The University of Alabama in Huntsville
Electrical & Computer Engineering
CPE/EE 422/522 01
Homework #1 Solution
Spring 2005

1. (10 points) Prove that the following identities are valid using algebraic manipulation.
   a. ab' + bc' + ca' = a'b + b'c + c'a
      ab' + bc' + ca' = ab'(c+c')+bc'(a+a')+ca'(b+b')
      = ab'c+ab'c'+abc'+a'bc'+a'bc+a'b'c
      = a'b(c'+c)+b'c(a+a')+ac'(b'+b)
      a'b+b'c+c'a
   b. ab + a'c + bcd = ab + a'c
      ab + a'c + bcd = ab(c + c')(d + d') + a'c(b' + b)(d + d') + bcd(a' + a)
      = abc'd'+abc'd+abcd'+abcd+a'b'cd'+a'b'cd+a'bcd'+a'bcd+~~a'bcd~~+~~abcd~~
      = abc(d'+d)+abc(d'+d)+a'b'c(d'+d) + a'bc(d'+d)
      = ab(c'+c)+a'c(b'+b)
      = ab + a'c
2. (10 points) Find the complements of the following functions.
   a. f = a + bc
      f' = (a + bc)' = a'(bc)' = a'(b' + c') = a'b' + a'c'
   b. f = ab + b'c + ca'd
      f' = (ab + b'c + ca'd)' = (ab)'(b'c)'(ca'd)' = (a' + b')(b + c')(c' + a + d') = (a'b + a'c' + b'b + b'c')(c' + a + d') = (a'b + a'c' + b'c')(c' + a + d') = a'bc' + a'ba + a'bd' + a'c'c' + a'c'a + a'c'd' + b'c'c' + ab'c' + b'c'd' = a'bc' + a'bd' + a'c' + a'c'd' + b'c' + ab'c' + b'c'd' = a'c'(b + 1 + d') + b'c'(1 + a + d) + a'bd' = a'c' + b'c' + a'bd'

3. (15 points) Obtain the truth table of the following functions and express each function in sum of minterms and product of maxterms,

   a. xyz + xy'z'

   =Σm(4, 7)=ΠM(0, 1, 2, 3, 5, 6)

x	y	z	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

   b. abc + ab'c' + a'b'c'

   =Σm(0, 4, 7)=ΠM(1, 2, 3, 5, 6)

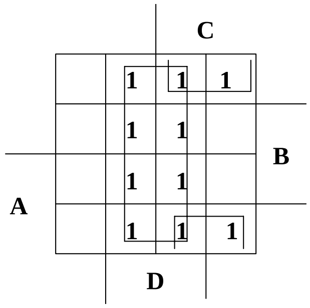
a	b	c	f
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

   c. $\overline{Y}Z + WX\overline{Y} + WX\overline{Z} + \overline{W}\,\overline{X}Z$ = Σm(1,3,5,9,12,13,14)=ΠM(0,2,4,6,7,8,10,11,15)

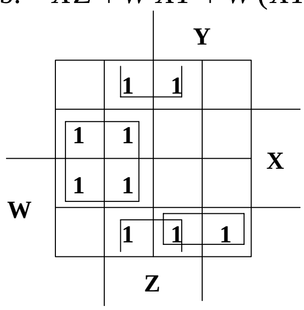
W	X	Y	Z	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

4. (20 points) Simplify the following expressions by means of a four-variable map.

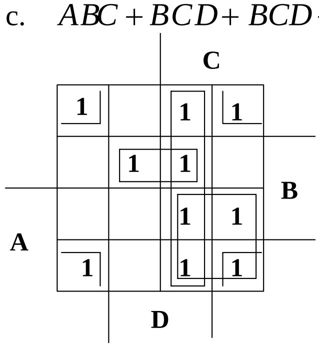
a. $\overline{A}D + BD + \overline{B}C + A\overline{B}D = D + \overline{B}C$



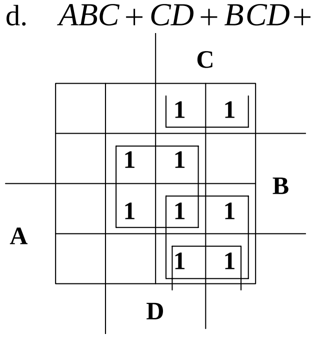
b. $\overline{X}Z + \overline{W}X\overline{Y} + W(\overline{X}Y + X\overline{Y}) = \overline{X}Z + W\overline{X}Y + X\overline{Y}$



c. $A\overline{B}C + \overline{B}\,\overline{C}\,\overline{D} + BCD + AC\overline{D} + \overline{A}\,\overline{B}C + \overline{A}B\overline{C}D = \overline{B}\,\overline{D} + CD + AC + \overline{A}BD$

