An Introduction to Microwave Communications

Laboratory Manual CT60

Issue: MT194/B

Lesson Module: 21.61 Version 1

About This Learning Program

Introduction

Microwave technology is being used in many ways as electronic communications have greater influence in our lives. Understanding the principles of how microwaves behave in differing situations is an important part of the design or implementation of a communication system.

The CT60 Introduction to Microwave Communications learning program provides you with a 'hands-on' introduction to the principles of microwave communications. The program uses a purpose-made microwave training module and a comprehensive student Laboratory Manual that contains both theory and practical microwave experimentation.

Topics covered in the Laboratory Manual include polarization, reflection, absorption, diffraction and interference of microwaves. Also included is an investigation of standing waves and a Young's Slits Experiment.

A series of hands-on experimental exercises reinforces the theory using the microwave training module. The instructions in the Laboratory Manual will provide you with a step-by-step guide to each experiment.

What do I need to follow CT60?

To follow the CT60 learning program you will need the following items, all of which are included in the CT60 Introduction to Microwave Communications Training Module:

1. Microwave Communications Base.
2. Microwave Transmitter.
3. Microwave Receiver.
4. Microwave Probe.
5. 2 wide metal plates.
6. 2 narrow metal plates.
7. 2 plastic sheets.
8. 2 support brackets with pegs and 2 support brackets without pegs.
9. 1 hardboard sheet.
10. Microphone.
11. Headphones.
12. Phono to phono audio wire cable.
13. Power supply extension lead.
14. Polarization grille.
15. Waveguide fitted with two horn antennas.

Items required but not supplied:

1. Tape Measure

Computerized Assessment of Student Performance

If your laboratory is equipped with the DIGIAC 3000 Computer Based Training System, then the system may be used to automatically monitor your progress as you work through the chapters of the Laboratory Manual.

If your instructor has asked you to use this facility, then you should key in your responses to questions at your computer managed workstation.

To remind you to do this, a  symbol is printed alongside questions, which require a keyed-in response.

To remind you to make notes in your student workbook, a  symbol is used.

The following D3000 Lesson Module is available for use with the CT60 Laboratory Manual:

D3000 Lesson Module 20.61

Contents

Chapter 3
Polarization of Microwaves

Objectives of this Chapter

Having completed this chapter you will be able to:

- Identify electromagnetic waves and the transverse nature of microwaves.
- Define the terms Horizontal Plane Polarization and Vertical Plane Polarization.
- Investigate the transmission and detection of plane polarized microwaves.

Items Required for this Chapter

- Microwave Communications Base
- Microwave Transmitter
- Microwave Receiver
- Power supply extension lead

3.1 Transverse Waves

It was mentioned earlier that microwaves belong to the family of **electromagnetic waves**. Electromagnetic waves are **transverse** waves. To illustrate what we mean by a transverse wave, consider what happens when the end of a rope is moved up and down, as shown in Figure 12.

