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Experimental Verification of Microwave Phenomena

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EXPERIMENTAL VERIFICATION OF MICROWAVE PHENOMENA

Strictly as per the compliance and regulations of :

Experimental Verification of Microwave Phenomena

Md. Maruf Morshed [α] & Md. Mannaf Hossain [σ]

Abstract - This paper deals with experimental evaluation and verification of different parameters of microwave signal, widely used in mobile cellular communication, TV, Radar, satellite and others point to point communication, all over the world. To achieve the experimental results Microwave Communication Base (Electronic Communications) of LJ Group is used. With introduction of microwave this project paper also contains experiments of beam width, reflection, diffraction, interference, and effect by polarization grill, penetration properties of materials, and benefits of using waveguides and behavior of microwave in a dielectric.

I. Introduction

Microwaves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas. Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct of each other, towers that are far apart need to be very tall. The curvature of the earth as well as other blocking obstacles do not allow two short towers to communicate using microwaves. Repeaters are often needed for long-distance communication. Very high-frequency microwave cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings. The microwave band is relatively wide. Therefore wider sub-bands can be assigned and a high data rate is possible. Use of certain portions of the band requires permission from authorities. [1]

II. Applications Of Microwaves

- Hundreds of satellites circle the earth and each one has a specific task - to exchange information many millions of times a day between itself and microwave transmitters and receivers on the earth. Satellites are used for satellite TV, data transmission, global positioning, transmission of infra-red and visible light pictures for weather forecasting, as well as forming part of the world wide telephone network.
- Mobile telephones use microwaves to transmit and receive from the local hub. This is sometimes called cellular mobile radio telephony.
- RADAR (Radio Detection And Ranging) is used by shipping in our busy sea lanes; aircraft and air traffic control use Radar to determine position information. Radar is also used for military purposes (for which it was first developed during World War II).
- Meteorologists use Radar Systems and Satellite Communications to detect and track weather systems around the globe & also used in aeronautics to determine the altitude of aircraft. This works in a similar way to Radar by measuring the time taken for a transmitted pulse to be reflected back.
- Microwaves are electromagnetic waves that have very high frequencies and very short wavelengths. The phenomena of microwaves arc as old as the early history of radio, yet the number of potential uses for microwaves is vast.
- The major area of microwave research and development today is in radar and guided missile telemetering applications. Microwaves are also used extensively in satellite programs and private industry. Additional uses include television, telephone and teletype applications.
- Microwaves have gained new prominence in the field of voice transmission. Microwave relay links have been developed and which are more convenient and in some cases, more economical than using telephone lines. In the future, microwave relay links could eventually replace the enormous network system of telephone lines and poles. [2]

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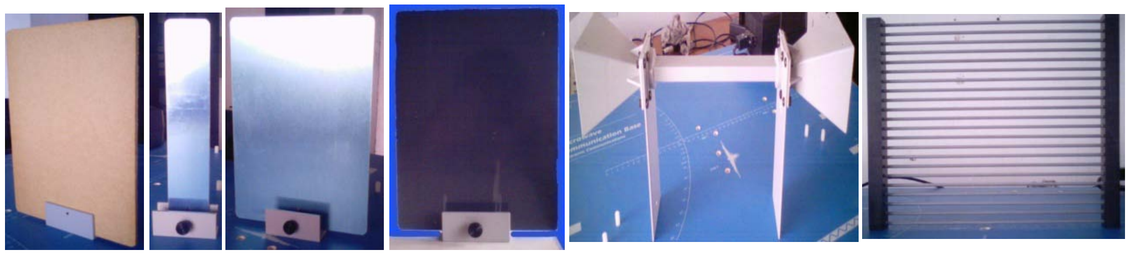
III. Require Equipments



