Lab 9: Rotary Dial and PWM Signals

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Lab 9: Rotary Dial and PWM Signals

- In this lab, you will design a circuit to change the brightness of the LEDs on the Spartan-3E board
  - The brightness of the LEDs is controlled by Pulse-Width Modulation (PWM)
  - The user uses the rotary dial to change the brightness

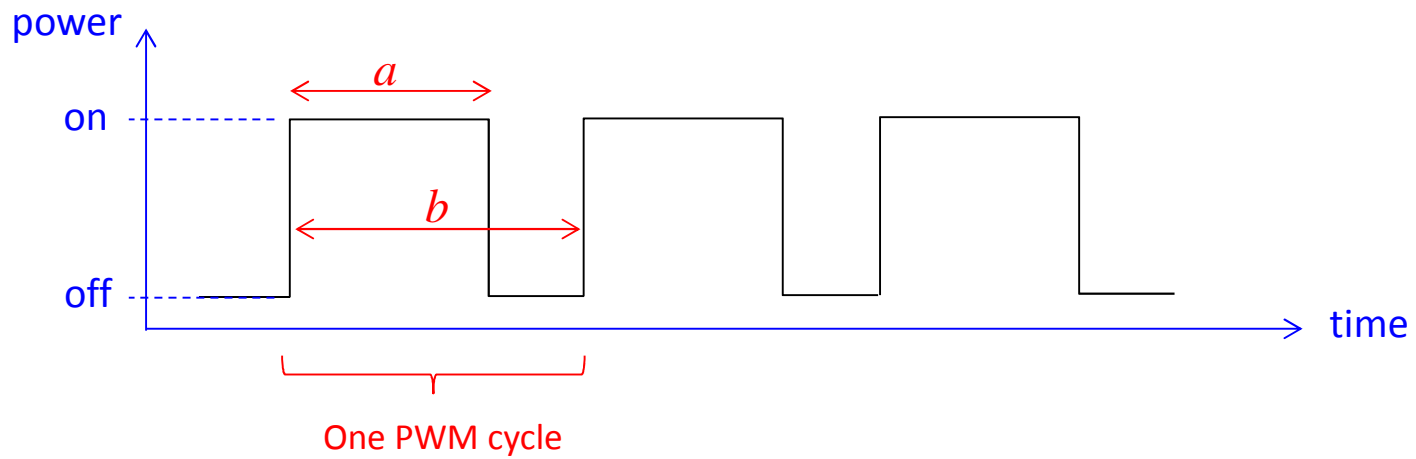
- You will demo the design to your TA during the lab hours on 12/13

Control of the LED Brightness

- The LED device in the Spartan-3e Starter Board can only be fully lit (full power) or turned off (zero power), you can not set it to different levels of brightness
- To trick your eyes to see different levels of brightness, you can send a PWM signal to its power input
- A PWM input to the LED turns it on-an-off quickly
  - The persistence of human visions will not see flickering but only different levels of brightness, as long as your PWM frequency is high enough

A PWM Signal

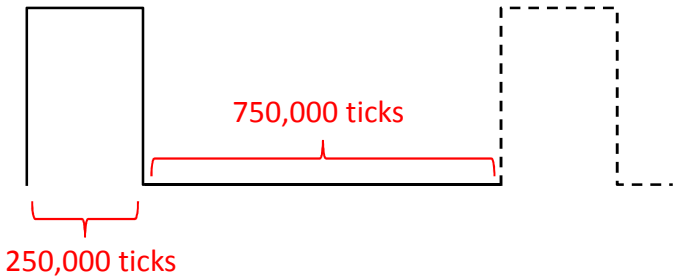
- A PWM signal is simply a square wave signal:



- Duty-cycle: the percentage of one cycle of PWM that is in "on" state (i.e., $(a/b)\times 100\%$ in the figure)
  - 50% duty-cycle means the signal is "on" half of the time

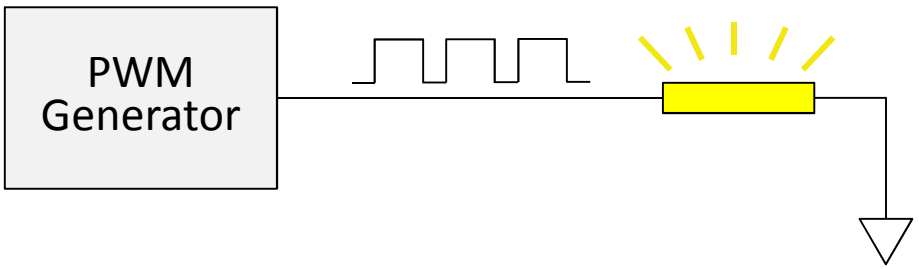
Generation of a PWM Signal

- The system clock of our boards is 50MHz
  - Each second has 50,000,000 clock ticks
- To generate a 50 Hz PWM signal, the full cycle period would be equal to 1,000,000 clock ticks
  - The clock ticks for a 25% duty cycle PWM signal @ 50Hz would be 250,000 clock ticks for “on” period and 750,000 clock ticks for “off” period



