



# **SNS COLLEGE OF TECHNOLOGY**

**Coimbatore-35**  
**An Autonomous Institution**



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade (3rd Cycle)  
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## **DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

### **19ECT302 – TRANSMISSION LINES AND ANTENNAS**

III YEAR/ V SEMESTER

#### **UNIT 1 – TRANSMISSION LINE THEORY**

**TOPIC– SMITH CHART AND ITS APPLICATIONS**



# HOW TO FIND THE PARAMETERS OF A TRANSMISSION LINE?



## **Disadvantages of numerical calculations**

Difficult to use formulas

Difficult to do calculations

Takes lot of time to compute



## SOLUTION



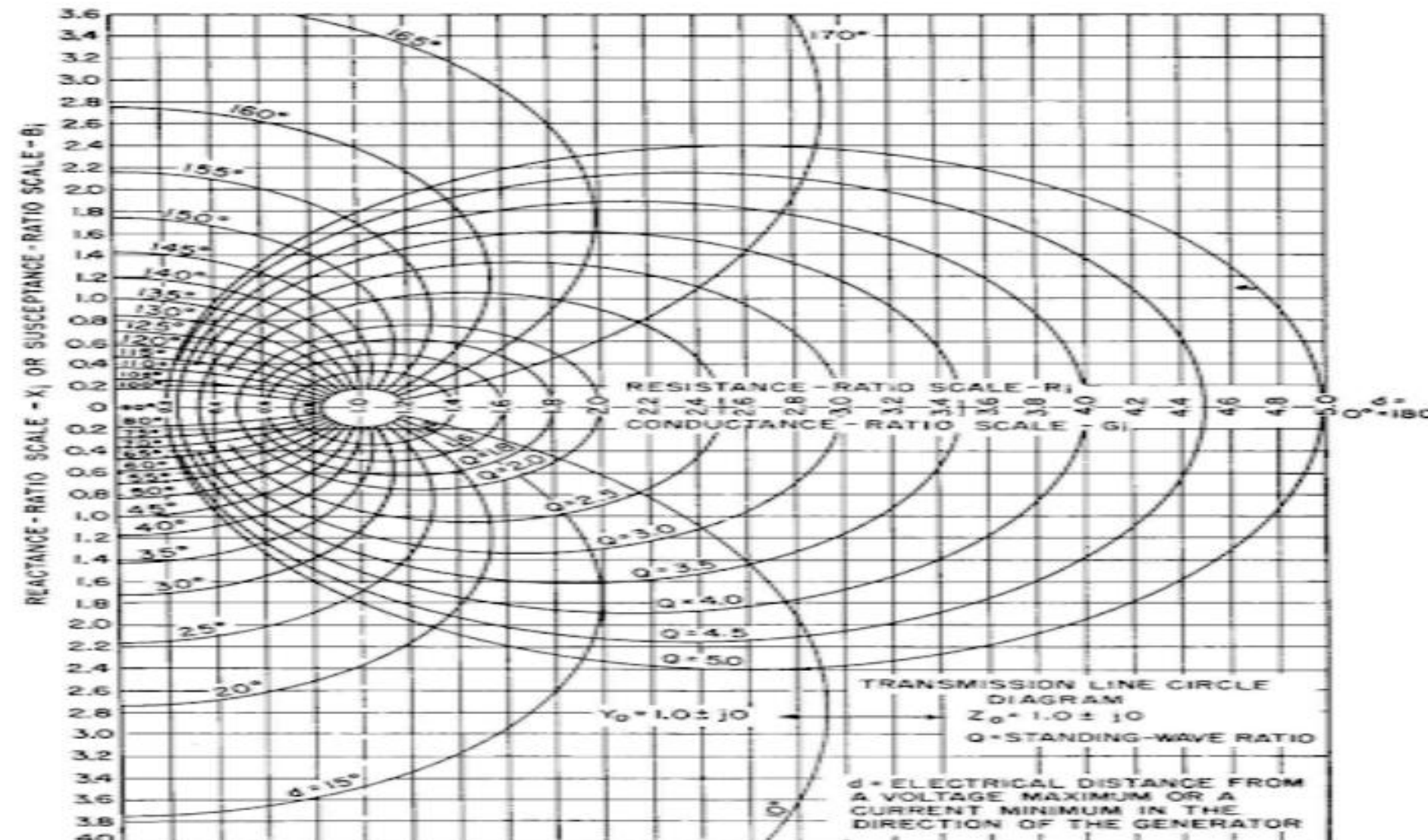
1. The tool must be easy to use without tedious calculations
2. Time consuming



# CARTESIAN CIRCLE DIAGRAM



- The range of Impedance or admittance values are limited.
- The interpolation of constant  $S$  circles and Constant  $\beta_s$  circles on the chart is difficult and inaccurate





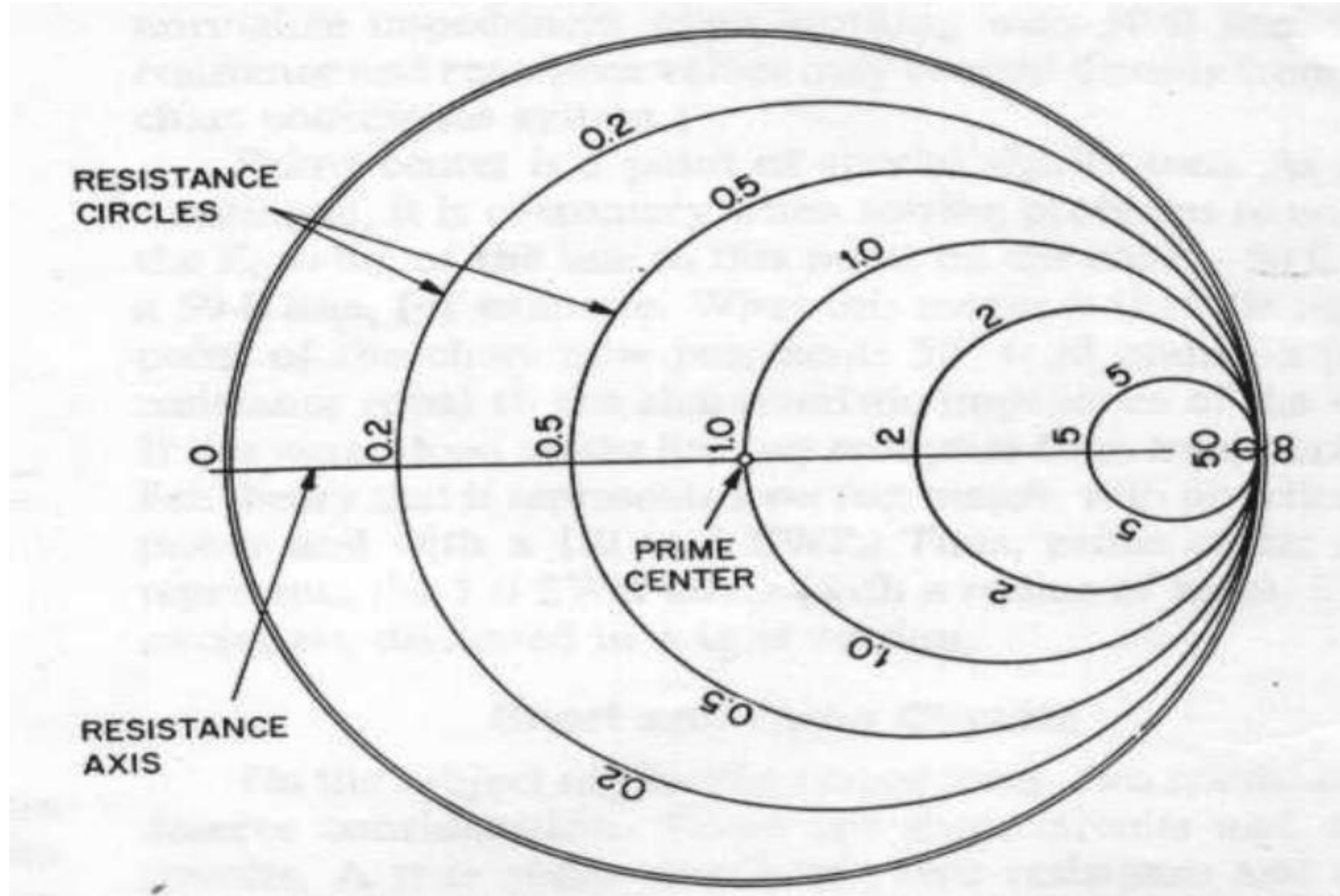
# THE SMITH CHART – A TRANSMISSION LINE CALCULATOR



- Overcome the drawbacks in the Cartesian circle diagram
- Developed by P H Smith in 1939.
- Graphical tool for use with transmission line circuits and microwave circuit elements.
- Only lossless transmission line will be considered
- Obtained from the reflection coefficient equation
$$K \angle \phi - 2\beta s = U + jV$$

