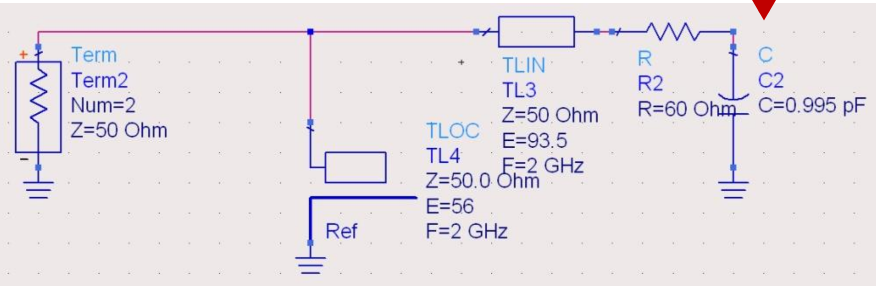
$$l_1=\frac{39.7^\circ}{360^\circ}\cdot\lambda=0.110\cdot\lambda$$

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

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

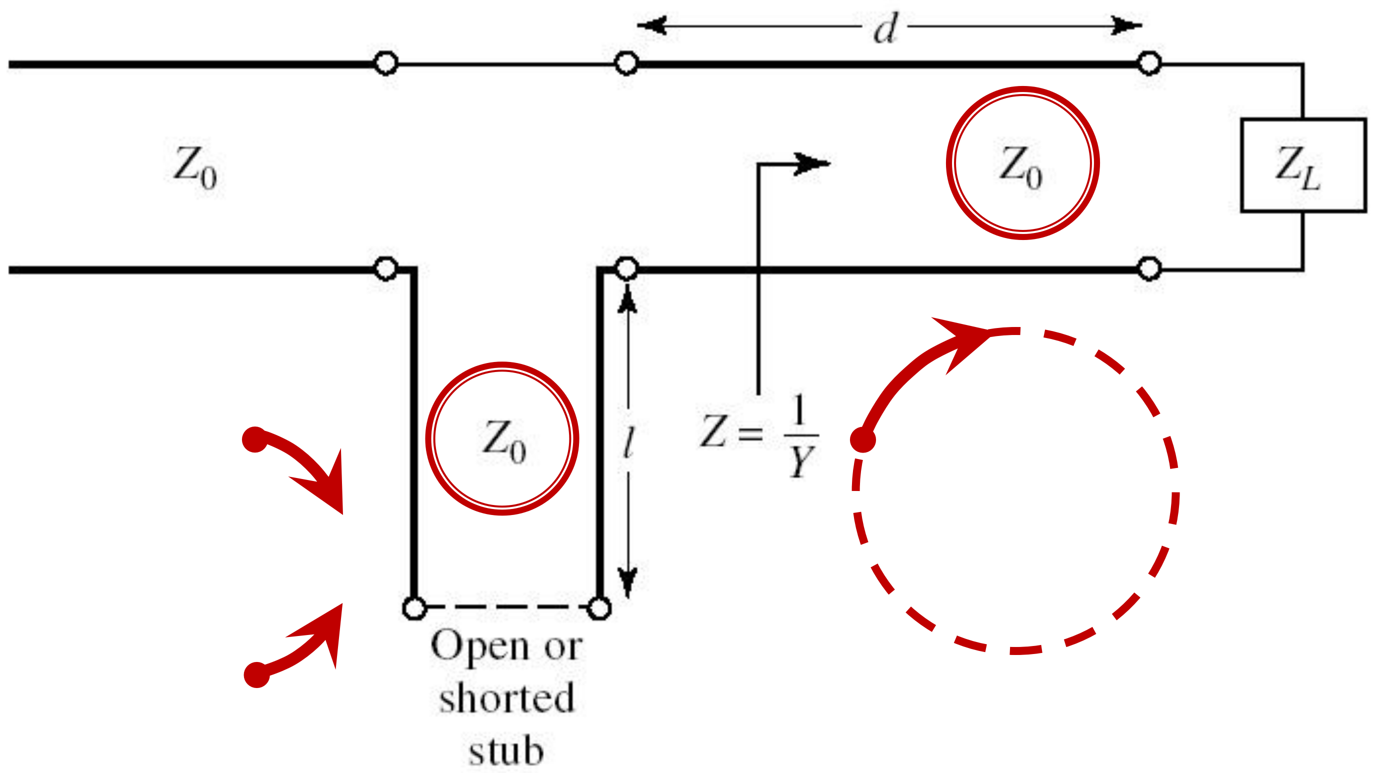
$$l_2=\frac{55.8^\circ}{360^\circ}\cdot\lambda=0.155\cdot\lambda$$



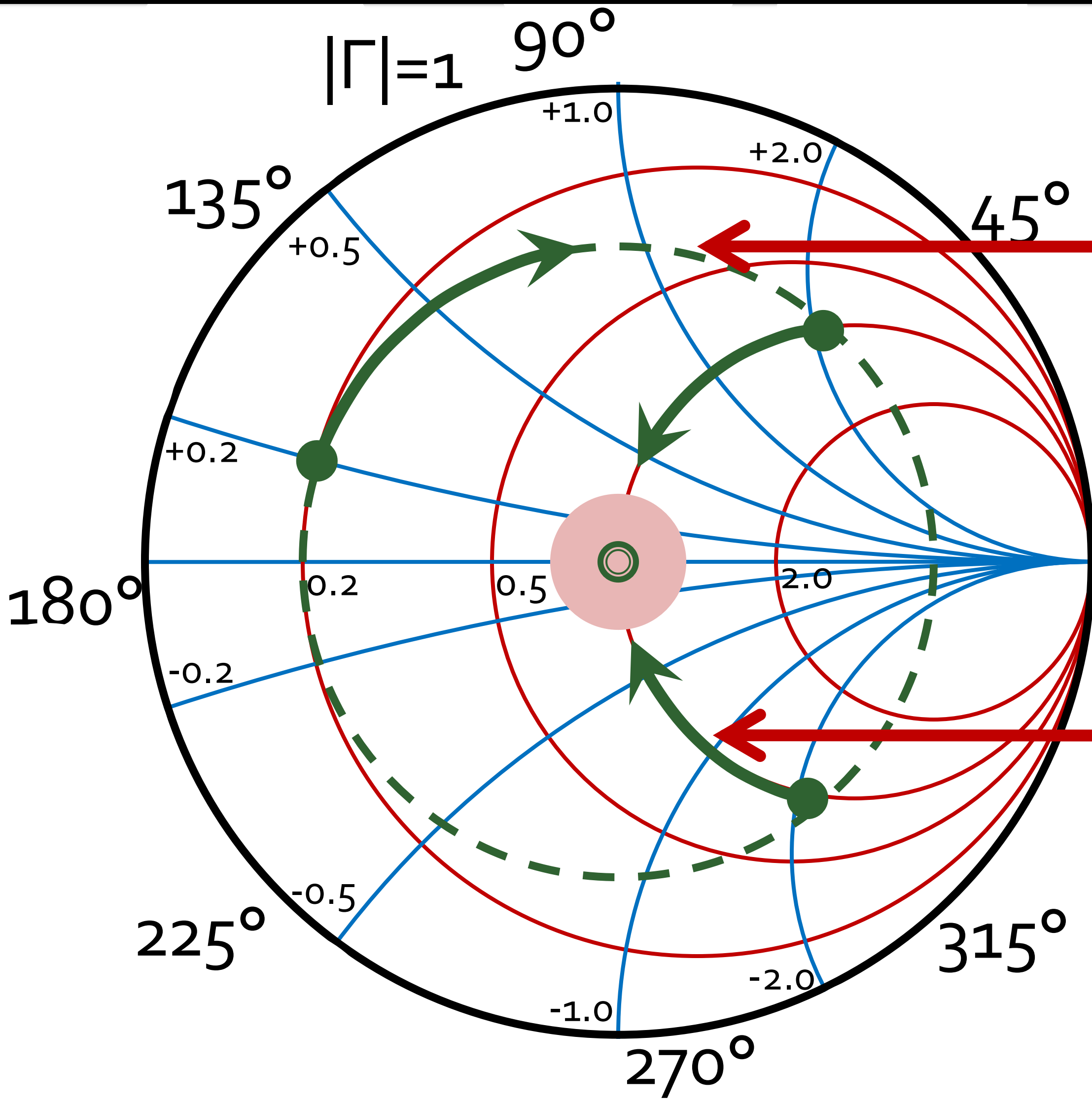


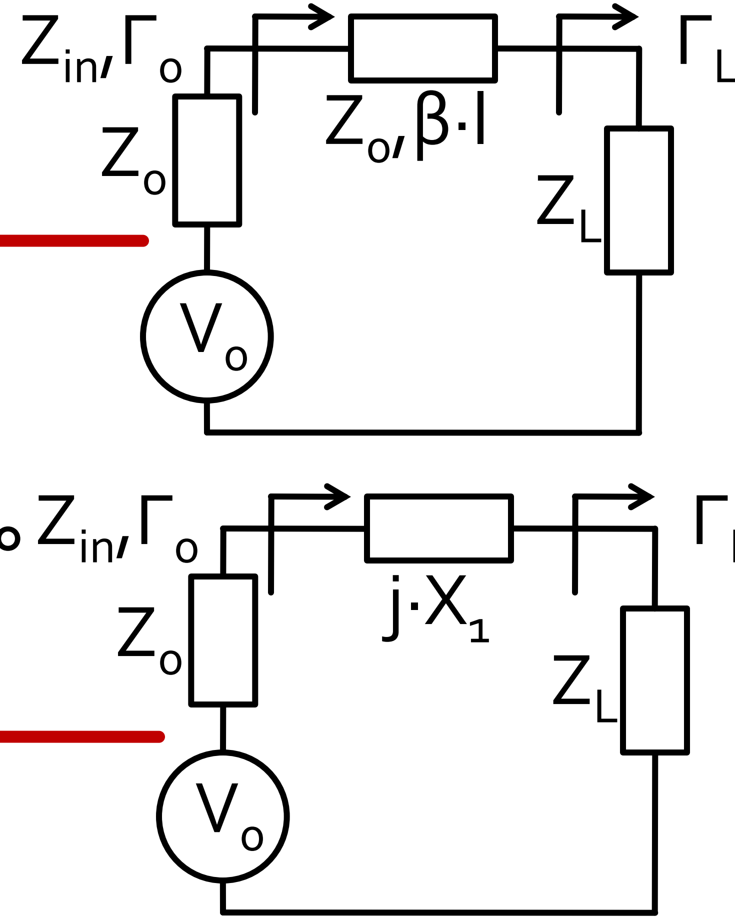
Caz 2, Series Stub

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



Adaptare, linie serie + reactanta in serie





$$\boxed{\left|\Gamma_{in}\right| = \left|\Gamma_L\right|}$$

$$\boxed{r_{in} = 1}$$

Calcul analitic (calcul efectiv)

$$\boxed{\cos(\varphi + 2\theta) = |\Gamma_S|}$$

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

$$\Gamma_S = 0.555\angle -29.92°$$

$$|\Gamma_S| = 0.555; \quad \varphi = -29.92°$$

$$\cos(\varphi + 2\theta) = 0.555 \Rightarrow (\varphi + 2\theta) = \pm 56.28°$$

- **Semnul** (+/-) solutiei alese la ecuatia **liniei serie** impune **semnul** solutiei utilizate la ecuatia **stub-ului serie**
  - **solutia "cu +"**

$$(-29.92° + 2\theta) = +56.28° \qquad \theta = 43.1° \qquad \mathrm{Im}\, z_S = \frac{+2 \cdot |\Gamma_S|}{\sqrt{1 - |\Gamma_S|^2}} = +1.335$$

$$\theta_{ss} = -\cot^{-1}(\mathrm{Im}\, z_S) = -36.8°\underline{(+180°)} \rightarrow \theta_{ss} = 143.2°$$

  - **solutia "cu -"**

$$(-29.92° + 2\theta) = -56.28° \qquad \theta = -13.2°\underline{(+180°)} \rightarrow \theta = 166.8°$$

$$\mathrm{Im}\, z_S = \frac{-2 \cdot |\Gamma_S|}{\sqrt{1 - |\Gamma_S|^2}} = -1.335 \qquad \theta_{ss} = -\cot^{-1}(\mathrm{Im}\, z_S) = 36.8°$$

Calcul analitic (calcul efectiv)

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

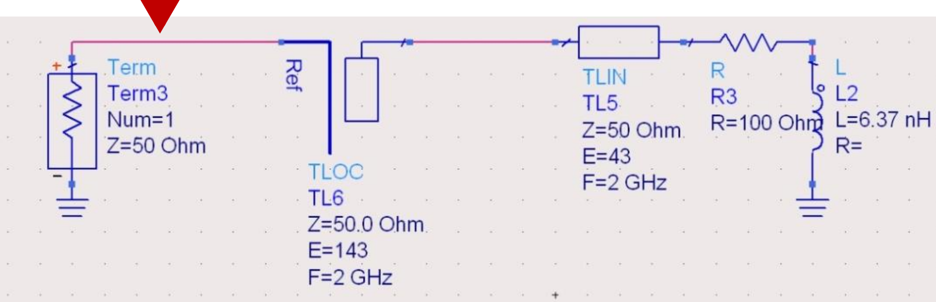
- Se alege **una** din cele doua solutii posibile
- **Semnul** (+/-) solutiei alese la **prima** ecuatie impune **semnul** solutiei utilizate la a **doua** ecuatie

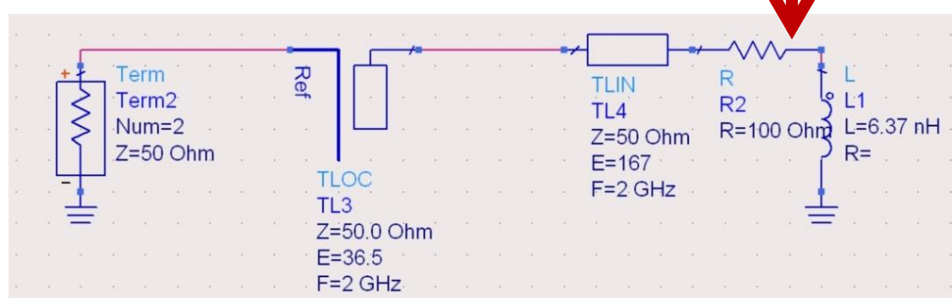
$$l_1=\frac{43.1^\circ}{360^\circ}\cdot\lambda=0.120\cdot\lambda$$

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

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

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





Stub, observatii

- adunarea si scadere de **180°** (λ/2) nu schimba rezultatul (rotatie completa in jurul diagramei

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

  - pentru linii de "lungime" / "lungime electrica" **negative** se adauga λ/2 / 180° pentru a avea valoare pozitiva (realizabila fizic)
- o adaugare sau scadere de **90°** (λ/4) transforma impedanta stub-ului:

