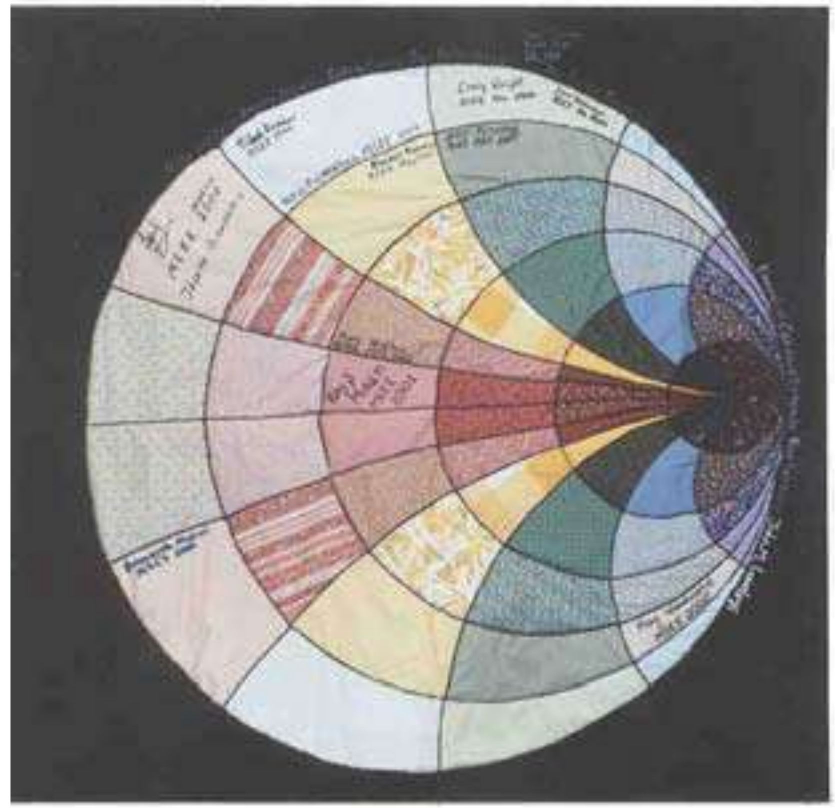
Microwave Engineering

Smith Chart

Ahmad Bilal

Objectives

- To develop a understanding about frame work of smith chart



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But Why Should I Study Smith Chart … Are the formulas not enough

Smith Chart

- Smith Chart is a **graphical** method to solve many transmission line problems and provides us with a **visual** indication of microwave device performance.

- Where it can not help us

- Where it can help us

The Foundations

Before Looking at basics of smith chart .. Always Keep in mind

All impedance that are being considered are normalized.

We will consider all cases as Loss less line , until , unless we are not told to do so

Normalized Impedance is Z/Zo

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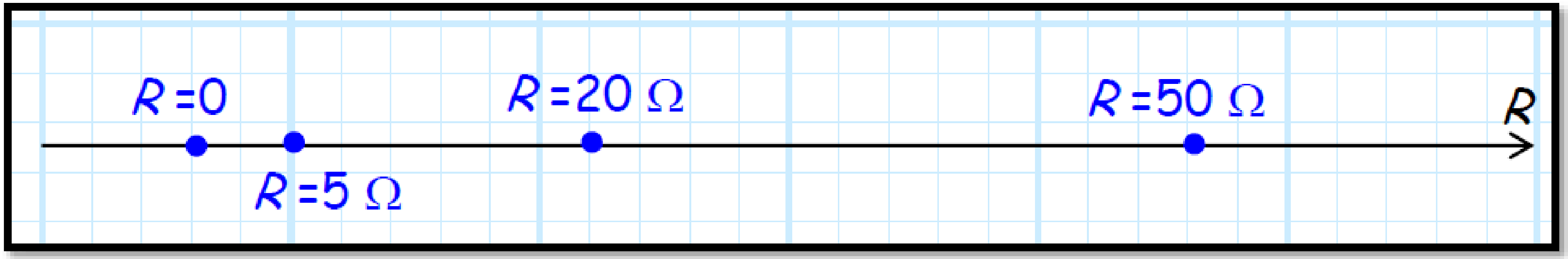
Microwave Engineering