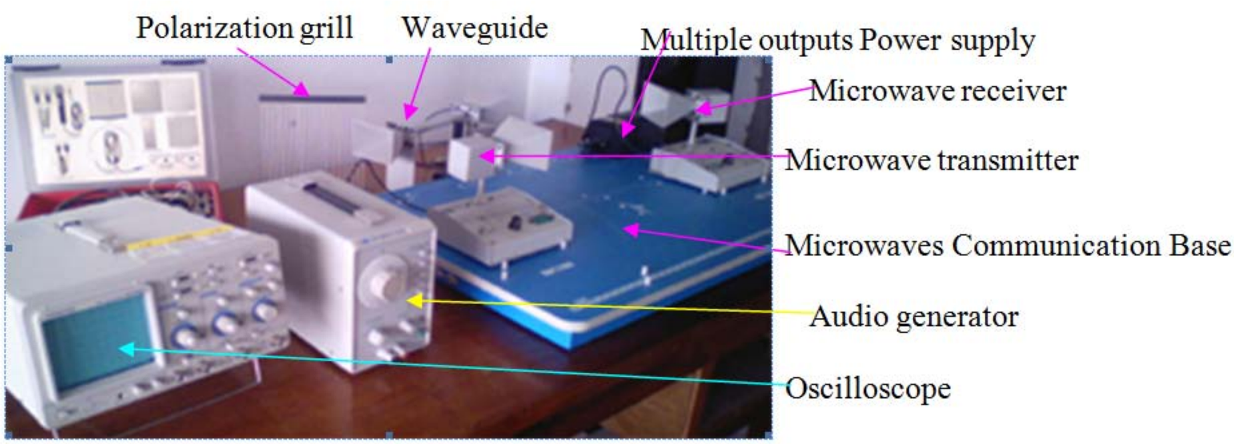


Figure 1.2 : Total arrangement of require equipments for examine the phenomena of Microwave

Experiment No. 01

a) Name of the Experiment

Measuring the beam width of the microwave transmitter antenna using the graduations on the semi-circular line.

b) Objectives

After completed this experiment we will be able to:

1. Identify the terms radiation pattern, beam width and directionality,
2. Investigate the microwave pattern produced.

c) Procedure

Connect the system as shown in fig1.Set switch to1KHz tone generator of microwave transmitter. Set the receiver switches as shown in fig.2.

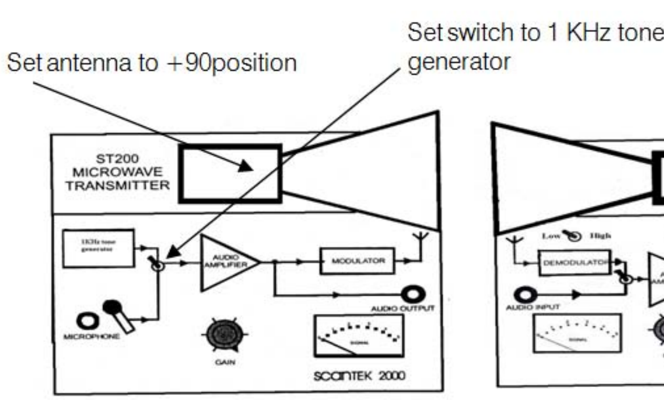


Figure 1 : Position of transmitter section

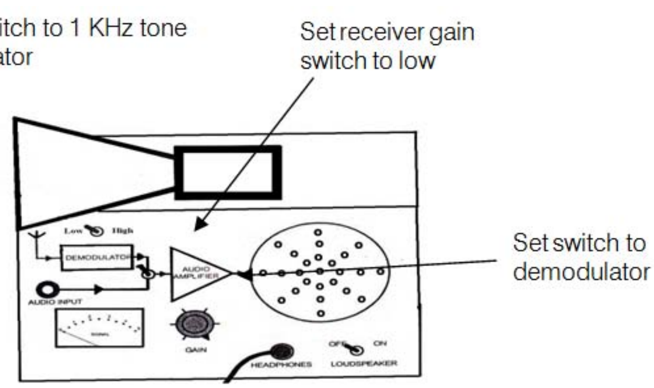


Figure 2 : Position of receiver section

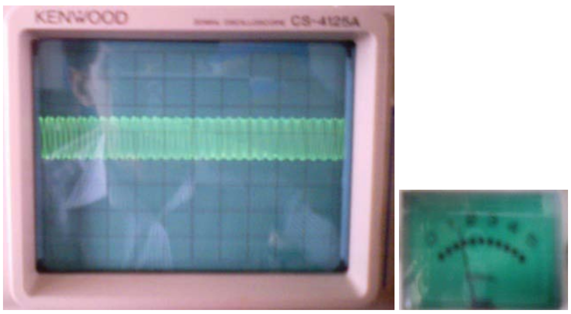


Figure 3 : Input signal fixed in 1.3 volt (pick to pick.)

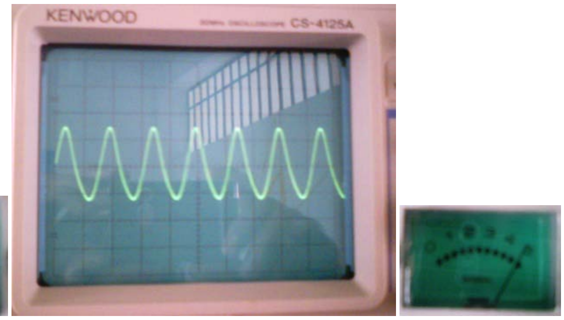


Figure 4 : Output signal 6.8volt (pick to pick.)

