National Exams December 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) 2, (b) 4, (c) 3, (d) 3, total = 12
2. (a) 4, (b) 4, (c) 4, total = 12
3. (a) 6, (b) 6, total = 12
4. (a) 3, (b) 4, (c) 2, (d) 3, total = 12
5. (a) 3, (b) 3, (c) 3, (d) 3, total = 12
6. (a) 4, (b) 8, total = 12

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

1.- Consider the function

$$f = A \cdot \overline{C} + A \cdot \overline{B} + \overline{A} \cdot \overline{B} \cdot C$$

(a) Synthesize the function f as written above using AND, OR and NOT gates.

(b) Using Boolean algebra put the function f into:

i) Its minimized sum-of-products (SoP) form, and

ii) Its minimized product-of-sums (PoS) form.

(c) Check both results obtained in part (b) by using the K-map method.

(d) Determine if there is a hazard in the minimized functions found above. Justify your answer. If required modify your minimized SoP expression to produce the simplest hazard-free implementation in SoP form.

Note: A list of Boolean identities is attached at the end of exam.

2.- (a) Implement the following Boolean functions by using 8:1 multiplexers:

i) $f_1(A,B,C) = \sum m_i(1,4,6)$, We are also told that the input combinations ABC = 011 and ABC = 111 are not of concern for f_1.

ii) $f_2(A,B,C) = \prod M_i(0,1,2,5)$.

(b) Implement the same Boolean functions f_1 & f_2, given above in part (a), using one 4:1 multiplexer for each function.

(c) Implement all 3 Boolean functions below by using one 3:8 decoder and three OR gates. Specify all the decoder inputs.

i) $f_1(A,B,C) = A \cdot (\overline{B} + C)$

ii) $f_2(A,B,C) = \sum m_i(0,3,4)$

iii) $f_3(A,B,C) = A \cdot B \cdot C + B \cdot \overline{C}$

3.- The following is a truth table of a 3-input, 4-output combinational circuit.

(a) Use K-maps to obtain the simplified expressions for A, B, C and D.

(b) Implement them using a Programmable Logic Array (PLA) architecture.

Inputs			Outputs			
A	B	C	X	Y	Z	W
0	0	0	0	1	1	1
0	0	1	0	1	1	1
0	1	0	1	0	0	1
0	1	1	0	1	0	1
1	0	0	0	0	0	0
1	0	1	0	1	1	1
1	1	0	1	1	0	1
1	1	1	1	1	0	0

4.- The following circuit contains two RS flip-flops.

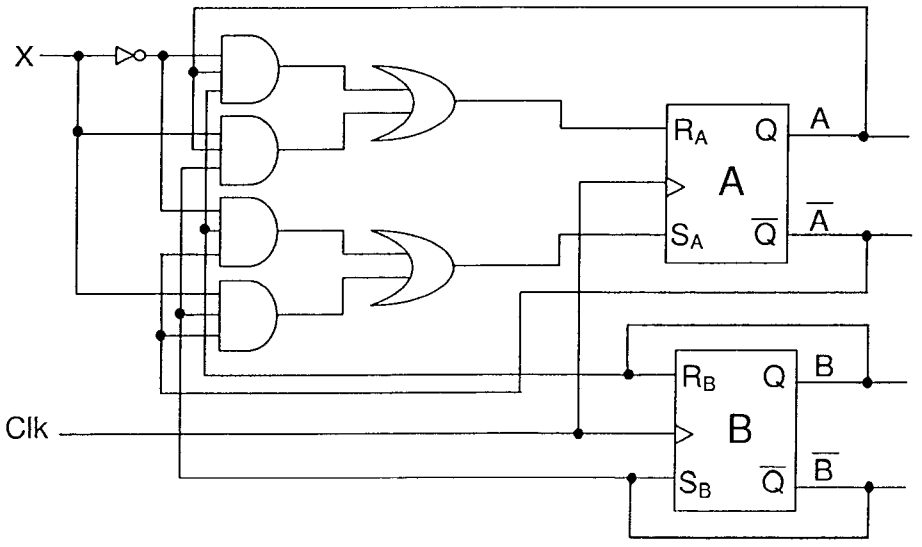
(a) Write the logic expressions for R_A, S_A, R_B and S_B.

