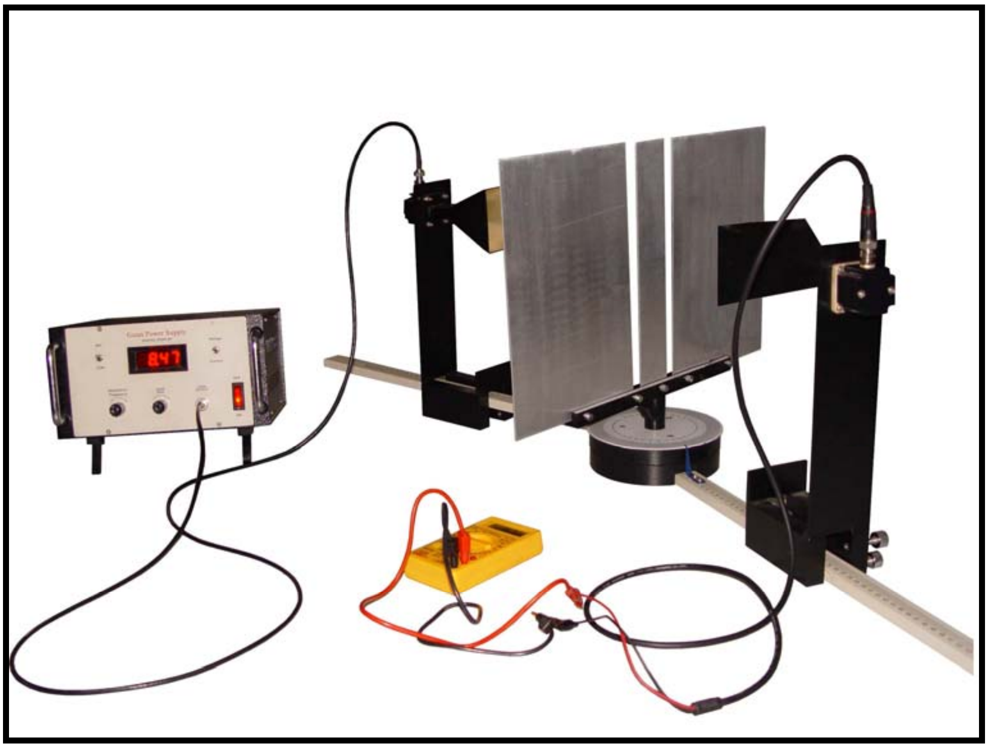
INSTRUCTION MANUAL FOR
MICROWAVE OPTICS SYSTEM



MICROWAVE APPARATUS

INTRODUCTION:

Microwave apparatus is used for study of Wave Phenomenon of the radiation produced, because its properties are very similar to those of light. This apparatus is designed for the students to understand and learn the basic concepts of wave phenomenon. Students use this kit for demonstration of the Standing Wave, Reflection, Refraction, Polarization, Interference and Diffraction phenomenon.

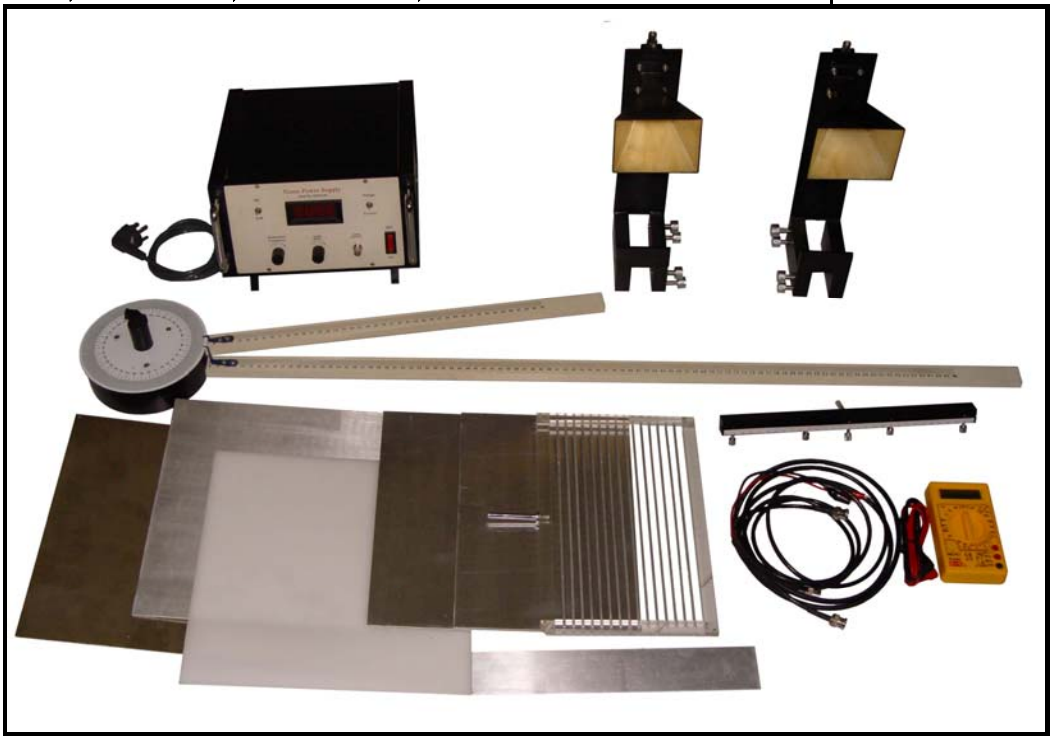


Figure 1: Microwave Optics System

TECHNICAL SPECIFICATIONS:

