Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	MICROPROCESSOR AND MICROCONTROLLER
COURSE CODE	:	BEJ 30203 / BEC 30403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS

INSTRUCTION

1. ANSWER ALL QUESTIONS
2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) By referring to **Figure Q1(a)**, with a suitable example, discuss what is meant by "greater complexity at the processor level in CISC" and "greater complexity at compiler in RISC".

(5 marks)

(b) Discuss which microprocessor architecture is suitable for low power application in mobile devices, CISC or RISC?

(4 marks)

(c) Using the smallest data size possible, either a byte (8 bits), a halfword (16 bits), or a word (32 bits), convert the following values into two's complement representations:

(i) -18304

(1 mark)

(ii) -20

(1 mark)

(iii) -128

(1 mark)

(iv) -129

(1 mark)

(d) Discuss the "Load-Store" architecture in the ARM processor.

(5 marks)

Q2 **Listing Q2(i)** shows a simple ARM Cortex-M3 assembly program. After the program is assembled, the disassembly file is given in **Listing Q2(ii)**.

(a) Give the value in PC (R15) when the microprocessor is executing the instruction in Line 5 (**MOV** R0, #0x10).

(1 marks)

(b) Give machine code and the size of the instruction in Line 7 (**ADDS** R2, R0, R1). Explain the instruction and determine the value in the destination register after the instruction is executed.

(4 marks)

(c) Determine the value in LR (R14) and PC (R15) microprocessor is executing the instruction in Line 21 (**SUBS** R0, R0, #0x05).

(2 marks)

(d) Draw the stack and determine the values in it when the microprocessor is executing the instruction in Line 22 (**BL** Routine3).

(4 marks)

Q3 A program to converts a binary value between 0 and 9 in R4 into its ASCII representation is to be designed. Example of the initial inputs and outputs in R4 are given in **Figure Q3**. The program will return 0x0000FFFF if the initial content of R4 is not between 0 and 9.

(a) Draw a flowchart to devise the program.

(10 marks)

(b) Write an assembly program to implement the given specifications.

(10 marks)

Q4 **Figure Q4** shows the memory mapped I/O of a LPC1768 microcontroller. It shows that the microcontroller uses the same address space to address both memory and I/O devices. The memory and registers of the I/O devices are mapped to (associated with) address values.

(a) By referring to the memory map, give the starting and an end address of the general-purpose input/output (GPIO) and the Analog-to-digital (ADC) registers.

(2 marks)

(b) Write a sequence of assembly instruction to set byte 2 of port 1 to be an input port, while byte 3 of port 1 be an output port.

(4 marks)

Q5 A conveyor system is a mechanical handling equipment that moves materials from one location to another as shown in **Figure Q5**. Suppose that the rotor of the conveyor system in **Figure Q5** is connected to a DC motor where the L293D motor driver is used to control the speed of the motors by using the pulse-width modulation (PWM) signal. The PWM signals with different duty cycles is generated by the LPC1768 microcontroller. Four speed levels are determined by three switches as shown in **Table Q5**.

(a) Draw a flowchart to devise a program for the conveyor system based on the specifications above.

(9 marks)

(b) Write a program in C using the Common Microcontroller Software Interface Standard (CMSIS) to implement the conveyor system based on your flowchart in **Q5(a)**. Given the PWM's frequency is 10 KHz.

(8 marks)

(c) If an analog light sensor is connected to the conveyor such that the system is now able to detect the light intensity of the environment. Suppose that the system will immediately stop working when the light level is less than 100 lux. Write a sequence of codes to initialize the ADC and stop the conveyor as stated above. Assume that 100 lux is approximately 2.3-volt analog.

(9 marks)

(d) Now suppose that the light sensor in **Q5(c)** is replaced by the digital sensor that uses the I2C bus to interface with the microcontroller;

(i) If the I2C link is running with a 500 kHz clock. How long does it take for a single message containing one data byte to be transferred from the sensor to the microcontroller?

(4 marks)

(ii) By giving suitable examples, discuss the disadvantage of the SPI protocol as compared to I2C protocol.

