Session 1520

Computer Based Antenna Experiments In Telecommunication Engineering Technology Program

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Abstract

Engineering technology programs are characterized by strong hands-on experiential instructions that prepare the graduate to be productive in industry with minimal extra training, once employed. For this reason, it is essential to introduce the latest technology into technology curricula. Currently, computers are applied in all fields, and in particular, in electrical and electronic related fields. Such is the case in Telecommunications Engineering Technology (TelT) in which instruction on antennas forms a major component.

This paper describes computer-based antenna experiments in the TelT program at Penn State Wilkes-Barre. Computers are used in these experiments to facilitate the collection of large amounts of data and to convert the data from one set to another for different graphs.

Introduction

Current technology is based largely on the transmission and reception of information. Factors such as speed of transmission and size of memory in computers have propelled the information age forward. Research and developmental work that have been done in the recent past have been directed mostly at such factors in support of data communication.

Factors such as ease of accessibility and unlimited bandwidth have made use of radioelectric space as a medium of transmission in wireless applications attractive to industry. The prominence being experienced by wireless applications makes it important to include in TelT programs with the view of exposing TelT students to current technology. An essential component to any wireless system is the antenna. An antenna has the ability to transform electric energy into electromagnetic waves. It couples energy from a transmitter to the earth's atmosphere at the transmitting end, and couples energy from the atmosphere to the receiver at the receiving end[1]. For an antenna to work effectively, it must be designed to radiate and receive electromagnetic energy in a prescribed manner[2].

Antennas are used for fixed and mobile transmissions in both terrestrial and space communication applications. Many different types of antennas are in use today in a variety of applications. Every antenna in use has been designed based on specifications that make it suitable for a particular application. TelT students are exposed to basic characteristics that are common to all antennas such as gain and radiation pattern.

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Experimental Set-up

The equipment[3] used in the experiment consist of a transmission support which is used to hold the transmitting antenna, and an antenna positioner which supports the receiving antenna. The antenna positioner uses a motor to rotate the receiving antenna. An RF (radio frequency) generator is used to supply the transmitting antenna at either 1 GHz or 10 GHz as the experiment requires. The receiving antenna is connected to a data acquisition interface (DAI) through the antenna positioner, and from the DAI to a computer. The DAI module houses a power supply that is used to supply the antenna positioner. The experimental set-up is shown in Figure 1.

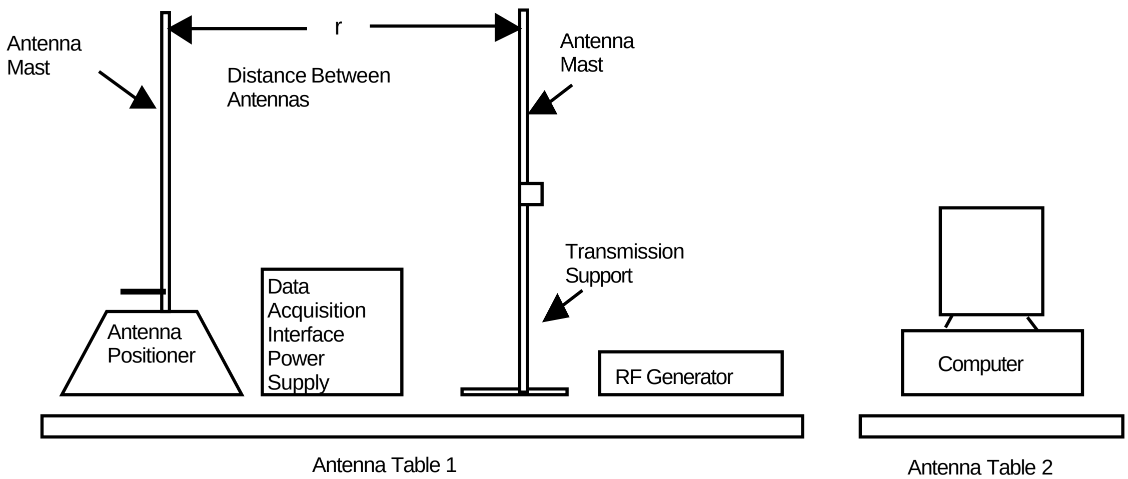

Figure 1. Experimental Set-up

The DAI performs three basic functions.

