UNIVERSITY OF GLASGOW

Degree of BEng in Electronic and Electrical Engineering

Embedded Processors (UESTC)

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. These marks are for guidance only.

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:

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

First, there is some period of time when the output voltage Vi is not tied to either ground or to Vs. Secondly, the current that will flow through the circuit on the output is not limited by a pull-up or pull-down resistor. If the output circuit is primarily reactive rather than resistive, a large transient current will flow that may damage the circuitry.

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

A pull-up resistor.

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

A pull-down resistor.

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

The general purpose pins on the LPC1768 can have up to four different functions. Depending on the pins selected, the primary function may or may not be a digital or analogue I/O pin. Therefore, you should set the function of the pins that you will use in a program before you actually use them. In certain microprocessors, you may also need to turn on the power to the pins before they are used. However, the default on the mend is the power to pins is on when the microcontroller is first turned on.

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

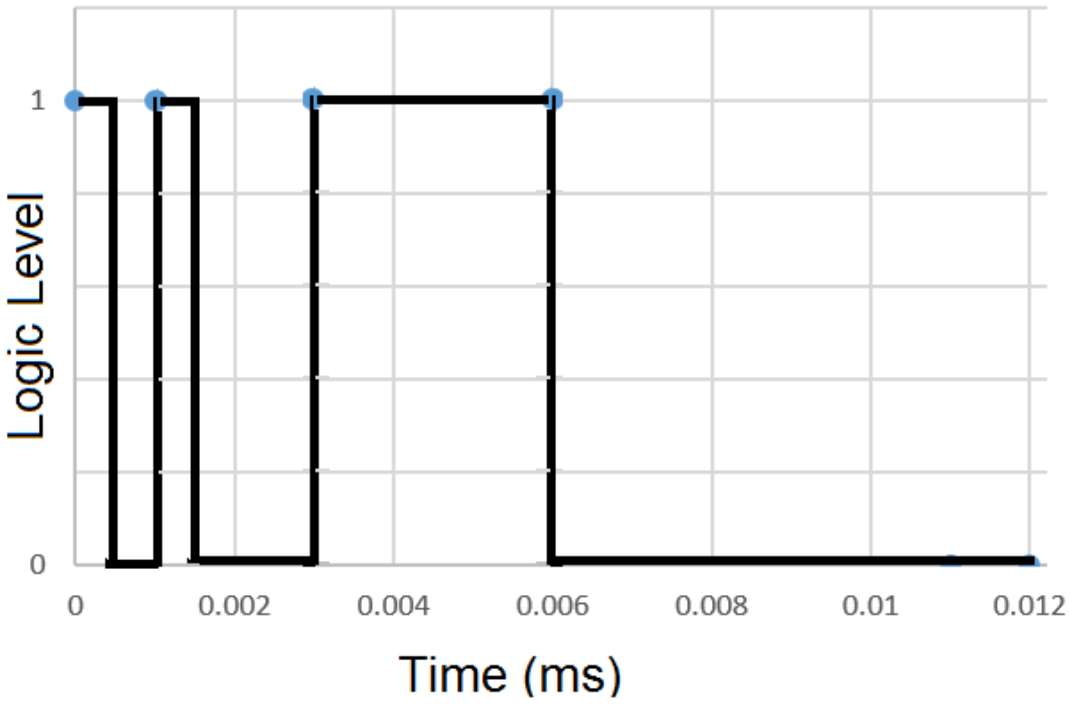
i. Using PWMOut as an example, explain the purpose of line. [4]

The embed header file defines a number of functions such as PWMOut. These functions are used to insure that power is turned on at the appropriate pin (although the default is for the power to be on for the embed), that the port associated with the function of the port and pinion the LPC1768 that corresponds to pin p26 is set to pulse width modulation, and the embed registers are identified properly.

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

It would change the value of yy during the execution as yy is not a constant. Thus, the output of the PWM would differ from the output obtained when floating point numbers are used. Neither xx or yy are easily divisible by powers of 2.

iii. Sketch the output voltage on pin 26 from 0 ms to 25 ms. [6]


Logic Level
1
0
0
0.002
0.004
0.006
0.008
0.01
0.012
Time (ms)

Question 2

Answer the following given the circuit in Fig. Q2.1.

