8 BIT MICROPROCESSOR DESIGN USING VHDL

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I dedicate this to my beloved parents,
My whole family, and to all of my friends
who have stood by me throughout these 4 years

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ABSTRACT

A microprocessor (sometimes abbreviated **μP**) is a digital electronic component with transistors on a single semiconductor integrated circuit (IC). One or more microprocessors typically serve as a central processing unit (CPU) in a computer system or handheld device [1]. Microprocessors made possible the advent of the microcomputer. Before this, electronic CPUs were typically made from bulky discrete switching devices containing the equivalent of only a few transistors. By integrating the processor onto one or a very few large-scale integrated circuit packages, the cost of processor power was greatly reduced. Since the advent of the IC in the mid-1970s, the microprocessor has become the most prevalent implementation of the CPU, nearly completely replacing all other forms. This project is trying to design an 8 bit microprocessor by using VHDL. VHDL is stand for Very High Speed Integrated Circuit Hardware Description Language. It is one of the most popular design application uses by most designers nowadays. The microprocessor will be synthesized in VHDL using Xilinx ISE. Then it will be simulated using ModelSim and the programs are burn into FPGA board. The FPGA should act as actual microprocessor. The 8 bit microprocessor is widely use in microcontroller devices with specific task because it has a specific instruction where it only done a given instruction.

ABSTRAK

Mikropemproses adalah komponen elektronik digital yang terdiri dari transistor di dalam sebuah litar terbina dalaman (IC). Satu atau lebih mikropemproses bertindak sebagai unit pemproses utama (CPU) di dalam sistem komputer atau peranti elektronik. Mikropemproses menjadi tunjang kepada penciptaan mikrokomputer. Sebelum kewujudan mikropemproses, CPU dibina dari peranti suis yang besar yang terdiri dari beberapa transistor. Dengan menggabungkan pemproses di dalam pakej litar terbina dalaman berskala besar, kos untuk menghasilkan pemproses menurun dengan mendadak. Sejak penciptaan IC dalam pertengahan tahun 1970-an, mikropemproses digunakan secara meluas dalam CPU, dan hampir menguasai keseluruhan litar. Objektif projek ini adalah untuk mereka mikropemproses 8 bit dengan menggunakan "Very High Speed Integrated Circuit Hardware Description Language" atau singkatannya VHDL. VHDL adalah salah satu kaedah yang popular digunakan oleh pereka system elektronik pada masa sekarang. Mikropemproses ini akan disintesiskan menggunakan perisian Xilinx ISE. Kemudian, rekaan ini akan disimulasikan menggunakan perisian ModelSim dan seterusnya ia diimplementasi ke dalam "Programmable logic device" iaitu Spartan II. Litar tersebut akan berfungsi sebagai sebuah mikropemproses sebenar. Mikropemproses 8 bit digunakan secara meluas di dalam pelbagai peranti elektronik dan pengawal mikro dengan operasi-operasi tertentu, dimana ia hanya menjalankan operasi yang spesifik.

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LIST OF ABBREVIATION

VHDL	-	Very High Speed Integrated Circuit Hardware Description Language
FPGA	-	Field Programmable Gate Array
ADD	-	Addition
SUB	-	Subtraction
IN	-	Input
JZ	-	Jump to Zero
JPOS	-	Jump to Position
IC	-	Integrated Circuit
TTL	-	Transistor-transistor Logic
CMOS	-	Complementary Metal Oxide Semiconductor
CADC	-	Central Air Data Computer
ROM	-	Read Only Memory
RAM	-	Random Access Memory
ASICs	-	Application Specific Integrated Cicuits
PLD	-	Programmable Logic Devices
ALU	-	Arithmetic and Logic Unit
ACC	-	Accumulator
PC	-	Program Counter

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CHAPTER I

INTRODUCTION

Digital hardware plays a prominent role in many electrical and computer engineering products today. This is principally due to the rapid increase in transistor densities and speed of integrated circuits and steep decline in their cost caused by the advance in micro-electronic implementation technologies. This trend is likely to continue in the foreseeable future. The "computer revolution" has affected every aspect of society and many problems viewed as being intractable can now be solved. Modern digital design relies on engineering groups made up of individuals that have an understanding of all aspects of the problem, from the top to the bottom in the hierarchical chain, with expertise in one or two areas. Present industry practice has created a high demand for systems designers with knowledge and experience in using programmable logic in the form of CPLDs and FPGAs in addition to hardware description languages.

