GLASGOW COLLEGE UESTC

Exam paper

Microelectronic Systems (UESTC1008)

Date: 25th August 2020
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) You are given an mbed microcontroller board and 2 LEDs, one red and one yellow.

i) Write a block of C++ code to control the LEDs where the following cycle is repeated for 10 seconds. First the yellow LED is illuminated for 0.5 seconds with the red LED off, then the red LED is illuminated for 0.5 seconds with the yellow LED off [10 marks]

ii) Explain the purpose of each line in the code. [3 marks]

(b) Using 4 digital outputs led1 to led4 in mbed and create a program to produce following sequence by turning leds on and off : 1000, 0100, 0010, 0001, 0010, 0100 (where 0 if off and 1 in on). Each sequence will remain turn on for 0.25 seconds. The above leds switching sequence is called "Knightrider" sweep effect, where leds turn on and off in forward and backward direction.

[7 marks]

(c) Explain the difference between volatile and non-volatile memory and give one example of each.

[5 marks]

Q2 (a) In the context of microcontrollers, what is meant by an '**active low**' configuration? Draw and explain the block diagram representing a microcontroller whose DigitalOut pin is operating an LED in the active low mode. [5 marks]

(b) Determine the truth table for the circuit of Figure Q2b in which MA and MB are NMOS switches connected to inputs A and B respectively while ML is a load transistor. The truth table should have inputs A & B and output V_o. [10 marks]

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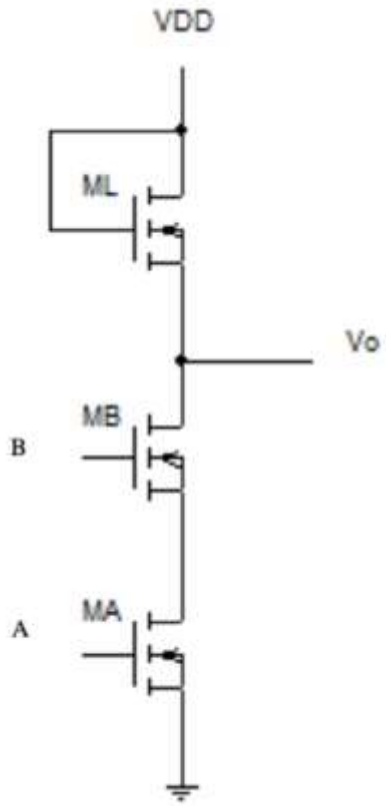

Figure Q2b.

(c) The code of Figure Q2c is run on an LPC1768 microcontroller board whose reference voltage is 3.3 V. The microcontroller has a 10 bit Digital to Analog Converter (DAC).

```
/* Program to check DAC resolution of mbed*/
#include “mbed.h”
AnalogOut Aout(p18);
DigitalOut led1(LED1);
float i;
int main(){
  while(1){
    for (i=0;i<1;i=i+0.0001){
      Aout=i;
      wait(1);
```

Continued overleaf

```
        led1=!led1;
      }
    }
  }
```

Figure Q2c

On connecting the AnalogOut pin to a voltmeter or an oscilloscope, the output voltage can be measured or observed.

Assume that the circuit is connected at time at t = 0 when LED1 is in the OFF state.

i) At what time will LED1 turn ON for the first time? [2 marks]
ii) What is the minimum value of voltage by which the output changes? [2 marks]
iii) After how many iterations of the *for* loop, will the output change value? [3 marks]
iv) After how many seconds will the output reach its maximum value of voltage? What would be the maximum value of voltage? [3 marks]

Q3(a)

i) Simply the below Boolean expression [5 marks]

$(x + y)(x + y')$

Note: y' is the invert of y

ii) Draw a logic diagram of the circuits that implement the original and simplified expressions

[5 marks]

(b) Implement the following Boolean function with NAND and inverter gates

$F = xy + x'y' + y'z$

[5 marks]

(c) Use four half-adders to build a four-bit combination circuit incrementor (a circuit that adds 1 to a four-bit binary number)

Continued overleaf

[10 marks]

Q4 (a) Define the terminology computer register and give two applications. [5 marks]

(b) Sketch the circuit diagram of a basic Set-Reset (SR) latch and write down truth table.

[8 marks]

c) Use Fig. Q4c2 to graph the outputs Q0, Q1, Q2 and Q3 of the circuit of Fig. Q4c1. Assume that the circuit clock operates at the rising edge and that all Q outputs are initialized as 0 (meaning that $\overline{Q}$ is initialized as 1).

