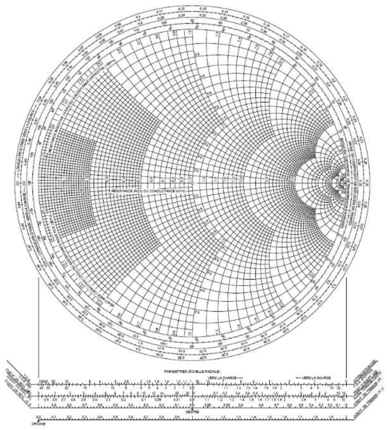
Chapters:

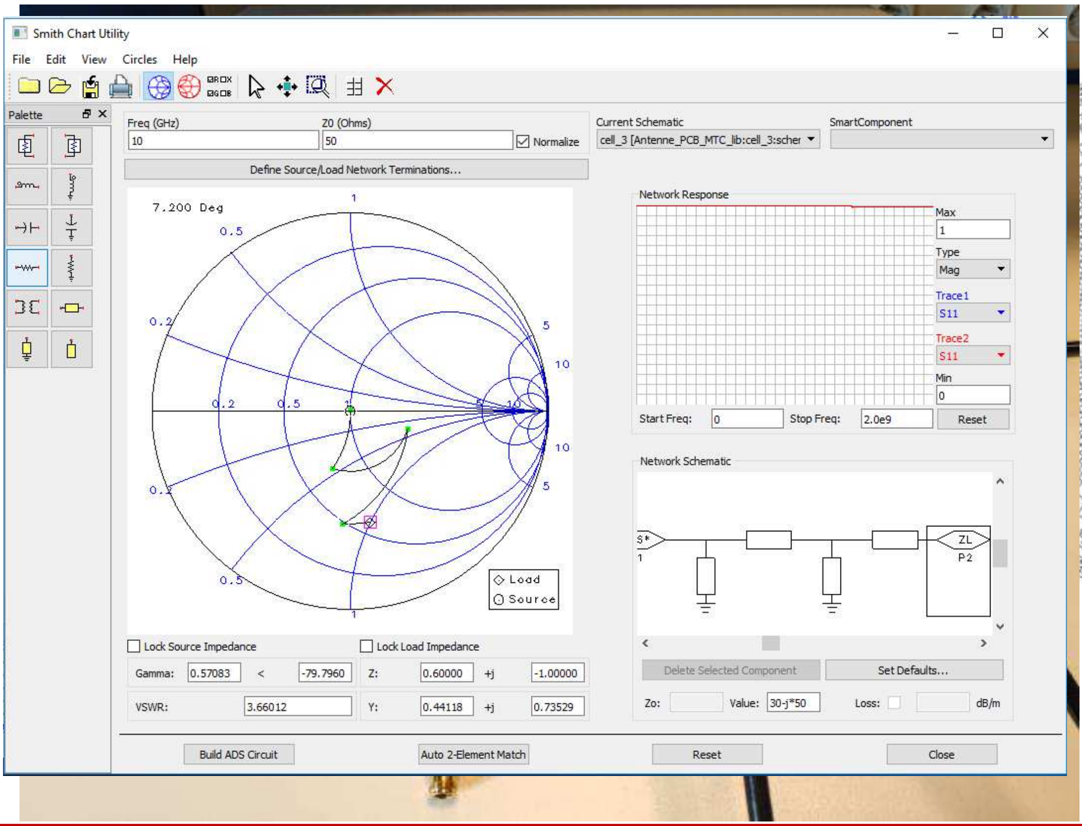
Smith chart (1939) : graphical tool to link the reflection coefficient along the line to the variation of the complex impedance along this waveguide

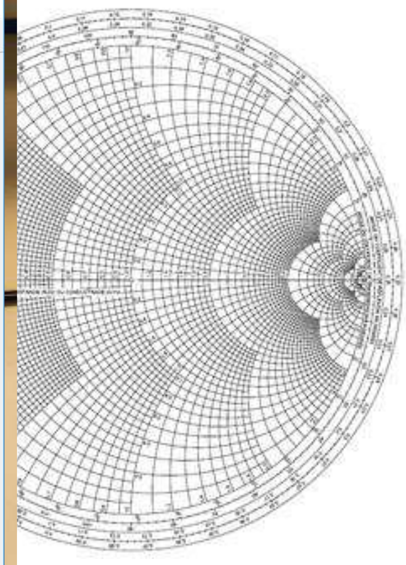


Phillip H. Smith (1905-1987) :

