SNS COLLEGE OF ENGINEERING

(Autonomous)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19EC502 – TRANSMISSION LINES AND ANTENNAS

III YEAR/ V SEMESTER

1

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

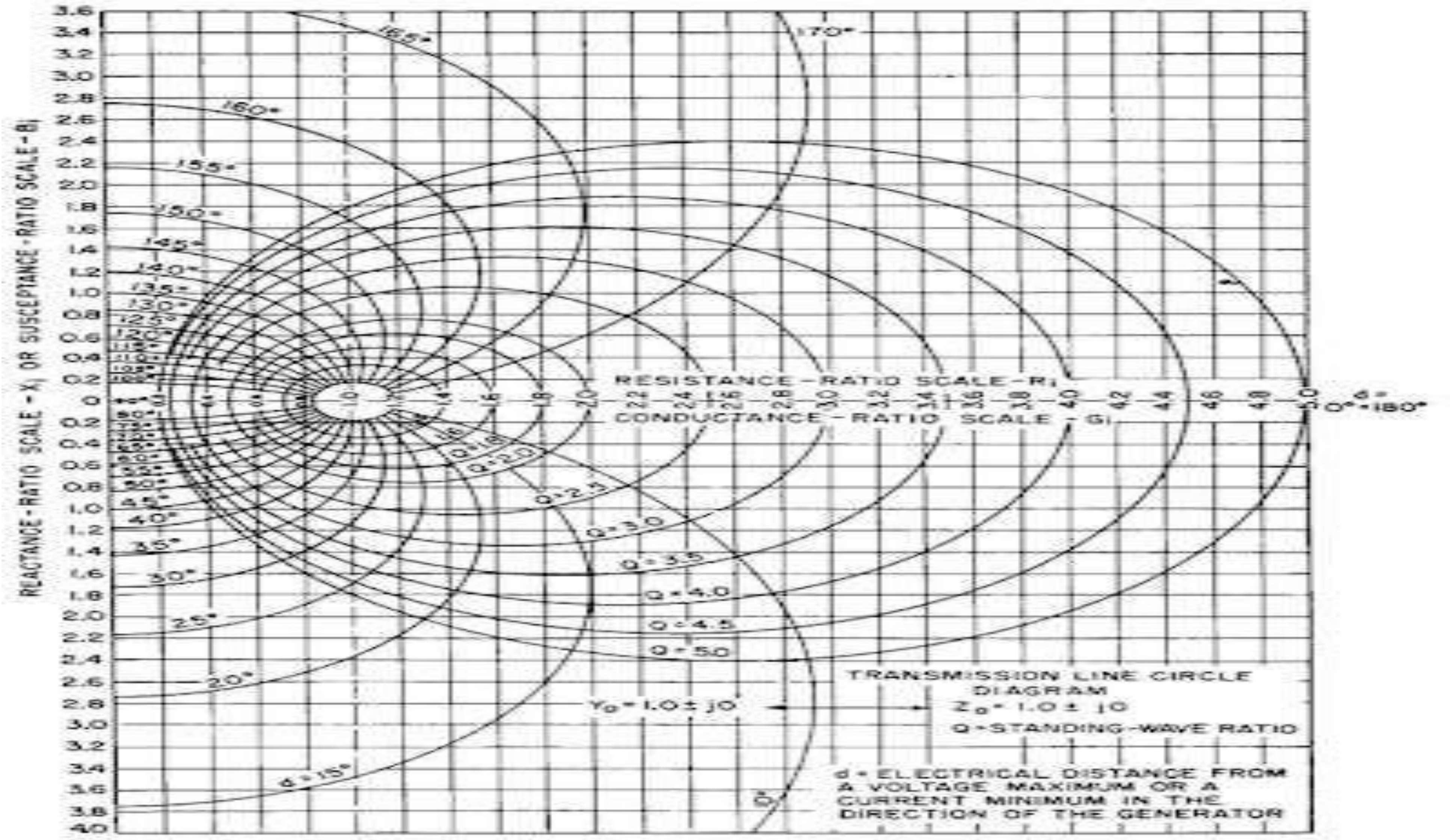
SOLUTION

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

2. Time consuming

CARTESIAN CIRCLE DIAGRAM

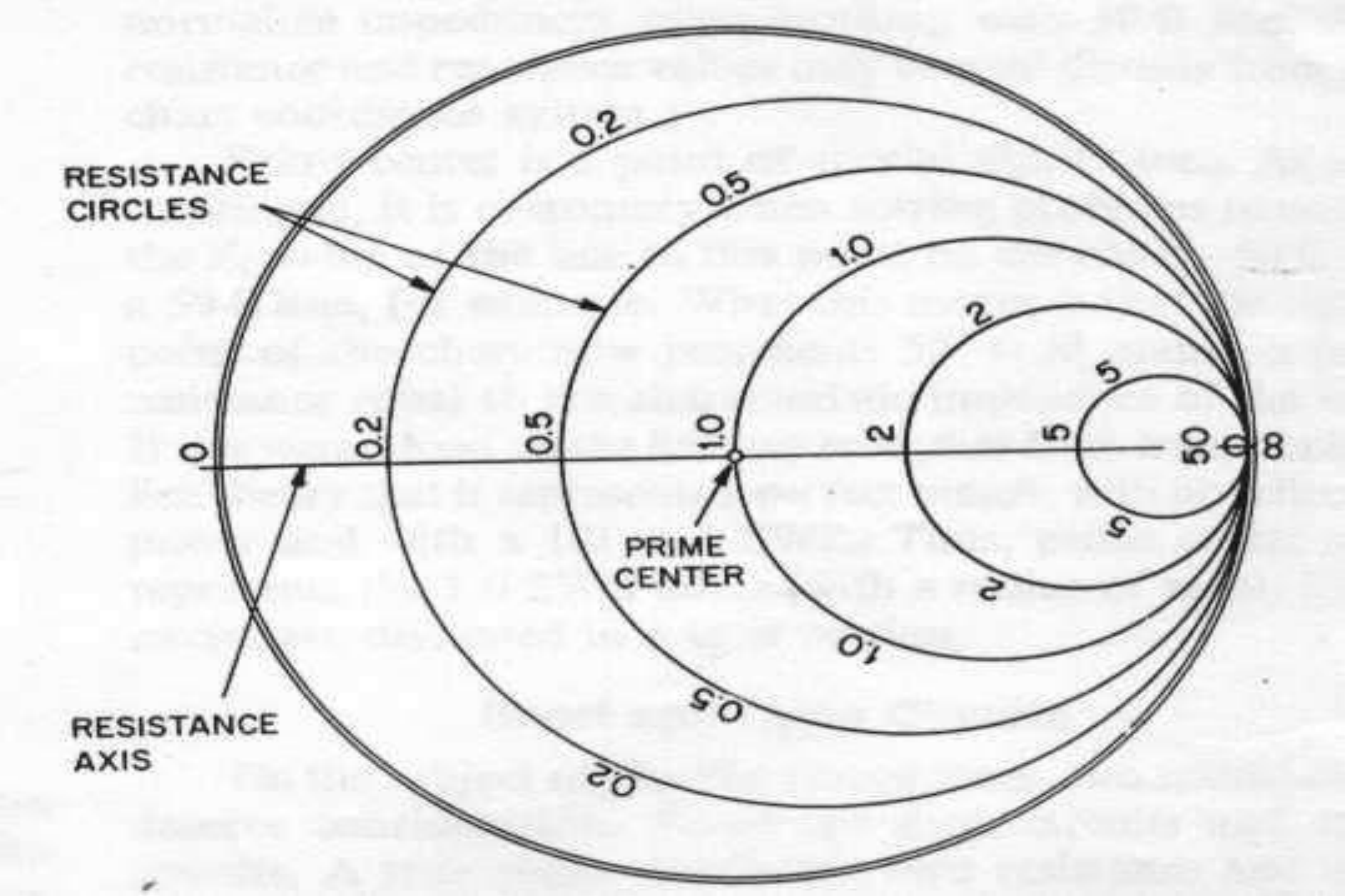
- The range of Impedance or admittance values are limited.
- The interpolation of constant S circles and Constant βs circles on the chart is difficult and inaccurate



