School of Electrical Engineering and Computer Science
National University of Sciences & Technology (NUST)

Practice Assignment No-3

Subject:	**Digital Logic Design**	Course:	**BEE-12CD**
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- ✓ *This is a non-graded assignment prepared to enhance problem-solving skills of students from chapter3 of the textbook.*
- ✓ *The students are advised to attempt it any time of their convenience.*

Problem No-1 Use K-map to find a minimal sum-of-product (SOP) expression for the following function: -

$$F(a, b, c, d) = a'b' + cd' + abc + a'b'cd' + abc'd + a'c'd'$$

Problem No-2 Find two different minimal sum-of-product (SOP) expressions for the following function: -

$$F(a, b, c, d) = \sum_m (3, 7, 11, 12, 13, 15) + \sum_d (5, 8, 9, 14)$$

Problem No-3 Find a minimal product-of-sums (POS) expression for the following function: -

$$F(a, b, c, d) = \pi_M (0, 2, 10, 11, 12, 14, 15). \pi_D (5, 7)$$

Problem No-4 Assuming that the inputs abcd = 0101; abcd = 1001; abcd = 1011 never occur, find a simplified expression for

$$F = a'bc'd + a'b'd + a'cd + abd + abc$$

Problem No-5 Find the essential prime implicants for the following function:

$$F(a, b, c, d, e) = \sum (0, 3, 4, 5, 6, 7, 8, 12, 13, 14, 16, 21, 23, 24, 29, 31)$$

Problem No-6 Find the minimum sum-of-products expression for:

$$F(a, b, c, d, e) = \sum (0, 2, 6, 7, 8, 10, 11, 12, 13, 14, 16, 19, 29, 30)$$

$$+\Sigma_d (a, b, c, d) = \sum(4, 9, 21)$$

Problem No-7 Realize the function f = a'bc' + bd + ac + b'cd' using only 2-input NAND gates.

Problem No-8 The following equation is implemented using AND gates, OR gates, and inverters. Convert the circuit to use only NAND gates and inverters (do not manipulate the equation with Boolean algebra).

$$F(a, b, c, d) = b(a(bc + d') + c'd)$$

Problem No-9 Repeat problem 8 above, using only NOR gates and inverters.

Problem No-10 Implement the function $F(a, b, c, d) = \sum(0, 1, 4, 6, 7, 9, 11, 13, 14) + \sum_d(2, 5, 12)$, in all non-degenerate Forms.

Problem No-11 Design a network of NAND gates and inverters that converts from 8,4,-2,-1 BCD code to 6,3,1,1 code.

Problem No-12 After completing the design and fabrication of a digital system, a designer finds that one more inverter is required. However, the only spare gates in the system are a 3-input OR, a 2-input AND, and a 2-input XOR. How should the designer realize the inverter function without adding another IC?

Problem No-13 Use Quine-McCluskey procedure to find all the minimum sum-of-products (SOP) expression for the following function F

$$F(A,B,C,D,E)=\Sigma_m(0,2,6,7,8,10,11,12,13,14,16,18,19,29,30) +\Sigma_d(4,9,21)$$

Problem No-14 Use the Quine-McCluskey procedure to find all of the prime implicants for

$$F(a, b, c, d) = \sum(0, 1, 3, 5, 6, 7, 8, 10, 14, 15)$$

Problem No-15 Using a prime implicant chart, find all minimum sum-of-products (SOP) solutions for the function of problem 14.

Problem No-16 Use the Petrick's method to find all of the minimal sum-of-product (SOP) expressions for the following function:

$$f(a, b, c, d) = \sum(0, 2, 6, 7, 8, 9, 10, 13, 15)$$

Problem No-17 Use the Petrick's method to find all of the minimal sum-of-product expressions for

$$f(w, x, y, z) = \sum(7, 12, 14, 15) + \sum_d(1, 3, 5, 8, 10, 11, 13)$$

Problem No-18 Optimize the following Boolean functions together with the don't care conditions d in the forms indicated using map method by finding all the prime implicants and essential prime implicants and apply the selection rule: -

a. $F_1(A,B,C,D)=(A'+B'+D')(A+B'+C')(A'+B+D')(B+C'+D')$

SOP & POS

b. $F_2(W,X,Y,Z)=\pi_M\,(0,1,6,8,11,12).\pi_D\,(3,7,14,15)$

SOP

c. $F_3(a,b,c,d,e)=\sum_m$ (0,3,4,5,6,7,8,12,13,14,16,21,23,24,29,31)

SOP

Problem No-19 Implement the following expression (which is already in minimum sum-of-product form) using only two-input NAND gates. No gate may be used as a NOT. All the inputs are available both in complemented and uncomplemented form.

$$g(a,b,c,d,e)= a'b'c'd'+abcd'+a'ce+ab'd+be$$

Problem No-20 Consider the following functions

$$F(A,B,C,D)=\Sigma_m\,(1,3,4,5,9,10,11,12,13,14,15)$$
$$G(A,B,C,D)=\Sigma_m\,(0,2,3,4,5,7,8,10,11,12,13,15)$$

a. Optimize the functions using map method. Find all prime implicants and essential prime implicants and apply the selection rule.
b. Apply postulates and theorems of Boolean Algebra to find minimum sum-of-products expression for $F\cdot G$ and $F+G$.
c. Use map method to obtain minimum sum-of-product expressions for F.G and F+G and verify your answer in part b above.

Problem No-21 Simplify the following functions to the minimum Sum-of-Product (SOP) and Product-of-Sum (POS) forms using map method: -

a. $F1=AC'+B'D+A'CD+ABCD$
b. $F2=(A'+B'+D')\,(A+B'+C')\,(A'+B+D')\,(B+C'+D')$
c. $F3=(A'+B'+D)\,(A'+D')\,(A+B+D')\,(A+B'+C+D)$
d. $F4=(A+C'+D')(A'+B'+D')(A'+B+D')(A'+B+C')$

Problem No-22 Four large tanks at a chemical plant contain different liquids being heated. Liquid-level sensors are being used to detect whenever the level in tank A or tank B rises above a predetermined level. Temperature sensors in C and D detect when the temperature in either of the tanks drops below a prescribed temperature limit. Assume that the liquid-level sensor outputs A and B are LOW when the level is satisfactory and HIGH when the level is too high. Also, the temperature sensor outputs C and D are LOW when the temperature is satisfactory and HIGH when the temperature is too LOW.

Design a logic circuit that will detect whenever, the level in tank A or tank B is too high at the same time that the temperature in either tank C or tank D is too low. List the truth table and implement the design using two-level (a) AND-NOR, (b) OR-NAND forms.

Problem No-23 Realize $Z=A[BC'+D+E(F'+GH)]$ using minimum number of 2-input NOR gates. Assume that double-rail inputs are available.

Problem No-24 For the following function F, use map method to show that $FF'=0$ and $F+F'=1$

$$F=(V'W+X)\,Y+Z'$$

"Good Luck"