Interactive Learning Software for Engineering Subjects Based on MATLAB-GUI

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***Abstract*—This paper presents the development and application of interactive learning software for communication engineering subjects. Currently, the software consists of two interactive communication engineering subjects; electromagnetic and digital signal processing (DSP). The software is developed using MATLAB R2014a and its Graphic User Interface (GUI). By using this software, students are able to understand the subjects well as it shows the required value automatically and it also displays the appropriate plots. This software is also suitable to be used as a teaching aid for the lecturers. The standalone program is also developed such that user does not need to install MATLAB in order to use this interactive learning software.**

***Index Terms*—Interactive Learning Software; MATLAB; Graphic User Interface (GUI); Engineering.**

I. INTRODUCTION

MATLAB and its Graphic User interface (GUI) have been acknowledged as powerful software and have been widely used especially in engineering [1]. In [2], a GUI tool for teaching control system is developed using MATLAB. It presents a user friendly tool called the Automatic Control Systems Teaching Assistant no.2 which performs complex Automatic Control Systems calculations and graphs in a user friendly method.

A virtual laboratory environment based on MATLAB-GUI for teaching induction generators has also been developed in [3]. A software tool is developed based on MATLAB Graphical User Interface (GUI) to educate analytically the performance of an induction machine as generator under different configurations such as Self Excited Induction Generator (SEIG) and Grid Connected Induction Generator (GCIG). A front end visual tool is designed employing the GUI capabilities of MATLAB and embedding the mathematically modeled operating conditions in MATLAB codes.

MATLAB GUI for digital communication system with tone jamming is developed by [4]. In this paper, the proposed GUI is a simulation of the baseband digital communication system. It demonstrates the transmission of the Binary Phase Shift Keying signal over an AWGN channel with a tone jamming interference and the reduction of the jamming effect using a digital notch filter. The output response can be selected to demonstrate the differences of the signal corresponding to each section of the communication system.

In [5], A MATLAB GUI package for studying small signal characteristics of power systems with wind and energy storage units as an education tool is presented. In this software package which enables users to study small signal behavior of power systems with wind unit and Energy Capacitor Systems (ECSs). For hybrid systems including wind and storage units, studying dynamic behavior of overall system is a complicated and time consuming task. Thus, the development of interactive educational software for communication engineering subjects is very crucial to enhance the understanding of the subject matters especially among the students

II. OPERATION PRINCIPLE

This software is developed using MATLAB R2014a. Basically, it integrates all the m-files that have been developed using MATLAB and its graphic user interface (GUI) are designed to ease the user. Currently, this software consists of engineering subjects; Electromagnetic and Digital Signal Processing. The subjects are chosen based on the feedback from the students regarding the tough subjects in the faculty of electrical engineering.

For the electromagnetic subject, several exercises are available for the user. For instance, user is able to determine the value of cross and dot product automatically by inserting the desired value. User is also able to determine the electric field intensity at certain location due to a charge. The electrical field plot can also be displayed. In addition, the electromagnetic wave propagation in a free space and in a conductor can also be viewed. All the exercises in the GUIs will allow the students to understand the subject more effectively. Figure 1 and Figure 2 show the main menu and the electromagnetic GUIs, respectively. For the electromagnetic subject, user is able to determine the cross and dot product value, based on the vector value inserted. In addition, user is also able to determine the electrical field intensity value due to a point charge. The plot of the electrical field will also be displayed as shown in Figure 4. The electromagnetic wave propagation through the free space and good conductor can also be visualized using this software as demonstrated in Figure 5.

