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Microwave Engineering Expt no- 7

Aim:

Introduction to Smith chart and its application for the unknown impedance measurement.

Software: Virtual Labs – IIT Kanpur

Theory:

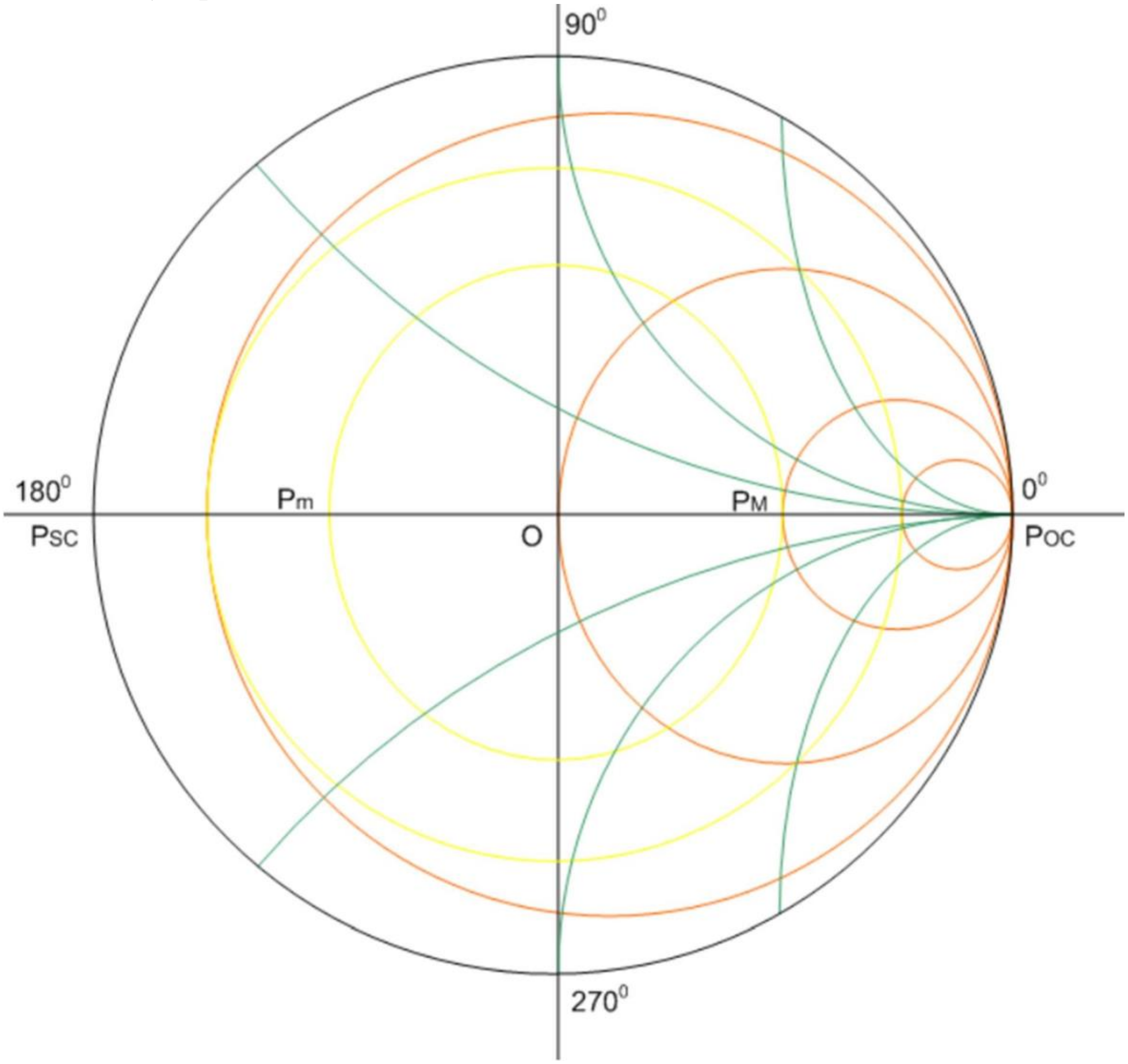
Transmission-line calculation - such as determination of input impedance, reflection coefficient and load impedance, involve tedious manipulation of complex numbers. This tedium can be alleviated by using a graphical method of solution. The best known and most widely used graphical chart is the Smith chart devised by P.H. Smith.

