PC-MATLAB based Signal Generator Development

Ariffuddin bin Joret[1], Nur Artikah binti Mohd Rashid1, Nor Ashidi Mat Isa[2], Jiwa Abdullah1, Kamal Zuhairi Zamli[2], Muhammad Faiz Liew Abdullah[1], Asmarashid Ponniran[1],

[1]Department of Electrical Engineering, Universiti Tun Hussein Onn Malaysia
[2]School of Electrical and Electronic Engineering, Universiti Sains Malaysia

Abstract: Signal generator is one of the most important equipment needs in electrical and electronic field. Signal generator, also called as function generator is an expensive device and consume high cost in its maintenance. Plus, it also hard for the user to adjust the frequency and amplitude due to the tuning difficulty using potentiometer. PC-Matlab based Signal Generator development is a project Matlab software based. Its objective is to generate signals which are Sinusoidal waveform, Triangle waveform and Rectangular waveform using Matlab and then being verified using Oscilloscope. Signal which is in digital form will be generated in Matlab before it is passed to the PC-soundcard to convert it to analogue signal. This analogue signal is then verified using Oscilloscope for the measurement and comparison purpose. The output result shown in Oscilloscope is the same as viewed from Matlab window which verified that the propose PC-MATLAB based Signal Generator Development can be use as a function generator.

Keywords: Signal generator, Digital Signal Processing, Analogue-Digital converter

1. Introduction

In practical implementation electronic circuit, each experiment has conditions that must be met to comply with the procedure which is only the input signal to be provided on the network. This input signal can vary depending on the experiment performed, such as signal in sinusoidal, triangular, or square. To generate these signals, the practicum used a device called a function generator. In educational field, especially for electrical engineering course, the function of function generator is very important to the student. A lot of assessment are using function generator to generate pulse and signal; completing their syllabus that were applied in industries and engineering field. But there is a limitation of spaces, time and devices that can interrupt the teaching and learning process. Also the function generators itself is that costing in the term of its value and maintenances. An alternative for this situation, within this Engineering Project the title *'PC-MATLAB based Signal Generator Development'* is proposed.

This Project will use **MATLAB® Graphical User Interface (GUI)** as main engine to generate signal that can replace the application of function generator. Wider awareness of these new methods of generating signal will be of great benefit to those who work in the area of signal processing especially to student and industry. Besides, it also has commercialized value.

The GUI will provide an interface between the MATLAB user and the application of the soft function generator. Thus, the user will not need to have a complete knowledge of command-line level MATLAB programming to effectively utilize the graphical user interface MATLAB. In this way, knowledge and use of these applications will greatly increase, to the benefit users.

Within this project, a GUI is created for generating signal which are the sinusoidal, triangle and square signal. The signal, which is in digital form, will be mathematically manipulated through a technique of Digital Signal Processing. In general, Digital Signal Processors (DSPs) take real-world signals like voice, audio, video, temperature, pressure, or position that have been digitized and then mathematically manipulate them [1]. Signals need to be processed so that the information that they contain can be displayed, analyzed, or converted to another form that may be of use [2]. To obtain the output, signals will be generated in MATLAB environment and, then by using the soundcard of the Personal Computer (PC), it will be converted to analogue. The analogue output signal will be measured by using oscilloscope for the comparison and verification.

In developing this project, there is some other's project that becomes part of guidance as it has several similarities that related to this project [3-6]. The project created by Debraj [3] having similarity with this project as it generates signal using personal computer software. Referring to Harry Jacobs [4], he creates a system that was designed using MAX038 high frequency waveform integrated circuit (IC) as the primary signal source. On the other hand, Diana L. Matcovich [5] used MATLAB Graphical User Interface (GUI) to demonstrate the potential uses of mathematical algorithms as user interface. Besides that, Denis Pavliha, Matej Reberšek and Damijan Miklavčič [6] had created a system using Graphical User Interface (GUI) for the biomedical equipment to perform reliably and to assure fast response at a maximum level of safety. Another project's example

that has similarity with this project had been created by C. Dughir [7], as he develop a complex mathematical signals generator by using the software of Visual C++ that can generate a combination of mathematical signals at the output of a PC sound card.