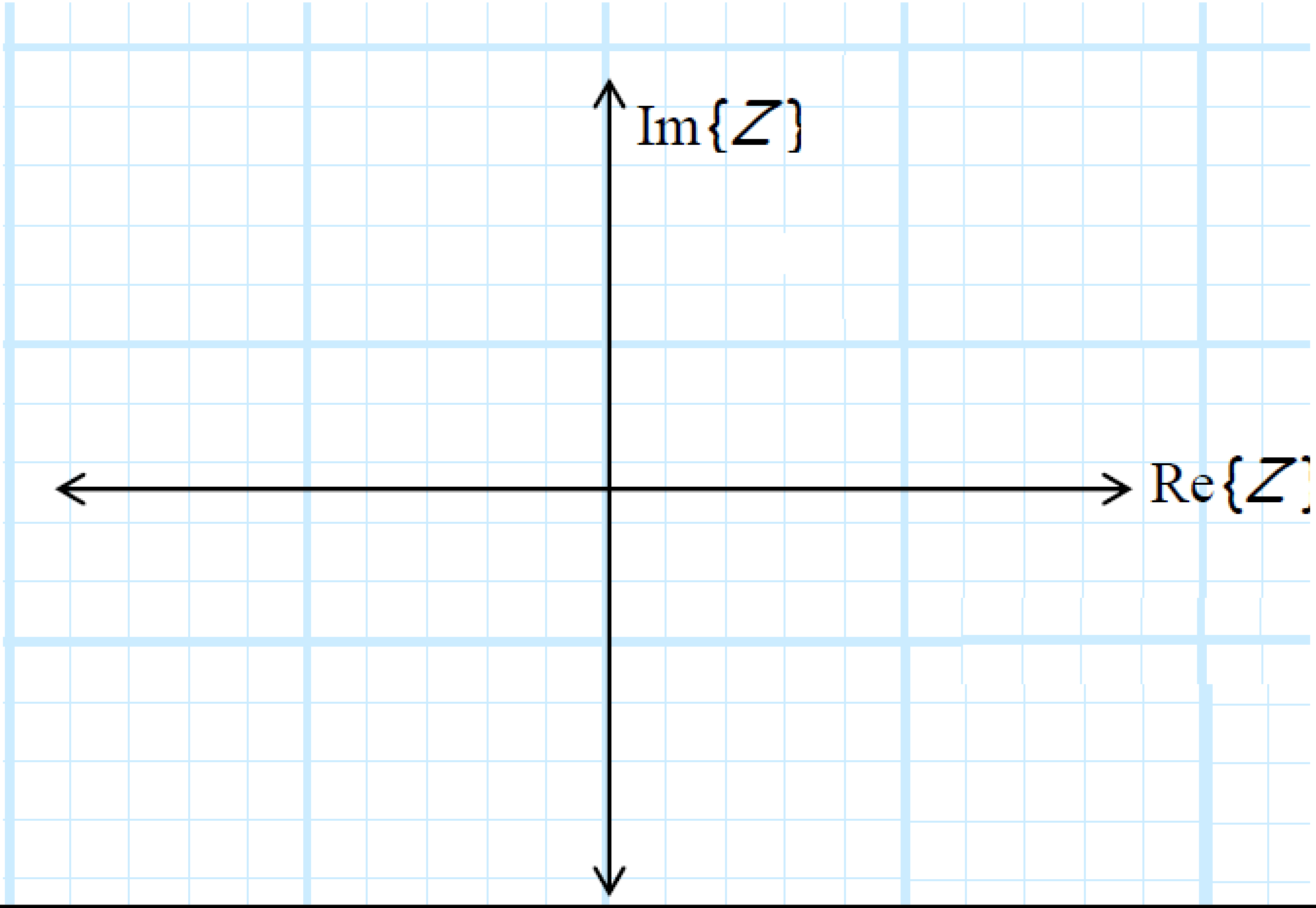
Smith Chart
The Complex Gamma Plane

Resistance

- Resistance R is a real value and can be plotted on a real line .
- For Passive Resistance , Real parts are considered