Microwave Transmitter,	01
Gunn Diode Power Supply, 110V AC	01
Microwave Receiver,	01
Goniometer Scale,	01
Aluminum Reflectors size 200x300mm,	02
Aluminum Reflectors size 50x300mm,	01
Aluminum Reflectors size 300x300mm,	01
Acrylic Reflectors size 300x300x3mm,	01
Semi-Silvered reflector size 300x300mm	01
Polarizing Grill size 190x300mm,	01
Digital Multi-meter,	01

LIST OF EXPERIMENTS:

1. To study the Microwave Optics System.
2. To study the Reflection in Microwave (Incident angle = Reflected angle).
3. To study the Refraction in Microwave (Snell's Law).
4. To study the Polarization on Microwave.
5. To study the Double Slit Interference in Microwave.
6. To study the Single Slit Diffraction Phenomena.

1: TO STUDY THE MICROWAVE OPTICS SYSTEM

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Digital Multi-meter,	01

PURPOSE:

This experiment gives a systematic introduction to the Microwave Optics System.

PROCEDURE:

1. Arrange the Transmitter and Receiver on the Goniometer as shown in Figure 1.3 with the Transmitter attached to the fixed arm. Be sure to adjust both Transmitter and Receiver to the same polarity. The horns should have the same line of orientation, as shown in figure 1.1.
2. Plug in the one end of BNC cable to Transmitter and other end to Gunn Power Supply and selection switch on the INT and Voltage.
3. Plug in the one end of BNC cable to Receiver and other end to Digital Multi-meter.

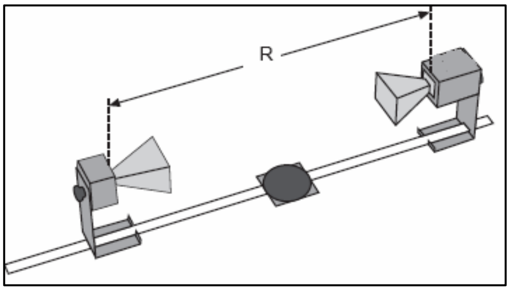


Figure 1.1

4. Adjust the Transmitter and Receiver so the distance between the source diode in the Transmitter and the detector diode in the Receiver (the distance labeled R in Figure 1.1) is 40 cm (see Figure 1.2 for location of points of transmission and reception).

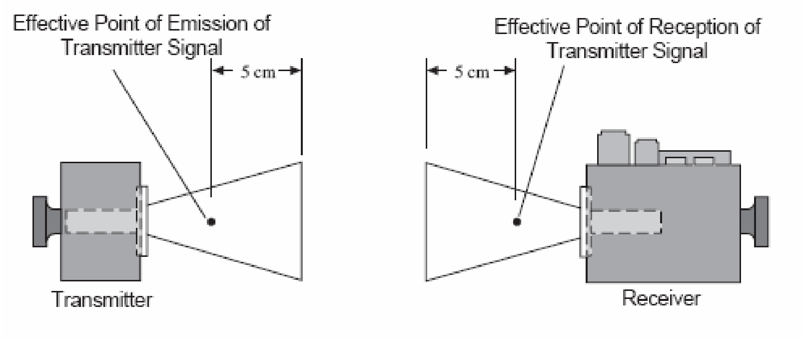


Figure 1.2

5. Adjust the selection knob of digital multi-meter at DC mV Range.
6. Adjust the Gunn Bias of Gunn Power Supply (i.e 8.5 volt) such that Multi-meter read the maximum reading (i.e 30 mV).
7. Set the distance R to each of the values shown in Table 1.1. For each value of R, record the meter reading. (Do not adjust the Gunn Bias voltage between measurements.) After making the measurements, perform the calculations shown in the table.

