A New Educational Modulation Simulator Using for Digital and Analog Modulations

Tolga Özer, Hasan Çimen, and Ayhan Akbal

***Abstract*—**Computer-aided education has become popular thanks to its flexible and useful structure in classroom environment. Therefore computers can be used for explaining easily some of theorical information to students. This paper includes a modulation simulator which made by using MATLAB GUI. By means of this simulator students can understand analog and digital type modulation easier than explaining only with theorical informations devoid of visual interface. It aims at improving the students' understanding of digital modulation techniques employed in the communication systems course. The first section defines graphical user interfaces(GUI) and describes interface components. This is followed by a giving some information kinds of modulation types and after these modulation types showing at modulation simulator window as a original signal type, modulation signal type and demodulation signal type.

***Keywords*—**Analog and digital signals, communication, engineering education, interfaces, modulation

I. Introduction

FROM past to today every time mankind is struggled with easy learning ways of information. All works are tend to prepare the environment for learning easily. The most important way of stable learning is giving visual explaining things to someone [1]. If a student or someone learn something with visual ways this knowledge can be remembered for a long time and also learned to be in a short time[2]. In engineering there are many numerical, mathematical and theoretical things within education of engineering. These topics which are stimulated in mind can be too hard in many times. To make easier this situation computer system can be used for this purpose. Computer-based system is an useful instrument in the engineering education [3,6,7,21]. It increases the students' ability of understanding about engineering topics. By means of this system the learning much more stable and it is also more palpable and more flexible. This teaching method provides to students easily understanding the topics, and these advantages make, this system more popular.

Tolga Özer is with the Afyon Kocatepe University Technology Faculty Electric and Electronic Engineering, Afyonkarahisar, Turkey
Email: tolgaozzer@gmail.com

Hasan Çimen is with the Afyon Kocatepe University, Technology Faculty, Electric and Electronic Engineering, Afyonkarahisar, Turkey Email:hcimen@aku.edu.tr

Ayhan Akbal is with the Fırat University, Engineering Faculty, Electric and Electronic Engineering Email:ayhanakbal@gmail.com

Computer-aided system has advantageous properties, educational tools have been increasingly used in engineering education for traditionally hard engineering subjects such as electrical, electronical, computer, etc. in the past years. Exercises and laboratory experimentations with computer-aided programmes are made more efficient than classical methods. The result of using this system the student's attention is attracted during the lessons. The recent technological trends in engineering education have evolved computers and software tools. The use of software simulation programmes in classroom environments have become an inseparable part of modern engineering education [3].

Recently, computer-aided education has been used increasingly day by day and we can see widely in literature. In the literature, software based educational programmes offer students a quick and ease of understanding and introduce to simulation experiments related to telecommunication [4]. If we have graphical results at the end of some process then we should use a interface software programme. In general the system can be called Graphical user interfaces or GUI[5]. Nowadays Graphical user interfaces or GUIs are employed everywhere today, even on our smart phones. Graphical user interfaces (GUIs) are used commonly for the creating interfaces and experimental applications. It provides users of computer simulations and visual approach [6,7]. GUI can be easily understood as an interface between user and computer program. The most important benefit of a GUI is that it can post-process the results of the simulation providing the user with instant feedback. Also there are lots of GUI software programme in software world. The main reason of to be chosen MATLAB GUI has more information sources and experimental applications on net or articles [8]. Matlab has been used as a teaching aid in many subjects such as mathematics, physics, heat conduction, control systems, mechatronics, mechanical design, circuit design, communication theory, random processes, electronics and many more disciplines and applications [6,7,8,9,10,11].

In the literature, for modulation applications or creating interface for its modulation process MATLAB is used generally. The comparing basic modulation for transmission and the transmitters and receivers characteristics description is made by using MATLAB [12]. It enables the easy analysis of the digital modulation techniques taught in the communication system courses by means of graphical presentations [13]. Net technology was used and presented a MATLAB GUI platform for multivariable frequency sampling filters algorithm [14]. The developed GUI is aimed to deliver information and summarization of analysis in terms of graphical representation for the user.

In this study, the educational software tool is presented. A graphical user interface (GUI) is used for showing changeable modulated, demodulated and original signal types through entering frequency and amplitude value. Students can be able to see kinds of analog and digital modulation types and these modulation signal wave shapes through this simulator. In the literature there are some works about modulation technics but these Works were made based on only one kind of modulation types. There has not been any work related to modulation simulator which serves more modulation kinds in same software programme so far. Our work most important aspect is hold multiple modulation types in one interface and values can be changed according to the desired value.

