

Curs 6

2014/2015

Dispozitive și circuite de microunde pentru radiocomunicații

Fotografii

FLORESCU DAN-CONSTANȚA



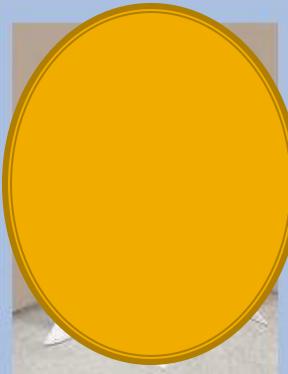
Date:

Grupa	5405 (2008)
Specializarea	Tehnologii si sisteme
Marca	3275

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Obiectiv
DCMR Dispozitive si circuite de microunde pentru radiocomunicații					
	Nota	19/06/2009	Nota finală	10	
	Exam	19/06/2009	Examen DCMR	9	
	Tema	05/06/2009	Proiect DCMR	10	

FLORESCU DAN-CONSTANȚA



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Detalii

Finantare	Buget
Bursa	Bursa de Studii
Domiciliu	Iasi, judet Iasi
Promovare	Promovare Integrala
Credite	60
Media	8.86

Adaptarea de impedanță

Diagrama Smith

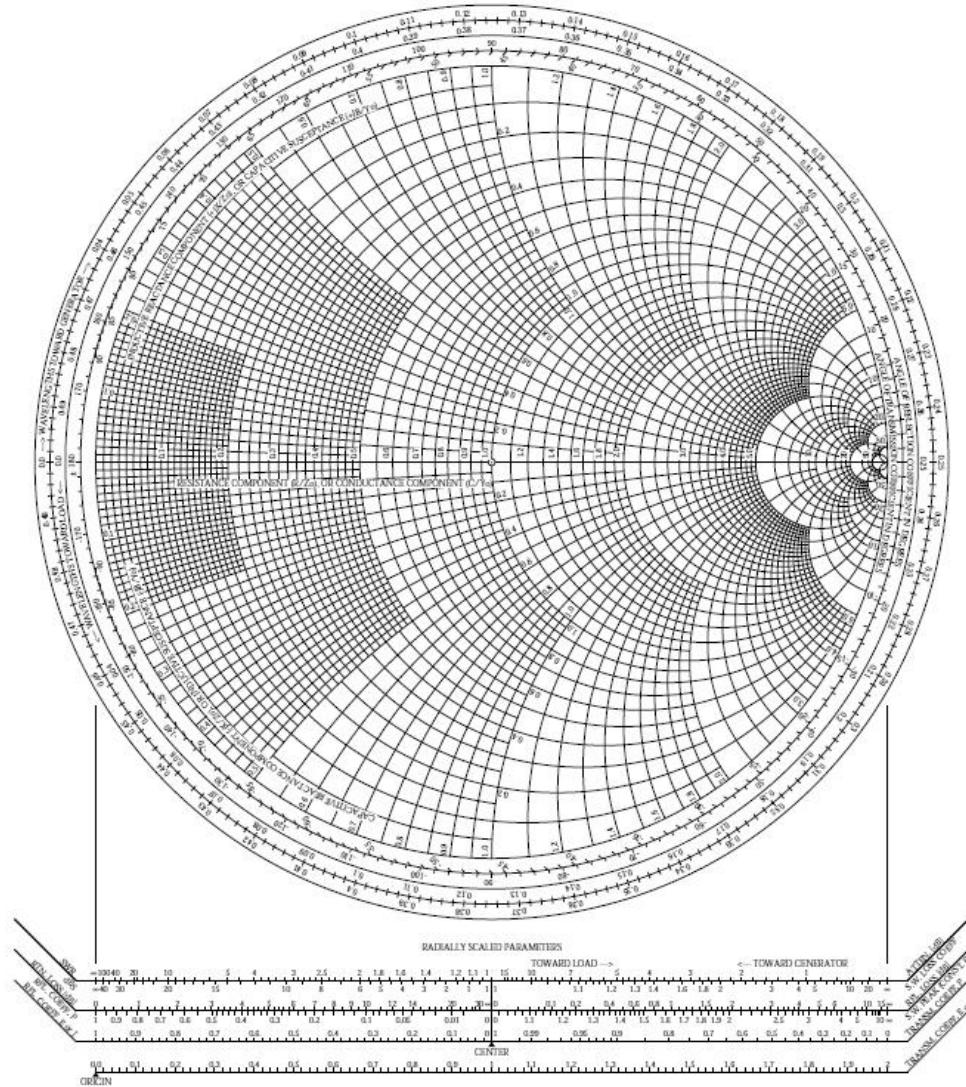


Diagrama Smith

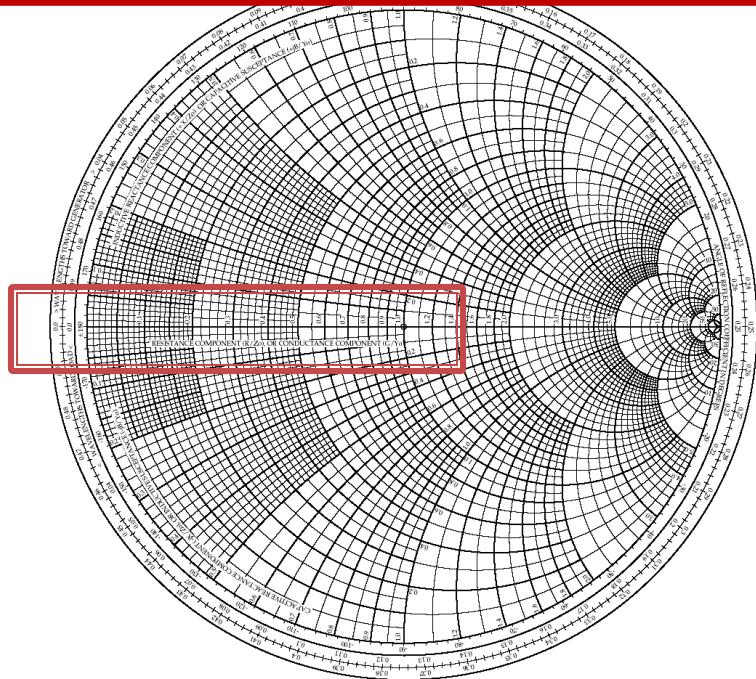
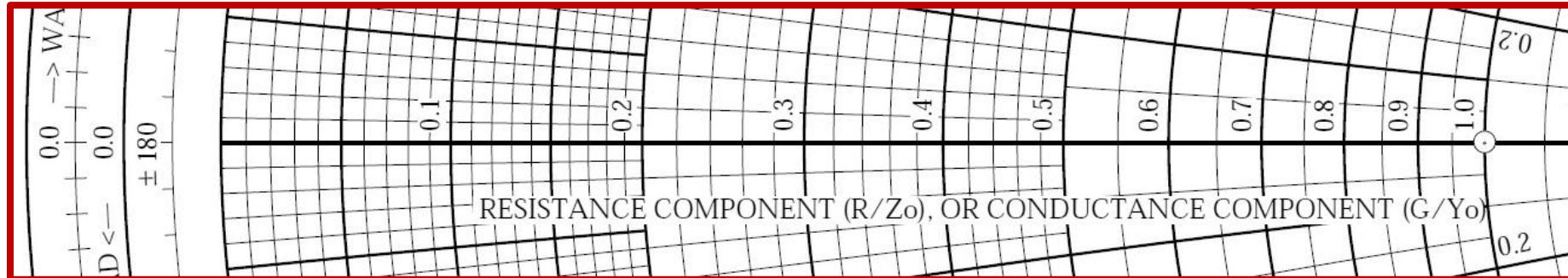


Diagrama Smith

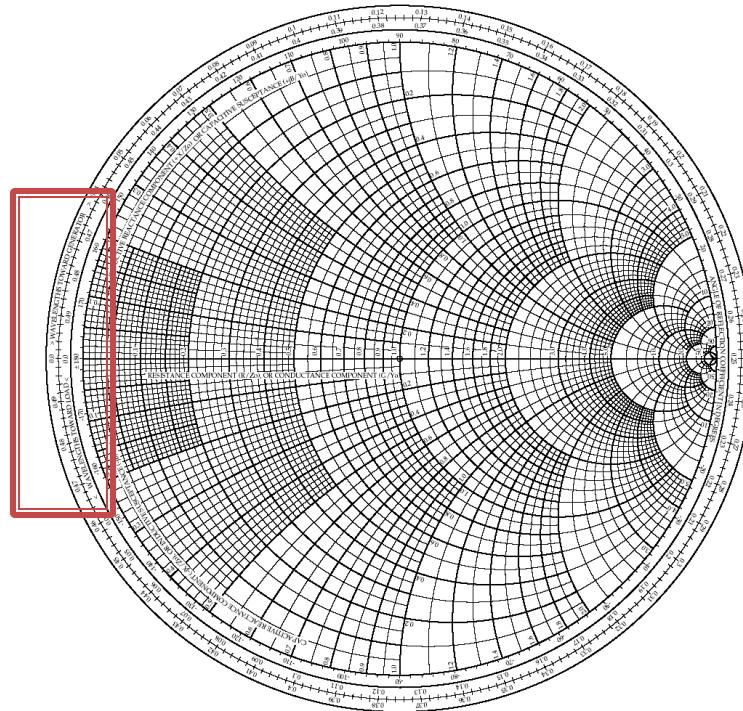
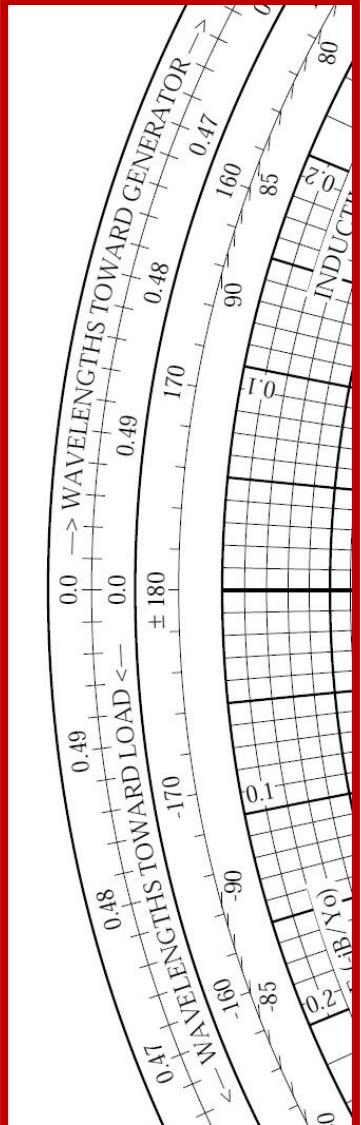


Diagrama Smith

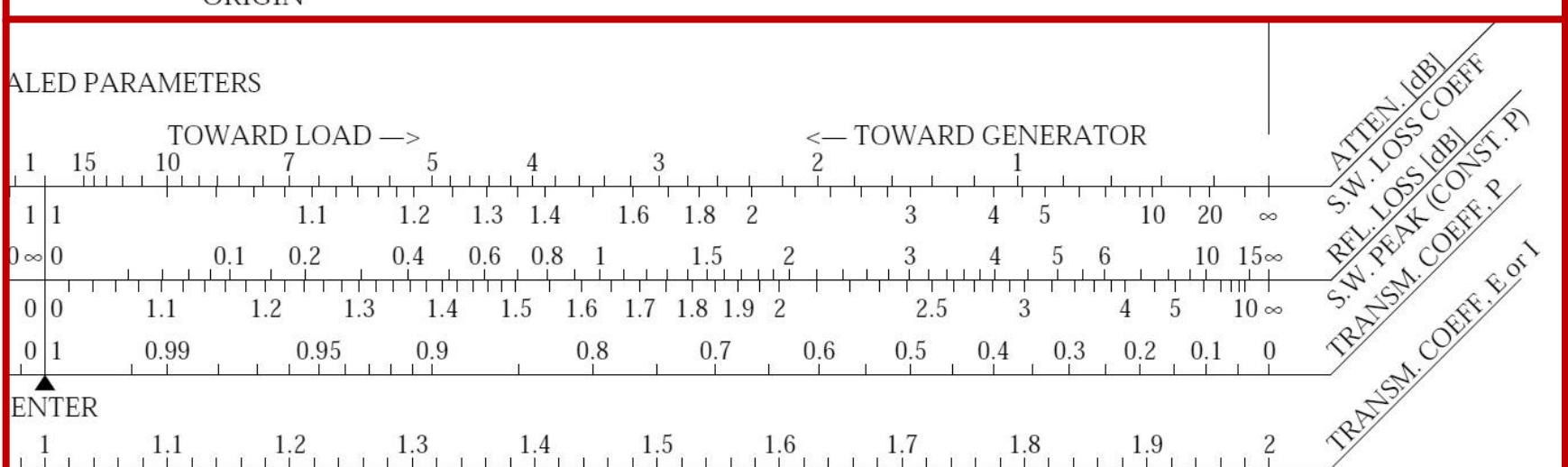
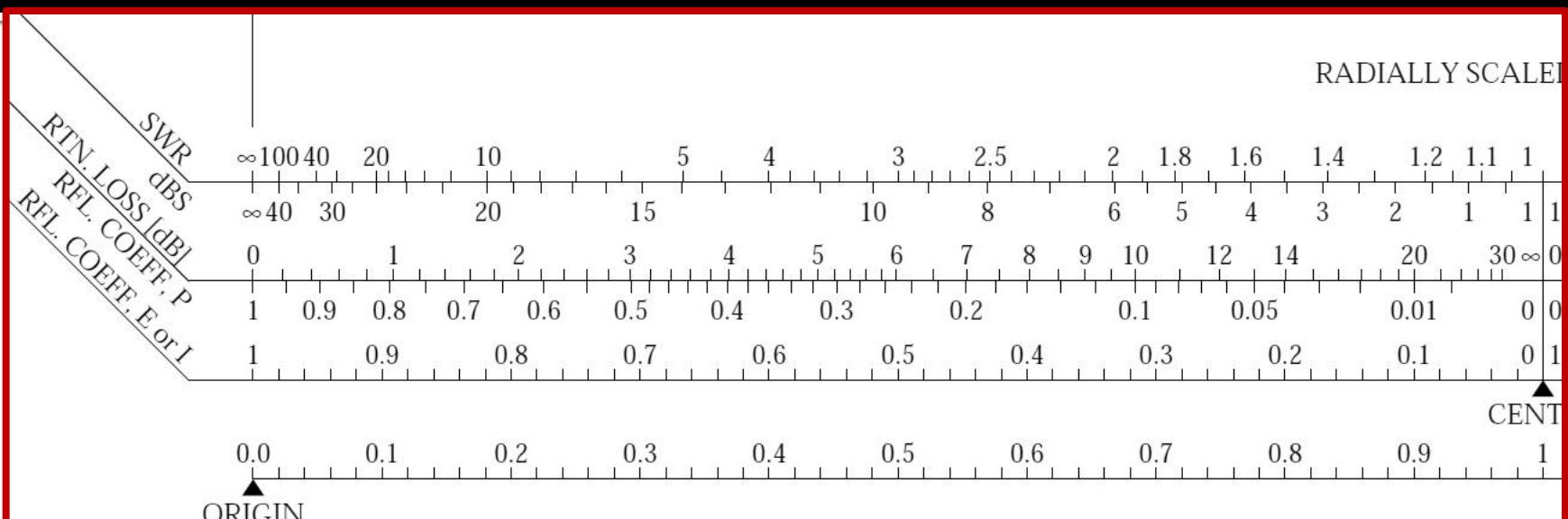


Diagrama Smith

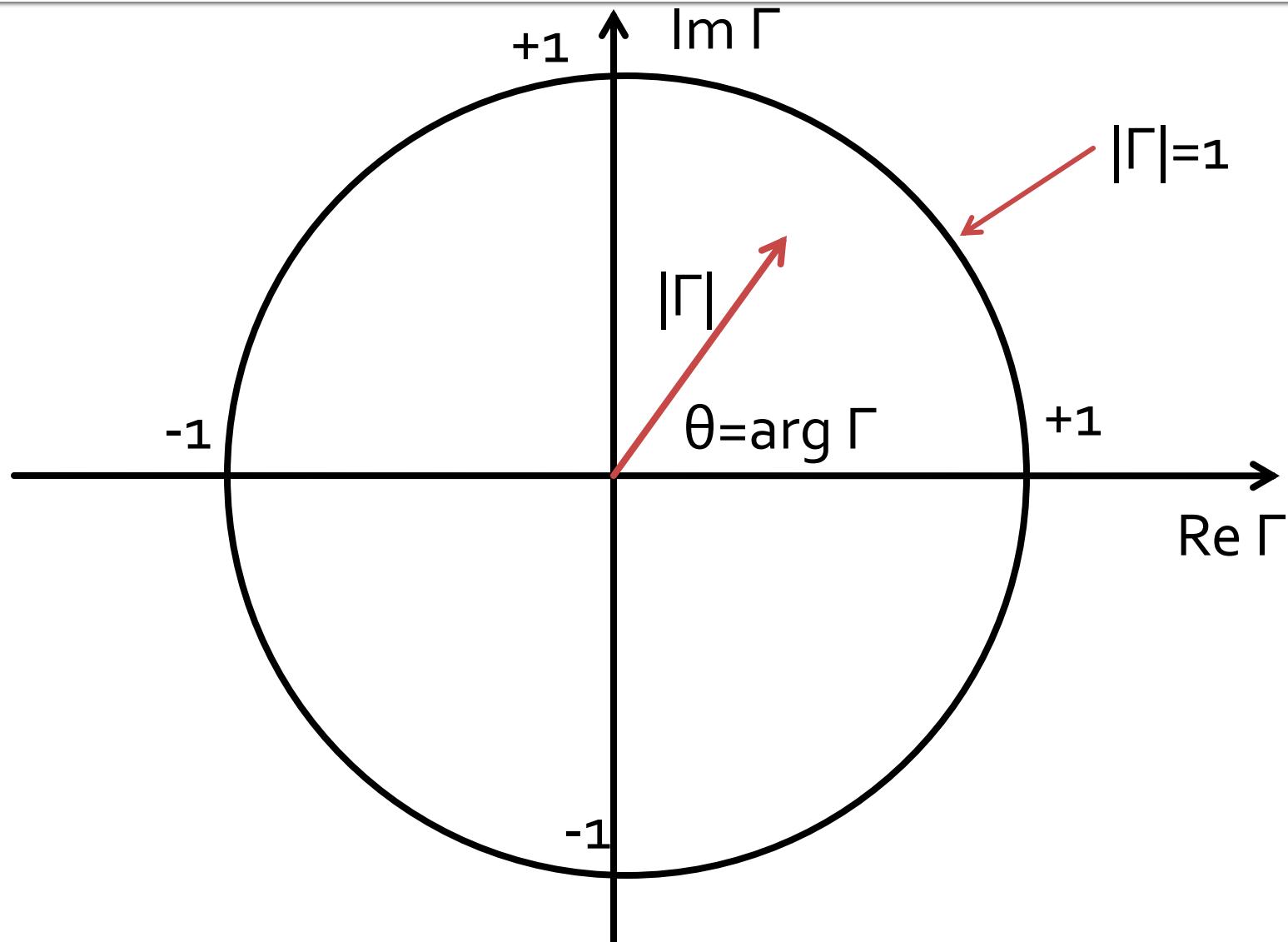
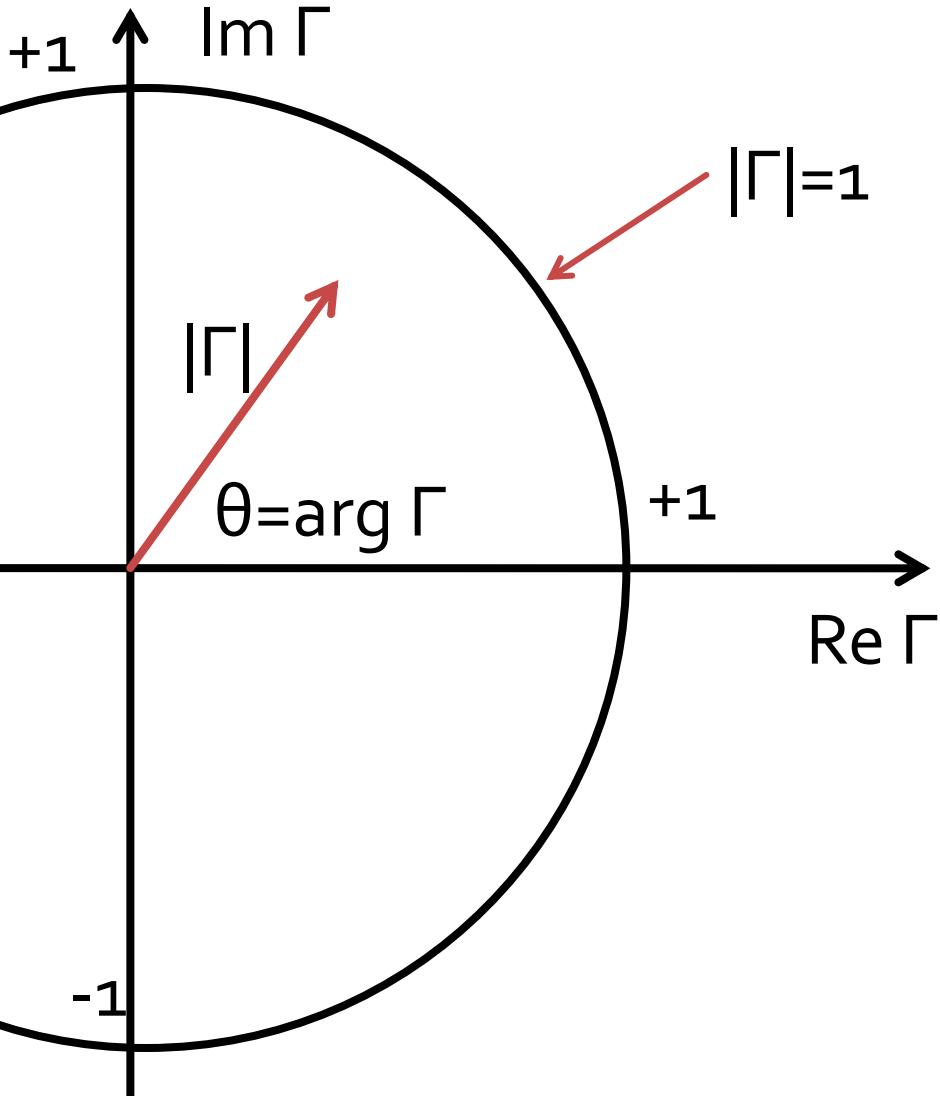