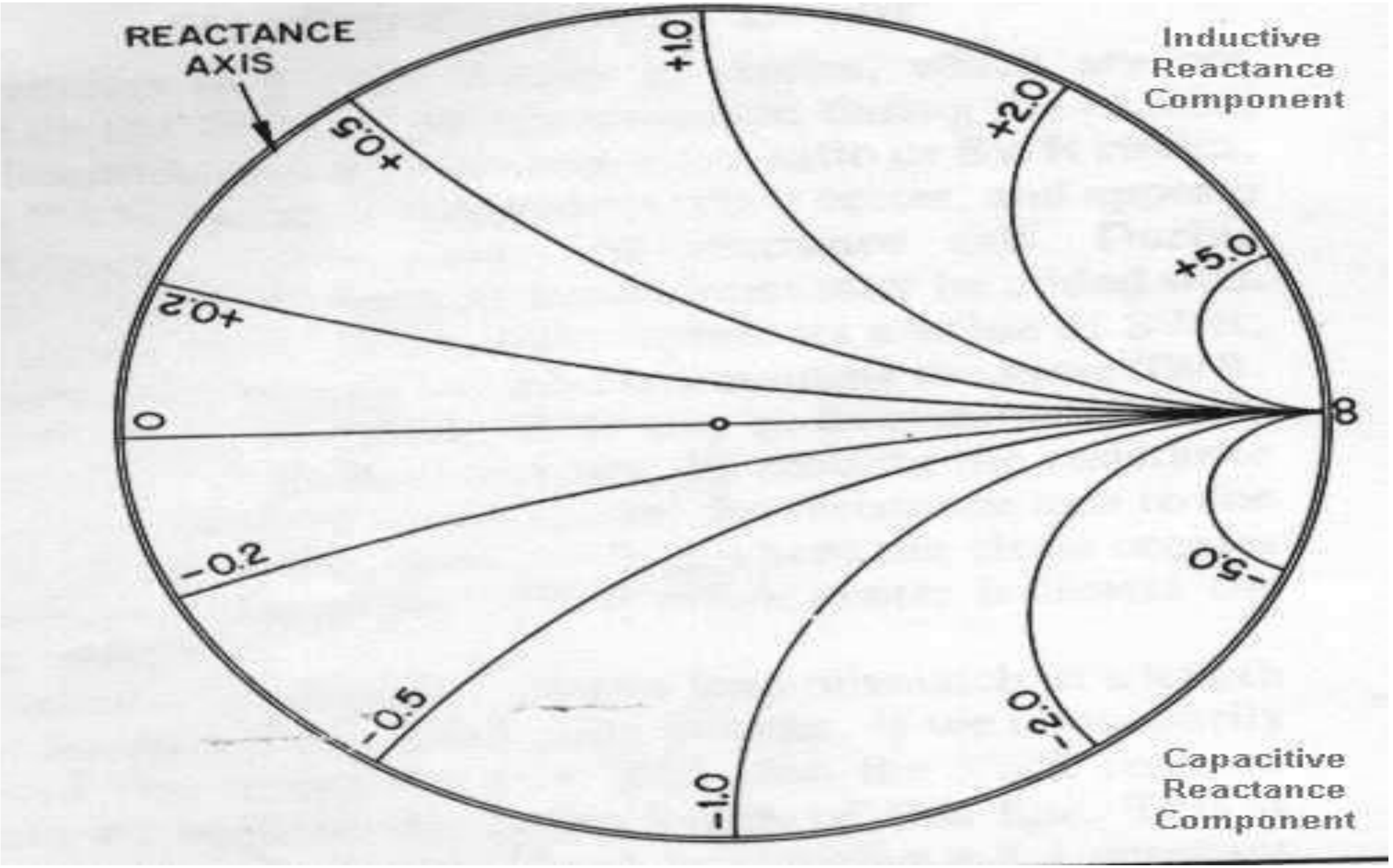
THE SMITH CHART –
A TRANSMISSION LINE CALCULATOR

- 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
  $K \angle \phi - 2\beta s = U + jV$