2. Methodology

Function Generator is an expensive electrical device whether its price or maintenance. Thus this soft function generator is software without costing of maintenance because it can be easily duplicated and modify make it has high commercialized value. Although the manual function generator is simple and easy to use, there are several weaknesses which limit its applications and its usage. It is often difficult for the users to adjust the frequency and amplitude of the waveforms to the exact value required because of the tuning difficulty using potentiometers.

There are three types of signal which will be focused on which are sinusoidal waveform, rectangular waveform and triangular waveform. For the validation purpose, each of the signals developed from the PC will be analyzed by using Oscilloscope.

To create this project, MATLAB 7.8.0 (R2009a) is used to generate the signal. MATLAB M-file is used to write the script and function files, interface boxes, function for user application to generate desired signal. Mathematical functions syntax is written at the functions for callback function and generating signal. The generated signal wave form will be displayed at GUI window after the user clicking the selected button. Graphical User Interface, (GUI) which is one of the tools in MATLAB is use to be the interface between the system and the user. Technique of Digital Signal Processing is used to manipulate the signals that are generated in MATLAB. The digital signal will be transferred to the Dell Inspiron 1420 Sigmatel C-Major HD Audio Sound Card to be converted from digital signal to analogue signal as the output.

2.1   Project Flowchart

Figure 2.0 reports a scheme of the approach that aims to generate signal using PC-Matlab as a based. Generally, there are three main steps that have been done during completing this project. By referring Figure 2.0;
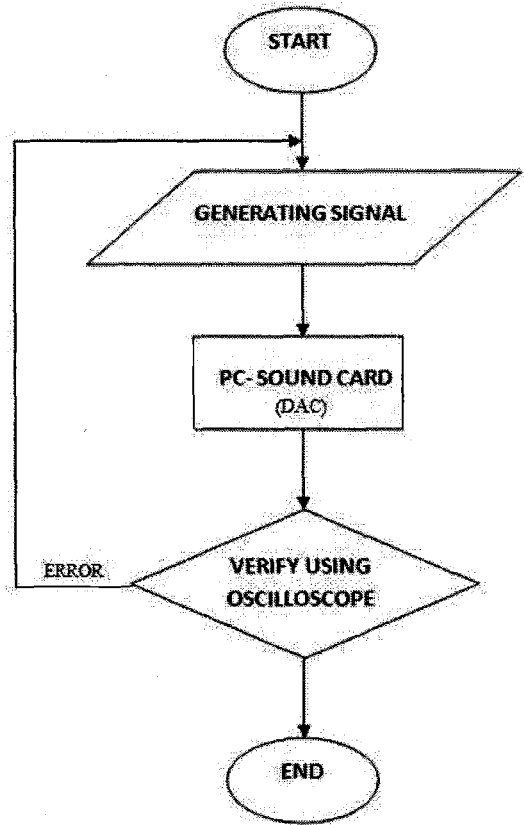

Figure 2.0: Methodology of the Project

2.1.1   Digital Signal Processing

Going through the first step (Fig.2.0), program is written in the Matlab M-File. The program will generate different types of signals which are sinusoidal waveform, triangle waveform and rectangular waveform according to the coding and equation given. At this point, the signal is in digital form. Digital Signal Processing technique will performs the encoding of the signal. After that, all the data will be stored in a built memory in the PC. This memory will gone through the technique of Digital Signal Processing again to decoding all the data back before the signal being converted from digital to analogue.

2.1.2   Digital to Analogue Converter

Going through the second step (Fig.2.0), when the signal successfully generated, digital-to-analogue signal converter will be done before it is validating using Oscilloscope. Digital-analogue process happens when the signal which is in digital form is stored or collected in a memory, and then passed through to the PC-soundcard where the process of digital-analogue converter is done. To get the analogue output from the PC-soundcard, microphone or amplifier is used.