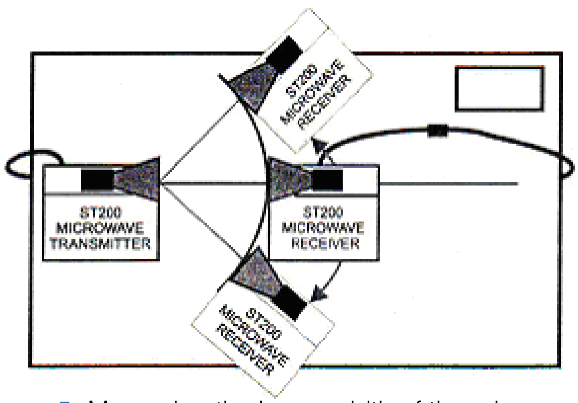


Figure 5 : Measuring the beam width of the microwave transmitter by moving the receiver around the transmitter on the semi-circular line

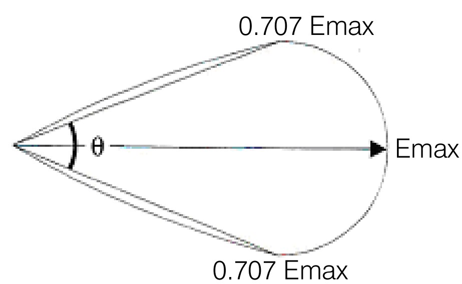


Figure 6 : Directional radiation pattern

Figure 7 : Original Photographs of Move the Receiver around the Transmitter on the Semi-Circular Line

Experiment No. 02

a) Name of the Experiment

Investigate the reflection of microwave signals.

b) Objectives

After completed this we will be able to know how:

1. The necessary conditions for the reflection of microwaves,
2. The concept of microwave reflection to specific materials,
3. The reflection of microwave signal.

c) Procedure

Locate the transmitter in position A and receiver in position B. Make sure the power leads are connected correctly. Put the plastic sheet, hard board, wide metal plate, narrow metal (approximately 3.5 cm wide) into the support stand at position SAT 3 on the base board. Ensure the metal plate is vertical. Adjust the angle of the transmitter and receiver antennas so that they are both directed at SAT3. Switch on the power.

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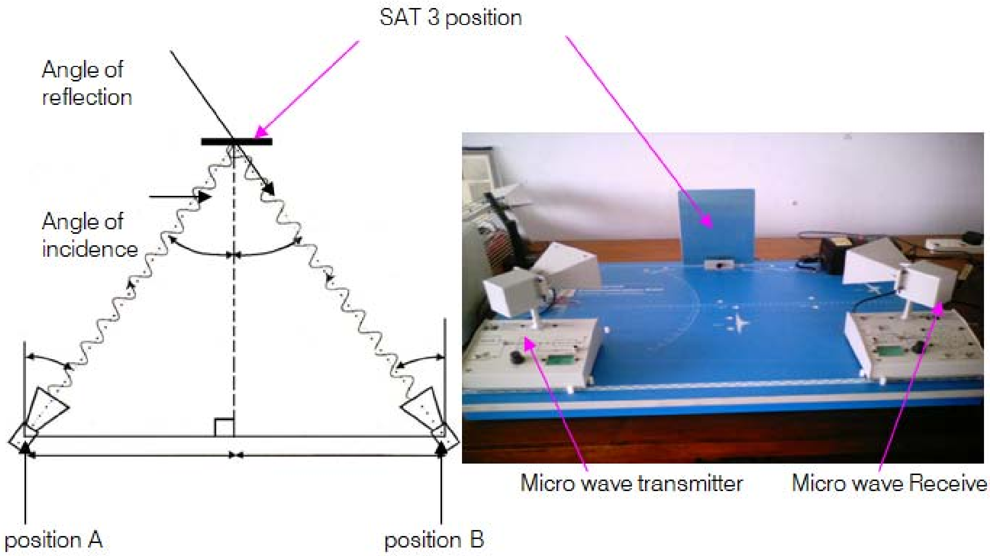

Figure 8 : Arrangement for investigate the reflection of microwave signals

The gain dial on the transmitter should be adjusted so that the tone produces a transmitter reading of 5. Set the receiver gain switch to low. Set the receiver gain dial to its mid position. Make sure the loud speaker is off and the receiver is switched to demodulator. Adjust the receiver gain if the signal is too low or too high.

