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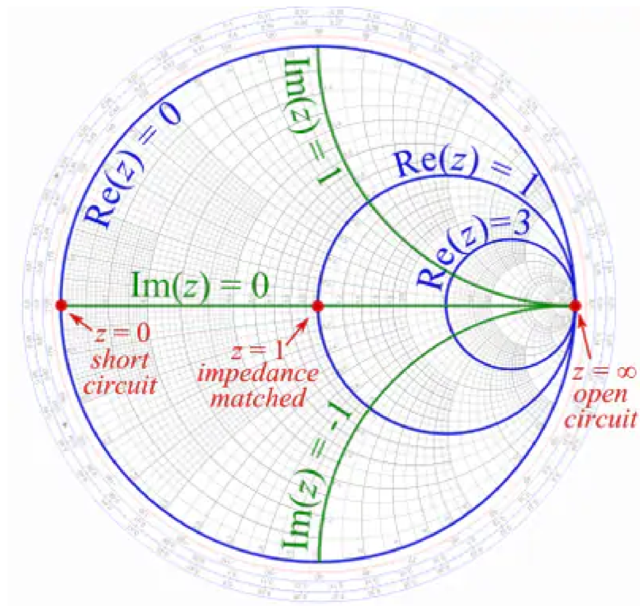
EXPERIMENT - 4

AIM - Introduction of smith chart and its application for unknown impedance measurement.

THEORY



The Smith Chart is a fantastic tool for visualizing the impedance of a transmission line and antenna system as a function of frequency. Smith Charts can be used to increase understanding of transmission lines and how they behave from an impedance viewpoint.

Smith Charts were originally developed around 1940 by Phillip Smith as a useful tool for making the equations involved in transmission lines easier to manipulate. With modern computers, the Smith Chart is no longer used to simplify the calculation of transmission line equations; however, their value in visualizing the impedance of an antenna or a transmission line has not decreased.

Normalization - Moving along a uniform transmission line doesn't change the magnitude of the reflection coefficient or its radial distance plotted on the Smith chart.Reflection coefficient (Gamma) is, by definition, normalized to the characteristic impedance (Z0) of the transmission line:

Gamma = $(Z_L-Z_0) / (Z_L+Z_0)$
where Z_L is the load impedance or the impedance at the reference plane. Note that Gamma is generally complex. Likewise, the impedance (admittance) values indicated on the grid lines are normalized to the characteristic impedance (admittance) of the transmission line to which the reflection coefficient is normalized.

