METRO STATE
UNIVERSITY

ICS 232 Computer Organization & Architecture
Homework 4 - Chapter 4 Part 1 - 10 points
Due Date: 6/7/2023

Name: Key

Note: Please post your homework to ICS232 D2L on or before the due date.

Chapter 4 – MARIE: An Introduction to a Simple Computer

Essential Terms and Concepts

4. Where are registers located and what are the different types?

On the CPU chip. General purpose to hold number and control registers to maintain CPU status.

10. What is a bus cycle?

The states needed to transfer data over the bus. The time between two clicks of the clock.

17. Explain the difference between memory-mapped I/O and instruction-based I/O.

In memory-mapped I/O, the device registers appear as memory locations. In instruction-based I/O CPU instructions transfer data to the device registers.

20. Why is address alignment important?

If data can be read from memory on aligned boundaries, performance is improved.

21. List and explain the two types of memory interleaving and the differences between them.

High-order interleaving means sequential addresses are on the same chip. Low-order interleaving means sequential addresses are spread over chips. Low-order can result in performance improvements.

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33. How does interrupt driven I/O work?

An interrupt causes the current state of the CPU to be saved, the interrupt is handled and then the CPU state is restored. Interrupts are used by devices to signal completion of a task.

38. What is a stack? Why is it important for programming?

A stack is used to store local variables for a function and the return address of a function. It makes modular programming and recursive functions feasible.

Exercises

1. What are the main functions of the CPU?

The CPU is responsible for fetching program instructions, decoding each instruction that is fetched and performing the indicated sequence of operations on the correct data.

2. How is the ALU related to the CPU? What are its main functions?

The ALU is part of the CPU. It carries out arithmetic operations (typically only integer arithmetic) and can carry out logical operations such as AND, OR, and XOR, as well as shift operations.

5. How many bits are required to address a 4M × 16 bits main memory if
a) Main memory is byte-addressable?
b) Main memory is word-addressable?

a) There are 4M × 2 bytes which equals $2^2 \times 2^{20} \times 2 = 2^{23}$ total bytes, so 23 bits are needed for an address
b) There are 4M words which equals $2^2 \times 2^{20} = 2^{22}$, so 22 bits are required for an address

13. A digital computer has a memory unit with 24 bits per word. The instruction set consists of 150 different operations. All instructions have an operation code part

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(opcode) and an address part (allowing for only one address). Each instruction is stored in one word of memory.

a) How many bits are needed for the opcode? 8

b) How many bits are left for the address part of the instruction? 16

c) What is the maximum allowable size for memory? 2^{16}

d) What is the largest unsigned binary number that can be accommodated in one word of memory? $2^{24} - 1$

21. Explain why, in MARIE, the MAR is only 12 bits wide while the AC is 16 bits wide. Hint: Consider the difference between data and addresses

MARIE can handle 16-bit data, so the AC must be 16 bits wide. However, MARIE's memory is limited to 4096 address locations, so the MAR only needs to be 12 bits wide to hold the largest address.

27. Write the assembly language equivalent of the following MARIE machine language instructions:

a) 0111 0000 0000 0000 Halt

b) 1011 0011 0011 0000 AddI 330

c) 0100 1111 0100 1111 Subt F4F

29. Write the following code segment in MARIE's assembly language:

```
if X > 1 then
  Y = X + X;
  X = 0;
endif;
Y = Y + 1;
```

```
       ORG      100
If,    Load     X      /Load X
       Subt     One    /Subtract 1, store result in AC
       Skipcond 800    /If AC>0 (X>1), skip the next
       Jump     Endif  /Jump to Endif if X is not >= 1
Then,  Load     X      /Reload X so it can be doubled
       Add      X      /Double X
```

```
      Store    Y     /Y= X + X
      Clear          /Move 0 into AC
      Store    X     /Set X to 0
Endif, Load    Y     /Load Y into AC
      Add      One   /Add 1 to Y
      Store    Y     /Y = Y + 1
      Halt           /Terminate program
X,    Dec      5     /X has starting value
Y,    Dec      6     /Y has starting value
One,  Dec      1     /Use as a constant
```

33. Write the following code segment in MARIE assembly language:

```
X = 1;
while X < 10 do
   X = X + 1;
endwhile;
```

```
          ORG       100
          Load      One
          Store     X    /Initialize X
Loop,     Load      X    /Load loop constant
          Subt      Ten  /Compare X to 10
          SkipCond  000  /If X is less than 10, loop
          Jump      Endloop /terminate loop
          Load      X    /Begin body of loop
          Add       One  /Add 1 to X
          Store     X    /Store new value in X
          Jump      Loop /Continue loop
Endloop,  Halt           /Terminate program
X,        Dec 0          /Storage for X
One,      Dec 1          /The constant value 1
Ten,      Dec 10         /The loop constant
```

Prepare for next class by continuing to read Chapter 4 – MARIE: An Introduction to a Simple Computer.

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Start working on Your Group Project

Start working on Project 1