Chapter 2

# Switches, Buttons, and Knob

## Slide Switches

### Locations and Labels

The Spartan-3E Starter Kit board has four slide switches, as shown in Figure 2-1. The slide switches are located in the lower right corner of the board and are labeled SW3 through SW0. Switch SW3 is the left-most switch, and SW0 is the right-most switch.

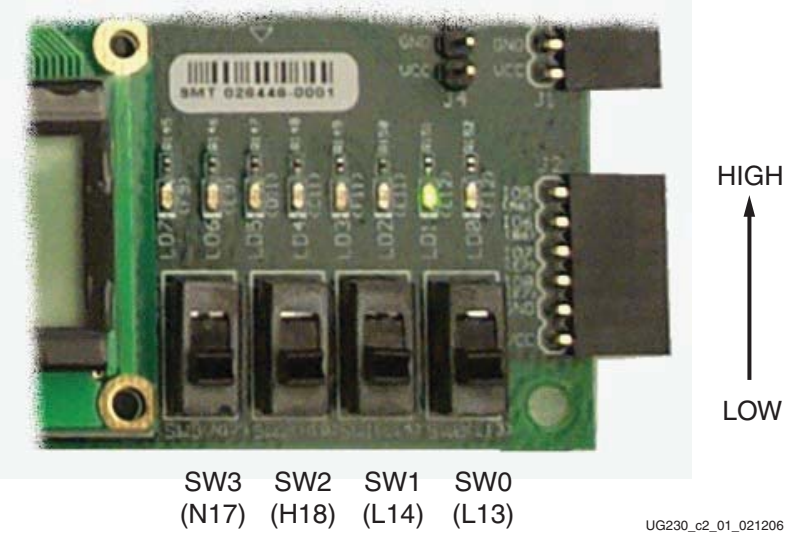



*Figure 2-1:* **Four Slide Switches**

### Operation

When in the UP or ON position, a switch connects the FPGA pin to 3.3V, a logic High. When DOWN or in the OFF position, the switch connects the FPGA pin to ground, a logic Low. The switches typically exhibit about 2 ms of mechanical bounce and there is no active debouncing circuitry, although such circuitry could easily be added to the FPGA design programmed on the board.

### UCF Location Constraints

Figure 2-2 provides the UCF constraints for the four slide switches, including the I/O pin assignment and the I/O standard used. The PULLUP resistor is not required, but it defines the input value when the switch is in the middle of a transition.

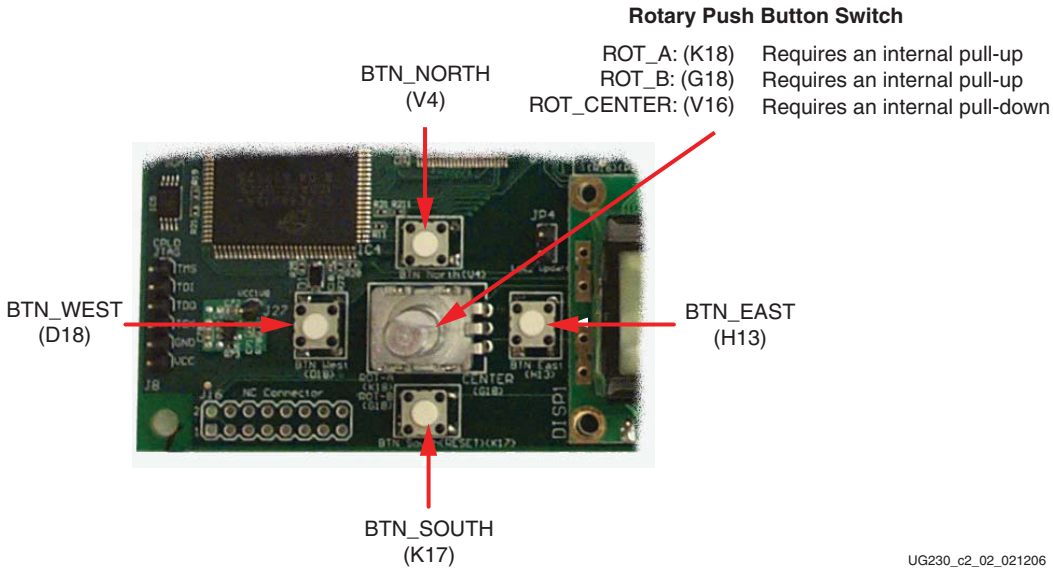
```
NET "SW<0>" LOC = "L13" | IOSTANDARD = LVTTL | PULLUP ;
NET "SW<1>" LOC = "L14" | IOSTANDARD = LVTTL | PULLUP ;
NET "SW<2>" LOC = "H18" | IOSTANDARD = LVTTL | PULLUP ;
NET "SW<3>" LOC = "N17" | IOSTANDARD = LVTTL | PULLUP ;
```