Diagramma Smith



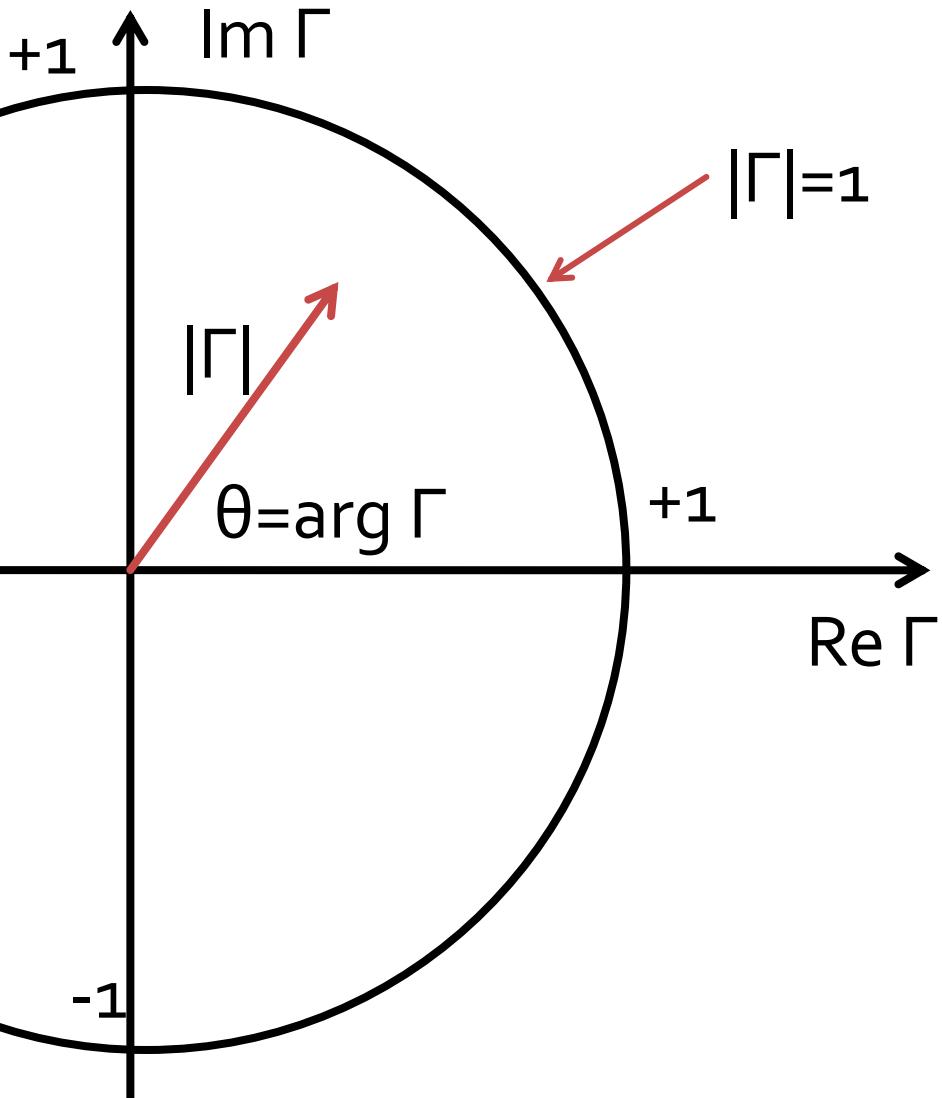
$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{z_L - 1}{z_L + 1} = |\Gamma| \cdot e^{j\theta}$$

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

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

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

Diagramma Smith



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

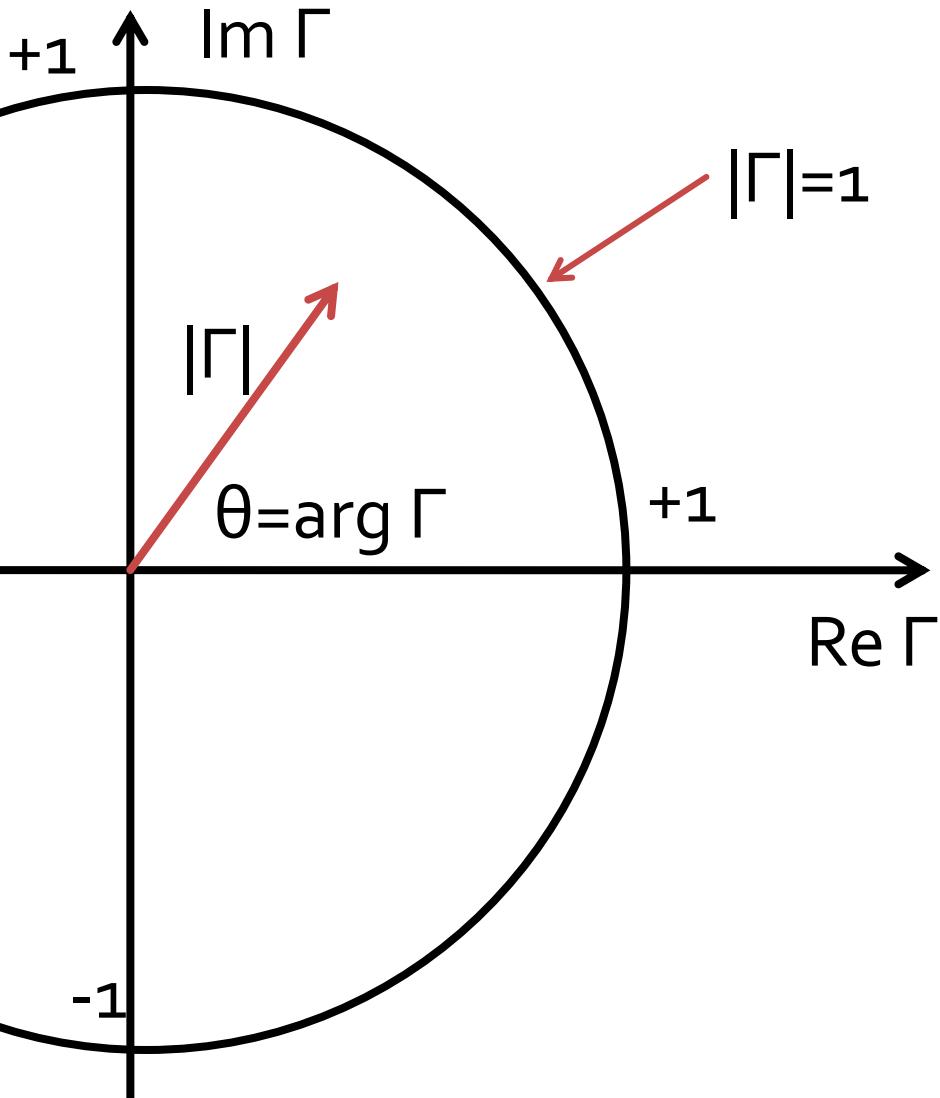
$$x_L = \frac{2 \cdot \Gamma_i}{(1 - \Gamma_r)^2 + \Gamma_i^2}$$

■ 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



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

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

- Cercuri in planul complex

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

Diagrama Smith

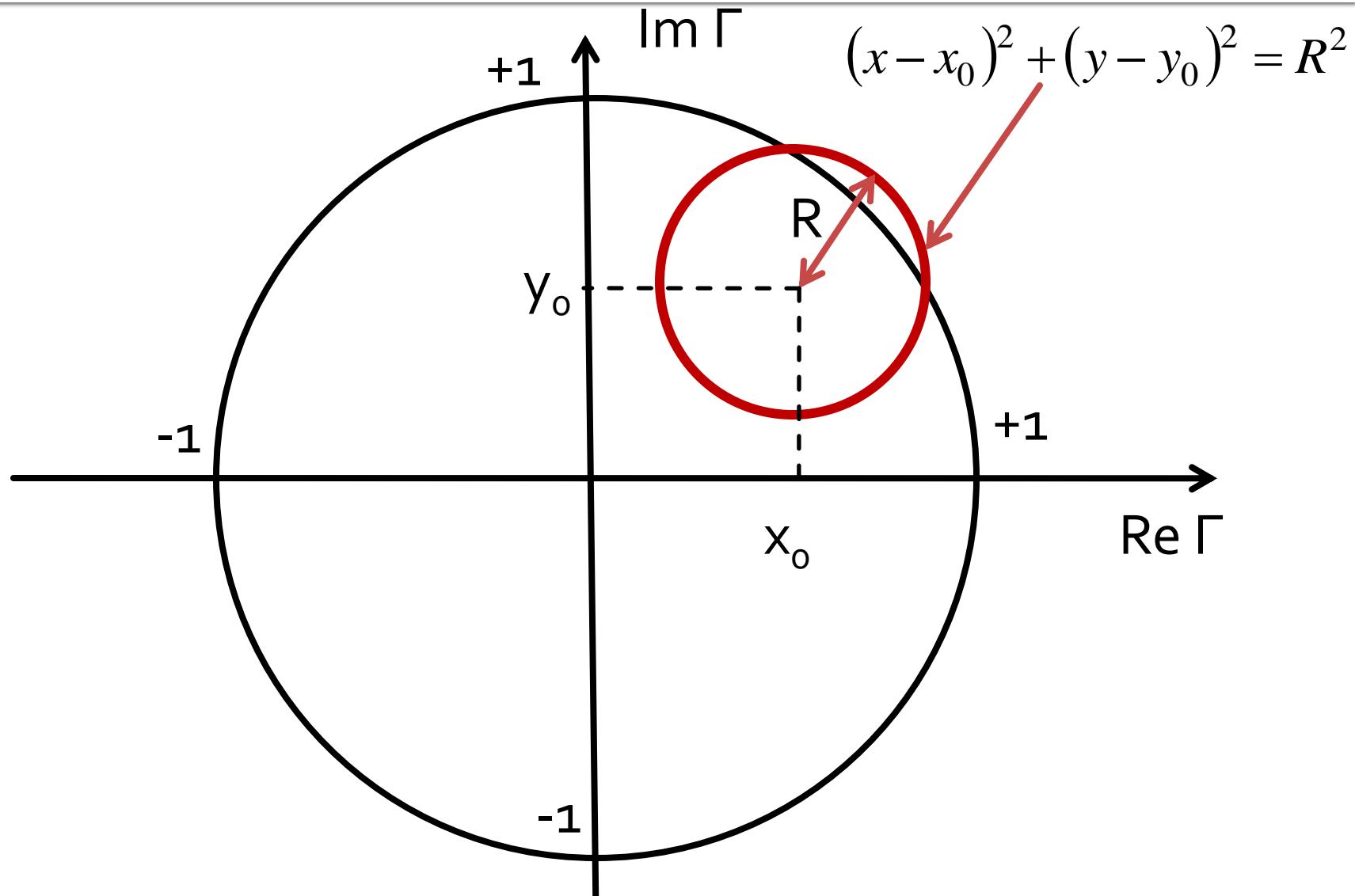


Diagrama Smith, rezistenta

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

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

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

- 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**

Diagrama Smith, rezistenta

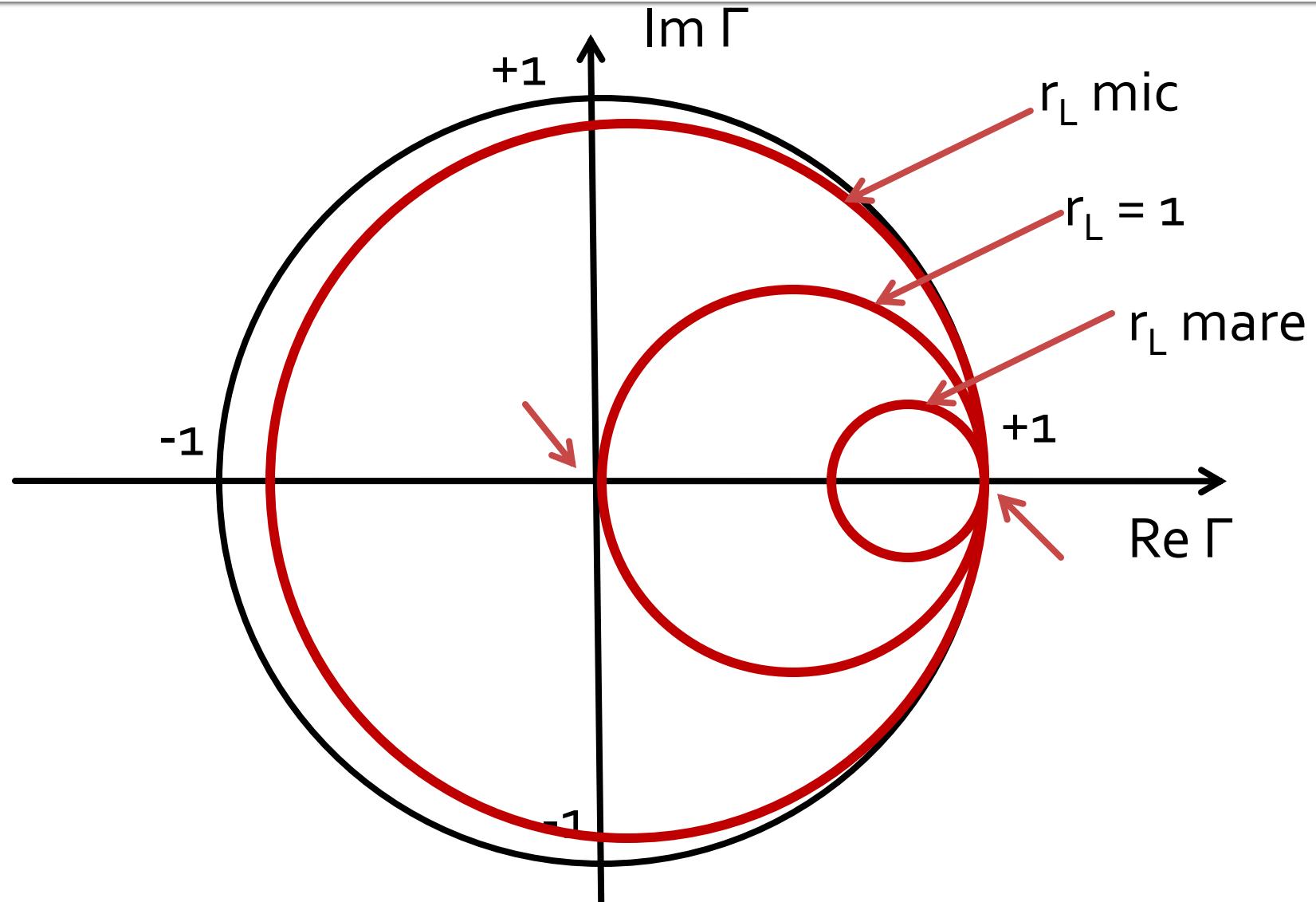


Diagrama Smith, reactanta

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

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

$$\begin{cases} x_0 = 1 \\ y_0 = \frac{1}{x_L} \\ R = \frac{1}{x_L} \end{cases}$$

