The GUI-MATLAB based Simulation Program for Principle of Communication System Course

Pinit Nuangpirom[1]* Kanokwan Ruangsiri [2] and Somsak Akatimagool [3]
[1] Faculty of Engineer, Rajamangala University of Technology Lanna, Chiang Mai, Thailand
[2] Faculty of Industrial Technology, Chitralada Technology College, Bangkok, Thailand
[3] Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
*Corresponding author: hs5qab@hotmail.com

ABSTRACT

This article aims to develop a simulation program using GUI-MATLAB in telecommunication engineering course. The instruments used in this research are the GUI-MATLAB based simulation program for signal processing subject including 1) basic signal, 2) modulation signal, and 3) voice signal. The sample group consists of 30 students who registered in the Principle of Communication System course at Rajamangala University of Technology Lanna. The research results are as follows; 1) the result of evaluation of developed GUI-MATLAB simulation program assessed by 5 experts, shows that the quality of the simulation program is more appropriate, 2) the efficiency of the GUI-MATLAB simulation program is consistent with the standard criteria of Meguigans's formula (equaled to 1.10), and 3) the students' satisfaction is at high level (mean = 4.45, S.D. = 0.33). Therefore, the developed simulation program can be applied and developed in the teaching of telecommunication engineering and related as well.

Keyword: GUI MATLAB Software, Simulation Program, Signal Processing Subject.

1. Introduction

In the 21st century skills consortium (AT21CS), the teaching and assessment of knowledge, attitudes and organization skills are divided into four categories as following; ways of thinking, ways of working, tools for working, and living in the world. Most highlight similar types of complex thinking, learning, and communication skills, and all demand learning through teaching and learning more than rote skills. These capabilities are also more commonly referred to as higher-order thinking skills, deeper learning outcomes, and complex thinking and communication skills [1]. The STEM education purposes to provide students to be professional which integrates four subjects: Science, Technology, Engineering and Mathematics. This is done by taking the nature of instruction as well as different teaching disciplines to come together seamlessly, which can provide students to get knowledge of all fields. For several years, this has been used to solve the educational research and there has been recent development [2], in telecommunication engineering. The various developed instructional tools were utilized in teaching, in order to design and to construct electronic circuits. However, typically, in an experiment set, an oscilloscope, and signal generator were not enough and incurred high costs. [3], [4], [5]. This problem issues have been found in many universities that lack integration of modern instructional media [6], [7]. Thus, the STEM education promotes development of important and necessary skills for the globalization of the 21st century [8]. The educational simulation development is necessary to use in engineering education [9], [10] such as, IE3D, Sonnet Lite, Computer Simulation Technology (CST), Pspice, and etc. Moreover, it can be found that most researchers have applied the GUI-MATLAB for the simulation program in electrical engineering course such as a GUI-MATLAB program for learning controller design in the frequency domain [11], GUI-MATLAB based simulation platform design of flexible satellite attitude control and vibration suppression [12] and implementation of a GUI-MATLAB function to visualize electromagnetic fields [13].

The contents of the subject matter can be intricate and difficult, which leads to the inefficiency of learning by students. The applications of knowledge to real life situations are emphasized by the STEM education concept in higher education. In this paper, the GUI-MATLAB based simulation program is implemented in the teaching of signal processing subject in Principle of Communication System course.

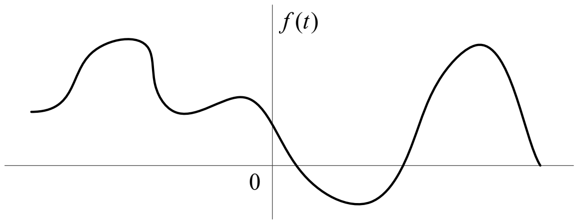
2. Theory

Considering an arbitrary signal *f(t)* of finite energy, which is specified for all time (*t*), a segment of the signal *f(t),* shown in Fig.1(a), postulates that we sample the signal f(t) instantaneously and at a uniform rate, once every T_s seconds. Consequently, we obtain an infinite sequence of samples spaced T_s seconds apart and denoted by $\{f(nT_s)\}$, where *n* takes on all possible integer values, both positive and negative. We refer to T_s as the sampling period or sampling interval and to its reciprocal $f_s=1/T_s$ as the sampling rate. This ideal form of sampling is called instantaneous sampling.