- (i) It converts the received signal transmitted by the antenna positioner to binary and transmits it as digital signal to the computer.
- (ii) It transmits the positioner shaft encoder signals to the computer.
- (iii) It provides the signals required to control the drive motor and a variable attenuator in the antenna positioner.

The role of the DAI is central to the performance of the set-up in the three functions stated above. Data acquisition and management (DAM) software is loaded into the computer to acquire the data and provide the plots for the radiation patterns.

The experiments involve taking several E-field and the H-field strength readings to plot the radiation patterns at the frequency of operation. These provide a 2-dimensional plot, showing the received signal strength at various angles from 0^o to 360^o. This set of data can be used to plot an E- and H-plane radiation pattern where the E-plane is in the vertical direction and the H-plane is in the horizontal direction. The set of data can also be used to plot a 3-dimensional radiation pattern. This shows the volume in the

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radioelectric space the electromagnetic radiation occupies and gives a better visual idea of radiation. These tasks are performed very easily using the DAM software and can be done within minutes by the computer. Industry employs such methods; hence students who are introduced to this software gain an advantage in the currency of the technology being applied.

Instructional Procedure

Instruction on antennas is started with a lecture on the propagation of energy on a pair of wires that are spread through 180^{o} at the end[1]. The students are then introduced to the principles and theories of electromagnetic propagation through the atmosphere. This makes students aware how antennas are basically formed. Examples of applications are cited. The examples used are common ones that students can identify with such as TV and radio transmission and reception. Topics such as the relation of the length of say a dipole to the wavelength of operating frequency, capture area, gain and directivity are discussed. The next step is to work examples in class to show how equations are employed to determine necessary parameters. The students are then taken to the laboratory for a hands-on experience.

One of the experiments performed is on the pyramidal horn, as its gain can be calculated from its physical dimensions. Horn antennas are used in applications such as point-to-point microwave communications. Through the hands-on experience, they are able to identify other parameters such as half-power beamwidth. The laboratory manual[3] lays all these processes out in a systematic fashion; hence students are able to perform the exercises with minimal supervision. The plots students obtain from this experiment are shown in Figures 2, 3 and 4. Figure 2 shows the 2-D plots of the E- and H-planes. Figure 3 shows the combined plot of the two planes, and Figure 4 shows the 3-D plot of the radiation pattern. An experiment on a half-wave dipole that shows the characteristic doughnut shaped radiation pattern is followed by an experiment on a six-element Yagi antenna to show the effect of a reflector and a director. Figures 5, 6 and 7 show the 2-D, the combined E- and H-plane, and the 3-D plots respectively.

Students like the fact that they are able to perform the experiment using the lab handout as a guide and not being told how to perform each step in the procedure. They experience the function of a transmitting antenna and the performance of a receiving antenna. This helps them to realize that the radiation pattern recorded is that of the receiving antenna. From the E- and H-plane plots, they appreciate the orthogonal nature of the E-field and the H-field. The 3-D plot helps the students to understand the volumetric nature of the radiated field in space.

The students observe that the 2-D plots show slight distortions due to reflections off objects in close proximity to the experimental set-up. It also becomes apparent to them the critical nature of the relationship between the length of the antenna and the wavelength of the operating frequency.

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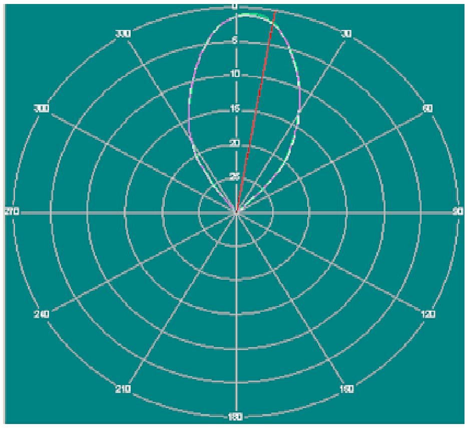

