Batch: A1 Roll No.: 16010322014
Experiment / assignment / tutorial No. 4
Grade: AA / AB / BB / BC / CC / CD /DD
21/9/25
Signature of the Staff In-charge with date

TITLE: Measurement of unknown Impedance by using Smith Chart Method

AIM: To Measure unknown impedance of the given load by using Smith Chart Method

OUTCOME: Analyse microwave passive components for RF measurements
Understand microwave communication system aspects

Purpose:

a) Impedance measurement of any microwave device is important since it decides amount of reflections created by the device.
b) If the impedance of the component is not matched, reflections results in standing wave patterns.
c) Maximum power transfer takes place only when impedance is perfectly matched.

Stepwise-Procedure:

1. Klystron Power Supply Setting:
   Beam Voltage 230-300 V D.C.
   Beam current 20-30 mA.
   Modulation Frequency "FIXED".
   Modulation Signal mode. in "AM" or "INT"
2. Adjust the values of beam voltage to less than 300V and beam current to less than 30mA.
3. Adjust the repeller voltage from power supply for any mode to get max. output on C.R.O.
4. Terminate the slotted wave-guide section with Short circuit plate.
5. Note the distance of first minima from the short load end.
6. The distance between two successive minima is noted.
7. Replace carefully short circuit plate with the horn antenna and again distance of first minima from the load is noted.
8. Note down V_{max} and V_{min} to calculate VSWR.
9. Plot VSWR circle on Smith chart and mark point x.
10. Draw a line passing through center of smith chart and point x. cross section point gives the value of normalized load impedance.

Calculations

$D_1 = 10.85$

$D_1, D_2 = 12.41$

$D = (D_1 - D_2) = \lambda g/2$

$= 2.07 cm$

$V_{max} = 92 mV$

$V_{min} = 52 mV$

$VSWR = \frac{V_{max}}{V_{min}}$

$= \frac{92}{52}$

$= 1.769$

$\lambda g = 2D$

$= 2 \times 2.07$

$= 4.14 cm$

$x = \frac{|D_3 - D_1|}{\lambda g}$

$D_3 < D_1$

$= \frac{|8.15 - 10.35|}{4.14}$

$= \frac{2.2}{4.14}$

$x = 0.531$

Observations:

1. Distance of first minima from the shorted end: D_1 = 10.85.
2. Distance of successive minima from the D1, D2 = 12.41.
3. Distance between two successive minima or maxima: D=(D1-D2) = $\lambda_g / 2$ = 2.07 cm
4. Distance of first minima for the horn antenna (Load): D3 = 8.15.
5. With load find: V_{max}: 92mV ~~V~~.
   V_{min}: 52mV ~~V~~.

Calculations:

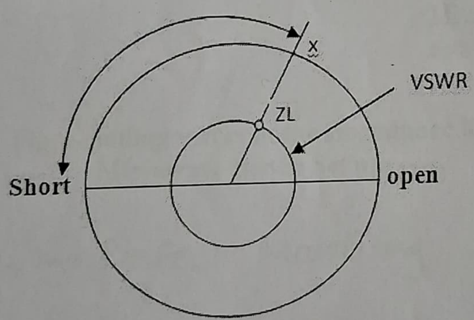
By using Smith Chart:

1. The distance between two successive min

$$D = \lambda_g / 2 \text{ cm}$$

$$\lambda_g = D*2 \text{ cm.}$$

b. The distance of first minima from the short load end is noted (D_1).
c. The distance of first minima from the given load is noted (D3).
d. Measure V_{max} and V_{min} and calculate VSWR = V_{max} / V_{min} (For given load).
e. Calculate x = $|D_3 - D1|/\lambda_g$. Mark this point on the smith chart using towards generator scale if D3 > D_1 else use the towards load scale.



Result:

The impedance of the given component using the Smith Chart = $\bar{Z}_L$= 0.6-0.13j Ω.

$Z_L = \bar{Z}_L \times 50$

$\therefore Z_L = 30 - 6.5j$

Conclusion:
(The conclusion should discuss briefly about results.)

In this experiment, we have measured unknown impedance of given load using Smith Chart. We have observed that from the VSWR obtained VSWR = 1.769, we can see the shifting of point towards the load & $\bar{Z}_L = 0.6 - 0.13j$

$Z_L = \bar{Z}_L \times 50$

$= 30 - 6.5j$

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Post Lab Subjective Questions

1. With examples explain various techniques to achieve impedance matching

Impedance matching means adjusting the source & load impedance so that maximum power is transferred & signal reflections are minimized

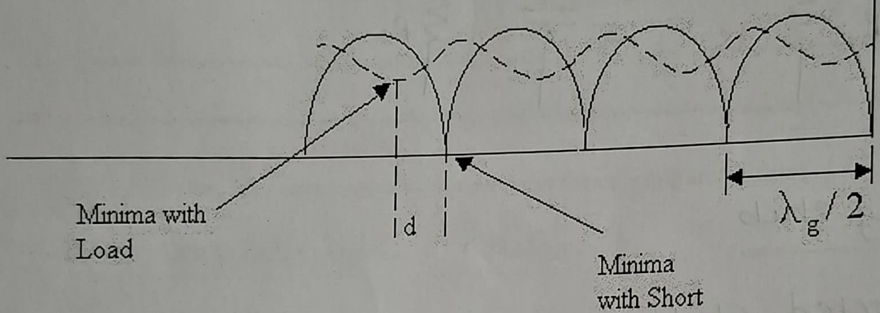


Fig: Standing waves in the Impedance Measurement Microwave Bench Set up:

If $Z_L = Z_0 \rightarrow$ Perfect Matching

$\Gamma = 0$

$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} = 1$

* Prevents signal reflection in transmission lines.
* Improves efficiency & bandwidth.
* maximize power transfer between circuits.