Experiment No. 03

a) Name of the Experiment

Investigate the diffraction of microwave signal.

b) Objectives

Having completed this observation we will be able to know:

1. Conditions for diffraction process,
2. Pattern of microwave signal diffraction.

c) Procedure

Make sure that the power to the microwave trainer is switched off. Connect the system as shown in fig.9

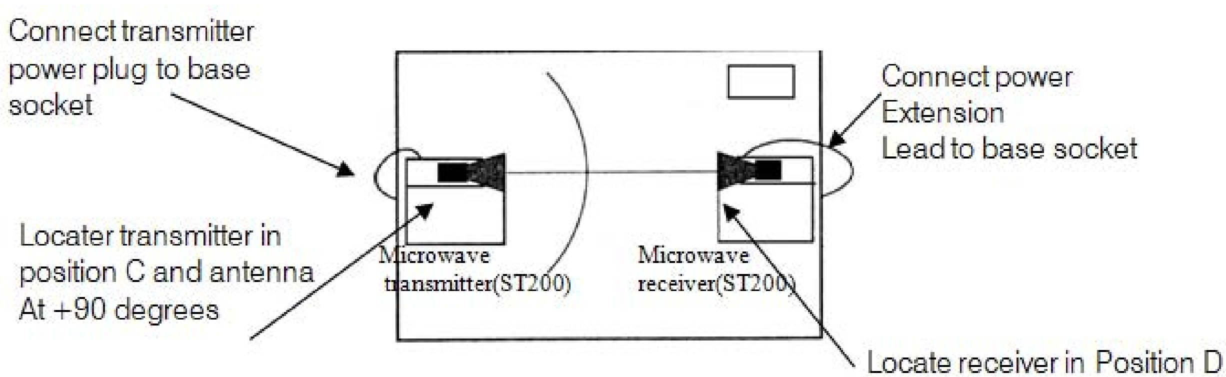

Figure 9 : Investigate the diffraction of microwave signal

Set up the transmitter switches and dials. Set up the receiver switches and dials. Set both the transmitter and receiver gain controls to their midway positions. Switch on the power. Adjust the receiver gain control until the signal strength meter on the receiver reads 4. Move the receiver to position B, taking care not to move the receiver gain control. Move the receiver horn antenna to get a maximum. Switch the power off. move the receiver back to position D and point the horn antenna at the transmitter. Again take care not to move the receiver gain control. Assemble the two metal plate in two support stands and place in the position shown in fig.10. Switch on the power. Adjust the receiver gain control so that the receiver meter reads 4 again. Now move the receiver to position B as shown in fig.11, taking care not to move the receiver gain control.

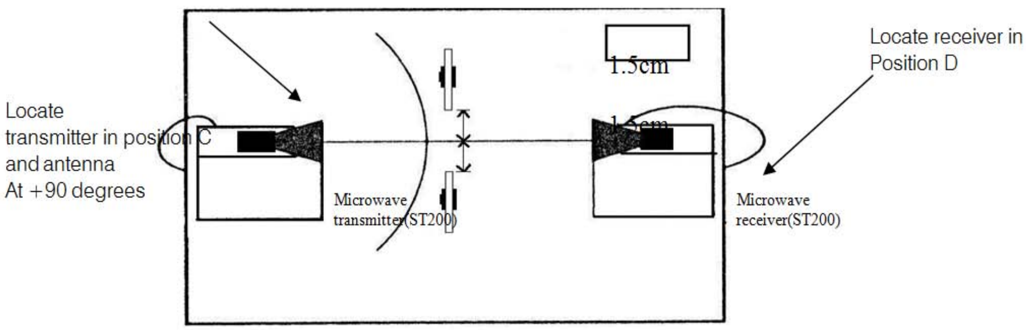

Figure 10 : Using two plates investigates the diffraction of microwave signal

Point the horn antenna at the gap between the metal plates and make the fine adjustments to the horn antenna to get the maximum reading. Record this reading.

