

Curs 5
2018/2019

Dispozitive și circuite de microunde pentru radiocomunicații

Disciplina 2018/2019

- 2C/1L, DCMR (CDM)
- Minim 7 prezente (curs+laborator)
- Curs - conf. Radu Damian
 - Vineri 11-13, P7
 - E – 50% din nota
 - probleme + (2p prez. curs) + (3 teste) + (bonus activitate)
 - 3pz=+0.5p
 - toate materialele permise
- Laborator – conf. Radu Damian
 - Joi 8-14 impar II.13
 - L – 25% din nota
 - P – 25% din nota

Documentatie

■ <http://rf-opto.etti.tuiasi.ro>

Laboratorul de Microunde si Optică

Not secure | rf-opto.etti.tuiasi.ro/microwave_cd.php?chg_lang=1

RF-OPTO

EN English | RO Romana |

Start Didactic Master Colectiv Cercetare Studenti Admin

Microunde Comunicatii Optice Optoelectronica Internet Antene Practica Retele Soft didactic

Dispozitive si circuite de microunde pentru radiocomunicatii

Disciplina: DCMR (2017-2018)

Coordinator Disciplina: conf. dr. Radu-Florin Damian

Cod: DOS412T

Tip Disciplina: DOS; Disciplina Optionala, Disciplina de Specialitate

Credite: 4

An de Studiu: 4, Sem. 7

Activitati

Curs: Cadru Didactic: conf. dr. Radu-Florin Damian, 2 Ore/Saptamana, Sectie Specializare, Orar:

Laborator: Cadru Didactic: conf. dr. Radu-Florin Damian, 1 Ore/Saptamana, Grupa, Orar:

Evaluare

Tip: Examen

A: 50%, (Examen/Colocviu)

B: 25%, (Activitate Seminar/Laborator/Proiect)

D: 25%, (Teme de casa/Lucrari de specialitate)

Note

[Rezultate totale](#)

Prezenta

[Curs](#)

[Laborator](#)

Liste

[Bonus-uri acumulate \(final\)](#)

[Studenti care nu pot intra in examen](#)

Fotografii

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

Start Didactic Master Colectiv Cercetare Studenti Admin

Note Lista Studenti Fotografi Statistici

Grupa 5403

Nr.	Student	Prezent	Nr.	Student	Prezent	Nr.	Student	Prezent
1	ANGHELUS IONUT-MARCUS		<input type="checkbox"/> Prezent	2	ANTIGHIN FLORIN-RAZVAN	 Fotografia nu există	<input type="checkbox"/> Prezent	
		Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>
		Nota: 0			Nota: 0			Nota: 0
		Obs: <input type="text"/>			Obs: <input type="text"/>			Obs: <input type="text"/>
4	APOSTOL PAVEL-MANUEL	 Fotografia nu există	<input type="checkbox"/> Prezent	5	BALASCA TUDIAN-PETRU	 Fotografia nu există	<input checked="" type="checkbox"/> Prezent	
		Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>
		Nota: 0			Nota: 0			Nota: 0
		Obs: <input type="text"/>			Obs: <input type="text"/>			Obs: <input type="text"/>
7	BOTEZAT EMANUEL		<input type="checkbox"/> Prezent	8	BUTUNOI GEORGE-MADALIN	 Fotografia nu există	<input type="checkbox"/> Prezent	
		Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>
		Nota: 0			Nota: 0			Nota: 0
		Obs: <input type="text"/>			Obs: <input type="text"/>			Obs: <input type="text"/>
10	CHIRITOIU EGATERINA		<input type="checkbox"/> Prezent	11	CODOC MARCUS		<input checked="" type="checkbox"/> Prezent	
		Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>			Puncte: 0 <input type="button" value="▼"/> <input checked="" type="button" value="■"/> <input type="button" value="▲"/>
		Nota: 0			Nota: 0			Nota: 0
		Obs: <input type="text"/>			Obs: <input type="text"/>			Obs: <input type="text"/>

Nr. Student

Prezent

2 ANTIGHIN
FLORIN-RAZVAN

Fotografia nu există

Prezent

Puncte: 0

Nota: 0

Obs:

Acces

Personalizat



Date:

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

[Acceseaza ca acest student](#)

Note obtinute

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

Nume

Email

Cod de verificare

Trimite

Examen: Reprezentare logaritmică

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

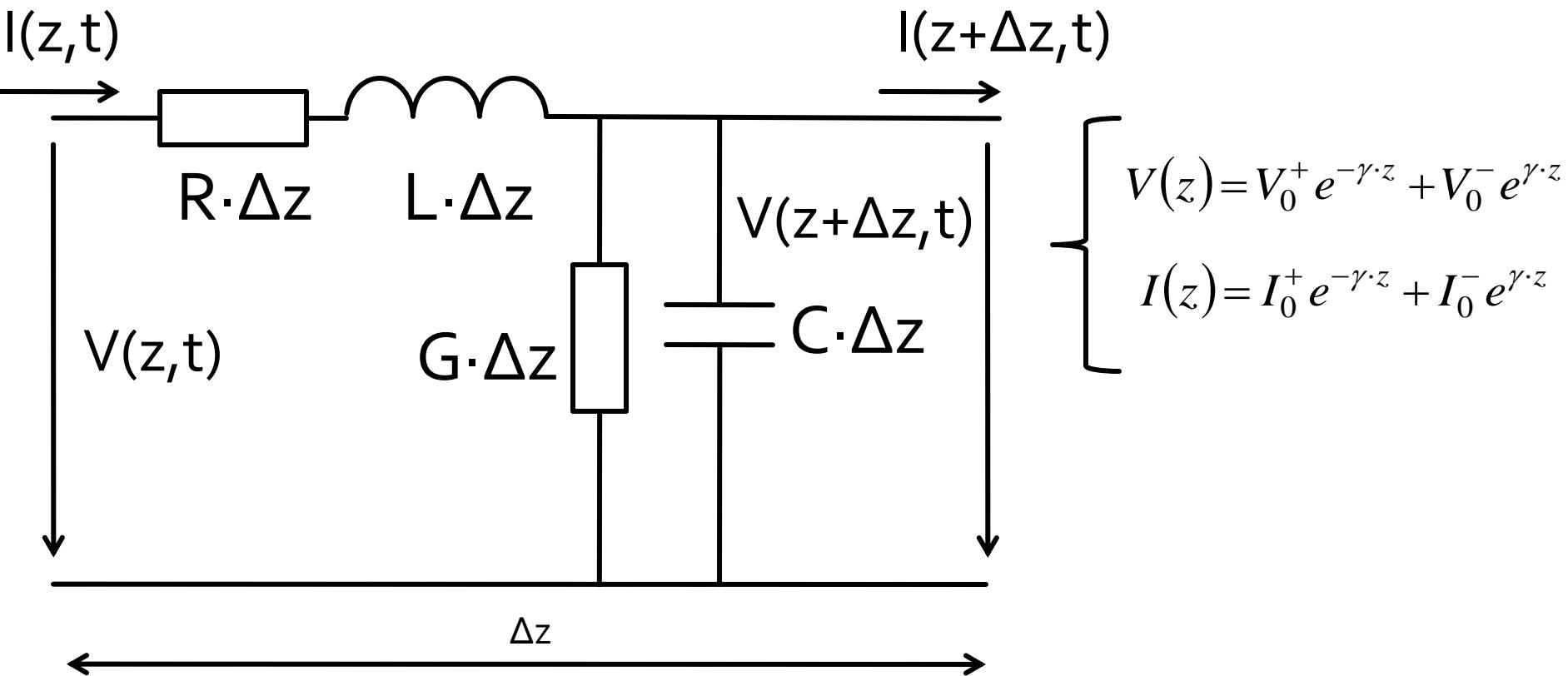
Examen

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

Linii de transmisie in mod TEM

Linie de transmisie model echivalent

- mod TEM, doi conductori



Linie fara pierderi

$$V(z) = V_0^+ \cdot (e^{-j\beta z} + \Gamma \cdot e^{j\beta z})$$

$$I(z) = \frac{V_0^+}{Z_0} \cdot (e^{-j\beta z} - \Gamma \cdot e^{j\beta z})$$

■ Puterea medie

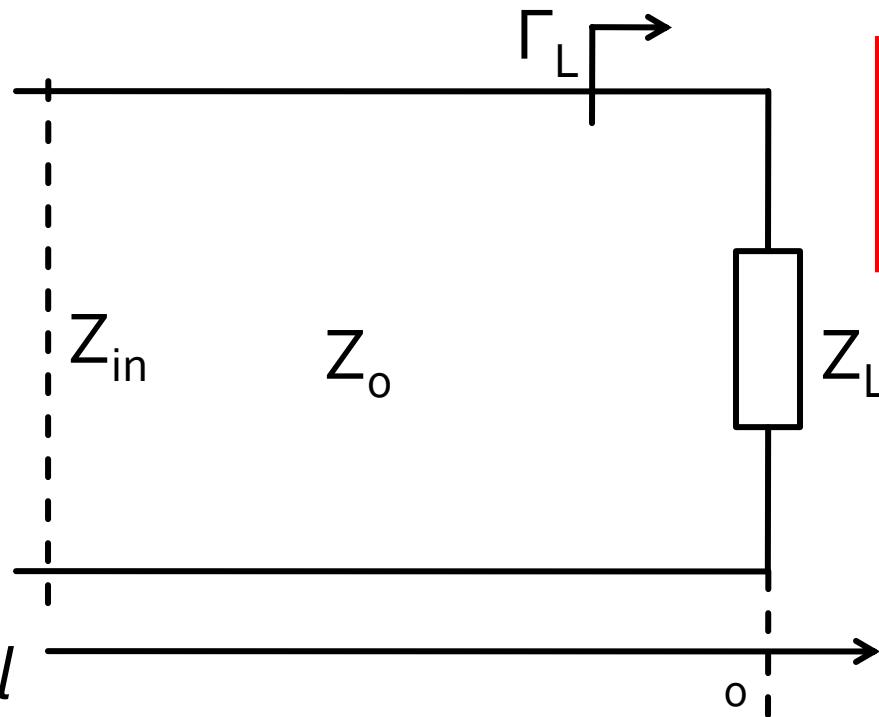
$$P_{avg} = \frac{1}{2} \cdot \text{Re}\{V(z) \cdot I(z)^*\} = \frac{1}{2} \cdot \frac{|V_0^+|^2}{Z_0} \cdot \text{Re}\left\{1 - \Gamma^* \cdot e^{-2j\beta z} + \Gamma \cdot e^{2j\beta z} - |\Gamma|^2\right\}$$
$$P_{avg} = \frac{1}{2} \cdot \frac{|V_0^+|^2}{Z_0} \cdot \left(1 - |\Gamma|^2\right)$$

$(z - z^*) = \text{Im}$

- Puterea transmisa sarcinii = Puterea incidenta - Puterea "reflectata"
- Return Loss [dB]
$$\text{RL} = -20 \cdot \log|\Gamma| \quad [\text{dB}]$$

Linie fara pierderi

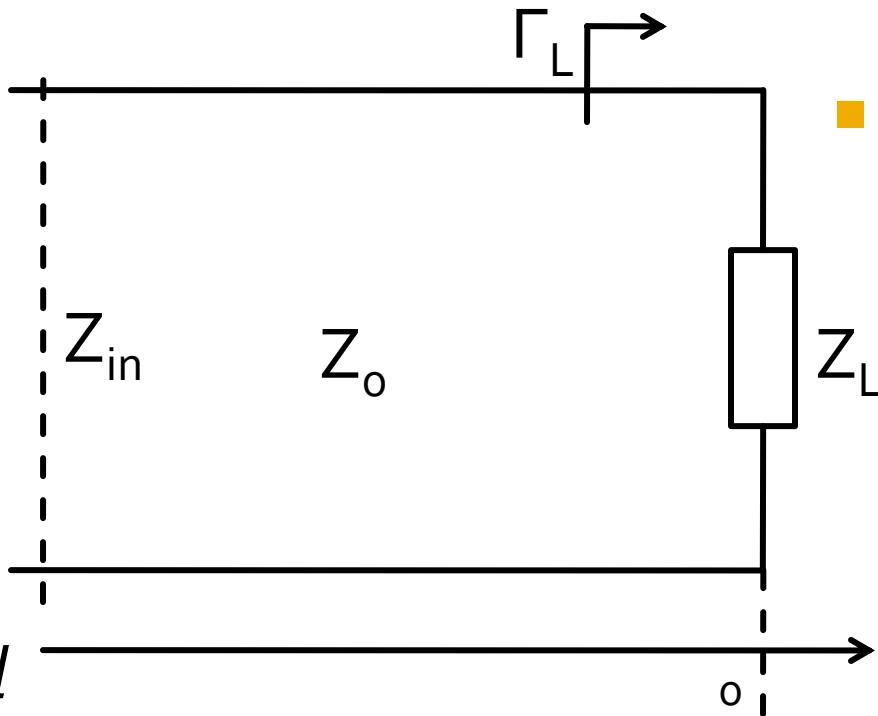
- impedanta la intrarea liniei de impedanta caracteristica Z_0 , de lungime l , terminata cu impedanta Z_L



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

Linie fara pierderi, cazuri particulare

- $l = k \cdot \lambda / 2$ $\beta \cdot l = \frac{2\pi}{\lambda} \cdot l = k \cdot \pi$ $\tan \beta \cdot l = 0$ $Z_{in} = Z_0$
- $l = \lambda / 4 + k \cdot \lambda / 2$ $\tan \beta \cdot l \rightarrow \infty$ $Z_{in} = \frac{Z_0^2}{Z_L}$



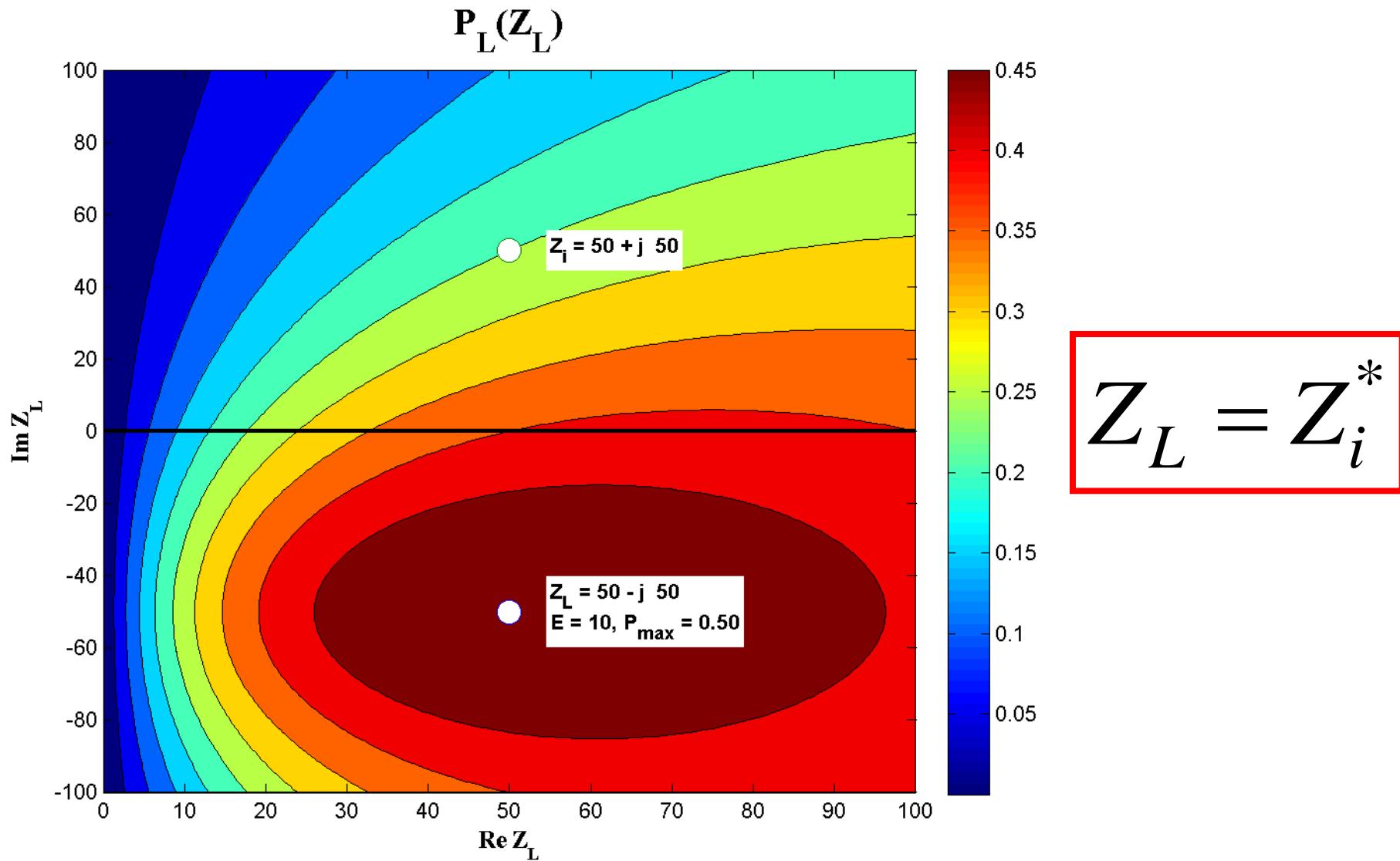
- Transformatorul în sfert de lungime de undă

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

Adaptarea cu transformatoare de impedanta (Lab. 1)

Adaptarea de impedanță

Adaptare, impedante complexe



Adaptare dpdv al puterii

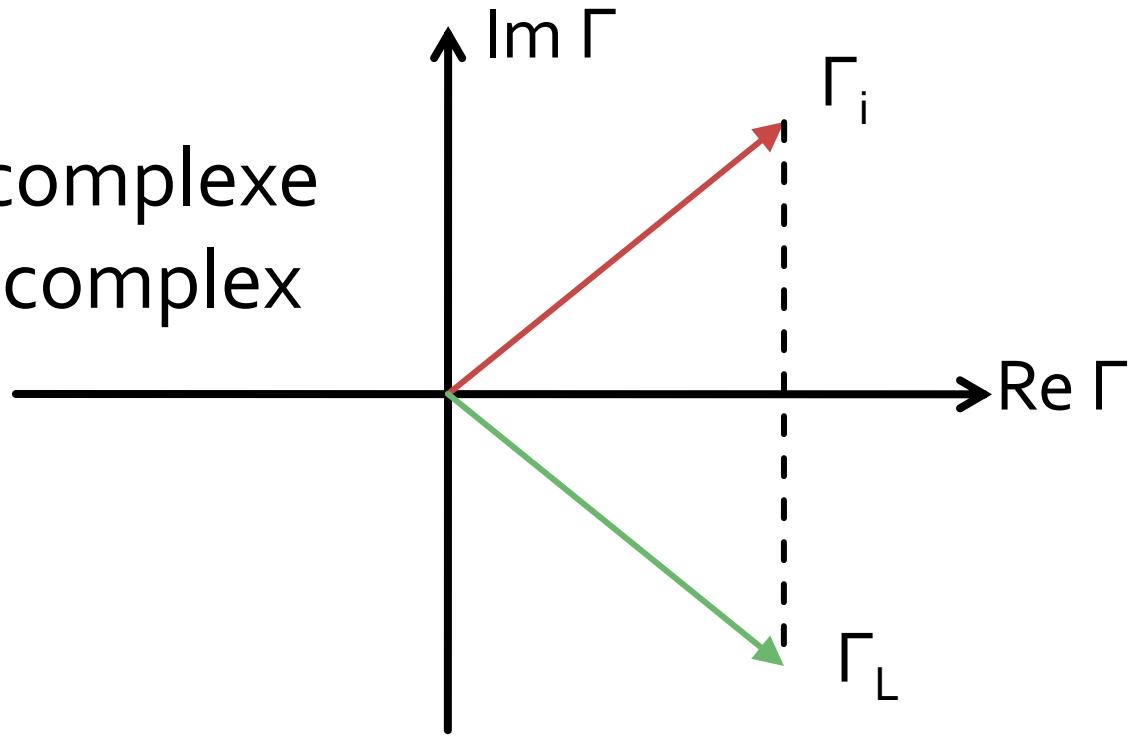
$$Z_L = Z_i^*$$

Daca se alege un Z_0 real

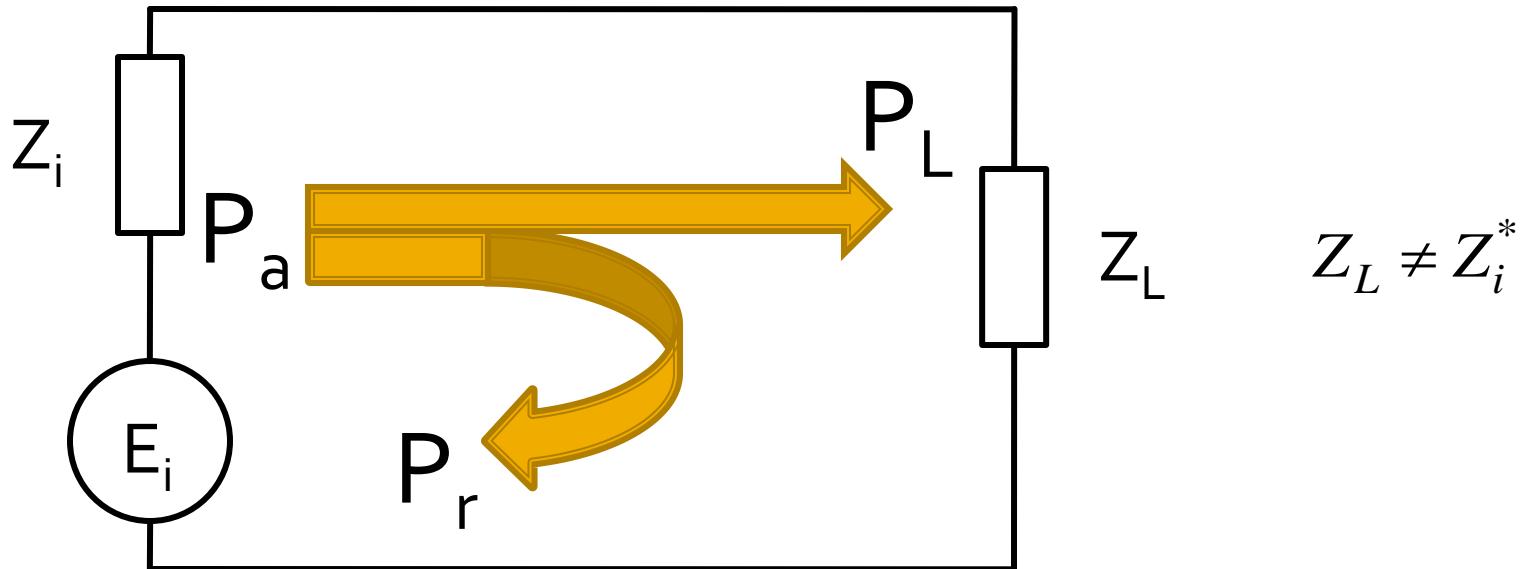
$$\Gamma = \frac{Z - Z_0}{Z + Z_0}$$

$$\Gamma_L = \Gamma_i^*$$

- numere complexe
- in planul complex

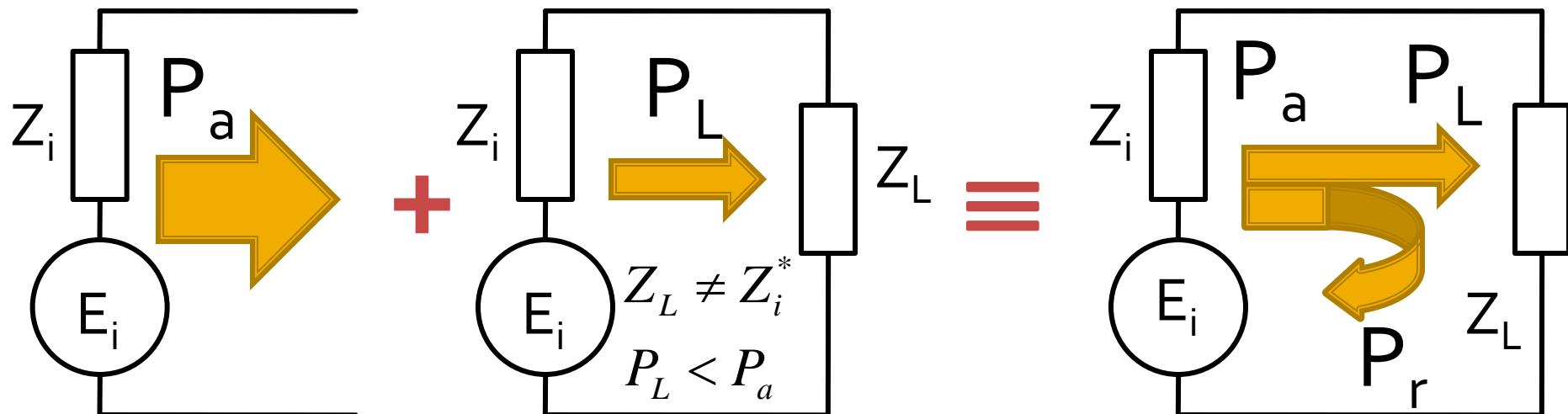


Reflexie de putere / Model



- Putere reflectata
- Putere a undei reflectate

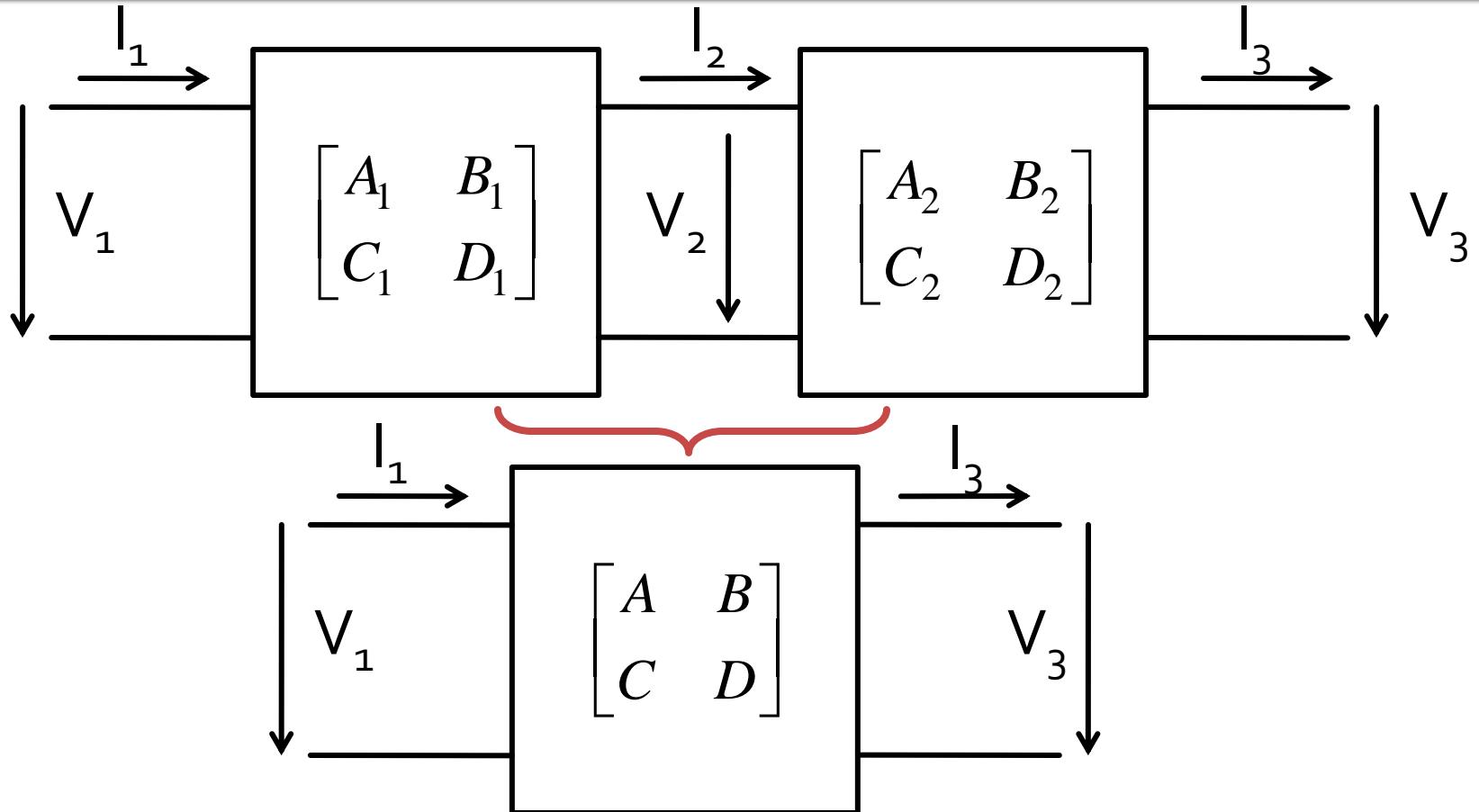
Reflexie de putere / Model



- 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!**

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

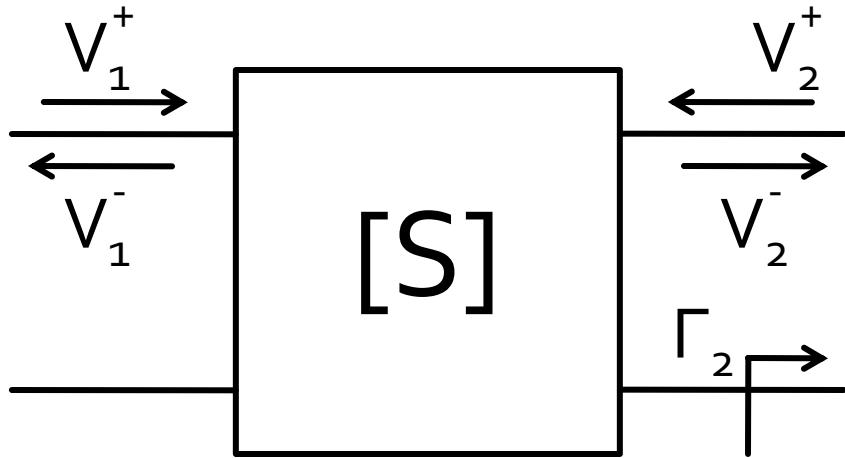
Matricea ABCD – de transmisie



$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \cdot \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

