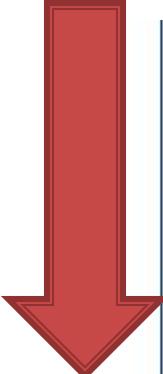


Problems

2020/2021

Microwave Devices and Circuits for Radiocommunications

Website history



Laboratory

[Laborator 1 DCMR \(pdf, 1.24 MB, ro, !\[\]\(31dc830bf8206b94b5a585ce61ce9013_img.jpg\)
\[Laborator 2 DCMR \\(pdf, 1.35 MB, ro, !\\[\\]\\(92fe6ec8c8b0011d3746d04c5962f469_img.jpg\\)
\\[Laborator 3 DCMR \\\(pdf, 2.11 MB, ro, !\\\[\\\]\\\(331831374f10e8c7fe483c7fa2c6e388_img.jpg\\\)\\]\\(#\\)\]\(#\)](#)

Project/Design

[Proiect DCMR 2019 \(pdf, 122.41 KB, ro, !\[\]\(59a6d1a83fdb24579739802677391c72_img.jpg\)
\[Exemplu Proiect 2018 \\(valid si 2019\\) \\(pdf, 2.4 MB, ro, !\\[\\]\\(f7d0469f5f606ed760feb4851784f3d8_img.jpg\\)
\\[Selection guides 2010 \\\(zip, 4.17 MB, en, !\\\[\\\]\\\(fbb28cc5380f785062bfa030a99ad597_img.jpg\\\)
\\\[Selection guides 2019 \\\\(zip, 3.2 MB, en, !\\\\[\\\\]\\\\(3356a7c089b4e6b11ecdbb76cf615f86_img.jpg\\\\)\\\]\\\(#\\\)\\]\\(#\\)\]\(#\)](#)

Other data

[Factorul "Andrei" \(ndf, 15.85 MB, ro, !\[\]\(11c04e7b9bd8dfee71fbba6e540fd21d_img.jpg\)](#)

Previous years

2018-2019 2017-2018 2016-2017 2015-2016 2014-2015 More years...

Server-ul "rf-opto" pastreaza istoricul materialelor pentru anii anteriori
Alegeti anul recent corespunzator pentru vizualizare sau "More years" pentru a afisa mai multi ani din istoric

Website history 2009 - 2020

Previous years

2018-2019	2017-2018	2016-2017	2015-2016	2014-2015	2013-2014	2012-20
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Microwave Devices and Circuits for Radiocommunications (English)

Course: MDCR (2018-2019)

Course Coordinator: Assoc.P. Dr. Radu-Florin Damian

Code: EDO5412T

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

Laboratory: Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, 1

Evaluation

Type: Exam

A: 50%, (Test/Colloquium)

B: 25%, (Seminary/Laboratory/Project Activity)

D: 25%, (Homework/Specialty papers)

2016-2017

2015-2016

2014-2015

2013-2014

2012-2013

2011-2012

2010-2011

2009-2010

Grades

Circuits for Radiocommunications

Week, Specialization Section, Timetable:
Hours/Week, Half Group, Timetable:

Subjects and Results

- 2009 – 2019
 - every year 1-2 sets (~50) of problems
 - numerical solutions
 - less in English -> Google translate

The screenshot shows a webpage with a light blue header bar. Below it, there's a section titled "Selection guides 2019" with a link to a zip file (3.2 MB). A red oval highlights the word "Examen" in bold blue text. Underneath, there are three download links: "Examen DCMR 10 feb 2019" (pdf, 934.2 KB), "Rezolvari DCMR 10 feb 2019" (pdf, 825.2 KB), and "Detalii notare DCMR/MDCR 2018 2019" (htm, 13.05 KB). At the bottom, there's a section titled "Other data" with a link to "Factorul 'Andrei'" (pdf, 15.85 MB).

Selection guides 2019 (zip, 3.2 MB, en,

Examen

[Examen DCMR 10 feb 2019](#) (pdf, 934.2 KB, ro,
[Rezolvari DCMR 10 feb 2019](#) (pdf, 825.2 KB, ro,
[Detalii notare DCMR/MDCR 2018 2019](#) (htm, 13.05 KB, ro,

Other data

[Factorul "Andrei"](#) (pdf, 15.85 MB, ro,

Ex: Problem 1

- For a impedance equal to $50.2\Omega + j \cdot 46.2\Omega$, compute the normalized admittance. (1p)
- For a impedance equal to $63.1\Omega + j \cdot 51.7\Omega$, compute the normalized admittance. (1p)
- For a impedance equal to $66.6\Omega - j \cdot 67.2\Omega$, compute the normalized admittance. (1p)
- For a impedance equal to $42.5\Omega + j \cdot 45.3\Omega$, compute the normalized admittance. (1p)

Examen 2015/2016

- 6 problems
 - P₁ – 1p
 - P₂ – 2p
 - P₃ – 2p
 - P₄ – 2p
 - P_{5a} – 4p
 - P_{5b} – 4.5p
- Total: 15.5p
- Maximum: 7.6p
- Minimum: 0.0÷0.5p

Examen 2016/2017

- 5 problems
 - P₁ – 1p+1p
 - P₂ – 1p
 - P₃ – 1p+1p
 - P₄ – 1p+1p
 - P₅ – 5p
- Total: 12p
- Maximum: 5.35p
- Minimum: 0.0÷0.35p
- Bonus: 0-4.25p

Important 1

Examen

- Complex numbers arithmetic!!!!
- $z = a + j \cdot b ; j^2 = -1$

Polar representation

- Euler's formula

$$e^{j \cdot x} = \cos x + j \cdot \sin x; \forall x \in R$$

- Polar representation

$$z = a + j \cdot b = |z| \cdot e^{j \cdot \varphi}$$

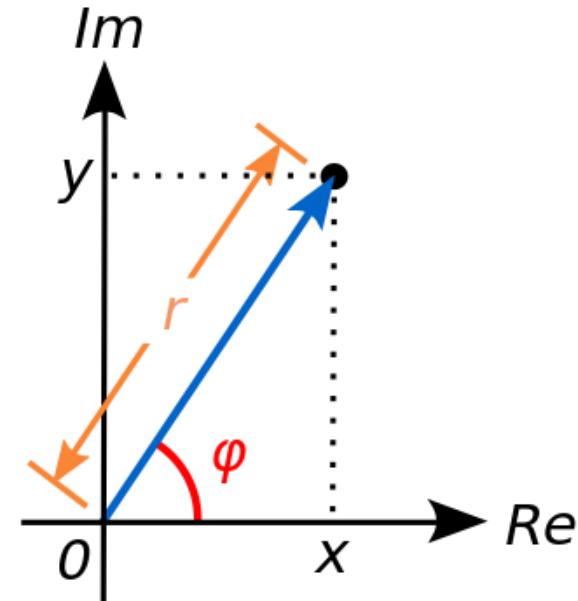
$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$z^n = (|z| \cdot e^{j \cdot \varphi})^n = |z|^n \cdot e^{j \cdot n \cdot \varphi} = |z|^n \cdot [\cos(n \cdot \varphi) + j \cdot \sin(n \cdot \varphi)]$$

→ $\sqrt{z} = (|z| \cdot e^{j \cdot \varphi})^{1/2} = \sqrt{|z|} \cdot e^{j \cdot \frac{\varphi}{2}} = \sqrt{|z|} \cdot \left(\cos \frac{\varphi}{2} + j \cdot \sin \frac{\varphi}{2} \right)$

$$z \cdot w = |z| \cdot e^{j \cdot \varphi} \cdot |w| \cdot e^{j \cdot \theta} = |z| \cdot |w| \cdot e^{j \cdot (\varphi + \theta)} = |z| \cdot |w| \cdot [\cos(\varphi + \theta) + j \cdot \sin(\varphi + \theta)]$$

$$z/w = \frac{|z| \cdot e^{j \cdot \varphi}}{|w| \cdot e^{j \cdot \theta}} = \frac{|z|}{|w|} \cdot e^{j \cdot \varphi} \cdot e^{-j \cdot \theta} = \frac{|z|}{|w|} \cdot [\cos(\varphi - \theta) + j \cdot \sin(\varphi - \theta)]$$



Polar representation

■ Euler's formula

$$e^{j \cdot x} = \cos x + j \cdot \sin x; \forall x \in R$$

$$e^{j \cdot x} + e^{-j \cdot x} = \cos x + j \cdot \sin x + \cos(-x) + j \cdot \sin(-x)$$

$$e^{j \cdot x} + e^{-j \cdot x} = \cos x + j \cdot \sin x + \cos x - j \cdot \sin x = 2 \cdot \cos x$$


$$\cos x = \frac{e^{j \cdot x} + e^{-j \cdot x}}{2}$$

$$e^{j \cdot x} - e^{-j \cdot x} = \cos x + j \cdot \sin x - \cos(-x) - j \cdot \sin(-x)$$

$$e^{j \cdot x} - e^{-j \cdot x} = \cos x + j \cdot \sin x - \cos x + j \cdot \sin x = 2j \cdot \sin x$$

