Digital Design through Pygmy

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Contents

Abstract—In this document we show how to design a decade counter using Pygmy and boolean logic.

Display	Pygmy
a	IO_4
b	IO_5
c	IO_6
d	IO_7
e	IO_8
f	IO_10
g	IO_11
COM	3.3 V

Input Variable	Pin
W	IO_28
X	IO_23
Y	IO_31
Z	IO_12

TABLE 2.1.1: Pin connections between pygmy and the display.

1 Software

All codes used in this manual are available at the following link.

```
https://github.com/gadepall/vaman/
    tree/master/fpga/boolean/codes
```

2 Setup

2.1. Fig. 2.1.2 shows the pin diagram for the pygmy. Using the bank J5, connect the pins of the seven segment display in Fig. 2.1.1 to the pygmy according to Table 2.1.1. Make sure that the COM pin is connected to 3.3V through a resistor.

2.2. Implement Table 2.2.1 using the pygmy and the display.

Solution: In Table 2.2.1, the output variables a, b, c, d, e, f, g can be expressed in terms of the input variables W, X, Y, Z as

$$a = WX'Y'Z' + W'X'YZ' \tag{2.2.1}$$

$$b = WX'YZ' + W'XYZ' \tag{2.2.2}$$

$$c = Z'Y'XW' \tag{2.2.3}$$

$$d = WX'Y'Z' + W'X'YZ' + WXYZ' + WX'Y'Z \tag{2.2.4}$$

$$e = WX'Y'Z' + WXY'Z' + W'X'YZ' + WX'YZ' + WXYZ' + WX'Y'Z \tag{2.2.5}$$

$$f = WX'Y'Z' + W'XY'Z' + WXY'Z' + WXYZ' \tag{2.2.6}$$

$$g = W'X'Y'Z' + WX'Y'Z' + WXYZ' \tag{2.2.7}$$

Execute the following program.

```
codes/decoders/dispdec.v
codes/decoders/pygmy.pcf
```

Connect W, X, Y, Z to GND. For different values of the input variables, verify the output in on the display using Table 2.2.1.

2.3. Table 2.3.1 describes the properties of the incrementing decoder. Using Boolean logic, express A, B, C, D in terms of W, X, Y, Z. Subsequently, implement this decoder by implementing the the expressions so obtained in the pygmy using verilog.

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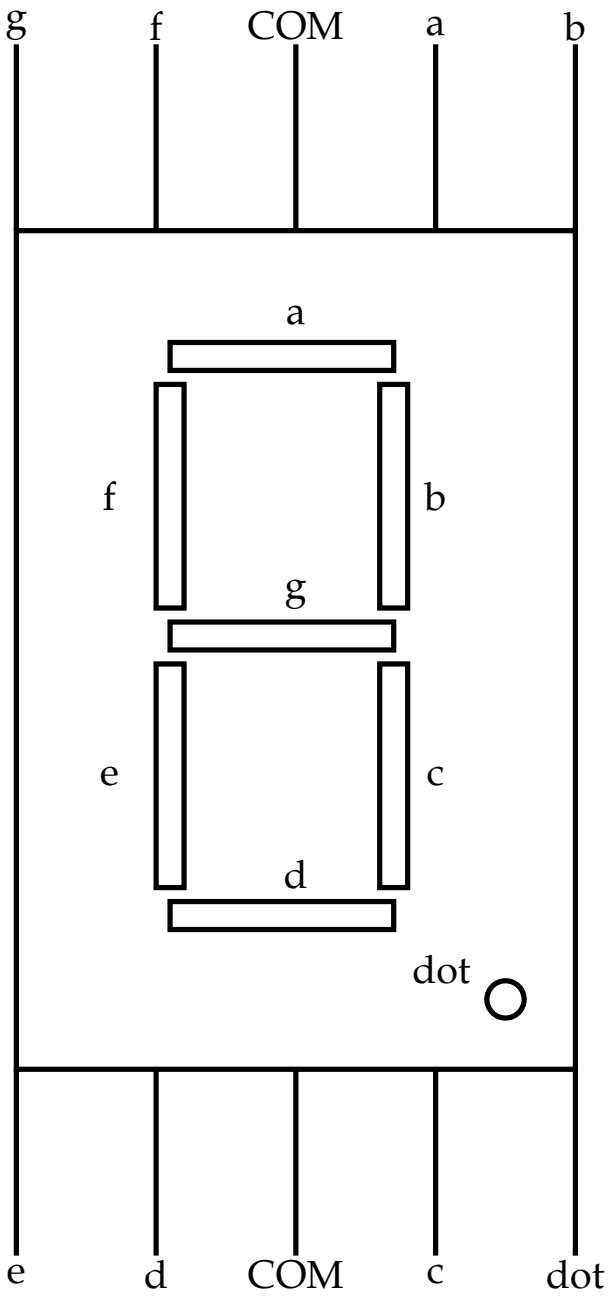