Matricea S (repartitie)

- Scattering parameters



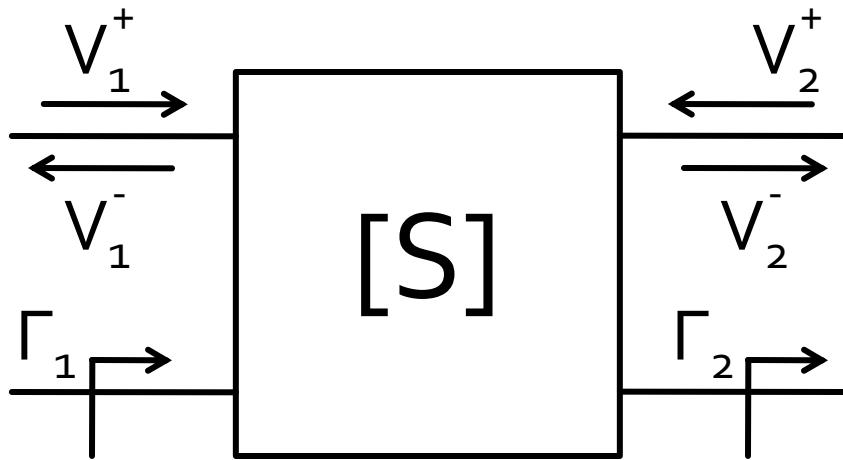
$$\begin{bmatrix} V_1^- \\ V_2^- \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} V_1^+ \\ V_2^+ \end{bmatrix}$$

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

- $V_2^+ = 0$ 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)



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

$$S_{11} = \left. \frac{V_1^-}{V_1^+} \right|_{V_2^+ = 0} = \Gamma_1 \Big|_{\Gamma_2 = 0}$$

$$S_{21} = \left. \frac{V_2^-}{V_1^+} \right|_{V_2^+ = 0} = T_{21} \Big|_{\Gamma_2 = 0}$$

- S_{11} este coeficientul de reflexie la portul **1** cand portul **2** este terminat pe impedanta care realizeaza adaptarea
- S_{21} este coeficientul de transmisie de la portul **1** (**al doilea indice!**) la portul **2** (**primul indice!**) cand se depune semnal la portul **1** portul **2** este terminat pe impedanta care realizeaza adaptarea

Matricea S (repartitie)

- Matricea S poate fi extinsa (generalizata) pentru multiporti (n-porturi)

$$S_{ii} = \left. \frac{V_i^-}{V_i^+} \right|_{V_k^+=0, \forall k \neq i}$$

$$S_{ij} = \left. \frac{V_i^-}{V_j^+} \right|_{V_k^+=0, \forall k \neq j}$$

- S_{ii} este coeficientul de reflexie la portul i cand toate celelalte porturi sunt conectate la impedanta care realizeaza adaptarea
- S_{ij} este coeficientul de transmisie de la portul j (**al doilea** indice!) la portul i (**primul** indice!) cand se depune semnal la portul j si toate celelalte porturi sunt conectate la impedanta care realizeaza adaptarea

Proprietati [S]

- Daca portul i este conectat la o linie cu impedanta caracteristica Z_{oi}
- Curs 2

$$V(z) = V_0^+ e^{-j\beta z} + V_0^- e^{j\beta z} \quad I(z) = \frac{V_0^+}{Z_0} e^{-j\beta z} - \frac{V_0^-}{Z_0} e^{j\beta z}$$

In planul de referinta al portului, $z=0$

$$V_i = V_i^+ + V_i^- \quad I_i = \frac{V_i^+}{Z_{0i}} - \frac{V_i^-}{Z_{0i}} \quad [Z_0] = \begin{bmatrix} Z_{01} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & Z_{0n} \end{bmatrix}$$

- Legatura cu matricea Z $[Z] \cdot [I] = [V]$

$$[Z] \cdot [I] = [Z_0]^{-1} \cdot [Z] \cdot [V^+] - [Z_0]^{-1} \cdot [Z] \cdot [V^-] \quad [V] = [V^+] + [V^-]$$

$$[Z_0]^{-1} \cdot [Z] \cdot [V^+] - [Z_0]^{-1} \cdot [Z] \cdot [V^-] = [V^+] + [V^-] \quad ([Z] - [Z_0]) \cdot [V^+] = ([Z] + [Z_0]) \cdot [V^-]$$

$$[V^-] = [S] \cdot [V^+]$$

$$[S] = ([Z] - [Z_0]) \cdot ([Z] + [Z_0])^{-1}$$

Matricea S generalizata

- Definim undele de putere

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

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

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

O impedanta de referinta
oarecare, complexa

- Tensiuni si curenti

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

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

Unde de putere pentru multiporti

$$[b] = [F] \cdot ([Z] - [Z_R]^*) \cdot ([Z] + [Z_R])^{-1} \cdot [F]^{-1} \cdot [a]$$

- legatura intre undele de putere incidenta si reflectata

$$[b] = [S_p] \cdot [a]$$

$$[S_p] = [F] \cdot ([Z] - [Z_R]^*) \cdot ([Z] + [Z_R])^{-1} \cdot [F]^{-1}$$

$$[S] = ([Z] - [Z_0]) \cdot ([Z] + [Z_0])^{-1}$$

- tipic

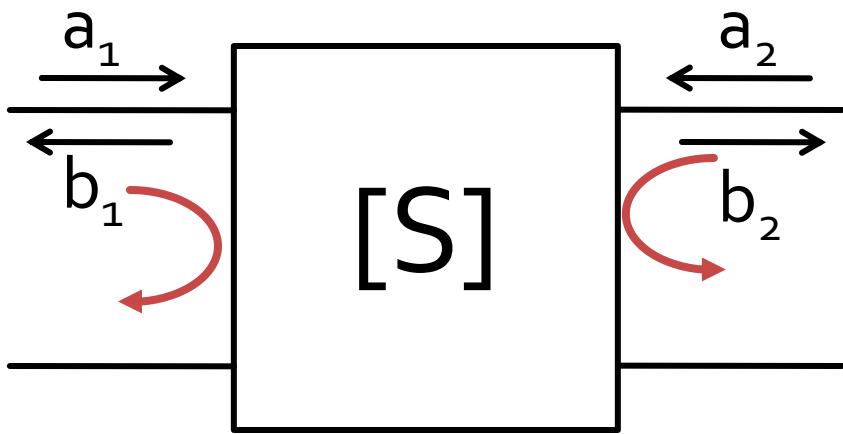
$$Z_{0i} = Z_{Ri} = R_0, \forall i$$

$$R_0 = 50\Omega$$

$$[S_p] \equiv [S]$$

■ coincid!!!

Matricea S (repartitie)

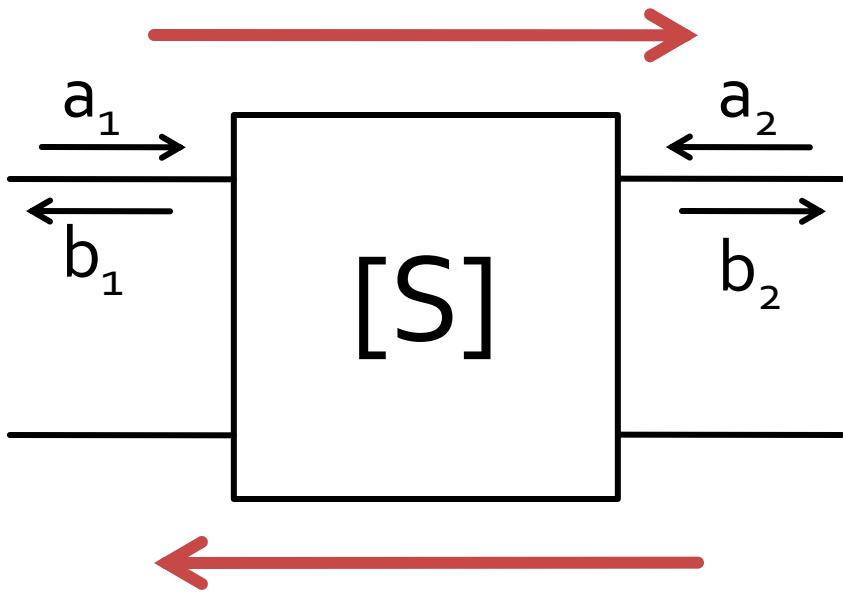


$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

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

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

Matricea S (repartitie)



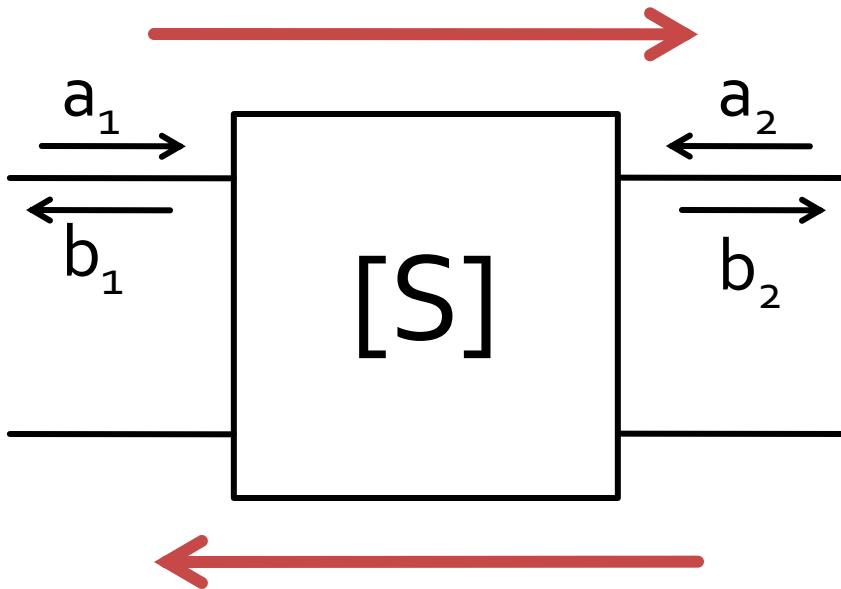
$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \cdot \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

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

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

- 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

Masurare S - VNA

■ Vector Network Analyzer

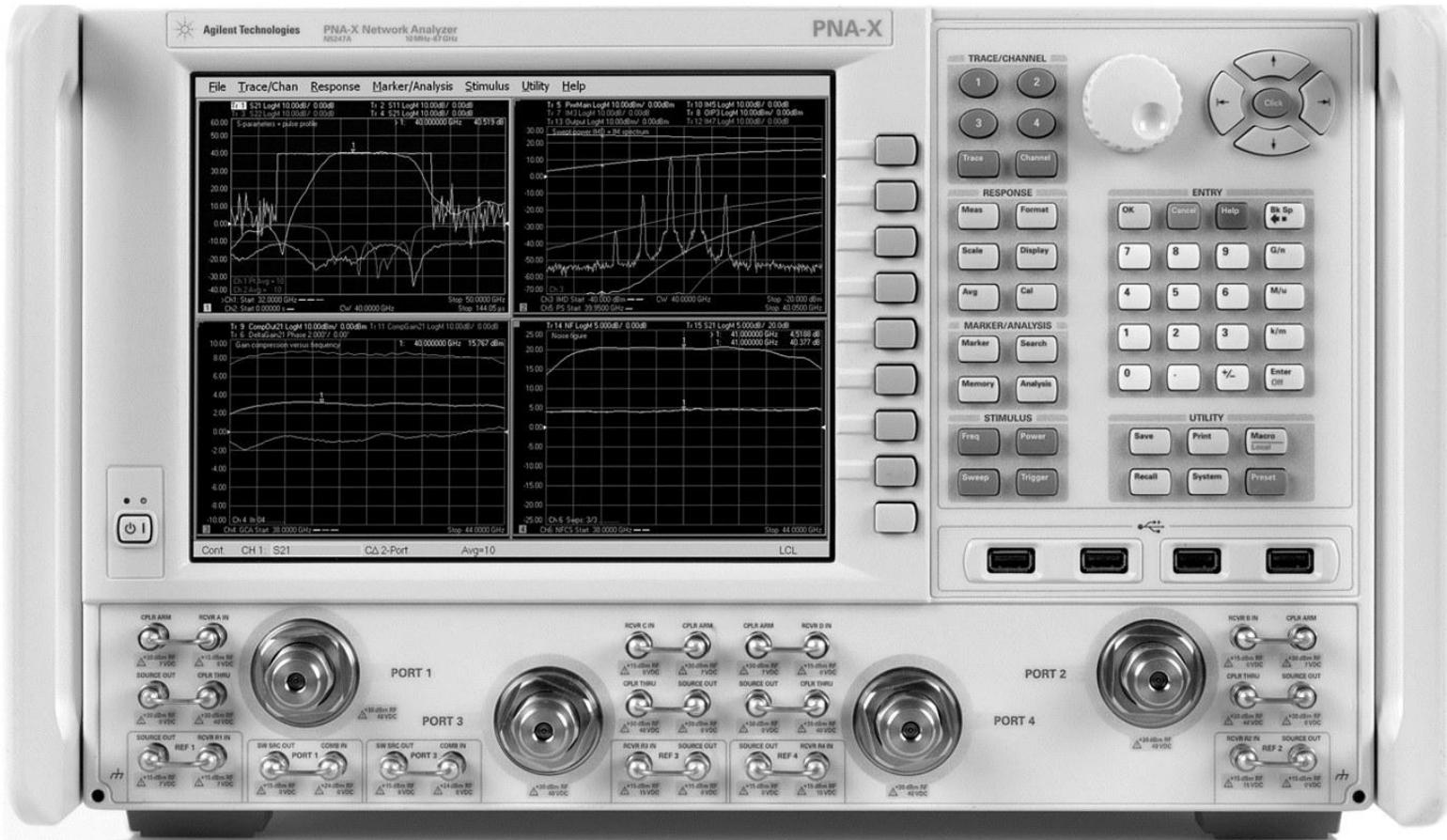


Figure 4.7
Courtesy of Agilent Technologies

Adaptarea de impedanță

Diagrama Smith

Diagrama Smith

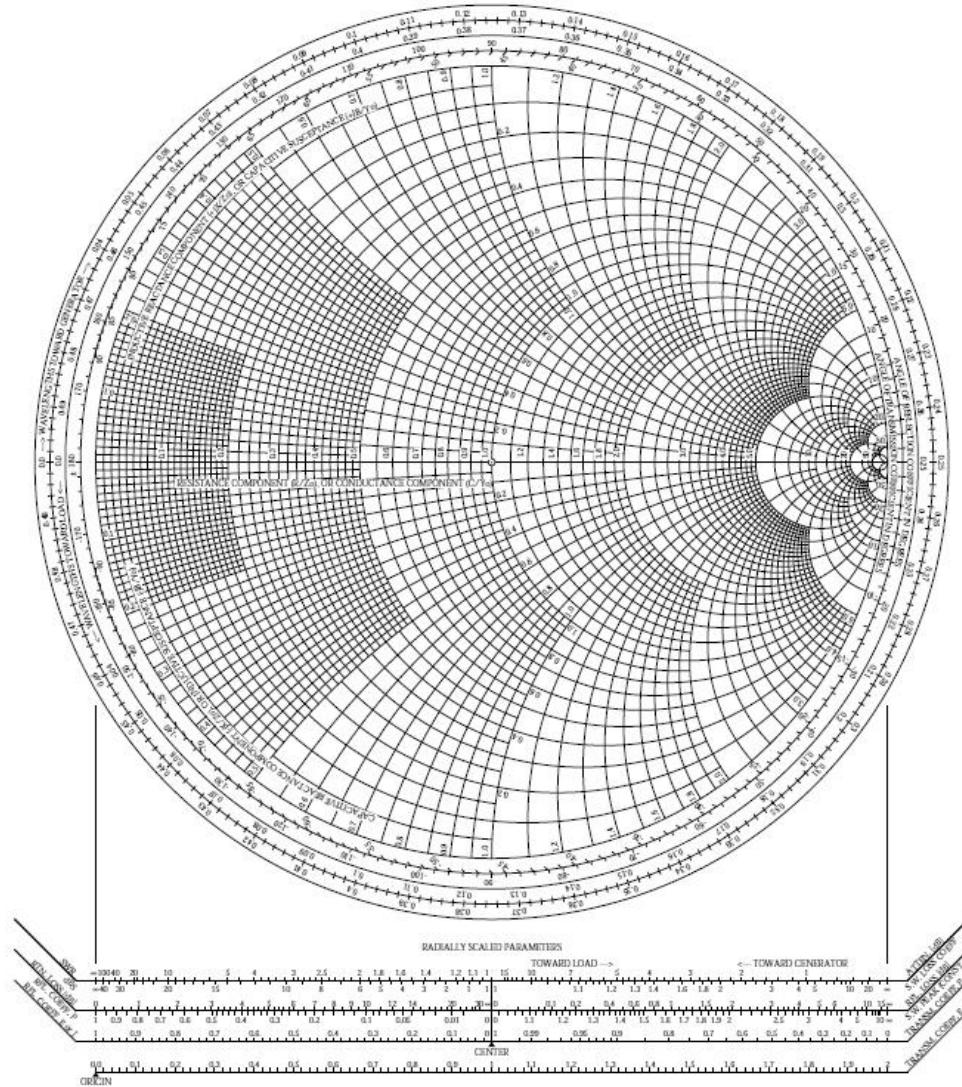


Diagrama Smith

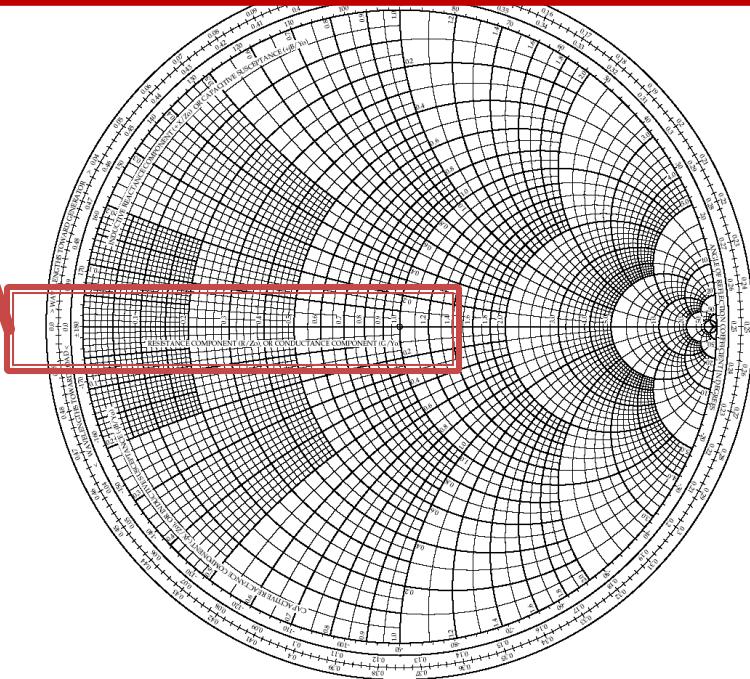
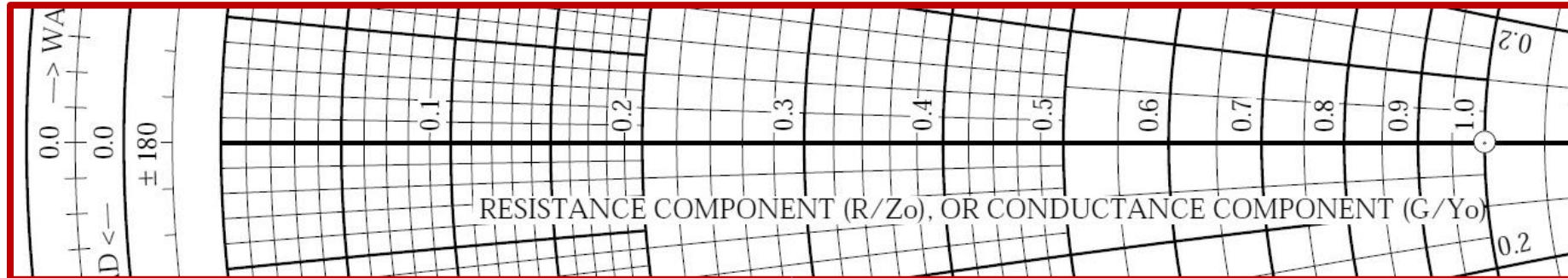


Diagrama Smith

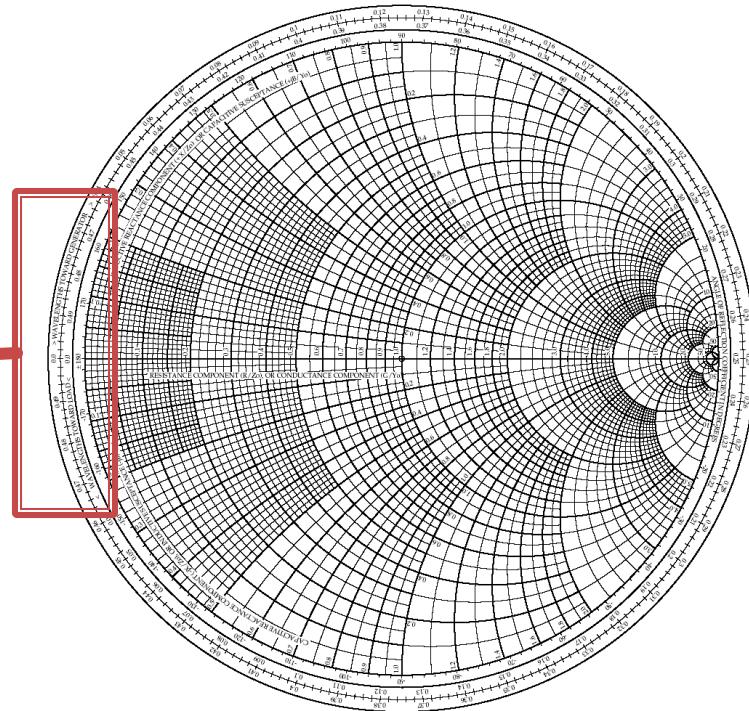
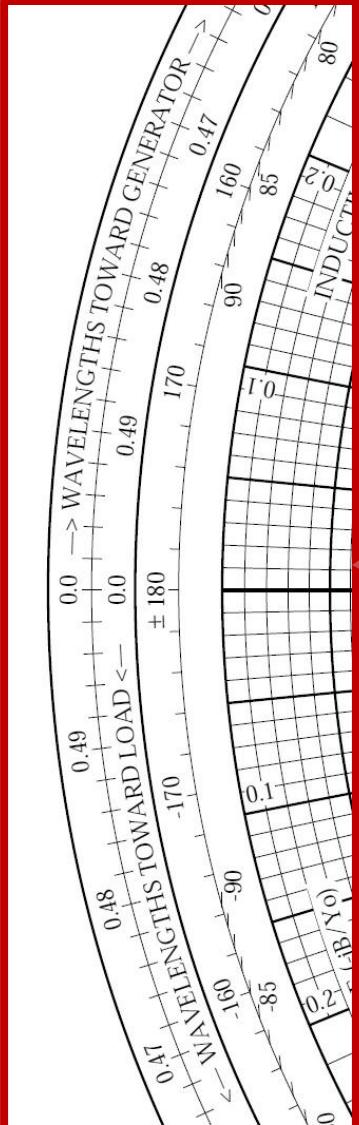
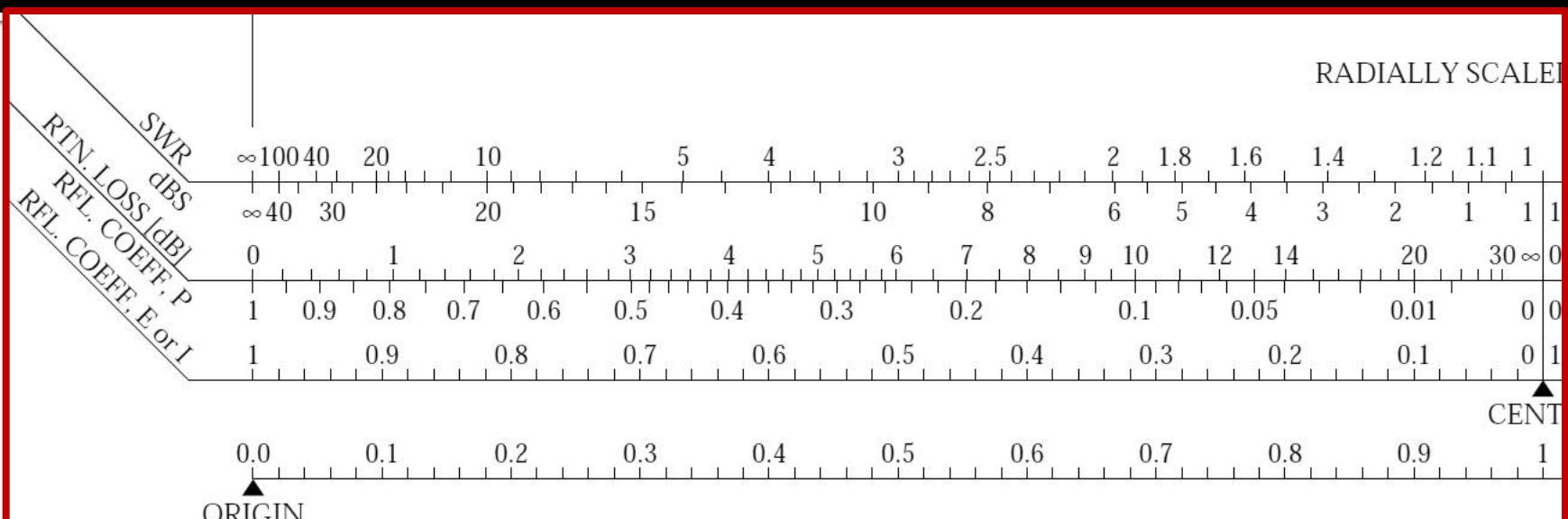