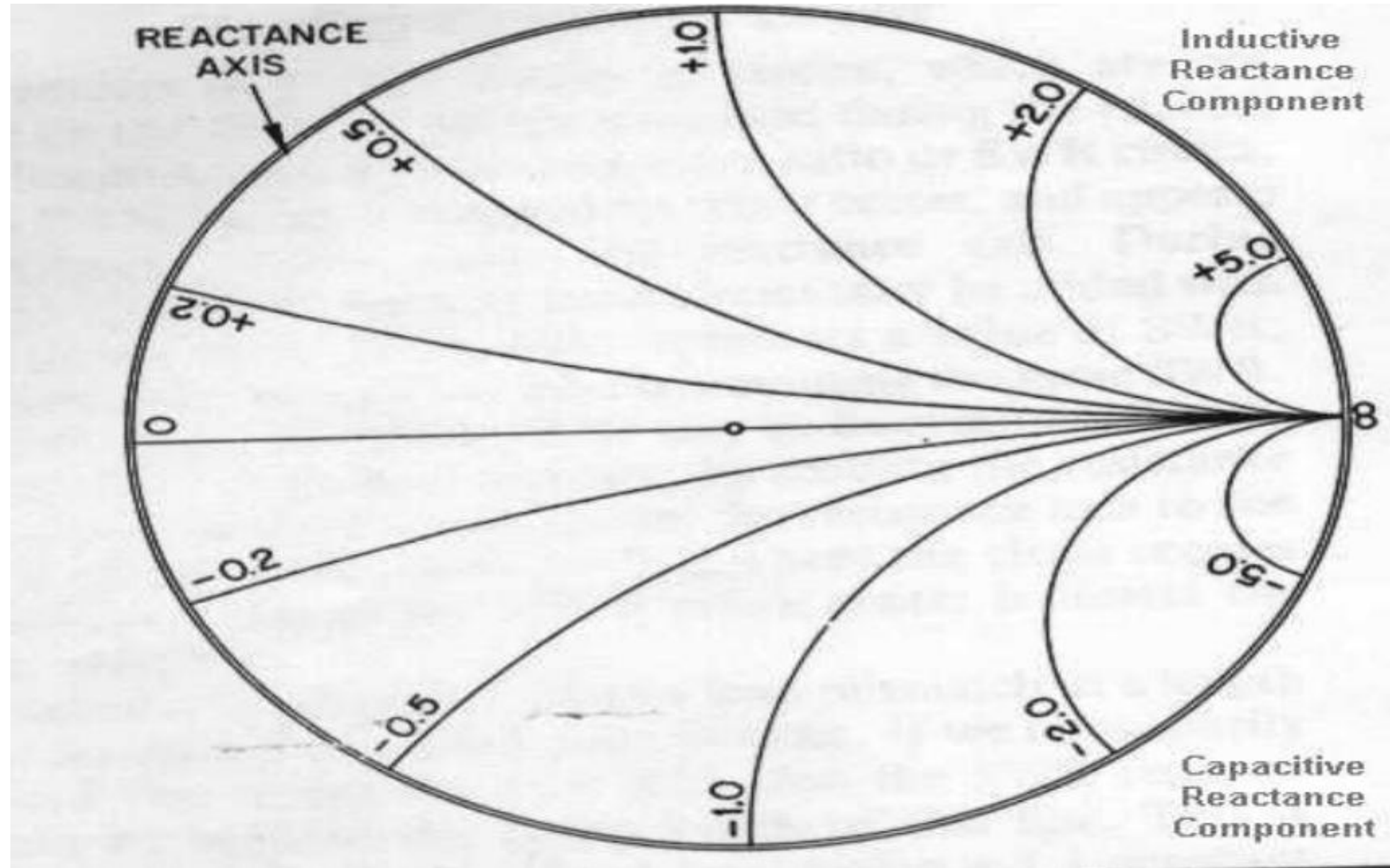


# CONSTANT R CIRCLES



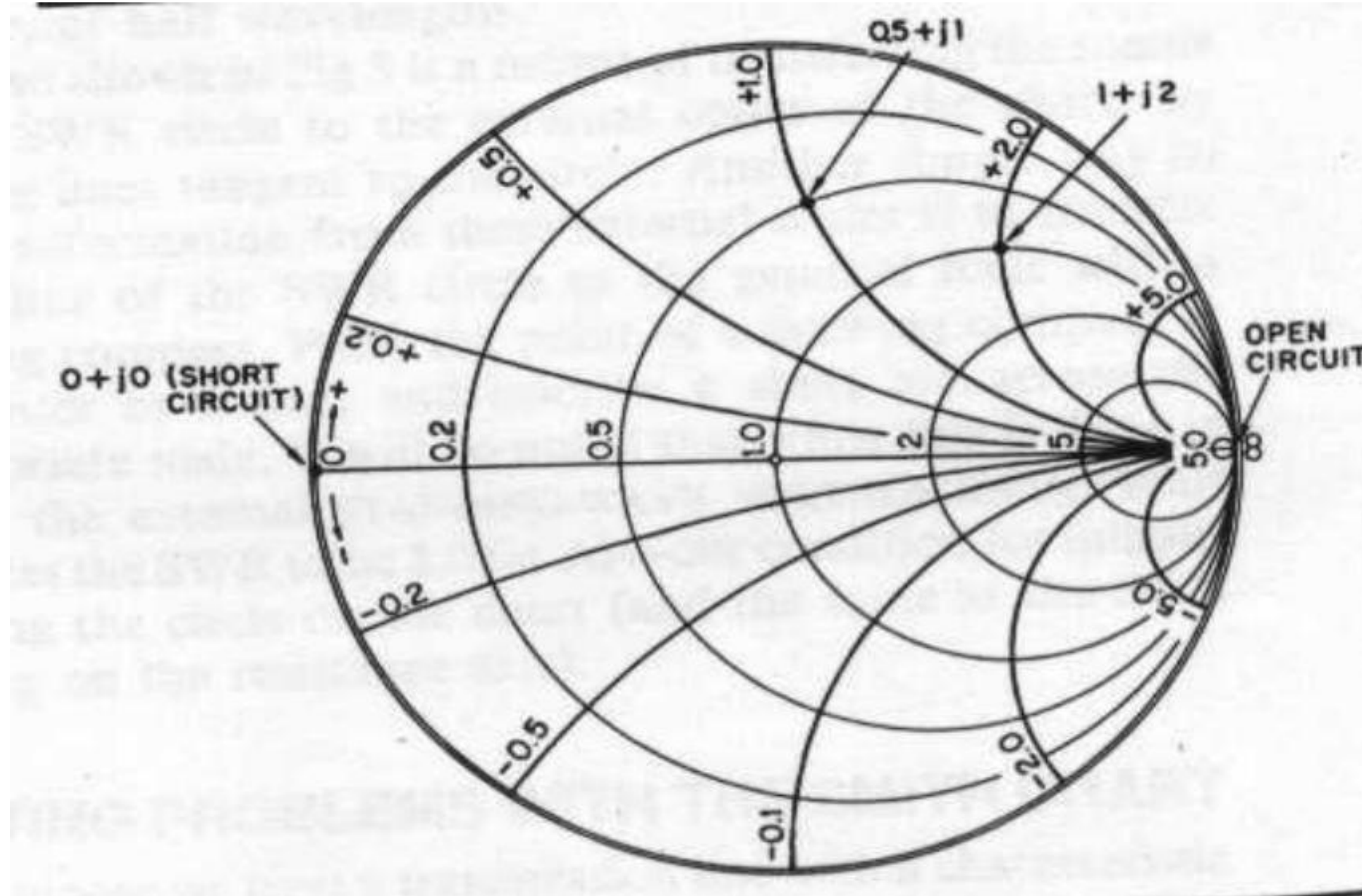


# CONSTANT X CIRCLES





# SMITH CHART



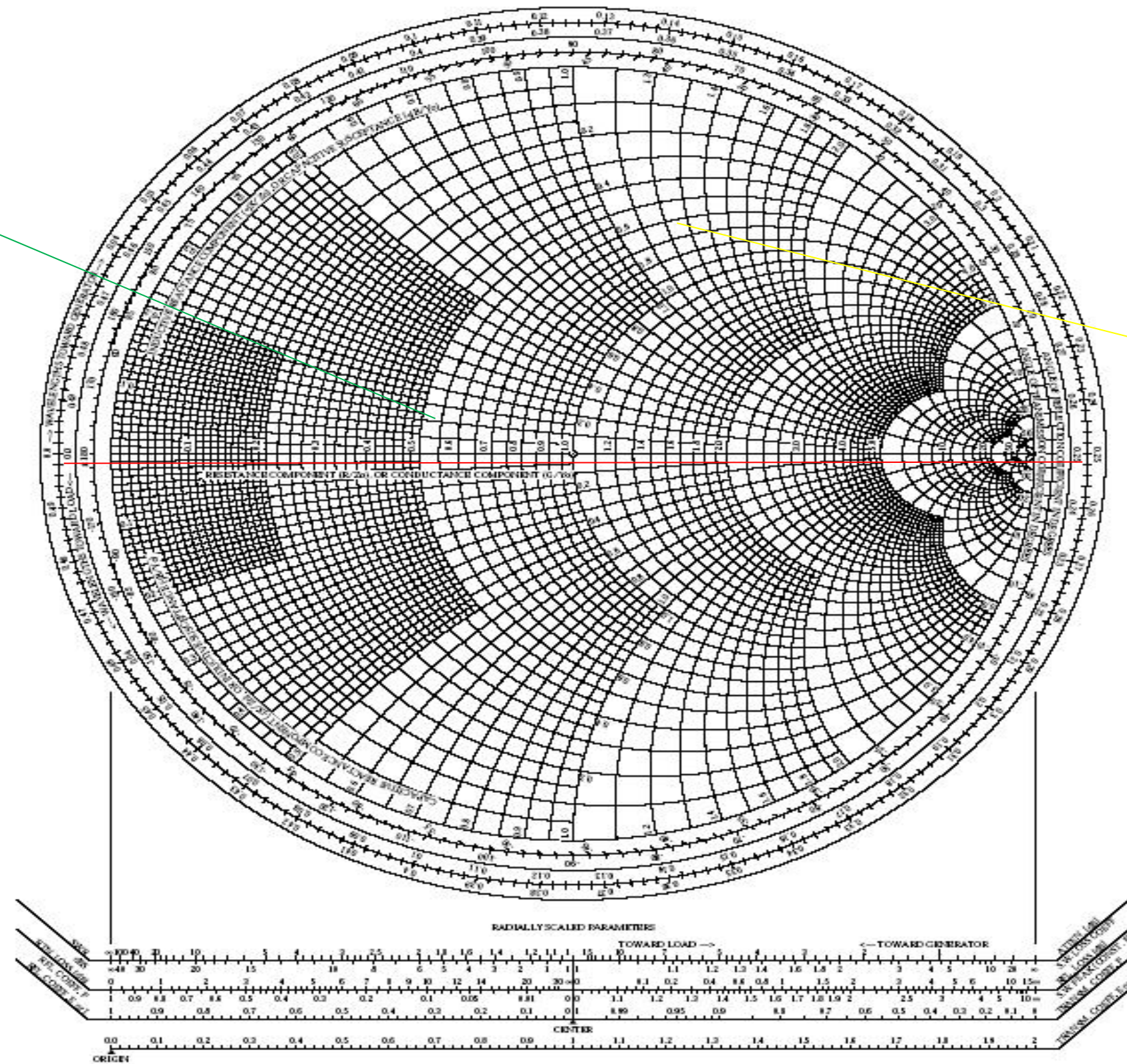




# THE SMITH CHART

Real  