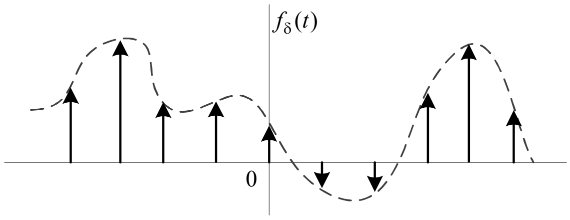
Let $f_\delta(t)$ denote the signal obtained by weighting individually the elements of a periodic sequence of Dirac delta functions spaced T_s seconds apart by the sequence of numbers $\{f(nT_s)\}$, as shown by [10].

$$f_\delta(t) = \sum_{n=-\infty}^{\infty} f(nT_s)\delta(t-nT_s) \qquad (1)$$

We refer to $f_\delta(t)$ as the instantaneously sampled signal. The term $\delta(t-nT_s)$ represents a delta function positioned at time $t = nT_s$. A delta function weighted is closely approximated by a rectangular pulse of duration Δt and amplitude $f(nT_s)/\Delta t$; the smaller, we make Δt, the better the approximation will be used.



(a) Analog waveform *f(t)*



(b) Instantaneously sampled representation *f(t)*

Fig. 1 Illustration of the sampling process.

The waveform of a PAM signal is illustrated in Fig.2. The dashed curve in this figure depicts the waveform of the message signal *m(t)*, and the sequence of amplitude-modulated rectangular pulses shown as solid lines represents the corresponding PAM signal *s(t)*.

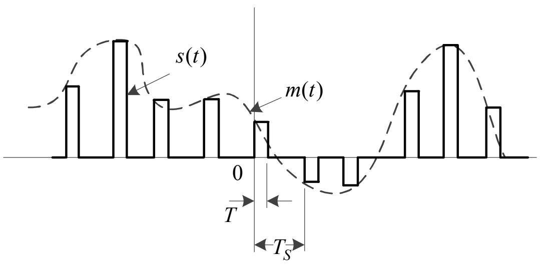


Fig.2 Flat-top sampling of message signal.

Amplitude quantization is defined as the process of transforming the sample amplitude $m(nT_s)$ of a baseband signal m(t) at time $t = nT_s$ into a discrete amplitude $v(nT_s)$ taken from a finite set of possible levels. We confine attention to a quantization process that is memory less and instantaneous, which means that the transformation at time $t = nT_s$ is not affected by earlier or later samples of the message signal. This form of quantization, though not optimal, is commonly used in practice because of its simplicity.

Quantizes can be a uniform or non-uniform type. In a uniform quantize, the representation levels are uniformly spaced; otherwise, the quantize is non-uniform. The quantization considered in this section are of the uniform variety. The quantized characteristic can also be a midrise type. Fig. 3 shows the corresponding input-output characteristic of a uniform quantize of the midrise type, in which the origin lies in the middle of a rising part of the staircase like graph.

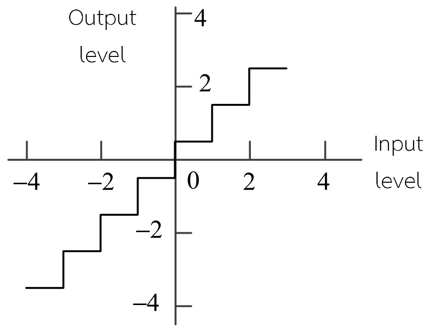


Fig.3 Signal quantization

3. GUI-MATLAB Based Simulation Design

GUI-MATLAB software means that the graphical user interfaces contain windows, cursors, buttons, menu, text and other objects. Using GUI function optimizes performance, by providing a visual for the user, it reduces the need of unnecessary thinking.

The process of designing a GUI function for voice signal processing is applied to the study of Principle of Communication System, as shown in Fig. 4. The GUI-MATLAB based simulation program consists of 3 parts: 1) signal plot simulation, 2) signal modulation, and 3) voice signal processing. We can select the desired circuit type, afterwards, the initial calculating values are set up. The simulation program will calculate and process according to various signal types and will show the analyzed results.

