Preliminary Design of Automatic Antenna Radiation Pattern Measurement System for Antenna and Propagation Laboratory Course

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***Abstract*—Antenna radiation pattern is the major topic of Antenna and Propagation course in Telecommunication Engineering Program Study. Antenna radiation pattern measurement system is strongly required to conduct practical work in the laboratory. This study aims to design Automatic Antenna Radiation Pattern Measurement System based microcontroller for conducting Antenna and Propagation Laboratory course. This system will expand and enrich the topics of practical subjects in the laboratory, and it leads to the achieving of more learning indicators of the Antenna and Propagation course. The methodology used in this research is quantitative method where data obtained through student response questionnaire. The result of student response to designing of this system is 0.86. The interview is conducted with both the expert of media and content. The result shows that this system is necessitated to run the laboratory of Antenna and Propagation course.**

Keywords—antenna radiation pattern; antenna; microcontroller

I. Introduction

Antenna radiation pattern is the main property of an antenna; therefore, the understanding of this parameter is essentially required by engineering telecommunications students. Radiation pattern is main antenna parameter which is the response of the antenna to the electromagnetic power rate surrounding it. By definition, antenna radiation pattern is "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. In most cases, the radiation pattern is determined in the far-field region and is represented as a function of the directional coordinates" [1].

Radiation pattern is three dimensional shapes, but for practical purpose, it is measured and plotted in two dimensional, namely principal planes. Principal plane consists of E-plane (elevation plane) and H-plane (azimuth plane), and the two planes are orthogonal one another. These planes are analyzed theoretically and measured practically in the laboratory.

The existing measurement system of the antenna radiation pattern at Telecommunication Laboratory, Electrical Department, Bandung State Polytechnic, is still manually performed. The number of the current equipment is also limited since the price is expensive, and depends on imported product. This is the common problem faced by almost all the university especially in underdeveloped countries [2].

To overcome this problem, innovative learning is required. In this research, an automatic antenna radiation pattern measurement system is proposed. This performance of the equipment is fast in process, portable, user friendly, and low cost. This is made possible with the availability of the advance of technology in either hardware or software. The price of the components is relatively cheap and some of them are open sources. This leads to prompt the development the low cost media for engineering education [3,4].

The use of these technology products leads to development of much automation learning process. Indonesia University of Education, e.g., has built an industrial automation training kit based real mobile plant to improve the ability of problem solving in actual control systems [2].

Some studies related to the elaboration of the automatic antenna radiation pattern measurement have been attempted. Brown et al designed an economical antenna gain and radiation pattern measurement system [5]. The advanced technology leads to the availability of integrated components and devices. Hence, the design and development of the radiation pattern measurement becomes simpler and cheaper [6]. Another design of the antenna radiation pattern measurement utilizes the LABVIEW software [7].

II. Methods

The first step in developing this research is analyzing the system requirement. This step basically identifies the problems that lead to the gap between the performance standard of the learning objectives of the Antenna and Propagation course and that achieved by current learning process [8,9]. The result of the need analysis directs to the development of learning product where the automatic antenna radiation pattern measurement system is part of it. Hence, this research is focused on the development of this measurement system to improve the learning objectives.

To get the students response, the assessment is directed by introducing the system design, the function, features, and advantages. The assessment is in the form of questioner that asks the students the needs of the system to realize, to help and motivate them in learning process. The interview is also conducted to the expert of media and that of content to get the feasibility of the system to construct and to implement.

Figure-1 shows the block diagram of the proposed automatic antenna radiation pattern measurement system. The transmitter transmits electromagnetic wave in certain frequency and power level. The antenna under test (AUT) is placed on a rotator at receiving side, which is moved step by step circularly by stepping motor. The movement of the motor is controlled by microcontroller. In each step where the antenna points to associated direction, the antenna will have received an RF level and sends it to the receiver.

The receiver converts this RF level into DC level which is proportional to the RF level. In fact, the commercial device of receiver (3DR 915 MHz) provides output of RSSI (Received Signal Strength Indicator) which is an analog signal proportional to the signal strength received by the antenna. This output is connected to the PC (personal computer/laptop) via serial communication.

At PC, Visual Basic software is utilized. This software is programmed to perform three main tasks: (1) to command stepper motor controlling which is programmed using microcontroller, (2) to convert RSSI signal into dBm unit, and (3) to command the spreadsheet to make plot of radiation pattern (E-plane and H-plane).