Impedance  
axis

Imaginary  
Impedance  
Circles





# THE SMITH CHART

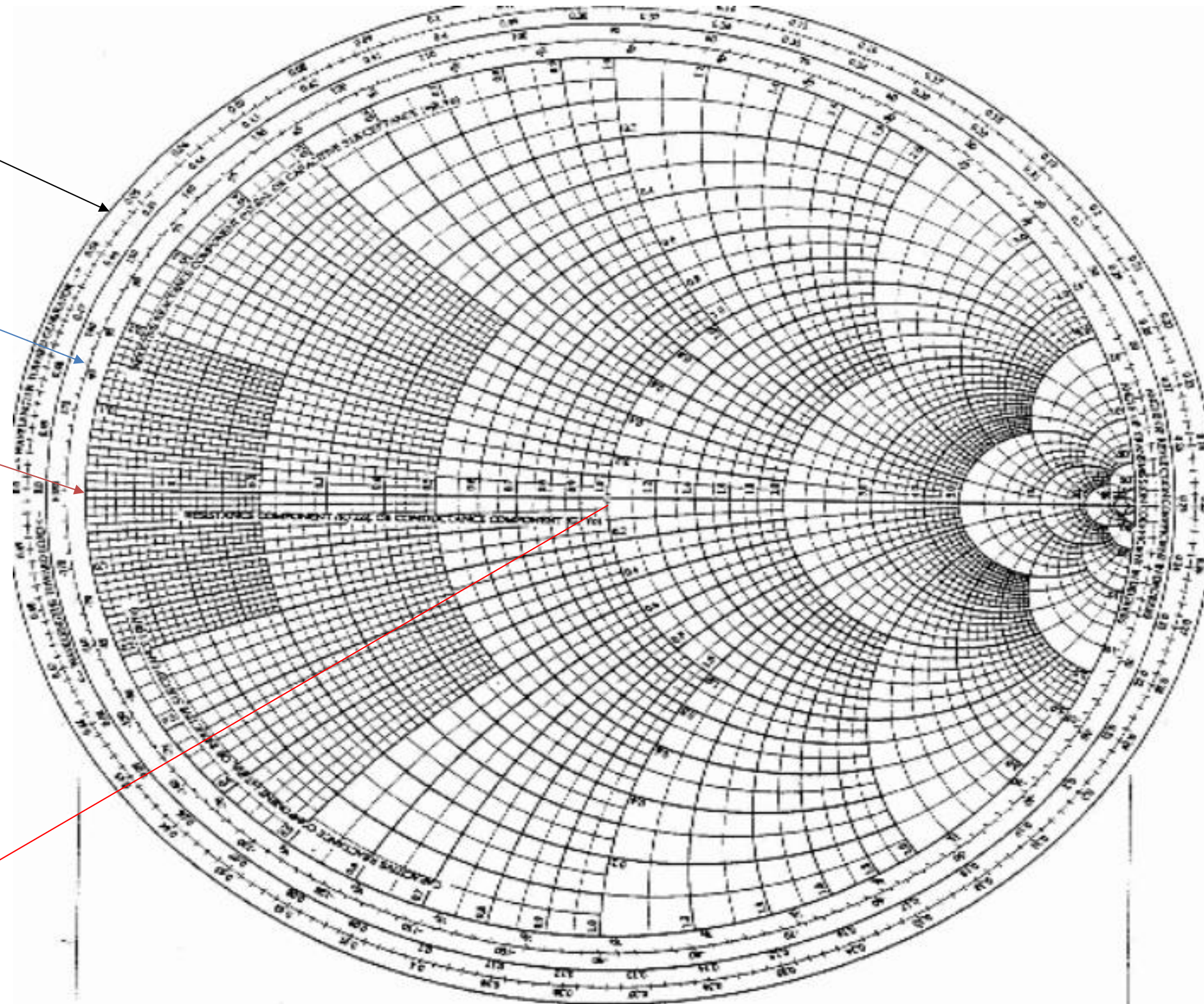


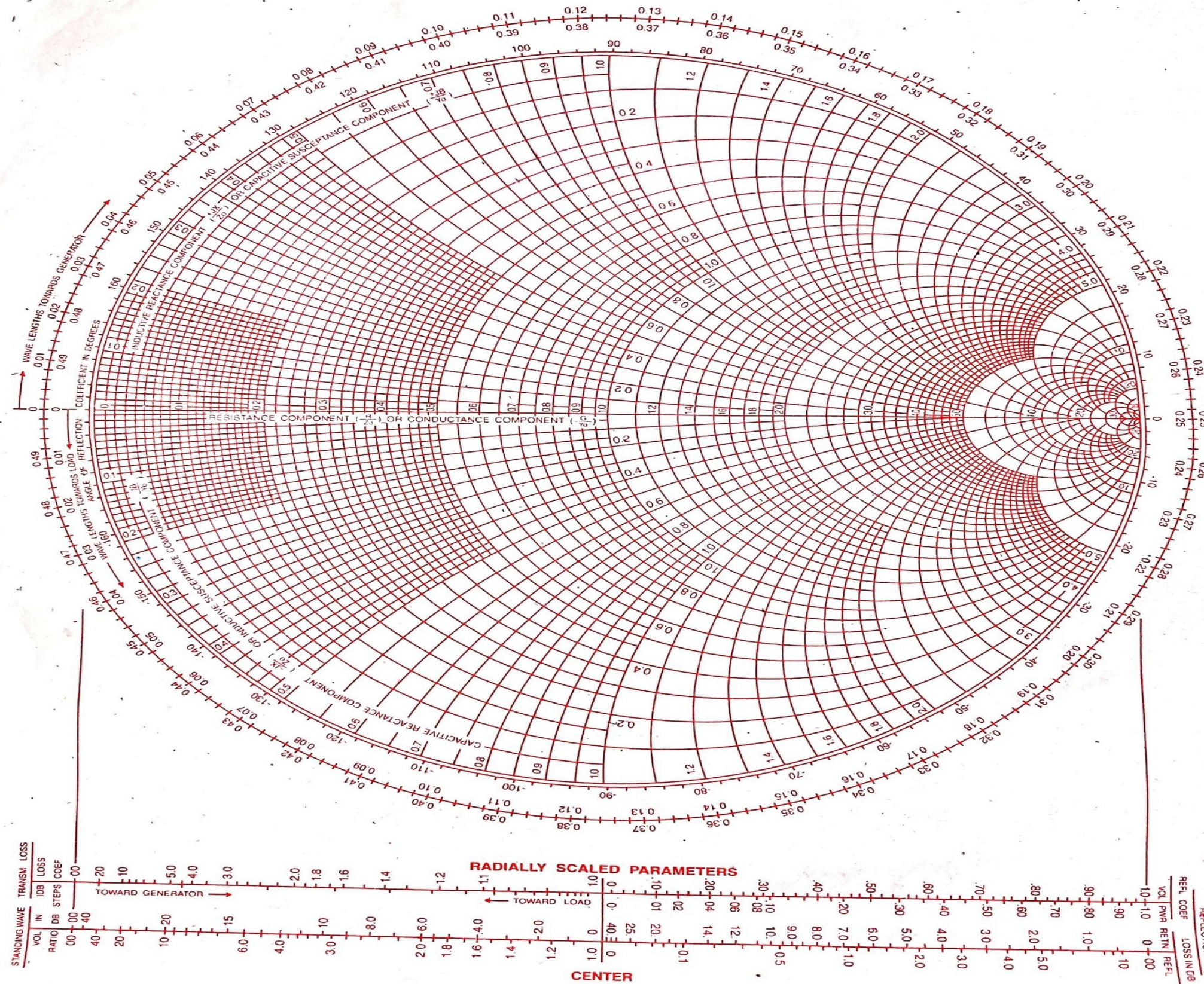
Distance along the transmission lines ( $\lambda$ )