Diagrama Smith



Scaled Parameters

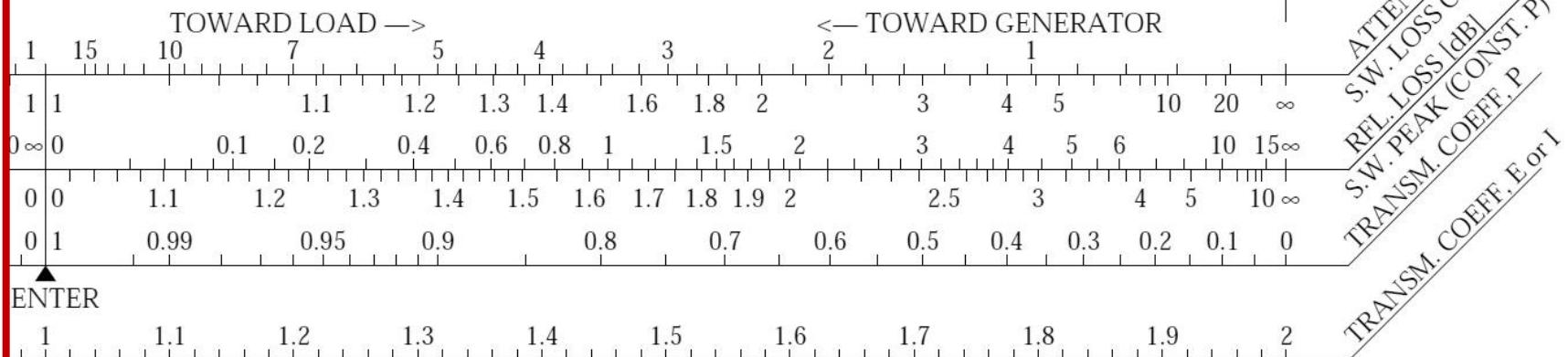


Diagrama Smith

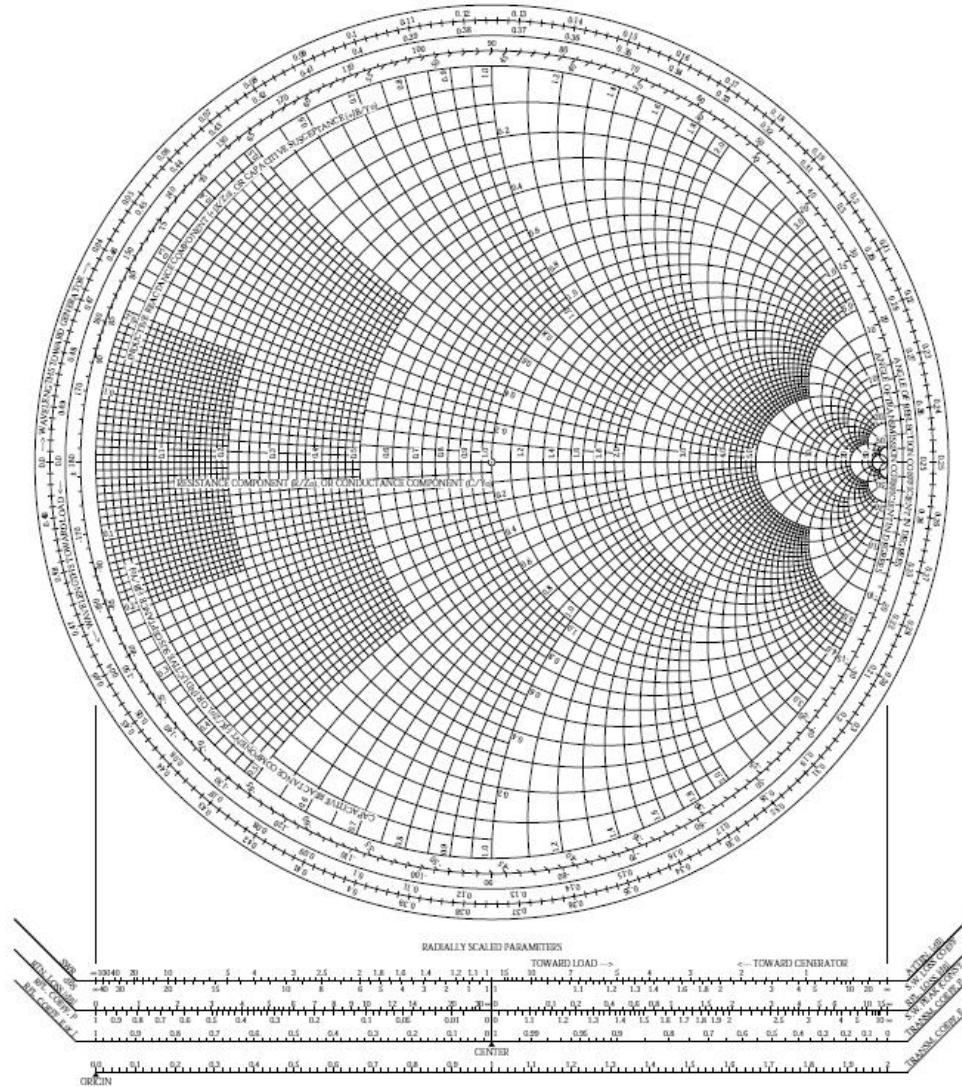
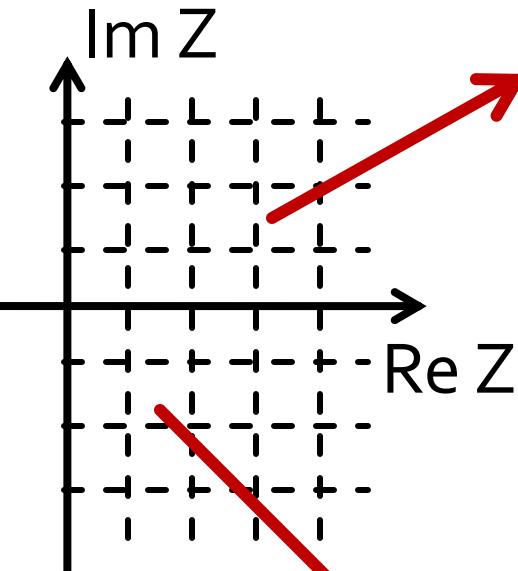
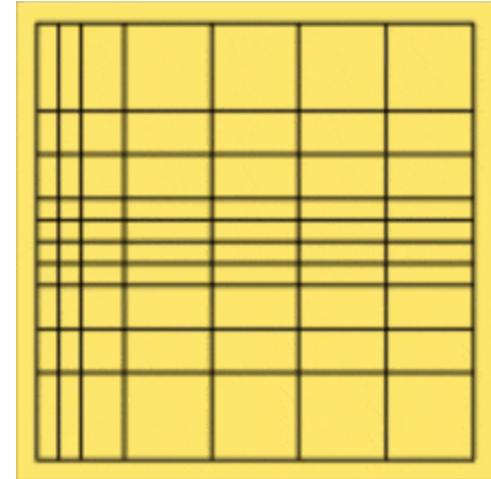


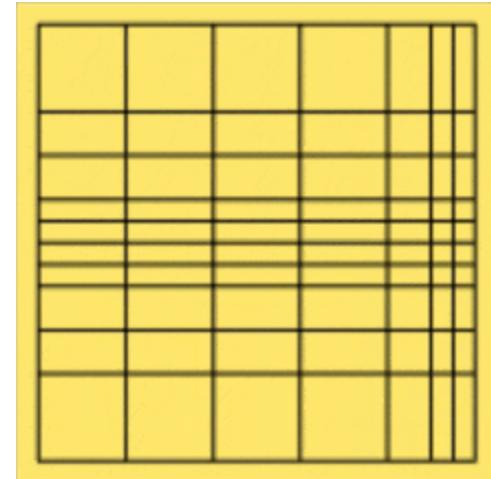
Diagrama Smith



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

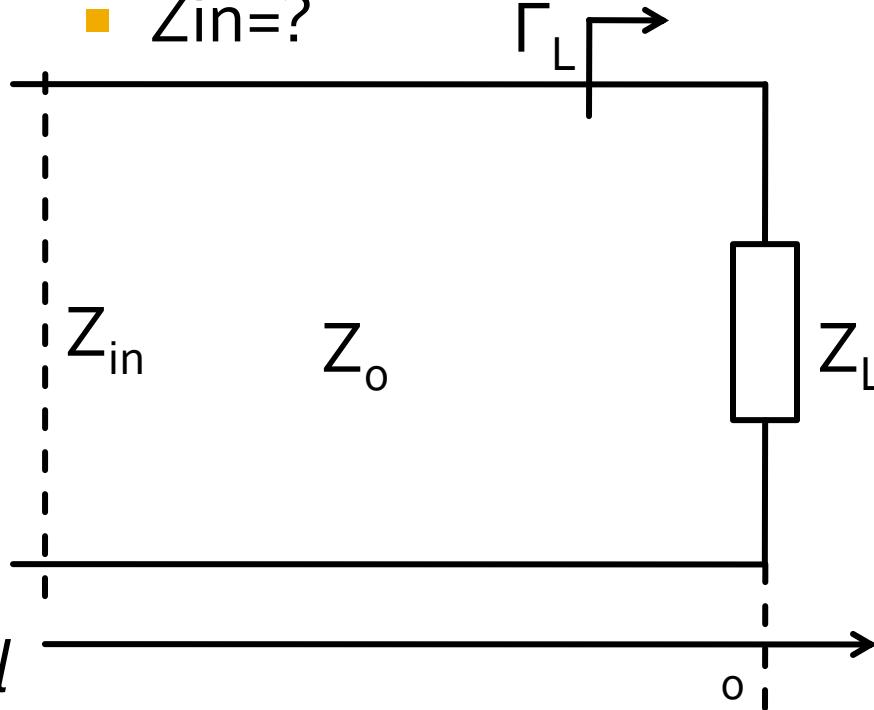


$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{Y_0 - Y_L}{Y_0 + Y_L} = \frac{1 - y_L}{1 + y_L}$$



Utilizare standard

- linie de transmisie
 - 100Ω impedanta caracteristica
 - 0.3λ lungime
 - $Z_L = 40\Omega + j \cdot 70\Omega$
- $Z_{in}=?$



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

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

Utilizare standard

- linie de transmisie

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

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

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

- Plecand din z_L (0.105λ)
- Pana la z_{in} (0.405λ)

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

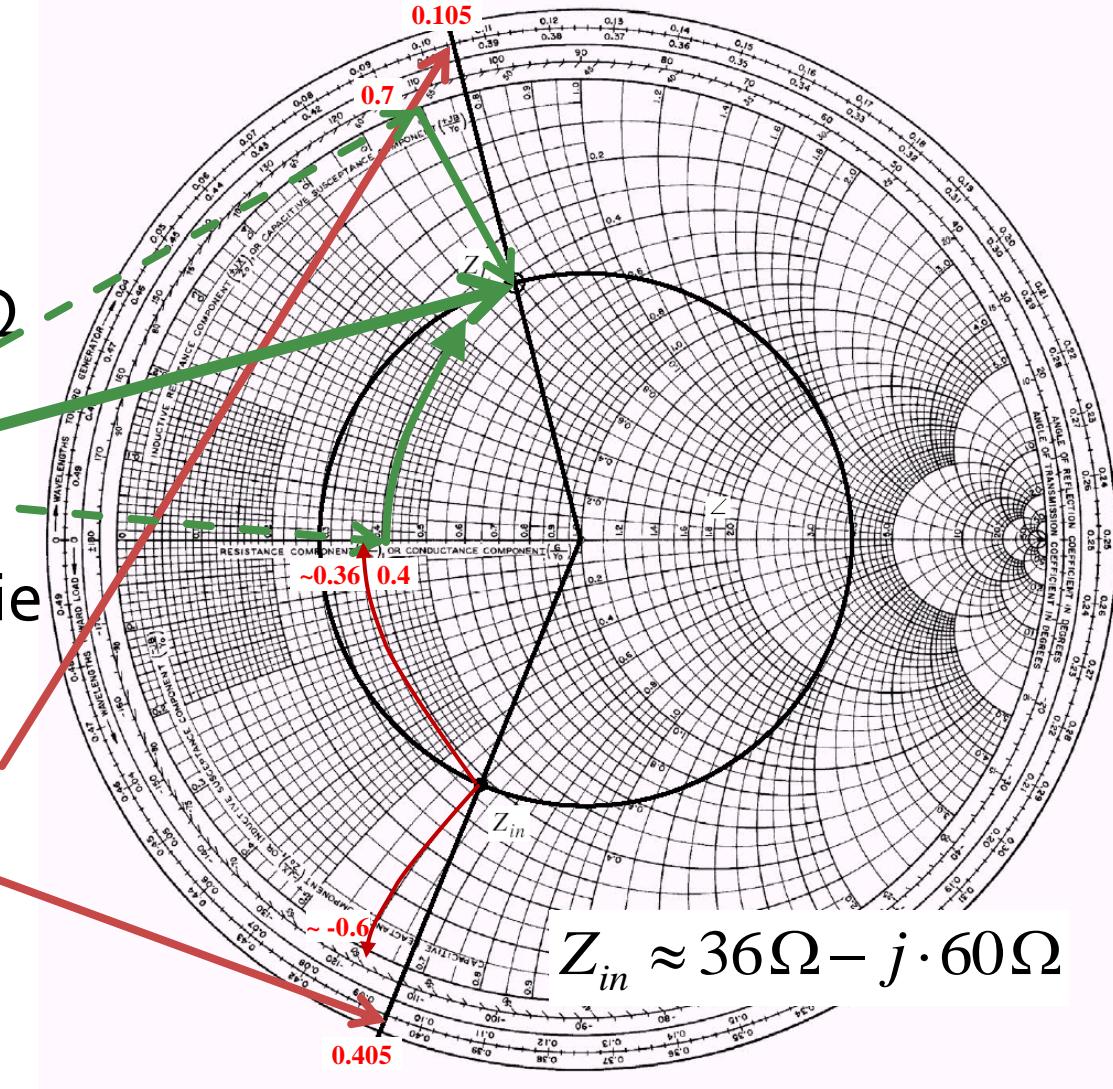


Diagrama Smith

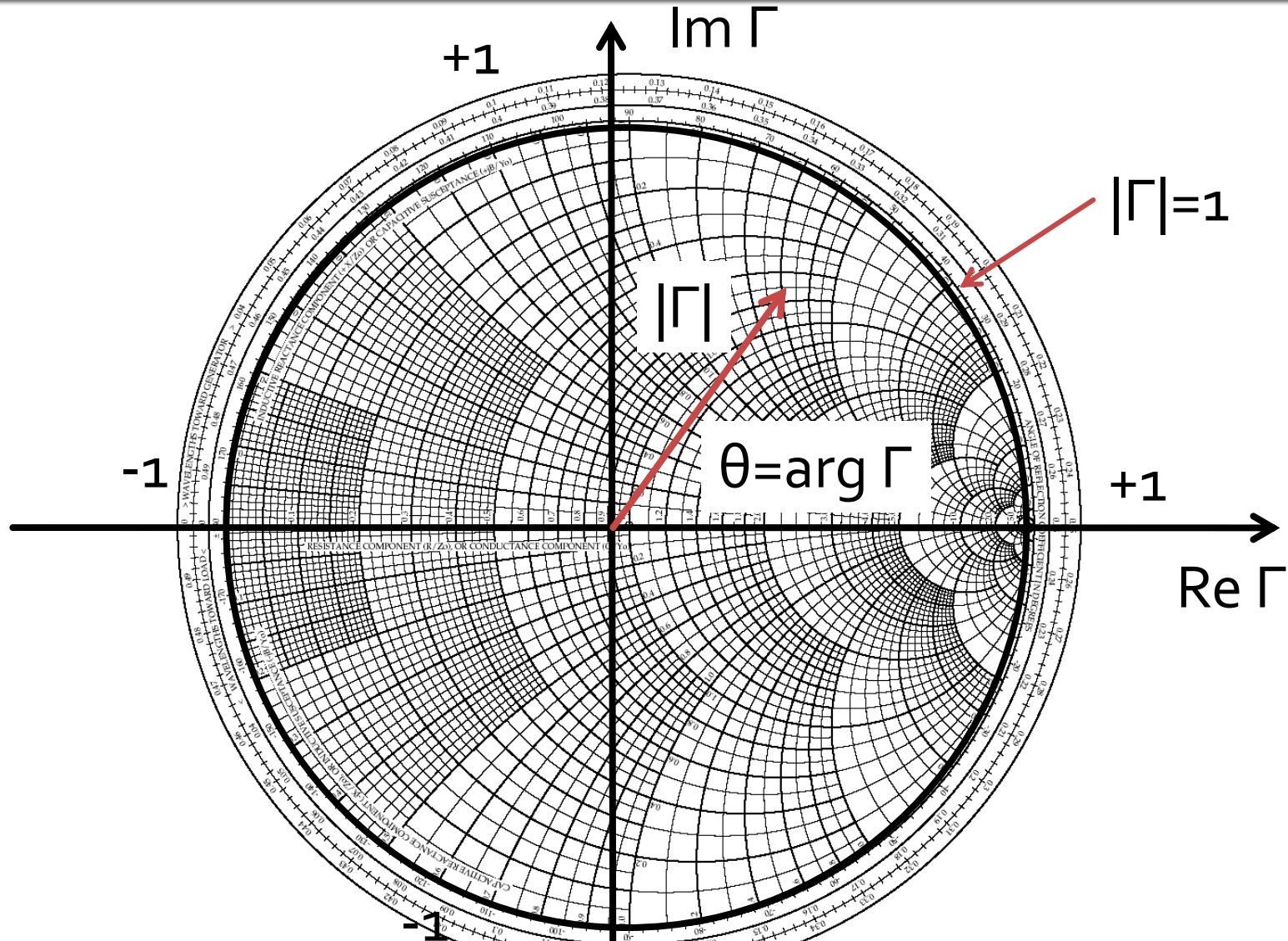


Diagrama Smith

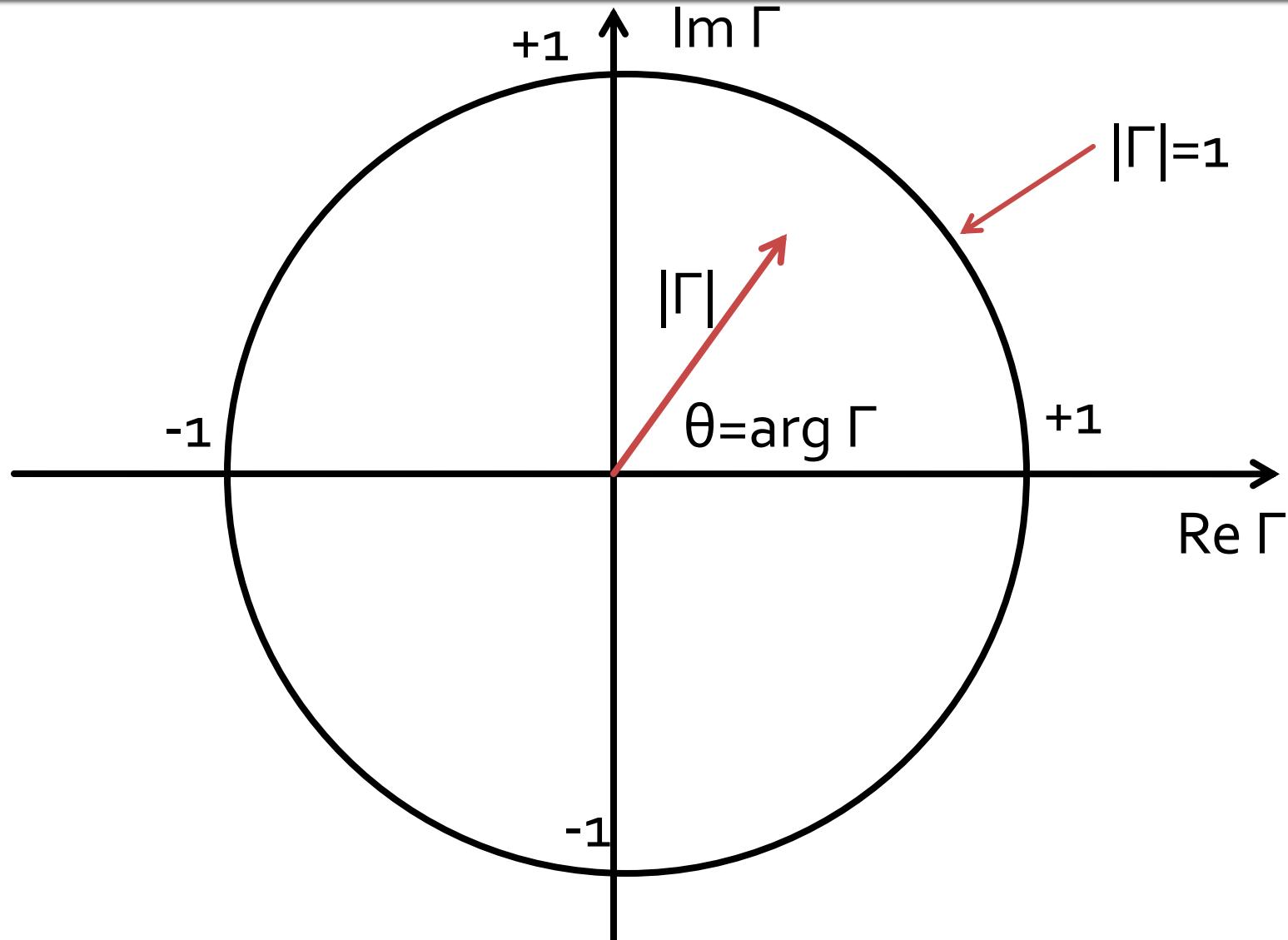
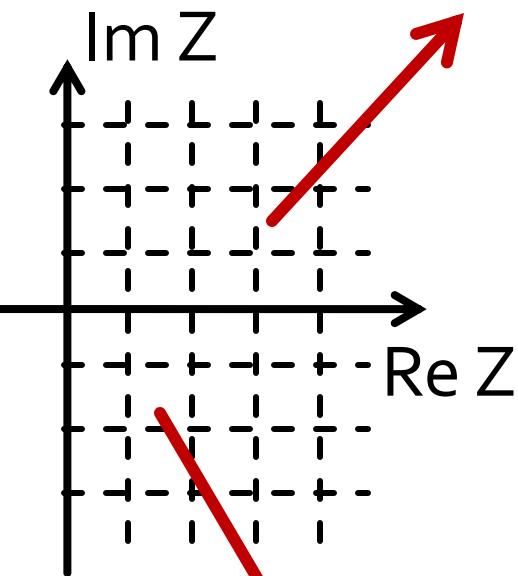


Diagrama Smith

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



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

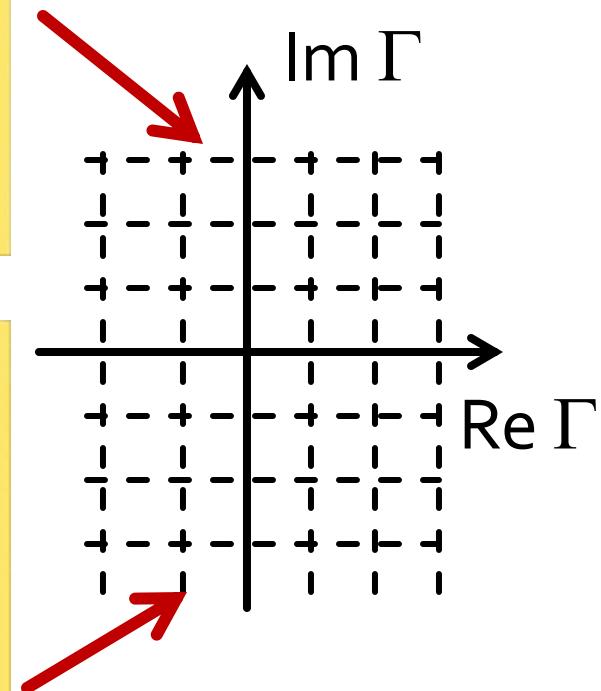
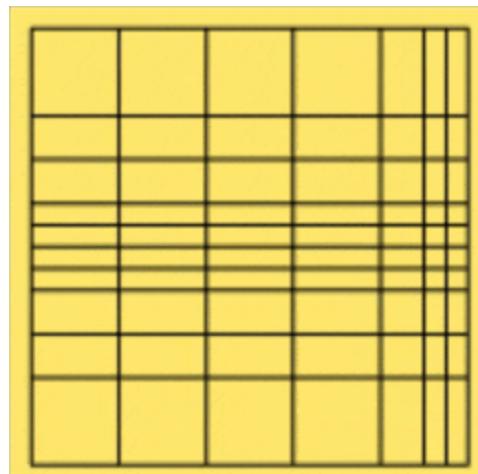
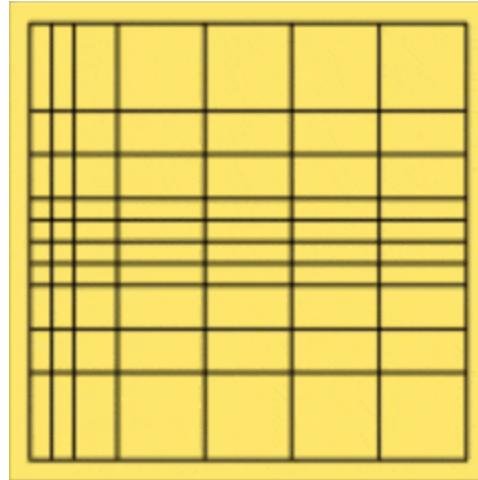
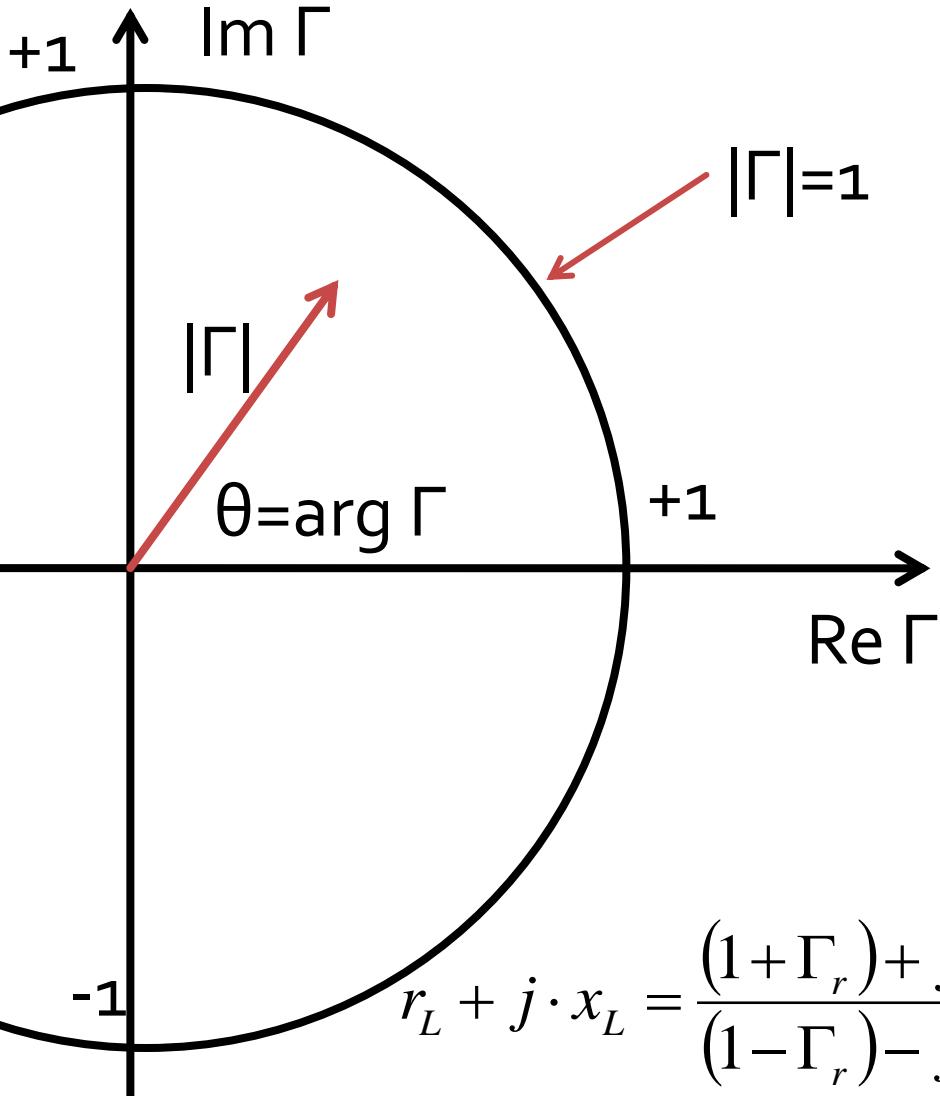


Diagrama Smith



$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{z_L - 1}{z_L + 1} = |\Gamma| \cdot e^{j\theta}$$

$$z_L = \frac{Z_L}{Z_0} \quad y_L = \frac{Y_L}{Y_0} = \frac{Z_0}{Z_L}$$

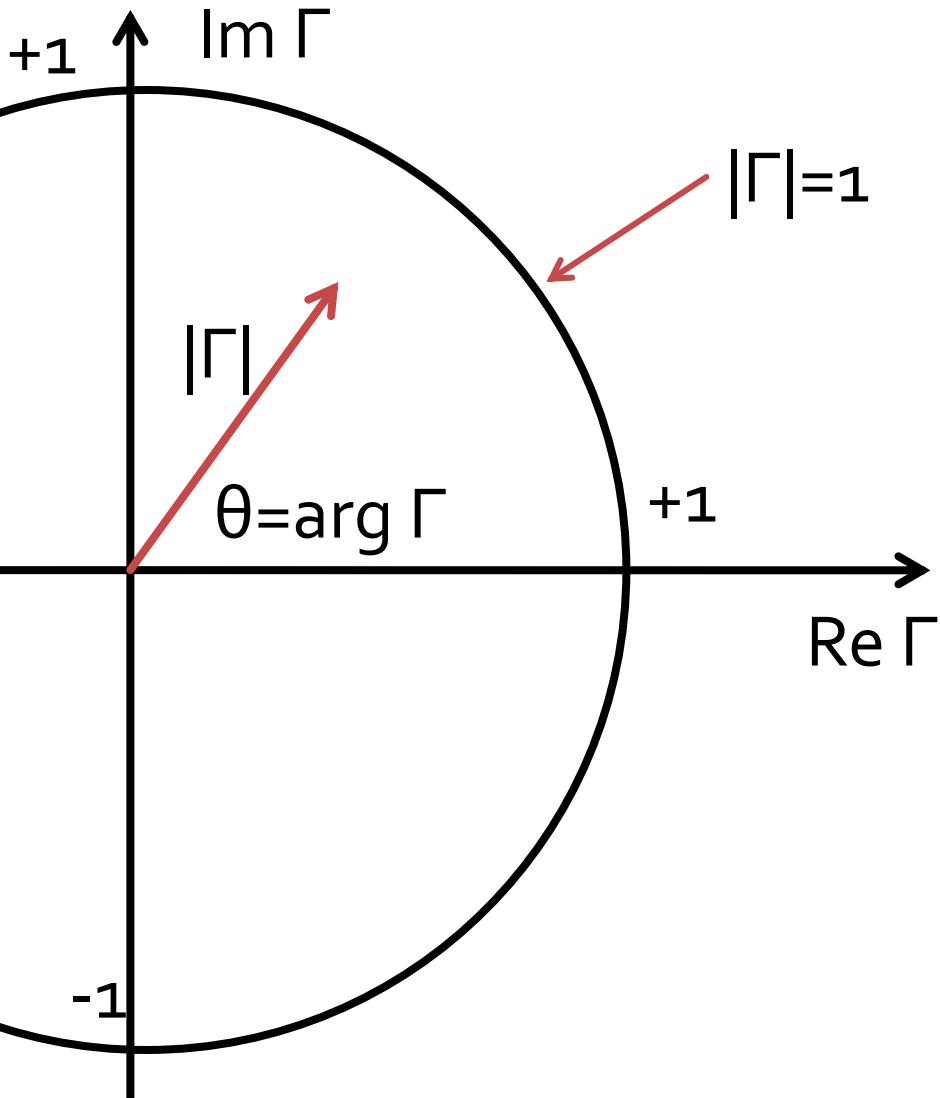
Raportarea $Z_L \rightarrow z_L$ permite utilizarea aceleiasi diagrame pentru oricare impedanta de referinta Z_0 (face reprezentarea independenta de valoarea aleasa pentru Z_0)

$$\Gamma = \Gamma_r + j \cdot \Gamma_i$$

$$z_L = \frac{1 + |\Gamma| \cdot e^{j\theta}}{1 - |\Gamma| \cdot e^{j\theta}} = r_L + j \cdot x_L$$

$$r_L + j \cdot x_L = \frac{(1 + \Gamma_r) + j \cdot \Gamma_i}{(1 - \Gamma_r) - j \cdot \Gamma_i} = \frac{1 - \Gamma_r^2 - \Gamma_i^2}{(1 - \Gamma_r)^2 + \Gamma_i^2} + j \cdot \frac{2 \cdot \Gamma_i}{(1 - \Gamma_r)^2 + \Gamma_i^2}$$

