KHOA HỌC - KỸ THUẬT

TRAINER MODEL FOR MEASURING DIRECTIONAL CHARACTERISTICS OF UHF ANTENNAS

MÔ HÌNH THÍ NGHIỆM ĐO ĐẶC TÍNH PHƯƠNG HƯỚNG CỦA ANTEN DẢI TẦN UHF

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Abstract

In radio communication, the antenna plays an important role as a radiation element (in transmitters) the engergy of electromagnetic waves to free space and as an interceptioin one (in receivers) some of the power of an electromagnetic wave from free space. The directional characteristics is one of the most fundamential features of the antennas.

Currently, antennas in the UHF frequency band are widely used in digital terrestrial television Therefore, this paper proposes the trainer model for measuring the directional characteristics of UHF antennas. The results are applied in teaching, practising the subject of Antenna Engineering as well as supporting students to understand more deeply the basical characteristics of some kinds of antennas.

Keywords*: UHF, antenna, directional characteristics.*

Tóm tắt

Trong hệ thống thông tin vô tuyến, anten là một thành phần quan trọng, đóng vai trò là thành phần phát xạ (phía phát) sóng điện từ ra không gian tự do và thu nhận (phía thu) sóng điện từ trong không gian tự do. Một trong những đặc tính quan trọng nhất của anten chính là đặc tính phương hướng.

Hiện nay, anten dải tần UHF đang được sử dụng rộng rãi trong truyền hình số mặt đất. Vì vậy, bài báo đề xuất thiết kế mô hình thí nghiệm xác định đặc tính phương hướng của các anten ở dải tần UHF. Kết quả nghiên cứu được áp dụng trong việc giảng dạy, thực hành thí nghiệm môn kỹ thuật anten, giúp sinh viên hiểu rõ hơn về đặc trưng cơ bản của một số loại anten trong thực tế.

Từ khóa*: UHF, antenna, directional characteristics.*

1. Overview

The directional characteristics is one of the most fundamential features of the antennas including UHF antennas. In order to determine the directional characteristics of UHF antennas, firstly, it is necessary to study the essential equipment to be performed. In addition, it is necessary to calculate and select specific types of antennas, according to its main physical and electrical characteristics to ensure emission in the UHF frequency. Besides, antennas must be made of high conducting material with a chrome coating for ensuring durabitity and fixed on the glass epoxy printed circuit boards for effortless installing and dismantling.

Moreover, the directional characteristics indicates the relative variation of the radiation field strength and is expressed by the radiation pattern which can be plotted using polar or rectangular coordinates. As a result, the proposed trainer model must be designed to support the students in observing it.

The trainer kit is designed to provide the following experimental content [1]:

- Polar plot and polarization;
- Wave modulation and demodulation;
- Antenna gain;
- Antenna beam width;
- Distribution of current on antennas;
- Front back ratio;
- Antenna matching;
- Measurement of Standing Wave Ratio (SWR);
- Radiation of antenna with distance.

In order to support student to easily practise, the antenna trainer kit is provided many features including:

- Integrated, user-friendly trainer;
- Low cost;
- Manual installation in ploting radiation patterns of antennas;
- RF and tone generators are integrated on board;
- Antenna matching stub;
- Antenna characteristics and measurement of Standing Wave Ratio (SWR);
- Transmitting and receiving levels observed on built in digital meters;
- Functional block indicated on board mimics;
- Build in DC power supply;
- Compact design;
- Light weight.

Besides, in this antenna trainer model, for the convenience to plot the polar graph the readings are plotted after converting them in to dB. A conversion chart is provided. The procedure for normalizing the readings is also given. Any procedure can be chosen for drawing the polar plot.

2. Setting up the Trainer model of Antennas

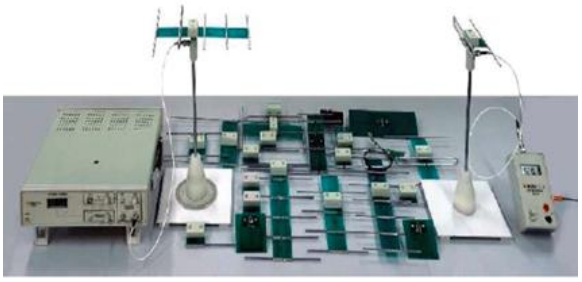

Figure 1. Trainer Model of Antennas

The trainer consists of some components as shown in Fig. 1. It consists:

- Main unit: is designed for desktop use with screen print on the front panel showing the trainer mimic diagram. It includes a RF generator, a modulation generator and a directional coupler as illustrated in Fig. 2:

o RF generator: in charges of delivering a signal to the antennas during the experiment. The RF generator operates at a frequency of 750MHz, which reduces the size of antennas.

o Modulation generator: provides amplitude ajdustable sine wave (approximately 2Vpp, 1kHz) for modulation of the RF generator.

o Directional coupler: allows separate metering of power flowing in the forward direction (generator to antenna) and the reserve direction (antenna to generator)

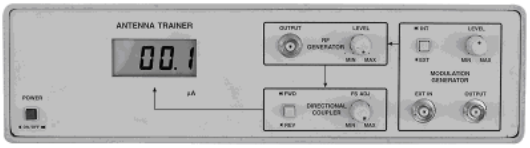

Figure 2. Main Unit of Antenna Trainer Model

- Matching stub: this is a strunk of the transmission line, which is given separately provided with a slide cursor shortening the line at presetable length from the other end (input).

- RF detector: is used to detect and measure the radiation pattern of the antennas under study. It consists of a folded dipole antenna as a receiving element and a reflector to reduce possible disturbance to the measurement due to reflection of waves from objects and laboratory walls behind the detector as in Fig. 3.

