Lab 5: Microwaves Linear Polarization

Goal

Linear Polarization of microwaves.

Objectives

- Polarization measurements and discover how a polarizer can be used to alter the polarization of microwave radiation

Expectations

1. You are expected to take detailed notes during each step outlined in the procedure that can be used during the lab report write-up.
2. You are expected to provide a neat table of the data that you measured where you clearly label what each data set is and include units for all measured quantities.
3. You are expected to clearly record the measured values of any components that you use.
4. You are expected to clearly record the detail related to images captured by the oscilloscope.
5. You are expected to make your final plots in a program such as Excel. Make sure that your data points appear clearly on the plots, that all axes are clearly labeled and have units.
6. If it is possible to compare your measurements with an expectation or a prediction, you are expected to do so in your lab report
7. You are expected to answer the questions encountered in this manual as well as discuss exercises given during the lectures in your lab write up.

Introduction to Concepts

Linearly Polarized Microwaves

The microwave radiation from the Transmitter is linearly polarized along the Transmitter diode axis. The electric field component of the microwave 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 1-Right. If the detector diode were at an angle θ to the Transmitter diode, as shown in Figure 1-Left, it would only detect the component of the incident electric field that was aligned along its axis.

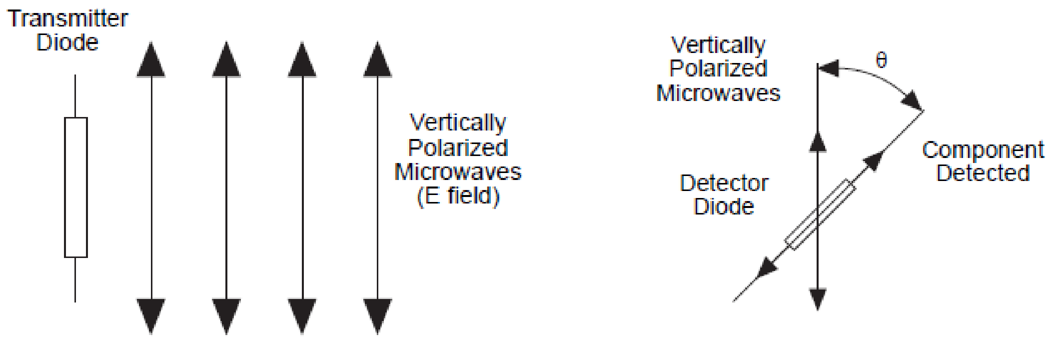

Figure 1: Left: Vertical Polarized wave from the source. Right: Detecting Polarized Radiation

Preliminary Lab Questions

1. The intensity, I of a linearly polarized electromagnetic wave is directly proportional to the square of the electric field ($I \propto |E^2|$). If the Receiver is making an angle θ with respect to the electric field direction, show that the relationship, receiver's intensity $I = I_o \cdot Cos^2(\theta)$ where I_o is the incident intensity of the electric field.

Equipment and Parts

1. PASCO microwave optics system : Transmitter, Receiver, polarizer, and Goniometer

Procedure

Linearly Polarization relationship to Microwave Intensity

1. Arrange the equipment as shown in Figure 2 and adjust the receiver controls for nearly full-scale meter deflection.

2. Loosen the hand screw on the back of the Receiver and rotate the receiver in increments of ten degrees. At each rotational position, record the meter reading in a table similar to Figure 3 ★

3. What happens to the meter readings if you continue to rotate the receiver beyond 180^o?

4. If the Receiver meter reading (M) were directly proportional to the electric field component (E) along its axis, the meter would read the relationship $M = M_o \cdot Cos(\theta)$ (where θ is the angle between the receiver and incident electric field and M_o is the meter reading when $\theta = 0^o$ ★

5. Plot data from above step. On the same graph, plot the relationship $M = M_o \cdot Cos(\theta)$ by fixing M_o to fit your data. Compare the two graphs. ★

6. The intensity, I of a linearly polarized electromagnetic wave is directly proportional to the square of the electric field ($I \propto |E^2|$). If the Receiver's meter reading was directly proportional to the incident microwave's intensity, the meter would read the relationship $M = M_o \cdot Cos^2(\theta)$. ★

7. Plot this relationship on the same graph generated in for electric field. ★
8. Based on your graphs, discuss the relationships between the meter reading of the Receiver, the polarization, amplitude and the intensity of the incident microwave. ★

