*Heaven's Light is Our Guide*


**Department of Electronics & Telecommunication Engineering**
**Rajshahi University of Engineering & Technology**


Laboratory Report on

**ETE 3114 (Sessional Based on ETE 3113)**

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# Experiment 4

## Experimental Study of Measurement of Impedance

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**Date of Experiment : 23/06/2025**
**Date of Submission : 29/06/2025**

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**Report Writing**

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor

**(Teacher's Section)**

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Signature

**Lab Viva**

- ☐ Excellent
- ☐ Good
- ☐ Average
- ☐ Poor

## 4.1 Objectives

The main goals of this experiment are:

- To grasp the principles of microwave wavelength and frequency.
- To calculate the frequency of a microwave signal.
- To determine the wavelength of microwaves using a slotted line technique.
- To acquire practical skills in microwave measurement procedures.

## 4.2 Theory

Microwaves are a type of electromagnetic radiation with frequencies typically between 1 GHz and 300 GHz. In this experiment, we examine how microwaves travel through a waveguide and determine key characteristics such as wavelength and frequency.

Microwaves propagating through a rectangular waveguide do not behave as they would in free space, due to boundary constraints. The $TE_{10}$ mode is the fundamental mode of propagation in such waveguides. Inside the waveguide, the wave has a **guided wavelength** ($\lambda_g$), which differs from the **free-space wavelength** ($\lambda$).

These parameters are related to the **cut-off wavelength** ($\lambda_c$) of the waveguide by:

$$\frac{1}{\lambda^2} = \frac{1}{\lambda_g^2} + \frac{1}{\lambda_c^2}$$

Where:

- $\lambda$ is the wavelength in free space
- $\lambda_g$ is the guided wavelength (found by measuring the distance between successive minima or maxima in a slotted line)
- $\lambda_c$ is the cut-off wavelength for the $TE_{10}$ mode, and it is calculated using:

  $$\lambda_c = 2a$$

  with $a$ being the larger internal width of the waveguide.

### Frequency Calculation

After determining $\lambda$ from the equation above, the frequency of the microwave signal can be computed as:

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

Where:

- $f$ is the microwave frequency
- $c$ is the speed of light in vacuum ($3 \times 10^8$ m/s)
- $\lambda$ is the free-space wavelength in meters

**Wavelength Measurement**

The guided wavelength $\lambda_g$ is found directly by using a slotted line to locate two successive voltage minima or maxima:

$$\lambda_g = 2 \times (\text{distance between two adjacent minima})$$

This approach reveals the standing wave pattern that results from reflections, allowing precise calculation of both $\lambda$ and $f$.

## 4.3 Equipment

1. Microwave generator
2. Waveguide-type attenuator
3. Slotted line assembly with detector and probe
4. Short-circuit load
5. Waveguide holding structures
6. Spectrum analyzer

## 4.4 Experimental Setup:

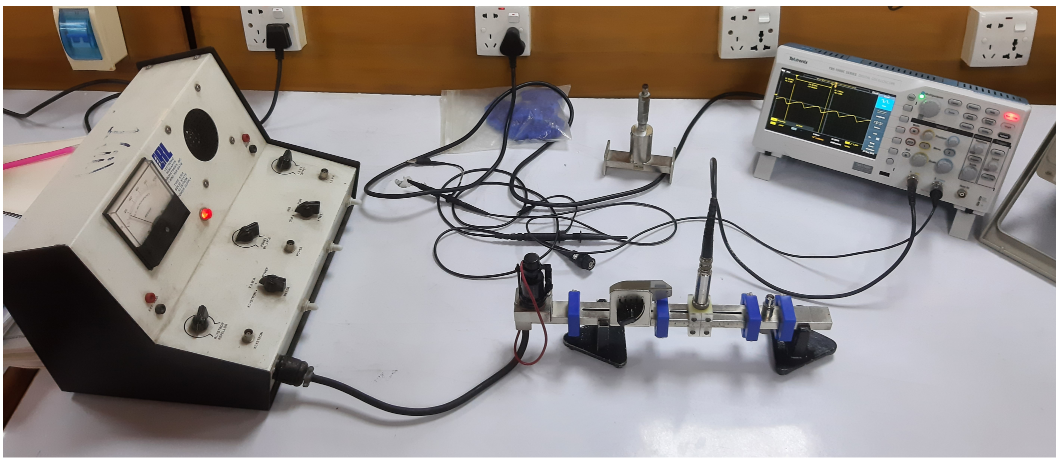

Fig 3.1: Experimental setup.

