Implementation of Control Unit for Microprocessor Trainer (Data Transfer and Program Control Instructions)

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Abstract

The main objective of this paper is to implement a control unit for the 16 bit CPU used in Microprocessor Trainer. In Microprocessor Trainer, there are six modules and they are connected by the address bus (A [0...15]), the data bus (D [0...15]) and the control buses (MEMWR, MEMRD, IOWR and IORD). The modules involved in Microprocessor Trainer are CPU module, DMA module, Memory module, I/OCPU module, I/O Interface module and power supply. The Microprocessor Trainer uses 16-bit wide instruction sets. The whole module is supplied +5V DC from the power supply. The control unit is responsible for instruction fetching, decoding, executing, generating control signals such as MEMWR, MEMRD, IOWR, IORD etc. Control unit of this paper consists of following data transfer and program control instructions: Move, Store Word, Load Word, Load Halfword, Branch on equal, Branch on not equal, Branch on zero, Branch on not zero, Branch Greater than, Branch Less than, Jump, Call, Return, In, Out and Halt. All operations are controlled by using PIC 18F452 microcontroller. The control microprogram is developed with assembly language to control the operation precisely and to minimize the clock cycle.

Keywords-control unit, Microprocessor Trainer, PIC 18F452 microcontroller

1. Introduction

A microcontroller is a complete computer system, including a CPU, memory, a clock oscillator, and I/O on a single integrated circuit chip. The parts of any computer are:

- A central processor unit (CPU)
- A clock to sequence the CPU
- Memory for instructions and data
- Inputs to get information into the computer system
- Outputs to get information out of the computer system
- A program to make the computer do something useful.

The main component of any computer system is the central processing unit (CPU). A central processing unit (CPU) is the “brain” of the computer which reads and executes program instructions, performs calculations, and makes decisions. There are two main components in the CPU. One is control unit, and another one is arithmetic logic unit [4]. CPU consists of several sub-components connected via internal buses and a number of external components [1]. The CPU operates in four steps: fetch, decode, execute, and write back [5].

The control unit controls the entire computer system to carry out stored program instructions. [5] The control unit fetches instructions from memory and decodes them to produce signals which control the other parts of the computer. These signals cause it to transfer data between memory and ALU or to activate peripherals to perform input or output [7].

The control unit is the main component that directs the system operations by sending control signals to the data path. These signals control the flow of data within the CPU and between the CPU and external units such as memory and I/O [6].

2. Background Theory

PICs are popular with developers due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability [2].

The PIC18F452 microcontrollers represent a very clear step forward in the PIC design strategy. The main advantages of PIC18F452 microcontroller are the number of instructions more than doubled, with 16-bit instruction word, Enhanced Status register, Hardware 8 × 8 multiply, Enhanced address generation for program and data memory and so on. This is the motivation for the effort to develop the implementation of control unit for the 16 bits Central Processing Unit used in Microprocessor Trainer.

Microcontroller differs from a microprocessor in many ways. First and the most important is its functionality. In order for a microprocessor to be used, other components such as memory, or components for receiving and sending data must be added to it. In short that means that microprocessor is the very heart of the computer. On the other hand, microcontroller is designed to be all of that in one. No other external components are needed for its application because all necessary peripherals are already built into it. Thus, we save the time and space needed to construct devices [9].

Most Microcontrollers are general purpose Microprocessors which have additional parts that allow them to control external devices. We often use the terms Microcontroller and Microprocessor interchangeably [3].

The key difference between a microprocessor and a microcontroller is that a microprocessor contains only a central processing unit (CPU) while a microcontroller has memory and I/O on the chip in addition to a CPU. Microcontrollers are generally used for dedicated tasks. Microcomputer is a general term that applies to complete computer systems implemented with either a microprocessor or microcontroller [8].

Developing a PIC microcontroller-based project simply takes no more than five or six steps.

- Type the program into a PC
- Assemble (or compile) the program
- Optionally simulate the program on a PC
- Load the program into PIC's program memory
- Design and construct the hardware
- Test the project [2].

3. Contribution

The main contribution of this paper is to implement the control unit for the16 bit Central Processing Unit used in Microprocessor Trainer for data transfer and program control instruction. To implement this control unit, PIC 18F452, two 74ALS573Bs and other required peripheral devices are used. The PIC18F452 microcontrollers represent a very clear step forward in the PIC design strategy.