Diagramma Smith



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

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

■ Rearajate

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

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

Diagrama Smith

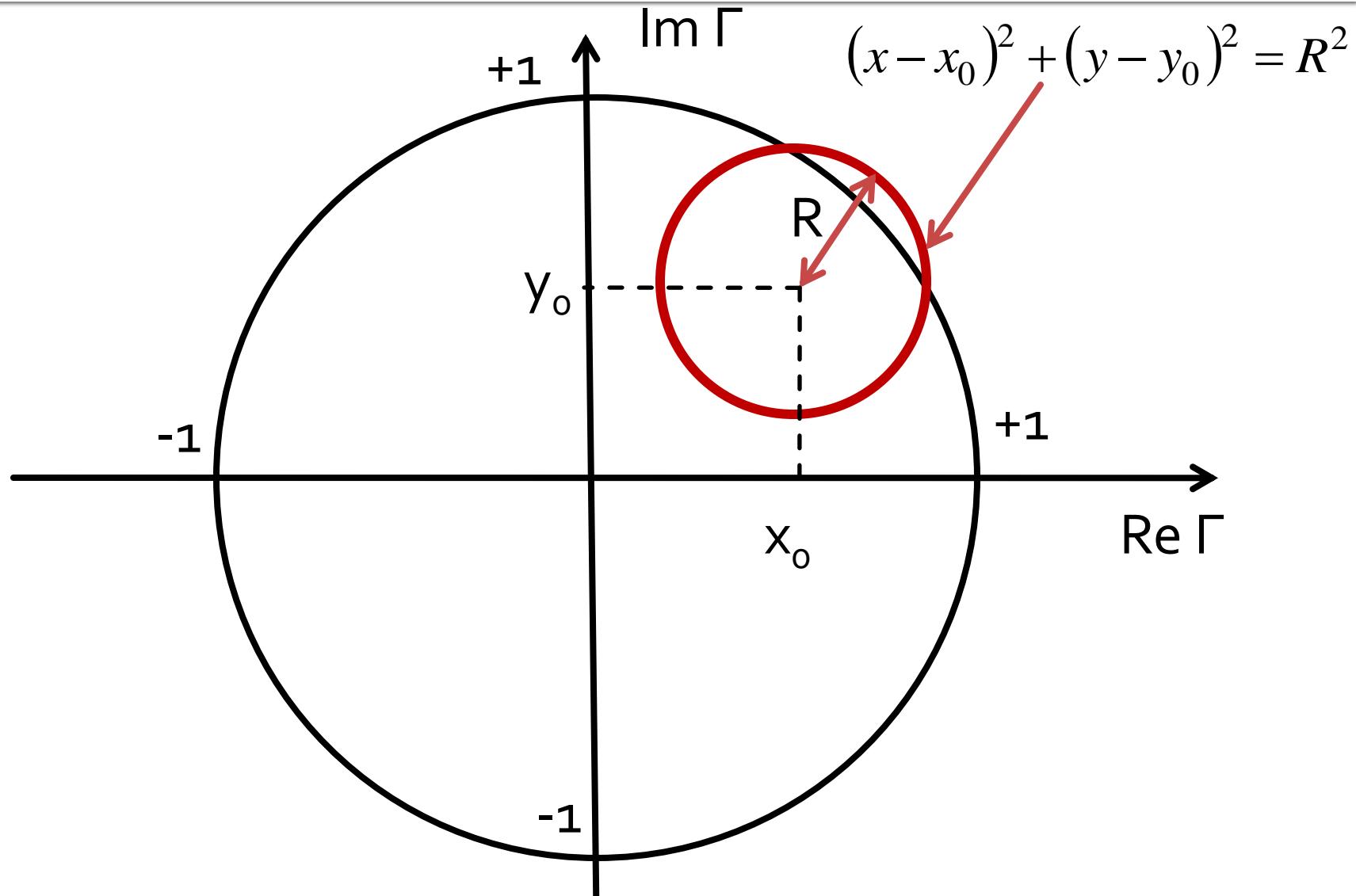
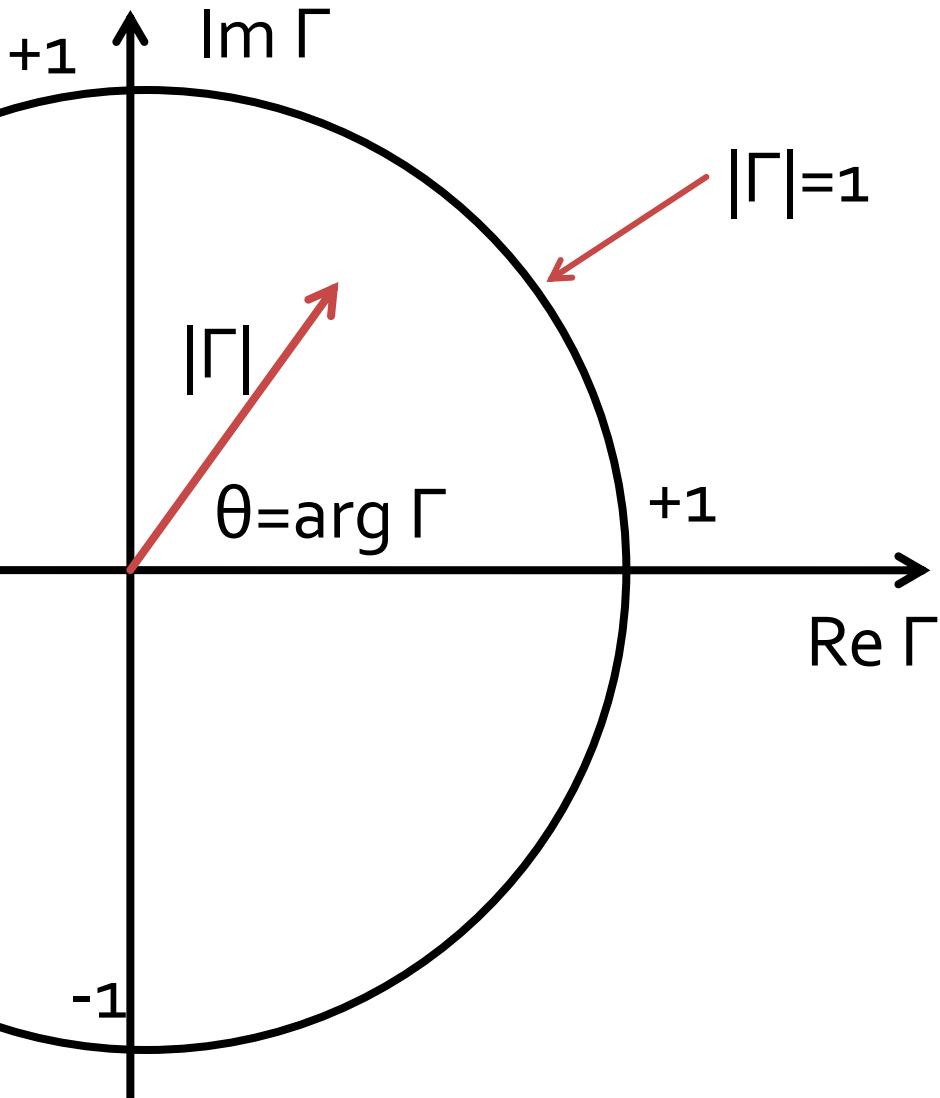


Diagrama Smith



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

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

- Cercuri in planul complex

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

Diagrama Smith, rezistenta

$$\begin{aligned} & \left(\Gamma_r - \frac{r_L}{1+r_L} \right)^2 + \Gamma_i^2 = \left(\frac{1}{1+r_L} \right)^2 \\ \rightarrow & (x-x_0)^2 + (y-y_0)^2 = R^2 \end{aligned}$$

$$\begin{cases} x_0 = \frac{r_L}{1+r_L} \\ y_0 = 0 \\ R = \frac{1}{1+r_L} \end{cases}$$

- Locul geometric al punctelor care pot fi ocupate de impedantele cu rezistenta r_L este un cerc:

- Cu **centrul pe axa reală** ($y_0=0$)

- trece prin punctul **$x=1, y=0$** oricare x_0, r_L

- are raza intre 0 si 1

- tinzand spre 0 cand r_L este mare

- tinzand spre 1 cand r_L este mic

- cand r_L este **1** trece si prin **origine**

$$\left(1 - \frac{r_L}{1+r_L} \right)^2 + 0 = \left(\frac{1}{1+r_L} \right)^2$$

$$\left(0 - \frac{r_L}{1+r_L} \right)^2 = \left(\frac{1}{1+r_L} \right)^2 \Leftrightarrow r_L = 1$$

Diagrama Smith, rezistenta

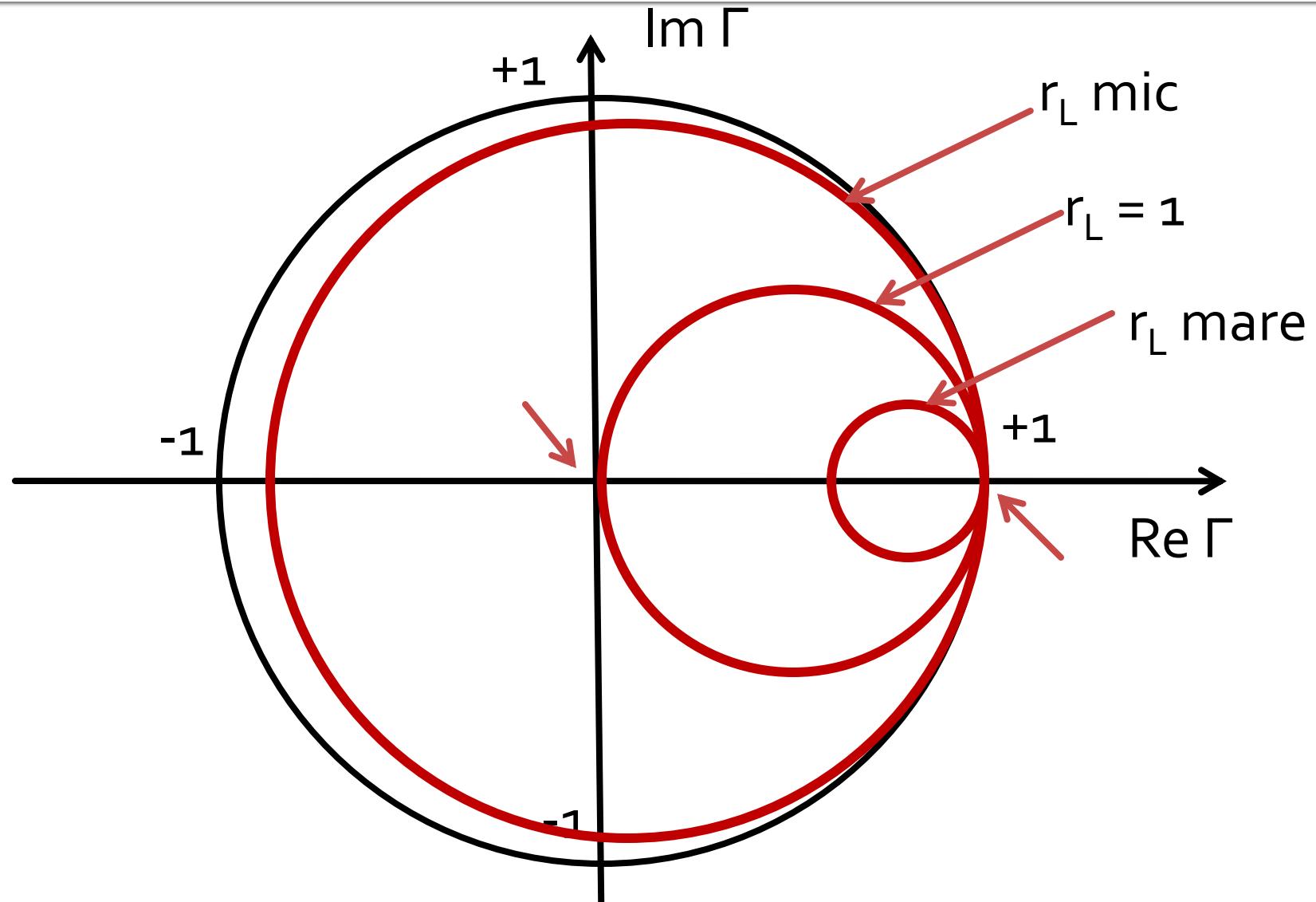


Diagrama Smith, reactanta

$$\begin{array}{l} \text{Circunferinta: } (\Gamma_r - 1)^2 + \left(\Gamma_i - \frac{1}{x_L} \right)^2 = \left(\frac{1}{x_L} \right)^2 \\ \text{Punctul originii: } (x - x_0)^2 + (y - y_0)^2 = R^2 \end{array}$$

$$\left\{ \begin{array}{l} x_0 = 1 \\ y_0 = \frac{1}{x_L} \\ R = \frac{1}{x_L} \end{array} \right.$$

■ Locul geometric al punctelor care pot fi ocupate de impedantele cu reactanta x_L este un cerc:

- Cu **centrul pe o dreapta paralela cu axa imaginara** ($x_0=1$)
- trece prin punctul **$x=1, y=0$** oricare x_0, x_L
- are raza intre 0 si ∞
 - tinzand spre 0 cand $|x_L|$ este mare
 - tinzand spre ∞ cand $|x_L|$ este mic
- cand x_L este **0**, la limita se transforma in **axa reala**
- daca $x_L > 0$ cercul e deasupra axei reale, altfel e sub axa reala

$$0 + \left(0 - \frac{1}{x_L} \right)^2 = \left(\frac{1}{x_L} \right)^2$$

Diagrama Smith, reactanta

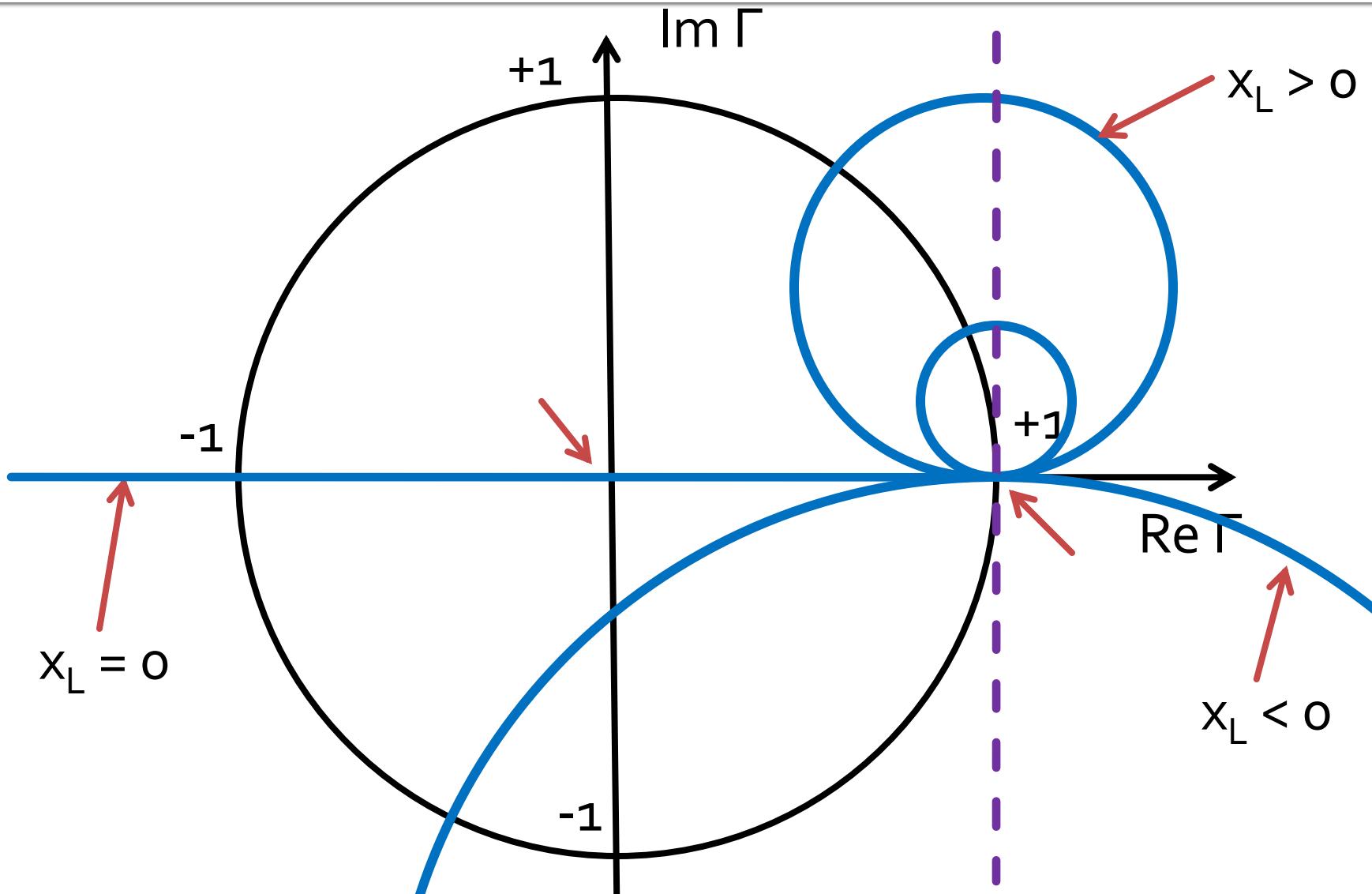


Diagrama Smith, impedanta

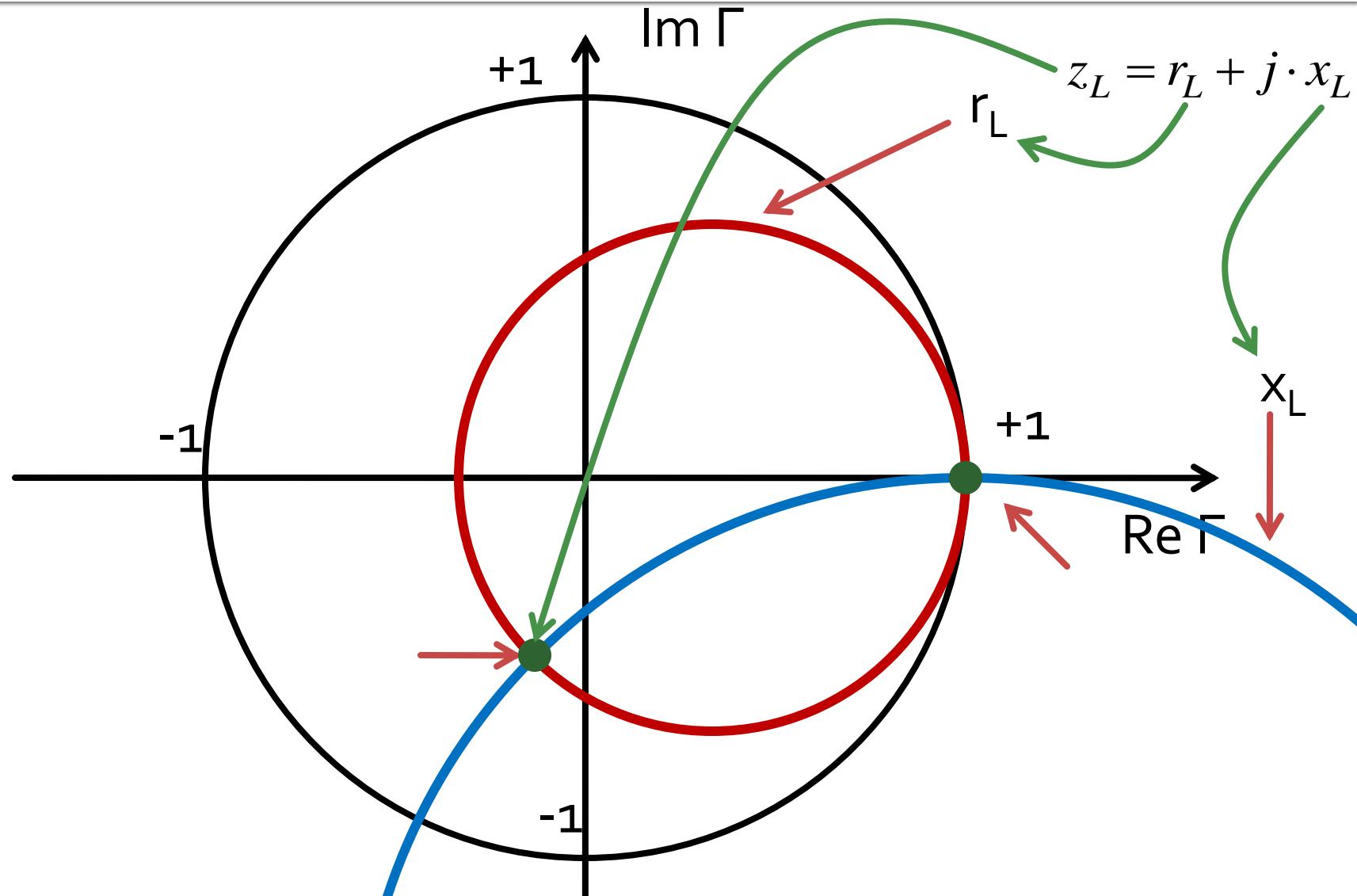


Diagrama Smith, coeficient de reflexie, coordonate rectangulare

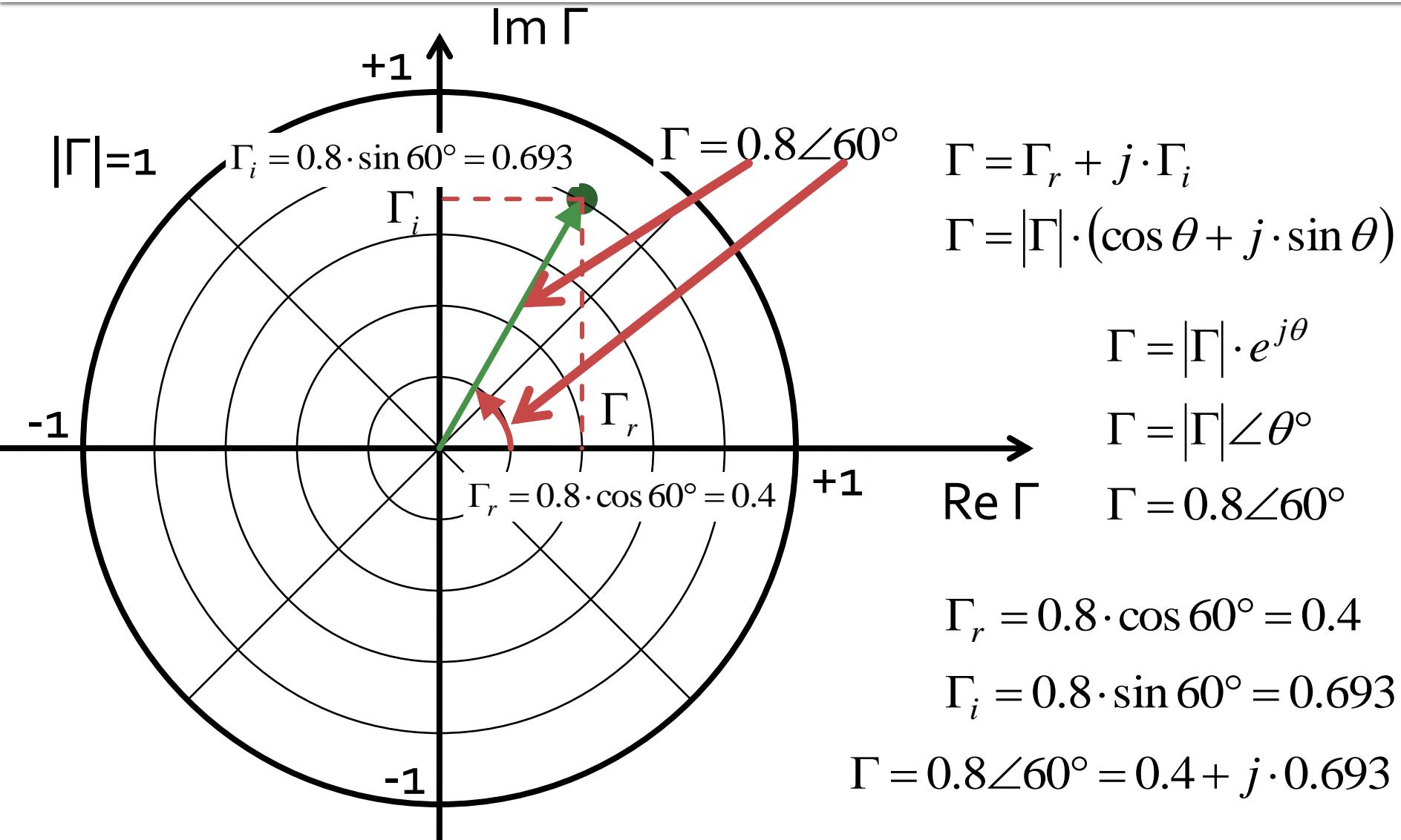
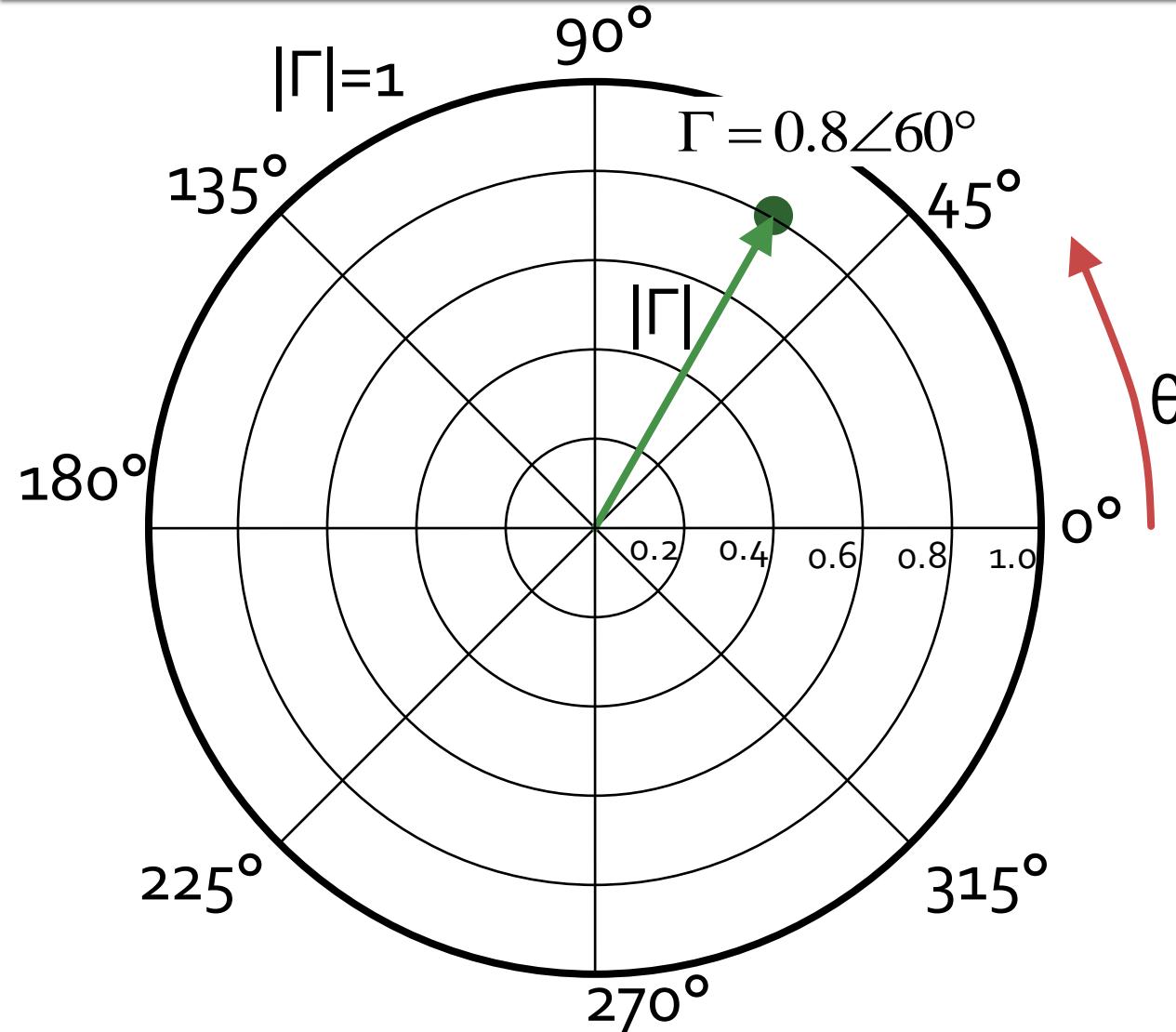