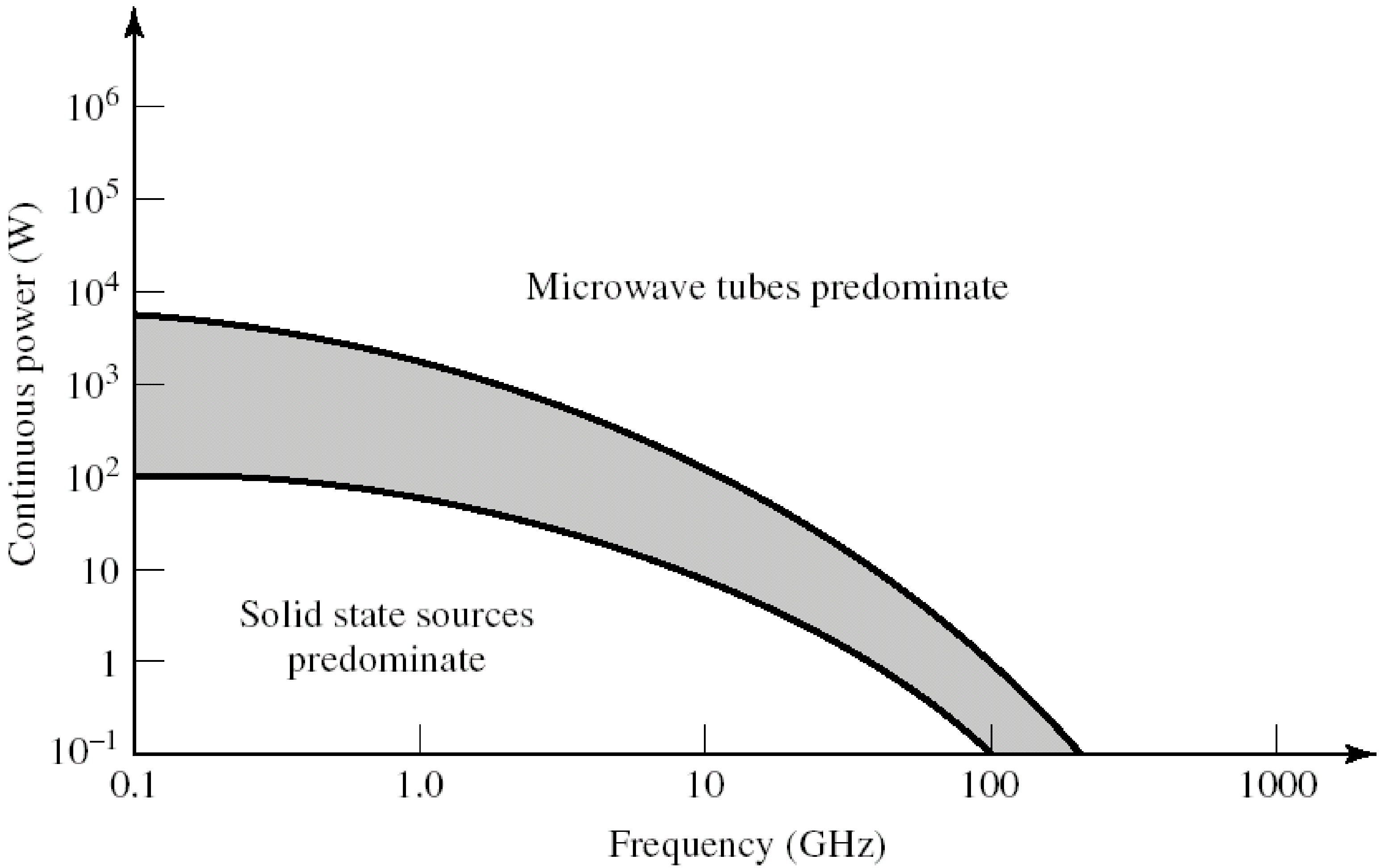
$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l \quad \Leftrightarrow \quad Z_{in,g} = -j \cdot Z_0 \cdot \cot \beta \cdot l$$

  - pentru stub se poate adauga/scadea 90° (λ/4) simultan cu schimbare **gol** ⇔ **scurtcircuit**

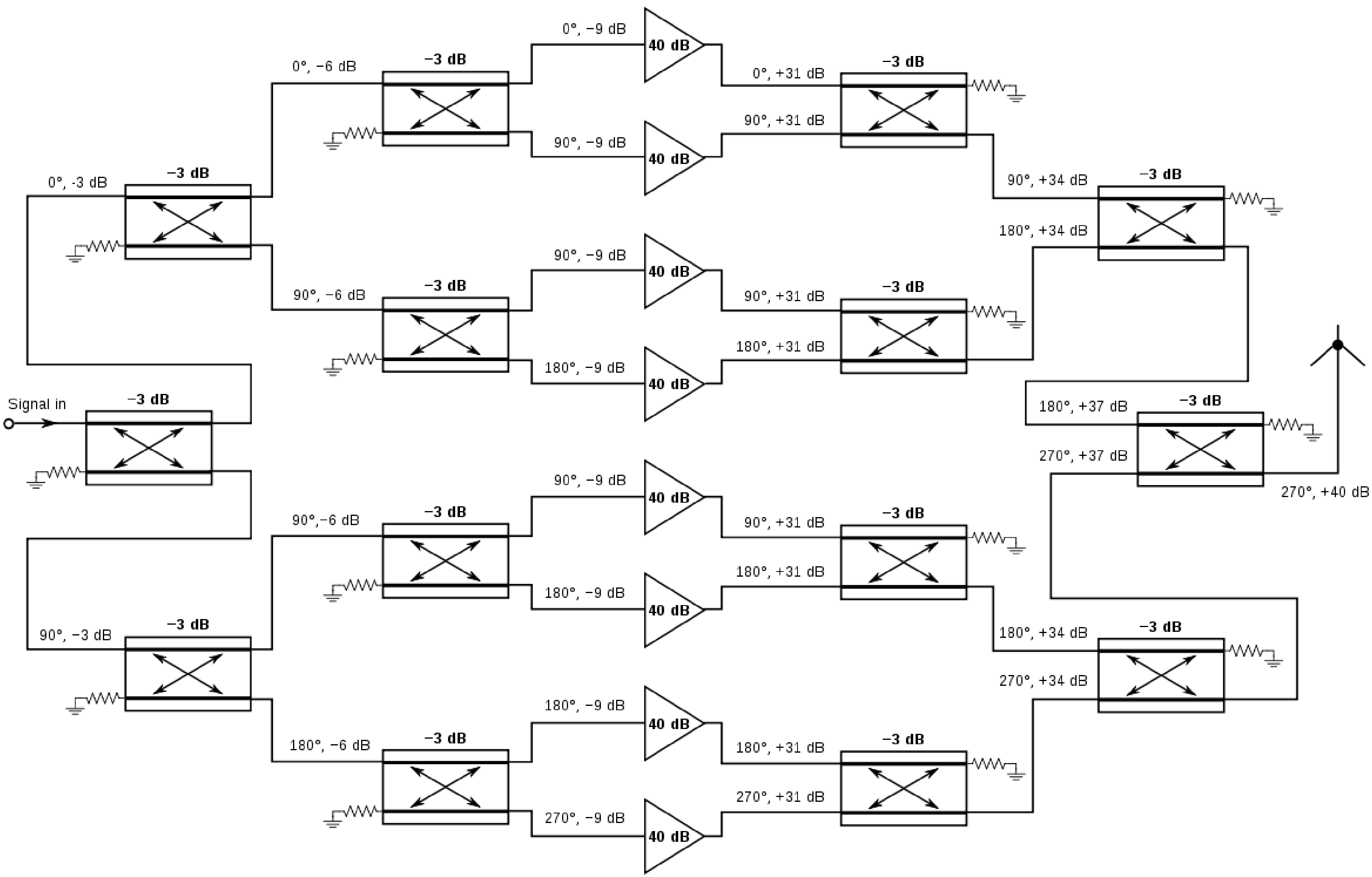
Continuare

Amplificatoare de microunde

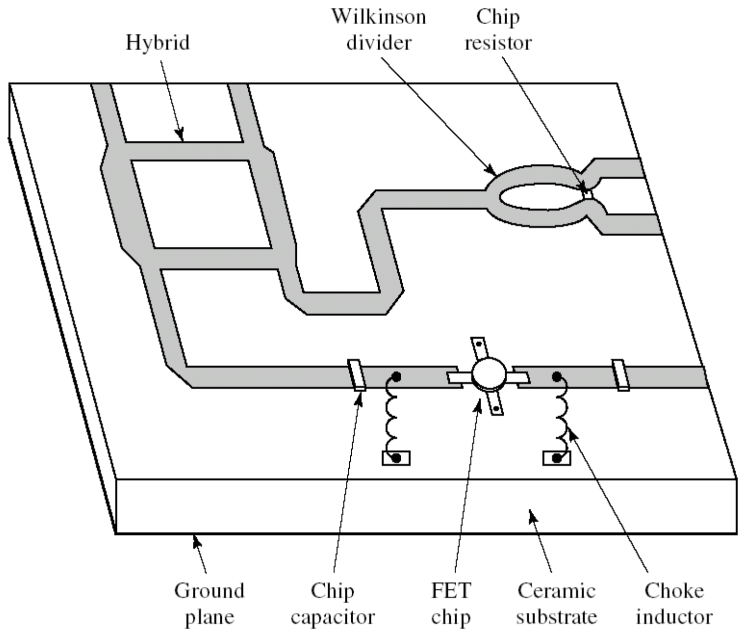
Amplificatoare pentru microunde

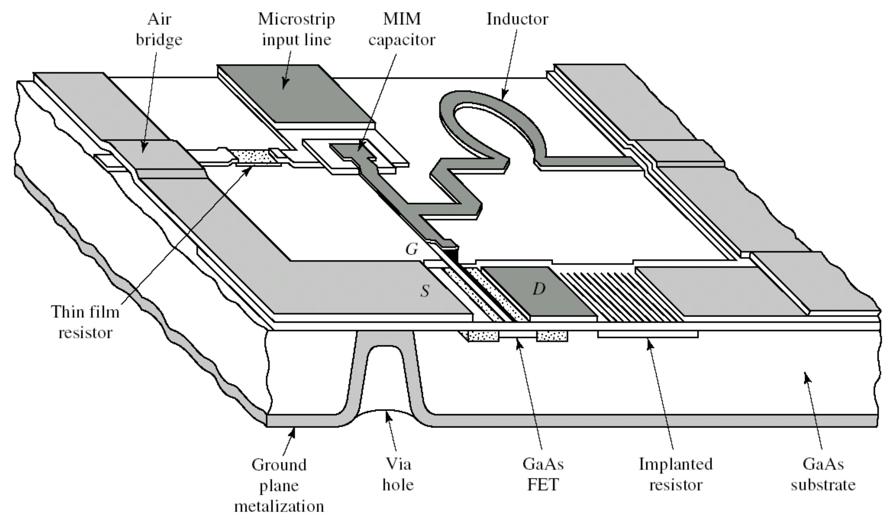


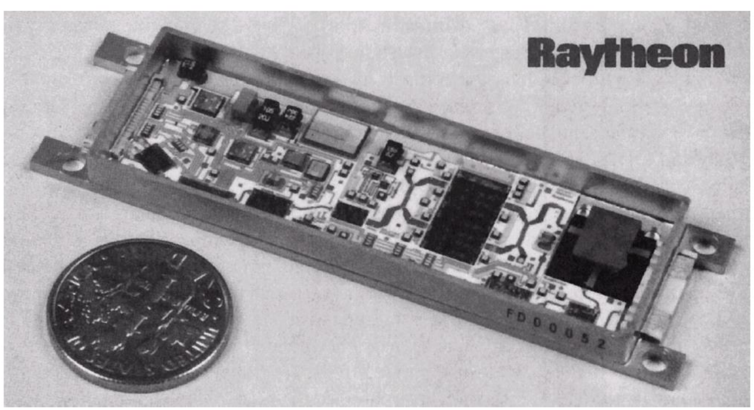
Amplificatoare echilibrate

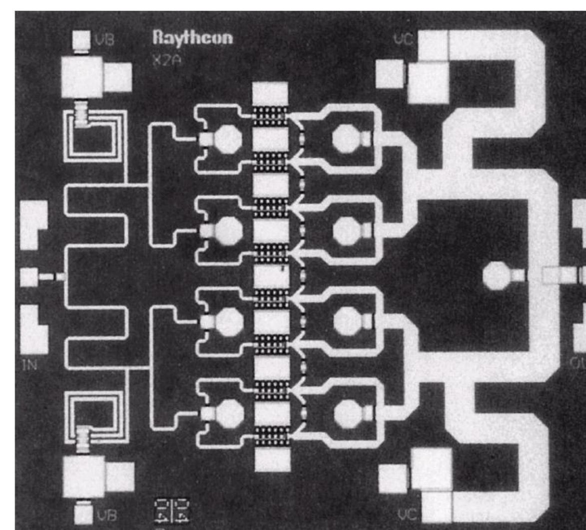


Circuite integrate pentru microunde

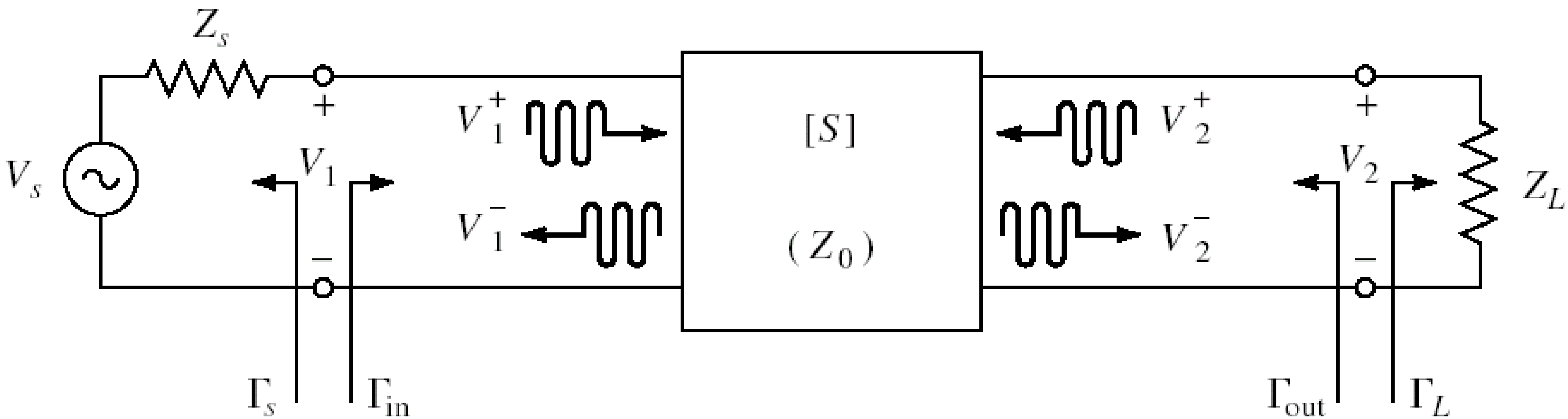






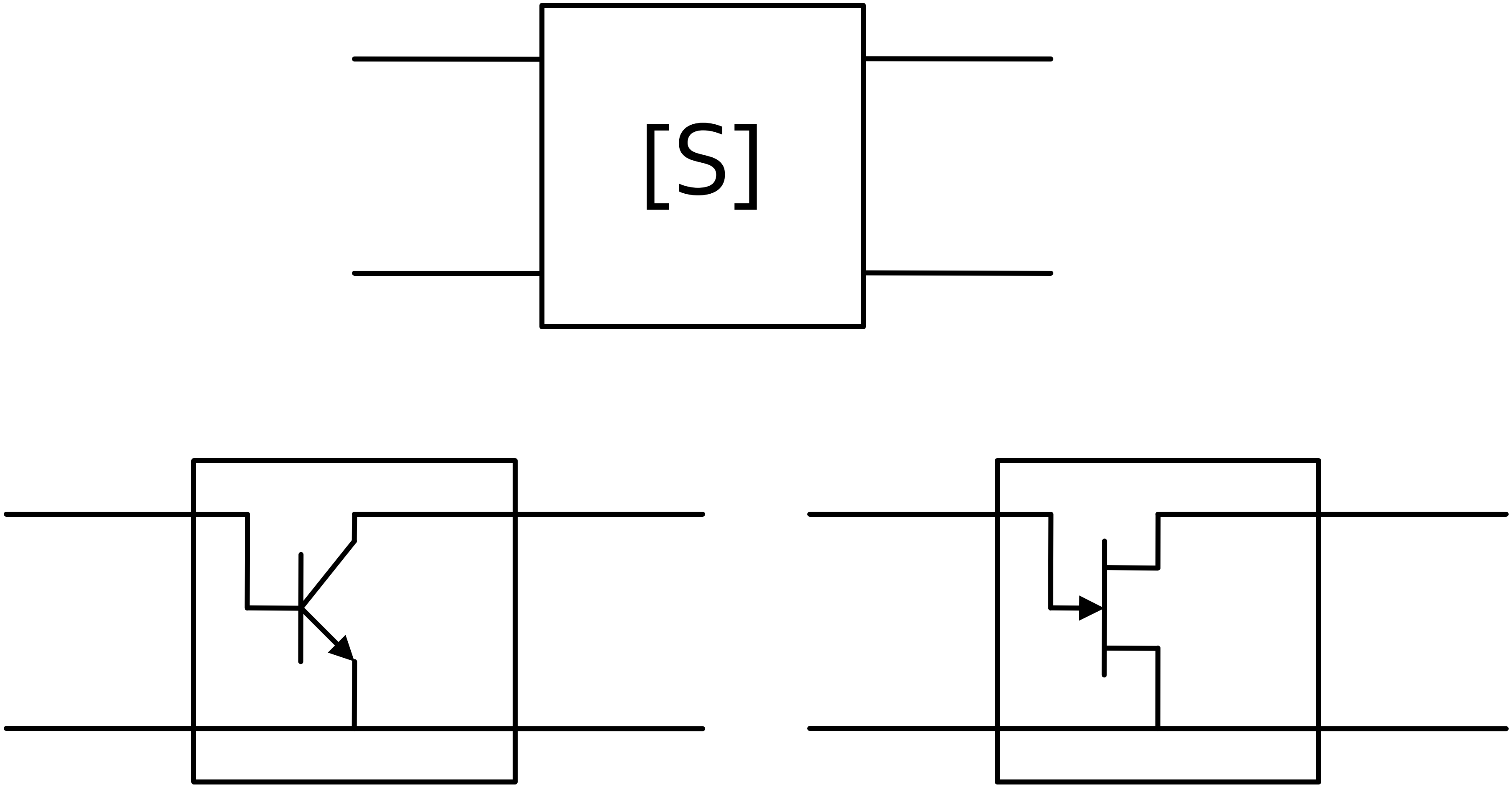


Cuadripol Amplificator (diport)