- 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

Diagrama Smith, reactanta

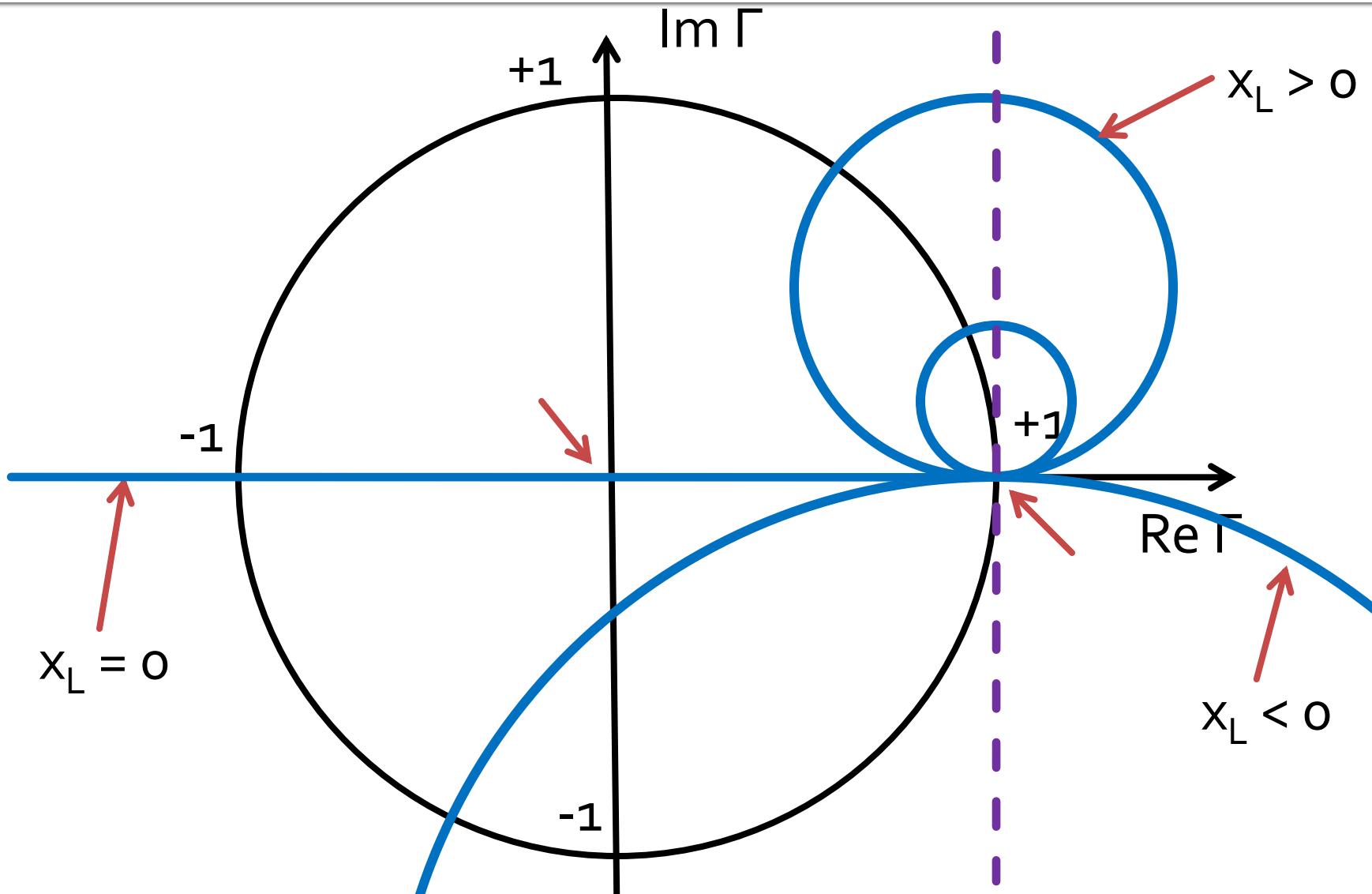


Diagrama Smith, impedanta

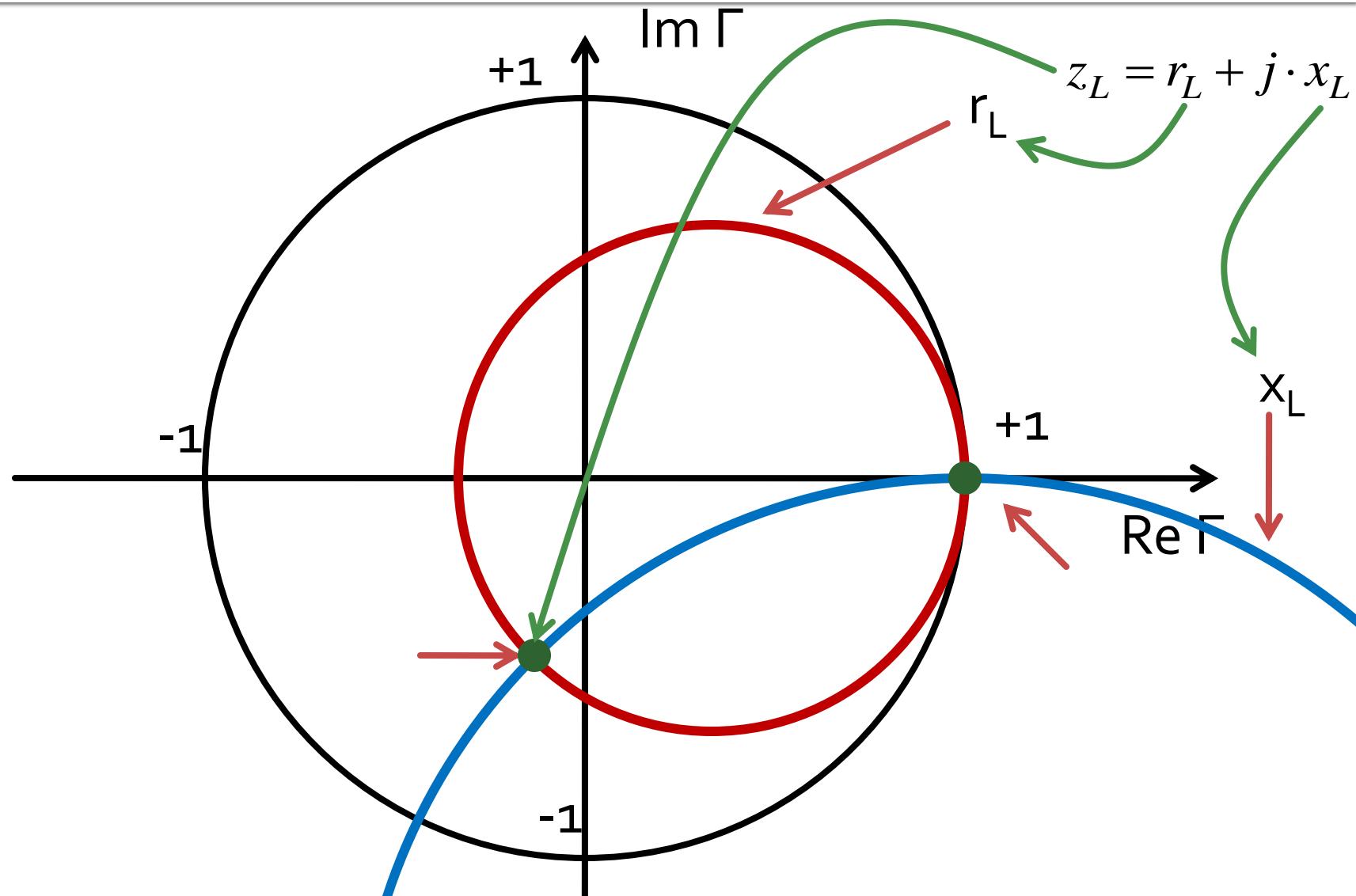
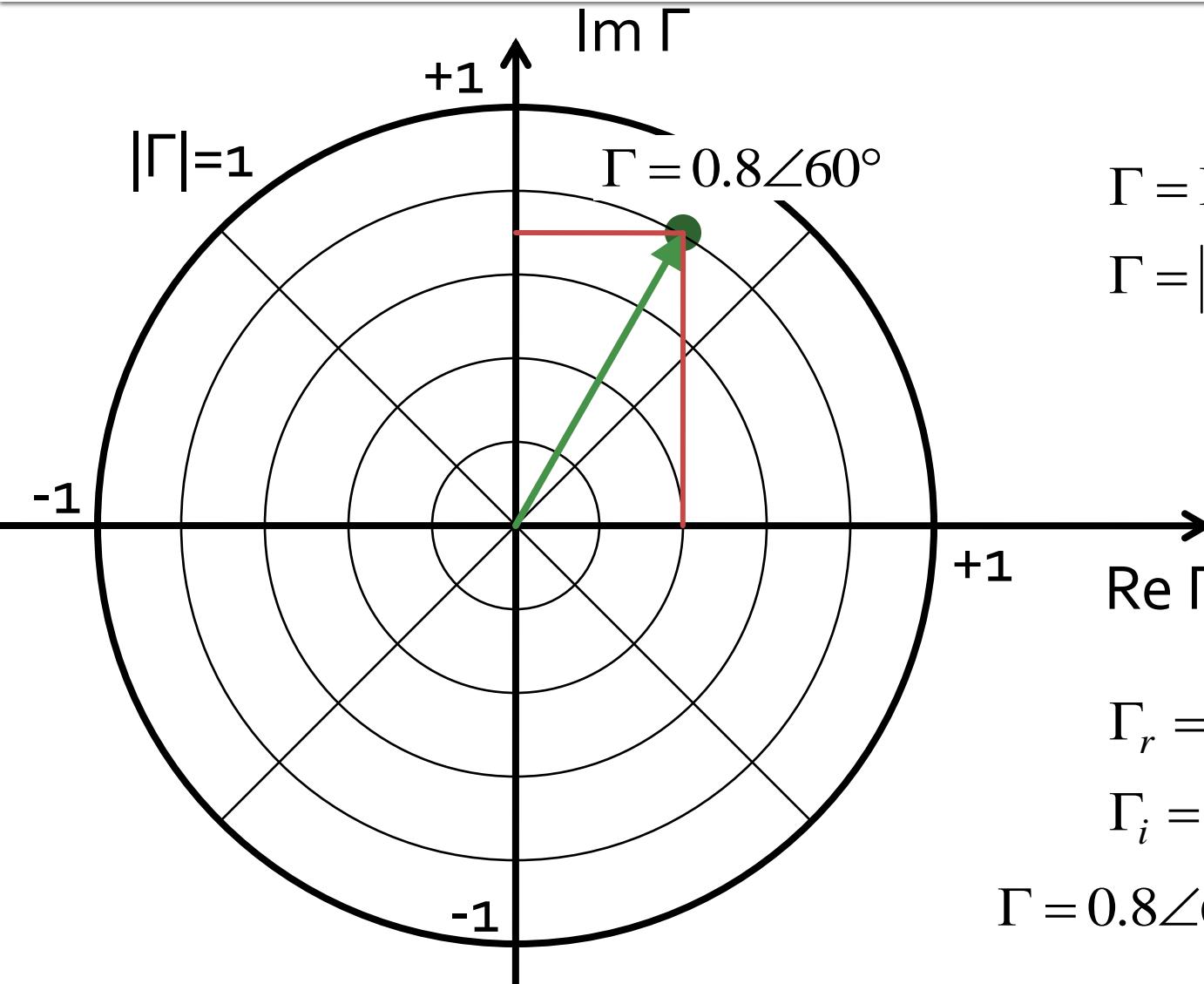


Diagrama Smith, coeficient de reflexie, coordonate rectangulare



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

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

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

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

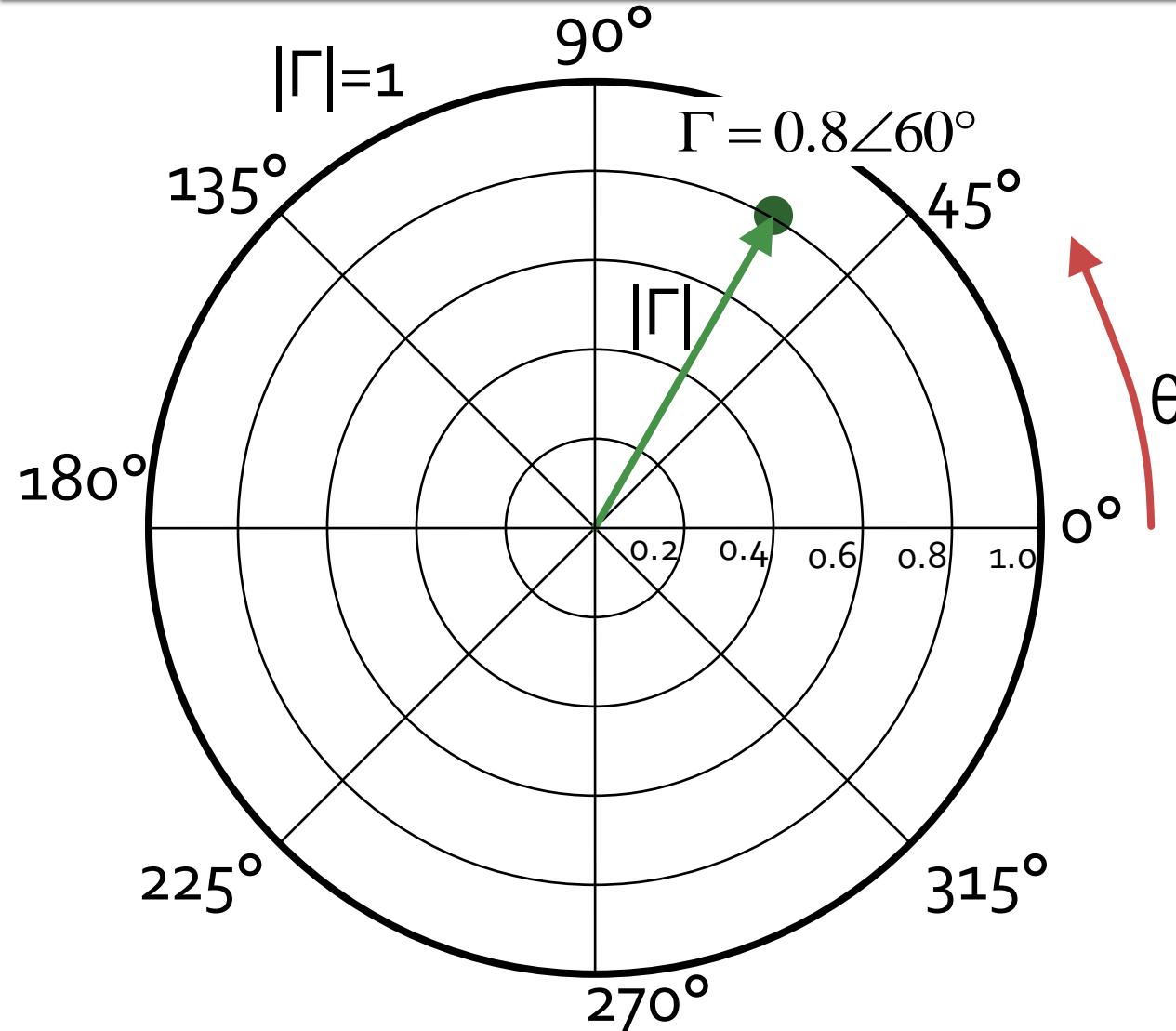
$$\Gamma = 0.8 \angle 60^\circ$$

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

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

$$\Gamma = 0.8 \angle 60^\circ = 0.4 + j \cdot 0.693$$

Diagrama Smith, coeficient de reflexie, coordonate polare



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

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

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

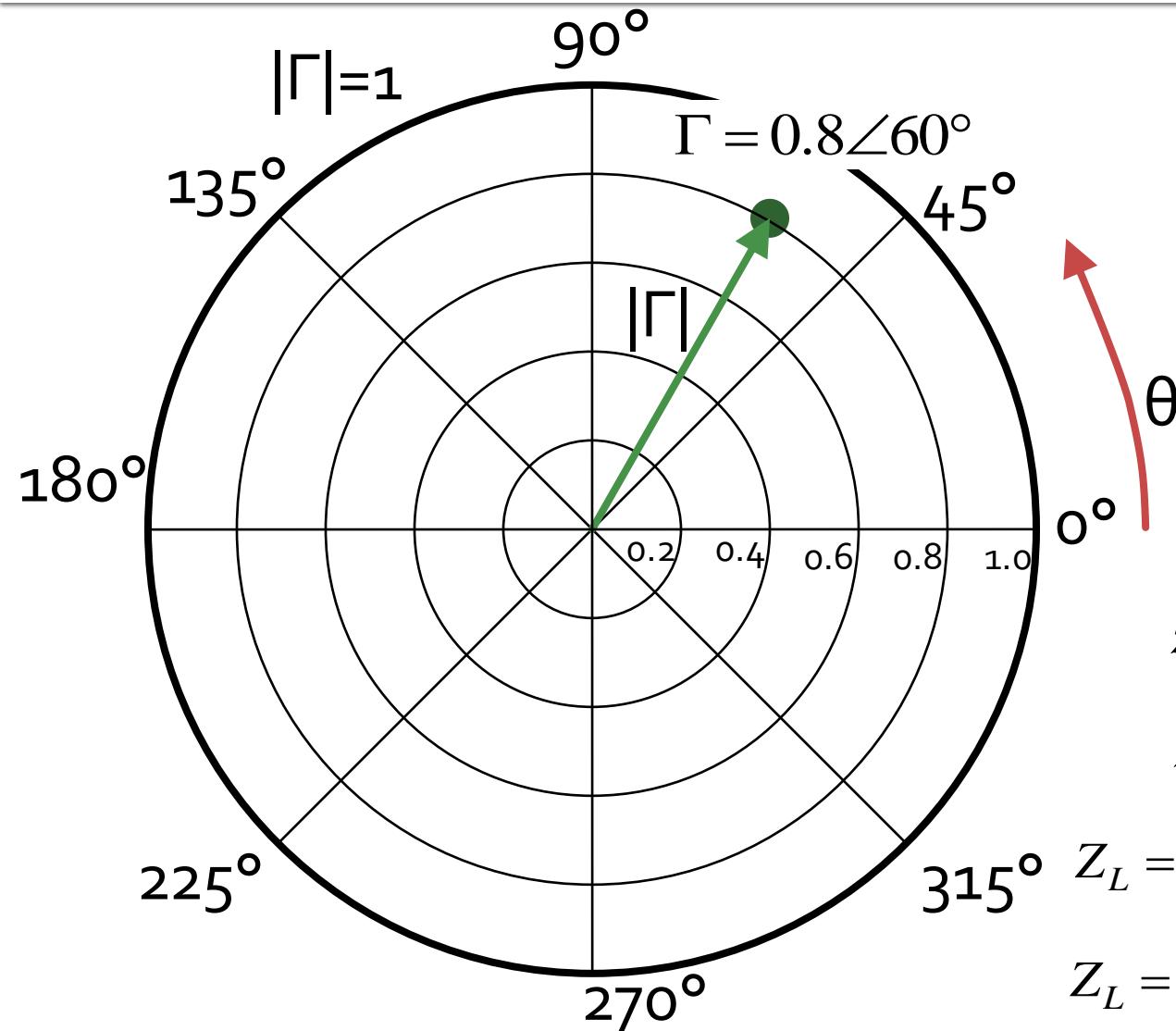
$$\Gamma = |\Gamma| \angle \theta^\circ$$

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

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

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

Diagrama Smith, coeficient de reflexie, impedanta



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

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

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

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

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

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

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

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

Diagrama Smith, coeficient de reflexie \leftrightarrow impedanta

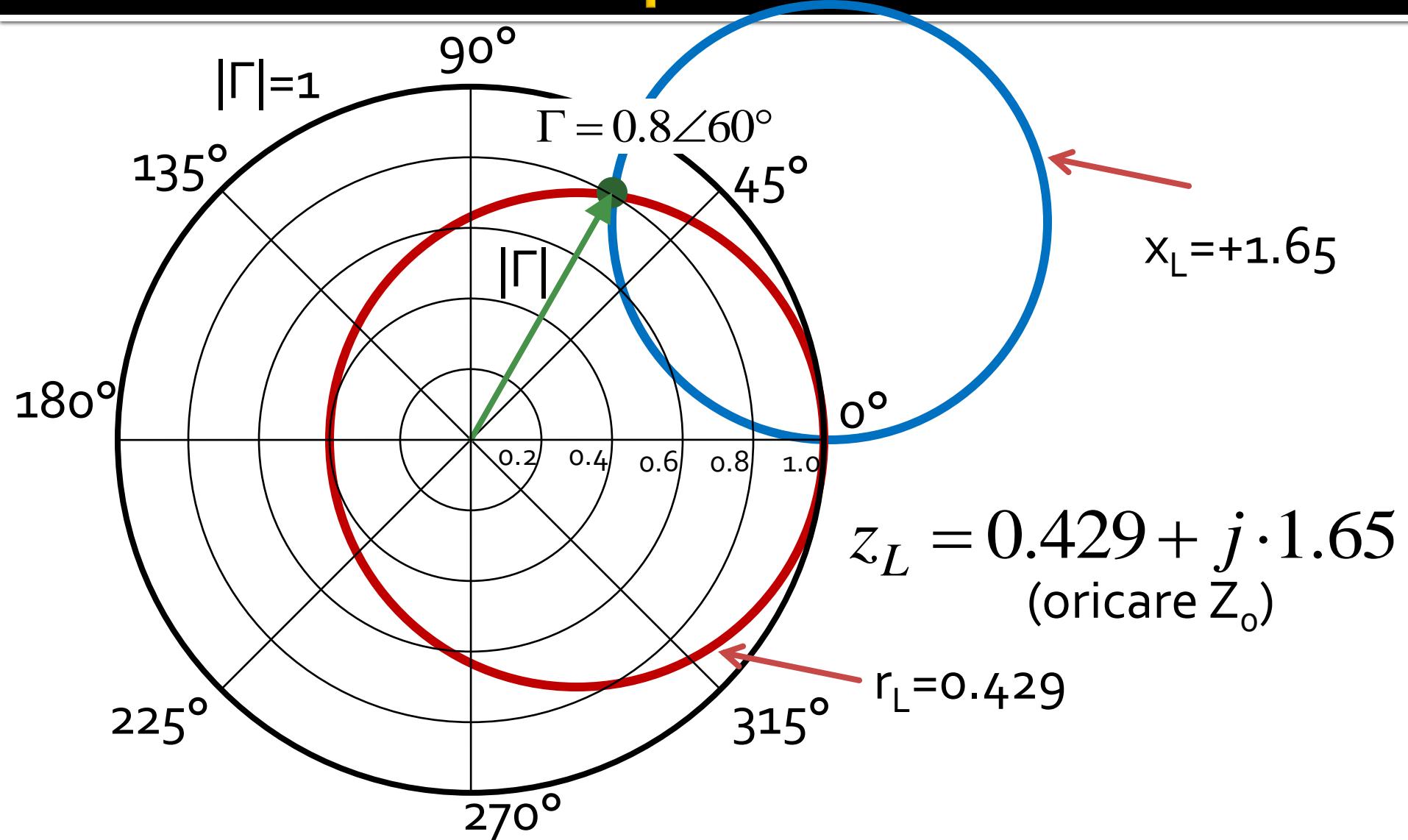
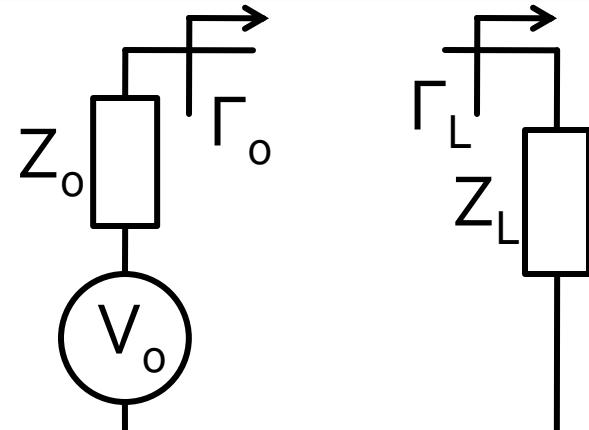
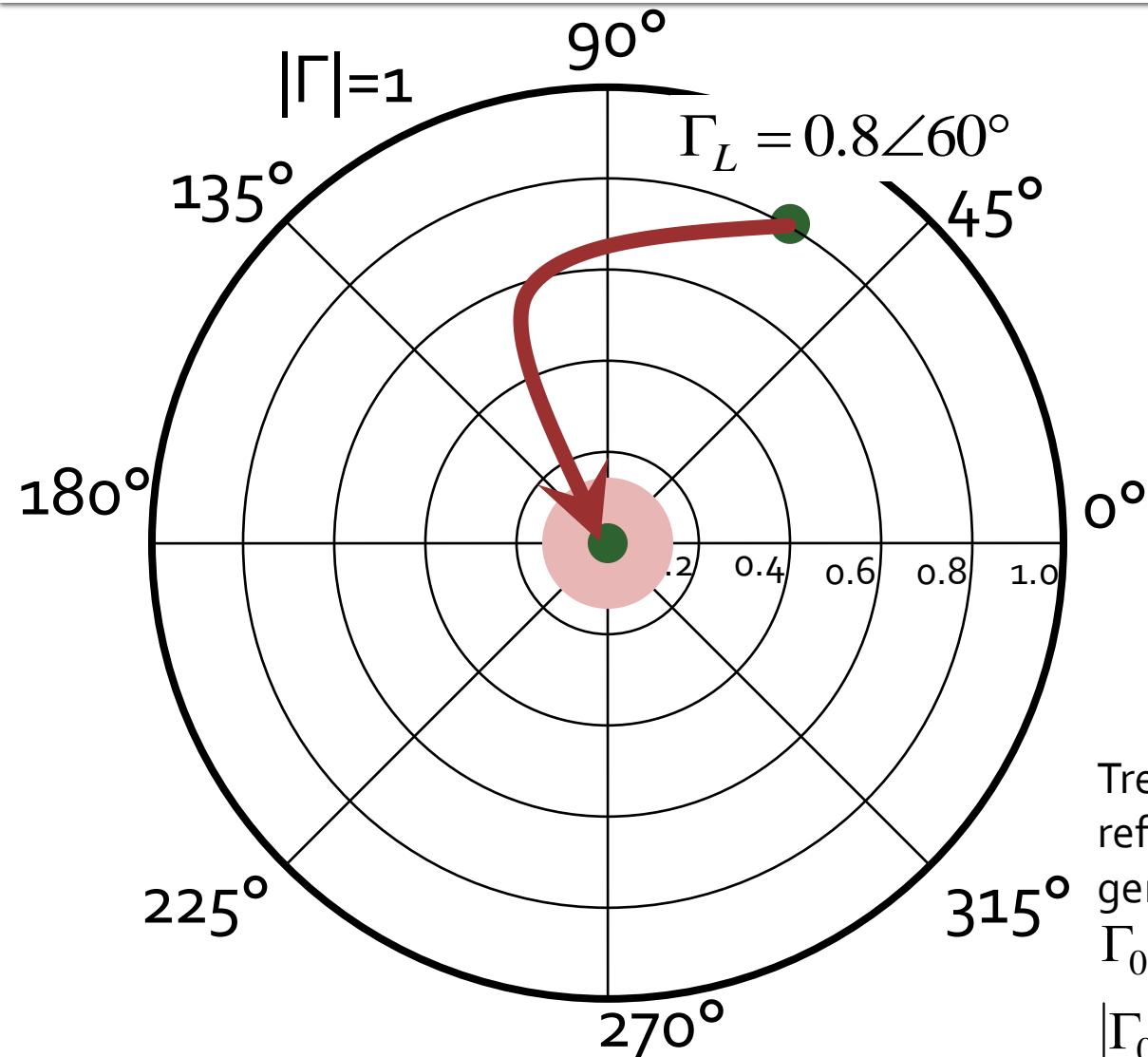