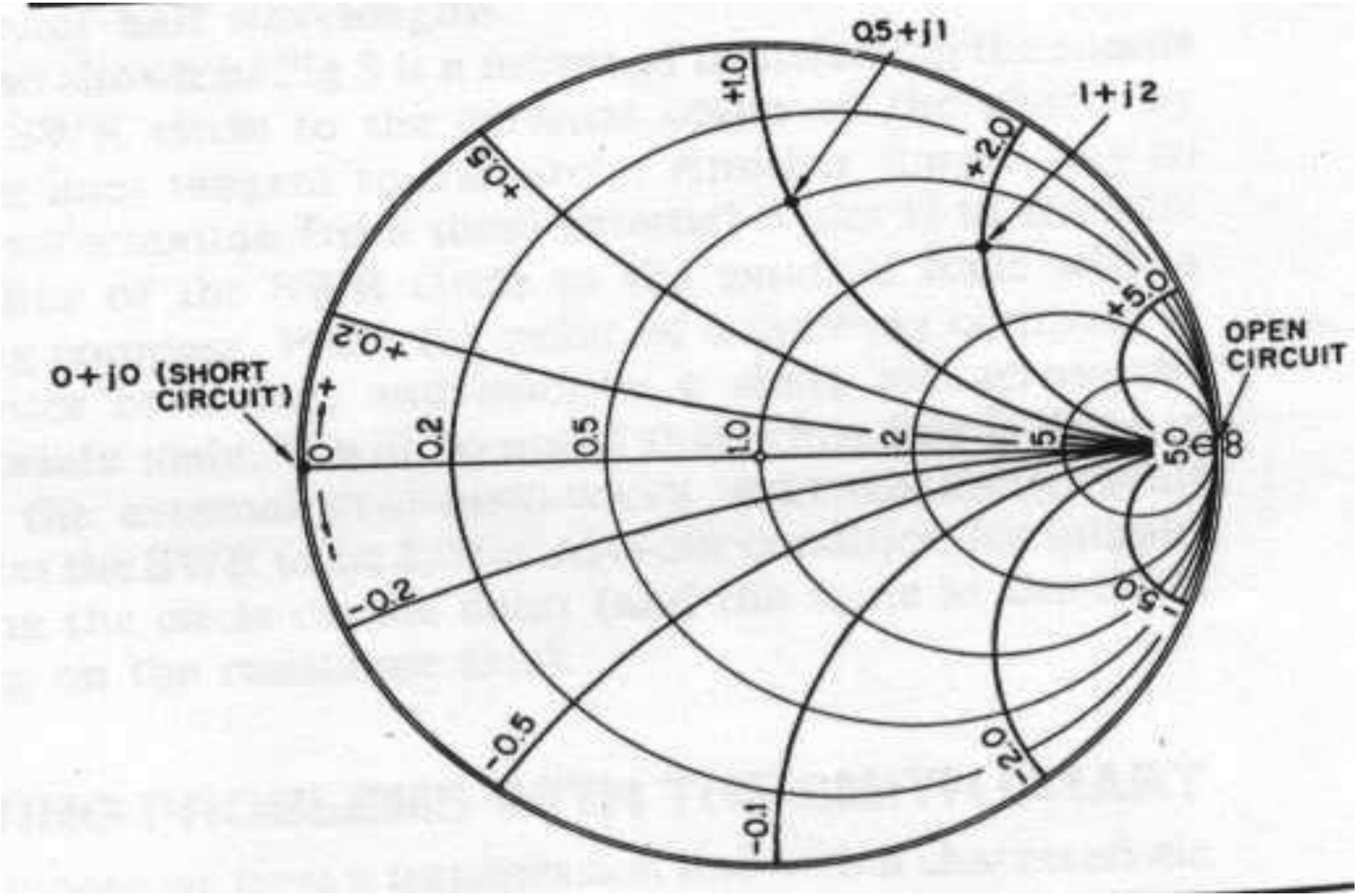
CONSTANT R CIRCLES



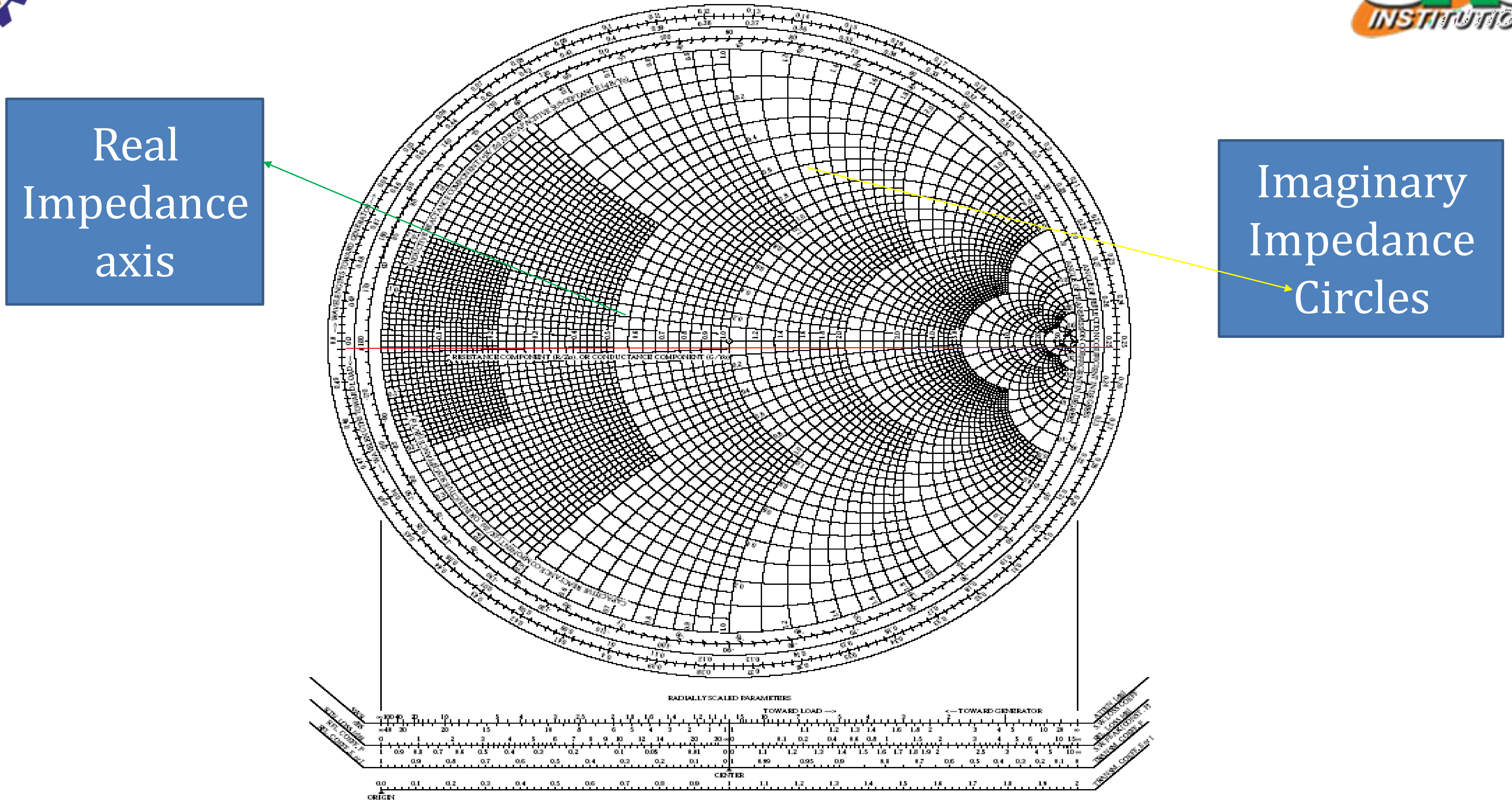
CONSTANT X CIRCLES



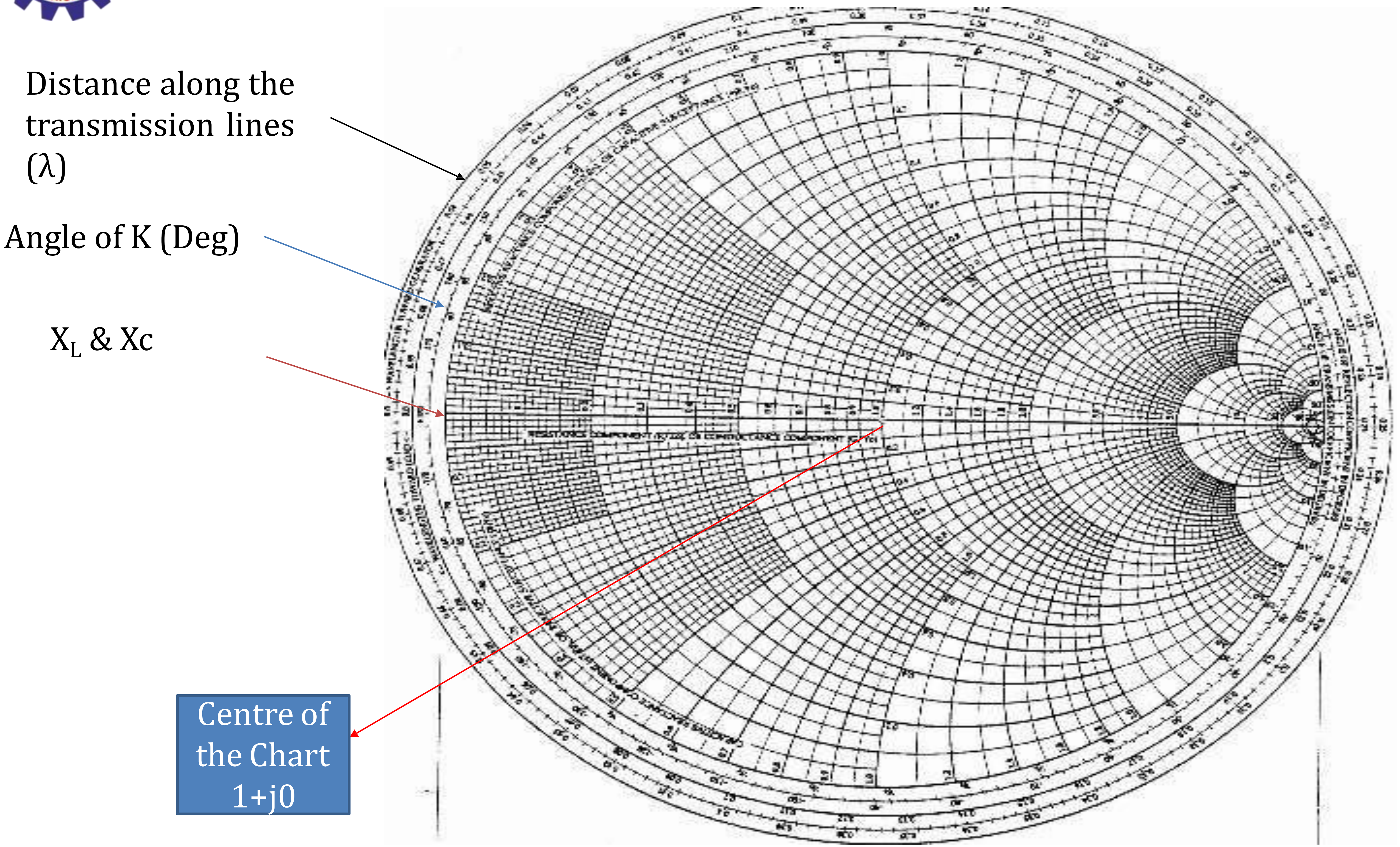
SMITH CHART

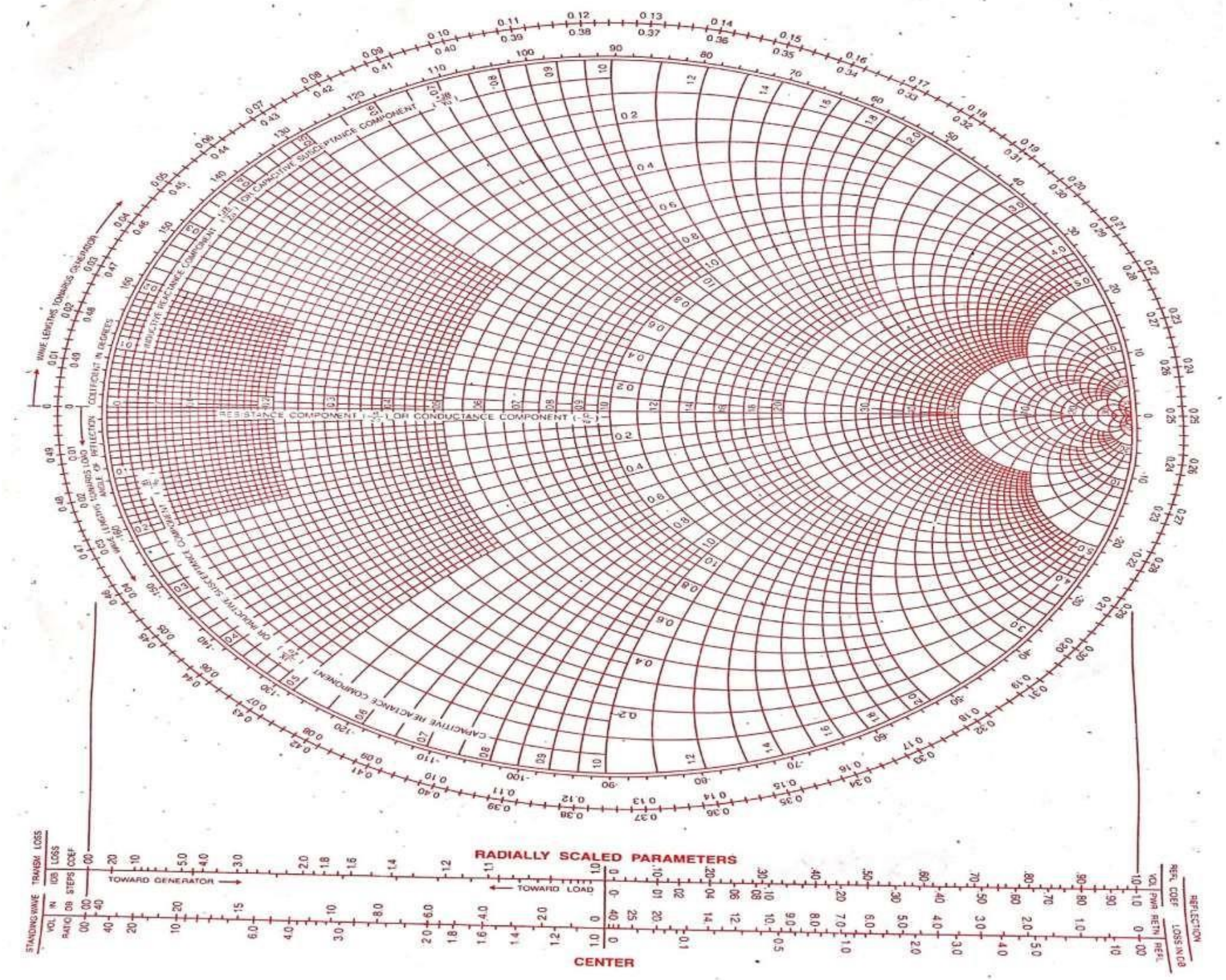

0.5+j1
1+j2
+1.0
+2.0
+0.5
+5.0
OPEN CIRCUIT
+0.2
0+j0 (SHORT CIRCUIT)
0
0.2
0.5
1.0
2
5
50
∞
-0.2
-5.0
-0.5
-2.0
-0.1

THE SMITH CHART



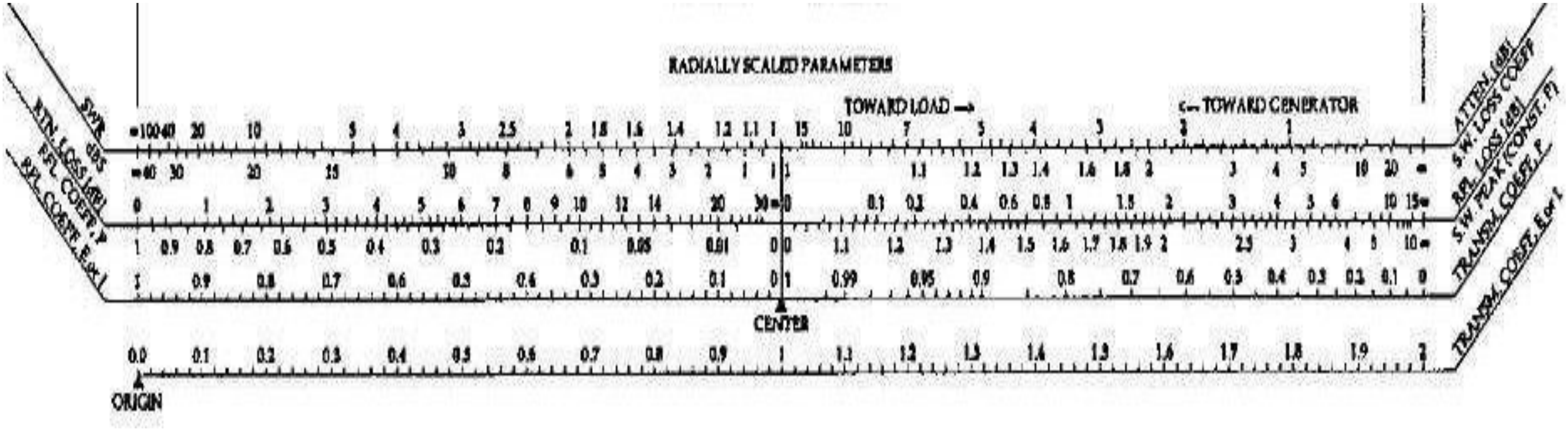
THE SMITH CHART




RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
CAPACITIVE SUSCEPTANCE COMPONENT
INDUCTIVE REACTANCE COMPONENT
CAPACITIVE REACTANCE COMPONENT
WAVELENGTHS TOWARD GENERATOR
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
RADIALLY SCALED PARAMETERS
TOWARD GENERATOR
TOWARD LOAD
CENTER

SMITH CHART

THE SMITH CHART



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

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/Ro
- Centre of the Chart – (1,0)
- Real Axis (Horizantal 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 λ
- Clockwise motion – wavelengths towards the generator

Anticlockwise direction – wavelengths towards load.

- Vmax – right side of the chart (Infinite impedance or open circuit condition)
- Vmin – left side of the chart (zero impedance or short circuit condition)

APPLICATIONS

Smith chart is used to find

- Magnitude and angle of reflection co efficients
- VSWR
- Unknown load impedance & admittance
- Unknown input impedance & admittance
- Vmax & Vmin &
- Also useful in stub matching

APPLICATIONS OF SMITH CHART

- Consider a 20 m long lossless transmission line with the characteristic impedance of 50 Ω operating at 2 MHz. If the line is terminated by an impedance 60+j40 Ω, calculate reflection coefficient k, standing wave ratio S and input impedance of the transmission line. Velocity of the line is 0.6c.

- **Given**

  $l = 20$ m, $Z_0 = 50\ \Omega$, $f = 2X10^6$ Hz, $V = 0.6c$ & $Z_L = 60+j40\ \Omega$

