

# **COSC 3215 Embedded Systems Laboratory**

## **Lab 6: Sequential logic design, synthesis**

### **Specification**

Your task is to design a stepper motor controller using the **EPF10K70RC240-4** device on the Altera UP2 development board that will operate in a similar fashion as a windshield washer wiper blade on a car.

The wiper blade controller operates as follows:

1. The wiper blade controller has two operating modes continuous and delay that can be selected by FLEX\_SW-4. Setting FLEX\_SW-4 to the ON position selects delay mode.
2. When in continuous mode the wiper blade moves back and forth from the home position to the end position at either a slow or fast speed.
3. When the wiper blade is operating in delay mode the wiper blade will move from the home position to the end position once every 1 to 16 seconds at the slow speed setting. The delay setting is selectable via FLEX\_SW [5..8], which codes the wiping rate in seconds as a binary number.
4. The continuous-mode wiper blade speed is controlled by FLEX\_SW-3. Setting FLEX\_SW-3 to the ON position selects the fast speed setting. The slow speed setting moves the wiper blade from the home position to the stop position at a frequency of 1Hz. The fast speed setting increases the slow speed by 45%.
5. FLEX\_SW-2 will act as an ON/OFF switch, when the switch is in the ON position the system is on, and vice versa.
6. The controller must operate according to the FLEX\_SW settings upon power up if the wiper blade is turned on. If the wiper blade is in a position between the home and end position and FLEX\_SW-2 is switched off then the controller must move the wiper blade to the home position and stop at the speed setting selected by FLEX\_SW-3.

### **Reference Reading**

Altera UP2 Development Kit Users Guide  
Upds.pdf

Hamblen and Furman, Rapid Prototyping of Digital Systems  
Second Edition (available in the library)

Introductory Verilog information. Ciletti (2003) Chapter 4, Appendices A-D

Other possibilities include introductory digital logic texts such as Brown and Vranesic or Mano and Kine

## Hints

The pin connections for the FLEX push buttons, dip switches, 7-Segment displays, and the motor drive connections are listed in Appendix A.

The AlteraUP2 development board has an onboard 25MHz clock. This will have to be divided down to a suitable frequency to operate the wiper blade controller. You can design your own clock divider or you can implement the CLK\_DIV module found in the UP1CoreII library. Also note the 25MHz clock is connected to pin 91 of the **EPF10K70RC240-4** device.

The truth table for driving the stepper motor is given in Appendix B.

## PreLab

Develop a plan on how you will design your wiper blade controller. **Draw a block diagram, state machine and other supporting documents showing the components you will need and describe their function within the overall design.**

Develop the Verilog code for your design. Simulate any components you develop separately and as a whole.

## In Lab Procedure

**Make appropriate notes and answer all questions clearly in your lab book.**

1. Show the T.A. the code you developed for the prelab and describe the approach you have taken to implement your wiper blade controller.
2. After receiving permission to proceed from the T.A., connect the circuit to the Altera according to the schematic attached to the end of this document.
3. Connect the Altera to the PC.
4. Program the Altera and get it to work. Verify the signals generated with the appropriate test equipment.
5. Test that the program functions as per the design specifications.

## Lab Evaluation

You must demonstrate that your wiper blade motor controller is functioning properly on the Altera UP2 development board to the lab demonstrator (note this means you must show convincing evidence that it works).

All code and simulation results must be submitted using the submit command.

## Appendix A: Flex Peripheral Pin Connections

FLEX_DIGIT Segment I/O Connections		
Display Segment	Pin for Digit 1	Pin for Digit 2
A	6	17
B	7	18
C	8	19
D	9	20
E	11	21
F	12	23
G	13	24
Decimal Point	14	25

FLEX_SW1 Pin Assignments	
Switch	FLEX10K
FLEX_SWITCH-1	41
FLEX_SWITCH-2	40
FLEX_SWITCH-3	39
FLEX_SWITCH-4	38
FLEX_SWITCH-5	36
FLEX_SWITCH-6	35
FLEX_SWITCH-7	34
FLEX_SWITCH-8	33

Wiper Blade Connections		
Signal Name	Pin Assignment	FLEX_EXPAN_B
Phase A	116	21
Phase B	118	23
Phase C	120	25
Phase D	127	27
Home	117	22
End	119	24
GND	--	60
VCC	--	59

## Appendix B: Stepper Motor Drive Half-Step Truth Table

State	Phase			
	A	B	C	D
0	1	0	0	1
1	1	0	0	0
2	1	0	1	0
3	0	0	1	0
4	0	1	1	0
5	0	1	0	0
6	0	1	0	1
7	0	0	0	1