The process of receiving the electromagnetic power by the antenna, sending this power to the receiver, processing the power to that of RSSI, sending this RSSI signal to PC, and converting this RSSI into dBm unit, is repeated until the whole step of the rotator completed. For example, if the step is 3.6-degrees, the processed will be completed in 100 steps. In the laptop, the digital signal is processed by Visual Basic to plot and display on the monitor as a graph in the polar form.

The development of the system is supported by the availability of cheap components and the advance technology in both hardware and software. It can be seen from the block diagram, the system consists of the following main components: PC (laptop), microcontroller (Arduino), motor, and radio transceiver (RX and TX). The price of microcontroller (Arduino), motor, and radio transceiver (RX and TX) is relatively cheap.

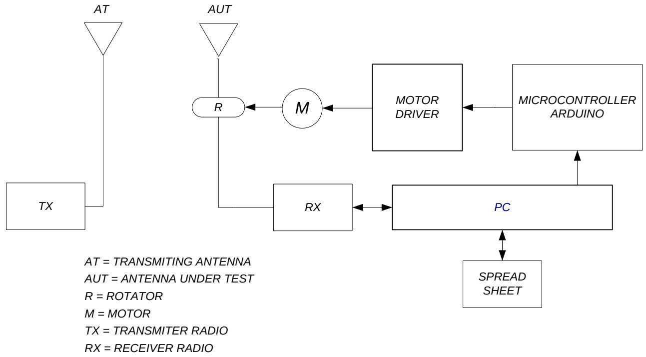

Fig. 1. Block diagram of automatic radiation pattern measurement system.

III. Result and Discussion

This system is intended to gain the capabilities of the students to analyze and work with exercises of the antenna radiation pattern. The radiation pattern should be analyzed, simulated and measured to indicate that the antenna will provide signal coverage as required by the system. Hence, the measurement has to be completed as fast as possible, and also as accurate as possible. The accuracy will be provided by high resolution of the motor rotation.

To get the student response, questionnaire was delivered to 34 students of Telecommunication Program Study. Figure 2 shows the plot data of the student response which consists of 10 questionnaires. In this questionnaire, Linkert scale is applied to acquire the student perception and receptivity to the design of the system. Based on the data in the figure, the overall response is calculated by averaging the 10 questionnaires, which is 0.86. This student response indicates the system is strongly needed to realize and to apply in the learning process.

The design of the system was validated by interviewing the expert of media and that of the content. From the media view, the media is reasonably feasible to construct with the availability of commercial component in the market and relatively low in price. The feature of the system is faster in process and leads to higher resolution. From the content view, since the system has the feature of fast processing time, more topics of experiments are able to enhance. In addition, the high resolution leads to more accuracy of measurement results.

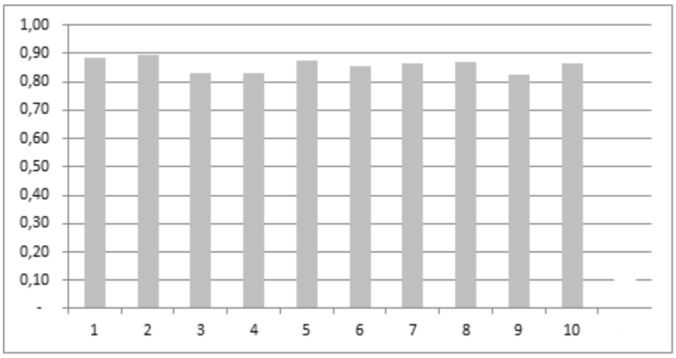

Fig. 2. Radiation pattern measurement responses.

Note:

1. Learning the concept and formation of antena radiation pattern requires antenna radiation pattern measurement system
2. Hand-on measurement makes the antenna radiation pattern easier to learn
3. The existing radiation pattern measurement system is not suitable to run since its physical system is relatively large
4. The radiation pattern measurement requires portable equipment
5. The existing manual antenna radiation pattern measurement system is time-consuming
6. The existing manual antenna radiation pattern measurement system has low resolution motor rotation
7. The existing manual antenna radiation pattern measurement system results in less accuracy measured data
8. Using the existing manual antenna radiation patterm measurement system, student is inconsistent to read the measured data
9. In the existing manual antenna radiation patterm measurement system, the students that are doing measurement, affect the measured data
10. In the existing manual antenna radiation patterm measurement system, the plotting data is time consuming

Figure 3 shows the plan of the physical size of the designed equipment. The equipment comprises of a radio transmitter on one side and receiving part on the other side. The sizes are small enough and hence the equipment is portable. The antenna under test is placed as receiving antennas on the receiving part. With these sizes, it is easy for the student to move and position the equipment. In addition, these sizes make the student be easier to analyze the working principle of antenna radiation pattern measurement. The size of the system is designed as shown in figure 3. Control box in the figure contains Arduino board and motor driver.