Smith Chart:

Smith chart devised by P.H. Smith is the most widely used graphical chart for transmission line calculations. It is a chart of resistance (r) and reactance (x) circles in the Γ_r-Γ_i plane for $|\Gamma| \leq 1$ where, r- and x- circles are everywhere orthogonal to one another. The intersection of an r-circle and an x-circle defines a point that represents normalized load impedance $z_L = r+jx$. This can be obtained on the labview programme by selecting option 3 from menu and providing the values of r and x in the space specified. The actual load impedance is $Z_L=R_0 (r+jx)$. Since a Smith chart plots the normalized impedance for $|\Gamma| \leq 1$, it can be used for calculations concerning a lossless transmission line only with arbitrary characteristic impedance.

The Smith chart in the figure below is marked with Γ_r and Γ_i rectangular coordinates. The same chart can be marked with polar coordinates, such that every point in the Γ- plane is specified by a magnitude |Γ| and a phase angle θ_Γ this is also shown in the figure below. All |Γ|-circles are centred at the origin, and their radii vary uniformly from 0 to 1. The |Γ|-circles can be drawn in the labview programme provided with the experiment by selecting option 6 from the menu and giving desired value of |Γ| in the column specified. The radius of the VSWR circle is equal to the magnitude |Γ| of the load reflection coefficient.

Each |Γ|-circle intersects the real axis (Γr) at two points. The points are marked in the figure given below as PM on the positive-real axis (OPOC) and Pm on the negative-real axis (OPSC). Since x=0 along the real axis, PM and Pm both represent situations with a purely resistive load, ZL=RL. Obviously, RL > R0 at PM, where r > 1; and RL0 at Pm, where r < 1. Value of the r-circle passing through the point Pm is numerically equal to the standing-wave ratio(S). Similarly, the value of the r-circle passing through the point Pmon the negative-real axis is numerically equal to 1/S.



Procedure:

1) Select the option from menu according to your requirement.
2) Enter the values corresponding to the option provided in previous step.
3) Run the VI to see the desired plot in Smith chart.

