Problem 3.2.4

Asynchronous Counters: Now Serving Display Using PLTW S7

INTRODUCTION

In this design project, you will have the opportunity to draw together all of the concepts and skills that you have developed pertaining to **asynchronous counter** design. You will design, simulate, and build a *Now Serving Display*. This is the type of display that you might see at a deli counter.

EQUIPMENT

- Circuit Design Software (CDS)
- Digital MiniSystem (DMS)
- PLTW S7 FPGA Module
- #22-gauge Solid Wire

RESOURCES

Multisim Files

Procedure

Design

Design a digital circuit that displays the count from 00 to 80. This design has two control inputs and two output displays. The two inputs are **Next** and **Reset**. The **Next** signal comes from a push-button switch that, when pressed, advances the display by one. The **Reset** signal, which is also a push-button switch, will reset the display to a count of 00. When the display reaches 80, the count will cease. (The employee at the deli counter takes a break and a new employee takes over the counter after the 80^{th} customer is served.)

Design Specification

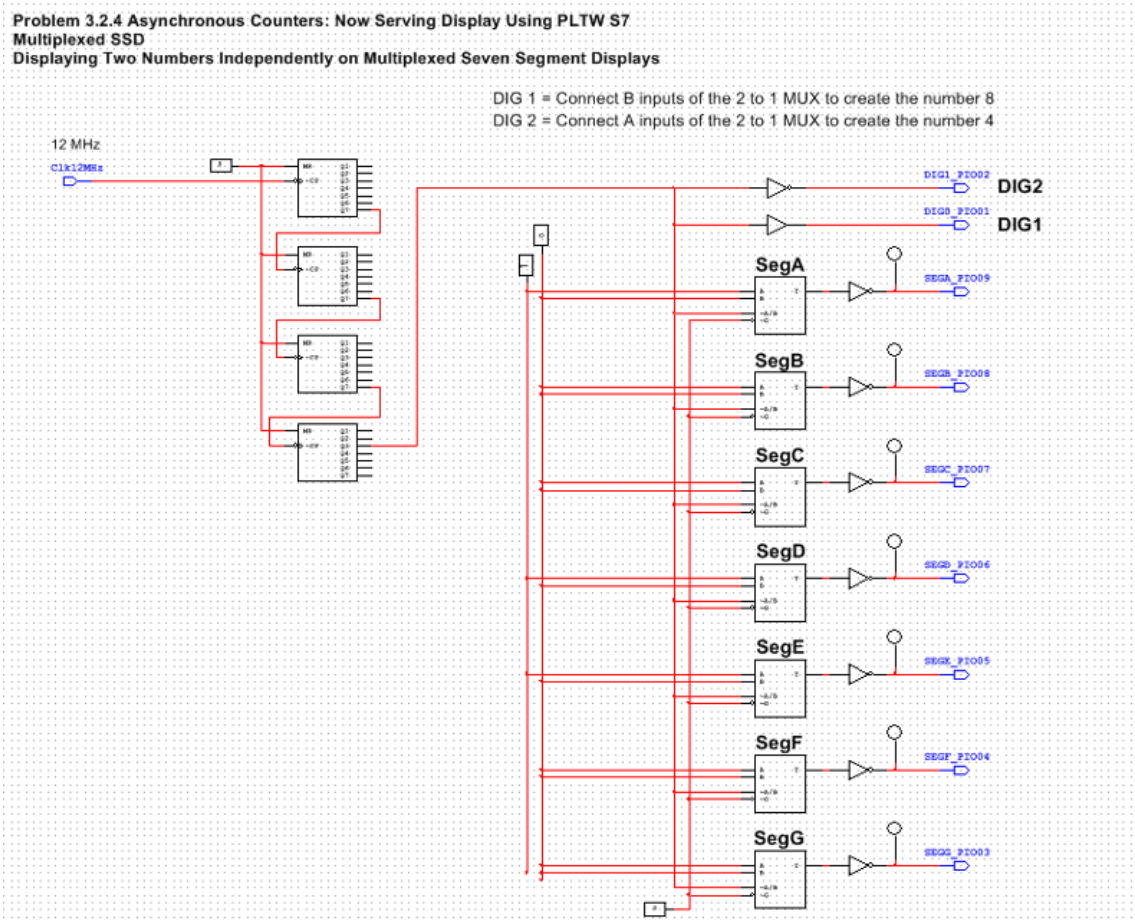
- The two output displays are common cathode seven-segment displays.
- The two displays require a multiplexed design.
- The ones-unit display (Least Significant Digit) is controlled by an asynchronous counter designed with a 74LS93 MSI counter IC. The PLD mode equivalent of the 74LS93 is the CNTR_4BIN_AS (Counter_4-Bit_Binary_Asynchronous).
- The tens-unit display (Most Significant Digit) is controlled by an asynchronous counter designed with SSI logic gates (D Flip-Flops).
- Any additional logic may be used as needed to support the counter designs.
- Add a design feature that holds the count when it reaches 80.