Diagrama Smith, coeficient de reflexie, adaptare



Adaptare Z_L la Z_0 . Se raporteaza Z_L la Z_0

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

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

$\Gamma_0 = 0$ adaptare perfecta

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

Simulare

■ Similar Lab. 1

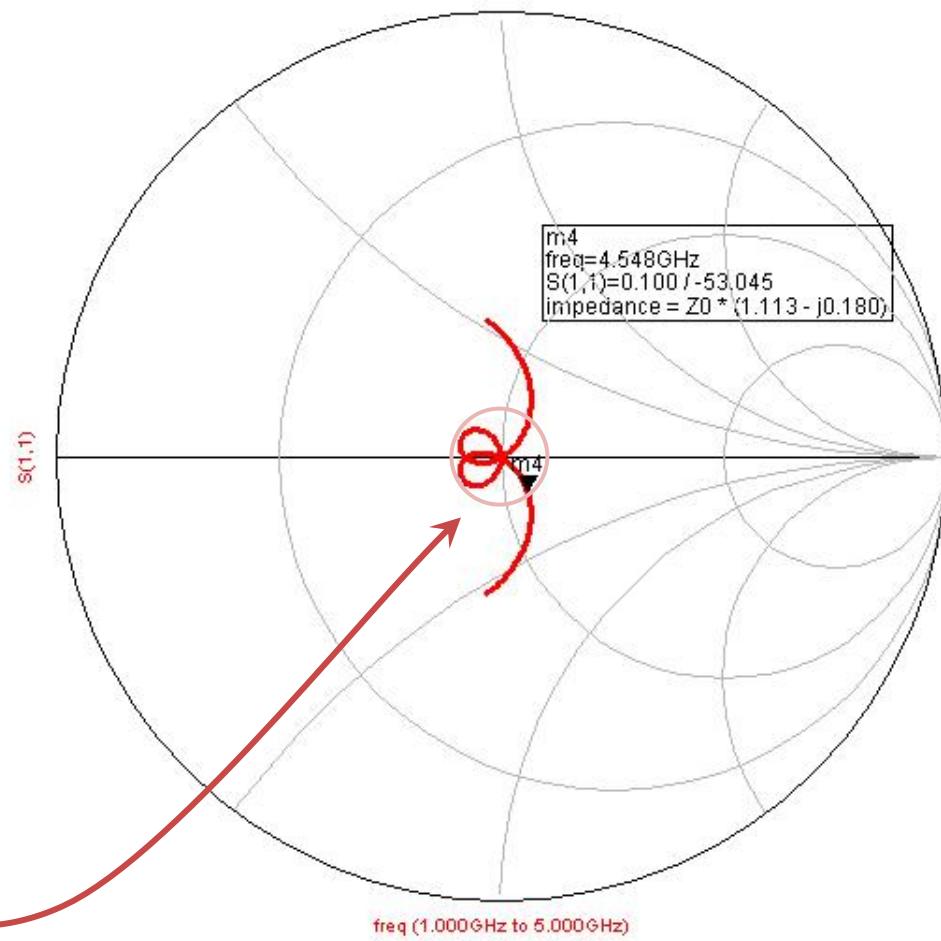
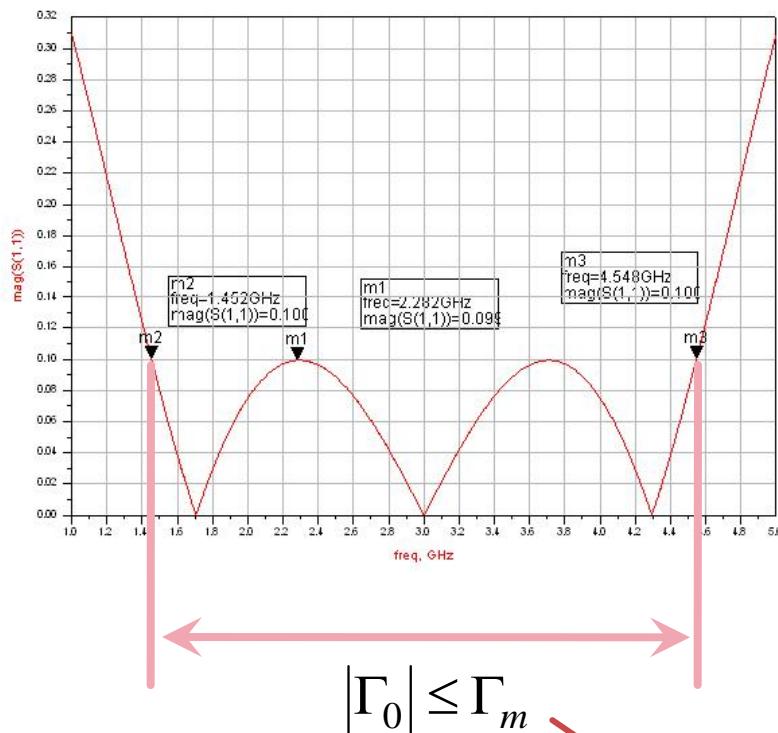
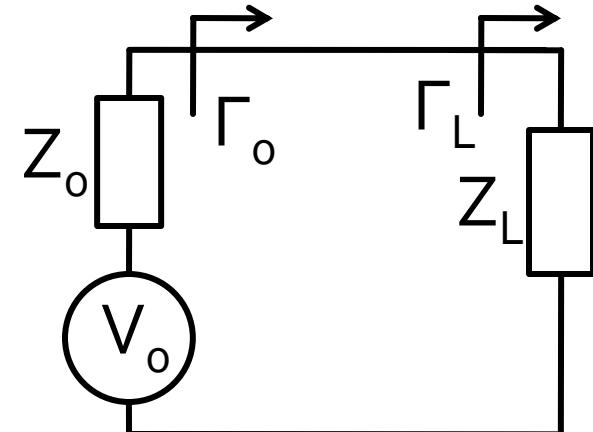
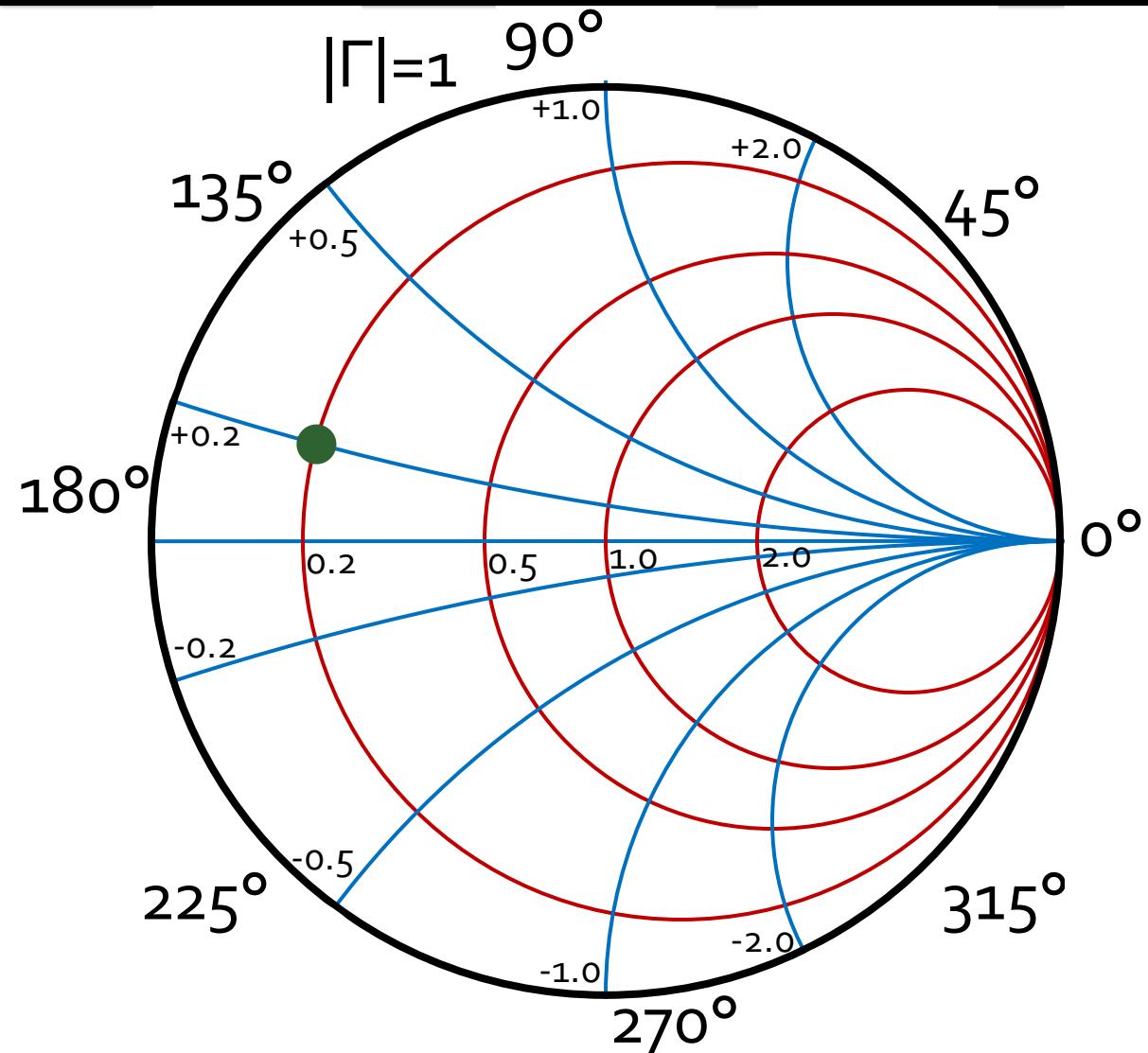


Diagrama Smith, coeficient de reflexie



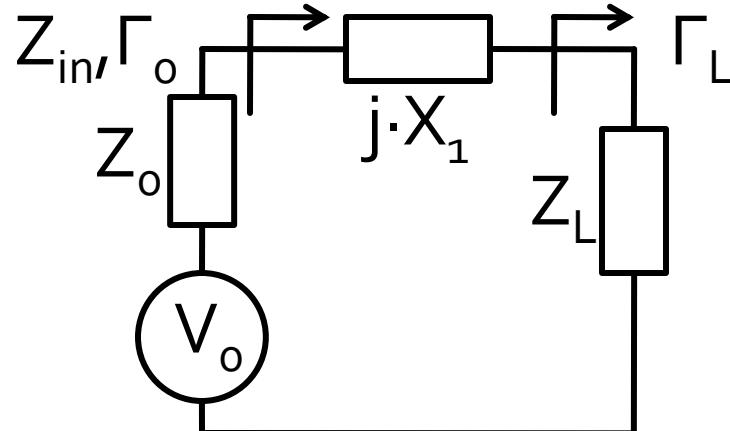
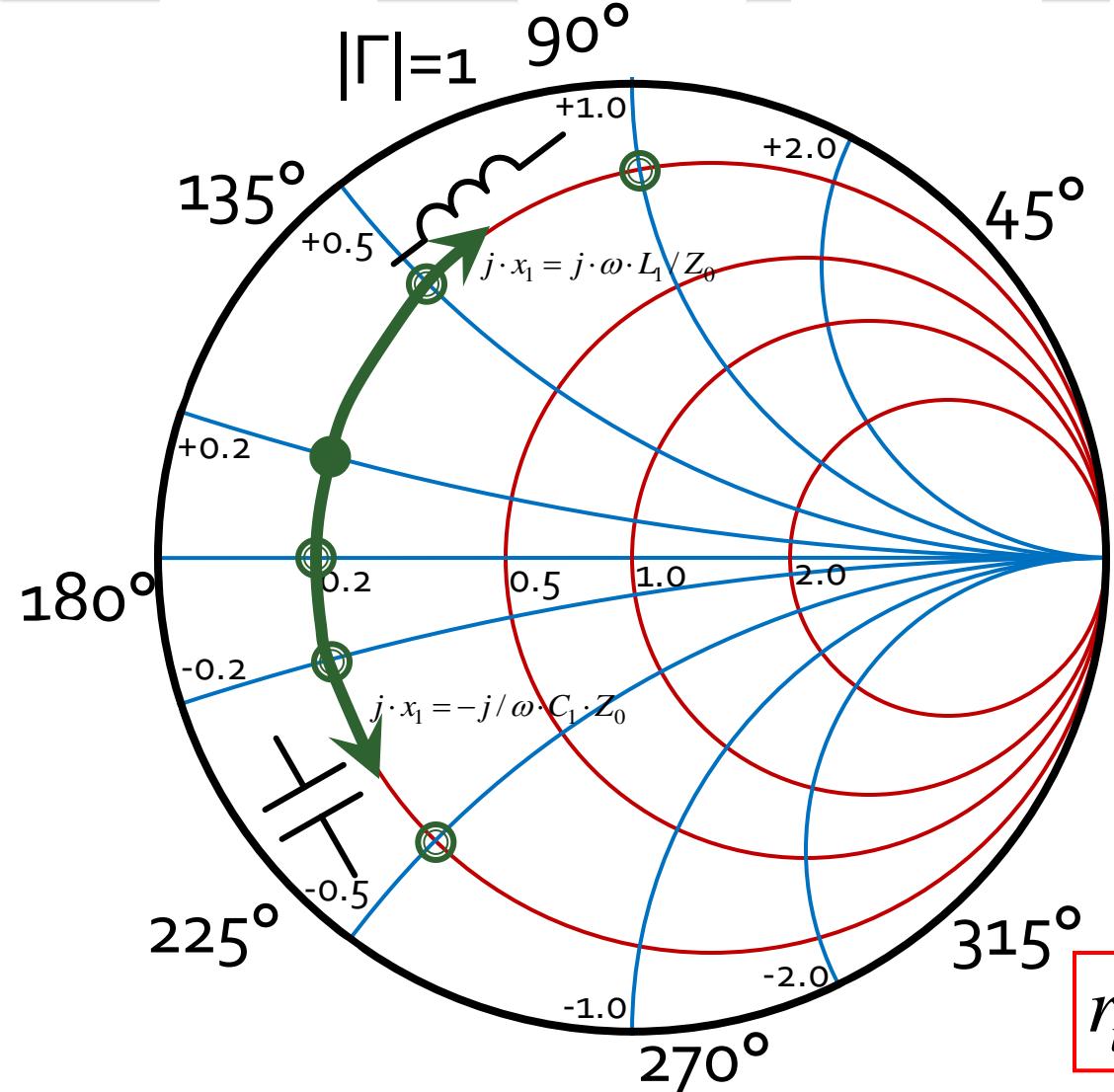
$$Z_0 = 50\Omega$$

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

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

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

Diagrama Smith, coeficient de reflexie, reactanta in serie



$$Z_0 = 50\Omega$$

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

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

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

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

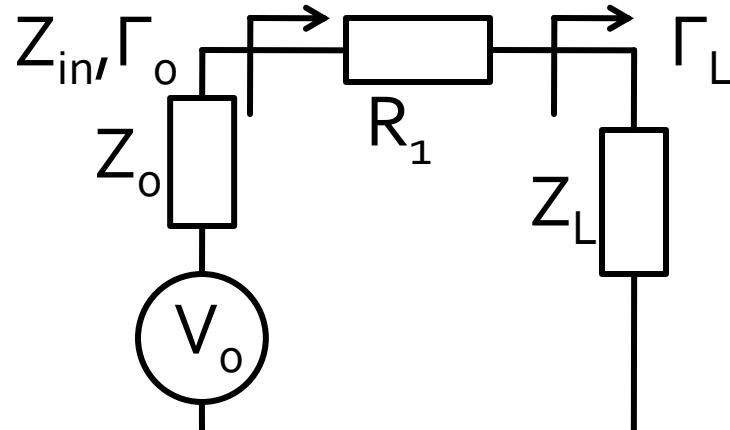
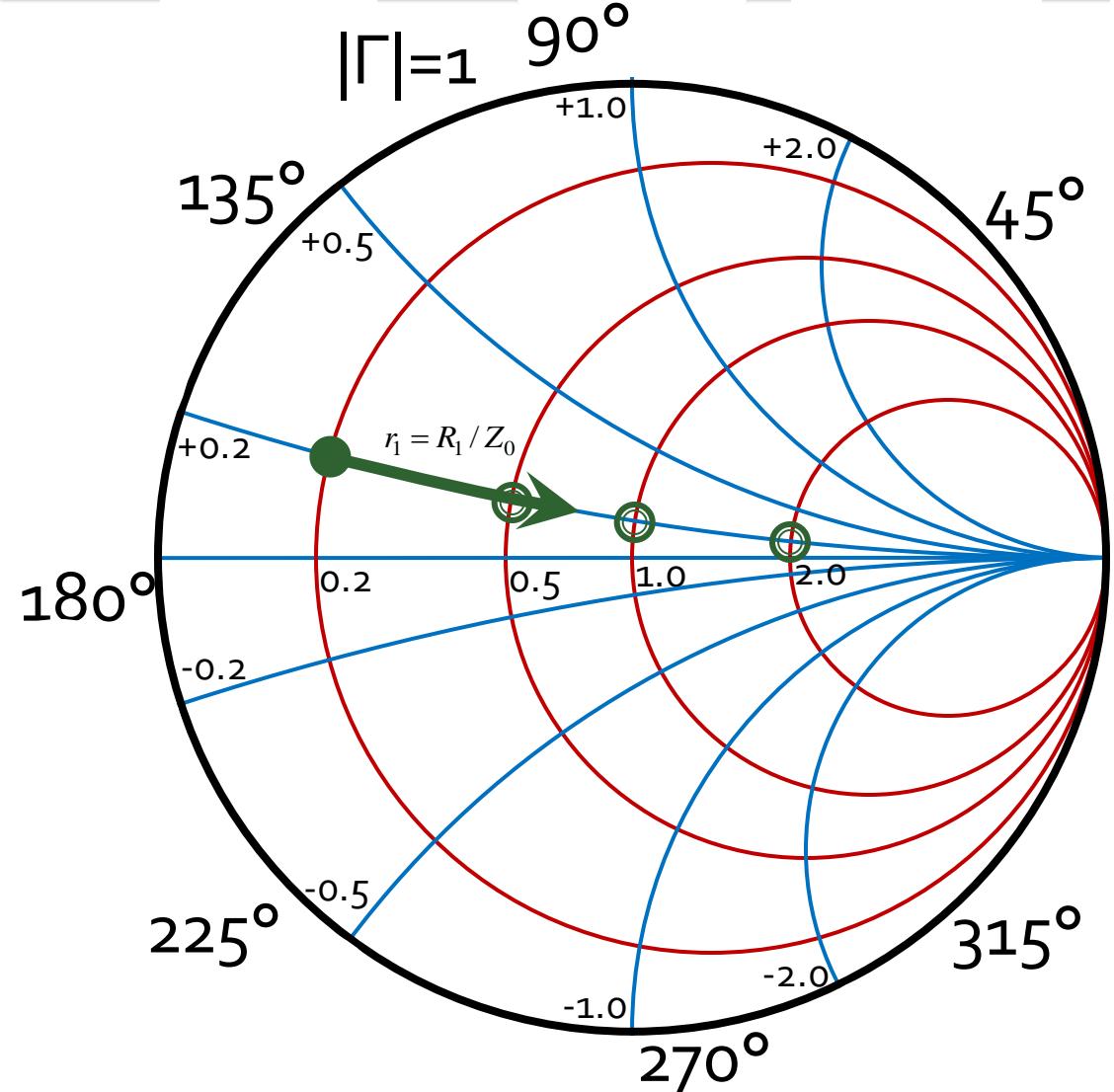
$$z_{in} = r_L + j \cdot (x_L + x_1)$$

$$r_{in} = r_L$$

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

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

Diagrama Smith, coeficient de reflexie, rezistenta in serie



$$Z_0 = 50\Omega$$

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

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

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

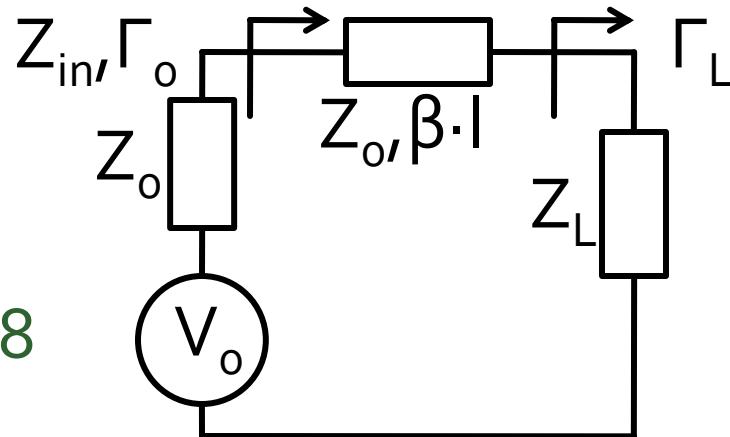
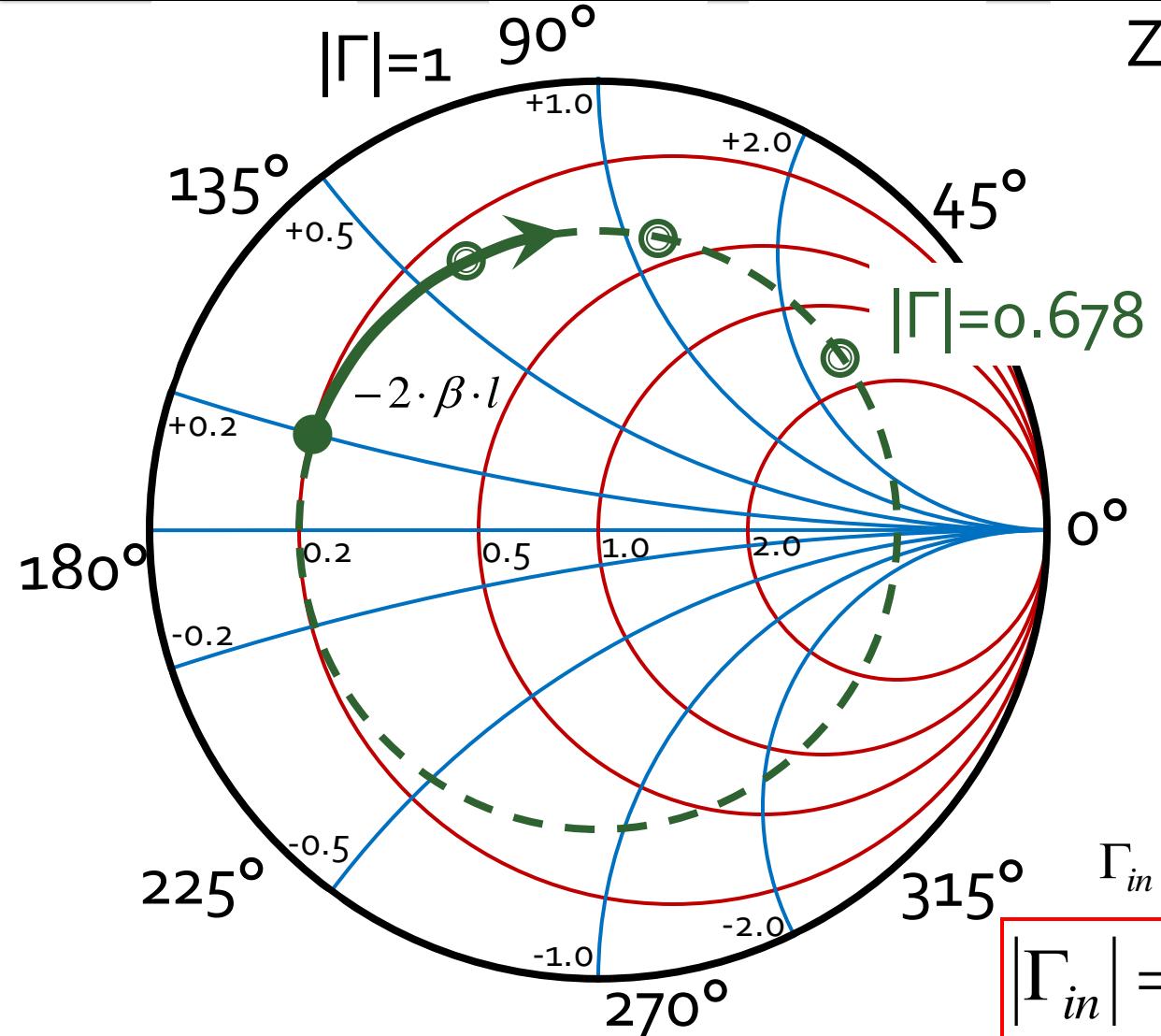
$$Z_{in} = Z_L + R_1 = (R_L + R_1) + j \cdot X_L$$