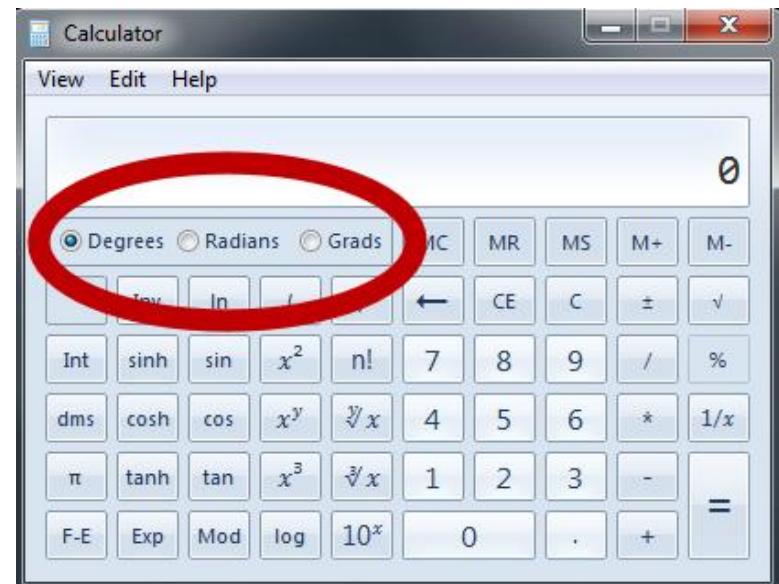

$$\sin x = \frac{e^{j \cdot x} - e^{-j \cdot x}}{2j}$$

Polar representation

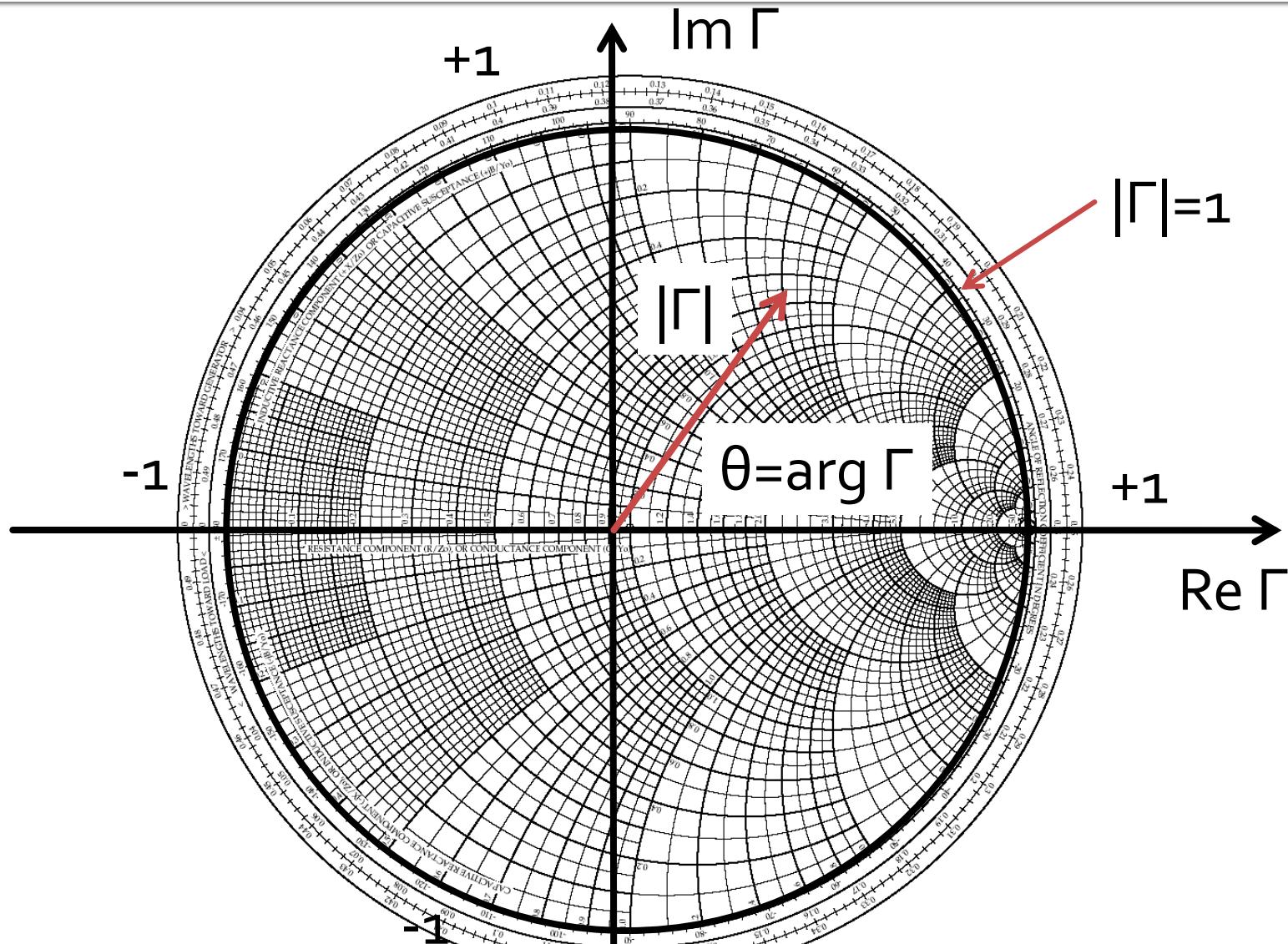
- standard unit for angles – radians
- microwaves traditional unit for angles –
degrees in decimal notation (55.89°)

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{ne definit } a = 0 \end{cases}$$

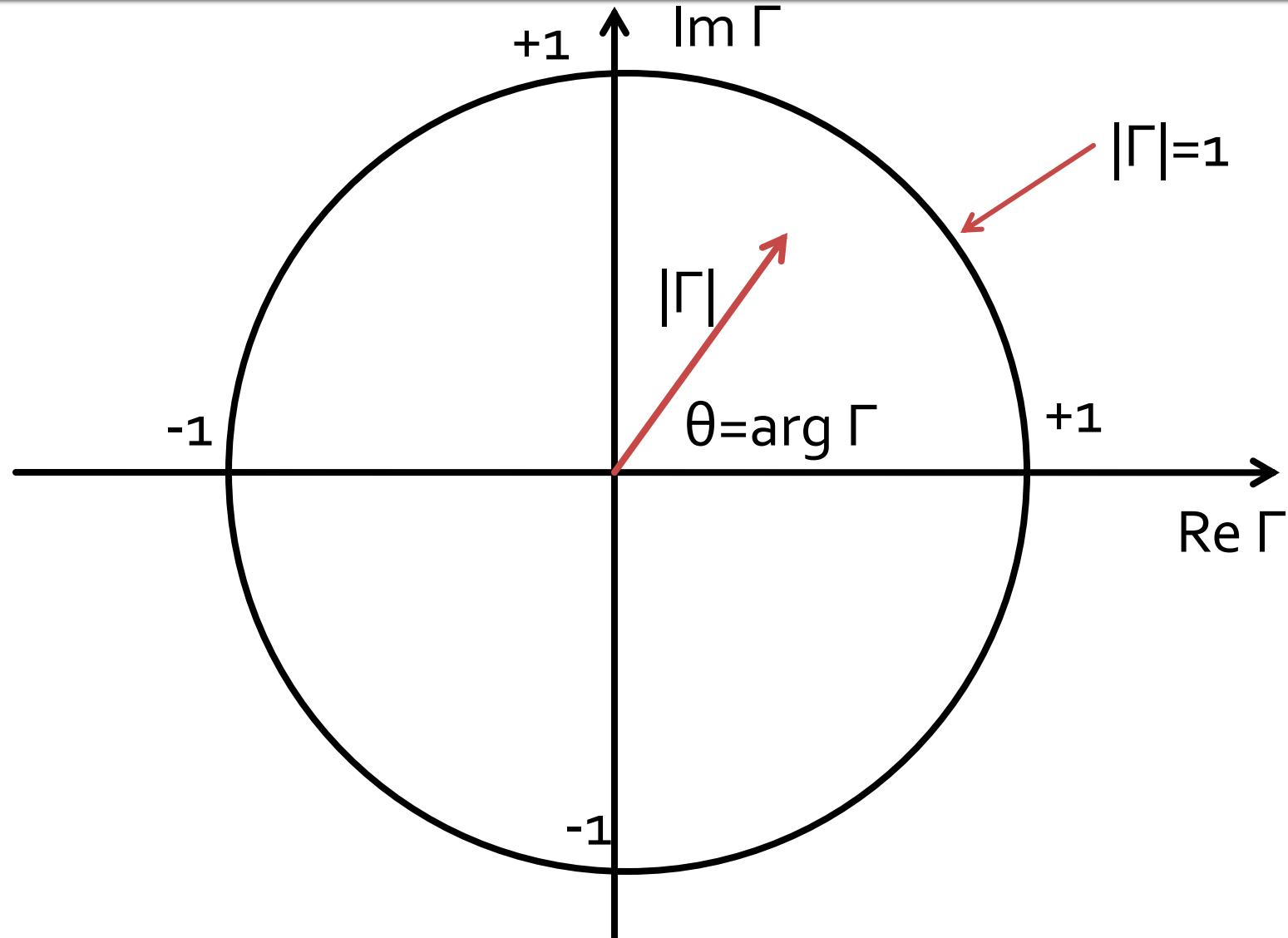
$$\varphi[\circ] = 180^\circ \cdot \frac{\varphi[\text{rad}]}{\pi} \quad \varphi[\text{rad}] = \pi \cdot \frac{\varphi[\circ]}{180^\circ}$$