2.1.3   Verification

At the third step (Fig.2.0), the process of verification is done to the analogue signal. The analogue signal will be passed to the Oscilloscope by using an interface between the audio jack and the probe of the Oscilloscope. If the signals generated are not as preferred, the step of second block will be done again and again until the preferred signal is developed.

3.   Results

3.1   Triangular Wave

Figure 3.1.1 shows the output result of triangle wave from the Matlab window with the input frequency of 50Hz and amplitude of 1 and -1. On behalf, Figure 3.1.2 shows the validation result of triangle wave as viewed from an Oscilloscope.
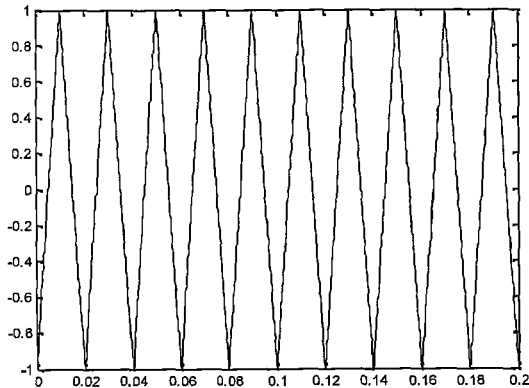

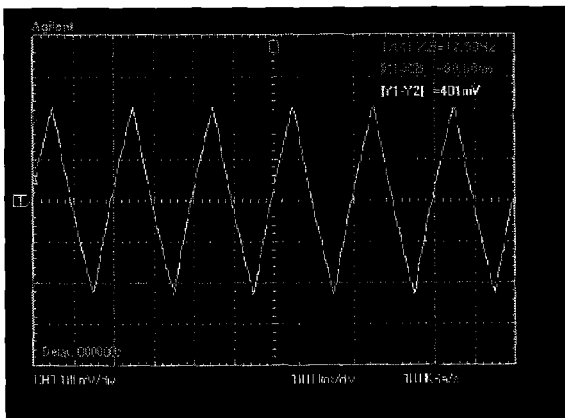Figure 3.1.1: Triangle wave shown from Matlab

Figure 3.1.2: Triangle wave from the Oscilloscope

Value obtains from the Oscilloscope:

Vpp	4.64E-01
Vmax	2.32E-01
Vmin	-2.32E-01
Vavg	-1.51E-03
Vamp	4.64E-01
Vtop	2.32E-01
Vbase	-2.32E-01
Vrms	1.34E-01
Vover	6.90%
Vpre	0.00%
Frequency	4.98E+01
Rise Time	8.20E-03
Fall Time	8.10E-03
Period	2.01E-02
Pulse Width+	1.00E-02
Pulse Width-	1.00E-02
Duty+	49.80%
Duty-	49.80%

Based on Figure 3.1.1 and Figure 3.1.2, it could be seen that the shape for Triangular wave is same.
As the signal being validate using the Oscilloscope, the actual value of the frequency drop a little bit from the given frequency which is 50Hz to 49.80Hz. Meaning that;

$$\text{Percentage of error} = \frac{50\ Hz - 49.80Hz}{50\ Hz} \times 100\%$$
$$= 0.4\%$$

However, the Amplitude of the signal generated in Matlab is 1V and -1V. As viewed from the Oscilloscope, it becomes 0.232V and -0.232V.

3.2   Sinusoidal Wave

Figure 3.2.1 shows the output result of sinusoidal wave from the Matlab window with the input frequency of 50Hz and amplitude of 1 and -1. Figure 3.2.2 shows the validation result of sinusoidal wave as viewed from an Oscilloscope.
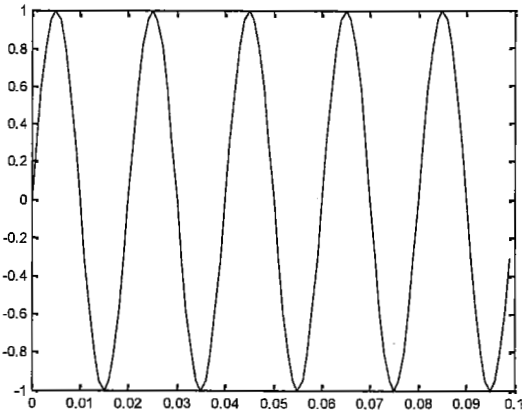
Figure 3.2.1: Sinusoidal wave shown from Matlab