II. MODULATION

Modulation is the process of make easier and conveying one or more kind of wave signal to the receiver. Through of carrier signal information signal is transmitted. The configuration of signal modulation is shown in Fig.1.

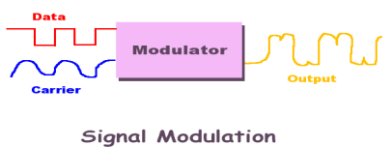

Fig. 1 The block diagram of signal modulation

Digital modulation is aimed to transfer a collection of digital bits over an analog bandpass channel. In the public switched telephone network or over a limited radio frequency band can be shown as a example for this event.

Analog modulation purpose is to transfer an analog signal. An audio signal or TV signal can be given as an example for analog modulation.

The aim of pulse modulation methods is to transfer a narrowband analog signal, for example a phone call over a wideband baseband channel or, in some of the schemes, as a bit stream over another digital transmission system. Color figures will be appearing only in online publication. All figures will be black and white graphs in print publication.

Modulation is extremely necessary in communication system due to the following reasons:

- Using small length antenna for communication.
- Communicating with the distance places.
- Communicating with wireless system to each other of users.

A. *Types of Modulation*

B. *Analog modulation methods*

There are 3 basic types of modulation: Amplitude modulation, Frequency modulation, and Phase modulation [17].

C. *Amplitude Modulation(AM)*

In this modulation type the amplitude of the carrier signal is modulated (changed) in proportion to the message signal while the frequency and phase are kept constant.

We can divide AM modulation a few subheading as follows.

Double-sideband modulation (DSB)

- Double-sideband modulation with carrier (DSB-WC) (used on the AM radio broadcasting band)
- Double-sideband suppressed-carrier transmission (DSB-SC)
- Double-sideband reduced carrier transmission (DSB-RC)

Single-sideband modulation (SSB, or SSB-AM)

- SSB with carrier (SSB-WC)
- SSB suppressed carrier modulation (SSB-SC)

D. *Frequency Modulation(FM)*

A type of modulation where the frequency of the carrier signal is modulated (changed) in proportion to the message signal while the amplitude and phase are kept constant [15].

E. *Phase Modulation(PM)*

A type of modulation where the phase of the carrier signal is varied accordance to the low frequency of the message signal is known as phase modulation [15].

F. *Pulse modulation methods*

Pulse modulation schemes aim at transferring a narrowband analog signal over an analog baseband channel as a two-level signal by modulating a pulse wave. Some pulse modulation schemes also allow the narrowband analog signal to be transferred as a digital signal (i.e. as a quantized discrete-time signal) with a fixed bit rate, which can be transferred over an underlying digital transmission system, for example some line code. These are not modulation schemes in the conventional sense since they are not channel coding schemes, but should be considered as source coding schemes, and in some cases analog-to-digital conversion techniques [17].

G. *Demodulation*

Demodulation is the process of recovering the audio signal from the modulated wave. At the broadcasting station, modulation is done to transmit the audio signal over larger distances to a receiver. When the modulated wave is picked up by the radio receiver, it is necessary to recover the audio signal from it. This process is accomplished in the radio receiver and is called demodulation. Transmitter and receiver structures are shown in Fig.2.

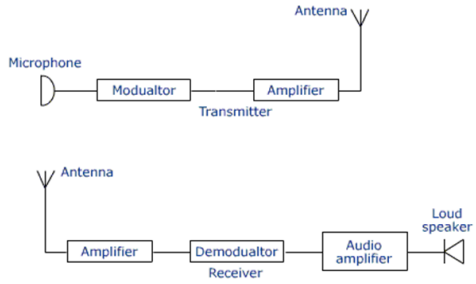

Fig. 2 The Block Diagram of Transmitting and Receiving System

III. MATLAB GUI

MATLAB is a scientific computing comprehensive software programme and this programme provides powerful graphical user interface (GUI) function. Matlab Guide user window is shown in Fig. 3. GUI's user window consists of the window, toolbar, plots, icon, menu, the mouse pointer, and many other elements, users can easy to realize some specific functions by means of clicking or selecting these elements [19-20]. Guide extends MATLAB's support and gives opportunity for rapid coding into the realm of building GUIs. You can arrange a complex graphical tool for any interface in minutes. You can put buttons and plots are in same place and the Guide Callback Editor give you opportunity for writing the MATLAB code in these callback section. These codes make its job when a particular button is pressed. This system uses all kinds of interface and creating interface for user's request. MATLAB GUI not only used for experimental teaching, it can also be used to assist in theory teaching, which serve visual media, easy usage and reliable. When Practical applications are done with GUI, it shows certain result for the experimental system and it improves the effectiveness of teaching.