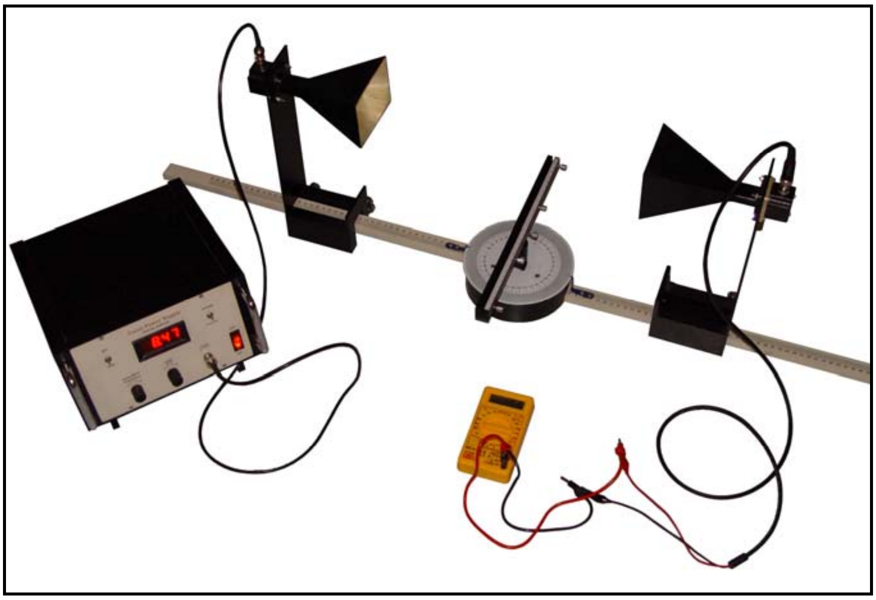


Figure 1.3

Table 1.1

S.No.	**R (cm)**	**Multi-Meter Reading I (mV)**	**IxR**	**IxR^2**
1	40			
2	50			
3	60			
4	70			
5	80			
6	90			
7	100			

8. Set R to some value between 70 and 90 cm. While watching the multi-meter reading, slowly decrease the distance between the Transmitter and Receiver. Does the meter deflection increase steadily as the distance decreases?

IMPORTANT: Reflections from nearby objects, including the table top, can affect the results of your microwave experiments. To reduce the effects of extraneous reflections, keep your experiment table clear of all objects, especially metal objects, other than those components required for the current experiment.

9. Rotate the Receiver end as shown in Figure 1.4. This varies the polarity of maximum detection. (Look into the receiver horn and notice the alignment of the detector diode.) Observe the meter readings through a full 360 degree rotation of the horn. At what polarity does the Receiver detect no signal?

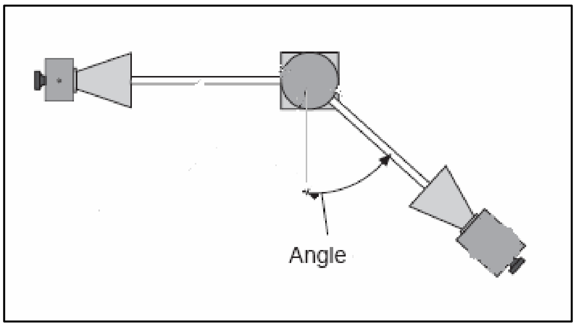


Figure 1.4

10. Try rotating the Transmitter horn end as well. When finished, reset the Transmitter and Receiver so their polarities match (e.g., both horns are horizontal and both horns are vertical).
11. Rotatable arm of the Goniometer as shown in the figure 1.4. Set the angle of rotation (measured relative to the 180-degree point on the degree scale) to each of the values shown in Table 1.2, and record the meter reading at each setting.

Table 1.2

S.No.	Angle of Receiver	Multi-Meter Reading I (mV)
1	0	
2	10	
3	20	
4	30	
5	40	
6	50	
7	60	

ANALYSIS:

1. The electric field of an electromagnetic wave is inversely proportional to the distance from the wave source (i.e., E = 1/R).
2. The intensity of an electromagnetic wave is inversely proportional to the square of the distance from the wave source (i.e., I = 1/R2).
3. Considering your results in tale 1.2, to what extent can the Transmitter output be considered a spherical wave? - A plane wave?

2: TO STUDY THE MICROWAVE REFLECTION PHENOMENON

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Aluminum Reflector (300x300mm)	01
Semi-Silvered Reflector (300x300mm)	01
Slit Holder	01
Digital Multi-meter,	01

PURPOSE:

Study the Microwave Optics Reflection Phenomenon (Angle of Incidence = Angle of Reflection).

PROCEDURE:

1. Arrange the equipment as shown in figure 2.1 with the Transmitter attached to the fixed arm of the Goniometer. Be sure to adjust the Transmitter and Receiver to the same polarity; the horns should have the same orientation as shown.

