Chapter 8

Optimized Implementation of Logic Circuits

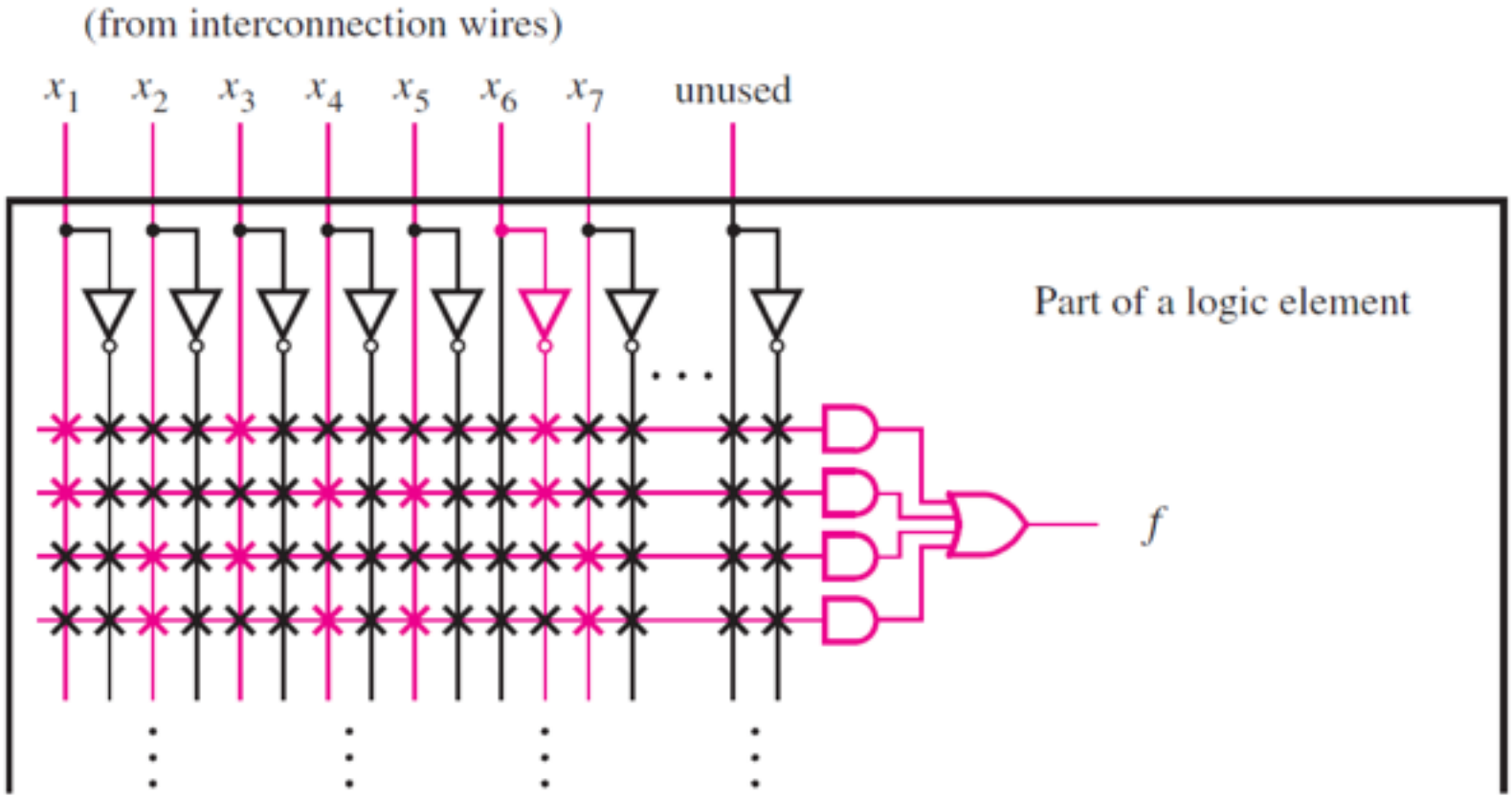


Figure 8.1. Implementation in a CPLD.

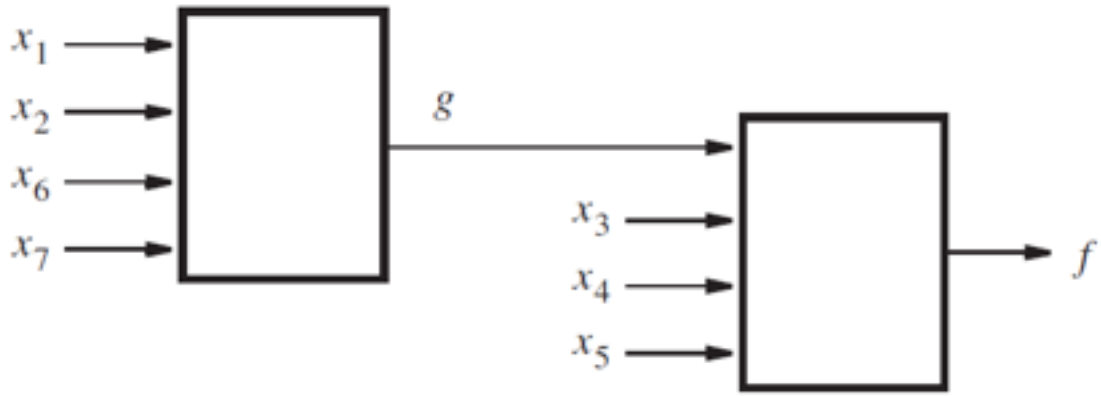


Figure 8.2. Using three LUTs after factoring.

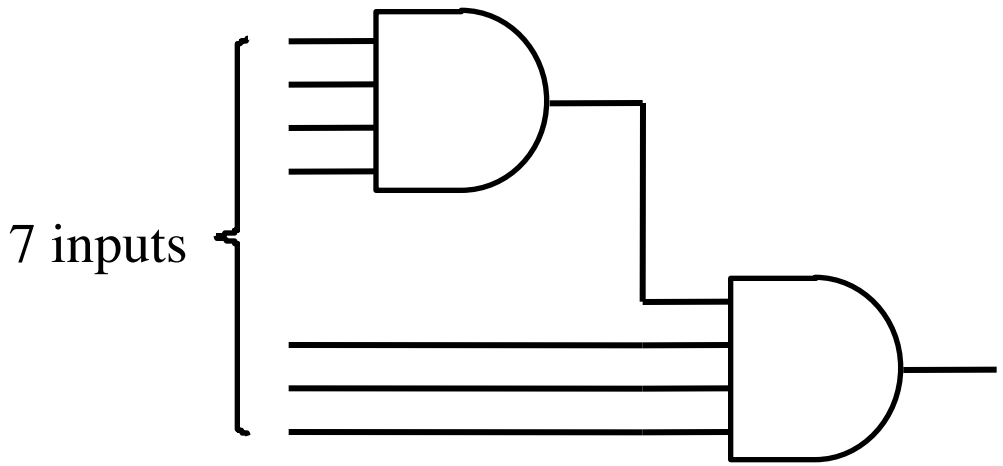


Figure 8.3. Using four-input AND gates to realize a seven-input product term.

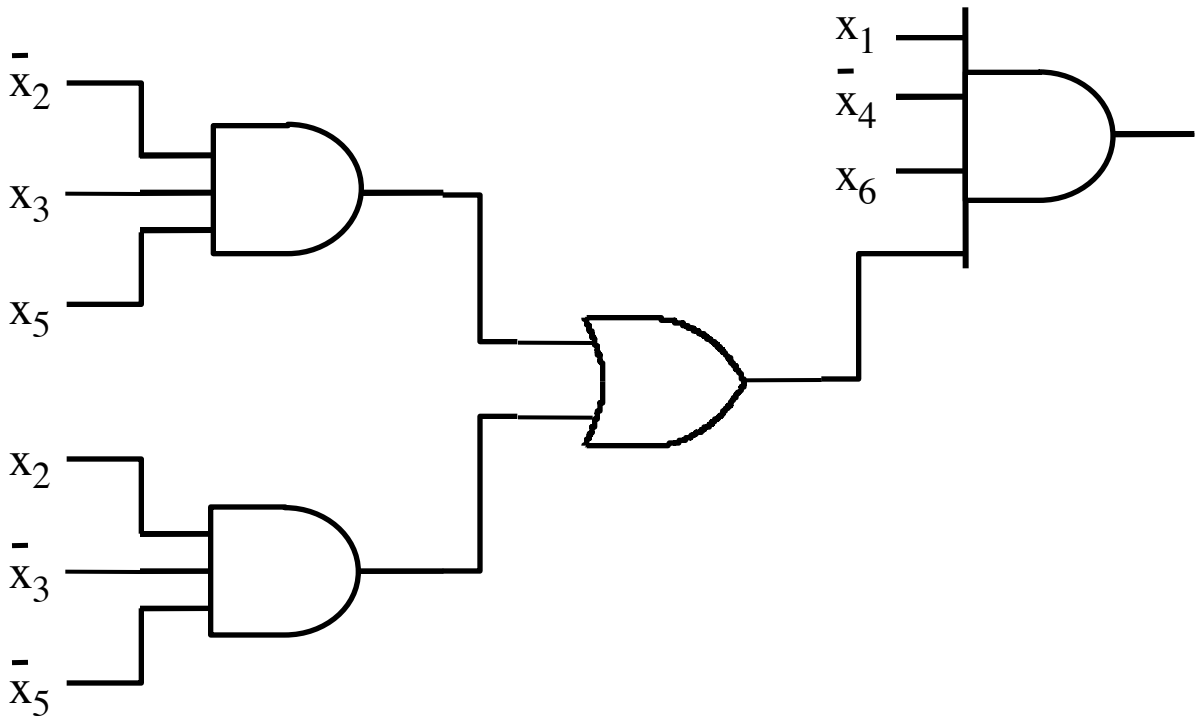


Figure 8.4. A factored circuit.