RESULTS AND DISCUSSIONS

1. **Resistance Circle**

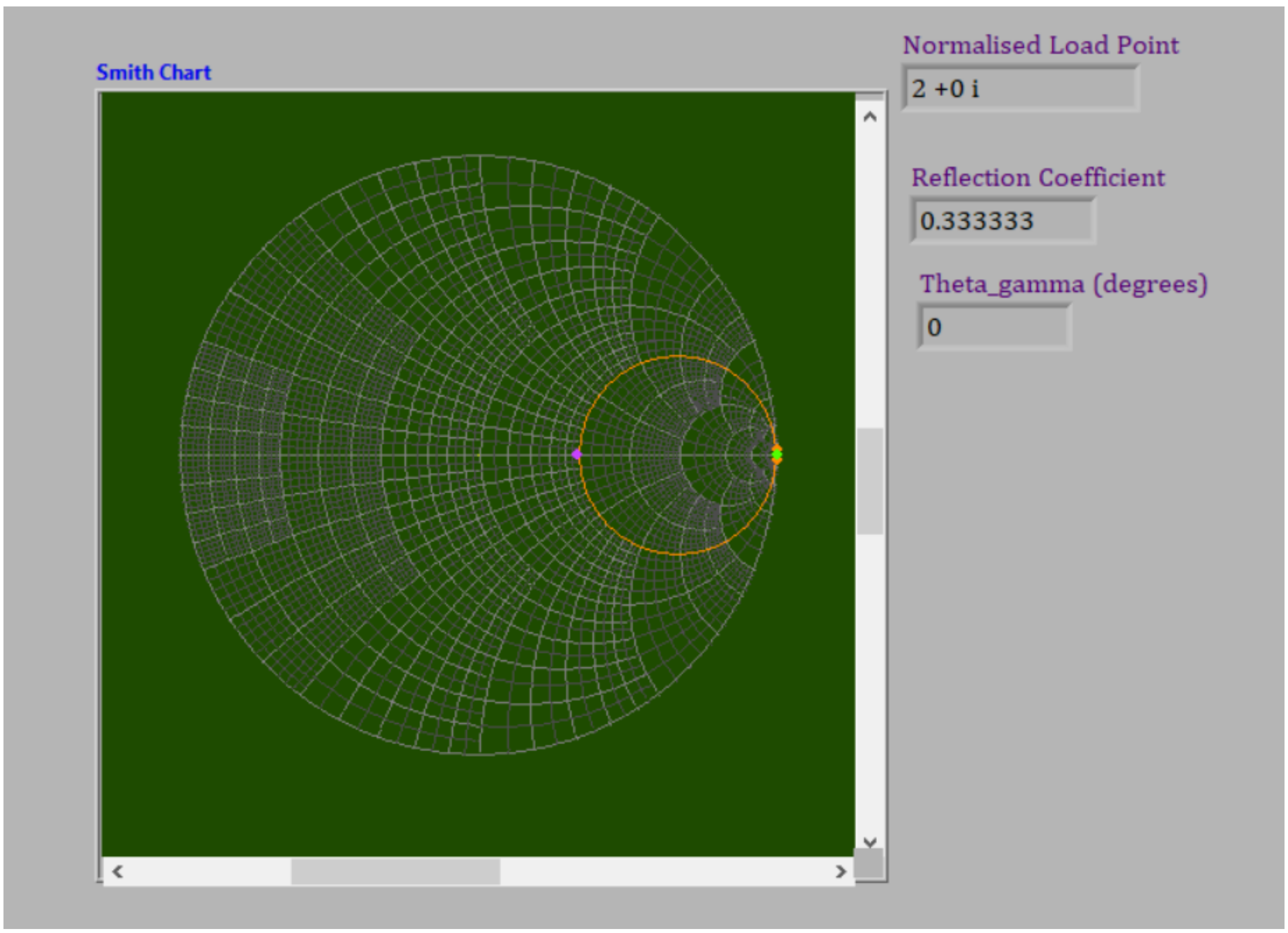
   Parameters taken :-

   Normalised Resistance = 2 ohm

   Characteristic Impedance = 50 ohm

   Normalised Load Point = 2 + 0i

   Reflection Coefficient = $\frac{K-1}{K+1}$ = $\frac{2-1}{2+1}$= 0.3333



Observations :

a) The constant resistance circle is formed with the radius of 2 load points when provided with 2 ohm of normalized resistance.

b) Reactance is zero therefore the reactance circle is not formed.

c) The Reflection Coefficient came out to be 0.3333.