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

$$x_{in} = x_L$$

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

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



$$Z_0 = 50\Omega$$

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

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

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

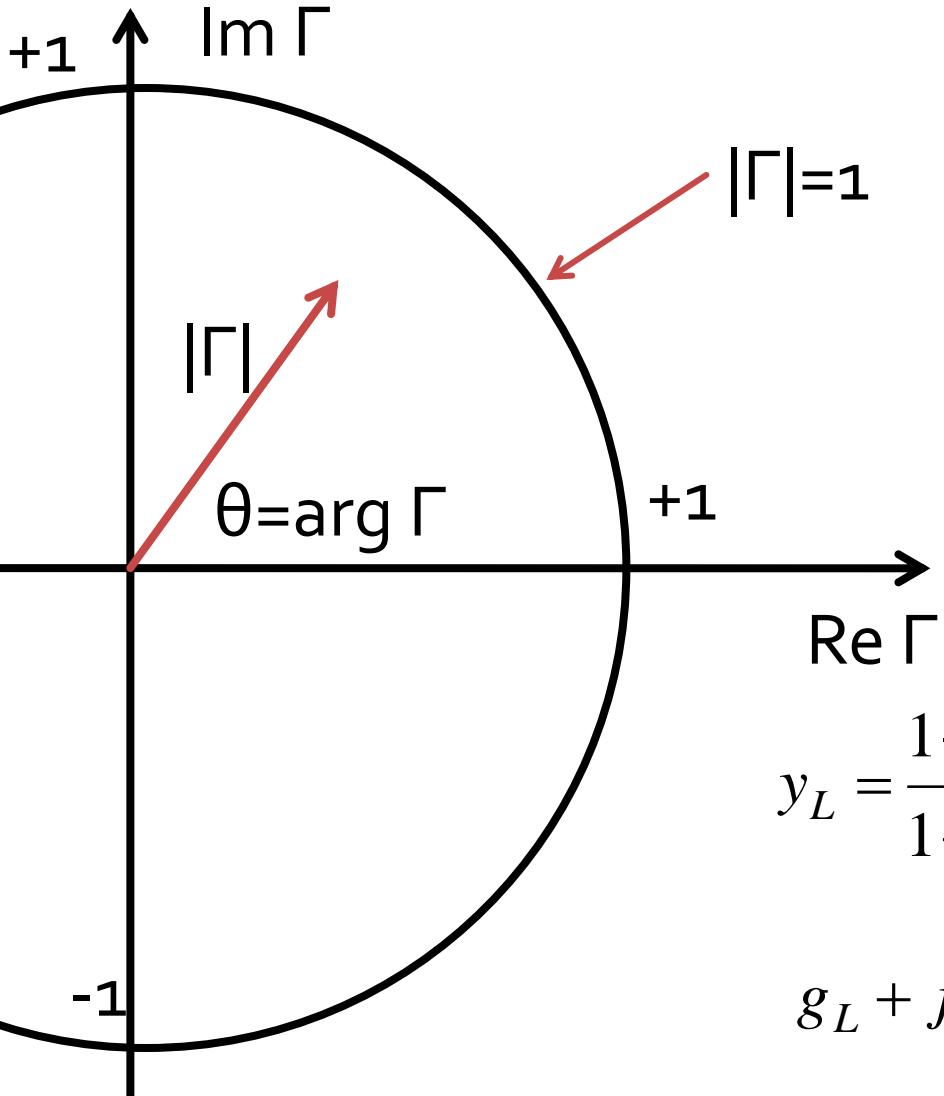
$$Z_{in} = Z_0 \cdot \frac{1 + \Gamma_L \cdot e^{-2j\beta l}}{1 - \Gamma_L \cdot e^{-2j\beta l}}$$

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

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

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

Diagramma Smith, admitante



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

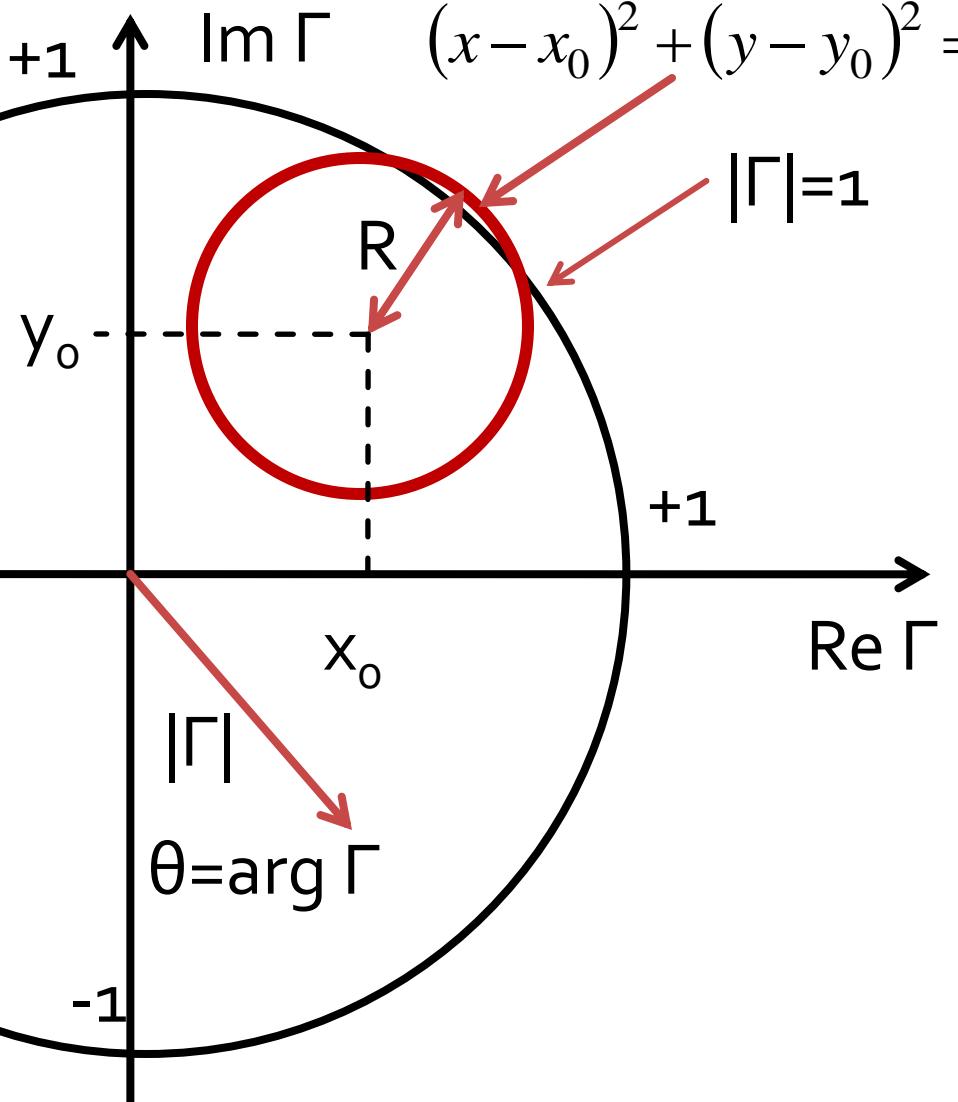
$$\Gamma = \Gamma_r + j \cdot \Gamma_i$$

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

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

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

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

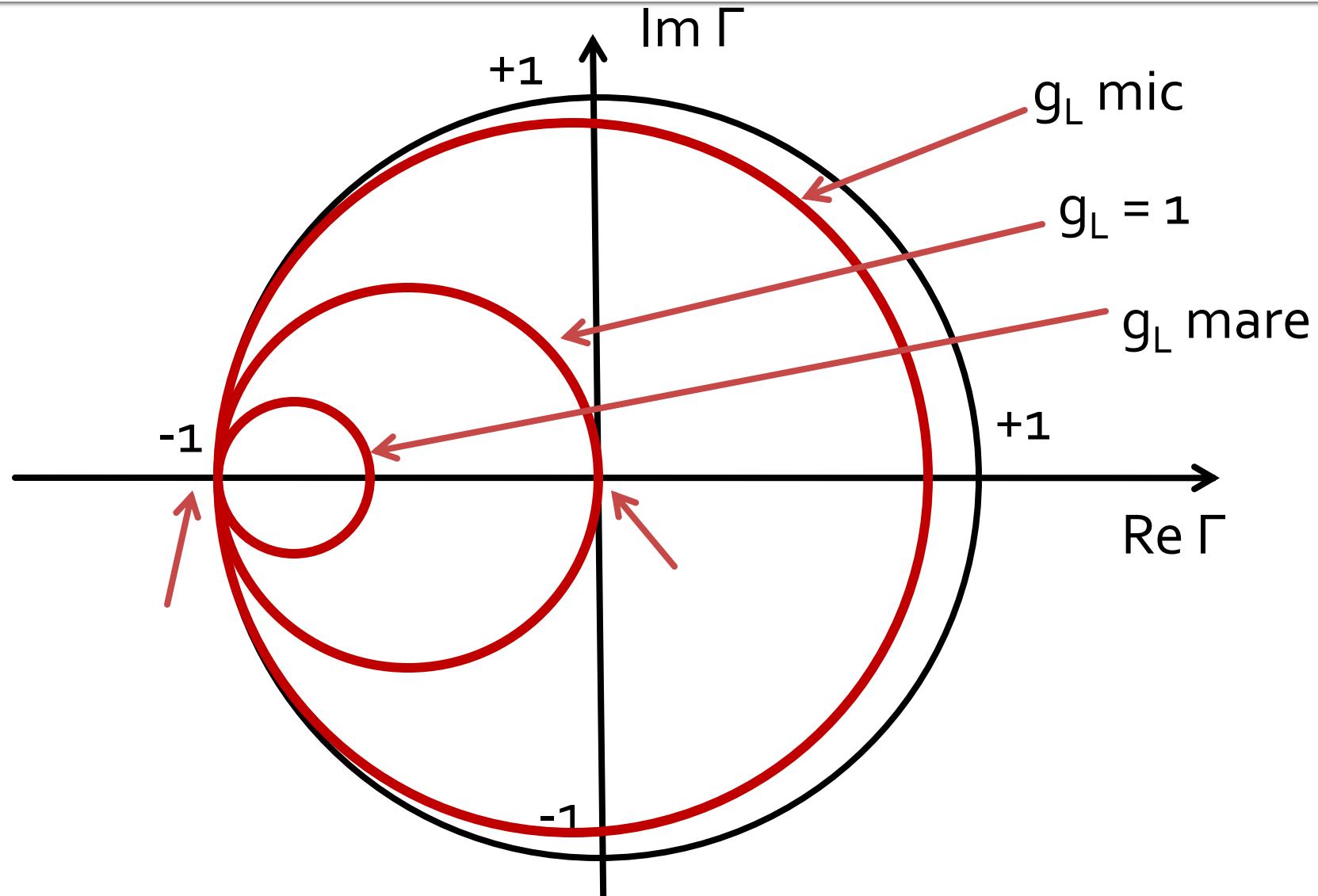


Diagrama Smith, susceptanta

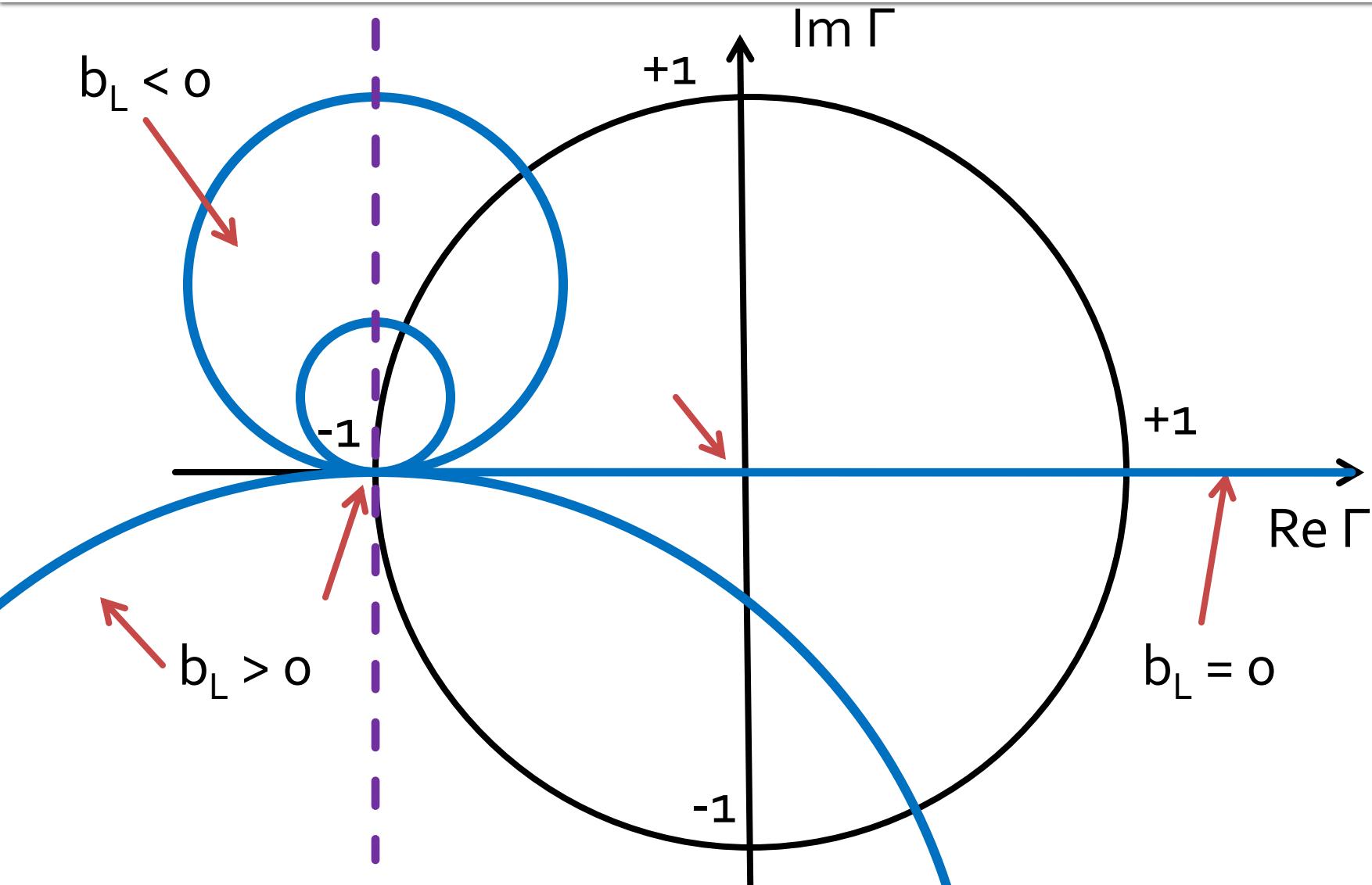
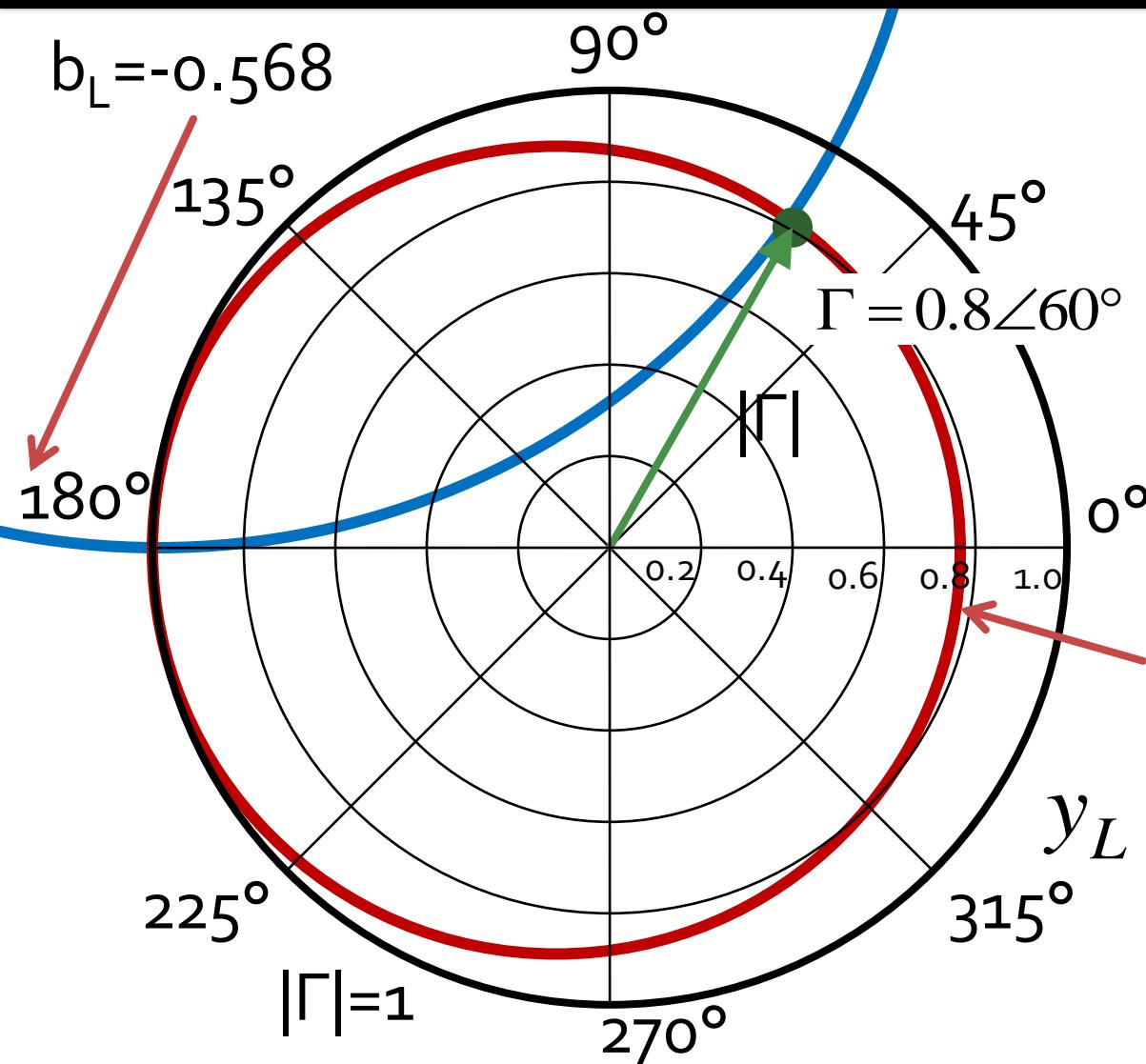


Diagrama Smith, coeficient de reflexie \leftrightarrow admitanta



$$\Gamma = 0.8∠60^\circ$$

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

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

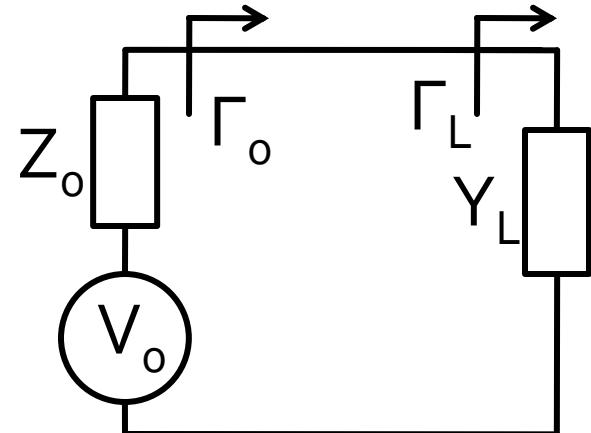
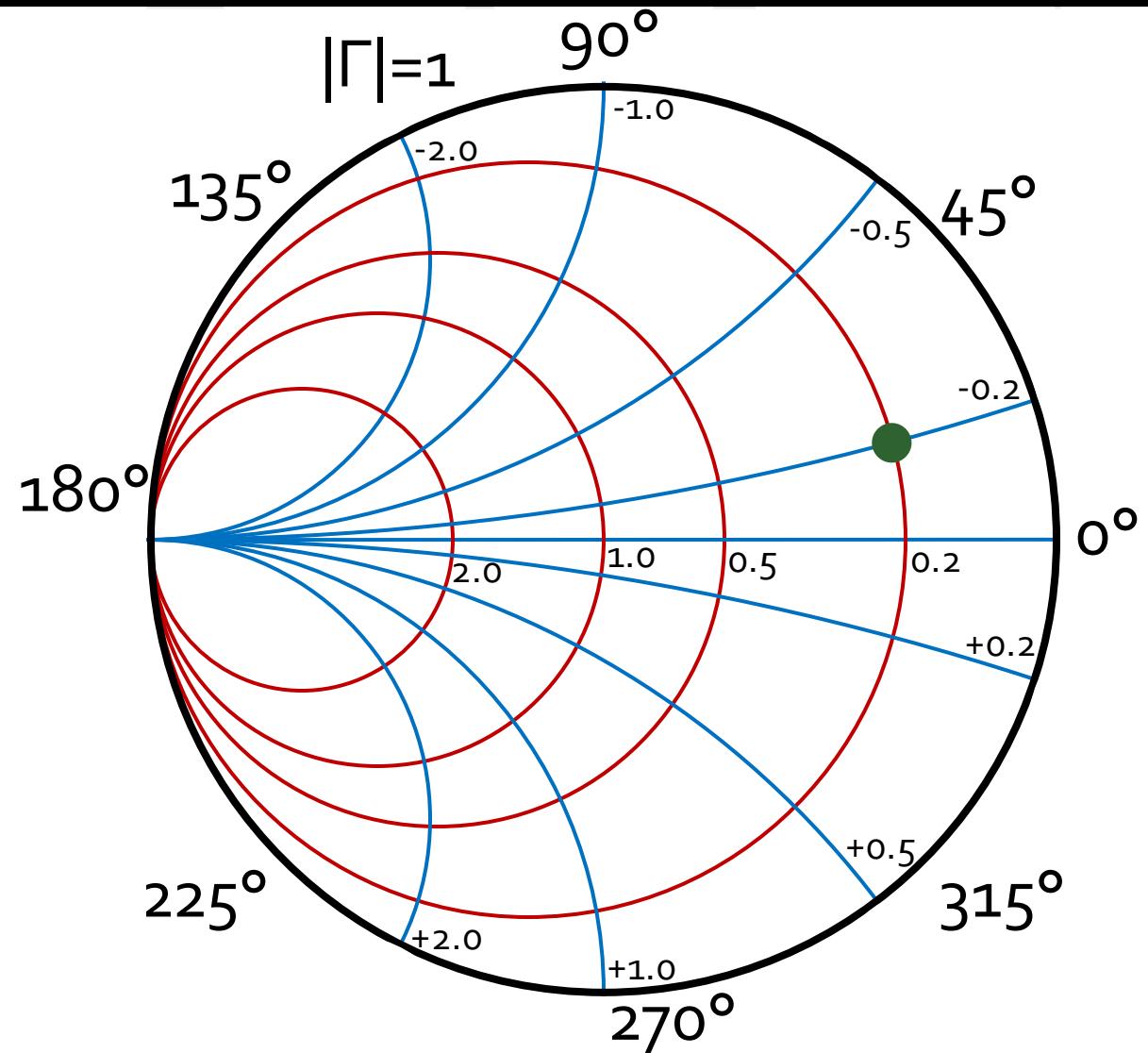
$$y_L = \frac{1}{z_L} = 0.148 - j \cdot 0.568$$

$$g_L = 0.148$$

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

(oricare Z_0)