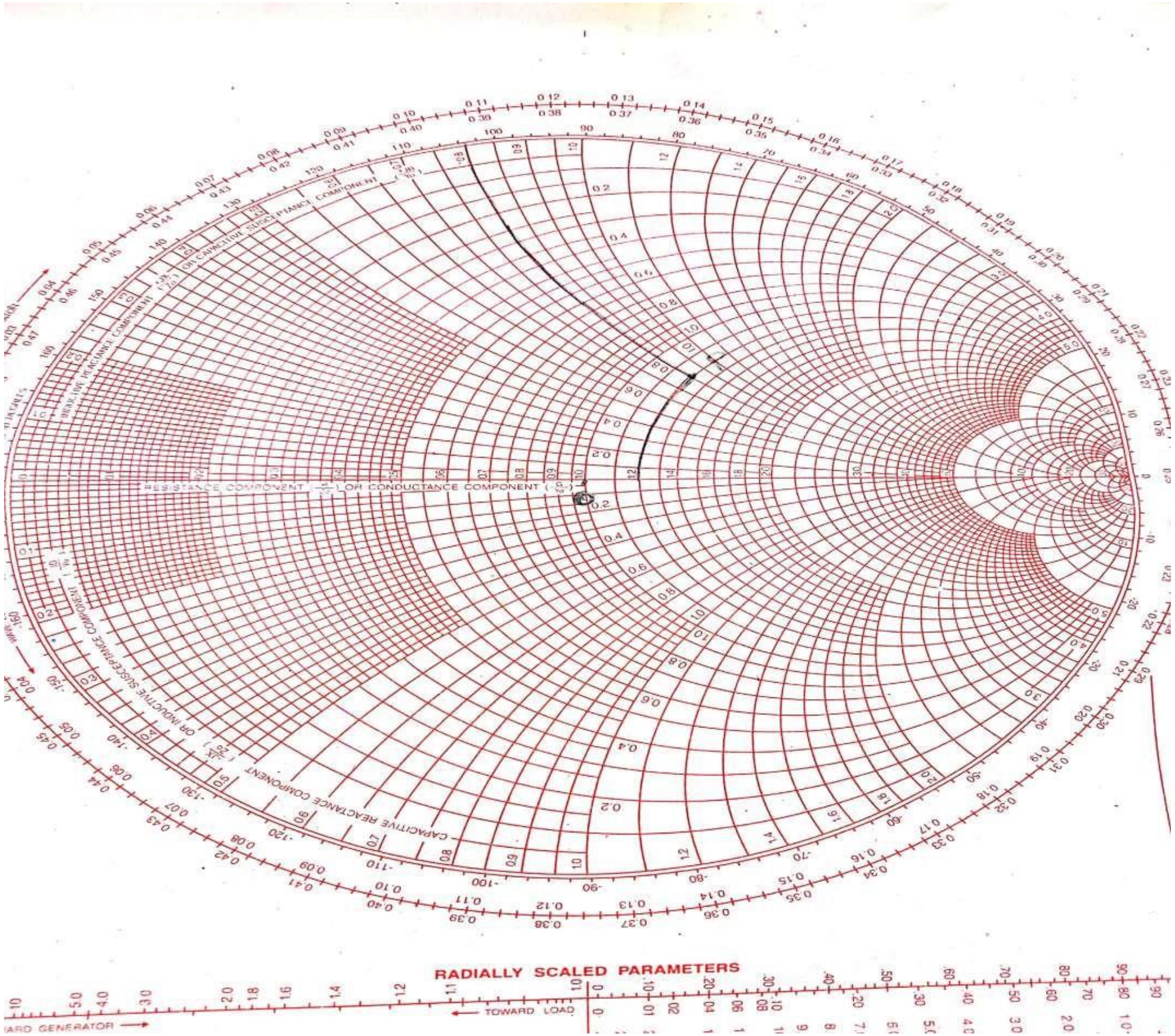
  Find K, S & Zs

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



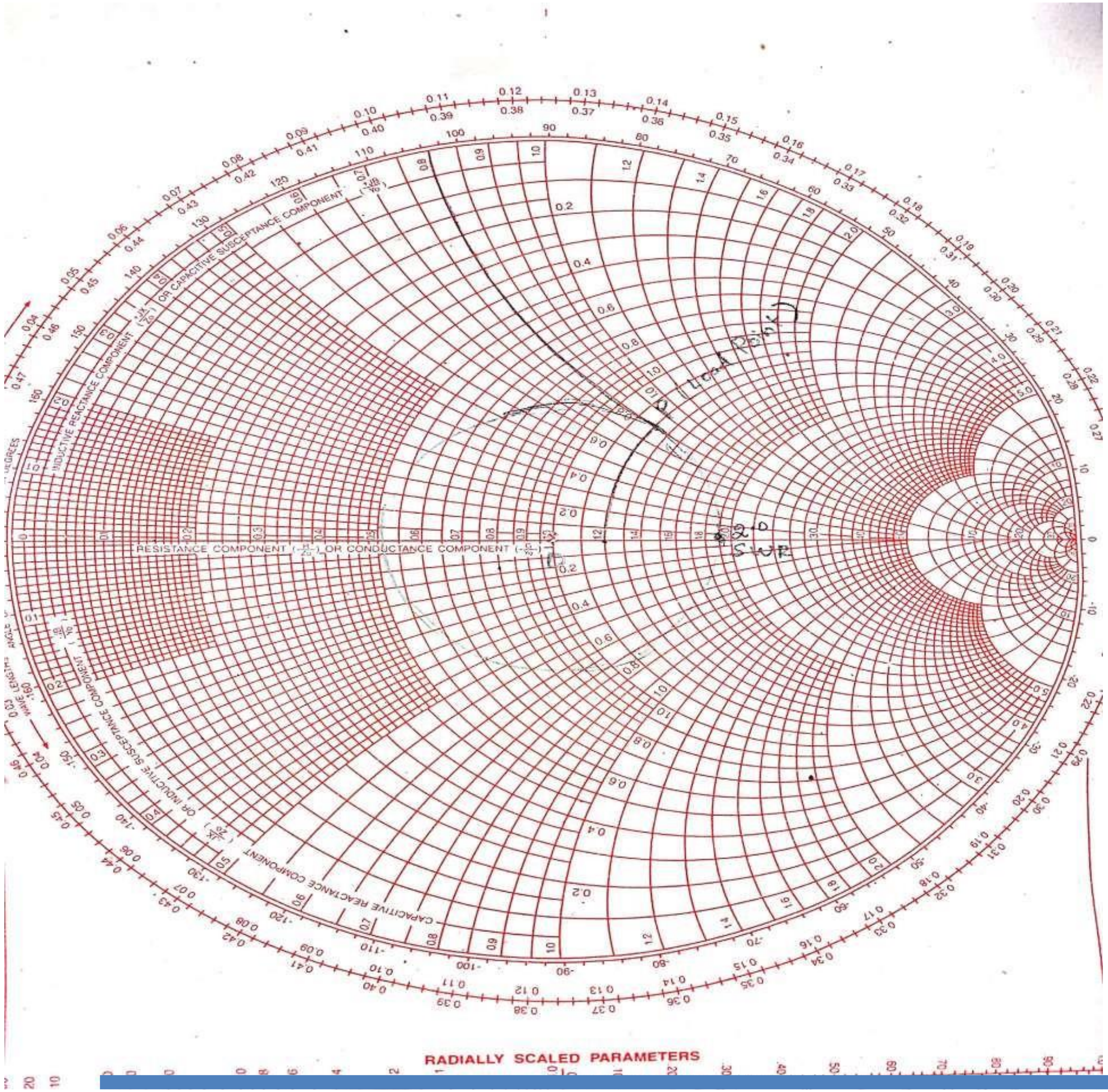
RESISTANCE COMPONENT (R/Z0) OR CONDUCTANCE COMPONENT (G/Y0)
CAPACITIVE REACTANCE COMPONENT
RADIALLY SCALED PARAMETERS
TOWARD LOAD

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.

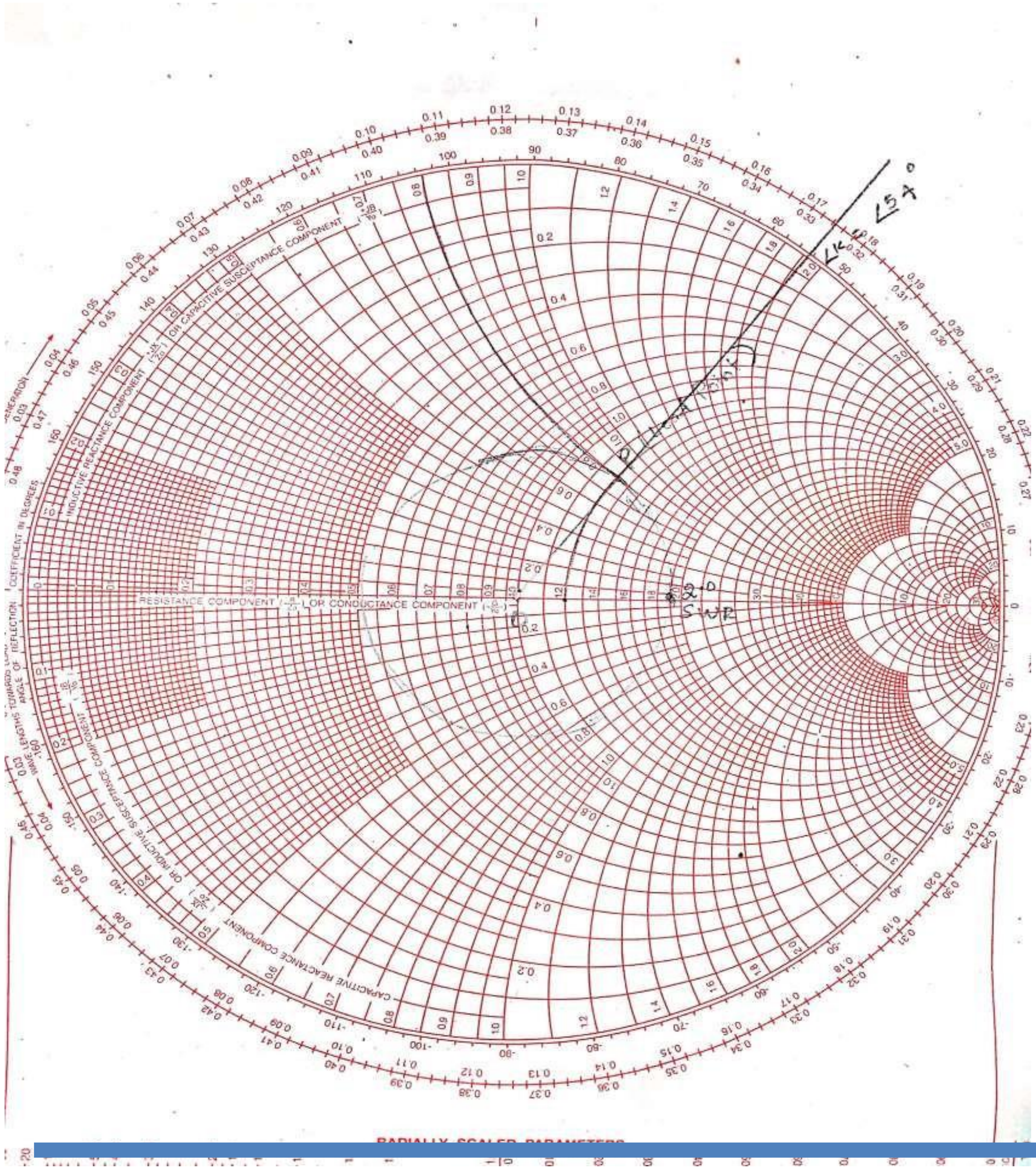

RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
CAPACITIVE SUSCEPTANCE COMPONENT
INDUCTIVE REACTANCE COMPONENT
CAPACITIVE REACTANCE COMPONENT
OR INDUCTIVE SUSCEPTANCE COMPONENT
RADIALLY SCALED PARAMETERS

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.