Plotting Imaginary Part



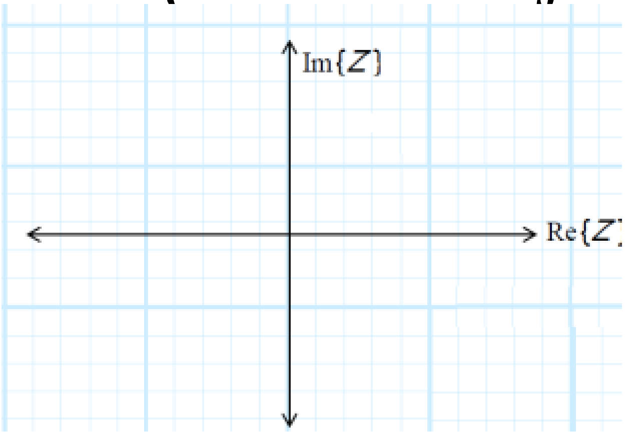
Plotting Normalized Impedance

- We know that normalized impedance is represented as

$$\bar{z} = \frac{Z}{Z_0} = r + jx$$

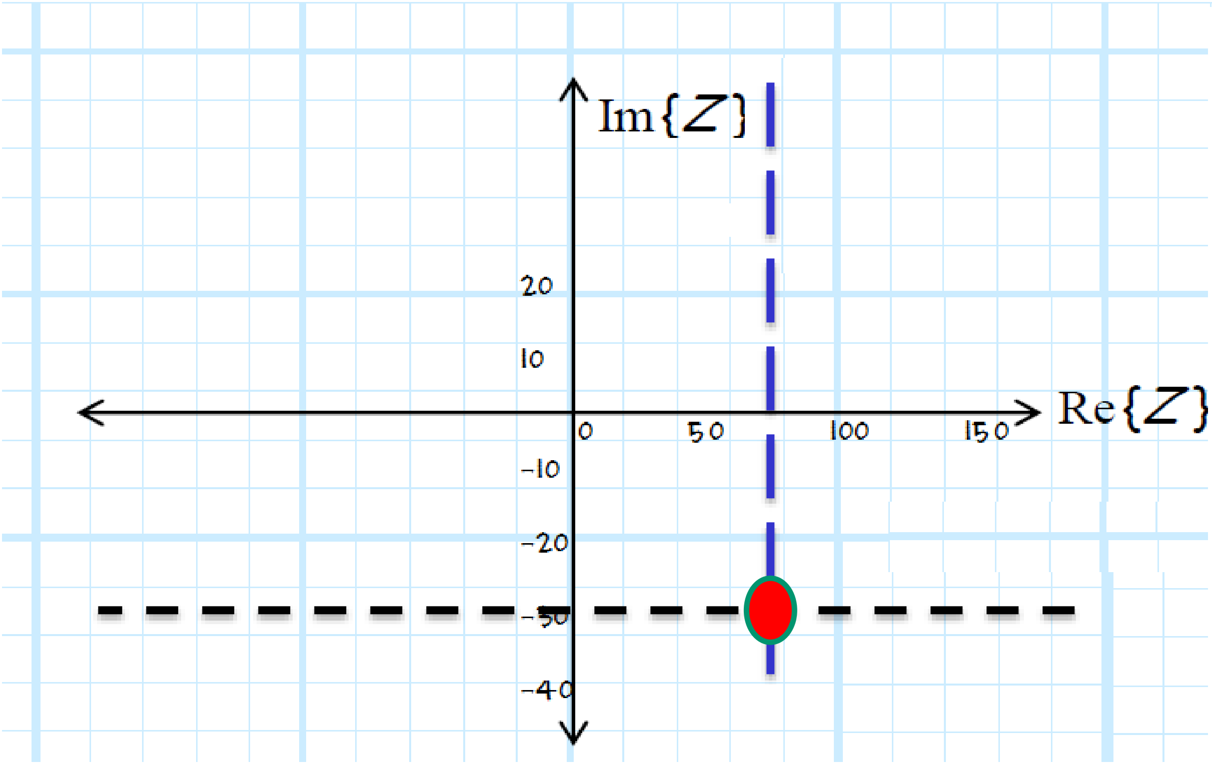
- And hence can be easily plotted on graph

Note each dimension is defined by a single real line: the **horizontal** line (x axis) indicating the **real** component of Z (i.e., $Re\{Z\}$), and the **vertical** line (y axis) indicating the **imaginary** component of impedance Z (i.e., $Im\{Z\}$). The **intersection** ofthese two lines is the point denoting the impedance **Z = 0**.