Figure 3.2.2: Sinusoidal Wave shown from the Oscilloscope

Value obtains from the Oscilloscope:

Vpp	4.64E-01
Vmax	2.32E-01
Vmin	-2.32E-01
Vavg	-7.39E-04
Vamp	4.59E-01
Vtop	2.32E-01
Vbase	-2.27E-01
Vrms	1.64E-01
Vover	1.20%
Vpre	1.20%
Frequency	5.03E+01
Rise Time	6.00E-03
Fall Time	5.90E-03
Period	1.99E-02
Pulse Width+	9.90E-03
Pulse Width-	1.01E-02
Duty+	49.70%
Duty-	50.80%

Based on Figure 3.2.1 and Figure 3.2.2, it could be seen that the shape for Sinusoidal wave is same.

As the signal being validate using the Oscilloscope, the actual value of the frequency increase a bit from the given frequency which is 50Hz to 50.30Hz. Meaning that;

$$\text{Percentage of error} = \frac{50 \text{ Hz} - 50.3 \text{ Hz}}{50 \text{ Hz}} \times 100\%$$
$$= -0.6\%$$

On the other hand, the Amplitude of the signal generated in Matlab is 1V, -1V. As viewed from the Oscilloscope, it becomes 0.232V and -0.232V.

3.3 Rectangular wave

Figure 3.3.1 shows the output result of rectangular wave from the Matlab window with the input frequency of 150Hz and amplitude of 1 and -1. Then, Figure 3.3.2 shows the validation result of rectangular wave as viewed from an Oscilloscope.
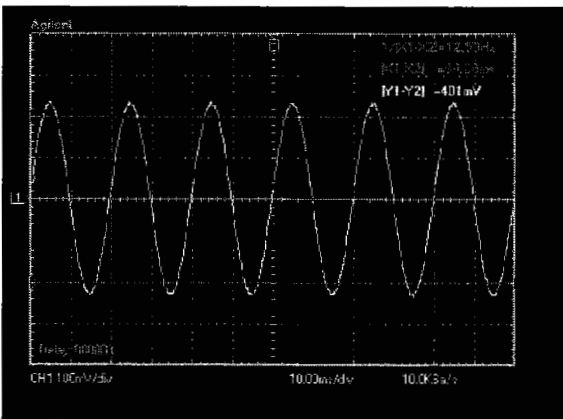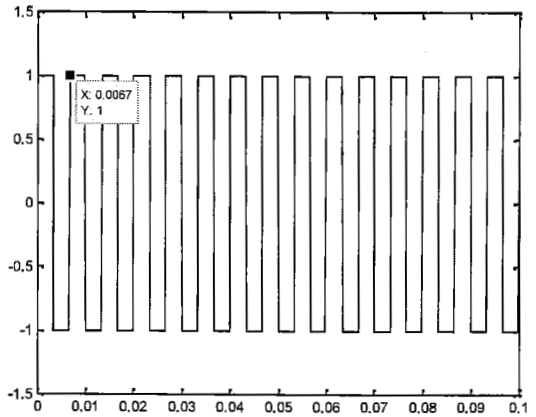

Figure 3.3.1: Triangular wave shown from Matlab
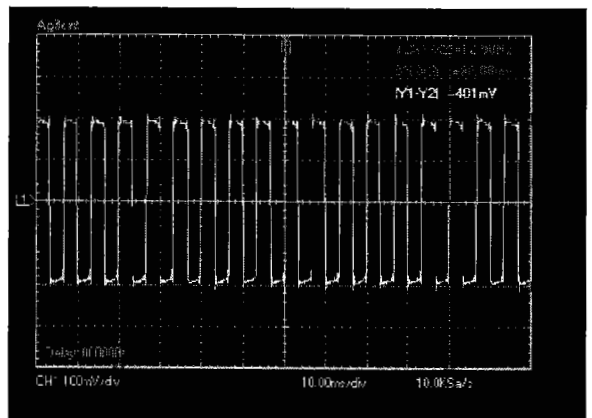
Figure 3.3.2: Rectangular wave shown from the Oscilloscope

35

Value read from the Oscilloscope:

Vpp	4.40E-01
Vmax	2.16E-01
Vmin	-2.24E-01
Vavg	-1.23E-03
Vamp	3.79E-01
Vtop	1.87E-01
Vbase	-1.92E-01
Vrms	1.89E-01
Vover	8.60%
Vpre	2.20%
Frequency	1.49E+02
Rise Time	<4.00e-04
Fall Time	<4.00e-04
Period	6.70E-03
Pulse Width+	3.30E-03
Pulse Width-	3.30E-03
Duty+	49.30%
Duty-	49.30%

Based on Figure 3.3.1 and Figure 3.3.2, it could be seen that the shape for Rectangular wave is same.

As the signal being validate using the Oscilloscope, the actual value of the frequency drop a little bit from the given frequency which is 150Hz to 149Hz. Meaning that;

$$\text{Percentage of error} = \frac{150Hz - 149.00Hz}{150Hz} \times 100\%$$
$$= 0.67\%$$

In addition, the Amplitude of the signal generated in Matlab is 1V and -1V. As viewed from the Oscilloscope, it becomes 0.216V and -0.224V.

4.0 Discussion

A signal generator could be developed by using a PC-MATLAB. The shapes for the three signals generated in this project are same as it has been verified using Oscilloscope. The frequency differs of each signals generated in Matlab also not too differed from the actual frequency that are validate in Oscilloscope. With a small percentage of error of frequency which are 0.4% for triangular waveform, 0.17% for rectangular waveform, and 0.67% for sinusoidal waveform. However, there is a small distortion happen at the signal due to the PC-soundcard noises and other errors for the rectangular waveform. The plotted graphs shown in Matlab are only diagrammatic representation of the actual values shown in Oscilloscope. As it could only be a representation, the amplitude of plotted graphs which is 1 is representing for 0.232V and -1 is representing for -0.232V. Without any distortion or noises, the voltage supply from the audio jack gives out the value of 0.232V/-0.232V for a wave's

amplitude of 1/ -1. This is because the peak amplitude of Dell Inspiron 1420 Sigmatel C-Major HD Audio Sound Card approximately 0.464Volts. As the line level signal is an alternating current signal, meaning that its voltage varies from −0.232 V to +0.232 V.

5.0 Conclusion

As a conclusion, signals which are sine wave, triangular wave and rectangular wave could be generated by using PC-Matlab based. With this soft function generator, user are much more easier to applied the signal in their experiments; just run the program in user personal computer; the user interface at the desktop and clicking the mouse rather than setting function generator manually at the lab. Besides, the user has no need to buy expensive signal generators or expensive signal generation systems in order to generate the desired waveforms. It could also be simply duplicates and consume low cost in maintenance.

6.0 References

[1]   Steven W. Smith, "The Scientist and Engineer's Guide to Digital Signal Processing",1st ed. California Technical Publishing, 1997.
[2]   http://www.analog.com/en/content/beginners_gu ide_to_dsp/fca.html
[3]   Debraj, "PC-Based Signal Generator", 2010.
[4]   Harry Jacobs, "PC-Based Function Generator", Indiana University - Purdue   University   Fort Wayne, 2002.
[5]   Diana L. Matcovich, "Development of MATLAB® GUI for Signal Processing   Methods for the Extraction of Non-Stationary Sinusoids" 2005.
[6]   Denis Pavliha, Matej Reberšek, Damijan Miklavčič, "A Graphical User-interface   Controller for the Biomedical High-voltage   Signal   Generator", University of   Ljubljana,   Faculty   of   Electrical Engineering, Tržaška 25, SI-1000 Ljubljana, Slovenia.
[7]   C. Dughir, "Visual C++ Complex Mathematical Signal   Generator", "Politehnica" University of Timisoara, Electronics and Telecomunications