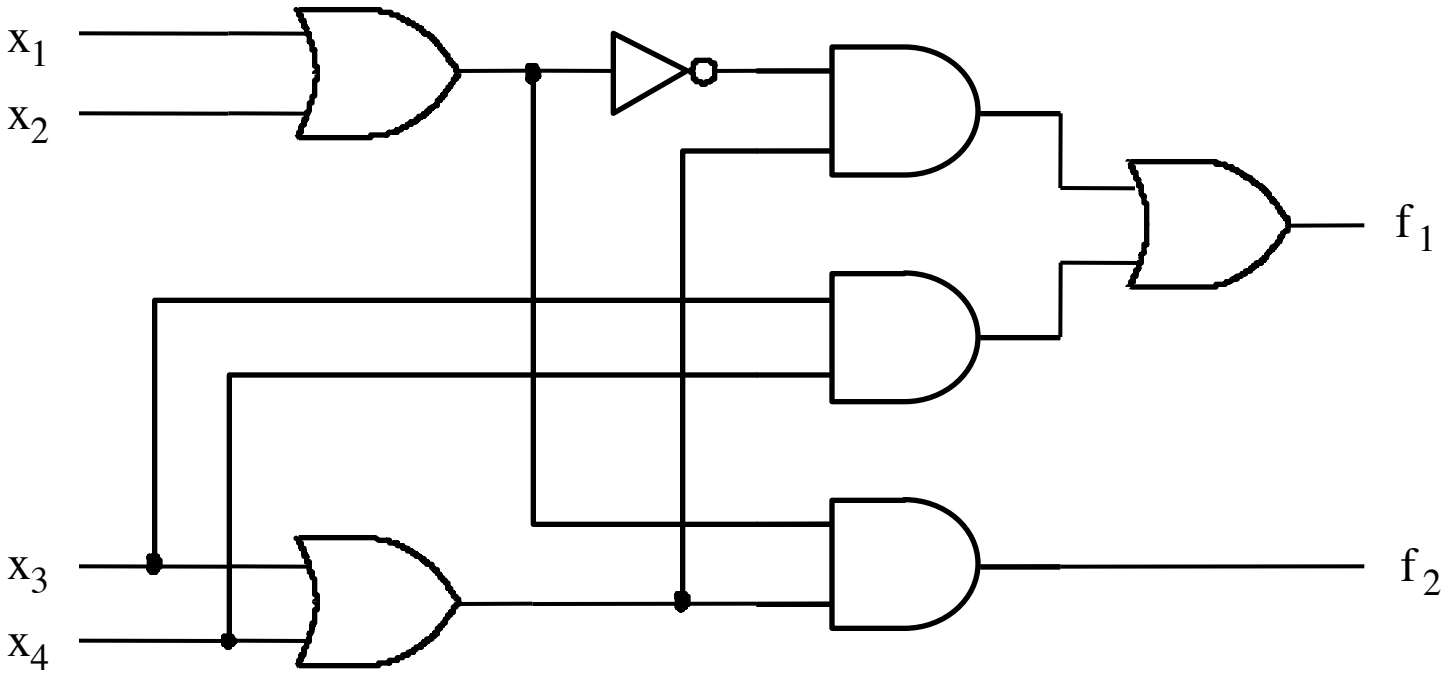
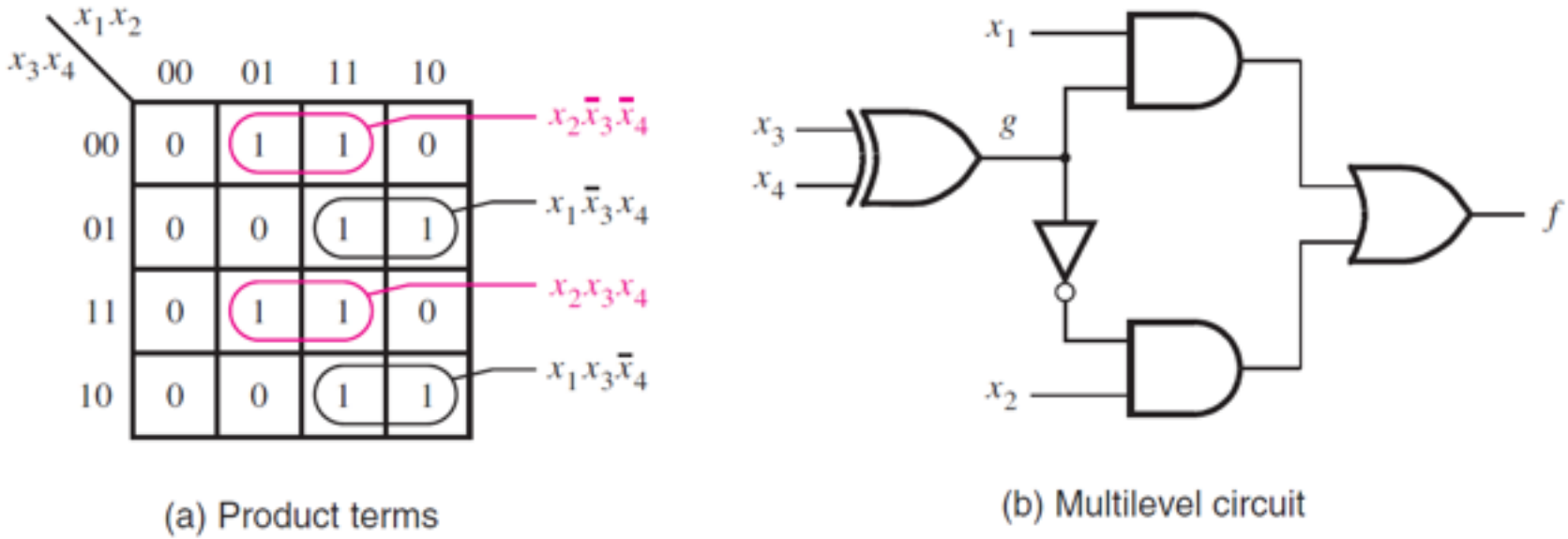


Figure 8.5. Circuit for Example 8.1.



(a) Product terms

(b) Multilevel circuit

Figure 8.6. The function for Example 8.2.

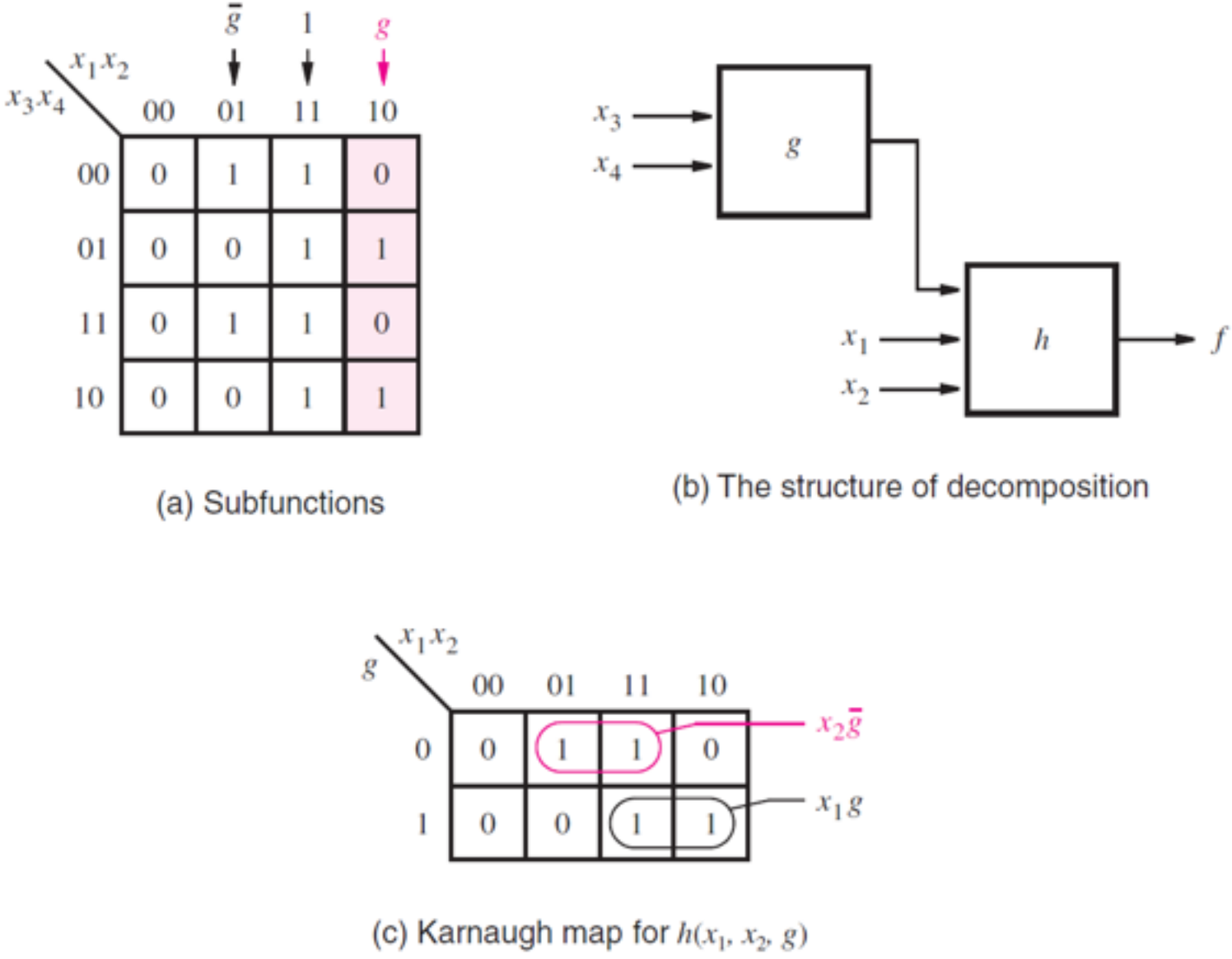
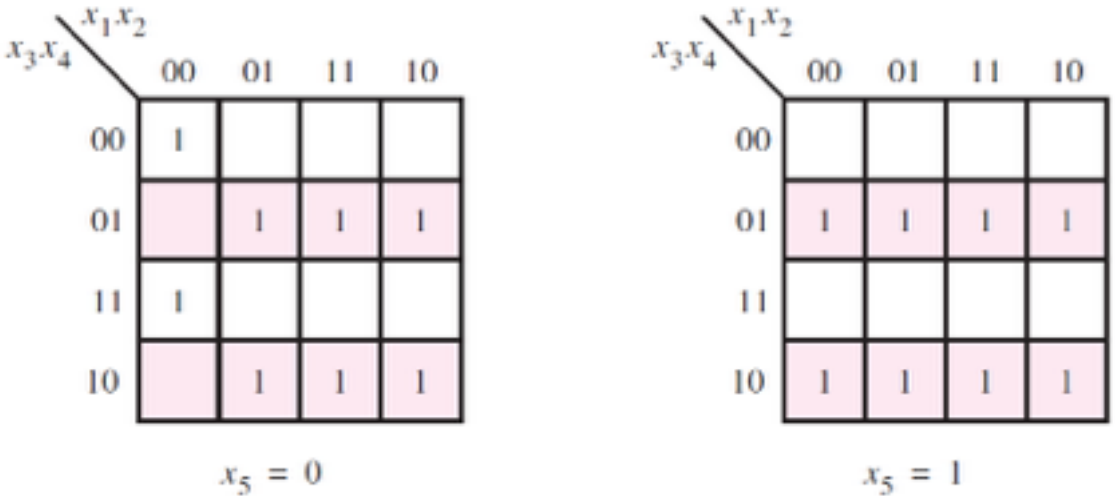
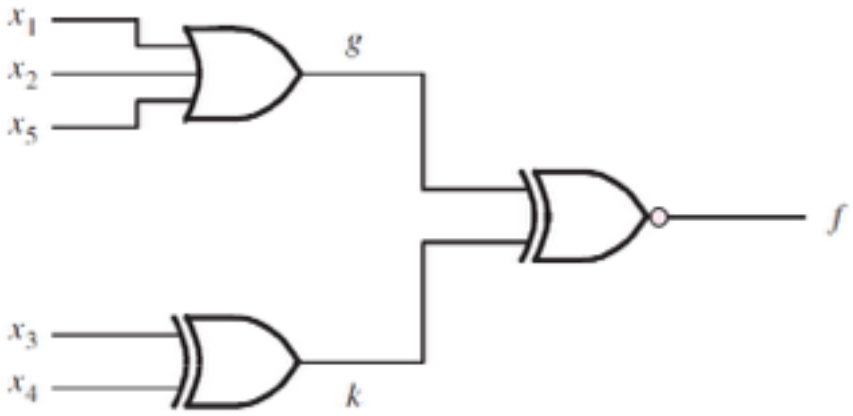


Figure 8.7. Subfunctions used in decomposition.