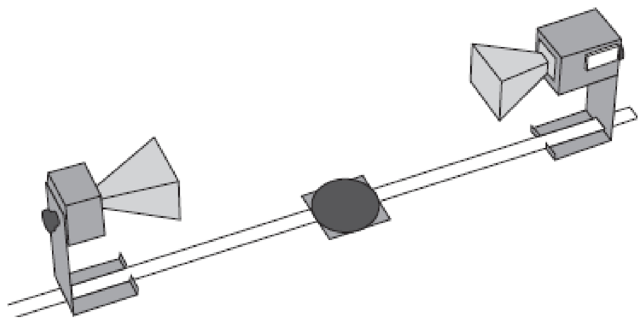

Figure 2: Equipment setup to measure linear polarization with no polarizer

Angle of Receiver	Meter Reading	Angle of Receiver	Meter Reading	Angle of Receiver	Meter Reading
0°		70°		140°	
10°		80°		150°	
20°		90°		160°	
30°		100°		170°	
40°		110°		180°	
50°		120°			
60°		130°			

Figure 3: Rotate the receiver while transmitter is fixed and no polarizer between receiver and transmitter

Linearly Polarization relationship to Polarizers: Part 1

1. Set up the equipment as shown in Figure 4. Align the polarizer slits horizontally.
2. We will keep the receiver angle to 0^o fixed, all the time.
3. Reset the receiver angle to 0^o (the horns should be oriented as shown with the longer side horizontal).
4. Adjust the receiver controls for nearly full-scale meter deflection.
5. Record the meter deflection value.
6. Set the polarizer slits to 45^o
7. Record the meter deflection value.
8. Set the polarizer slits to 90^o so that polarizer slits are vertical.

9. Record the meter deflection value.
10. Tabulate your measurements and theoretical predictions for meter deflection values in a single table in a table similar to Figure 5-Right ★
11. Describe your intensity measurement variation with the polarizer slits. ★
12. How does the polarizer affect the incident microwave? ★

Linearly Polarization relationship to Polarizers: Part 2

1. Set up the equipment as shown in Figure 4. Align the polarizer slits horizontally.
2. Reset the receiver angle to 0^o (the horns should be oriented as shown with the longer side horizontal).
3. Adjust the receiver controls for nearly full-scale meter deflection.
4. Record the meter reading by adjusting the receiver to 0^o, 22.5^o, 45^o, 67.5^o and 90^o with respect to the horizontally oriented polarizer
5. Record the data set in a table similar to Figure 5-Left. ★
6. Add a new column to this table for theoretical estimation of the intensity measurement ★
7. Reset the receiver angle to 0^o (the horns should be oriented as shown with the longer side horizontal).
8. Adjust the receiver controls for nearly full-scale meter deflection.
9. Align the polarizer slits vertically.
10. Record the meter reading by adjusting the receiver to 0^o, 22.5^o, 45^o, 67.5^o and 90^o with respect to the horizontal or the polarizer
11. Record the data set in a table similar to Figure 5-Left. ★
12. Add a new column to this table for theoretical estimation of the intensity measurement ★
13. Set up the equipment as shown in Figure 4. Align the polarizer slits to the angle 45^o.
14. Set the receiver angle to 45^o
15. Adjust the receiver controls for nearly full-scale meter deflection.
16. Record the meter reading by adjusting the receiver to 0^o, 22.5^o, 45^o, 67.5^o and 90^o with respect to the horizontal or the polarizer
17. Record the data set in a table similar to Figure 5-Left. ★

18. Add a new column to this table for theoretical estimation of the intensity measurement ★

19. How can the insertion of a polarizer at 45^o allowed detection of microwave signal levels at all the angles? ★

20. HINT: Construct a diagram like that shown in Figure 1 showing following, ★

    (a) The wave from the transmitter,

    (b) The wave after it passes through the polarizer, and

    (c) The component detected at the detector diode.

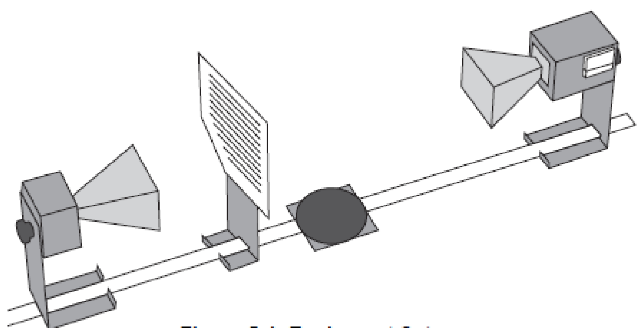

Figure 4: Equipment setup to measure linear polarization using a polarizer

Angle of Polarizer	Meter Reading
0° (horizontal)	
22.5°	
45°	
67.5°	
90° (vertical)	

Angle of Slits	Meter Reading
Horizontal	
Vertical	
45°	

Figure 5: Left: Rotate the receiver with polarizer between the transmitter and receiver. Right: Rotate the polarizer (slit angle)