Angle of K (Deg)

$X_L$  &  $X_C$

Centre of the Chart  
 $1+j0$

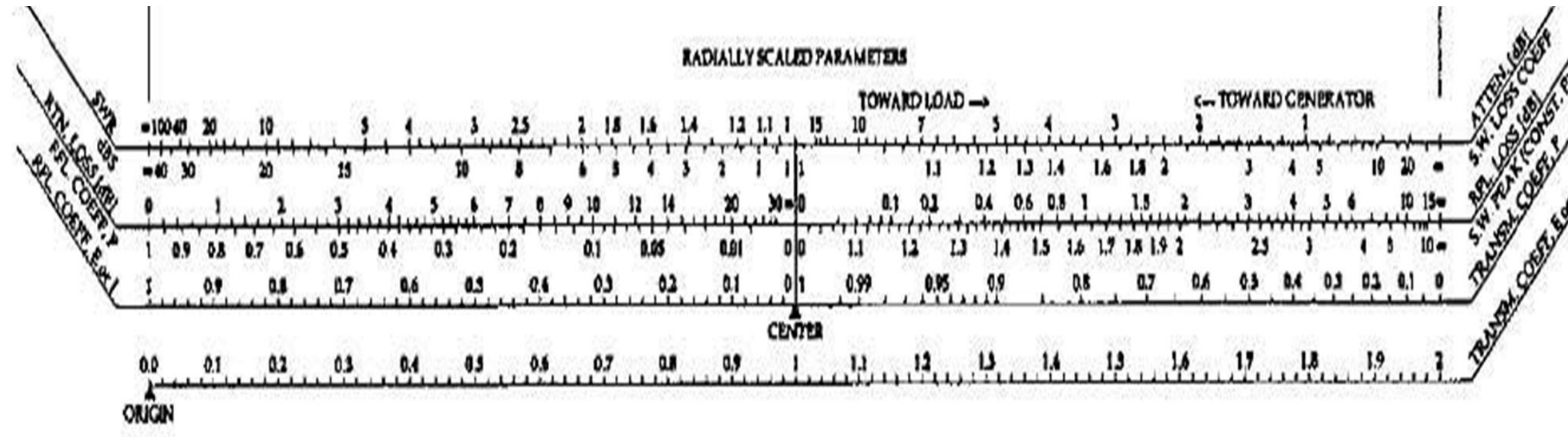




**SMITH CHART**



# THE SMITH CHART



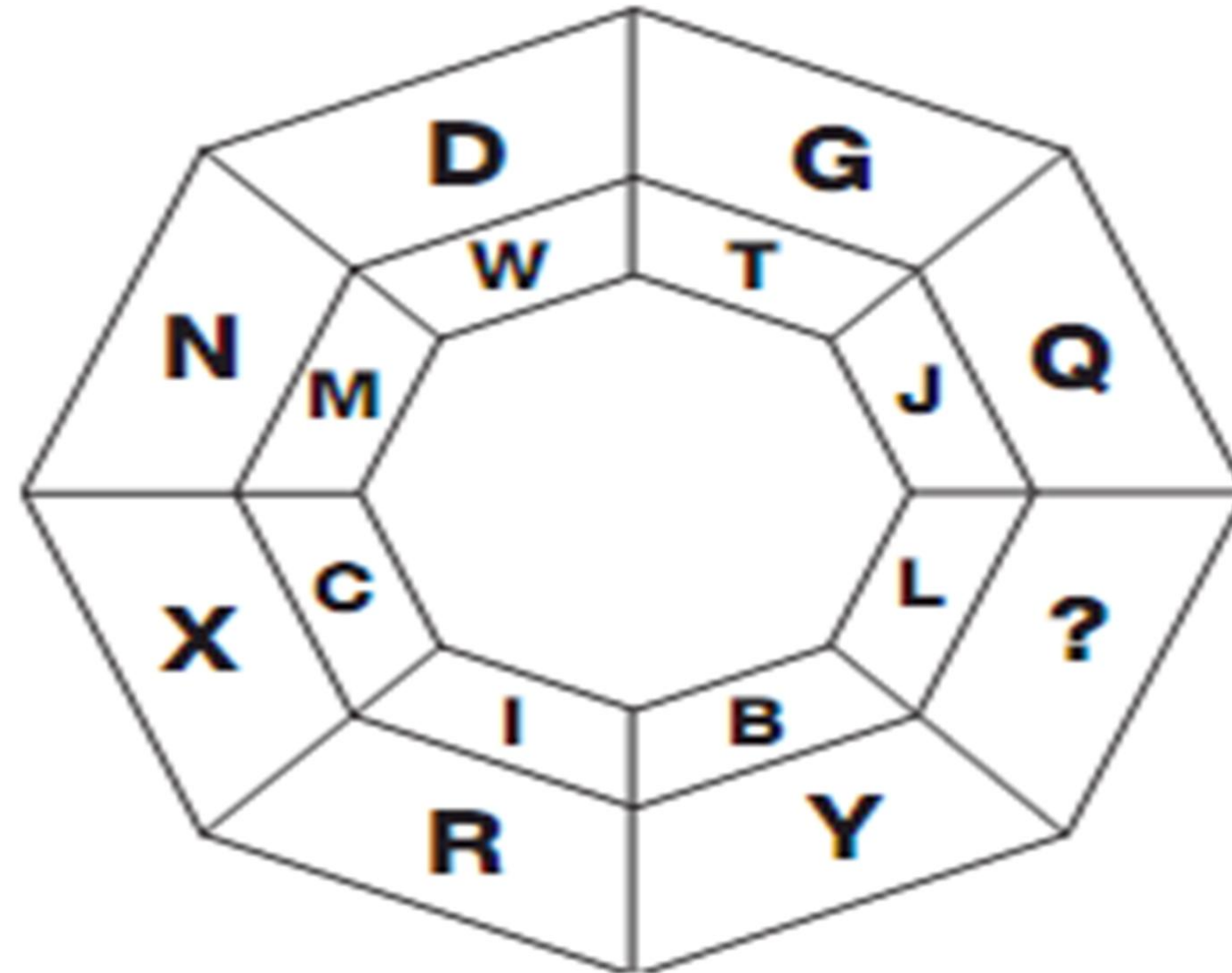
Below the Smith chart there is a scale for finding magnitude of reflection coefficient.



# ACTIVITY



Which letter replaces the question mark?





## PROPERTIES



Smith chart can be used as Impedance chart or as admittance charts.

### Impedance Chart

- In Smith chart all the Impedances are normalized impedance i.e  $Z/R_0$
- Centre of the Chart – (1,0)
- Real Axis (Horizontal axis) represents resistance or real part of the impedance



## PROPERTIES



Cont..

- Imaginary circles represents reactance.
- Upper half imaginary circles - Inductive reactance
- lower half imaginary circles - capacitive reactance
- In smith chart there are three concentric external circles
- Innermost circle – on the inside of circle are graduations of inductive and capacitive reactance
- Second circle – angle of reflection coefficient in degrees



## PROPERTIES



Cont..

- Third circle – graduations represents distances along the transmission lines in wavelengths. Total length of the Chart is  $0.5 \lambda$

- Clockwise motion – wavelengths towards the generator

Anticlockwise direction – wavelengths towards load.

- $V_{max}$  – right side of the chart (Infinite impedance or open circuit condition)

- $V_{min}$  – left side of the chart (zero impedance or short circuit condition)





## APPLICATIONS



Smith chart is used to find

- Magnitude and angle of reflection co efficient
- VSWR
- Unknown load impedance & admittance
- Unknown input impedance & admittance
- $V_{max}$  &  $V_{min}$  &
- Also useful in stub matching



## APPLICATIONS OF SMITH CHART



- Consider a 20 m long lossless transmission line with the characteristic impedance of  $50 \Omega$  operating at 2 MHz. If the line is terminated by an impedance  $60+j40 \Omega$ , calculate reflection coefficient  $k$ , standing wave ratio  $S$  and input impedance of the transmission line. Velocity of the line is  $0.6c$ .
- **Given**  
 $l = 20 \text{ m}$ ,  $Z_0 = 50 \Omega$ ,  $f = 2 \times 10^6 \text{ Hz}$ ,  $V = 0.6c$  &  $Z_L = 60+j40 \Omega$   
Find  $K$ ,  $S$  &  $Z_s$