*Figure 2-2:* **UCF Constraints for Slide Switches**

# Push-Button Switches

## Locations and Labels

The Spartan-3E Starter Kit board has four momentary-contact push-button switches, shown in Figure 2-3. The push buttons are located in the lower left corner of the board and are labeled BTN_NORTH, BTN_EAST, BTN_SOUTH, and BTN_WEST. The FPGA pins that connect to the push buttons appear in parentheses in Figure 2-3 and the associated UCF appears in Figure 2-5.




**Notes:**

1. All BTN_* push-button inputs require an internal pull-down resistor.
2. BTN_SOUTH is also used as a soft reset in some FPGA applications.

*Figure 2-3:* **Four Push-Button Switches Surround Rotary Push-Button Switch**

## Operation

Pressing a push button connects the associated FPGA pin to 3.3V, as shown in Figure 2-4. Use an internal pull-down resistor within the FPGA pin to generate a logic Low when the button is not pressed. Figure 2-5 shows how to specify a pull-down resistor within the UCF. There is no active debouncing circuitry on the push button.

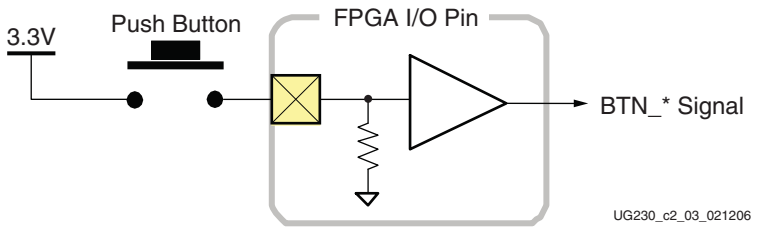



*Figure 2-4:* **Push-Button Switches Require an Internal Pull-Down Resistor in FPGA Input Pin**

In some applications, the BTN_SOUTH push-button switch is also a soft reset that selectively resets functions within the FPGA.

### UCF Location Constraints

Figure 2-5 provides the UCF constraints for the four push-button switches, including the I/O pin assignment and the I/O standard used, and defines a pull-down resistor on each input.

```
NET "BTN_EAST"  LOC = "H13" | IOSTANDARD = LVTTL | PULLDOWN ;
NET "BTN_NORTH" LOC = "V4"  | IOSTANDARD = LVTTL | PULLDOWN ;
NET "BTN_SOUTH" LOC = "K17" | IOSTANDARD = LVTTL | PULLDOWN ;
NET "BTN_WEST"  LOC = "D18" | IOSTANDARD = LVTTL | PULLDOWN ;
```

*Figure 2-5:* **UCF Constraints for Push-Button Switches**

## Rotary Push-Button Switch

### Locations and Labels

The rotary push-button switch is located in the center of the four individual push-button switches, as shown in Figure 2-3. The switch produces three outputs. The two shaft encoder outputs are ROT_A and ROT_B. The center push-button switch is ROT_CENTER.

### Operation

The rotary push-button switch integrates two different functions. The switch shaft rotates and outputs values whenever the shaft turns. The shaft can also be pressed, acting as a push-button switch.

#### Push-Button Switch

Pressing the knob on the rotary/push-button switch connects the associated FPGA pin to 3.3V, as shown in Figure 2-6. Use an internal pull-down resistor within the FPGA pin to generate a logic Low. Figure 2-9 shows how to specify a pull-down resistor within the UCF. There is no active debouncing circuitry on the push button.