(a) Karnaugh map for the function f



(b) Circuit obtained using decomposition

Figure 8.8. Decomposition for Example 8.3.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.9. Implementation of XOR.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.10. Conversion to a NAND-gate circuit.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.11. Conversion to a NOR-gate circuit.

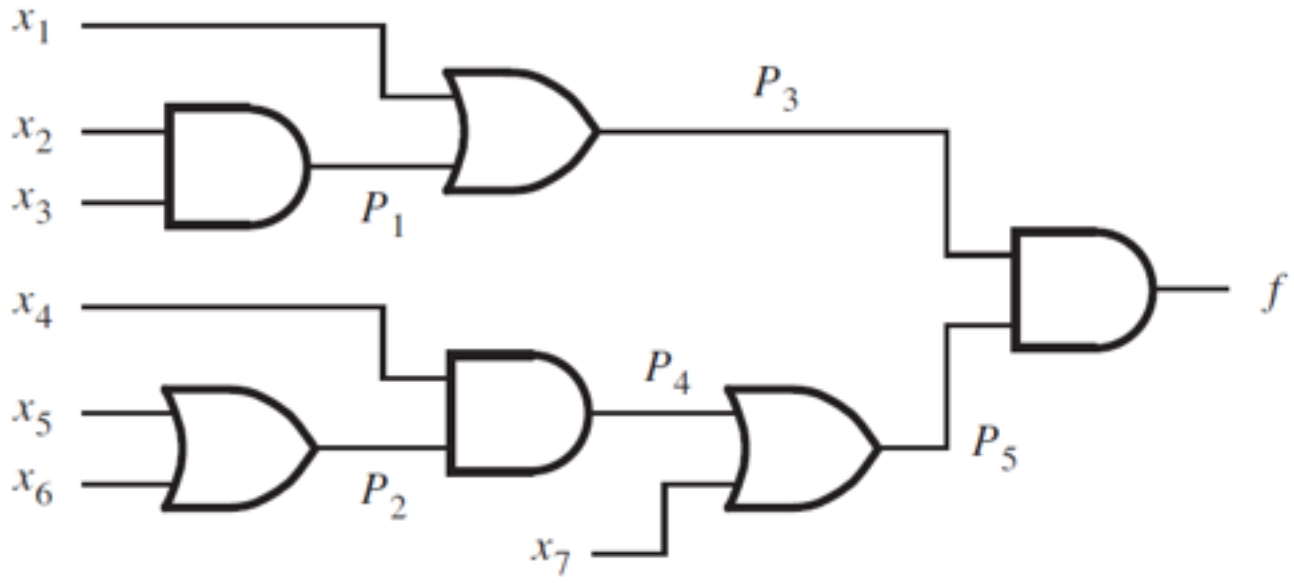


Figure 8.12. Circuit for Example 8.6.

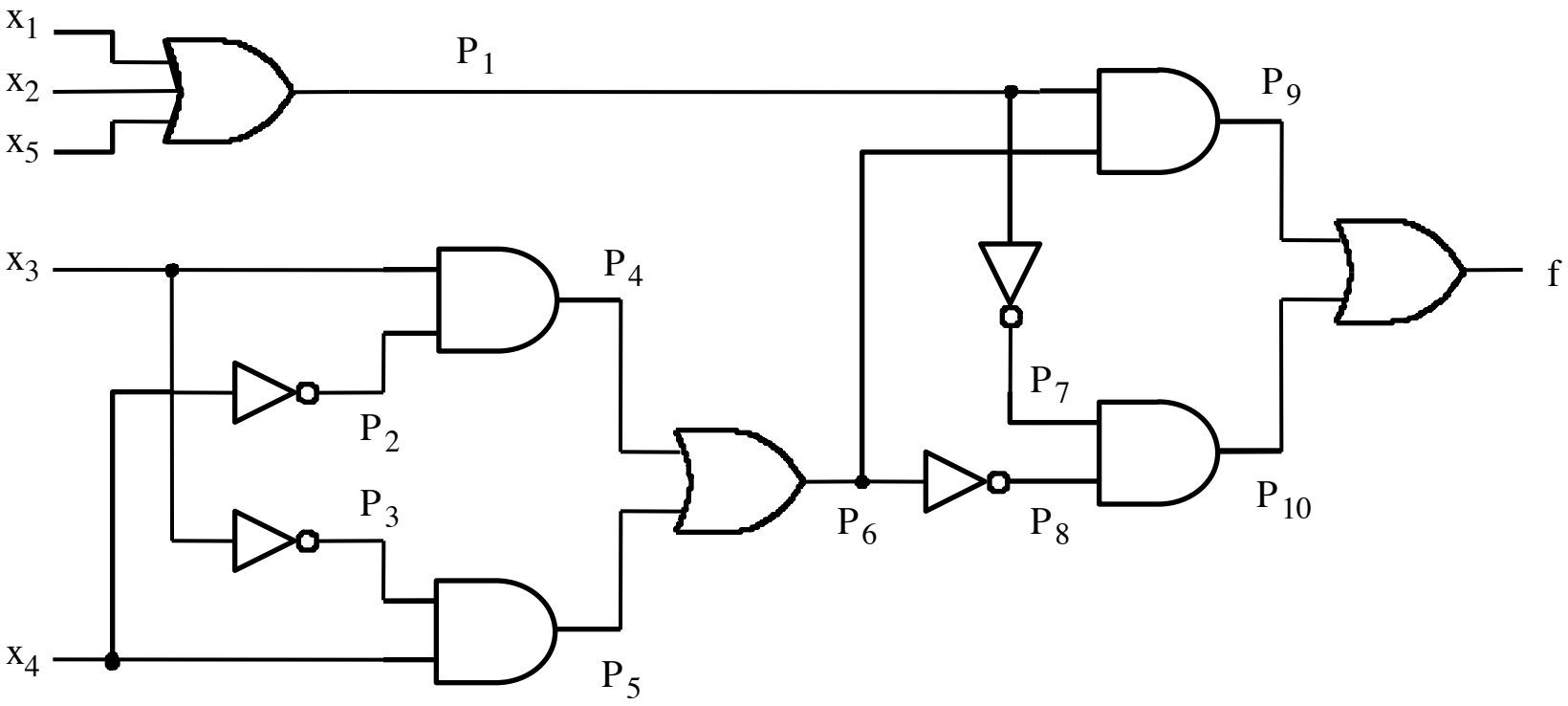


Figure 8.13. Circuit for Example 8.7.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.14. Circuit for Example 8.8.

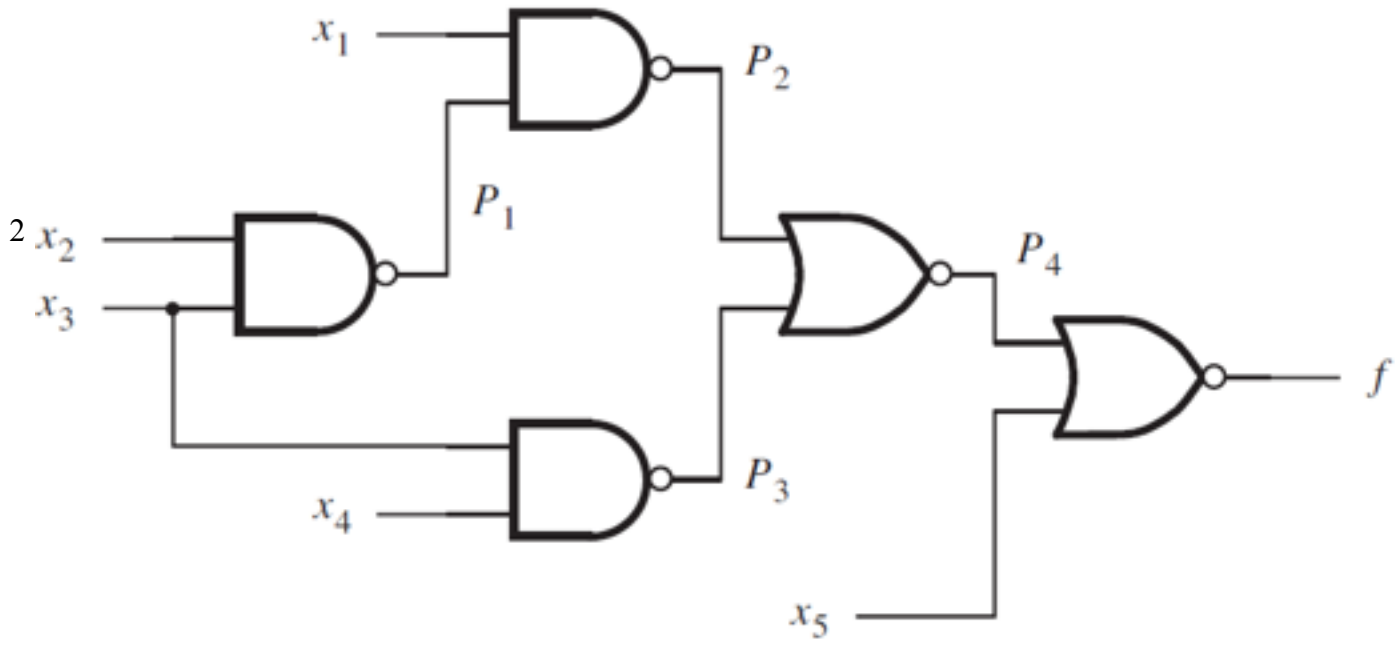
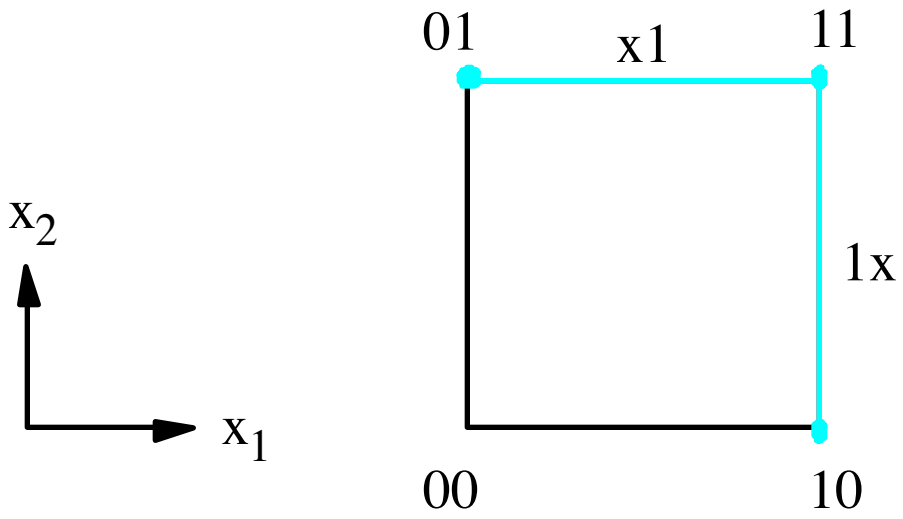


Figure 8.15. Circuit for Example 8.9.



x_1	x_2	f
0	0	0
0	1	1
1	0	1
1	1	1

Figure 8.16. Representation of $f(x_1, x_2) = \Sigma\, m(1, 2, 3)$.