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

Parametri S



Cataloage

CEL

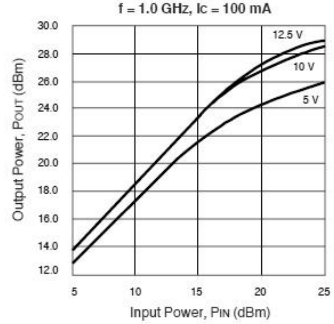
NE46100 / NE46134

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**

NE46134
TYPICAL OUTPUT POWER
vs. INPUT POWER
f = 1.0 GHz, Ic = 100 mA



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°C)

PART NUMBER EIAJ[1] REGISTERED NUMBER PACKAGE OUTLINE			NE46100 00 (CHIP)			NE46134 2SC4536 34		
SYMBOLS	PARAMETERS AND CONDITIONS	UNITS	MIN	TYP	MAX	MIN	TYP	MAX
f_T	Gain Bandwidth Product at V_{CE} = 10 V, I_C = 100 mA	GHz		5.5			5.5	
NF_{MIN}	Minimum Noise Figure[3] at V_{CE} = 10 V, I_C = 50 mA, 500 MHz V_{CE} = 10 V, I_C = 50 mA, 1 GHz	dB dB		1.5 2.0			1.5 2.0	
G_L	Linear Gain, V_{CE} = 12.5 V, I_C = 100 mA, 2.0 GHz V_{CE} = 12.5 V, I_C = 100 mA, 1.0 GHz	dB dB		9.0			 8.0	
$\lvert S_{21E}\rvert^2$	Insertion Power Gain at 10 V, 50 mA, f = 1.0 GHz	dB		10.0		5.5	7.0	
h_{FE}	DC Current Gain[2] at V_{CE} = 10 V, I_C = 50 mA		40		200	40		200
I_{CBO}	Collector Cutoff Current at V_{CB} = 20 V, I_E = 0 mA .	µA			5.0			5.0
I_{EBO}	Emitter Cutoff Current at V_{EB} = 2 V, I_C = 0 mA	µA			5.0			5.0
P_{1dB}	Output Power at 1 dB Compression, V_{CE} = 12.5 V, I_C = 100 mA, 2.0 GHz V_{CE} = 12.5 V, I_C = 100 mA, 1.0 GHz	dBm dBm	27.0				 27.5	
IM_3	Intermodulation Distortion, 10 V, 100 mA, F1 = 1.0 GHz, F2 = 0.99 GHz,							

Cataloage

NE46100

V_{CE} = 5 V, I_C = 50 mA

FREQUENCY (MHz)	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG	K	MAG[2] (dB)
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

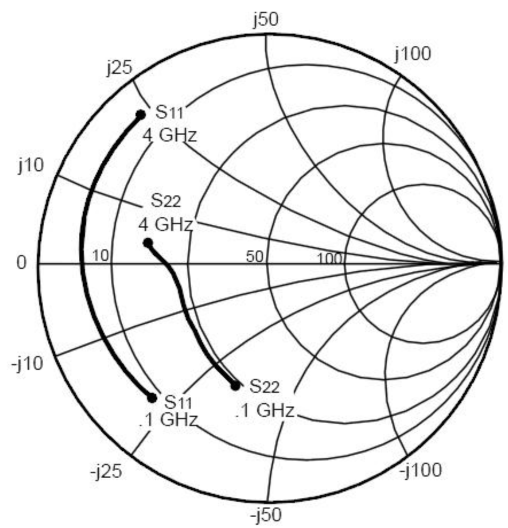
V_{CE} = 5 V, I_C = 100 mA

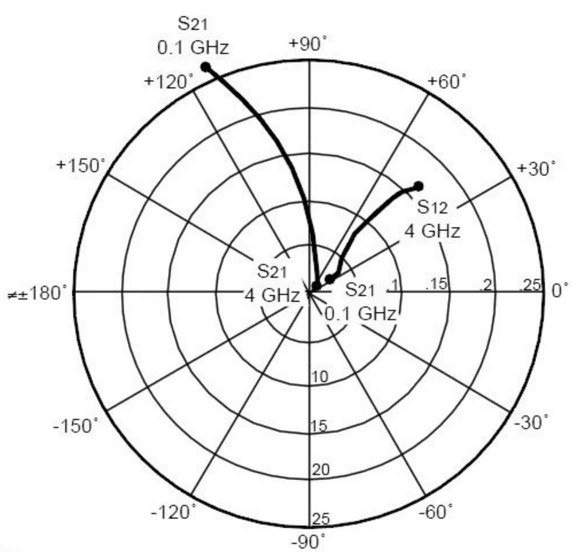
FREQUENCY (MHz)	S11 MAG	S11 ANG	S21 MAG	S21 ANG	S12 MAG	S12 ANG	S22 MAG	S22 ANG	K	MAG[2] (dB)
100	0.778	-144	27.669	111	0.027	35	0.523	-114	0.27	30.2
200	0.820	-164	14.559	97	0.029	29	0.445	-144	0.42	27.0
500	0.832	-179	5.885	84	0.035	38	0.435	-166	0.81	22.2
800	0.833	175	3.691	76	0.048	45	0.435	-173	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

Cataloage

NE46100, NE46134

TYPICAL COMMON EMITTER SCATTERING PARAMETERS[1] (T_A = 25°C)





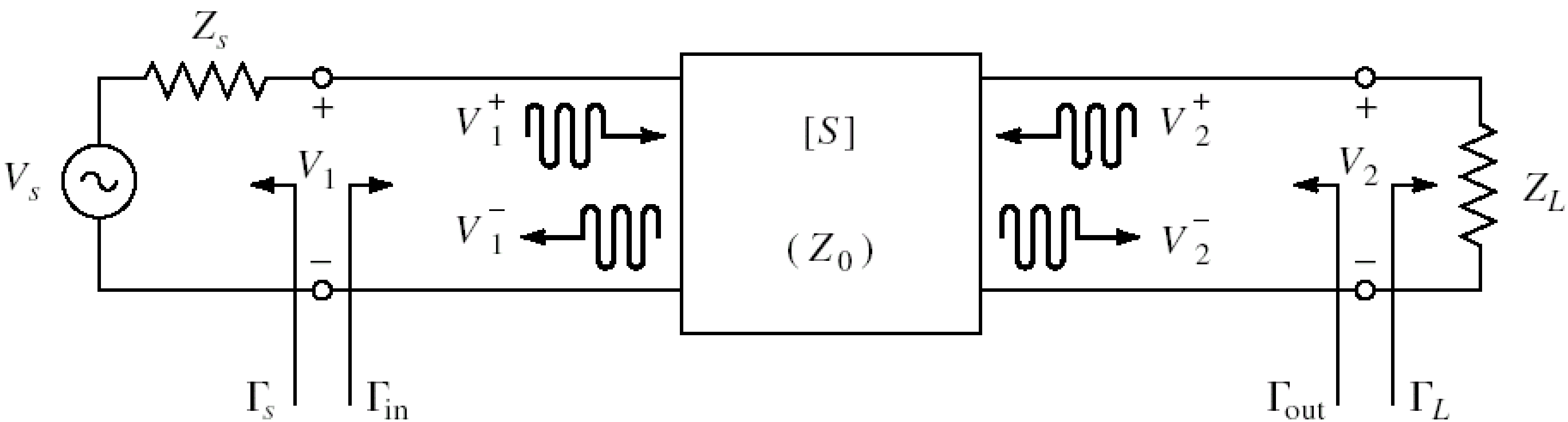
Coordinates in Ohms
Frequency in GHz
V_{CE} = 5 V, I_C = 50 mA

