Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	REAL-TIME EMBEDDED SYSTEM
COURSE CODE	:	BEH30802
PROGRAMME	:	BACHELOR OF ELECTRONIC ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015 / JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Provide a reason for implementing real-time system concepts in an embedded system.

(2 marks)

(b) List **FOUR (4)** typical characteristics of real-time system.

(4 marks)

(c) Recommend suitable of real-time system types for the following systems with a short justification for each of them.

(i) Automatic washing machine.

(2 marks)

(ii) Pacemaker.

(2 marks)

Q2 (a) Explain **TWO (2)** important functions or subroutines that are normally used in Arduino software sketch.

(2 marks)

(b) An Arduino-based mobile robot is designed to move forward by following a black line on white background. It has two motors, an LED, a user button, and three line sensors. Its system architecture and complete schematic are given in **Figure Q2**.

(i) Identify the LED connection mode and examine a logic state needed at pin D9 for turning on LED.

(2 marks)

(ii) The user button is connected to pin D8 and has a problem of floating state during inactive (i.e. button not pressed). Find **TWO (2)** solutions to this problem.

(4 marks)

(iii) Data of line sensors need to be transferred to a computer for debugging purpose through a serial UART-Bluetooth module. Construct a schematic of basic connection between this module and Arduino. Please provide a short explanation on interface connection and baud rate principle.

(4 marks)

(iv) Assume that left motor (ML) and right motor (MR) have the same specification and performance. Rewrite the following subroutine for controlling speed and direction of both motors with correct syntax and code statement.

```
your_data_type robotForward( your_data_type ML, your_data_type MR)
{
        //your code
}
```

(4 marks)

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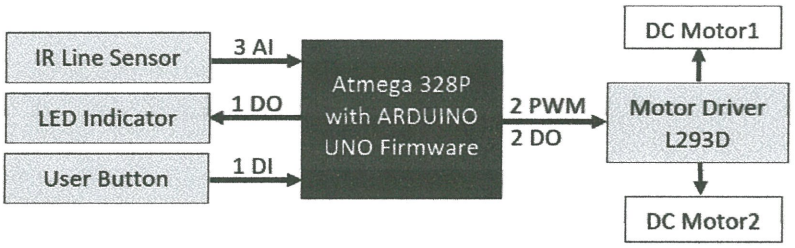

