National Exams December 2017

16-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) 3, (b) 6, (c) 3, total = 12
3. (a) 4, (b) 4, (b) 4, total = 12
4. (a) 4, (b) 4, (c) 4, total = 12
5. (a) 3, (b) 4, (c) 2, (d) 3, total = 12
6. (a) 6, (b) 6, total = 12

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

1.- Consider the function

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

(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 and/or PoS forms to produce the simplest hazard-free implementations of these forms.

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

2.- Given the following function in sums-of-product (SoP) form:

$$f(A, B, C, D) = \sum m_i(0,1,2,4,5,6,7,8,10)$$

(a) Prepare its truth table.

(b) Map the function f in a K-map and identify:

i. One implicant that is not a prime implicant,

ii. One prime implicant that is not essential, and

iii. All essential prime implicants.

In identifying each implicant above list all the minterms m_i in each of them.

(c) Write the minimized SoP form for f.

3.- Given the multilevel function f below

$$f = A \cdot (B \cdot C + D \cdot E) + \bar{A} \cdot (F \cdot G + \bar{B} \cdot \bar{E})$$

(a) Draw the circuit implementing this function using AND, OR & NOT gates. Assume literal complements are available.

(b) Convert the circuit to NOR-only and draw the circuit for f using only NOR gates.

(c) Note that $f = \bar{\bar{f}}$ and use De Morgan's identities to show that only six NOR gates are required to implement the function f. Synthesize this circuit.

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

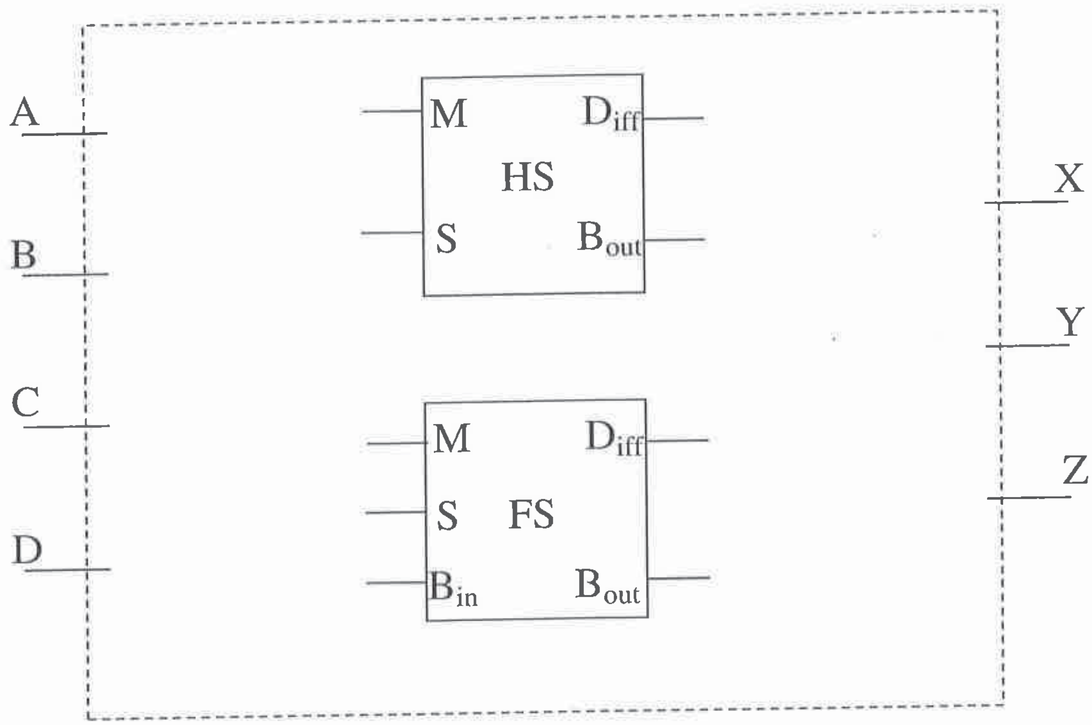
4.- The logic box shown below performs the substraction of two 2-bit unsigned numbers N_1 =AB (minuend) and N_2 = CD (subtrahend). The result (difference) is a three-bit 2's complement number D = XYZ.

(a) Build the truth table for the functions X, Y & Z.

(b) Use K-maps to minimize the functions X, Y & Z in sum of products form.

(c) You are given one half subtractor (HS) and one full subtractor (FS) in the diagram below. Complete the diagram to obtain the difference D = XYZ of $N_1 - N_2 =$ AB − CD.