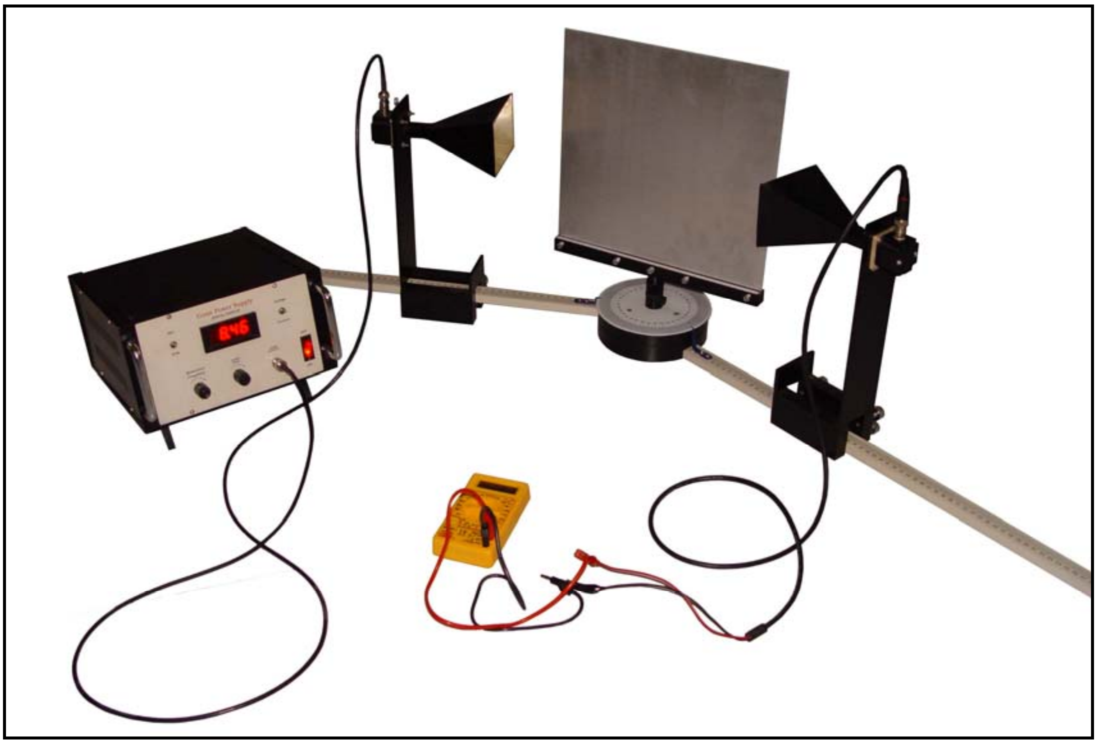


Figure 2.1

2. Plug in the Transmitter and turn the Multimeter at Receiver end to mV.
3. The angle between the incident wave from the Transmitter and a line normal to the plane of the Reflector is called the Angle of Incidence (see Figure 2.2). Adjust the Rotating Component Holder so that the Angle of Incidence equals 45-degrees.

4. Without moving the Transmitter or the Reflector, rotate the movable arm of the Goniometer until the meter reading is a maximum. The angle between the axis of the Receiver horn and a line normal to the plane of the Reflector is called the Angle of Reflection.
5. Measure and record the angle of reflection for each of the angles of incidence shown in Table 2.1.

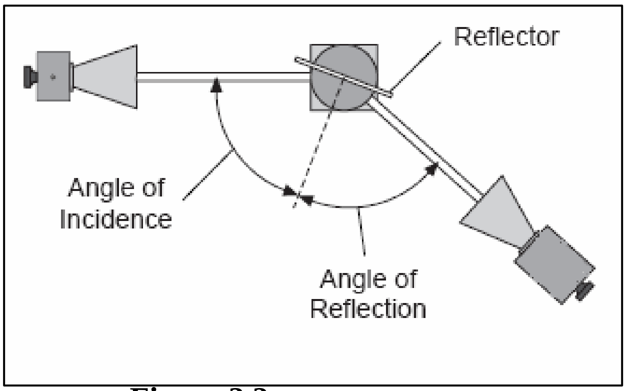


Figure 2.2

Table 2.1

S.No.	Angle of Incident	Angle of Reflection
1	20	
2	30	
3	40	
4	50	
5	60	

NOTE: *At various angle settings the Receiver will detect both the reflected wave and the wave coming directly from the Transmitter, thus giving misleading results. Determine the angles for which this is true and mark the data collected at these angles with an asterisk "*".*

3: TO STUDY THE MICROWAVE REFRACTION PHENOMENON

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Acrylic Reflector (300x300mm)	01
Slit Holder	01
Digital Multi-meter,	01

PURPOSE:

Study the Microwave Optics Refraction Phenomenon (Snell's Law).

INTRODUCTION

An electromagnetic wave usually travels in a straight line. When, wave crosses a boundary between two different media, the direction of propagation of the wave changes. This change in direction is called Refraction, and it is summarized by a mathematical relationship known as the Law of Refraction (otherwise known as Snell's Law):

$$n_1 \sin\theta_1 = n_2 \sin\theta_2;$$

Where,

θ_1: is the angle between the direction of propagation of the incident wave and the normal to the boundary between the two media, and

θ_2: is the corresponding angle for the refracted wave (see Figure 3.1).

