UNIVERSITY OF GLASGOW
Glasgow College UESTC

Degree of BEng in Electronic and Electrical Engineering

Embedded Processors (UESTC2002)

Monday 26th Dec. 2016
10.00 – 12.00

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.

Attempt all questions

An electronic calculator may be used provided that it does not have a facility for either textual storage or display, or for graphical display.

Question 1

(a) Given Figure Q1.1 on the following page:

i. Explain why Circuit 1 is **not** the best way to switch the voltage Vi from Vs to ground. [2]

ii. What name is used for a resistor that is located in a circuit at the same place as R1? [1]

iii. What name is used for a resistor that is located in a circuit at the same place as R2? [1]

iv. Explain why input and output pins on the mbed have to be initialized. [3]

(b) Given the code shown in Figure Q1.2 on the following page:

i. Using PWMOut as an example, explain the purpose of line. [4]

ii. In line 2, why should variables xx and yy not be defined as fixed point numbers? [3]

iii. Sketch the output voltage on pin 26 from 0 ms to 15 ms. [6]

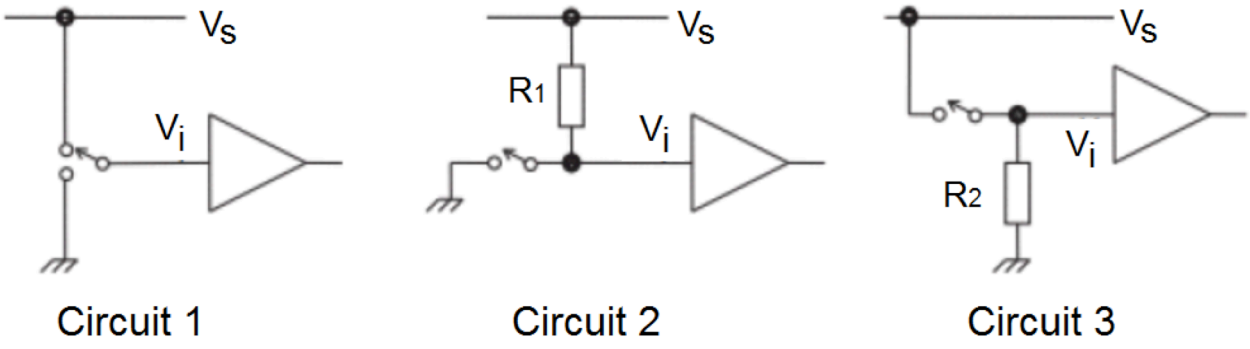

Figure Q1.1

Question 2

(a) Calculate n the number of bits required for the DAC such that the resolution is less than or equal to 500 μV. The reference voltage is equal to 5 V. [2]

(b) Calculate the value of the analogue voltage A_{12} produced by the DAC when the value of the digital input to the DAC is $D_1 = 6666$. Write the solution using 5 significant figures. [4]

(c) Calculate the resolution of the 12-bit ADC of the mbed. [2]

(d) Given the value for A_{12} from part (b), calculate the output D_2 from the mbed. [4]

(e) What range of inputs to the DAC will result in the same value of D_2 from the mbed ADC as obtained in part (d)? [6]

(f) At what minimum value of D_1 will the output D_2 become its maximum value? [2]

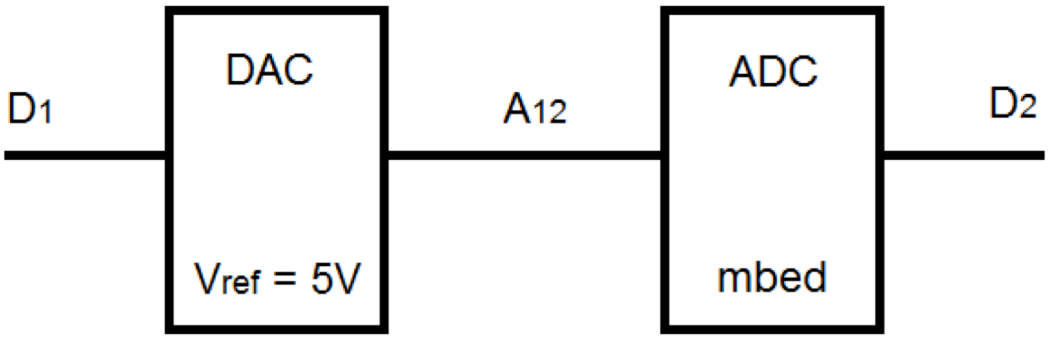

Figure Q2.1

Line number	Code
1	#include "mbed.h"
2	float xx, yy;
3	int i = 0
4	PWMOut PWM(p26);
5	xx = 0.001
6	yy = 0.3
7	int main () {
8	while (i<5) {
9	PWM.period(xx);
10	PWM=0.15/yy;
11	yy=2*yy/(i+1)
12	i=i++
13	xx=xx*i
14	}
15	}

Question 3

A sensor is connected to an mbed microcontroller. The communication protocol used to send and receive data between the sensor and the mbed is UART. The baud rate is 56k.

