UNIVERSITY EXAMINATIONS: 2022/2023

EXAMINATION FOR BACHELORS DEGREE IN APPLIED COMPUTING/SOFTWARE DEVELOPMENT

BAC 3203/ BSD 3205: EMBEDDED SYSTEMS

FULL TIME/ PART TIME

ORDINARY EXAMINATION

DATE: DECEMBER, 2022 **TIME: 2 HOURS**

INSTRUCTIONS: Question One Is Compulsory, Choose Two Other Questions

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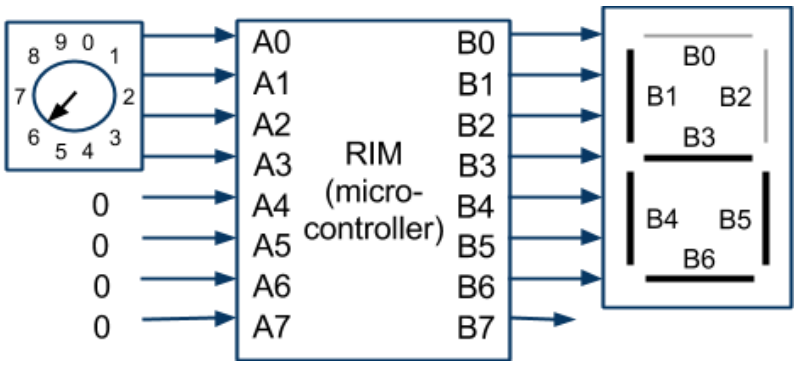
QUESTION ONE (20 marks) Compulsory

a) Consider the following embedded system with a dial that can set A3..A0 to binary 0 to 9, and a 7-segment display (Wikipedia: 7-Segment Display) connected to B6..B0 as shown:



Below is a (partial) RIM C program that appropriately sets the display for the given dial position:

```
#include "RIMS.h"


void main()
{
 while (1) {
```

```
switch( A )
{
  case 0 : B = 0x77; break; // 0111 0111 (0)
  case 1 : B = 0x24; break; // 0010 0100 (1)
  case 2 : B = 0x5D; break; // 0101 1101 (2)
  //...
  case 9 : B = 0x6F; break; // 0110 1111 (9)
  default: B = 0x5B; break; // 0101 1011 (E for Error)
 }
}
}
```

i) What B_ outputs should be set to 1 for case 3? List in ascending order separated by spaces, e.g., B0 B2 ... [5 marks]

ii) To what should B be set for case 3? B = ____; Use uppercase letters for the hex literal. [5 marks]

b) State and explain the results of the following bitwise operation. [10 marks]

i) 00001111 & 10101010

ii) 00001111 | 10101010

iii) 00001111 ^ 10101010

iv) ~00001111

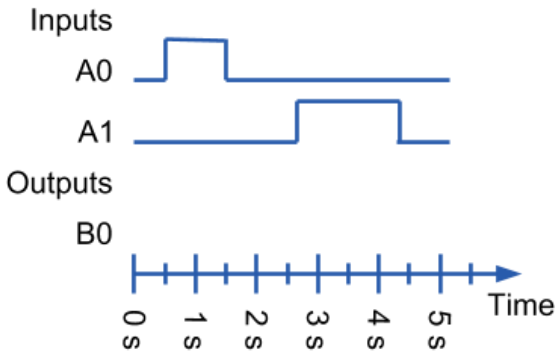
v) Give a statement that sets B's bits to the opposite of A's bits, so if A is 11110000, B will be 00001111. End with ;

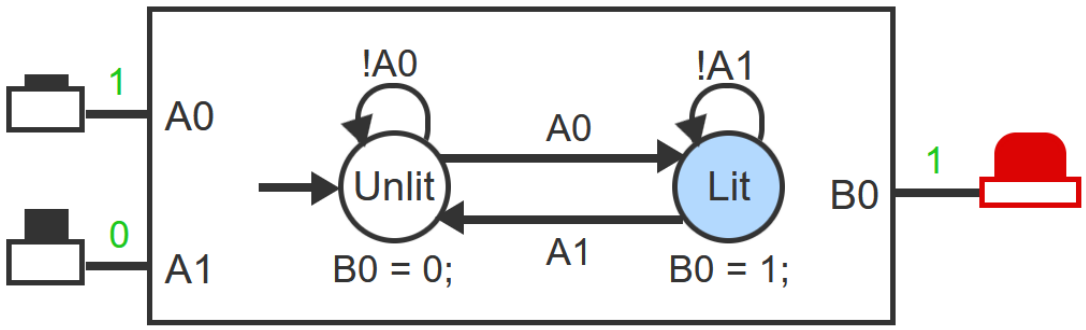
QUESTION TW0 (15 marks)

