Introduction to Digital Systems Laboratory 3a:

BCD to 7-Segment Decoder and Introduction to Schematic capture

ABSTRACT

The purpose of this lab is to introduce students to Schematic capture in Quartus II. These concepts will be explored through the implementation of a binary coded decimal (BCD) to 7-segment display driver. Part B of this lab will introduce Verilog coding.

Introduction

In this lab you will be building a three-character binary coded decimal to seven-segment display system. This system will accept a 10-bit, BCD number and display its value on three seven-segment displays.

Seven Segment Display Basics

A seven-segment display is an electronic device consisting of seven display segments, used to represent alphanumeric characters. Display segments are usually made from Light Emitting Diodes also known as LEDs. Segments in the display are either connected in a common anode or common cathode configuration. The meaning of common anode and common cathode is material reserved for a course on electronics, however in order to properly design this system we must know what configuration of seven segment display is on the development board.

From a digital standpoint the difference between common anode and common cathode determines if a logic 1 or logic 0 causes a display segment to illuminate. The displays on the DE0 and DE2 development boards are common anode, which means to illuminate a display segment; logic 0 must be applied to the control pin for that segment. To turn the display segment off logic 1 is applied to the control pin for that segment. The inverse of this would be true if the seven-segment display was a common cathode configuration.

The segments in a display are referred to using the letters A through G, Figure 1 shows a diagram of a typical seven-segment display.

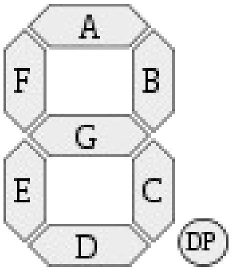

Figure 1 - Seven Segment Display Diagram

Binary Coded Decimal (BCD)

Binary coded decimal (BCD) is a method of representing a base 10 number as sets of 4 bit binary numbers. Each four-bit number represents a single base 10 digit from 0 to 9. For this lab we will use a BCD number consisting of three four-bit numbers. Here are a few examples of BCD numbers:

Base 10 Number	Binary Number	BCD Number
001	00000001	0000 0000 0001
		0 0 1
255	11111111	0010 0101 0101
		2 5 5
128	10000000	0001 0010 1000
		1 2 8

System Overview

The system you will build is a three number BCD to seven-segment display decoder. You will first build a single seven-segment decoder and test it. Once the functionality has been verified you will create three copies of the decoder and hook them up to switches and three seven segment displays on the development board.

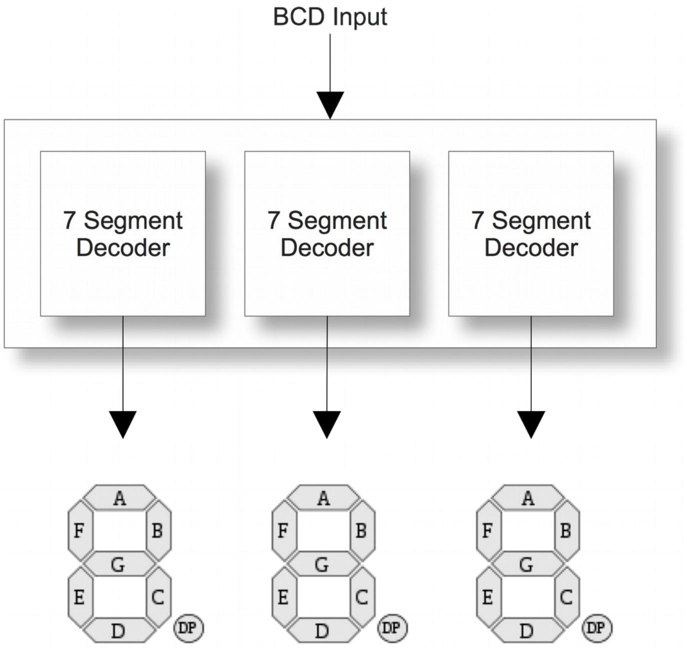

Figure 2 - System Overview

Design

The first step in designing this system is to derive logic functions for each of the display segments A - G. Below is a truth table, which needs to be filled in; it would be to your advantage to replicate this table in excel or another program so you can have it for reference in the future.

Base 10	BCD Single Digit (a b c d)	A	B	C	D	E	F	G
0	0000							
1	0001							
2	0010							
3	0011							
4	0100							
5	0101							
6	0110							
7	0111							
8	1000							
9	1001							
10	1010	X	X	X	X	X	X	X
11	1011	X	X	X	X	X	X	X
12	1100	X	X	X	X	X	X	X
13	1101	X	X	X	X	X	X	X
14	1110	X	X	X	X	X	X	X
15	1111	X	X	X	X	X	X	X

After filling in the truth table you should be able to derive seven logic functions, one for each segment A, B, C, D, E, F, and G. Fill in the logic functions below before continuing on to the next portion of the lab.

A =

B =

C =

D =

E =

F =

G =

Single Decoder using Schematic Capture

In this section of the lab you will implement the single seven-segment decoder using a Schematic File.

Create a new project with the following details:

Store In:	C:/Projects/Digital_1/Lab_3a
Name:	Lab_3a
Top-Level Entity:	Lab_3a
Family:	Select device family
Device:	Select device number

You may either create one large schematic with the circuits for all seven segments or you can create smaller schematics for each segment and combine them together.

Create a new Schematic File and add it to the project.

1. Choose **File** -> **New**
2. In the window that appears choose **Block Diagram/Schematic File**
3. An editor window will appear.
4. Save the file with a meaningful name (e.g. "BCD_to_7seg" or BCD_to_7seg_segA")
5. Repeat steps 1 – 4 each time you need to create a new Schematic File

It is recommended that you watch the provided Quartus II Schematic videos, the Quartus II Top-Level Entity video, and the Lab 3a videos at this time.

Now that you understand the basics of using the Schematic editor in Quartus II you can create your BCD to seven segment code converter and make it into a block to be used in your Top-Level Entity.

In your first Top-Level Entity you will create a single block instance of the BCD to 7seg converter and connect switches 0-3 (SW[3..0]) to the input and connect the output to the input of a NOT gate (singe the seven segment display is common anode) and connect the NOT gate's output to HEX0 (HEX0[6..0]).

Once you have wired in the inputs and outputs, load the pin assignments file, compile your design, and load it onto the development board using the JTAG method that was described in the previous lab. Verify the functionality of your design before continuing to the next step.

Three Decoder Implementation using Three Copies of a the Seven Segment Decoder

In this section of the lab you will implement a three-display driver using three copies of the seven-segment decoder that you designed previously.

This system will have 12 inputs, (3 sets of 4 wires to represent each BCD number) and 21 outputs, (3 sets of 7 wires for each seven segment display).

If you are using the DE0 development board you will only have 10 switches so you must convert the 10-bit bus from the SW input to a 12-bit 0 padded bus. Refer to the Lab 3a 10-bit bus to 12-bit bus example video for further instruction.

Create three copies of the seven segment decoder and connect the inputs and outputs as suggested by Figure 2.

Compile and test your design on the development board.

Deliverables
Demonstration

Grade Scale

Demonstration Shows:	Grade:
Nothing	0
Tried something	3
Designed but no functionality	6
Functions improperly	8
Works as expected	10