2. Reactance Circle

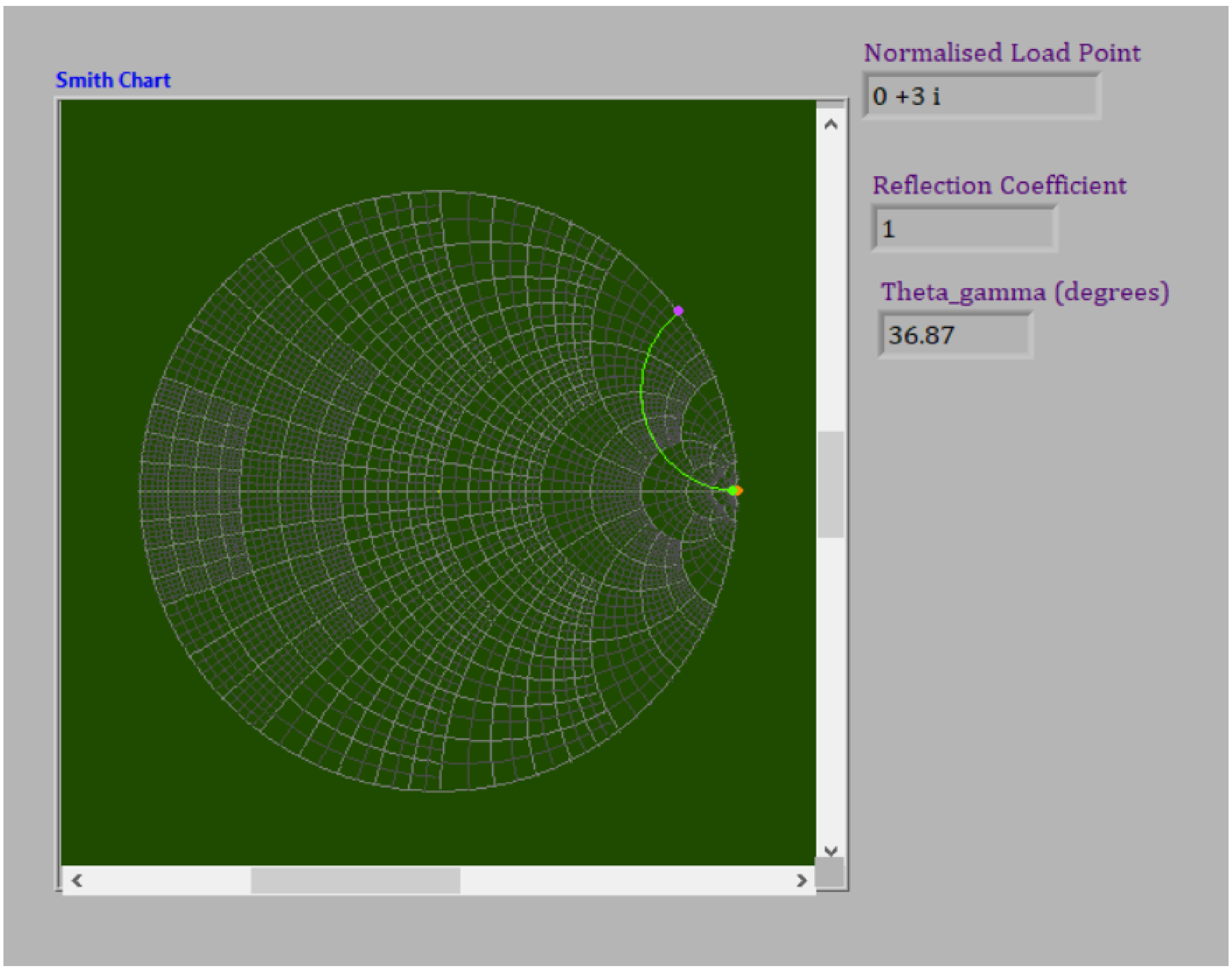
Parameters taken :-

Normalised Resistance = 3 ohm

Characteristic Impedance = 100 ohm

Normalised Load Point = 0 + 3i

Reflection Coefficient = $\dfrac{K-1}{K+1}$ = $\dfrac{0-1}{0+1}$ = 1 (Magnitude)



Observations :

a) The constant reactance circle is formed at an angle of 36.87 degrees when provided with 3 ohm of normalized reactance.

b) Resistance is zero therefore the resistance circle is not formed.

c) As Normalized resistance is zero, the Reflection Coefficient came out to be unity.