The Smith Chart



The Smith Chart



Important 2

Examen: Logarithmic scales

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

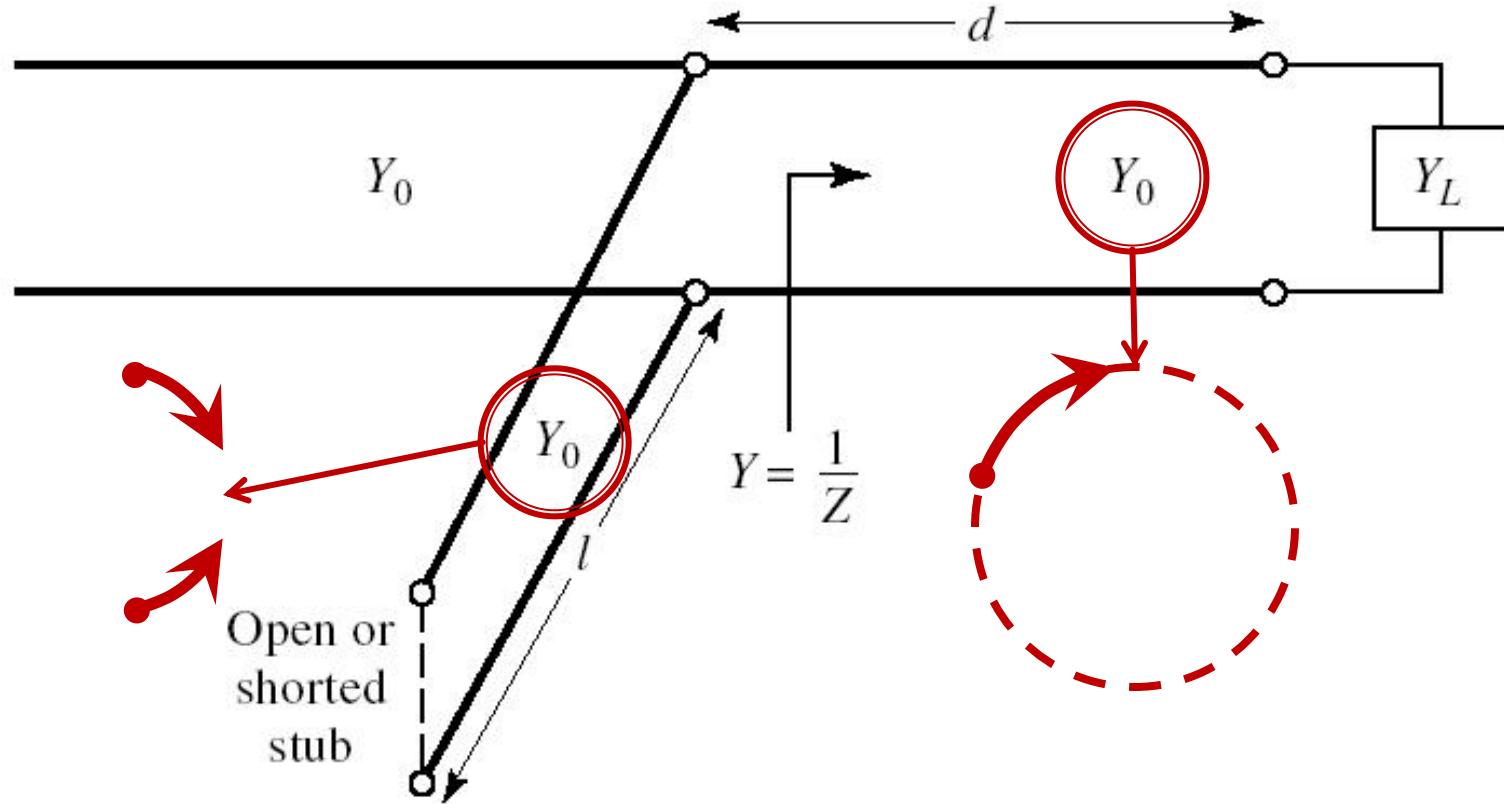
$$[\text{dBm}/\text{Hz}] + [\text{dB}] = [\text{dBm}/\text{Hz}]$$

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

Important 3

Case 1, Shunt Stub

Shunt Stub



Analytical solution, usage

$$\cos(\varphi + 2\theta) = -|\Gamma_s|$$

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

$$|\Gamma_s| = 0.593; \quad \varphi = 46.85^\circ \quad \cos(\varphi + 2\theta) = -0.593 \Rightarrow (\varphi + 2\theta) = \pm 126.35^\circ$$

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

- The **sign** (+/-) chosen for the **series line** equation imposes the **sign** used for the **shunt stub** equation

- “+” solution**

$$(46.85^\circ + 2\theta) = +126.35^\circ \quad \theta = +39.7^\circ \quad \text{Im } y_s = \frac{-2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}} = -1.472$$

$$\theta_{sp} = \tan^{-1}(\text{Im } y_s) = -55.8^\circ (+180^\circ) \rightarrow \theta_{sp} = 124.2^\circ$$

- “-” solution**

$$(46.85^\circ + 2\theta) = -126.35^\circ \quad \theta = -86.6^\circ (+180^\circ) \rightarrow \theta = 93.4^\circ$$

$$\text{Im } y_s = \frac{+2 \cdot |\Gamma_s|}{\sqrt{1 - |\Gamma_s|^2}} = +1.472 \quad \theta_{sp} = \tan^{-1}(\text{Im } y_s) = 55.8^\circ$$

Analytical solution, usage

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

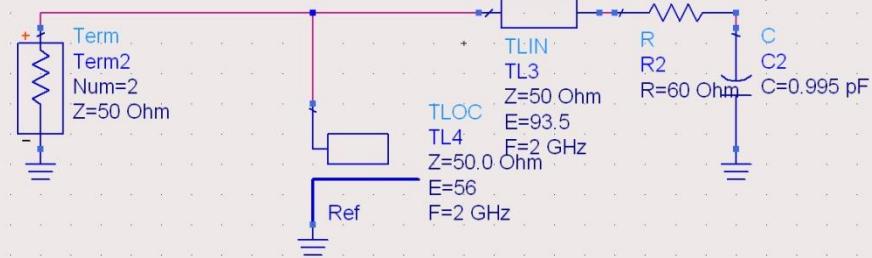
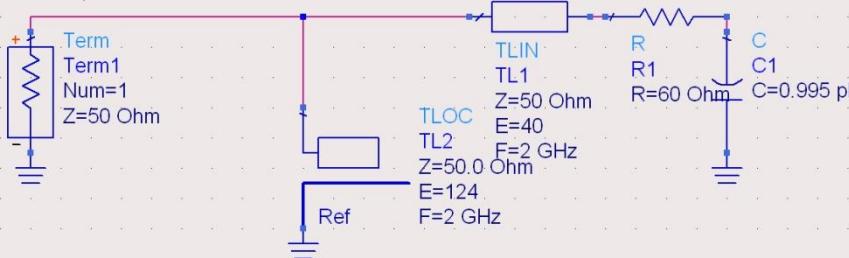
- We choose **one** of the two possible solutions
- The **sign** (+/-) chosen for the **series line** equation imposes the **sign** used for the **shunt stub** equation

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

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

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

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



Important 4

Computing powers

$$\text{LOSS} = \frac{P_{out}}{P_{in}}$$

$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_0} \cdot \frac{P_0}{P_{in}} \right) = [-] 10 \cdot \left[\log_{10} \left(\frac{P_{out}}{P_0} \right) - \log_{10} \left(\frac{P_{in}}{P_0} \right) \right]$$

$$\text{Loss[dB]} = [-] (P_{out} [\text{dBm}] - P_{in} [\text{dBm}])$$



=



-



Examples

Problem 1

- For a normalized admittance equal to $0.705 - j \cdot 0.965$, compute the impedance. (1p)
 - Note.** Except where **otherwise specified**, assume **50Ω** reference impedance.