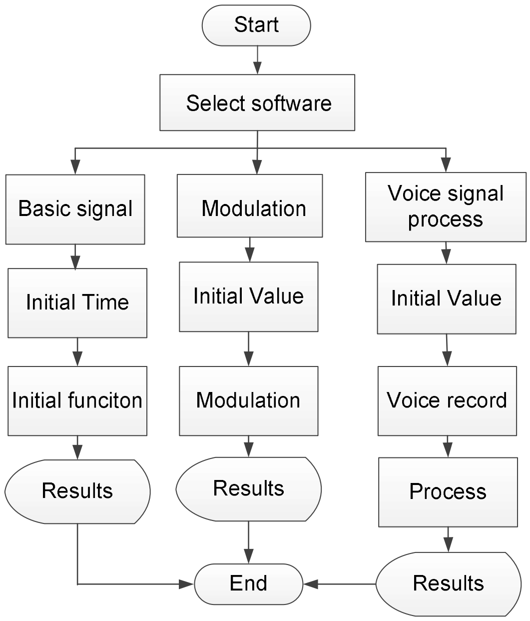


Fig. 4 Flow chart of GUI-MATLAB based simulation program

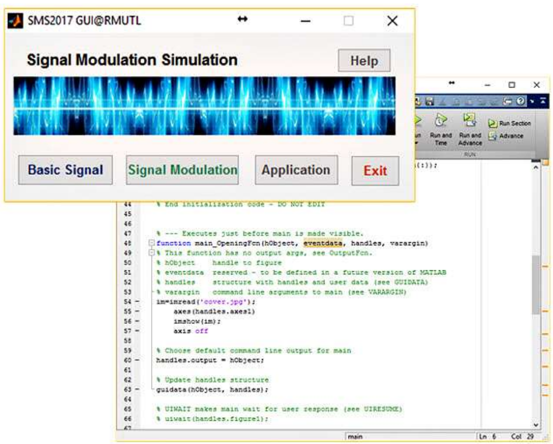


Fig.5 Example of signal processing software

The development of the simulation program makes use of the graphical user interface (GUI) function of MATLAB software, as illustrated in Fig.5. The developed simulation program can simulate both analog and digital modulation systems, as a basic signal function, analog modulation, digital modulation and voice signals process.

4. Results

The research is carried out in 3 sections including 1) the developed simulation program, 2) the quality evaluation of simulation program by 5 experts, and 3) the students' satisfaction.

4.1 The result of developed simulation program

The developed simulation program can be analyzed within the basic signal time domain, as shown in Fig.6. In this topic, we illustrated an example for basic signal simulation as shown in equation (2).

$$f(t)=\sin(t)+\frac{\sin(3t)}{3}+\frac{\sin(5t)}{5} \qquad (2)$$

In Eq.(2), we can state that the Fourier series of the square wave function simulated by the developed simulation program can be displayed and is consistent with signal theory. Moreover, The users can set up required equation parameters in a text box of f(t) and these signal will appear, as illustrated in Fig.6.

Moreover, the developed simulation program can be analyzed in 8 modulating signals, including Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM), Amplitude-Shift Keying (ASK), Frequency-Shift Keying (FSK), Phase-Shift Keying (PSK), Pulse Width Modulation (PWM) and Pulse Amplitude Modulation (PAM). The example of frequency modulation is shown in Fig. 7. The diagram of frequency modulation defines the peak amplitude of message signal that equals 5 V, and the frequency of message signal that is at 25 Hz. For the carrier signal, we set the peak amplitude equaled to 1 V and frequency at 400 Hz. The results of simulation tool are shown in Fig. 8.

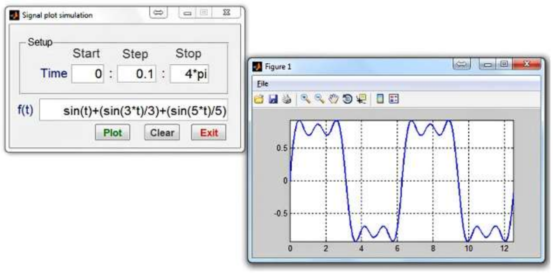


Fig.6 Example of basic signal simulation

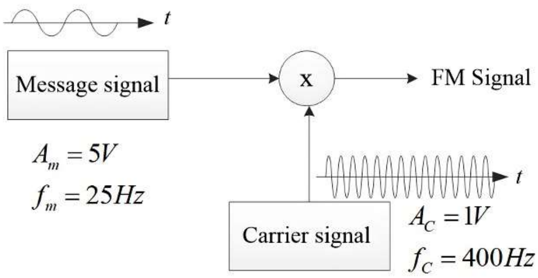


Fig 7. Diagram of amplitude modulation

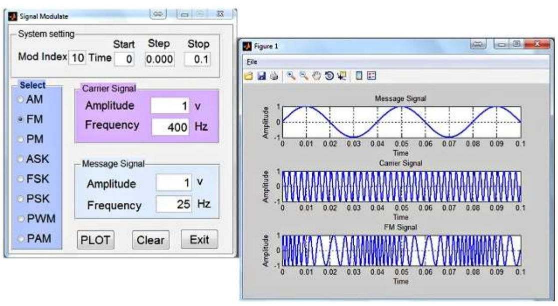


Fig. 8. The FM simulation using developed simulation program

Fig. 8 presents the results of the frequency modulation. We can observe that the frequency of carrier signal is varied depending on the message signal. The result is therefore analyzed as consistent with the properties of frequency modulation. For simulation of voice signal processing, the voice signals are recorded by using the sound card on a personal computer (PC) and WINDOWS operating system. The microphone is connected to the voice input on PC, and the voice signal is saved on the recorder, as shown in Fig.9.