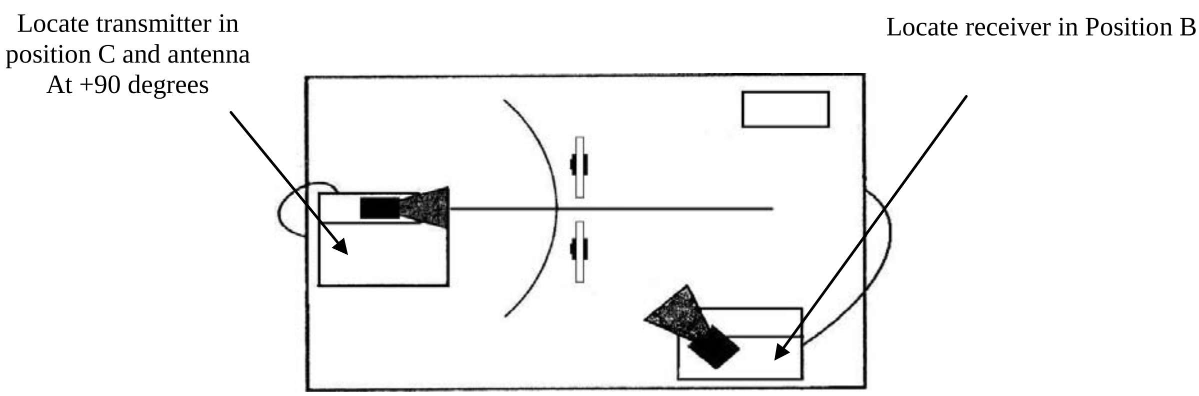

Figure 11 : Receiver section position change, to investigate the diffraction of microwave signal

Experiment No. 04

a) Name of the Experiment

Investigate the interference of microwave signal.

b) Objectives

After completing this experiment we will be able to know:

1. Conditions for interference process,
2. Patterns of microwave signal interference.

c) Procedure

Make sure that the power to the microwave trainer is switched off. Control the system as shown in fig.12.

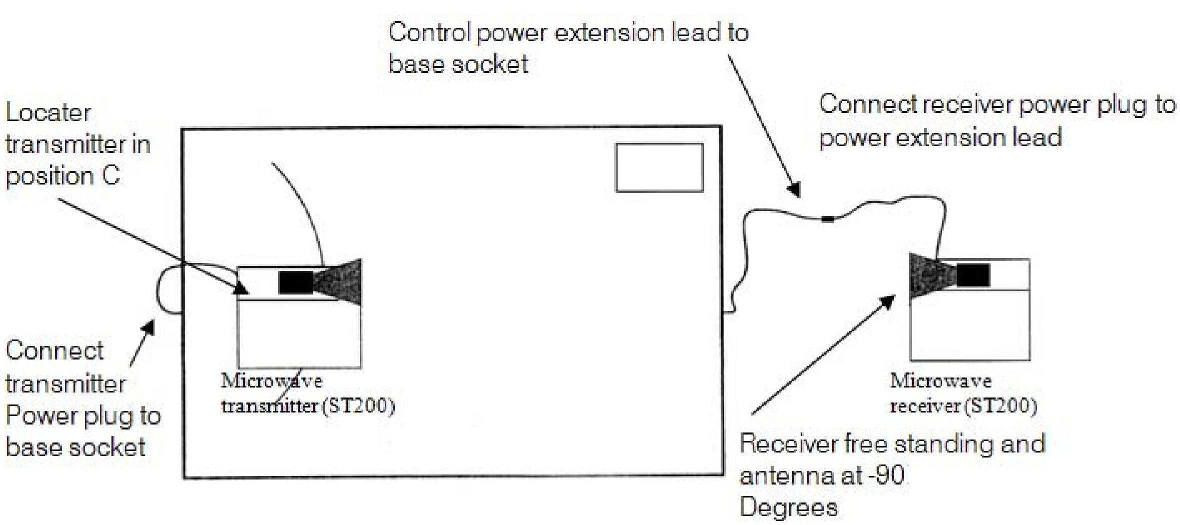

Figure 12 : Investigate the interference of microwave signal

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Set the transmitter switches and dials. Set the receiver switches and dials. Place the narrow metal plate on its support stand and locate in position STW1. Assemble the two wide metal plates on the support stands without pegs.

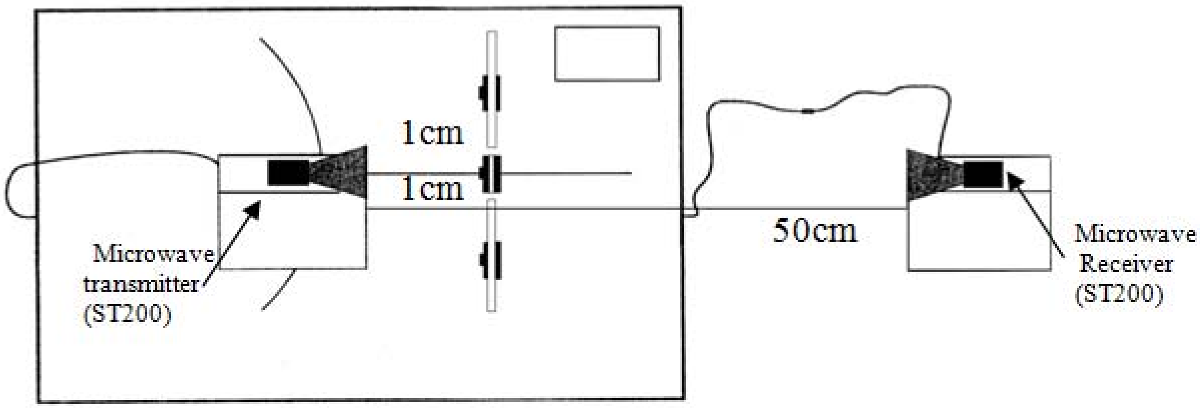

Figure 13 : Distance increase from transmitter to investigate the interference of microwave signal