$$Y = \frac{1}{Z} \quad Y_0 = \frac{1}{Z_0} = \frac{1}{50\Omega} = 0.02S$$

$$z = \frac{Z}{Z_0} \qquad \qquad y = \frac{Y}{Y_0} = \frac{Z_0}{Z}$$

$$Z = \frac{Z_0}{y} = \frac{50\Omega}{0.705 - j \cdot 0.965} = 24.68\Omega + j \cdot 33.78\Omega$$

Problem 1 (classroom)

- For a normalized admittance equal to $0.930 + j \cdot 0.745$, compute the impedance. (1p)

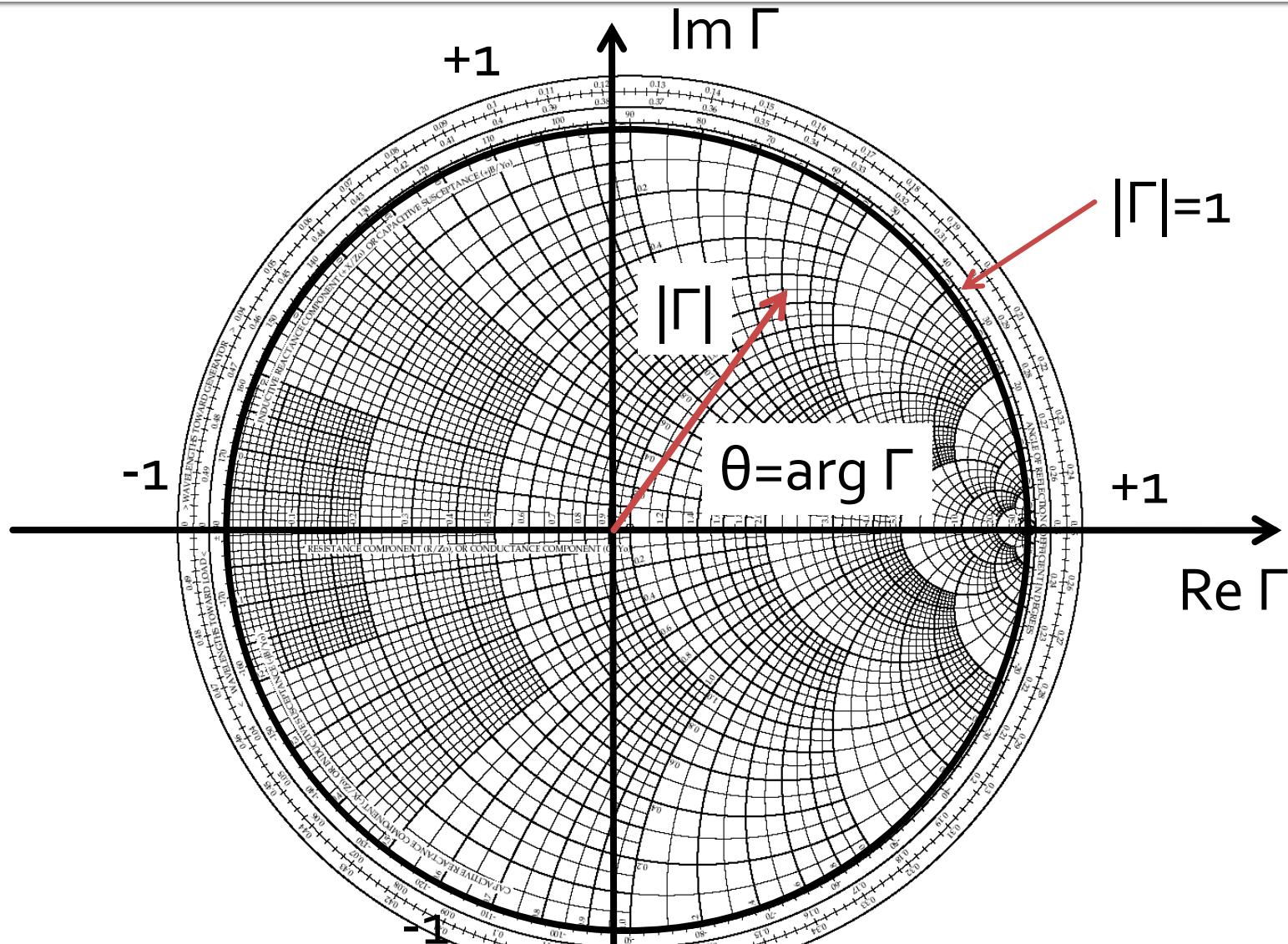


!

Problem 2

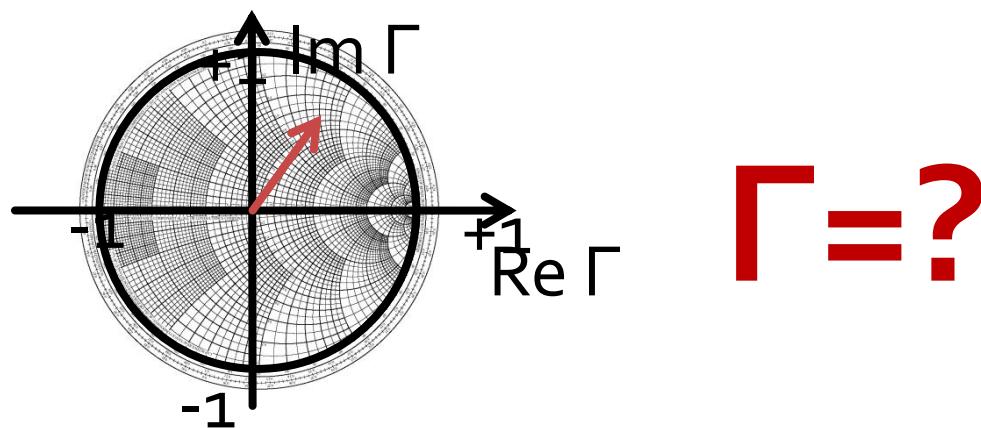
- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a **reference impedance of 75Ω** and:
 - a normalized impedance equal to $0.870 - j \cdot 0.975$ (**1p**)
 - a load composed from a 63Ω resistor **series** with a 0.84nH **inductor**, at 7.4 GHz (**1p**)

The Smith Chart



Problem 2

- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a **reference impedance of 75Ω** and:
 - a normalized impedance equal to $0.870 - j \cdot 0.975$ (**1p**)



Problem 2

- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a **reference impedance of 75Ω** and:
 - a normalized impedance equal to $0.870 - j \cdot 0.975$ (**1p**)

$$\Gamma = \frac{Z - Z_0}{Z + Z_0} = \frac{z - 1}{z + 1} = \operatorname{Re}\Gamma + j \cdot \operatorname{Im}\Gamma = |\Gamma| \cdot e^{j \cdot \arg(\Gamma)}$$

$$\Gamma = \frac{z - 1}{z + 1} = \frac{0.870 - j \cdot 0.975 - 1}{0.870 - j \cdot 0.975 + 1} = 0.159 - j \cdot 0.438$$

Polar representation

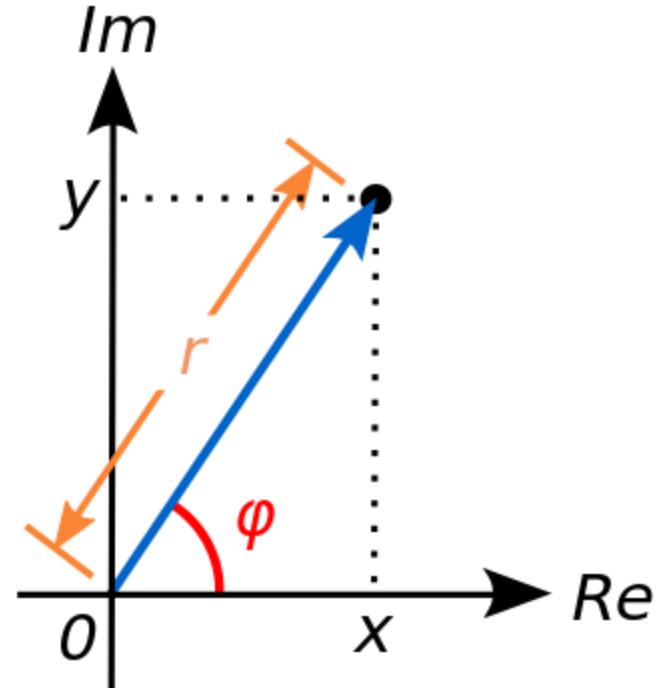
- Polar representation
 - modulus
 - phase relative to the real axis

$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$|z| = \sqrt{a^2 + b^2}$$

$$|z| = z \cdot z^*$$

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{ne definit} & a = 0 \end{cases}$$