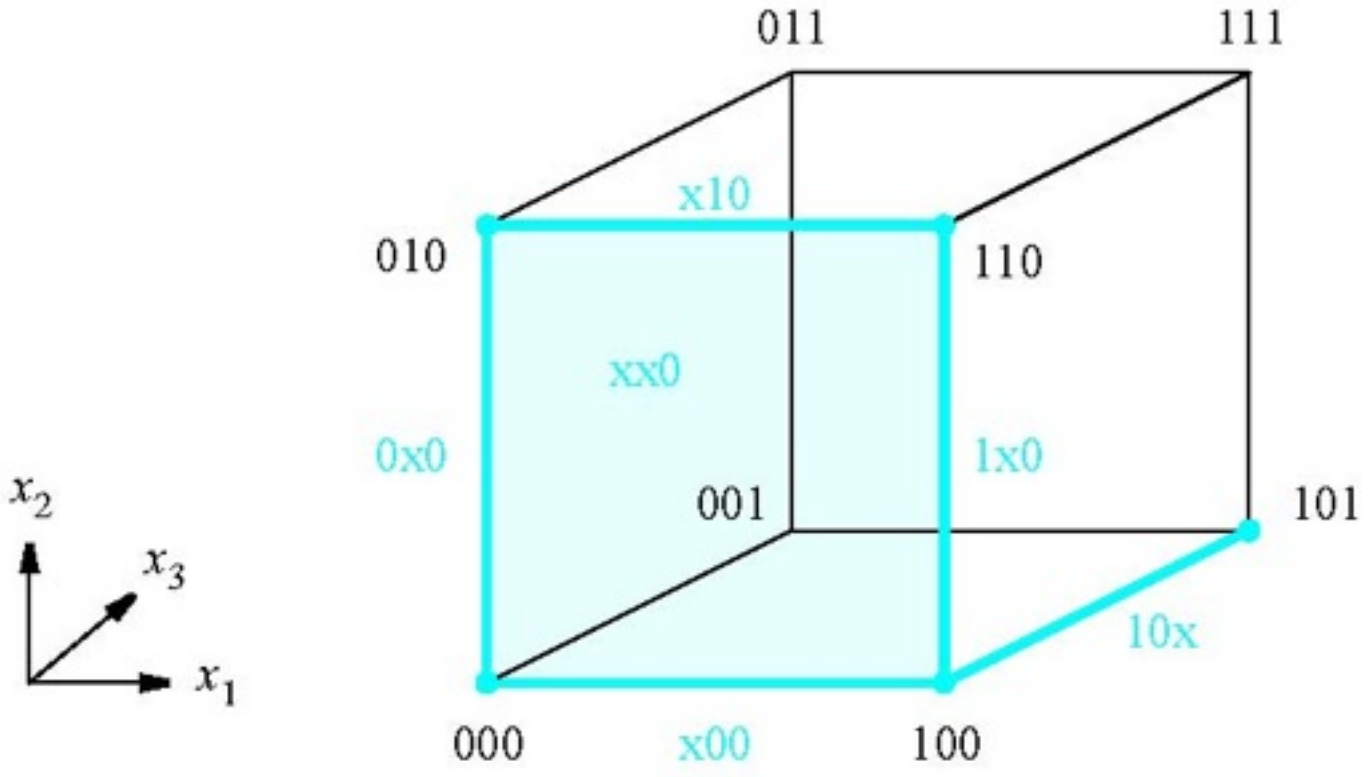


Figure 8.17. Representation of $f(x_1, x_2, x_3) = \Sigma\, m(0, 2, 4, 5, 6)$.

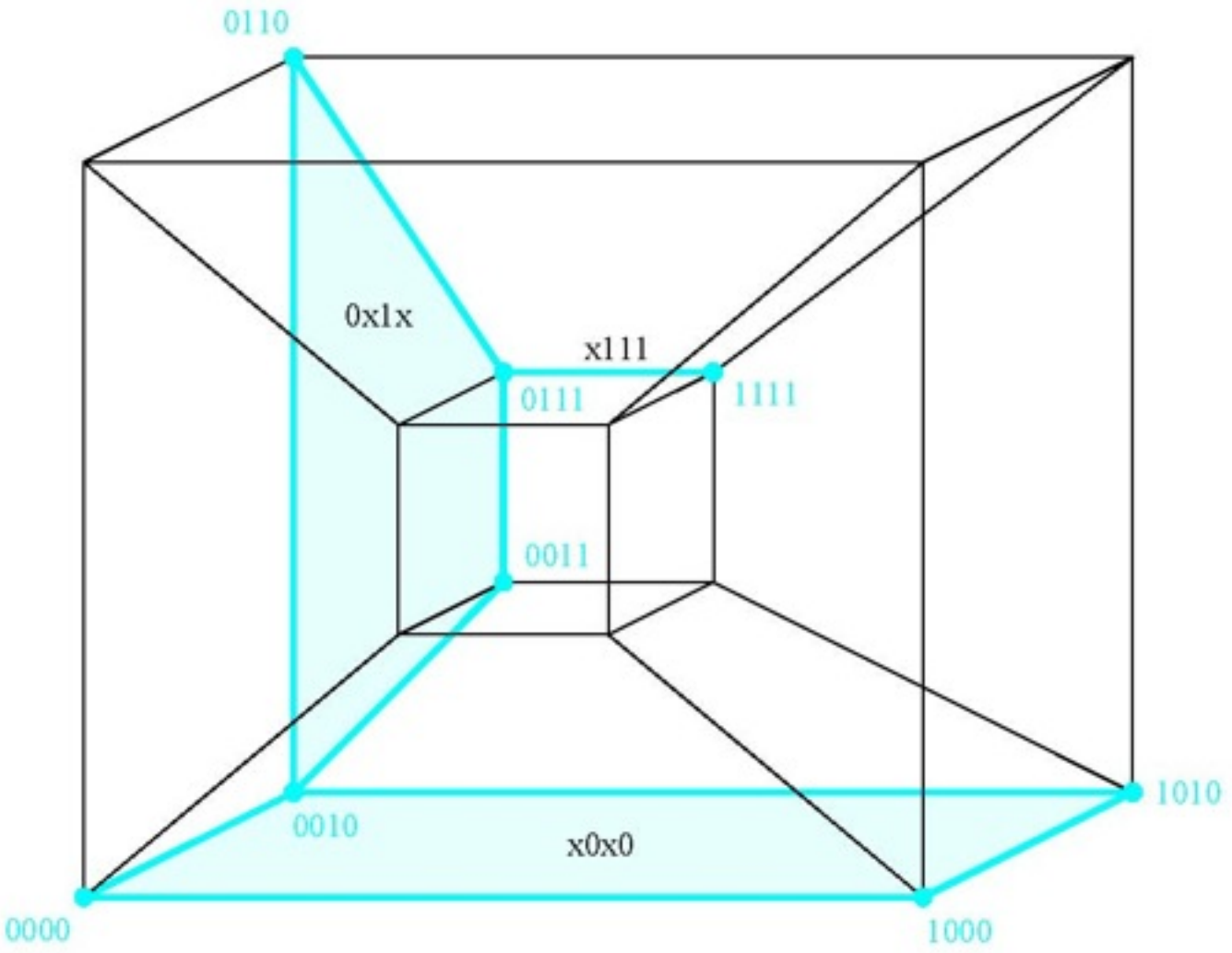
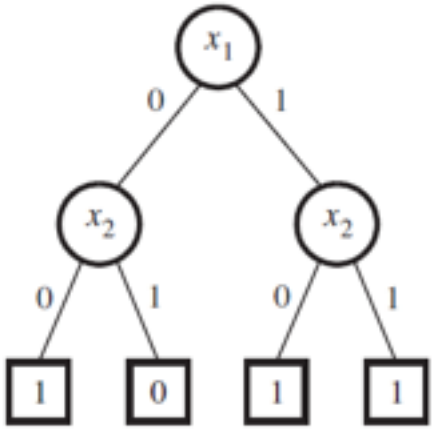


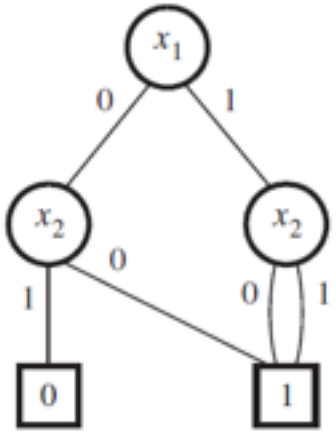
Figure 8.18. Representation of f_3 from Figure 2.54.

x_1	x_2	f
0	0	1
0	1	0
1	0	1
1	1	1

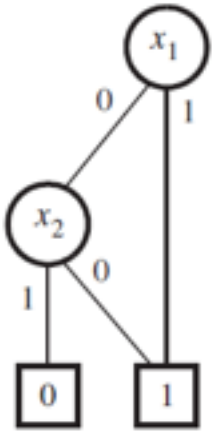
(a) Truth table



(b) Decision tree



(c) Reducing nodes



(d) BDD

Figure 8.19. Derivation of a binary decision diagram (BDD).

