I. Overall Design Flow[1]

Authorized Resources: Your instructor will inform you if you can work in pairs or not. For all assignments in this course, unless otherwise noted on the assignment, you may work with anyone. We expect all graded work, to include code, lab notebooks, and written reports, to be in your own work. Copying another person's work, with or without documentation, will result in NO academic credit. Furthermore, copying without attribution is dishonorable and will be dealt with as an honor code violation.

Big Picture: In this lab, you will develop a hardware-based binary to hex converter. To do this, you will write, test, and implement a seven-segment display decoder on the Basys3 Development Board. A four-bit value will be input using switches (circled in red in Figure 1 below). Upon pressing the center button, a seven-segment display will output the correct hex digit.

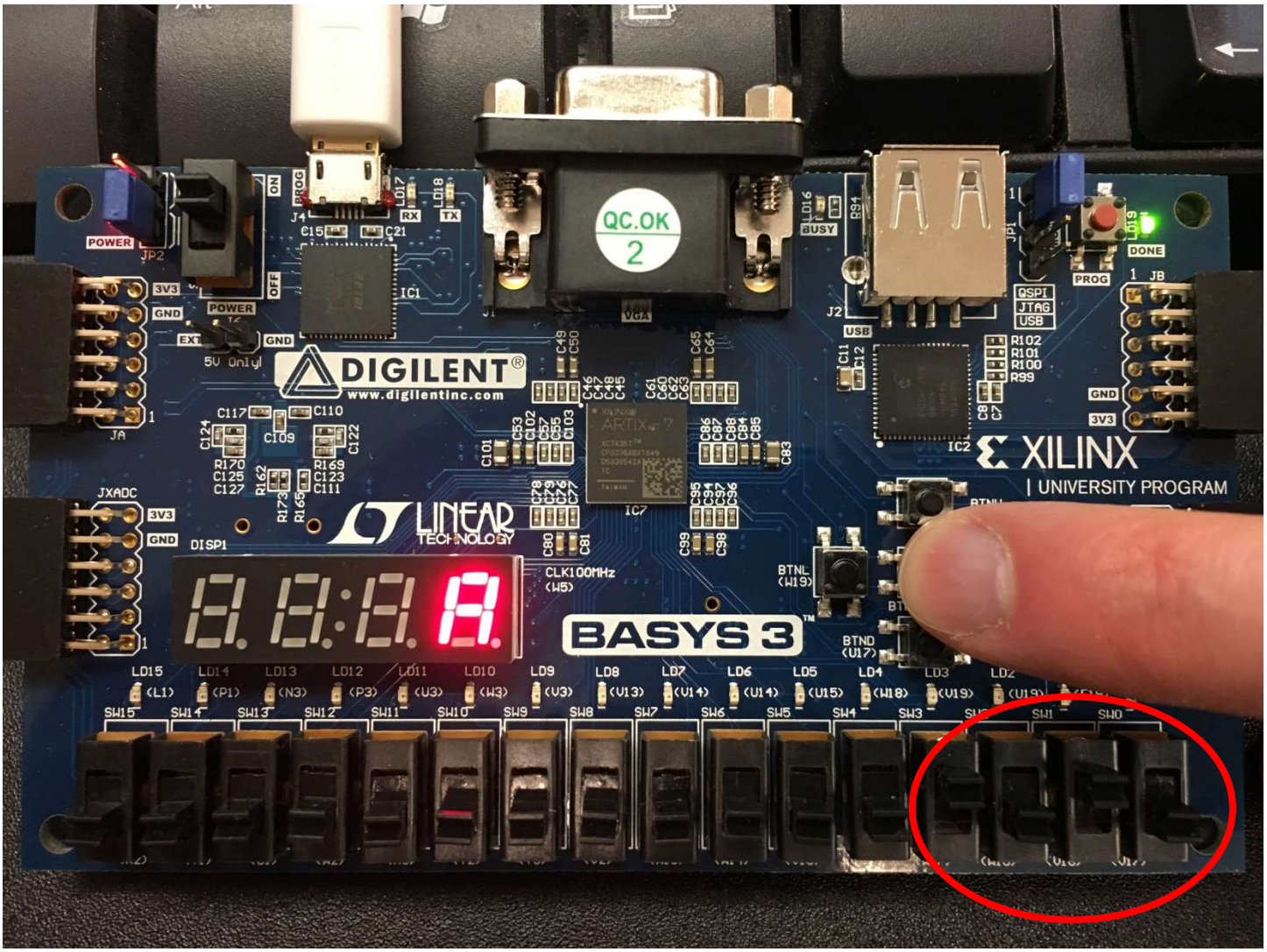

FIGURE 1 – EXAMPLE DEMO OF FINAL HARDWARE IMPLEMENTATION FOR BINARY TO HEX QUIZ.