Figure 2. 2-D Plot of E- and H-plane of Pyramidal Horn Radiation Patterns

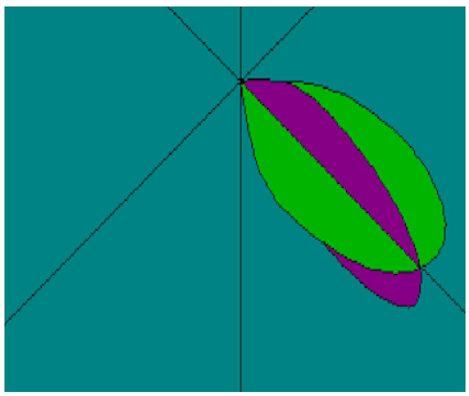

Figure 3. Plot of E- and H-plane of Pyramidal Horn

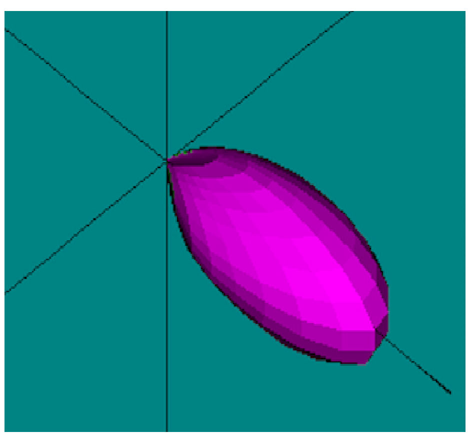

Figure 4. 3-D Plot of E- and H-plane of Pyramidal Horn

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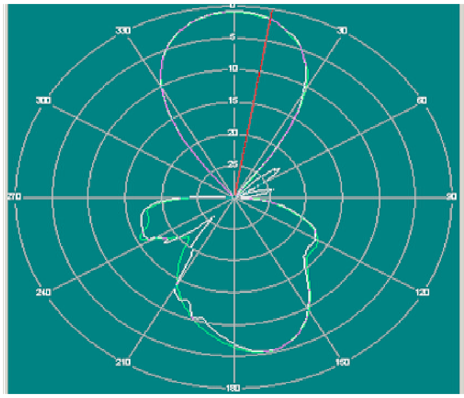

Figure 5. 2-D Plot of E- and H-plane Radiation Patterns of 6-element Yagi. Transmitter is 89mm Dipole

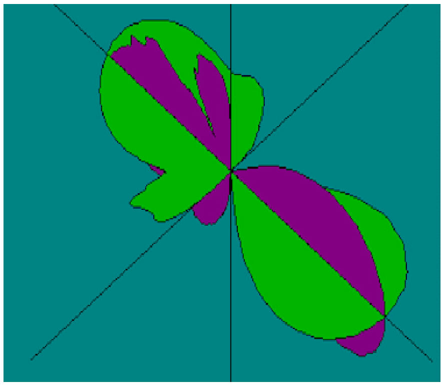

Figure 6. Plot of E- and H-plane Radiation Pattern of 6-element Yagi. Transmitter is 89mm Dipole

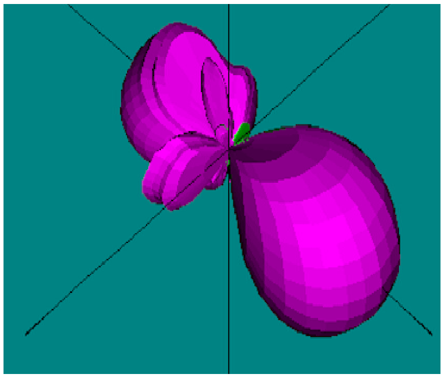

Figure 7. 3-D Plot of E- and H-plane Radiation Pattern of 6-element Yagi. Transmitter is 89mm Dipole

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Conclusion

The plots for both the pyramidal horn and the Yagi array are characteristic of such antennas. The fact that the computer produces the 2-D plots while the data is being acquired impresses on the students the usefulness of the computer in the experiment. They also understand the need of using software to efficiently convert from 2-D plots to E- and H-plane plots, and to 3-D plots. They appreciate the effectiveness of the use of computer in acquiring vast amount of data used to plot the patterns.

References

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3. Antenna Fundamentals Manual, Lab-Volt

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