Lab 2

Soldering and programming external LEDs,

buttons, and a 2-digit seven segment display.

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Contents

Abstract

This lab is designed to become familiar with soldering and wire wrapping external components, calculating any required values for those components, and writing a program to test functionality. Upon success all LEDs will illuminate, all segments of the display will illuminate, and the buttons will control the LEDs.

Introduction

The purpose of this lab is to wire wrap or solder (4) external LEDs, (4) external buttons, and a dual digit 7-segment display with the respective resistors for each component. Once complete, a simple program to test the functionality of the components is written. The finished Verilog file is written to board using the JTAG connection. The external LEDs as well as all segments of the display should illuminate, and the buttons should control the LEDs.

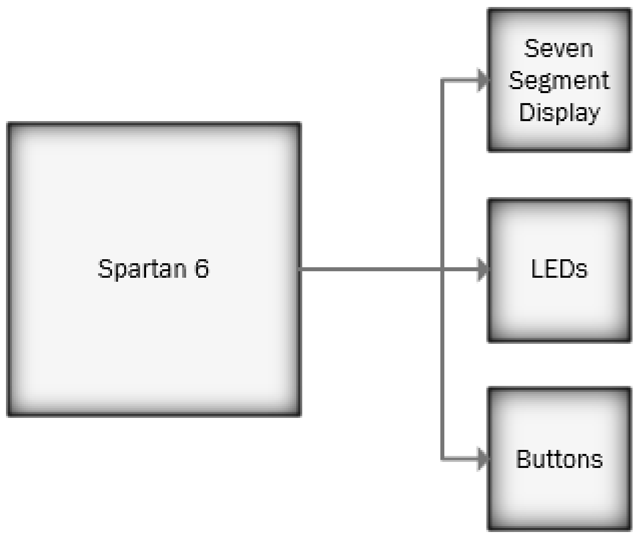


Figure 1: Block diagram

Design

Physical Hardware Design

The components used for this lab are (4) generic blue 3mm or 5mm LEDs, (4) generic through hole buttons, a dual digit 7-segment display from Lumex (LDD-E2802RD) which is common anode, and (12) 270Ω resistors. The LEDs are wired in an active high, or sourcing, configuration. The buttons require internal pull-up resistors in the Spartan 6, and these are defined in the UCF file.

$$V = IR$$

Figure 2: Ohm's Law equation

The voltage supplied by the Spartan 6 is 3.3V, and the current supplied is 5mA to 10mA. This voltage and current are used to calculate the value of the required resistors. The LEDs have no form of identification, so a common forward voltage of 2V is used. Subtracting the LED forward voltage from this source leaves 1.3V through the resistor. Using Ohm's Law equation, resistance is equal to voltage divided by current. 1.3V / 5mA is equal to 260 Ω. The closest resistor value of 270 Ω was used instead.

$$P = IV$$

Figure 3: Power equation

The power consumed by the components can be calculated using the power equation. The LEDs forward voltage of 2V is multiplied by the current of 5mA to equal 10mW. The voltage drop across the resistor of 1.3V is multiplied by the current of 5mA to equal 6.5mW.

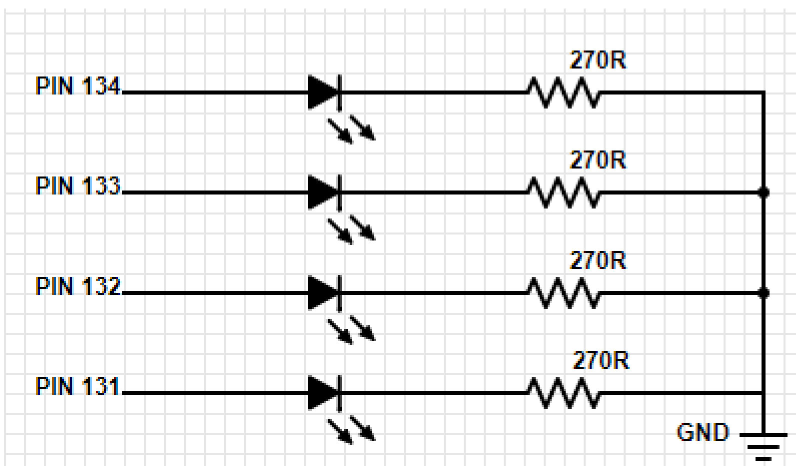


Figure 4: LED circuit schematic

The buttons are of the normally open type connected with a pull-up resistor. When the button is idle, the FPGA reads a high logic level (3.3V.) When pressed, the FPGA reads a low logic level (0V.) A schematic of the pull-up resistor is located in Appendix – A under Figure 8.

