Graphical user interface at MatLab in teaching telecommunication engineering

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Abstract

This paper presents the antenna parameter calculator program using basic antenna theory, i. e., principle of radiation power density, radiation intensity, maximum directivity and polarization for telecommunication engineering education. After analyzing results from questionnaire survey, the instructor found that the antenna engineering related subject is difficult to learn because of mathematical model. Therefore, simulation program is important in the teaching of telecommunication engineering. The proposed antenna parameter calculation program consists of input, output, and radiation patterns of electromagnetic (EM) polarization for Graphic User Interface (GUI) of MatLab®. The research results were as follows, the simulated response comparison agrees well with theory and the evaluation of tools by 5 experts was high level. Thus, the GUI of MatLab® tools can be applied and developed effectively for teaching in telecommunication engineering.

Keywords: graphical user interface, parameters antenna, telecommunication engineering

1. Introduction

Studying telecommunication engineering requires mastery on numerical methods for scientists, engineers and researcher. The development and applications are necessary for technical solutions [1]. Traditional methods like blackboard plots or slide presentations do not provide a good simulation of the radiation patterns and do not offer interactivity needed for a better understanding of the concepts [2]. Currently, students cannot understand antenna engineering subject without graphical content. However, most universities have insufficient educational tools so students cannot learn numerical contents easily and efficiently. Computer-based simulation tools have been developed for RF printed circuit, electronics component, antennas design, such as SONNET, IE3D, ADS (Agilent Advance Design System), HFSS (High Frequency Structure Simulation), MatLab®, etc. [3]. It is important to provide students with theoretical and practical knowledge to achieve expertise and soft skill to solve various problems in real life situations. [4] In this paper, the antenna parameters calculation program (APCP) with MatLab®-based GUI in the teaching of telecommunication engineering was developed.

2. Background Concept of the Calculation Program

Three modules are included in the development of software package, which are radiation power density, radiation intensity, and maximum directivity. Theoretical background of each module is briefly described below:

2.1 Radiation power density

The power density associated with the electromagnetic fields of an antenna in its far-field region is predominately real and will be referred to as radiation density [5].

$$P_{rad} = P_{av} \oiint_s W_{rad} \bullet ds = \oiint_s W_{av} \bullet \hat{n}\partial a_r$$
$$= \frac{1}{2} \oiint_s RE[E \times H^*] \bullet ds \qquad (1)$$

2.2 Radiation Intensity

Radiation intensity of an antenna is defined as the power radiated from the antenna in a given direction per unit solid angle. It is expressed in watts per steradian (W/sr).

$$U = r^2 W_{rad} \qquad (2)$$

2.3 Maximum directivity

According to the standard definition, "The ratio of maximum radiation intensity of the subject antenna to the radiation intensity of an isotropic or reference antenna, radiating the same total power is called the directivity." [6]

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An Antenna radiates power, but the direction in which it radiates matters much. The antenna, whose performance is being observed, is termed as subject antenna.

Its radiation intensity is focused in a particular direction, while it is transmitting or receiving. Hence, the antenna is said to have its directivity in that particular direction.

- The ratio of radiation intensity in a given direction from an antenna to the radiation intensity averaged over all directions, is termed as directivity.

- If that particular direction is not specified, then the direction in which maximum intensity is observed, can be taken as the directivity of that antenna.

- The directivity of a non-isotropic antenna is equal to the ratio of the radiation intensity in a given direction to the radiation intensity of the isotropic source.

The ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. Stated more simply, the directivity of a non-isotropic source is equal to the ratio of its radiation intensity in a given direction over that of an isotropic source [7].

$$D = D(\theta, \phi) = \frac{U(\theta, \phi)}{U_0} = \frac{4\pi U(\theta, \phi)}{P_{rad}} \qquad (3)$$

If the direction is not specified, the direction of maximum radiation intensity is implied.

$$D_{maax} = D_0 = \frac{U}{U_0} = \frac{(U_{max})}{U_0} = \frac{4\pi U_{max}}{P_{rad}}$$

(4)

3. Flowchart and GUI of the Developed Program

The process of designing a calculation program is shown in Figure 1. A user can begin the program by selecting from the main menu. Next, the initial calculating values are set up. The program will calculate and process according to the parameters of the antenna. Finally, it will show the output and radiation patterns.

The calculation tool developed for graphical user interface (GUI) function of MatLab® program is illustrated, as show in Figure 2. The developed program can calculate power density, radiation intensity and maximum directivity.

4. Results and Discussion

In this paper, we present Matlab®-based GUI for antenna parameters by using the antenna parameters calculation program. Finally, the environments of simulation tool are evaluated from educational viewpoint.
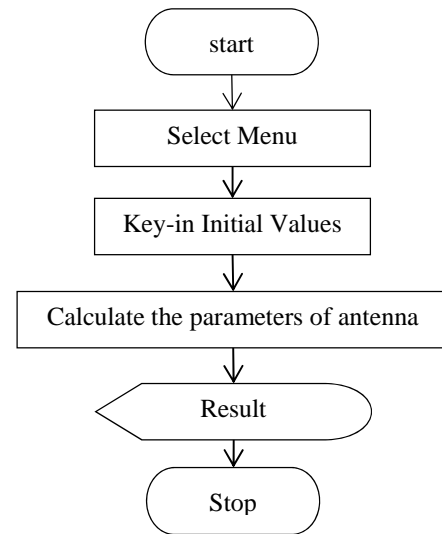

Figure 1. Flowchart of antenna parameters calculation program

4.1 GUI for Antenna Parameters Calculation Program

The antenna parameters calculated by proposed system can analyze radiation power density, radiation intensity, maximum directivity and polarization. In this research, we present antenna parameters the example for calculation program, as shown in Figure 3.