Diagrama Smith, coeficient de reflexie, coordonate polare



$$\Gamma = \Gamma_r + j \cdot \Gamma_i$$

$$\Gamma = |\Gamma| \cdot (\cos \theta + j \cdot \sin \theta)$$

$$\Gamma = |\Gamma| \cdot e^{j\theta}$$

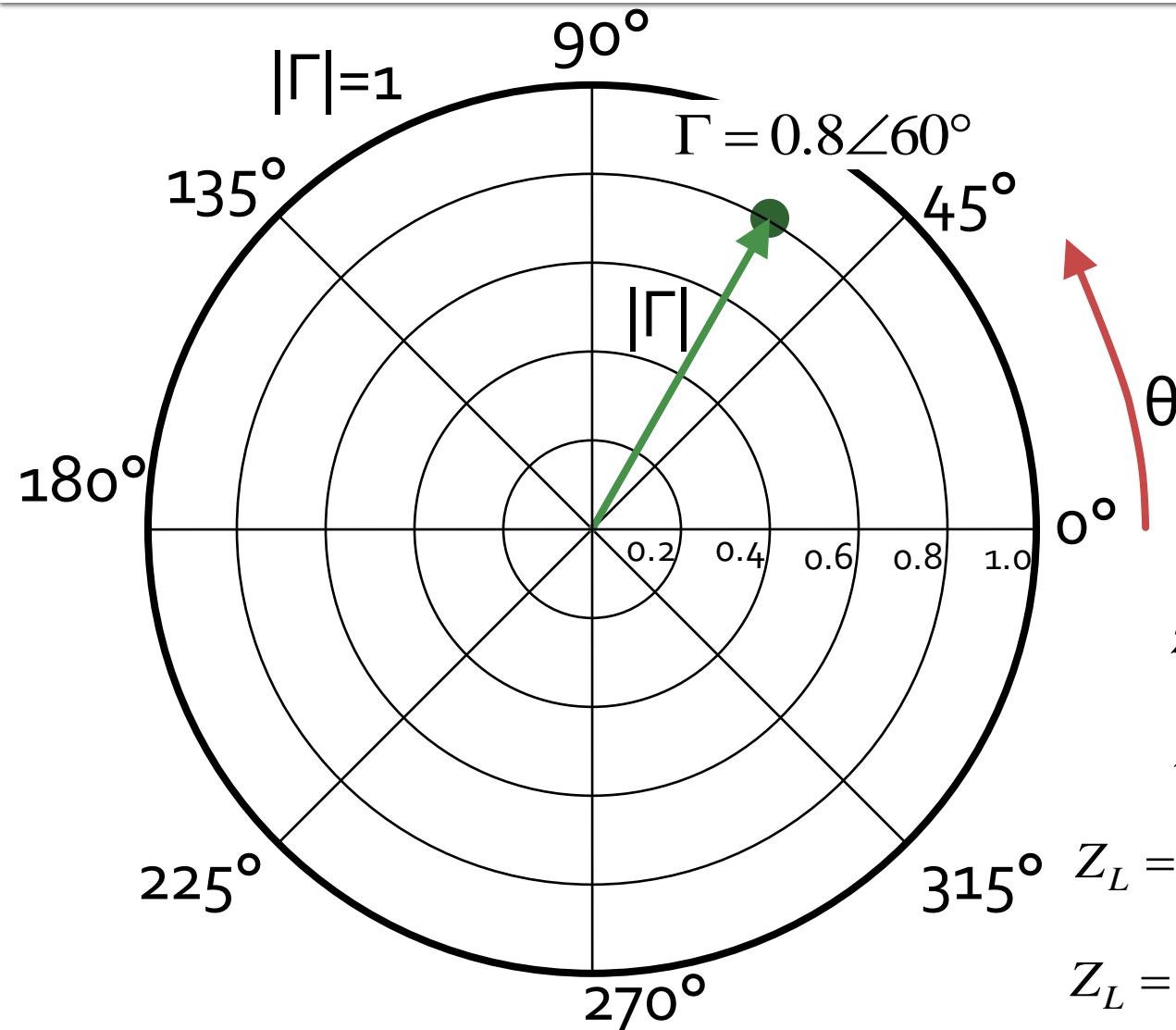
$$\Gamma = |\Gamma| \angle \theta^\circ$$

$$\Gamma = 0.8 \angle 60^\circ$$

$$\Gamma_r = 0.8 \cdot \cos 60^\circ = 0.4$$

$$\Gamma_i = 0.8 \cdot \sin 60^\circ = 0.693$$

Diagrama Smith, coeficient de reflexie, impedanta



$$\Gamma = |\Gamma| \cdot e^{j\theta}$$

$$\Gamma = |\Gamma| \angle \theta^\circ$$

$$\Gamma = 0.8 \angle 60^\circ$$

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

$$z_L = \frac{1 + \Gamma}{1 - \Gamma} = \frac{1 + 0.8 \angle 60^\circ}{1 - 0.8 \angle 60^\circ}$$

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

$$Z_L = Z_0 \cdot \frac{1 + \Gamma}{1 - \Gamma} = 50\Omega \cdot \frac{1 + 0.8 \angle 60^\circ}{1 - 0.8 \angle 60^\circ}$$

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

Echivalenta coeficient de reflexie \Leftrightarrow impedanta

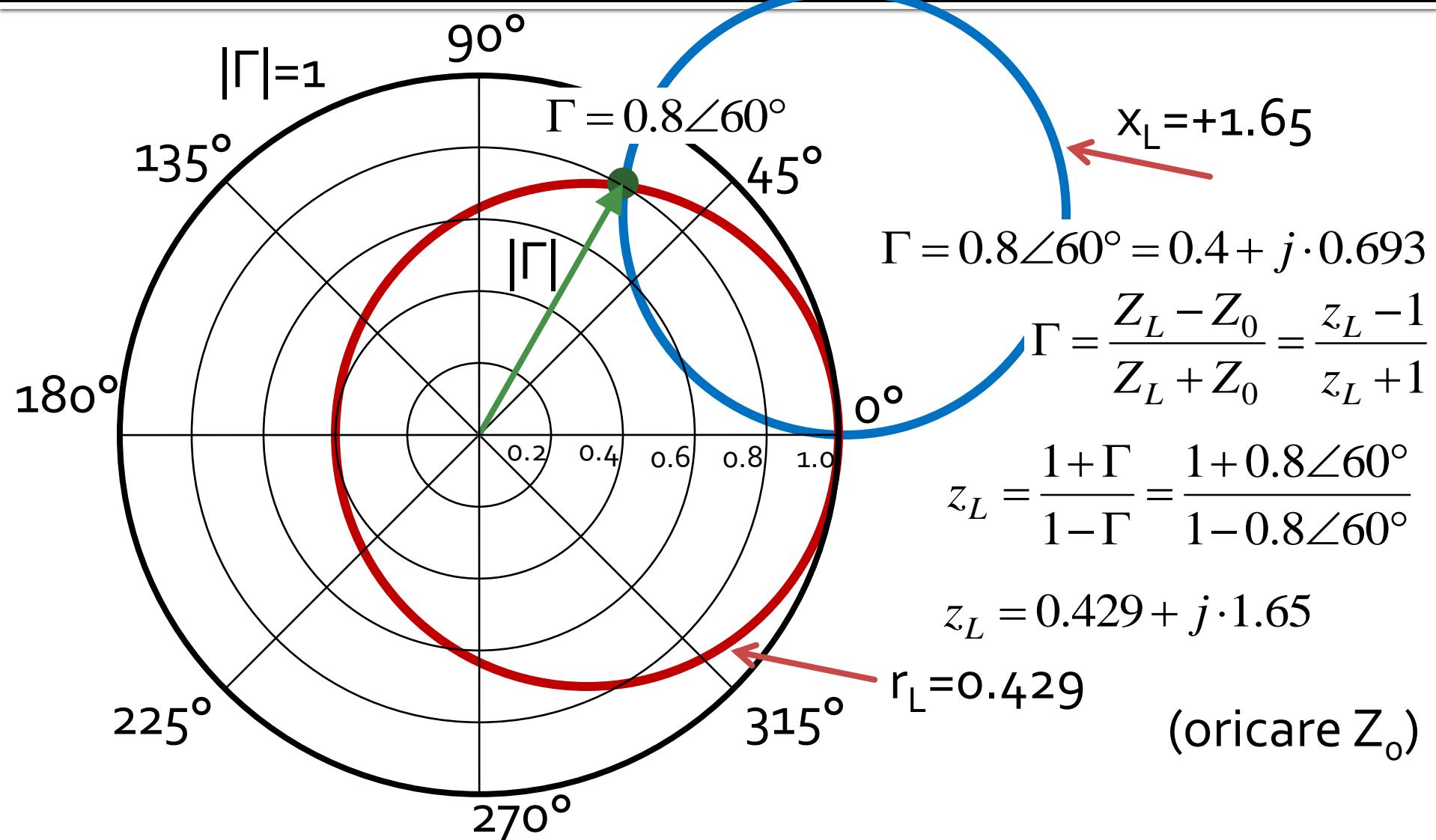


Diagrama Smith, coeficient de reflexie \leftrightarrow impedanta

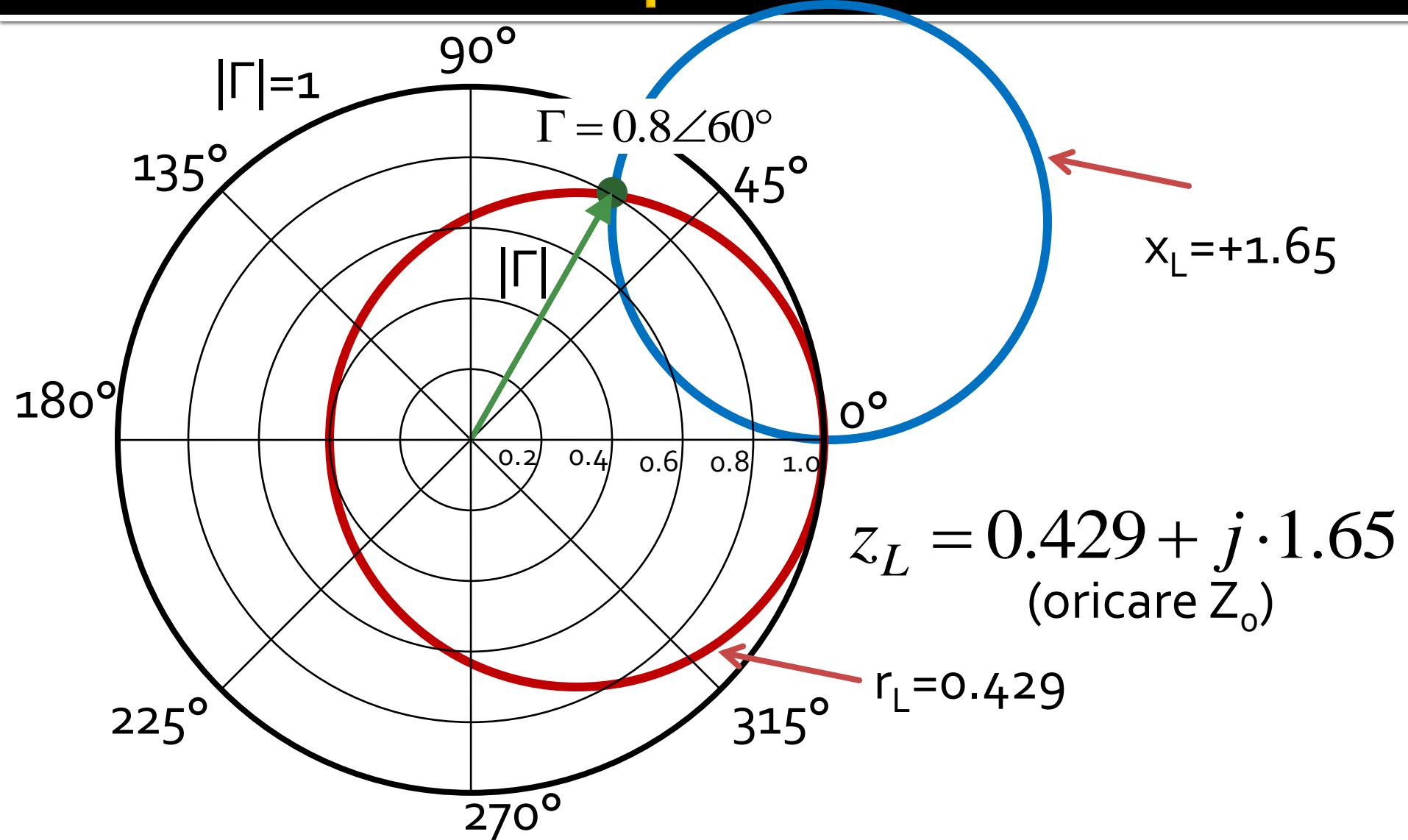
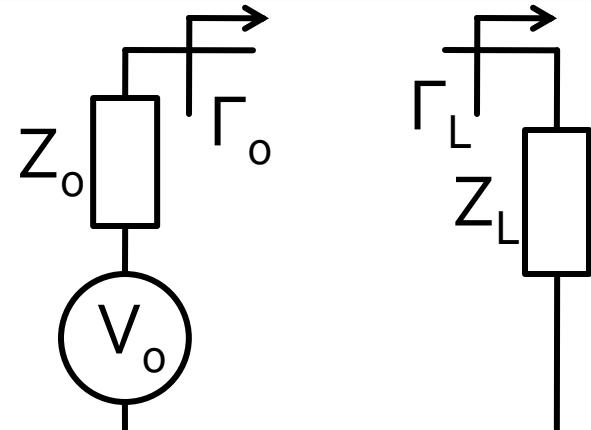
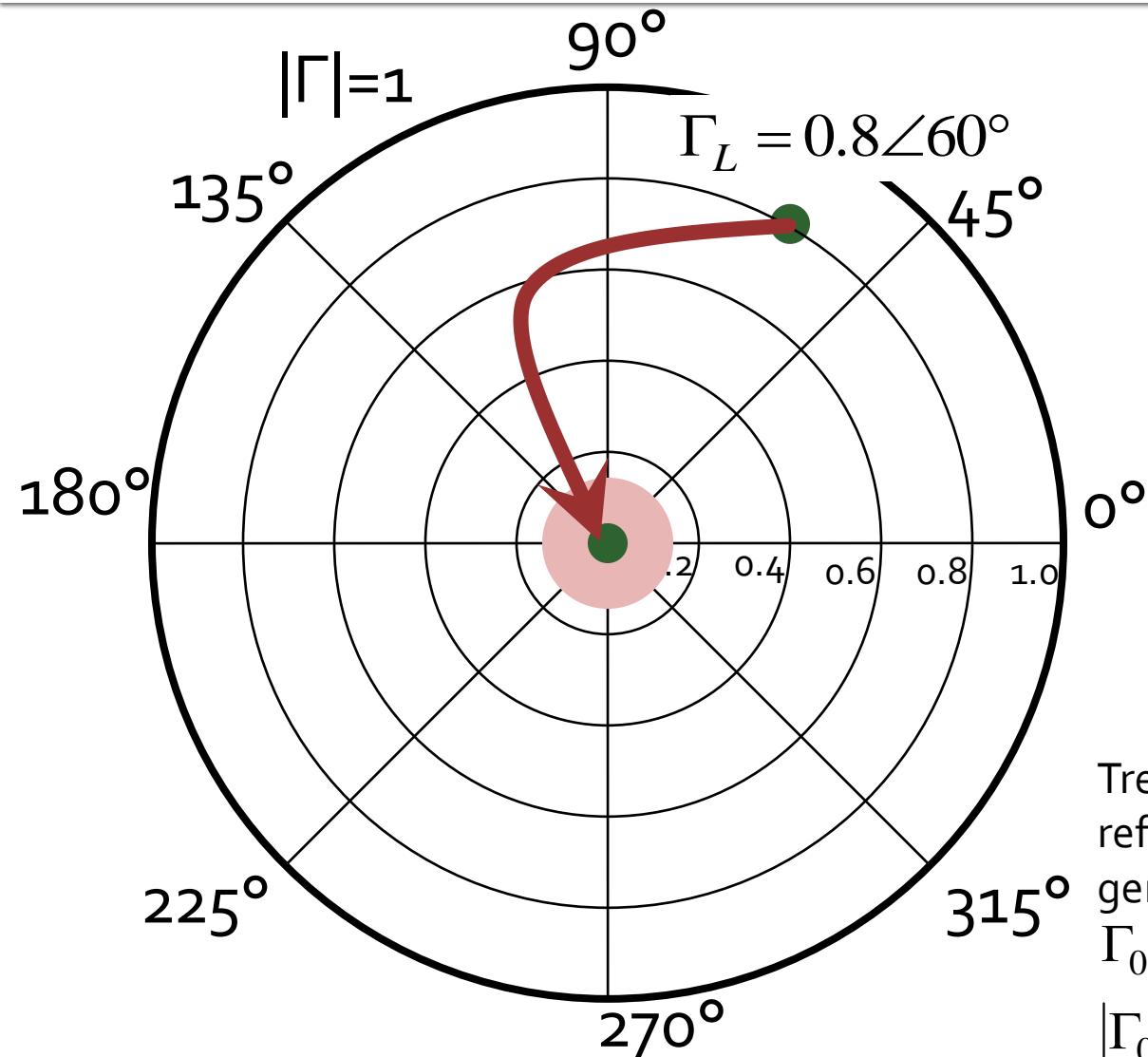


Diagrama Smith, coeficient de reflexie, adaptare



Adaptare Z_L la Z_0 . Se raporteaza Z_L la Z_0

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

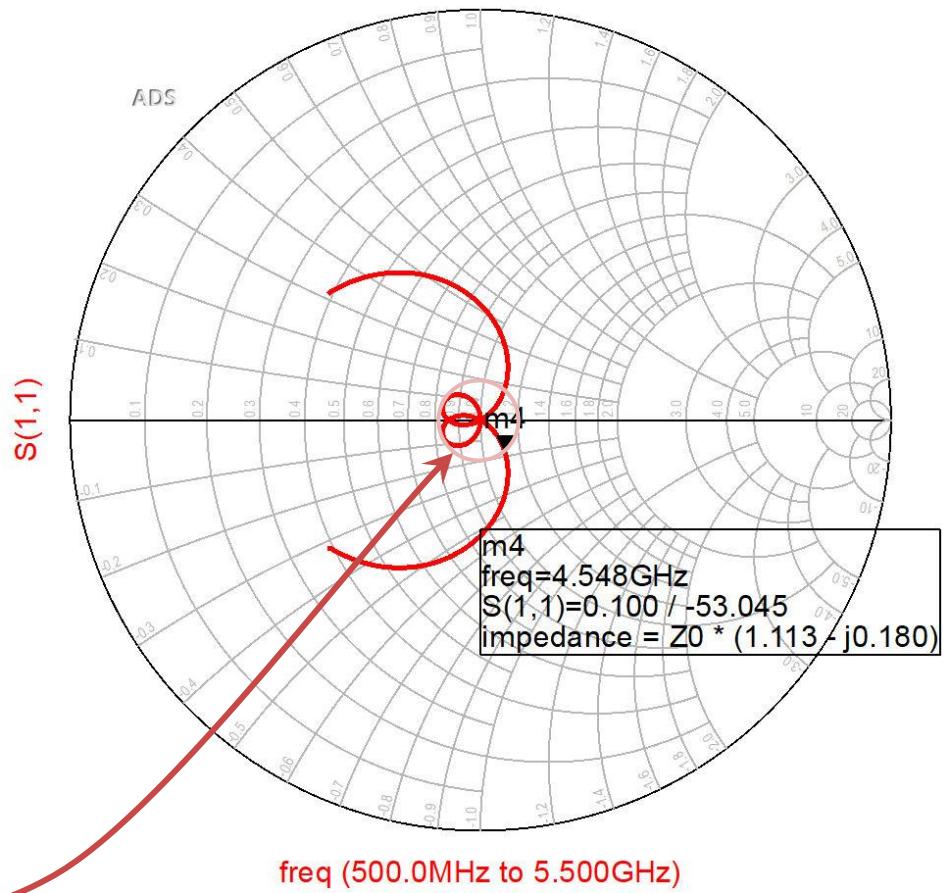
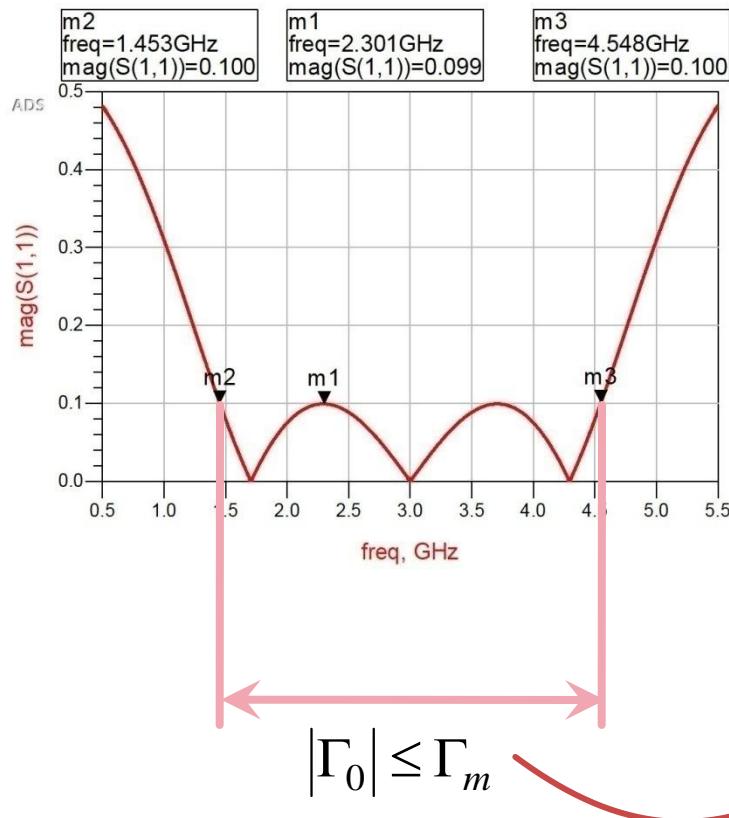
Trebuie sa deplasez coeficientul de reflexie in zona in care pentru generator cu Z_0 am:

$\Gamma_0 = 0$ adaptare perfecta

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

Simulare

■ Similar Lab. 1



Simulare

■ Similar Lab. 1

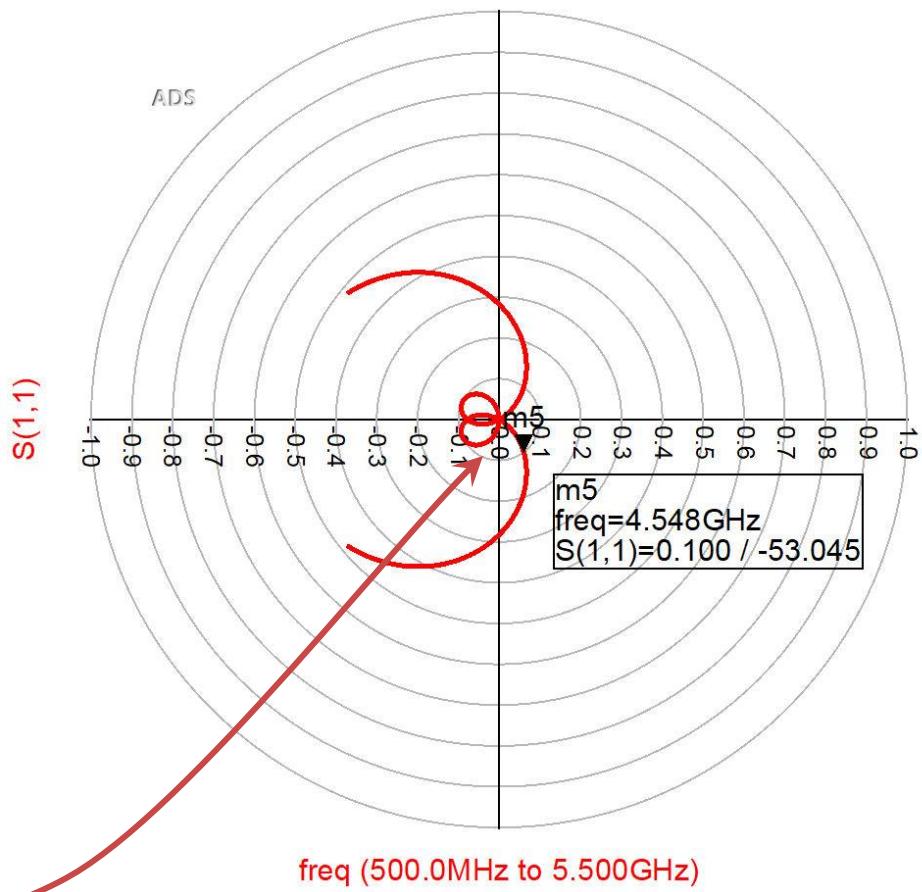
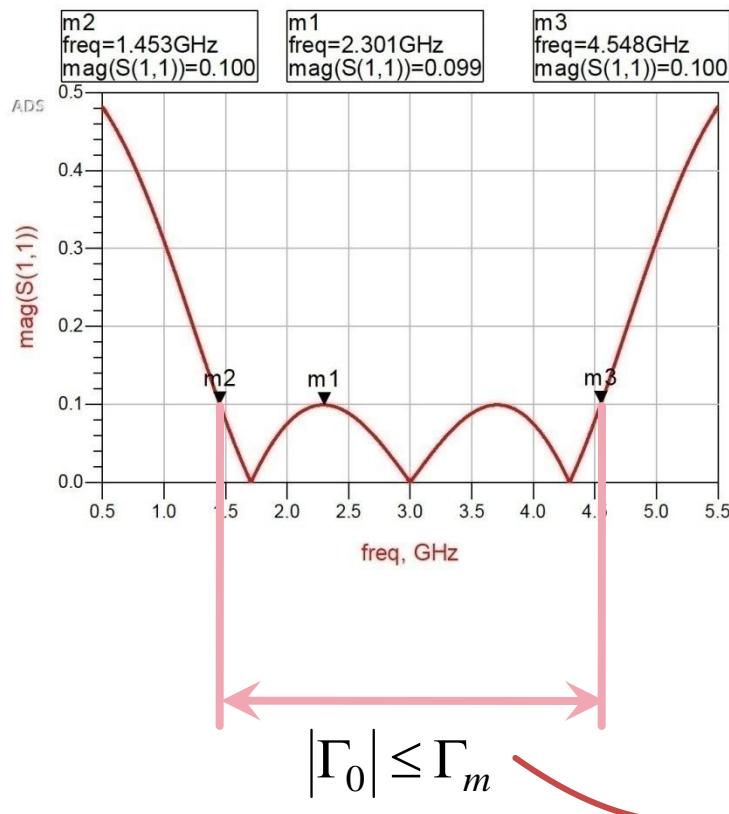
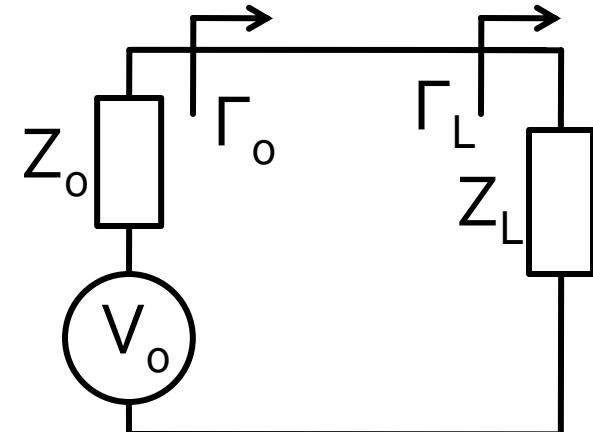
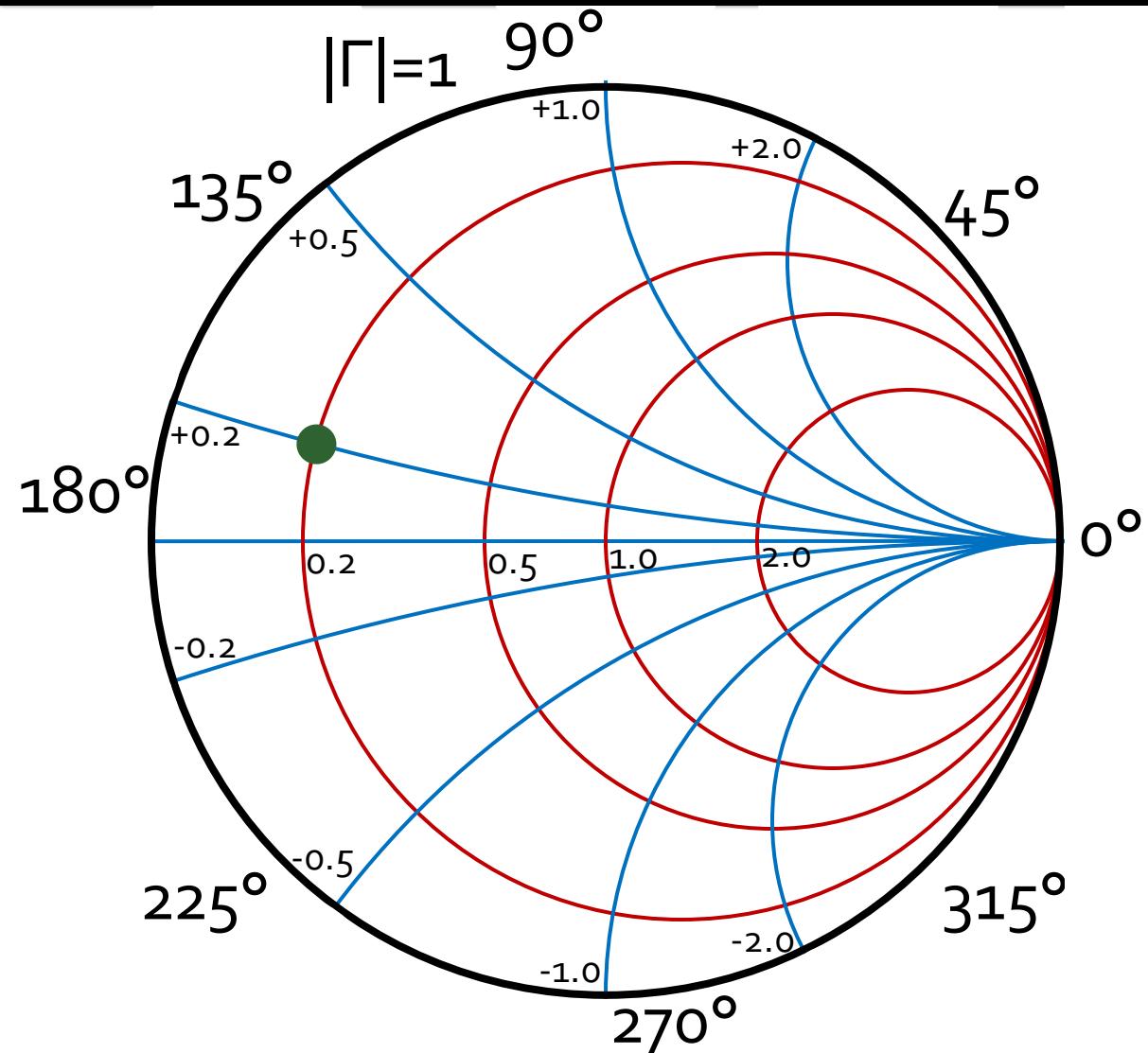