(4 marks)

(e) If a push button is used to manually stop the conveyor using interrupt signal;

(i) Write a sequence of codes to initialize the interrupt and stop the conveyor when the button is pressed.

(7 marks)

(ii) Explain the differences between using polling and event-driven (interrupt) techniques for testing the state of one of the digital input pins on a microcontroller.

(4 marks)

-END OF QUESTIONS-

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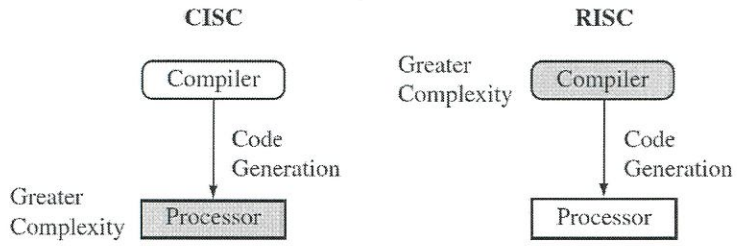

Figure Q1(a)

```
1:  __main   LDR    SP, =0x10000200
2:           MOVW   R3, #0x0200
3:           MOVT   R3, #0x1000
4:           BL     Routine1
5:           MOV    R0, #0x10
6:           MOV    R1, #0x10
7:           ADDS   R2, R0, R1
8:           STR    R2, [R3]
9:
10: stop              B stop
11:
12: Routine1 PUSH   {LR}
13:          MOV    R0, #0x20
14:          SUBS   R1, R0, #0x05
15:          BL     Routine2
16:          NOP
17:          POP    {PC}
18:
19: Routine2 PUSH   {LR}
20:          MOV    R0, #0x30
21:          SUBS   R0, R0, #0x05
22:          BL     Routine3
23:          NOP
24:          POP    {PC}
25:
26: Routine3 MOV    R0, #0x40
27:          SUBS   R0, R0, #0x05
28:          BX     LR
```

Listing Q2(i)