Diagrama Smith, coeficient de reflexie, admitanta



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

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

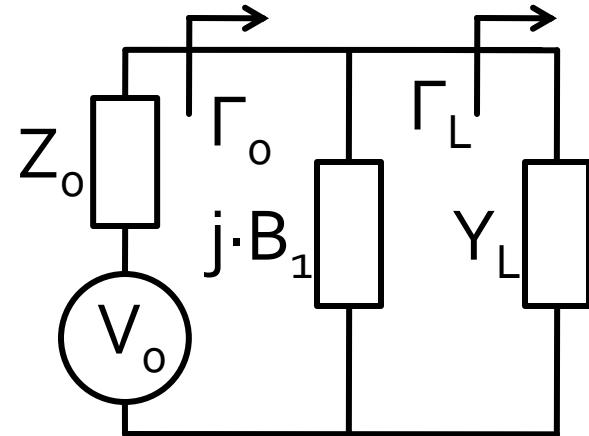
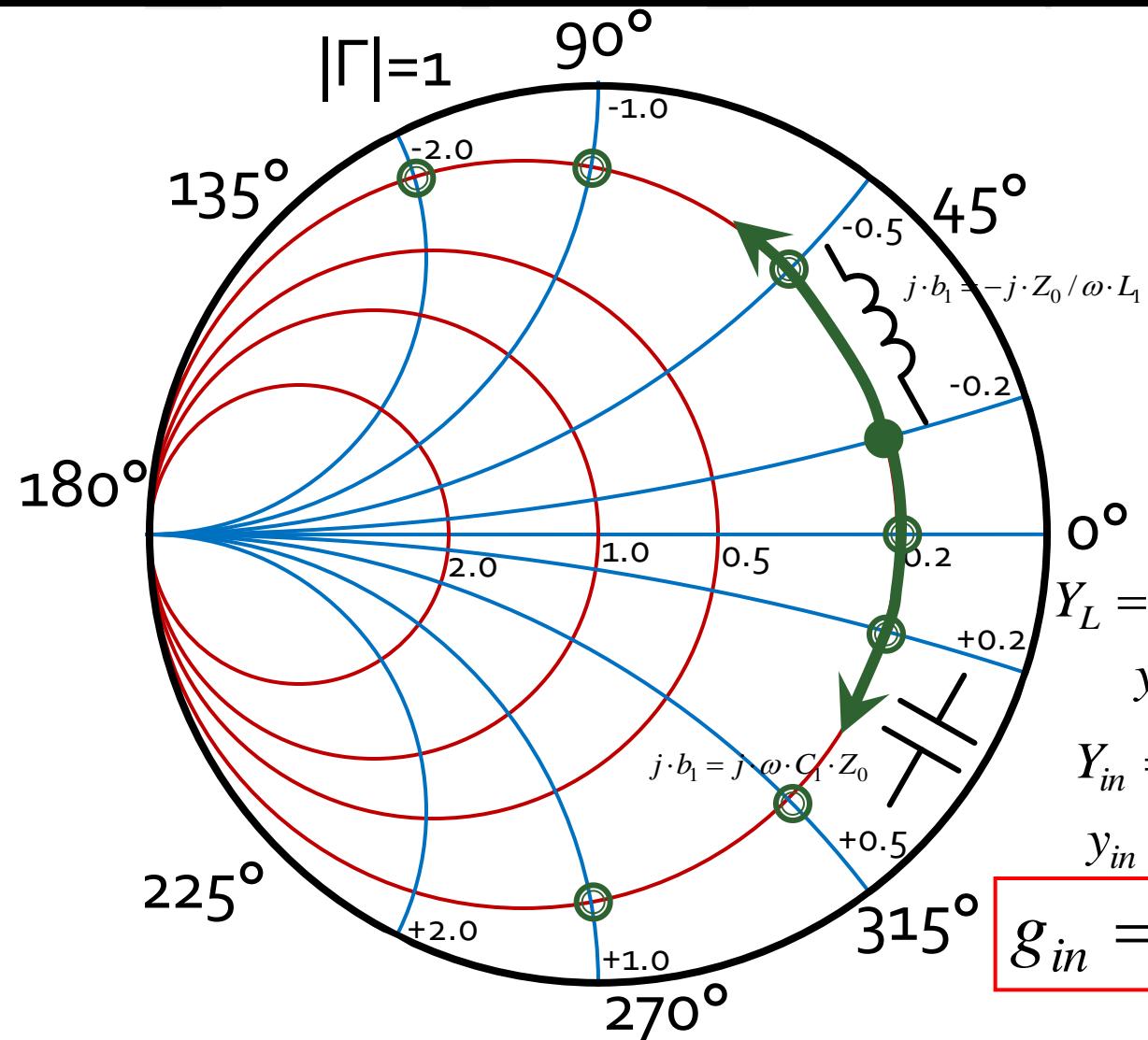
$$z_L = 2.5 + j \cdot 2.5$$

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

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

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

Diagrama Smith, coeficient de reflexie, susceptanta in paralel



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

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

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

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

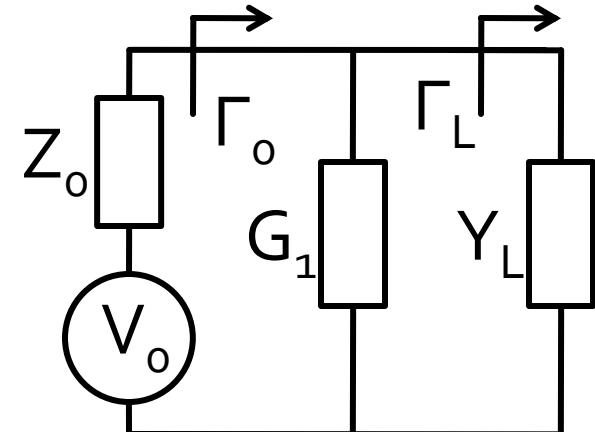
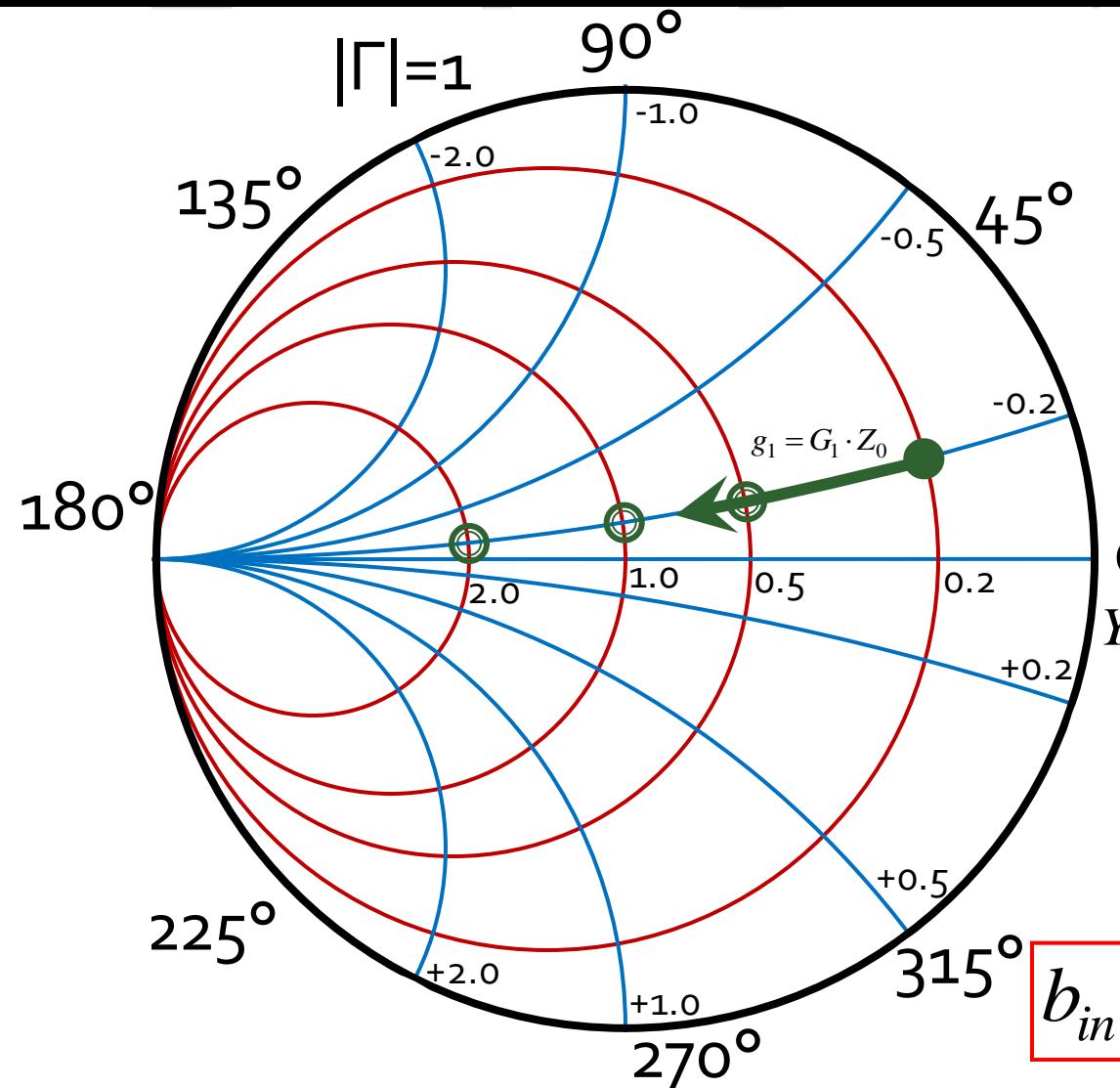
$$Y_{in} = Y_L + j \cdot B_1 = G_L + j \cdot (B_L + B_1)$$

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

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

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

Diagrama Smith, coeficient de reflexie, conductanta in paralel



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

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

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

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

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

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

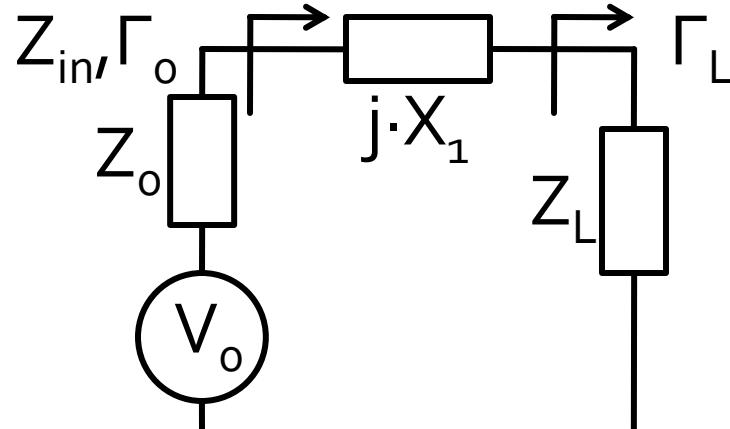
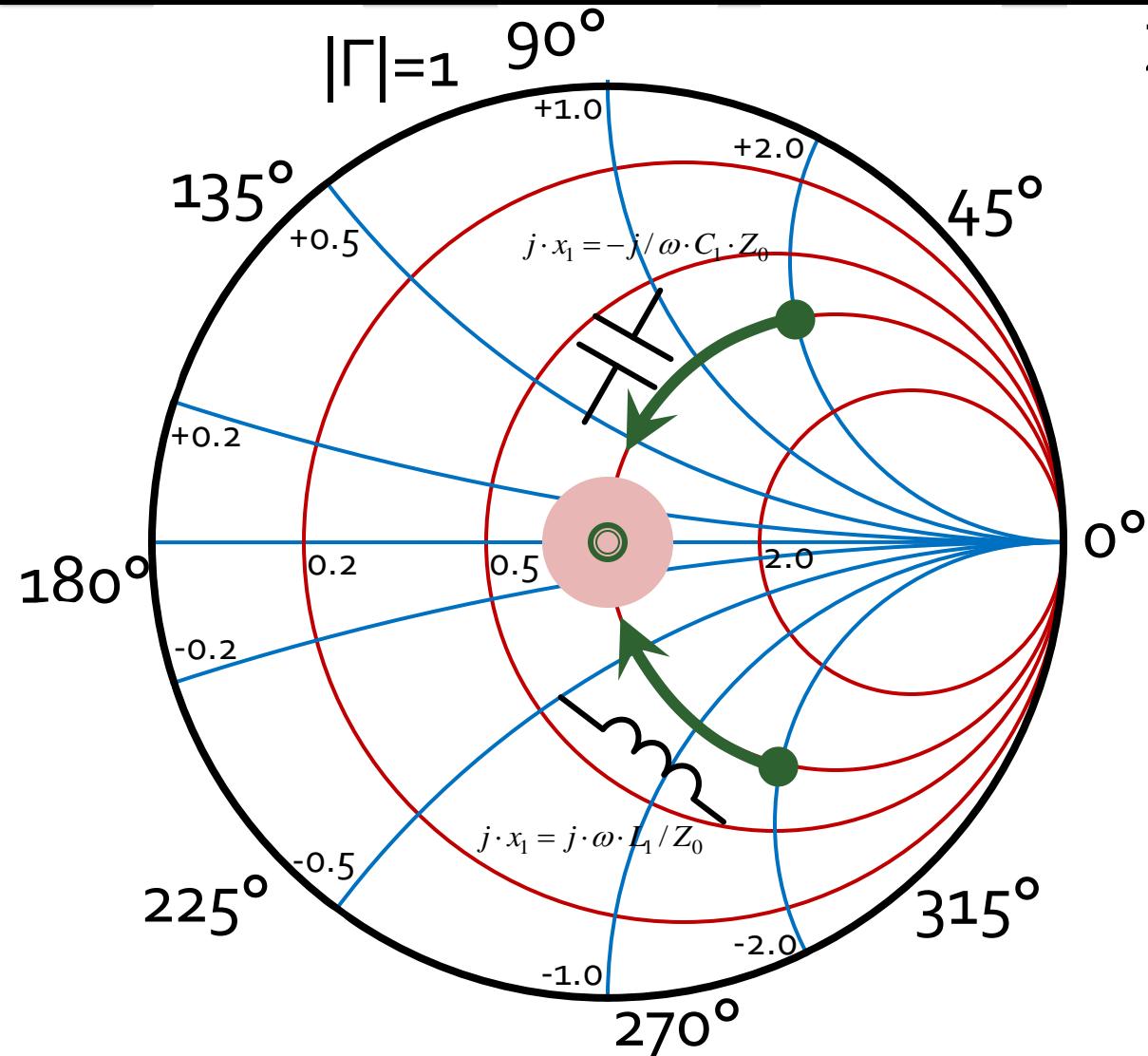
$$b_{in} = b_L$$

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

Adaptarea cu elemente concentrate (Retele in L)

Adaptarea de impedanță

Adaptare, reactanta in serie



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

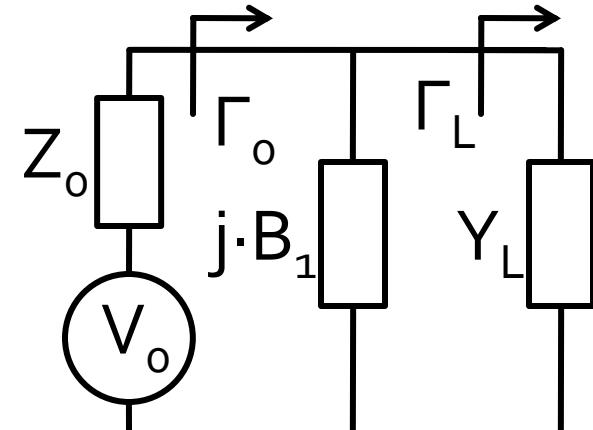
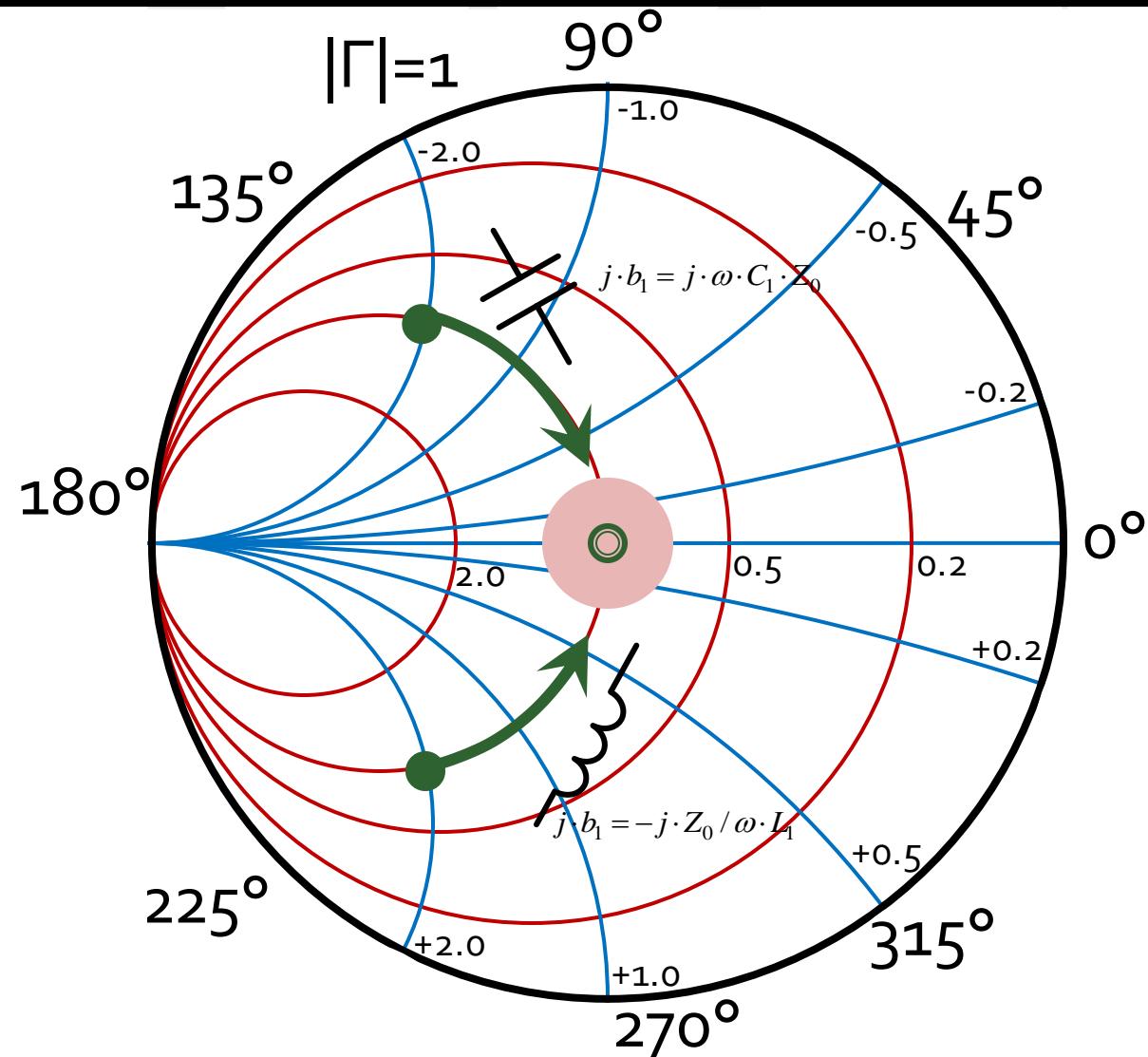
$$z_{in} = r_L + j \cdot (x_L + x_1)$$

$$r_{in} = r_L$$

- 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



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

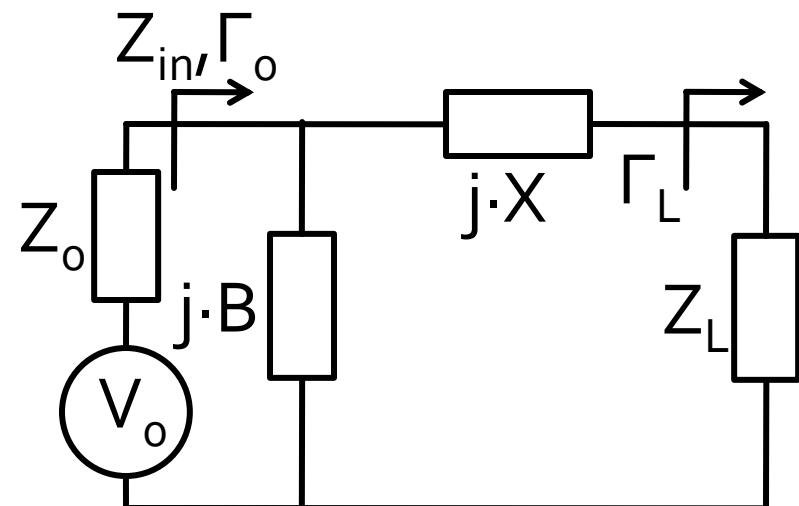
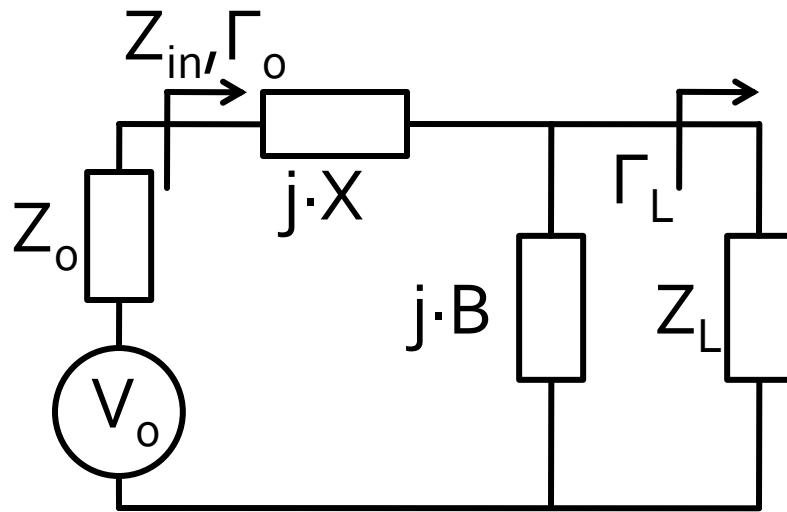
$$y_{in} = g_L + j \cdot (b_L + b_1)$$

$$g_{in} = g_L$$

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

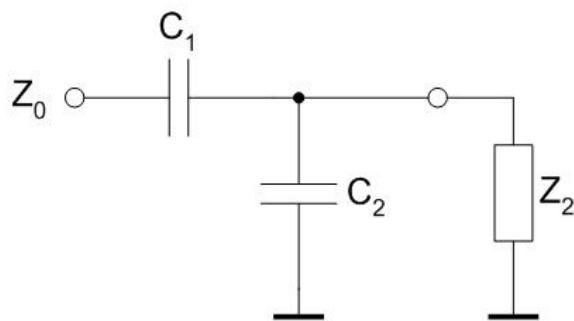
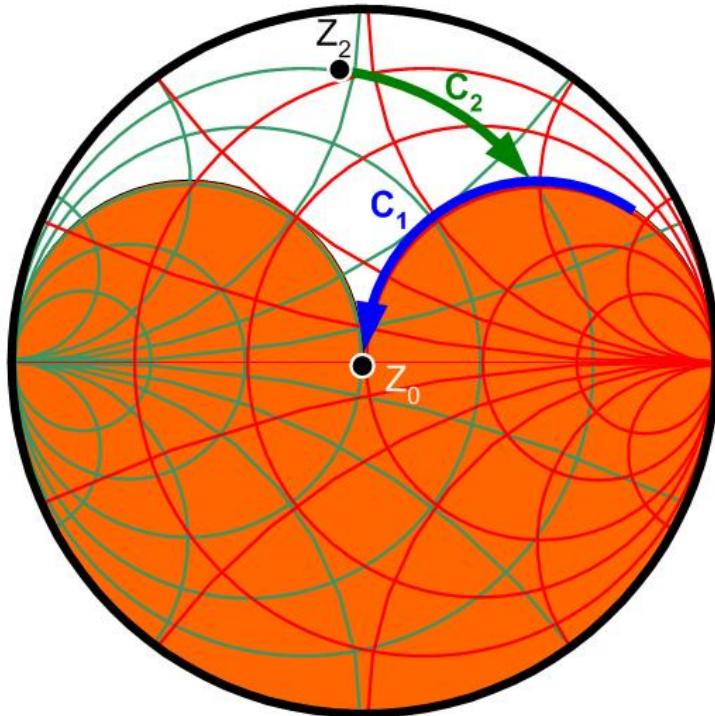
$$j \cdot b_1 = -j \cdot b_L$$