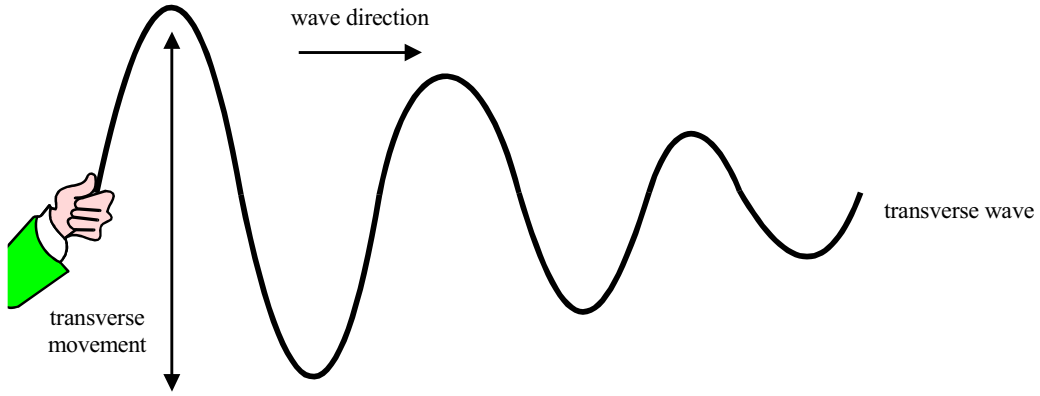

Figure 12 - A Simple Example of a Transverse Wave

Moving the end of the rope up and down causes a wave to travel away from the held end. Since the up and down movement is at right angles (90°) to the direction of travel of the wave, we say that this is a **transverse** movement.

Now consider an electromagnetic wave, such as a microwave. An **electro***magnetic* wave contains energy associated with **electric** and *magnetic* fields.

Each of these fields has a **transverse** motion, that is to say the electric field and magnetic field are at right-angles to the direction of propagation (travel) of the wave. This is illustrated in Figure 13.

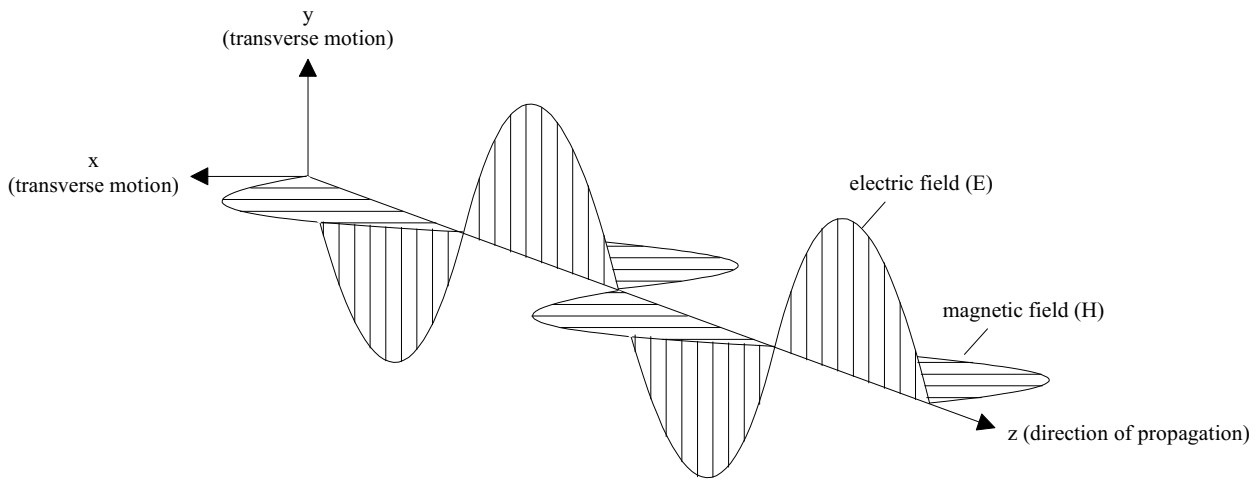

Figure 13 - The Transverse Electric and Magnetic Fields of an Electromagnetic Wave

3.2 Polarization

The polarization of an electromagnetic wave (such as a microwave) depends on the direction in which the **electric** field of the wave lies. Note from Figure 13 above that the electric field varies within one plane only (the y-z plane in this example), so we say that the wave is **plane-polarized**.

Two specific cases of plane polarization are **vertical plane polarization** and **horizontal plane polarization**. Referring again to the wave shown in Figure 13 above, if the direction of the electric field (the y direction) is vertical (relative to the surface of the Earth), we say that the wave is **vertically plane polarized**. Conversely, if the direction of the electric field is horizontal, the wave is said to be **horizontally plane polarized**.

Plane polarization is of particular interest to us because plane polarized waves are transmitted by microwave antennas and other types of radio antenna used in communication systems. The electrical field generated by a transmitting antenna actually runs **parallel to the antenna**, while the magnetic field is at right angles to the antenna.