[12 marks]

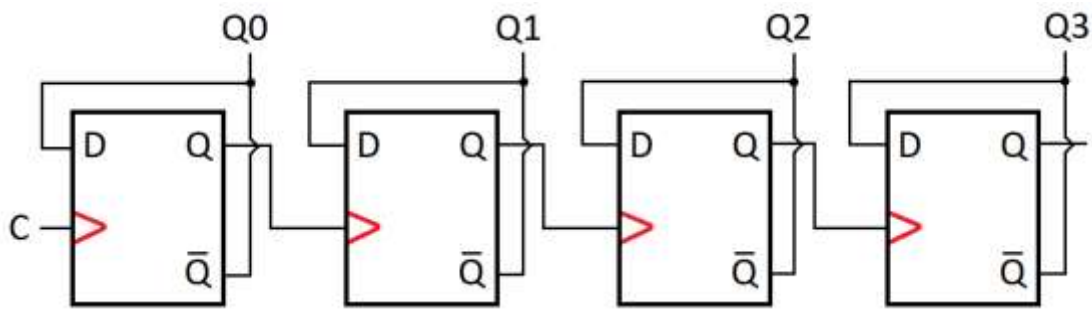

Fig. Q4c1

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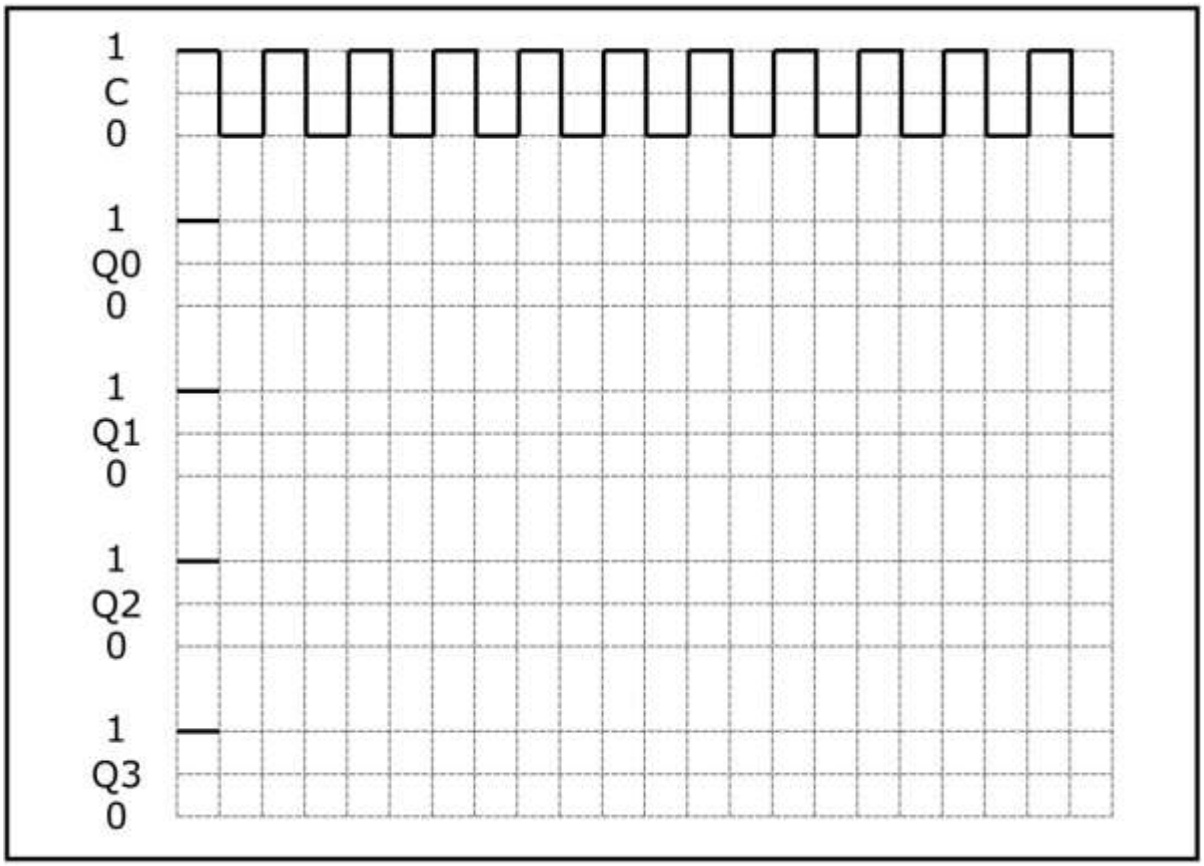

Fig. Q4c2

End of question paper