3. Short Circuit Point

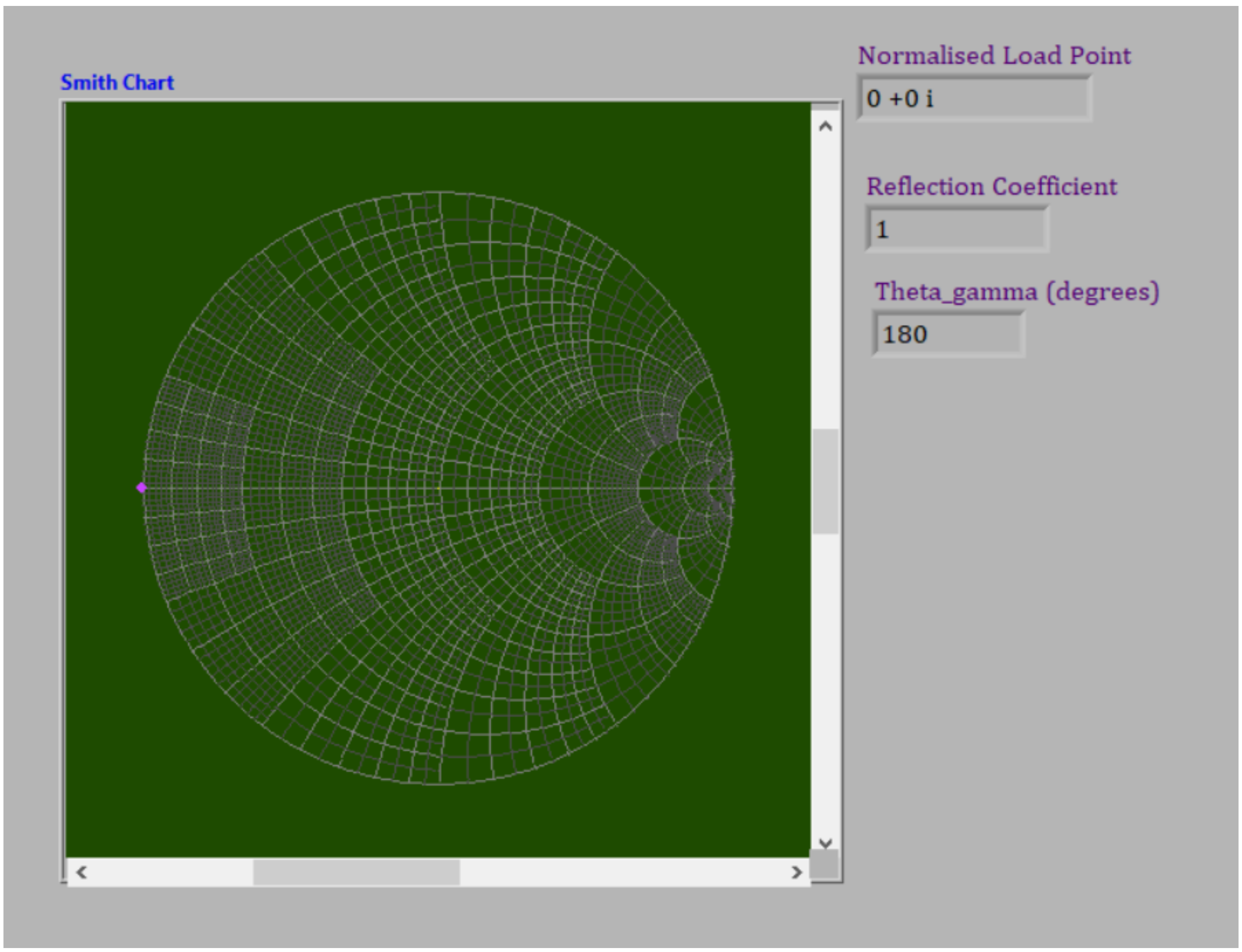
Parameters taken :-

Normalized Resistance = 0

Characteristic Impedance = 100 ohm

Normalised Load Point = 0 + 0i

Reflection Coefficient = $\dfrac{K-1}{K+1} = \dfrac{0-1}{0+1} = 1$ (Magnitude)



Observations :

a) **The left end on the real axis is** the short circuit point.

b) The voltage of the reflected wave at a short circuit cancels the voltage of the incident wave so that zero potential exists across the short circuit.

