ECE 460M
Digital System Design using Verilog
Lab Manual

Lab Assignment #3

Guideline

This lab can be done with a partner.

Objective

Your objective in this lab is to develop a simplified version of the activity tracking device, Fitbit, on an FPGA. The Fitbit will implement a subset of features offered by the real Fitbit device and app. A circuit that would provide input pulses to your Fitbit module will also be synthesized and implemented in this lab.

Description

The inputs to the Fitbit module are:

1. A sequence of pulses denoting steps
2. The system clock and reset

Your module is expected to display the following information on the 7-segment screen:

1. **Total step count:** The total number of steps or pulses being counted. Since the 7-segment can only display up to 9999, your circuit should saturate at 9999 and would assert the signal SI to 1 as soon as the step count becomes more than 9999, indicating that the step count value being displayed is inaccurate and is more than 9999. Whenever reset is asserted, the step count will be set to 0000 and SI will go low if it was previously high. Note that the reset is active high.

2. **Distance covered:** The displayed value of distance covered should be as per the following criterion: 2048 steps will constitute half a mile for distance calculation assuming the size of the steps to be fixed at an average value. To make distance calculation in hardware simpler, you are required to display the distance in denominations of 0.5 miles i.e., 0.5 miles, 1.0 miles, 1.5 miles and so on. This is achieved by rounding down the actual distance covered to the nearest multiple of 0.5, so that the following are the display values for the total distance covered:
   [0,0.5) -> 0
   [0.5,1.0) -> 0.5
   [1.0, 1.5) -> 1.0
   [1.5, 2.0) -> 1.5 and so on**.**

   Note that the correct distance should be displayed even when the display count for the number of steps saturates at 9999.

3. **Number of seconds with over 32 steps/second:** This exhibits the number of seconds, which holds 32 steps per second, within the first 9 seconds. For example, there are 4 seconds where the number of steps per second is larger than 32 within the first 9 seconds, then your board should display 4 on the 7-segment. The value should be held on even after 9 seconds until reset is asserted. This value should be cleared when reset is asserted. Once reset is deasserted, the 9-second window should start from scratch and recount on the first 9 seconds.

4. **High activity time greater than threshold:** The tracker should recognize and award active seconds when the activity is more strenuous than regular walking. The criterion for recognizing **high activity time** is "**at least a minute of activity at a rate of equal or larger than 64 steps per second**". For example, if the tracker detects an activity of 64 steps (or larger) in a second for 60 continuous seconds for the first time, the high activity timer should go from 0 to 60 seconds and the timer should increment per second for continued activity at a rate higher than 64 steps per second (60, 61, 62…). The displayed value should freeze when the step rate goes below 64 at any second. If the high activity is detected again, the frozen display should accumulate with the additional **high activity time**.

   Case 1:
   Suppose the display froze at 67, and high activity time is detected again (a minute of activity at a rate of equal or larger than 64 steps per second), the display should go from 67 to 127 after high activity at the end of the minute.

   Case 2:
   Suppose there is activity at a rate equal to or higher than 64 steps per second for a period of 40 seconds, followed by a period of rest/low activity. Then another 30 seconds of activity at a rate higher than 64 steps/second is detected. In this case, no high activity time should be counted.

Display Specifications for the Fitbit tracker:

Information from the Fitbit module should be displayed on the 7-segment display in a rotating fashion with a period of 2 seconds. The display should follow the following sequence: Total step count, Distance covered, Steps over 32(time), High activity time, Total step count, Distance covered...and so on, with each piece of information being displayed for 2 seconds.

To display a decimal value like distance, represent the decimal point with a _. For e.g., 1.5 should be represented as 1_5 on the display. You can choose to display a 0 or leave the upper unused digits unlit.

Pulse generator:

We require a pulse generator to model the steps. Your pulse generator should generate a sequence of pulses fed to the Fitbit tracker module. The generator should not be affected by the tracker nor affect the tracker, it is a stand-alone module from tracker. Your generator should start generating the pulses once the input START signal goes high. When the START signal goes low, the generator should stop generating any more pulses. It should start afresh when the signal goes high again. The generator should have at least 4 modes:

1. Walk mode (MODE = 2'b00): In this mode, the generator should output a sequence of pulses at a rate of 32 pulses/steps per second.