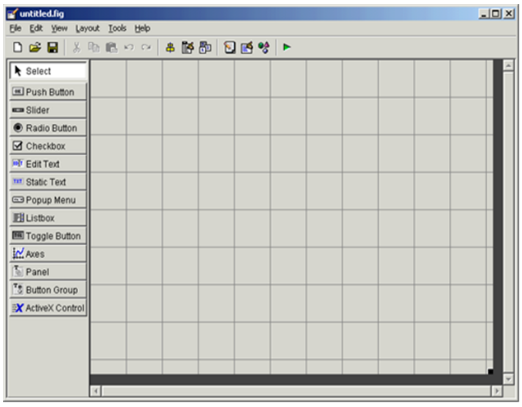

Fig. 3 Matlab Guide User Window

IV. CREATING MODULATION SIMULATOR INTERFACE

MATLAB 7.10 was chosen for this implementation. All of arrangement steps will explain continuation of the article. Three main principal elements required to create a MATLAB Graphical User Interface are [17]: Components: for example labels, edited boxes and pushbuttons. These components are used for controlling the graphical proses (pushbuttons, edit boxes, lists, sliders, etc.), static elements (frames and text strings), menus, and axes.

Figures: Every components of the GUI have to be used and laid out in an area within a figure. Figure is the layout of the GUI in computer screen. Data is represented at figures in the form of graph.

Call-backs: Call-backs functions give opportunity to execute desire action whenever users click a mouse on a button. A real good processing MATLAB program for graphical user interface must be able to respond to each event which represent by mouse click or key press. Call back is a process and result of this process code executed as response to an event.

Modulation simulator is designed for only one window and modulator simulator interface consists of four axes, two pop-up menu, edit texts, static texts and push buttons. All of these components tasks are defined at their related call back sections.

A. Simulation

Figure 4 illustrated the Modulation Simulator which is developed in order to showing all of modulation, demodulation and original signal types in the same window. As shown in Fig.4. Simulator consists of four main axes.

Fig. 4 Modulation Simulator Window

Axes1 shows us our original signal type and shape, axes2 shows modulated signal shape which any implemented modulation kinds, axes3 shows us demodulated signal type and axes4 shows us these kinds of modulations block diagram. We can write value of information signal frequency(Fc) and carrier signal(Fs) frequency. If there are wrong information for example verbal symbols are written to edit text instead of numerical value writing these edit text, error message warns us in order to get in numerical value.Also entered Fs value have to be bigger at least two times than Fc value.This event changeable for the kinds of modulation types.Especially this situation is valid for kinds of amplitude modulations,frequency modulations and phase modulations. In modulation simulator the amplitude of signal can be arranged. What value is desired this value can be entered in edit text which is named with"Amplitude".

There are a few choosable modulation opsions in modulation simulator. Any kind of modulation type can be chosen in pop-up menu which is named "Modulation Type" as it is shown in Fig.5.

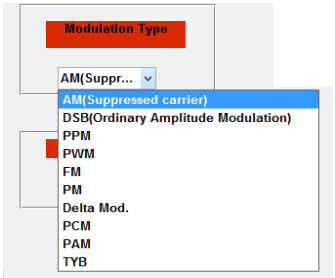

Fig. 5 Pop-up Menu Window of Modulation Type

Also this signal wave shape is able to change through with "Signal Type" pop-up menu. There are four signal

options.They are sinus,square,pulse and triangle wave shapes are seen respectively from top to bottom.

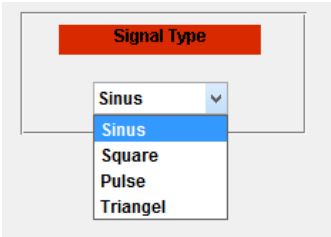

Fig. 6 Pop-up Menu Window of Signal Type

When modulation type and wave shape of signal are selected also frequencies and amplitude values enterred in simulator you press modulation button which is named "Modulation" the modulation operation is achieved. The simulator can be closed when pressed button which is named "CLOSE".These modulation simulator interface buttons can be seen in Fig.7.

