Chapter 5

Exercise 5.2

(a) the K-map for $E(x,y,z) = \sum m(1,5,7)$ is:

z

	0	1	0	0
x	0	1	1	0

y

(b)$E(w,x,y,z) = w'x'y + y'z + xz'$

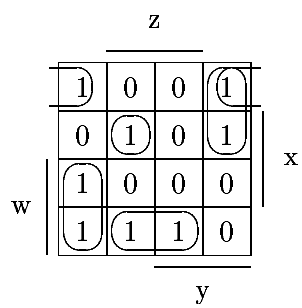
z

	0	1	1	1	
	1	1	0	1	x
w	1	1	0	1	x
w	0	1	0	0	

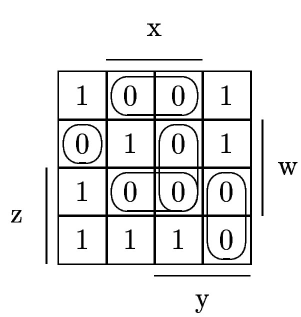
y

Exercise 5.6

(a) $E(w,x,y,z) = \prod M(1,3,4,7,10,13,14,15) = \sum m(0,2,5,6,8,9,11,12)$



minimal sum of products: $wy'z' + wx'z + w'x'z' + w'yz' + w'xy'z$



minimal product of sums: $(w+x+z')(w'+y'+z)(x'+y'+z')(w'+x'+z')(w+x'+y+z)$

(b)$E(w,x,y,z) = \sum m(0,4,5,9,11,14,15), dc(w,x,y,z) = \sum m(2,8)$

		z			
	1	0	0	-	
	1	1	0	0	x
w	0	0	1	1	
	-	1	1	0	
			y		

minimal SP: $w'y'z' + w'y'x + wx'z + wxy$

		z			
	1	0	0	-	
	1	1	0	0	x
w	0	0	1	1	
	-	1	1	0	
			y		

minimal PS: (w+x+z')(w+y')(x+y'+z)(w'+x'+y)

(c) $E(x,y,z) = \sum m(0,1,4,6) = \prod M(2,3,5,7)$

		z		
	1	1	0	0
x	1	0	0	1
			y	

minimal sum of products: $x'y' + xz'$

		z		
	1	1	0	0
x	1	0	0	1
			y	

minimal product of sums: $(x + y')(x' + z')$

Exercise 5.8

Input: (a, b, c, d), with $a, b, c, d \in \{0, 1\}$

Output: $y \in \{0, 1\}$

Function:

$$y = \begin{cases} 1 & \text{if } (8a + 4b + 2c + d) \text{ is prime} \\ 0 & \text{otherwise} \end{cases}$$

input value	abcd	y
0	0000	0
1	0001	0
2	0010	1
3	0011	1
4	0100	0
5	0101	1
6	0110	0
7	0111	1
8	1000	0
9	1001	0
10	1010	0
11	1011	1
12	1100	0
13	1101	1
14	1110	0
15	1111	0

d

	0	0	1	1
b	0	1	1	0
a, b	0	1	0	0
a	0	0	1	0

c

From the Kmap we get the following prime implicants: $a'bd$, $b'cd$, $a'b'c$, $a'cd$, and $bc'd$

The essential prime implicants are: $b'cd$, $a'b'c$, and $bc'd$

A minimal sum of products for function y is:

$$y = b'cd + a'b'c + bc'd + a'cd$$

and the gate network that implements this expression is shown in Figure **??**.

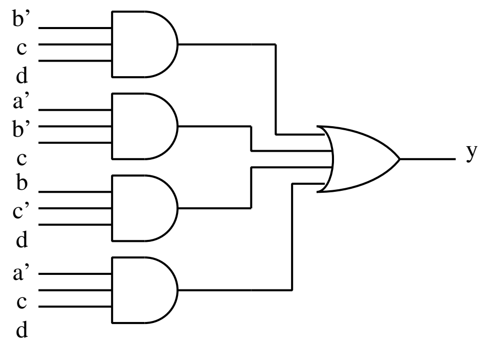
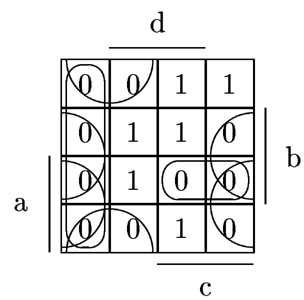


Figure 5.1: AND-OR gate network for "prime detector" (Exercise 5.8)



From the Kmap we get the following prime implicates: $(b'+d), (a'+d), (b+c), (c+d)$ and $(a'+b'+c')$. Only the $(c+d)$ prime implicate is not essential. So, the minimal product of sums in this case is:

$$y = (b'+d)(a'+d)(b+c)(a'+b'+c')$$

and the gate network that implements this expression is shown in Figure **??**. Notice that the cost of the product of sums is lower.