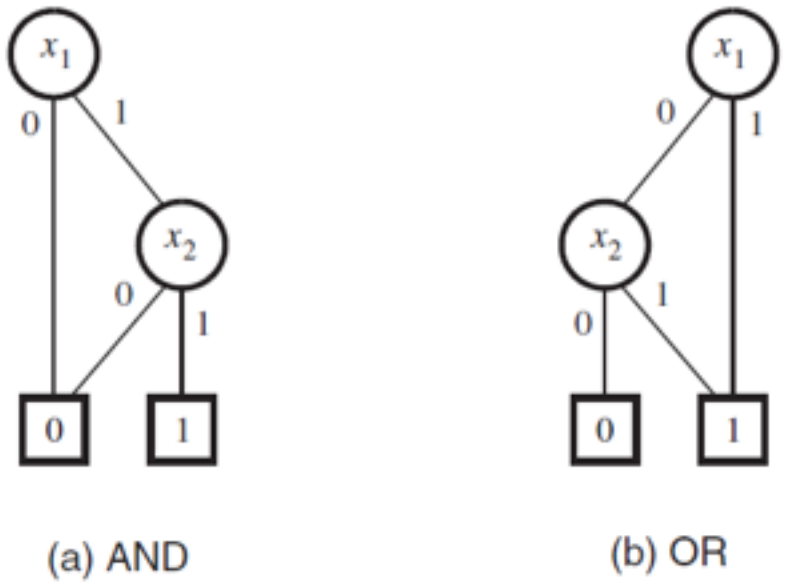


Figure 8.20. BDDs for the AND and OR functions.

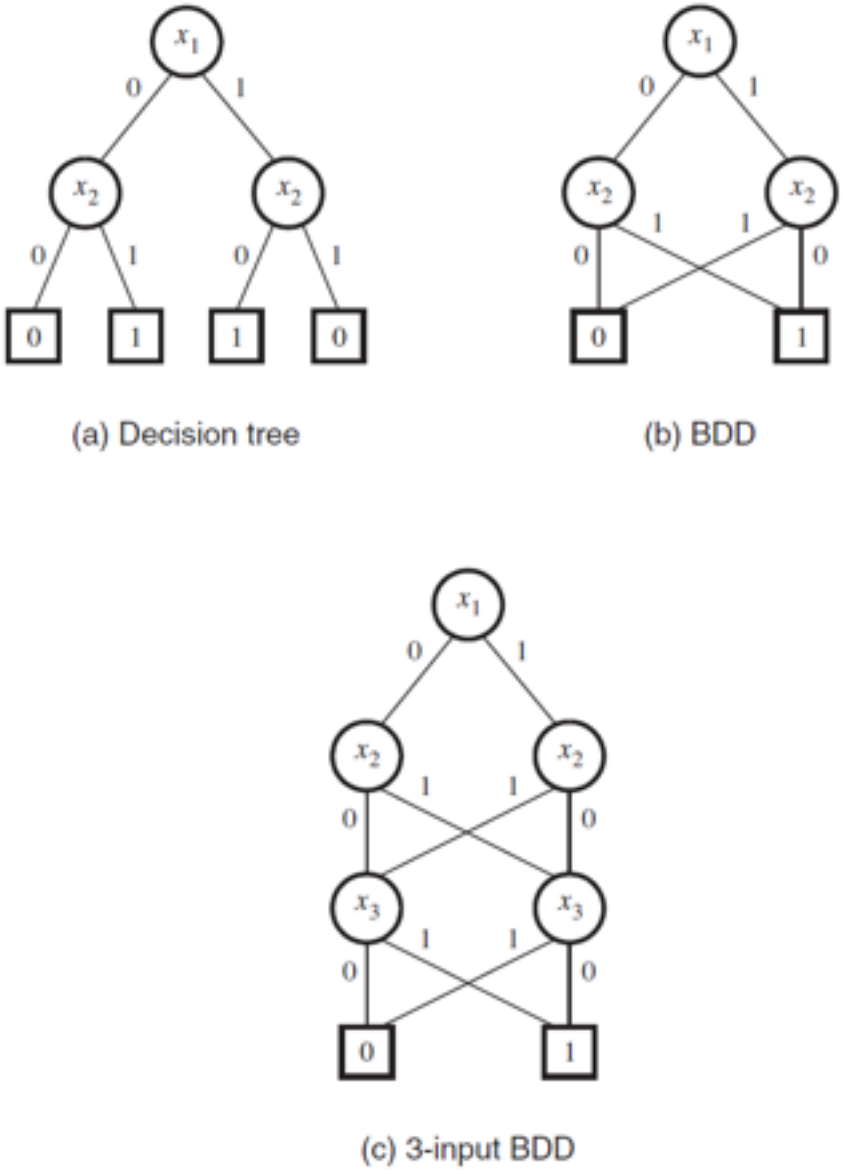


Figure 8.21. Derivation of BDDs for XOR functions.

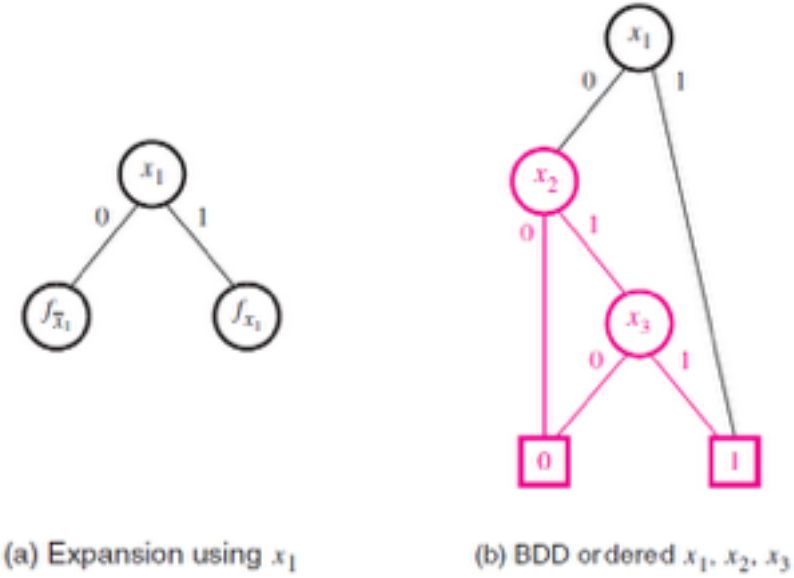
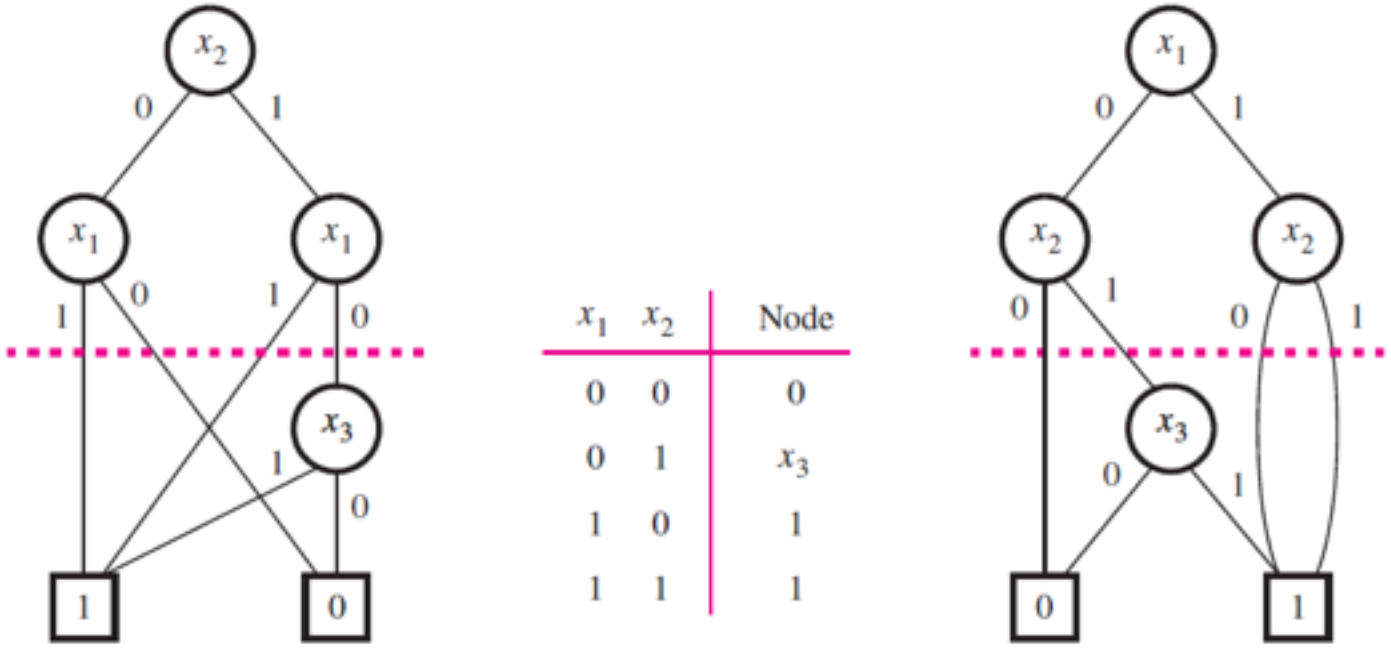


Figure 8.22. Derivation of BDDs for $f = x_1 + x_2 x_3$.



x_1	x_2	Node
0	0	0
0	1	x_3
1	0	1
1	1	1

(a) BDD ordered x_2, x_1, x_3

(b) Truth table

(c) Order x_1, x_2, x_3

Figure 8.23. Reordering the nodes in a BDD.

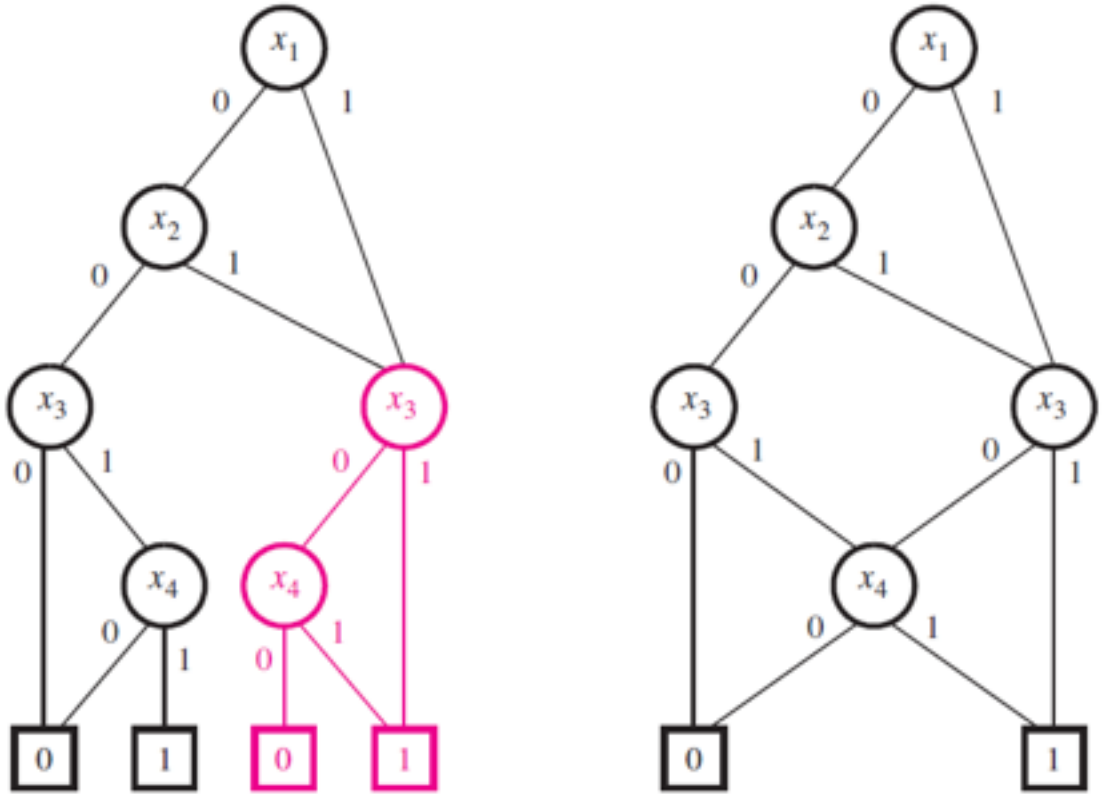


Figure 8.24. Derivation of a BDD for the function in Example 8.11.