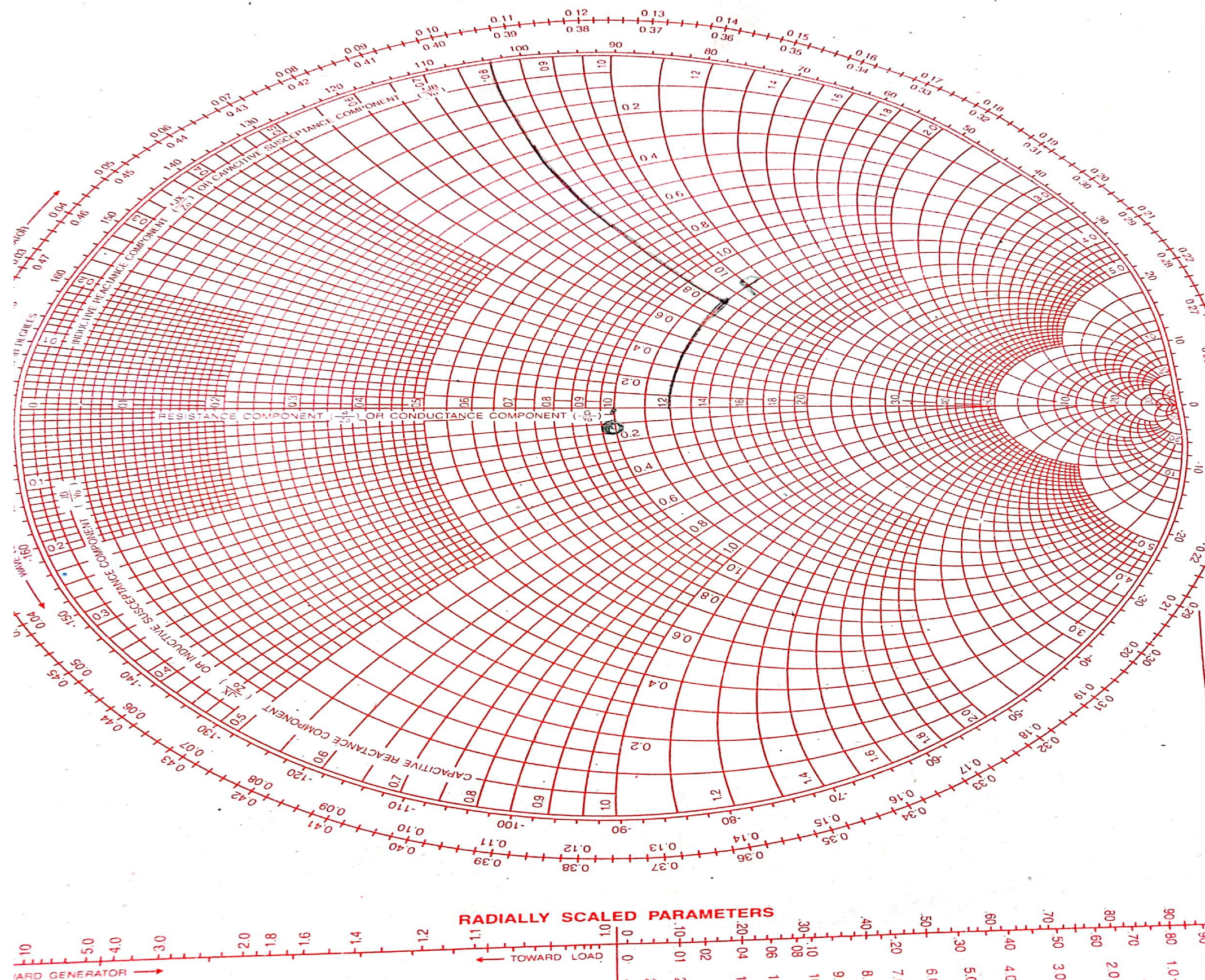
## APPLICATIONS OF SMITH CHART



➤ **Step 1 – Finding normalized load impedance**

$$\frac{Z_L}{Z_0} = \frac{60+j40}{50} = 1.2 +j0.8$$

Locate point P on the Smith chart, where real part is 1.2 and imaginary part is 0.8 meets together





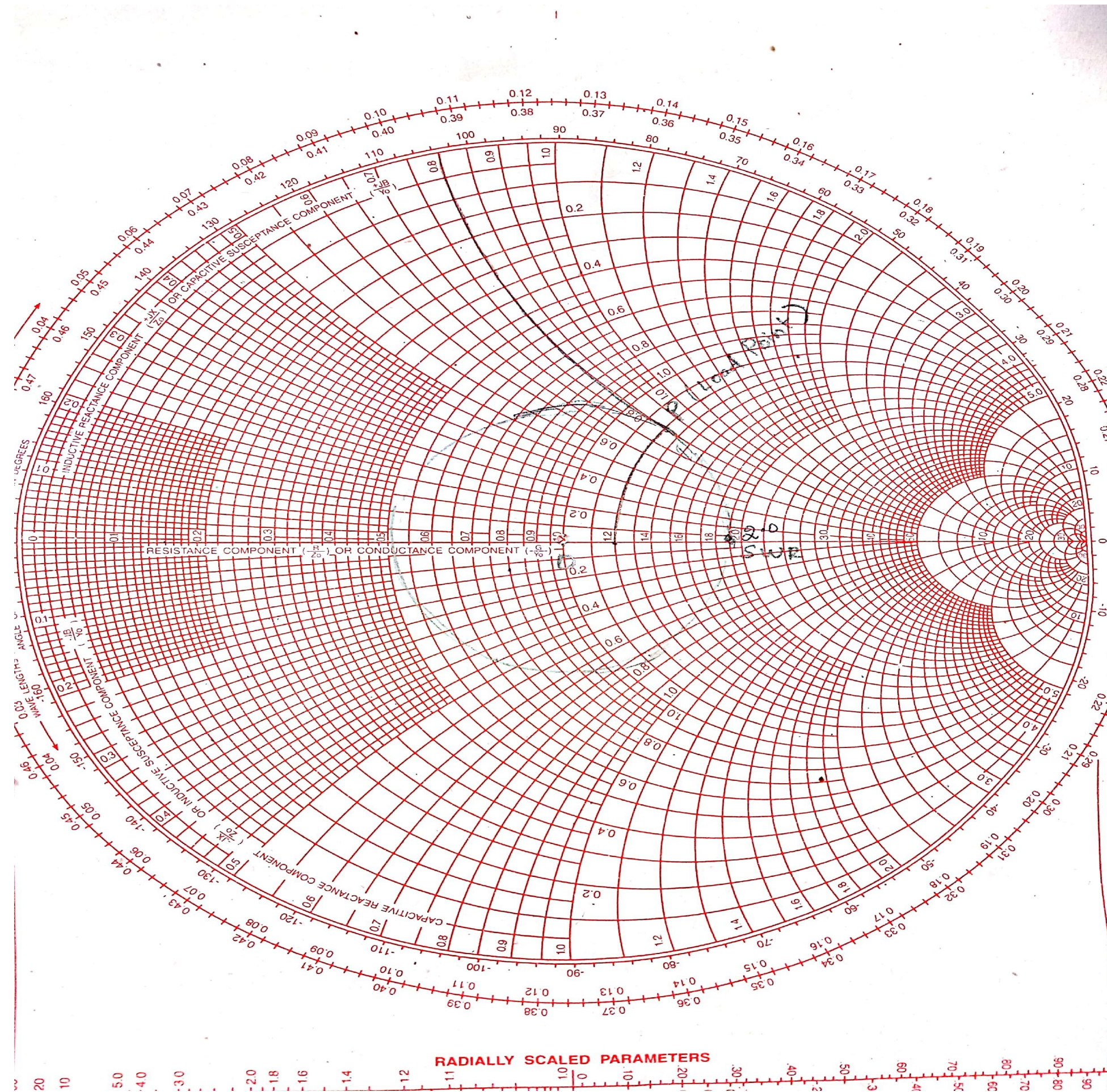
## APPLICATIONS OF SMITH CHART



### ➤ **Step 2 – Finding SWR**

Mark centre of the chart as “O”. SWR is obtained by drawing S circle with the centre of the chart and radius equal to the distance between O & P.

The circle cuts the real axis at right side gives the value of SWR & is 2.1 approximately.





