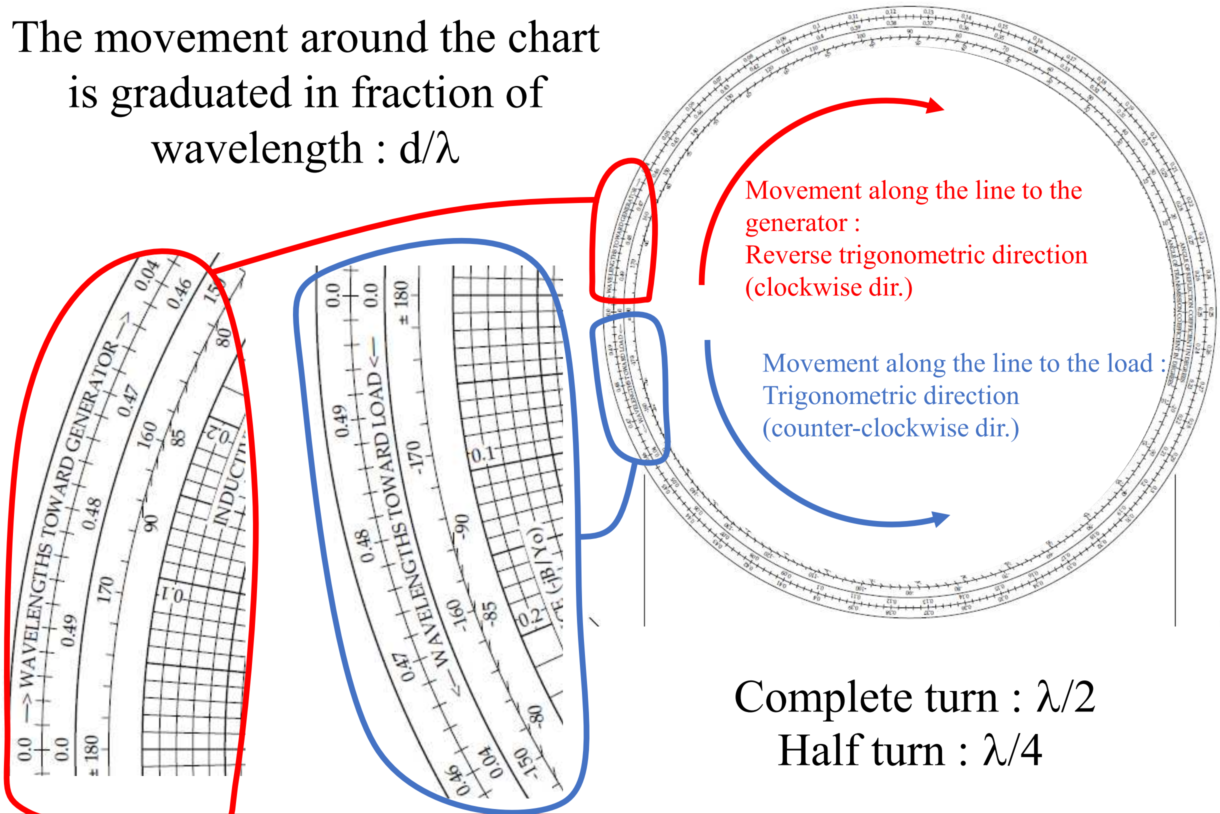
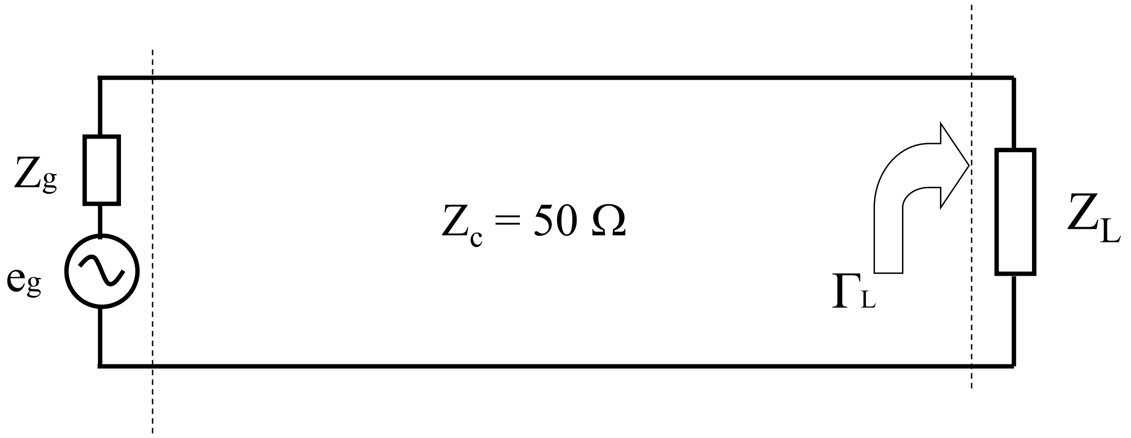
Chapters:

The movement around the chart is graduated in fraction of wavelength : d/λ



Complete turn : $\lambda/2$

Half turn : $\lambda/4$



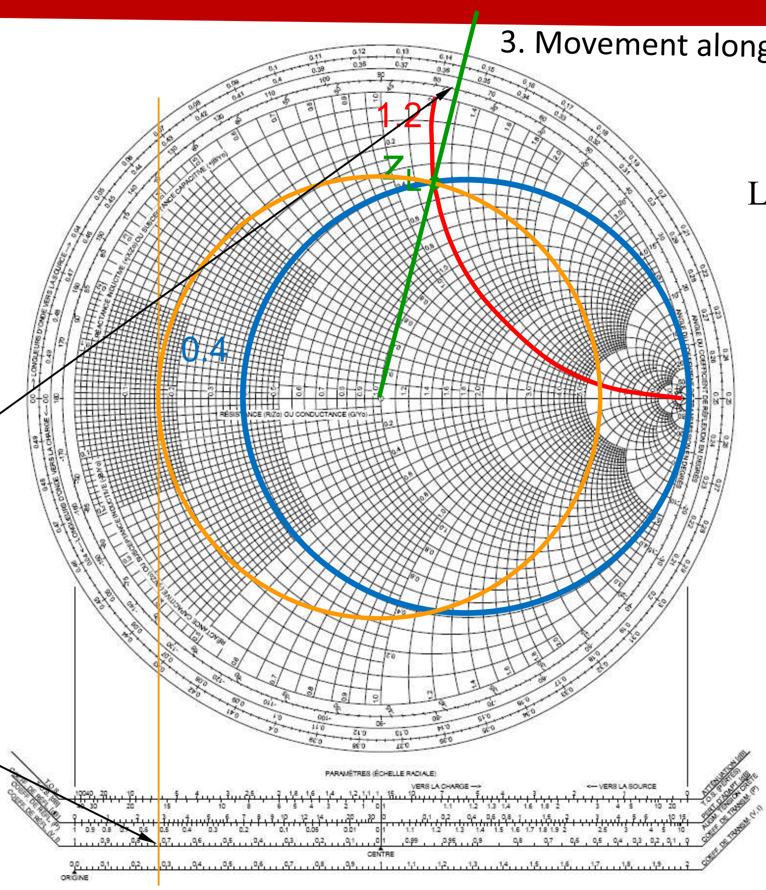
50 Ω line terminated by $Z_L = 20 + j\,60\ \Omega$ impedance

$Z_L = 20 + j\,60\ \Omega$

Reduced impedance :