2. Jog mode (MODE = 2'b01): A sequence of pulses at the rate of 64 pulses/steps per second.

3. Run mode (MODE = 2'b10): A sequence of pulses at the rate of 128 pulses/steps per second. (MODE = 10)

4. Hybrid mode (MODE = 2'b11): The sequence of pulses should be as follows:

Time	1st sec	2nd sec	3rd sec	4th sec	5th sec	6th sec	7th sec	8th sec	9th sec
No. of pulses	20	33	66	27	70	30	19	30	33

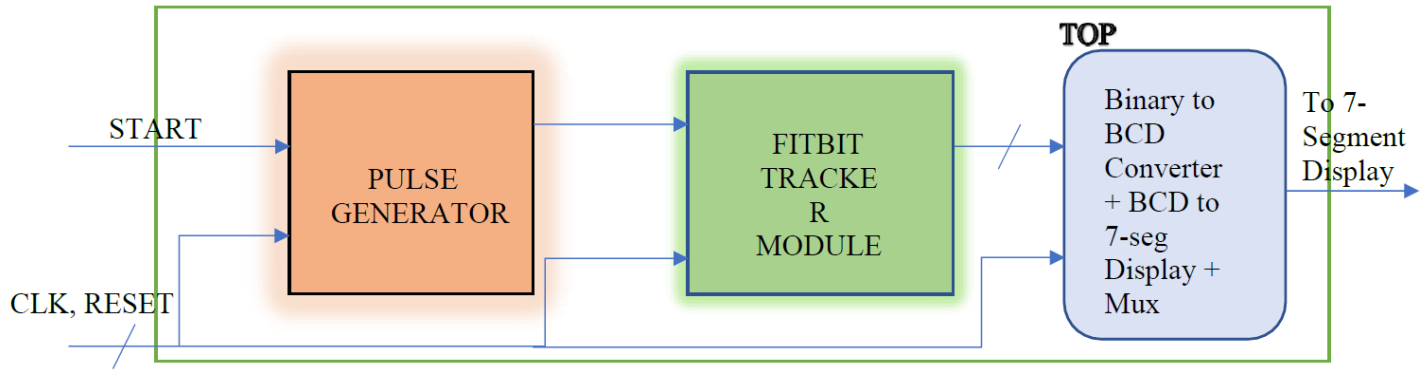
10th - 73rd sec	74th - 79th sec	80th - 144th sec	145th sec onwards
69	34	124	No pulses

You can add other modes for testing your tracker, but the modes above are required to be present.

Mapping Information:

MODE – {Switch 3, Switch 2}
RESET – Switch 1
START – Switch 0
SI – LED0

Fig. Block Diagram for a top module containing the pulse generator, Fitbit tracker and display controller



Clarifications/Useful Information

1. The tracker can display a maximum step count of 9999. However, it should continue to display the correct value for distance, total activity time and high activity time.

2. The reset, when asserted, should clear the step counter, distance counter, steps over 32 time and high activity time and a 0000(or 0) should be displayed for each of them. The pulse generator should also be reset with an asserted reset signal.

3. Check for the overflow condition (saturation at 9999) in your code and make sure it works.

4. Ensure that there are no inferred latches in your design when you implement it.

5. It is okay if certain display information is updated by your Fitbit module after a constant time lag, which you will need to update the registers in your module. This can be made very low by using clock(s) with higher frequencies.

6. The tracker should detect the pulse from the generator, you are not allowed to hard-code the tracker for the four modes.

Submission Details

All parts of this lab are to be submitted on Canvas. No hard-copy submission is needed. Please include files below and zip them in **your_last_name.zip** in your submission.

1. All Verilog codes
2. Bit file and XDC file

Checkout Details

During your checkout you will be expected to demonstrate your fitbit module and answer verbal questions about the assignment.