CSE/EE 5/7385 Microcontroller Architecture and Interfacing

HOMEWORK 1

1. An embedded systems engineer is designing a room temperature controller that has a digital thermometer that outputs temperature (in Fahrenheit) with an accuracy of $1/10^{th}$ of a degree. Her choices include microcontrollers with 4-, 8-, 16-, and 32-bit word sizes and bigger word sizes are most expensive. Of these four choices, which is the most appropriate and lowest cost? For full credit, give numerical calculations that justify your choice and you can assume room temperature ranges from 55 to 95 degrees.

Step size is 0.1 degrees. Total range of values is 95-55=40. 40/0.1=400 different temperature readings. 2^8=256 and 2^{16}=65536, so she must choose 16-bit word size since 8- and 4-bit will not record all ranges and 32-bit has too many.

ANSWER: 16-bit word size

2. An embedded systems designer is designing a handheld data collection device. The handheld device is battery powered and is used to collect data in the field. The handheld device is then plugged in to a USB port at the company headquarters where stored data is downloaded into a server. The designer must choose a type of memory for the handheld device. His choices are RAM, ROM, and Flash. Which type of memory should he choose for his device among these three? For full credit, you must give the REASON why a particular type is chosen.

ANSWER: Flash is best because it will retain the data even if the batteries die before returning to the company headquarters. RAM is volatile and would lose data if the batteries die. ROM is a bad choice because it is read-only.

ANSWER: Flash

3. The handheld device in question three (3) uses a microcontroller with a 12-bit address bus and an 8-bit data bus. The memory chips selected have a size of 4K×4 bits. If the handheld device is to have a maximum amount of addressable memory, how many memory chips are required per device?

Total amount of addressable memory is 2^{12} bytes or 4KB or 32Kb. Each chip has a capacity of 16Kb or 2KB. 4KB/2KB=2.

ANSWER: 2 chips are required

4. If a microcontroller has a Harvard architecture, give an example of one advantage it offers as compared to a microcontroller with a von Neumann (or Princeton) architecture.

ANSWER: Instructions and data can be accessed simultaneously since a Harvard architecture has separate instruction and data busses. NOTE to grader: other advantages are possible.

5. If a microcontroller has a Harvard architecture, give an example of one disadvantage it has as compared to a microcontroller with a von Neumann (or Princeton) architecture.

ANSWER: It requires TWO bus controller interface circuits, one for the data memory and another for the instruction memory. The von Neumann architecture only requires ONE bus controller since data and instructions are accessed on the same bus. NOTE to grader: other disadvantages are possible.

The following questions refer to a portion of a byte-addressable memory is shown in the table below.

ADDRESS	DATA
E20C2	C8
E20C3	20
E20C4	0E
E20C5	04
E20C6	DA
E20C7	65
E20C8	91
E20C9	9A

6. How many wires are required for the address bus that interfaces to this memory?

ANSWER: 5 hex digits so 5×4=20

7. How many wires are required in the data bus? HINT: assume the data bus is bidirectional

ANSWER: 8 bits can be read or written on same bus so 8

8. An ARM halfword is stored at location E20C7 in big endian format. What is the value of this halfword?

ANSWER: 6591

9. An ARM word is stored at E20C5 in little endian format. What is the value of this word?

ANSWER: 9165DA04

10. Location E20C4 contains a pointer to an ARM halfword that is stored in the portion of memory shown in the table, what is the value of this halfword?

ANSWER: There is an error in this question. Everyone who turned in their homework on time received full credit for this question. Those who were late received full credit less the late penalty.