

National Exams May 2014

**07-Elec-A4, Digital Systems & Computers**

3 hours duration

**NOTES:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a Closed Book exam.  
Candidates may use one of two calculators, the Casio or Sharp approved models.
3. FIVE (5) questions constitute a complete exam.  
Clearly indicate your choice of any five of the six questions given otherwise the first five answers found will be considered your pick.
4. All questions are worth 12 points.  
See below for a detailed breakdown of the marking.

**Marking Scheme**

1. (a) 3, (b) 3, (c) 3, (d) 3, total = 12
2. (a) 6, (b) 3, (c) 3, total = 12
3. (a) 6, (b) 6, total = 12
4. (a) 3, (b) 3, (c) 6, total = 12
5. (a) 4, (b) 4, (c) 4, total = 12
6. (a) 4, (b) 4, (c) 4, total = 12

The number beside each part above indicates the points that part is worth

1.- Given the following function:

$$f = \bar{A} \cdot C \cdot D + A \cdot \bar{B} \cdot C + A \cdot B \cdot D + \bar{A} \cdot \bar{C} \cdot D + \bar{A} \cdot \bar{B} \cdot C \cdot \bar{D}$$

- (a) Prepare its truth table.
- (b) Express  $f$  in canonical sum-of-products (SoP) form using the shorthand  $\sum m_i$  notation, where  $m_i$  are the function minterms.
- (c) Express  $f$  in minimized SoP form.
- (d) Check if the minimized expression found in (c) is hazard-free. Justify.  
If it is not hazard-free provide the smallest SoP hazard-free expression for  $f$ .

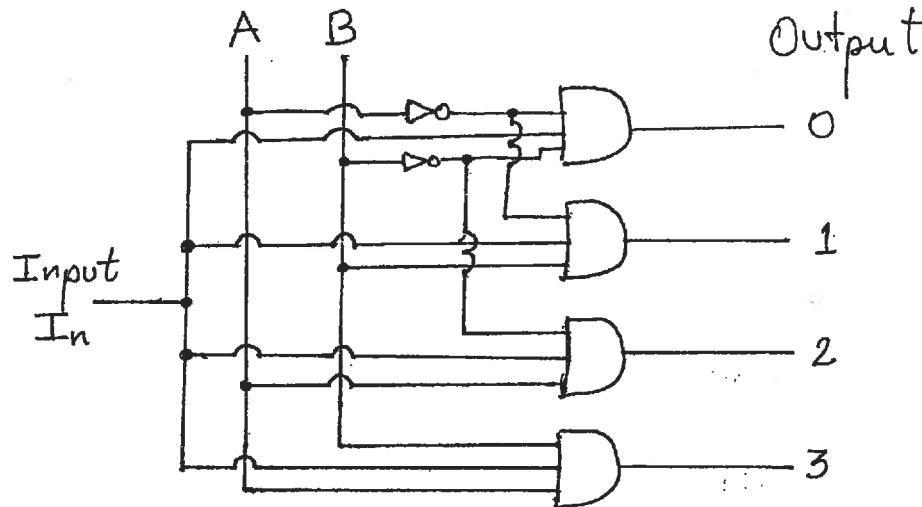
2.- A 3-bit counter advances through the sequence 000, 010, 100, 101, 011, 001 back to 000 and repeats.

- (a) Using the standard design process for synchronous counters, show how to implement this counter using JK flip-flops. Include:
  - state transition diagram,
  - state transition table including flip-flop inputs, and
  - a drawing of the final circuit implementing the counter.
- (b) Check whether the counter is self-starting or not.
- (c) Sketch the timing diagram for the counter showing its dynamic behavior for 8 clock pulses, include:
  - The clock waveform CLK, containing at least six clock pulses after  $t = 0$ , and
  - The output waveforms  $Q_A$ ,  $Q_B$  &  $Q_C$ , where  $Q_A$  is the output of flip-flop A (MSB<sup>1</sup>),  $Q_B$  is the output of flip-flop B and  $Q_C$  is the output of flip-flop C (LSB<sup>1</sup>).

Assume the  $\overline{CLR}$  input of all flip-flops is temporarily held LOW during the clock cycles preceding time  $t = 0$ , then it goes HIGH.

<sup>1</sup> MSB: most significant bit, LSB: least significant bit

- 3.- (a) Analyze the behavior of the circuit below and make a truth table showing the output for values of the control lines A & B.



- (b) Describe in a few words the function performed by this circuit.

