JOINT INSTITUTE 交大密西根学院

Ve270 Introduction to Logic Design

Homework 2

Assigned: May 21, 2020

Due: May 28, 2020, 2:00pm.

A pop quiz will be given on the due date.

1. Prove DeMorgan's Law. (5 points)

   Use Truth Table.

2. Problem 2.28 (5 points)

   2.28 Use algebraic manipulation to convert the following equation to sum-of-products form: F = a'b(c + d') + a(b' + c) + a(b + d)c

$$F = a'bc + a'bd' + ab' + ac + (ab+ad)c$$
$$= a(b' + c + bc + dc) + a'(bc + bd')$$
$$= ab' + ac + a'bc + abd'$$
$$= ab' + ac + bc + ad'$$

3. Problem 2.30 (5 points)

   2.30 Use DeMorgan's Law to find the inverse of the following equation: F = ac' + abd' + acd. Reduce to sum-of-products form.

$$F = ac' + abd' + acd$$
$$F' = (a(c' + bd' + cd))'$$
$$= a' + (c' + bd' + cd)'$$
$$= a' + c \cdot (bd')' \cdot (cd)'$$
$$= a' + c \cdot (b' + d) \cdot (c' + d')$$
$$= a' + cd'(b' + d)$$
$$= a' + b'cd'$$

4. Problem 2.37 (5 points)

2.37 Convert the function F shown in the truth table in Table 2.9 to an equation. Don't minimize the equation.

F = a'b'c + a'bc' + a'bc + ab'c + abc' + abc

Table 2.9

a	b	c	F
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

5. Problem 2.38 (5 points)

2.38 Use algebraic manipulation to minimize the equation obtained in Exercise 2.37

$$F = a'b'c + a'bc' + a'bc + ab'c + abc' + abc$$

$$= a'c + ab + ac + a'b$$

$$= b + c$$

6. Problem 2.48 (c) (5 points)

2.48 Convert the following Boolean equations to canonical sum-of-minterms form:

c. F(a,b,c) = abc + ab + a + b + c

c) F(a,b,c) = a'b'c + a'bc' + a'bc + ab'c' + ab'c + abc' + abc

7. Problem 2.52 (10 points)

2.52 Determine whether the two circuits in Figure 2.81 are equivalent circuits using: (a) algebraic manipulation, and (b) truth tables.

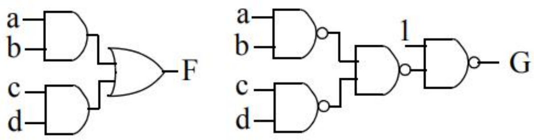


Figure 2.81

a) F = ab + cd and G = (1*((ab)' * (cd)')')'

In canonical sum-of-minterms form, F = a'b'cd + a'bcd + ab'cd + abc'd' + abc'd + abcd' + abcd and G = a'b'c'd' + a'b'c'd + a'b'cd'+ a'bc'd' + a'bc'd + a'bcd' + ab'c'd' + ab'c'd + ab'cd'. F and G are not equivalent (F = G')

b)

Inputs				Outputs
a	b	c	d	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

(a)

Inputs				Outputs
a	b	c	d	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

(b)

8. Problem 2.54 (10 points)

2.54 A museum has three rooms, each with a motion sensor (m0, m1, and m2) that outputs 1 when motion is detected. At night, the only person in the museum is one security guard who walks from room to room. Create a circuit that sounds an alarm (by setting an output A to 1) if motion is ever detected in more than one room at a time (i.e., in two or three rooms), meaning there must be one or more intruders in the museum. Start with a truth table.

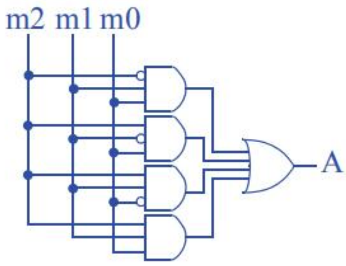
Step 1 - Capture the function

Inputs			Outputs
m2	m1	m0	A
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Step 2A - Create equations

A = m2'm1m0 + m2m1'm0 + m2m1m0' + m2m1m0

Step 2B- Implement as a gate-based circuit



9. Problem 6.3. (10 points)

6.3) Perform two-level logic size optimization for `F(a,b,c) = ab'c + abc + a'bc + abc'` using (a) algebraic methods, (b) a K-map. Express the answers in sum-of-products form.