Since the transmitting radio antenna shown in Figure 14 is vertical, the radio waves transmitted will be vertically plane polarized. The radio signal picked up by a receiving antenna will be at a maximum when this antenna is also in the vertical position.

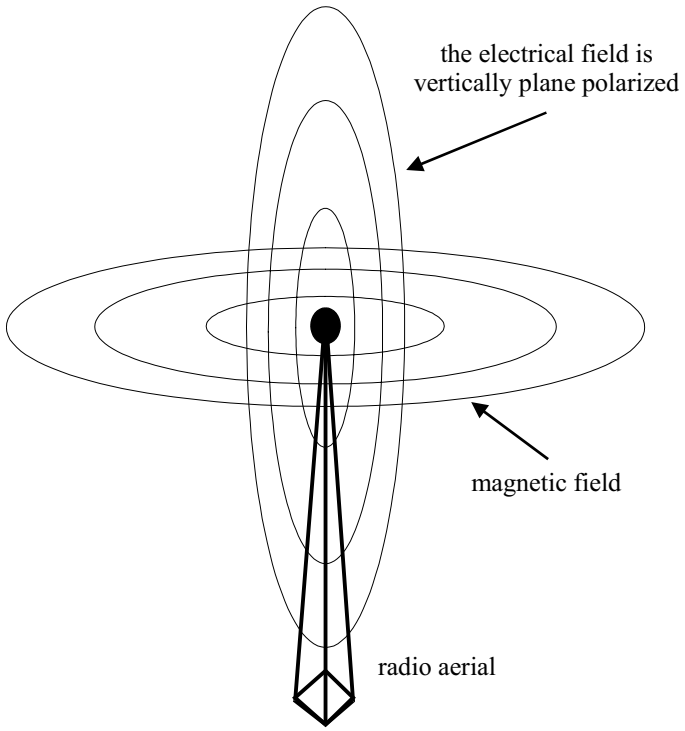

Figure 14 - Generation of a Vertically Plane Polarized Wave

In the Transmitter horn antenna of the microwave trainer, vertically plane polarized microwaves are generated by an oscillator and launched into a rectangular metal tube called a waveguide. The waveguide opens into a horn which emits the microwaves into the atmosphere, as shown in Figure 15.

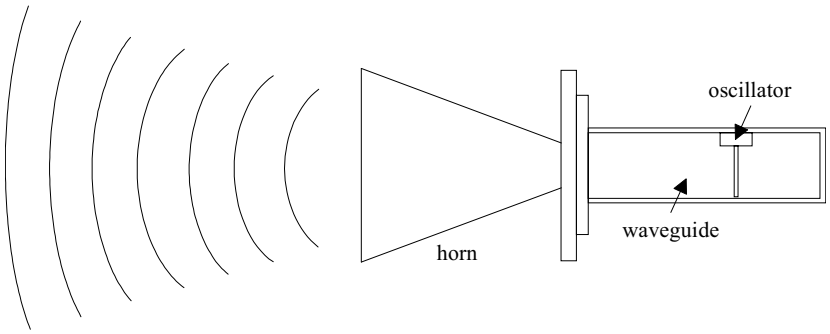

Figure 15 - Vertically Plane Polarized Microwaves Transmitted by a Horn Antenna

The level of the received microwave signal will be at a maximum when the Receiver horn is correctly aligned with the Transmitter horn, and will be at a minimum when the two horns are 90° out of alignment.

This requirement for the Transmitter and Receiver horns to be correctly aligned will be investigated in the following practical exercise.

3.3 Practical Exercise

- Make sure that the power is switched off.
- Connect the system as shown in Figure 16.

