LOGIC DESIGN LAB (CS-288)

ASSIGNMENT-3

STOPWATCH

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Objective:

To Implement a seconds stop watch on ATLYS board using the onboard 100Mhz clock using push button switched for start/stop and reset and display the output on LEDs in BCD.

Example:

'23' would be displayed as: '0010 0011'.

Preview:

We are asked to design a stopwatch with start/stop and reset modes. The stopwatch can either be in a running state (the counter is on) or a non-running state. While in running state, at each rising edge of the 1hz clock, we increment the BCD counter representing the time. The start/stop signal toggles the stopwatch between the states of the stopwatch. The overall state comprises of BCD count and ticking state (ticking state '0' means: the stopwatch counting is off, '1' means the inverse).

State Description:

State 'xx.0' means the BCD counter is 'xx' and ticking is off.

State 'xx.1' means the BCD counter is 'xx' and ticking is on.

Input Description:

There are 3 on board switches -

1. Start/Stop (SS) push button : Toggle button to start/stop the timer on the stopwatch. (Mapped to button P4 on FPGA)

2. Reset button: To get the timer back to 0 (Mapped to button F6 on FPGA)

3. Rollover DIP Switch: To decide whether to stop or to continue when the count overflows. (Mapped to switch A10 on FPGA)

Example: Following transitions show the effect of asynchronous inputs start, stop and reset on the state of the stopwatch.

'23.0' __SS___=> '23.1' : Transition when SS button is pressed (start ticking)

'23.1'__SS___=> '23.0' : Transition when SS button is pressed (stop ticking)

'23.1'__reset___=> '0.0' : Transition when reset button is pressed (reset)

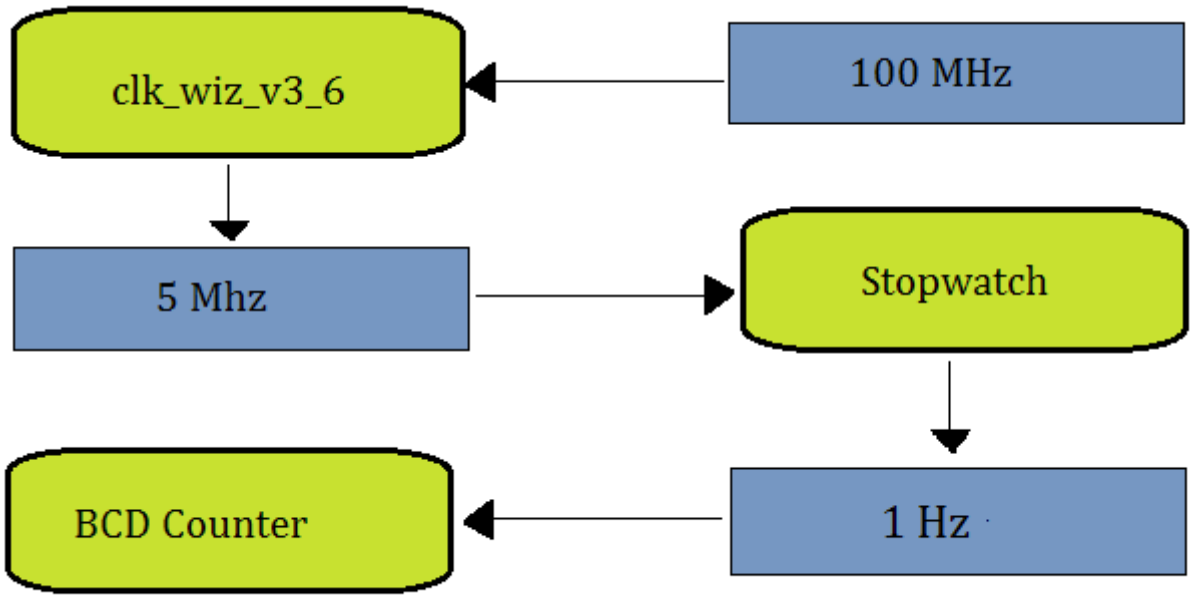
'23.0'__reset___=> '0.0' : Transition when reset button is pressed (reset)

Procedure:

The assignment contains three modules:

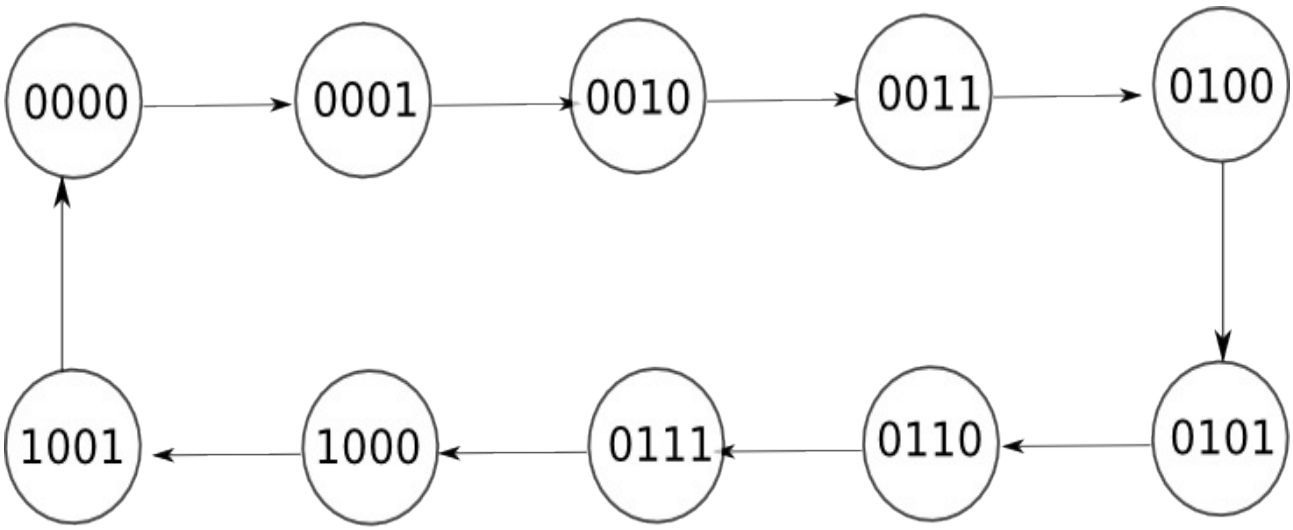
1. Clocking Module:

For the seconds counter in the stopwatch, we need a 1hz clock. But, the on board clock has frequency 100 Mhz. For this we wrote a clock module which uses the clocking wizard to generate a 5 Mhz clock signal from the input 100 Mhz signal. Now, to get a 1 hz signal, we maintain a counter counting from 0 to 5 million (5 Mhz) which is incremented on each rising edge of the 5 Mhz clock. After every 2.5 million counts, we toggle our 1 hz clock. Thus generating a 1hz signal.



2. BCD Counter:

It is the main counting mechanism used to implement the seconds stopwatch. It is fed the generated 1hz clock signal. It counts from 0 to 99 and back. It uses four flip-flops for each BCD digit and has a total of 100 states. It also has a reset input that sets all flip-flops to 0. Following is the state diagram for a 0 to 9 BCD counter:



State diagram of BCD Counter

3. Stopwatch:

It uses the clocking and BCD counter modules to finally implement the stopwatch design. To stop the BCD counter (when start/stop button toggles the stopwatch to non-running state) we stop generating the 1hz signal i.e., when the ticking state is 0, we stop toggling the 1hz clock. The start button resumes the clock generation.

If rollover mode is off and the count reaches 99 i.e, before overflow we stop generating the clock. In other words, the stopwatch comes to a halt. If the rollover mode is on and when count is 99, we simply start counting from 0 in the next tick.

Results Captured :

1. The stopwatch counts from 0 to 99. At this point one of the following things happen:

a. If the Rollover DIP switch is disabled (Rollover='0'), then the stopwatch stops counting. If the start/stop (SS) button is pressed in this condition(when the count is still 99), the clock doesnot start and remains in the stop state.

b. If the Rollover DIP switch is enabled (Rollover='1'), then the stopwatch restarts counting from 0 back until 99. If the start/stop button is pressed in this condition, the clock stops if it was running and restarts from the same count when the SS button is hit again.

2. If the start/stop button is pressed in between (before reaching 99), it stops and restarts from the same count when the SS button is pressed again.

3. If the reset button is pressed at any point of time, the stopwatch starts counting from 0 again.