M - minuend, S - subtrahend, D_{iff} - difference, B_{in} - borrow-in, B_{out} - borrow-out



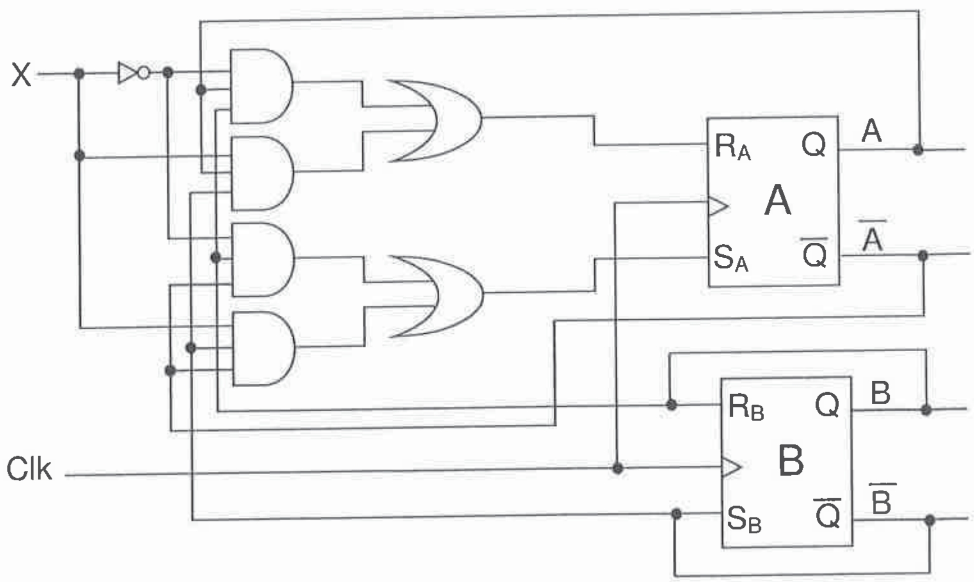
5.- The first of the two circuits below contains two RS flip-flops.

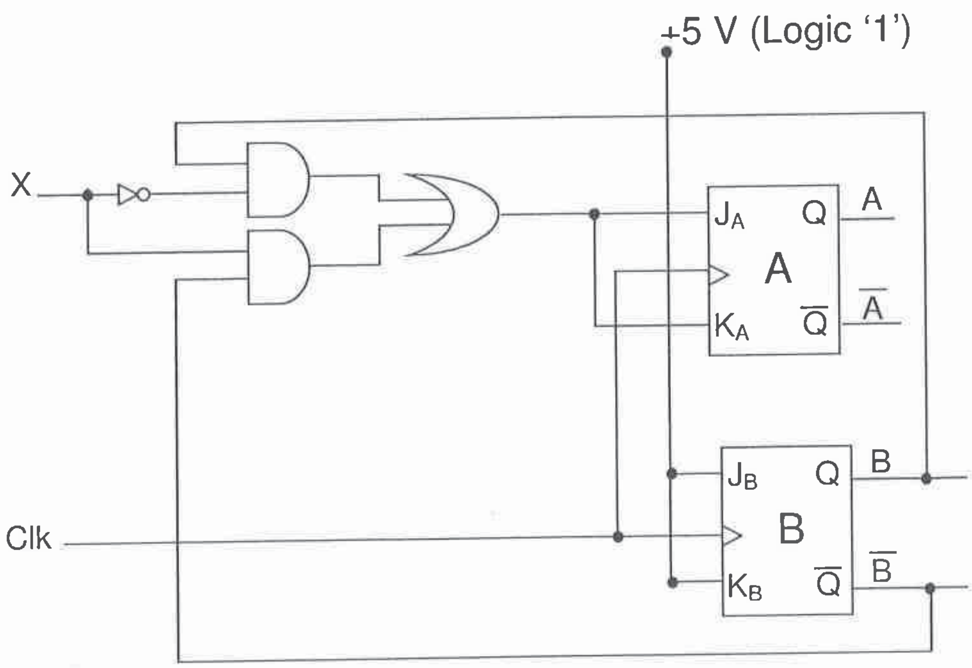
(a) Write the logic expressions for R_A, S_A, R_B and S_B.

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

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

(d) Compare RS and JK flip-flops, you can use the excitation table in the last page. Explain their relationship and advantage of one type over the other knowing that the same finite state machine (FSM) shown in the first diagram can be implemented using JK flip-flops by the second diagram shown below.





6.- A computer system establishes interaction with the external world through interfaces.

(a) One of the common interfaces is the timer system.

i. Mention uses or applications of the timer Input Capture (IC) function.

ii. Mention uses or applications of the timer Output Compare (OC) function.

iii. How is the time base kept by the timer system?

(b) Interfaces like the timer system are serviced by the system processor through an efficient process called interrupts.

i. Mention the main components that allow implementing the interrupt process.

ii. Mention the sequence of steps involved in the interrupt servicing process.

iii. Which processor registers are most significantly involved in this process?

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