KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF ELECTRICAL ENGINEERING

EE 200 DIGITAL LOGIC CIRCUIT DESIGN

EXAMINATION I

October 24, 2007

Solution

NAME :					
I.D. # :					
SECTION :	**1**		**3**	**4**	**5**

PROBLEM #	**SCORE**	**MAXIMUM**
1.		**25**
2.		**25**
3.		**25**
4.		**25**
TOTAL		**100**

Q.# 1)

a. Convert the following octal number $(751.4)_8$ to decimal, binary and hexadecimal.
b. Determine the value of the base x, such that $(204)_x = (114)_8$.
c. Perform the following **binary** arithmetic operations:
   1) 11110.11 + 110.1
   2) 101101 x 1011
d. A 16 bit register has the state : 1001011101100101. What is the decimal number in the register if it represents:
   1) BCD code 2) Excess-3 code 3) 84-2-1 code

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a) $(751.4)_8 = 7(8)^2 + 5(8) + 1 + 4(8)^{-1} = (489.5)_{10}$

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$(751.4)_8 = (111101001.1)_2$

$(751.4)_8 = (1E9.8)_{16}$

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b) $2x^2 + 4 = 8^2 + 8 + 4 = 76 \Rightarrow x = \sqrt{36} = 6$

c)
1)

6

$$\begin{array}{r} 11110.11 \\ +\quad 110.10 \\ \hline 1\;00101.01 \end{array}$$

2)

$$\begin{array}{r} 101101 \\ 1011 \\ \hline 101101 \\ 101101 \\ 000000 \\ 101101 \\ \hline 111101111 \end{array}$$

d) 1. $(9765)_{BCD}$

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2. $(6432)_{Excess\text{-}3}$

3. $(7123)_{84\text{-}2\text{-}1}$

Q # 2)

a. Perform the following arithmetic operation in binary using the signed 2's complement representation for negative numbers. Use 8 bits to represent each number.

(-125) + (+72)

b. Simplify the following Boolean expressions to a minimum number of literals.

1. $F(x,y,z) = x'y'z' + x'y'z + x'yz' + xy'z' + xy'z + xyz'$
2. $F(w,x,y,z) = w'x'yz + wxy + w'y' + xy' + x'y'$

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a. $125 = 64 + 32 + 16 + 8 + 4 + 1 = 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^0 \rightarrow 1111101_2$

$\therefore +125 \equiv 01111101$ and $\therefore -125 \equiv 10000011$

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$72 = 64 + 8 = 2^6 + 2^3 \rightarrow 1001000_2 \quad \therefore +72 \equiv 01001000$

	(-125)	→	10000011	
+	(+72)	→	01001000	

Result		→	11001011	
Result is negative		→	- 00110101 →	- (32+16+4+1) = - 53

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b. 1.

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$$\begin{aligned} F(x,y,z) &= x'y'z' + x'y'z + x'yz' + xy'z' + xy'z + xyz' \\ &= x'y'(z'+z) + x'yz' + xy'(z'+z) + xyz' \\ &= x'y' + x'yz' + xy' + xyz' \\ &= (x'+x)y' + x'yz' + xyz' = y' + x'yz' + xyz' \\ &= y' + x'z' + xz' = \boxed{y'+z'} \end{aligned}$$

2.

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$$\begin{aligned} F(w,x,y,z) &= w'x'yz + wxy + w'y' + xy' + x'y' \\ &= w'x'yz + wxy + w'y' + (x+x')y' \\ &= w'x'yz + wxy + w'y' + y' = w'x'yz + wxy + (w'+1)y' \\ &= w'x'yz + wxy + y' = (w'x'z + wx)y + y' = \boxed{w'x'z + wx + y'} \end{aligned}$$

Q # 3)

For the following Boolean function:

$$F(A,B,C,D)=\left[(A+D')\cdot(B'+C)\right]'+\left[(C+D)\cdot(AC'+B'(D'+C))\right]'+(A'+B)'\cdot C'D$$

a. Express F as a sum of Minterms.
b. Express F as a product of Maxterms.
c. Simplify F in sum of products (SOP) form using K-map.