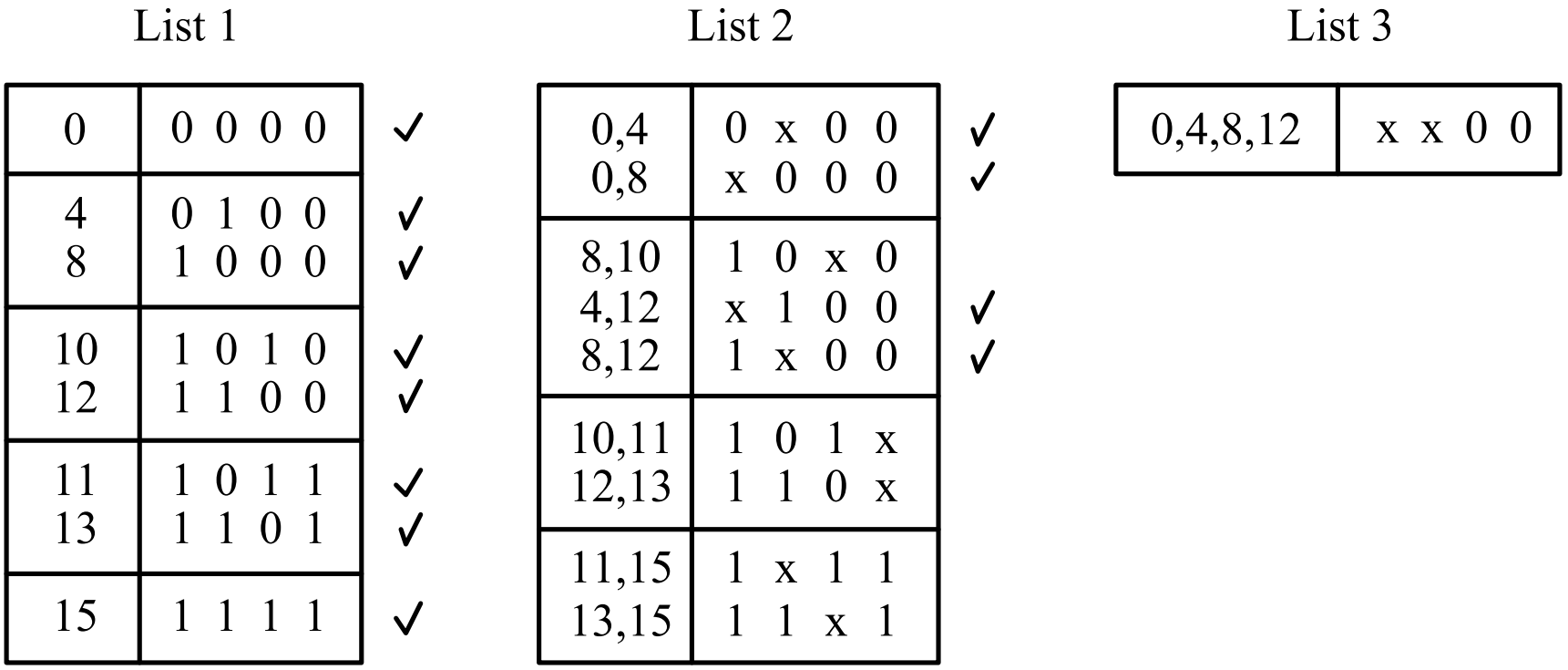


Figure 8.25. Generation of prime implicants for the function in Figure 2.58.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.26. Selection of a cover for the function in Figure 2.58.

List 1

0	0 0 0 0	✓
1	0 0 0 1	✓
2	0 0 1 0	✓
8	1 0 0 0	✓
5	0 1 0 1	✓
6	0 1 1 0	✓
9	1 0 0 1	✓
12	1 1 0 0	✓
7	0 1 1 1	✓
13	1 1 0 1	✓
15	1 1 1 1	✓

List 2

0,1	0 0 0 x	✓
0,2	0 0 x 0	
0,8	x 0 0 0	✓
1,5	0 x 0 1	✓
2,6	0 x 1 0	
1,9	x 0 0 1	✓
8,9	1 0 0 x	✓
8,12	1 x 0 0	✓
5,7	0 1 x 1	✓
6,7	0 1 1 x	
5,13	x 1 0 1	✓
9,13	1 x 0 1	✓
12,13	1 1 0 x	✓
7,15	x 1 1 1	✓
13,15	1 1 x 1	✓

List 3

0,1,8,9	x 0 0 x
1,5,9,13	x x 0 1
8,9,12,13	1 x 0 x
5,7,13,15	x 1 x 1

Figure 8.27. Generation of prime implicants for the function in Example 8.12.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.28. Selection of a cover for the function in Example 8.12.

Please see “portrait orientation” PowerPoint file for Chapter 8

Figure 8.29. Selection of a cover for the function in Example 8.13.

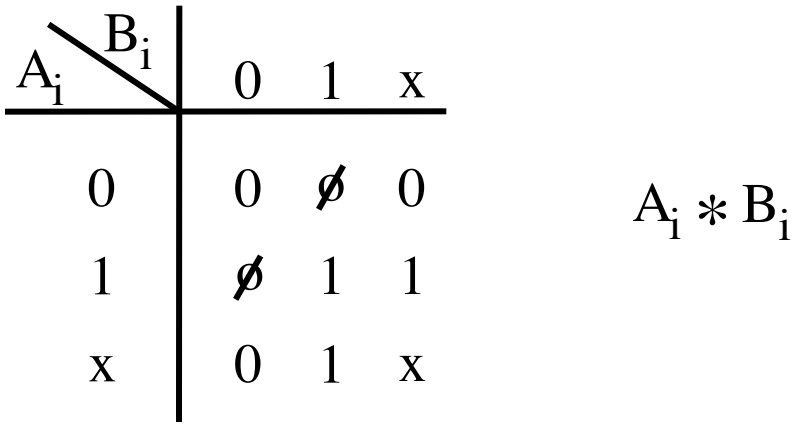


Figure 8.30. The coordinate *-operation.

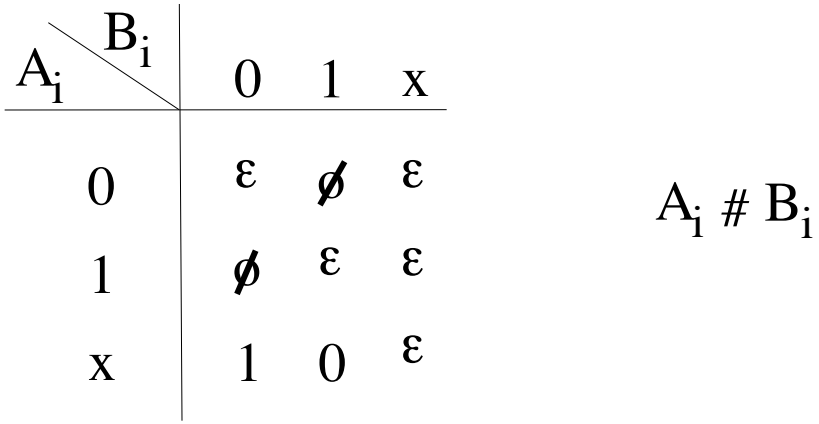


Figure 8.31. The coordinate #-operation.

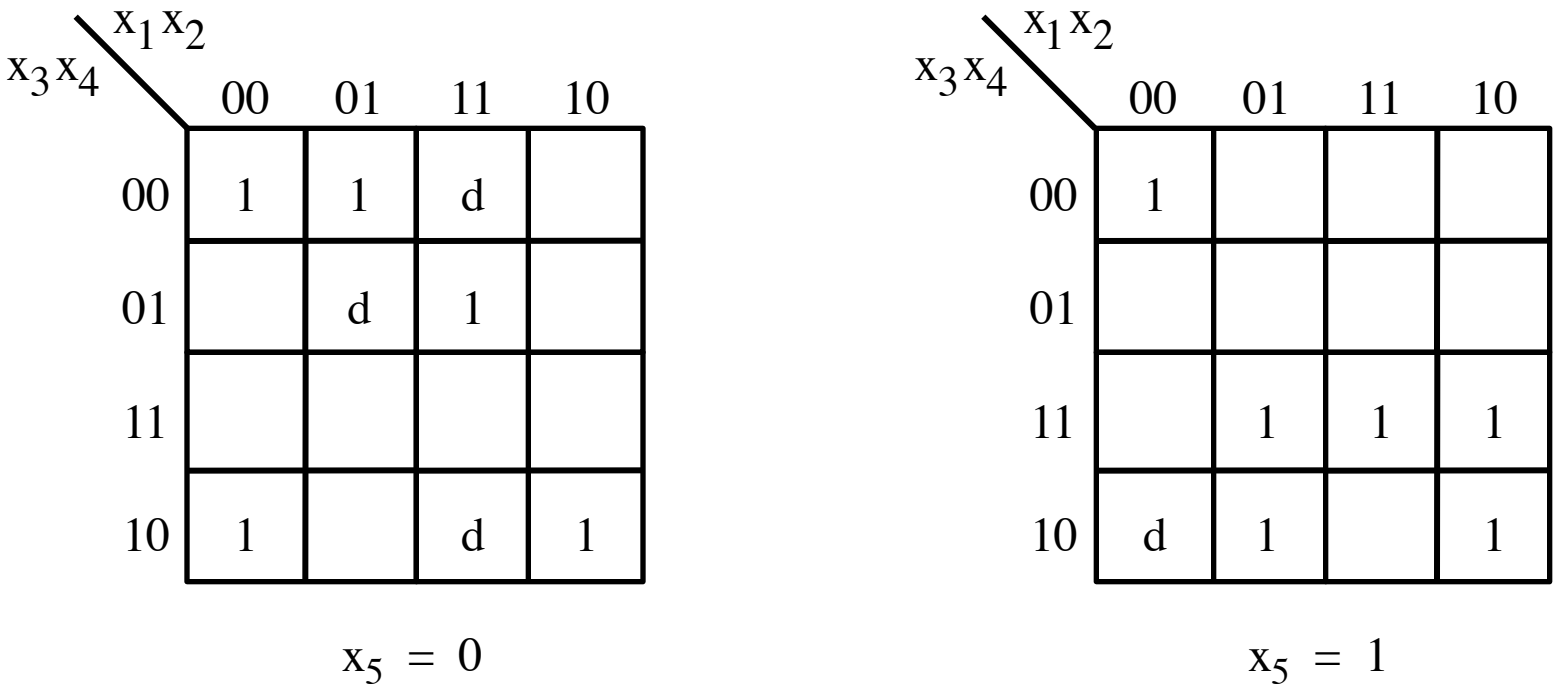


Figure 8.32. The function for Example 8.18.