Lets Plot

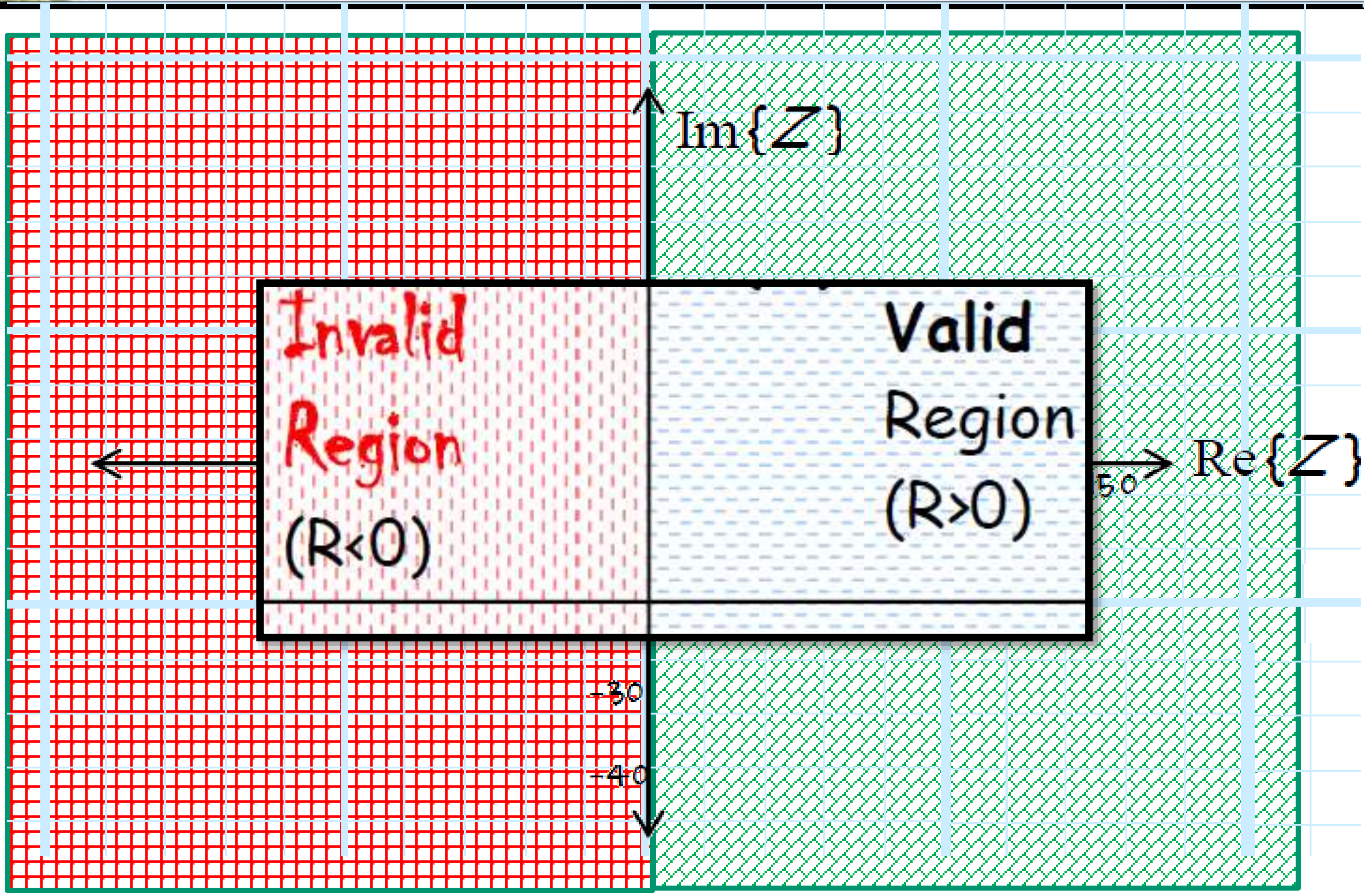
- If we have to plot : Lets say Z= 75 -j30



Selecting Region

- Considering positive passive load
- Graph area ?
-

Defining Areas



Recall

For every passive load we have a equivalent value of reflection co-efficient If we know one we can plot other

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

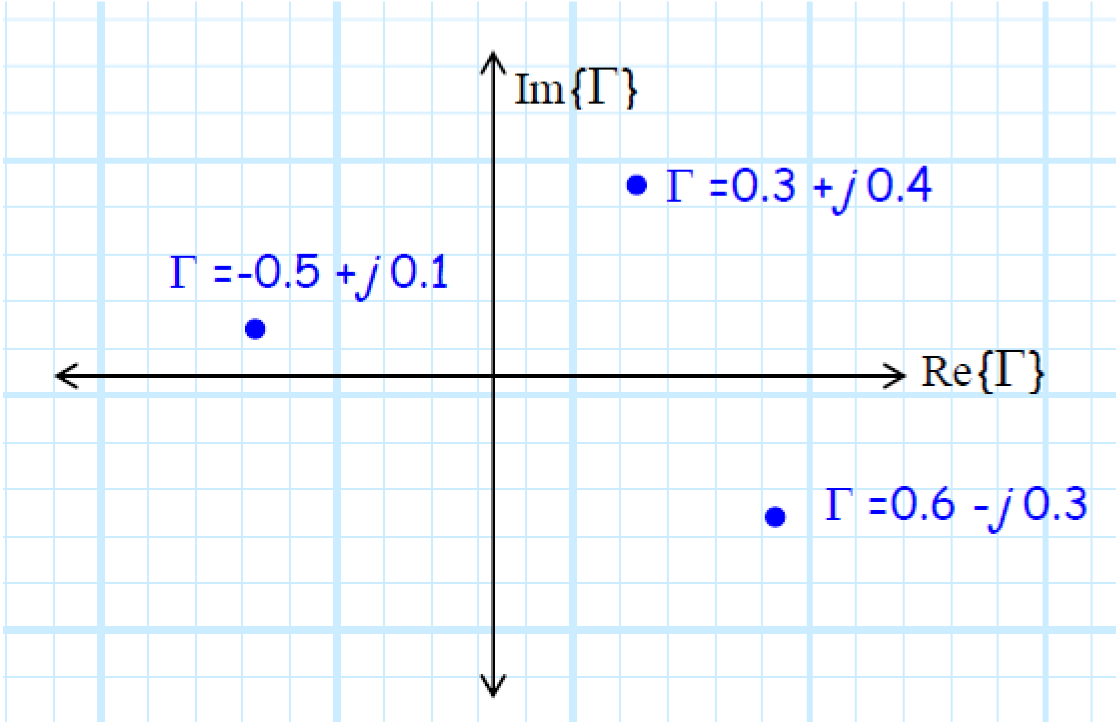
$$\Gamma = \frac{Z - Z_0}{Z + Z_0} = \frac{\bar{z} - 1}{\bar{z} + 1}$$