$z_L = (20 + j\,60) / Z_c$

$z_L = 0.4 + j\,1.2$

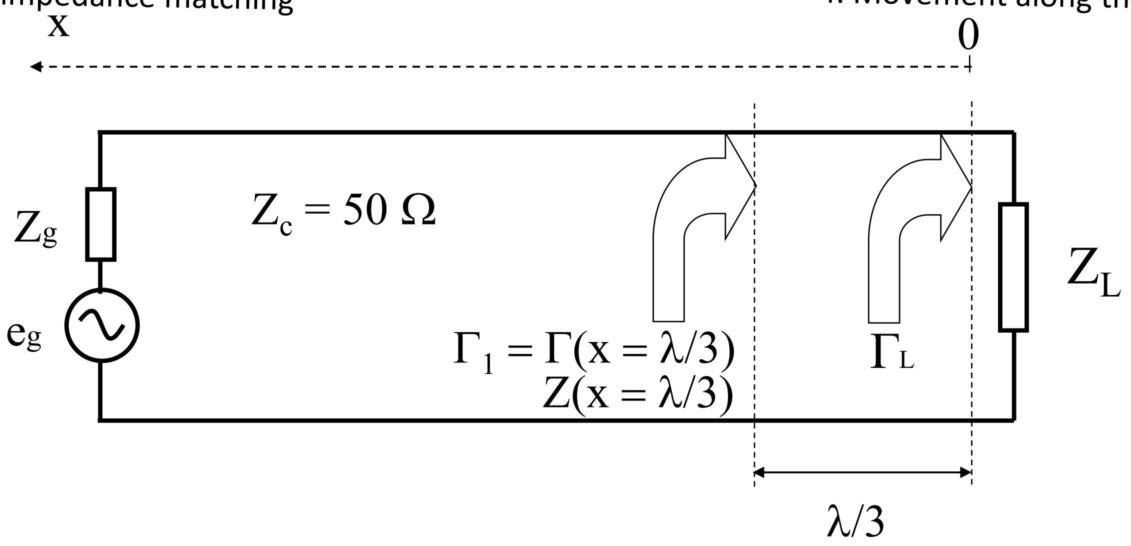


LLL

$\Gamma_L = 0.73\, e^{j.76°}$

3. Smith Chart and impedance matching

4. Movement along the line



To calculate the impedance and reflection coefficient in $x = \lambda/3$, we move from the load to the generator of a normalized distance $d/\lambda = 1/3 = 0.333$

3. Smith Chart and impedance matching

5. Movement along the line

$\Gamma(x=\lambda/3) = 0.73\ e^{-j.164°}$

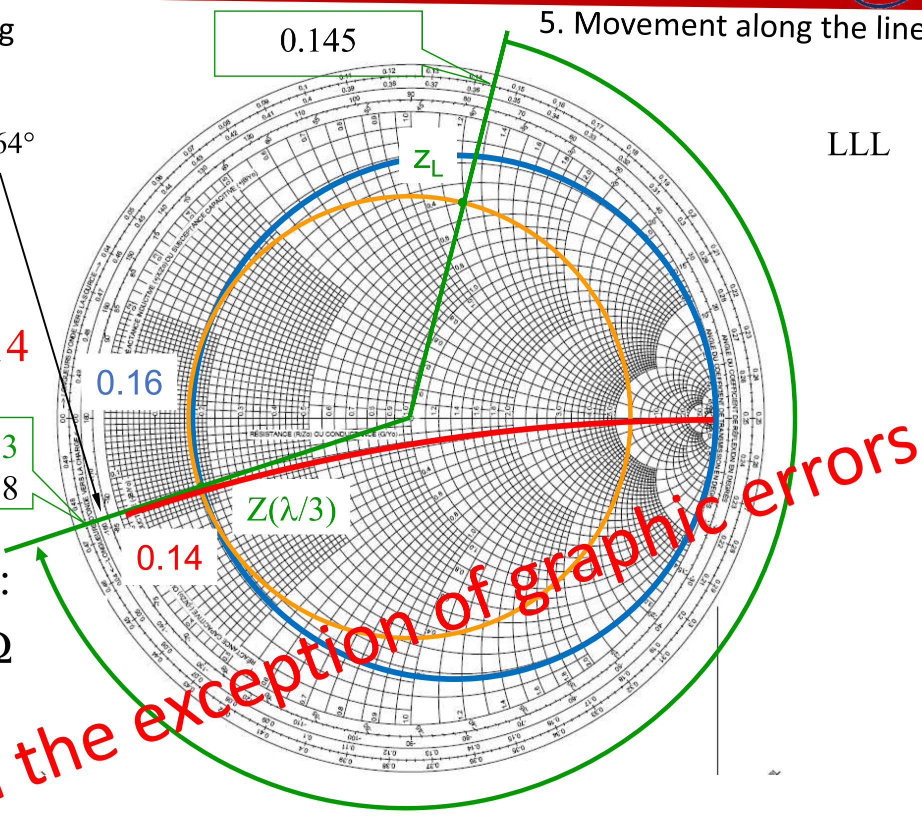
Reduced impedance:

$z(x=\lambda/3) = 0.16 - j\ 0.14$

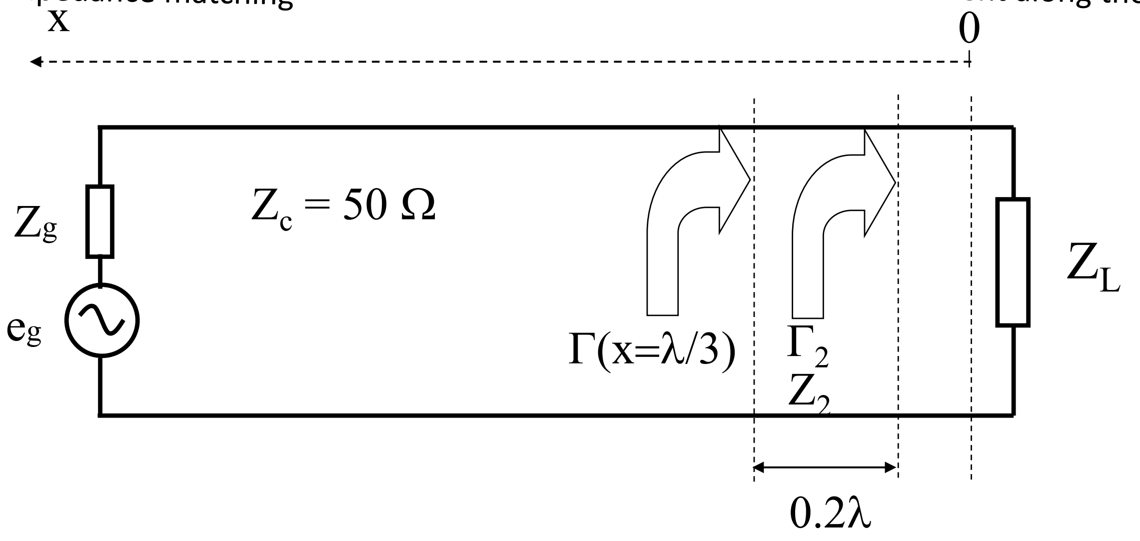
0.145+0.333
= 0.478

Denormalized impedance:

$Z(x=\lambda/3) = 8 - j\ 6.8\ \Omega$

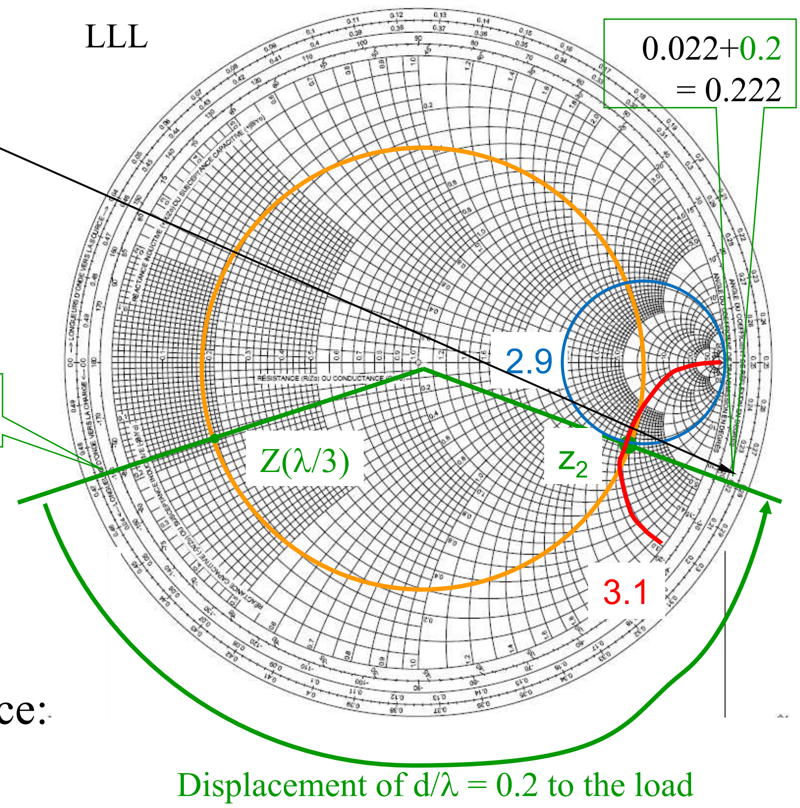


Displacement of $d/\lambda = 0.333$ to the generator



To calculate the impedance Z_2 and the reflection coefficient Γ_2 from a point returning from 0.2 λ to the load,
we move from the generator to the load by a normalized distance
$d/\lambda = 0.2$

$\Gamma_2 = 0.73\ e^{-j20°}$



Reduced impedance:

$z_2 = 2.9 - j\ 3.1$

Denormalized impedance:

$Z_2 = 145 - j\ 155\ \Omega$

3. Smith Chart and impedance matching

1. Impedance conversion - admittance

LLL

Impedance :

$Z_L = 7.5 + j\,30\ \Omega$

Reduced impedance :

$z_L = 0.15 + j\,0.6$

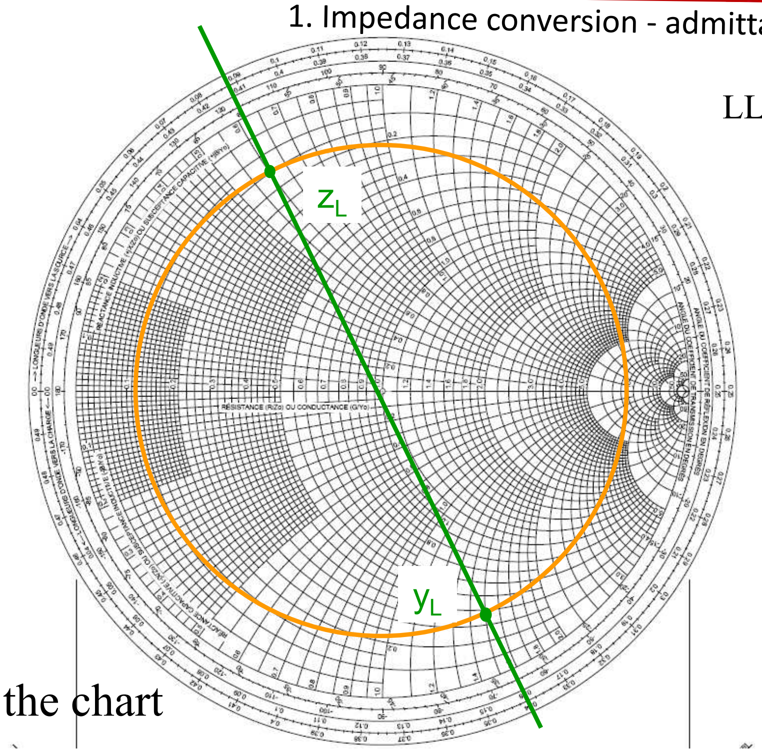
Reduced admittance:

$y_L = 0.4 - j\,1.6$

unreduced admittance:

$Y_L = 0.008 - j\,0.032\ \Omega^{-1}$

y_L is the symmetrical of z_L with respect to the center of the chart



$$z(x) = \frac{1 + \underline{\Gamma}(x)}{1 - \underline{\Gamma}(x)} \quad \text{Addition of } \pi \text{ to } \psi \quad y(x) = \frac{1 - \underline{\Gamma}(x)}{1 + \underline{\Gamma}(x)}$$