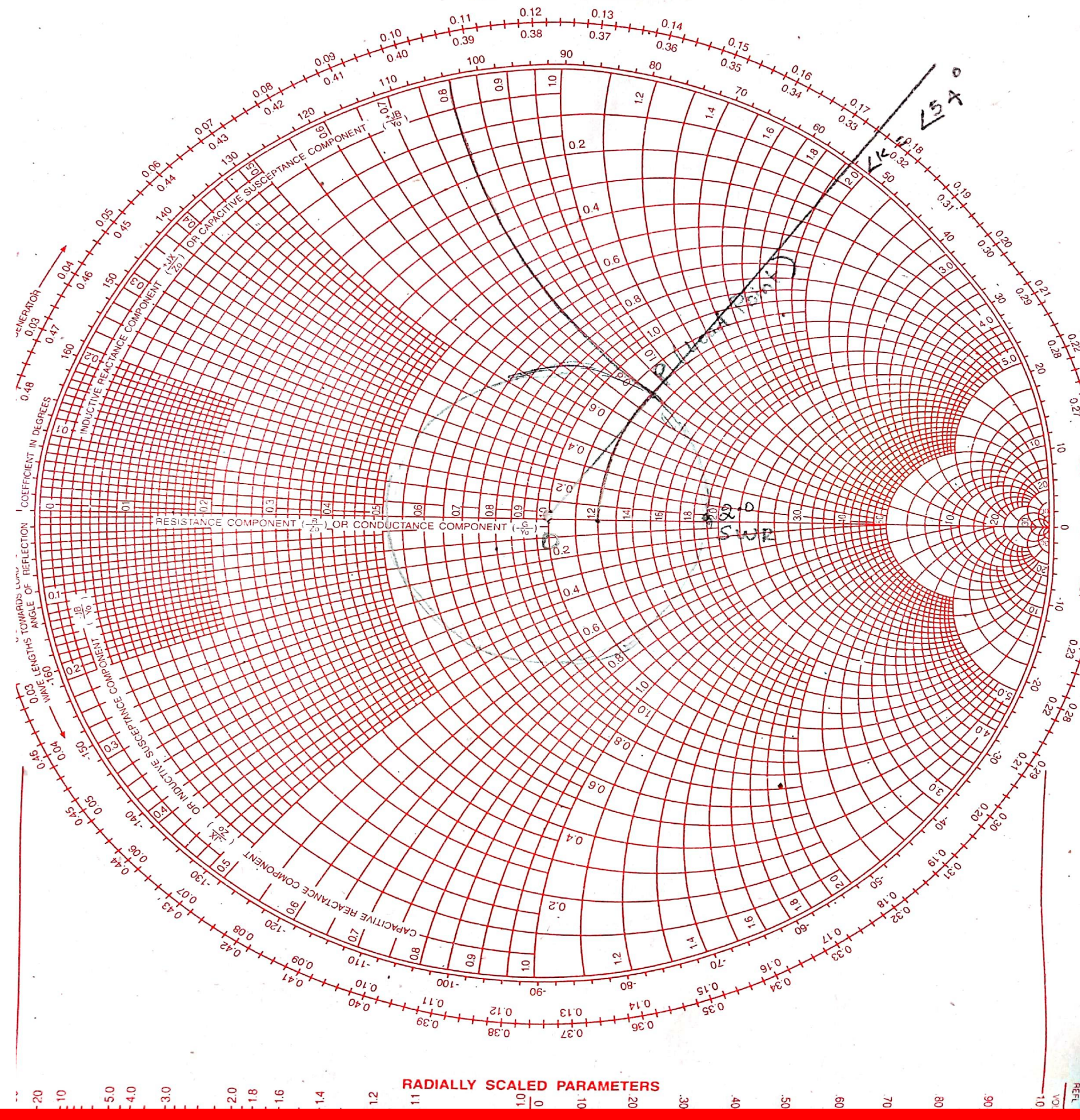
## APPLICATIONS OF SMITH CHART



### ➤ **Step 3 – Angle of reflection coefficient K**

To find the angle of K, extend the line OP to the outer rim of the chart. The point at which the line cuts the outer rim (second concentric circle) gives the angle of K in degrees.

$\angle K = \angle 54^\circ$  approx.







## APPLICATIONS OF SMITH CHART

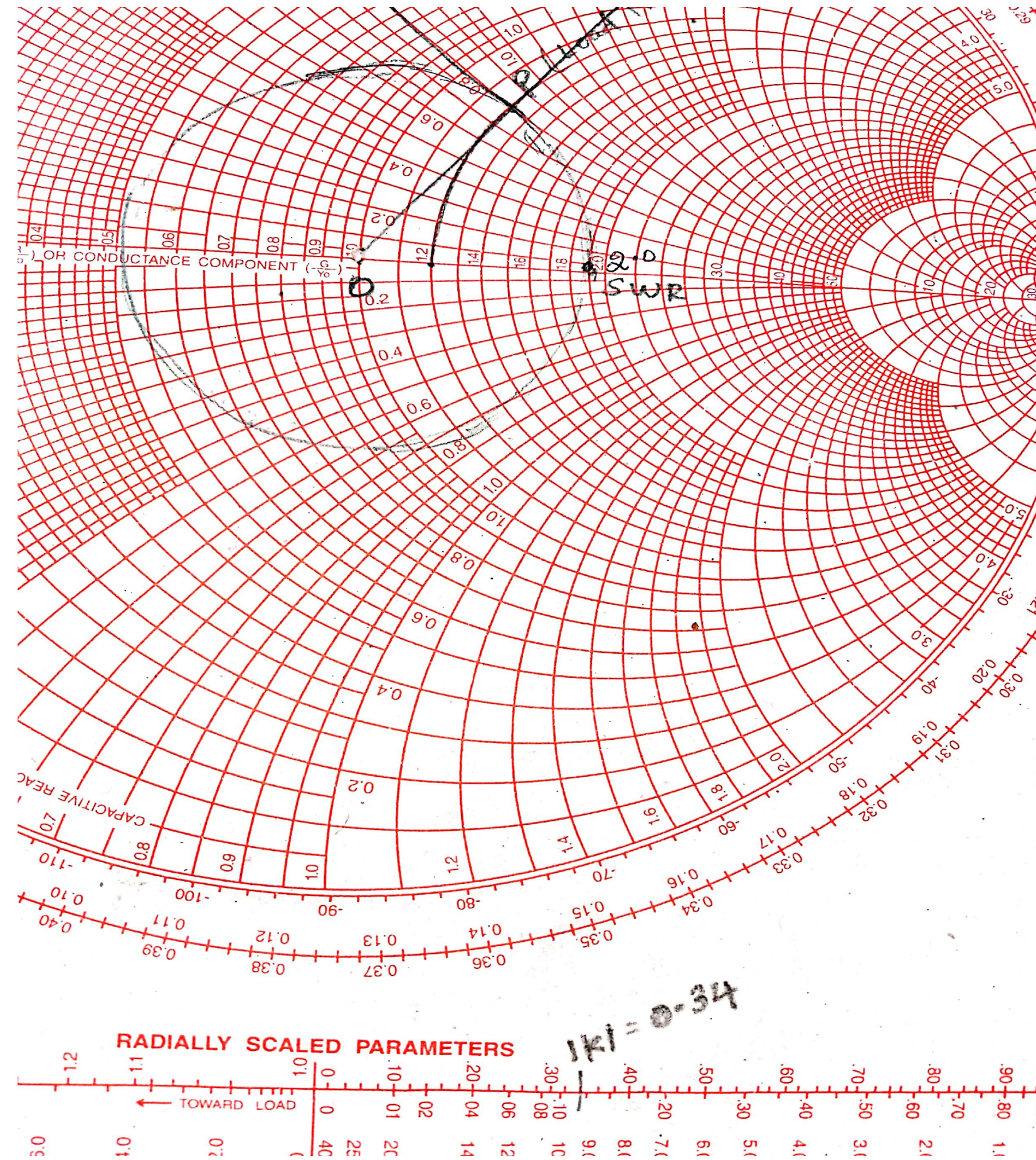


### ➤ Step 4 – Magnitude of reflection coefficient K

To find magnitude of K, measure the distance between O & P using a compass. The K scale is provided at the bottom of the chart. From the centre draw an arc from the centre of the scale at right side. This gives the magnitude of K.

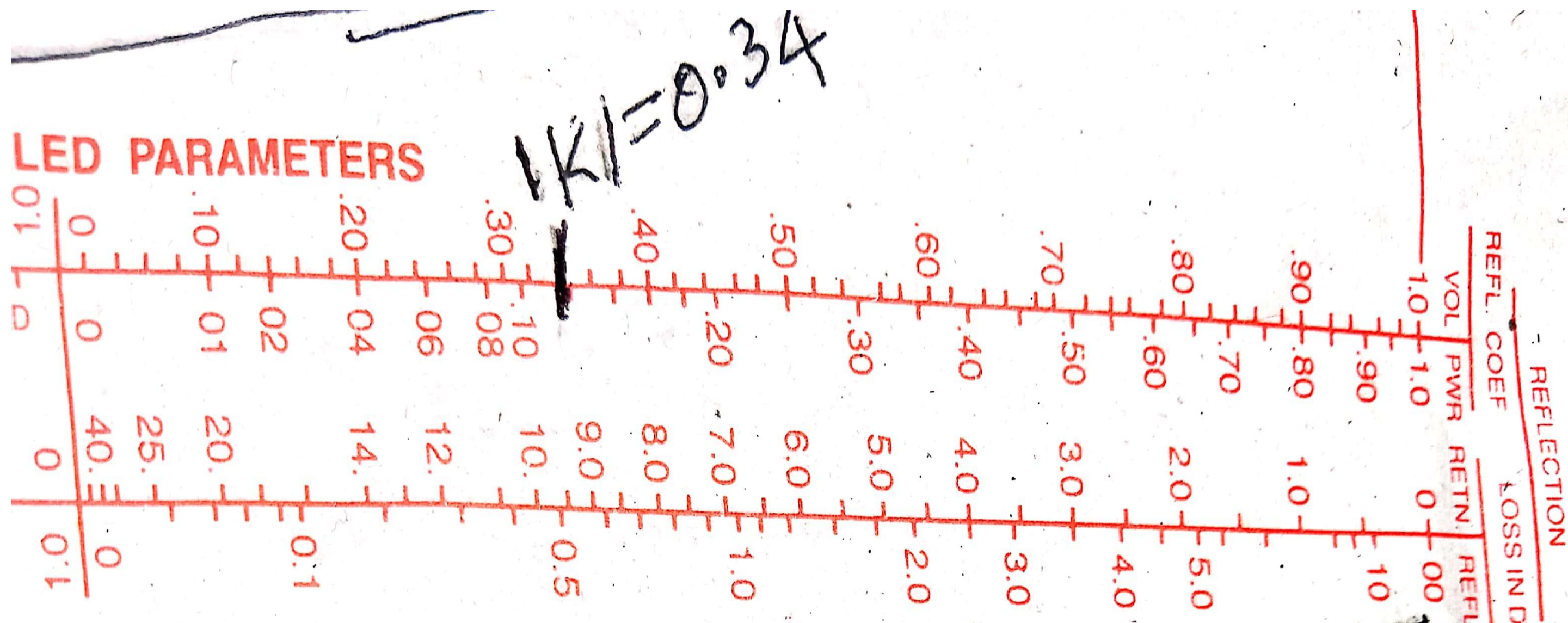
$$|K| = 0.34$$

$$K = 0.34 \angle 54^\circ$$





# APPLICATIONS OF SMITH CHART





## APPLICATIONS OF SMITH CHART



### ➤ Step 5 – Input impedance $Z_{in}$

From load impedance move towards generator in clockwise direction for the distance equal to the length of the line (in wavelengths), the input impedance point can be obtained.

