University of Glasgow–University of Electronic Science and Technology of China Joint School

Embedded Processors (UESTC2004)

Final Exam

5th January 2015

Answer all questions.

Use one answer sheet for each of the five questions in this exam.

Show all work on the answer sheet.

Correct answers without the required calculations shown on the exam answer sheet will not receive full marks.

When asked to "briefly explain," try not to use more than two or three sentences.

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

This examination is closed-book. Unless noted otherwise, answers must be explained. An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

The numbers in square brackets in the right-hand margin indicate the marks allotted to each part of the question. These marks are for guidance only.

Q1. Read the following C code (Figure Q1) executed on a NXP LPC1768 microcontroller, and answer the following questions.

```
#include "LPC17xx.h"

void delay(volatile int value)
{
    for(int i=0; i<value; i++)
    {
    }
}

int main()
{
    LPC_GPIO1->FIODIR |= 1<<5;
    while(1)
    {
          LPC_GPIO1->FIOSET |= 1<<5;
          delay(48000);
          LPC_GPIO1->FIOCLR |= 1<<5;
          delay(96000);
    }
}
```

Figure Q1

a) Briefly explain why the digital Input/Output pins on the microcontroller have to be initialized before they are used. Which line of code is responsible for the initialization of the I/O port pin? **[4]**

b) The initialization in the program is "friendly". Briefly explain why. **[2]**

c) Which pin is used? Which port does it belong to? **[2]**

d) Assume the waveform observed at this pin has a period of 9ms. Draw the output waveform, including more than one period of the wave. Show your calculations and label your drawing with numbers. **[7]**

e) Write C code to generate the same above output waveform on pin 21 of mbed development board. Please use period_ms() and pulsewidth_ms() functions defined in class PwmOut. **[5]**

Q2. Read the following provided assembly code (Figure Q2), and answer the following questions. Assume that Num is a 32-bit variable.

```
Change      LDR R1, =Num
            LDR R0, [R1]
            ADD R0, R0, #20
            STR  R0, [R1]
            BX LR
main        LDR R1, =Num
            MOV R0, #5
            STR R0, [R1]
loop        BL Change
            B loop
```

Figure Q2.

a) How many fields are there in a line of code in an assembly language program? What are they? **[4]**

b) What are the addressing modes used in each of the following instructions: **[3]**

```
LDR R1, =Num
LDR R0, [R1]
MOV R0, #5
```

c) How is a subroutine defined? How is a subroutine called? **[5]**

c) What is the value of variable Num after the subroutine is called twice? Explain how you calculated this. **[4]**

e) What is the execution sequence for the above assembly program? **[4]**

Q3. Answer the following questions.

a) Briefly explain what are microprocessors, microcomputers, and microcontrollers? **[5]**

b) Convert the decimal number -3 into the equivalent binary representation and hexadecimal representation. Use the two's complement system, and assume the value has 8 bits. **[4]**

c) What is π (approximately equal to 3.14159) represented as in memory, when using Decimal Fixed-Point with m = -3 (resolution of 0.001)? What is π represented as in memory when using binary Fixed-Point with m = -8 (resolution of 1/256)? **[6]**

d) Briefly explain the key difference between Von Neumann Architecture and Harvard Architecture? Which architecture does ARM Cortex-M3 use? **[5]**

Q4. The following program (Figure Q4) produces an output waveform through the DAC of an mbed development board. Please answer the following questions:

```
#include "mbed.h"
AnalogOut Aout(p18);
float i;

int main()
{
      while(1)
      {
            for(i= 0; i<1; i = i+0.1)
            {
                  Aout = i;
                  wait(0.001);
            }
      }
}
```

Figure Q4.

a) Sketch the output voltage waveform for at least 20 milliseconds. Note the mbed normally uses its own power supply voltage, i.e., 3.3V, as voltage reference. Label your axes. **[7]**

b) What is the period of the output waveform? **[2]**

c) Explain how to create a smoother waveform? **[2]**

d) If we use LPC1768 DAC directly to generate the voltage (when i = 0.1), what value we should put in the DACR register? Please show how this value is obtained.
LPC_DAC->DACR = ??? **[5]**

Note: In DACR register, bits 15:6 are used to contain this value. LPC1768 DAC is a 10-bit DAC.

e) Time between the steps was determined by the software. What is a better solution to achieve the same delay time? Without writing the C code describe how it can be done. **[4]**

Q5. Please answer the following questions related to serial communications.

a) Briefly describe the benefit of using serial communications compared with parallel communications. **[5]**

b) Briefly describe the main differences between synchronous serial communication and asynchronous serial communication. **[5]**

c) The ASCII character '9' is transmitted through a UART from an LPC1768 microcontroller at 9600 baud. Assume one stop bit and no parity bit are being used. Describe the order in which the bits are transmitted. How long will it take to transmit the entire frame?

Sketch the waveform which you would observe both at the output pin of the board and after the signal has been converted to RS232 levels. The ASCII code for '9' is 0x39. **[10]**