For matching:

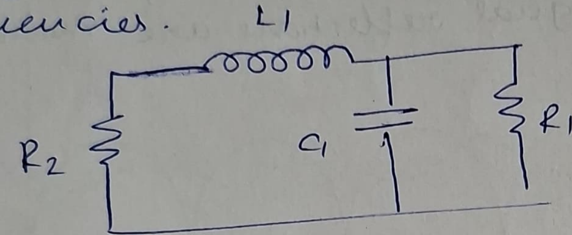
1) Using lumped elements (R, L, C)
2) Quarter wave transformer
3) Stub Matching → series, → shunt

L- Network

The L-Network is one of the most commonly used antenna matching network. Different L-sections exist such as inversted L section networks.

Uses inductors (L) and capacitors (C) to transform impedance

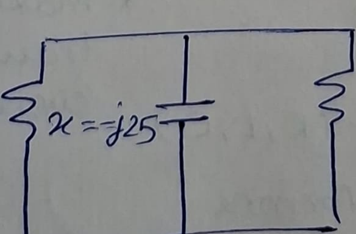
Mostly used in RF circuits & at low to medium frequencies.



Matching stub

The shorted stub can be constructed which can produce reactance of any value. This can act as impedance matching device which cancels reactive part of complex impedance.

Example If $Z = R + j25$ then we need stub of reactance value $-j25\Omega$ to match



$x = j25\Omega$ Stub matching

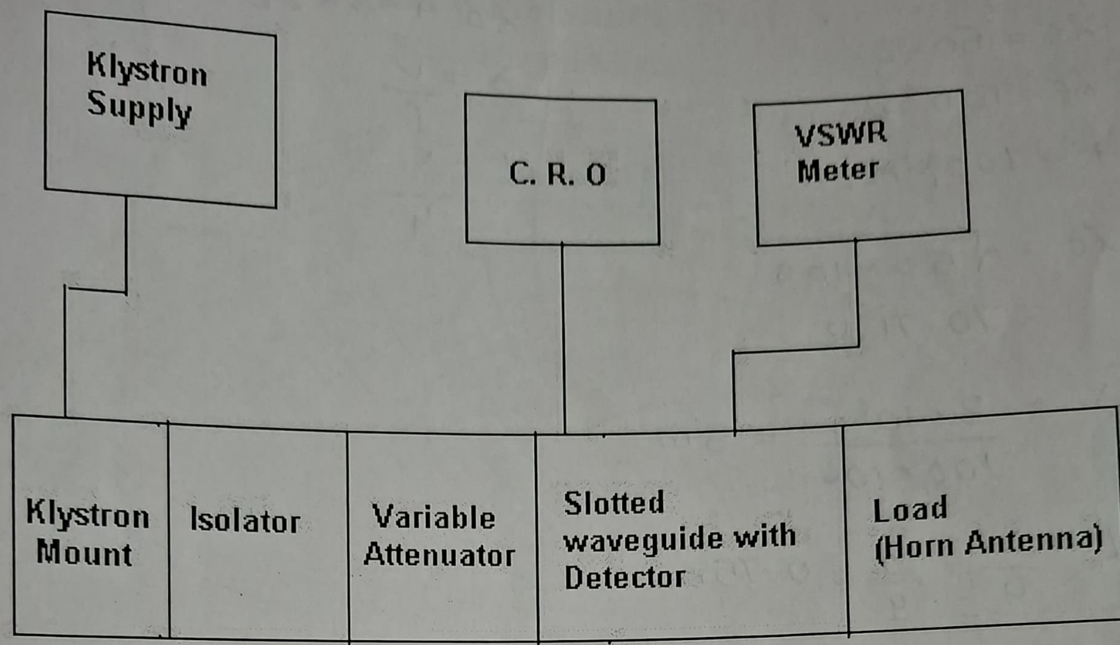
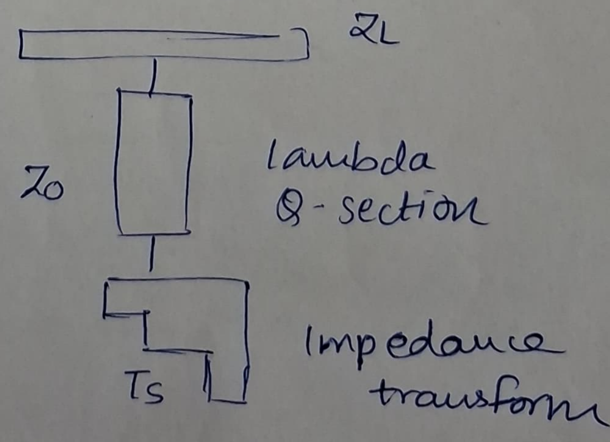


Fig. Measurement of unknown impedance using smith chart

Quarter wavelength transformer:

Transformer can be connected between transformer and antenna load. This is also known as Q-section. The transformer is capable of matching feed line impedance of Z_0 with antenna feed impedance matching transmission line impedance Z_0 should be equal to $(Z_S + Z_r)^{0.5}$



Example

$$Z_0 = \sqrt{Z_S \times Z_L}$$

$$\lambda = \frac{v}{f}$$

$$l = \frac{\lambda}{4}$$

$Z_S = 50\ \Omega$

$Z_L = 100\ \Omega$

$f = 100\,MHz$

$$Z_0 = \sqrt{50 \times 100}$$

$$= 70.71\ \Omega$$

$$\lambda = \frac{3 \times 10^8}{100 \times 10^6} = 3m$$

$$l = \frac{\lambda}{4} = \frac{3}{4} = 0.75m$$

The Complete Smith Chart

Black Magic Design

$\bar{Z}_L = 0.6 - 0.13j$