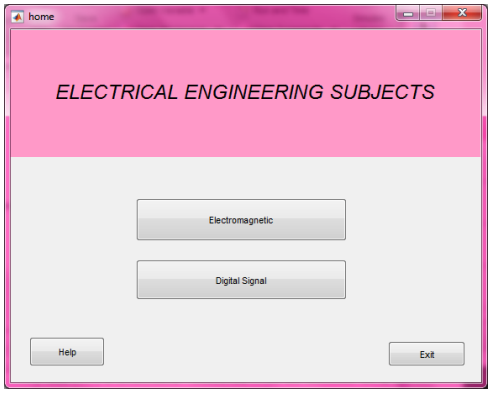

Figure 1: The GUI of the main menu

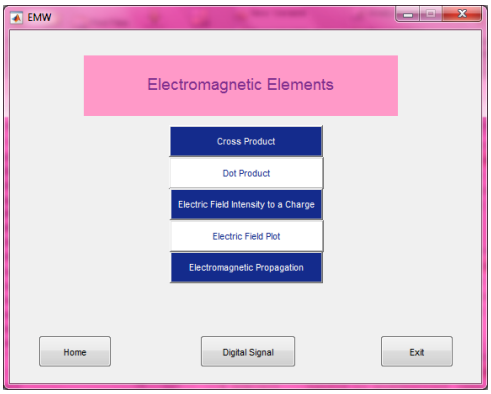

Figure 2: The GUI for Electromagnetic subject

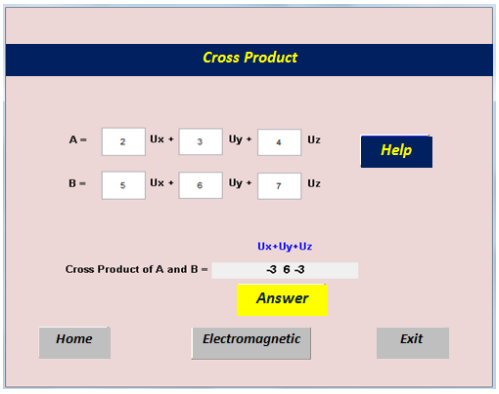

Figure 3: The cross product of the vectors

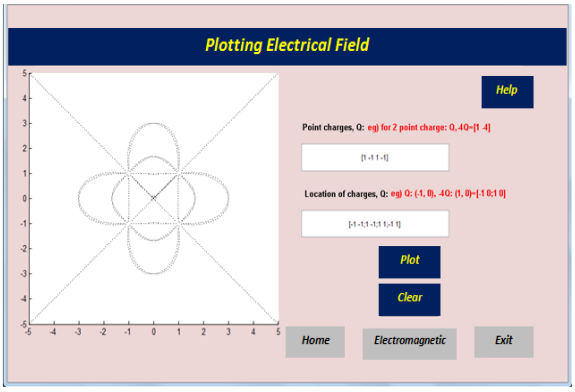

Figure 4: The electrical field intensity due to a point charge

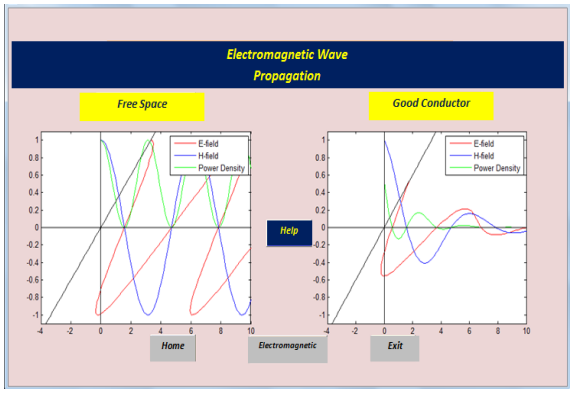

Figure 5: The electromagnetic wave propagation in a freespace and good conductor

For the digital signal processing (DSP) part, currently, user is able to learn on digital modulation and analyze a high frequency signal. The main GUI for DSP is shown in Figure 6. Figure 7 displays various types of digital modulation techniques consist of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM). Figure 8 and 9 demonstrate the ASK and FSK signal, respectively when user enters the appropriate values. Figure 10 shows another type of digital modulation which is the QAM. Various types of QAM displays are presented. Finally, Figure 11 exhibits the signal analysis from .wav file. User is able to playback the signal, filter and perform the time and frequency domain analysis.