Fig. 2.1.1: Seven segement display

Solution: The following equations contain the desired expressions.

$$A = W'X'Y'Z' + W'XY'Z' + W'X'YZ' + W'XYZ' + W'X'Y'Z \quad (2.3.1)$$

$$B = WX'Y'Z' + W'XY'Z' + WX'YZ' + W'XYZ' \quad (2.3.2)$$

$$C = WXY'Z' + W'X'YZ' + WX'YZ' + W'XYZ' \quad (2.3.3)$$

$$D = WXYZ' + W'X'Y'Z \quad (2.3.4)$$

Z	Y	X	W	a	b	c	d	e	f	g	Decimal
0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	1	1	0	0	1	1	1	1	1
0	0	1	0	0	0	1	0	0	1	0	2
0	0	1	1	0	0	0	0	1	1	0	3
0	1	0	0	1	0	0	1	1	0	0	4
0	1	0	1	0	1	0	0	1	0	0	5
0	1	1	0	0	1	0	0	0	0	0	6
0	1	1	1	0	0	0	1	1	1	1	7
1	0	0	0	0	0	0	0	0	0	0	8
1	0	0	1	0	0	0	1	1	0	0	9

TABLE 2.2.1: Truth table for the display decoder.

Z	Y	X	W	D	C	B	A
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	0	0	0	0

TABLE 2.3.1: Truth table for the incrementing decoder.

Execute the following code. The next number should be displayed.

