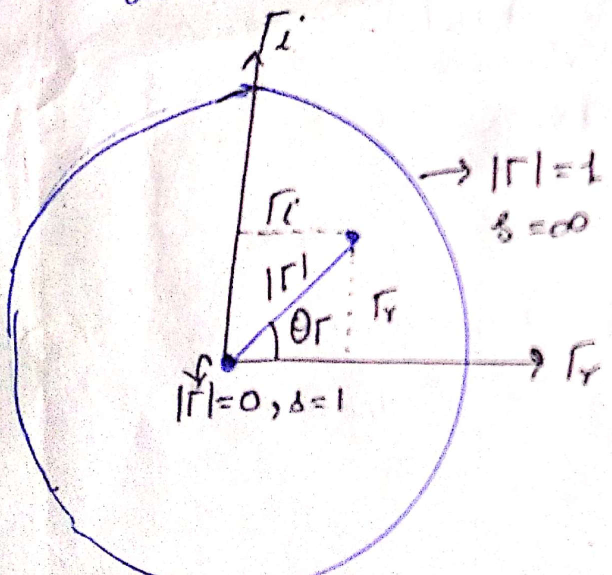
SMITH CHART :

Smith chart is a graphical techniques, it is basically a indication of the impedance of a transmission line and of the corresponding reflection coefficient as one moves along the line.

- With the help of smith chart we can calculate reflection coefficient (Γ_L), standing wave ratio (S) and characteristic impedance (Z_0), Input Impedance (Z_{in})
- We will assume that the transmission line to which the Smith chart will be applied is lossless ($Z_0 = R_0$).
- The Smith chart is constructed within a circle of unit radius ($|\Gamma| \leq 1$)



→ The construction of the chart is based on the relation;

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

$|\Gamma|$ — magnitude $= \sqrt{\Gamma_r^2 + \Gamma_i^2}$

$\angle\theta_r$ — Angle

$\Rightarrow \Gamma = |\Gamma| \underline{/\theta_r} = \Gamma_r + j\Gamma_i$

$\Rightarrow \Gamma_r \Rightarrow$ Real part of Γ

$\Rightarrow \Gamma_i \Rightarrow$ Imaginary part of Γ.

- Instead of having separate smith charts for transmission lines with different characteristics impedances (different values of Z_0), just one smith chart is used for any line.

→ So a normalised value of impedance with respect to the characteristic impedance Z_0 is calculated.

- For Z_L (load impedance)

$$Z_L = R_L + jX_L$$

R_L → Resistance load
X_L → load inductance / capacitance

$R_L + jX_L \Rightarrow X_L$ is inductance
$R_L - jX_L \Rightarrow X_L$ is capacitance

⇓

- Normalised impedance ($\bar{Z}_L$)

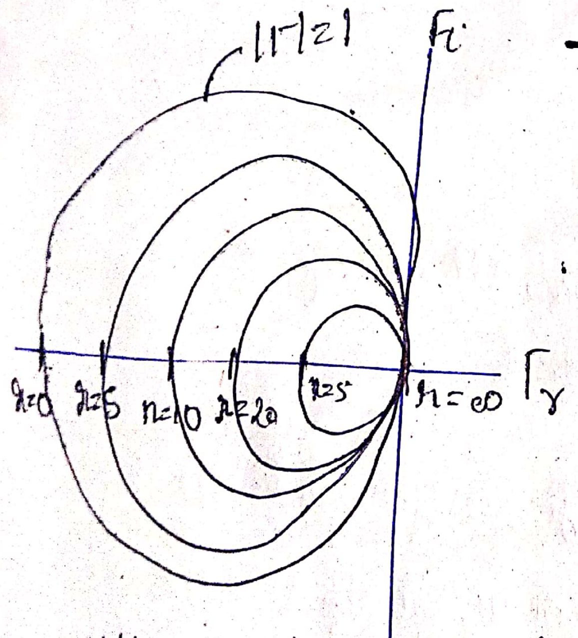
$$\bar{Z}_L = \frac{Z_L}{Z_0} = \frac{R}{Z_0} + j\frac{X_L}{Z_0}$$

$$\boxed{\bar{Z}_L = r_L + jx_L}$$

⇓

Normalised parameters ($\bar{Z}_L$, r_L and x_L)

→ Construction of Smith Chart :