Design and implementation of a low cost Microprocessor Trainer (Control Unit) that is suitable for student learning.

4. Hardware Implementation of Controller Module

The complete block diagram of Microprocessor Trainer is shown in Figure 1.The complete circuit diagram of control unit for Microprocessor Trainer is shown in Figure 2. In this design, the PIC 18F452 20MHz microcontroller from Microchip Corporation, is used as main processing unit. Oscillator can be 10MHz crystal and either two 15pF capacitors or the ceramic resonator of the same frequency. The 10MHz crystal and capacitors connected to pins 13 and 14 of the 18F452 produce the clock pulses that are required to step the microcontroller through the program and provide the timing pulses. The most common power supply connecting for the controller is 5V zener diode voltage regulator.

PORTA is used analog and digital signals. In the main CPU, PORTA pins must be used digital I/O pins as they are used address latch enable, address enable, DMA INT, memory read and memory write signals. It is used to set up the PORTA to use as digital I/O pins. RA2 is used AE (Address Enable) signal which is used to control the 16-bit address output by the main processor.RA1 is used ALE (Address Latch Enable) signal which is used to control the 16-bit address output by the main processor. RA0 pin is used DMA ACK into RE0 of the DMA which signal is controlled by the main processor and that signal controls the bus service of the DMA. RA3 is used MEMWR control signal which signal to control to write the system DMA and memory module. RA5 is used MEMRD control signal which signal to control to read the system DMA and memory module. RE0 is used IOWR control signal which signal to control to write the system DMA, IOCPU and Parallel IO module. RE1 is used IORD control signal which signal to control to read the system DMA, IOCPU and Parallel IO module. RC0-RC7 and RD0-RD7 are used for 16-bit address output and data input/output. RB0-RB2 is used for the interrupt pins. RB0 pin is used interrupt request from RE1 of DMA which is DMA INT signal that signal is used for the DMA REQ signal which is used to request the bus service from the main processor. While DMA ACK pin of the CPU is going high, the DMA controller cannot use the system buses as all the buffers are disabled at that time. While DMA ACK pin is going low, all the buffers are enabled and the DMA controller can use the system buses. When the DMA controller needs to control the system bus, it will request the bus service from the main processor. The DMA controller sends out the DMA REQ signal to the main processor and then the main processor allows it to use the system buses by sending out the BUS GRANT signal. When the DMA controller receives the RUN command, it will give back the bus service to the main processor.

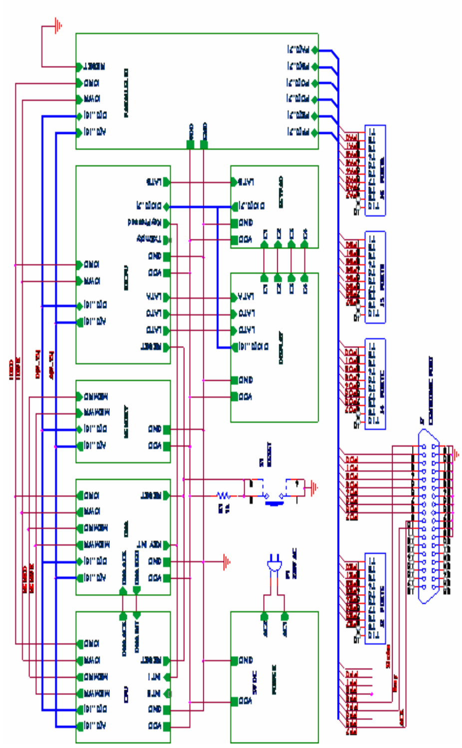

Figure. 1 Complete Block Diagram of Microprocessor Trainer

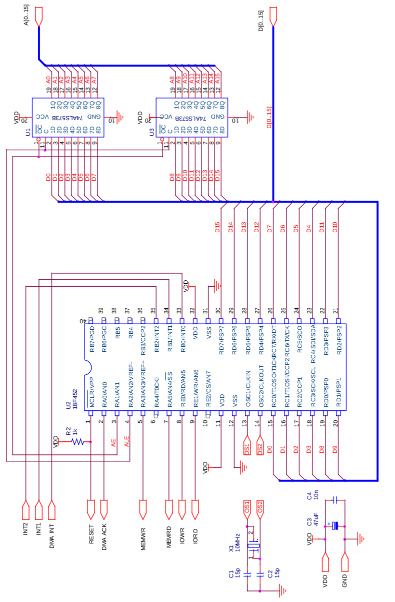

Figure. 2 Complete Circuit Diagram of CPU Module

5. Simple RISC Instructions for Control Unit for Data Transfer and Program Control Instructions

Simple RISC Instructions for Control Unit for Data Transfer and program control instructions are Move, Store Word, Load Word, Load Halfword, Branch on equal, Branch on not equal, Branch on zero, Branch on not zero, Branch Greater than, Branch Less than, Jump, Call, Return, In, Out.