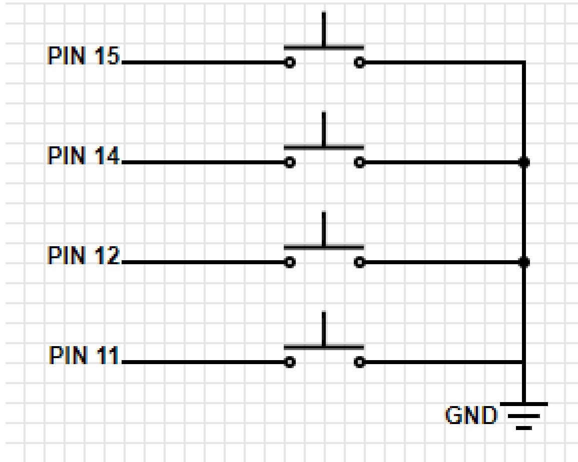
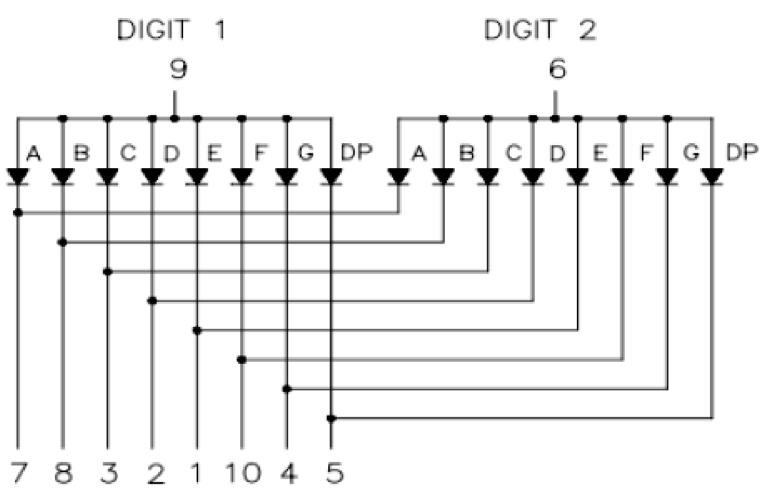


Figure 5: Button circuit schematic

The dual digit 7-segment display used is from Lumex, part number LDD-E2802RD. This display is common anode which means it is in a sinking configuration. The forward voltage of the LEDs used in this display is 2.2V. This can be found in the datasheet of this component. Subtracting the LED forward voltage from the source voltage leaves 1.1V through the resistor. Using Ohm's Law equation, resistance is equal to voltage divided by current. 1.1V / 5mA is equal to 220 Ω. For simplicity, the resistor value of 270 Ω was used again.



PIN CONNECTION

NO.	CONNECTION
1	CATHODE E
2	CATHODE D
3	CATHODE C
4	CATHODE G
5	CATHODE DP
6	COMMON ANODE (DIGIT 2)
7	CATHODE A
8	CATHODE B
9	COMMON ANODE (DIGIT 1)
10	CATHODE F

Figure 6: Dual 7-segment display circuit schematic

The power consumed by the components can be calculated using the power equation. The LEDs forward voltage of 2.2V is multiplied by the current of 5mA to equal 11mW. The voltage drop across the resistor of 1.1V is multiplied by the current of 5mA to equal 5.5mW. Important information from the 7-segment display datasheet can be found in Appendix – A under Figure 9 and Figure 10.

Synthesized Hardware Design

A single module called “top” is used to test the functionality of the components.

Design Structure

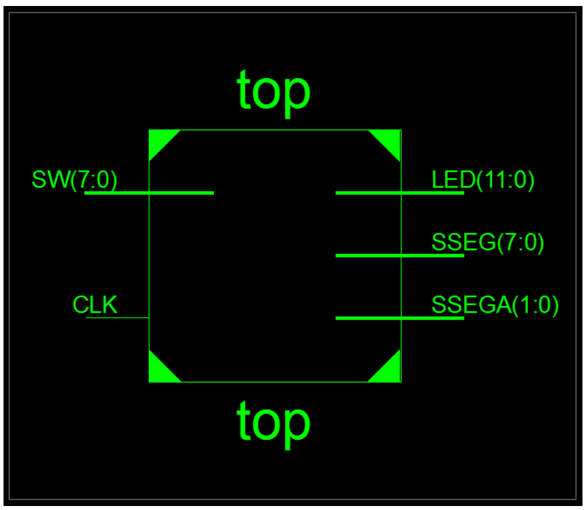


Figure 7: “top” module block diagram

Modules

Top:

This module is designed to simply test the functionality of the components. The 4 onboard buttons as well as the 4 external buttons are accepted as inputs SW(7:0), along with a clock signal (unused.) The 8 onboard LEDs as well as the 4 external LEDs are outputs LED(11:0). LED(7:0) is reserved for the onboard LEDs, and LED(11:8) is reserved for the external LEDs. The output SSEG is used to decide which segments are lit in the display, and the output SSEGA decides which digit is displayed by driving the anodes. The code for this module is found in Appendix – A under Figure 11.

Simulation and Testing

To test the functionality of the board, the external LEDs are illuminated by setting LED(11:8) equal to 4’b1111. Every segment of the display is lit by setting SSEG(7:0) equal to 8’b00000000. Both digits of the display are lit by setting SSEGA(1:0) equal to 2’b11. The total of 8 buttons are tested using the 8 onboard LEDs. This is done by setting LED[7:0] equal to SW[7:0]. The LEDs should remain illuminated until a button is pressed.

