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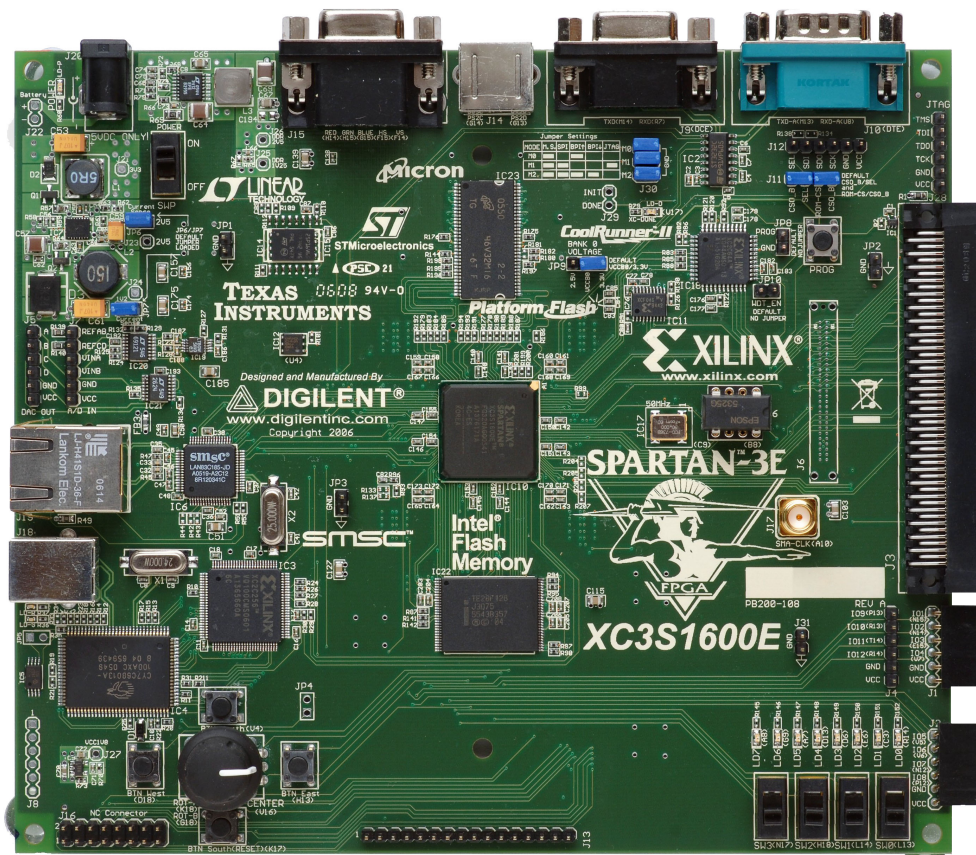
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MicroBlaze Development Kit Spartan-3E 1600E Edition User Guide

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Revision History

The following table shows the revision history for this document.

Date	Version	Revision
6/23/06	1.0	Initial release.
12/5/07	1.1	Updated Figures 15-8, 15-9, and 15-10 to comply with UCF I/O location constraints.

Table of Contents

Preface: About This Guide

Acknowledgements	7
Guide Contents	7
Additional Resources	8

Chapter 1: Introduction and Overview

Choose the Starter Kit Board for Your Needs	9
Spartan-3E FPGA Features and Embedded Processing Functions	9
Learning Xilinx FPGA, CPLD, and ISE Development Software Basics	9
Advanced Spartan-3 Generation Development Boards	9
Key Components and Features	10
Design Trade-Offs	11
Configuration Methods Galore!	11
Voltages for all Applications	11
Related Resources	11

Chapter 2: Switches, Buttons, and Knob

Slide Switches	13
Locations and Labels	13
Operation	13
UCF Location Constraints	13
Push-Button Switches	14
Locations and Labels	14
Operation	14
UCF Location Constraints	15
Rotary Push-Button Switch	15
Locations and Labels	15
Operation	15
UCF Location Constraints	17
Discrete LEDs	17
Locations and Labels	17
Operation	18
UCF Location Constraints	18
Related Resources	18

Chapter 3: Clock Sources

Overview	19
Clock Connections	20
Voltage Control	20
50 MHz On-Board Oscillator	20
Auxiliary Clock Oscillator Socket	20
SMA Clock Input or Output Connector	20

UCF Constraints	20
Location	21
Clock Period Constraints	21
Related Resources	21

Chapter 4: FPGA Configuration Options

Configuration Mode Jumpers	25
PROG Push Button	26
DONE Pin LED	26
Programming the FPGA, CPLD, or Platform Flash PROM via USB	27
Connecting the USB Cable	27
Programming via iMPACT	28
Programming Platform Flash PROM via USB	30