6. Controlling with PIC18F452 Assembly Software

The complete block diagram of Microprocessor Trainer is shown in Figure 6.1.

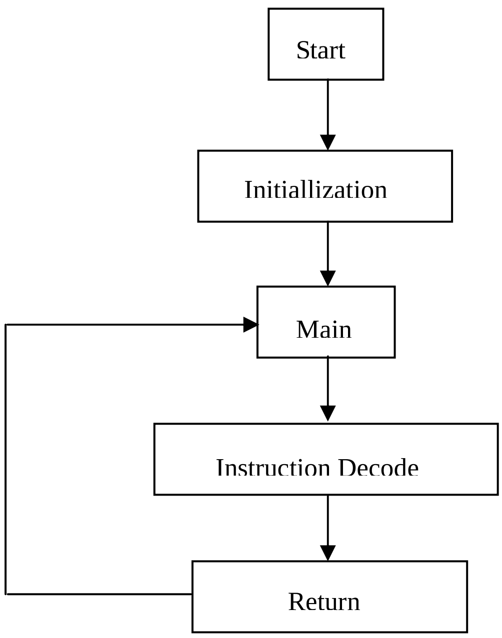

Figure 6.1 Block diagram of Microprocessor Trainer

6.1 Flow of Move Instruction

In Move instruction, sources register Rs1 and destination register Rs2 have to be extracted. And then, data are copied from source to destination register. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.2.

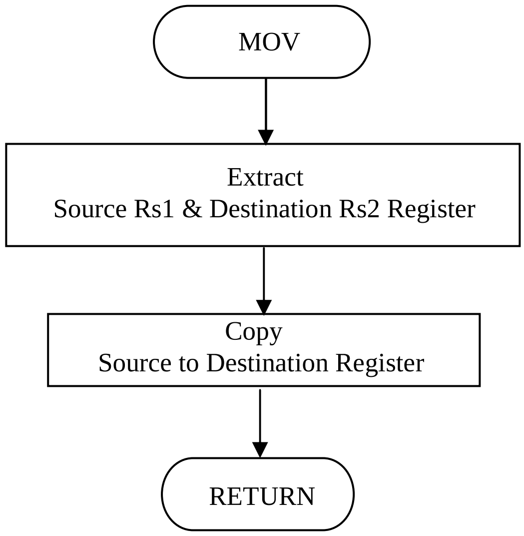

Figure. 6.2 Flow Chart for MOV Instruction

6.2 Flow of Load Halfword Instruction

In Load Halfword instruction, at first, register field is extracted and then data field is extracted and stored in register. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.3.

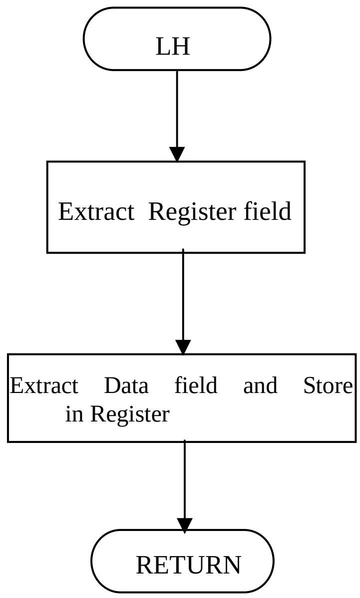

Figure. 6.3 Flow Chart for LH Instruction

6.3 Flow of Store Word Instruction

In Store word instruction, register Rs1 and register Rs2 have to be extracted. Address value is read. Increasing Program Counter must be taken. Adding address and Rs1 is performed. And then the system releases the output address. Rs2 data are written to the memory. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.4.