Find the real and imaginary values.

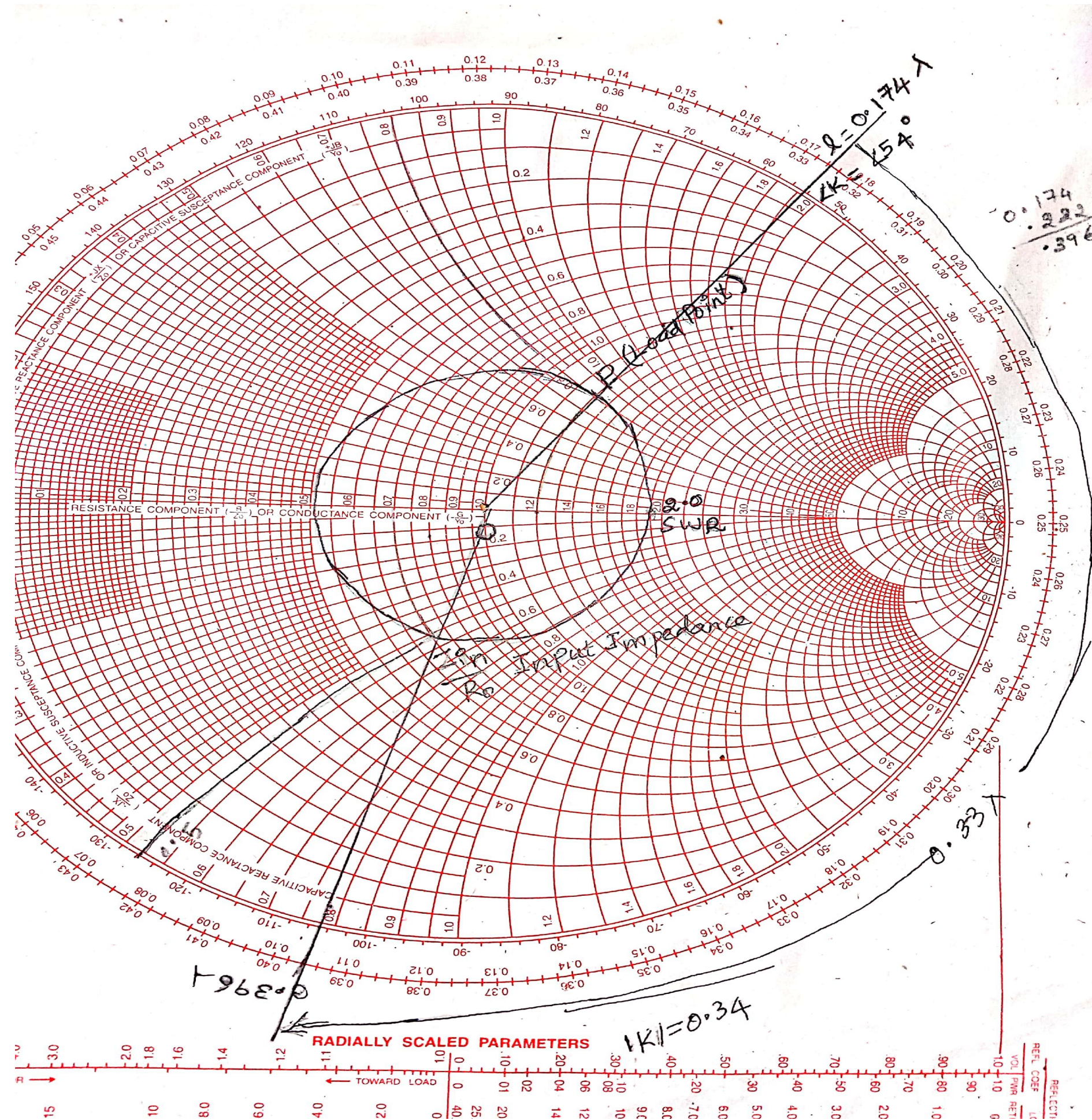
Given the length of the line  $l = 20$  m

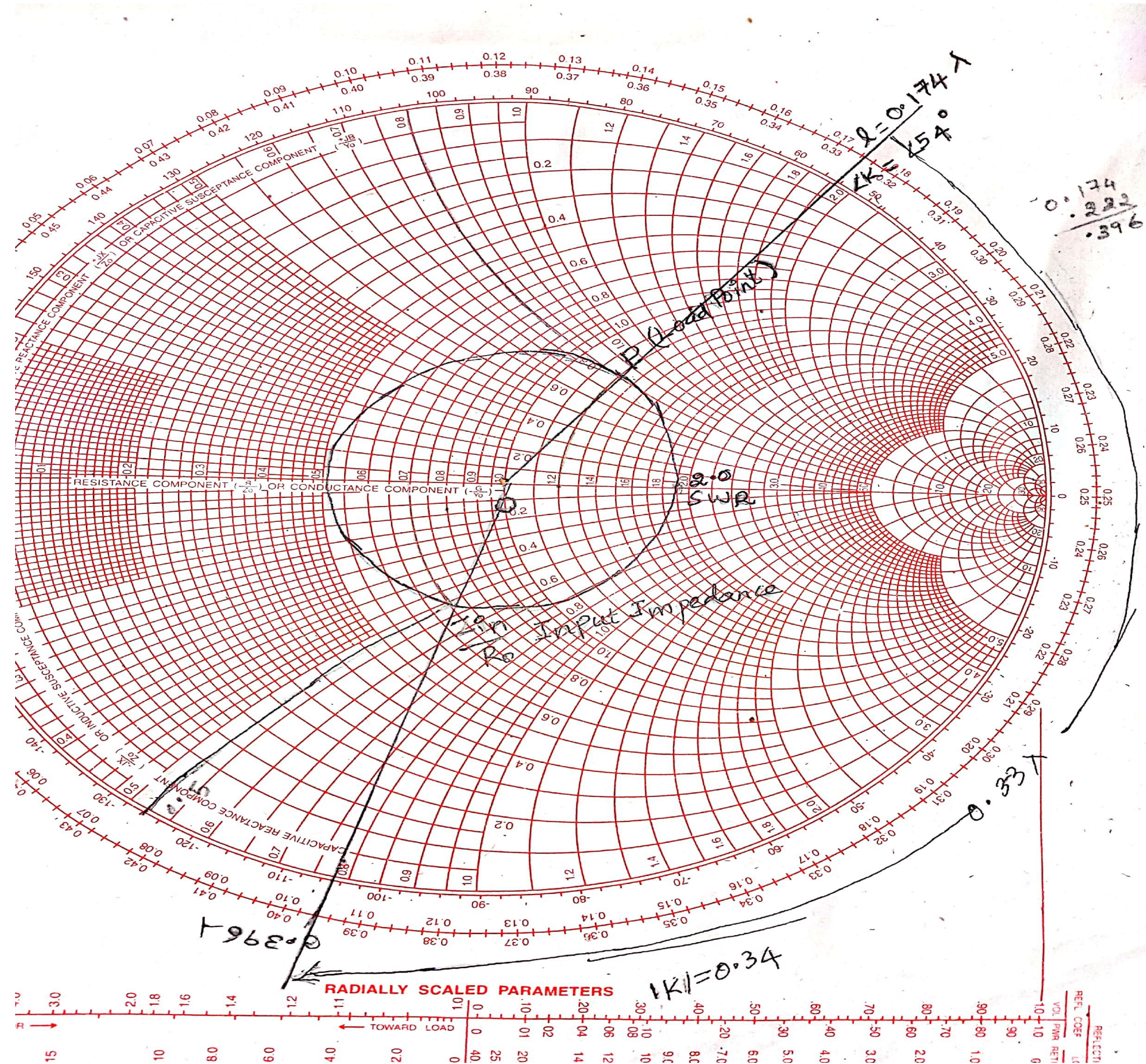
Line length in wave lengths =  $(l/\lambda) = (20/90) = 0.222 \lambda$