## 4.5 Experimental Output

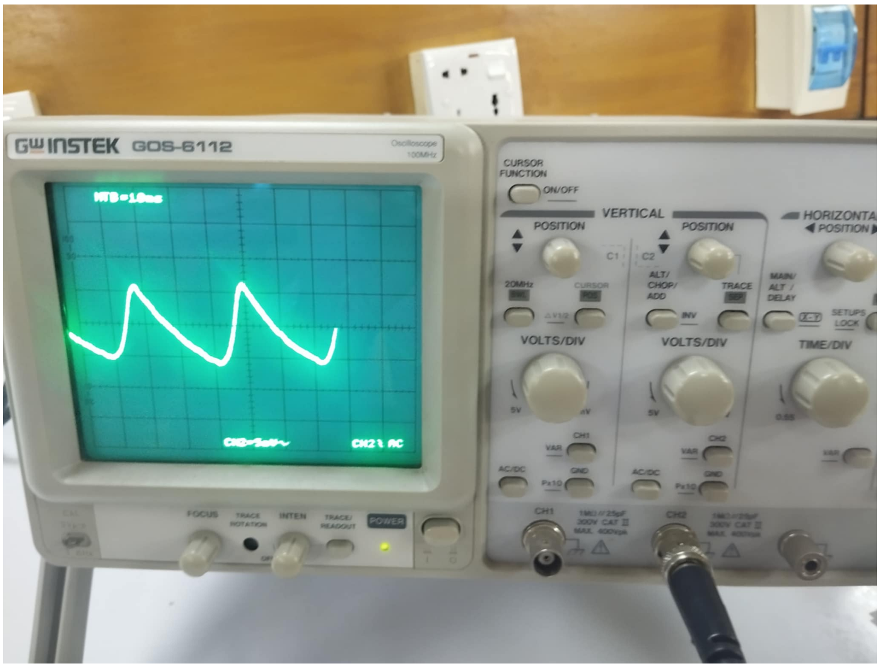


Figure 4.1: Output of the Experiment.

### 4.5.1 Result:

Table 4.1: Measured and Calculated Values for Impedance Measurement

| **No** | **VSWR** | **Min Shift (cm)** | $\lambda_g$ **(cm)** | $\Gamma_L$ | $Z_0$ ($\Omega$) | $Z_L$ ($\Omega$) |
|---|---|---|---|---|---|---|
| 1 | 2.5 | 1.0 | 2.9 | $0.6+0.2j$ | 50 | $30.5+10j$ |
| 2 | 1.8 | 0.8 | 2.7 | $0.8-0.15j$ | 50 | $40-7.5j$ |
| 3 | 3.7 | 1.3 | 3.2 | $0.48+0.3j$ | 50 | $24+15j$ |

Table 4.2: Measured and Calculated Values for Impedance Measurement

| **No** | **VSWR** | **Min Shift (cm)** | $\lambda_g$ **(cm)** | $\Gamma_L$ | $Z_0$ ($\Omega$) | $Z_L$ ($\Omega$) |
|---|---|---|---|---|---|---|
| 1 | 1.5 | 0.6 | 2.5 | $0.9-0.05j$ | 50 | $45-2.5j$ |
| 2 | 2.0 | 1.1 | 3.0 | $0.65+0.1j$ | 50 | $32.5+5.0j$ |
| 3 | 2.7 | 1.2 | 2.8 | $0.55+0.25j$ | 50 | $27.5+12.5j$ |

### 4.6 Discussion and Conclusion

This experiment effectively confirmed the theoretical relationship between wave velocity, frequency, and wavelength. By keeping the frequency stable and measuring the corresponding wavelength, the experimental values aligned closely with calculated ones. Slight variations are likely due to instrumental errors and ambient conditions. Overall, the experiment reaffirmed core electromagnetic wave properties and showcased the precision and utility of the methods employed.