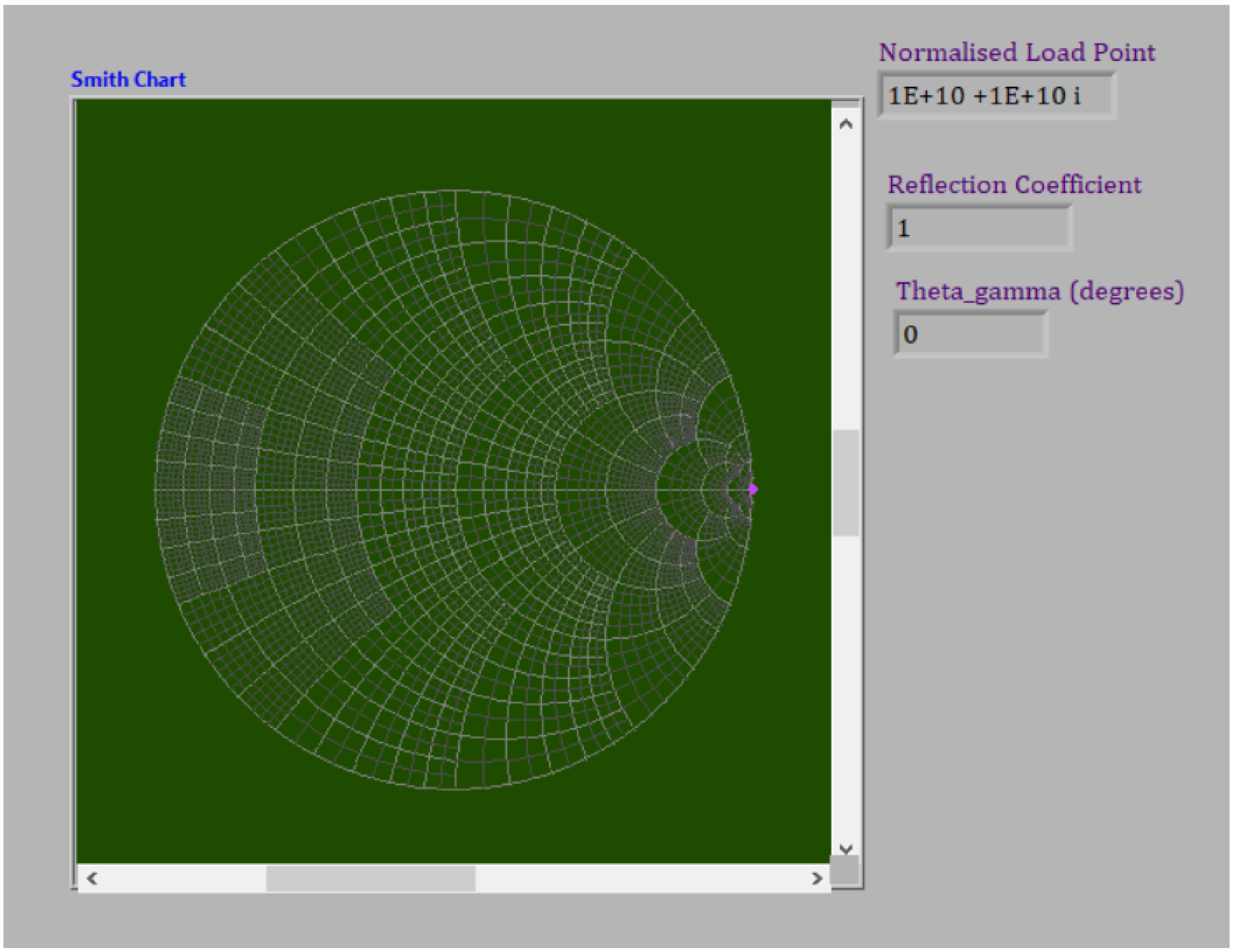
c) The voltage reflection coefficient is -1 or magnitude is 1 at an angle of 180 degrees.

4. Open Circuit Point

Parameters taken :-

Normalized Resistance = 0
Characteristic Impedance = 100 ohm

Normalised Load Point = 1E+10 + 1E+10i



Observations :

a) **The right end on the real axis is** the open circuit point.

b) The reflected voltage is equal to and in phase with the incident voltage so that the open circuit location is on the right.

c) The reflection coefficient has a magnitude other than unity and is complex, which lies anywhere above the real axis is inductive (L) and anywhere below is capacitive (C).