Adaptare cu două elemente reactive (retele in L)

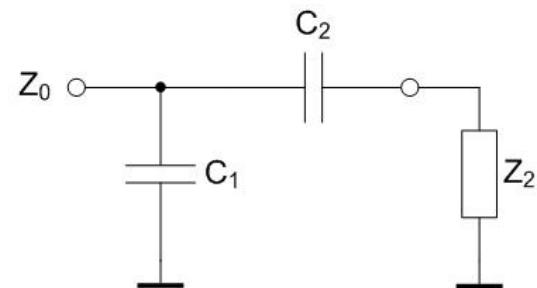
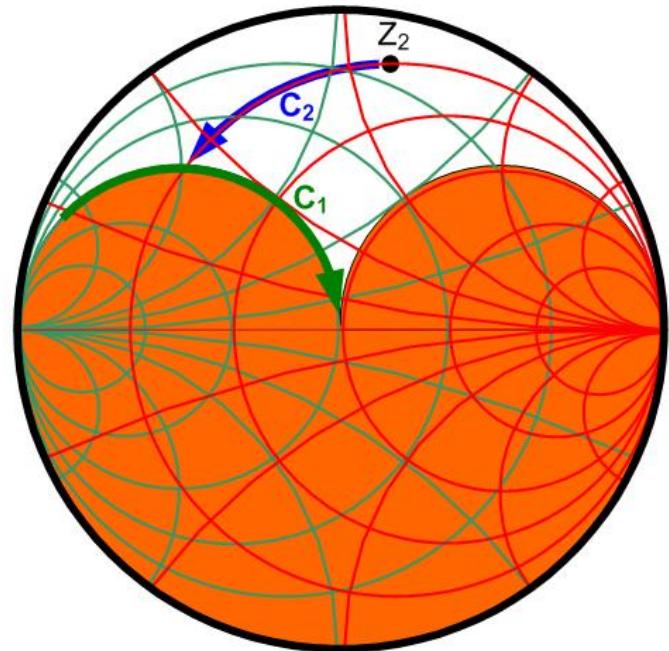


- Adaptare in doi pasi
 - un prim element muta coeficientul de reflexie pe cercul $r_L = 1/g_L = 1$
 - al doilea element realizeaza adaptarea

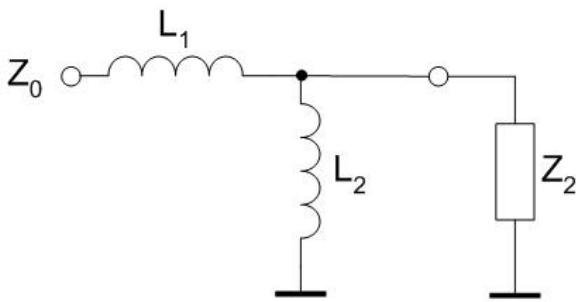
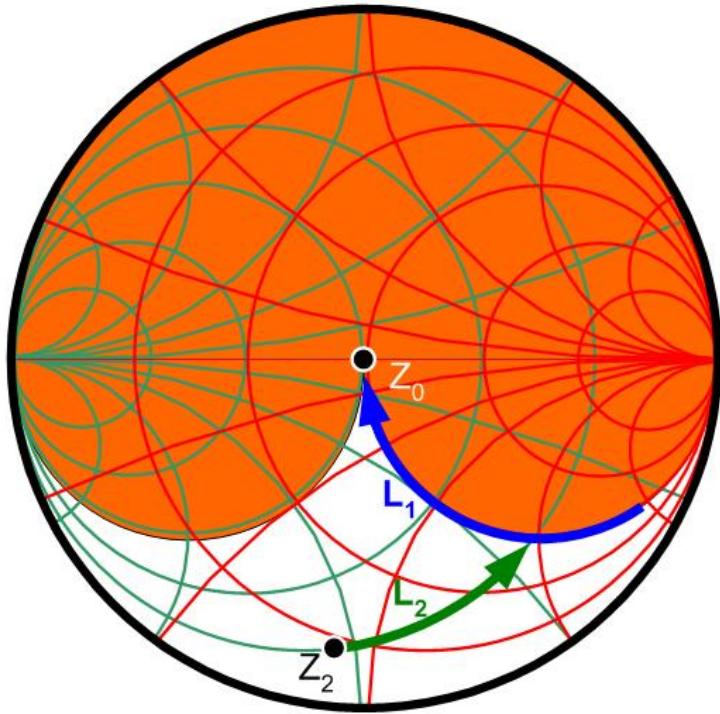
C serie, C paralel / C paralel, C serie



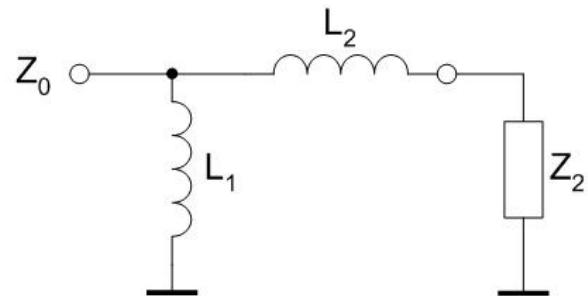
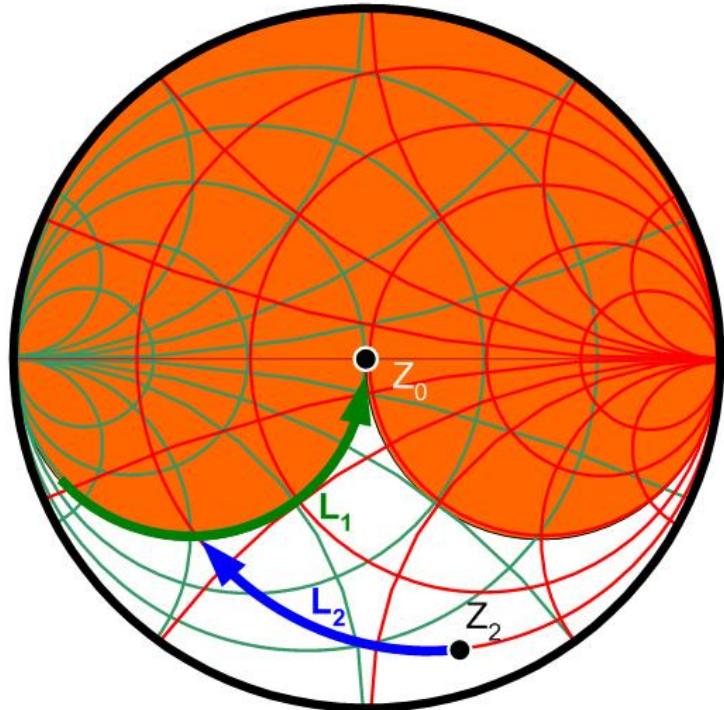
Zona interzisa cu
schema curenta



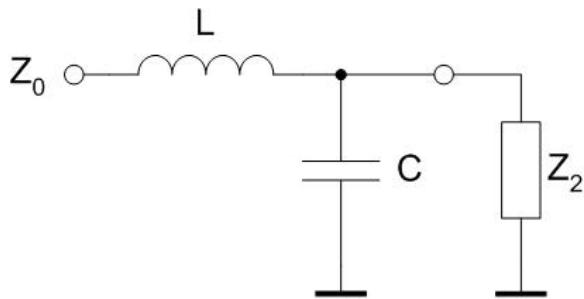
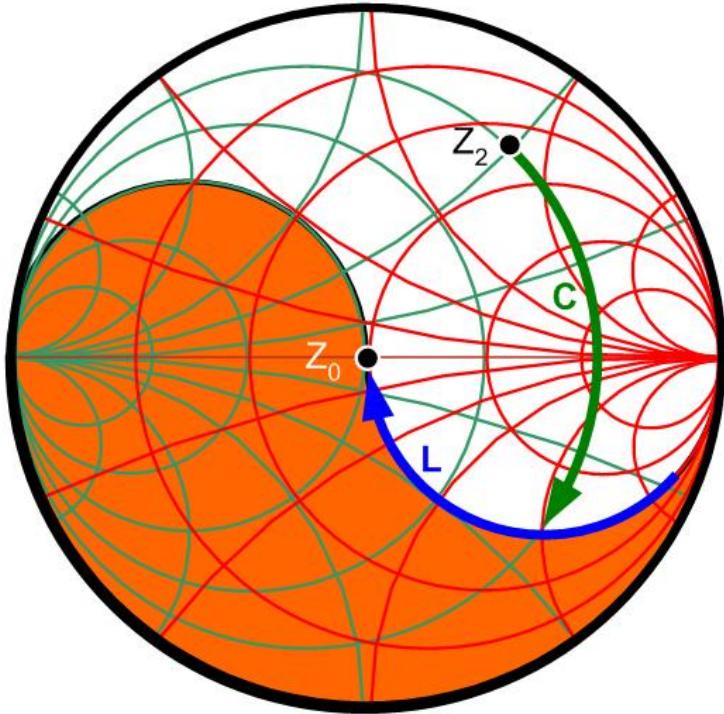
L serie, L paralel / L paralel, L serie



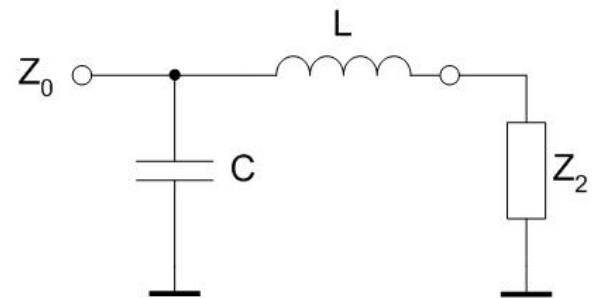
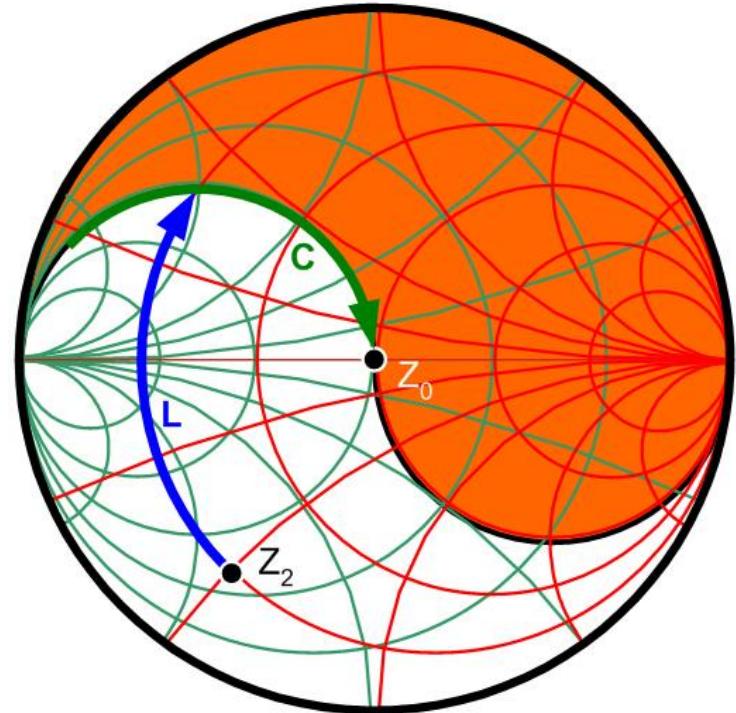
Zona interzisa cu
schema curenta



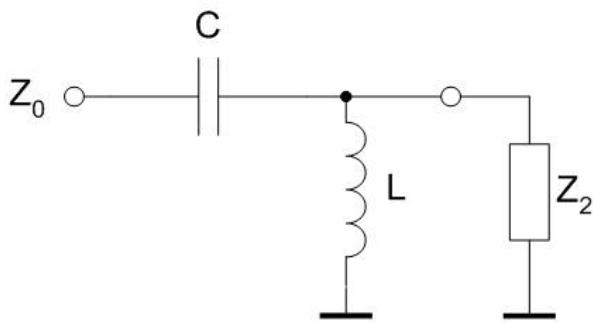
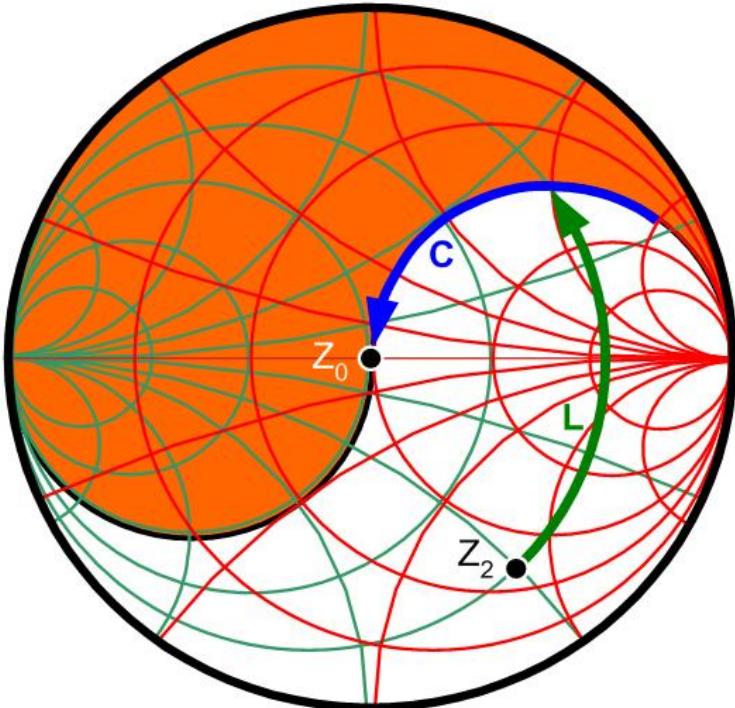
L serie, C paralel / C paralel, L serie



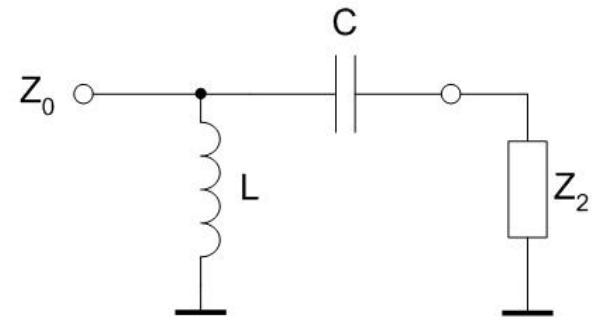
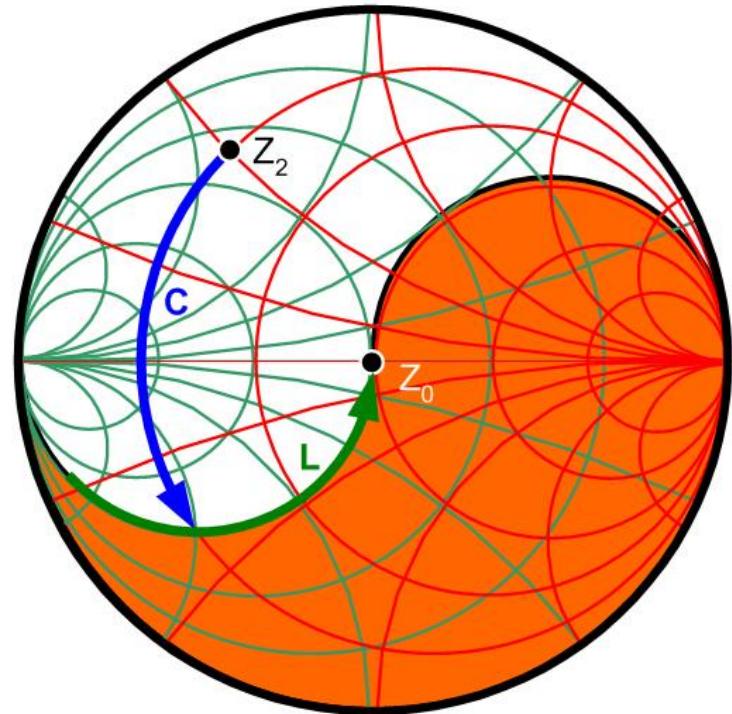
Zona interzisa cu
schema curenta



C serie, L paralel / L paralel, C serie



Zona interzisa cu
schema curenta



Adaptare cu doua elemente reactive (retele in L)

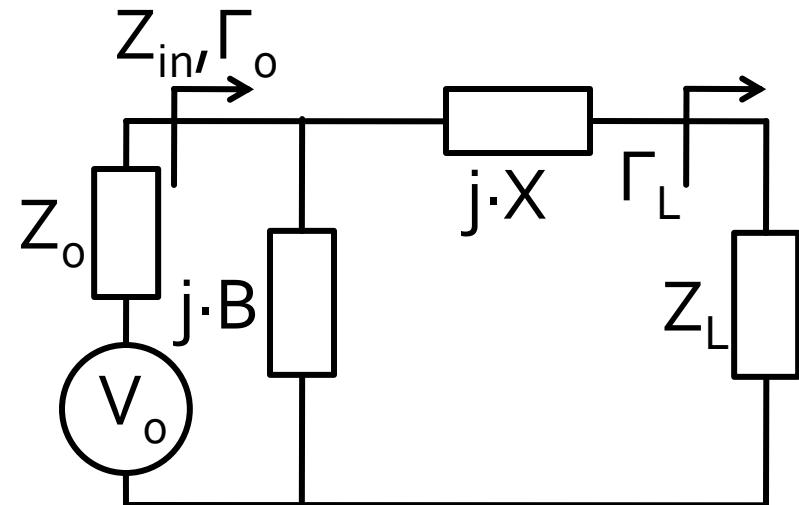
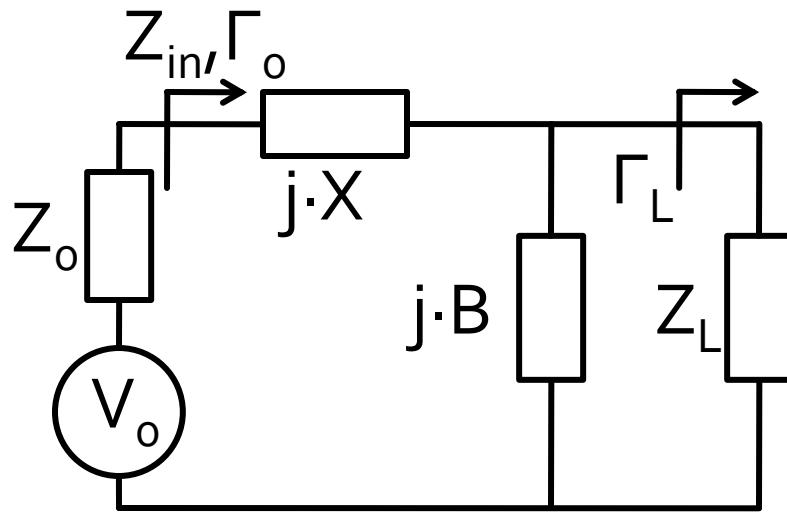
- Pentru orice Γ_L exista cel putin 2 retele in L de adaptare posibile (L+C)
- Pentru anumite zone de start de pe diagrama Smith exista 4 posibilitati (+2 C+C/L+L)
- Se alege reteaua care necesita componente de valori realizabile
- Prin adaugarea elementelor rezistive se pot suplimenta retelele posibile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

Adaptare cu elemente rezistive

- Circuitele active lucreaza in zona frecventei unitare
- Orice "risipa" de putere este **nerecomandata**
- Exista situatii in care este **necesara** o astfel de actiune pentru asigurarea stabilitatii