(a) Sketch the circuit schematic of the sensor – mbed system and label the connections. [3]

(b) Select the best answer: [1]

i. The maximum number of bits that the sensor will send or receive in a single data transmission is 56 kbytes.
ii. The number of bytes per unit time that the sensor will send or receive 7 kbytes/s.
iii. The number of bits per unit time that the mbed will send or receive is 448 kbits/s

(c) The transmission of the 7-bits of data plus a parity bit from the sensor as well as the start and stop bits is shown in Fig. Q3.1 on the following page.

i. What is the 7-bit string of the data that were transmitted? [3]
ii. Assuming that the data transmission is correct, is the parity odd or even? [3]

(d) An incorrect program is shown in Fig. Q3.2 on the following page. The program should enable the mbed to receive a string of data from the sensor, one byte in length. The data transmission via UART occurs every 10 ms for a period of 120 ms, beginning 2s after the execution of the program is initiated. If the data received only contains zeros, the mbed should immediately transmit a string of 8 ones.

i. Rewrite the code shown to fix errors in the existing code and so that the program executes as described above. [10]

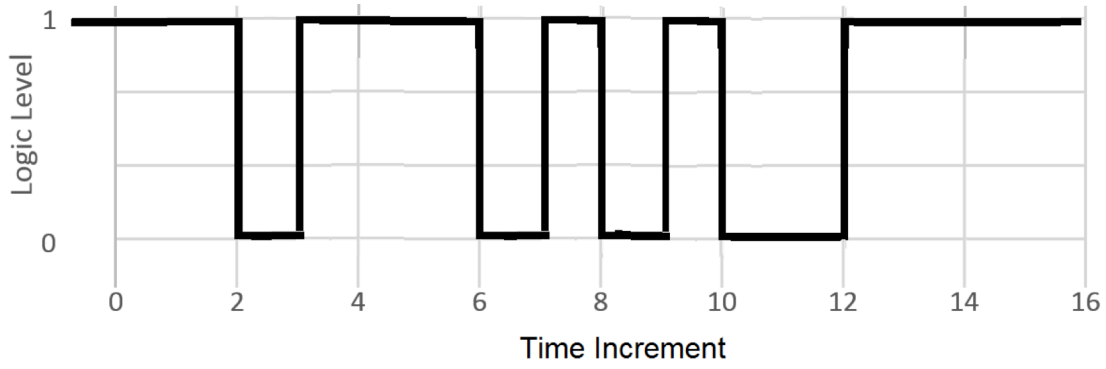

Figure Q3.1

Line Number	Code
1	**#include "LPC1768.h"**
2	**serial async_port(p9, p10);**
3	**char send_val;**
4	**char recd_val;**
5	**int i=0**
6	**int main() {**
7	**async_port.baud();**
8	**for(i = 0; i<120)**
9	**{**
10	**if (async_port.readable()==1);**
11	**recd_val=async_port.getc**
18	**async_port.putc();**
19	**wait_us();**
20	**}**
21	**}**

Figure Q3.2

Question 4

(a) Which of the following statements is true? [3]

i. An interrupt is a synchronous signal from a peripheral to indicate that the microprocessor should read data from or send data to the peripheral.
ii. An interrupt is a synchronous signal from the processor to indicate to the peripheral that data will be transmitted to or receive data from the peripheral.
iii. An interrupt is an asynchronous signal from peripheral to indicate that the microprocessor should read data from or send data to the peripheral.
iv. An interrupt is an asynchronous signal from the processor to indicate to the peripheral that data will be transmitted to or receive data from the peripheral.

(b) Which of the following statements are correct? [3]

i. An interrupt service routine (ISR) is supposed to disable the non-maskable interrupt.
ii. An interrupt service routine (ISR) is supposed to restore the context and return.
iii. An interrupt service routine (ISR) is supposed to restore the lowest-priority interrupt.
iv. An interrupt service routine (ISR) is supposed to increase the program counter.

(c) Which of the following statements is incorrect? [3]

i. Assembly language is a low-level programming language for a computer, microprocessor, or other programmable device.
ii. Assembly language does not need to be converted into machine language as assembly language is machine code.
iii. A program written in assembly language consist of a series of processor instructions, comments, data, and meta-statements.
iv. A practical application of assembly language is the optimization of execution run time.

(d) Which of the following statements is correct? [3]

i. A compile translates a program written in a high-level language to machine code.
ii. A compiled program is portable; any microprocessor will be able to run the same compiled program.
iii. The output generated from a program is compiled by the mbed online compiler and the output generated when the same program compiled by Keil uVision are identical.
iv. All mbed programs must be compiled as it is impossible to write a program that can be executed directly by the mbed.

(e) Explain the differences between a timer, timeout, and a ticker. [8]

Question 5

(a) Describe one advantage of serial communication as compared to parallel communication. [2]

(b) Describe a disadvantage of serial communication as compared to parallel communication. [2]

(c) Explain the difference between full duplex and half duplex communication. [2]

(d) Given the program in Figure Q5.1:

i. Which pin is used to transmit data from the microcontroller to the peripheral? [2]

ii. Explain line 11. [3]

iii. How many bits will be transmitted when line 18 is executed? [4]

iv. Assume that the time it takes to execute lines 1-18 can be neglected. Determine the number of milliseconds that it will take to transmit all of the bits that will be sent when this code is run. [8]

Line Number	Code
1	**#include "mbed.h"**
2	**SPI ser_port(p11, p12, p13);**
3	**char switch_word ;**
4	**int i=0**
5	**int main() {**
6	**ser_port.format(8,0);**
7	**ser_port.frequency(1000000);**
8	**for(i = 0; i<100; i++)**
9	**{**
10	**switch_word=0xa0;**
11	**if(i%2 == 0)**
12	**{**
13	**switch_word=switch_word|0x01;**
14	**}**
15	**else {**
16	**switch_word=switch_word|0x02;**
17	**}**
18	**ser_port.write(switch_word);**
19	**wait_us(50);**
20	**}**
21	**}**

Figure Q5