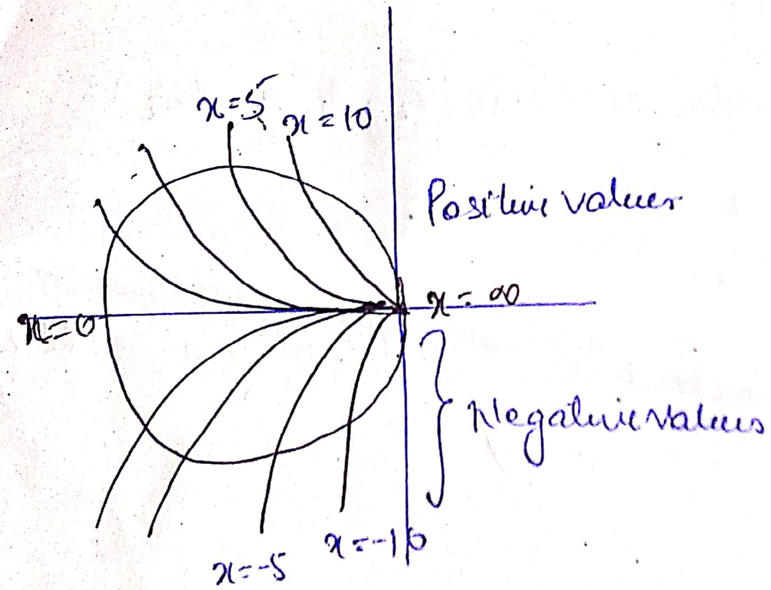
→ Smith chart consists of → constant R Circle
↳

- The constant R Circle : Smith chart is an impedance chart containing two sets of lines.

The first set of lines referred to as constant resistance lines form circles, all tangent to each other at the right hand of horizontal diameter. These circles are constant R circles.

- Each circle represents resistance.
- The outermost resistance circle at extreme left is zero resistance.
- While the circle at extreme right represents infinite resistance.

- **The Constant X Circle:** - Another set of lines called constant Reactance lines.



- These lines are arcs of circles, all tangent to each other. ~~on the right hand~~
- The lines in the upper half represent positive reactances while those in lower half represent negative reactances.

→ The complete Smith Chart is obtained by the superposition of the two sets of X-circles and R circles.

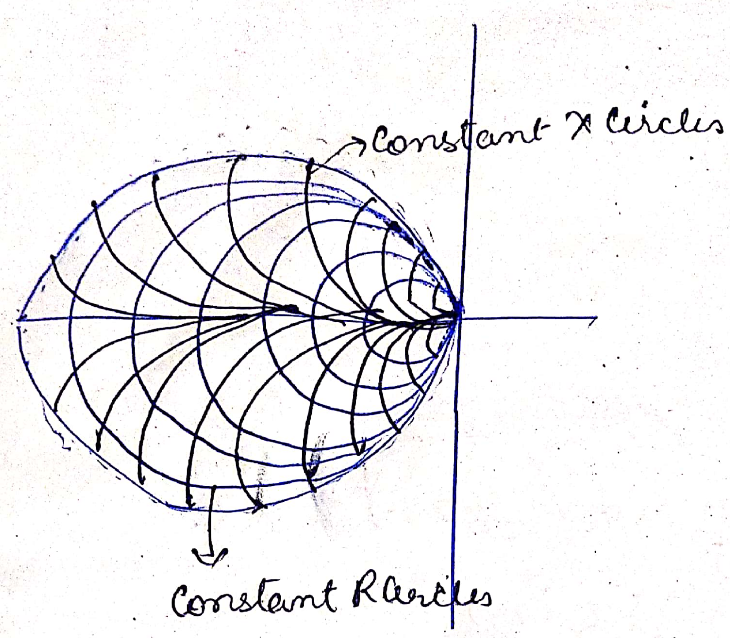
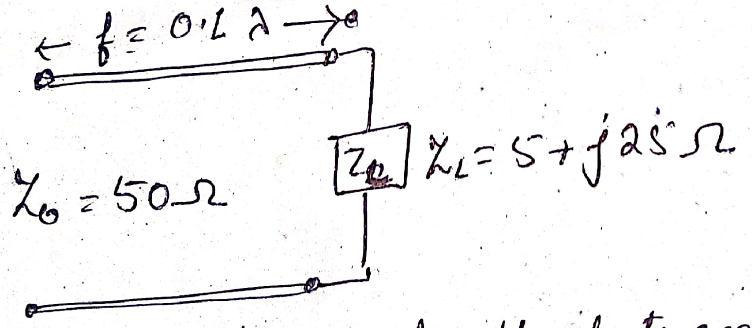


fig. Smith chart

→ How to calculate VSWR, Reflection Co-efficient and Input Impedance:

Exp:

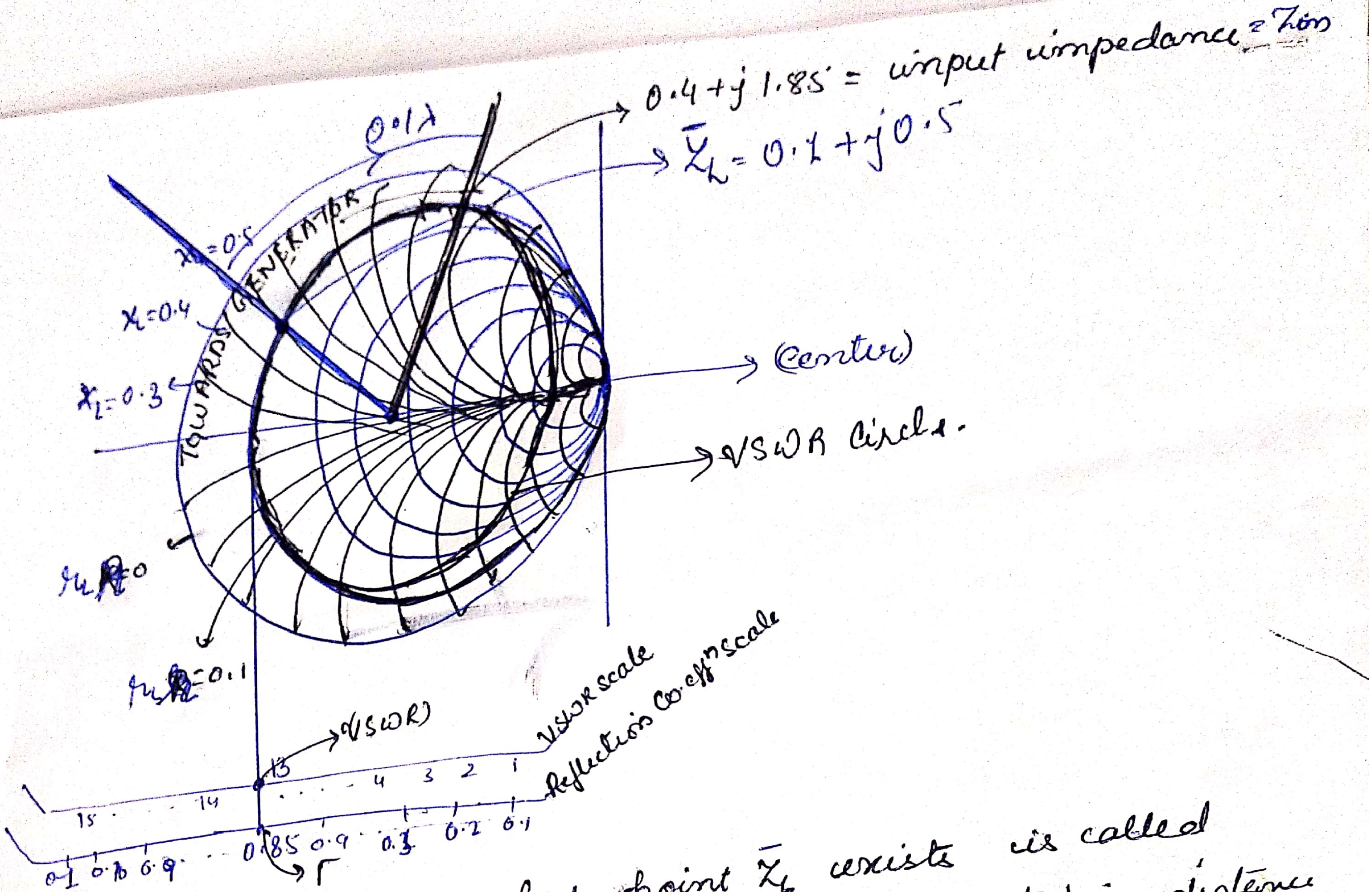


In the above figure, length of transmission line $l = 0.1\lambda$, $Z_0 = 50\Omega$ and $Z_L = 5 + j25\ \Omega$.

Step I: Find normalised load impedance

$$z_L = \frac{Z_L}{Z_0} = \frac{5 + j25\Omega}{50} = \underset{\Downarrow \atop r_L}{0.1} + j\underset{\Downarrow \atop x_L}{0.5}$$

Step II: From Constant-R circles, choose $r_L = 0.1$ circle and from constant-x circles, choose $x_L = 0.5$ circle.



Step 3: The circle on which point $\bar{Z}_L$ exists is called VSWR circle. (It is drawn from center by taking distance between point ($\bar{Z}_L$) and center as radius).

Step 4: Draw a straight line from the point on ~~R~~ VSWR circle (where it cuts horizontal axis) towards the VSWR and Reflection Co-efficient scale.

Where the line cuts the scale, mark the value of VSWR and reflection co-efficients.

Step 5: Draw a straight line from center of unity circle towards the point $\bar{Z}_L$.

Move the line clockwise ~~at~~ towards the generator.

Turn the line in clockwise direction for length equals to length of transmission line

Step 6. After turning the line by the distance of 0.1λ, the point of intersection of the line and ~~R circle~~ VSWR circle gives the input impedance (normalised) $\bar{Z}_{in}$