ECE 272 Pre-Lab 3
Fall 2018

Combinational Logic (Seven Segment Driver)

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Design a 7 segment display decoder.

A seven-segment display is an electronic device that uses seven LEDs to display decimal digits (0 - 9). The seven segments are arranged like an italic 8 and have an alphabetical order, as illustrated by Figure 1 below:

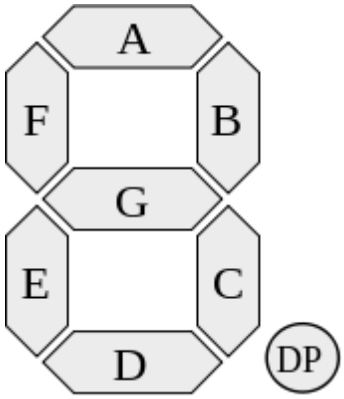

Figure 1: The LED segments and their order in a seven-segment display. Source

Depending on the input (0 - 9), some LEDs will turn on or off to form a pattern that illustrates the according decimal digit. Based on this concept, the input (0 - 9) can be represented as a 4-bit binary number—as circuits, logic, and computers operate in binary. The decimal digit patterns of the seven-segment display are as in Figure 2 below:

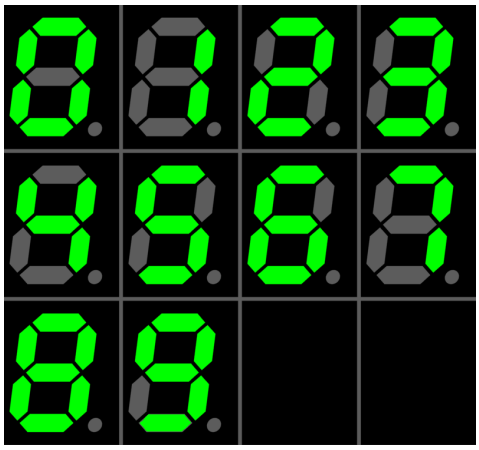

Figure 2: Decimal digits illustrated by a seven-segment display. Source

Based on these concepts, a truth table converting 4-bit binary numbers to decimal digits on a seven-segment display is shown in Table **??**.

Digit	4-bit input				7-segment output						
	A	**B**	**C**	**D**	**a**	**b**	**c**	**d**	**e**	**f**	**g**
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

Table 1: Truth table showing decimal digits' 4-bit binary inputs and their corresponding 7-segment outputs

To better grasp the layout of the input, output, and the decoder, the block diagrams of the seven-segment display is shown in Figure 3 below:

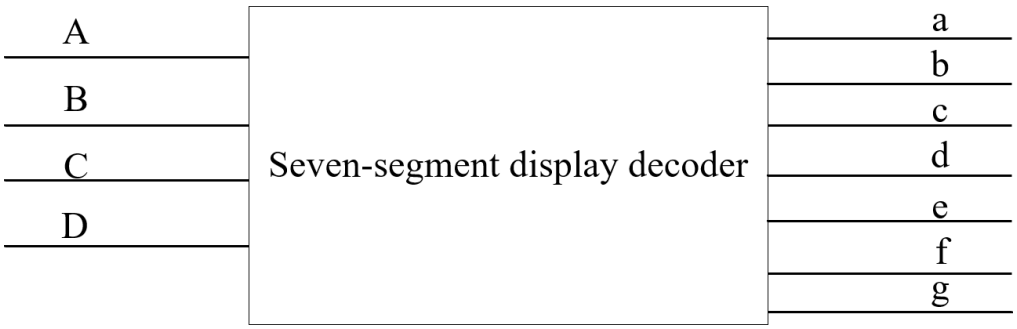

Figure 3: The block diagram of the design

Since the device is a decoder, it asserts exactly one of its outputs depending on the input combination. Based on Table 1, the following Karnaugh maps are constructed:

a

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	X	X	X	X
10	1	1	X	X

$a = BD + C + A + \bar{B}\bar{D}$

b

AB \ CD	00	01	11	10
00	1	1	1	1
01	1	0	1	0
11	X	X	X	X
10	1	1	X	X

$b = \bar{B} + \bar{C}\bar{D} + CD$

c

AB \ CD	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	X	X	X	X
10	1	1	X	X

$c = \bar{C} + CD + \bar{A}B$

d

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	X	X	X	X
10	1	1	X	X

$d = \bar{B}\bar{D} + \bar{B}C + C\bar{D} + A\bar{B}$

e

AB \ CD	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	X	X	X	X
10	1	0	X	X

$e = \bar{B}\bar{D} + C\bar{D}$

f

AB \ CD	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	X	X	X	X
10	1	1	X	X

$f = \bar{C}\bar{D} + B\bar{C} + B\bar{D} + A$

g

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	X	X	X	X
10	1	1	X	X

$g = A + B\bar{C} + C\bar{D} + \bar{B}C$

Based on these maps,

$$a = BD + C + A + \bar{B}\bar{D} \tag{1}$$

$$b = \bar{B} + \bar{C}\bar{D} + CD \tag{2}$$

$$c = \bar{C} + CD + \bar{A}B \tag{3}$$

$$d = \bar{B}\bar{D} + \bar{B}C + C\bar{D} + A\bar{B} \tag{4}$$

$$e = \bar{B}\bar{D} + C\bar{D} \tag{5}$$

$$f = \bar{C}\bar{D} + B\bar{C} + B\bar{D} + A \tag{6}$$

$$g = A + B\bar{C} + C\bar{D} + \bar{B}C \tag{7}$$

Using the simplified Boolean equation of a, b, c, and d, a schematic of the seven-segment display is as in Figure 4.

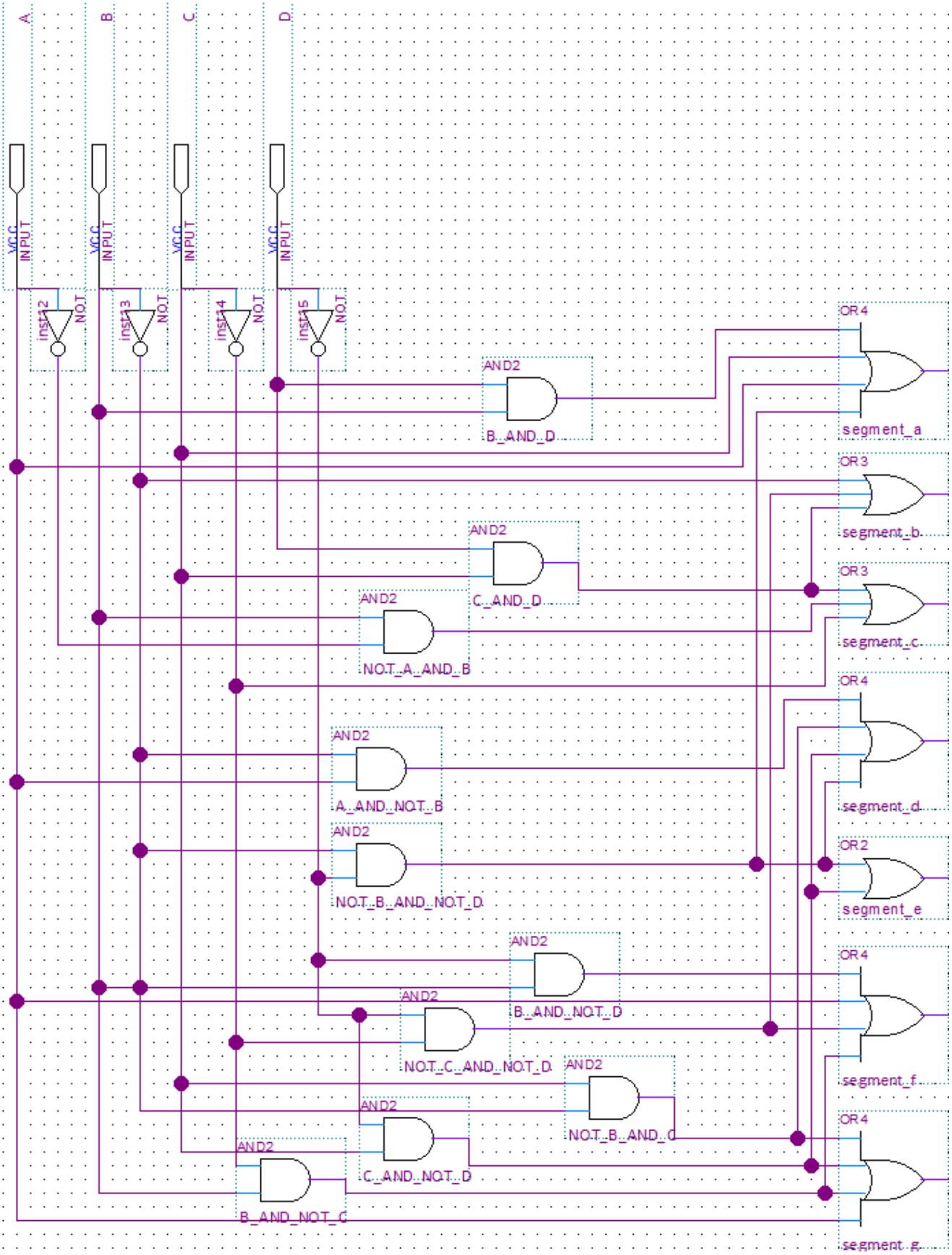

Figure 4: A schematic design of a seven-segment display. Due to limit of space, output pins were not illustrated.