codes/decoders/incdec.v

3 Decade Counter

3.1. Using Fig. 3.1.1 and modifying the code in Problem 2.3, design the decade counter.

3.2. Design and implement the down counter.

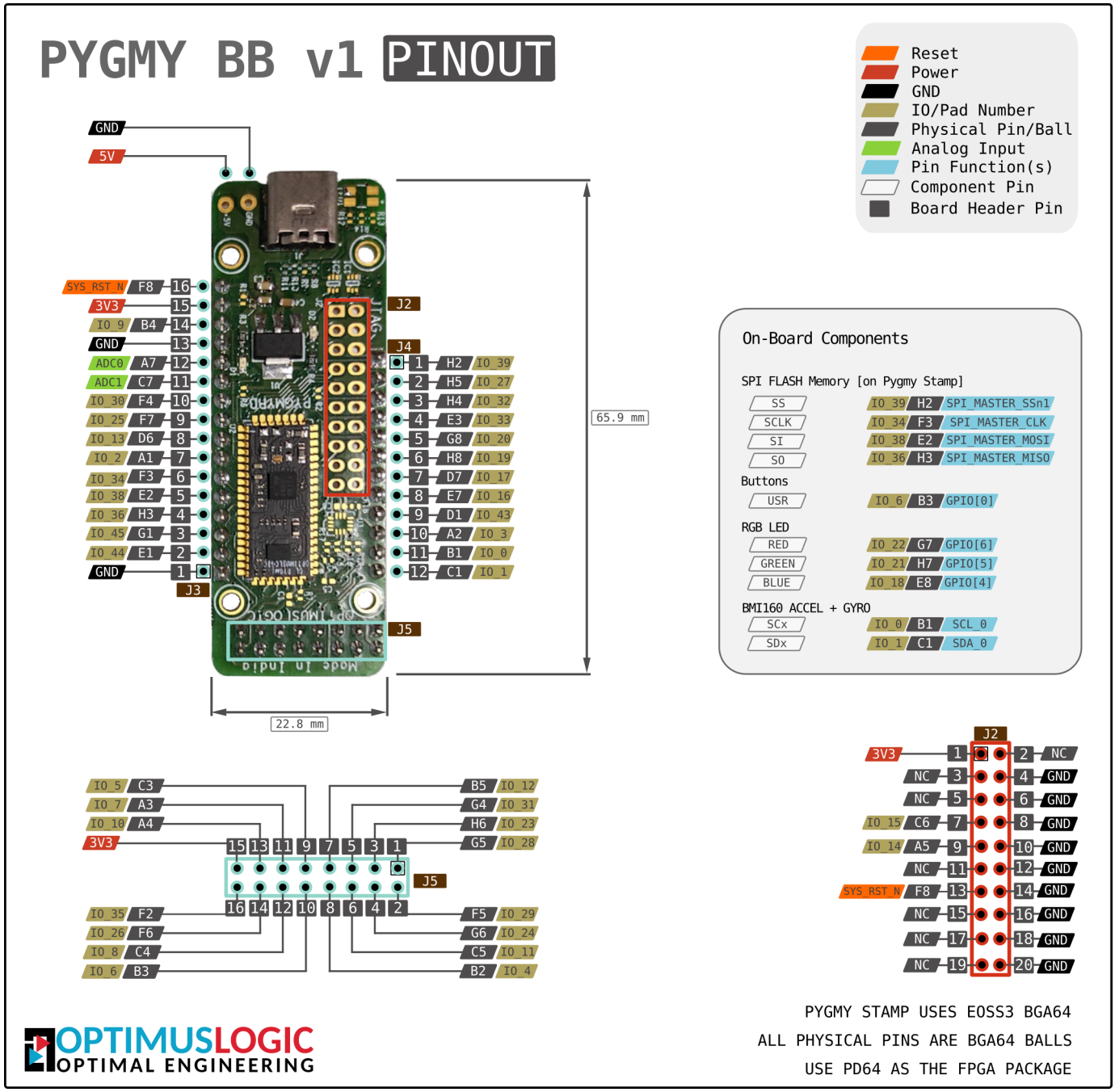

Fig. 2.1.2: Pin diagram

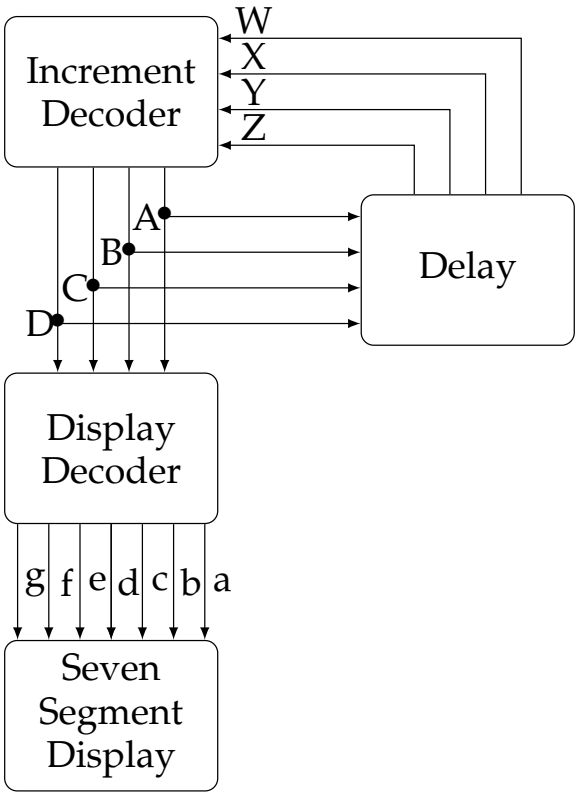

Fig. 3.1.1: Block diagram of the decade counter.