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
```

Diport amplificator



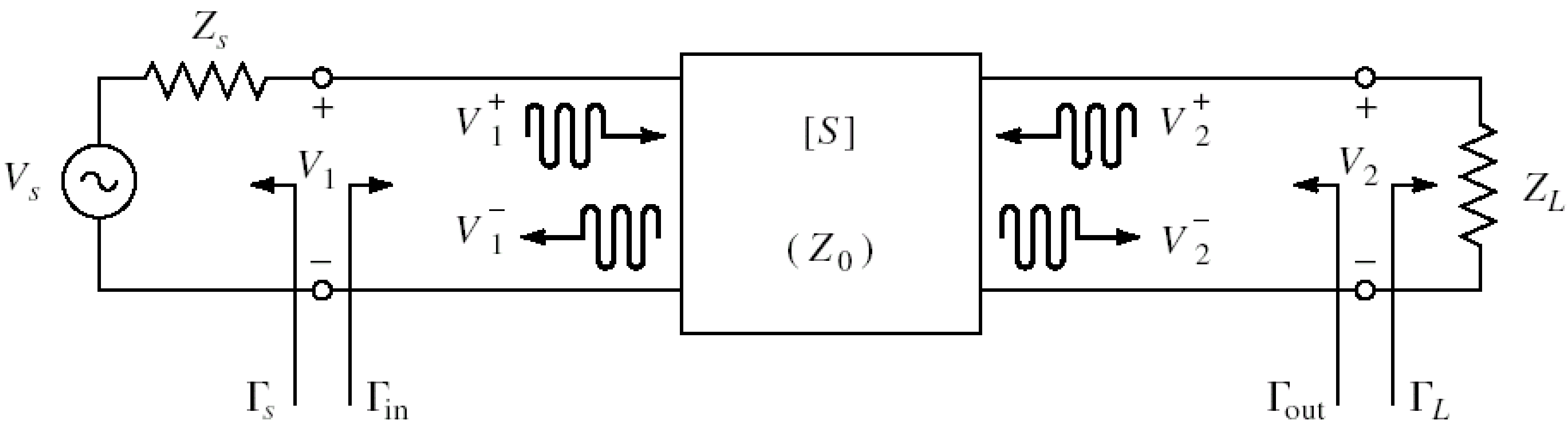
$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} \qquad \Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0} \qquad \begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

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

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

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

Diport amplificator



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

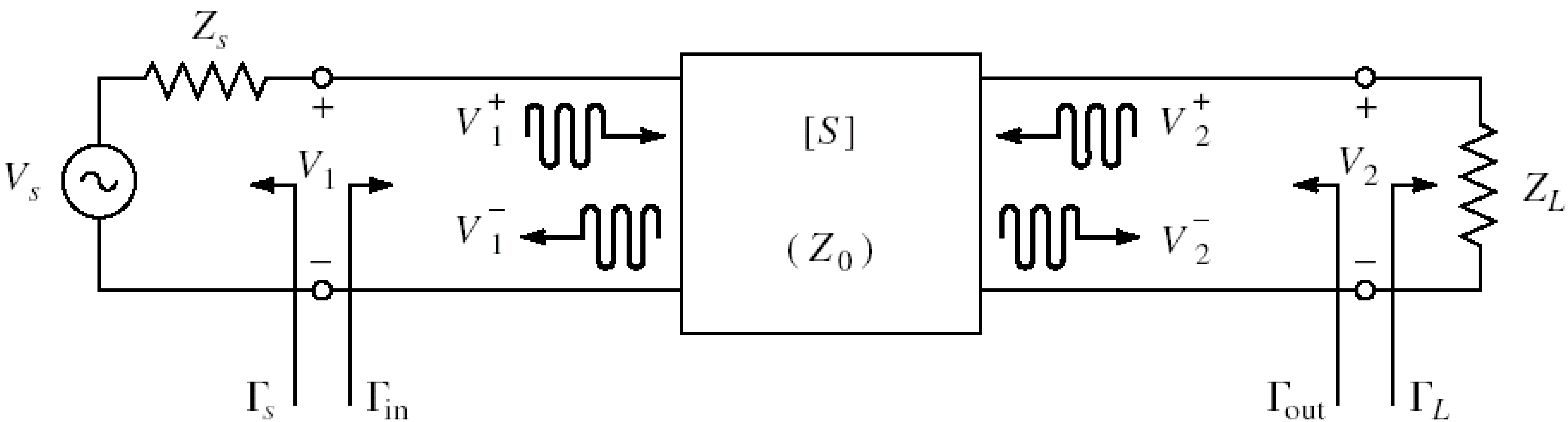
$$V_2^- = S_{21} \cdot V_1^+ + S_{22} \cdot V_2^+ = S_{21} \cdot V_1^+ + S_{22} \cdot \Gamma_L \cdot V_2^-$$

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

- similar

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

Diport amplificator

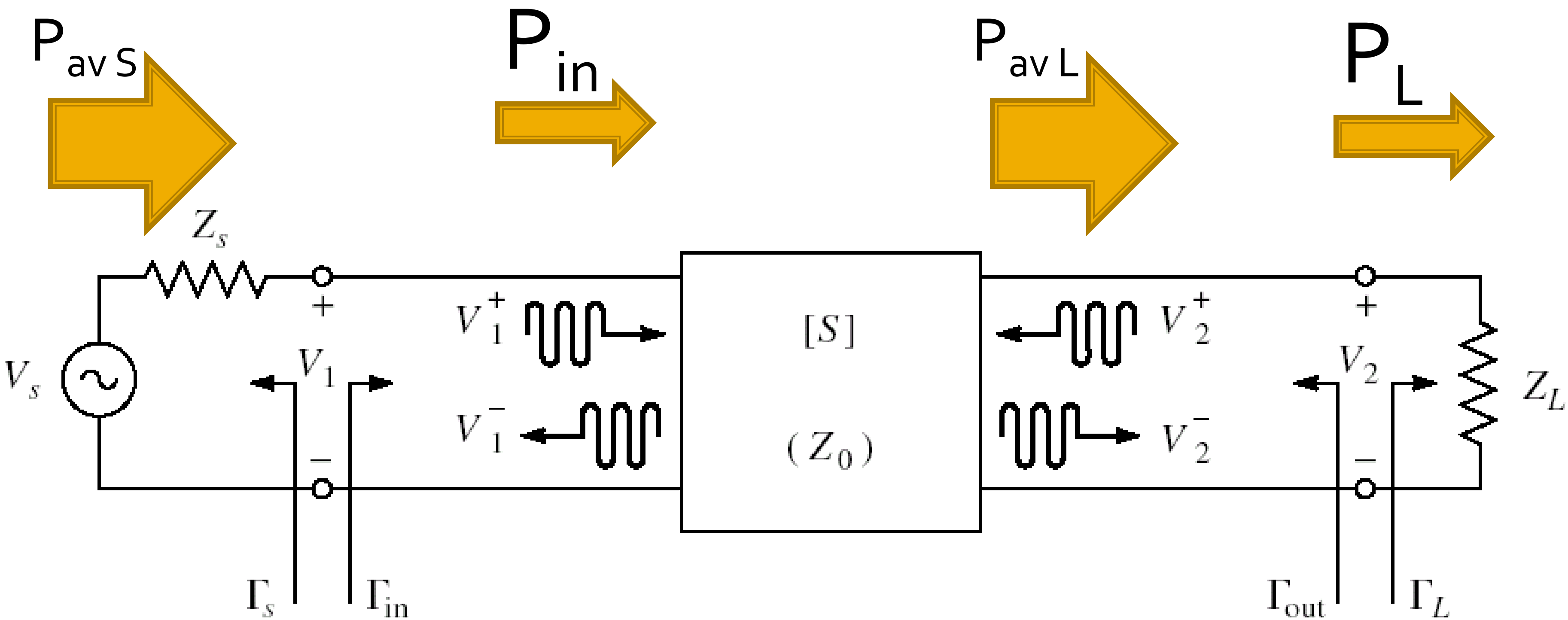


$$\Gamma_{in} = \frac{V_1^-}{V_1^+} = S_{11} + \frac{S_{12} \cdot S_{21} \cdot \Gamma_L}{1 - S_{22} \cdot \Gamma_L}$$

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

Puteri / Adaptare

- Doua porturi in care adaptarea influențează transferul de putere



Puteri

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

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

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

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

- C3 $P_{in} = \frac{1}{2 \cdot Z_0} \cdot \left|V_1^+\right|^2 \cdot \left(1 - \left|\Gamma_{in}\right|^2\right)$ $P_L = \frac{1}{2 \cdot Z_0} \cdot \left|V_2^-\right|^2 \cdot \left(1 - \left|\Gamma_L\right|^2\right)$

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

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

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

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

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

Puteri

- Puteri

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

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

- Puterea disponibila de la sursa

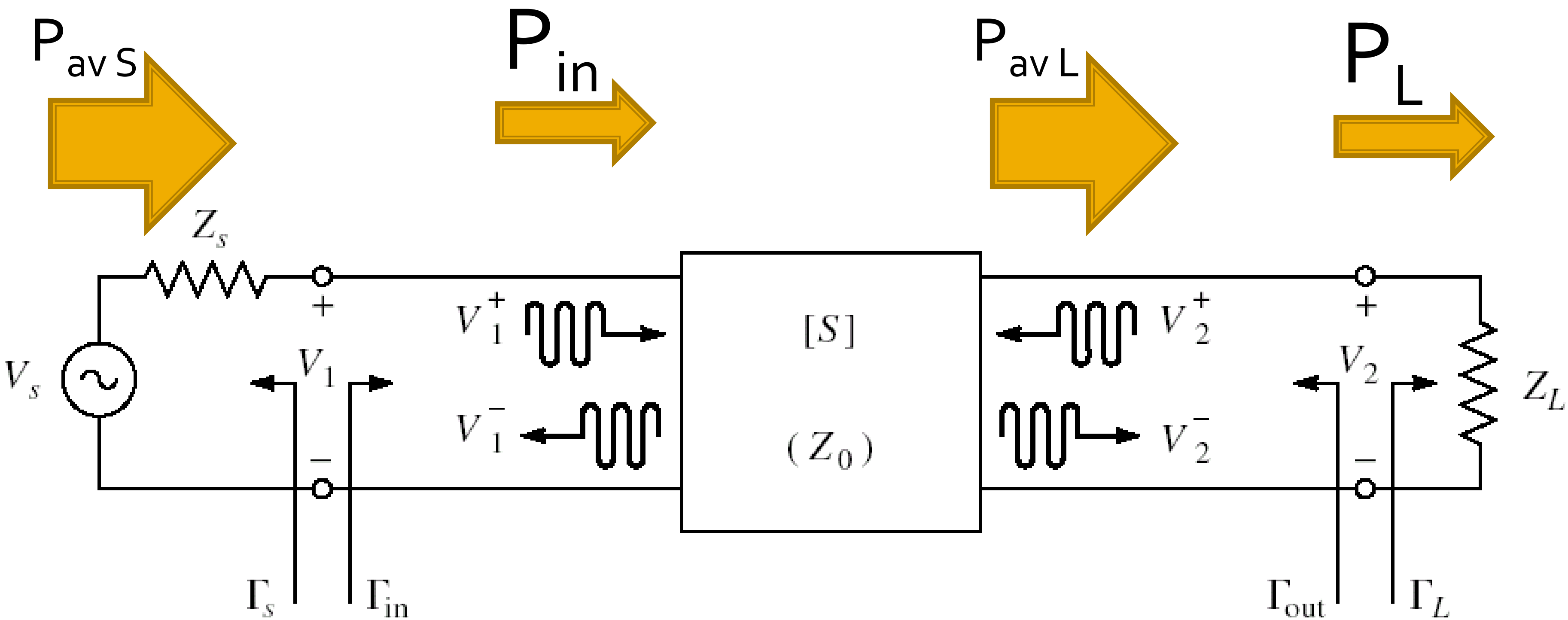
$$P_{av\,S} = P_{in}\Big|_{\Gamma_{in}=\Gamma_S^*} = \frac{|V_S|^2}{8 \cdot Z_0} \cdot \frac{|1-\Gamma_S|^2}{\left(1-|\Gamma_S|^2\right)}$$

- Puterea disponibila la sarcina

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

Puteri / Adaptare

- Doua porturi in care adaptarea influențează transferul de putere



Castig de putere

- Castigul de putere

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

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

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

- 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**

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

- Castigul de putere de **transfer** (transducer power gain)

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

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

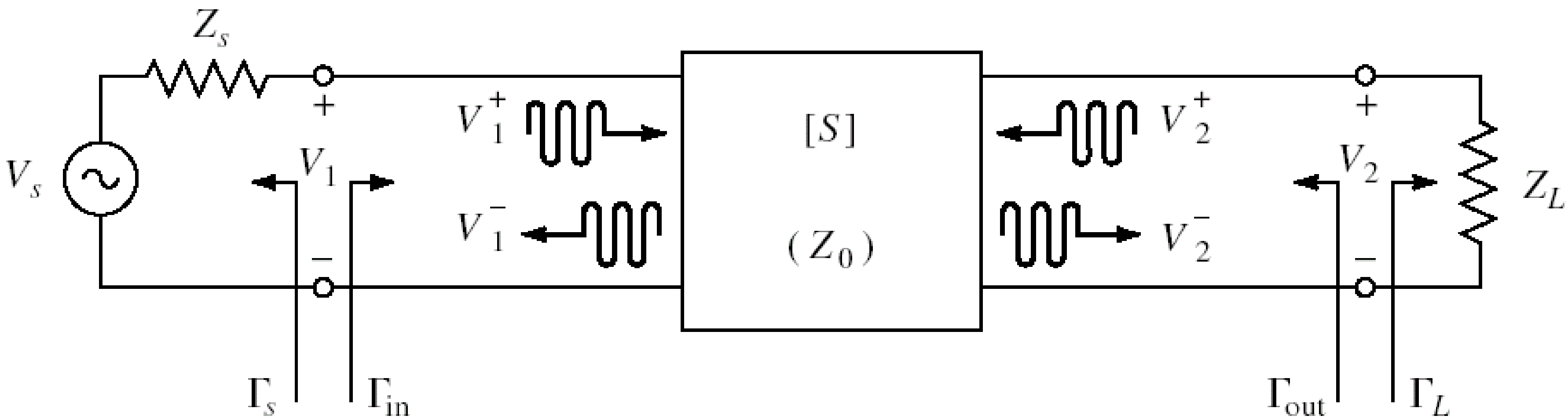
- Castigul de putere de **transfer unilateral**

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

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

Permite tratarea separata a intrarii si iesirii

Cuadripol Amplificator

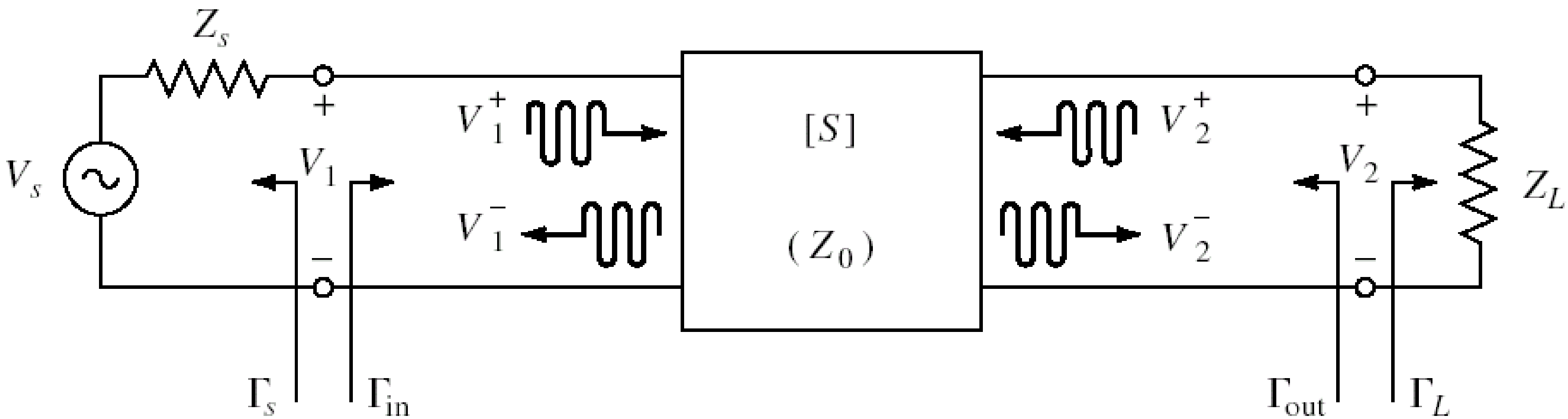


- marimi care intereseaza:
  - stabilitate
  - castig de putere
  - zgomot (uneori – semnal mic)
  - liniaritate (uneori – semnal mare)

Amplificatoare de microunde

Stabilitate

Cuadripol Amplificator



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

Stabilitate

- C7 $\Gamma = \Gamma_r + j \cdot \Gamma_i$ $r_L = \dfrac{1-\Gamma_r^2-\Gamma_i^2}{(1-\Gamma_r)^2+\Gamma_i^2}$

  Z_{in} $\Gamma_{in} = \Gamma_r + j \cdot \Gamma_i$

- instabilitate

  $\mathrm{Re}\{Z_{in}\} < 0 \quad \Leftrightarrow \quad 1-\Gamma_r^2-\Gamma_i^2 < 0$ $|\Gamma_{in}| > 1$

- stabilitate, Z_{in}
  - conditii ce trebuie indeplinite de Γ_L pentru a obtine stabilitatea (la intrare)

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

- similar Z_{out}
  - conditii ce trebuie indeplinite de Γ_S pentru a obtine stabilitatea (la iesire)

Stabilitate

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

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

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

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

Stabilitate

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

- Limita de stabilitate/instabilitate

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