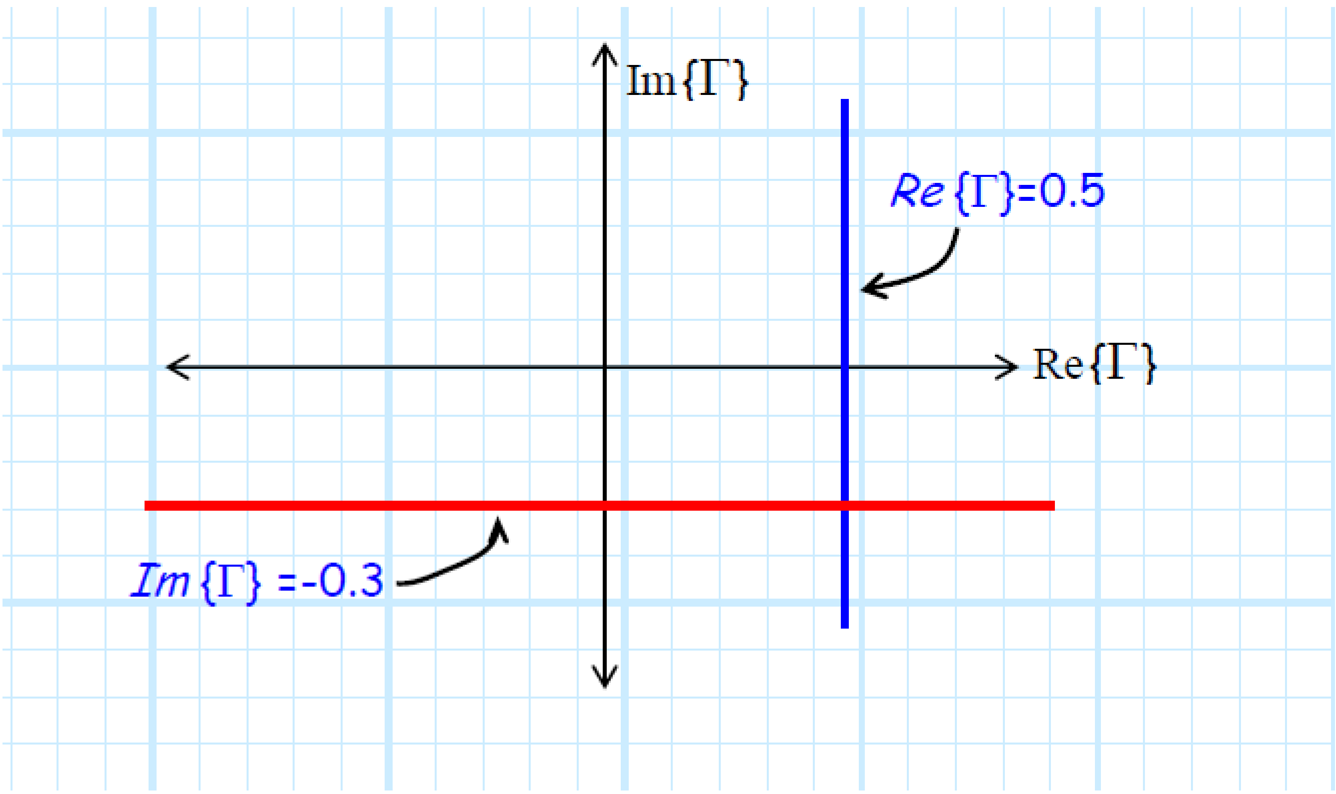
I can write reflection co-efficient in terms of its real and imaginary part as follow

$$\Gamma = \frac{\bar{z} - 1}{\bar{z} + 1}$$

$$= \frac{(r + jx) - 1}{(r + jx) + 1}.$$

Plotting Values on Reflection Co-efficient Plane





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The reflection Co-efficient

- The value of gamma can be represented ,
- Either in terms of Polar or rectangular components
- If I represent Gamma in terms
- of polar it will have form of
- $=Re^{j\theta}$