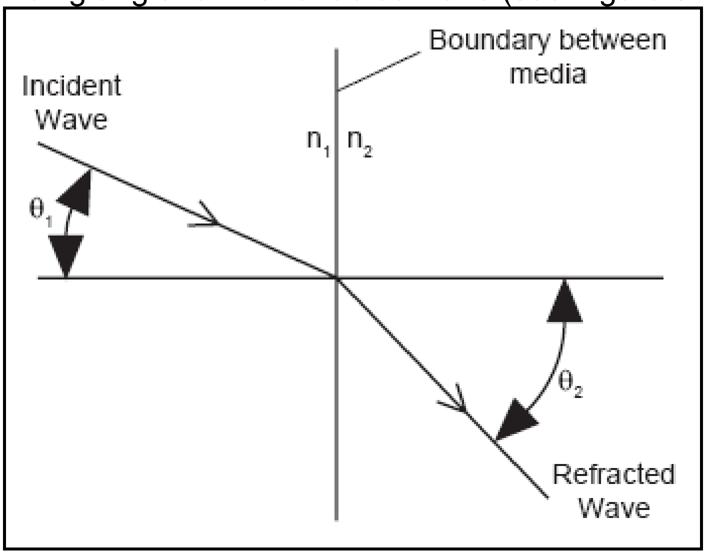


Figure 3.1: **Angles of Incidence and Refraction**

Every material can be described by a number n, called its Index of Refraction. This number indicates the ratio between the speed of electromagnetic waves in vacuum and the speed of electromagnetic waves in the material, also called the medium. In general, the media on either side of a boundary will have different indices of refraction. Here they are labeled n_1 and n_2. It is the difference between indices of refraction (and the difference between wave velocities this implies) which causes "bending", or refraction of a wave as it crosses the boundary between two distinct media. In this experiment, you will use the law of refraction to measure the index of refraction for Acrylic Plate.

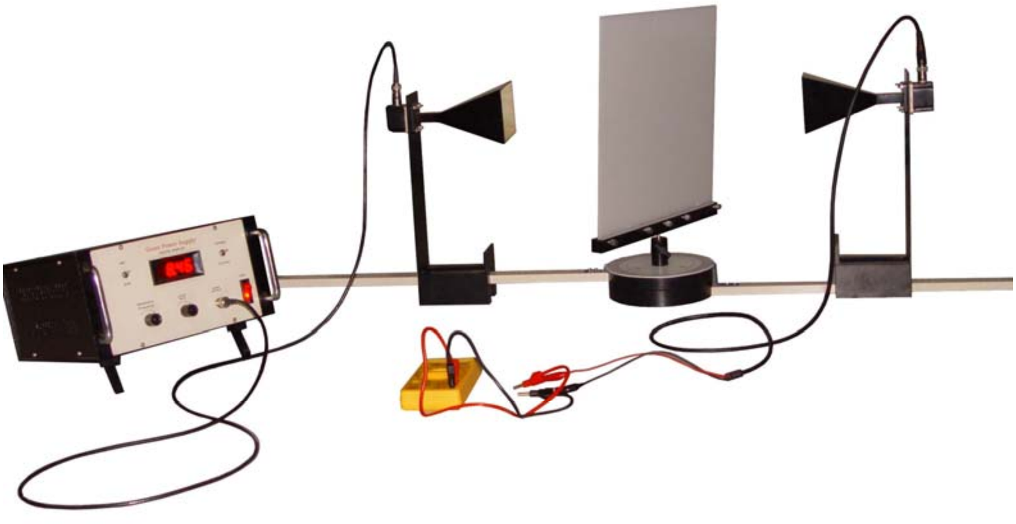


Figure 3.2

PROCEDURE:

1. Set–up the experiment as shown in figure 3.2. Arrange the reflector on goniometer scale. Rotate the reflector and see how it affects the incident wave. Does it reflect, refract, or absorb the wave?
2. Rotate the movable arm of the Goniometer and locate the angle θ at which the refracted signal is a maximum.

NOTE: *θ is just the angle that you read directly from the Degree Scale of the Goniometer.*

3. Measure the angle of incidence θ_1.
4. Measure the angle of refraction θ_2.
5. Plug these values into the Law of Refraction to determine the value of n_1/n_2.

n_1/n_2 = ___________________________.

6. The index of refraction for air is equal to 1.00. Use this fact to determine n_1, the index of refraction for the reflector plate.

4: TO STUDY THE MICROWAVE POLARIZATION PHENOMENON

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Polarizing Grill (190x300mm)	01
Digital Multi-meter,	01

PURPOSE:

Study the Microwave Optics Polarization Phenomenon.

INTRODUCTION:

The microwave radiation from the Transmitter is linearly polarized along the Transmitter diode axis (i.e., as the radiation propagates through space, its electric field remains aligned with the axis of the diode). If the Transmitter diode were aligned vertically, the electric field of the transmitted wave would be vertically polarized, as shown in Figure 4.1.