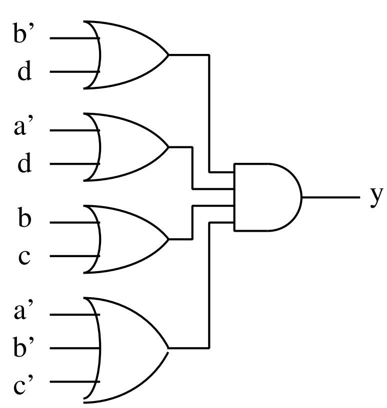


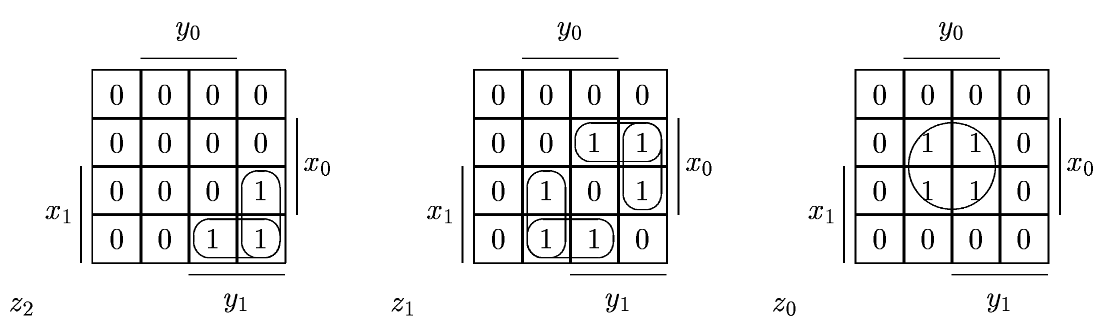
Figure 5.2: OR-AND gate network for "prime detector" (Exercise 5.8)

Exercise 5.14

The multiplier is specified as follows:
Inputs: x, y where $x, y \in \{0, 1, 2, 3\}$
Output: $z \in \{0, 1, 2, 3, 4, 6, 9\}$
Function: $z = x \cdot y$
Coding the inputs and outputs in a binary code, produces the switching function of the following table:

x		y		z			
x_1	x_0	y_1	y_0	z_3	z_2	z_1	z_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	1	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	1
0	1	1	0	0	0	1	0
0	1	1	1	0	0	1	1
1	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0
1	0	1	0	0	1	0	0
1	0	1	1	0	1	1	0
1	1	0	0	0	0	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	1	1	0
1	1	1	1	1	0	0	1

From the table we get the following K-maps and expressions for the multiplier binary outputs:



$z_0 = x_0 y_0$
$z_1 = x_1 x_0' y_0 + x_0 y_1 y_0' + x_1' x_0 y_1 + x_1 y_1' y_0$
$z_2 = x_1 x_0' y_1 + x_1 y_1 y_0'$
Output z_3 corresponds to only one minterm (no Kmap is needed in this case):
$z_3 = x_1 x_0 y_1 y_0$
The NAND-NAND network is obtained directly from the sum of products. The correspoding network is presented in Figure **??**.

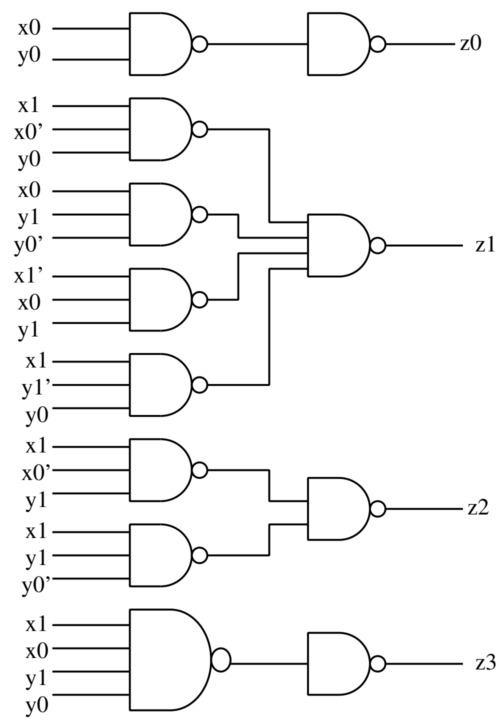


Figure 5.3: Network for a 2x2 bit multiplier. Exercise 5.14

Exercise 5.18 A high-level specification for the system is:
Input: x is a decimal digit, represented in BCD
Output: y is an unsigned integer represented in binary
Function: $y = x^2$
The switching functions for this exercise are given as:

x (BCD)	$y = x^2$ (Binary)
0000	0000000
0001	0000001
0010	0000100
0011	0001001
0100	0010000
0101	0011001
0110	0100100
0111	0110001
1000	1000000
1001	1010001