Observation

The value of magnitude of R

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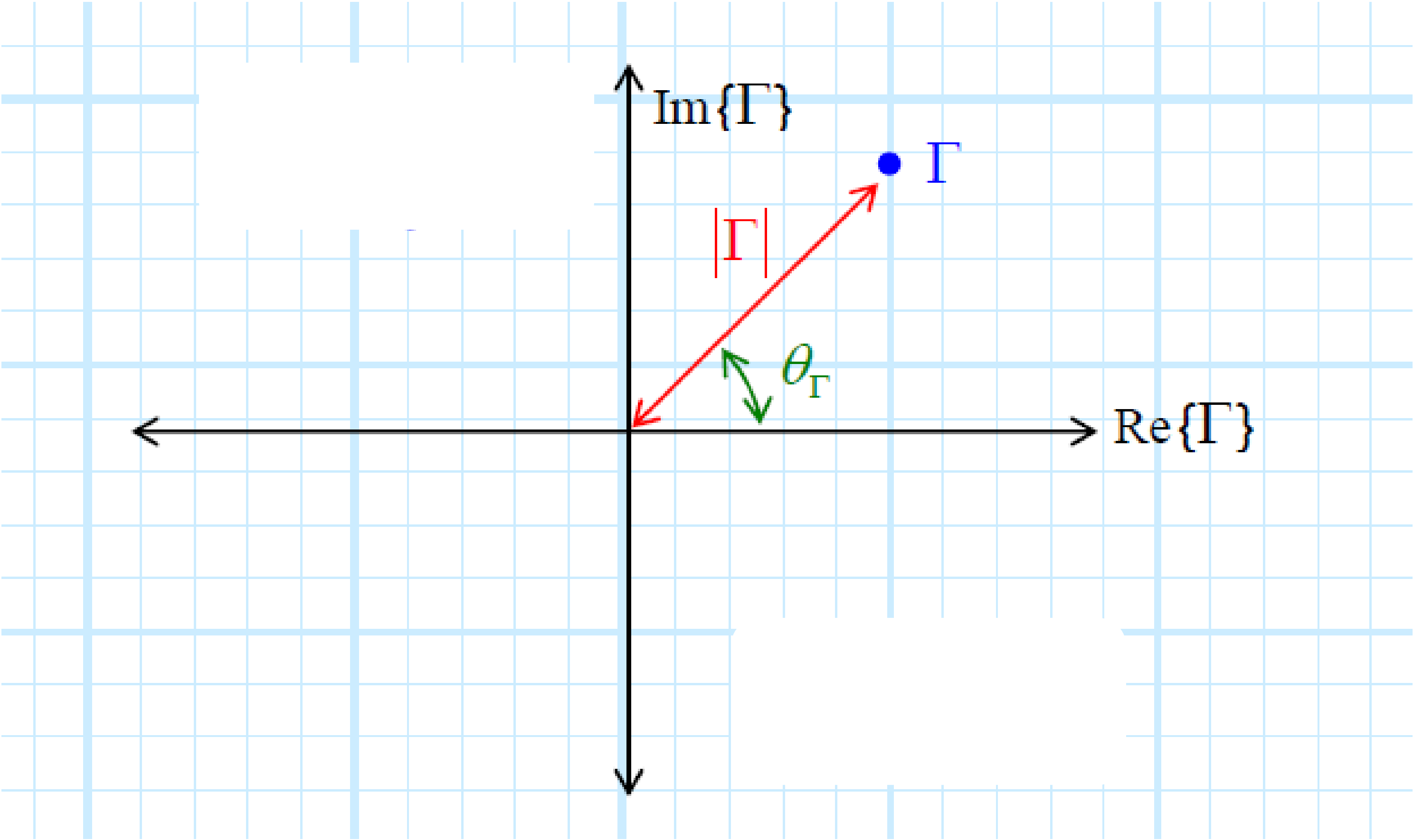
Plotting




Wait wait .. Why are we doing these conversions from one form to another ?
Lets Ask Class
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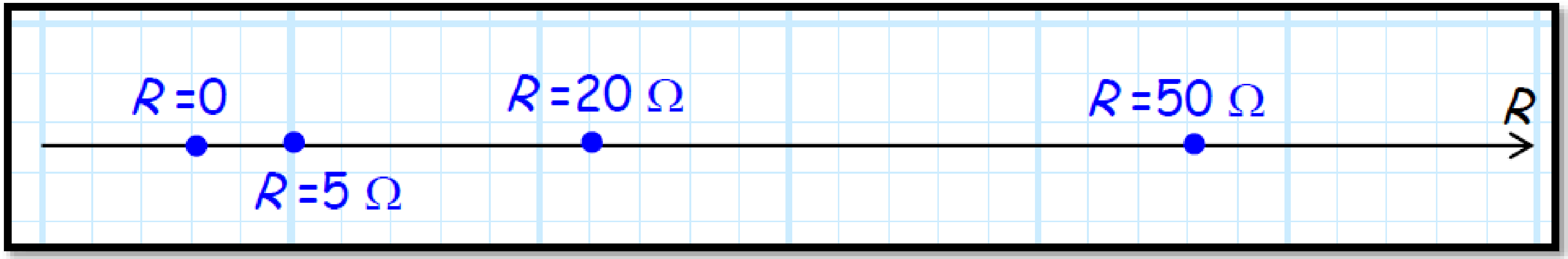
Understanding

- To understand it , we need to answer few questions from previous topics, which my class has completely understood.