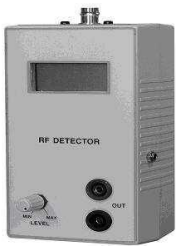

Figure 3. RF Detector

- Antennas: set of antennas consists 22 different types of antennas.

Besides above-mentioned components, the antenna trainer model also consists other accessories such as transmitting mast, receiving mast to mount and locate transmitting antenna and receiving antenna, respectively as shown in Fig. 4 and Fig. 5.

Figure 4. Transmitting mast

Figure 5. Receiving mast

3. Methodology of measuring the directional characteristics of UHF antennas

3.1 Set up the trainer model and perform the functional checks

Before implementing any measurements, the trainer model should be set up and functionally checked. All steps for doing the trainer model set up is follows:

1. Put the main unit on the plane such as the table and connect to the power supply.
2. Adjust the Level Pot of the RF generator to the middle position.
3. Set the switch of the modulation generator to the INT position and adjust the Level potentiometer to the middle position.
4. Set the switch of the directional couple to the FWD position and adjust the FS ADJ potentiometer to the middle position.
5. Set up the transmitting mast.
6. Connect to the main unit using cable (25" or 60cm long).
7. Set up the receiver mast. Adjust the distance between the transmitter mast and receiver mast to gain the optimum radiation at RF detector.
8. Connect the RF detector unit to the receiver mast using cable (25" or 60cm long).

Figure 6. Installation the Trainer model of Antennas

9. Pivot the stand of the Goniometer to the 0^0 position towards the RF dectector.

10. Install the dectector antenna on the receiver mast.

11. Pivot counterclockwise direction to put it and transmitter mast into a straight line.

12. Install the folded dipole antenna on the transmitter mast.

13. Pivot counterclockwise direction to put it and receiver mast into a straight line.

14. Turn the main unit ON and check the DPM display of the directional coupler.

15. Connect the adapter to the RF detector, turn it ON.

16. Depending on the position of the level knob setting, several reading should be shown.

17. In case of overloading, diminish it by adjusting the RF detector level potentiometer.

18. Adjust the FS potentiometer of the directional coupler to obtain a 100μA display reading. After that, adjust the level of the RF detector to obtain ¾ reading on the display of the main unit.

19. Pivot the transmitter antenna from 0^0 to 360^0 and perceive the display of RF detector to obtain the form of radiation pattern.

It is noted that some actions should be taken in order to get the optimum radiation levels at the RF detector such as: antenna match adjustment, adjusting the RF generator level and adjustment of distance.

3.2 Mesuring the directional characteristics of various types of antennas

As mentioned in section 2, this antenna trainer model consists 22 different types of antennas. However, without losing generality, this paper only presents the measurement of the directional characteristics of typical types of antennas including simple Dipole ($\lambda/2$) antenna, Yagi-UDA 5E simple dipole and $\lambda/2$ phase array antenna.

The following steps are implemented for the directional characteristics measurement with any types of antennas:

- Plot the polar graph for the transmitting antenna by taking the readings at 5^0 or 10^0 intervals and note the reading of the RF detector display.
- Convert the recorded readings in μA to dB, plot the polar graph for degrees of antenna rotations in degrees against the readings in dB.
- Plot the radiation pattern of the antenna with the new dB readings as usual.

1. Simple Dipole ($\lambda/2$) antenna

A simple Dipole is the simplest form of antenna having 2 poles each of halfwave length ($\lambda/2$) as illustrated in Fig. 7. The nominal impedance of this antenna is 73Ω [2]. The actual value departs from this due to construction constraints, such on non-zero diameter rods, presence of BNC connector body and the antenna mast. The effect of all this are partially corrected by a "Y match" arrangement connection.

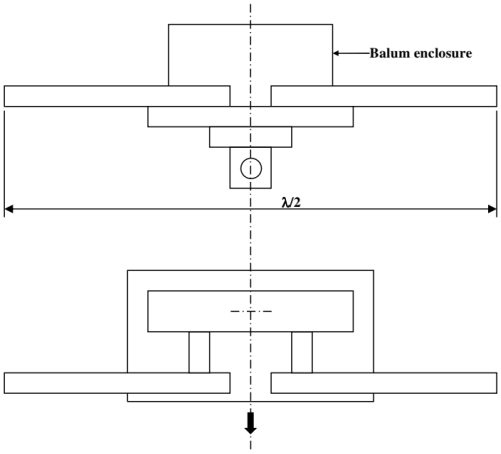

Figure 7. The Diagram of Simple Dipole ($\lambda/2$) antenna

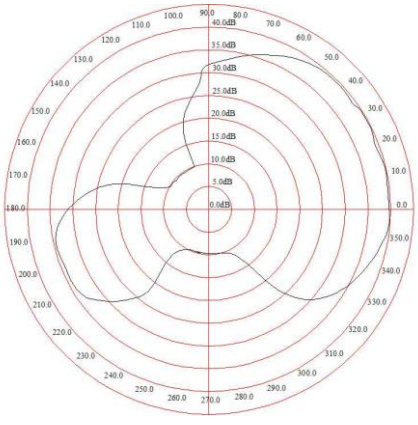

Figure 8. The radiation patterns of simple Dipole ($\lambda/2$) antenna

The radiation pattern of simple dipole ($\lambda/2$) is uniform in forward and reverse direction. The polarization is horizontal. The typical radiation pattern of this antenna is given in the Fig. 8.

2. $\lambda/2$ phase array antenna