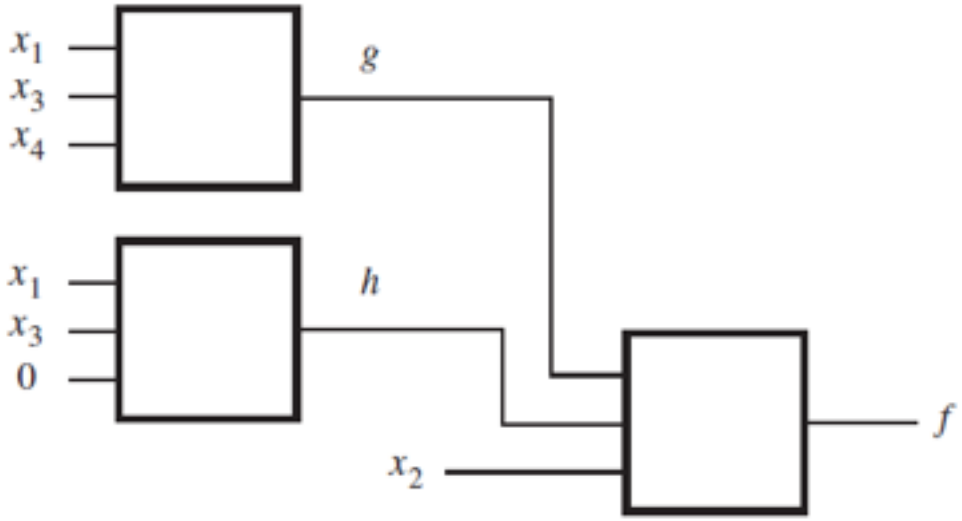


Figure 8.33. The function in Example 8.19.

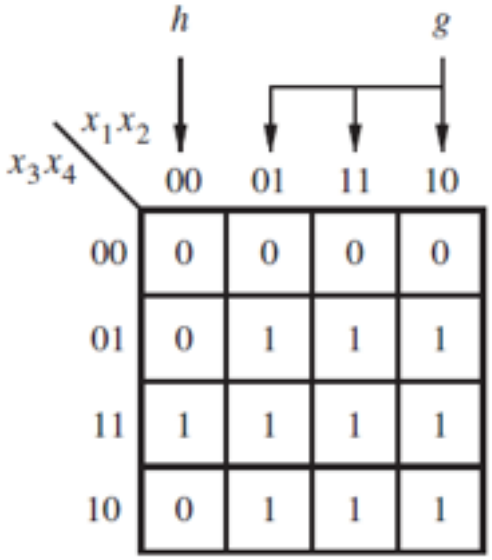


Figure 8.34. The function for Example 8.20.

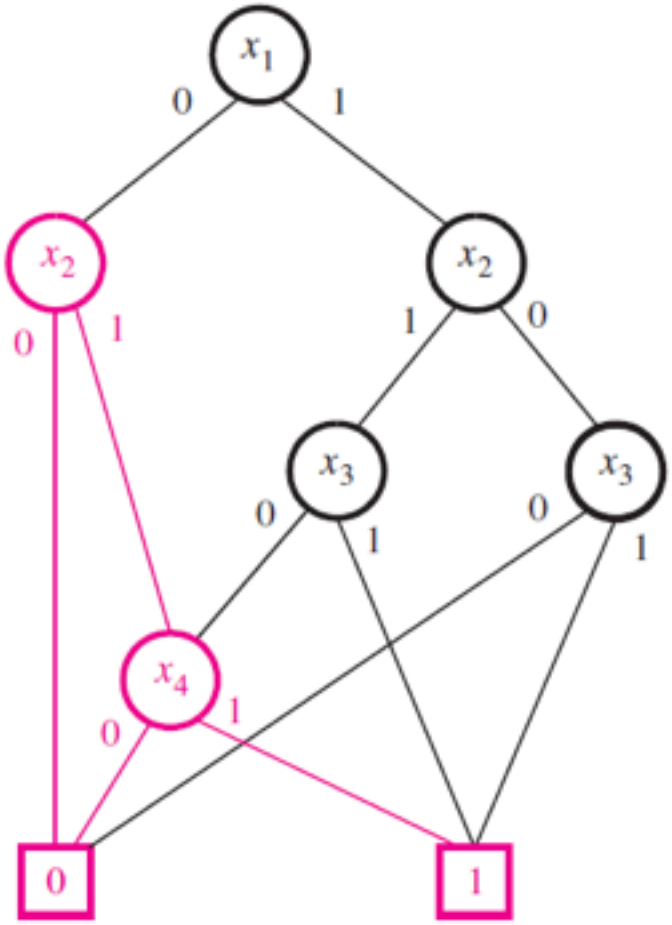
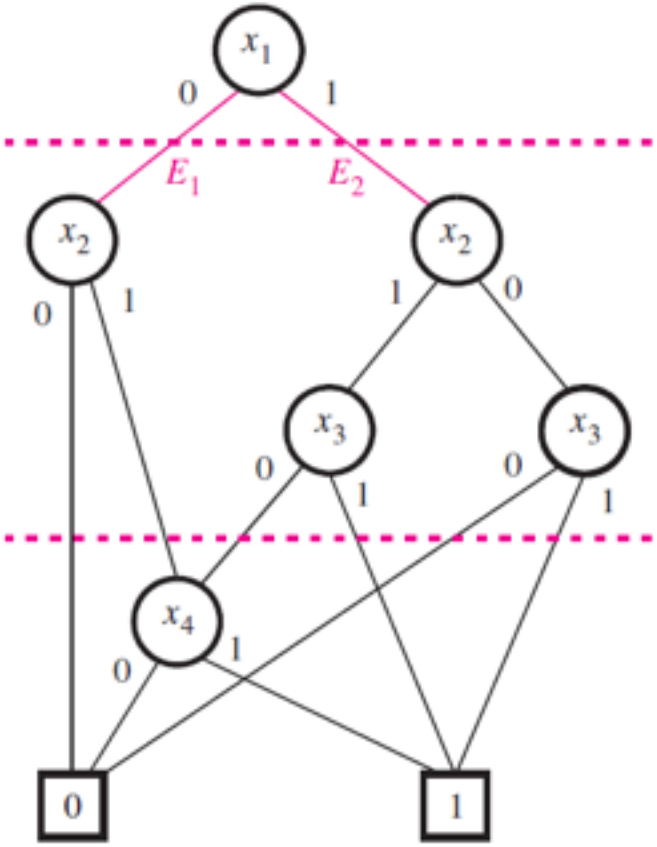


Figure 8.35. The BDD for Example 8.21.



(a) Isolating x_2 and x_3

x_2	x_3	E_2
0	0	0
0	1	1
1	0	x_4
1	1	1

(b) Truth table

Figure 8.36. Reordering the BDD in Figure 8.35.

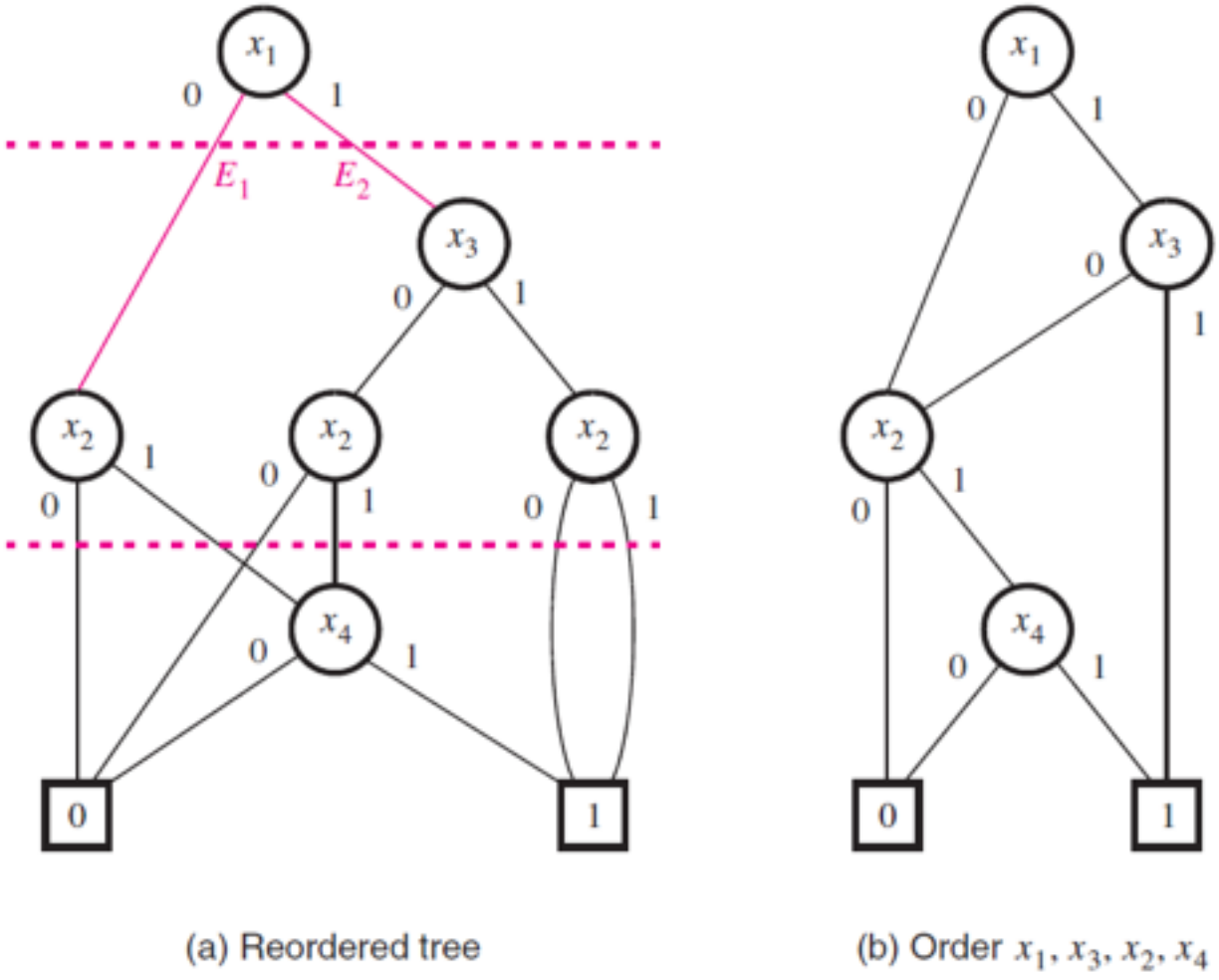


Figure 8.37. The BDD for Example 8.22.