(a) F = ab'c + abc + a'bc + abc'

F = ab'c + abc + abc + a'bc + abc + abc'

F = ac(b' + b) + bc(a + a') + ab(c + c')

F = ac + bc + ab

(b)

F: a \ bc	00	01	11	10
0	0	0	1	0
1	0	1	1	1

bc, ac, ab

F(a,b,c) = ab + ac + bc

10. Problem 6.6, using both algebraic methods and K-map. (10 points)

6.6) Perform two-level logic size optimization `F(a,b,c,d) = ab + a'b'd'` using a K-map.

F: ab \ cd	00	01	11	10
00	1	0	0	1
01	0	0	0	0
11	1	1	1	1
10	0	0	0	0

a'b'd', ab

F(a,b,c,d) = ab + a'b'd'

Neither algebraic method nor K-map can simplify the equation.

11. Problem 6.8. (10 points)

Groups with only don't care is not needed.

6.8) Perform two-level logic size optimization for `F(a,b,c,d) = a'bc'd + ab'cd'`, assuming that `a` and `b` can never both be `1` at the same time, and that `c` and `d` can never both be `1` at the same time (i.e., there are don't cares).

F: ab \ cd	00	01	11	10
00	0	0	x	0
01	0	1	x	0
11	x	x	x	x
10	0	0	x	1

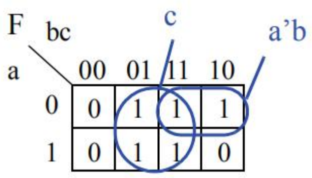
bd, ac

F(a,b,c,d) = ac + bd

12. Problem 6.10 (a) (10 points)

6.10) For the function F(a,b,c) = a'c + ac + a'b, determine all prime implicants and all essential prime implicants: (a) using a K-map, (b) using the tabular method.

(a)

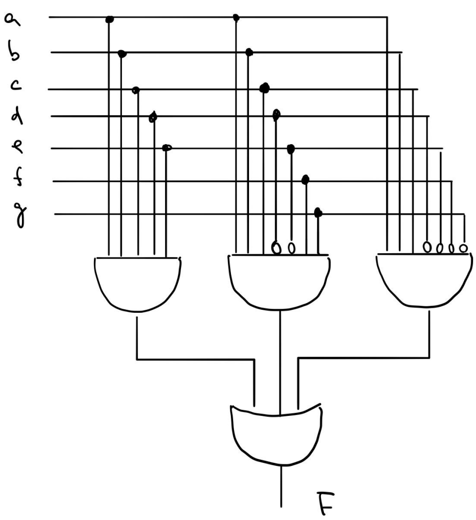


a'b and c are both prime implicants and also essential prime implicants; each is the only cover of some particular 1.

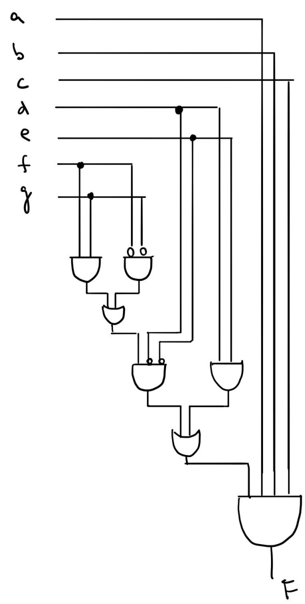
13. Problem 6.14 (10 points)

6.14) Using algebraic methods, reduce the number of gate inputs for the following equation by creating a multilevel circuit: F(a,b,c,d,e,f,g) = abcde + abcd'e'fg + abcd'e'f'g'. Assume only AND, OR, and NOT gates will be used. Draw the circuit for the original equation and for the multilevel circuit, and clearly list the delay and number of gate inputs for each circuit.

$F = abc(de + d'e'(fg + f'g'))$



22 input , 2 gate delay



17 input
5 delay