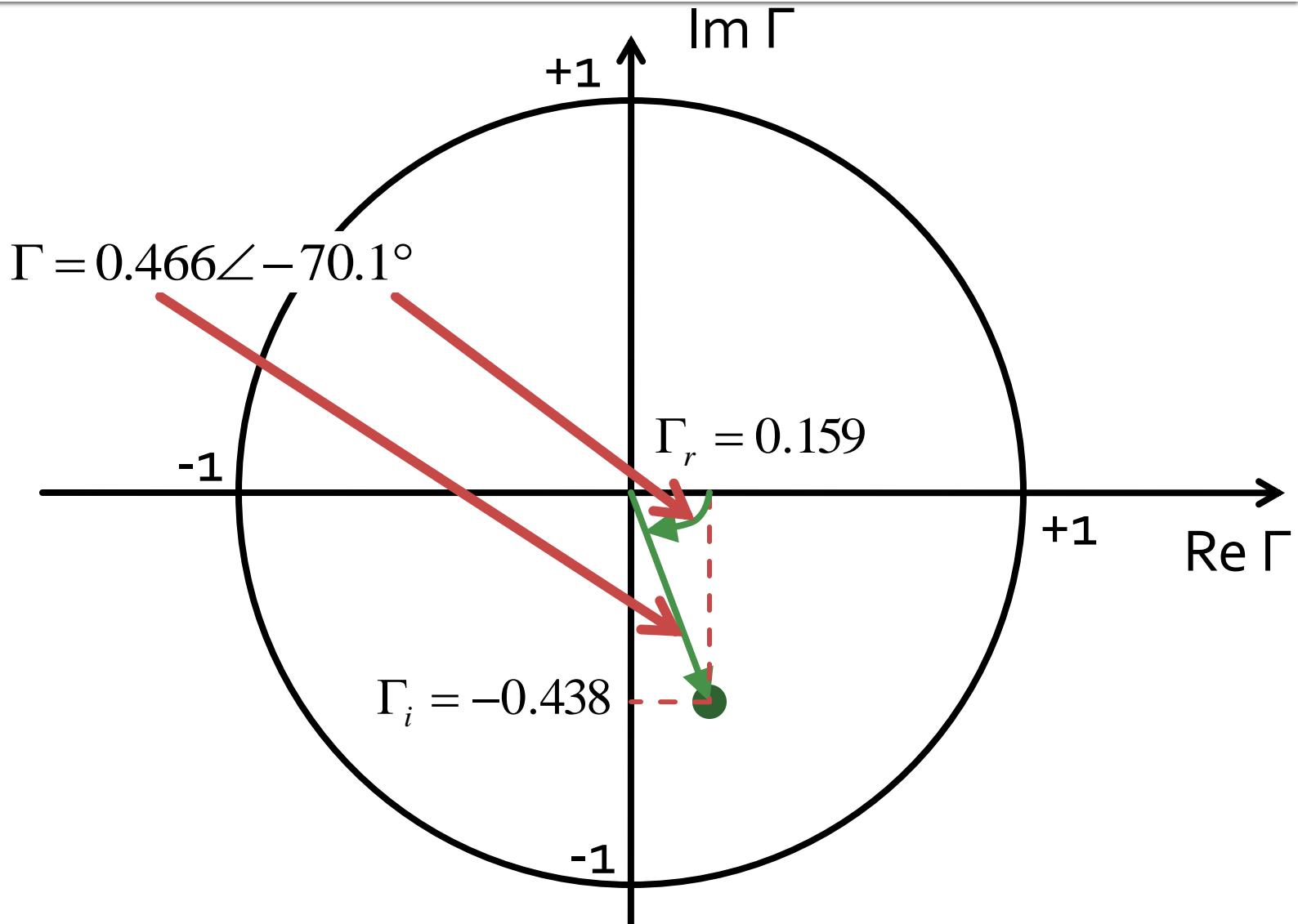
Problem 2

$$\Gamma = 0.159 - j \cdot 0.438$$

$$|\Gamma| = \sqrt{0.159^2 + 0.438^2} = 0.466$$

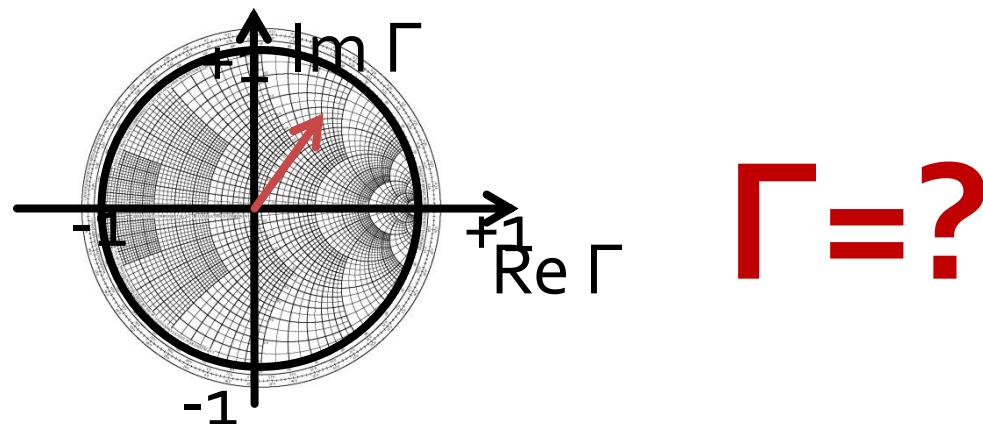
$$\arg(\Gamma) = \arctan\left(\frac{-0.438}{0.159}\right) = -1.223 \text{ rad} = -70.05^\circ$$

Problem 2



Problem 2

- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a **reference impedance of 75Ω** and:
 - a load composed from a 63Ω resistor **series** with a 0.84nH **inductor**, at 7.4 GHz (1p)



Problem 2

- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a **reference impedance of 75Ω** and:
 - a load composed from a 63Ω resistor **series** with a 0.84nH **inductor**, at 7.4 GHz (1p)

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

$$Z = R + j \cdot \omega \cdot L = R + j \cdot 2\pi \cdot f \cdot L = 63\Omega + j \cdot 2\pi \cdot 7.4 \cdot 10^9 \cdot 0.84 \cdot 10^{-9}$$

$$Z = 63\Omega + j \cdot 39.20\Omega$$

Problem 2

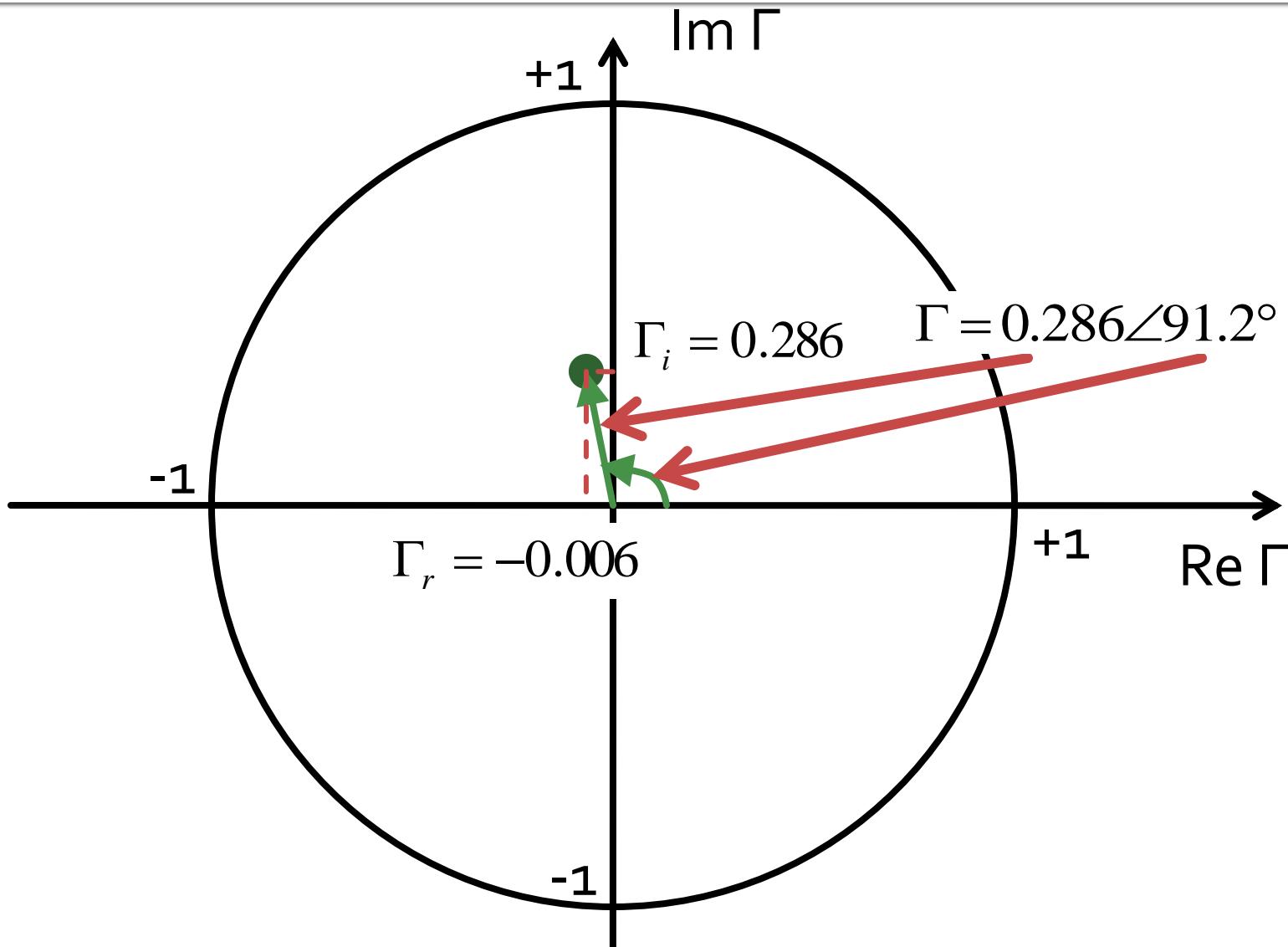
$$\Gamma = \frac{Z - Z_0}{Z + Z_0} = \frac{63\Omega + j \cdot 39.20\Omega - 75\Omega}{63\Omega + j \cdot 39.20\Omega + 75\Omega} = -0.006 + j \cdot 0.286$$