List 1

0	0 0 0 0	✓
1	0 0 0 1	✓
4	0 1 0 0	✓
3	0 0 1 1	✓
9	1 0 0 1	✓
12	1 1 0 0	✓
7	0 1 1 1	✓
11	1 0 1 1	✓
13	1 1 0 1	✓
14	1 1 1 0	✓
15	1 1 1 1	✓

List 2

0,1	0 0 0 x	
0,4	0 x 0 0	
1,3	0 0 x 1	✓
1,9	x 0 0 1	✓
4,12	x 1 0 0	
3,7	0 x 1 1	✓
3,11	x 0 1 1	✓
9,11	1 0 x 1	✓
9,13	1 x 0 1	✓
12,13	1 1 0 x	✓
12,14	1 1 x 0	✓
7,15	x 1 1 1	✓
11,15	1 x 1 1	✓
13,15	1 1 x 1	✓
14,15	1 1 1 x	✓

List 3

1,3,9,11	x 0 x 1
3,7,11,15	x x 1 1
9,11,13,15	1 x x 1
12,13,14,15	1 1 x x

Figure 8.38. Generation of prime implicants for the function in Example 8.23.

Prime implicant	Minterm 0	1	3	4	7	11	13	15
$p_1 = 0\ 0\ 0\ x$	✓	✓						
$p_2 = 0\ x\ 0\ 0$	✓			✓				
$p_3 = x\ 1\ 0\ 0$				✓				
$p_4 = x\ 0\ x\ 1$		✓	✓			✓		
$p_5 = x\ x\ 1\ 1$			✓		✓	✓		✓
$p_6 = 1\ x\ x\ 1$						✓	✓	✓
$p_7 = 1\ 1\ x\ x$							✓	✓

(a) Initial prime implicant cover table

Prime implicant	Minterm 0	1	4	13
$p_1 = 0\ 0\ 0\ x$	✓	✓		
$p_2 = 0\ x\ 0\ 0$	✓		✓	
$p_4 = x\ 0\ x\ 1$		✓		
$p_6 = 1\ x\ x\ 1$				✓

(b) After the removal of rows p_3, p_5 and p_7, and columns 3, 7, 11 and 15

Figure 8.39. Selection of a cover for the function in Example 8.23.

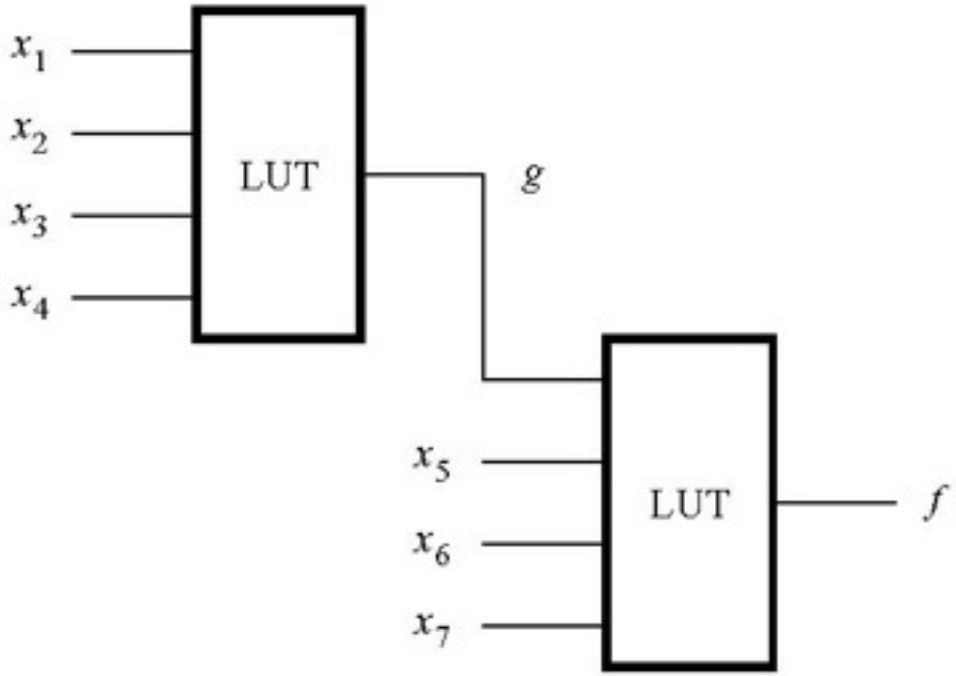


Figure 8.40. Circuit for Example 8.26.

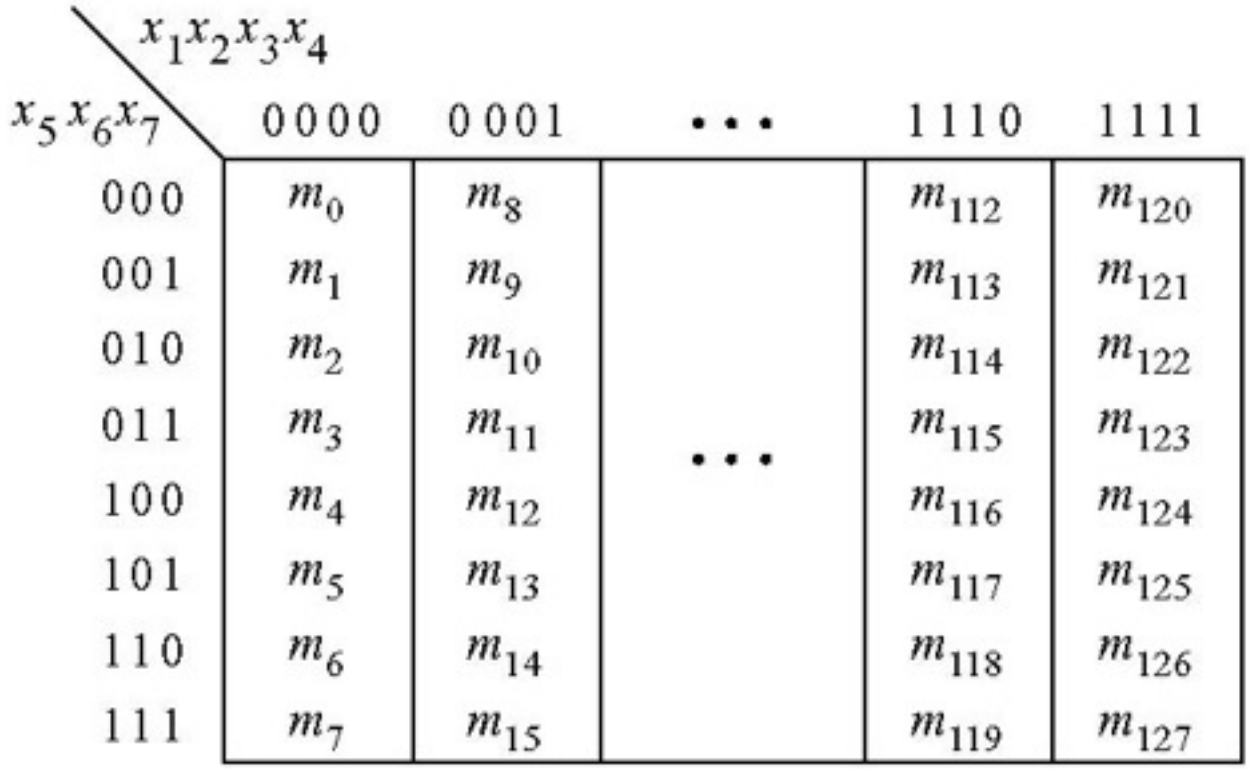


Figure 8.41. A possible format for truth tables of seven-variable functions.

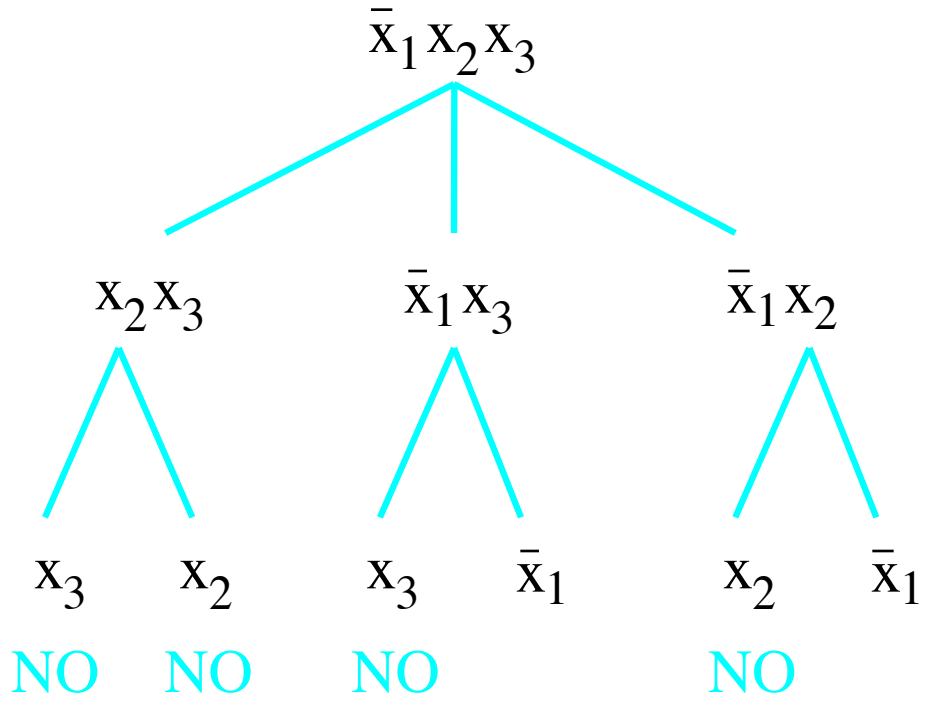


Figure P8.1. Expansion of implicant $x_1x_2x_3$.

Please see “portrait orientation” PowerPoint file for Chapter 4

Figure P4.2. Circuit for problem 4.33.

Please see “portrait orientation” PowerPoint file for Chapter 4

Figure P4.3. Circuit for problem 4.34.