A parking lot has eight parking spaces, each with a sensor connected to input A. Write a program that sets B to the number of occupied spaces, by counting the number of 1s using the GetBit() function. [15 marks]

QESTION THREE (15 marks)

Given the following timing diagram and the light on/off SM, determine the value of B0 at the specified times. [15 marks]





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i) 0 s [3 marks]

ii) 1 s [3 marks]

iii) 2 s [3 marks]

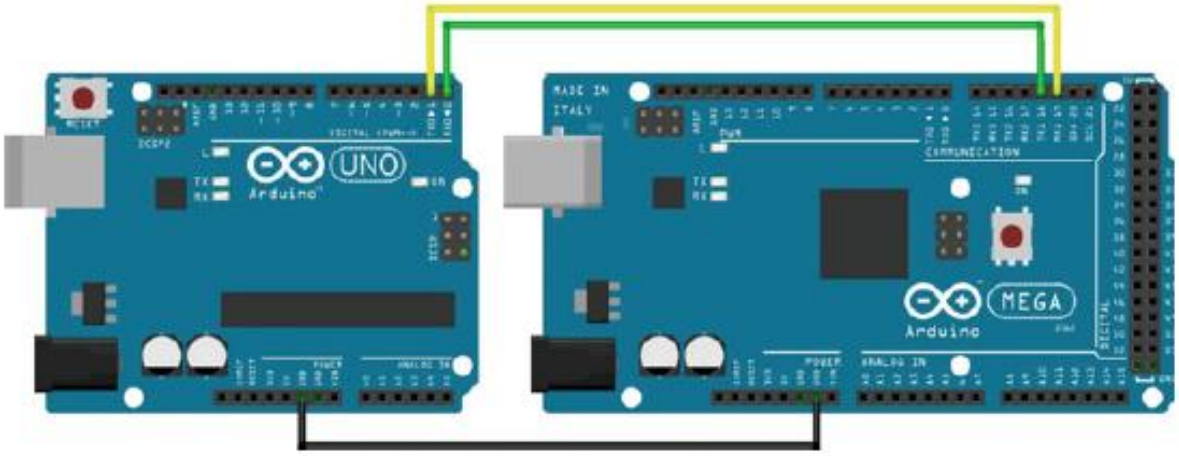
iv) 3 s [3 marks]

v) 4 s [3 marks]

QUESTION FOUR (15 marks)

a) Explain and give an example of an embedded system [5 marks]

b) Consider the following schematic diagram for a serial communication



Two Arduino boards are used. The Arduino Uno on the left is the sender and the Arduino Mega on the right is the receiver. We use the Mega to make it easier to display debugging information on the computer. The Arduinos are connected together using digitals 0 and 1 (RX and TX) on the Uno and digitals 16 and 17 (RX2 and TX2) on Mega. The receiver on one needs to be connected to the transmit on the other and vice versa. The Arduinos also need to have a common reference between the two, this is done by running a ground wire. The first step in creating a serial communication system is to package the string to be communicated. In general a packet is comprised of some start byte, a payload (the data you wish to send), and a checksum to validate your data. Here, the packet is: [0x53] +[counter value]+[static value]+ [checksum]. The sender code is shown below that increments our counter and send our packet.

```
1   // Sender Information
2   unsigned char START_BYTE = 0x53; // ASCII "S"
3   unsigned char counterValue = 0;
4   unsigned char staticValue = 5;
5   unsigned char checksum = 0;
6
7   void setup() {
8     Serial.begin(9600);
9   }
10  void loop() {
11    // Increment our counter
12    counterValue = counterValue + 1;
13    // Check for overflow, and loop
14    if (counterValue > 250)
15      counterValue = 0;
16    // Calculate our checksum
17    checksum = counterValue + staticValue;
18    // Important: Serial.write must be used, not print
19    Serial.write(START_BYTE);
20    Serial.write(counterValue);
21    Serial.write(staticValue);
22    Serial.write(checksum);
23    // We only need to send a packet every 250ms.
24    // If your code starts to get complicated,
25    // consider using a timer instead of a delay
26    delay(250);
27  }
```

Write the Receiver code for the above send information. [10 marks]