$$\left|S_{11} \cdot (1 - S_{22} \cdot \Gamma_L) + S_{12} \cdot S_{21} \cdot \Gamma_L\right| = \left|1 - S_{22} \cdot \Gamma_L\right|$$

- Determinantul matricii S $\quad \Delta = S_{11} \cdot S_{22} - S_{12} \cdot S_{21}$

$$\left|S_{11} - \Delta \cdot \Gamma_L\right| = \left|1 - S_{22} \cdot \Gamma_L\right|$$

$$\left|S_{11} - \Delta \cdot \Gamma_L\right|^2 = \left|1 - S_{22} \cdot \Gamma_L\right|^2$$

Stabilitate

$$\left|S_{11}-\Delta\cdot\Gamma_L\right|^2=\left|1-S_{22}\cdot\Gamma_L\right|^2$$

$$a\cdot a^*=|a|\cdot e^{j\theta}\cdot|a|\cdot e^{-j\theta}=|a|^2$$

$$|a+b|^2=(a+b)\cdot(a+b)^*=(a+b)\cdot\left(a^*+b^*\right)=\underline{|a|^2}+|b|^2+\underline{a^*\cdot b}+\underline{a\cdot b^*}$$

$$|S_{11}|^2+|\Delta|^2\cdot|\Gamma_L|^2-\left(\Delta\cdot\Gamma_L\cdot S_{11}^*+\Delta^*\cdot\Gamma_L^*\cdot S_{11}\right)=1+|S_{22}|^2\cdot|\Gamma_L|^2-\left(S_{22}^*\cdot\Gamma_L^*+S_{22}\cdot\Gamma_L\right)$$

$$\left(|S_{22}|^2-|\Delta|^2\right)\cdot\Gamma_L\cdot\Gamma_L^*-\left(S_{22}-\Delta\cdot S_{11}^*\right)\cdot\Gamma_L-\left(S_{22}^*-\Delta^*\cdot S_{11}\right)\cdot\Gamma_L^*=|S_{11}|^2-1$$

$$\Gamma_L\cdot\Gamma_L^*-\frac{\left(S_{22}-\Delta\cdot S_{11}^*\right)\cdot\Gamma_L+\left(S_{22}^*-\Delta^*\cdot S_{11}\right)\cdot\Gamma_L^*}{|S_{22}|^2-|\Delta|^2}=\frac{|S_{11}|^2-1}{|S_{22}|^2-|\Delta|^2}$$

$$+\frac{\left|S_{22}-\Delta\cdot S_{11}^*\right|^2}{\left(|S_{22}|^2-|\Delta|^2\right)^2}$$

$$\left|\Gamma_L-\frac{\left(S_{22}-\Delta\cdot S_{11}^*\right)^*}{|S_{22}|^2-|\Delta|^2}\right|^2=\frac{|S_{11}|^2-1}{|S_{22}|^2-|\Delta|^2}+\frac{\left|S_{22}-\Delta\cdot S_{11}^*\right|^2}{\left(|S_{22}|^2-|\Delta|^2\right)^2}$$

Plan complex – geometrie analitica

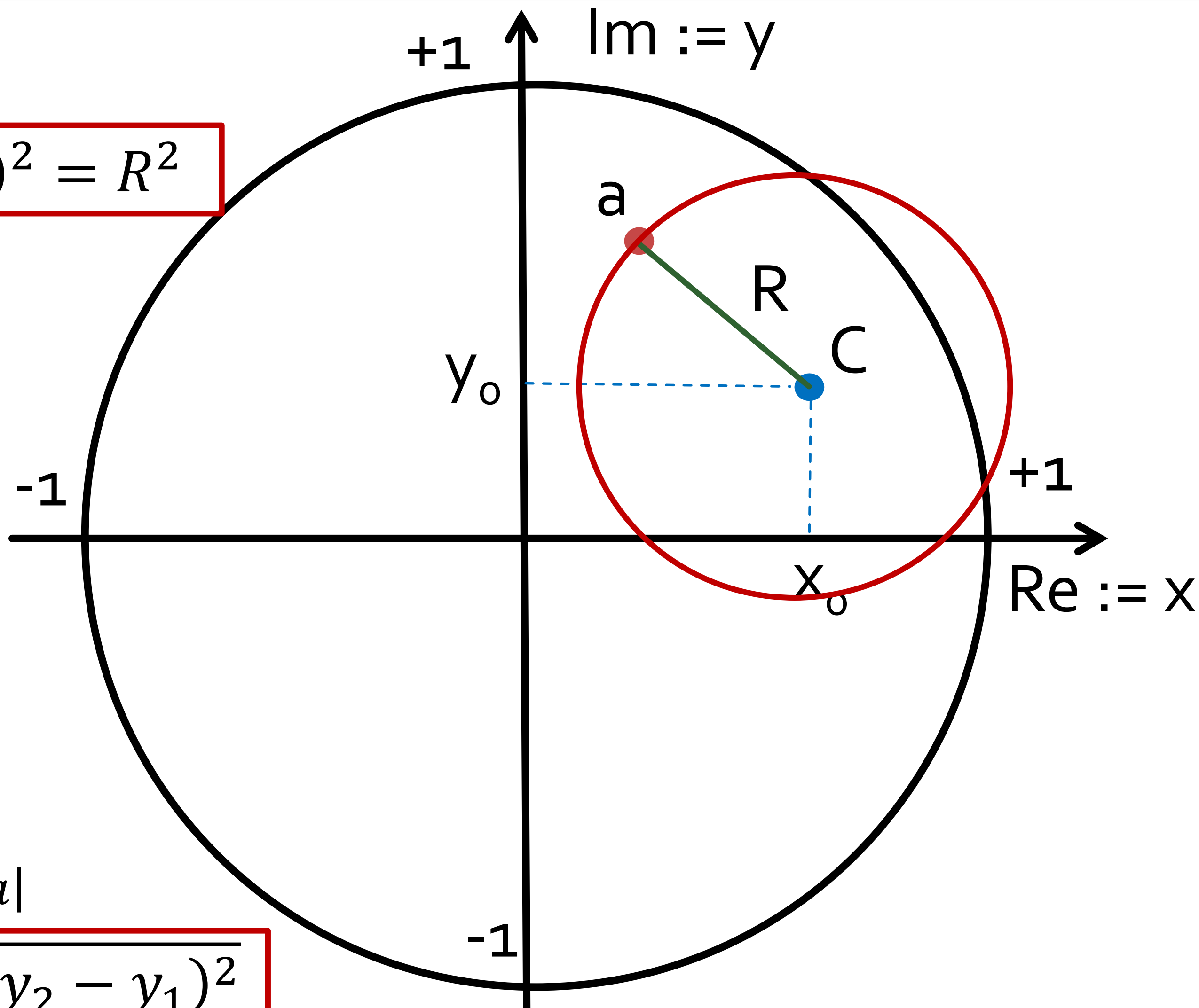
- solutii

$$\boxed{(x-x_0)^2+(y-y_0)^2=R^2}$$

$$a = x + j\cdot y$$

$$C = x_0 + j\cdot y_0$$

$$D(a,C) = |a-C| = R$$



$$a = x_1 + j\cdot y_1$$

$$b = x_2 + j\cdot y_2$$

$$D(a,b) = |a-b| = |b-a|$$

$$\boxed{D=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}}$$

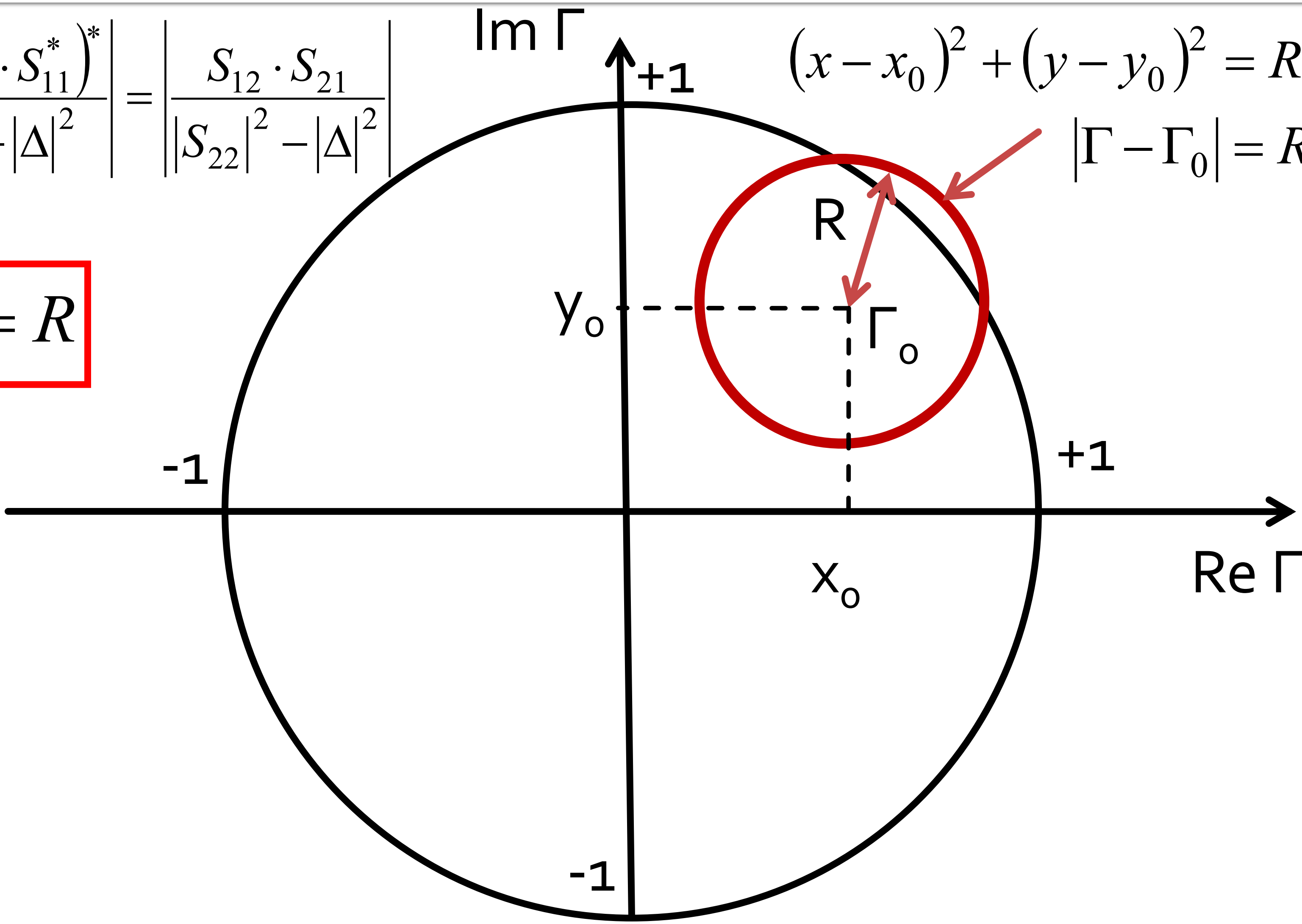
Stabilitate

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

$$\boxed{\left|\Gamma - \Gamma_0\right| = R}$$

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

$$\left|\Gamma - \Gamma_0\right| = R$$



Cerc de stabilitate la iesire (CSOUT)

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

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

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

Cerc de stabilitate la intrare (CSIN)

- Similar

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

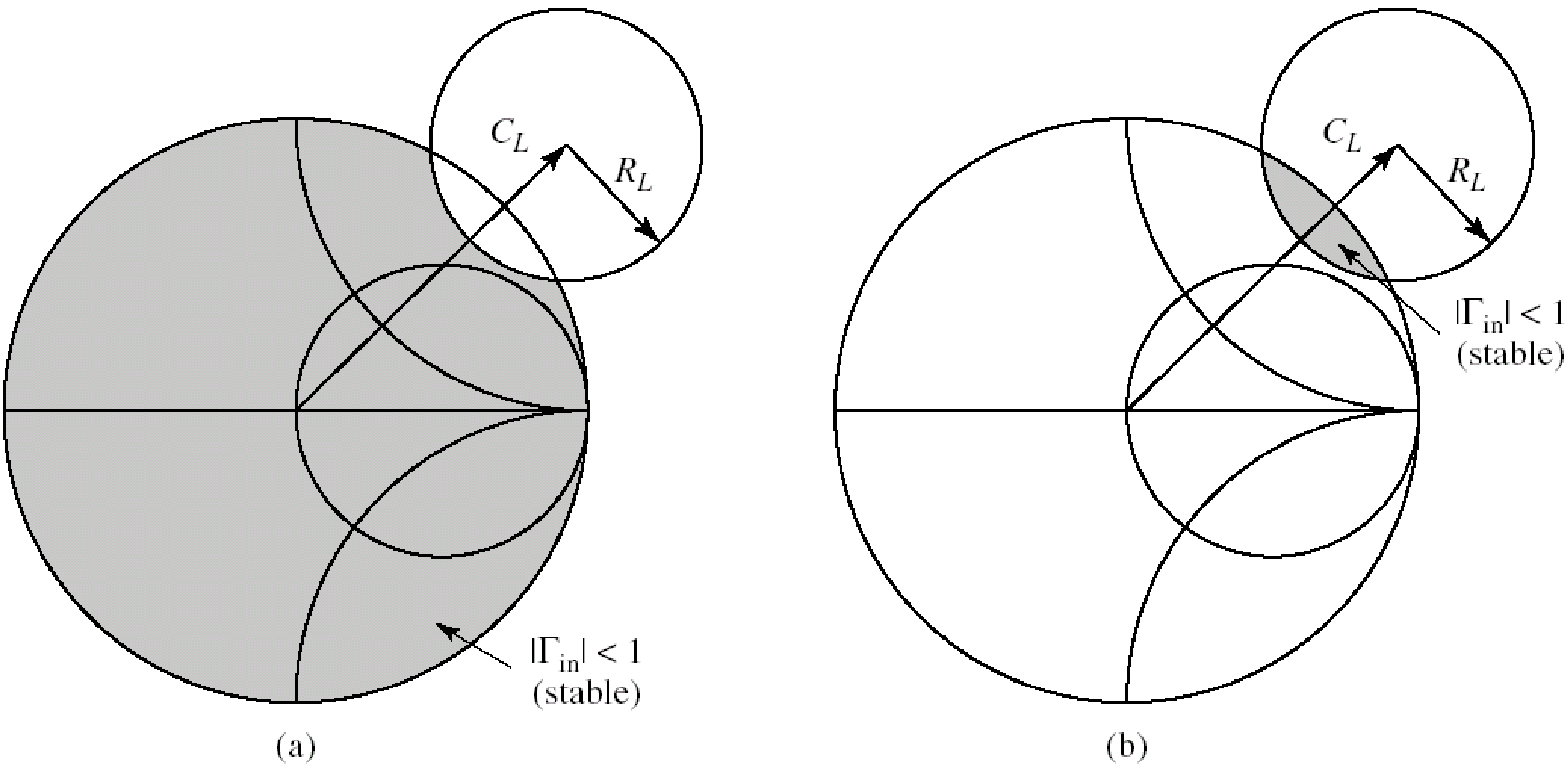
- Ecuatia unui cerc, care reprezinta locul geometric al punctelor Γ_S pentru **limita** de stabilitate
- Cercul se numeste **cerc de stabilitate la intrare** (Γ_S)

$$C_S = \frac{\left(S_{11} - \Delta \cdot S_{22}^{*}\right)^{*}}{\left|S_{11}\right|^2 - \left|\Delta\right|^2} \qquad R_S = \frac{\left|S_{12} \cdot S_{21}\right|}{\left|\left|S_{11}\right|^2 - \left|\Delta\right|^2\right|}$$

Cerc de stabilitate la iesire (CSOUT)

- **Cercul de stabilitate la iesire** reprezinta locul geometric al punctelor Γ_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 Γ_L de stabilitate ($|\Gamma_{in}|<1$) / instabilitate ($|\Gamma_{in}|>1$)

Cerc de stabilitate la iesire (CSOUT)



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

Cerc de stabilitate la iesire (CSOUT)

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

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

  - Decizia se poate lua in functie de valoarea pe care o are |S11| si de pozitia centrului diagramei Smith fata de cercul de stabilitate

Identificarea zonelor

- Cerc de stabilitate la iesire
  - **|S11| < 1** → centrul diagramei pe care se reprezinta Γ_L este punct **stabil**, se gaseste in zona stabila (cel mai des)
  - |S11| > 1 → centrul diagramei pe care se reprezinta Γ_L este punct **instabil**, se gaseste in zona instabila
- Cerc de stabilitate la intrare
  - **|S22| < 1** → centrul diagramei pe care se reprezinta Γ_S este punct **stabil**, se gaseste in zona stabila (cel mai des)
  - |S22| > 1 → centrul diagramei pe care se reprezinta Γ_S este punct **instabil**, se gaseste in zona instabila

Exemplu

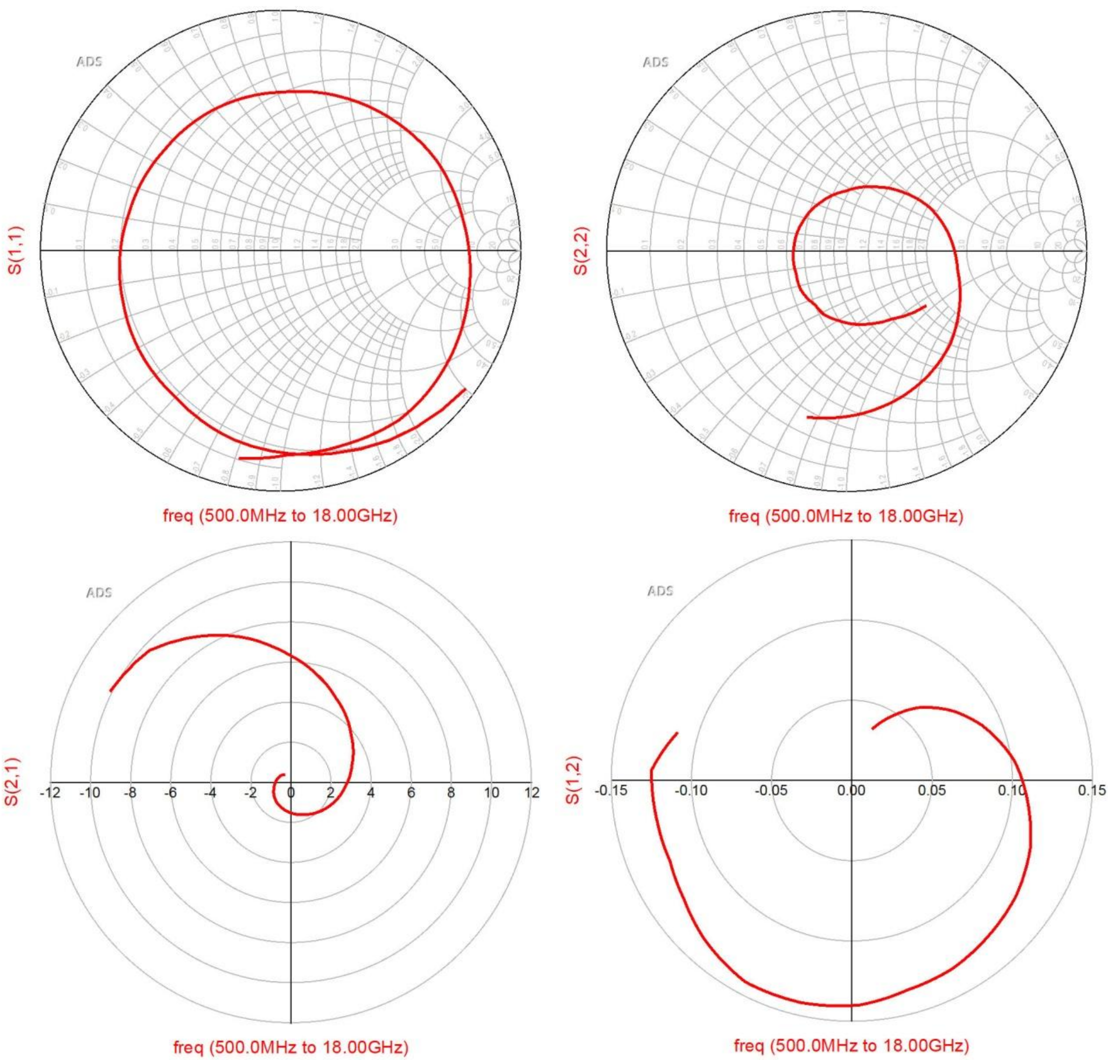
- ATF-34143 **la Vds=3V Id=20mA.**
- @5GHz
  - $S_{11} = 0.64\angle 139°$
  - $S_{12} = 0.119\angle -21°$
  - $S_{21} = 3.165\angle 16°$
  - $S_{22} = 0.22\angle 146°$

$$\begin{cases} S_{11} = 0.64\angle 139° \\ S_{11} = 0.64\cdot\cos 139° + j\cdot 0.64\cdot\sin 139° \end{cases}$$