American electrical engineer who has worked for **Radio Corporation of America and BELL** laboratories

3. Smith Chart and impedance matching





3. Smith Chart and impedance matching

Either the reflection coefficient $\underline{\Gamma}(x) = \underline{\Gamma}_L e^{-2\gamma x}$, the impedance Z(x) at a

point x of the line can be written : $Z(x) = Z_c \dfrac{1+\underline{\Gamma}(x)}{1-\underline{\Gamma}(x)}$

Round trip, z origin : at the location of load

Likewise, the load impedance $Z_L = Z_c \dfrac{1+\underline{\Gamma}_L}{1-\underline{\Gamma}_L}$ is expressed in terms of

the load reflection coefficient $\underline{\Gamma}_L$

Or the ratio $z(x) = \dfrac{Z(x)}{Z_c}$ which corresponds to a normalized impedance z(x)

The two previous impedances in normalized form are written :

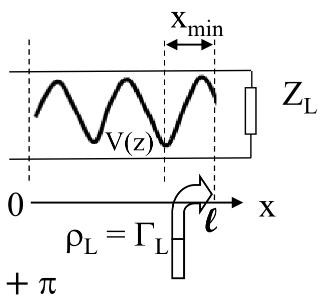
$$\boxed{z(x) = \frac{1+\underline{\Gamma}(x)}{1-\underline{\Gamma}(x)}} \qquad \boxed{z_L = \frac{1+\underline{\Gamma}_L}{1-\underline{\Gamma}_L}}$$

Note :

Or the reflection coefficient $\underline{\Gamma}_L = |\underline{\Gamma}_L| e^{j\varphi}$, its determination

is made through the knowledge of the VSWR $|\underline{\Gamma}_L| = \frac{s-1}{s+1}$

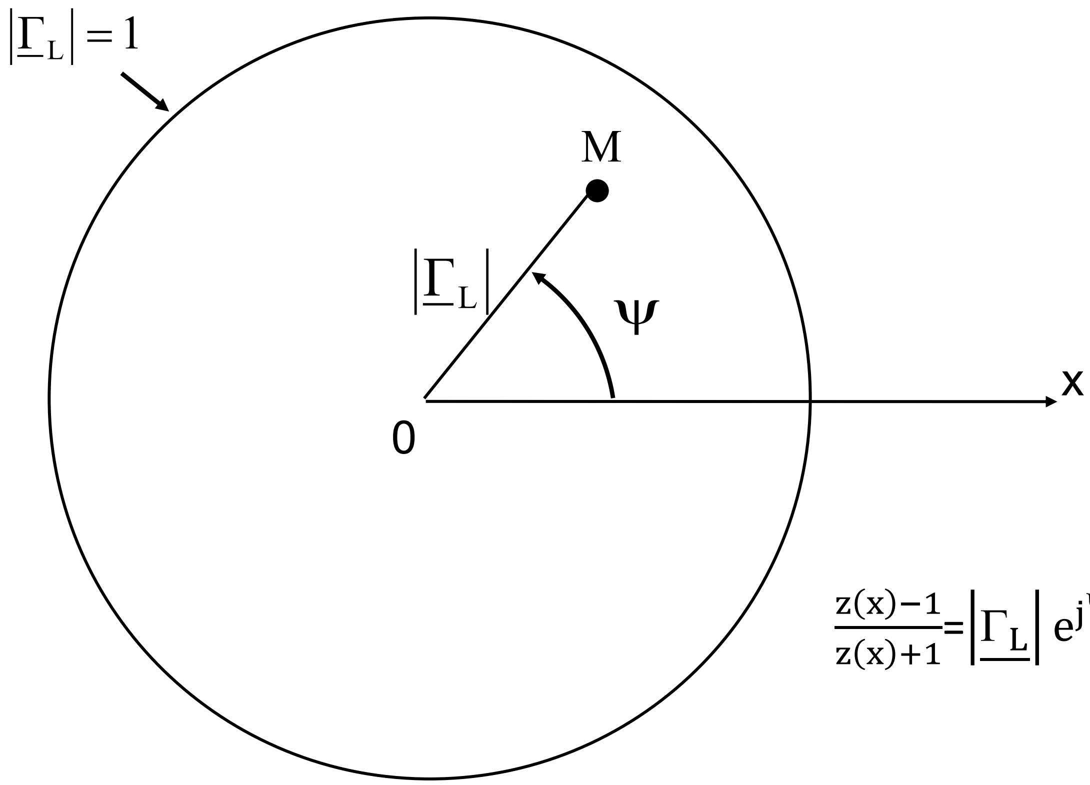
and by the distance from the first minimum voltage : $\varphi = 2.\beta.x_{min} + \pi$