■ similar:

$$|\Gamma| = \sqrt{0.006^2 + 0.286^2} = 0.286$$

$$\arg(\Gamma) = \arctan\left(\frac{0.286}{-0.006}\right) + \pi = 1.5911 \text{ rad} = 91.17^\circ$$

Problem 2



Problem 2 (classroom)

- Outline a Smith Chart (only the external circle and the complex plane axes) and plot the point corresponding to a reference impedance of 80Ω and:
 - a normalized impedance equal to $0.710 - j1.155$ (**1p**)
 - a load composed from a 25Ω resistor parallel with a 0.56pF capacitor, at 7.2GHz (**1p**)

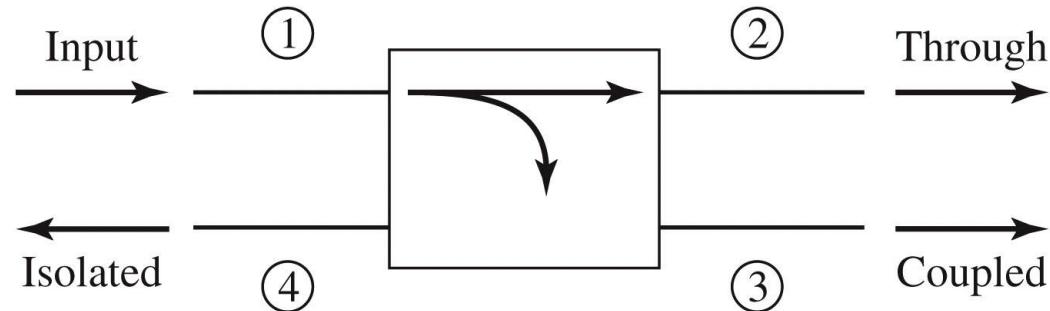


!

Problem 3

- A signal with a power of 1.75mW is applied at the input of a lossless coupler characterized by a coupling coefficient of 4.1dB and an isolation of 23.3dB , having an input VSWR = 2.465 .
 - Calculate the output power (in dBm) at the through port. (1p)
 - Design an ideal ring coupler that provides the same coupling coefficient. (1p)

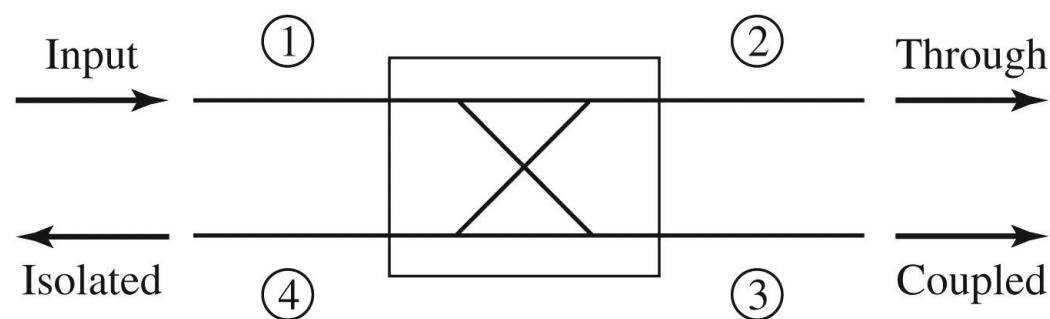
Directional Coupler



$$|S_{12}|^2 = \alpha^2 = 1 - \beta^2$$

$$|S_{13}|^2 = \beta^2$$

Coupling



$$C = 10 \log \frac{P_1}{P_3} = -20 \cdot \log(\beta) [\text{dB}]$$

Directivity

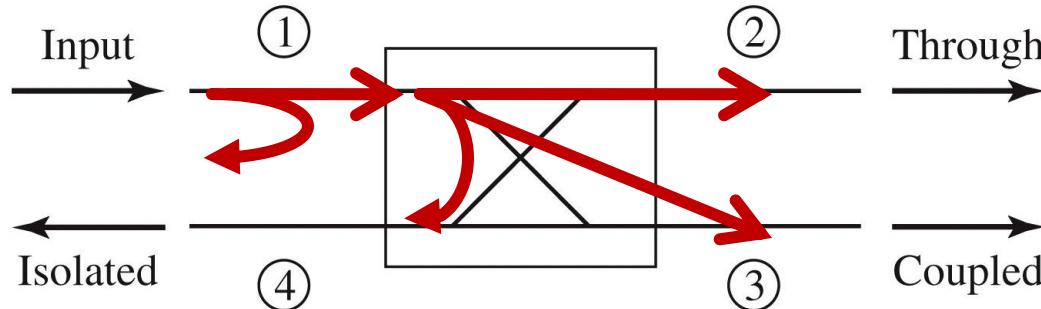
$$D = 10 \log \frac{P_3}{P_4} = 20 \cdot \log \left(\frac{\beta}{|S_{14}|} \right) [\text{dB}]$$

Isolation

$$I = 10 \log \frac{P_1}{P_4} = -20 \cdot \log |S_{14}| [\text{dB}]$$

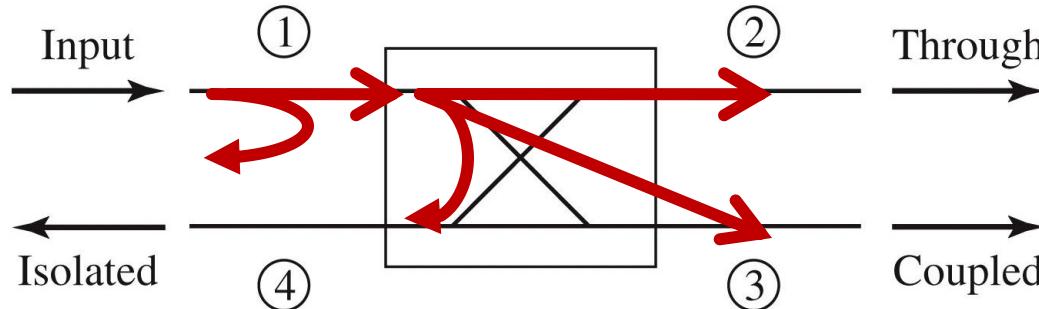
$$I = D + C, [\text{dB}]$$

Problem 3



- **Lossless** coupler, the input power is found entirely at:
 - through port,
 - coupled port,
 - isolated port,
 - or is reflected at the input **before** entering the coupler