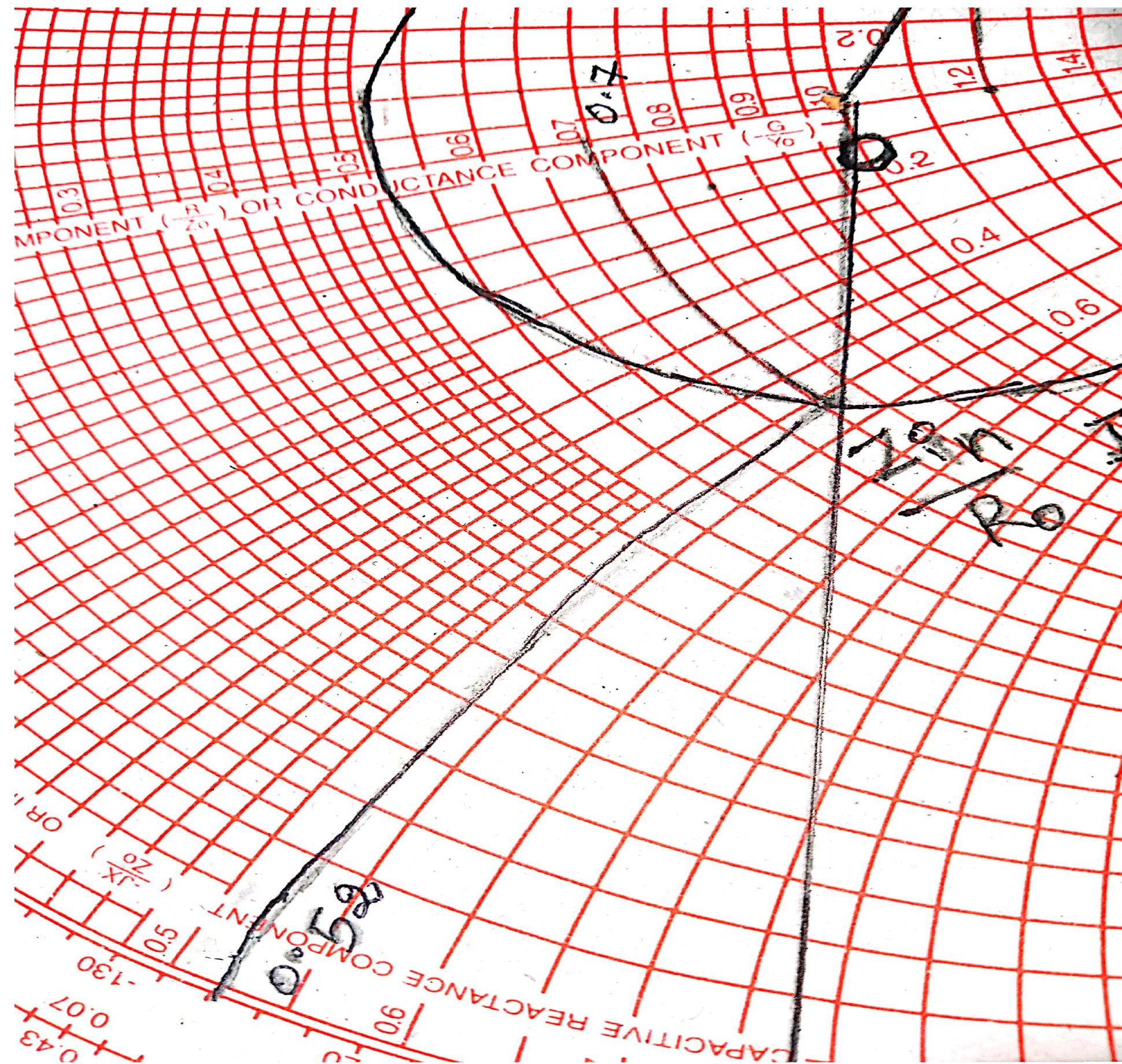
Wave length  $\lambda = v/f = 0.6 \times 3 \times 10^8 / 2 \times 10^6 = 90$  m

$$Z_{in}/R_0 = 0.7 - j 0.52$$

$$\begin{aligned} Z_{in} &= (0.7 - j 0.52) R_0 = (0.7 - j 0.52) 50 \\ &= 35 - j26 \Omega \end{aligned}$$









## APPLICATIONS OF SMITH CHART

### ➤ Step 6 – Impedance to Admittance conversion

After getting normalized impedance, the diametrically opposite point will give the admittance value.

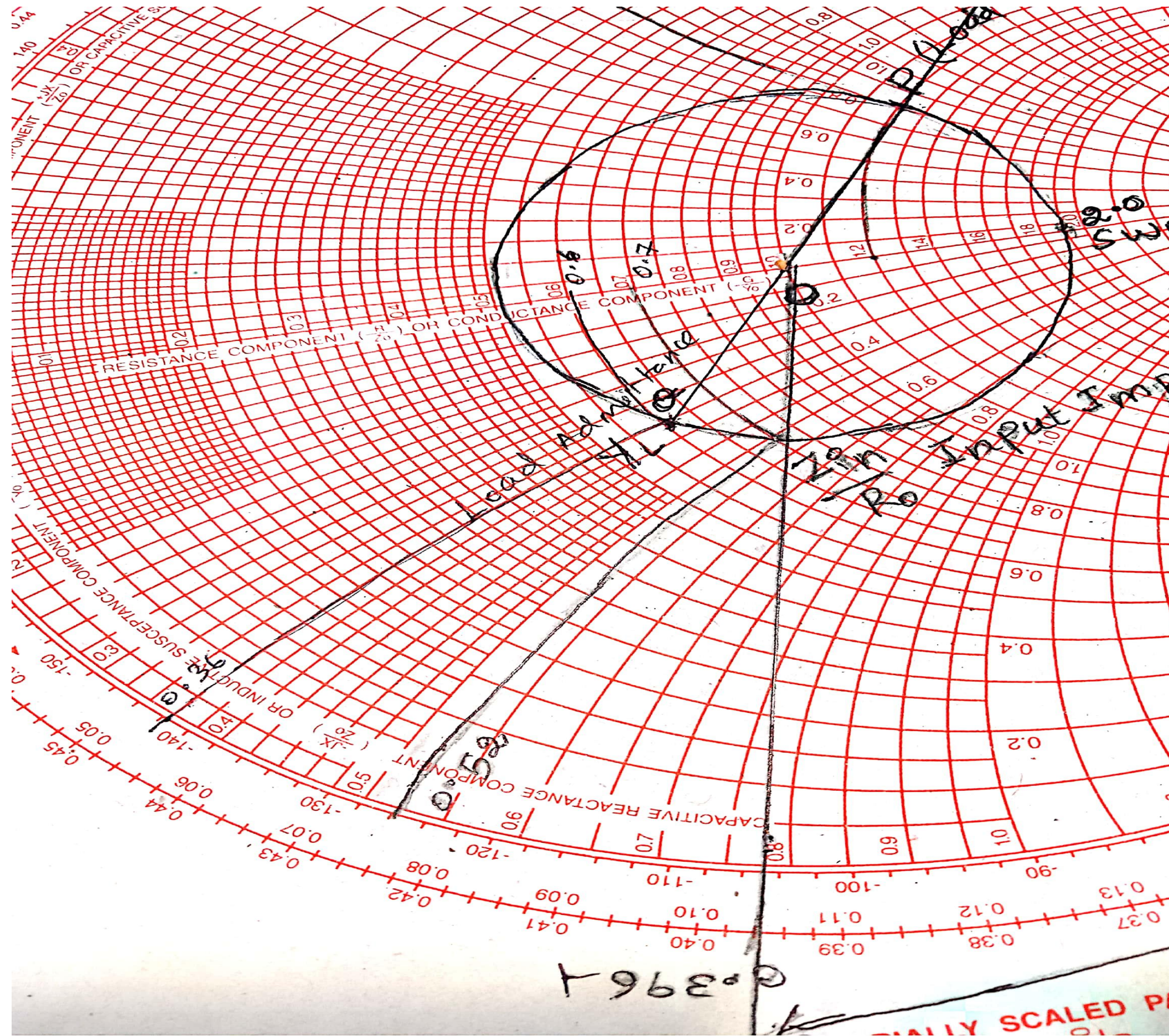
$$Y_R/G_0 = 0.6 - j 0.36$$

$$y_R = (0.6 - j 0.36) G_0 = (0.6 - j 0.36) / R_0$$

$$= (0.6 - j 0.36) / 50$$

$$= (0.012 - j 0.0072) \text{ } \mathcal{U}$$







## ASSESSMENT



**1. The Smith chart is graphical technique used in the scenario of transmission lines.**

State true/false

**2. The Smith chart consists of the**

a) Constant R and variable X circles  
X circles

c) Constant R and constant X circles  
X circles

b) Variable R and constant  
X circles

d) Variable R and variable  
X circles



## ASSESSMENT



**3. The circles in the Smith chart pass through which point?**

- a) (0,1)
- b) (0,-1)
- c) (-1,0)
- d) (1,0)

**4. Moving towards the clockwise direction in the Smith chart implies moving**

- a) Towards generator
- b) Towards load
- c) Towards stub
- d) Towards waveguide View Answer



## REFERENCES



- J.D.Ryder “Networks, Lines and Fields”, PHI, New Delhi, 2003
- Raju, “Electromagnetic Field Theory and Transmission Lines”, Pearson Education, 2005

**THANK YOU**