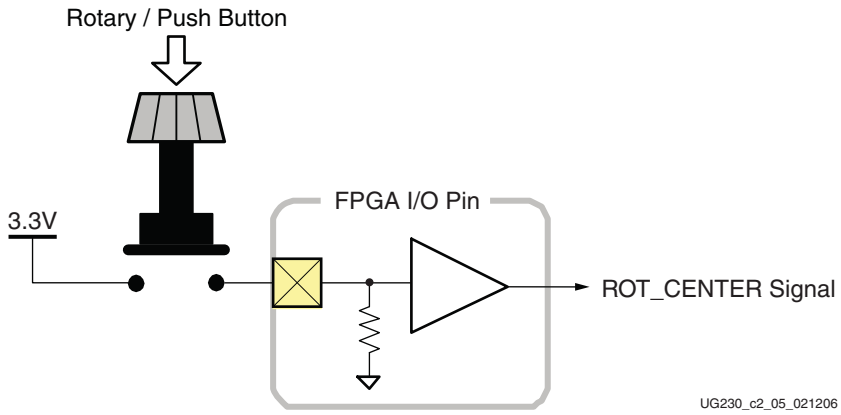



*Figure 2-6:* **Push-Button Switches Require Internal Pull-up Resistor in FPGA Input Pin**

## Rotary Shaft Encoder

In principal, the rotary shaft encoder behaves much like a cam, connected to central shaft. Rotating the shaft then operates two push-button switches, as shown in Figure 2-7. Depending on which way the shaft is rotated, one of the switches opens before the other. Likewise, as the rotation continues, one switch closes before the other. However, when the shaft is stationary, also called the *detent* position, both switches are closed.

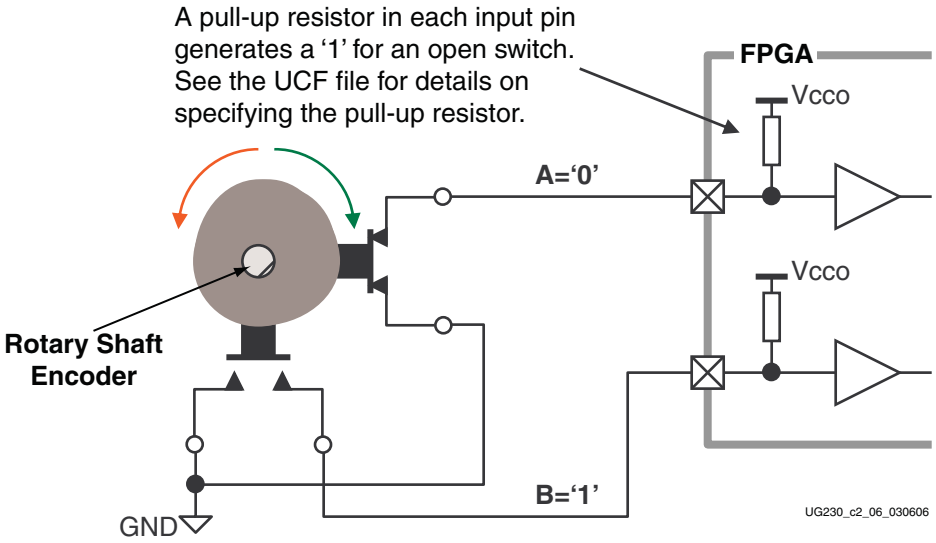



*Figure 2-7:* **Basic example of rotary shaft encoder circuitry**

Closing a switch connects it to ground, generating a logic Low. When the switch is open, a pull-up resistor within the FPGA pin pulls the signal to a logic High. The UCF constraints in Figure 2-9 describe how to define the pull-up resistor.

The FPGA circuitry to decode the 'A' and 'B' inputs is simple, but must consider the mechanical switching noise on the inputs, also called chatter. As shown in Figure 2-8, the chatter can falsely indicate extra rotation events or even indicate rotations in the opposite

direction! See the Rotary Encoder Interface reference design in"Related Resources" for an example.

