**CITY UNIVERSITY OF HONG KONG**

Course code & title : EE2004 Microcomputer Systems

Session : Semester A 2020/21

Time allowed : 2 hours and 15 minutes

This paper has 6 pages (including this cover page).

**Instructions:**

Please make sure you follow all instructions from the University, ARRO, and EE. Please note the following:

1. This paper consists of 4 questions. The questions are ALL compulsory. Make sure that you attempt all of them. The total score is 100.

2. This is an **open-book exam.** Students can read the lecture notes and/or other materials available online.

3. You are responsible for receiving the questions on Canvas. Enter your name, student ID number, and the answers in a single MS Word file or a single PDF file. Name the file with your student ID number. Submit the file by e-mail ([itklchan@cityu.edu.hk](mailto:itklchan@cityu.edu.hk)) **before the deadline** of the exam.

4. **Stay on Zoom after the deadline** until the examiner allows you to leave.

Answering this exam paper implies your acknowledgment of the Pledge for following the Rules on Academic Honesty:

“I pledge that the answers in this examination are my own and that I will not seek or obtain an unfair advantage in producing these answers. Specifically,

1. I will not plagiarize (copy without citation) from any source;
2. I will not communicate or attempt to communicate with any other person during the examination; neither will I give or attempt to give assistance to another student taking the examination; and
3. I will use only approved devices (e.g., calculators) and/or approved device models.
4. I understand that any act of academic dishonesty can lead to disciplinary action.”

- 2 -

**On the first page of your answer sheets,** copy the following sentence and sign it: *I pledge to follow the Rules on Academic Honesty and understand that violations may lead to severe penalties. (*Signature) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Date) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Contact Information**

* Should you have any technical problem during the exam, contact your course leader or invigilator via Zoom private chat, email: itklchan@cityu.edu.hk or by phone call at 3442 7133.
* If you are not able to contact course leader/invigilator, you can reach the department via:

1. Departmental hotline at (+852) 3442-7740
2. Department Whatsapp phone: 9269-4066
3. Department WeChat ID: wxid\_lly7yf5fzoj722 or scan the following QR Code



- 3 -

Question 1 (30%)

1. Given two decimal numbers A = **XY** and B = 87. **X** is the last digit of your student ID number. **Y** is the second last digit of your student ID number.
2. convert A and B into 2’s complement numbers and show the calculation of A – B

[4 marks]

1. convert A and B into BCD codes and show the calculation of A + B

[4 marks]

1. In a given byte-addressable computer with a 21-bit address bus, memory locations 80000h to 1FFFFFh are available for user programs. Each RAM chip is 512 KB.
2. Draw a diagram to show the connection of CPU, memory chips and address decoder circuit. Assume each memory chip demands active high memory read, memory write and chip select signals.

[10 marks]

1. Assume that numbers A and B are stored in memory locations 80000h and 80001h respectively. The computer, assuming A and B are 2’s complement numbers, is to calculate A – B. Describe, with the aid of a timing diagram, the process how CPU can get number A.

[6 marks]

1. The computer will save the calculation result to memory location 80002h. Describe, with the aid of a timing diagram, the process how CPU can save the subtraction result.

[6 marks]

- 4 -

Question 2 (20%)

1. Show the calculation of the number of machine cycles for the following program.

Machine cycle

DELAY: MOVLW b’00110100’ 1

MOVWF R1 1

AGAIN: MOVLW 99 1

MOVWF R2 1

HERE: NOP 1

NOP 1

DECF R2, F 1

BNZ HERE 1 or 2

DECF R1, F 1

BNZ AGAIN 1 or 2

RETURN 2

[4 marks]

1. Calculate the actual time required to execute the program in part (a) if the clock frequency is 4 MHz.

[2 marks]

1. Modify the program in part (a) such that the time required to execute the modified program is **exactly** 48 msec.

[8 marks]

1. Write a program to generate a square wave of 50% duty cycle on pin PORTB.3. Each logic state lasts for 48 msec. Assume that the clock frequency is 4 MHz.

[6 marks]

- 5 -

Question 3 (20%)

1. Write a program to generate the digital values of a cosine wave with angles between 0 and 360 degrees (with 30-degree increments). The full-scale output of the DAC is 10V. Store the cosine function values in a table. Output the cosine wave to PORT D.

[10 marks]

1. The following program is to convert an analogue voltage to a digital value.

org 0x00

clrf TRISB

goto Start

Start: movlw 0x01

movwf ADCON0, A

movlw 0x0E

movwf ADCON1, A

movlw 0x92

movwf ADCON2, A

bsf ADCON0, GO, A

wait\_con:

btfsc ADCON0, DONE, A

bra wait\_con

movff ADRESH, PRODH

movff ADRESL, PRODL

movff PRODH, PORTB

end

1. Calculate TAD, assuming that the clock frequency is 10 MHz.

[3 marks]

1. Calculate TACQ.

[3 marks]

1. If PORTB is connected to 8 LEDs to display the digital value, what is the range of the digital values displayed in the LEDs?

[4 marks]

- 6 -

Question 4 (30%)

Perform arithmetic operation C = A – B, where A, B and C are 8-bit 2’s complement numbers. There are four numbers of A stored in locations **X**0h to **X**3h. Similarly, the four numbers of B are stored in locations **Y**0h to **Y**3h. The results of C are saved in locations **Z**0h to **Z**3h. **X** is the last digit of your student ID number plus one. **Y** is the second last digit of your student ID number plus one.If **X** and **Y** are the same, set **Y** equal to the second last digit of your student ID number plus two. **Z** is the third last digit of your student ID number plus one.

1. Write a program to perform the arithmetic operation using direct addressing mode.

[8 marks]

1. Write a program to perform the arithmetic operation using register indirect addressing mode with a loop.

[10 marks]

1. Write a program to perform two alternative arithmetic operations based on the interrupt signal. If the button “P1” is pressed, INT0 (PORTB.0) is activated. Perform arithmetic operation C = A + B. If the button “P2” is pressed, INT1 (PORTB.1) is activated. Perform arithmetic operation C = A – B.

[12 marks]

- END -