Carefully locate the wide metal plates as in fig.13, so that there are two 1cm slits. It is important that all three metal plates are aligned as shown. Place the transmitter so that the front edge of the horn is on the 18 cm line. Place the receiver so that the front edge of the horn is 50 cm from the metal plates. Set both the transmitter and receiver gain control to their midway positions. Switch on the power. Adjust the receiver gain control. Slowly move the receiver towards the transmitter. Switch the power off.

Experiment No: 05.

a) Name of the Experiment

Investigate the effect of microwave signal by polarization grill.

b) Objectives

After completing this observation we will be able to know:

1. Effect on microwave signal at horizontal or vertical condition of polarization grill.

c) Procedure

Set up the receiver so that the gain switch is set to low and the demodulator is selected. Set both the transmitter and receiver gain controls to their midway positions. Set up the transmitter so that it uses the 1KHZ tone. Switch the power supply on. With the transmitter and receiver horn antennas pointing at each other adjust the receiver gain control until the signal strength meter on the receiver reads 5. Place the grill between the transmitter and receiver so that the bars are vertically oriented, as shown in fig1.

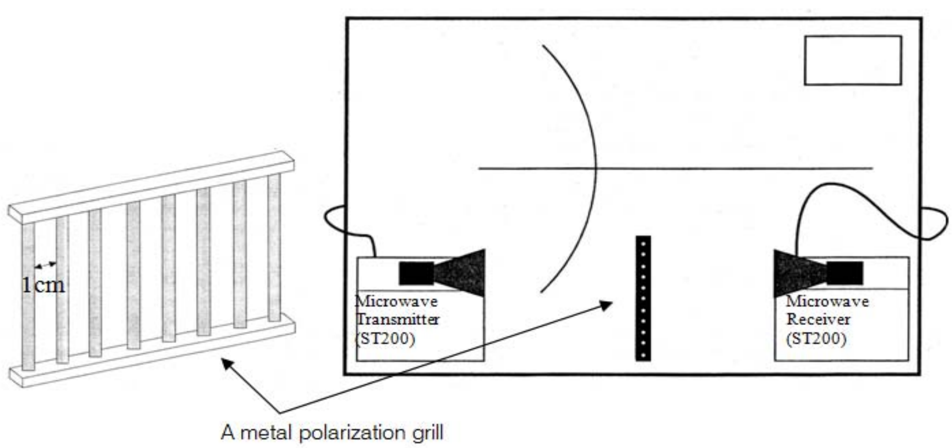

Figure 14 : Place the grill between the transmitter and receiver section

Now turn the polarization grill through 90 degrees so that the bars of the polarization grill are horizontal. Switch the power off.

IV. Results and Discussion

Table 1

For experiment no.01, the beam width of the microwave transmitter by moving the receiver around the transmitter on the semi-circular line.(At Room temperature 310 C, distance between microwave transmitter section & receiver is 30cm

Angle between transmitter& receiver antenna	Input signal (pick to pick)	Output signal (pick to pick)	Quality of sound hearing fromloud speaker in receiver section
0^0	1.3 volt	6.80 volt	Better
2.5^0	1.3 volt	6.80 volt	Better
5.0^0	1.3 volt	6.20 volt	Better
7.5^0	1.3 volt	5.80volt	Better
10.0^0	1.3 volt	5.12 volt	Better
12.5^0	1.3 volt	4.72 volt	Better
15.0^0	1.3 volt	3.80 volt	Low
20.0^0	1.3 volt	2.80 volt	Low
25.0^0	1.3 volt	2.20 volt	Very Low
30.0^0	1.3 volt	1.20 volt	No sound
35.0^0	1.3 volt	0.30 volt	No sound