Problems

The main problem of this lab was space management. In order to avoid shorts or bridges to unwanted pins, the components must be strategically placed to allow enough room for wire and solder.

Results and Conclusion

Overall, this lab was successful and was a good introduction to adding and interfacing with external components. It also introduced wire wrapping, and improved soldering ability along with design planning significantly. When adding the components to the board, there are a few tricks such as connecting to a common ground or first soldering to the pins closest to the component that made the design easier and cleaner to implement. Continuing into future labs it will be important to plan carefully where components are placed and how the connections are ran.

Appendix - A

LED pin mapping – Table 1

LED Name	Header Pin	Spartan 6 Pin
LED1	35	134
LED2	36	133
LED3	37	132
LED4	38	131

Button pin mapping – Table 2

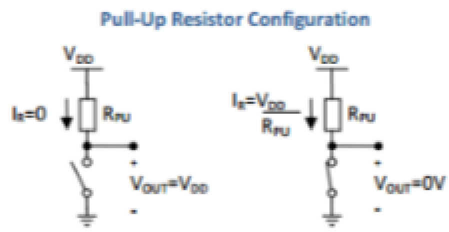
Button Name	Header Pin	Spartan 6 Pin
Button1	17	15
Button2	18	14
Button3	19	12
Button4	20	11

7-segment display pin mapping – Table 3

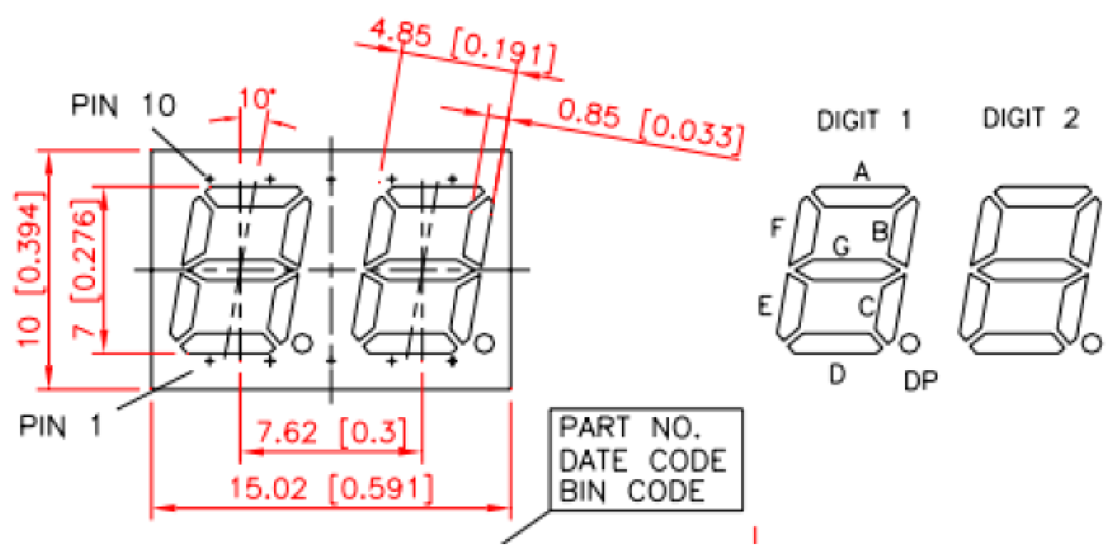
7-segment Pin	Header Pin	Spartan 6 Pin
1	9	27
2	8	29
3	7	30
4	11	24
5	12	23

6	3	35
7	5	33
8	6	32
9	4	34
10	10	26

Pull-up resistor schematic – Figure 8



Dual digit 7-segment display dimensions and pins – Figure 9



Dual digit 7-segment display important data – Figure 10

ELECTRO–OPTICAL CHARACTERISTICS T_A=25°C		I_f=10mA			
PARAMETER	MIN	TYP	MAX	UNITS	TEST COND
PEAK WAVELENGTH		565 (GREEN)		nm	
FORWARD VOLTAGE		2.2	2.6	V_f	
REVERSE VOLTAGE	5.0			V_r	I_r=100μA
AXIAL INTENSITY		3900		μcd	I_f=10mA
EMITTED COLOR:	GREEN				
FACE COLOR:	BLACK				
SEGMENT COLOR:	MILKY WHITE DIFFUSED				

"top" module code – Figure 11

```
module top(
    input CLK,
    input [7:0] SW,
    output [11:0] LED,
    output [7:0] SSEG,
    output [1:0] SSEGA
);

assign LED[11:8] = 4'b1111;
assign LED[7:0] = SW[7:0];

assign SSEG[7:0] = 8'b00000000;
assign SSEGA[1:0] = 2'b11;


endmodule
```

References

[1] Lumex, LDD-E2802RD, 2013, p. 1 [Online].

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[2] Hogen, Alexander, OwlBoard Users Guide, 2015, p. 1-22 [Online].

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[Accessed: 17- Jan- 2019]

[3] Xilinx, Spartan-6 FPGA Packaging and Pinouts, 2014, [Online].

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[4] Xilinx, Spartan-6 FPGA Configuration, 2017, [Online].

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