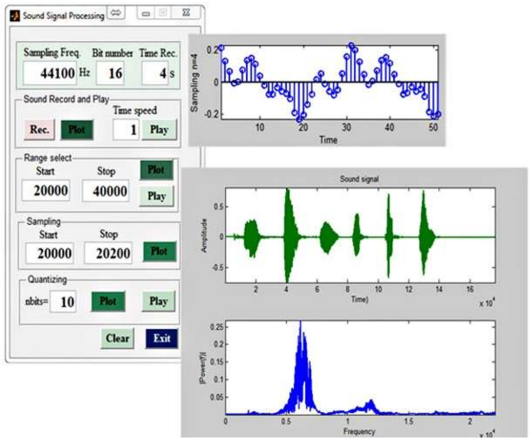


Fig.9 Windows of voice signal processing

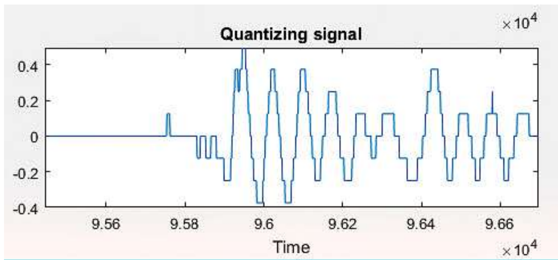


Fig.10 The example of quantize characteristic

Fig. 9 shows an example of audio signals in time domain and frequency domain. Moreover, the program can also reveal the appearance of quantize according to the theory [10], as shown in Figure 10.

4.2 The quality evaluation of simulation program

The developed GUI-MATLAB based simulation program in the teaching of Principle of Communication System course was evaluated by 5 experts who hold a long experience in the teaching of electronic engineering or related fields. The findings shows that the quality of simulation program is highly appropriate (mean value equals 4.48, and S.D. equals 0.52), as shown in table 1.

The developed GUI- MATLAB based simulation program was implemented by using a sampling group of 30 students who registered in the Principle of Communication System course in academic year 2/2016 at Rajamangala University of Technology Lanna.

TABLE I The results of the quality of simulation program

Evaluated topics	$\overline{X}$	S.D.
1. Appropriation of simulation program	4.60	0.89
2. Accurately simulation program	4.80	0.45
3. Easy to use	3.40	0.55
4. Appropriation of content and design	4.20	0.84
5. Encourage student to understand knowledge	4.40	0.89
Total	**4.48**	**0.52**

The validation of the efficiency of simulation program can been found in the pre-test and the post-test score percentage that are equal to 49.40 and 86.46 respectively. The efficiency of the GUI-MATLAB simulation program is conformed to the standard criteria of Meguigans's formula (1.10), as shown in Table II.

TABLE II The efficiency of simulation program

Test	Average (out of 80)	Percent
Pre – test	39.52	49.40
Post – test	69.17	86.46
Efficiency	1.10	

4.3 The students' satisfaction

The developed GUI-MATLAB based simulation program was experimented by 30 students, as shown in Fig.11. The sample group was taught by using the developed simulation program. After learning all lessons, we evaluated students' satisfaction using a 5 rating scale of questionnaire. The findings after learning and teaching using the developed simulation program can be stipulated that the students are able to gain more knowledge and understand the contents more clearly. The students' satisfaction is in high level (mean value equals 4.45 and S.D. equals 0.33), as shown in table 3.

Fig. 11 The experiment in a classroom

TABLE III The students' satisfaction of simulation program

Evaluated topics	$\overline{X}$	S.D.
1. Appropriation for students	4.46	0.37
2. Accurate results	4.40	0.52
3. Easy to use	4.41	0.38
4. Appropriation for content and purpose	4.55	0.35
5. Encourage students to learn	4.51	0.32
Total	4.45	0.33

5. Conclusion

This research presents the development of the GUI-MATLAB based simulation program in the teaching of telecommunication engineering. The developed simulation program is able to analyze and simulate correctly various signals used in communication systems and is consistent with the signal theory.

Considering the research results, it can be seen that instructional media development for engineering education based on 21st century and STEM education [14], [15], [16] will encourage students to acquire complex knowledge, practical and creative thinking skills and a positive attitude towards learning. Moreover, the students' learning achievement will increase more significantly.

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