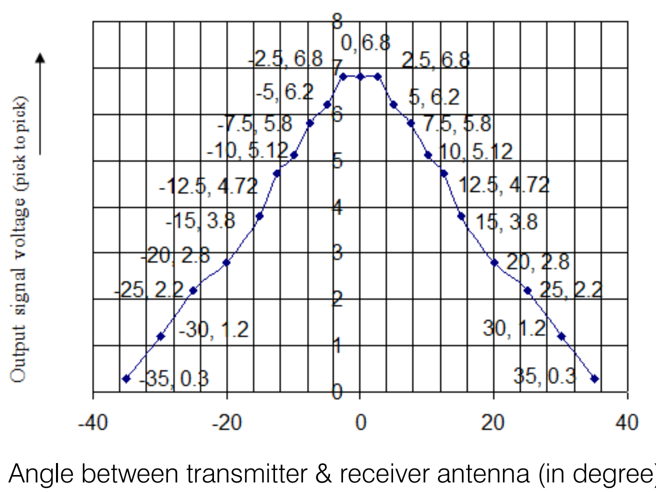

Figure 1 : Graphical representation of the beam width of the microwave transmitter, for moving the receiver around the transmitter on the semi-circular line

When put the values of output signal into graph then maximum output (i.e. 6.8 volt pick- to- pick), which found at angle between transmitter & receiver antenna is 0^0. So

$$V_{max} = 6.8 \text{ volt}$$

$$70.70\% \text{ of } V_{max} = 4.80 \text{ volt},$$

From the graph we see that 4.72 volt (pick to pick) found when angle between transmitter & receiver antenna is 12.5^0 and quality of sound hearing from loud speaker in receiver section is better. So the beam width of the microwave transmitter by moving the receiver around the transmitter on the semi-circular line is $(12.5^0+12.5^0=)\ 25^0$.

Graph contains negative value of angle it means that when values are taken downwardly then it consider positive and when values taken upwardly from axis then it consider negative.

Table 2

For experiment no.02, reflection when all the plates are at the same location
(i.e. SAT 3 position).

Types of reflector	Gain of the receive signal
Plastic sheet	0.75
Hard board	4.25
Wide metal plate	5.00
Narrow metal plate	3.75

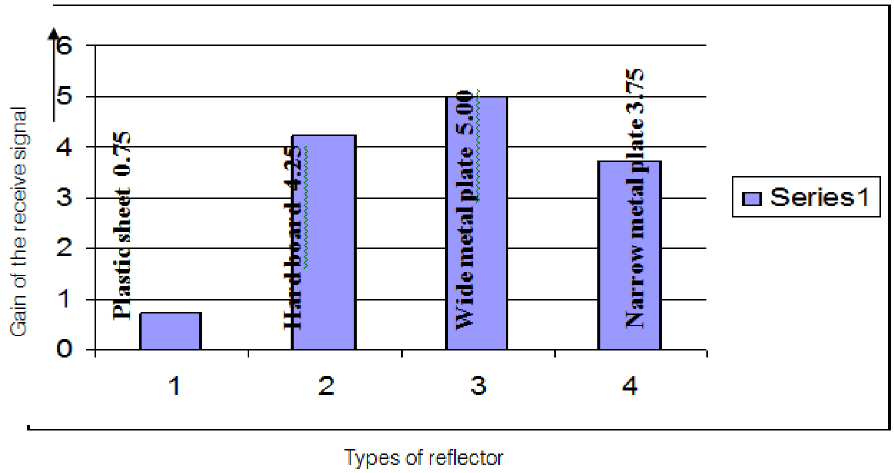

Figure 2 : Graph for different types of reflector and corresponding gain of the receive signal

When the angle of the transmitter and receiver is 45° then we get the maximum reading at the receiver signal strength meter. Though, the receiver is not directly facing the transmitter, a signal is being received because the microwaves are being reflected by the metal plate. From this observation it is seen that, the gain of the receive signal depends on the type of reflector. For wide metal plate the gain is maximum otherwise it is minimum (as shown in table 2). If the angle between the reflection and incidence is same then we get maximum reflection. When the metal plate is moved slightly then the strength of the received signal would decrease (i.e. the gain would decrease) because the angle between the incidence and reflection are different. A good reflector depends on its materials and size. In this experiment wide metal plate reflects microwave better than narrow metal plate, hardboard and plastic wood.

Table 3

For experiment no.03, diffraction of microwave signal (when two metal plates are used)

Distance between the two metal plate (cm)	Gain of the received signal
0.5	0.5
1	0.9
1.5	1.5
2	2.5