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

500 μV = floor ($5V/2^n$)
n =14

(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 = 6 666. Write the solution using 5 significant figures. [4]

$A_{12} = [D_1//2^n]$ 5V = 2.0343 V

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

$(3.3\ V/2^{12}) = 0.806$ mV

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

$[A_{12}/3.3V](2^{12}) = 2525$

(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]

D_2 will be equal to 2525 until A_{12} = 2.0343 V + 0.806 mV

$D_1 = 2^{14}$ (2.0343 V + 0.806 mV)/5V = 6668.64

Thus, D_1 = 6666, 6667, and 6668 all produce the same output D_2 from the mbed ADC.

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

D_1 =ceiling $\{2^{14}[(3.3\ V - 0.806\ mV)/5V]\}$ = 10,811

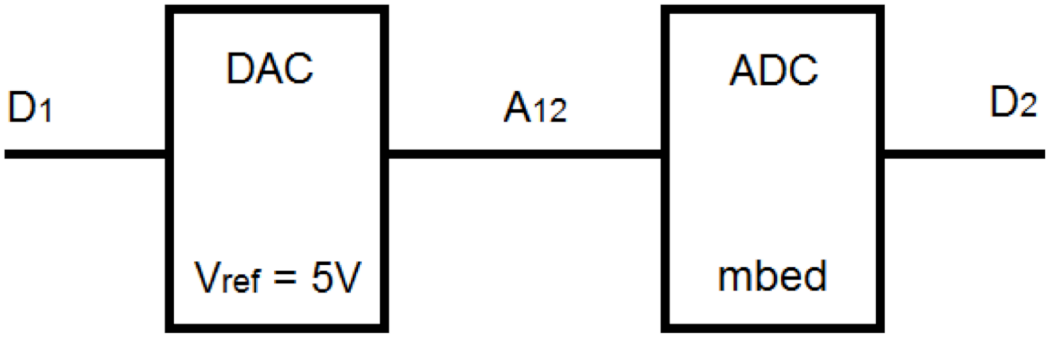
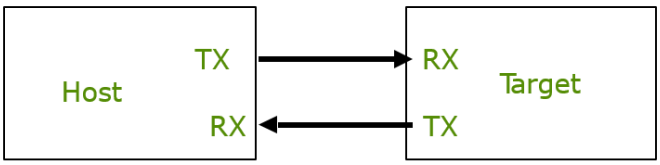


Figure Q2.1

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 data transmitted from the sensor is shown in Fig. Q3.1.

i. What is the 7-bit string of the data that were transmitted? [3]

1101010

ii. Assuming that the data transmission is correct, is the parity odd or even? [3]

As the sum of the 7 bits is even and the 8th bit was a 1, the parity is odd.

iii. An incorrect program is shown in Fig. Q3.2. 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]

Line Number	Code
1	**#include "mbed.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(56000);**
	wait(2)
8	**for(i = 0; i<12)**
9	**{**
10	**if (async_port.readable()==1);**
11	**recd_val=async_port.getc**
	if(recd_val ==0x000) {
18	**async_port.putc(0xFF)};**
19	**wait_us(10000);**
20	**}**

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]

Timer: Used for simple timing applications, execution is halted until timer has completed. Multiple timers can be employed in a program. The minimum time for a timer is a single clock pulse; the maximum is the full cycle of the 32 bit counter (the 32 bit architecture of an mbed where the full cycle is $2^{32-1} - 1$ clock pulses).

Timeout: Calls a function after a predetermined delay. Timeout sets up an interrupt to call a function after a specified delay. Any number of Timeout objects can be created

Ticker: Repeatedly calls a function at a predetermined rate, program can continue to execute while ticker is running. The Ticker interface is used to setup a recurring interrupt to repeatedly call a designated function at a specified rate. **An advantage of the ticker object** is that we do not need to read the time, so we can execute other code while the ticker is running in the background and calling the attached function as necessary. **There is no limited on the number of Tickers created**. The mbed ticker object can also be used for scheduled programming.

Question 5

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

Fewer wires to make connections between host and peripheral.

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

Slower as individual bits are transferred between host and peripheral one at a time.

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

Each allows the host and peripheral to transmit and receive. Full duplex can do this simultaneously while half duplex can only transmit or receive at any one instant in time.

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

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

Pin 11

ii. Explain line 11. [3]

& is a bitwise AND. If the second bit of i is a 1, then the if statement is executed.

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

8 bits

iv. Assume that the time it takes to execute lines 1-19 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. [5]

50(50 us) = 2.5 ms