COL215 - Hardware Assignment 1

4-Digit 7-Segment Display

Submission Deadline: 21 October 2022

1 Introduction

Design and implement a circuit that takes a 4-digit decimal/hexadecimal number (so each number is 4-bit) from switches in the Basys3 board and displays it on the 4-seven segment displays on the board. Use the on-board clock and create a timing circuit to drive all the displays.

2 Problem Description

The assignment requires you to design the following:

1. Design a combinational circuit that takes a single 4-bit hexadecimal or decimal digit input from the switches and produces a 7-bit output for the seven-segment display of Basys3 FPGA board.
2. Extend the design to create a timing circuit that will drive all 4-displays for displaying 4-digits together.

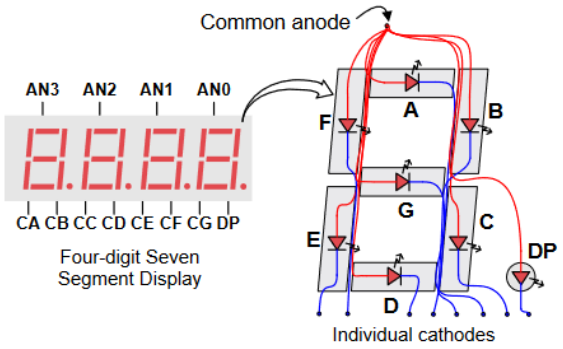

Figure 1: Pin details for 7 seven display on Basys 3 board

2.1 Seven segment decoder

The first module to be implemented is for displaying a 4-bit number on a one 7-segment display. Figure 1 shows the pin-out details for the one display. It has 7 cathode pins, 1 anode pin (connected to all 7 LEDs) and 1 pin for decimal point. To switch an LED on, the anode should be driven HIGH and cathode LOW. In general, LED display is activated via driving anode HIGH and the corresponding digit via varying cathode signals. Now, if the input number is "0000", then all LEDs except G should be switched ON. Similarly, for "0011" LEDs F and E will be OFF, and rest wil be ON. Note that you have to take the input from the switches present on the board (4-digits use 4-switches).

Note that **on basys 3 board anode/cathode are ACTIVE LOW pins** (i.e., 0 = ACTIVE, 1 = INACTIVE). For details, refer to the Basys 3 reference manual.

Design a combinational circuit for which the inputs are the four bits of the given decimal number and outputs correspond to the 7 cathode pins. The following need to be completed:

- Create a Truth Table with 4 inputs and 7 outputs. Using this, find out the minimized combinational logic to drive the 7 output signals.

- Implement a decoder module in VHDL, with input as a 4-bit number and output as 7-bit cathode signal, and 4-bit Anode signal. To test your implementation on the board, you can use the slider switch for entering the number.

NOTE: use of VHDL case/if-else for this module is not allowed. Use elementary operations (AND, OR, etc.)

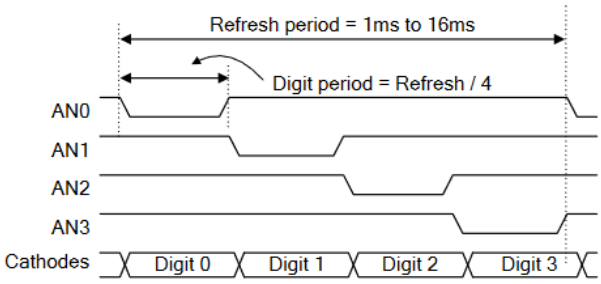

Figure 2: Timing details for 7 seven segment displays

2.2 Driving all four LED displays

As shown in Figure 1, 7 cathode pins are common for each LED display. This means only one display can be activated at a given time. To display a separate digit on each LED display, the corresponding anode signal needs to be activated in cyclic manner. To avoid flickering, refresh rate should vary between 1kHz - 60Hz (1-16 ms). Figure 2 shows the timing details and the signal waveforms. For more details, refer to the Basys 3 reference manual.

Using the module designed in section 2.1, create a 4:1 multiplexer module and timing circuit to drive the LED displays. The following need to be completed:

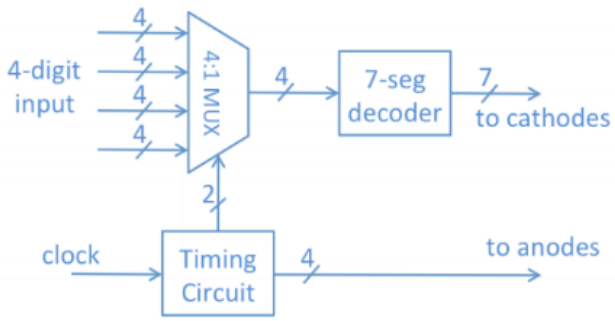

Figure 3: Block diagram for driving four 7 seven segment displays

- Multiplexer module with four 4-bit inputs from slider switches and output going to 7-segment module.
- Timing circuit to drive Anode signals and select signal of multiplexer.

Refer to Figure 3. You need to divide the onboard 100 MHz clock to the suitable display frequency.

3 Resources references

- IEEE document: `https://ieeexplore.ieee.org/document/8938196`
- Basys 3 board reference manual: `https://digilent.com/reference/_media/basys3:basys3_rm.pdf`
- Online VHDL simulator: `https://www.edaplayground.com/x/A4`