National Exams December 2013

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) 4, (b) 4, (c) 4, total = 12
3. (a) 6, (b) 6, total = 12
4. (a) 8, (b) 2, (c) 2, total = 12
5. (a) 3, (b) 3, (c) 3, (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.- Given the following function in product-of-sums (PoS) form:

$$f(A,B,C,D) = \prod M_i(0,2,6,7,8,10,14,15)$$

Map the function f in a K-map and:

(a) Find the minimized PoS expression for f.

(b) Check if the minimized expression found in (a) is hazard-free. Justify.
If it is not hazard-free provide the smallest PoS hazard-free expression for f.

(c) Find the minimized sum-of-products (SoP) expression for f.

(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) Implement the following Boolean functions using 8:1 multiplexers:

i) $f_1(A,B,C) = \sum m_i(0,5,6,7)$

ii) $f_2(A,B,C) = \prod M_i(0,3,6)$. We are also told that the input combinations ABC = 100 and ABC = 111 are not of concern (don't cares) for f_2.

(b) Implement the same Boolean functions f_1 & f_2 given above using 4:1 multiplexers.

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

i) $f_1(A,B,C) = \sum m_i(5,6,7)$

ii) $f_2(A,B,C) = \overline{A}\cdot(B+\overline{C})$

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

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

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

(b) Implement using a PAL or PLA architecture. Justify your choice.

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

4.-(a) Using the minimum 2-level SoP logic required, design a sequential circuit with three T flip-flops, A, B and C, and two inputs E and X that performs as follows:

- If E = 0 the circuit remains in the same state regardless the value of X,
- When E = 1 and X = 1 the circuit goes through the state transitions 000 to 001 to 010 to 011 to 100 back to 000, and repeats,
- When E = 1 and X = 0 the circuit goes through the state transitions 111 to 110 to 101 to 100 to 011 back to 111, and repeats.

(b) Is the countup self-starting, *i.e.* if X remains at 1? Justify. Include state transition diagram.

(c) Is the countdown self-starting, *i.e.* if X remains at 0? Justify. Include state transition diagram.

5.- Serial communication is one of the ways a microprocessor can communicate with the external world.

(a) Polling and interrrupts are the two main protocols for the processor to communicate with a serial port.

Explain each of this two protocols.

Compare their differences, highlight advantages of one over the other.

(b) What is the main difference between synchronous and asynchronous serial communication?

(c) In asynchronous serial communication, line speed is the most critical parameter the two communications units establishing the connection need to agree on.

i) What is the line speed?

ii) What would be the consequence of these two units not agreeing on this parameter?

(d) In asynchronous serial communication, when transmitting one character information besides the actual data bits is included in each frame.

Mention what other bits are included.

Explain the reason for including them.

6.- (a) Using the following memory chips, how many chips will be needed to build a 256KB, 8-bit memory system for an 8-bit microprocessor? Justify your answer for each case.

The memory is to be designed so that 8-bit data can be accessed in one read/write operation.

i. 128K x 1 RAM

ii. 64K x 4 RAM

iii. 256K x 8 RAM

iv. 128K x 4 RAM

Note: KB = KiloByte, 1K = 2^{10}

(b) i. Using 8K x 4 RAM memory chips, how many RAM chips will be needed to build a 32KB (kilobyte), 16-bit memory system for a 16-bit microprocessor?
CPU word size = 16bits. .

ii. What is the size of the address bus required by the CPU in order to be able to address this memory space?

iii. What is the size of the data bus?

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