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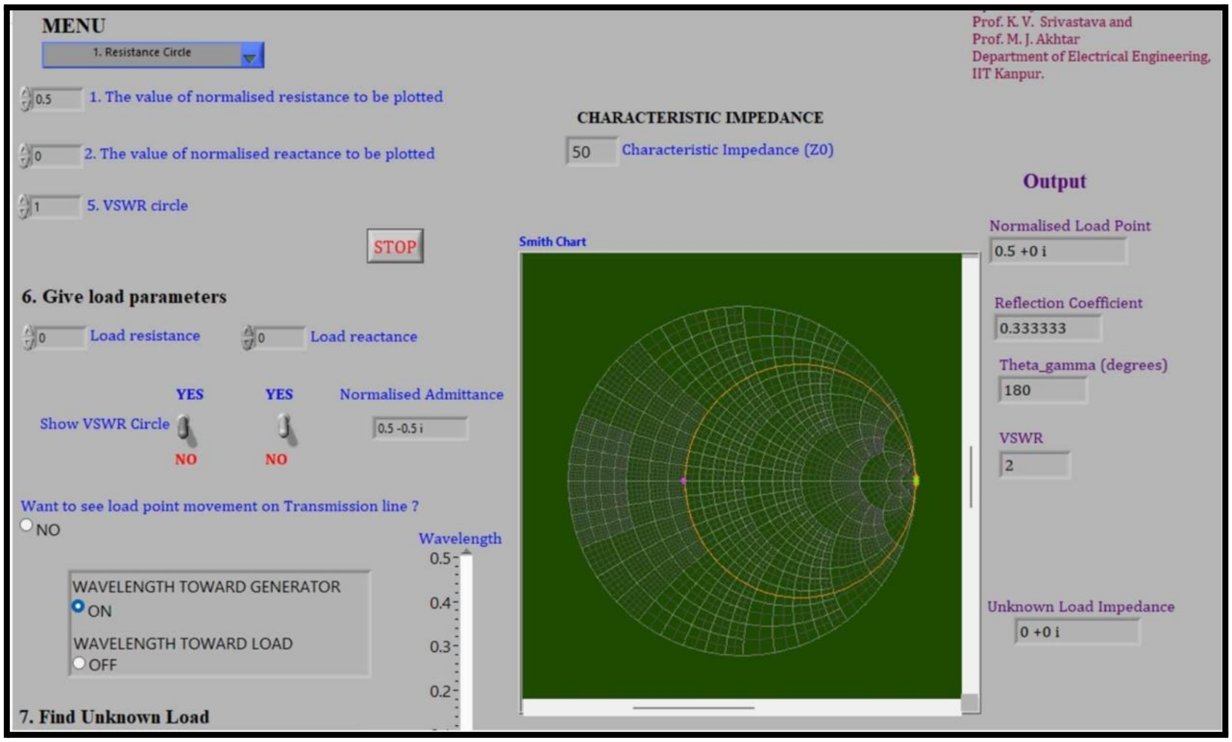
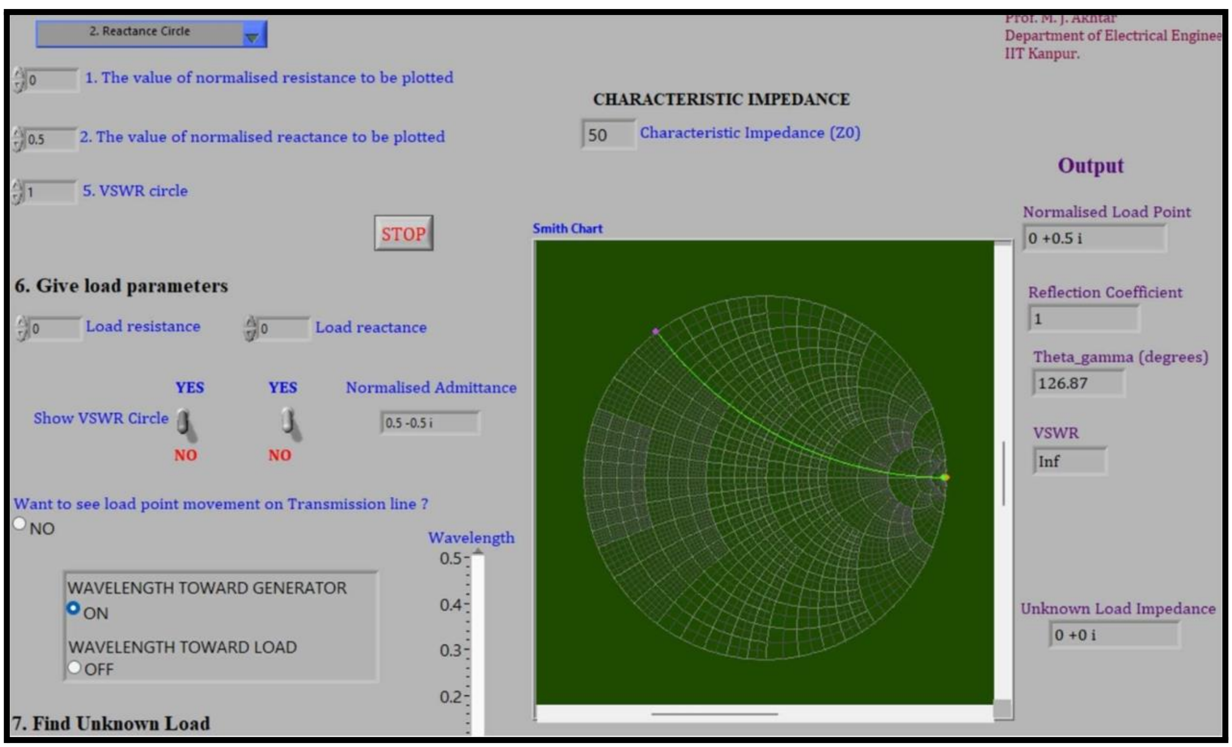
Output:

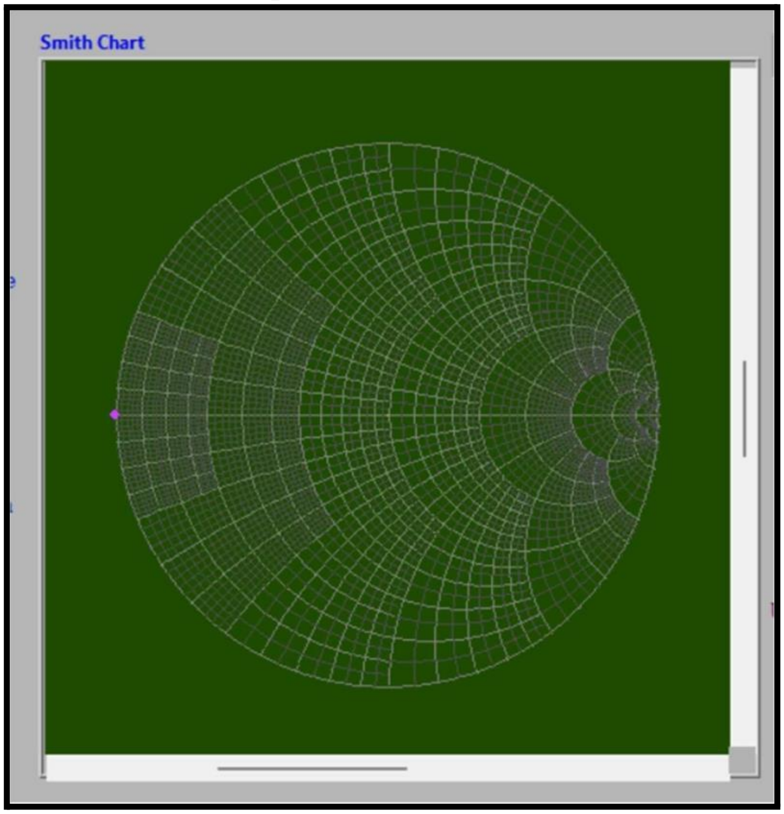
1. Resistance Circle:
   Normalised resistance to be plotted = 0.5



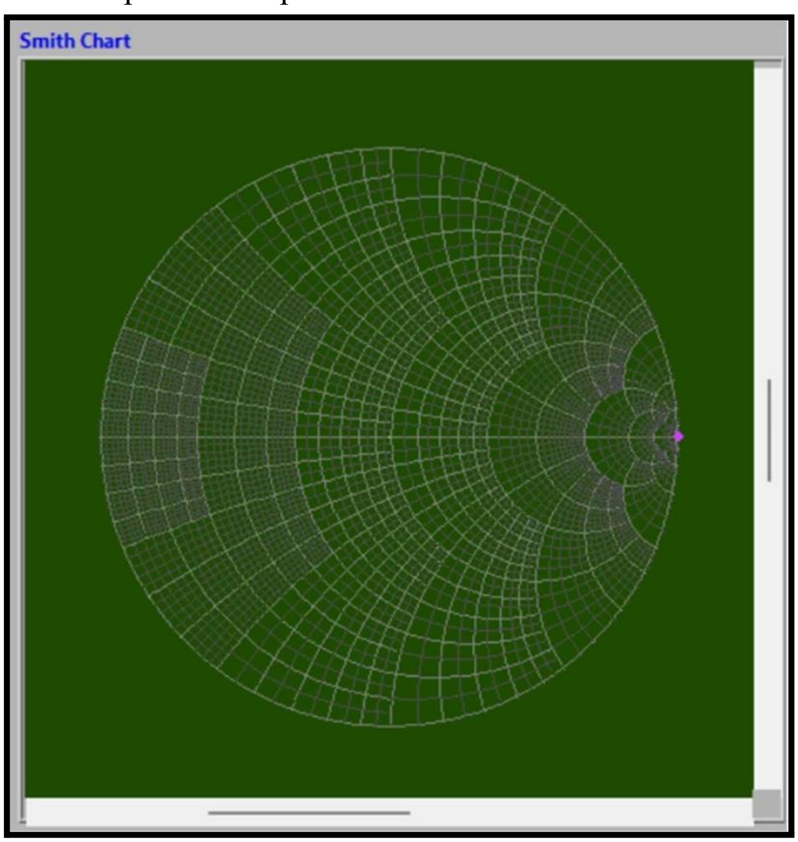
2. Reactance Circle:
   Normalised reactance to be plotted = 0.5