Which leads to the determination of :

$$\underline{\Gamma}(x) = |\Gamma_L| e^{j\varphi}.e^{-2\gamma x} = |\Gamma_L| e^{-2\alpha x}.e^{j(\varphi - 2.\beta x)} \quad \text{with} \quad \underline{\Gamma}(x) = \frac{z(x)-1}{z(x)+1}$$

for a lossless line $\boxed{\underline{\Gamma}(x) = |\underline{\Gamma}_L| e^{j\Psi}}$ with $\boxed{\Psi = \varphi - 2\beta x}$

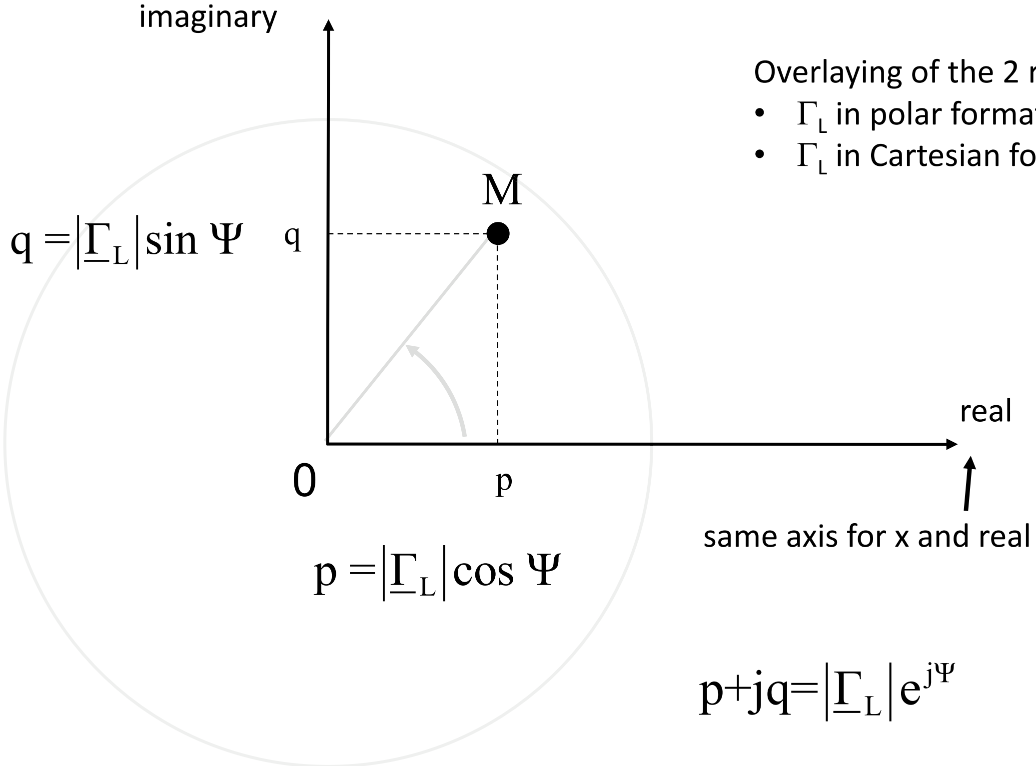


$$\frac{z(x)-1}{z(x)+1} = |\underline{\Gamma}_L| e^{j\Psi}$$

6. Introduction, uses and principles

Overlaying of the 2 representations:

- Γ_L in polar format
- Γ_L in Cartesian format



$$p + jq = |\Gamma_L| e^{j\Psi}$$

7. Introduction, uses and principles

Normalized impedance $z(x) = r_n + j\, x_n$

$$|\Gamma_L| e^{j\Psi} = p + j\,q = \frac{z(x)-1}{z(x)+1} \quad \Rightarrow \quad p + j\,q = \frac{(r_n-1)+j\,x_n}{(r_n+1)+j\,x_n} \qquad (1)$$