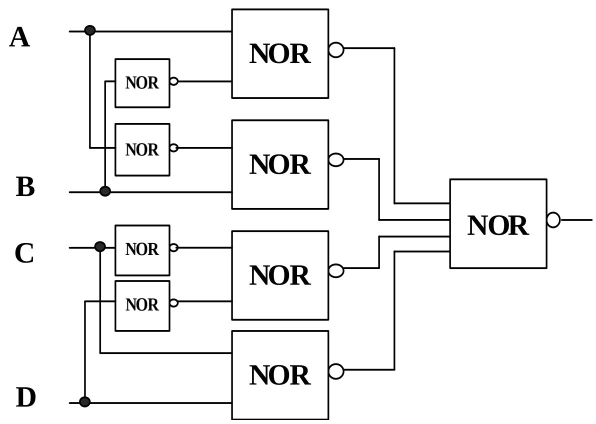


d. $ABC + CD + B\overline{C}D + \overline{B}C = AC + BD + \overline{B}C$



5. (10 points) Implement the following expression with two-input NOR gates.

$$(AB + \overline{A}\overline{B})(C\overline{D} + \overline{C}D)$$



6. (15 points) Design a combinational circuit whose input is a four-bit number and whose output is the 2's complement of the input number.

$A_3A_2A_1A_0$	$F_3F_2F_1F_0$
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
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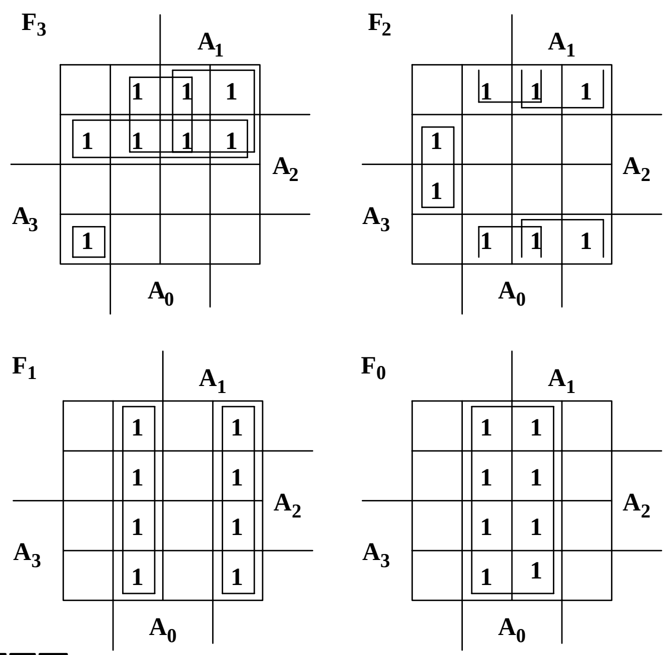
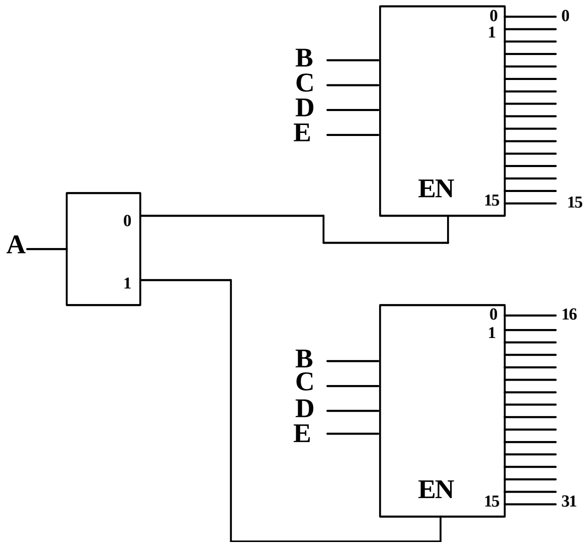
1 1 0 0	0 1 0 0
1 1 0 1	0 0 1 1
1 1 1 0	0 0 1 0
1 1 1 1	0 0 0 1



$$F_3 = \overline{A_3}A_2 + \overline{A_3}A_1 + \overline{A_3}A_0 + A_3\overline{A_2}\,\overline{A_1}\,\overline{A_0}$$
$$F_2 = \overline{A_2}A_0 + \overline{A_2}A_1 + A_2\overline{A_1}\,\overline{A_0}$$
$$F_1 = A_1\overline{A_0} + \overline{A_1}A_0$$
$$F_1 = A_0$$

7. (10 points) Construct a 5-to-32-line decoder with two 4-to-16 decodes with enable input and one 1-to-2-line decoder.



8. (10 points) Construct a 5-to1 line multiplexer with as many 2-to-1 line multiplexers as are needed.