3. Short circuit point:



4. Open circuit point:



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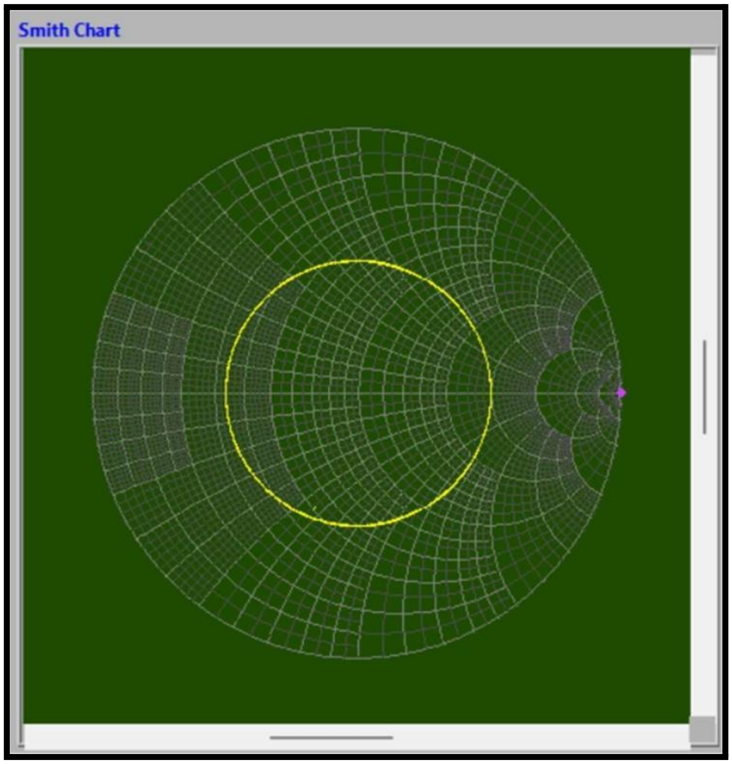
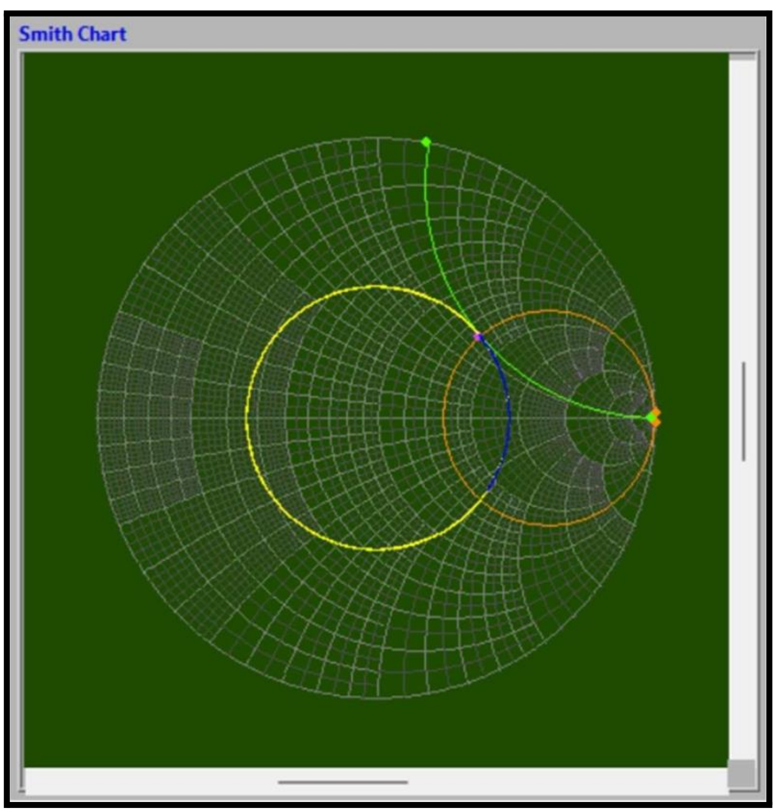
5. VSWR
   circle:
   VSWR = 3