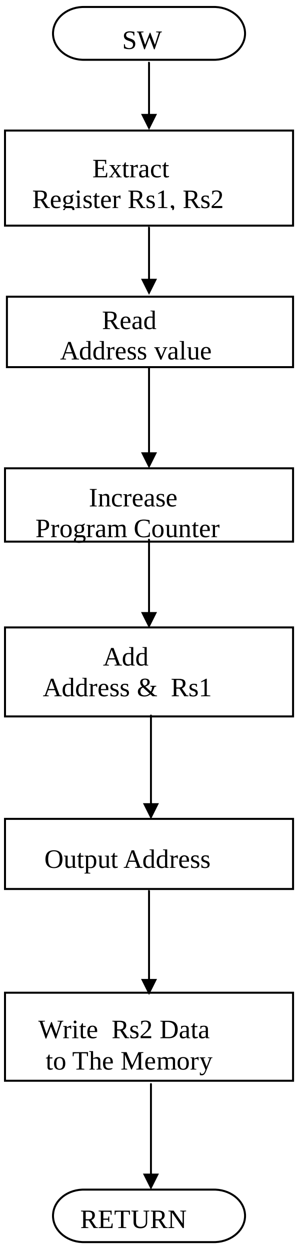

Figure 6.4 Flow Chart for SW Instruction

6.4 Flow of Load Word Instruction

In Load Word instruction, register Rs1 and Rs2 are extracted. The value of address is read. Program counter is increased and add address and Rs1. And it releases the address as output. Data are read from the memory and stored in register Rs2. . It must be returned to the main menu. The flow chart of this process is shown in Figure 6.5.

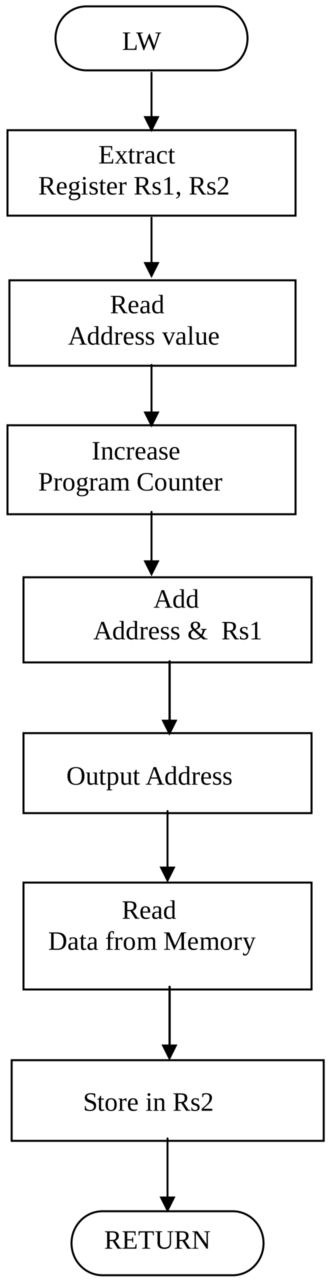

Figure 6.5 Flow Chart for LW Instruction

6.5 Flow of Branch on equal Instruction

In Branch on equal instruction, register Rs1 and register Rs2 field are extracted. The program checks whether Rs1 is equal to Rs2 or not. If Rs1is equal to the Rs2, Output address is released from program counter and read new address to the program counter. If Rs1 is not equal to Rs2, program counter must be increased. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.6.