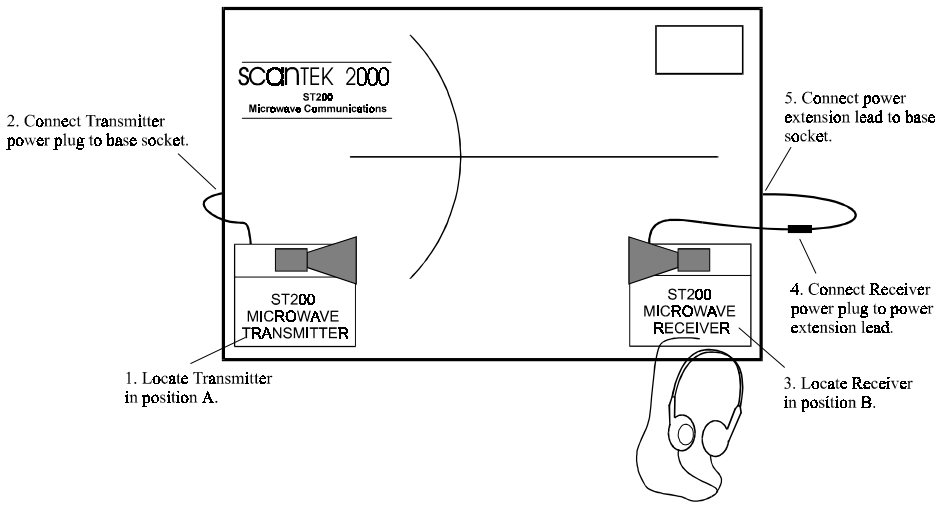

Figure 16

- Set the Transmitter switches and dials as shown in Figure 17.

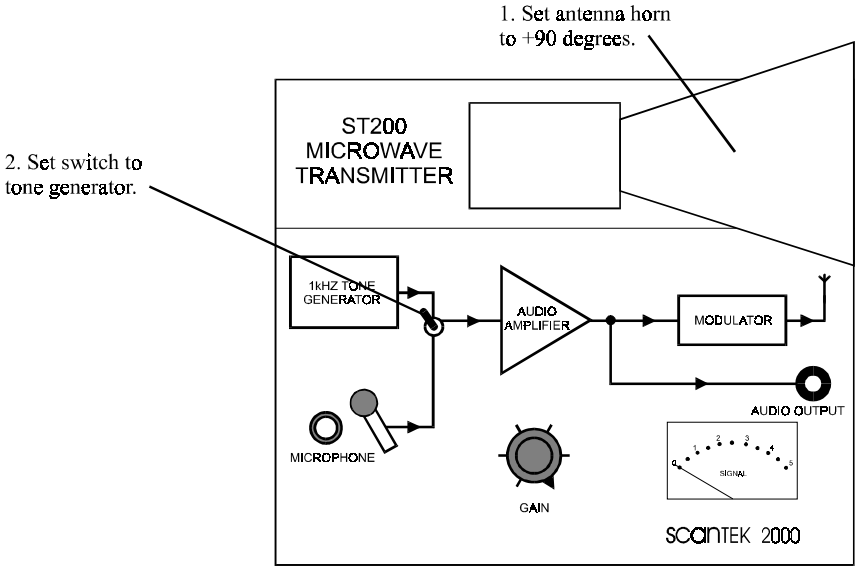

Figure 17

- Set the Receiver switches and dials as shown in Figure 18. Set both the Transmitter and Receiver Gain Controls to their midway positions, then switch the power on.