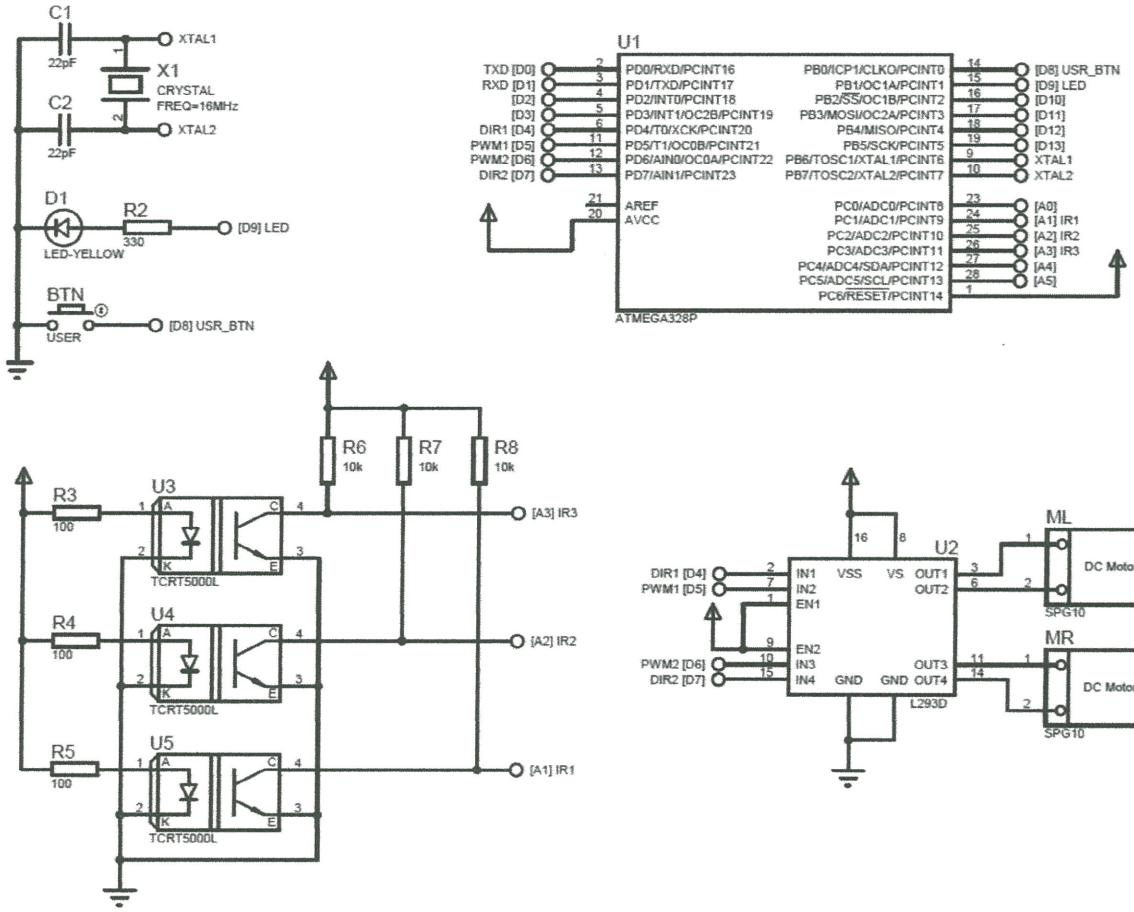

FIGURE Q2

Q3 (a) Explain the following terminologies in real time operating system.

(i) Deadline

(2 marks)

(ii) Priority

(2 marks)

(b) The ChibiOS is a real-time operating system that implements "fixed priority preemptive" scheduling algorithm. Draw and illustrate how the threads can change their state in ChibiOS scheduler.

(6 marks)

Q4 (a) Explain the following terminologies in temporal scope of a task with an illustration for each.

(i) Start delay

(2 marks)

(ii) Elapse time

(2 marks)

(b) Assume the Arduino-based mobile robot as in **Q2(b)** has a tick period of 20 ms to keep track of time and consists of three independent tasks, A, B and C. The task priorities, periods and CPU (execution) times for the three-task system are tabulated in **Table 1**.

TABLE 1: Task Execution

Task	Priority No. (i)	Period (P_i)	CPU time (C_i)
A	1	20 ms	15 ms
B	2	60 ms	4 ms
C	3	40 ms	2 ms

(i) Plot a task activition diagram for time, t = 0 ms to t = 80 ms for all tasks.

(6 marks)

(ii) Analyse the start delay, elapse time, deadline and completion time by showing the result in a table for the three-task system.

(6 marks)

(iii) Reconstruct an appropriate priority assignment for each of the three tasks according to the rate monotonic scheduling (RMS) algorithm.

(3 marks)

(iv) Analyse the ability of each task to meet its deadline based on RMS calculation.

(8 marks)

(v) Give an opinion on the result of **Q4(i)** and **Q4(iv)**, which priority assignment is suitable for implementing in the system.

(2 marks)

Q5 The Arduino-based mobile robot as in **Q2** and **Q3** has three-task system as described in **Table 2.**

TABLE 2: Task Description

<table>
<tr><th>Task</th><th>Description</th><th>Period</th></tr>
<tr><td>A</td><td>Read line sensors and save ADC result data into 'data1', 'data2' and 'data3' global variables.</td><td>20 ms</td></tr>
<tr><td>B</td><td>Control robot movement based on ADC result data of task A as given below.
<table>
<tr><th>data1</th><th>data2</th><th>data3</th><th colspan="2">Robot Movement Control</th></tr>
<tr><td>Pin A1</td><td>Pin A2</td><td>Pin A3</td><td>ML</td><td>MR</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>100% DC</td><td>100% DC</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>20% DC</td><td>100% DC</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>100% DC</td><td>20% DC</td></tr>
</table>
Note:
1. '1' means black line detected (ADC data ≥1000).
2. '0' means white background detected (ADC data ≤20).
3. 'DC' means duty cycle</td><td>40 ms</td></tr>
<tr><td>C</td><td>Send ADC result data of task A through the Bluetooth module (UART protocol) with 115200 bps.</td><td>60 ms</td></tr>
</table>

(a) Write your code of C-statement for the following comments.

```
#include <ChibiOS_AVR.h>
int data1, data2, data3; //Global variables for holding ADC result of line sensors data.

void setup( )
{
        your code
}
```

//Configure output pins
//Configure input pin
//Configure serial baud rate
//LED is turned OFF
//wait here until button is pressed
//LED is turned ON
//start ChibiOS using chBegin function
//loop here forever

```
void chSetup( )
{
        your code        //Create Task A
                         //Create Task B
                         //Create Task C
}
```

(10 marks)

(b) Write your C-statement code for a subroutine of task B based on the following comments. You can use the subroutine as in **Q2(iv)** for controlling the robot. Assume the working area size is 128 bytes.

```
your code
```

```
//Working area specification
//Subroutine name
//loop forever
//{ check variable data1, data2 and data3 then call
//  robotForward(?,?) subroutine to control the robot.
//}
//call ChibiOS sleep function
//return from subroutine.
```

(7 marks)

(c) Construct a flow-chart for task A and C.

(6 marks)

(d) Write a complete programming code for a subroutine of task A and C by referring to the flow-chart in **Q5(c)**. Assume the working area size for both tasks is 64 bytes.

(12 marks)

- END OF QUESTION –