If we know p and q, we can know r_n and x_n by equalizing the real and imaginary parts of the equation (1) :

at constant r_n $$\boxed{\left(p - \frac{r_n}{1+r_n}\right)^2 + q^2 = \left(\frac{1}{1+r_n}\right)^2} \Rightarrow$$

Center of the circle ($r_n/(1+r_n)$, 0)
with radius $1/(1+r_n)$
Circle centered on p axis
All pass through a fixed point
$p = 1$, $q = 0$

Special cases: Circle $r_n = 0$ $\Rightarrow$ center p = 0, q = 0 , circle of radius 1 (the largest)

Circle $r_n \rightarrow \infty$ $\Rightarrow$ center p = 1, q = 0 , circle of radius 0 (point) at constant x_n

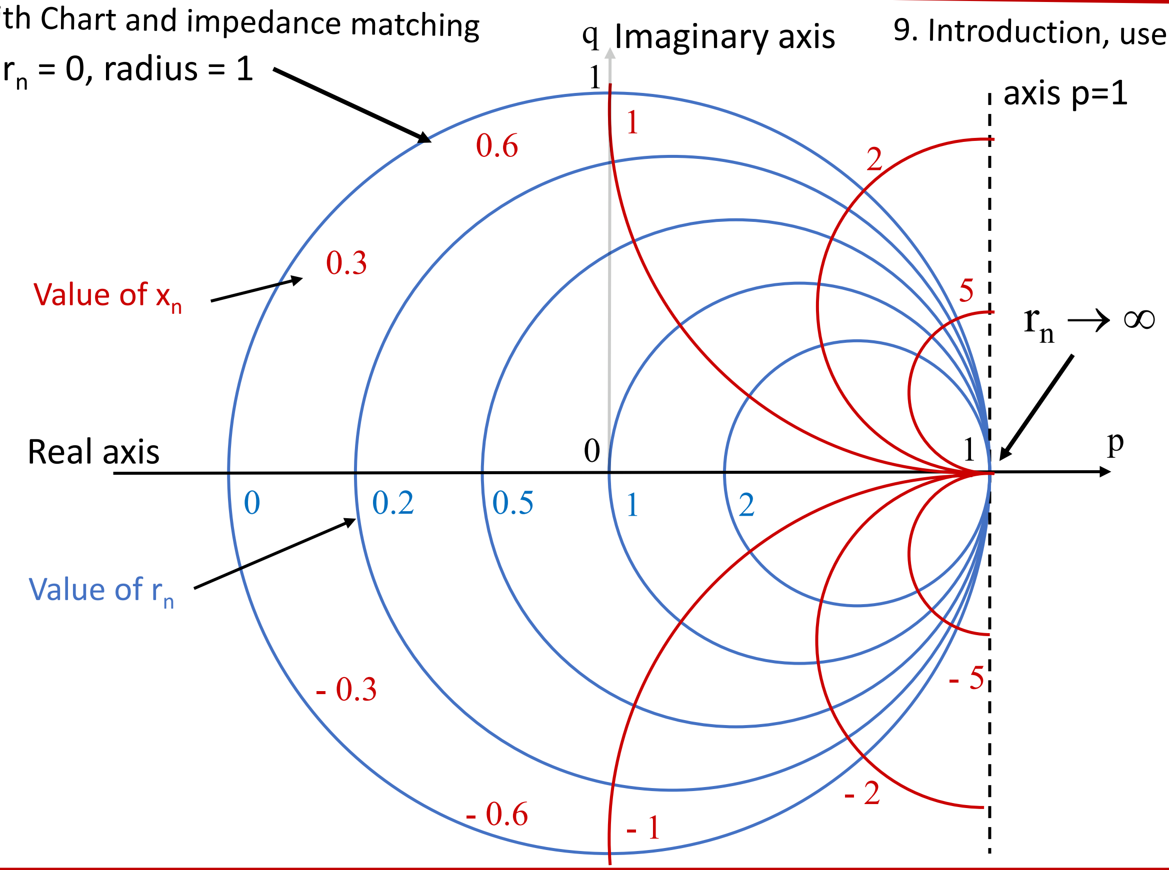
$$\boxed{(p-1)^2+\left(q-\frac{1}{x_n}\right)^2=\frac{1}{x_n^2}}$$

