Batch: A2   Roll No.: 16010322014
Experiment / assignment / tutorial No. 2
Grade: AA / AB / BB / BC / CC / CD /DD

Signature of the Staff In-charge with date 6/8/25

TITLE: Measurement of microwave frequency of test bench setup

AIM: To measure microwave frequency using
   a) **Absorption type frequency meter**
   b) **Slotted wave-guide section**

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

Purpose:

1. Measurement of frequency in microwave range is necessary because various frequency bands are used for different applications.
2. After measurement of frequency one can classify it according to a particular band of frequency like C, X, Ku, Ka etc.
3. All the microwave components and dimensions of wave-guides are designed according to a particular band of frequency and it changes along with the change in the frequency band.

Stepwise-Procedure:

a. Absorption type frequency meter (Direct Method):

Procedure:

1. Klystron Power Supply Setting:
   a) Beam Voltage 230-300 V D.C.
   b) Beam current 20-30 mA.
   c) Modulation Frequency "FIXED".
   d) Modulation Signal mode. in "AM" or "INT"

2. Frequency measurement using Absorption Type Frequency Meter:
   a) Adjust the Repeller voltage and get the maximum signal on the C.R.O.

a) Tune the frequency meter till you get voltage drop on the C.R.O, i.e. the moment at which maximum energy is absorbed by frequency meter cavity.

b) Observe the reading of micrometer position and the corresponding frequency from calibration chart provided with frequency meter.

Note: Use Calibration chart as per the model no. of microwave bench.

b. <u>Frequency measurement using Slotted Wave Guide Section:</u>
1. Replace carefully the matched terminal with the slotted wave-guide section along with the short.
2. Find the distance between the two successive maxima or minima from C.R.O. using venire scale on slotted wave-guide section. This gives us the value of guided wavelength (λ_g) as

λ_g = 2*(distance between the two successive maxima or minima)

<u>Observations:</u>
1. <u>Frequency measurement using Absorption Type Frequency Meter:</u>
   a) Micrometer reading: **9.86** mm.
   b) The corresponding frequency from calibration chart: ~~9.239~~ GHz.
   9.32

2. <u>Frequency measurement using Slotted Wave Guide Section:</u>
   a) Distance between the two successive maxima or minima (d): ~~2.7~~ cm. ~~1.9~~ **2.23**
   b) Broader dimension of wave-guide (a): **2.4** cm.
   c) Guide wavelength (λ_g): ~~5.4~~ cm. ~~3.8~~ **4.46**

Calculations:

a) λ_g = d*2 cm.
b) $(1/\lambda_0)^2 = (1/\lambda_g)^2 + (1/(2a))^2$
c) Find λ_0
d) Freq. f = (c/λ_0) Hz.

Where, λ_g = guide wavelength

λ_0 = free space wavelength

a = broader dimension of wave guide
d = distance between the two successive maxima or minima
c = 3* 10^{10} cm/sec.

Part 1 : F = 9.32 GHz

Part 2 :

$$\left(\frac{1}{\lambda_0}\right)^2 = \left(\frac{1}{\underset{3.8}{\overset{5.4}{}} \, 4.46}\right)^2 + \left(\frac{1}{2(2.41)}\right)^2$$

$$\left(\frac{1}{\lambda_0}\right)^2 = \left(\frac{1}{\underset{3.8}{}5.4}\right)^2 + \left(\frac{1}{4.8}\right)^2$$

$$\frac{1}{\lambda_0^2} = \frac{0.0776}{0.1126} \quad\quad \lambda_0^2 = \frac{1}{0.0776}$$

$$0.095 \quad\quad 0.1126 \quad\quad \lambda_0 = 8.58 \, cm$$

$$0.0995 \quad 3.24$$

Measured values of microwave frequency by both methods given in table below.

Using Absorption Type Frequency Meter	Using Slotted Wave Guide Section
9.32 GHz	8.37 GHz 9.25 GHz

Bench Set-up

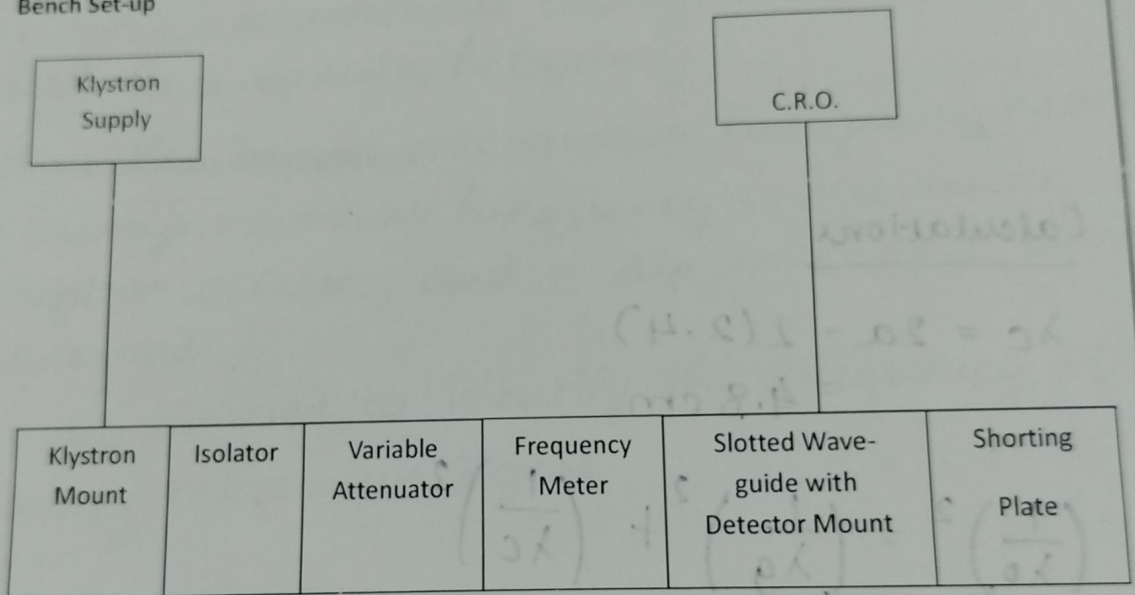| Klystron Supply				C.R.O.	
Klystron Mount	Isolator	Variable Attenuator	Frequency Meter	Slotted Wave-guide with Detector Mount	Shorting Plate