$\angle K = \angle 54°$ approx.



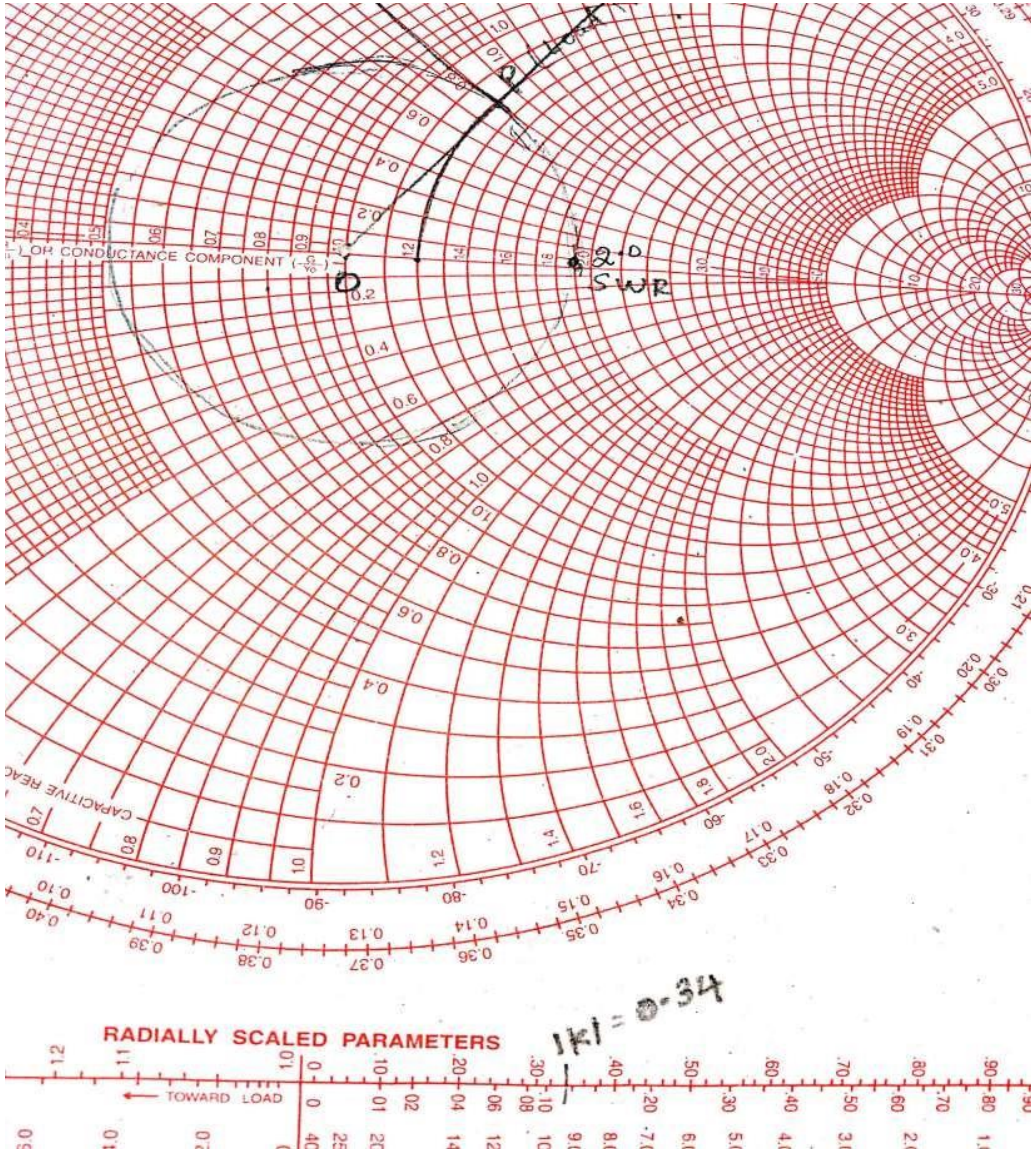
APPLICATIONS OF SMITH CHART

- **Step 4 – Magnitude of reflection coefficient K**

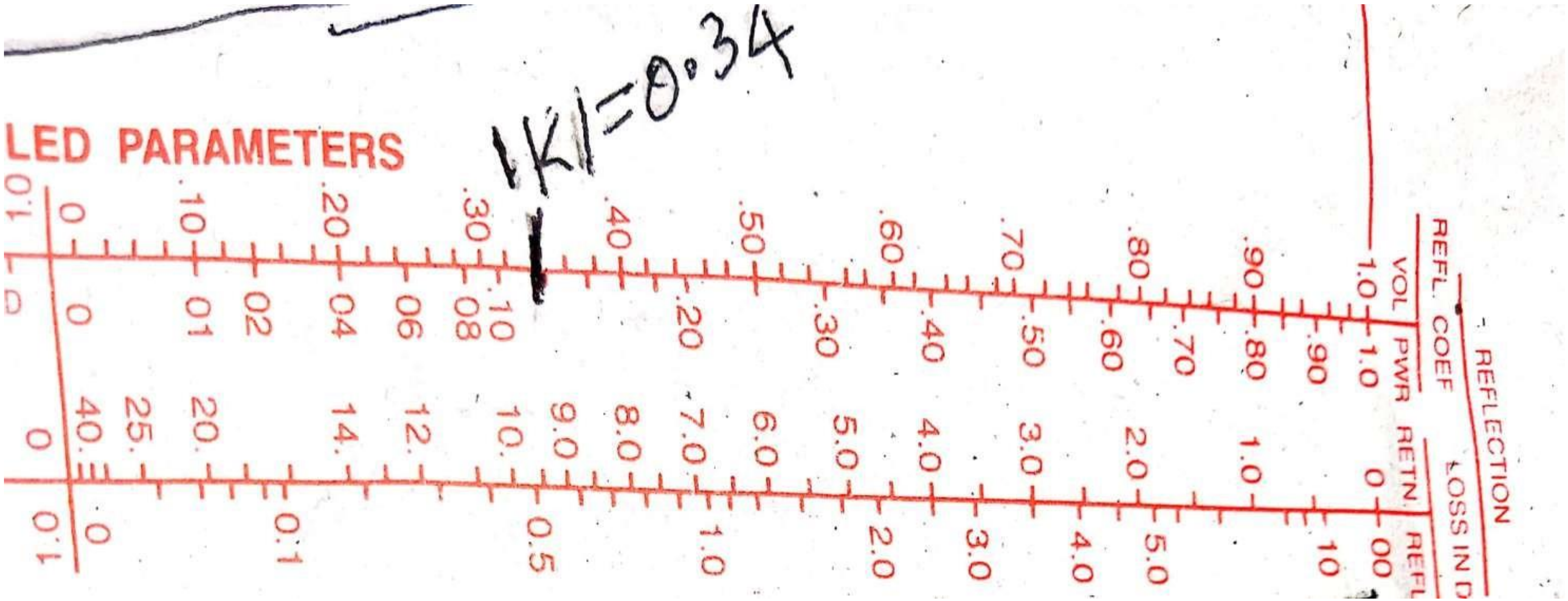
To find magnitude of K, measure the distance between O & P using a compass. The K scale is provided at the bottom of the chart. From the centre draw an arc from the centre of the scale at right side. This gives the magnitude of K.

$$|K| = 0.34$$

$$K = 0.34 \angle 54°$$


RADIALLY SCALED PARAMETERS
TOWARD LOAD
2.0
SWR
|K| = 0.34

APPLICATIONS OF SMITH CHART



APPLICATIONS OF SMITH CHART

- **Step 5 – Input impedance Zin**

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

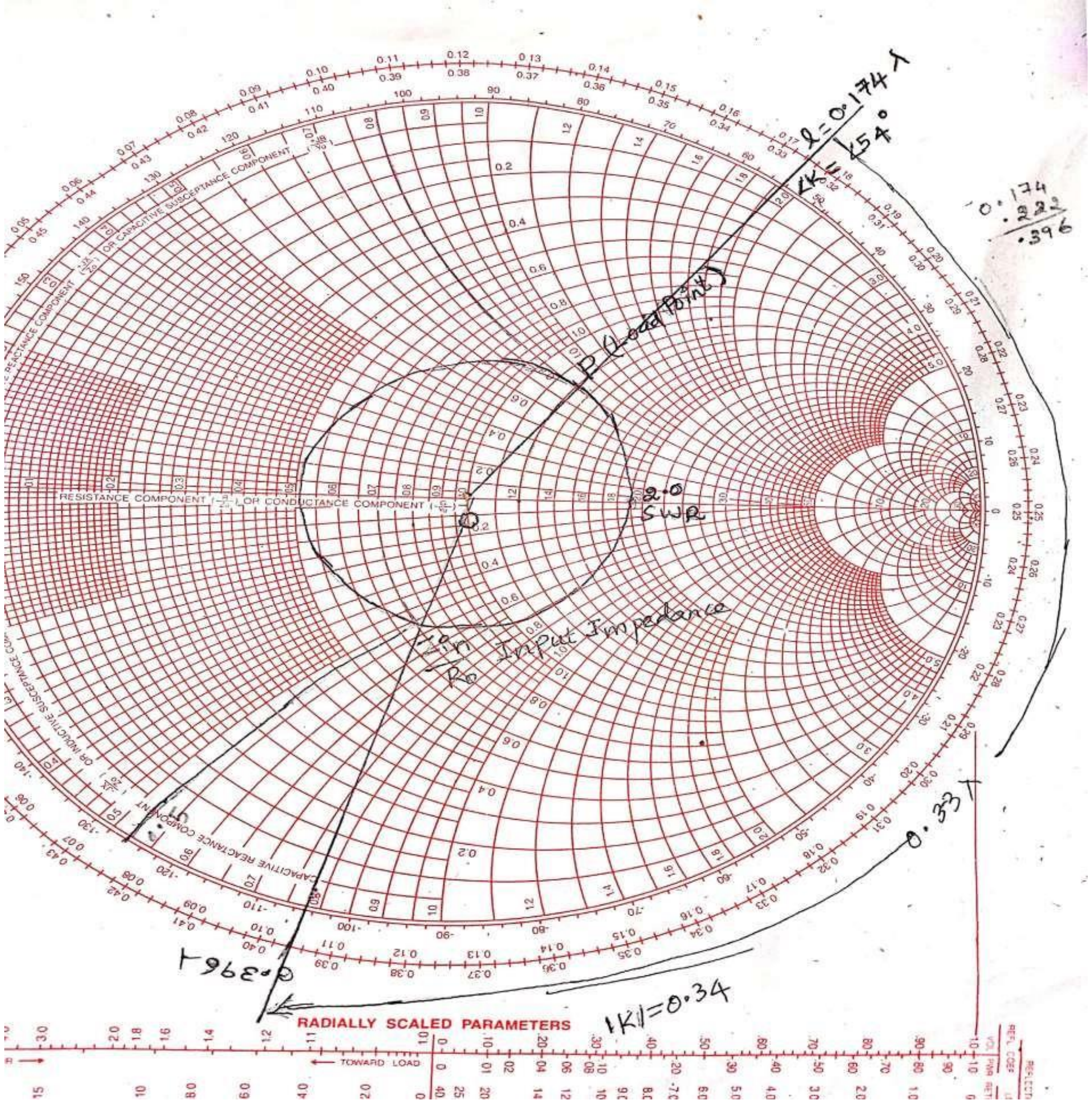
Line length in wave lengths = $(l/\lambda) = (20/90) = 0.222\lambda$