$\Rightarrow$ Circles center coordinates $(1, 1/x_n)$ and with radius $1/x_n$

Circle centered on p=1 axis // imaginary axis
All pass through a fixed point p = 1 , q = 0

Special cases: Circle $x_n = 0$ $\Rightarrow$ center p = 1, q = ∞ , circle with radius ∞
Real axis

Circle $x_n \to \infty$ $\Rightarrow$ center p = 1, q = 0 , circle with 0 (point)



Some loads on the Smith chart (z_n impedance):

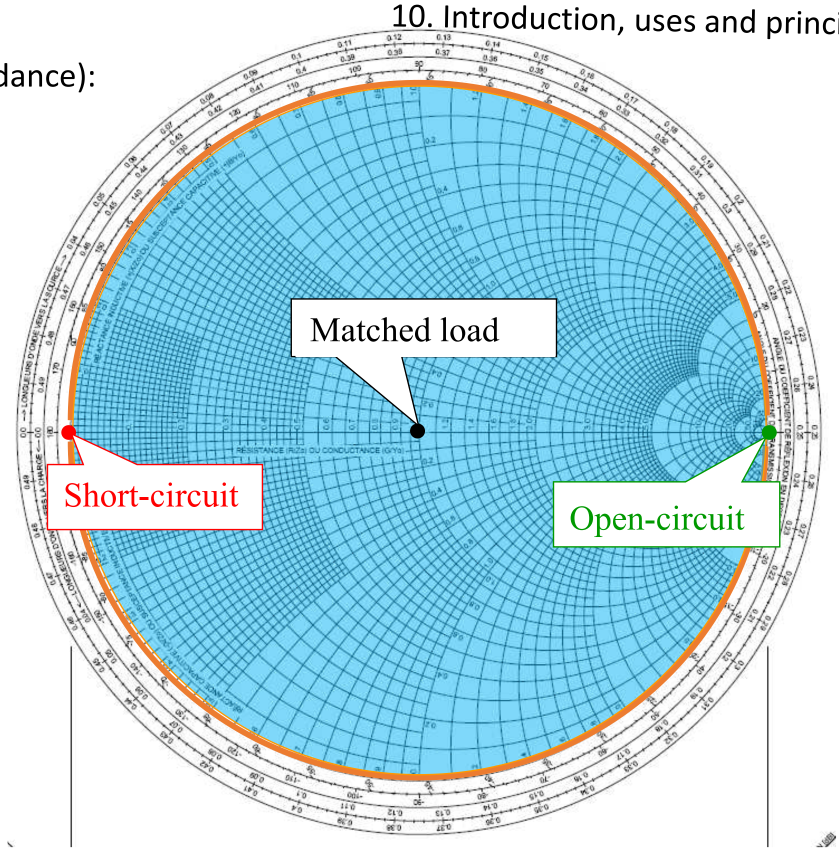
- matched load

- Short-circuit

- Open circuit

- Short-circuit delay

- Location of all normalized loads