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```
0x00000110   F8DFD044   LDR.W   sp,[pc,#68] ; @0x00000158
0x00000114   F2402300   MOVW    r3,#0x200
0x00000118   F2C10300   MOVT    r3,#0x1000
0x0000011C   F000F807   BL.W    0x0000012E
0x00000120   F04F0010   MOV     r0,#0x10
0x00000124   F04F0110   MOV     r1,#0x10
0x00000128   1842       ADDS    r2,r0,r1
0x0000012A   601A       STR     r2,[r3,#0x00]
0x0000012C   E7FE       B       0x0000012C
0x0000012E   B500       PUSH    {lr}
0x00000130   F04F0020   MOV     r0,#0x20
0x00000134   1F41       SUBS    r1,r0,#5
0x00000136   F000F802   BL.W    0x0000013E
0x0000013A   BF00       NOP
0x0000013C   BD00       POP     {pc}
0x0000013E   B500       PUSH    {lr}
0x00000140   F04F0030   MOV     r0,#0x30
0x00000144   1F40       SUBS    r0,r0,#5
0x00000146   F000F802   BL.W    0x0000014E
0x0000014A   BF00       NOP
0x0000014C   BD00       POP     {pc}
0x0000014E   F04F0040   MOV     r0,#0x40
0x00000152   1F40       SUBS    r0,r0,#5
0x00000154   4770       BX      lr
```

Listing Q2(ii)

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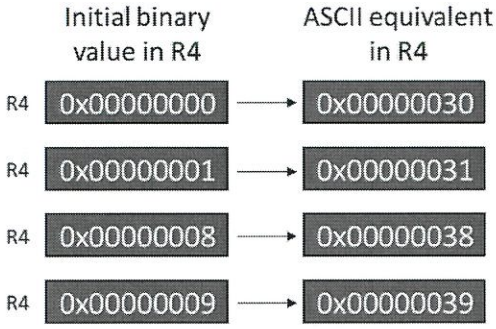

Note that ASCII value for no 0 is 0011 0000, 1 is 0011 0001
Please refer to the given ASCII table.

Figure Q3

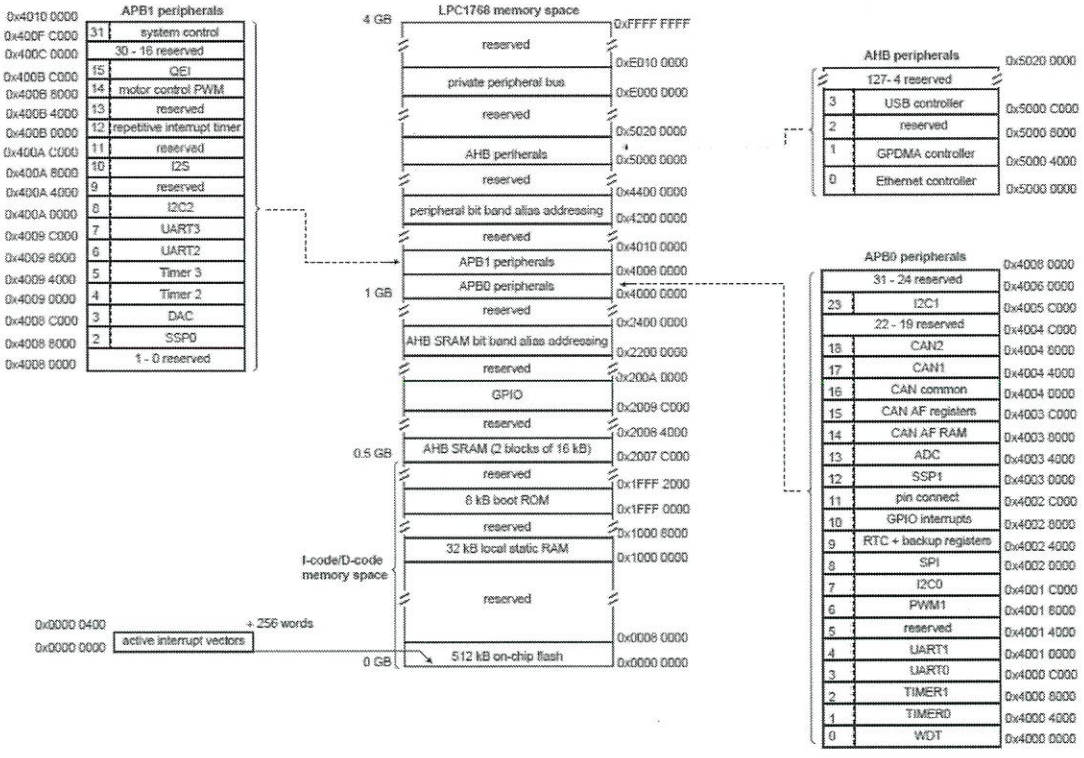

Figure Q4

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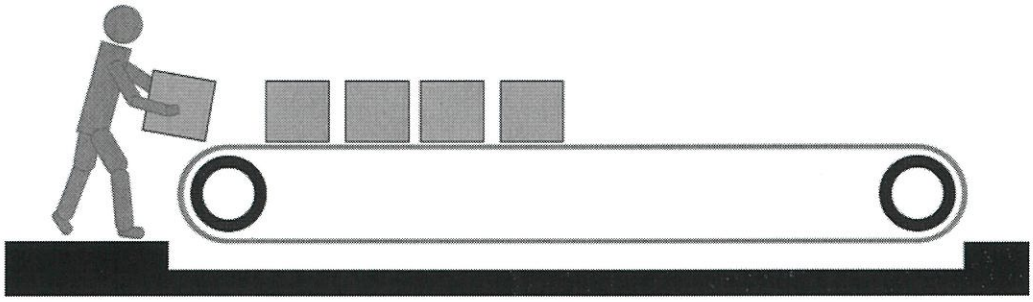

Figure Q5

Table Q5

Duty cycle	Speed level	Switch
10%	Level 0	No press
30%	Level 1	S1
50%	Level 2	S2
70%	Level 3	S3