DESIGN 8 BIT CPU BY IMPLEMENTED ON FPGA

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Dedicated to my beloved family especially my mother and father and also to my friends.

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ABSTRACT

This project is about designing 8 bit CPU using Very High Speed Integrated Circuit Hardware Description Language (VHDL) and implements the design into Field Programmable Gate Array (FPGA). The CPU is stand for Central Processing Unit, is a brains of a computer divided into two main elements which are the Datapath Unit and Control Unit. VHDL is used since it is a Hardware Description Language (HDL) that used in designing VLSI (Very Large Scale Integration), the process of placing thousands of electronic components on a single chip. Nowadays it is one of the most popular design application uses by most designers. The process begins with design entry which the coding process by using Xilinx ISE Webpack 8.2i software. Then followed by synthesis process to checking the code and implement design. Lastly the simulation process using ModelSim which check out the truthful of coding designed and the programs are load into FPGA board.

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ABSTRAK

Projek ini adalah berkenaan merekabentuk Unit Pemprosesan Pusat (CPU) 8 bit menggunakan bahasa Bahasa Penerangan Perkakasan Litar Bersepadu Berkelajuan Tinggi (VHDL) dan mengaplikasikan rekaan tersebut ke FPGA. CPU bertindak sebagai otak dalam komputer yang terdiri daripada dua komponen utama, Unit Laluan Data, dan Unit Kawalan. VHDL digunakan kerana ianya merupakan bahasa untuk mereka Penyepaduan Berskala Besar (VLSI), iaitu proses meletakkan ribuan komponen elektronik dalam satu chip, dan juga merupakan aplikasi rekaan yang amat popular diguna pakai oleh kebanyakan pereka pada masa kini. Proses bermula dengan rekabentuk menggunakan perisian Xilinx ISE Webpack 8.2i bagi menulis bahasa VHDL, diikuti oleh proses sintesis dimana pengekodan yang telah ditulis akan diperiksa dan dilaksanakan rekaan tersebut. Kemudian, rekaan tadi akan disimulasi menggunakan ModelSim untuk menentukan kesahihan pengekodan yang direka dan beban turun ke FPGA.

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LIST OF ABBREVIATIONS

PLD	-	Programmable Logic Device
CPU	-	Central Processing Unit
VHDL	-	Very High Speed Integrated Circuit Hardware Description Language
FPGA	-	Field Programmable Gate Array
ALU	-	Arithmetic Logic Unit
IC	-	Integrated Circuit
VLSI	-	Very Large Scale Integration
HDL	-	Hardware Description Language
ISA	-	Instruction Set Architecture
PC	-	Program Counter
SP	-	Stack Pointer
Z	-	Zero
CY	-	Carry
S	-	Sign
P	-	Parity
AC	-	Auxiliary Carry
I/O	-	Input/output

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The central processing unit, CPU is a programmable integrated device that has computing and decision-making capability. CPU is the component in a digital computer that interprets computer program instructions and processes data. The CPU provides the fundamental digital computer trait of programmability, and one of the necessary components found in computers of any era. In everyday functioning and industrialized societies, the microprocessor plays a significant role. The microprocessor can be viewed as a programmable logic device (PLD) that can be used to control processed and turn on/off devices. Because of that, the microprocessor can be viewed as a data processing unit or a computing unit [1].

The project of design 8 bits CPU by implemented on Field Programmable Gate Array (FPGA) using Very High Speed Integrated Circuit Hardware Description Language (VHDL) is the real implementation of CPU. The coding in VHDL uses logical expression and some terms in designing of CPU.

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1.2 Objectives

Objectives of this project are to design an 8 bit CPU by using VHDL (Very high speed integrated circuit Hardware Description Language). The CPU will be design part by part of the consisting component and finally combined together to perform complete 8 bit CPU. This microprocessor has the several basic instructions that have been learned on microprocessor subject. This design will use VHDL and Xilinx FPGA as a programmable microprocessor chip. Programming codes are load using FPGA board and perform 8 bit CPU operations. The implementation of the design will be done by component to testing the correctness towards what has been designed.