3. Smith Chart and impedance matching

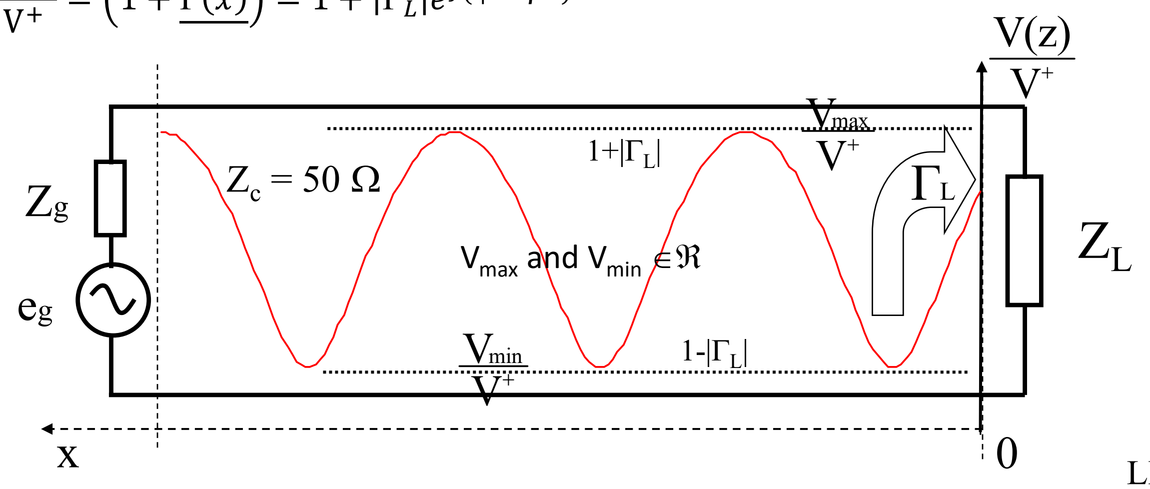
1. Representation of voltages and currents

Voltage $V(x) = \underline{V_i} e^{j\beta x} + \underline{V_r} e^{-j\beta x} = V^+ + V^-$

$$\frac{V(x)}{V^+} = \left(1 + \underline{\Gamma(x)}\right) = 1 + |\Gamma_L| e^{j(\varphi - 2\beta x)}$$

Current

$$I(x) = \frac{\underline{\underline{V_i}}}{Z_c} e^{j\beta x} - \frac{\underline{\underline{V_r}}}{Z_c} e^{-j\beta x} = \frac{V^+}{Z_c} - \frac{V^-}{Z_c}$$