Wave length $\lambda = v/f = 0.6 \times 3\times10^8 / 2\times10^6 = 90$ m

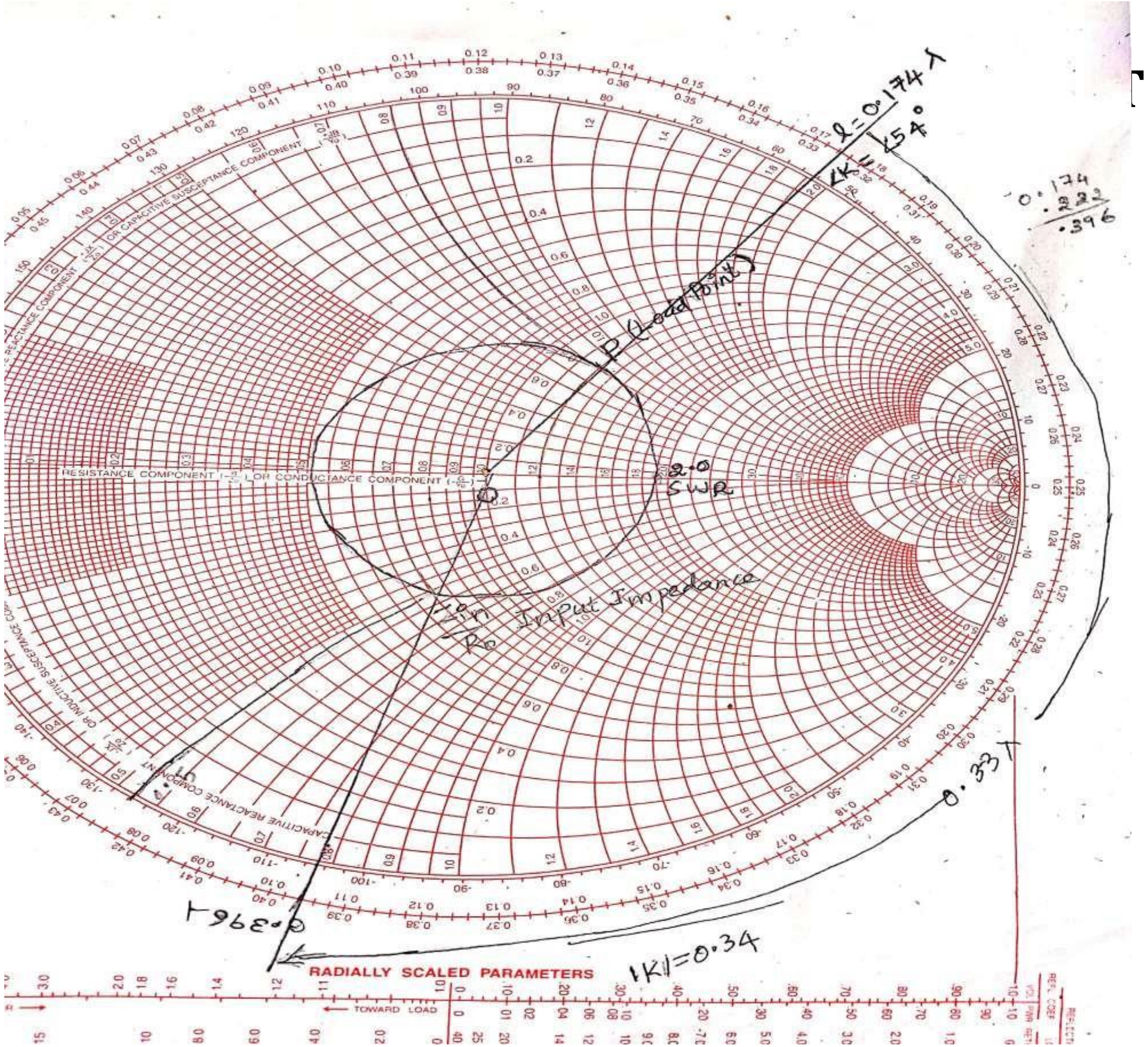
$$Zin/R_0 = 0.7 - j\,0.52$$

$$Zin = (0.7 - j\,0.52)\,R_0 = (0.7 - j\,0.52)\,50$$

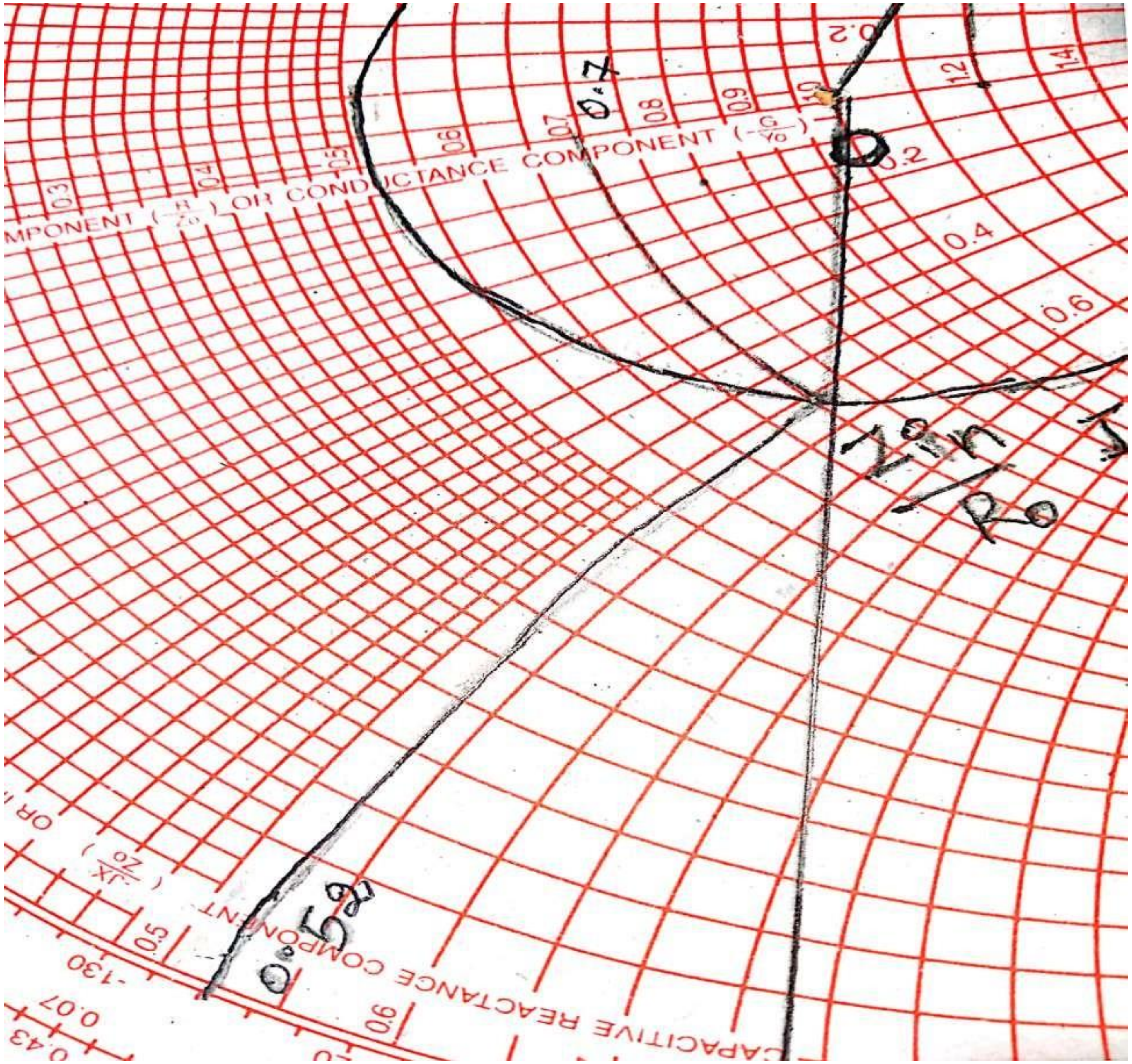
$$= 35 - j26\,\Omega$$



l = 0.174 λ
∠K = 54°
0.174
.222
.396
P (Load Point)
2.0
SWR
Input Impedance
Zin/Ro
0.33 λ
0.396 λ
|K| = 0.34
RADIALLY SCALED PARAMETERS
RESISTANCE COMPONENT
OR CONDUCTANCE COMPONENT
CAPACITIVE SUSCEPTANCE COMPONENT
CAPACITIVE REACTANCE COMPONENT
TOWARD LOAD



l = 0.174 λ
∠K = 54°
0.174
.222
.396
P (Load Point)
2.0
SWR
Input Impedance
0.33λ
0.396λ
|K| = 0.34
RADIALLY SCALED PARAMETERS
TOWARD LOAD
RESISTANCE COMPONENT


0.7
0.52
Zin/Ro

APPLICATIONS OF SMITH CHART

- **Step 6 – Impedance to Admittance conversion**

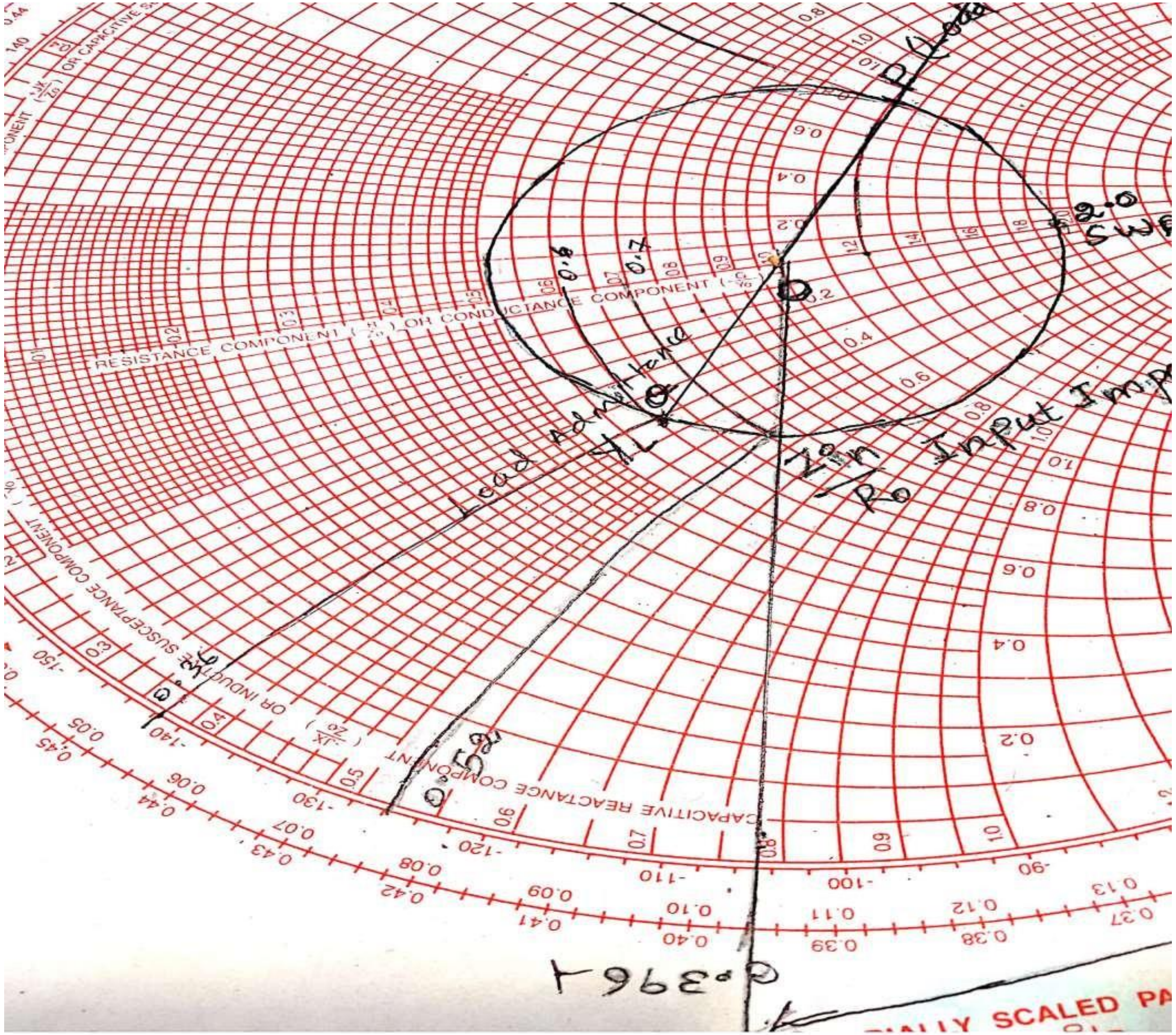
After getting normalized impedance, the diametrically opposite point will give the admittance value.

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

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

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

$$= (0.012 - j\,0.0072)\ \mho$$


RESISTANCE COMPONENT ( ) OR CONDUCTANCE COMPONENT
CAPACITIVE REACTANCE COMPONENT
Load admittance
Input Imp
SWR
0.3961