1.3 Problem Statement

The present problem in designing the 8 bit microprocessor based on Intel 8085 didn't bring to much difficulty to the project. The knowledge and comprehension of the chip itself is important to make sure the design is exactly same. By research on the Intel 8085, it can prove the understanding how to design it and bring the problem at lower level. The VHDL design which uses the Xilinx software sometimes didn't work to some code of VHDL. Therefore, an alternative way to generate the code has been use to make it compatible with Xilinx software. Xilinx software is important since the same software use to implement the design into FPGA board.

In this project, the designing of 8 bit CPU will use VHDL. VHDL is a fairly general-purpose language, although it requires a simulator on which to run the code. It can read and write files on the host computer, so a VHDL program can be written that generates another VHDL program to be incorporated in the design being developed. Because of this general-purpose nature, it is possible to use VHDL to write a test bench that verifies the functionality of the design using files on the host computer to define stimuli, interacts with the user, and compares results with those expected. This is similar to the capabilities of the Verilog language. VHDL is a strongly typed language, and as a result is considered by some to be superior to

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Verilog. In fact there has always been quite an intense debate which amounts to a holy war amongst developers over which is the superior language. However, both languages make it easy for the unwary and inexperienced to produce code that simulates successfully, but that cannot be synthesized into a real device, or else is too large to be practicable. A particular pitfall in both languages is the accidental production of transparent latches rather than D-type flip-flops as storage elements.

The design is implemented on Field Programmable Gate Array (FPGA) board it is a semiconductor device containing programmable logic components and programmable interconnects. The programmable logic components can be programmed to duplicate the functionality of basic logic gates such as AND, OR, XOR, NOT or more complex combinational functions such as decoders or simple math functions. In most FPGAs, these programmable logic components (or logic blocks, in FPGA parlance) also include memory elements, which may be simple flip-flops or more complete blocks of memories.

A hierarchy of programmable interconnects allows the logic blocks of an FPGA to be interconnected as needed by the system designer, somewhat like a one-chip programmable breadboard. These logic blocks and interconnects can be programmed after the manufacturing process by the customer or designer so that the FPGA can perform whatever logical function is needed. The characteristics of the FPGA are suitable for design and testing a CPU since the testing requires synthesize and trying to find the error and re-correct it.

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1.4 Scopes of Work

The scope of work is designing the CPU based on Intel 8085 microprocessor architecture using VHDL. The design will be tested and implemented on Xilinx FPGA board.

1.4.1 Central Processing Unit (CPU)

A CPU, or sometimes simply processor, is the component in a digital computer that interprets computer program instructions and processes data. CPUs provide the fundamental digital computer trait of programmability, and are one of the necessary components found in computers of any era, along with primary storage and input/output facilities. A CPU that is manufactured as a single integrated circuit is usually known as a microprocessor. Beginning in the mid-1970s, microprocessors of ever-increasing complexity and power gradually supplanted other designs, and today the term "CPU" is usually applied to some type of microprocessor.

The phrase "central processing unit" is a description of a certain class of logic machines that can execute computer programs. This broad definition can easily be applied to many early computers that existed long before the term "CPU" ever came into widespread usage. However, the term itself and initialise have been in use in the computer industry at least since the early 1960. The form, design and implementation of CPU have changed dramatically since the earliest examples, but their fundamental operation has remained much the same.

Early CPU was custom-designed as a part of a larger, usually one of a kind computer. However, this costly method of designing custom CPU for a particular application has largely given way to the development of mass-produced processors that are suited for one or many purposes. This standardization trend generally began in the era of discrete transistor mainframes and minicomputers and has rapidly accelerated with the popularization of the integrated circuit (IC). The IC has allowed increasingly complex CPU to be designed and manufactured in very small spaces. Both the miniaturization and standardization of CPU have increased the presence of

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these digital devices in modern life far beyond the limited application of dedicated computing machines. Modern microprocessors appear in everything from automobiles to cell phones to children's toys.