Figure 12 to Figure 21 display the result that can be obtained using the offline system analysis. Figure 12 and 13 show the signal representation of the .wav file in time domain before and after filtering process, respectively. User can clearly that the filter is used to filter unwanted signal and it produces a smoother signal. Figure 14 shows the periodogram of an amplitude shift keying (ASK) signal. The frequency of the signal can be clearly seen from the frequency domain representation. The spectrogram of the ASK signal demonstrates a clearer information as there is only one frequency and different amplitude of signal. Figure 16 and Figure 17 show a Morse code which is represented by dot and dash and its frequency is also constant. Figure 18 displays the periodogram of Morse Code and Figure 17 depicts the spectrogram of the Morse code. Basically, Morse code consists of short and long signals called “dot” and “dash” [6]. Figure 18 displays a binary phase shift keying (BPSK) signal representation and Figure 19 shows the scatter plot of 128 quadrature amplitude modulation (QAM) signal.

Figure 6: GUI for Digital signal processing (DSP) which consists of digital modulation and high frequency analysis

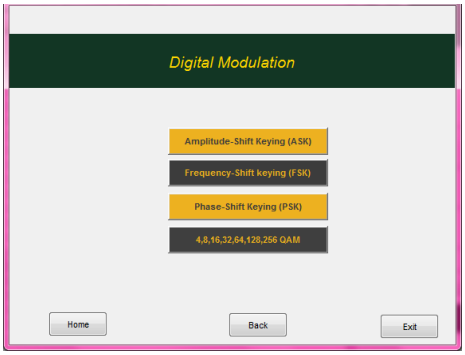

Figure 7: Digital modulation of ASK, FSK, PSK and QAM

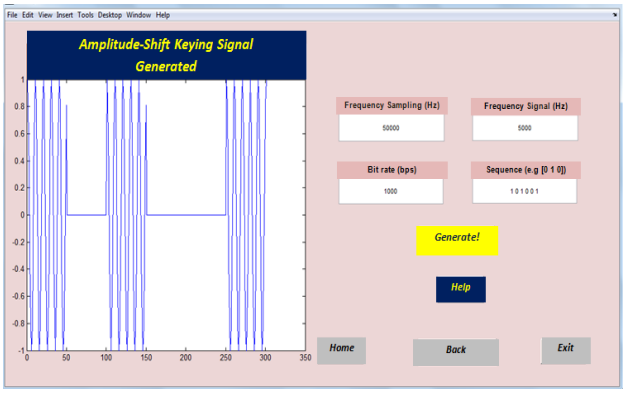

Figure 8: The plot of ASK signal when user enters the appropriate values

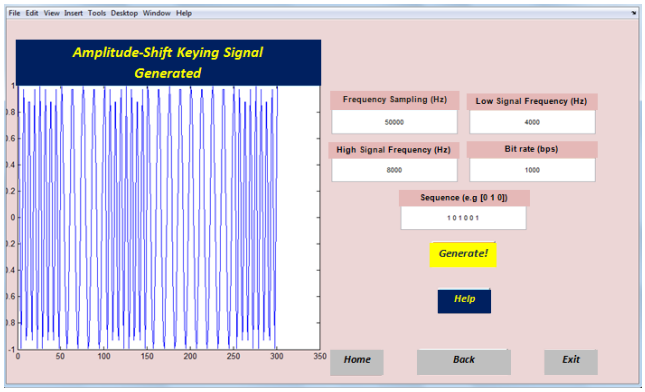

Figure 9: The plot of FSK signal when user enters the appropriate values

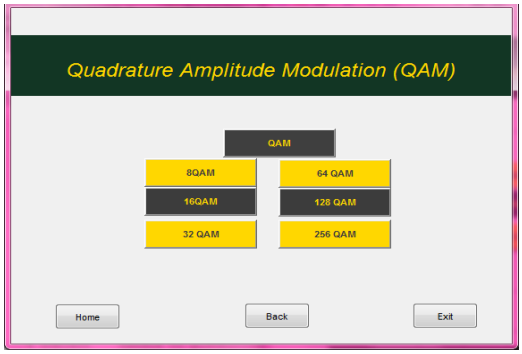

Figure 10: Various types of QAM visualizations

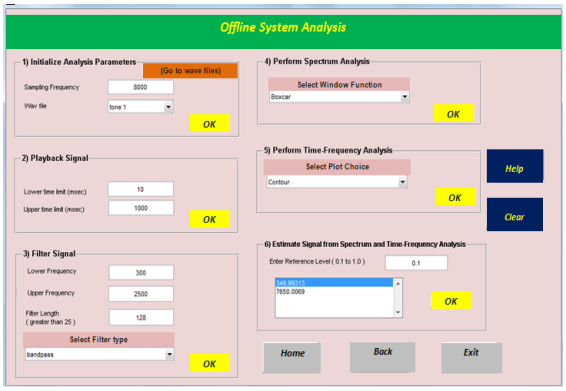

Figure 11: High frequency analysis allows user to insert a .wav file and process the signal

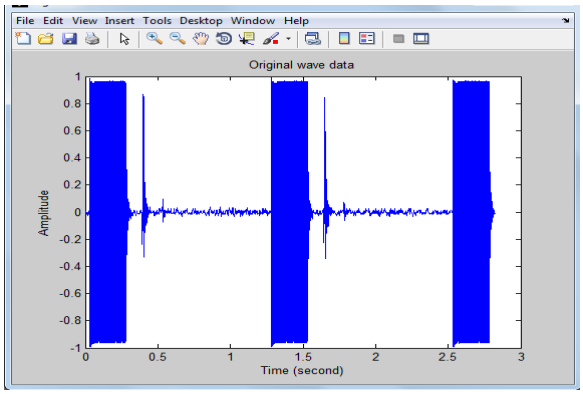

Figure 12: Time domain representation of the .wav file

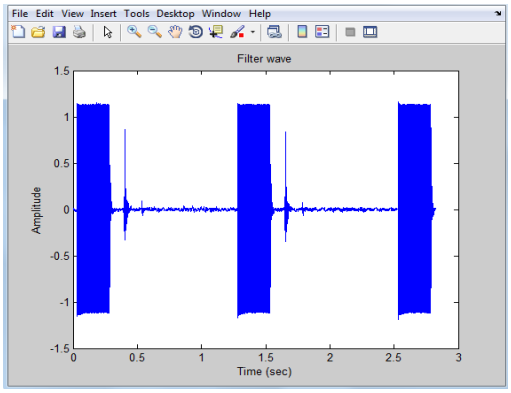

Figure 13: Time domain representation of the signal after the signal has been filtered