(b) Obtain the state transition table for the circuit.

(c) Sketch the state transition diagram for the circuit.

(d) If you were asked to implement this finite state machine (FSM) using JK flip-flops instead of RS flip-flops, would there be any advantage?
Justify based on the relationship between these flip-flops.

Note: Flip-flop excitation tables are attached at the end of exam.



5.- The diagram below shows the use of a D flip-flop governing two digital switches in order to route line PD_0 of the HC11 microcontroller unit (MCU) to one of two connectors: the HOST computer I/O port or the MCU I/O port connector.

Digital switch *i* close when control input C_i is at a logic '1' and remain open when C_i is '0'.

HC11 address lines A_{15} - A_{13} are connected to the 3 address inputs of a 3:8 decoder as shown in the figure, the most significant address input of the decoder is A_2 and the least significant is A_0. Assume the decoder is enabled and towards the end of the execution of each instruction cycle all its active-low outputs $\overline{Y}_0$ - $\overline{Y}_7$ go back to their inactive logic '1' state.

Data bus line D_4 of the HC11 is connected to the flip-flop D input.

Which of the following set of instructions will direct HC11 line PD_0 to the HOST computer I/O port, which to the MCU I/O port connector and which will not affect the current routing.

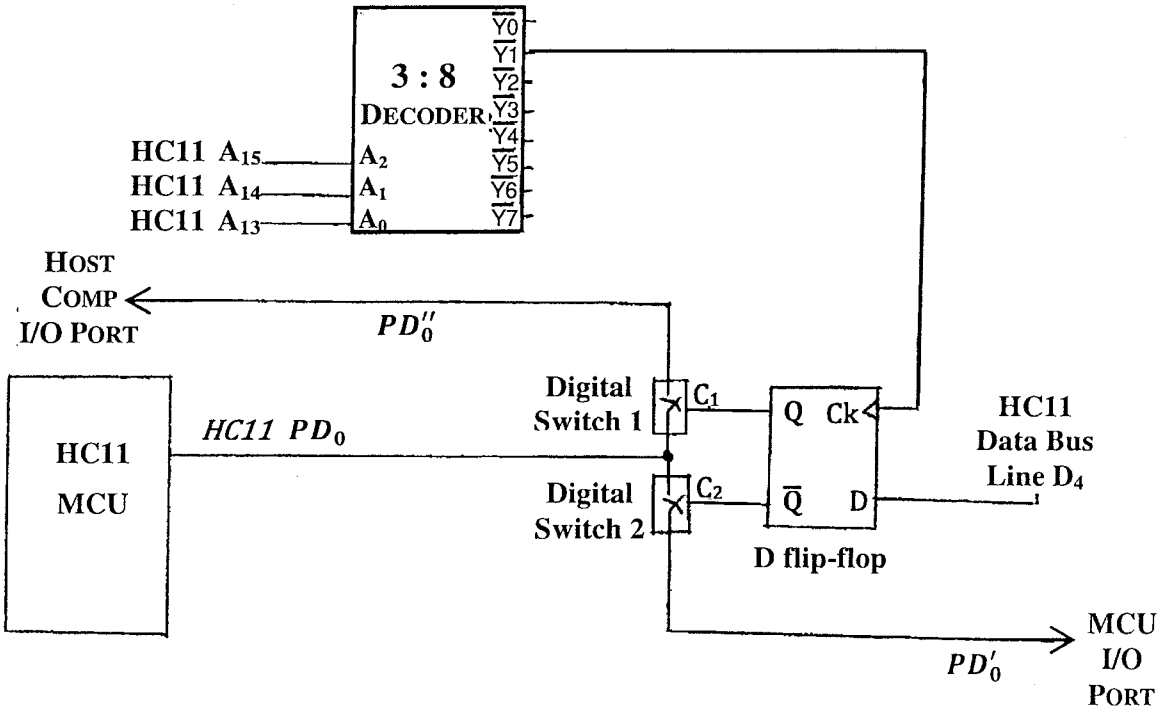
Mark your choice with an **X** and **justify** your selection in each case.