```
!ATF-34143
!S-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
```

Exemplu

- ATF-34143
- **Ia**
  - **Vds=3V**
  - **Id=20mA.**



Calcul + identificare zone

- Parametri S
  - S11 = -0.483+0.42·j
  - S12 = 0.111-0.043·j
  - S21 = 3.042+0.872·j
  - S22 = -0.182+0.123·j
- | S11 | = 0.64 < 1
- $|C_L| < R_L \quad 0 \in CSOUT$

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

$$|C_L| = 4.032$$

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

- Centrul diagramei Smith este in interiorul cercului de stabilitate ($0 \in CSOUT$) si apartine zonei stabile
  - interior cerc – stabil
  - exterior cerc – instabil

Calcul + identificare zone

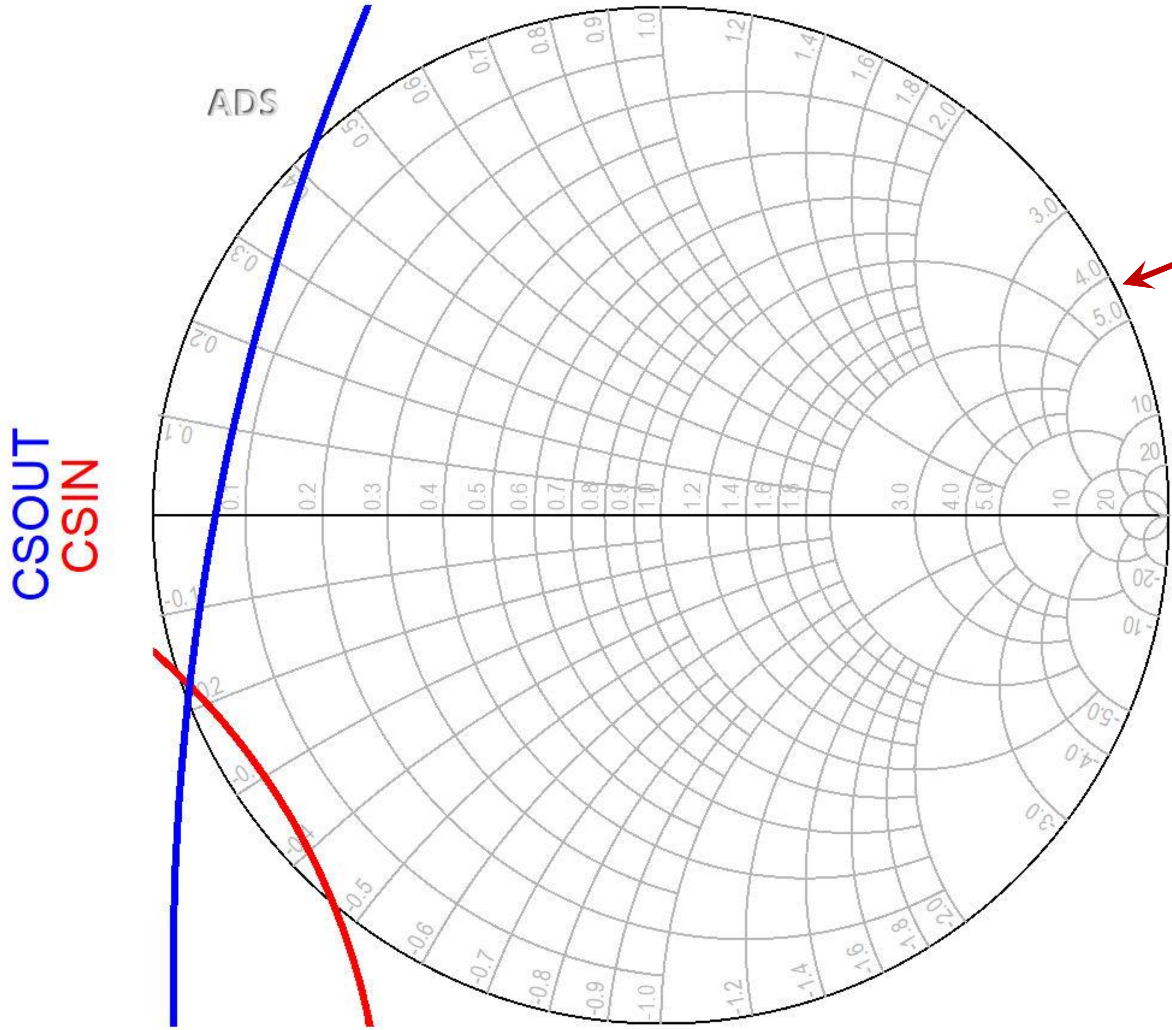
- Parametri S
  - S11 = -0.483+0.42·j
  - S12 = 0.111-0.043·j
  - S21 = 3.042+0.872·j
  - S22 = -0.182+0.123·j
- | S22 | = 0.22 < 1
- $|C_S| > R_S \quad 0 \notin CSIN$
- Centrul diagramei Smith este in exteriorul cercului de stabilitate ($0 \notin$ CSIN) si apartine zonei stabile
  - exterior cerc – stabil
  - interior cerc – instabil

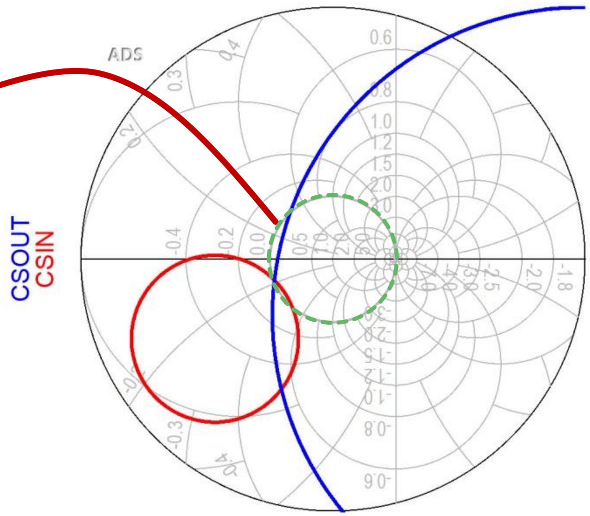
$$C_S = \frac{\left(S_{11} - \Delta \cdot S_{22}^*\right)^*}{|S_{11}|^2 - |\Delta|^2} = -1.871 - 1.265 \cdot j$$