Diagrama Smith, coeficient de reflexie



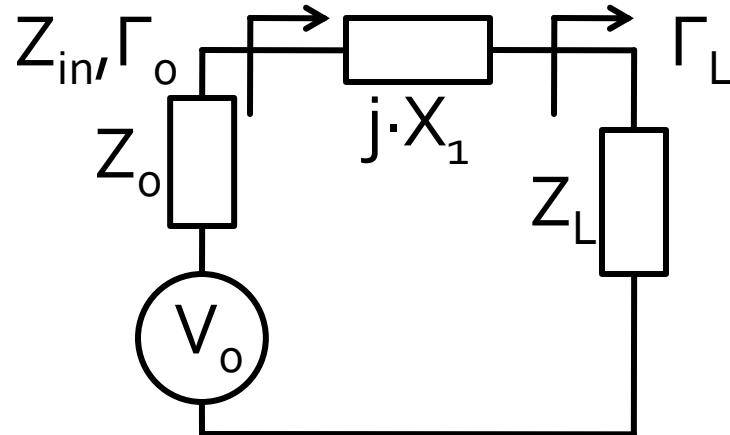
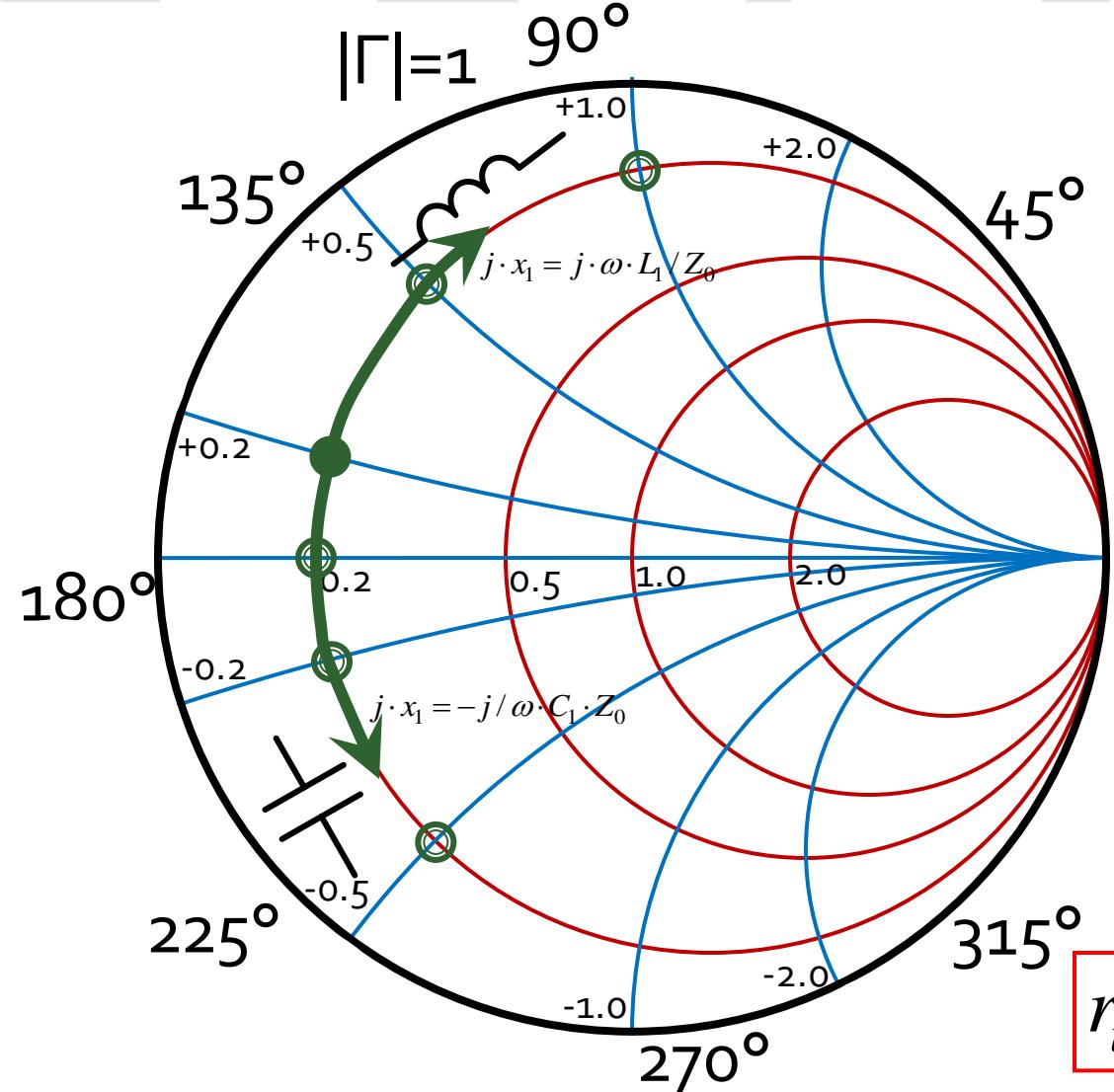
$$Z_0 = 50\Omega$$

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

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

$$\Gamma_L = \Gamma_0 = 0.678 \angle 156.5^\circ$$

Diagrama Smith, coeficient de reflexie, reactanta in serie



$$Z_0 = 50\Omega$$

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

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

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

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

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

$$r_{in} = r_L$$

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

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

ADS, Diagrama Smith, reactanta in serie

The image shows the Advanced Design System (ADS) interface. On the left, a schematic diagram of a series RLC circuit is displayed. The circuit consists of two resistors (Term1, Term3), one capacitor (C1), and one inductor (L1). The component values are labeled as terms:

- Term1: Num=1, Z=50 Ohm
- Term3: Num=3, Z=50 Ohm
- C1: C=1 pF {t}
- L1: L=1 nH {t}
- Term2: Num=2, Z=10+j*10
- Term4: Num=4, Z=10+j*10
- Term5: Num=5, Z=50 Ohm
- Term6: Num=6, Z=10+j*10

Below the schematic, an "S-PARAMETERS" button is visible, along with the text "S_Param SP1 Freq=1.0 GHz".

On the right, a "Tune Parameters" dialog box is open, showing the parameters for the components C1 and L1. The dialog box has the following settings:

Parameter	Value	Max	Min	Step	Scale
C1.C (pF)	39.605	50	0.5	0.1	Lin
L1.L (nH)	0.895	40	0.5	0.1	Lin

ADS, Diagramma Smith, reactanta in serie

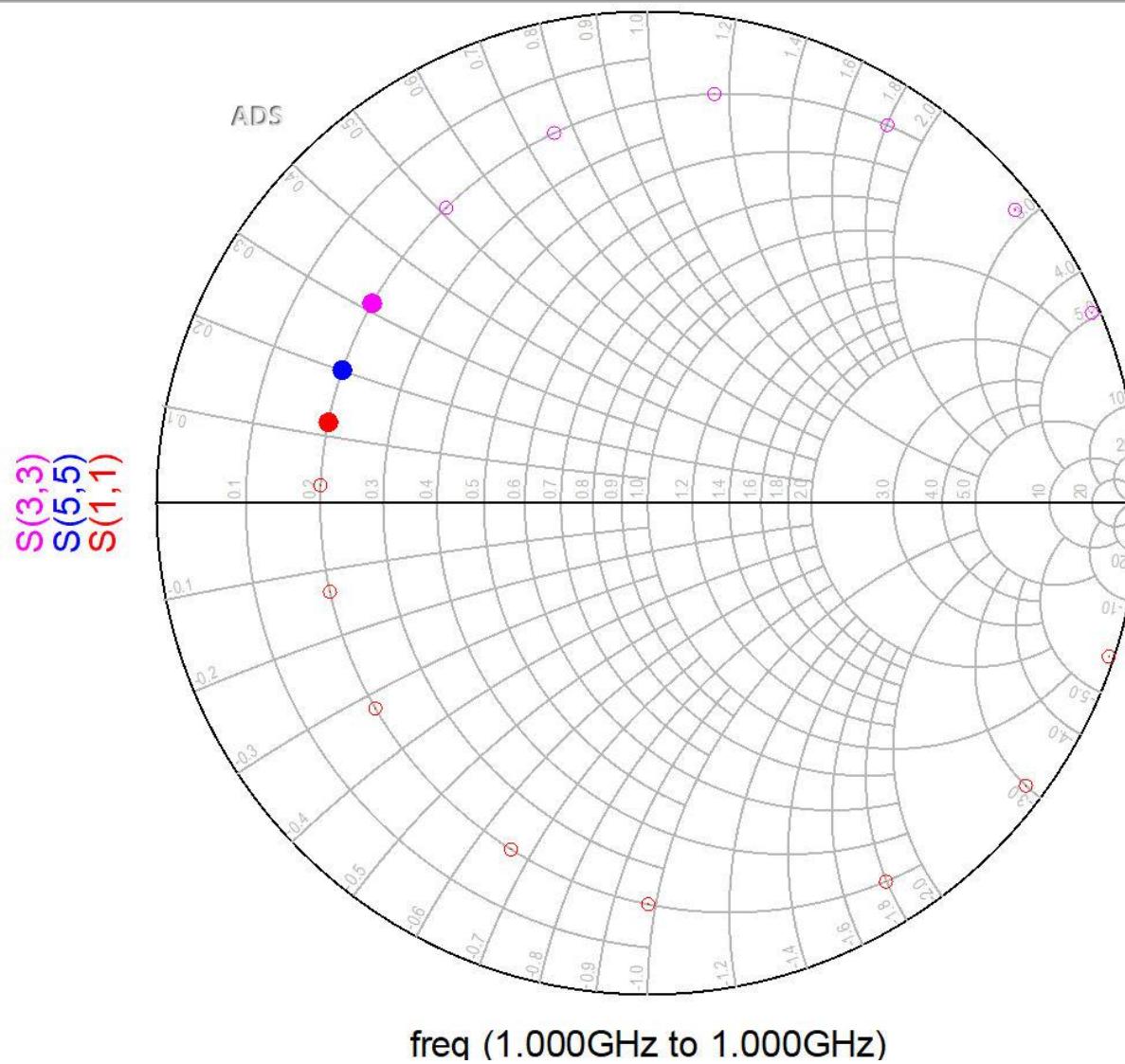
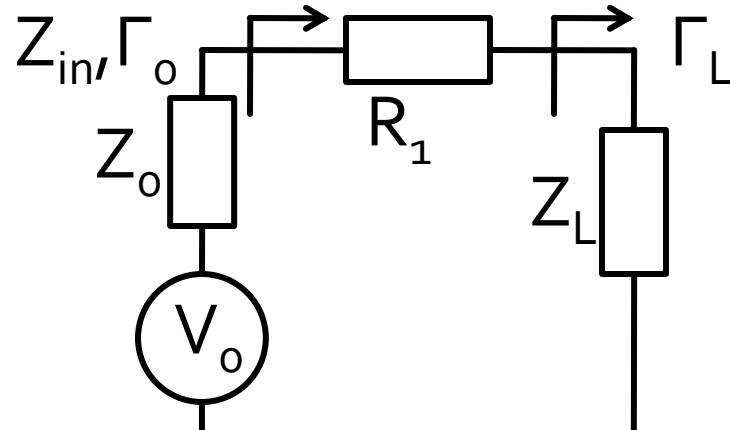
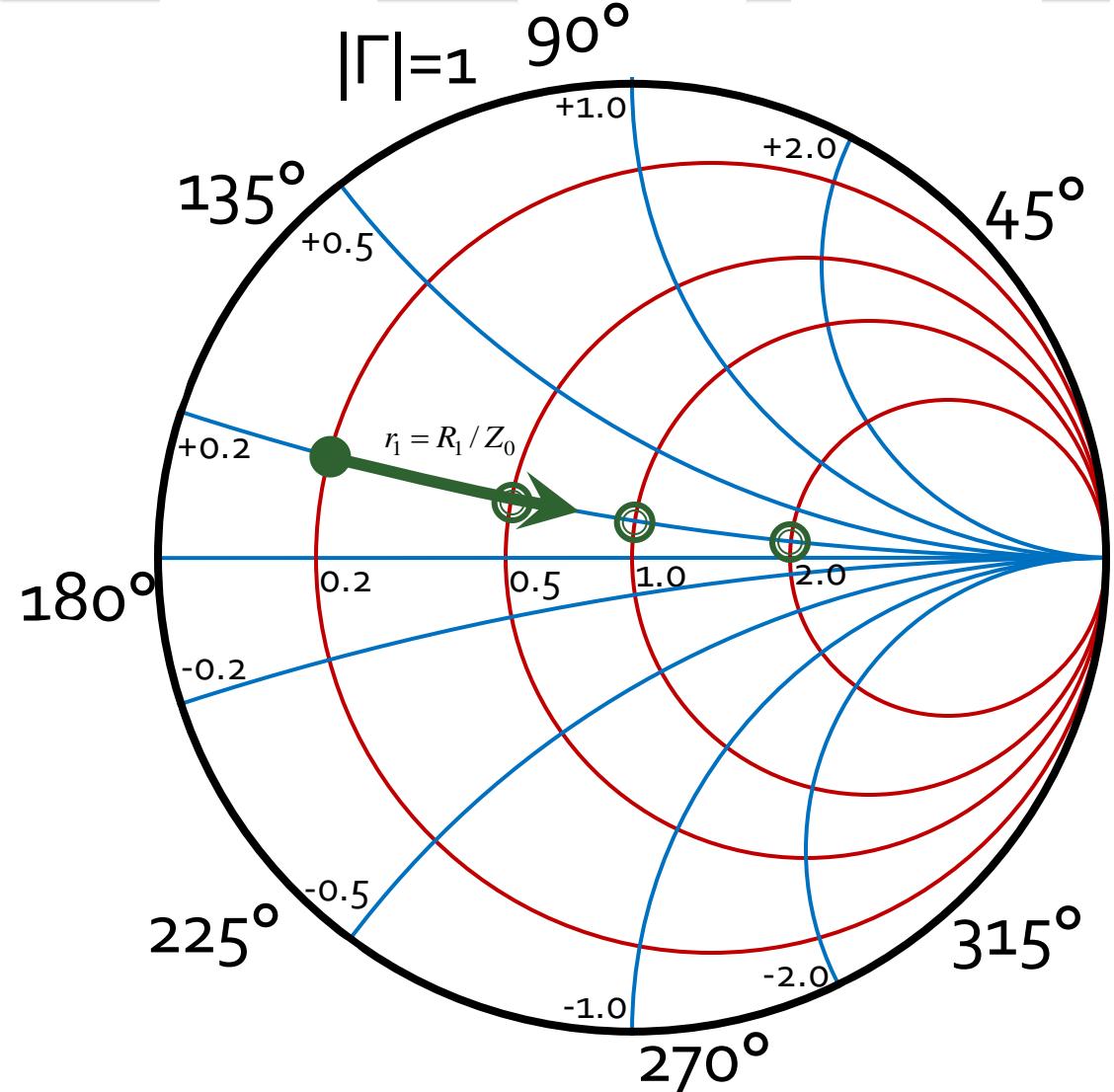


Diagrama Smith, coeficient de reflexie, rezistenta in serie



$$Z_0 = 50\Omega$$

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

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

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

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

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

$$x_{in} = x_L$$

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

ADS, Diagramma Smith, rezistenza in serie

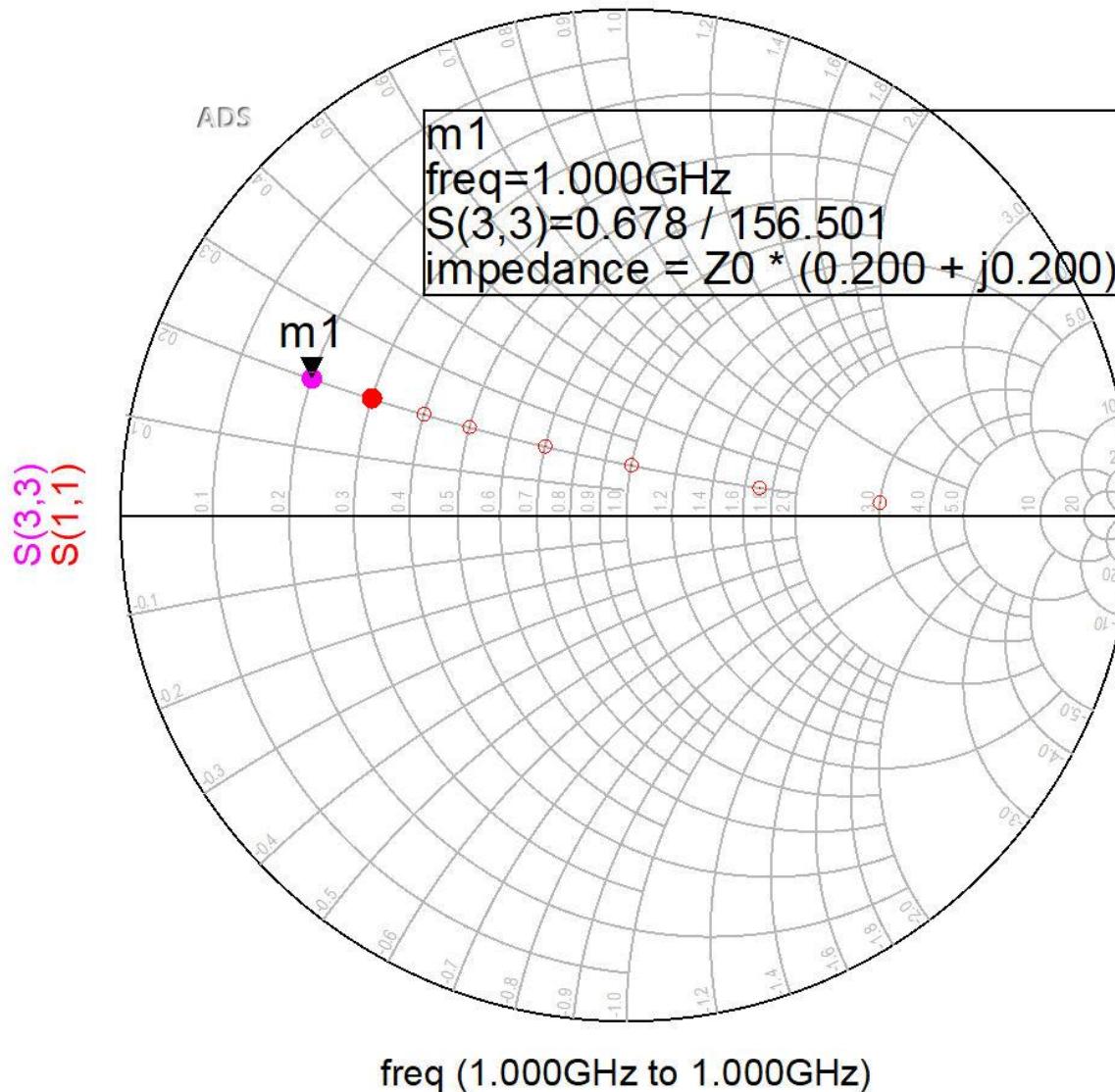
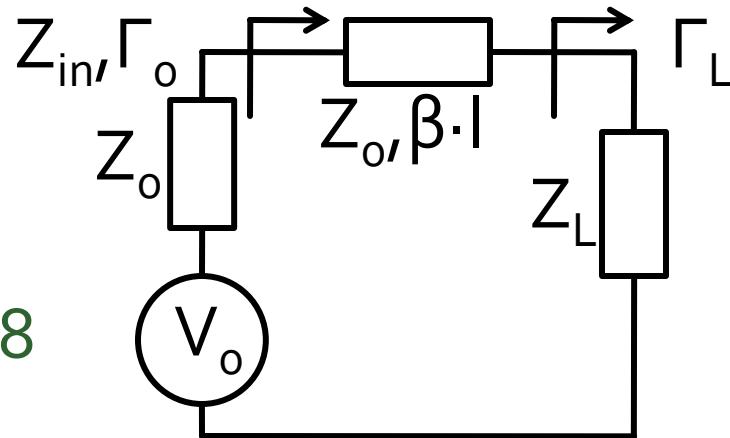
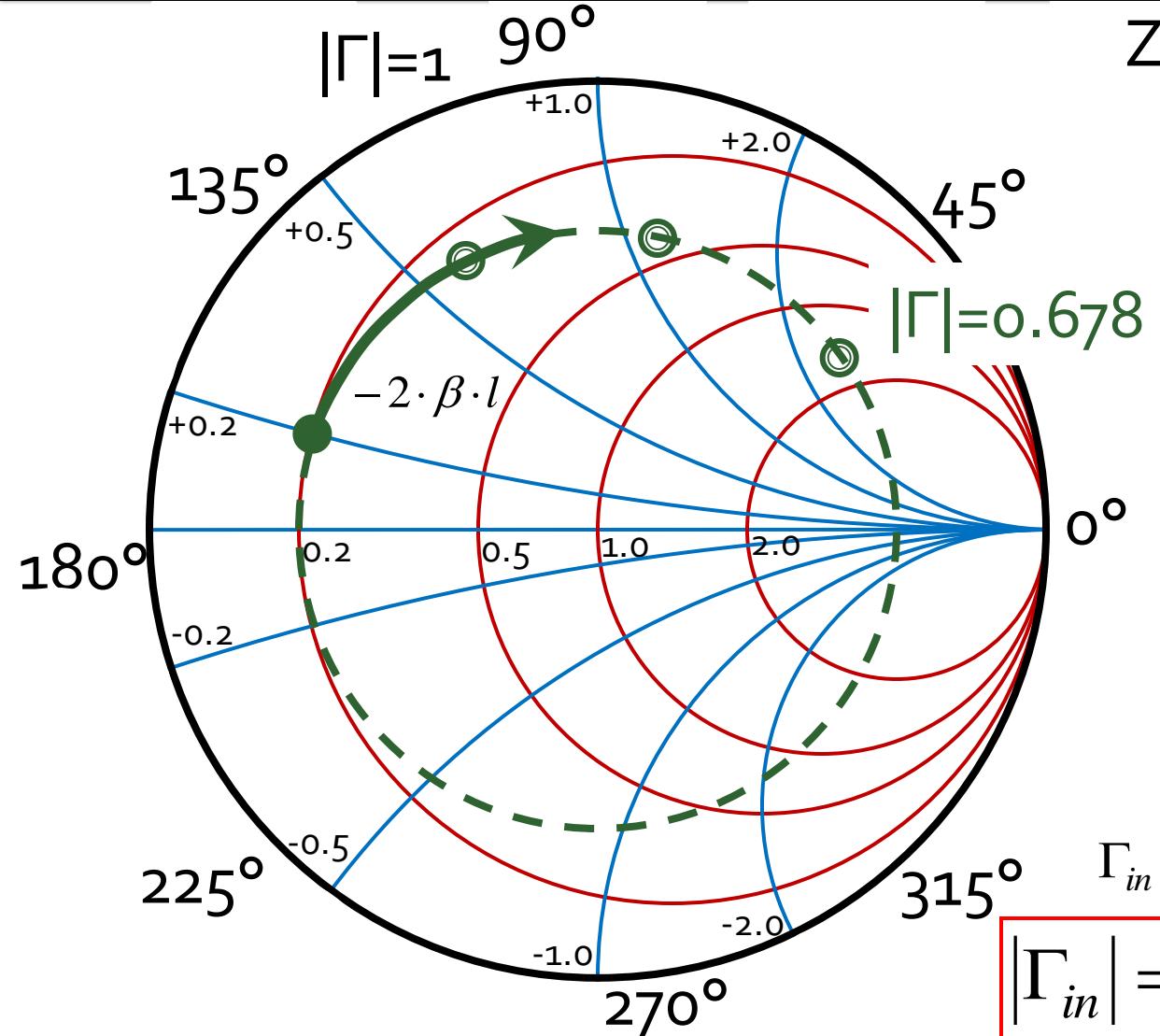


Diagrama Smith, coeficient de reflexie, linie de transmisie in serie



$$Z_0 = 50\Omega$$

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

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

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

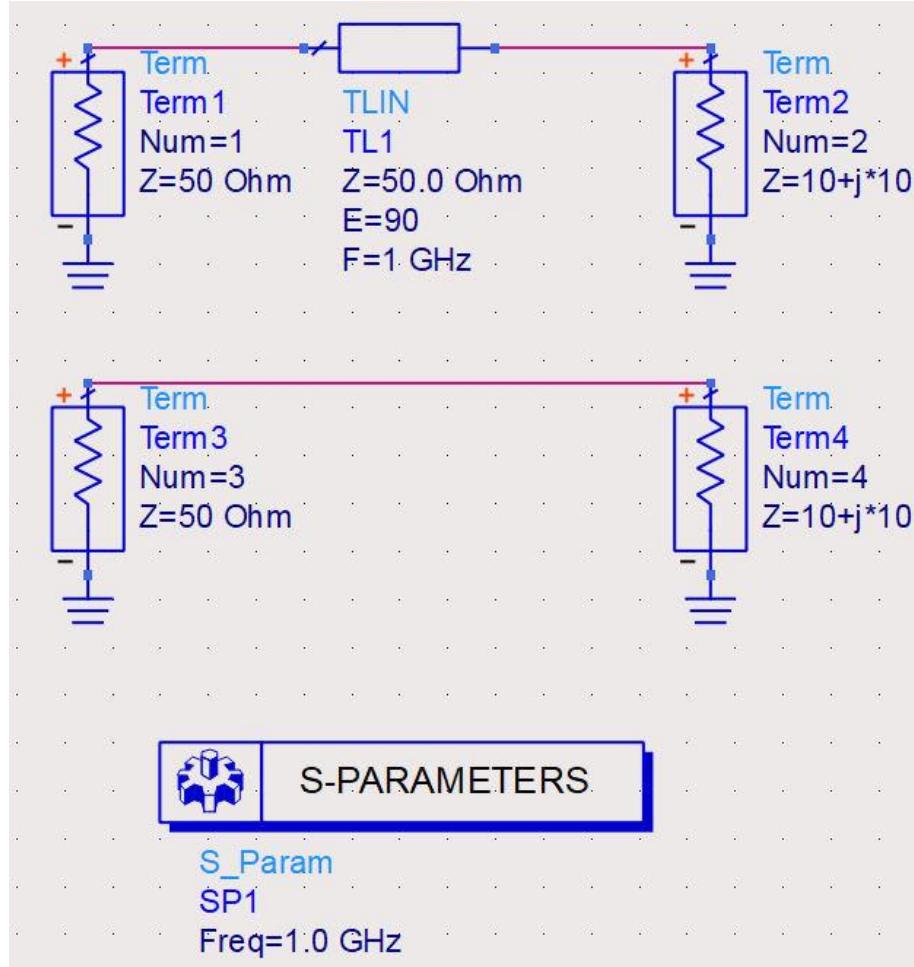
$$Z_{in} = Z_0 \cdot \frac{1 + \Gamma_L \cdot e^{-2j\beta l}}{1 - \Gamma_L \cdot e^{-2j\beta l}}$$

