EXP NO: 3 IMPEDENCE MEASUREMENT BY SLOTTED LINE METHOD

3.1 OBJECTIVE

To measure the impedance of an unknown load using slotted Line.

3.2 HARDWARE REQUIRED

Klystron Power supply, Klystron with mount, Isolator, Frequency meter, Variable attenuator, Slotted section, Movable Short, CRO.

3.3 INTRODUCTION

The simplest method for measurement of impedance at microwave frequencies is as follows. The unknown impedance is connected at the end of a slotted coaxial line. Microwave power is fed from the other end of coaxial line. Unknown impedance reflects a part of this power. This reflection coefficient is measured by probing the standing wave fields in the slotted line by a suitable arrangement. The reflection coefficient is given by

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

Z_L - Load impedance at any point

Z_0 - Characteristics impedance of waveguide at operating frequency

Thus if Γ is measured & Z_0 is known, Z_L can be found. In general Z_L is complex, both magnitude and phase of Γ is needed. The magnitude of Γ may be found from VSWR measurement.

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

The phase of Γ may be found by measuring the distance of first voltage minima from the load. Thus the measurement of impedance involves the measurements of VSWR and the distance of the voltage minima from the load. These measurements may be carried out by using a slotted line and probe arrangement.

3.4 PRELAB QUESTIONS

1. What are the types of methods used in microwave frequencies to measure impedance?
2. Relation-ship between S & P.
3. Define VSWR.
4. Microwave impedance measurement at different frequencies can be achieved with the help of ____
5. A loaded cavity has a lower value of Q factor than an unloaded cavity. Comment.

3.5 EXPERIMENT

3.5.1 EXPERIMENT PROCEDURE

1. Assemble the components as per the circuit diagram
2. After making initial adjustments, mode 3 is set up for operations
3. The frequency of the excited wave is found by adjusting the frequency meter for a dip in the output meter. Thereafter detune the frequency meter slightly
4. The VSWR is found for the given load (horn), by measuring V_{max} and V_{min}.
5. Probe carriage is moved to one reference point. With load-end terminated with the given load, the first minima (X) is noted from the reference point.
6. The given load is replaced with short-circuit, the first minima (Y) or d_1 is noted down from the same reference point. Moving the carriage further determine the successive minima (d_2). i.e., With load - end short circuited, two successive minimas (d_1 and d_2) are found out by moving the probe carriage along the slotted waveguide line.
7. Find the shift (X-Y). Depending on whether the carriage is moved towards the load or source, it will be positive or negative.
8. The impedance of the unknown load is found using smith chart and verified using formula.

Calculation of Impedance using Smith Chart

1. Determine VSWR of the given load from the measurement
2. Draw a VSWR Circle
3. Calculate the shift $\beta\Lambda l$ in terms of wavelength.
4. Locate the shift point from (0,0) moving clockwise (if $\beta\Lambda l$ is negative) or anticlockwise(if $\beta\Lambda l$ is positive) on the circumference.
5. Join the point to the centre of smith chart.
6. The intersection of VSWR circle and the line gives the normalized load impedence (Z_L)

Theoretical Calculations:

Load impedance **(Z_L)** is calculated from the product of normalized impedance and characteristic impedance of slotted line.

OBSERVATIONS AND FORMULA

Observations

$f_o =$

For the Load

$V_{max} =$

$V_{min} =$

$X =$ (First minima from the ref. point)

For the Short

$Y = d_1 =$ (First minima from the ref. point)

$d_2 =$ (successive minima)

FORMULA:

Characteristics Impedance Z_0

$Z_0 = 120\pi / \sqrt{(1-(f_c/f_0))^2}$

$$Z_L = z_o \frac{1 - j(VSWR)\tan\beta\Lambda l}{VSWR - j\tan\beta\Lambda l}$$

$\beta\Lambda l = (X-Y) / \lambda_g$

$F_c \rightarrow$ Cutoff frequency

$F_c = c/\lambda_c$

$\Lambda_c \rightarrow$ Cut off wavelength

$\Lambda_c = 2a$

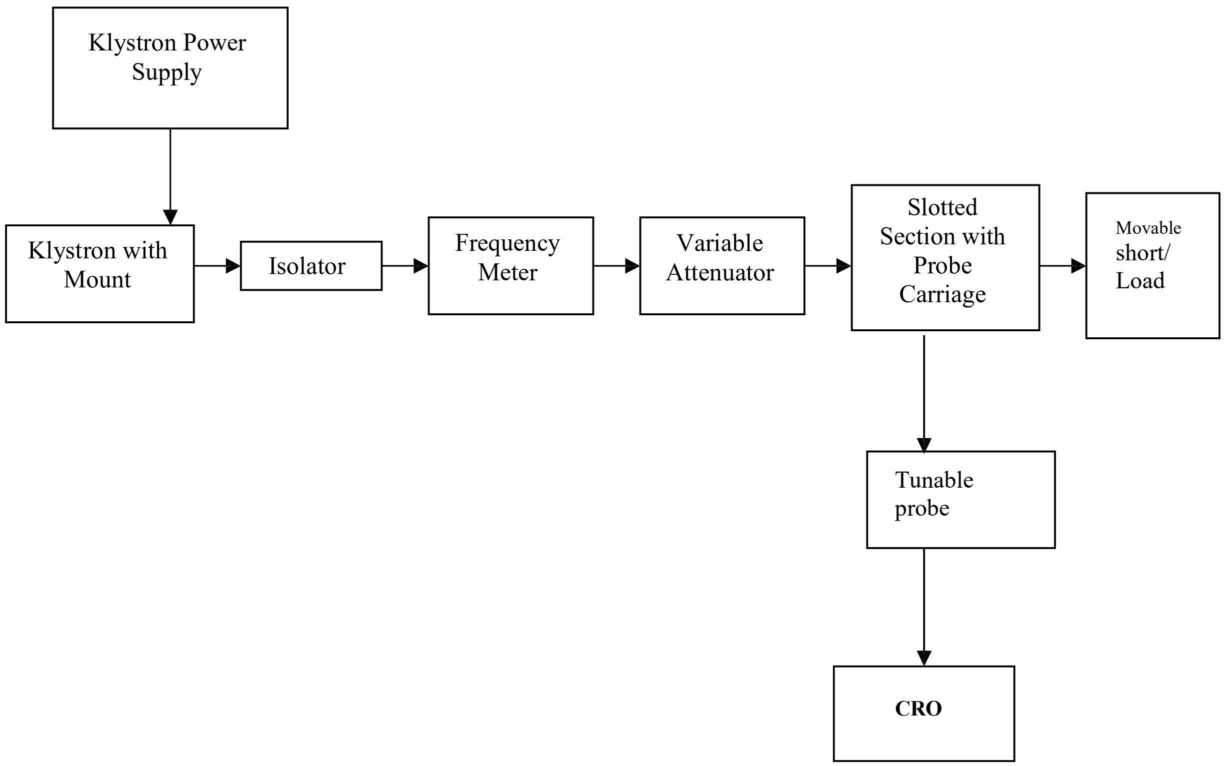
$A \rightarrow$ inner broad dimension of waveguide

$\Lambda_g = 2(d_1 - d_2)$

$VSWR = V_{max}/V_{min}$

3.5.2 BLOCK DIAGRAM

IMPEDANCE MEASUREMENT



3.6 POSTLAB QUESTIONS

1. How will you measure the impedance of the unknown load in the microwave setup bench?
2. What are the application of smith chart?
3. What is the input impedance of the shorted line and open line?
4. The normalized impedance of horn antenna $0.87 + j0.36\Omega$ is obtained from the smith chart and the characteristics impedance of slotted line section is 500Ω. Calculate the following parameters
   a. Frequency of transmission, λ_0, λ_g, VSWR and Z_L.
   b. Identify Z_L is capacitive or reactive.

3.7 RESULT

The impedance of an unknown load was calculated the value was found out to be

From smith chart:

From theoretical calculations: