UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF FPGA BASED PORTABLE LOW-COST DIGITAL SIGNAL GENERATOR

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Computer Engineering Technology (Computer System) with Honours

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DEVELOPMENT OF FPGA BASED PORTABLE LOW-COST DIGITAL SIGNAL GENERATOR**

SESI PENGAJIAN: **2017/2018 Semester 1**

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I hereby, declared this report entitled “Development Of FPGA Based Portable Low-Cost Digital Signal Generator” is the result of my own research except as cited in references.

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Date **: 15 DECEMBER 2016**

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the Bachelor's Degree of Computer Engineering Technology (Computer System) with Honours. The members of the supervisory committee are as follow:

…….

(Encik Aiman Zakwan bin Jidin)

…….

(Encik Noor Mohd Ariff bin Brahin)

ABSTRACT

Signal Generator is a device that generates the repeating voltage waveforms that important to generate the accurate control frequency and amplitude. Signal generator also has a microcontroller (CPU unit) and can be used on any test system with other instrument or to be controlled by the computer. However, most of the commercial signal generators are very expensive. The price for each signal generator is about RM1 500 – RM 20 000. The size of signal generator also big and heavy cause it difficult to carry everywhere. Therefore, the purpose of this project is to develop a portable low-cost digital signal generator by using Field Programmable Gate Array (FPGA). The proposed project is designed by using High Description Language (HDL) in Altera Quartus Software Design Interface and verified via simulation in ModelSim. After the design code verified by ModelSim, the design will be implemented in the FPGA board and the SignalTap will display the signal. Based on the result from the SignalTap, the analysis can be made by making a calculation and compared to the result either the frequency and amplitude is accurate or not.This signal generator is built with same facilities which available in another commercial signal generator for practical implementation in laboratories which is it can generate the basic signal such as Sine, Triangular and Square wave. This develops signal generator is portable and configurable. This signal generator also affordable for universities, students, researchers or other average people to have their own signal generator.

ABSTRAK

Penjana Isyarat adalah alat yang menjana bentuk gelombang voltan berulang yang penting untuk menjana kawalan frekuensi dan amplitud yang tepat.Penjana isyarat juga mempunyai melengkapkan mikropengawal (CPU) yang boleh digunakan pada mana-mana sistem ujian dengan surat cara lain atau dikawal oleh komputer. Walau bagaimanapun, sebahagian besar daripada penjana isyarat komersial adalah sangat mahal. Harga bagi setiap penjana isyarat adalah kira-kira RM1 500 - RM 20 000. Saiz penjana isyarat juga besar dan berat menyebabkan ia sukar untuk menjalankan mana-mana. Oleh itu, tujuan projek ini adalah untuk membangunkan kos rendah mudah alih penjana isyarat digital dengan menggunakan *Field Programmable Gate Array* (FPGA). Cadangan projek yang dinyatakan di dalam *High Discription Language* (HDL) dan huraian disahkan dengan menggunakan *Altera Quartus Software Design Interface* dan *ModelSim*. Selepas kod rekabentuk yang disahkan oleh *ModelSim*, reka bentuk akan dilaksanakan di papan FPGA dan *SignalTap* sebagai *Logik Analyzer* akan menjana isyarat. Berdasarkan keputusan dari *SignalTap*, analisis boleh dibuat dengan membuat pengiraan dan dibandingkan dengan keputusan sama ada kekerapan dan amplitud isyarat dengan penjana isyarat tepat atau tidak. Ia dibina dengan kemudahan yang sama yang didapati dalam satu lagi penjana isyarat perdagangan bagi pelaksanaan praktikal di makmal yang ia boleh menjana isyarat asas seperti gelombang Sinus, gelombang segi tiga dan gelombang persegi. Ini membangunkan penjana isyarat mudah alih dan boleh dikonfigurasikan. Penjana isyarat ini juga mampu dimiliki oleh universiti, pelajar, penyelidik atau pengguna lain untuk mempunyai penjana isyarat mereka sendiri.

DEDICATIONS

Alhamdulillah..

Thank Allah because of His grace, I have been able to prepare this project successfully. Appreciation to my beloved parents, En Mahzan Bin Paiman and Pn. Habibah Binti Said. I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. I am really thankful for their sacrifice, patience, giving spirit and strength to me in a life filled with these allegations.

Thanks also to my parents who always understand my situation that is difficult to prepare the report within the time frame given and also pray for my success and provide guidance for me to finish the report. Lastly, I would like to send my gratitude to any person that contributes to my final year project whether it is directly or indirectly. I would like to acknowledge their comments and suggestions, which are crucial for the successful completion of this study. I pray and hope that you will always happy and extended lifetime, may Allah bless you.

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First and foremost, all praise to Allah the Almighty for giving me the strength, health, knowledge and patience to successfully complete this Finale Year Project report at the given time. I have to thank my parents for their love and support throughout my life.I would like to address my deepest appreciation to the supervisor, Encik Aiman Zakwan bin Jidin and to the co-supervisor, Encik Noor Mohd Ariff bin Brahin who provide encouragement, comments guidance and advice to me in conducting research and writing report.

As the end of this speech, I would like to take this opportunity to thank my friends that have been through thick and thin throughout the completion of this project. This project report might be impossible to complete without all of your help. Last but not least, thank you to everyone that directly and indirectly involved in helping me finishing this Finale Year Project report. Thank you.

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LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

FPGA	-	Field Programmable Gate Array
HDL	-	High Digital Language
CPU	-	Control Processor Unit
RF	-	Radio Frequency
AM	-	Amplitude Modulation
FM	-	Frequency Modulation
FSK	-	Frequency-shift Keying
DDS	-	Direct Digital Synthesizer
DAC	-	Digital Analog Converter
UART	-	Universal Asynchronous Receiver/Transmitter
DSC	-	Digital Signal Controllers
VHDL	-	Very High Description Language
GUI	-	Graphical User Interface

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter explains the background of this project, problem statement, objectives, work scope, project significant and conclusion. The structure of this report of the project is briefly explained to ensure a better visualization of the sequence of the entire project.

1.1 Background

The signal generator is a device that generates repeating voltage waveforms. It is important device to find a wide range of applications in the electronic laboratory. Most of all signal generator is used to generate the signal with accurate controlled frequency and amplitudes. Besides, the signal generator can generate a high frequency to provide high-frequency resolution. It is used for designing, testing and troubleshooting electronic devices. Besides, the signal generator also can be used on any test system with other instrument or to be controlled by the computer.

Function generator produces simple and basic signal waveform including sine wave, square wave, triangle wave, and a ramp wave. The signal generator is extensively used in wide range of applications. The function generator is delivered a sinusoidal output of accurately calibrated frequency. Usually, the output signals are frequency and amplitude modulated. Besides, function generator is used to test and

align all types of transmitters and receivers, to measure frequency, and to generate a signal, waveform, or noise source. Signal generators can use AC energy, audio frequency (AF), and radio frequency (RF) to function. They are also used to troubleshoot various electronic devices and to measure frequency. The function of a signal generator is to produce alternating current (AC) of the desired frequencies and amplitudes with the necessary modulation for testing or measuring circuits. It is important that the amplitude of the signal generated by the signal generator be correct. In many signal generators, output meters are included in the equipment to adjust and maintain the output at standard levels over wide ranges of frequencies. When using the signal generator, the output test signal is connected to the circuit being tested. The progress of the test signal can then be tracked through the equipment by using electronic voltmeters or oscilloscopes.

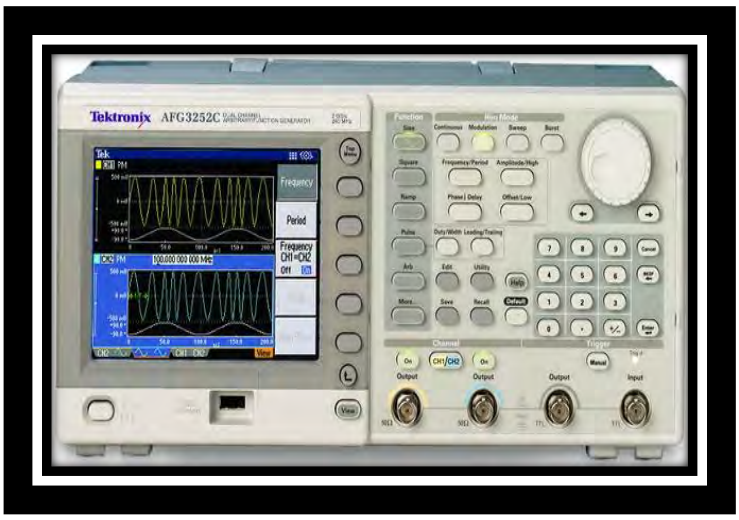

Figure 1.1: Function Generator

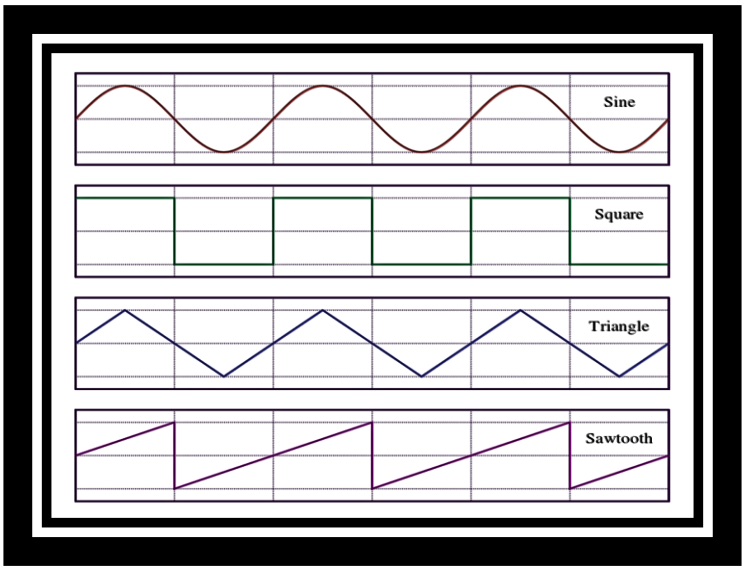

Figure 1.2: Basic Signal Waveform

1.2 Problem Statement

The signal generator is the device that is important in many communication and other signal related applications. It is widely used in an experimental course in UTeM. The signal generator is used to get generate square wave, sine wave and triangle wave signal. It is usually as a standard signal in electronic circuit testing, parameter measurement, or demonstration in the experimental course.

However, most of the signal generator is too expensive. UTeM known as technical universities are really needed many of this device for the lab session. Therefore, the universities need to spend high budget for buy this device. The result is limited working mode and cannot be played entirely in the teaching experiments of a common signal generator.

Other than that, the size of the signal generator is bulky and hard to take everywhere. Besides, most of the commercially available signal generator has very high bandwidth that most average user or students do not want to generate the high-frequency waveforms for their experiments. Basically, in several test or experiment in research need digital input so it needs to interface with the ADC.

Furthermore, most of commercial low-cost function generator are limited in term of frequency and amplitude variation. It provides a very small range of frequency and amplitude of the signal. Therefore, the purpose of this project is to develop a small-sized and highly accurate economic digital signal generator by using FPGA which can provide wave signals commonly used in experiments.

1.3 Objective

The objectives of this project are:

1. To study about basic digital signal generation method.
2. To develop a portable behaviour low-cost digital signal generator by using FPGA.
3. To interface Graphical User Interface(GUI) for signal configuration.
4. To analyse the overall performance and the reliability of the system.

1.4 Scope of Work

In order to obtain a clearer visualisation and to achieve the objective for this project, the scope of this project has optimised. This current project consisting of two work scope. First work scope is about hardware which is Field-Programmable Gate Array (FPGA). FPGA device will be used in this project. It is a programmable IC which has highest integration and complexity. The function of FPGA is to install the Altera design and generate basic signal generation such as Sine, Pulse and Triangle signal. Using USB cable, the FPGA will be connected to the computer.

The second scope is Altera Quartus Software Design to design the Verilog code using HDL language. Before implementing the design or coding in the FPGA board, it needs to ascertain its correctness by using ModelSim. It can simulate without having to recompile again. The coding can be implemented into FPGA if there is no error.

This project is using GUI application for choosing the type of signal and frequency value. The software to design GUI is using Processing Software. Then, SignalTap will display the desired frequency of the basic signal generation. The function of SignalTap is it can be used to capture and display signal in real time in any FPGA design.

After the signal is displayed, test analysis will be carried out. The frequency is correctly proving by doing the mathematical operation and compared to the frequency output signal on SignalTap as a Logic Analyzer. Logic Analyzer displays signal in a digital circuit that to observe and presents which can be more easily check the operation of the digital system with precision. The signal should have an output data rate at is condition 1 kHz- 1 MHz. It provides a clear and precise window into the frequency spectrum measuring all of the signals with more accurate measurements and interpreting the result correctly.

1.5 Project Significant

This project is contributed to universities or students which need to do experiments which generate the basic signal and not too high-frequency waveform. Besides, this project is not too expensive and it is affordable for students, researchers or average user to buy and have their own signal generator. The size of this project signal generator also small and easy to carry anywhere. It also has a higher performance of the portable digital signal generator. Furthermore, it is reusable because it can be generated or use many times.

1.6 Outline

Chapter 1 describes the introduction of the project which includes project background, problem statement, objectives, work scope and project significant. In the next chapter, which is Chapter 2 briefly explains the overview or related work that

relates to project in details. In Chapter 3, the methodology clearly explains the method and strategy to achieve the objectives. It explains about working procedure, previous work and component or device that will use in details. Chapter 4 presents the result and the findings and the result of the project in tables, figures, drawing and graph. Chapter 5 about summarises the outcomes of the project which is an analysis of the result. It also gives a recommendation for further development and innovation.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

A literature review is a previous study in the form of the reference book, articles, journals and the internet that used to refer, taking ideas from previous has or studies in order to improve future use. All of the sources have a very useful information that guides in doing this project. Each review sources are selected according to the similarity of project's scope.

2.1 Types of Signal Generator

There are different types of signal generators with different capability and functionality. All the signal generators have different designs, dimensions and parameters. Therefore, there have different purposes and cover a range of applications. Every versatile signal generators can create an unlimited number of the signal to meet the debug challenges.

2.1.1 Function Generator

The function generator is the important device for electronic test equipment. It is useful when there is troubleshooting in electronic design, the circuit which needs critical observation often requires a controllable signal to simulate its normal operation. The testing of physical system and transducer often need a stable and