04.10.2013

Istanbul Technical University
Department of Computer Engineering

BLG 231E - Digital Circuits
Assignment 2

Due Date: 10.10.2013, **Thursday,** 17.00.

- Please **write <u>neatly</u>**.
- If you are not preparing your homework in a computer, please show complement of a symbol by putting a **dash** over the symbol (e.g. do not use *x'* use $\bar{x}$).
- Plagiarized assignments will be given a negative mark.
- **No late submissions** will be accepted.

Submissions: Please submit your solutions to the Digital Circuits Course Assignment Box at the department secretary's office.

1. The truth table of expression f is given as follows.

a	*b*	*c*	*d*	*f*
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
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	1

a. Write the first and second canonical form of f.
b. Minimize the second canonical form of the expression by using the axioms and theorems of the Boolean algebra.
c. Draw the minimized expression in b by only using 2-input NOR.

Answers:

a. The first canonical form of the expression

$$f(a,b,c,d) = \sum m\,(1,4,5,6,7,9,12,13,14,15)$$
$$= \bar{a}\bar{b}\bar{c}d + \bar{a}b\bar{c}\bar{d} + \bar{a}b\bar{c}d + \bar{a}bcd + \bar{a}bcd + a\bar{b}\bar{c}d + ab\bar{c}\bar{d} + ab\bar{c}d + abc\bar{d} + abcd$$

The second canonical form of the expression

$$f(a,b,c,d) = \prod M\,(0,2,3,8,10,11)$$
$$= (a+b+c+d)(a+b+\bar{c}+d)(a+b+\bar{c}+\bar{d})(\bar{a}+b+c+d)(\bar{a}+b+\bar{c}+d)(\bar{a}+b+\bar{c}+\bar{d})$$

b. Minimization of the second canonical form

$$f = (a+b+c+d)(a+b+\bar{c}+d)(a+b+\bar{c}+\bar{d})(\bar{a}+b+c+d)(\bar{a}+b+\bar{c}+d)(\bar{a}+b+\bar{c}+\bar{d})$$

$$= [(a+b+\bar{c})(d+\bar{d})][(a+\bar{a})(b+c+d)][(a+\bar{a})(b+\bar{c}+d)][(\bar{a}+b+\bar{c})(d+\bar{d})]$$

$$= (a+b+\bar{c})(b+c+d)(b+\bar{c}+d)(\bar{a}+b+\bar{c})$$

$$= [(a+b+\bar{c})(\bar{a}+b+\bar{c})][(b+c+d)(b+\bar{c}+d)]$$

$$= [(a+\bar{a})(b+\bar{c})][(b+d)(\bar{c}+c)]$$

$$= (b+\bar{c})(b+d)$$

c. The given expression has operations with only two parameters. Thus, in PoS form, it can be easily implemented with 2-input NOR gates by just replacing the AND, OR, NOT gates with NOR gates.