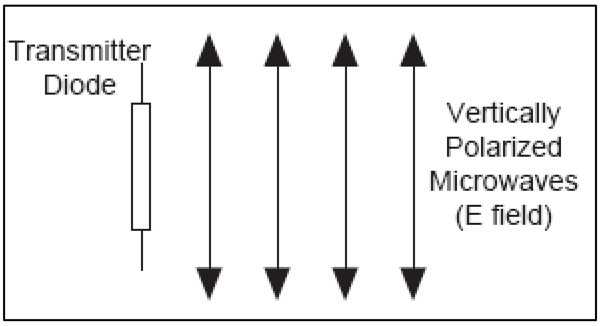


Figure 2.1: Vertical Polarization

If the detector diode were at an angle θ to the Transmitter diode, as shown in Figure 4.2, it would only detect the component of the incident electric field that was aligned along its axis. In this experiment you will investigate the phenomenon of polarization and discover how a polarizer can be used to alter the polarization of microwave radiation.

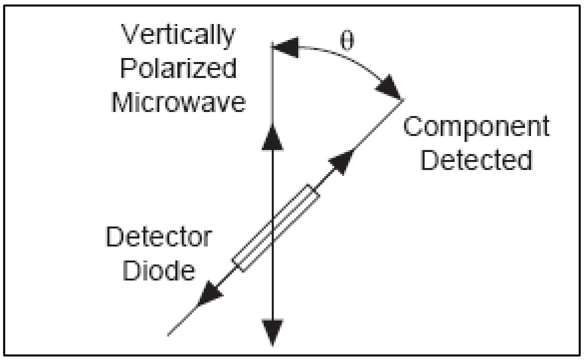


Figure 4.2: Detecting Polarized Radiation

PROCEDURE:

1. Arrange the equipment as shown in Figure 4.3 and adjust the Receiver controls for nearly full-scale meter deflection.
2. Record the meter reading with the Polarizer slits horizontal, vertical, and at 45^0 degree

Table 4.1

S.No.	Angle of Polarizing Grill	Multi-meter Reading
1	Horizontal	
2	Vertical	
3	45^0	

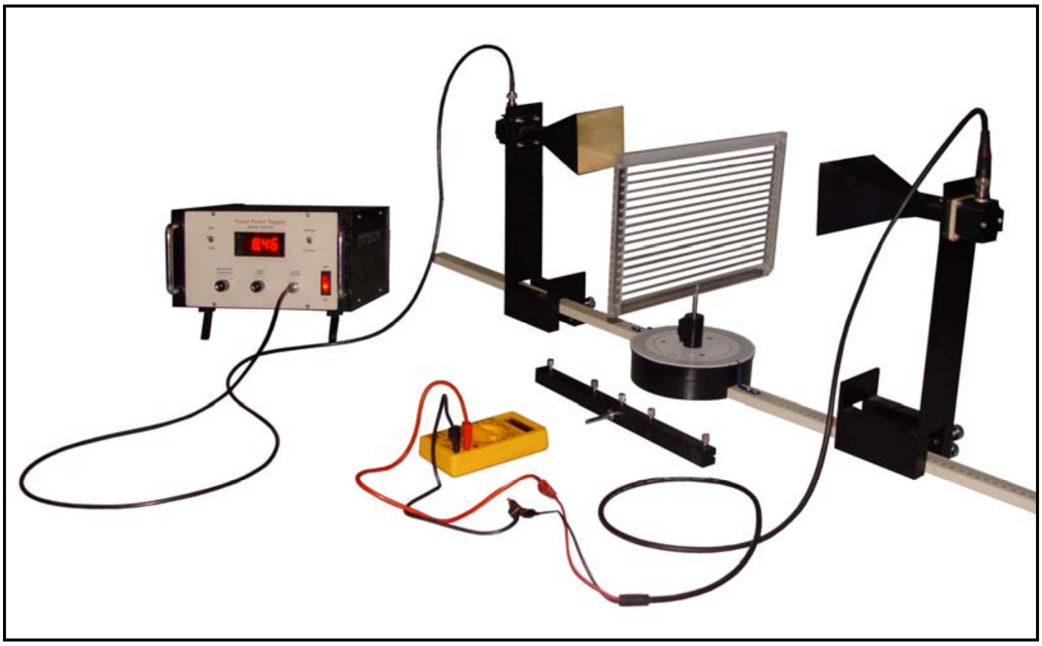


Figure 4.3: Equipment Set-Up

5. TO STUDY THE MICROWAVE DOUBLE SLIT INTERFERENCE PHENOMENON

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Aluminum Reflector (200x300mm)	02
Aluminum Reflectors size 50x300mm,	01
Digital Multi-meter,	01

PURPOSE:

Study the Microwave Optics Single slit Interference Phenomenon.

INTRODUCTION:

The wave nature of light demonstrated more clearly than in the phenomenon of interference. Many kinds of wave's exhibit interference: light waves, sound waves, water waves, Microwave and so on. The underlying physics is relatively simple: when several different waves arrive at the same point in space at the same time, they pass right through each other. But at the point where the waves overlap, the total wave strength there is just the sum of the individual waves' strengths at that point. We say that these waves obey the superposition principle.