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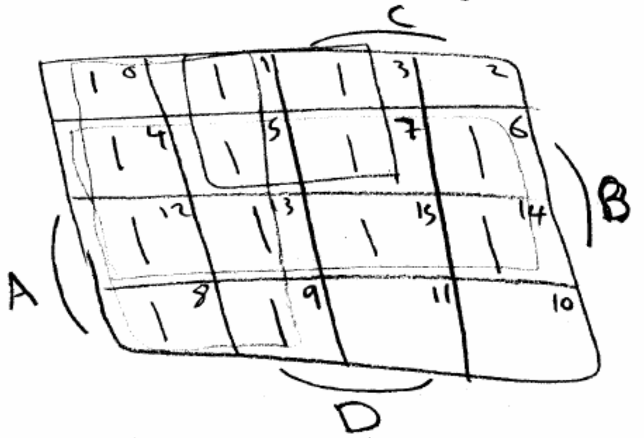
$$F(A,B,C,D) = A'D + BC' + C'D' + (A'+C)\cdot(B+DC') + AB'C'D$$
$$= A'D + BC' + C'D' + A'B + A'C'D + BC + \cancel{CC'D}_{\to 0} + AB'C'D$$
$$= A'D + BC' + C'D' + A'B + BC + A'C'D + AB'C'D$$



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(a) $F(A,B,C,D) = \sum(0,1,3,4,5,6,7,8,9,12,13,14,15)$

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(b) $F(A,B,C,D) = \prod(2,10,11)$

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(c) $F = C' + B + A'D$

Q # 4)

Consider the 2's complement operation on unsigned 4-bit binary numbers.

a. Prepare a truth table for the conversion of unsigned 4-bit binary numbers to their 2's complement equivalent. Use for the input side the symbols $A=A_3A_2A_1A_0$, and for the output side the symbols $T= T_3T_2T_1T_0$.
b. Using k-maps, give the minimal expression for each of the outputs in part (1).
c. Draw the complete circuit using random logic.

Problem (4)

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TRUTH TABLE

Binary Number				2's complement			
A_3	A_2	A_1	A_0	T_3	T_2	T_1	T_0
0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1
0	0	1	0	1	1	1	0
0	0	1	1	1	1	0	1
0	1	0	0	1	1	0	0
0	1	0	1	1	0	1	1
0	1	1	0	1	0	1	0
0	1	1	1	1	0	0	1
1	0	0	0	1	0	0	0
1	0	0	1	0	1	1	1
1	0	1	0	0	1	1	0
1	0	1	1	0	1	0	1
1	1	0	0	0	1	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	0	1	0
1	1	1	1	0	0	0	1

By inspection:

$\boxed{T_0 = A_0}$

A_1A_0 \ A_3A_2	00	01	11	10
00				
01	1	1	1	1
11				
10	1	1	1	1

$\boxed{T_1 = \bar{A}_1 A_0 + A_1 \bar{A}_0}$ $= A_0 \oplus A_1$

A_1A_0 \ A_3A_2	00	01	11	10
00		1	1	
01	1			1
11	1			1
10	1			1

$\boxed{T_2 = A_2\bar{A}_1\bar{A}_0 + \bar{A}_2 A_0 + \bar{A}_2 A_1}$

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A_1A_0 \ A_3A_2	00	01	11	10
00		1		1
01	1	1		
11	1	1		
10	1	1		

$\boxed{T_3 = \bar{A}_3 A_2 + \bar{A}_3 A_0 + \bar{A}_3 A_1 + A_3 \bar{A}_2 \bar{A}_1 \bar{A}_0}$

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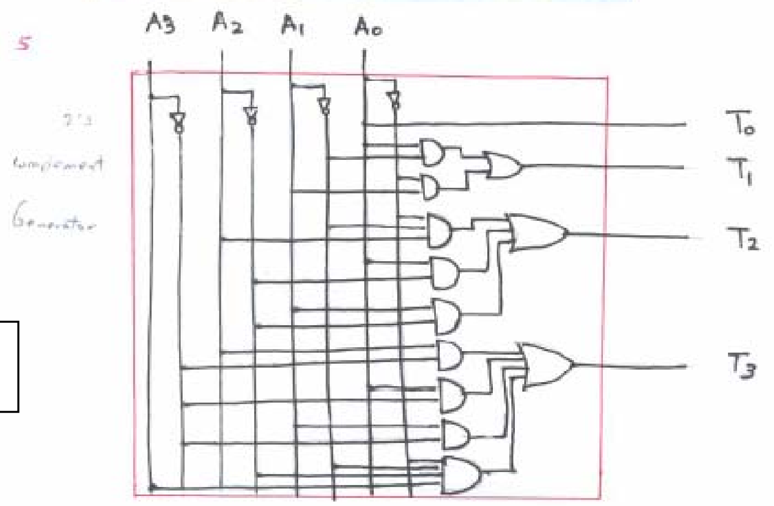

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