[1] Modeled after a lab provided with instructor notes for Digital Design and Computer Architecture, David Money Harris & Sarah L. Harris, 2nd Edition

II. BACKGROUND

When creating simple embedded digital designs, a seven-segment display is a common way to display numbers or simple letters to the end-user. In this lab, you will design a seven-segment display decoder. This decoder takes a 4-bit binary input, and produces 7 bits that indicate whether each "segment" of the display is on ('0') or off ('1').

There are seven "segments" (labeled a – g, see Figure 2 on the next page) and one decimal point (we will ignore the d.p. in this lab) in a seven-segment display. **Placing a '0' on a segment will cause it to light up, while a '1' will keep the segment dark** (i.e., active low). For example, to display the number "0", a logic '0' must be placed on segments b-g, while segment a will be a logic '1'.

Your first task in this lab is to complete the missing 15 rows in the truth table show in Table 1. Using this completed truth table, you will generate logic equations for each output. Once you have created these equations, you will implement and test the design using Xilinx Vivado. Finally, you will demonstrate the logic on the Basys3 Development Board.

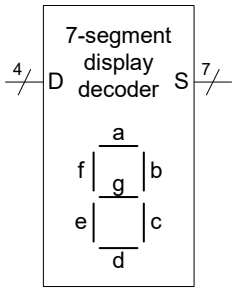

FIGURE 2 – BLOCK DIAGRAM OF THE LOGIC YOU WILL CREATE IN THIS LAB. THE SEVEN-SEGMENT DISPLAY DECODER WILL TAKE A NIBBLE INPUT, AND OUTPUT THE SEVEN SEGMENT BINARY VALUES NEEDED TO DISPLAY THAT HEX DIGIT. THE LABELS FOR THE SEVEN SEGMENTS ARE SHOWN IN THIS DIAGRAM.

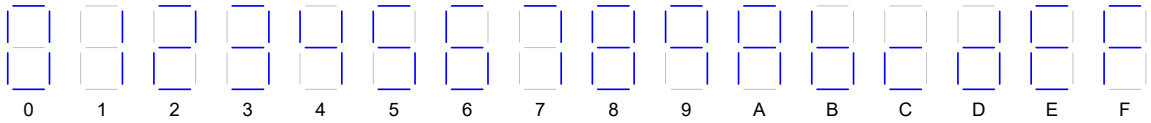

FIGURE 3 – THIS DIAGRAM SHOWS YOU WHICH SEGMENTS SHOULD BE TURNED ON FOR EACH HEX DIGIT.

Hexadecimal Digit	Inputs				Outputs							(in hex)
	D3	D2	D1	D0	Sg	Sf	Se	Sd	Sc	Sb	Sa	
0	0	0	0	0	1	0	0	0	0	0	0	0x40
1	0	0	0	1								
2	0	0	1	0								
3	0	0	1	1								
4	0	1	0	0								
5	0	1	0	1								
6	0	1	1	0								
7	0	1	1	1								
8	1	0	0	0								
9	1	0	0	1								
A	1	0	1	0								
B	1	0	1	1								
C	1	1	0	0								
D	1	1	0	1								
E	1	1	1	0								
F	1	1	1	1								

TABLE 1 – THIS TRUTH TABLE SHOWS THE MAPPING BETWEEN THE POSSIBLE INPUTS AND OUTPUTS FOR THE SEVEN-SEGMENT DISPLAY DECODER. THE FIRST ROW IF FILLED OUT FOR YOU. *YOU MUST FILL IN THE REMAINING 15 ROWS.* REFER TO FIGURE 2 TO SEE WHERE EACH SEGMENT (A-G) IS ON THE ACTUAL SEVEN-SEGMENT DISPLAY CHIP.

III. Prelab (15% of lab score)

a. **Create a new project** in your repo called "Lab2".

b. **Copy the report draft from teams** to the newly created Lab2 folder and fill out the *title*, *author*, and *documentation*.
   i. Go ahead and create folders called **images** and **code** in your Lab2 folder.

THE FOLLOWING WILL BE SUBMITTED TO GRADESCOPE PRIOR TO CLASS ON LESSON 14. YOU WILL ALSO INCLUDE PORTIONS OF YOUR PRELAB IN YOUR LAB 2 REPORT.

c. **Fill out the truth table** in Table 1 with the correct decoding outputs to display the correct hexadecimal digit on the seven-segment display. The first row is filled out for you as an example.
   i. Be careful when converting the output to hex. The MSB (BIT7) is not included, so it is always 0.
   ii. A MS Excel version of the table is provided along with blank K-maps.
   iii. The segment labels are shown in the Figure 2, and the hex-digit format is shown in Figure 3.

d. **Write the Boolean equation for each output**. Use K-Maps for the simplification process
   i. Include the K-map(s) with prime implicants circled in your report (again, print preview helps).