Chapter 5: Character LCD Screen

Overview	41
Character LCD Interface Signals	42
Voltage Compatibility	42
Interaction with Intel StrataFlash	43
UCF Location Constraints	43
LCD Controller	44
Memory Map	44
Command Set	46
Operation	50
Four-Bit Data Interface	50
Transferring 8-Bit Data over the 4-Bit Interface	51
Initializing the Display	51
Writing Data to the Display	52
Disabling the Unused LCD	52
Related Resources	52

Chapter 6: VGA Display Port

Signal Timing for a 60 Hz, 640x480 VGA Display	54
VGA Signal Timing	56
UCF Location Constraints	57
Related Resources	57

Chapter 7: RS-232 Serial Ports

Overview	59
UCF Location Constraints	60

Chapter 8: PS/2 Mouse/Keyboard Port

Keyboard	64
Mouse	66
Voltage Supply	67

UCF Location Constraints	67
Related Resources	67

Chapter 9: Digital to Analog Converter (DAC)

SPI Communication	69
Interface Signals	70
Disable Other Devices on the SPI Bus to Avoid Contention	70
SPI Communication Details	71
Communication Protocol	71
Specifying the DAC Output Voltage	72
DAC Outputs A and B	72
DAC Outputs C and D	73
UCF Location Constraints	73
Related Resources	73

Chapter 10: Analog Capture Circuit

Digital Outputs from Analog Inputs	76
Programmable Pre-Amplifier	77
Interface	77
Programmable Gain	77
SPI Control Interface	78
UCF Location Constraints	79
Analog to Digital Converter (ADC)	79
Interface	79
SPI Control Interface	79
UCF Location Constraints	80
Disable Other Devices on the SPI Bus to Avoid Contention	81
Connecting Analog Inputs	81
Related Resources	81

Chapter 11: Intel StrataFlash Parallel NOR Flash PROM

StrataFlash Connections	84
Shared Connections	87
Character LCD	87
Xilinx XC2C64A CPLD	87
SPI Data Line	87
UCF Location Constraints	88
Address	88
Data	88
Control	89
Setting the FPGA Mode Select Pins	89
Related Resources	89

Chapter 12: SPI Serial Flash

UCF Location Constraints	92
Configuring from SPI Flash	92
Setting the FPGA Mode Select Pins	92

Creating an SPI Serial Flash PROM File	93
Downloading the Design to SPI Flash	98
Downloading the SPI Flash using XSPI	98
Additional Design Details	101
Shared SPI Bus with Peripherals	101
Other SPI Flash Control Signals	102
Variant Select Pins, VS[2:0]	102
Jumper Block J11	102
Programming Header J12	102
Multi-Package Layout	102
Related Resources	104

Chapter 13: DDR SDRAM

DDR SDRAM Connections	106
UCF Location Constraints	108
Address	108
Data	108
Control	109
Reserve FPGA VREF Pins	109
Related Resources	109

Chapter 14: 10/100 Ethernet Physical Layer Interface

Ethernet PHY Connections	112
MicroBlaze Ethernet IP Cores	113
UCF Location Constraints	114
Related Resources	114

Chapter 15: Expansion Connectors

Hirose 100-pin FX2 Edge Connector (J3)	115
Voltage Supplies to the Connector	116
Connector Pinout and FPGA Connections	116
Compatible Board	118
Mating Receptacle Connectors	118
Differential I/O	118
UCF Location Constraints	122
Six-Pin Accessory Headers	123
Header J1	123
Header J2	123
Header J4	124
UCF Location Constraints	124
Connectorless Debugging Port Landing Pads (J6)	125
Related Resources	126

Chapter 16: XC2C64A CoolRunner-II CPLD

UCF Location Constraints	128
FPGA Connections to CPLD	129
CPLD	129

Related Resources	130
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Chapter 17: DS2432 1-Wire SHA-1 EEPROM

UCF Location Constraints	131
Related Resources	131

Appendix A: Schematics

FX2 Expansion Header, 6-pin Headers, and Connectorless Probe Header	134
RS-232 Ports, VGA Port, and PS/2 Port	136
Ethernet PHY, Magnetics, and RJ-11 Connector	138
Voltage Regulators	140
FPGA Configurations Settings, Platform Flash PROM, SPI Serial Flash, JTAG Connections	142
FPGA I/O Banks 0 and 1, Oscillators	144
FPGA I/O Banks 2 and 3	146
Power Supply Decoupling	148
XC2C64A CoolRunner-II CPLD	150
Linear Technology ADC and DAC	152
Intel StrataFlash Parallel NOR Flash Memory and Micron DDR SDRAM . . .	154
Buttons, Switches, Rotary Encoder, and Character LCD	156
DDR SDRAM Series Termination and FX2 Connector Differential Termination	158

Appendix B: Example User Constraints File (UCF)

About This Guide

This user guide provides basic information on the MicroBlaze Development Kit board capabilities, functions, and design. It includes general information on how to use the various peripheral functions included on the board. For detailed reference designs, including VHDL or Verilog source code, please visit the following web link.

- Spartan™-3E Starter Kit Board Reference Page
<http://www.xilinx.com/sp3e1600e>

Acknowledgements

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- Intel Corporation for the 128 Mbit StrataFlash memory
- Linear Technology for the SPI-compatible A/D and D/A converters, the programmable pre-amplifier, and the power regulators for the non-FPGA components
- Micron Technology, Inc. for the 32M x 16 DDR SDRAM
- SMSC for the 10/100 Ethernet PHY
- STMicroelectronics for the 16M x 1 SPI serial Flash PROM
- Texas Instruments Incorporated for the three-rail TPS75003 regulator supplying most of the FPGA supply voltages
- Xilinx, Inc. Configuration Solutions Division for the XCF04S Platform Flash PROM and their support for the embedded USB programmer
- Xilinx, Inc. CPLD Division for the XC2C64A CoolRunner™-II CPLD

Guide Contents

This manual contains the following chapters:

- [Chapter 1, "Introduction and Overview,"](#) provides an overview of the key features of the MicroBlaze Development Kit board.
- [Chapter 2, "Switches, Buttons, and Knob,"](#) defines the switches, buttons, and knobs present on the MicroBlaze Development Kit board.
- [Chapter 3, "Clock Sources,"](#) describes the various clock sources available on the MicroBlaze Development Kit board.
- [Chapter 4, "FPGA Configuration Options,"](#) describes the configuration options for the FPGA on the MicroBlaze Development Kit board.

- [Chapter 5, “Character LCD Screen,”](#) describes the functionality of the character LCD screen.
- [Chapter 6, “VGA Display Port,”](#) describes the functionality of the VGA port.
- [Chapter 7, “RS-232 Serial Ports,”](#) describes the functionality of the RS-232 serial ports.
- [Chapter 8, “PS/2 Mouse/Keyboard Port,”](#) describes the functionality of the PS/2 mouse and keyboard port.
- [Chapter 9, “Digital to Analog Converter \(DAC\),”](#) describes the functionality of the DAC.
- [Chapter 10, “Analog Capture Circuit,”](#) describes the functionality of the A/D converter with a programmable gain pre-amplifier.
- [Chapter 11, “Intel StrataFlash Parallel NOR Flash PROM,”](#) describes the functionality of the StrataFlash PROM.
- [Chapter 12, “SPI Serial Flash,”](#) describes the functionality of the SPI Serial Flash memory.
- [Chapter 13, “DDR SDRAM,”](#) describes the functionality of the DDR SDRAM.
- [Chapter 14, “10/100 Ethernet Physical Layer Interface,”](#) describes the functionality of the 10/100Base-T Ethernet physical layer interface.
- [Chapter 15, “Expansion Connectors,”](#) describes the various connectors available on the MicroBlaze Development Kit board.
- [Chapter 16, “XC2C64A CoolRunner-II CPLD”](#) describes how the CPLD is involved in FPGA configuration when using Master Serial and BPI mode.
- [Chapter 17, “DS2432 1-Wire SHA-1 EEPROM”](#) provides a brief introduction to the SHA-1 secure EEPROM for authenticating or copy-protecting FPGA configuration bitstreams.
- [Appendix A, “Schematics,”](#) lists the schematics for the MicroBlaze Development Kit board.
- [Appendix B, “Example User Constraints File \(UCF\),”](#) provides example code from a UCF.

Additional Resources

To find additional resources for the MicroBlaze Processor or the Xilinx Embedded development tools, see the Xilinx website at:

<http://www.Xilinx.com/Microblaze> or <http://www.Xilinx.com/EDK>

To find additional documentation, see the Xilinx website at:

<http://www.xilinx.com/literature>.

To search the Answer Database of silicon, software, and IP questions and answers, or to create a technical support WebCase, see the Xilinx website at:

<http://www.xilinx.com/support>.

Introduction and Overview

Thank you for purchasing the Xilinx MicroBlaze™ Development Kit Spartan™-3E 1600E Edition. You will find it useful in developing your Spartan-3E FPGA application.

Choose the Starter Kit Board for Your Needs

Depending on specific requirements, choose the Xilinx development board that best suits your needs.

Spartan-3E FPGA Features and Embedded Processing Functions

The MicroBlaze Development Kit board highlights the unique features of the Spartan-3E FPGA family and provides a convenient development board for embedded processing applications. The board highlights these features:

- Spartan-3E specific features
 - ◆ Parallel NOR Flash configuration
 - ◆ MultiBoot FPGA configuration from Parallel NOR Flash PROM
 - ◆ SPI serial Flash configuration
- Embedded development
 - ◆ MicroBlaze 32-bit embedded RISC processor
 - ◆ PicoBlaze™ 8-bit embedded controller
 - ◆ DDR memory interfaces
 - ◆ 10-100 Ethernet
 - ◆ UART

Learning Xilinx FPGA, CPLD, and ISE Development Software Basics

The MicroBlaze Development Kit board is more advanced and complex compared to other Spartan development boards.

Advanced Spartan-3 Generation Development Boards

The MicroBlaze Development Kit board demonstrates the basic capabilities of the MicroBlaze embedded processor and the Xilinx Embedded Development Kit (EDK). For more advanced development on a board with additional peripherals and FPGA logic, consider the V4 FX12 Board:

- http://www.xilinx.com/xlnx/xebiz/designResources/ip_product_details.jsp?key=DO-ML403-EDK-ISE

Also consider the capable boards offered by Xilinx partners:

- <http://www.xilinx.com/products/devboards/index.htm>

Key Components and Features

The key features of the MicroBlaze Development Kit board are:

- Xilinx XC3S1600E Spartan-3E FPGA
 - ◆ Up to 250
 - ◆ user-I/O pins
 - ◆ 320-pin FBGA package
 - ◆ Over 33,000 logic cells
- Two Xilinx 4 Mbit Platform Flash configuration PROM
- Xilinx 64-macrocell XC2C64A CoolRunner CPLD
- 64 MByte (512 Mbit) of DDR SDRAM, x16 data interface, 100+ MHz
- 16 MByte (128 Mbit) of parallel NOR Flash (Intel StrataFlash)
 - ◆ FPGA configuration storage
 - ◆ MicroBlaze code storage/shadowing
- 16 Mbits of SPI serial Flash (STMicro)
 - ◆ FPGA configuration storage
 - ◆ MicroBlaze code shadowing
- 2 x 16 LCD display screen
- PS/2 mouse or keyboard port
- VGA display port
- 10/100 Ethernet PHY (requires Ethernet MAC in FPGA)
- Two 9-pin RS-232 ports (DTE- and DCE-style)
- On-board USB-based FPGA/CPLD download/debug interface
- 50 MHz and 66 MHz clock oscillators
- SHA-1 1-wire serial EEPROM for bitstream copy protection
- Hirose FX2 expansion connector with 40-user I/O
- Three Digilent 6-pin expansion connectors
- Four-output, SPI-based Digital-to-Analog Converter (DAC)
- Two-input, SPI-based Analog-to-Digital Converter (ADC) with programmable-gain pre-amplifier
- ChipScope™ SoftTouch debugging port
- Rotary-encoder with push-button shaft
- Eight discrete LEDs
- Four slide switches
- Four push-button switches
- SMA clock input

- 8-pin DIP socket for auxiliary clock oscillator

Design Trade-Offs

A few system-level design trade-offs were required in order to provide the MicroBlaze Development Kit board with the most functionality.

Configuration Methods Galore!

A typical FPGA application uses a single non-volatile memory to store configuration images. To demonstrate new Spartan-3E capabilities, the MicroBlaze Development Kit board has three different configuration memory sources that all need to function well together. The extra configuration functions make the starter kit board more complex than typical Spartan-3E applications.

The starter kit board also includes an on-board USB-based JTAG programming interface. The on-chip circuitry simplifies the device programming experience. In typical applications, the JTAG programming hardware resides off-board or in a separate programming module, such as the Xilinx Platform USB cable. This USB port is for programming only and can not be used as an independent USB interface.

Voltages for all Applications

The MicroBlaze Development Kit board showcases a triple-output regulator developed by Texas Instruments, the [TPS75003](#) specifically to power Spartan-3 and Spartan-3E FPGAs. This regulator is sufficient for most stand-alone FPGA applications. However, the starter kit board includes DDR SDRAM, which requires its own high-current supply. Similarly, the USB-based JTAG download solution requires a separate 1.8V supply.

Related Resources

- Xilinx MicroBlaze Soft Processor
<http://www.xilinx.com/microblaze>
- Xilinx PicoBlaze Soft Processor
<http://www.xilinx.com/picoblaze>
- Xilinx Embedded Development Kit
http://www.xilinx.com/ise/embedded_design_prod/platform_studio.htm
- Xilinx software tutorials
<http://www.xilinx.com/support/techsup/tutorials/>
- Texas Instruments TPS75003
<http://focus.ti.com/docs/prod/folders/print/tps75003.html>

Switches, Buttons, and Knob

Slide Switches

Locations and Labels

The MicroBlaze Development 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.

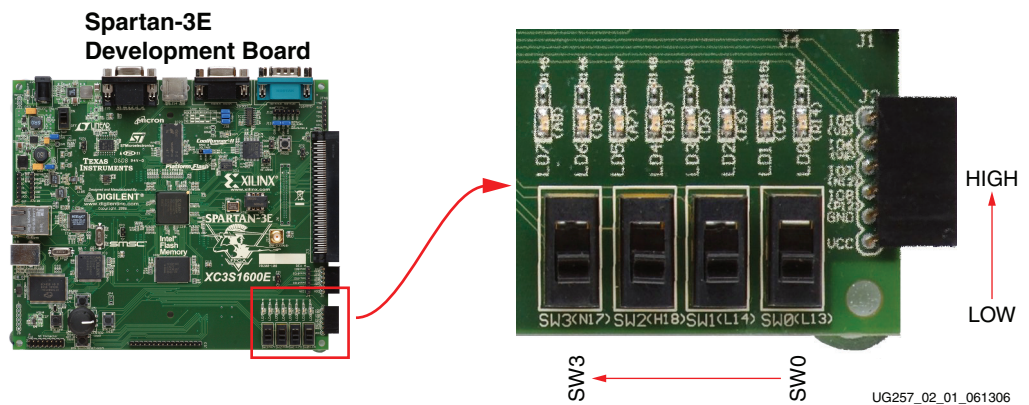


Figure 2-1: Four Slide Switches

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 = LVTTTL | PULLUP ;
NET "SW<1>" LOC = "L14" | IOSTANDARD = LVTTTL | PULLUP ;
NET "SW<2>" LOC = "H18" | IOSTANDARD = LVTTTL | PULLUP ;
NET "SW<3>" LOC = "N17" | IOSTANDARD = LVTTTL | PULLUP ;

```

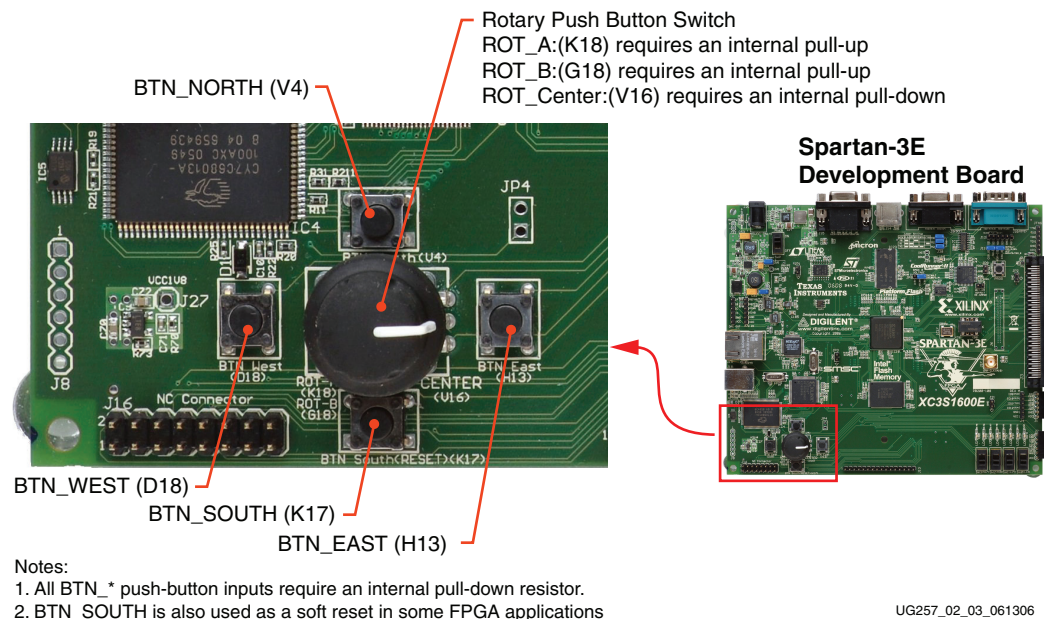
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Figure 2-2: UCF Constraints for Slide Switches

Push-Button Switches

Locations and Labels

The MicroBlaze Development 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.



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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.

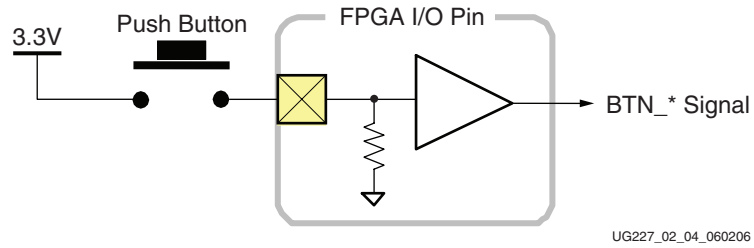


Figure 2-4: Push-Button Switches Require an Internal Pull-Down Resistor in FPGA Input Pin

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 = LVTTTL	PULLDOWN ;
NET "BTN_NORTH"	LOC = "V4"	IOSTANDARD = LVTTTL	PULLDOWN ;
NET "BTN_SOUTH"	LOC = "K17"	IOSTANDARD = LVTTTL	PULLDOWN ;
NET "BTN_WEST"	LOC = "D18"	IOSTANDARD = LVTTTL	PULLDOWN ;

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

Rotary Push-Button Switch

Locations and Labels

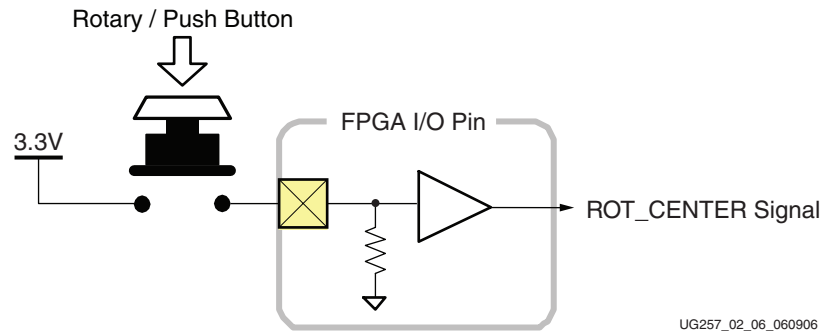
The rotary push-button switch is located in the center of the four individual push-button switches, as shown in Figure 2-3. The switch produces three outputs. The two shaft encoder outputs are ROT_A and ROT_B. The center push-button switch is ROT_CENTER.

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.

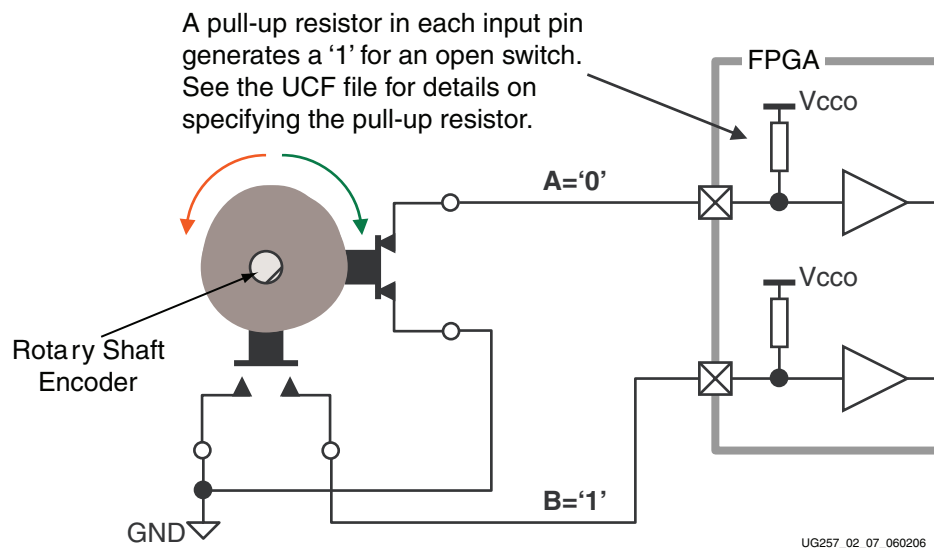


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Figure 2-6: Push-Button Switches Require Internal Pull-up Resistor in FPGA Input Pin

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.



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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.

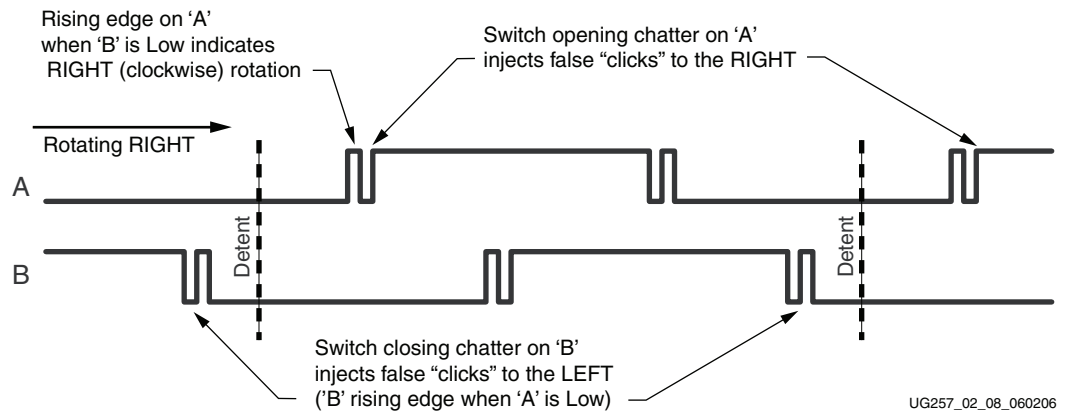


Figure 2-8: Outputs from Rotary Shaft Encoder May Include Mechanical Chatter

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 = LVTTTL | PULLUP ;
NET "ROT_B"      LOC = "G18" | IOSTANDARD = LVTTTL | PULLUP ;
NET "ROT_CENTER" LOC = "V16" | IOSTANDARD = LVTTTL | PULLDOWN ;
```

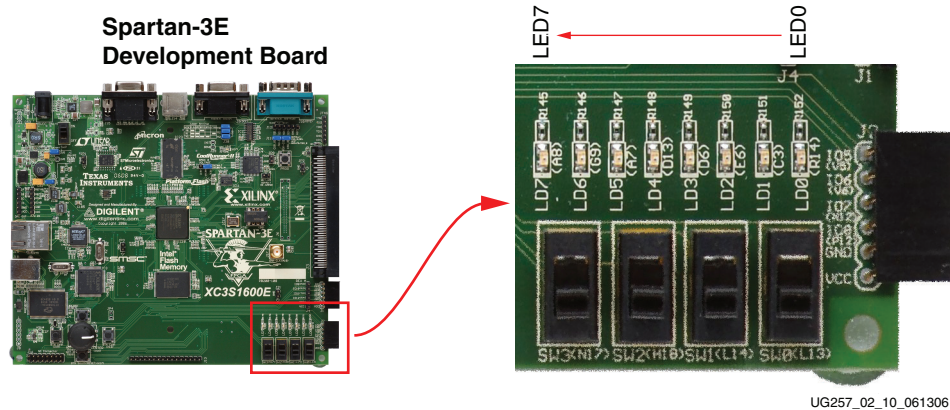
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Figure 2-9: UCF Constraints for Rotary Push-Button Switch

Discrete LEDs

Locations and Labels

The MicroBlaze Development 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.



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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 = "A8" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<6>" LOC = "G9" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<5>" LOC = "A7" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<4>" LOC = "D13" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<3>" LOC = "E6" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<2>" LOC = "D6" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<1>" LOC = "C3" | IOSTANDARD = LVTTTL | SLEW = SLOW | DRIVE = 8 ;
NET "LED<0>" LOC = "D4" | IOSTANDARD = SSTL2_I ;

```

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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>
<http://www.xilinx.com/sp3e1600E>

Clock Sources

Overview

As shown in [Figure 3-1](#), the MicroBlaze Development Kit board supports three primary clock input sources, all of which are located below the Xilinx logo, near the Spartan-3E logo.

- The board includes an on-board 50 MHz clock oscillator.
- The user clock socket is populated with a 66 MHz oscillator
- Clocks can be supplied off-board via an SMA-style connector. Alternatively, the FPGA can generate clock signals or other high-speed signals on the SMA-style connector.
- Optionally install a separate 8-pin DIP-style clock oscillator in the supplied socket

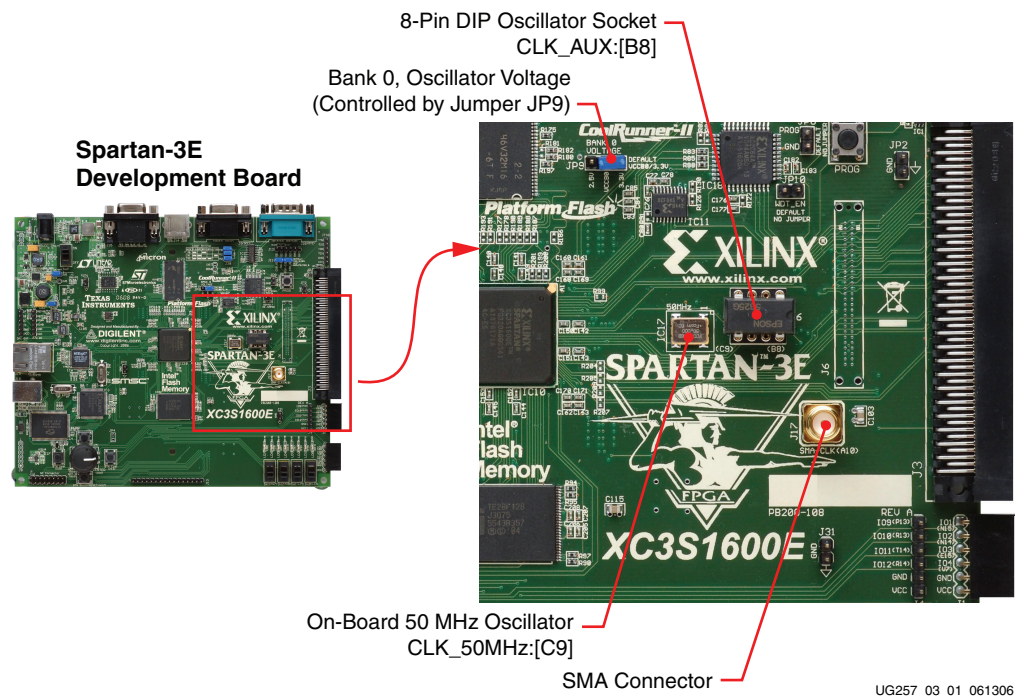


Figure 3-1: Available Clock Inputs

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Clock Connections

Each of the clock inputs connect directly to a global buffer input in I/O Bank 0, along the top of the FPGA. As shown in [Table 3-1](#), each of the clock inputs also optimally connects to an associated DCM.

Table 3-1: Clock Inputs and Associated Global Buffers and DCMs

Clock Input	FPGA Pin	Global Buffer	Associated DCM
CLK_50MHZ	C9	GCLK10	DCM_X0Y1
CLK_AUX	B8	GCLK8	DCM_X0Y1
CLK_SMA	A10	GCLK7	DCM_X1Y1

Voltage Control

The voltage for all I/O pins in FPGA I/O Bank 0 is controlled by jumper JP9. Consequently, these clock resources are also controlled by jumper JP9. By default, JP9 is set for 3.3V. The on-board oscillator is a 3.3V device and might not perform as expected when jumper JP9 is set for 2.5V.

50 MHz On-Board Oscillator

The board includes a 50 MHz oscillator with a 40% to 60% output duty cycle. The oscillator is accurate to ± 2500 Hz or ± 50 ppm.

Auxiliary Clock Oscillator Socket

The provided 8-pin socket accepts clock oscillators that fit the 8-pin DIP footprint. Use this socket if the FPGA application requires a frequency other than 50 MHz. This socket is populated with a 66 MHz oscillator. This clock input is used for some of the reference designs provided with the board. Alternatively, use the FPGA's Digital Clock Manager (DCM) to generate or synthesize other frequencies from the on-board 50 MHz oscillator.

SMA Clock Input or Output Connector

To provide a clock from an external source, connect the input clock signal to the SMA connector. The FPGA can also generate a single-ended clock output or other high-speed signal on the SMA clock connector for an external device.

UCF Constraints

The clock input sources require two different types of constraints. The location constraints define the I/O pin assignments and I/O standards. The period constraints define the clock period—and consequently the clock frequency—and the duty cycle of the incoming clock signal.

Location

Figure 3-2 provides the UCF constraints for the three clock input sources, including the I/O pin assignment and the I/O standard used. The settings assume that jumper JP9 is set for 3.3V. If JP9 is set for 2.5V, adjust the IOSTANDARD settings accordingly.

```
NET "CLK_50MHZ" LOC = "C9" | IOSTANDARD = LVCMOS33 ;  
NET "CLK_SMA" LOC = "A10" | IOSTANDARD = LVCMOS33 ;  
NET "CLK_AUX" LOC = "B8" | IOSTANDARD = LVCMOS33 ;
```

UG257_03_02_061306

Figure 3-2: UCF Location Constraints for Clock Sources

Clock Period Constraints

The Xilinx ISE development software uses timing-driven logic placement and routing. Set the clock PERIOD constraint as appropriate. An example constraint appears in Figure 3-3 for the on-board 50 MHz clock oscillator. The CLK_50MHZ frequency is 50 MHz, which equates to a 20 ns period. The output duty cycle from the oscillator ranges between 40% to 60%.

```
# Define clock period for 50 MHz oscillator  
NET "CLK_50MHZ" PERIOD = 20.0ns HIGH 40%;
```

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Figure 3-3: UCF Clock PERIOD Constraint

Related Resources

- Epson SG-8002JF Series Oscillator Data Sheet (50 MHz Oscillator)
http://www.eea.epson.com/go/Prod_Admin/Categories/EEA/QD/Crystal_Oscillators/prog_oscillators/go/Resources/TestC2/SG8002JF

FPGA Configuration Options

The MicroBlaze Development Kit board supports a variety of FPGA configuration options:

- Download FPGA designs directly to the Spartan-3E FPGA via JTAG, using the on-board USB interface. The on-board USB-JTAG logic also provides in-system programming for the on-board Platform Flash PROM and the Xilinx XC2C64A CPLD. SPI serial Flash and StrataFlash programming are performed separately.
- Program the on-board 4 Mbit Xilinx XCF04S serial Platform Flash PROM, then configure the FPGA from the image stored in the Platform Flash PROM using Master Serial mode.
- Program the on-board 16 Mbit ST Microelectronics SPI serial Flash PROM, then configure the FPGA from the image stored in the SPI serial Flash PROM using SPI mode.
- Program the on-board 128 Mbit Intel StrataFlash parallel NOR Flash PROM, then configure the FPGA from the image stored in the Flash PROM using BPI Up or BPI Down configuration modes. Further, an FPGA application can dynamically load two different FPGA configurations using the Spartan-3E FPGA's MultiBoot mode. See the Spartan-3E data sheet ([DS312](#)) for additional details on the MultiBoot feature.

[Figure 4-1](#) indicates the position of the USB download/programming interface and the on-board non-volatile memories that potentially store FPGA configuration images. [Figure 4-2](#) provides additional details on configuration options.