

EE2000 - Assignment 1

Question 1

- (a) For the logic function $F(A,B,C,D) = \sum m(0,1,2,5,6,7,9,10,11,13,14,15)$, draw a 4-variable Karnaugh map. Instead of plotting the cells with 1's, fill the corresponding cells with their minterm notations such as m_0 , m_1 , m_2 , etc.
- (b) Based on the K-map, list all possible pairs of two adjacent minterms such as (m_0, m_1) , i.e. list/group all possible combinations of two adjacent minterms. Write the resulting implicants produced by the minterm pairs in term of logic variables, use “-” for the reduced variables, e.g.

$$(m_0, m_1): \bar{A}\bar{B}\bar{C}-$$

$$(m_0, m_2): \bar{A}\bar{B}-\bar{D}$$

- (c) Based on the K-map, list all possible of four adjacent minterms in term of two-minterm pairs given in (b). Write the resulting implicants produced by the two minterm pairs in term of logic variables, use “-” for the reduced variables, e.g.

$$(m_0, m_1), (m_4, m_5) : \bar{A}-\bar{C}-$$

- (d) Based on (b) and (c), express F in the form of sum-of-products. Make sure all the minterms given in (a) have been included in your result.

Question 2

- (a) Use the Quine-McCluskey method to minimize the logic function given in Question 1(a). Comments on the procedures given in Question 1 and the Quine-McCluskey method you used in this question.
- (b) Can Quine-McCluskey method be applied to the maxterm case (so as to have product-of-sums result) or not? If “no”, give reasons, If “yes”, give the procedures.

Question 1

(a) The K-map is

AB \ CD				
	00	01	11	10
00	m ₀	m ₁		m ₂
01		m ₅	m ₇	m ₆
11		m ₁₃	m ₁₅	m ₁₄
10		m ₉	m ₁₁	m ₁₀

5 marks

(b) From the K-map (with first two grouping shown), possible of two adjacent minterms are:

Minterm	ABCD
0,1	000- $\bar{A}\bar{B}\bar{C}$ -
0,2	00-0 $\bar{A}\bar{B}-\bar{D}$
1,5	0-01
1,9	-001
2,6	0-10
2,10	-010
5,7	01-1
5,13	-101
6,7	011-
6,14	-110
9,11	10-1
9,13	1-01
10,11	101-
10,14	1-10
7,15	-111
11,15	1-11
13,15	11-1
14,15	111-

15 marks

(c) From the K-map, four adjacent minterms are:

		CD			
		00	01	11	10
AB	00	m ₀	m ₁		m ₂
	01		m ₅	m ₇	m ₆
	11		m ₁₃	m ₁₅	m ₁₄
	10		m ₉	m ₁₁	m ₁₀

Minterm	ABCD
1,5,9,13	--01 -- $\bar{C}D$
2,6,10,14	--10 -- $C\bar{D}$
5,7,13,15	-1-1 - $B-D$
6,7,14,15	-11- - $BC-$
9,11,13,15	1--1 $A--D$
10,11,14,15	1-1- $A-C-$

15 marks

(d)

$$F(A, B, C, D) = C'D + CD' + \left\{ \begin{array}{l} BD + AD \text{ or} \\ BD + AC \text{ or} \\ BC + AD \text{ or} \\ BC + AC \end{array} \right\} + \left\{ \begin{array}{l} A'B'C' \\ \text{or} \\ A'B'D' \end{array} \right\} \quad (\text{Any one of these combinations is acceptable})$$

5 marks

Question 2

(a) $F(A,B,C,D) = \sum m(0,1,2,5,6,7,9,10,11,13,14,15)$

List 1		
Minterm	ABCD	
0	0000	√
1	0001	√
2	0010	√
5	0101	√
6	0110	√
9	1001	√
10	1010	√
7	0111	√
11	1011	√
13	1101	√
14	1110	√
15	1111	√

10 marks

List 2

List 3

Minterm	ABCD	
0,1	000-	PI7
0,2	00-0	PI8
1,5	0-01	√
1,9	-001	√
2,6	0-10	√
2,10	-010	√
5,7	01-1	√
5,13	-101	√
6,7	011-	√
6,14	-110	√
9,11	10-1	√
9,13	1-01	√
10,11	101-	√
10,14	1-10	√
7,15	-111	√
11,15	1-11	√
13,15	11-1	√
14,15	111-	√

Minterm	ABCD	
1,5,9,13	--01	PI1
2,6,10,14	--10	PI2
5,7,13,15	-1-1	PI3
6,7,14,15	-11-	PI4
9,11,13,15	1--1	PI5
10,11,14,15	1-1-	PI6

10 marks

10 marks

$$\sum m(0,1,2,5,6,7,9,10,11,13,14,15)$$

		0	1	2	5	6	7	9	10	11	13	14	15
PI1	--01		*		*			*			*		
PI2	--10			*		*			*			*	
PI3	-1-1				*		x				*		x
PI4	-11-					*	x					*	x
PI5	1--1							*		x	*		x
PI6	1-1-								*	x		*	x
PI7	000-	x	*										
PI8	00-0	x		*									

Many combinations: (PI1 and PI2 cover 8 minterms)

10 marks

$$F(A, B, C, D) = \text{PI1} + \text{PI2} + \left\{ \begin{array}{l} \text{PI3} + \text{PI5} \text{ or} \\ \text{PI3} + \text{PI6} \text{ or} \\ \text{PI4} + \text{PI5} \text{ or} \\ \text{PI4} + \text{PI6} \end{array} \right\} + \left\{ \begin{array}{l} \text{PI7} \\ \text{or} \\ \text{PI8} \end{array} \right\}$$

$$F(A, B, C, D) = C'D + CD' + \left\{ \begin{array}{l} BD + AD \text{ or} \\ BD + AC \text{ or} \\ BC + AD \text{ or} \\ BC + AC \end{array} \right\} + \left\{ \begin{array}{l} A'B'C' \\ \text{or} \\ A'B'D' \end{array} \right\}$$

10 marks

- (b) Quine-McCluskey method can also be applied to the maxterm cases. The procedures are similar to the minterm cases. Instead of looking at “1”, we consider “0” in this case. For “partitioning”, we group the terms in term of number of “0”. For “combining”, we compare the partitioned terms that follows Gary code property. Then following the same procedure to identify prime implicants (PI), generate PI chart, and reduce the PI chart. For result reporting, the PI terms are expressed in their logical duals, i.e. product of sums.

10 marks