Fig. 7 Close Button and Modulation Button View on Modulation Simulator Interface

V. Modulation Simulator Interface Of Modulation Types

A. *Double-sideband suppressed-carrier transmission (DSB-SC)*

For this modulation kind "AM" option have to be selected in pop-up menu. After the entering frequency values, selecting sinusoidal signal wave shape, entering amplitude value and then pressed to modulation button the modulation simulator interface will be in figure 8. Amplitude value was chosen 5, Fc frequency value was chosen 100, Fs frequency value was chosen 400.Results can be seen in Fig.8.

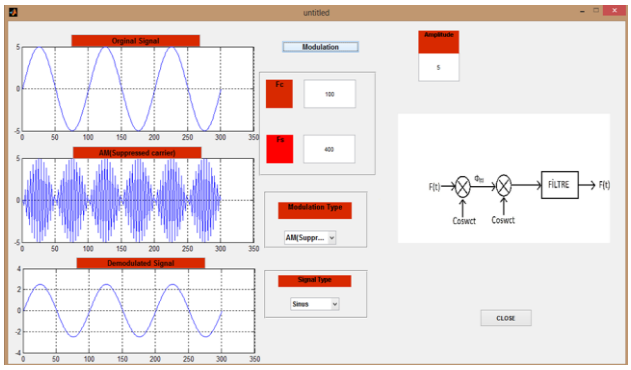

Fig. 8 Modulation Simulator Interface View of Double-sideband Suppressed-carrier Transmission Modulation

B. *Double-sideband Modulation with Carrier (DSB-WC) (used on the AM radio broadcasting band)*

In this modulation type "DSB" option have to be selected from pop-up menu. After the entered necessary values such as Fc, Fs, amplitude and arranged the pop-up menu sections the interface can be seen as follows. As it is shown in Fig.9. Fc was entered 100,Fs was entered 400 and amplitude value is entered 3. Signal type was chosen sinusoidal.

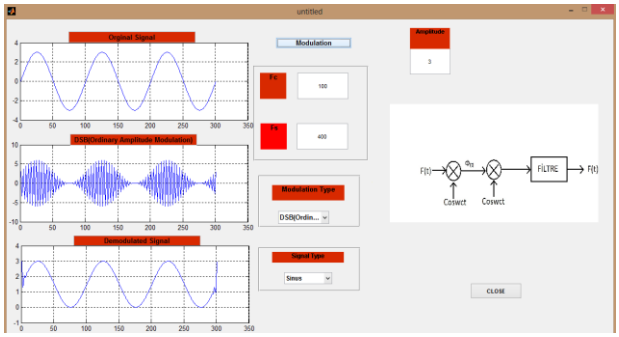

Fig. 9 Modulation Simulator Interface View of Double-sideband Modulation with Carrier

C. *Single-sideband Modulation (SSB or SSB-AM)*

For this modulation kind "TYB" option have to be selected in pop-up menu. After the entered frequency values selected square signal wave shape, entered amplitude value and then pressed to modulation button the modulation simulator interface will be shown results in Fig.10. Amplitude value was chosen 5, Fc frequency value was chosen 100, Fs frequency value was chosen 500.

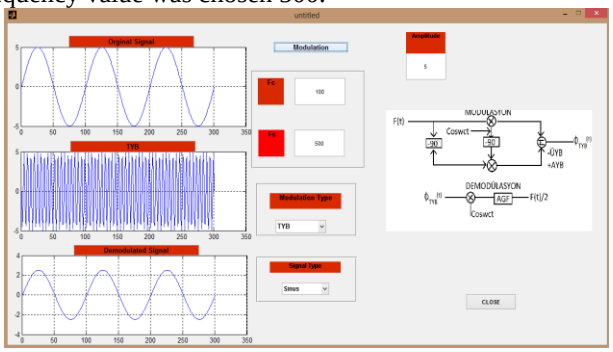

Fig. 10 Modulation Simulator Interface View of Single-sideband Modulation

D. *Delta Modulation*

This modulation interface has some differences than other interfaces. First difference is another edit text which is used for entering size of step in delta modulation. Also this interface have edit text for amplitude value. And second difference is Axes3 show us original signal and quantized signal with together. When entered the all suitable quantity to interface results can be seen in Fig.11.