1.1 INTRODUCTION TO THE PROJECT

This project entitles 8 bit microprocessor design using VHDL. For modern digital design, VHDL is one of the most popular design applications uses by designer. Microprocessors are the important part of the field of electrical engineering. This is a very interesting project because processors are not as flexible as programmable logic. The ability to emulate a microprocessor on a programmable chip can lead to cheaper, more efficient and more flexible performance.

The scope of this project was to design an 8 bit microprocessor using VHDL. The design was implemented by programming it into a FPGA. The design was first completed and simulated. Once the simulation proved successful, the VHDL was implementing into the FPGA. The desired instructions are executed and the data to be operated on were given to the system as inputs. The result of the executed instructions was the output. After testing the individual parts they were then combined to test functionality. The final goal was to program an FPGA with the VHDL that was written.

This microprocessor contains 8 instructions; LOAD A, STORE A, ADD A, SUB A, IN A, JZ, JPOS AND HALT. For LOAD instruction, it will load accumulator, A with content of memory location aaaaa. STORE is function to store A into memory location aaaaa. ADD instruction will add A with memory content M[aaaaa] and store the result back to A. SUB instruction will subtract A with memory location M[aaaaa] and store the result back to A. IN instruction will input to A. JZ instruction use to jump to address if A is zero.

1.2 PROBLEM STATEMENT

A solution to an engineering problem is based on a set of criteria that judge its success. The same can be said for designing microprocessors. Depending on the application, the best solution can be the fastest, the least expensive, or the smallest. To achieve the best balance that optimizes a design, a number of different architectures and techniques can be used. Even with a powerful design, a microprocessor can be hindered by its slowest component, the memory. The processor can be build, but the designation of it and the process will make it working properly. The right design method use can result up the best way to design the microprocessor.

In this project, the designing of 8 bit microprocessor 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 testbench 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 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/designer (hence the term "field programmable") 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.

1.3 PROJECT OBJECTIVES

The objectives of this project are to design an 8 bit microprocessor by using VHDL (Very High Speed Integrated Circuit Hardware Description Language). This microprocessor has the basic instruction that student has been learned on microprocessor subject. This design will use VHDL and Xilinx FPGA as a programmable microprocessor chip. Programming codes are burn into FPGA using FPGA board/trainer and forming an 8-bit microprocessor.

1.4 SCOPE OF WORK

The microprocessor designed in 8 bit system. Its mean that the microprocessor is operated with 8 bit data. By using VHDL, the programs are burn into programmable FPGA and it should be work as a real 8-bit microprocessor. This project demonstrates a few instructions to execute.

CHAPTER II

LITERATURE REVIEW

2.1 MICROPROCESSOR HISTORY

The evolution of the modern microprocessor is one of many surprising twists and turns. This article shows the defining decisions that brought the contemporary microprocessor to its present-day configuration.

At the dawn of the 19th century, Benjamin Franklin's discovery of the principles of electricity were still fairly new, and practical applications of his discoveries were few, the most notable exception being the lightning rod, which was invented independently by two different people in two different places. Independent contemporaneous discovery would remain a recurring theme in electronics.

So it was with the invention of the vacuum tube, invented by Fleming, who was investigating the Effect named for and discovered by Edison. It was refined four years later by de Forest (but is now rumored to have been invented 20 years prior by Tesla). So it was with the transistor: Shockley, Brattain and Bardeen were awarded the Nobel Prize for turning de Forest's triode into a solid state device, but they were not awarded a patent, because of 20-year-prior art by Lilienfeld. So it was with the integrated circuit or

IC for which Jack Kilby was awarded a Nobel Prize, but which was contemporaneously developed by Robert Noyce of Fairchild Semiconductor who got the patent. And so it was, indeed, with the microprocessor.