Quelques charges sur l'abaque de Smith

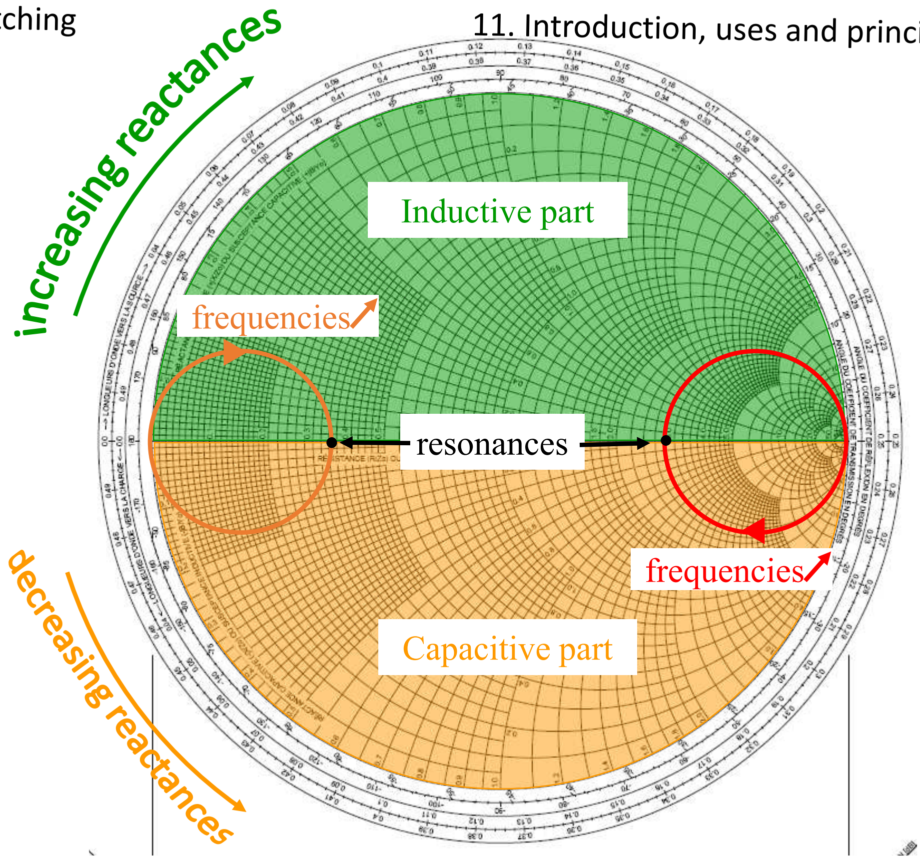
- capacitive load

-Inductive load

- Resonant circuit:

  - parallel

  - serial



If we know the impedance

⇒ Calculation of the reduced impedance

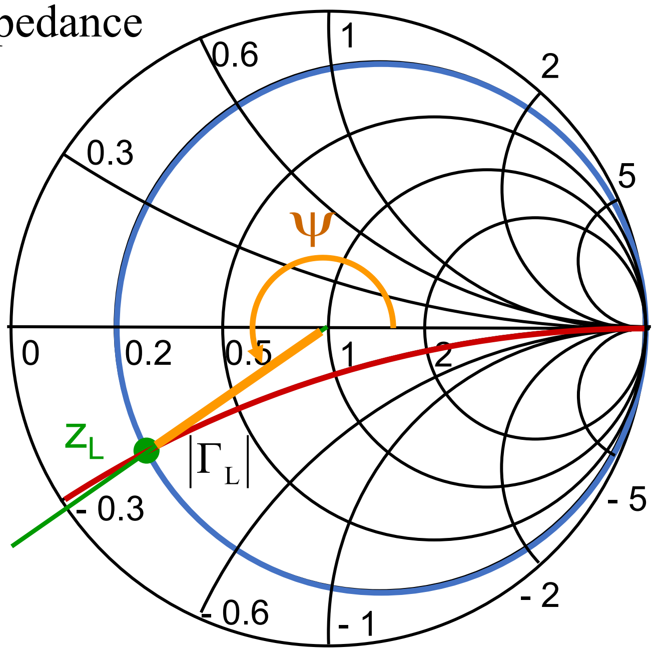
LLL

example : $Z_c = 50\ \Omega$
et $Z_L = 10 - j\ 15\ \Omega$

Normalized impedance:

$z_L = 0.2\ \ - j0.3$

Deduction of the reflection coefficient



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3. Smith Chart and impedance matching