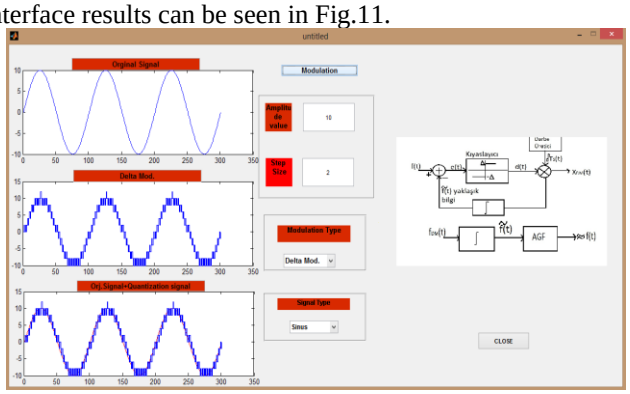

Fig.11.Modulation Simulator Interface View of Delta Modulation

E. *Frequency Modulation (FM)*

For this modulation kind "FM" option have to be selected in pop-up menu. After the entering frequency values,selecting

square signal wave shape,entering amplitude value and then pressing to modulation button the modulation simulator interface will be at bottom as seen. As it is shown Fig.12. amplitude value was chosen 5, Fc frequency value was chosen 100, Fs frequency value was chosen 400.

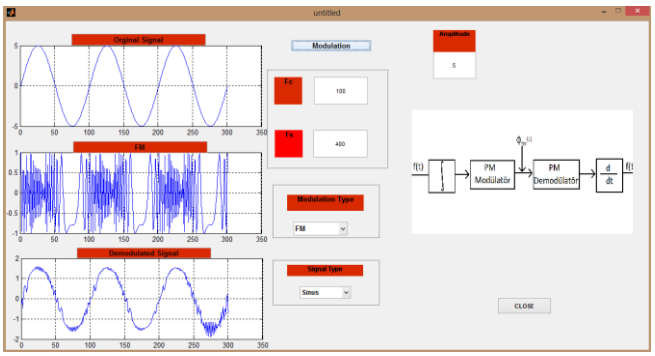

Fig.12 Modulation Simulator Interface View of Frequency Modulation

F. *Phase Modulation(PM)*

For this modulation kind "PM" option have to be selected in pop-up menu. After the entered frequency values, selected sinusoidal signal wave shape, entered amplitude value and then pressed to modulation button the modulation simulator interface will be seen at Fig.13. Amplitude value was chosen 3, Fc frequency value was chosen 100, Fs frequency value was chosen 2000.

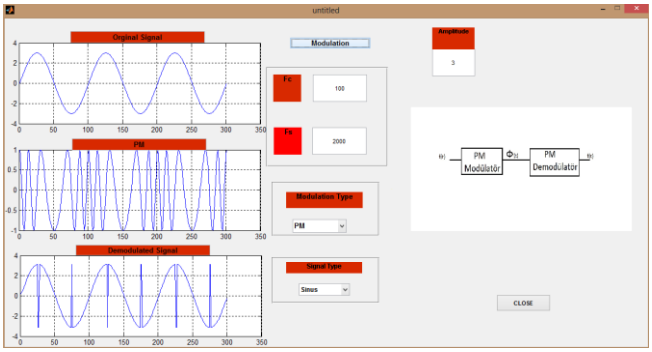

Fig.13 Modulation Simulator Interface View of Phase Modulation

G. *Pulse Code Modulation (PCM)*

For this modulation kind "PCM" option have to be selected in pop-up menu. There is a extra edit text in this interface as it is seen in Fig.14. This edit text used for entering step number value. After the entered frequency values, selected sinusoidal signal wave shape, entered amplitude value and then pressed to modulation button the modulation simulator interface will be at bottom as seen in figure 14. Amplitude value was chosen 2, Fc frequency value was chosen 10, Fs frequency value was chosen 40, step number value is chosen 4.

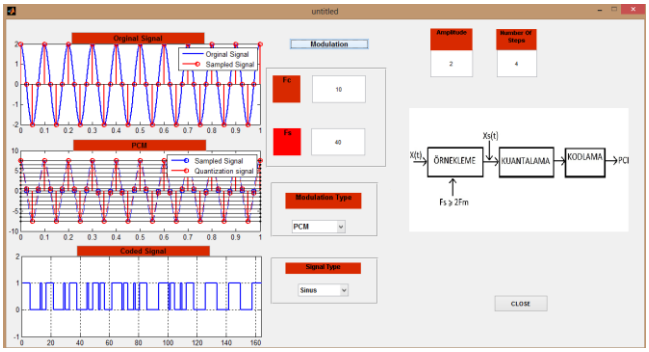

Fig.14 Modulation Simulator Interface View of Pulse Code Modulation

VI. Conclusion

In this paper modulation techniques simulations can be created by using MATLAB Simulink programme. In simulation, analog and digital modulation techniques avoid the derivation of any mathematics formulations. The simulation toolbox is created by using MATLAB's functions and MATLAB software codes. Comprehension of modulation types is hard when we compare of other palpable topics.

