GLASGOW COLLEGE UESTC

Exam paper

Embedded Processors (UESTC2004)

Date: 24th August 2020
Time: 16:30-18:30pm

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.

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Q1 (a) Briefly analyze the main differences between a floating-point number representation and a fixed-point number representation in order to explain the benefit of using a floating-point number representation. [5]

(b) Convert the decimal number -18 into the equivalent binary representation and hexadecimal representation. Use the two's complement number system and assume that the value has 8 bits. [5]

(c) Von Neumann Architecture is used in most general-purpose computers and Harvard Architecture is used in most microcontrollers. Evaluate these architectures to explain this difference. [5]

(d) The value 'y' (i.e., 0x51) is now transmitted from the mbed board through a SPI port. What are the transmitted bits and their sequence at the data output pin of the board? If the clock rate is 10MHz, how long will it take to transmit the character? [5]

(e) Figure Q1.e shows part of the address space for one kind of microcontroller. Analyze which kind of Input/Output is used and the size of the bus width. [5]

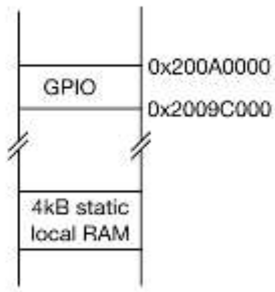

Figure Q1.e.

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Q2 (a) One mbed board transmits data to another mbed board via UART. The baud rate of the transmitting UART is 96k. An incorrect program is shown in Fig. Q2.a. The program should enable the receiver to receive a stream of data from the transmitter, one byte in length. The data transmission via UART occurs every 5ms, beginning 1s after the execution of the program is initiated. If bit 3 and bit 0 of the data received are ones, the receiving mbed should immediately transmit a stream of 8 zero bits. Default transmission settings (i.e., 8 bits data, no parity bit, one stop bit) are used.

(i) Rewrite the code shown to fix errors in the existing code and so that the program executes as described above. [12]

Line Number **Code**

```
#include "LPC1768.h"
serial async_port(p9, p10);
char recd_val;
int main(){
async_port.baud();
recd_val = async_port.getc
async_port.putc();
wait_us();
}
```

Figure Q2.a.

(ii) In order to correctly transmit data, what is the range of the baud rate for the receiving UART, and explain how to increase this range. [7]

(b) Evaluate the main challenges that arise when data are transferred in serial instead of parallel, and briefly explain how UART and SPI address these challenges. [6]

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Q3 (a) Design a 4-bit DAC using the binary-weighted configuration, which means each digital level is converted into an equivalent analog voltage. The DAC is controlled by four outputs port pins, PIN0-3.

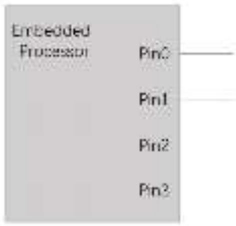

Figure Q3. a

(i) Choose four correct resistors for the DAC output and justify your choice. (correct resistors [3], justification [2]) [5]

(ii) Draw a schematic to generate a DAC output. [2]

(iii) For this 4-bit DAC, assume V_{OH} is 5V, and its V_{OL} is 0. N is the number of cases; Q1-Q4 is for digital inputs.

Fill the rest of rows in the table below. [3]

.	N	Q4	Q3	Q2	Q1	Theory output	V_{out}(v)
1st row	0	0	0	0	0	5*0/16	0.00
2nd row							
3rd row							
4th row							
5th row	15	5	5	5	5	5*15/16	4.69

(b) 8-bit ADC module has precision 8-bit and input voltage range 0 to +5V. what are the analog input voltage when the digital input is 0, 1, 512, 768, 1023 ? (correct value [3], workingout[2]). [5]

(c) In the design of position meter, a linear slide potentiometers converts position into resistance (0 < R <20K). An electrical circuit to convert resistance into voltage (Vin). The ADC module convert voltage into a 12-bit number. This ADC is a successive approximation device with a conversion time on the order of several micro seconds. The position measurement will be displayed on the LCD screen.

(i)What are main hardware modules used in this design and what are their functions? (description of modules [2], function explanation [3]) [5]

(ii) Draw a data flow chart for the position meter. (correct diagram [2], correct direction [3]) [5]

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Q4 (a) Please refer to UM10360LPC176X manual to complete this question. Consider a robot powered by two DC motors on the rear wheels, but the wheels are not perfectly matched. One wheel has more friction than the other. Experimental analysis shows the left wheel is slower than the right. The goal of this design is to go as fast as possible in a straight line. There are optical sensors on both wheels. There are an equal number of stripes on each wheel. Let NumLeft be the number of stripes counted on the left wheel. Let NumRight be the number of stripes counted on the right wheel. The approach will be to operate the left wheel at full speed and adjust the power to the right wheel so that the difference (error = NumRight – NumLeft) is driven to zero. If error is positive (right wheel is ahead of left wheel) then reduce power to the right wheel. If error is negative (right is behind of left) then increase power to the right wheel.

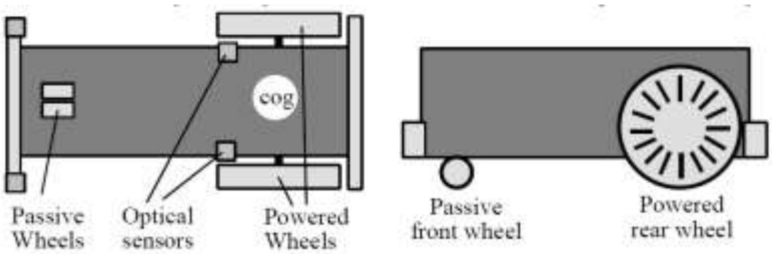

Figure Q4.a

(i) List five stages of interrupt routine in embedded systems and explain the purpose of this five stages. [5]

(ii) Assume the left wheel optical sensor is connected to GPIO0 and the right wheel optical sensor is connected to GPIO1. The hardware is LPC176X serial board. Write an initialization routine and two input capture ISRs that measure NumRight and NumLeft in the background? Note: you can used description /flow chart/source code or combination to provide solutions. [10]

(correct initialization steps [5], correct variable definition [3], comment [2])

(iii) Assume the left wheel motor is interfaced to PWM1[1] and the right wheel motor is interfaced to PWM1[2]. You will set PT2 high and use 8-bit PWM1 to adjust power to the right motor. Write an initialization routine that sets PWM1[1] and initializes a 100 Hz 8-bit PWM1[2]. Write a separate function that can be called to set the duty cycle of PT3 (0 to

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255). Assume a 4 MHz clock. PWM1[2] does not have to be exactly 100 Hz, Just approximately 100 Hz. Note: you can used description /flow chart/source code or combination to provide solutions. [10]

(Correct data flow [5], correct control flow [3], comments [2])

End of question paper