LLL

$\frac{V(x)}{V^+}$ move from min values to max values along the line

V_{max} and V_{min} are real

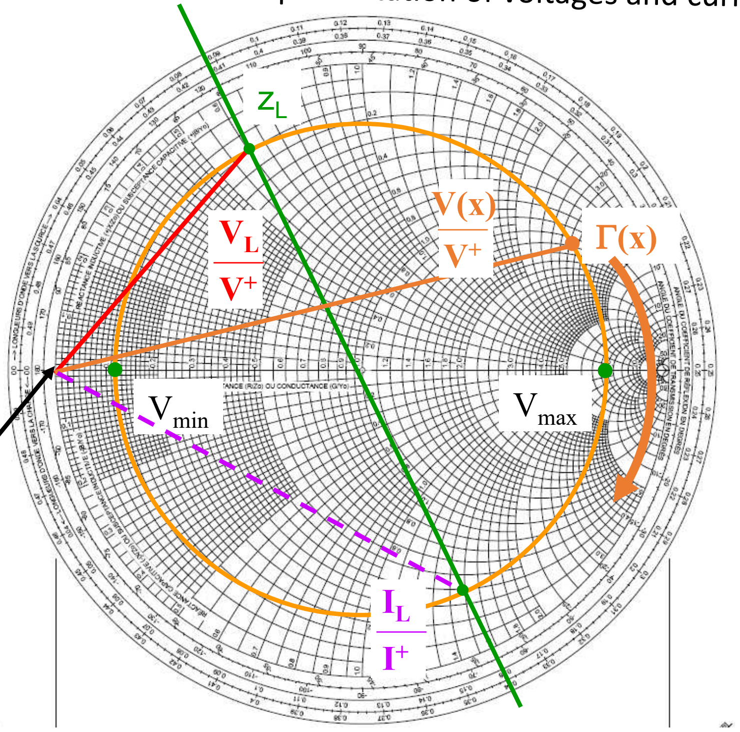
LLL

Reduced voltage : $\frac{V_L}{V^+}$

Reduced current : $\frac{I_L}{I^+}$

$\Rightarrow$ Take the opposite of the Z_L point

Voltage origin
Short-circuit, z = 0



Evolution of v(x) reduced along the line that goes through V_{max} and V_{min}

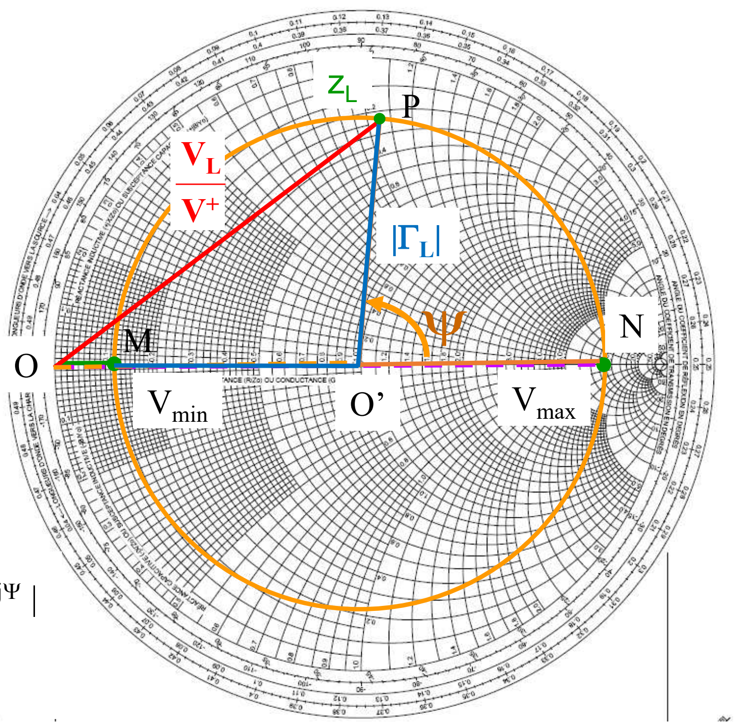
LLL

$|OO'| = 1$

$V_{min}/V^+ = |OM| = 1 - |\Gamma_L|$

$V_{max}/V^+ = |ON| = 1 + |\Gamma_L|$

$V_L/V^+ = |OP| = |1+\Gamma_L| = |1+|\Gamma_L|e^{j\Psi}|$



Exercise #1 : Analytical calculations versus Smith chart (tutorial_n1_Smith_chart.pptx)

An air line, with a characteristic impedance of $Z_C = 250\ \Omega$, is powered at the frequency $f_0 = 500$ MHz.

It is 2m long and ends at an impedance Z_L . The SWR along the line is s = 5 and the first maximum voltage is at d = 12 cm from the load.

• Calculate $|\rho_L|$, ρ_L module and argument of the reflection coefficient on the load.

• Calculate Z_L.

• The input voltage is 10V. What is the value of the voltage at the load terminals. Give V_{max} and V_{min} on the line.

Exercise #2 : Graphical calculations on Smith chart (tutorial_#2_Smith_chart)

An air line, with a characteristic impedance of $Z_C = 20\ \Omega$, is loaded at its end on an impedance $Z_L = R_L + j\,X_L = (24 + j\,36)\ \Omega$. At the frequency of $f_0 = 3$ GHz, the length of the line is $\ell = \lambda_0 /4$.

1) Give, using the Smith chart:
   - The reflection coefficient ρ_L, the SWR s_L on the load Z_L.
   - The reflection coefficient ρ_{in}, the SWR s_{in} and the impedance Z_{in} at the distance ℓ, for $f_0 = 3$ GHz and $f_1 = 4$ GHz

Exercise #2 : Graphical calculations on Smith chart

2) A line of length ℓ_1, with a characteristic impedance $Z_C = 20\ \Omega$, short-circuited at one end, is placed in parallel on the previous load admittance $Y_L = 1 / Z_L$.

Let :

- Y_a the input admittance of this line with ℓ_1 length
- $Y_t = Y_a + Y_L$ the total admittance in x = 0

ℓ_1 is selected to obtain a real Y_t named R_t. Use Smith chart to give ℓ_1 and R_t at f = 3 GHz.