With the original Smith chart

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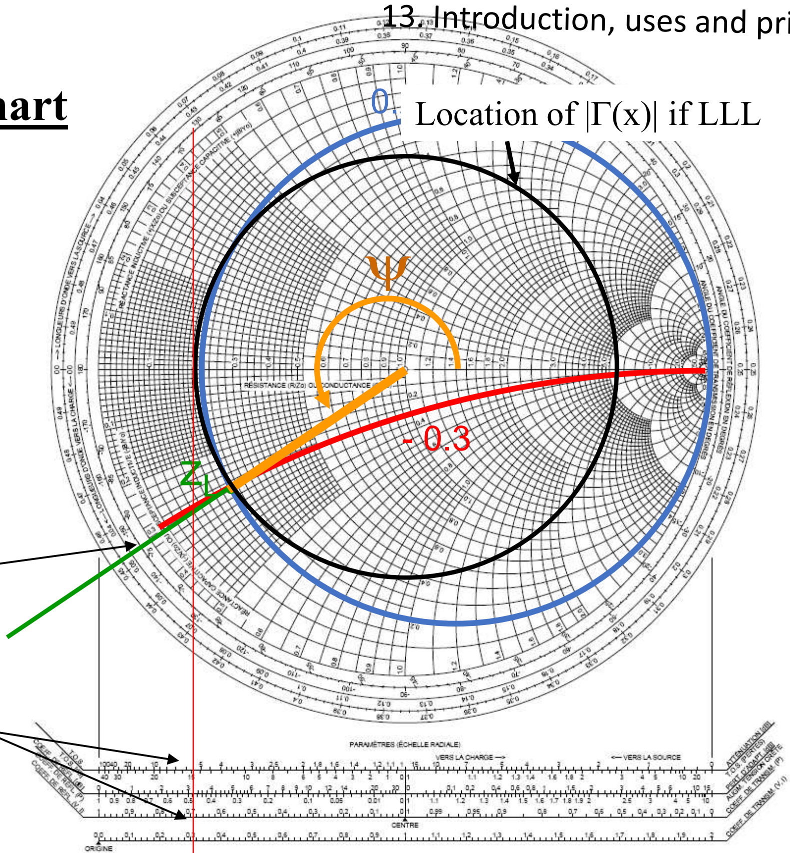
$z_L = 0.2\ \ - j0.3$

Deduction of the reflection coefficient



$\Gamma_L = 0.69\ e^{-j.146°}$

SWR= s = 5.5

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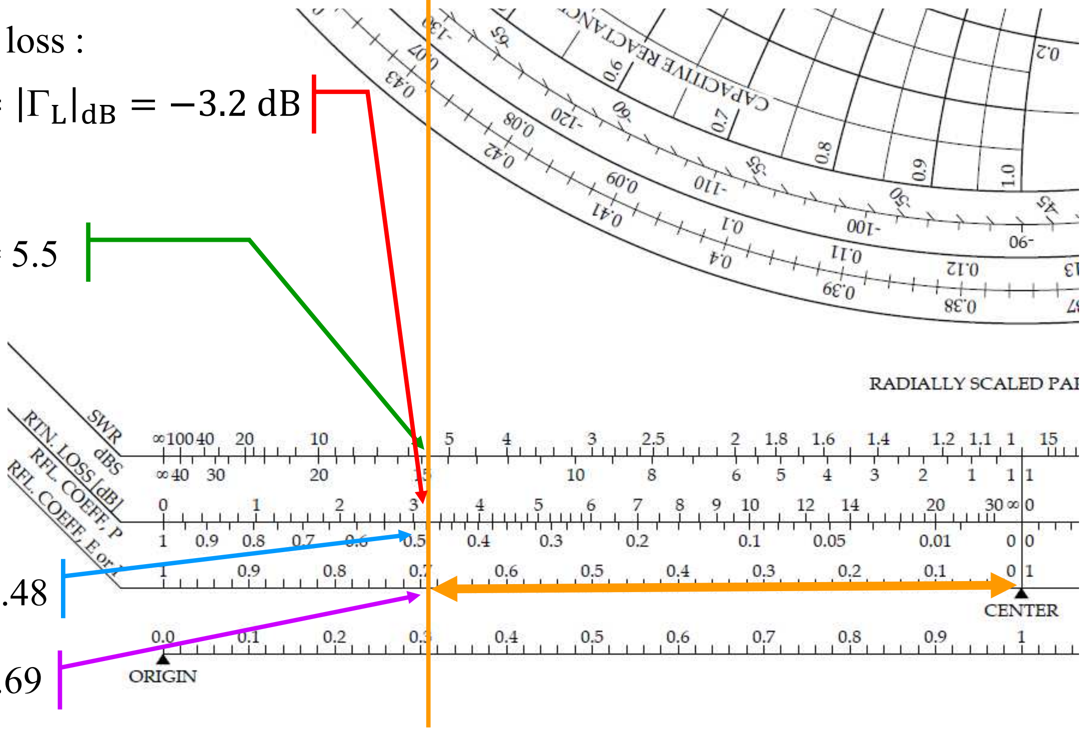
Return loss :

$$20.\log(|\Gamma_L|) = |\Gamma_L|_{dB} = -3.2\text{ dB}$$

SWR = 5.5

$|\Gamma_L|^2$=0.48

$|\Gamma_L|$=0.69



Reflected loss :

$$10.\log\left(1 - |\Gamma_L|^2\right) = -2.8\text{ dB}$$