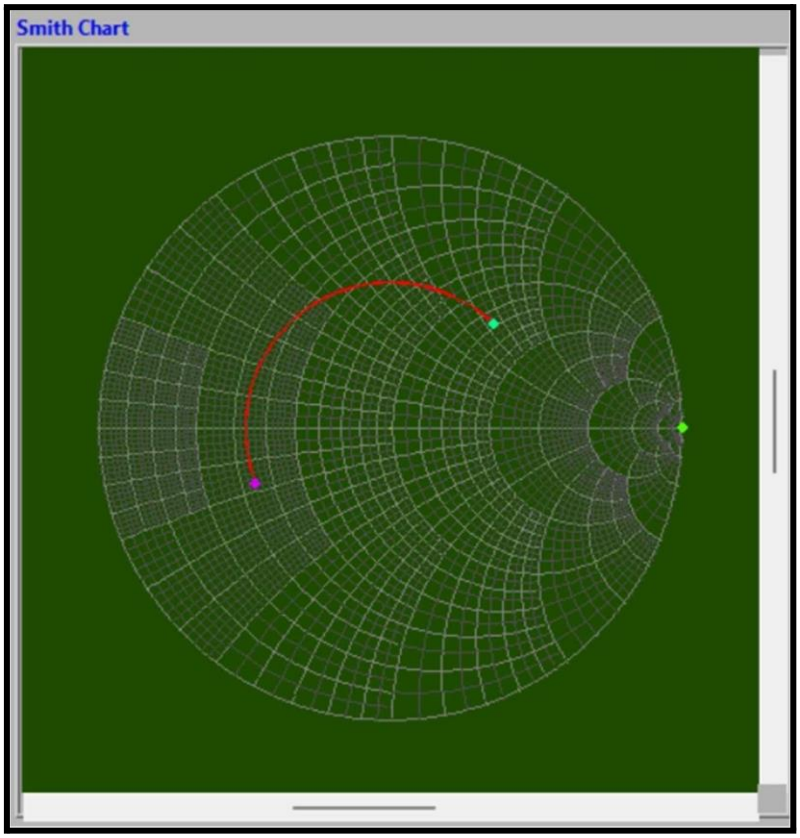


6. Load point:
   $Z_L = (80 + j60)\Omega$; $Z_0 = 50\Omega$



7. Unknown load impedance:

$\Gamma = 0.5 \angle 45^0$



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<u>Conclusion</u> :-

The Smith chart is a vital graphical tool for simplifying transmission line calculations. It visually represents resistance and reactance circles in the Γr-Γi plane, aiding in the determination of input impedance, reflection coefficients, and load impedance. It's particularly valuable for analyzing lossless transmission lines with arbitrary characteristic impedance, using polar coordinates to represent normalized impedance, and featuring VSWR circles.