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

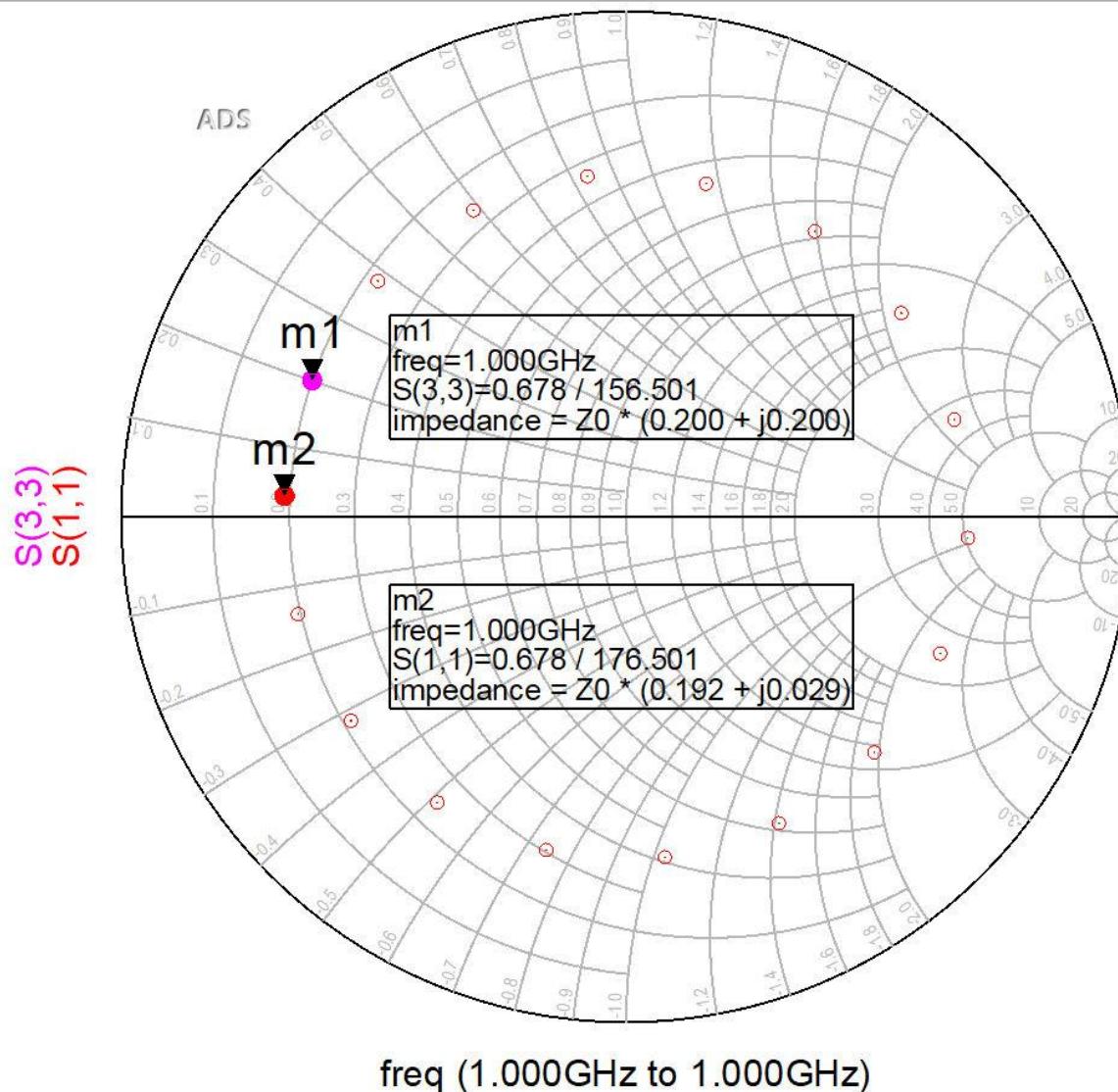
$$|\Gamma_{in}| = |\Gamma_L|$$

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

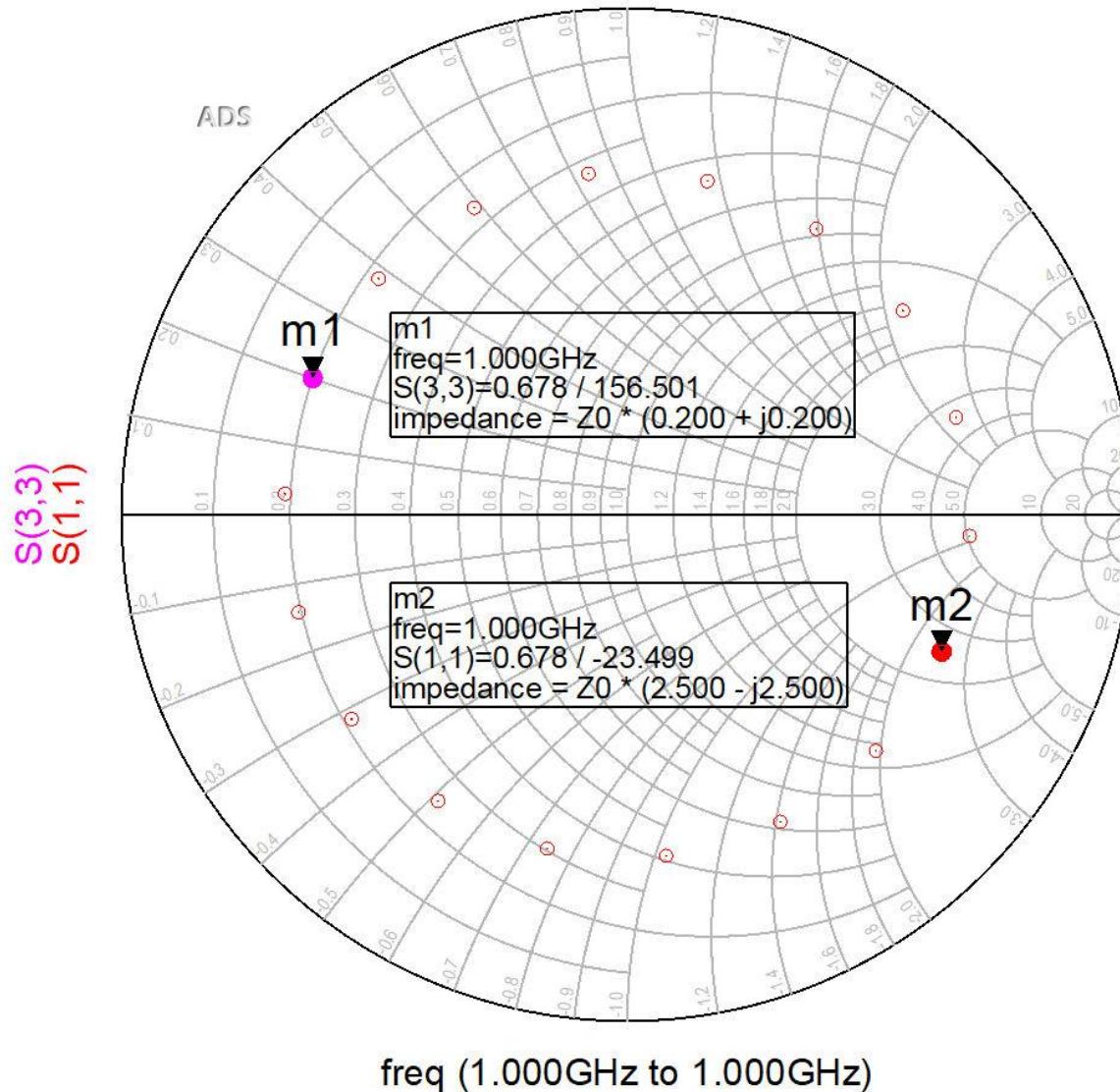
ADS, Diagrama Smith, linie de transmisie in serie



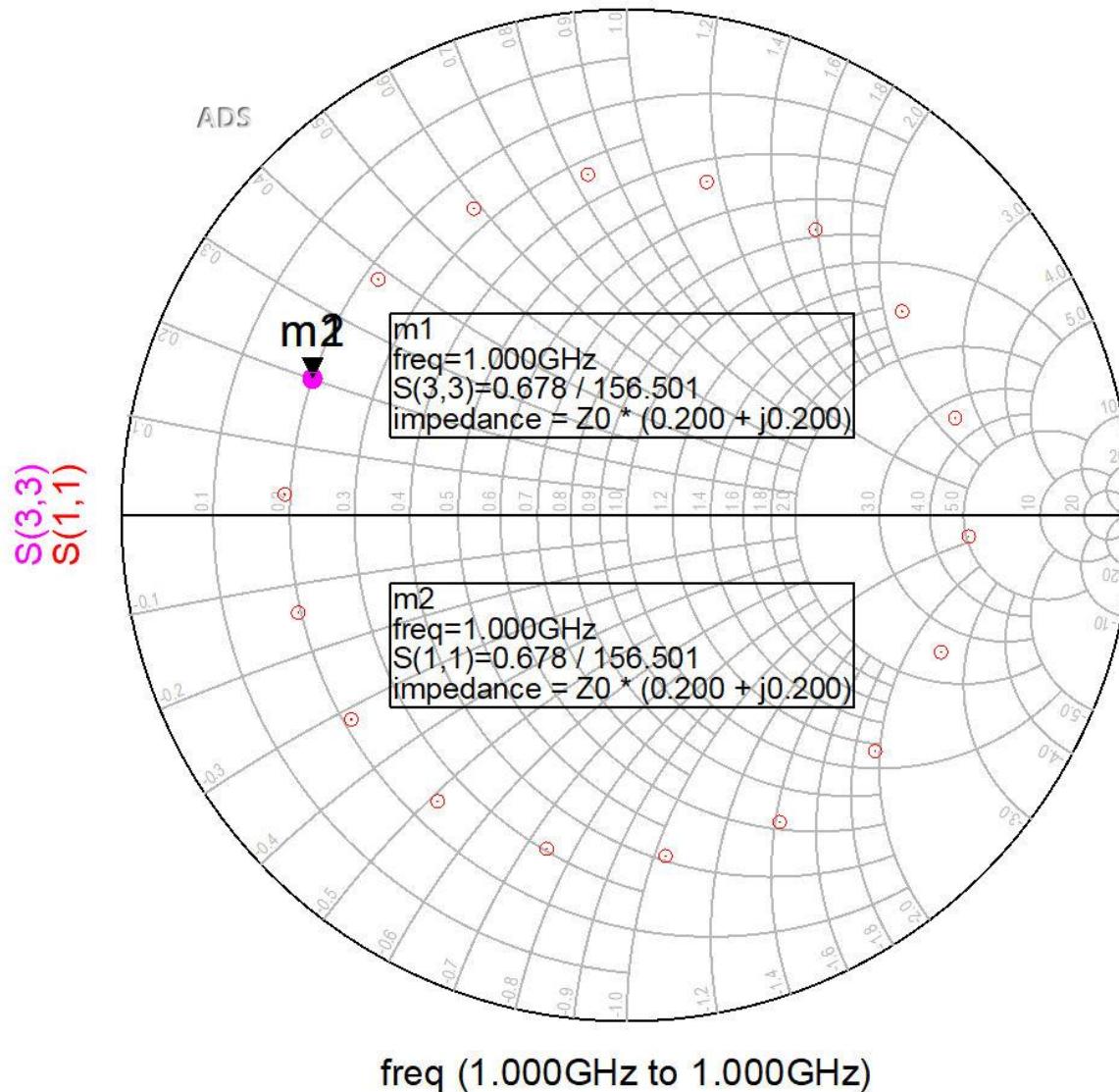
ADS, Diagrama Smith, linie de transmisie in serie



ADS, Diagrama Smith, linie de transmisie in serie, 90°



ADS, Diagrama Smith, linie de transmisie in serie, 180°



ADS, Diagrama Smith, linie de transmisie in serie, $Z=25\Omega \neq Z_0$

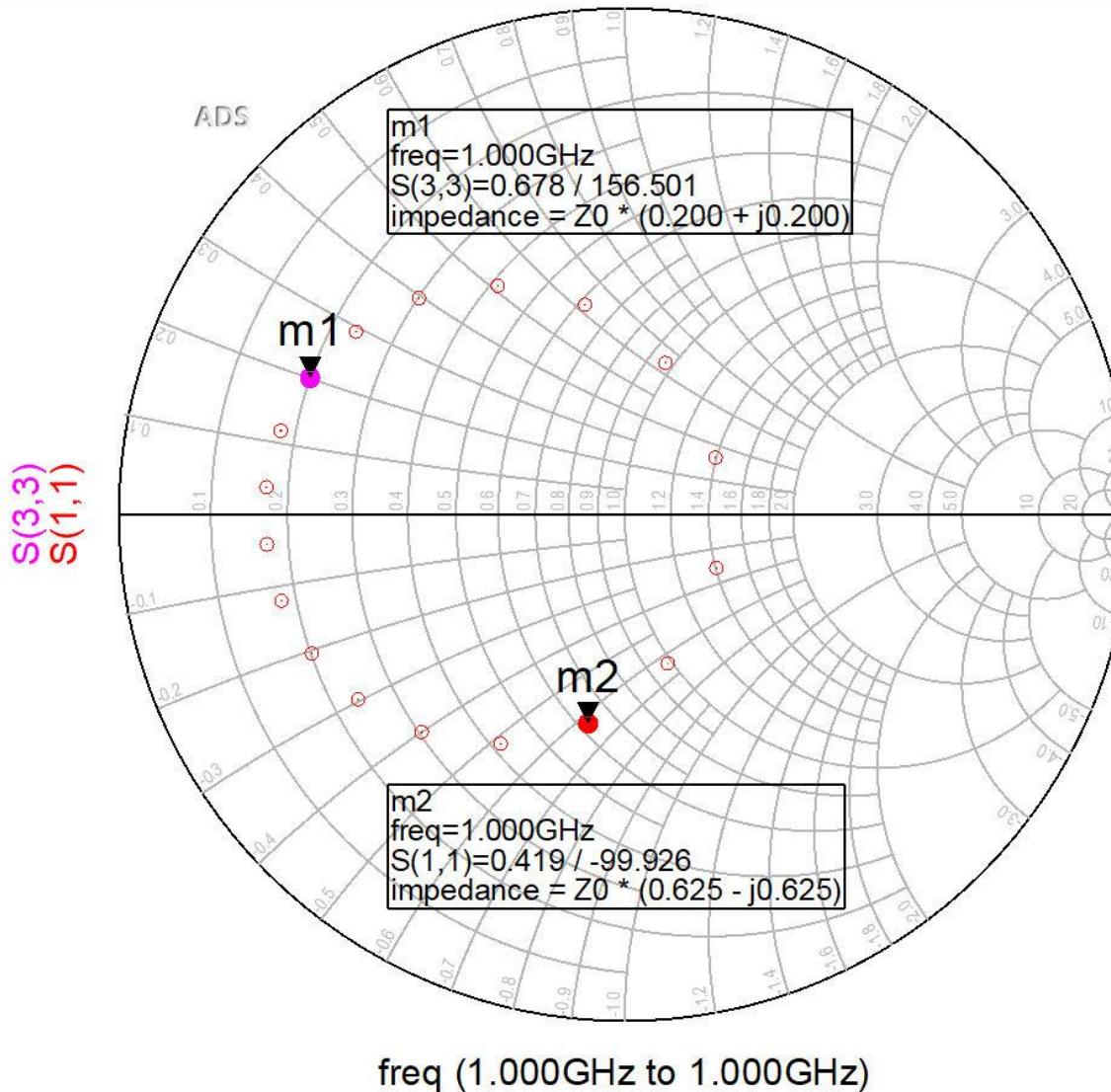
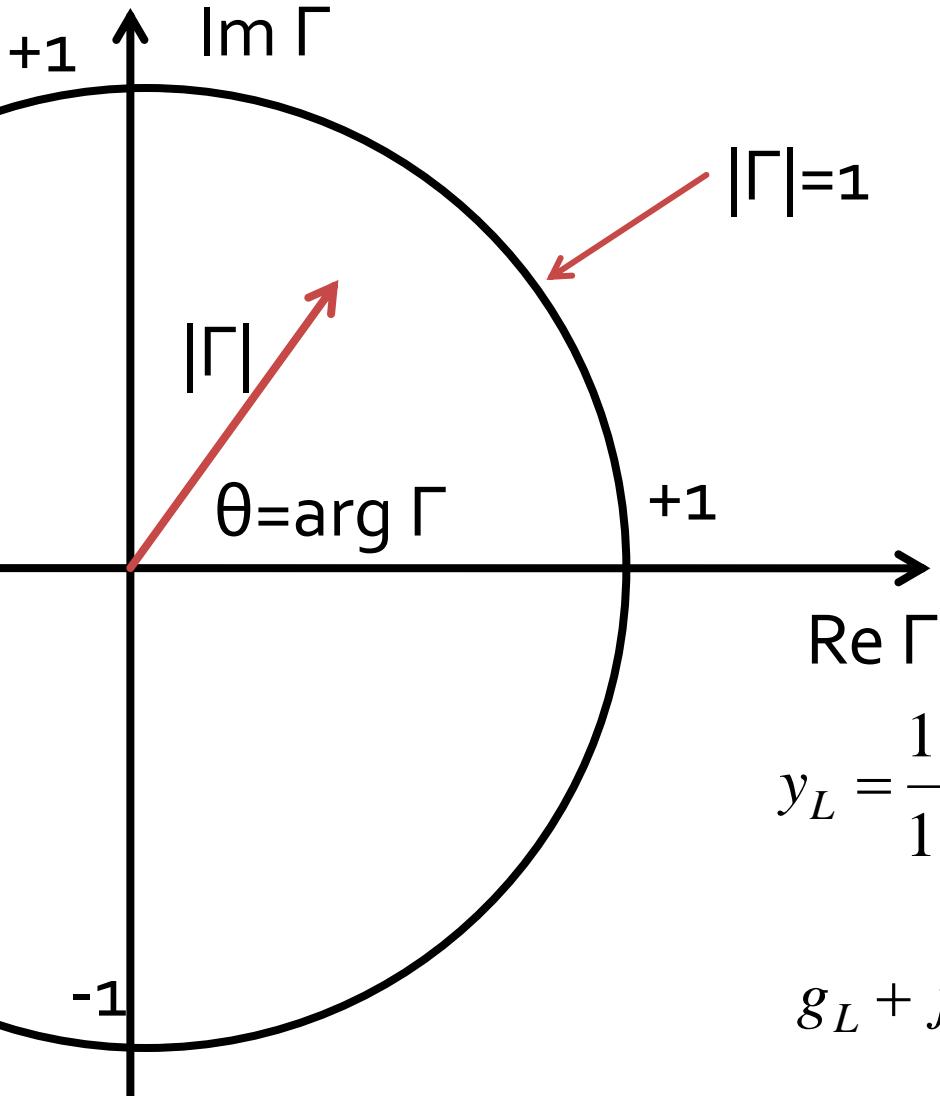


Diagramma Smith, admitante



$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{z_L - 1}{z_L + 1} = |\Gamma| \cdot e^{j\theta}$$

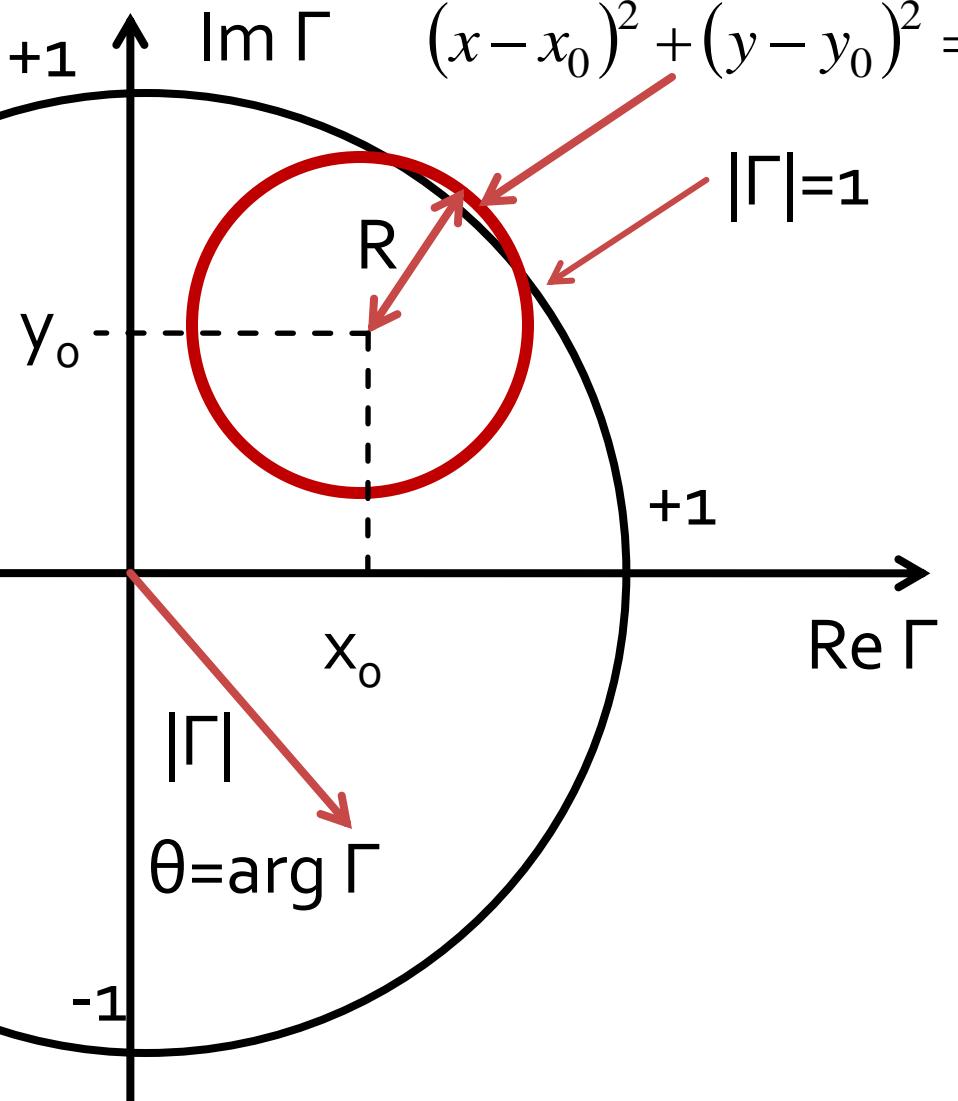
$$\Gamma = \Gamma_r + j \cdot \Gamma_i$$

$$z_L = \frac{1 + |\Gamma| \cdot e^{j\theta}}{1 - |\Gamma| \cdot e^{j\theta}} = r_L + j \cdot x_L$$

$$y_L = \frac{1 - |\Gamma| \cdot e^{j\theta}}{1 + |\Gamma| \cdot e^{j\theta}} = \frac{1}{r_L + j \cdot x_L} = g_L + j \cdot b_L$$

$$g_L + j \cdot b_L = \frac{(1 - \Gamma_r) - j \cdot \Gamma_i}{(1 + \Gamma_r) + j \cdot \Gamma_i}$$

Diagrama Smith, admitante



$$g_L = \frac{1 - \Gamma_r^2 - \Gamma_i^2}{(1 + \Gamma_r)^2 + \Gamma_i^2}$$

$$b_L = \frac{-2 \cdot \Gamma_i}{(1 + \Gamma_r)^2 + \Gamma_i^2}$$

- Rearajate

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

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

- Cercuri in planul complex

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

Diagrama Smith, conductanta

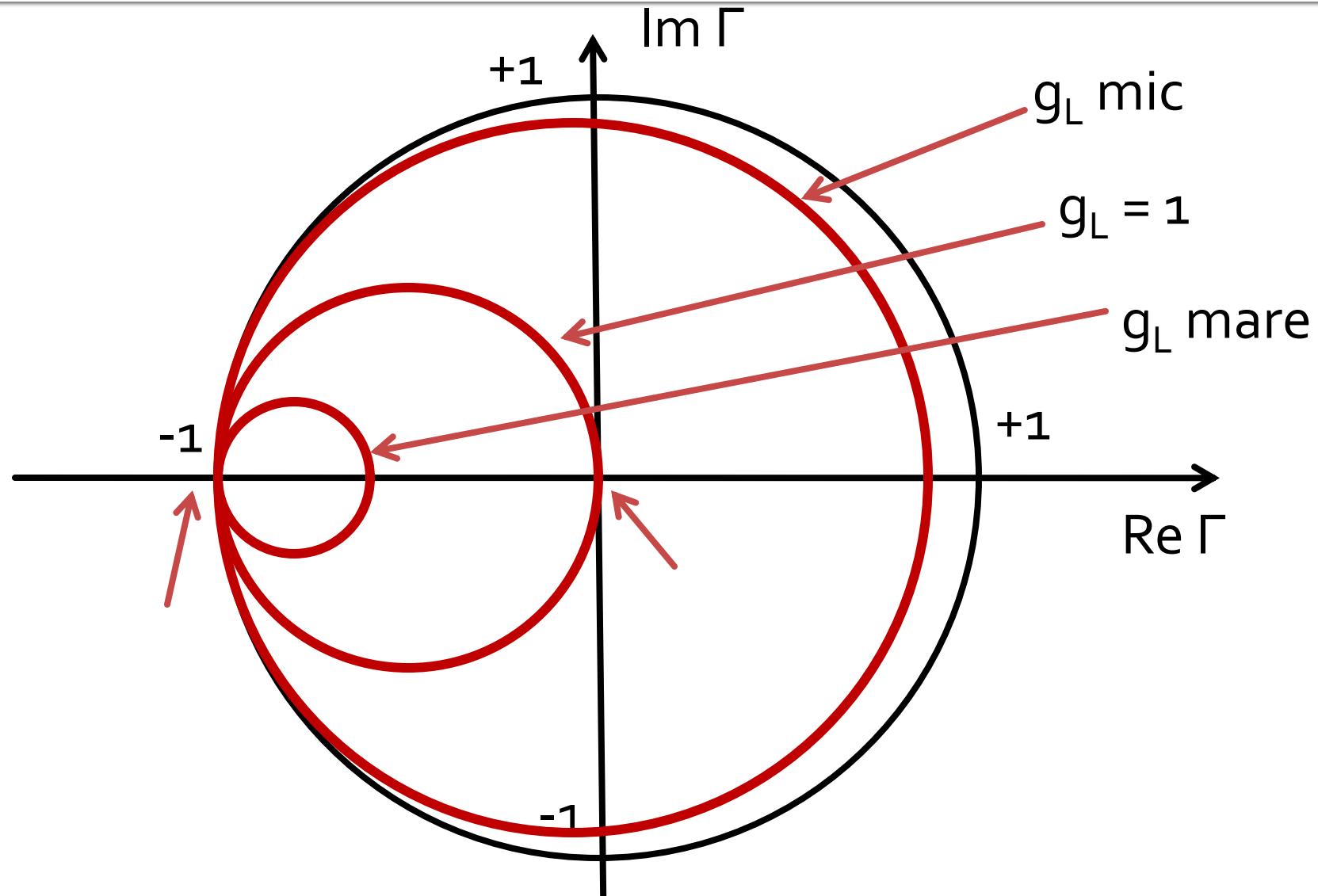


Diagrama Smith, susceptanta

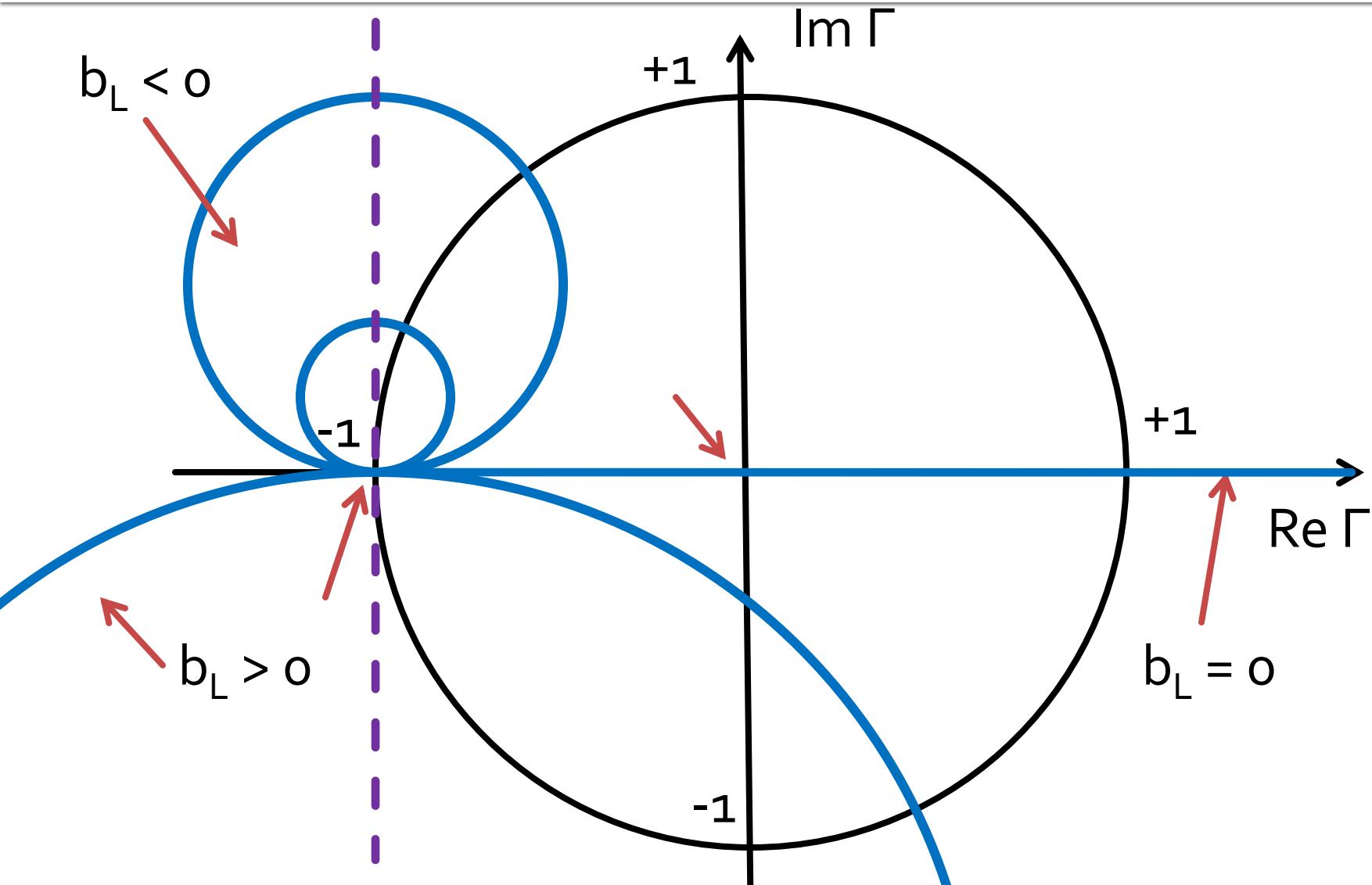
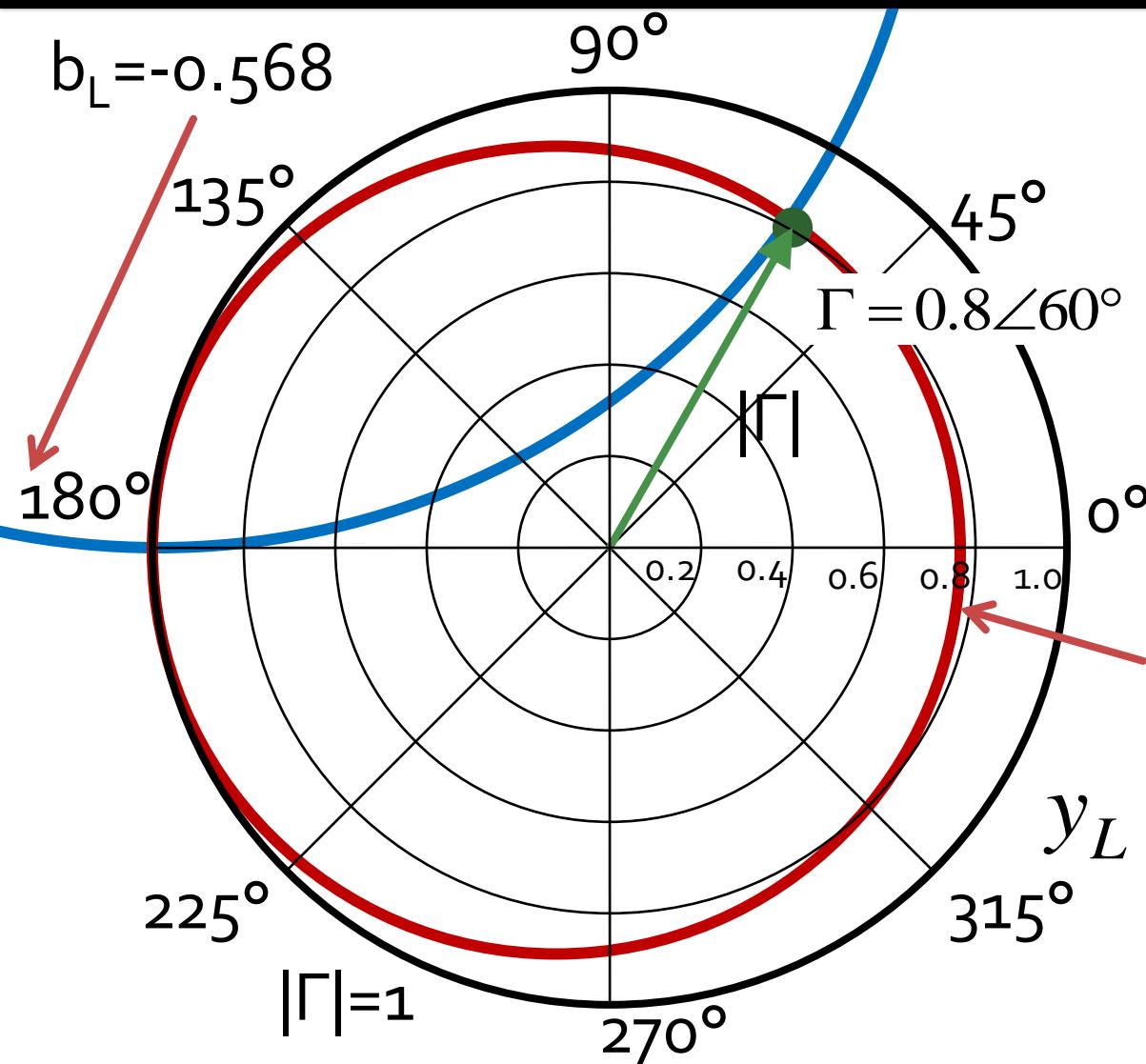