- Q1. What is the need of Taking two plots, What was the problem with Impedance plane

Resistance

- Q . Is it Possible to draw R= infinity .
- Q, Why do we need to consider R= infinity



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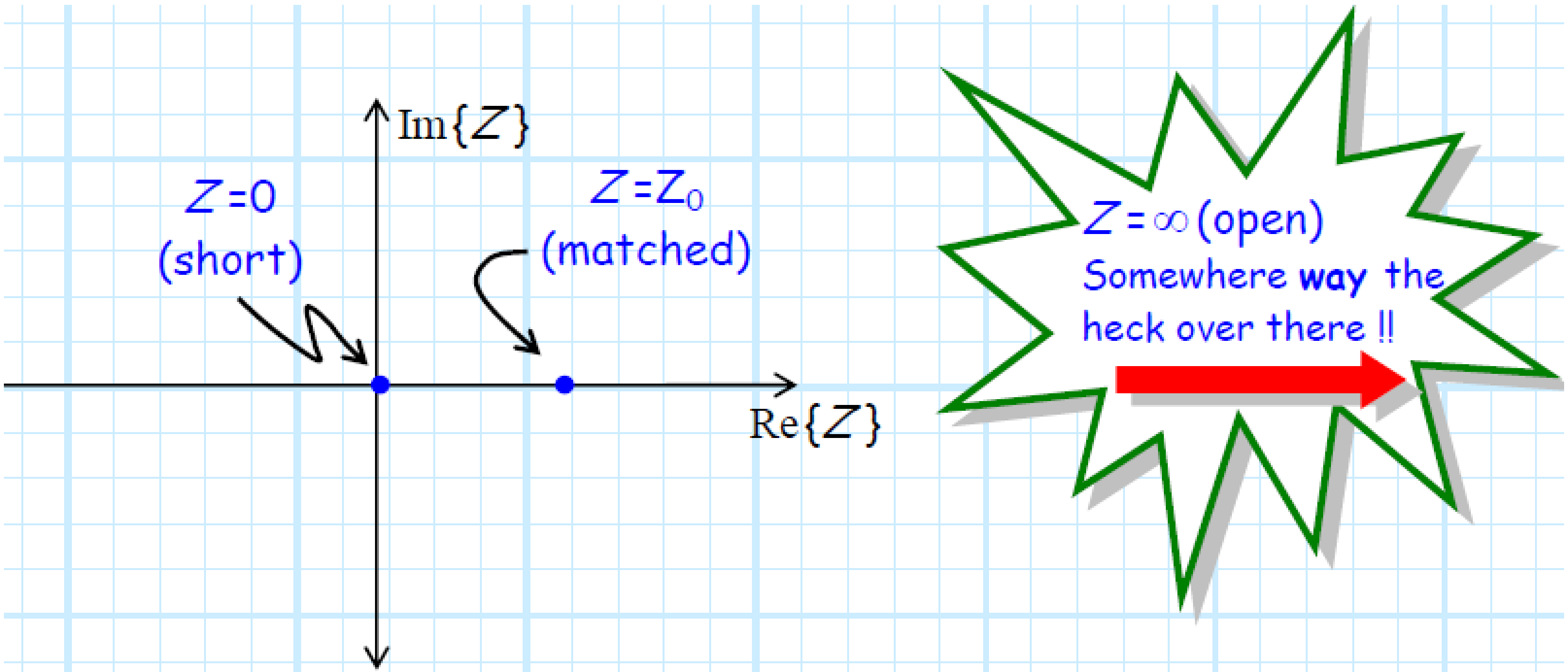
Answer



Im{Z}
Z=0
(short)
Z=Z0
(matched)
Re{Z}
Z=∞ (open)
Somewhere **way** the heck over there !!

