14/1/2019

09.30 - 11.30am

National Stadium, Irish Athletic Boxing Centre

DUBLIN INSTITUTE OF TECHNOLOGY

DT211C BSc. (Honours) Degree in Computer Science (Infrastructure)

Year 2

WINTER EXAMINATIONS 2018/2019

MICROPROCESSORS [CMPU2013]

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MONDAY 14TH JANUARY 9.30 A.M. – 11.30 A.M.

TWO HOURS

ANSWER 3 OUT OF THE FOLLOWING 4 QUESTIONS.
NUMBERS PREFIXED BY *0x* ARE IN HEXADECIMAL.

In addition to the DIT Approved List of Calculators (Use of Calculators in Examinations), the following calculator models are also permitted for this examination:

Casio fx-991es	Casio fx-991es PLUS
Sharp EL-520X	Sharp EL-520W
Sharp EL-W506	Sharp EL-W506x

Q1

(a)

(i) Show that all possible states of a 4 bit binary number can be encoded in a single hexadecimal digit.

[4 Marks]

(ii) Calculate the 32 bit result for each of the following C-language calculations:

0x7a4219ad ^ 0xab924014

[2 Marks]

~(0x1352d15a & 0x325b4a15)

[2 Marks]

(b) What is the value of X when each of the following C code fragments is executed

(i)

```
uint8_t Result,X,Y;
X = 212;
Y = 65;
Result = X + Y;
```

[4 Marks]

(ii)

```
int8_t Result,X,Y;
X = 120;
Y = 12;
Result = X + Y;
```

[4 Marks]

(c) What is the **minimum** number of bytes required to store

(i) The ASCII encoded C string "12345678"

[2 Marks]

(ii) The unsigned integer 12345678

[2 Marks]

(d)

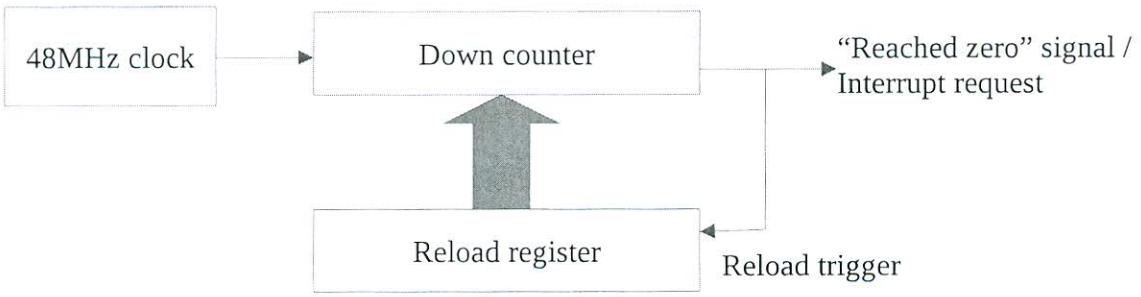

Figure Q1d

ARM Cortex based microcontrollers incorporate a 24 bit down-counter that can be used to generate interrupts at periodic intervals. This is illustrated in Figure Q1d. When the counter register reaches zero it is reloaded with a value from the reload register and then repeats the down count.

(i) What is meant by the term "clock" in this context?

[4 Marks]

(ii) If the counter has an input clock frequency of 48MHz, what value you write to the reload register to cause an interrupt every 8 milliseconds?

[4 Marks]

(iii) The 32 bit reload register is at memory address 0xe000e014. What C-code would you use to write a value to this address?

[5 Marks]

Q2

(a) What roles do GPIO0DATA and GPIO0DIR play in the LPC1114 microcontroller family?

[4 Marks]

(b)