PWM Control of Brightness

- Persistence of visions make most people do not see flickering when the LED is switching faster than 60 Hz
- We can use a PWM signal higher than 60Hz to control the brightness of an LED
- The PWM duty cycle determines the brightness



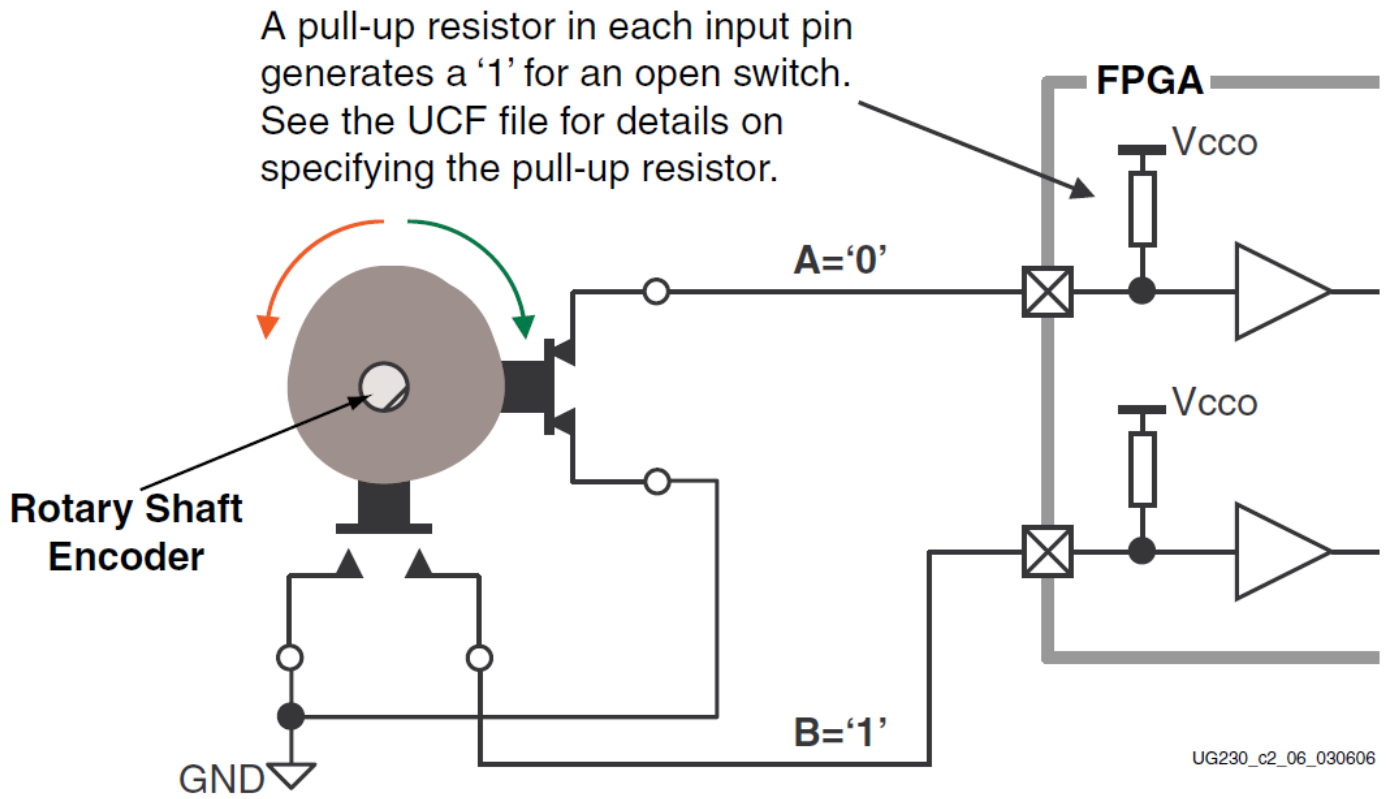
Parameters for PWM Signals in Lab 9

- For this lab, your circuit must generates two types of the PWM signals: 25 Hz and 100 Hz
  - Under 25 Hz PWM, you will see flickering of the LEDs
  - Under 100 Hz PWM, most of you will not see any flickering
- For each PWM frequency, you must allow five different duty cycles from 5% to 100%

Users press the WEST button to change the PWM frequency, and use the rotary dial to change the PWM duty cycle.