Figure 3 presents the GUI which the user can calculate and plot the radiation patterns of EM polarization. The input parameters are poynting vector (W_{rad}) in W/m and radius (R) in m. The program uses antenna parameters to calculate the radiation power density, radiation intensity, maximum directivity and plot radiation patterns of EM polarization. Upon completion of these aforementioned parameters, the user can determine the performance of the antenna by clicking on EM Fields which shows the graphic simulation of electromagnetic polarization.

4.2 Evaluation of Calculation Program

The evaluation of antenna parameters calculation program user clearly five experts (researches and educators). The findings related to the antenna parameters calculation program are 4.2 and 0.42 which are mean value and S.D. value, respectively. Hence, the quality of APCP was appropriate to be used, as shown in Table 1.

The developed tools were evaluated by 20 students who registered in the antenna engineering course at Rajamangala University of Technology Phra Nakhon. The sample group was taught with the proposed system in antenna engineering subject. After learning all lessons, we measured students' satisfaction for antenna parameters calculation program using questionnaires. The evaluation results after learning and teaching with the APCP are that students gain more knowledge and
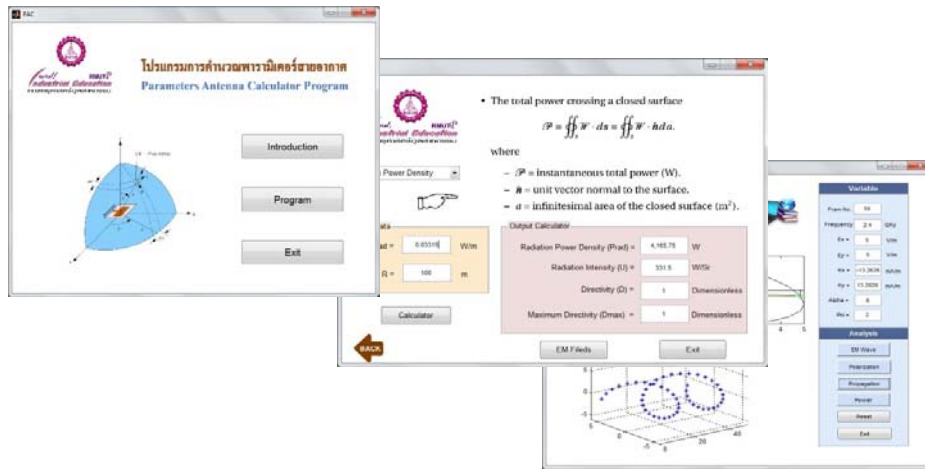
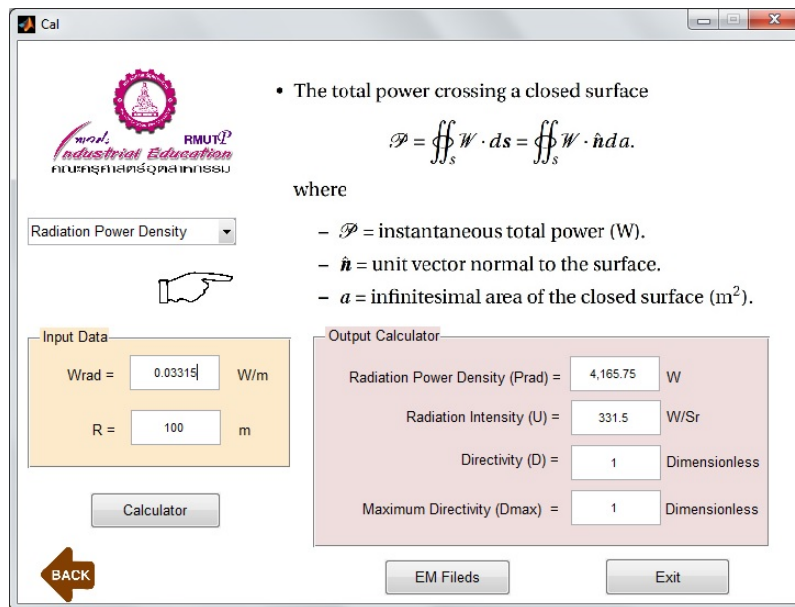**Figure 2.** The antenna parameters calculation program

Figure 3. The screen display of antenna parameters calculation program

understanding of the course contents. Also, the students' satisfaction to the antenna parameters calculation program are 4.24 and 0.51, which are mean value and S.D. value, respectively, as show in Table 2. Thus, the antenna parameters calculation program has good quality for use in the teaching of telecommunication engineering at Bachelor degree level.

5. Conclusions

This paper has presented the antenna parameters calculation program for telecommunication engineering education by using Matlab®-based GUI. The proposed approach based on the wave concept can calculate and illustrate the parameters of antenna by monitoring the radiation patterns. The beneficial aspect of this study is that it can be used in other teaching scenarios that let learners understand the calculation program of antenna engineering subject for telecommunication engineering. By these processes, APCP can develop further to enhance creative problem-solving and collaborative learning for 21st Century Learning [8].

Table 1. Quality Evaluation of Calculation program by 5 experts

Quality Attributes	mean	S.D.
1. Suitability for students	4.53	0.38
2. Accuracy of results	4.26	0.42
3. Simplicity of usage	4.13	0.42
4. Propriety for content and purpose	3.92	0.35
5. Encouragement in the classroom	4.19	0.52
Average	**4.21**	**0.42**

Table 2. The students' satisfaction of usage of program

Quality Attributes	mean	S.D.
1. Suitability for students	4.35	0.36
2. Accuracy of results	4.25	0.48
3. Simplicity of usage	4.32	0.63
4. Propriety for content and purpose	3.63	0.45
5. Encouragement in the classroom	4.63	0.64
Average	**4.24**	**0.51**

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