1.4.2 Xilinx FPGA

A field programmable gate array (FPGA) is a semiconductor device containing programmable logic components and programmable interconnects. The programmable logic components can be programmed to duplicate the functionality of basic logic gates such as AND, OR, XOR, NOT or more complex combinational functions such as decoders or simple math functions. In most FPGA, these programmable logic components (or logic blocks, in FPGA parlance) also include memory elements, which may be simple flip-flops or more complete blocks of memories.

A hierarchy of programmable interconnects allows the logic blocks of an FPGA to be interconnected as needed by the system designer, like a one-chip programmable breadboard. These logic blocks and interconnects can be programmed after the manufacturing process by the designer so that the FPGA can perform whatever logical function is needed.

In the project, the Xilinx FPGA board is uses. To define the behavior for the board, the user can choose between a Hardware Description Languages (HDL) and a schematic design to use. To program the Xilinx FPGA, the manufacturer has provided the Xilinx ISE Webpack 8.2i software to do the implementation and simulation.

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1.4.3 The VHDL

VHDL was originally developed at the behest of the US Department of Defense in order to document the behavior of the ASICs that supplier companies were including in equipment. That is to say, VHDL was developed as an alternative to huge, complex manuals which were subject to implementation-specific details.

The idea of being able to simulate this documentation was so obviously attractive that the logic simulators were developed that could read the VHDL files. The next step was the development of logic synthesis tools that read the VHDL, and output a definition of the physical implementation of the circuit. Modern synthesis tools can extract RAM, counter, and arithmetic blocks out of the code, and implement them according to what the user specifies. Thus, the same VHDL code could be synthesized differently for lowest cost, highest power efficiency, highest speed, or other requirements.

The VHDL has a several terms in defines the coding. The first one is entity which uses to declare the port uses. Port can be described as an input, output or input-output with the width of bus. While the second is architecture which uses to describe the behavior of the model designed.

1.5 Methodology

The availability of computer based tools has greatly influenced the design process in a wide variety of design environments [2]. The early process is literature review where the ideas can be getting to design the CPU. Then, continue by design of the structure of CPU. As described before, the design use is based on Intel 8085 architecture. After that is a synthesize process where the VHDL source code is implemented and simulation is done. Then, proceed to implementation process on Xilinx FPGA board.

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1.6 Thesis Outline

Chapter 1 covers the project overview. It includes the objectives, the scope of work, problem statement and an overview of methodology. Plus, it's also describing detail about the overview of VHDL, the CPU design and FPGA itself.

Chapter 2 will tell about the literature review in order to complete this project. This includes research on project that has been done before by another individual. Their project is nearly same, but different in architecture and method use.

Chapter 3 is about the project methodology. Project methodology is about what processes are being done to complete the project. It emphasizes the details on the processes that are used.

Chapter 4 is the results and discussion chapter. This chapter consists of the results and its analysis which most of them are figures. Alongside with some explanation, this chapter covers the output and the operation for this project.

Chapter 5 is about conclusion and suggestion on the overall project. This chapter emphasizes on advantages and disadvantages, and the achievement towards objectives. Plus, it includes future modifications and suggestions.

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CHAPTER II

LITERATURE REVIEW

2.1 Overview

A literature review is an account of what has been published on a topic by accredited scholars and researchers. There are few good reasons for spending time and an effort on literature before embarking on a research project. Some of its is to identify gaps in the literature, avoid reinventing the same thing, identify other people working in the same fields, identify information and ideas that may be relevant to apply in project and identify methods that could be relevant to the project.

2.2 CPU History

Prior to the advent of machines that resemble today's CPU, computers such as the ENIAC had to be physically rewired in order to perform different tasks. These machines are often referred to as "fixed-program computers," since it physically reconfigured in order to run a different program. Since the term "CPU" is generally defined as a software (computer program) execution device, the earliest devices that could rightly be called CPU came with the advent of the stored-program computer.

Stored-program idea of a computer was already present during ENIAC's design, but was initially omitted so the machine could be finished sooner. On June

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