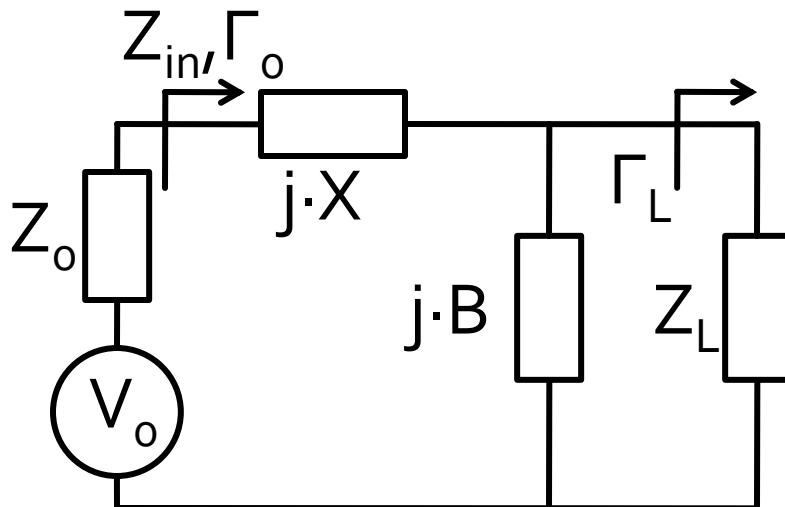
Adaptare cu doua elemente reactive (retele in L)



■ Adaptare in doi pasi

- pentru elementele situate in interiorul cercului $r_L = 1$ se utilizeaza prima schema
- pentru elementele situate in exteriorul cercului $r_L = 1$ se utilizeaza a doua schema

Adaptare cu două elemente reactive (retele în L)



$$Z_L = R_L + j \cdot X_L \quad R_L > Z_0 \quad Z_{in} = Z_0$$

$$Z_0 = j \cdot X + \frac{1}{j \cdot B + 1/(R_L + j \cdot X_L)}$$

$$\begin{cases} B \cdot (X \cdot R_L - X_L \cdot Z_0) = R_L - Z_0 \\ X \cdot (1 - B \cdot X_L) = B \cdot Z_0 \cdot R_L - X_L \end{cases}$$

$$B = \frac{X_L \pm \sqrt{R_L/Z_0} \cdot \sqrt{R_L^2 + X_L^2 - Z_0 \cdot R_L}}{R_L^2 + X_L^2}$$

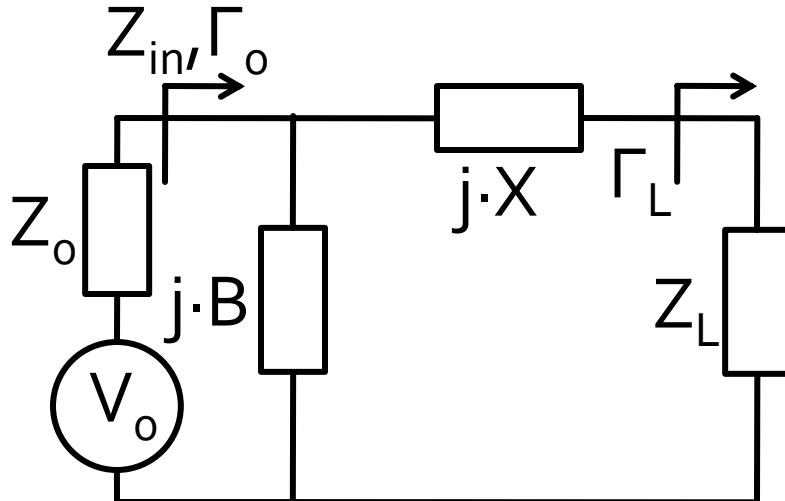
$$X = \frac{1}{B} + \frac{X_L \cdot Z_0}{R_L} - \frac{Z_0}{B \cdot R_L}$$

- valoarea de sub radical e intotdeauna pozitiva pentru

$$R_L > Z_0$$

- se obtin doua solutii realizabile

Adaptare cu doua elemente reactive (retele in L)



$$Z_L = R_L + j \cdot X_L \quad R_L < Z_0 \quad Y_{in} = Y_0 = \frac{1}{Z_0}$$

$$\frac{1}{Z_0} = j \cdot B + \frac{1}{R_L + j \cdot (X + j \cdot X_L)}$$

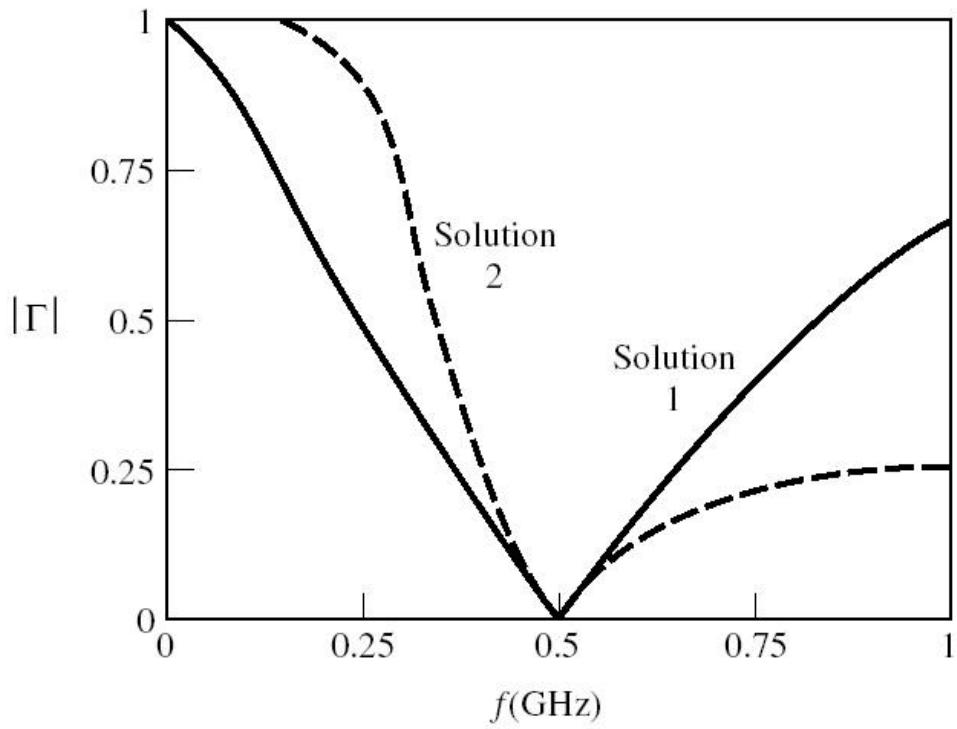
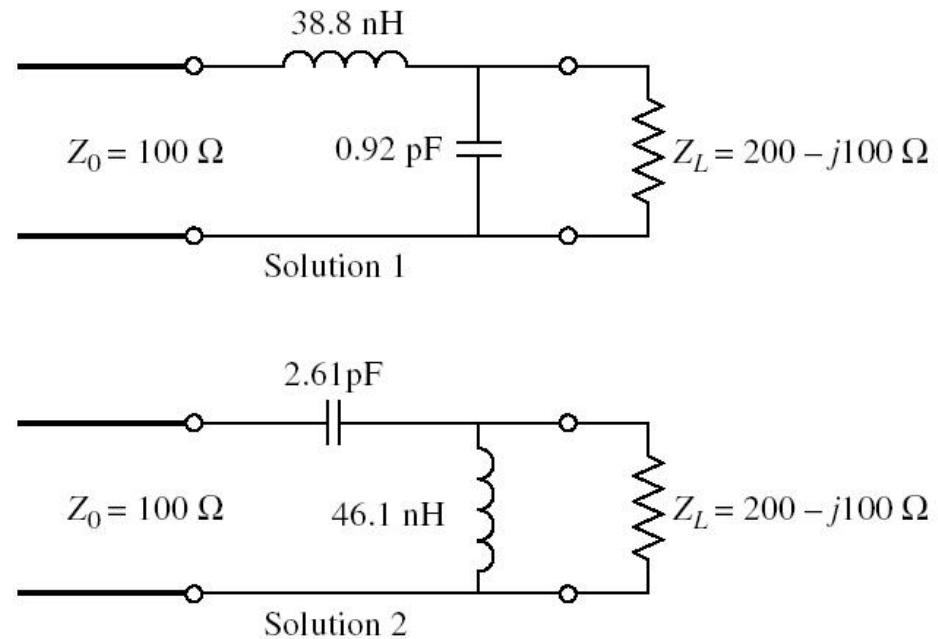
$$\begin{cases} B \cdot Z_0 \cdot (X + X_L) = Z_0 - R_L \\ (X + X_L) = B \cdot Z_0 \cdot R_L \end{cases}$$

$$X = \pm \sqrt{R_L \cdot (Z_0 - R_L)} - X_L$$

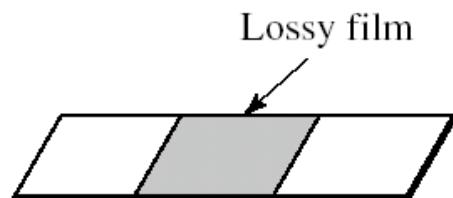
$$X = \pm \frac{\sqrt{(Z_0 - R_L)/R_L}}{Z_0}$$

- valoarea de sub radical e intotdeauna pozitiva pentru $R_L < Z_0$
- se obtin doua solutii realizabile

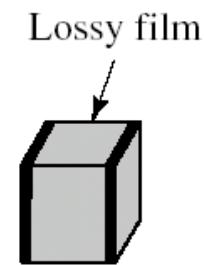
Exemplu



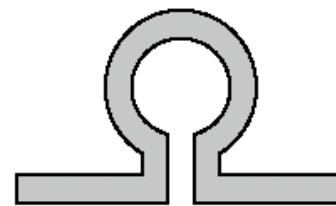
Realizare elemente concentrate



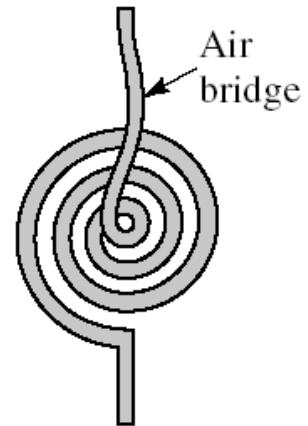
Planar resistor



Chip resistor



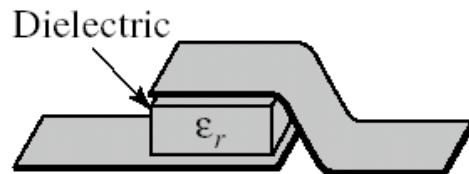
Loop inductor



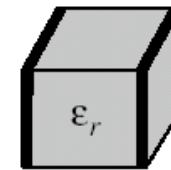
Spiral inductor



Interdigital
gap capacitor



Metal-insulator-
metal capacitor



Chip capacitor

Adaptarea cu sectiuni de linii (stub)

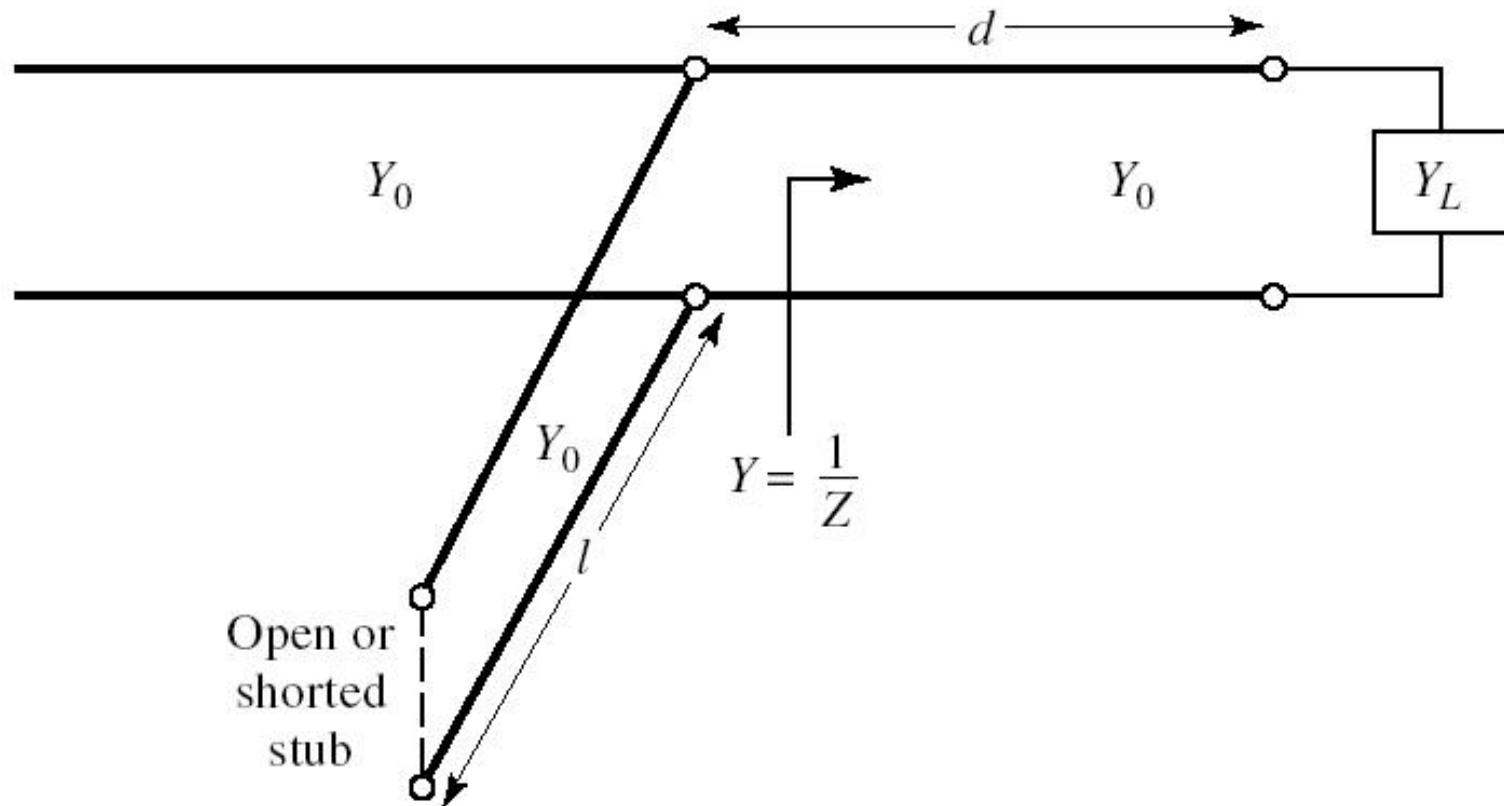
Adaptarea de impedanță

Stub

- stub=rest, ciot, cotor
- Se evita utilizarea elementelor concentrate
- Se realizeaza (foarte precis) utilizand liniile de transmisie uzuale ale circuitului
- Se utilizeaza sectiuni de linie (stub-uri) in serie sau paralel care pot fi:
 - in gol
 - scurtcircuitate
- De obicei liniile in gol sunt mai usor de implementat si sunt preferate

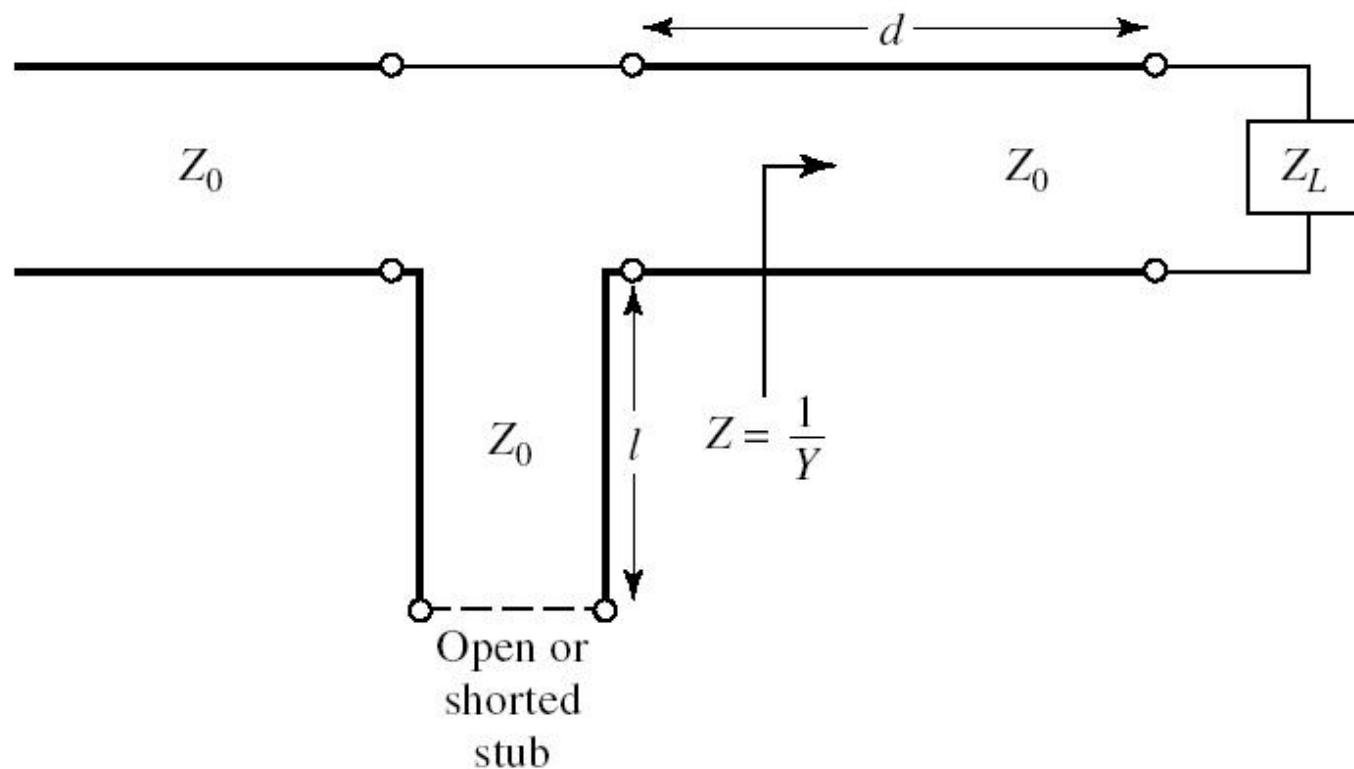
Single stub tuning

- Shunt Stub (secțiune de linie în paralel)



Single stub tuning

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



Caz 1, Shunt Stub

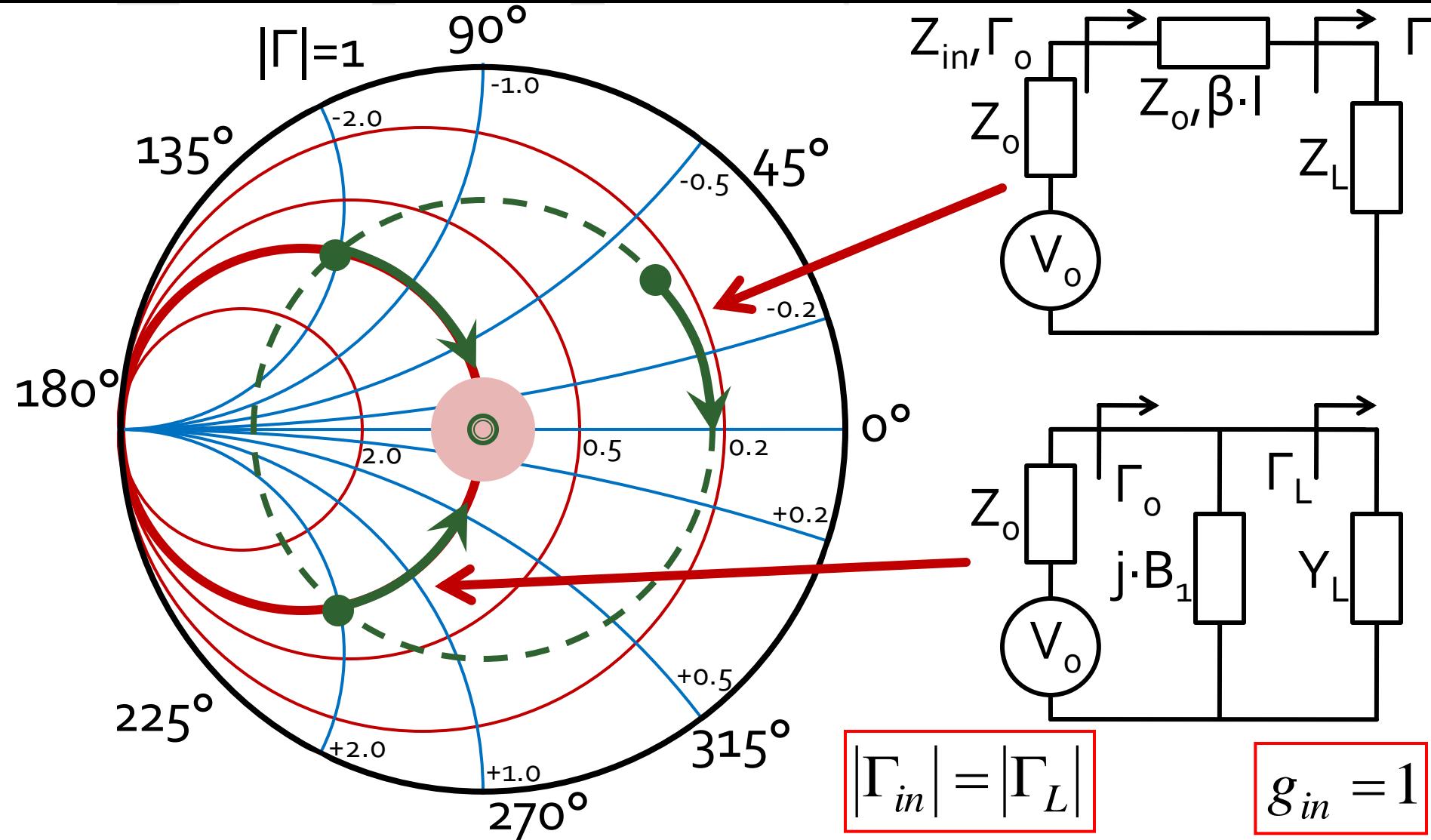
- Se utilizeaza o linie de transmisie serie pentru a muta coeficientul de reflexie pe cercul $g_L = 1$
- Se introduce o reactanta in paralel pentru a realiza adaptare
- Aceasta reactanta se realizeaza cu o linie de transmisie care poate fi dupa nevoie:
 - in gol
 - in scurtcircuit

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

$$Z_{in,sc} = j \cdot Z_0 \cdot \tan \beta \cdot l$$

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

Adaptare, linie serie + susceptanta in paralel



Contact

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- rdamian@etti.tuiasi.ro