National Exams December 2010

98-Comp-A2 - Digital Systems Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam. Candidates are allowed to bring ONE aid sheet of size 8.5" by 11", written on both sides, containing only notes and formulae.

   (a) A Casio or Sharp approved calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value.
5. Plan your answers carefully. Clarity and organization of the answer are important.
6. Some questions have sub-parts. The value for each sub-part is shown.

Marks: 20

1. Describe two methods by which you can get your microprocessor to respond to external events that drive input port pins. What are the major advantages and disadvantages with each method? Make sure to discuss both hardware and software design considerations and implications including statements of each of the problems and a brief description of wat you do to solve each problem.

Marks: 20

2. Your company has selected a microprocessor for an embedded system that you are designing. The microprocessor has a 24-bit address bus and a 16-bit data bus. Your application will require:

   - 228 kbytes of read-only memory,
   - 79 kbytes of random access memory,
   - 1923 bytes of EEPROM, and
   - 3 distinct I/O I/O devices each of which is selected with a single chip-select signal, and each of which has 7 distinct addresses internally.

   The sizes of the RAM, ROM and EEPROM integrated circuits that are available to you are as follows:

RAM	16 kbytes
	32 kbytes
	64 kbytes
	128 kbytes
	256 kbytes
	32 k × 16 bits
	256 k × 4 bits
	1024 k × 4 bits
ROM	64 k × 16 bits
	256 k × 16 bits
	512 k × 8 bits
	1024 k × 8 bits
EEPROM	2 k × 8 bits
	64 k × 8 bits

   Design an address decoding circuit for this system. Note that the system will never be expanded. The best design is one that meets the specifications and as well it minimizes the number of parts in the system.

Marks: 20

3. In most applications, a microprocessor has to transfer information and data to another device, or receive data and information from another device. Usually the microprocessor and the other device have different timing and may not share a clock. Simple examples of this type of communication are the serial communications port and the USB ports on desktop and laptop computers.

   For 5 of the 20 marks: Explain how you can guarantee that the microprocessor receives on its UART each byte of data from the remote once and only once in a polled I/O system. What is required to ensure this? This may include, but need not include, both hardware and software.

   For 10 of the 20 marks: Explain in detail how a UART receiver works. You should describe how it determines that a character is incoming, how it determines the timing and level of each bit, how it knows when the character is complete, how it knows when the character is correct, what kind of errors may happen, etc.

   For 5 of the 20 marks: Communications between two devices can occur over a parallel bus or a serial bus. What are the advantages and disadvantages of using a parallel bus as compared to a serial bus? You should be able to find at least two advantages and two disadvantages. Finally, under what conditions would you use a parallel bus?

Marks: 20

4. Input/Output operations can be handled by using interrupts.

   For 10 of the 20 marks: Interrupts can be triggered by a signal level (level-sensitive interrupts) or a change in signal level (edge-sensitive interrupts) on the interrupt input, either from a '0' to a '1' or from a '1' to a '0', or as a result of any state transition of the interrupt input. Explain each of these approaches and discuss their differences. Finally, explain when you would use edge-sensitive interrupts and when you would use level-sensitive interrupts, and why.

   For 6 of the 20 marks: Briefly explain the difference between maskable and non-maskable interrupts. Why are non-maskable interrupts always edge sensitive?

   For 4 of the 20 marks: When designing an interrupt service routine, what should you consider with respect to time. Provide at least two time considerations, with brief explanations.

Marks: 20

5. This question concerns the characteristics of logic families.

   For 10 of the 20 marks: Explain why there are set-up time and hold-time requirements on logic inputs. How do they come about? Do set-up and hold times apply only to sequential logic circuits, or are they important in combinatorial circuits as well? Describe how synchronous logic families attempt to solve the set-up time problem, but explain why the hold time may not be addressed satisfactorily by this method.

   For 10 of the 20 marks: Explain the importance of a logic threshold on the inputs to logic circuits. Why are they necessary? Also explain why designers of logic circuits try to ensure that the inputs to the circuits have some hysteresis. Again, why is this necessary, and what problem does it solve?

Marks: 20

6. Explain the operation of a typical microprocessor at the clock-cycle by clock-cycle level. You should consider what happens (address and data transfers, control signals, etc.) in each part of each clock cycle for a program that implements the pseudo-code found in Table 1. Use any microprocessor with which you are familiar as an example.

Table 1: Pseudo-code of a Typical Program Fragment

Label	Opcode	Operand
	load accumulator	with the value of the argument
	save the contents of accumulator	to the location specified in the argument
	if accumulator contents = 0	go to "cont1
	increment accumulator	
cont1:	save accumulator contents	to the location specified by argument plus contents of register X