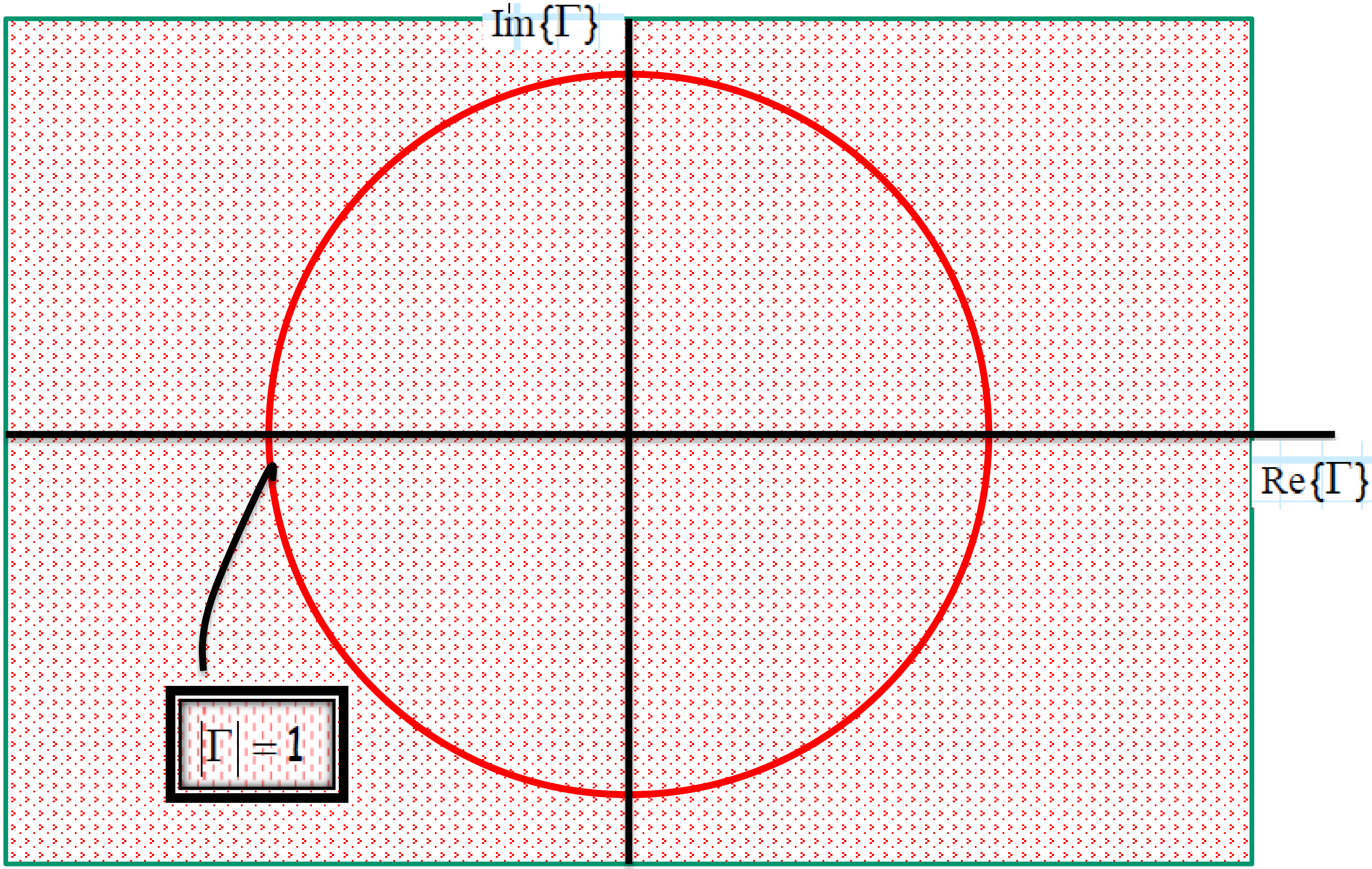
Question

The Question is still there?

Why we need to draw reflection Co-efficient

Recall

- The **magnitude** of the reflection coefficient was **limited**:
- $0 < \Gamma < 1$ Therefore, the **validity region** for the complex Γ plane consists of all points **inside the**


Im{Γ}
Re{Γ}
|Γ| = 1

Mapping Z to Γ

- Recall that line impedance and reflection coefficient are **equivalent**

$$\Gamma(z) = \frac{Z(z) - Z_0}{Z(z) + Z_0} \quad \text{and} \quad Z(z) = Z_0\left(\frac{1+\Gamma(z)}{1-\Gamma(z)}\right)$$

- **Recall for Smith chart we have to calculate the normalized values**

Normalized Impedance Values

$$z'(z) = \frac{Z(z)}{Z_0} = \frac{R(z)}{Z_0} + j\frac{X(z)}{Z_0} = r(z) + j\,x(z)$$

$$\Gamma(z) = \frac{Z(z) - Z_0}{Z(z) + Z_0} = \frac{Z(z)/Z_0 - 1}{Z(z)/Z_0 + 1} = \frac{z'(z) - 1}{z'(z) + 1}$$

Normalized Equation

$$\Gamma(z) = \frac{Z(z) - Z_0}{Z(z) + Z_0}$$

and

$$Z(z) = Z_0\left(\frac{1+\Gamma(z)}{1-\Gamma(z)}\right)$$

$$\Gamma(z) = \frac{z'(z) - 1}{z'(z) + 1}$$

$$z'(z) = \frac{1+\Gamma(z)}{1-\Gamma(z)}$$

Mini Assignment

- We know that Z, Z (normalized) and reflection coefficient can be mapped with respect to each other .
- Using The same method, fill out the table and draw, the point on both Reflection coefficient and Impedance plane

case	Z	z'	Γ
1	∞		
2	0		
3	Z_0		
4	jZ_0		
5	$-jZ_0$		