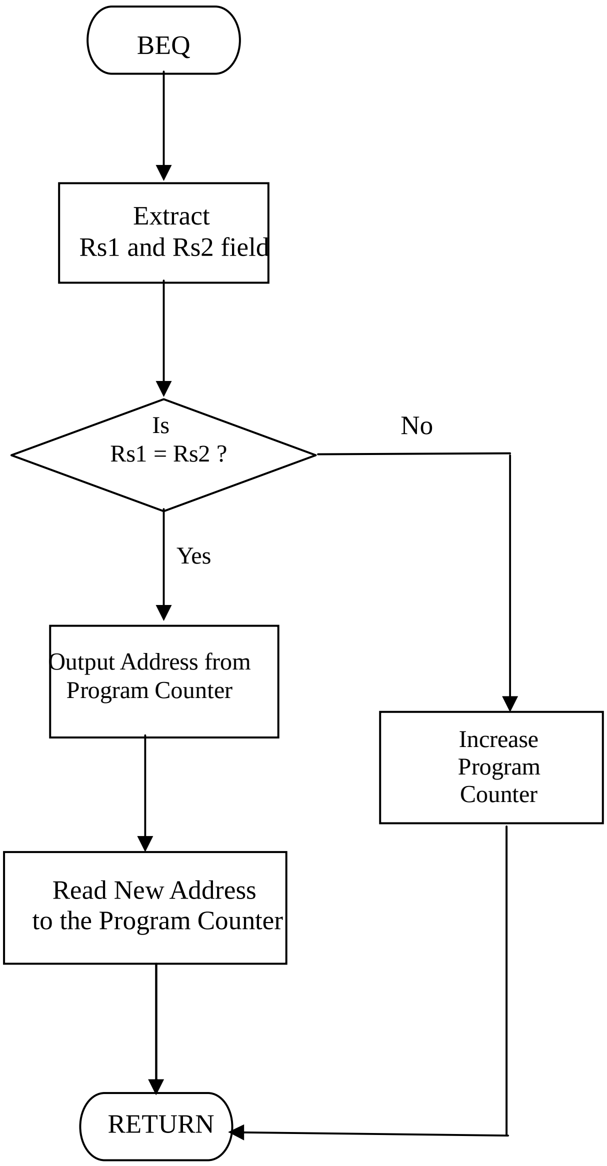

Figure 6.6 Flow Chart for BEQ Instruction

6.6 Flow of In Instruction

In In instruction, register Rs1 and register Rs2 field are extracted. IO address is released as output from the Rs2 and read data into register Rs1. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.7.

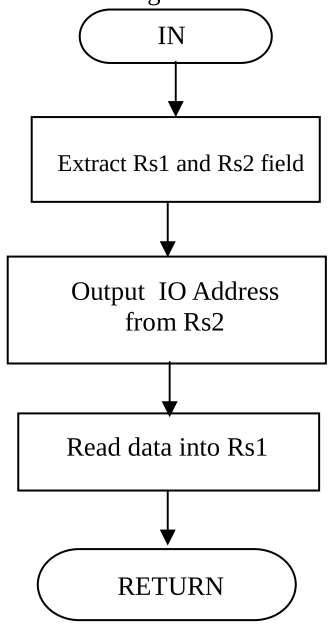

Figure 6.7 Flow Chart for IN Instruction

6.7 Flow of Out Instruction

In Out instruction, register Rs1 and register Rs2 field are extracted. IO address is released as output from the Rs2 and write data into register Rs1. It must be returned to the main menu. The flow chart of this process is shown in Figure 6.8.

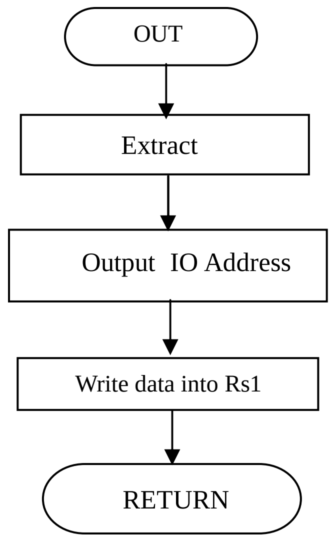

Figure 6.8 Flow Chart for OUT Instruction

7. Conclusion

The central processing unit (CPU) required for the Microprocessor Trainer is designed and built by both hardware and software controlled. And the main control parts are involved as software implementation. The CPU module is main part of the Microprocessor Trainer. PIC18F452 is implemented on both hardware and software designs as CPU. The other part of the CPU module is octal transparent latch with 3-state output 74ALS573B. CPU can execute the 35 instructions. These instructions of the CPU module are emulated by the PIC software.

In this paper, software technique was utilized to make control as it was not possible to do so by hardware system. It is more providable to reduce instruction cycles because the instruction sets become more powerful by using PIC18F452 rather than PIC16XX series. However, the cycles could not be reduced so much as 16 bit instructions were handled by 8 bit CPU. Instead of 'C' language, assembly language was used in programming to handle the instruction precisely. Without increasing clock speed, the throughput (instructions per second) of CPU could the incremental. To perform such function, it is advisable for testifying to redesign the instruction or increase the size of instruction. According to practically testifying data, the instruction could be done reasonably and in good quality.

8. References

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