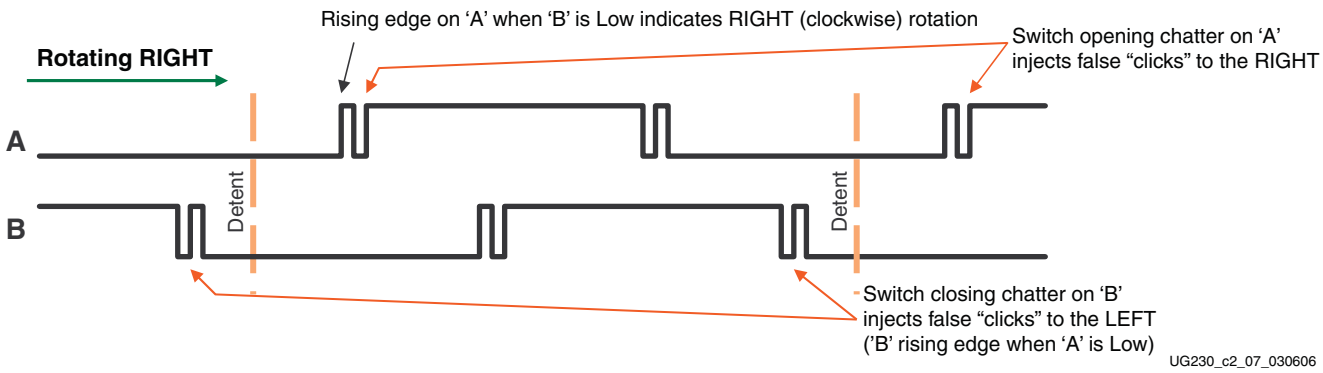



*Figure 2-8:* **Outputs from Rotary Shaft Encoder May Include Mechanical Chatter**

## UCF Location Constraints

Figure 2-9 provides the UCF constraints for the four push-button switches, including the I/O pin assignment and the I/O standard used, and defines a pull-down resistor on each input.

```
NET "ROT_A"      LOC = "K18" | IOSTANDARD = LVTTL | PULLUP   ;
NET "ROT_B"      LOC = "G18" | IOSTANDARD = LVTTL | PULLUP   ;
NET "ROT_CENTER" LOC = "V16" | IOSTANDARD = LVTTL | PULLDOWN ;
```

*Figure 2-9:* **UCF Constraints for Rotary Push-Button Switch**

# Discrete LEDs

## Locations and Labels

The Spartan-3E Starter Kit board has eight individual surface-mount LEDs located above the slide switches as shown in Figure 2-10. The LEDs are labeled LED7 through LED0. LED7 is the left-most LED, LED0 the right-most LED.

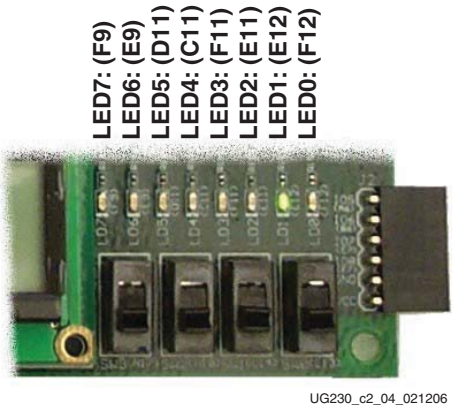



*Figure 2-10:* **Eight Discrete LEDs**

## Operation

Each LED has one side connected to ground and the other side connected to a pin on the Spartan-3E device via a 390Ω current limiting resistor. To light an individual LED, drive the associated FPGA control signal High.

## UCF Location Constraints

Figure 2-11 provides the UCF constraints for the four push-button switches, including the I/O pin assignment, the I/O standard used, the output slew rate, and the output drive current.

```
NET "LED<7>" LOC = "F9" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<6>" LOC = "E9" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<5>" LOC = "D11" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<4>" LOC = "C11" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<3>" LOC = "F11" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<2>" LOC = "E11" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<1>" LOC = "E12" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<0>" LOC = "F12" | IOSTANDARD = LVTTL | SLEW = SLOW | DRIVE = 8 ;
```

*Figure 2-11:* **UCF Constraints for Eight Discrete LEDs**

# Related Resources

- Rotary Encoder Interface for Spartan-3E Starter Kit (Reference Design)
  http://www.xilinx.com/s3estarter