Diagrama Smith, coeficient de reflexie \leftrightarrow admitanta



$$\Gamma = 0.8\angle 60^\circ$$

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

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

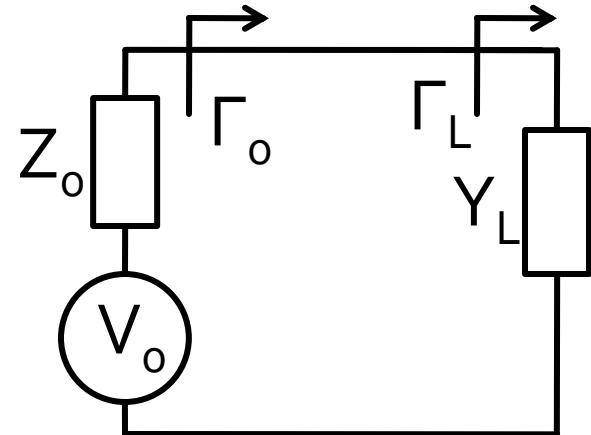
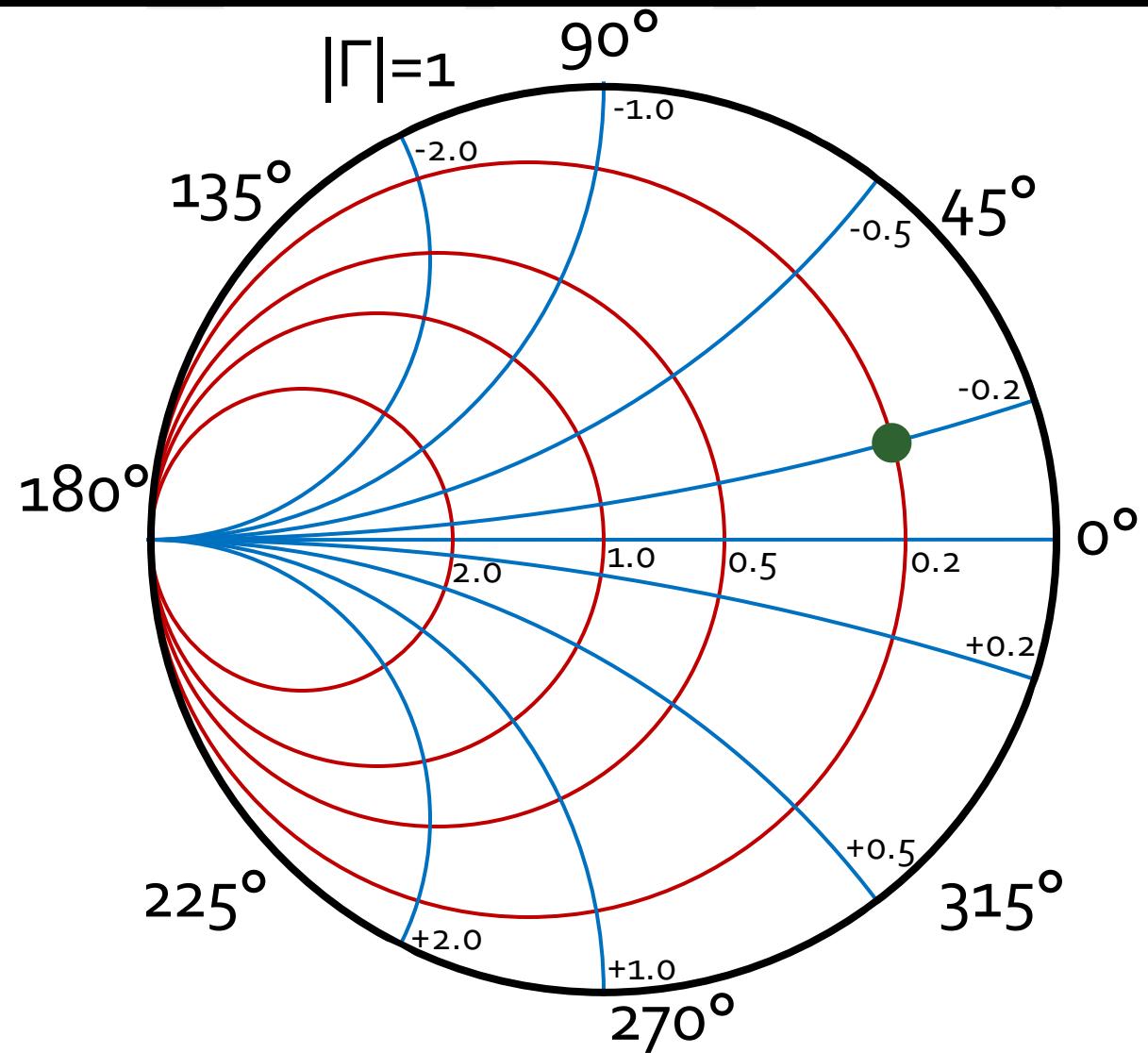
$$y_L = \frac{1}{z_L} = 0.148 - j \cdot 0.568$$

$$g_L = 0.148$$

$$y_L = 0.148 + j \cdot 0.568$$

(oricare Z_0)

Diagrama Smith, coeficient de reflexie, admitanta



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

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

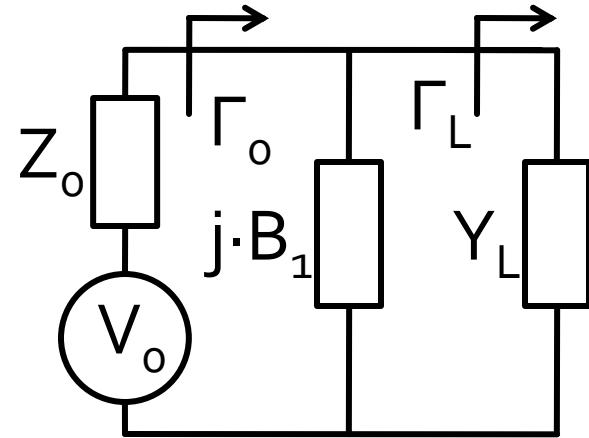
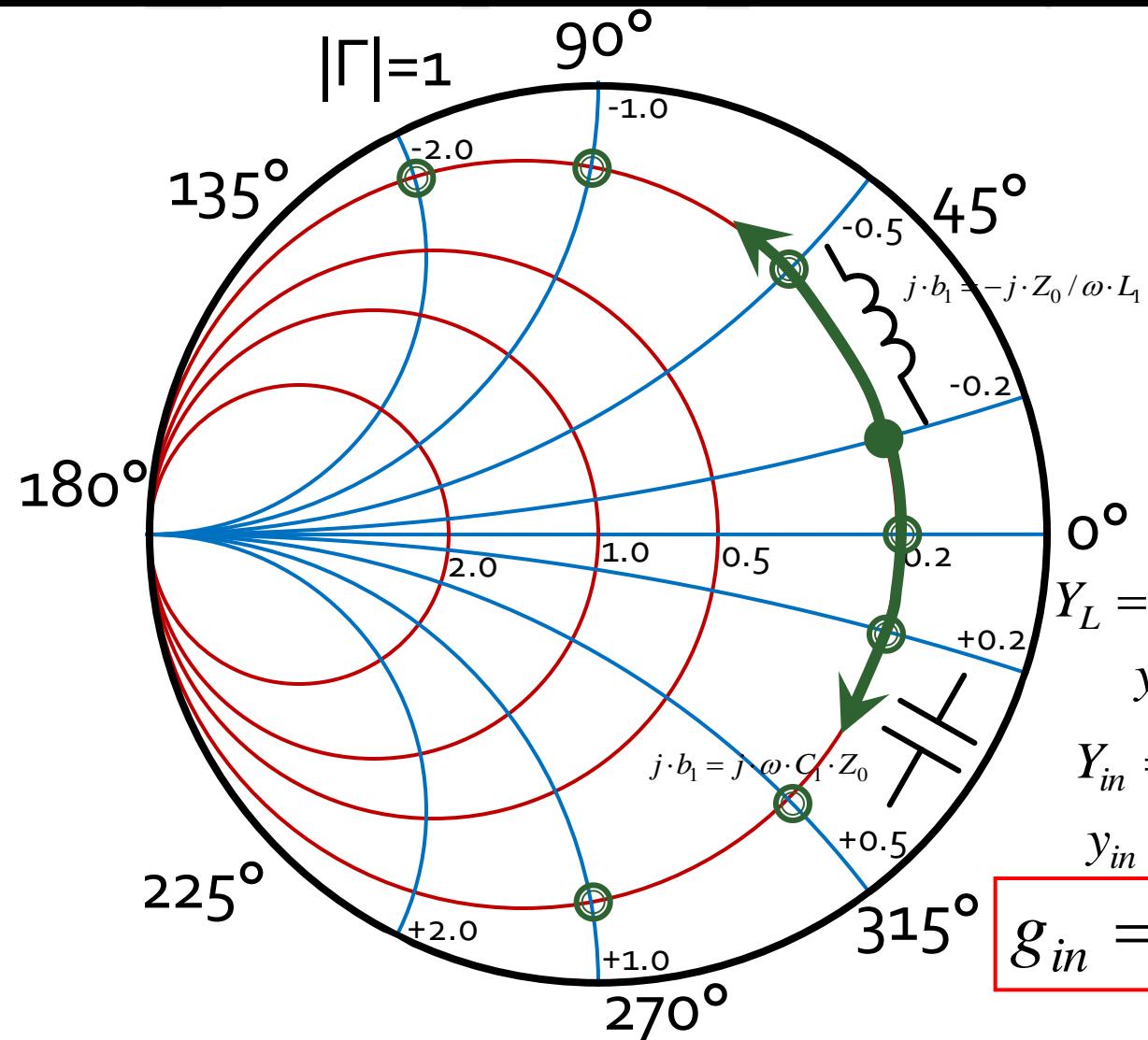
$$z_L = 2.5 + j \cdot 2.5$$

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

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

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

Diagrama Smith, coeficient de reflexie, susceptanta in paralel



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

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

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

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

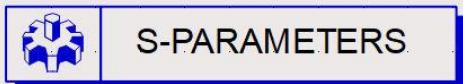
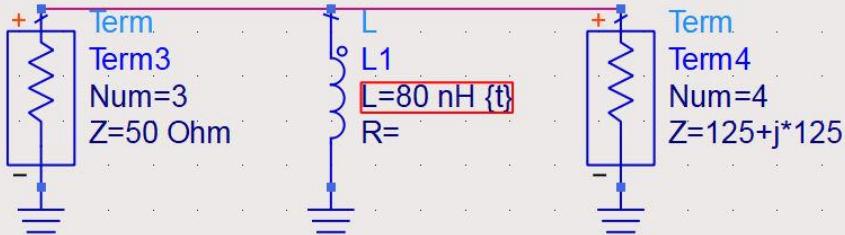
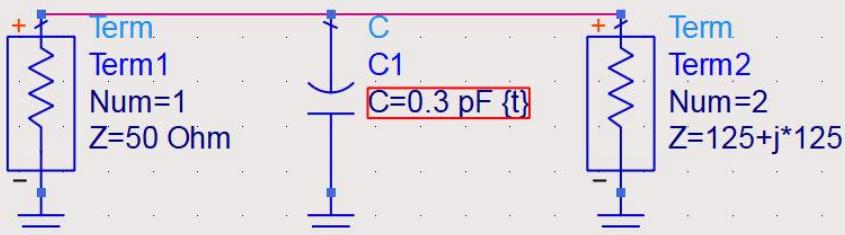
$$Y_{in} = Y_L + j \cdot B_1 = G_L + j \cdot (B_L + B_1)$$

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

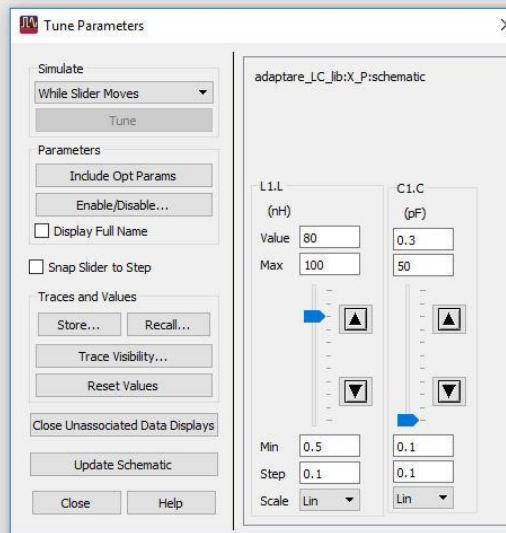
$$g_{in} = g_L \quad j \cdot b_1 = j \cdot \omega \cdot C_1 \cdot Z_0 > 0$$

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

ADS, Diagrama Smith, susceptanta in paralel



S_Param
SP1
Freq=1.0 GHz



ADS, Diagrama Smith, susceptanta in paralel

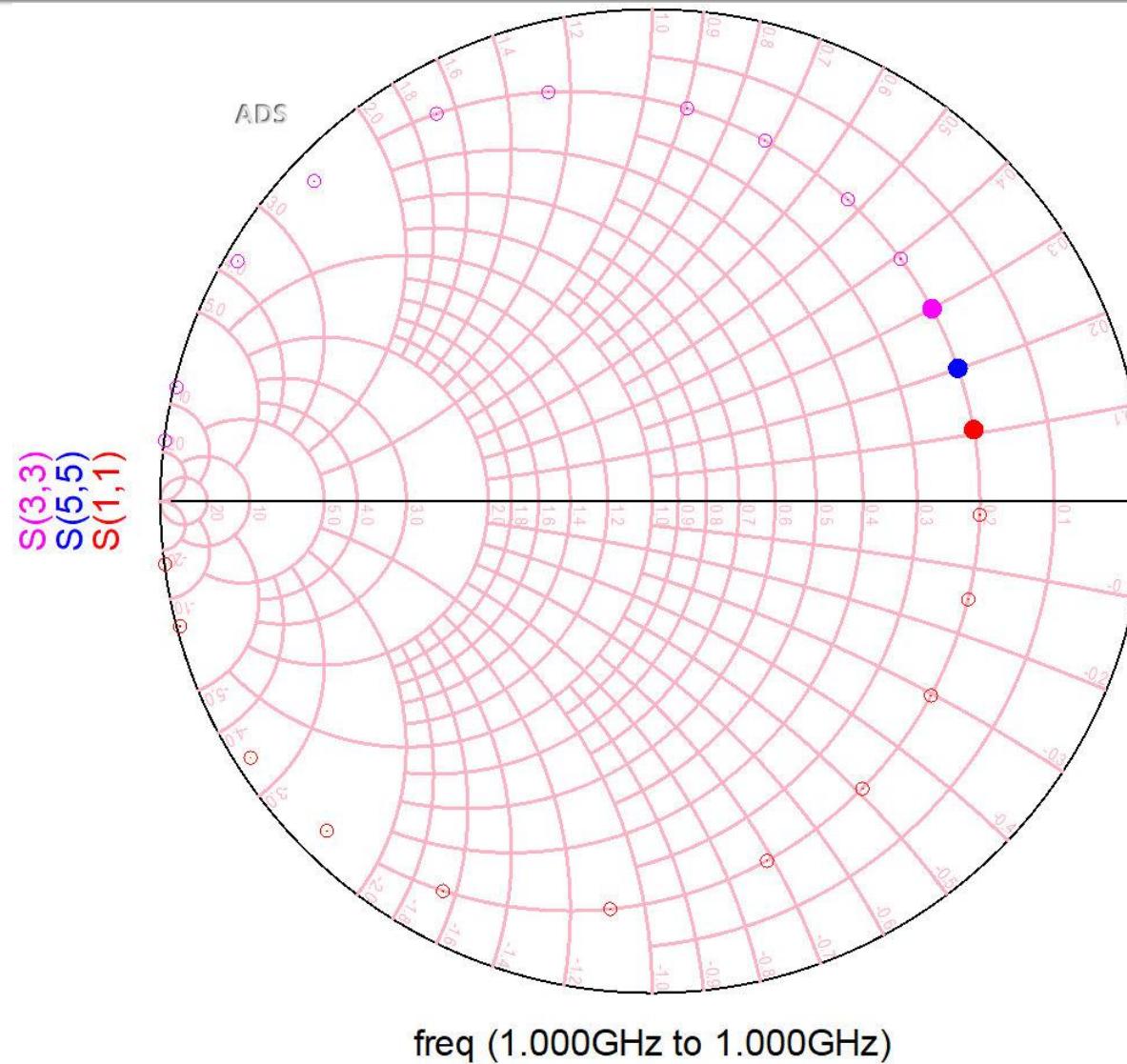
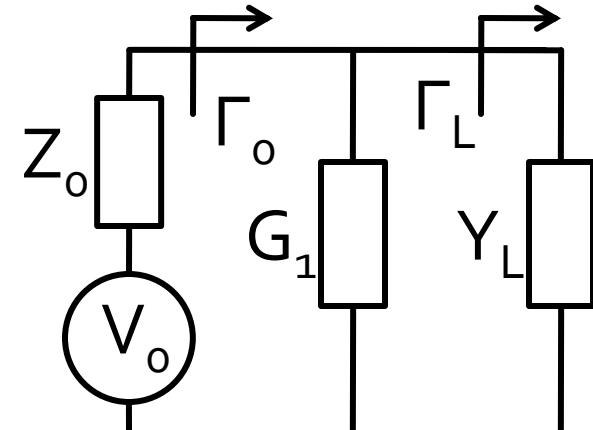
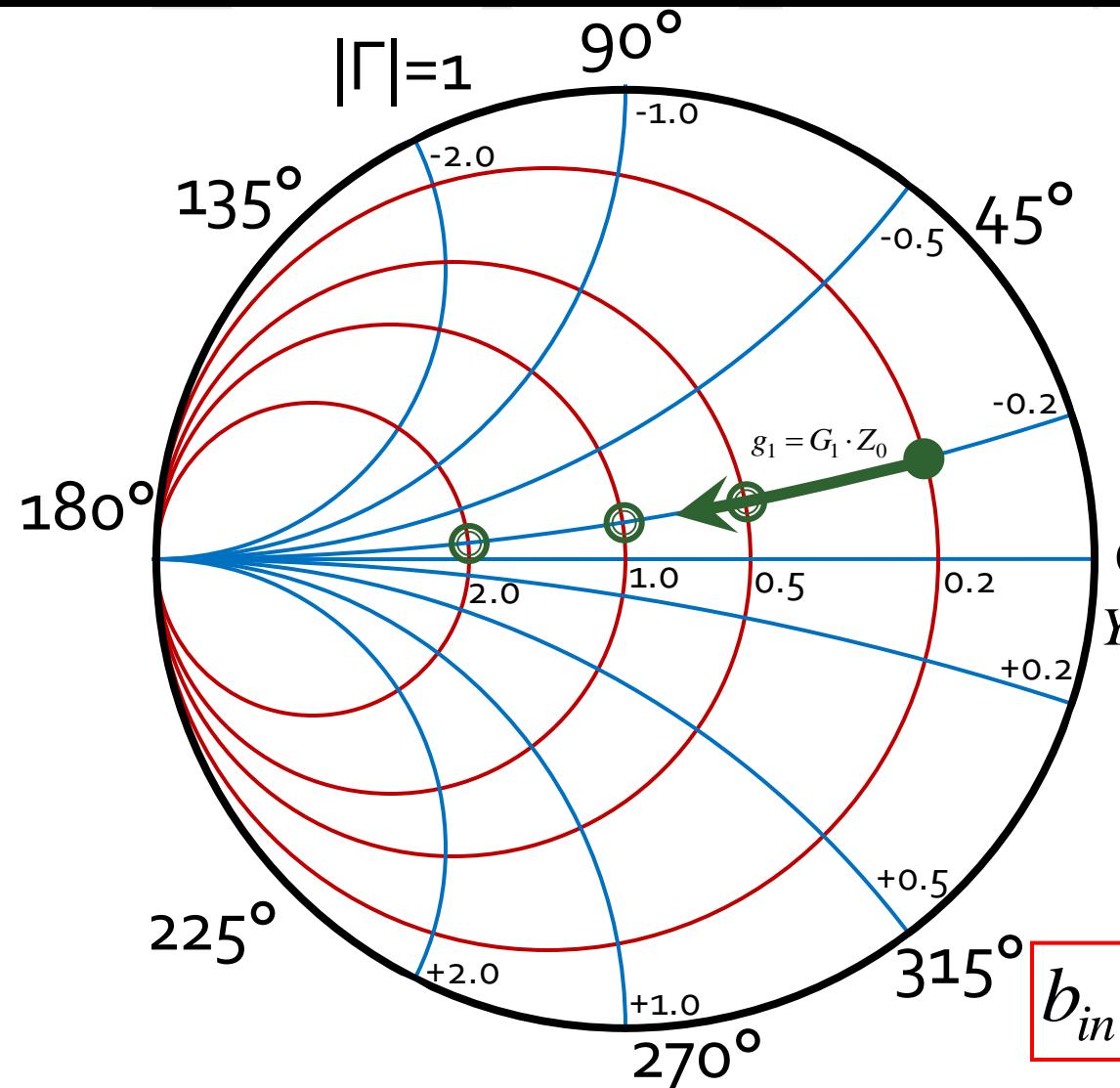


Diagrama Smith, coeficient de reflexie, conductanta in paralel



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

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

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

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

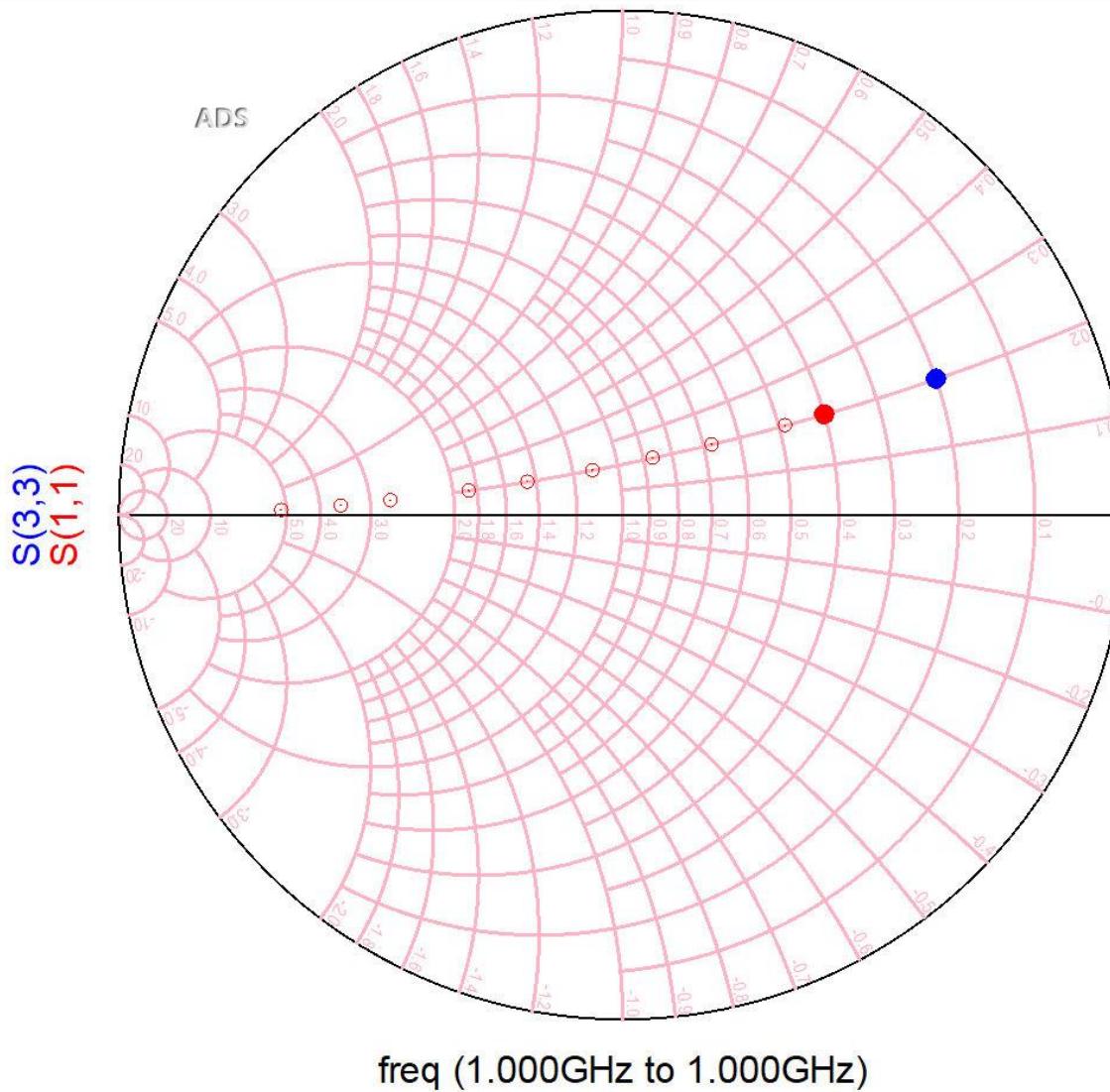
$$Y_{in} = Y_L + G_1 = (G_L + G_1) + j \cdot B_L$$

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

$$b_{in} = b_L$$

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

ADS, Diagrama Smith, conductanta in paralel



Contact

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