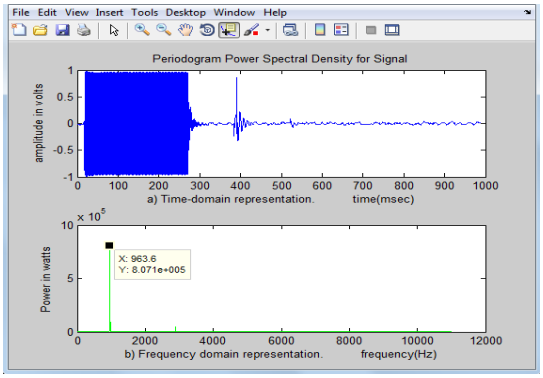

Figure 14: Periodogram and frequency domain representation of ASK signal

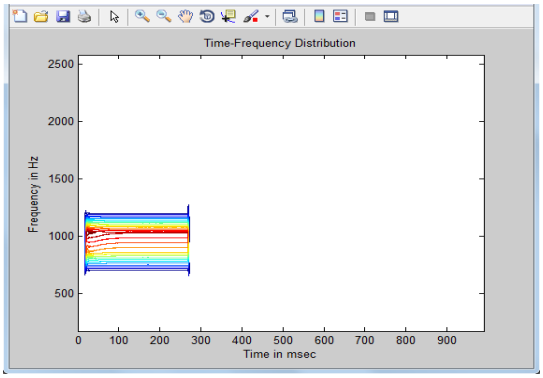

Figure 15: Spectogram of ASK signal

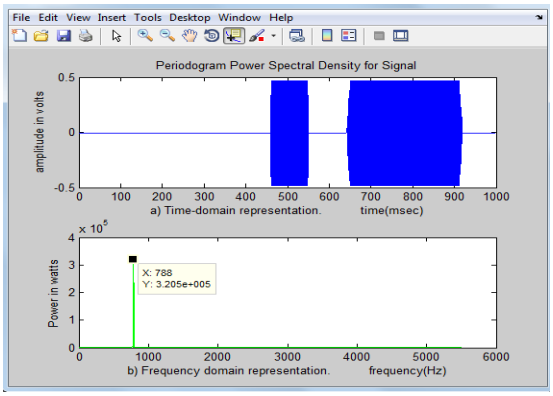

Figure 16: Periodogram and frequency domain representation of Morse Code signal

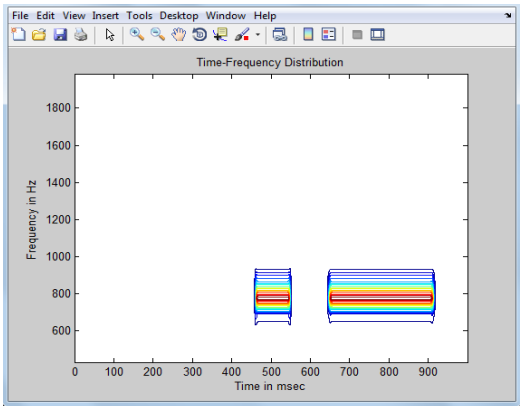

Figure 17: Spectogram of Morse Code representing dot and dash

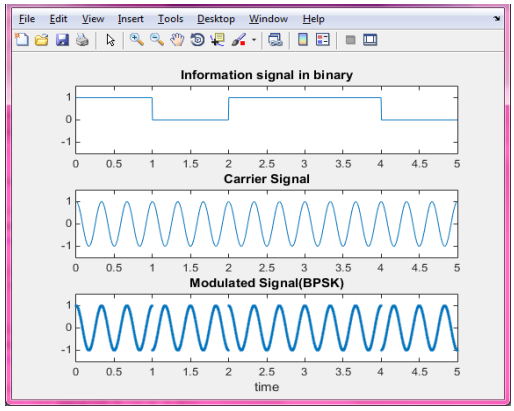

Figure 18: Time domain representation of BPSK signal

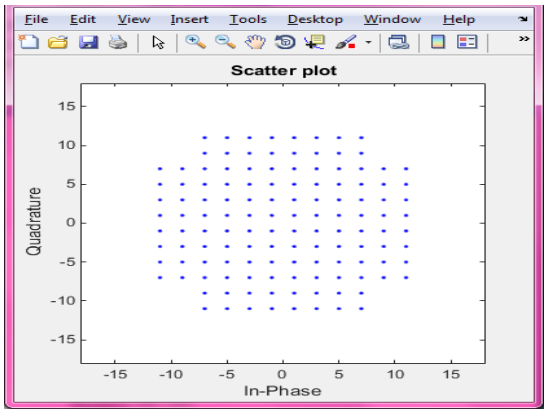

Figure 19: Scatter Plot for 128QAM

From the results obtained, it can be concluded that the system is capable to demonstrate user friendly software for two engineering subjects; electromagnetic and digital signal processing (DSP). Both subjects have been acknowledged as difficult subjects in the faculty of electrical engineering. Thus, by employing this software, the lecturer can automatically plot the desired plots using the software. In addition, the students can learn by themselves (self-learning) and increase their knowledge on the related fields.

III. CONCLUSION

In conclusion, educational software for electrical engineering students has been successfully developed using MATLAB R2014a and its GUI. Currently, two subjects are covered for this software; electromagnetic and digital signal processing (DSP). Both subjects are quite difficult for electrical engineering students. Thus, the development of this software is important to give a clearer understanding for the students. The software can also be used as an educational tool for the lecturers to attract the students to enjoy learning both subjects. The visualizations used in this interactive software will allow a better understanding on the related fields.

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