LAB#3
(Due: See course web page)

Objective

- Based on the experience from LAB#1&2, learn how to design, simulate, synthesize, program on FPGA and test FSM (Finite State Machine) digital system using Altera Quartus II CAD SW and DE1 FPGA board.
- Learn and become familiar with logic design using Verilog Hardware Description Language

Instructions

1. Your LAB#3 project name should be L3Cyyy, where yyy=your CID(e.g., L3C079 if your CID=079).

2. [Golden Solution] The golden solution .pof and .sof files are provided. In any LAB, student must play with golden solution as a reference whenever he/she has a question during design. Also check with golden solution before going to Demo to make sure your design follows it.

2. Use Verilog HDL design. Use the following Verilog top-level module interface code for your design. No part of this code is allowed to be modified. The top-level module name must be same as your LAB project name.

   module L3Cyyy( // where yyy=your CID. For example, L3C079 if your CID=079
   input [9:0] sw, // ten up-down switches, SW9 - SW0
   input [3:0] key, // four pushbutton switches, KEY3 - KEY0
   input clock, // 24MHz clock source on Altera DE1 board
   output [9:0] ledr, // ten Red LEDs, LEDR9 - LEDR0
   output [7:0] ledg, // eight Green LEDs, LEDG8 - LEDG0
   output reg [6:0] hex0, hex1, hex2, hex3 // four 7-segment, HEX3 - HEX0
   );

3. Our acceptable timing margin for real-time clock operation is -30% and +30%.
Soda VM (Vending Machine) Controller Design

A vending machine company requests you to design a Soda Vending Machine (VM) controller circuit with following specifications. The price of a soda was set to 35 cents.

LAB#3 Project Operation Overall Flow

Warning: Following operations are ***prerequisite*** conditions. You will get zero(0) point for LAB#3 if you fail these operations regardless of PARTS(#1-5).

1) **Initial state**
   When power is turned on, your DE1 board must be in the following **initial state**:
   - all SWs are in DOWN position
   - no key is PRESSSED
   - all leds(ledg and ledr) are OFF
   - VM is in stop state(i.e., not started yet)
   - HEX[3:0] displays your CID. For example, HEX[3:0]=0097 if your CID=097
     (Reminder: Golden solution has HEX[3:0]=0353 since it's CID=353)

2) How to start VM from the **initial state**:
   - Press key[1] once. The hex[3:0] should display "0000" as an initial display.

3) How to stop VM and return to **initial state**:
   - Turn off power first and turn on power with initial setting specified in 1).
VM Operation Specifications
(Warning: You must check & play with golden solution whenever you have a question.)

1) How to deposit money to VM:
Money deposit to VM is made by setting up amount of money first followed by pressing EnterKey.

Setting up amount of money

- sw[8]  // 1 for Reset input (=clearing current Deposit balance and Change balance to 0, but
  // NOT clearing the total number of dispensing - See Report mode case below sec.2)
- sw[4]  // 1 for Credit-card input (= makes 35 cents immediately regardless of current balance)
- sw[3]  // 1 for One-dollar bill input
- sw[2]  // 1 for Quarter input
- sw[1]  // 1 for Dime input
- sw[0]  // 1 for Nickel input

Enter key

- key[1]  // one pressing deposits above money input amount one time.

2) Operating modes(Normal, Report)

IF sw[9] = 0 { // Normal mode.....
  IF error cases (See sec. 4.) { // error cases....displaying error message
    hex[3:1] = "Err ";  hex[0] = off
  }
  ELSE { // good case ...
    hex[3:2] = Deposit balance. It displays value up to "35". (Note that soda price was set to 35 cents.)
    hex[1:0] = Change balance  e.g.,  15
    For example, a dispensing occurs and hex[3:0]=3515 after two quarters(=50 cents) were deposited.
    For example, a dispensing occurs and hex[3:0]=3520 after three dimes followed by a quarter(=55 cents)
  }
}
ELSE IF sw[9] = 1 (with all other sw are down) { // Report mode.....
  • hex[0] displays the total number of dispensing made only by coin input since board power was
    turned on. DO NOT make One-dollar-bill input or Credit-card input before testing sw[9]=1 function. Only
    coin input is allowed BEFORE testing this condition. hex[0] is in hex with modulo-16 format. hex[3:1] = OFF. The sw[8]
    reset input should NOT clear this total number of dispensing to 0.
  • sw[9]=1 operation pauses(not reset!) the current operation. Therefore it should NOT CHANGE the
    value of current variables in your design, such as Deposit balance or Change balance. So, when
    sw[9] returns back to 0(down), hex[3:0] should resume displaying the previous value that it was
    displaying before sw[9] went 1(up). For example, hex[3:0]=3515 if it had been displaying 3515.
}

3) Dispensing indication
Whenever Deposit balance is 35 or more, a dispensing occurs with following action(s).

- All green LEDs, led[7:0], blinking(half-second period with 50% duty cycle) when dispensing
  For example, a dispensing occurs after three dimes followed by a quarter(=55 cents)
- All LEDs(i.e., both green and red) are OFF when NOT dispensing
4) Three cases of error to be checked:

4.1) Multiple inputs case:
  When more than one sw are UP among sw[0,1,2,3,4,8] and EnterKey is pressed, hex[3:0] should display "Err" (note hex[0]=OFF). For example, sw[2]=sw[3]=1.

4.2) Consecutive Same inputs (of one-dollar bill or credit-card) case:
  Two consecutive one-dollar bill inputs, or two consecutive credit-card inputs should display "Err" on hex[3:0]. For example, one-dollar bill input followed by one-dollar bill input, or credit-card input followed by credit-card input.
  (However, note that one-dollar bill input followed by credit-card input, or credit-card input followed by one-dollar bill input is O.K.)

4.3) Credit Card input when hex[3:0]=3500 and LEDR blinking (i.e., when Deposit=35 and Change=00)
  This is another case when hex[3:0] should display "Err".
  The "Err" display should be cleared to hex[3:0]=0000 (i.e., value of Deposit and Change balance are cleared to zero) by either pressing EnterKey or Reset input. Then normal operation can continue.

Operations to be checked during Demo

PART 1 (3 pts) : Coin input (i.e., Quarter, Dime, Nickel) test
PART 2 (3 pts) : Report mode test
PART 3 (3 pts) : Credit-card and Reset inputs test
PART 4 (3 pts) : One-dollar bill input test
PART 5 (3 pts) : "Err" display test