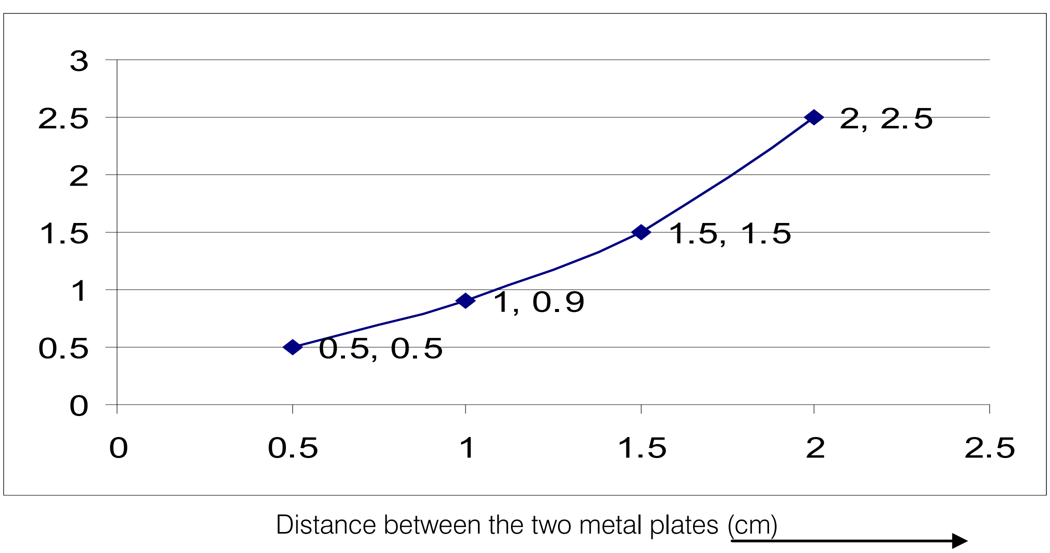

Figure 3 : Graph for Distance between the two metal plates Vs Gain of the received signal

From this experiment we have seen that, without two plates the gain is maximum i.e. 4. When two metals are placed between transmitter and receiver, and their distance is 1 cm from each, then gain is 0.9. The gain is decreased when the distance between the two metal plates is minimum .But if the distance is increased; the gain is also increased slowly. When there is no metal plate then the gain of the microwave signal on the meter is maximum at position D. But if two metal plates are placed, the gain becomes decreases. At position B the gain of the receive signal is minimum. Because the waves are spread when they pass through from an opening. When the slit width is the same as the wavelength of the microwaves then the spreading into the region of the geometrical shadow behind the slit is greatest. When a microwave beam is diffracted using a slit, the beam becomes more spread out, but its maximum strength is decreased. For microwaves of wave length 5 cm, the slit size required to cause maximum spreading due to diffraction is 2.5 cm.

Table 4

For experiment no.04, interference of microwave signal

Distance of the receiver from the transmitter antenna in cm	Gain of the receive signal
10	4.000
20	3.375
30	3.125
40	2.500
50	2.250
60	1.625
70	1.125

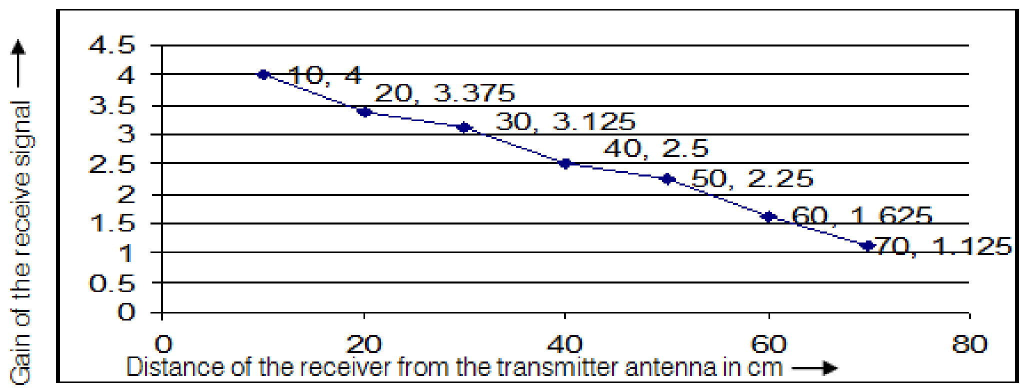

Figure 4 : Graph for distance of the receiver from the transmitter antenna Vs Gain of the receive signal

From this experiment we have seen that when the distance of the receiver from the transmitter is large then the gain of the signal is minimum on the meter but if the receiver moves slowly towards the transmitter the gain will be maximum. The receiver detects the maxima and minima of the fringe pattern when it is moved around. If the receiver is moved, the gain of the signal is decreased.

For experiment no.05, polarization grill is a rectangular metal grill. The edges of this grill are made of insulating material. The distance between the metal bars of the grill must be less than half a wave length, in this case less than 1.5 cm. If the grill is placed in the way of a vertically polarized microwave signal, with the grill bars in the vertical position, then the signal will be reflected. This occurs because the electric field is vertical, which means that the magnetic field must be horizontal. Therefore the magnetic fields cut across the metal bars, inducing a current in them and causing the microwaves to be reflected.

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