GLASGOW COLLEGE UESTC

Exam paper

Mircroelectronics Systems (UESTC1008)

Date: 28 June, 2021
Time: 09:30-11:30

Attempt all PARTS. Total 100 marks

Start each answer on a new 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.

Q1   (a)   Draw a block diagram to represent a typical microcontroller architecture. Please label all the parts of the diagram and interconnect them appropriately.   [5]

(b)   Please read the program segment below and answer the following questions:

```
#include "mbed.h"
DigitalOut myled (D5);
DigitalOut yourled (D6);
int main {
    while (1) {
        myled=1;
        yourled=0;
        wait(0.2);
        myled=0;
        yourled=1;
        wait(0.2);
    }
}
```

(i)   Plot the waveform that will be observed if **pin D5** is connected to an oscilloscope. Do not forget to mention the proper voltage levels on y-axis and time instants on x-axis. Plot for t=0 to t=1sec.   [5]

(ii)   Rewrite this program to do as follows: [5]
   ▪ The program output depends upon a digital input. When the digital input is 0, myled is ON while yourled is OFF. When the digital input is 1, myled is OFF and yourlead is ON.

(c)   The circuit of **Fig. Q1c** is used to connect a single pole, single throw (SPST) switch to mbed digital input. The pull-up resistor has a value of 10 kΩ, and is connected to the mbed supply V_s of 3.0 V. What current is consumed due to this circuit configuration when the switch is closed? If this current drain must be limited to 0.1 mA, to what value must the pull-up resistor be increased? [10]
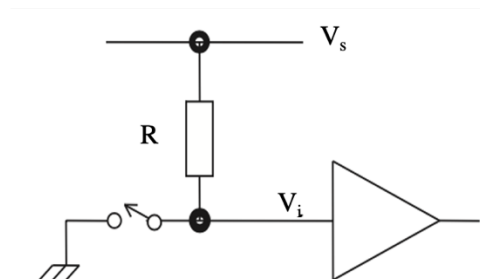

Fig. Q1c: Single-pole, single-throw (SPST) with pull-up resistor

Q2   (a) Describe four applications that need Analog to Digital Conversion.   [10]

(b) How does Sigma-Delta architecture function and what are its advantages?   [8]

(c) What are the main differences between a BJT and a MOSFET?   [7]

Q3   (a)   A microcontroller with a 5V supply is programmed to generate a pulse width modulated (PWM) output with a frequency of 100Hz and a duty cycle of 20%.

(i)   What is the period of the PWM output?   [3]

(ii)   What is the pulse width of the PWM output?   [3]

(iii) What is the average value of the PWM output?   [3]

(iv)   Sketch the waveform of the PWM output. Label the values with units.   [7]

(b)   Draw a circuit diagram to show how a PWM signal is converted back into an analogue signal using a low pass resistor-capacitor (RC) filter.   [5]

(c)   A PWM signal has two important parameters: period and duty cycle. For the following two applications, state whether each parameter is fixed or variable.

(i)   Control the brightness of an LED.   [2]

(ii)   Drive a speaker from a PWM signal to play a tune.   [2]

Q4   (a)   The following code is used by the serial peripheral interface (SPI) master to send its own switch position to the slave, and to display the position of the slave's switch on its own LED.

```
#include "mbed.h"
SPI ser_port(A6, A5, A4);
DigitalOut  red_led(D11);
DigitalOut cs(D3);
DigitalIn switch_ip1(D9);
char switch_word;
char recd_val;

int main() {
    while(1){
      switch_word=0xA0;
```

```
            if(switch_ip1==1)
               switch_word=switch_word|0x01;
            cs = 0;
            recd_val=ser_port.write(switch_word);
            cs = 1;
            wait(0.01);
            red_led=0;
            recd_val=recd_val&0x01;
            if(recd_val==1)
               red_led=1;
         }
      }
```

    (i)   Explain the purpose of this line: `SPI ser_port(A6, A5, A4).`   [2]

    (ii)   Explain why `while(1)` is used.   [2]

    (iii)   The `|` operator is the logical OR operator. What is the value of `switch_word` after executing this line:
`switch_word=switch_word|0x01.`   [2]

    (iv)   `wait(0.01)` causes the program to wait for 0.01s. Change this line to make the program wait for 25ms.   [2]

    (v)   In these two lines of code: `if(recd_val==1) red_led=1,` what is the difference between `==` and `=`.   [2]

(b)   A microcontroller needs to connect 40 peripherals. What would be your design choice: serial peripheral interface (SPI) or inter-integrated circuit (I2C), and why?   [5]

(c)   A universal asynchronous receiver-transmitter (UART) is used to send the value 0x13. The clock frequency is 1kHz, the output voltage is 3.3V and the least significant bit is sent first. The start bit is low, the stop bit is high, and idle is high. Sketch the output of the UART waveform.   [10]