Rotary Dial Control

- There is a rotary dial on the Spartan-3e board:

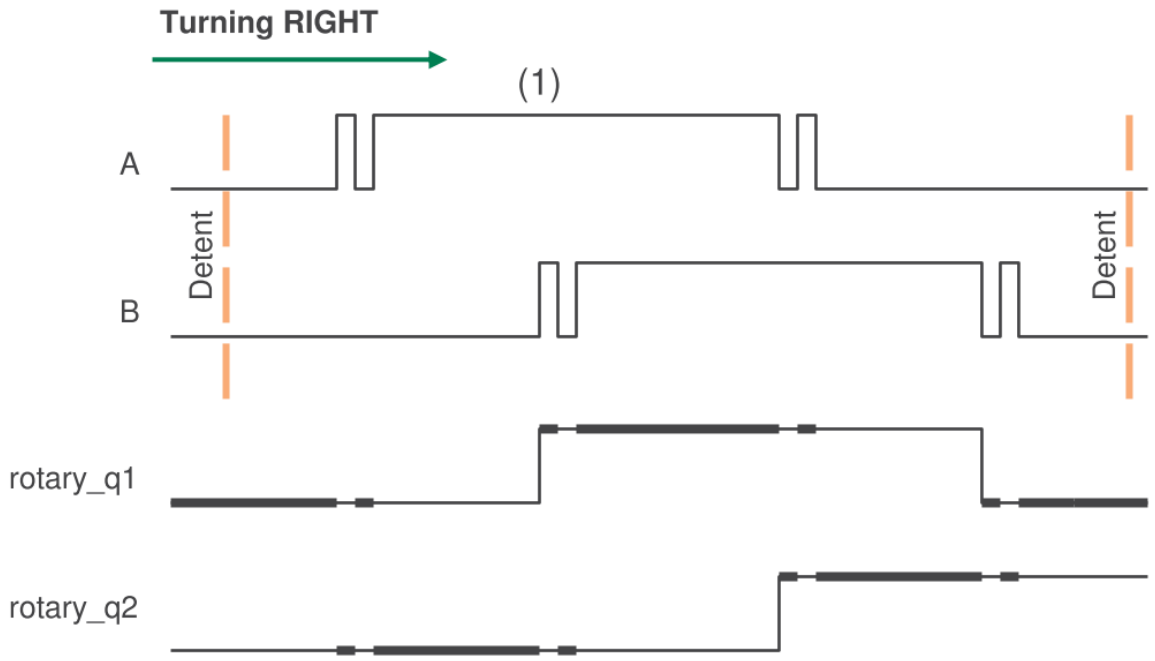


Rotary Controller

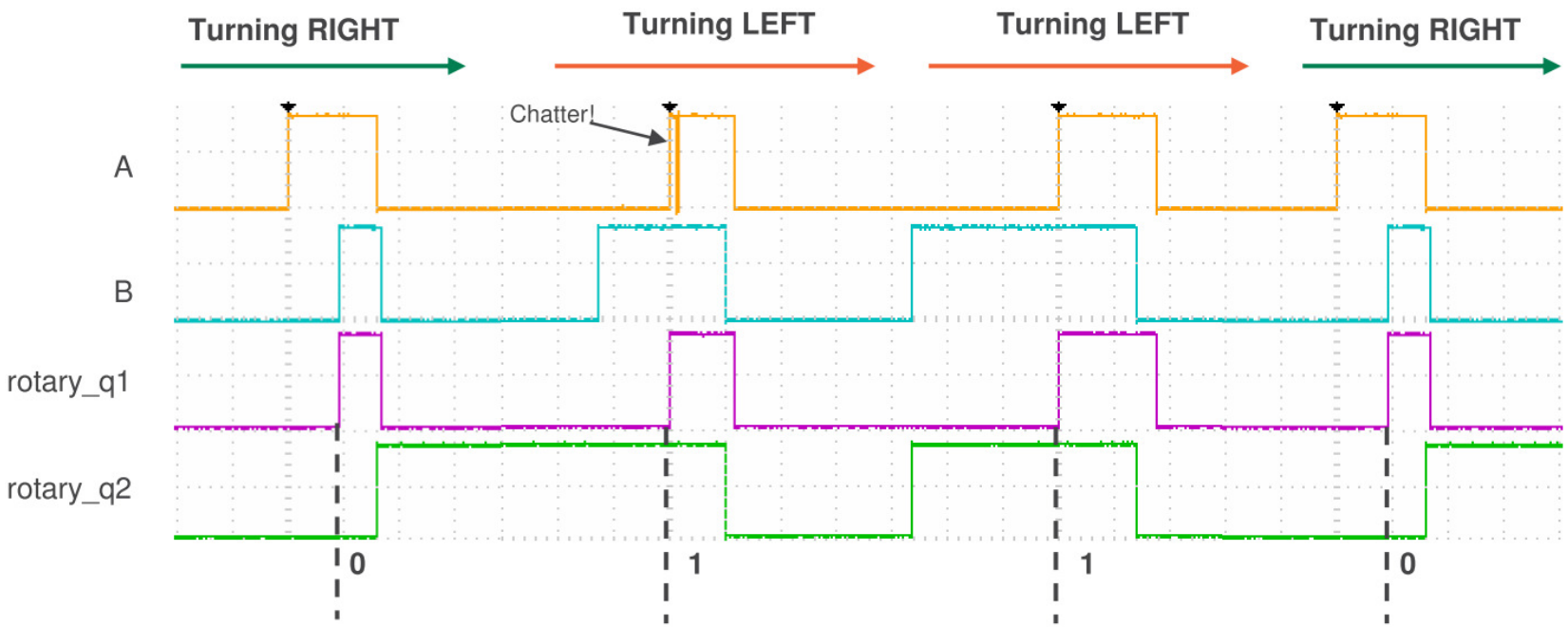
- A rotary controller module will be provided to you:

rotary_q1
Set ('1') when A is High and B is High
Reset ('0') when A is Low and B is Low.

rotary_q2
Set ('1') when A is Low and B is High
Reset ('0') when A is High and B is Low.



Rotary Controller Waveform Examples



Rotary Controller Specification

- The controller module has five ports:

```
module Rotation_direction(
    input CLK,
    input ROT_A,
    input ROT_B,
    output reg rotary_event,
    output reg rotary_right);
```

  - `CLK` is the 50MHz system clock
  - `ROT_A` and `ROT_B` are the two ports connect to the rotary pins
  - `rotary_event == 1` means the user is turning the rotary
  - `rotary_right == 1` means turning right, 0 means turning left