(a) ldaa #$21, staa $2B00 [ ] HOST Comp I/O port, [ ] MCU I/O port, [ ] No Action

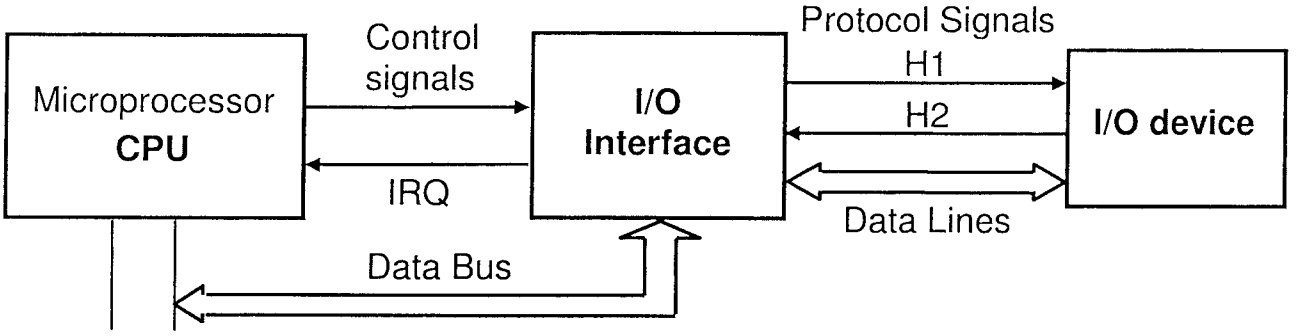
(b) ldaa #$FF, staa $10F0 [ ] HOST Comp I/O port, [ ] MCU I/O port, [ ] No Action

(c) ldaa #$90, staa $3000 [ ] HOST Comp I/O port, [ ] MCU I/O port, [ ] No Action

(d) ldaa #$8D, ldaa $2FFF [ ] HOST Comp I/O port, [ ] MCU I/O port, [ ] No Action



6.- The diagram below shows the main elements participating in the parallel I/O of data.



(a) Mention the two methods used in programming the CPU to communicate with the I/O interface in order to become aware of new available data, or interface readiness, and transfer the data between the two in the corresponding direction.

Which of the two methods is more efficient? Explain.

(b) i. Mention two parallel I/O protocols used for implementing the data exchange between the I/O interface and the external I/O device.

ii. Describe the main steps involved in these protocols for the INPUT of data from the I/O device and for the OUTPUT of data to the I/O device, separately.
Mention which protocol signal H1 or H2 work for signaling VALID DATA in data lines or ACKNOWLEDGEMENT of data reception in each case.

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

	Identity	Comments
1.	$A+0=A$	Operations with 0 and 1
2.	$A+1=1$	Operations with 0 and 1
3.	$A+A=A$	Idompotent
4.	$A+\overline{A}=1$	Complementarity
5.	$A\cdot 0=0$	Operations with 0 and 1
6.	$A\cdot 1=A$	Operations with 0 and 1
7.	$A\cdot A=A$	Idompotent
8.	$A\cdot \overline{A}=0$	Complementarity
9.	$\overline{\overline{A}}=A$	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.	$(A\cdot B)+(\overline{A}\cdot C)+(B\cdot C)=(A\cdot B)+(\overline{A}\cdot C)$	Consensus
19.	$\overline{A+B+C+\ldots}=\overline{A}\cdot\overline{B}\cdot\overline{C}\cdot\ldots$	De Morgan
20.	$\overline{A\cdot B\cdot C\cdot\ldots}=\overline{A}+\overline{B}+\overline{C}+\ldots$	De Morgan
21.	$(A+\overline{B})\cdot B=A\cdot B$	Simplification
22.	$(A\cdot\overline{B})+B=A+B$	Simplification