$$|C_S| = 2.259$$

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

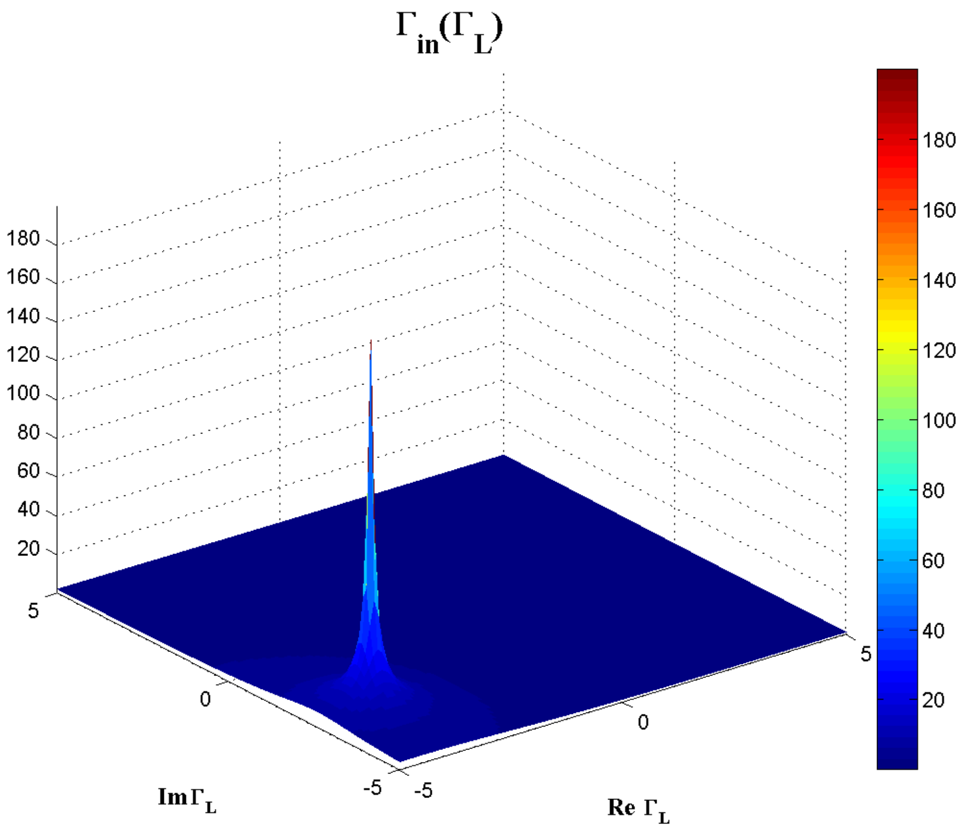
ADS

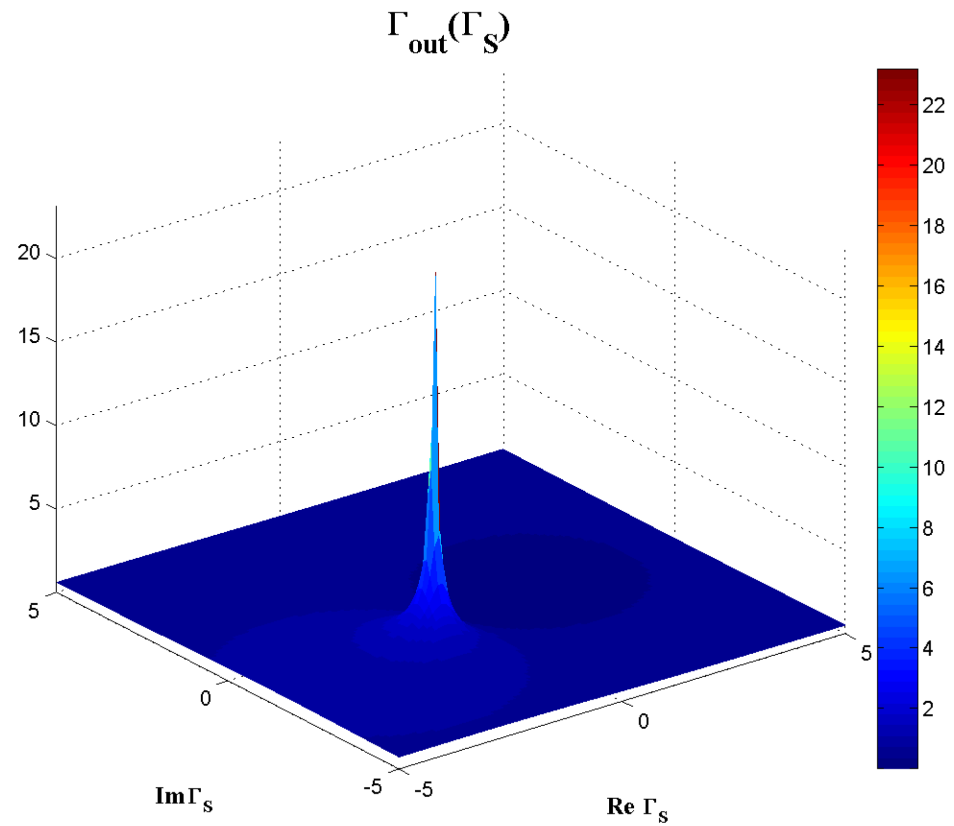




Reprezentare 3D $|\Gamma_{in}|$, $|\Gamma_{out}|$

- Variatii foarte mari ->logaritmic

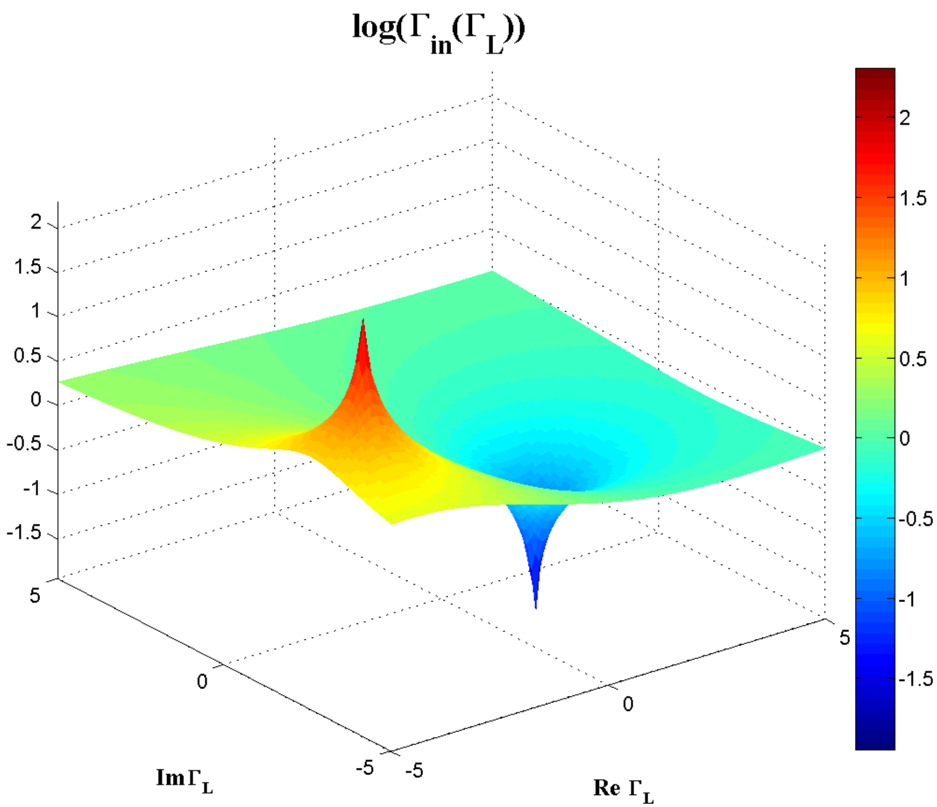


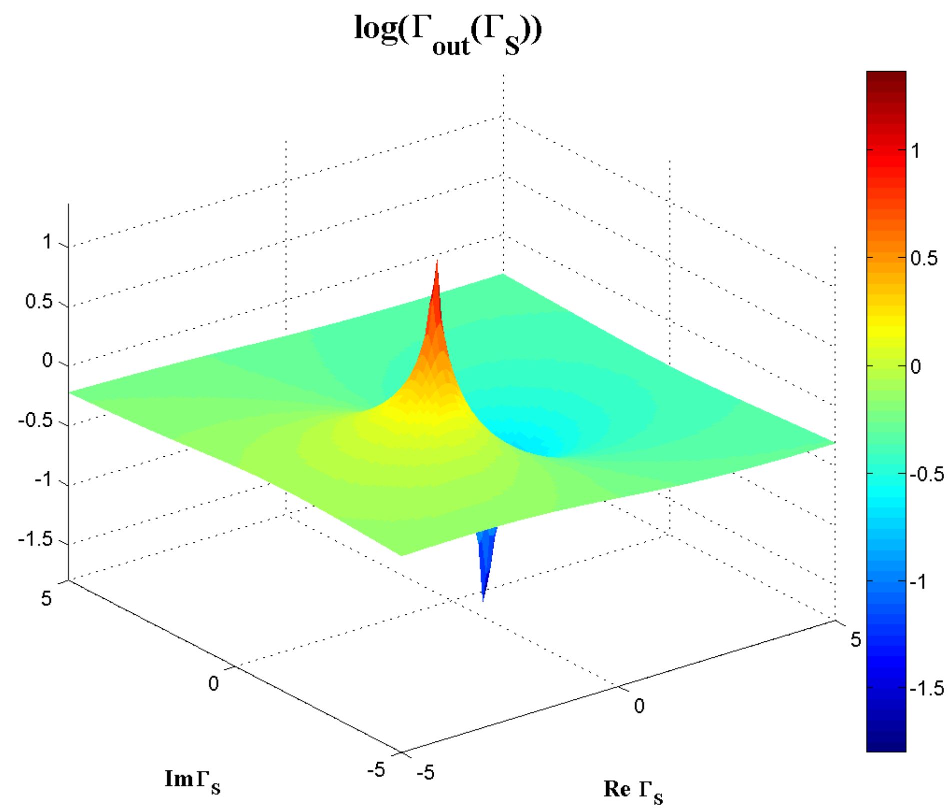


$$|\Gamma_{in}| <> 1$$

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

- $\log_{10}|\Gamma_{in}|$, $\log_{10}|\Gamma_{out}|$

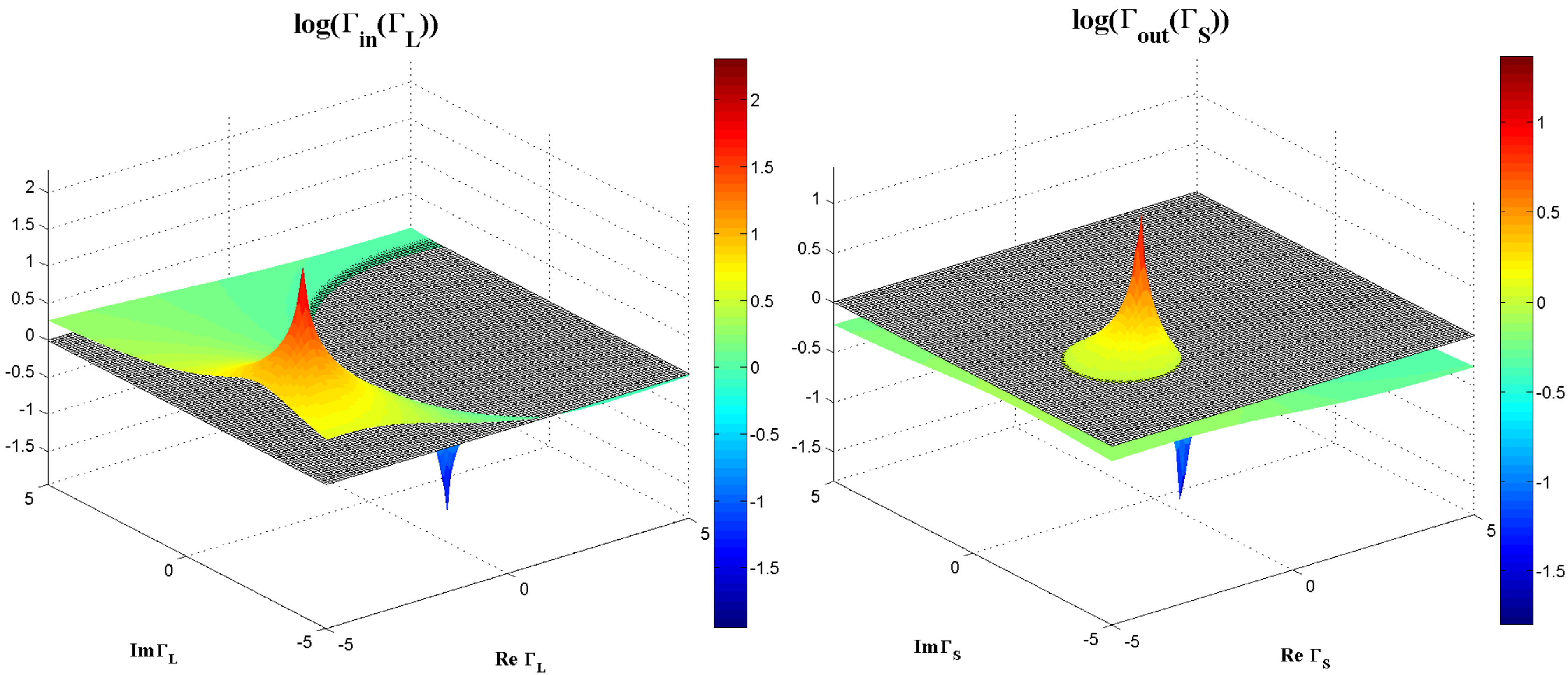




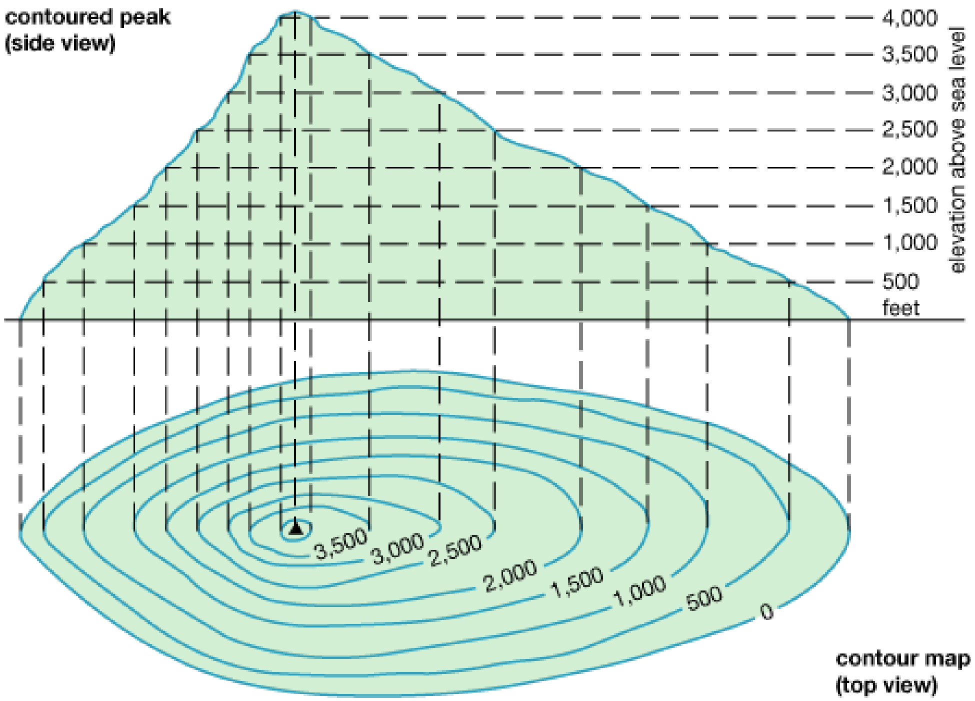
$$\log_{10}|\Gamma_{in}| \ <> \ 0$$

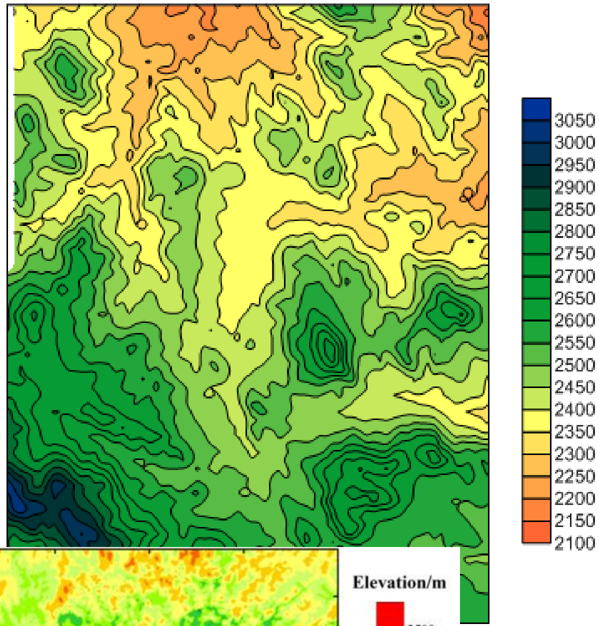
Reprezentare 3D $|\Gamma_{in}|$, $|\Gamma_{out}|$, $|\Gamma|=1$

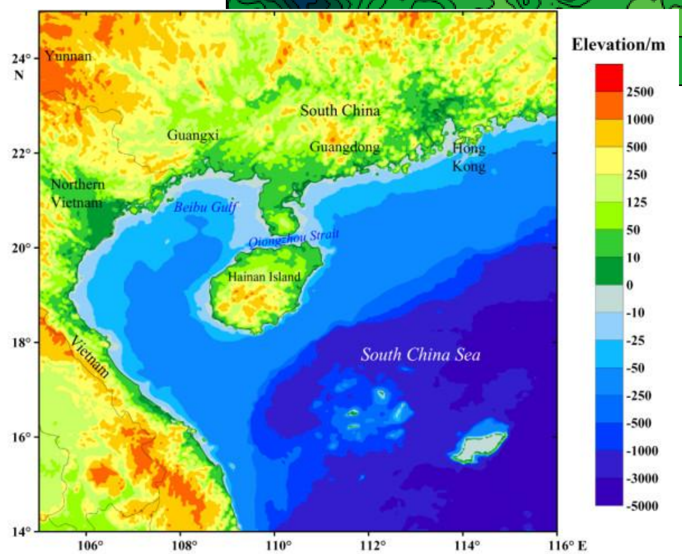
- $|\Gamma| = 1 \rightarrow \log_{10}|\Gamma| = 0$, intersectia = cerc



Contour map/lines

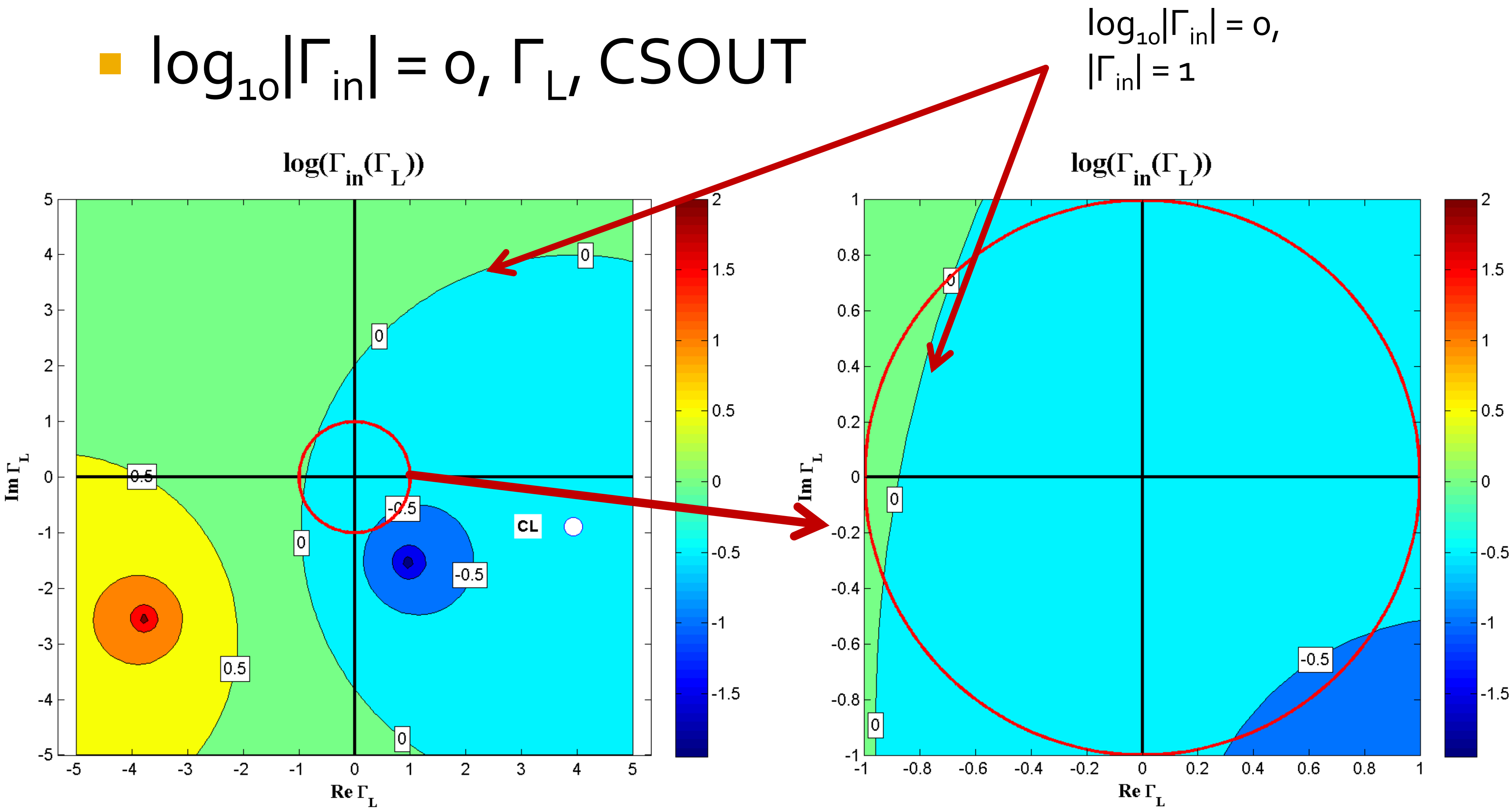






Reprezentare 3D $|\Gamma_{in}|$, $|\Gamma_{out}|$

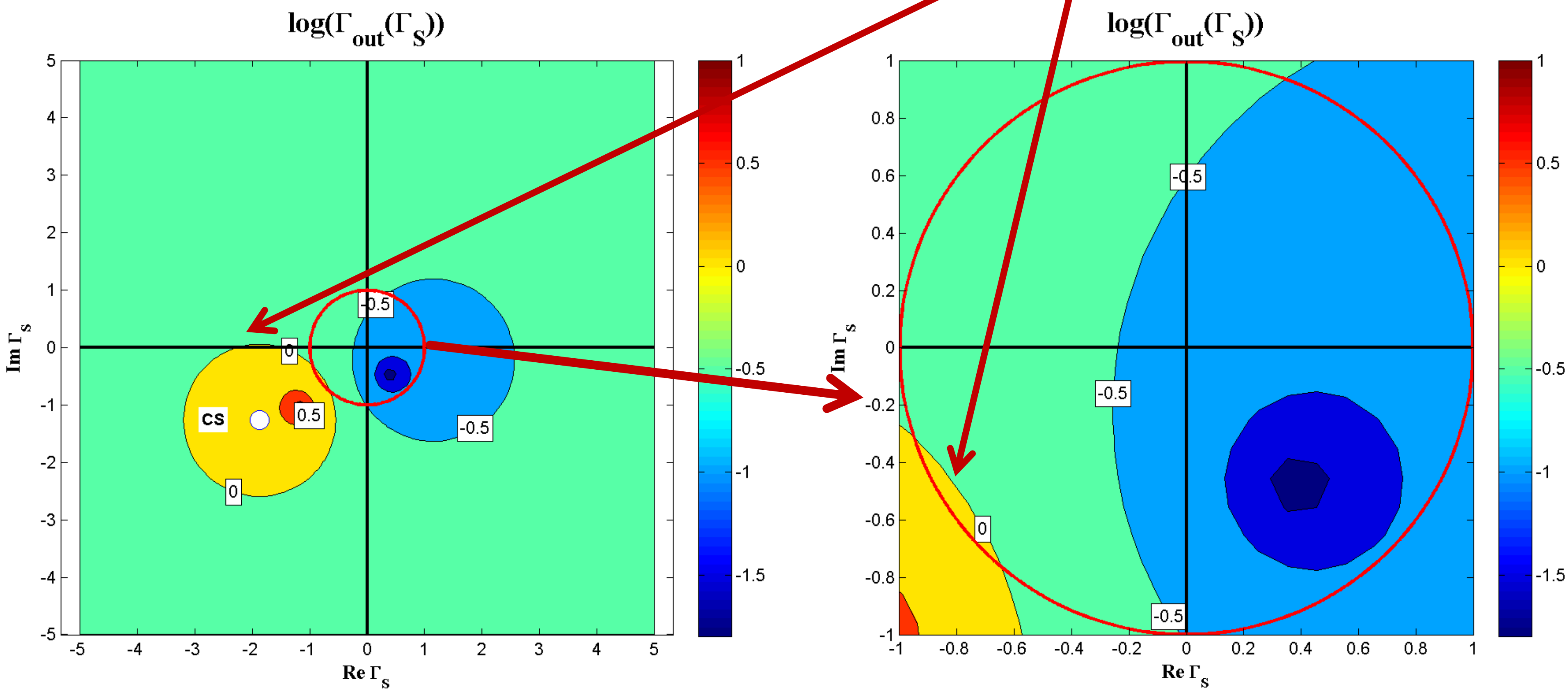
- $\log_{10}|\Gamma_{in}| = 0$, Γ_L, CSOUT



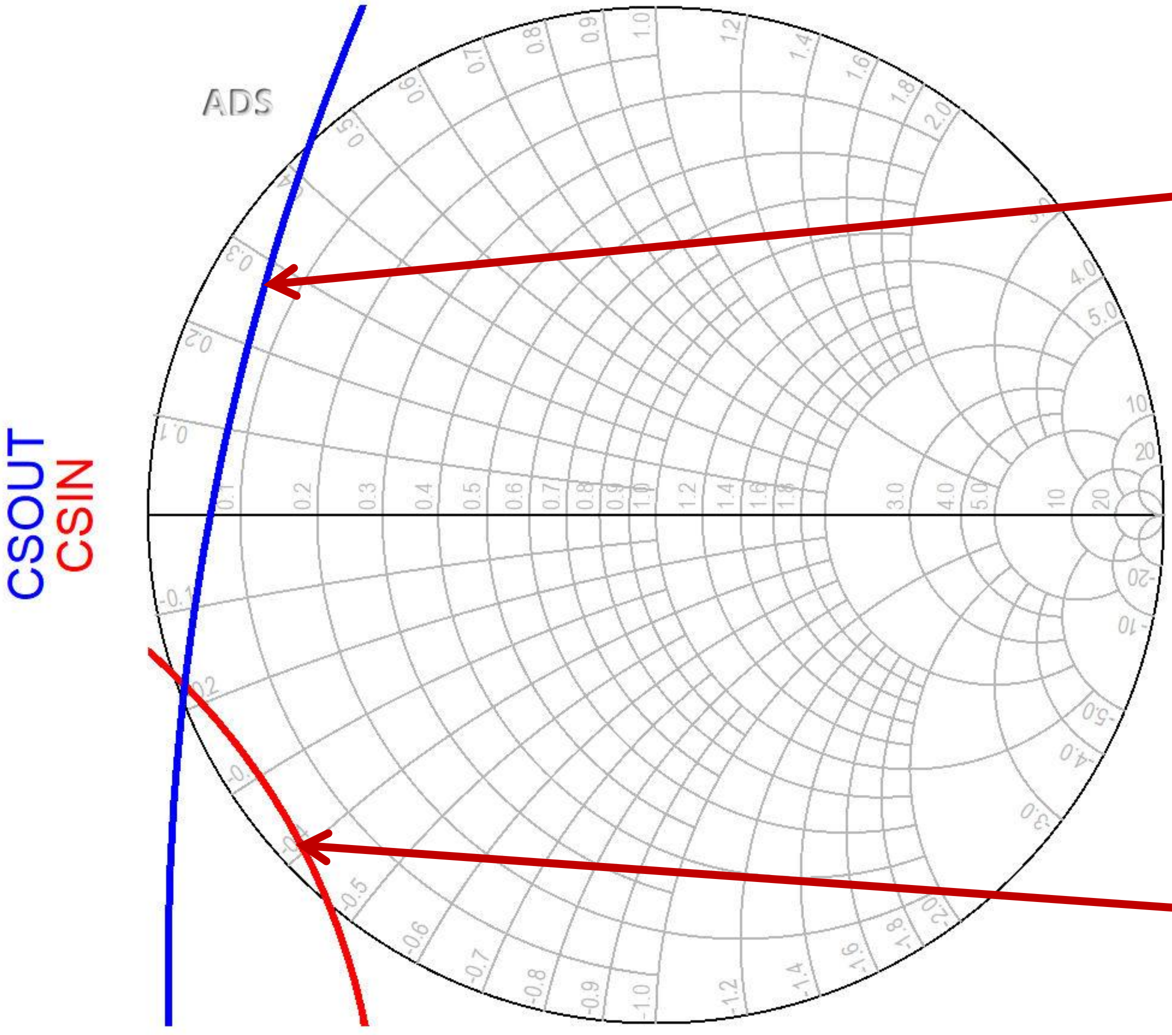
Reprezentare 3D $|\Gamma_{in}|$, $|\Gamma_{out}|$

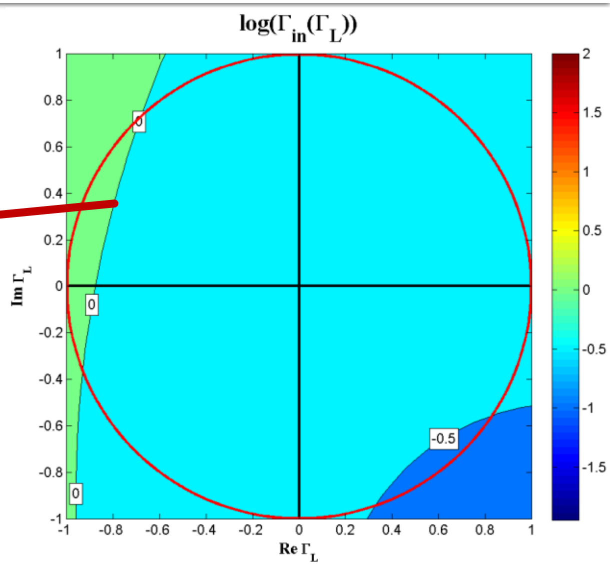