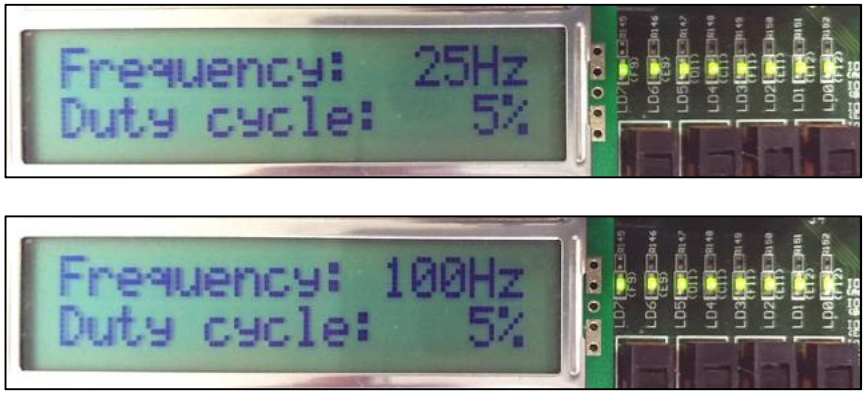
- Note that the initial state of the rotary dial may not be 0

The Sample Code of Lab 9

- For lab9, a sample ISE project that shows you how to use the rotary dial to do animations will be provided
  - As the user turns the dial toward left and right, the lighted LED will be moving toward left and right.
  - Also, a “*” character on the LCD module will be moving accordingly as well.

What You Need to Do for Lab 9

- Design a circuit to control the brightness of the LEDs
  - The WEST button toggles btw. 25Hz and 100Hz PWM signals
  - The rotary input changes the duty cycle of the PWM signal from 5%, 25%, 50%, 75%, to 100%
  - The frequency & duty cycle must be displayed on the LCD



References

- Ken Chapman, *Rotary Encoder Interface for Spartan-3E Starter Kit*, Feb. 2006:

  http://www.xilinx.com/products/boards/s3estarter/files/s3esk_rotary_encoder_interface.pdf