GLASGOW COLLEGE UESTC

Exam paper

Embedded Processors (UESTC2004)

Date: 25th June 2019
Time: 09:30-11:30am

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

Continued overleaf

Q1 (a) Write a single statement in blanks to accomplish each of the following sentence.

(i) An __is the automatic transfer of software execution in response to a hardware event that is asynchronous with the current software execution. [2]

(ii)___ bus is a vehicle bus standard designed to allow microcontrollers and device to communicate with each other within a vehicle without a host computer. [2]

(iii) Almost every processor has a number of *privileged* instructions for ___ [2]

(iv) On computer C1 all instructions last 10 ns. On computer C2 all instructions last 5ns. C2 is therefore ____ than C1. [2]

(v) Convert the decimal numbers 5.5 to binary ___. [4]

(vi)Explain what the *volatile* keyword in C does_____. What could happen if you forget to use it? _____ [4]

(b) Observe the following two C functions.

Function1:

```
1. void Set0(void){
2. PORTJ = PORTJ | 0x01; // PORTJ bit 0 is high and PORTJ is 8 bit parallel I/O
3. }
```

Function 2:

```
1. void Set1(void){
2. PORTJ = PORTJ | 0x02; // PORTJ bit 1 is high
3. }
```

(i) Are these two functions need to be executed sequentially or in parallel?[1] Why ? [2]

(ii) Do these two functions have critical sections?[1] If yes , how the critical sections are formed? If no, why are there no critical section? [2]

(iii) Intrusiveness is a measure of how much the measurement process itself modifies the operation being measured. The GCC compiler will generate the assembly code in below.

```
1. Set0 bset PORTJ,#01
2. rts
```

Assuming the software being debugged runs much slower than debug instrument, explain in what condition the Intrusiveness will happen during debugging? [3]

Q2(a) Imagine that you have a pushbutton switch wired up as follows (Fig Q2_i):

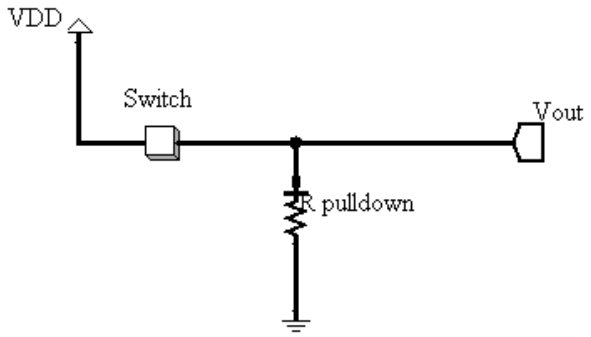

Figure Q2_i

(i)Sketch what Vout will look like when the button is pressed (at t=1) and released (at t=2) for a typical switch. [2]

(ii) Identify a common problem of this design and Draw how you would modify the circuit to deal with the problem. [5]

(iii)Describe how you might deal with this problem in software. [5]

(iv)Write an interrupt handler to process a push button connected to an in LPC1768 platform . (Function definition [4], variable definition [2], data flow [2])

(b) For the SysTick timer which is found in ARM Cortex microcontrollers.

(i).Describe how to initiate SysTick in software. [2]

(ii) The Assembly code created by the compiler for an interrupt service routine is shown in Fig. Q2_2. These two **`#define`** definitions are bit banded addresses for Port F. What is in lr during the execution of this interrupt routine? [3]

```
SysTick_Handler
    LDR r0,[pc,#8]
    LDR r1,[r0,#0x04]
    EOR r1,r1,#0x01
    STR r1,[r0,#0x04]
    BX  lr
```

```
#define GPIO_PF0 (*((volatile unsigned long *)0x40025004))
#define GPIO_PF1 (*((volatile unsigned long *)0x40025008))
void SysTick_Handler(void) {
  GPIO_PF0 = GPIO_PF0^0x01;
}
void otherFunction(void) { // called from foreground
  GPIO_PF1 = GPIO_PF1^0x02;
}
```


Continued overleaf

Q3 (a)

(i) A PWM module can provide several outputs using only one timer. Explain the relationship between these outputs. [3]

(ii) The following C program, Figure Q3.a.ii, is executed on an mbed board. Sketch the waveform with the time and voltage scale which you would observe at the output pin of the board. [5]

```
#include "mbed.h"
PwmOut   PWM1(p21);

int main()
{
    PWM1.period(0.008);
    PWM1.pulsewidth(0.004);
}
```

Figure Q3.a.ii

(iii) Explain the main difference between PWM and DAC. [4]

(b)

(i) An embedded system uses an ADC to measure a parameter. The measurement system's range is 0.0 to 9.999V and it has a resolution of 0.001V. What is the smallest number of ADC bits that needs to be used? [5]

(ii) Based on the following C program, Figure Q3.b.ii. Explain how to change the program in order to halve the period of the waveform. [5]

(iii) Briefly explain how to create a smoother waveform. [3]

```
#include "mbed.h"
AnalogOut Aout(p18);
float i;
int main()
{
    while(1) {
            for(i=0; i<2; i=i+0.1)
            {
                    Aout = 0.5+0.5*sin(i*3.142);
                    wait(0.01);
            }
    }
}
```

Figure Q3.b.ii

Q4 (a)

(i) Explain the key differences between synchronous serial communications and asynchronous serial communications. [4]

Read the following C program, Figure Q4.a, which is executed on an mbed board, and answer the following questions.

```
#include "mbed.h"
SPI ser_port(p11, p12, p13);
char switch_word;

int main()
{
    ser_port.format(8,0);
    ser_port.frequency(1000000);
    while(1)
    {
            switch_word = 0xA3;
            ser_port.write(switch_word);
            wait_us(50);
    }
}
```

Figure Q4.a

(ii) Explain the function of this line of code `SPI ser_port(p11, p12, p13);` [3]

(iii) Sketch the output of pin11 and pin13 of the SPI port based on the above program. Also show their relationship. [7]

For Mode 0, CPHA = 0 (Clock out of phase with data);
CPOL = 0 (Clock active high)

(b)The ASCII character 'E' is transmitted through a UART from an LPC1768 microcontroller. The ASCII code for 'C' is 0x45. Assume the baud rate is 9600 bits/sec, and one stop bit and even parity are being used. Answer the following questions:

(i) What are the transmitted bits and in which order? [5]
(ii) Explain the purpose of using parity bit. [2]
(iii) Calculate the throughput of the UART. [4]

End of question paper