Experiment - 7: Microwave Measurements

1. Aim: To measure the microwave frequency, guided wavelength and VSWR

2. Requirements

- Klystron Power Supply.
- Klystron Tube with Klystron Mount
- Isolator
- Frequency Meter
- Variable Attenuator
- Detector Mount
- VSWR meter or CRO
- Waveguide Stand and BNC cable

3. Pre-experiment Exercise

Brief Theory

The measurement of frequency is often a necessary part of microwave investigations. Direct reading type frequency meter is used to measure the frequency. The heart of this frequency meter is the resonant cavity and for any particular cavity size, a single frequency resonance will be “supported”. The cavity has a small window such allow some energy to enter. The energy is often said to be absorbed by the cavity, and hence the name “Absorption Type”.

Maximum absorption takes place when the cavity is tuned exactly to the frequency of the energy to be measured. For greatest accuracy, Q of the cavity is made very high, often as high as 10,000. It indicates that the tuned circuit is extremely sharp, absorbing a maximum of the energy at the exact frequency and much less at slightly different frequencies. At exact dial setting, where the maximum or peak absorption takes place, an accurate frequency measurement can be made. The indicating meter in the circuit indicates the energy level and shows a drop in energy level the moment energy is absorbed by the frequency meter cavity.

A frequency measurement would therefore, consist of tuning the cavity of the frequency meter until maximum "dip" occurs on the indicating meter and then reading the corresponding frequency from the frequency meter.

The wavelength of microwaves varies from medium in which it travels. Similarly the guided wavelength depends upon its internal dimensions. The guided wave length and free space wavelength are related by the equation,

$$\left(\frac{1}{\lambda_g}\right)^2 - \left(\frac{1}{\lambda_0}\right)^2 = \left(\frac{1}{2a}\right)^2 \tag{1}$$

where
λ_g = guided wavelength, λ_0 = free space wavelength, a = width of the waveguide

Frequency f can be obtained using the Direct reading type frequency meter. Thus we can find operating wavelength λ_0 using $\lambda_0=c/f$. Now substituting λ_0 in equation (1), we can find λ_g, where the longest dimension a of the waveguide is known to us. Also, λ_g can be practically determined by the following method. If the distance d between the two minimas on the standing wave pattern is measured, then $\lambda_g / 2 = d$.

For measurement of low VSWR, we use the detector probe carriage to determine the minimum and maximum standing wave voltage along the waveguide. The waveguide is assumed to be terminated appropriately. VSWR is determined as

$$VSWR = \frac{V_{max}}{V_{min}} \tag{2}$$

4. Laboratory Exercise

Precautions: Before firing the reflex klystron, the following points should be borne in mind:

1. During the operation of reflex klystron, the repeller does not carry any current and as such it may be severely damaged by electron bombardment. To protect the repeller from such damage, *the repeller negative voltage is always applied before anode voltage*. Also, the repeller voltage should be varied in one direction to avoid hysteresis in reflex klystron.
2. Switch ON the cooling fan before firing the reflex klystron.
3. While measuring power, the frequency meter should be *detuned* each time because there is a dip in the power when frequency meter is tuned.

Procedure:

1. Set up the components and equipments as shown in Fig.1
2. Keep position of variable attenuator at min.attenuation position
3. Set mode selector switch to AM –MOD position.
4. 'ON' the Klystron Power Supply and Oscilloscope
5. 'ON' beam voltage switch and set beam voltage to 300 V on beam voltage control knob.
6. By changing the reflector voltage and amplitude of FM modulation any mode of Klystron tube can be seen on Oscilloscope
7. Now adjust the direct reading frequency meter till you observe a dip in power on VSWR meter on CRO The position on the frequency meter indicates the microwave frequency. Measure and record this frequency.
8. Calculate λ_0 using the relation $\lambda_0 = c/f$.
9. Calculate λ_g using equation (1) where a = 2.286 cm.
10. Verify the above value of λ_g by the following experimental procedure.
    a. Move the plunger on the slotted line till you get minimum deflection on the VSWR meter or minimum voltage on CRO. Note down this reading in cm. Let it be X.
    b. Now move the plunger further till you get second minimum. Let it be Y. Now, $\lambda_g/2$ = X-Y = d. Therefore, $\lambda_g = 2d$.
11. Record the maximum and minimum voltage along the guide and determine the VSWR using equation (2).

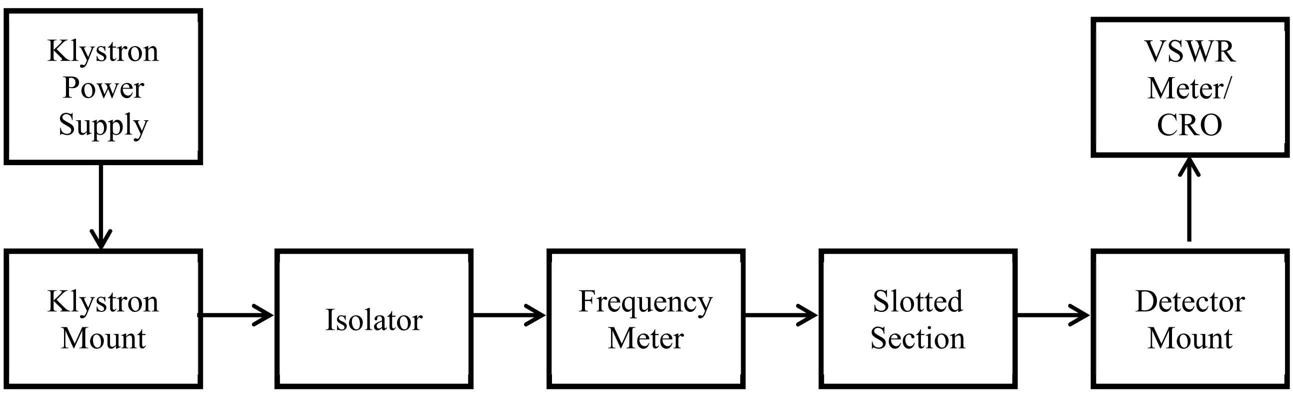

Fig.1. Set-up for Measurement of Guide Wavelength

4.2 Observations:

Sr. No.	**Parameter**	**Measured values**	**Calculated values**	$\%\text{Error} = \left\lvert \dfrac{\textbf{Experimental Value} - \textbf{Theoretical Value}}{\textbf{Theoretical Value}} \right\rvert \times 10$
1.	Frequency			
2.	Free space wavelength			
3.	First min/max position X		–	
4.	Second min/max position Y		–	
5.	Third min/max position Y (if any)		--	
6.	Guide wavelength			
7.	V_{max}		–	
8.	V_{min}		–	
9	VSWR		–	

5. Post Experiment Exercise:

5.1 Conclusion/Comments

5.2 Questions:

1. Explain the operation of Two cavity Klystron with a neat labelled diagram.
2. Derive the expression for velocity modulation in two cavity Klystron
3. Define guided velocity and phase velocity.