5. VSWR Circle

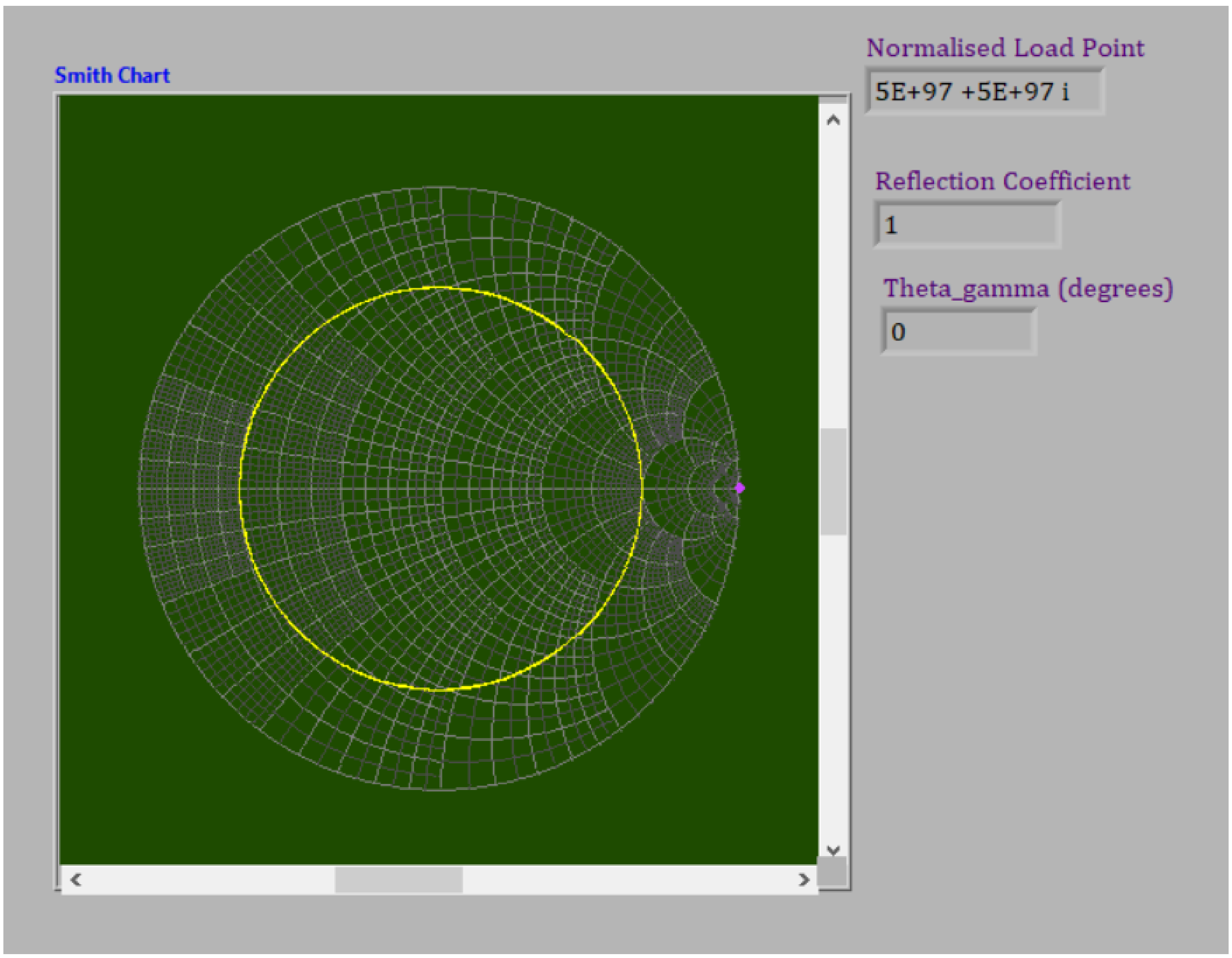
Parameters taken :-

VSWR (Voltage Standing Wave Ratio) Circle = 5

Characteristic Impedance = 200 ohm

Normalised Load Point = 5E+97 + 5E+97i

All points on the circle have the same VSWR.



Observations :

a) Since this circle is centered at the center (0,0) of the Smith Chart, the magnitude is constant along this curve. Hence, the VSWR is **constant everywhere along** this curve.

b) The point moves on a circle with radius R in the complex - plane.

c) VSWR is related to the magnitude of the voltage reflection coefficient.

6. Load Point

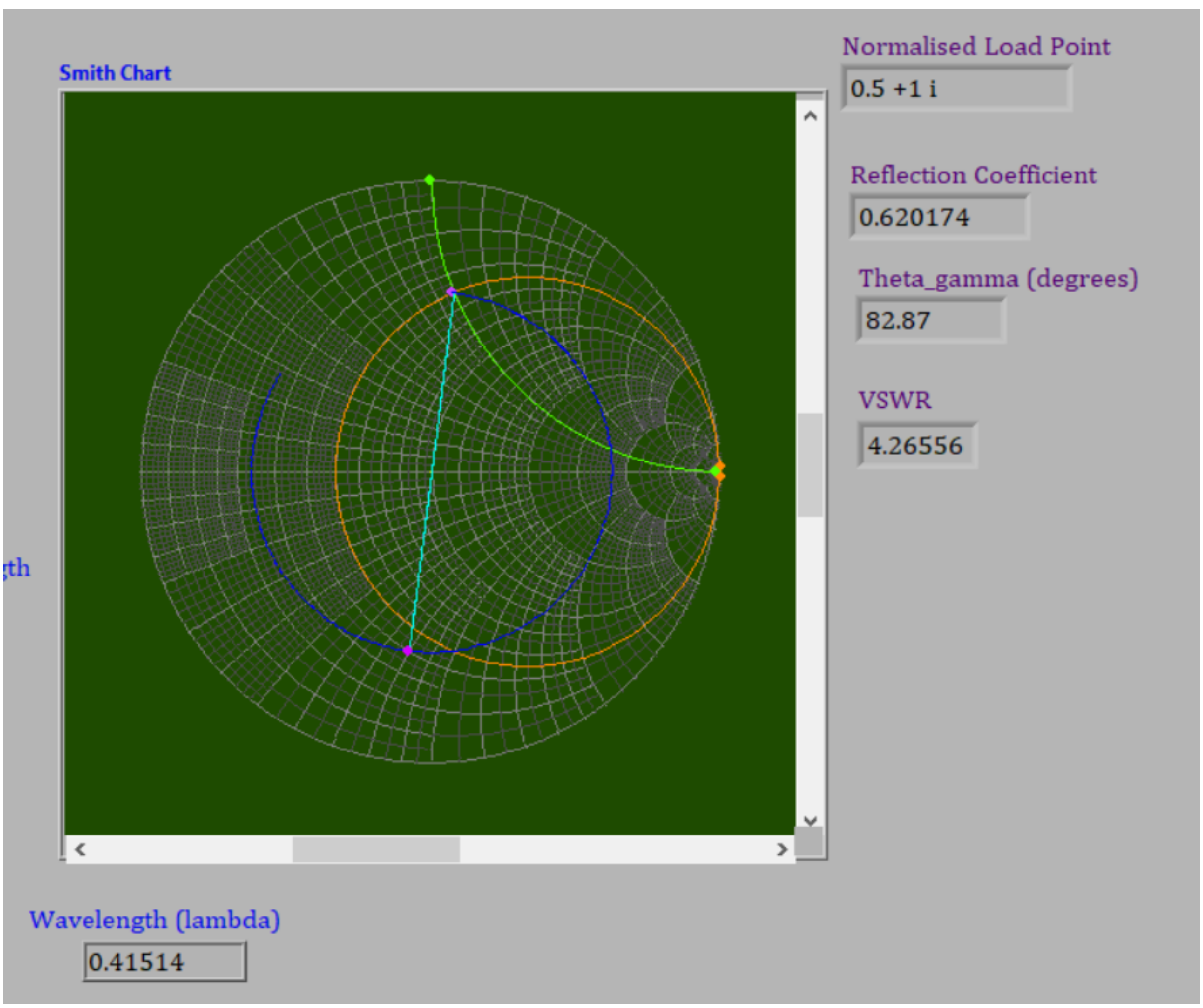
Parameters taken :-

Load Resistance = 50 ohm, Load Reactance = 100 ohm

Characteristic Impedance = 100 ohm

Normalised Load Point = $\frac{50}{100} + \frac{100}{100}$i = 0.5 + 1 i

Reflection Coefficient = $\frac{0.5 + 1i - 1}{0.5 + 1i + 1}$ = 0.62



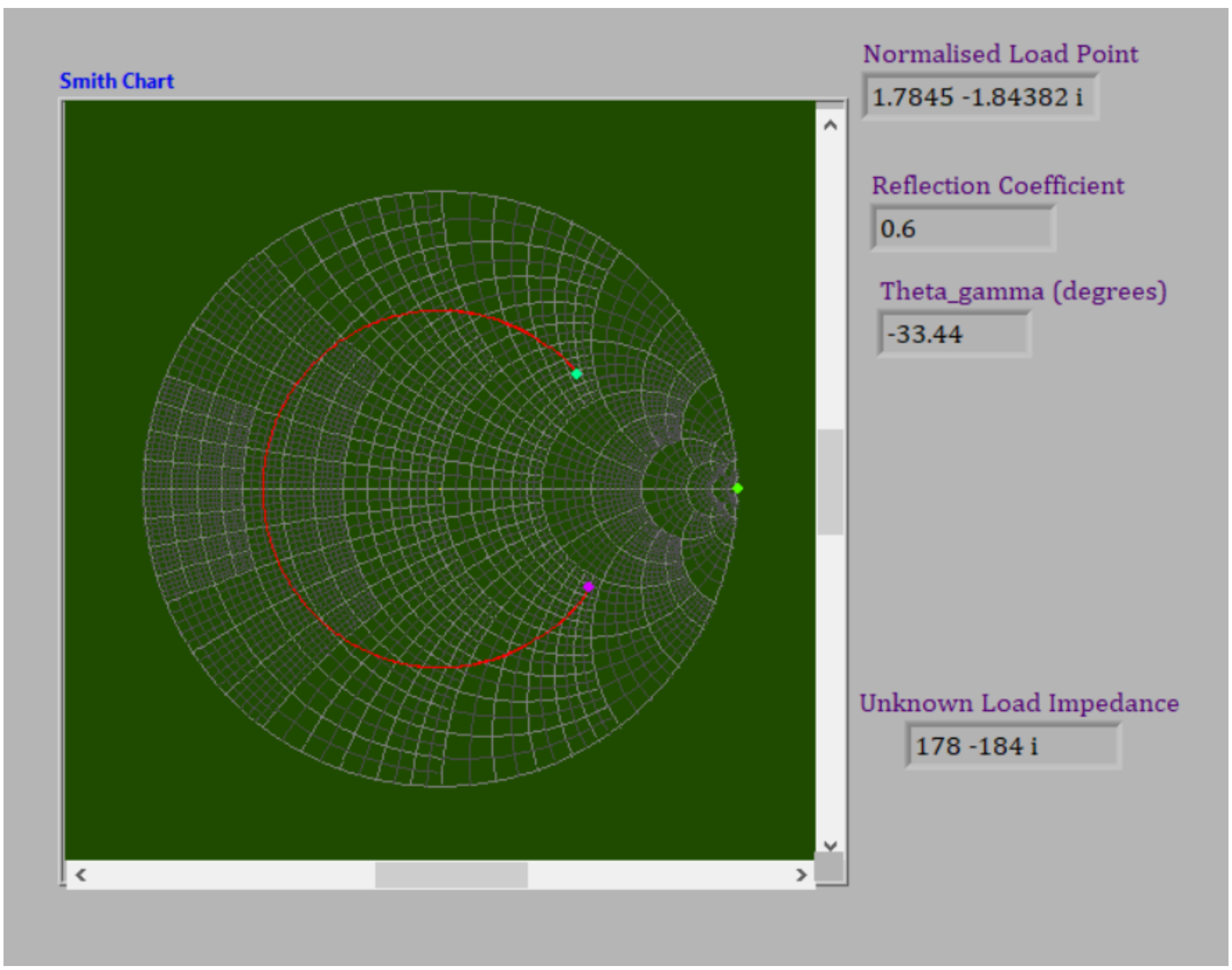
Observations :

a) The input impedance and reflection coefficient can be determined by using the Smith chart.
b) The load impedance is normalized, and the point (0.5 + 1 i) is plotted in the graph.

7. Unknown Load Impedance

Parameters taken :-

Magnitude = 0.6
Phase = 40 degrees
Distance from load end in terms of Wavelength = 0.4
Characteristic impedance = 100 ohm



Observations :

a) From the graph, it is observed that unknown load impedance came out to be 178 - 184 i.
b) Reflection coefficient is found to be 0.6, and the angle is -33.44 degrees.
c) So from the load to the input impedance, move toward the source to the length of the line between the location where impedance to the load is measured.

CONCLUSIONS

Basically, a Smith chart is a polar graph of normalized line impedance in the complex reflection coefficient plane.
Let $Z = R + jX$ be the impedance at some location along a lossless line. The reflection coefficient is given by:

$$\Gamma = \frac{Z - Z_0}{Z + Z_0} = \Gamma_r + j\,\Gamma_i$$

There constant-valued circles on the Smith chart:

a) A constant standing wave ratio (VSWR) circle consists of points that have the same magnitude in reflection coefficient. Moving along such a circle corresponds to moving along a lossless transmission line.
b) A constant resistance *R* circle consists of points that have the same normalized resistance. Moving along such a circle corresponds to adding a series inductor or capacitor.
c) A constant reactance *X* circle consists of points that have the same normalized reactance. Moving along such a circle corresponds to changing the real part of impedance.

Special points on an impedance chart:

- The left end on the real axis is the short circuit point.
- The right end on the real axis is the open circuit point.
- The center of the Smith chart is the impedance matching point.

The real axis on a Smith chart has x=0, which means purely resistive.

The $|\Gamma| = 1$ circle is the boundary of a Smith chart, which means r=0 and purely reactive.

END