Problem 3



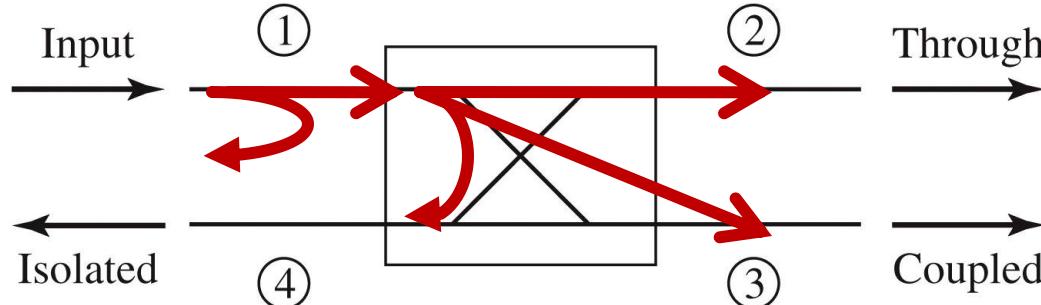
- Input reflected power, **before** entering the coupler

$$VSWR = \frac{V_{\max}}{V_{\min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|} \quad |\Gamma_{in}| = \frac{VSWR - 1}{VSWR + 1} = 0.423$$

$$P_{refl} = P_{in} \cdot |\Gamma_{in}|^2 = 1.75mW \cdot 0.423^2 = 0.313mW$$

$$P_1 = P_{in} - P_{refl} = 1.75mW - 0.313mW = 1.437mW$$

Problem 3



- Power transferred to:
 - coupled port
 - isolated port

$$I = 10 \log \frac{P_1}{P_4} = -20 \cdot \log |S_{14}| [\text{dB}]$$

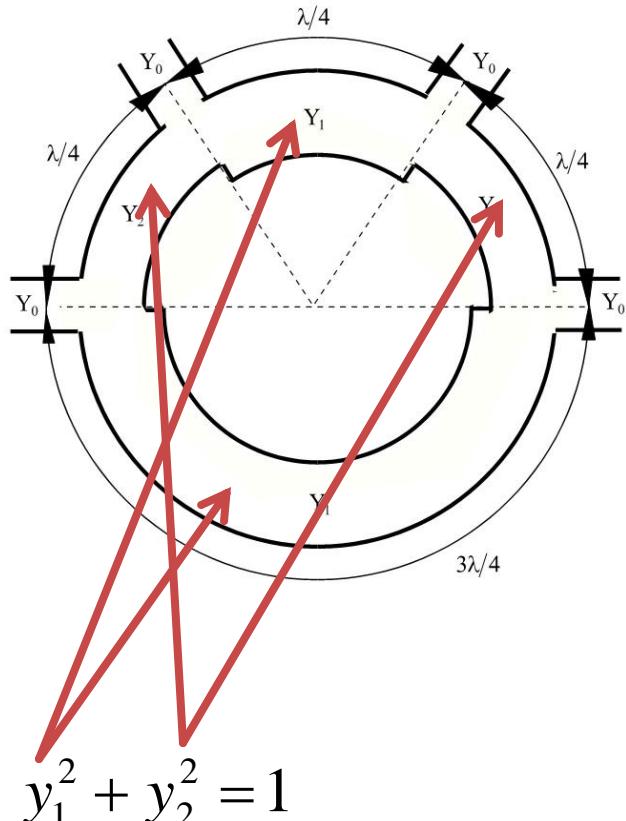
$$C = 10 \log \frac{P_1}{P_3} = -20 \cdot \log (\beta) [\text{dB}]$$

$$P_4 = \frac{P_1}{10^{I[\text{dB}]/10}} = \frac{1.437 \text{mW}}{213.8} = 0.0067 \text{mW} \quad P_3 = \frac{P_1}{10^{C[\text{dB}]/10}} = \frac{1.437 \text{mW}}{2.57} = 0.559 \text{mW}$$

$$P_2 = P_1 - P_3 - P_4 = 1.437 \text{mW} - 0.0067 \text{mW} - 0.559 \text{mW} = 0.871 \text{mW}$$

$$P_2 [\text{dBm}] = 10 \cdot \log \frac{P_2 [\text{W}]}{1 \text{mW}} = 10 \cdot \log 0.871 \text{dBm} = -0.06 \text{dBm}$$

The 180° ring coupler



$$C \text{ [dB]} = -20 \cdot \log(y_1)$$

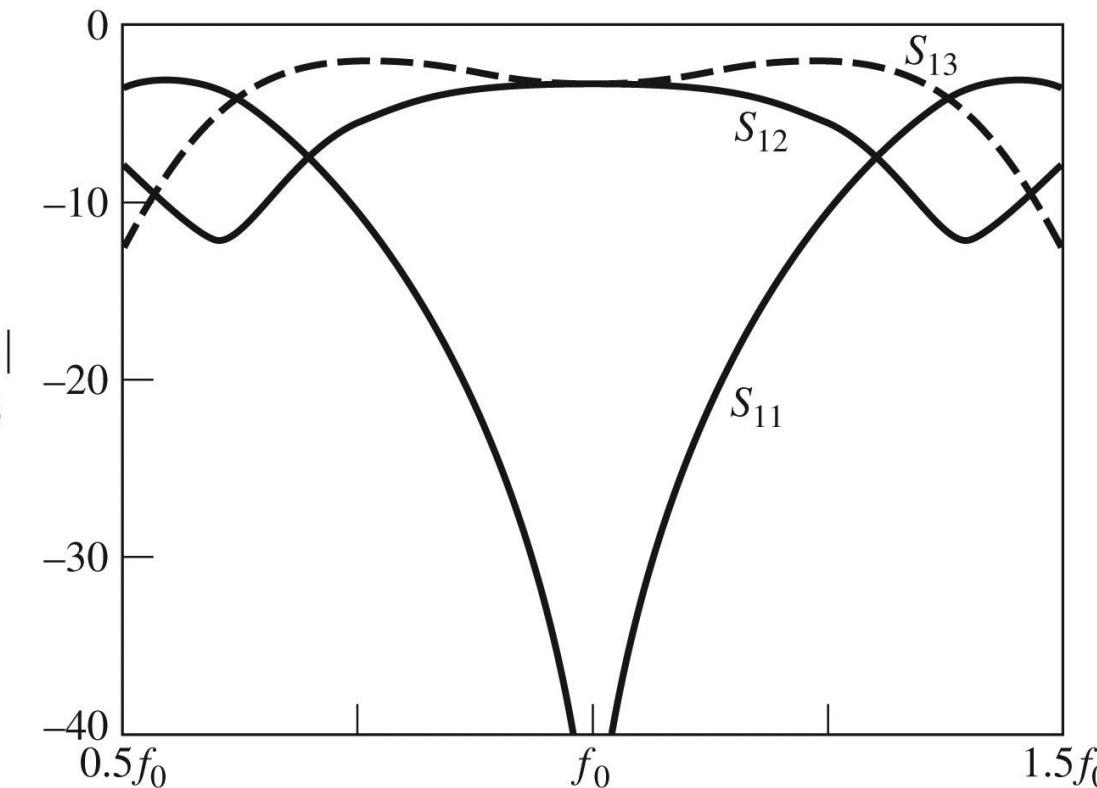
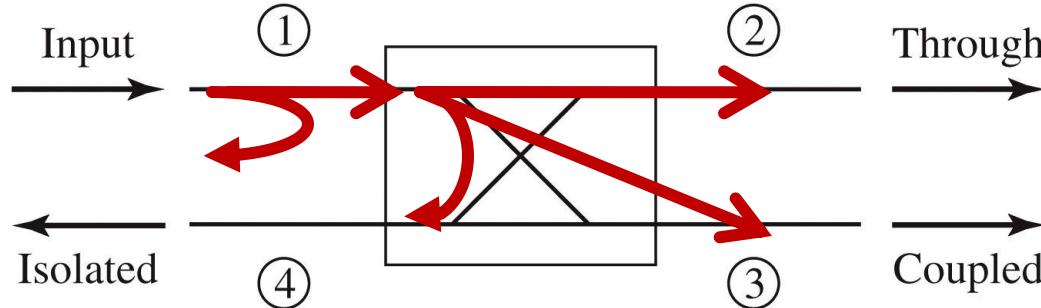


Figure 7.46
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Problem 3



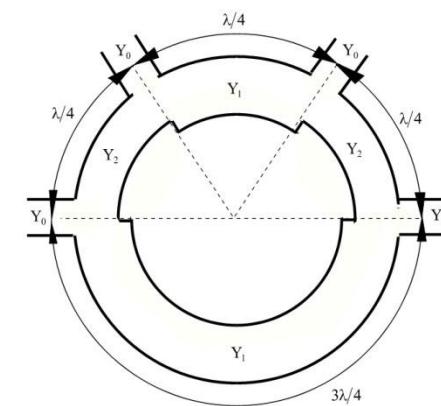
Coupler design (~lab)

$$y_1 = 10^{-C[\text{dB}]/20} = 0.624$$

$$y_2 = \sqrt{1 - y_1^2} = 0.781$$

$$Z_1 = \frac{Z_0}{y_1} = 80.128\Omega$$

$$Z_2 = \frac{Z_0}{y_2} = 63.986\Omega$$



$$y_1^2 + y_2^2 = 1$$

$$C [\text{dB}] = -20 \cdot \log(y_1)$$

Problem 3 (classroom)

- A signal with a power of 3.00mW is applied at the input of a lossless coupler characterized by a coupling coefficient of 5.2dB and an isolation of 18.5dB, having an input VSWR = 2.380.
 - Calculate the output power (in dBm) at the through port. (1p)
 - Design an ideal coupled line coupler that provides the same coupling coefficient. (1p)



!