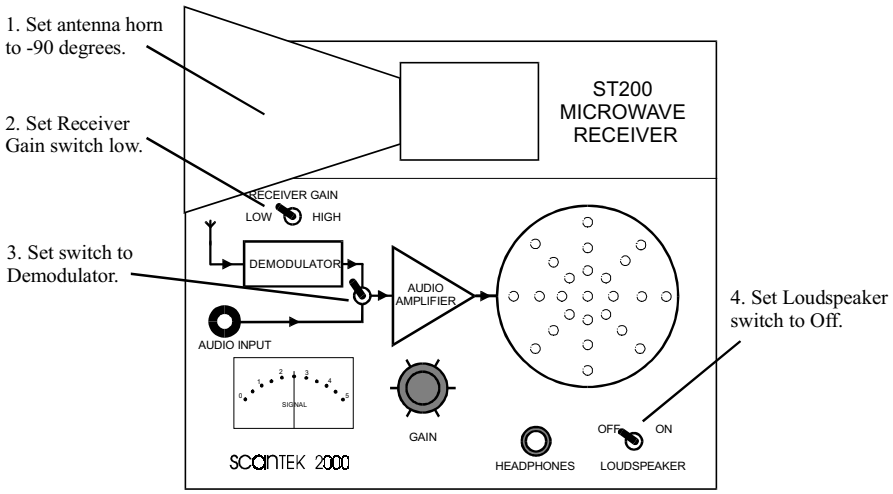

Figure 18

- Adjust the Receiver Gain Control until the signal strength meter on the Receiver reads 2.5. You may also need to adjust the Transmitter Gain Control to achieve this.

- Put on the headphones and note how loud the tone is, rotate the Receiver in the vertical plane as shown in Figure 19, while keeping the Receiver horn antenna in line with the Transmitter horn antenna. Note the positions of the maximum and minimum received signal, by listening to the tone from the headphones.

Record the positions of the maximum and minimum received signal in your student workbook.

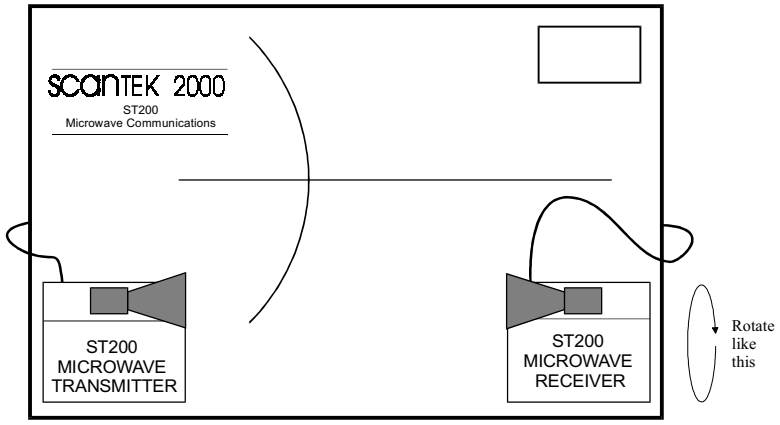

Figure 19

3.3a A minimum reading is obtained when the top side of the Receiver horn (the side that faces upwards when the Receiver is in its normal position):

a faces upwards or downwards.

b faces upwards or horizontally away from you.

c faces horizontally towards you or horizontally away from you.

d faces downwards or horizontally towards you.

3.3b Why do we get a minimum reading at certain positions?

a The transmitter is no longer emitting microwaves.

b The receiver is no longer aligned with the plane of polarization.

c The transmitter is no longer emitting plane polarized waves.

d The wavelength of the microwaves has increased.

■ Switch the power off.

Student Assessment 3

1. Microwaves are:

a sound waves.

b heat waves.

c electromagnetic waves.

d light waves.

2. Which of the following is <u>not</u> an electromagnetic wave?

a X-ray.

b Radio wave.

c Light wave.

d Mechanical wave.

3. Microwaves are:

a longitudinal in nature.

b slow in nature.

c long in nature.

d transverse in nature.

4. In an electromagnetic wave, the magnetic field is:

a in the same plane as the electric field.

b at right angles to the electric field.

c in the direction of propagation.

d only present if the wave is polarized.

Continued...

Student Assessment 3 Continued...

5. An electromagnetic wave whose electric field varies in the horizontal plane only is said to be:

a unpolarized.

b vertically plane polarized.

c horizontally plane polarized.

d longitudinally polarized**.**

6. The polarization of an electromagnetic wave transmitted by an antenna is always:

a at right angles to the antenna.

b parallel to the antenna.

c vertical.

d parallel to the Earth's surface.

Notes:

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