- $\log_{10}|\Gamma_{out}| = 0$, Γ_S, CSIN

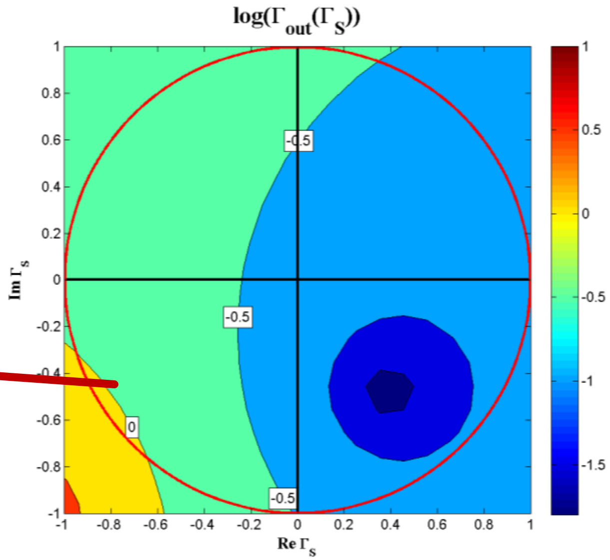
$\log_{10}|\Gamma_{out}| = 0$,
$|\Gamma_{out}| = 1$



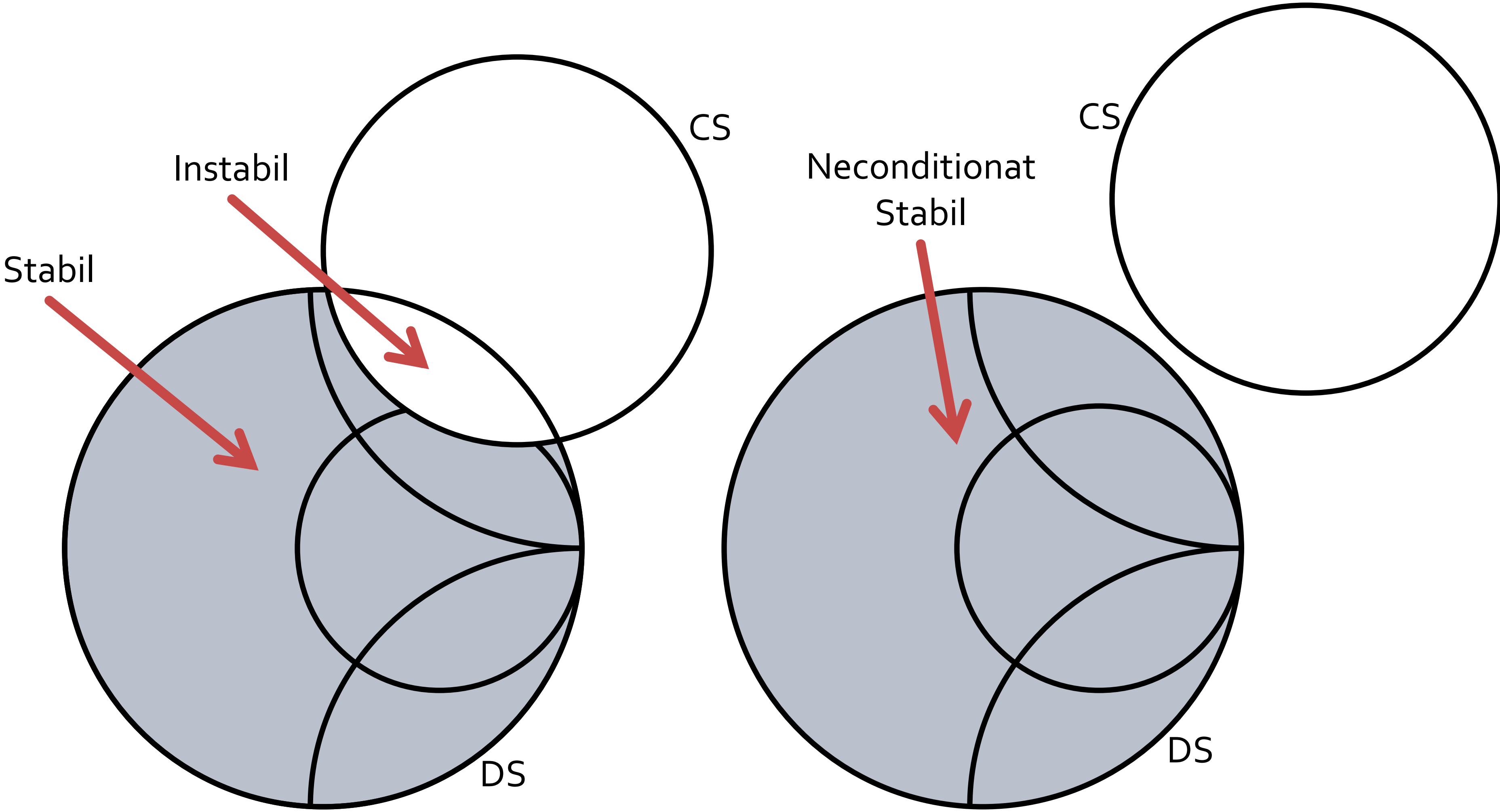
CSIN, CSOUT


ADS
CSOUT
CSIN

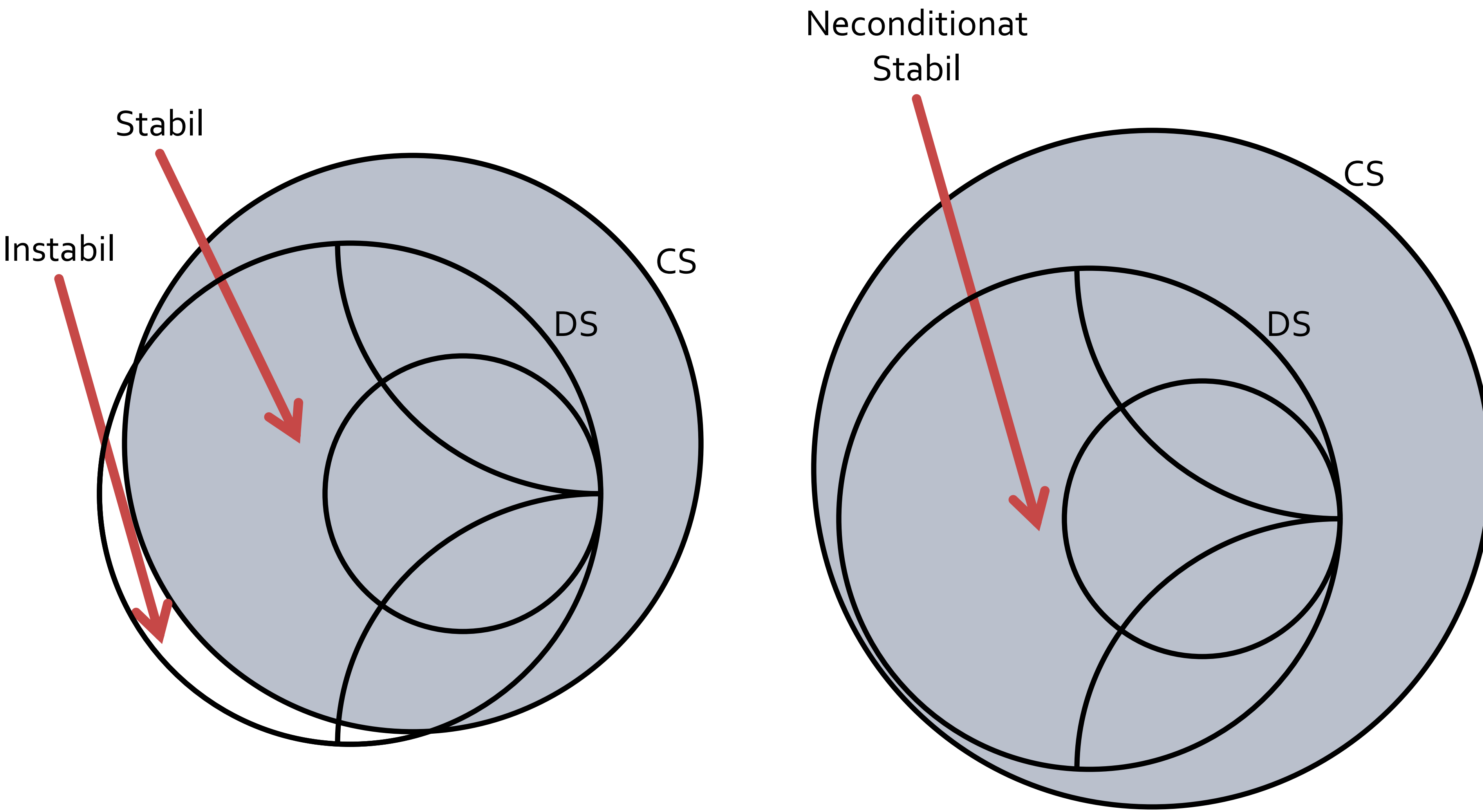

log(Γ_in(Γ_L))
Im Γ_L
Re Γ_L
0
-0.5


log(Γ_out(Γ_S))
Im Γ_S
Re Γ_S
0
-0.5

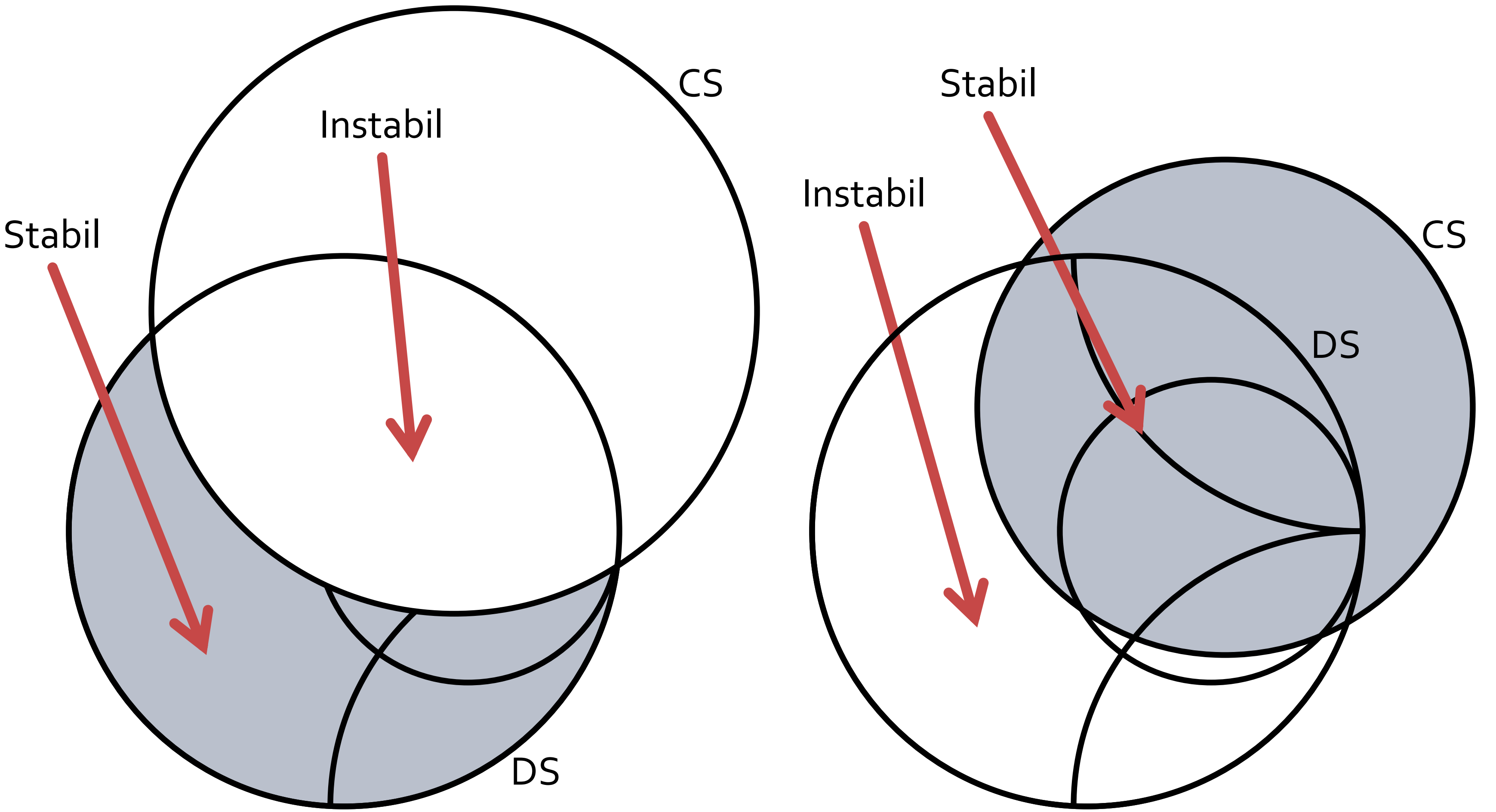
Mai multe pozitionari posibile



Mai multe pozitionari posibile



Pozitionari mai rare



Stabilitate

- **Stabilitatea necondiționată:** circuitul este necondiționat stabil dacă $|\Gamma_{in}|<1$ şi $|\Gamma_{out}|<1$ pentru **orice** impedanță pasivă a sarcinii şi sursei
- **Stabilitatea condiționată:** circuitul este condiționat stabil dacă $|\Gamma_{in}|<1$ şi $|\Gamma_{out}|<1$ doar pentru un anumit interval de valori pentru impedanța pasivă a sarcinii şi 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 |S11| < 1 (CSOUT) sau |S22| < 1 (CSIN)
- Matematic:

$$\begin{cases} \left| |C_L| - R_L \right| > 1 \\ |S_{11}| < 1 \end{cases} \qquad \begin{cases} \left| |C_S| - R_S \right| > 1 \\ |S_{22}| < 1 \end{cases}$$

Contact

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