Multiplexed Seven-Segment Display Design

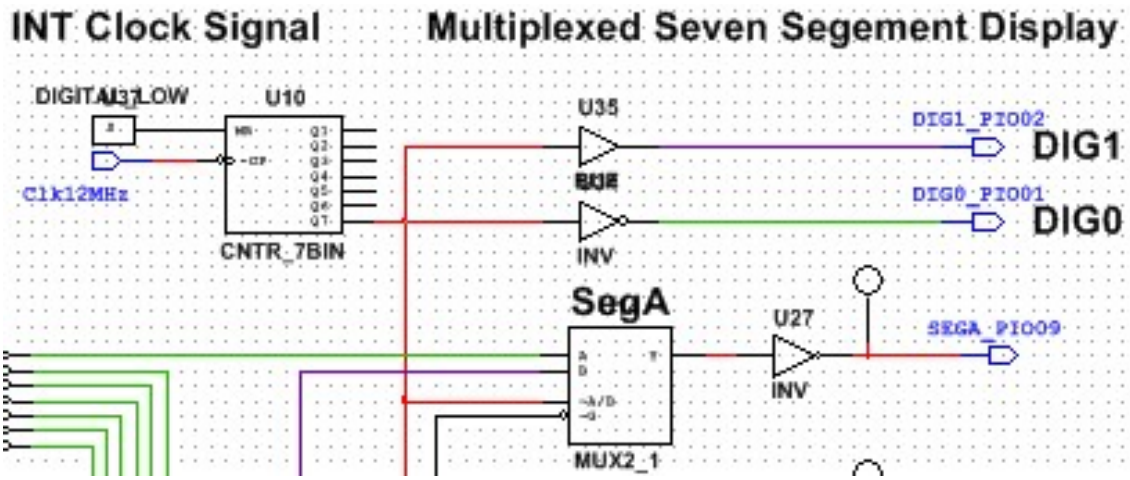
The common cathode seven-segment displays on the Digital MiniSystem share an input for each segment of both displays. It requires a multiplexed signal to display two separate numbers at the same time. This is a widely used digital design feature

in industry because it saves power. The input signals are alternated at a high rate so that the SSD appears to be powered on all the time. (In reality, it is only powered half the time with a 50% duty cycle).

Below is an example of a multiplexed seven-segment display that will display the number 84. The 8 and 4 will alternate at approximately 1 Hz. This clock signal is created from the 2 MHz internal clock and a series of Divide-by-Two counters to get the desired frequency



By changing the clock signal to a much higher frequency, the two numbers appear to be powered on all the time, even though the signal continues to alternate.



1. Open the Example Circuit **3.2.4a Multiplexed SSD_84 at 1Hz_PLD_DEMO_S7**. Export the design to the PLD Module (PLTW S7) of the Digital MiniSystem (DMS). Wire the circuit and verify that the numbers alternate as expected.

2. Now modify the circuit to display “84” at the same time. Export this new design to the PLD module and confirm that the numbers appear continuously as expected.

3. Open the Example **3.2.4b Mutliplexed SSD with 3_DEMO_S7**. This example lets you input 0–9 on the two SSDs independently of each other. Once you have confirmed that the circuit works as expected, you may delete the inputs to the display drivers and create your Now Serving Display.

Simulation: (Design Mode or PLD Mode)

Using PLD mode of the Circuit Design Software (CDS), enter and test your *Now Serving Display* design. Verify that the circuit is working as designed. If not, review your design work and circuit implementation to identify your mistake. Make necessary corrections and retest. Be sure to document all changes in your engineering notebook.

Prototyping

Using the Digital MiniSystem (DMS), export your *Now Serving Display* design to the PLTW S7 FPGA Module. Verify that the circuit is working as designed. Remember to use PIO16 for a clock signal. If your circuit isn't working correctly, review your circuit implementation to identify your mistakes, make the necessary corrections, and retest. Be sure to document all changes in your engineering notebook.

CONCLUSION

Using your engineering notebook as a guide, write a conclusion (minimum 100 words) that describes the process that you used to design, simulate, and create your Now Serving Display circuit. This conclusion must include all of your design work, preliminary and final schematics, parts list, and a digital photograph of your final circuit. The documentation should be complete enough that another student, with the same knowledge of digital electronics, could reproduce your design without any additional assistance.

Proceed to next lesson