Using K-maps we obtain:

$$\begin{aligned} y_0 &= x_0 \\ y_1 &= 0 \\ y_2 &= x_1 x_0' \end{aligned}$$

$$\begin{aligned}
y_3 &= x_2'x_1x_0 + x_2x_1'x_0 \\
y_4 &= x_2x_1' + x_2x_0 \\
y_5 &= x_2x_1 \\
y_6 &= x_3
\end{aligned}$$

The PLA implementation of this system is shown in figure **??**.

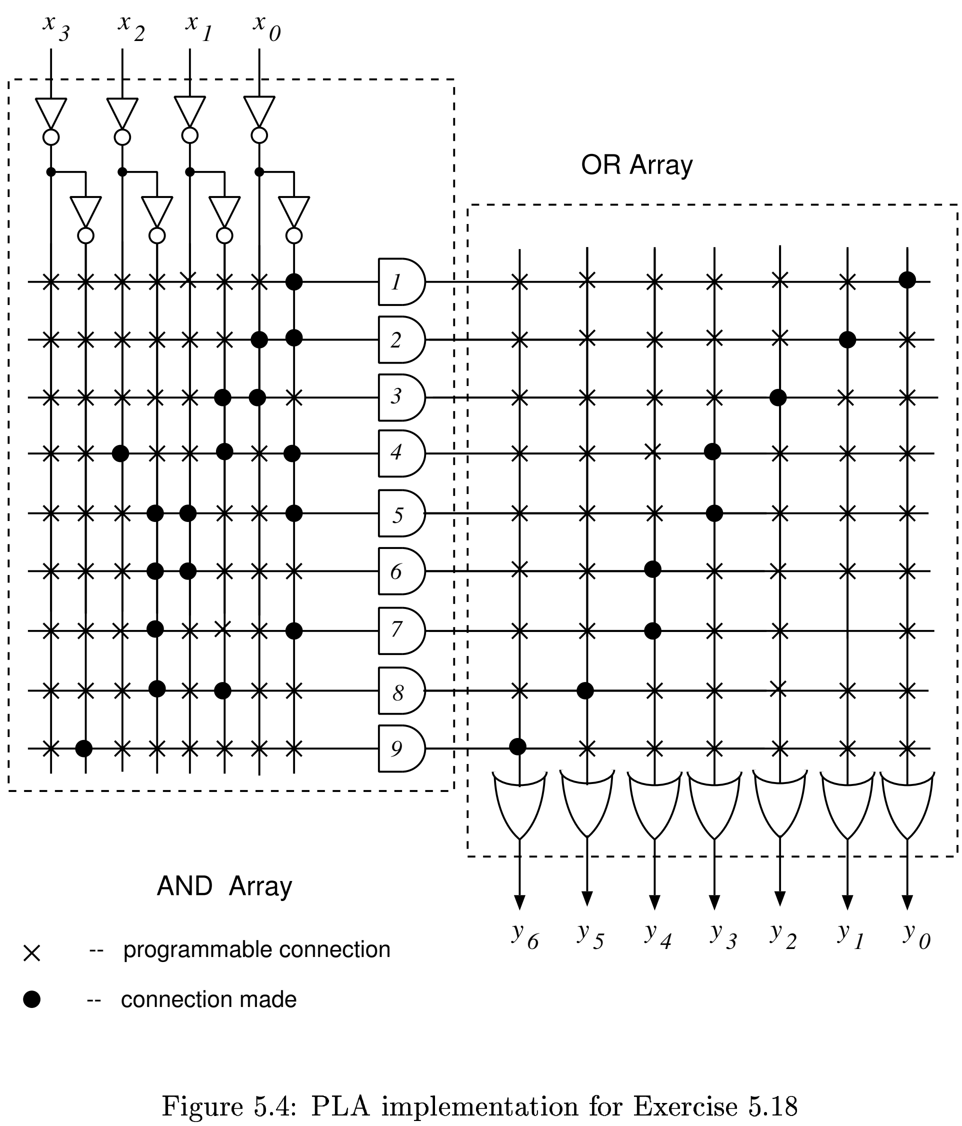


Figure 5.4: PLA implementation for Exercise 5.18