Problem 4

- Calculate the noise factor of the circuit which contains in cascade, in the order indicated, the following amplifiers: (2p)
 - Amplifier 1: Noise factor 2.1dB, Gain 8.0dB ,
 - Amplifier 2: Noise factor 2.1dB, Gain 11.1dB ,
 - Amplifier 3: Noise factor 3.7dB, Gain 13.8dB .
- Friis Formula (**!linear scale**)

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} + \frac{F_4 - 1}{G_1 \cdot G_2 \cdot G_3} + \dots$$

Problem 4

- Friis Formula **must** be used in **linear scale!**

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2}$$

$$F_1 = 10^{\frac{F_1 [dB]}{10}} = 10^{0.21} = 1.622 \quad G_1 = 10^{\frac{G_1 [dB]}{10}} = 10^{0.8} = 6.310$$

$$F_2 = 10^{\frac{F_2 [dB]}{10}} = 10^{0.21} = 1.622 \quad G_2 = 10^{\frac{G_2 [dB]}{10}} = 10^{1.11} = 12.882$$

$$F_3 = 10^{\frac{F_3 [dB]}{10}} = 10^{0.37} = 2.344$$

- Pay attention to the units
(they are all dimensionless!)

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 \cdot G_2} = 1.737$$

$$F_{cas} [dB] = 10 \cdot \log F_{cas} = 10 \cdot \log(1.737) = 2.398 dB$$

Problem 4 (classroom)

- Calculați factorul de zgomot al circuitului care conține inseriate, în ordinea indicată, următoarele amplificatoare: (2p)
 - Amplificator 1: Factor de zgomot 2.7dB, Câștig 7.3dB ,
 - Amplificator 2: Factor de zgomot 3.1dB, Câștig 11.7dB,
 - Amplificator 3: Factor de zgomot 4.5dB, Câștig 12.1dB.



!

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Compute the input and output stability circles. (1.5p)
- Is the transistor unconditionally stable at 0.9 GHz? (0.5p)
- The system where the output of the transistor is directly connected to a 50Ω load and it's input is connected to a 55Ω source by a 50Ω line 0.20λ in length is stable or not? (1p)
- How does the stability of the system change if, following a fault, the source becomes:
 - open-circuit? (0.5p)
 - short-circuit? (0.5p)

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Compute the input and output stability circles. (1.5p)

$$C_s = \frac{(S_{11} - \Delta \cdot S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2} = -1.215 + 2.928 \cdot j$$

$$|C_s| = 3.170$$

$$R_s = \frac{|S_{12} \cdot S_{21}|}{|S_{11}|^2 - |\Delta|^2} = 2.525$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows :

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Compute the input and output stability circles. (1.5p)

$$C_L = \frac{(S_{22} - \Delta \cdot S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} = 0.521 - 3.105 \cdot j$$

$$|C_L| = 3.149$$

$$R_L = \frac{|S_{12} \cdot S_{21}|}{|S_{22}|^2 - |\Delta|^2} = 3.562$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Is the transistor unconditionally stable at 0.9 GHz? (o.5p)
- Two methods:
 - use stability circles
 - use analytical stability conditions

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Is the transistor unconditionally stable at 0.9 GHz? (o.5p)
- Two methods:
 - use stability circles
 - use analytical stability conditions

$$\begin{cases} |C_s - R_s| = 0.645 > 1 & \text{FALSE} \\ |S_{22}| = 0.303 < 1 \end{cases}$$

$$\begin{cases} |C_L - R_L| = 0.413 > 1 & \text{FALSE} \\ |S_{11}| = 0.717 < 1 \end{cases}$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Is the transistor unconditionally stable at 0.9 GHz? (o.5p)
- Two methods:
 - use stability circles
 - use analytical stability conditions / Rollet**

$$|S_{11}| = 0.717 < 1$$

$$|S_{22}| = 0.303 < 1$$

$$\Delta = S_{11} \cdot S_{22} - S_{12} \cdot S_{21}$$

$$|\Delta| = 0.517 < 1$$

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2 \cdot |S_{12} \cdot S_{21}|} = 0.530 > 1 \quad FALSE$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- The system where the output of the transistor is directly connected to a 50Ω load and its input is connected to a 55Ω source by a 50Ω line 0.20λ in length is stable or not? (1p)
- Output connected to 50Ω , output reflection coefficient equal to S_{22} ,

$$|S_{22}| = 0.303 < 1$$

- At the output we have stability condition

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- The system where the output of the transistor is directly connected to a 50Ω load and it's input is connected to a 55Ω source by a 50Ω line 0.20λ in length is stable or not? (1p)
- Input connection, at the source/line transition we have mismatch $55/50\Omega$, we have an reflection coefficient ,

$$\Gamma_0 = \frac{Z - Z_0}{Z + Z_0} = \frac{55\Omega - 50\Omega}{55\Omega + 50\Omega} = 0.048$$

- After the 0.20λ line, at the input of the transistor this reflection coefficient becomes:

$$\Gamma_s = \Gamma_0 \cdot e^{-2j\beta l} = \Gamma_0 \cdot e^{-2j \frac{2\pi}{\lambda} \cdot l}$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- The system where the output of the transistor is directly connected to a 50Ω load and it's input is connected to a 55Ω source by a 50Ω line 0.20λ in length is stable or not? (1p)
- After the 0.20λ line, at the input of the transistor this reflection coefficient becomes:

$$\Gamma_s = \Gamma_0 \cdot e^{-2j\beta l} = \Gamma_0 \cdot e^{-2j \frac{2\pi}{\lambda} \cdot l}$$

$$\Gamma_s = \Gamma_0 \cdot e^{-2j \frac{2\pi}{\lambda} \cdot l} = 0.048 \cdot [\cos(-4\pi \cdot 0.20) + j \cdot \sin(-4\pi \cdot 0.20)]$$

$$\Gamma_s = -0.039 - j \cdot 0.028$$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- Se obține un sistem stabil dacă la ieșire se conectează tranzistorul la 50Ω , iar la intrare sursa cu impedanță de 55Ω este conectată printr-o linie de 50Ω de lungime 0.20λ ? (1p)
- Distance between this point (Γ_s) and the center of the stability circle

$$|\Gamma_s - C_s| = 3.182 > R_s = 2.525$$

- so the Γ_s point is **outside** the stability circle
- the center of the Smith Chart is a stable point (S_{11}) and is **outside** the stability circle

$$|C_s| = 3.170 > R_s = 2.525$$

- So the point Γ_s corresponds to a **stable point**

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- How does the stability of the system change if, following a fault, the source becomes:
 - open-circuit? (0.5p)
 - short-circuit? (0.5p)
- With source open-circuited or short-circuited the transistor is connected by a 50Ω line to an open-circuit or short-circuit, so the impedance seen at the input of the transistor is

- open-circuit $Z_s = -j \cdot Z_0 \cdot \cot \beta \cdot l = -j \cdot 50\Omega \cdot \cot(2\pi \cdot 0.20)$
- short-circuit $Z_s = j \cdot Z_0 \cdot \tan \beta \cdot l = j \cdot 50\Omega \cdot \tan(2\pi \cdot 0.20)$

Problem 5a

- 5a. The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.717	-123.4°	0.049	43.9°	12.733	105.2°	0.303	-138.8°

- How does the stability of the system change if, following a fault, the source becomes:
 - open-circuit? (0.5p)
 - short-circuit? (0.5p)
- Similar with previous situation we compute the reflection coefficient and it's positioning relative to the stability circle

$$\Gamma_s = \frac{Z_s - Z_0}{Z_s + Z_0}$$

- open-circuit $\Gamma_s = 0.809 + j \cdot 0.588$ $|\Gamma_s - C_s| = 3.094 > R_s = 2.525$
- short-circuit $\Gamma_s = -0.809 - j \cdot 0.588$ $|\Gamma_s - C_s| = 3.539 > R_s = 2.525$

Problem 5a (classroom)

- The scattering parameters of a transistor at 0.9 GHz are as follows:

S ₁₁		S ₁₂		S ₂₁		S ₂₂	
Mag.	Ang.	Mag.	Ang.	Mag.	Ang.	Mag.	Ang.
0.732	-115.8°	0.046	45.4°	13.834	109.6°	0.302	-132.4°

- Determinați cercurile de stabilitate la intrare și ieșire. (1.5p)
- Tranzistorul este necondiționat stabil la frecvența de 0.8 GHz? (0.5p)
- Se obține un sistem stabil dacă la ieșire se conectează tranzistorul la 50Ω , iar la intrare sursa cu impedanță de 64Ω este conectată printr-o linie de 50Ω de lungime 0.10λ ? (1p)
- Cum se modifică stabilitatea sistemului dacă în urma unei defecțiuni sursa devine:
 - gol? (0.5p)
 - scurtcircuit? (0.5p)



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Contact

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