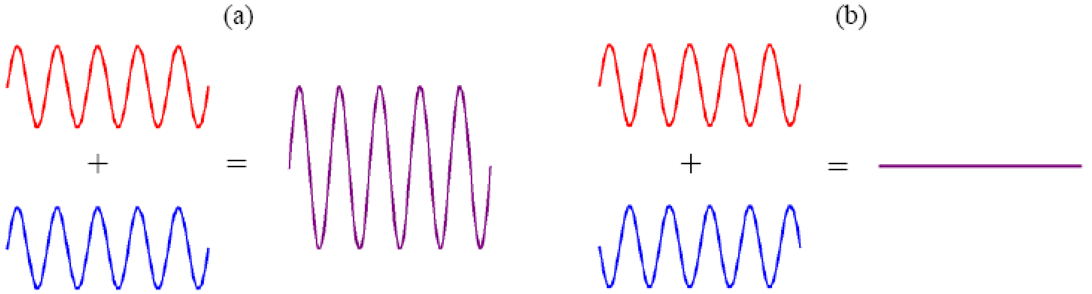


Figure 5.1

The two waves moving in opposite directions can superpose to create a standing wave pattern. A somewhat similar phenomenon occurs when an electromagnetic wave passes through a two-slit aperture. The wave diffracts into two waves which superpose in the space beyond the apertures. Similar to the standing wave pattern, there are points in space where maxima are formed and others where minima are formed. With a double slit aperture, the intensity of the wave beyond the aperture will vary depending on the angle of detection. For two thin slits separated by a distance d, maxima will be found at angles such that

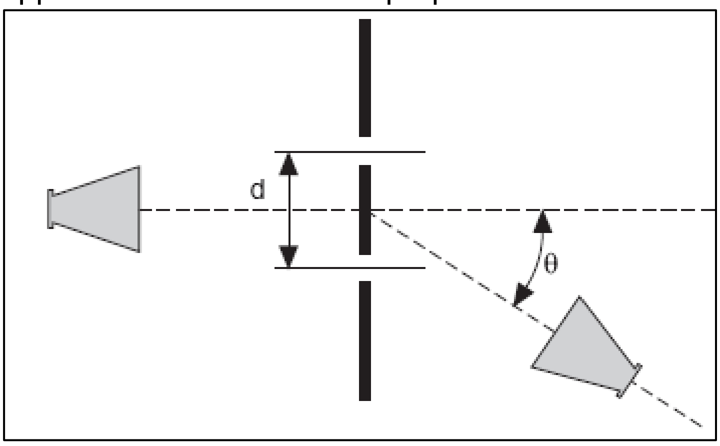


Figure 5.2: Double-Slit Interference

$$d \sin\theta = n\lambda$$

Where θ = the angle of detection, λ = the wavelength of the incident radiation, and n is any integer. Refer to a textbook for more information about the nature of the double-slit diffraction pattern.

PROCEDURE:

1. Arrange the equipment as shown in Figure 5.3. Use the Slit Extender Arm, two Reflectors, and the Narrow Slit Spacer to construct the double slit. (We recommend a slit width of about 1.5 cm.) Be precise with the alignment of the slit and make the setup as symmetrical as possible.
2. Adjust the Transmitter and Receiver for vertical polarization (0°) and adjust the Receiver controls to give a full-scale reading (Multi-meter Reading) at the lowest possible amplification.