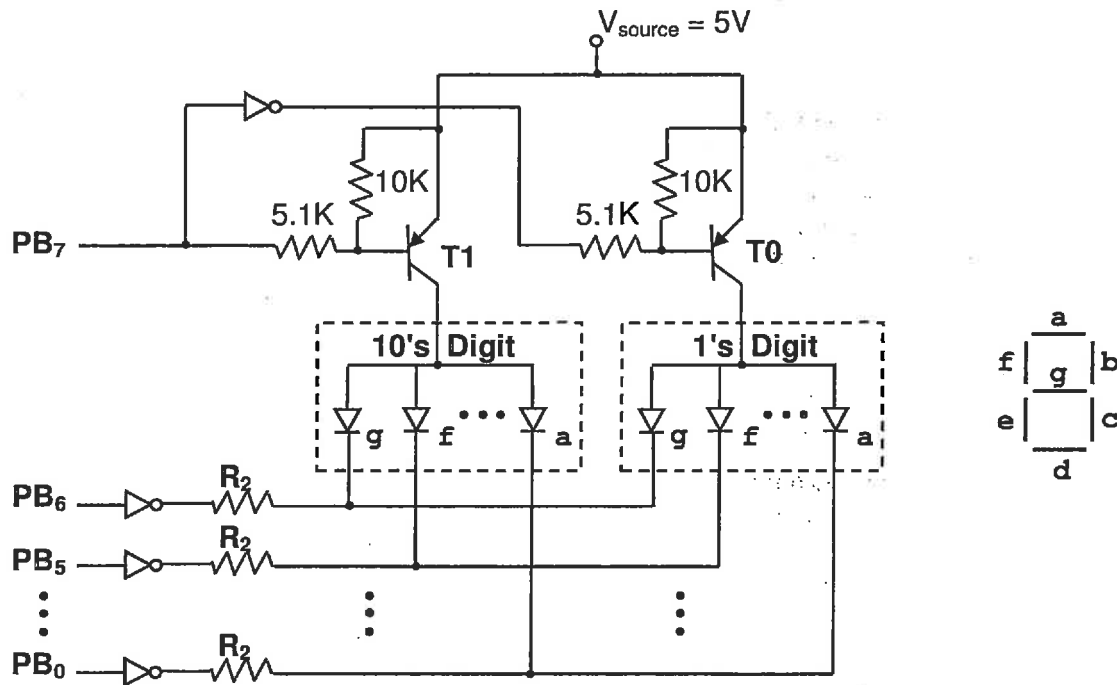
- 4.- (a) Where is the use of a parallel-to-serial shift register needed, in the receiving unit of a serial communication port or in its transmitting unit? Explain.
- (b) Where is the use of a serial-to-parallel shift register needed, in the receiving unit of a serial communication port or in its transmitting unit? Explain.
- (c) Draw the circuit for a 4-bit shift register using D flip-flops that can perform parallel-to-serial conversion as well as serial-to-parallel conversion.

In your diagram, identify:

- i) The serial input terminal,
- ii) The serial output terminal,
- iii) The parallel input terminals, and
- iv) The parallel output terminals.

5.- The figure below shows a circuit used to display two digits in two common-anode seven-segment LED displays. The LED arrangement for each seven-segment display is shown on the right side. Parallel Port B lines PB<sub>7</sub>-PB<sub>0</sub> of a microcontroller are used to control the two-digit display. PB<sub>7</sub> is used for digit selection, while PB<sub>6</sub>-PB<sub>0</sub> are used to determine which segments are lit. Consider that inverters are open-collector TTL inverters and transistor saturation V<sub>CE</sub> value is approximately 0.3V.

- (a) Provide the binary values needed in Port B lines to display the decimal number 40.
- (b) From the programming point-of-view suggest the sequence of steps that will allow observing the number 40 lit on the display. Explain.
- (c) Find the value for the resistors R<sub>2</sub> that will allow limiting the current through each LED to 10mA. When turned on, consider the nominal voltage across a LED is 2V.



6.- (a) Identify by marking with a X which of the following are the 4 essential components of a computer system.

- |  |  |
|--|--|
| <input type="checkbox"/> Mouse           | <input type="checkbox"/> Busses (address, data, control) |
| <input type="checkbox"/> Processor (CPU) | <input type="checkbox"/> Keyboard                        |
| <input type="checkbox"/> Printer         | <input type="checkbox"/> I/O ports                       |
| <input type="checkbox"/> Memory          | <input type="checkbox"/> Display monitor                 |
| <input type="checkbox"/> USB drive       | <input type="checkbox"/> Hard drive                      |

(b) Mention the main differences between a general purpose microprocessor and a microcontroller.

(c) Mention which CPU register(s) is(are) typically associated with each of the following

- the address of the next instruction to be executed : \_\_\_\_\_
- the next available location at the top of the stack : \_\_\_\_\_
- pointing to an array or list of data values in memory : \_\_\_\_\_
- containing the information an assembly program uses at decision making points (conditional branch statements): \_\_\_\_\_

Excitation Table

Q	Q+	R	S	J	K	T	D
0	0	X	0	0	X	0	0
0	1	0	1	1	X	1	1
1	0	1	0	X	1	1	0
1	1	0	X	X	0	0	1

Basic Boolean Identities

	<u>Identity</u>	<u>Comments</u>
1.	$A + 0 = A$	Operations with 0 and 1
2.	$A + 1 = 1$	Operations with 0 and 1
3.	$A + A = A$	Idempotent
4.	$A + \bar{A} = 1$	Complementarity
5.	$A \cdot 0 = 0$	Operations with 0 and 1
6.	$A \cdot 1 = A$	Operations with 0 and 1
7.	$A \cdot A = A$	Idempotent
8.	$A \cdot \bar{A} = 0$	Complementarity
9.	$\bar{\bar{A}} = A$	Involution
10.	$A + B = B + A$	Commutative
11.	$A \cdot B = B \cdot A$	Commutative
12.	$A + (B + C) = (A + B) + C = A + B + C$	Associative
13.	$A \cdot (B \cdot C) = (A \cdot B) \cdot C = A \cdot B \cdot C$	Associative
14.	$A \cdot (B + C) = (A \cdot B) + (A \cdot C)$	Distributive
15.	$A + (B \cdot C) = (A + B) \cdot (A + C)$	Distributive
16.	$A + (A \cdot B) = A$	Absorption
17.	$A \cdot (A + B) = A$	Absorption
18.	$(A \cdot B) + (\bar{A} \cdot C) + (B \cdot C) = (A \cdot B) + (\bar{A} \cdot C)$	Consensus
19.	$\overline{A + B + C + \dots} = \bar{A} \cdot \bar{B} \cdot \bar{C} \cdot \dots$	De Morgan
20.	$\overline{\bar{A} \cdot \bar{B} \cdot \bar{C} \cdot \dots} = A + B + C + \dots$	De Morgan
21.	$(A + \bar{B}) \cdot B = A \cdot B$	Simplification
22.	$(A \cdot \bar{B}) + B = A + B$	Simplification