Fig: Set-up for Frequency measurement using Slotted Wave Guide Section/Frequency meter

$$f_i = \left(\frac{c}{\lambda_0}\right)$$

$$= \left(\frac{3 \times 10^8}{3.5 \times 10}\right) = \left(\frac{3 \times 10^8}{3.24 \times 10^{-2}}\right)$$

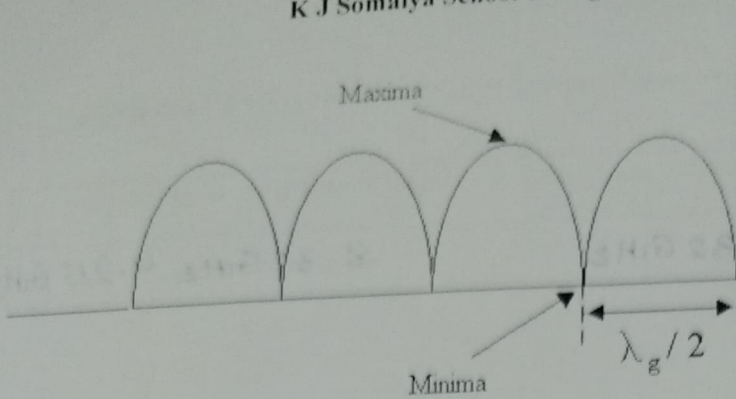$$= 8.37 \, GHz = 9.25 \, GHz$$

Fig: Standing Wave Pattern

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Calculations

$$\lambda_c = 2a = 2(2.4)$$
$$= 4.8 \text{ cm}$$

$$\left(\frac{1}{\lambda_0}\right)^2 = \left(\frac{1}{\lambda_g}\right)^2 + \left(\frac{1}{\lambda_c}\right)^2$$

$$\lambda_0 = ?$$

$$f = \frac{c}{\lambda_0}$$

$Vmax = 12.36 \text{ cm}$ $Vmin = 10.13 \text{ cm}$

$Vmax 1 = 10.3 \text{ cm}$

$Vmin 1 = 7.6 \text{ cm}$

$Vmax 2 = 12.51 \text{ cm}$

$Vmin 2 = 10.2 \text{ cm}$

$Vmax 3 = 14.9 \text{ cm}$

$Vmin 3 = 12.11 \text{ cm}$

$$d = 2.23 = Vmax - Vmin$$
$$\lambda_g = 2d = 2 \times 2.23 = \cancel{5.4 \text{ cm}}$$
$$4.46 \text{ cm}$$

* Theory questions :-

Q1] Explain absorption type microwave frequency meter.

A device used to measure the frequency of microwave signals. It operates on the principle of resonant absorption.

Working Principle

a) It contains a resonant cavity / absorber circuit tuned to a specific frequency.

b) When the input microwave frequency matches the cavity's resonant frequency, maximum absorption occurs, and a dip in output power is observed.

c) This dip is used to identify the frequency of the incoming microwave signal.

Features

- Non - invasive
- Accurate within the tuning range of cavity.
- Typically used in waveguide systems.

Applications

Common in microwave labs & radar systems to verify signal frequency.

Q2] Explain Slotted wave guide section.

A device used to measure microwave frequency to analyze standing wave patterns within a waveguide. The waveguide has a longitudinal slot along it's length, allowing access to the EM fields inside. A movable probe / detector is inserted through the slot to sample the electric field at different points along the waveguide.

As, the probe moves along the slot, it detects variations in the electric field intensity, which correspond to the standing wave pattern created by the interaction of incident & reflected waves within the waveguide. By measuring the distance between successive maxima / minima of the standing wave, the wavelength of microwave signal can be determined. The microwave frequency (f) is then calculated.

* Conclusion

In this experiment, we have measured frequency using 2 types of measurement methods, namely Absorption type frequency meter method & slotted waveguide section method & analyzed microwave passive components for RF measurements while performing the experiment. Absorption type frequency meter method → 9.32 GHz & slotted waveguide section method → 8.37GHz so, difference arises because of lower accuracy compared to precise standing wave measurement in slotted waveguide.