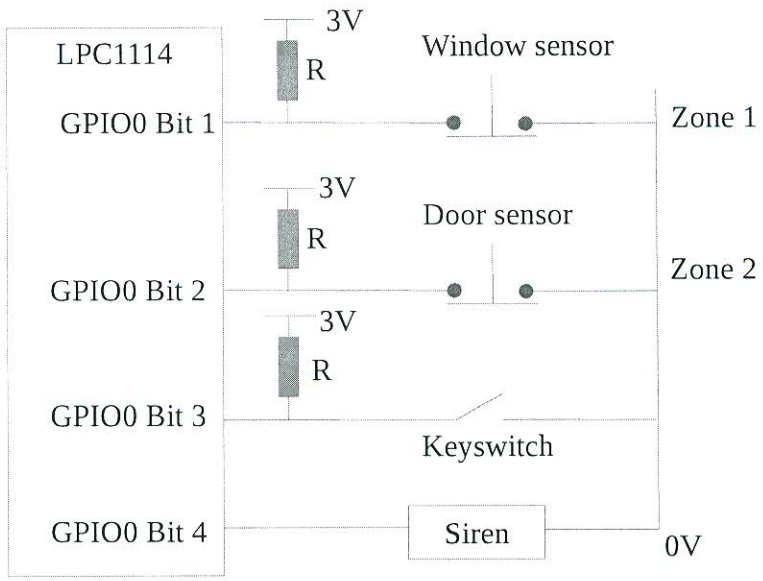

Figure Q2A shows a block diagram for a simple burglar alarm. If a window or door in either zone is opened, the input to the MCU becomes logic 1, otherwise it is pulled down to logic zero. The alarm is enabled with a key-switch which pulls the MCU input down to enable the alarm. The alarm also has a siren that sounds when the digital output to which it is connected goes high.

(i) Write a C function that configures the MCU input/output port appropriately for this alarm. Any unused port bits can be configured as inputs.

[4 Marks]

(ii) Write a C function that returns 1 if Zone 1 has an alarm condition (e.g. window open). The function should return 0 if there there is no alarm.

[3 Marks]

(iii) Write a C function that returns 1 if Zone 2 has an alarm condition (e.g. door open). The function should return 0 if there there is no alarm.

[3 Marks]

(iv) Write a C function that returns 1 if the keyswitch is closed ('armed'). The function should return 0 if the switch is open (disarmed).

[3 Marks]

(v) Write the pair of C-functions : SirenOn, SirenOff that can be used to control the Siren.

[4 Marks]

(c) The first five entries of the interrupt vector table for an ARM Cortex MCU are as follows:

0x10001000
0x00000011
0x00001001
0x00001501
0x00009251

(i) What is chain of events that occurs when an interrupt occurs and is responded to by a microprocessor?

[4 Marks]

(ii) The first entry in the interrupt vector table has a special significance – what is this and why is this helpful for C-programmers?

[5 Marks]

(iii) To what address does the microcontroller jump to when interrupt number 2 occurs (assume that "Reset" is interrupt number 0)?

[3 Marks]

Question 3

```
strcpy
; implements strcpy(char *dest,char *src);
; on entry R0 points to dest, R1 points to src
; copies bytes from src to dest until a null terminator
; is encountered in src
     PUSH {R0-R2,LR}
strcpy_loop
     LDRB R2,[R1]
     CMP R2,#0
     BEQ strcpy_exit
     STRB R2,[R0]
     ADDS R0,R0,#1
     ADDS R1,R1,#1
     B strcpy_loop
strcpy_exit
     STRB R2,[R0]
     POP {R0-R2,PC}
```

Listing Q3a

Listing Q3a contains the assembler implementation of the C-function **strcpy**.
(a) Write a line-by-line explanation of the function

[10 Marks]

(b) How would you modify the program so that it implements the **strncpy** function whose C prototype is:

```
char *strncpy(char *dest, const char *src, size_t n)
```

[6 Marks]

(c) Using three different examples explain what is meant by the term "addressing mode"

[12 Marks]

(d) What is meant by the term "Calling Convention". Illustrate your answer with a simple example.

[5 Marks]

Question 4

(a)

(i) Arrange the following types of storage in order of access speed (fastest first)
L1 Cache, Register, RAM, Rotating disk

[2 Marks]

(ii) What is meant by the term instruction pipeline?

[3 Marks]

(iii) Outline the mechanism by which the so-called "meltdown" CPU exploit operates.

[18 Marks]

(b)

Computers base all of their decisions on the status of arithmetic flags. Illustrate what is meant by this by showing how the following loop might be implemented in ARM Cortex assembler:

```
for (i=0;i != 10; i++)
{
// loop contents not shown
}
```

[6 Marks]

(c)

(i) An ARM Cortex MCU has the following register contents:
R13 (Stack pointer) = 0x10001000
R0 = 0x12345678
Exactly what happens when each of the following instructions is executed in sequence (i.e. what number goes where for each of the lines of code)?

```
PUSH {R0}
POP {R1}
```

[4 Marks]