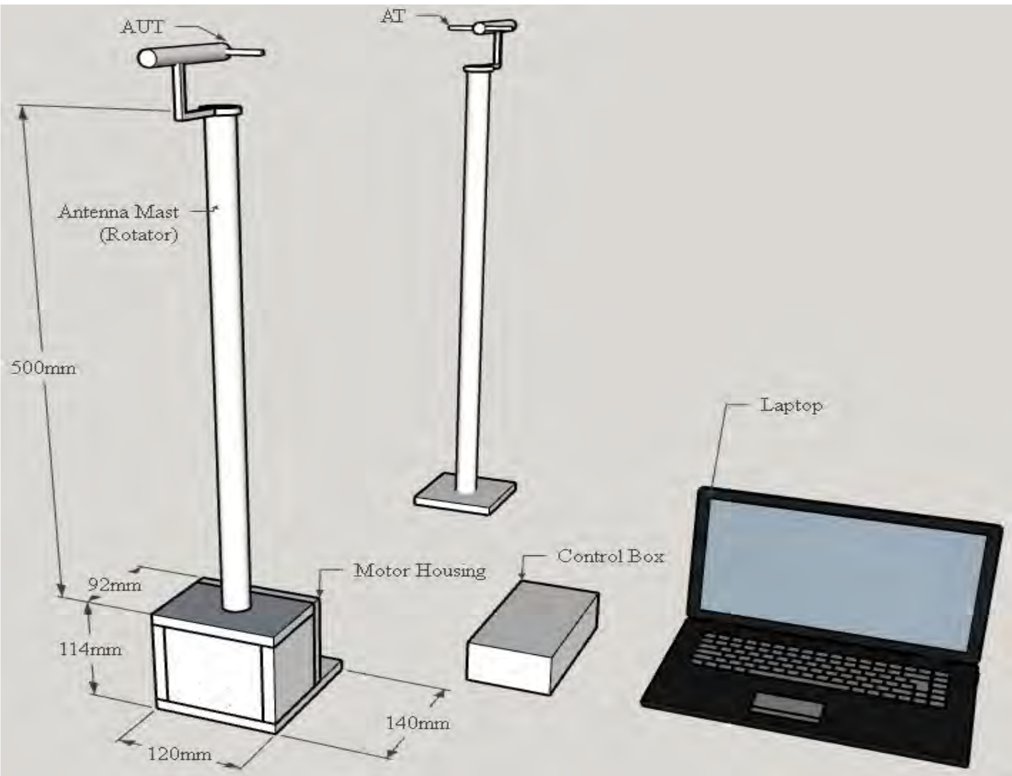

Fig. 3. Block diagram of automatic radiation pattern measurement system.

This system consists of two main separate units: transmitting and receiving units. Transmitting unit consists of radio transmitter that transmits electromagnetic power into free space via transmitting antenna toward receiver side. In this side, the antenna under test (AUT) is rotated 360 degrees every certain step and the received power will later be recorded, processed, and displayed by the computer.

Based on the design step, it can be identified the required materials, components and devices. These items are presented in table 1.

TABLE I. LIST OF MAIN MATERIAL AND COMPONENTS FOR AUTOMATIC RADIATION PATTERN MEASUREMENT SYSTEM.

No	Materials/Components	Quantity	Unit
1	Microcontroller Arduino	1	pcs
2	3 DR radio transceiver	1	packet
3	Motor stepper	1	pcs
4	Motor driver	1	pcs
5	Aluminum alloy	1	set
6	Hard nylon	1	set
7	Connectors	1	set
8	Timing belt	1	set
8	Cables	1	set
9	Bearings	5	pcs
10	Power switch	1	pcs

IV. CONCLUSION

In this research, low cost measuring equipment to measure and plot antenna radiation pattern has been designed. This system applies Arduino Uno microcontroller and 3DR radio (transmitter and receiver) as the main equipment which are simple to program, cheap in price, and available in the market. The student response to the proposed system directs to the need of building it. The expert perceptiveness expresses the feasibility of the system to build to run the antenna and propagation laboratory. The design and realization of the automatic antenna radiation pattern system will enrich more experiment topics and support the antenna and propagation laboratory.

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