2.1.1 Before The Flood: The 1960s

Just a scant few years after the first laboratory integrated circuits, Fairchild Semiconductor introduced the first commercially available integrated circuit, although at almost the same time as one from Texas Instruments.

Already at the start of the decade, process that would last until the present day was available: commercial ICs made in the planar process were available from both Fairchild Semiconductor and Texas Instruments by 1961, and TTL (transistor-transistor logic) circuits appeared commercially in 1962. By 1968, CMOS (complementary metal oxide semiconductor) hit the market. There is no doubt but that technology, design, and process were rapidly evolving.

Observing this trend, Fairchild Semiconductor's director of Research & Development Gordon Moore observed in 1965 that the density of elements in ICs was doubling annually, and predicted that the trend would continue for the next ten years. With certain amendments, this came to be known as Moore's Law.

The first ICs contained just a few transistors per wafer; by the dawn of the 1970s, production techniques allowed for thousands of transistors per wafer. It was only a matter of time before someone would use this capacity to put an entire computer on a chip, and several someone's, indeed, did just that.

2.1.2 Development Explosion: The 1970s

The idea of a computer on a single chip had been described in the literature as far back as 1952, and more articles like this began to appear as the 1970s dawned. Finally, process had caught up to thinking, and the computer on a chip was made possible. The air was electric with the possibility.

Once the feat had been established, the rest of the decade saw a proliferation of companies old and new getting into the semiconductor business, as well as the first personal computers, the first arcade games, and even the first home video game systems , thus spreading consumer contact with electronics, and paving the way for continued rapid growth in the 1980s.

At the beginning of the 1970s, microprocessors had not yet been introduced. By the end of the decade, a saturated market led to price wars, and many processors were already 16-bit.

The First Three

At the time of this writing, three groups lay claim for having been the first to put a computer in a chip: The Central Air Data Computer (CADC), the Intel® 4004, and the Texas Instruments TMS 1000.

The CADC system was completed for the Navy's "TomCat" fighter jets in 1970. It is often discounted because it was a chip set and not a CPU. The TI TMS 1000 was first to market in calculator form, but not in stand-alone form that distinction goes to the Intel 4004, which is just one of the reasons it is often cited as the first.

Early Intel: 4004, 8008, and 8080

Intel released its single 4-bit all-purpose chip, the Intel 4004, in November 1971. It had a clock speed of 108KHz and 2,300 transistors with ports for ROM, RAM, and I/O. Originally designed for use in a calculator, Intel had to renegotiate its contract to be able to market it as a stand-alone processor. Its ISA had been inspired by the DEC PDP-8.

The Intel 8008 was introduced in April 1972, and didn't make much of a splash, being more or less an 8-bit 4004. Its primary claim to fame is that its ISA, provided by Computer Terminal Corporation (CTC), who had commissioned the chip was to form the basis for the 8080, as well as for the later 8086 (and hence the x86) architecture. Lesser-known Intels from this time include the nearly forgotten 4040, which added logical and compare instructions to the 4004, and the ill-fated 32-bit Intel 432.

Intel put itself back on the map with the 8080, which used the same instruction set as the earlier 8008 and is generally considered to be the first truly usable microprocessor. The 8080 had a 16-bit address bus and an 8-bit data bus, a 16-bit stack pointer to memory which replaced the 8-level internal stack of the 8008, and a 16-bit program counter. It also contained 256 I/O ports, so I/O devices could be connected without taking away or interfering with the addressing space. It also possessed a signal pin that allowed the stack to occupy a separate bank of memory. These features are what made this a truly modern microprocessor. It was used in the Altair 8800, one of the first renowned *personal computers*.

Although the 4004 had been the company's first, it was really the 8080 that clinched its future. This was immediately apparent, and in fact in 1974 the company changed its phone number so that the last four digits would be 8080.