By means of this work, students can understand easily modulation types and can imagine these topics in their minds. The most of modulation types can be simulated through this simulator. It can be useful for telecommunication engineering students.

References

[1] Tovee, Martin J.; Rolls, Edmund T.; Ramachandran, Vilayanur S., Rapid visual learning in neurones of the primate temporal visual cortex, Neuroreport, 1996. http://dx.doi.org/10.1097/00001756-199611040-00070

[2] Richard M. Felder, "Learning and Teaching Styles In Engineering Education", Engr. Education, 78(7), 674–681, 1988

[3] S.Ranjith Kumar, P.Raja, M.P.Selvan , Virtual Laboratory Environment using MATLAB-GUI for Teaching of Induction Generators, IEEE, TamilNadu, India , 2012

[4] Murthy, S.S.; Bhuvaneswari, G.; Ahuja, R.K.; Gao, S.; , "A Novel MATLAB Graphical User Interface Based Methodology for Analysis, Design and Capacitor Estimation of Self Excited Induction Generators," Industry Applications Society Annual Meeting (IAS), 2010 IEEE , vol., no., pp.1-6, 3-7 Oct. 2010.

[5] Wendy L. Martinez, Graphical user interfaces, John Wiley & Sons,Volume 3, March/April 2011

[6] Bhatt, T.M.; McCain, D, "Matlab as a development environment for FPGA design", Proceeding of Design Automation Conference, 2005. 13-17 June 2005 Page(s): 607 – 610

[7] "Development of a MATLAB-Based Model for Advanced High Power Density Diesel Engine for Military Applications" Project http://arc.engin.umich.edu/arc/research/ta4/T4DevMatlab Model AdvHPD.htm

[8] Muhammad Hilmi R. A. Aziz, Lee Kim Huat, Rosmiwati Mohd-Mokhtar, Development of MATLAB GUI for Multivariable Frequency Sampling Filters Model, 2012 IEEE Control and System Graduate Research Colloquium

[9] Leon W. Couch, II. Digital and Analog Communication Systems. Prentice Hall, New Jersey, sixth edition, 2001.

[10] http://www.mathworks.com/access/helpdesk_r13/help/toolbox /commblks /ref/simref-7.html#611864

[11] John Okyere Attia, "Teaching AC Circuit Analysis with Matlab", the World Wide Web electronic version of the 1995 ASEE/IEEE Frontiers in Education Conference Proceedings.

[12] Dragan Mitic, Aleksandar Lebl, Selection procedure for modulation using simulation in Matlab, Mipro 2011, Croatia

[13] Cuneyt Bayılmıs, Development of a Web-Based Educational Interface Using MATLAB Builder NE With Web Figure for Digital Modulation Techniques, 2010 Wiley Periodicals
[14] Attia, J.O, "Teaching electronics with MATLAB", Proceeding of Frontiers in Education Conference, 1996, Salt Lake City, USA.
[15] SS Haykin, M Moher, T Song - 1989 An introduction to analog and digital communications
[16] http://en.wikipedia.org/wiki/Modulation
[17] http://en.wikibooks.org/wiki/Communication_Systems/What_is_Modulation%3F
[18] S. J. Chapman, "MATLAB Programming for Engineers," Brooks Cole, 2001.
[19] Muhammad Hilmi R. A. Aziz, Lee Kim Huat & Rosmiwati Mohd-Mokhtar, "Development of MATLAB GUI for Multivariable Frequency Sampling Filters Model" Malaysia 2012
[20] Refaat Yousef Al Ashi, Ahmed Al Ameri, "Introduction to Graphical User Interface (GUI) MATLAB 6.5", UAE University College of Engıneerıng Electrıcal Engıneerıng Department IEEE UAEU Student Branch
[21] Richard M. Felder, Learnıng and teachıng styles ın engıneerıng educatıon, Engr. Education,2002
[22] http://www.mathworks.com/matlabcentral/fileexchange/30377-pulse-codemodulation/content/pcm.m