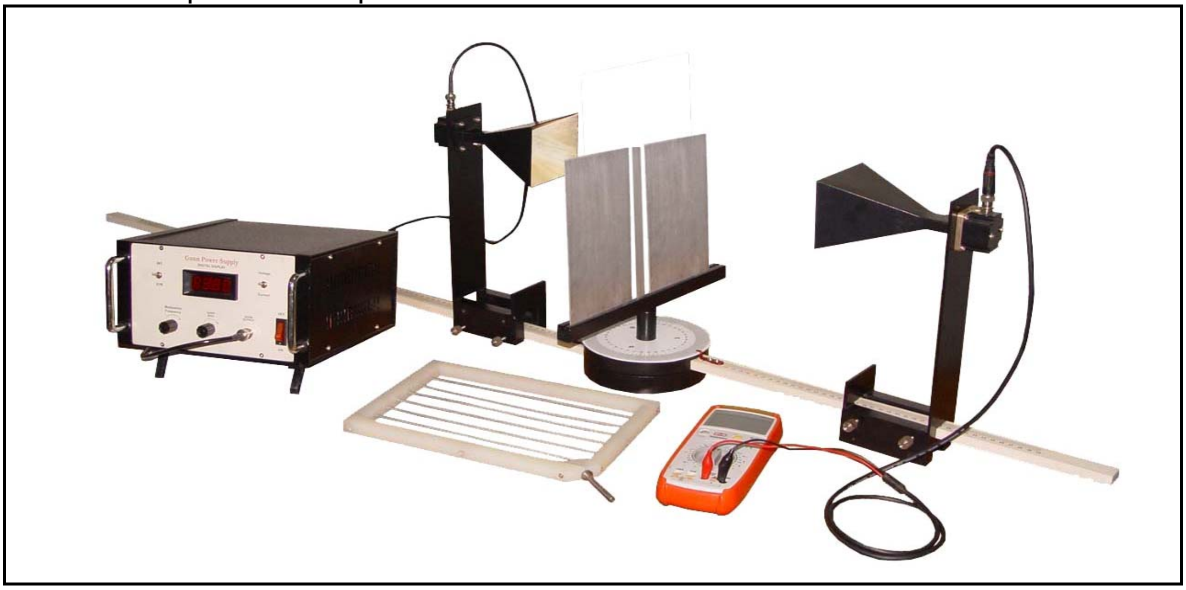


Figure 5.3 Equipment Setup

3. Rotate the rotatable Goniometer arm (on which the Receiver rests) slowly about its axis. Observe the meter readings.
4. Reset the Goniometer arm so the Receiver directly faces the Transmitter. Adjust the Receiver controls to obtain a meter reading. Now set the angle θ to each of the values shown in Table5.1. At each setting record the meter reading in the table. (In places where the meter reading changes significantly between angle settings, you may find it useful to investigate the signal level at intermediate angles.)

Table5.1

S.No.	Angle	Multi-meter Reading
1	0	
2	5	
3	10	

6: TO STUDY THE MICROWAVE SINGLE SLIT DIFFRACTION

COMPONENT REQUIRED:

Microwave Transmitter,	01
Gunn Diode Power Supply,	01
Microwave Receiver,	01
Goniometer Scale,	01
Reflector (200x300mm)	02
Digital Multi-meter,	01

PURPOSE:

Study the Microwave Optics Single Slit Diffraction Phenomenon.

THEORY OF SPHERICAL WAVELETS

In the late eighteenth century, Christian Huygens postulated the wavelet theory of electromagnetic wave propagation. This theory states that each point on a wave front acts as the source of an elemental, spherically expanding wavelet, and all of the wavelets add in proper phase to form the succeeding wave front of the propagating wave. This theory explains a variety of transverse-polarized waves, including plane and spherical waves. When a small aperture in a metal screen is illuminated, the wavelets in this aperture cause a spherically expanding wave. If a slit, narrow in one dimension, is illuminated by a plane wave, a cylindrically-expanding wave results whose axis lies in the long dimension of the slit.

PROCEDURE

1. Set up the apparatus as shown in 6.1 but with the transmitter moved forward on the fixed arm so its horn aperture is over the turntable disc pivot, and with the receiver fully back on the rotatable arm.
2. Slide the single slit horn cover fully-down on the transmitter horn and note the decreased signal.
3. Slowly rotate the receiver unit and rotatable arm off axis as in the previous Procedure for the open horn. The signal level will decrease off-axis since the slit has some directivity but the pattern lobe will be much broader than that measured for the open horn. Plot the receiver meter reading vs. angle off axis every 5 degrees on graph paper for the power pattern.
4. Change the slit widths and see the radiation pattern.

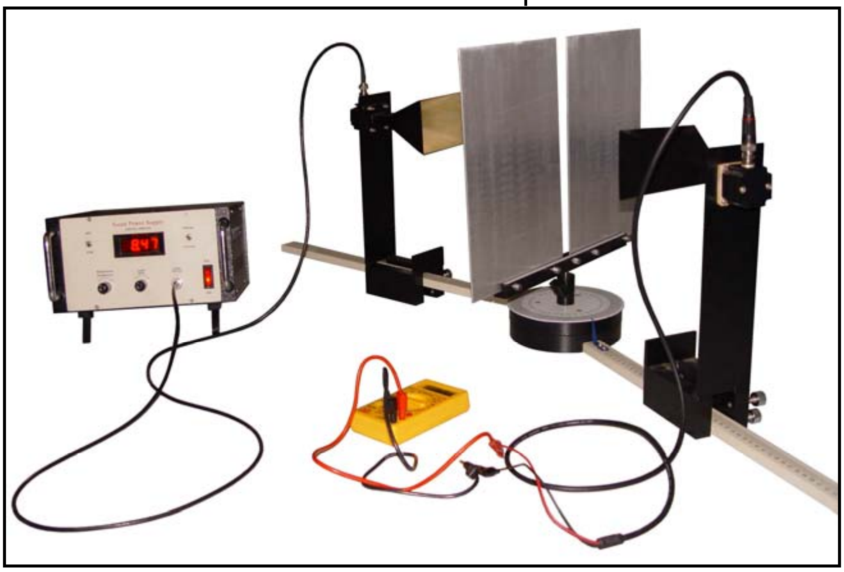


Figure6.1: Equipment Setup