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iCE40 UltraPlus Breakout Board

User Guide

FPGA-UG-02001 Version 1.1

March 2017

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1. Introduction

Thank you for choosing the Lattice iCE40 UltraPlus™ Breakout Board.

This guide describes how to begin using the iCE40 UltraPlus Breakout Board, an easy-to-use platform for demonstrating the high-current LED drive capabilities of the iCE40 UltraPlus ; which has more memory to achieve functions mainly required in the customer mobile market. Along with the evaluation board and accessories, this kit includes a pre-loaded LED Driver Demo that demonstrates driving the RGB LEDs with a PWM circuit. In addition, most of the device's I/O pins are accessible via one of the several header locations on the board, facilitating rapid prototyping of user functions.

The contents of this user guide include demo operation, top-level functional descriptions of the various portions of the evaluation board, descriptions of the onboard connectors, shunts, and a complete set of schematics and the bill of materials for the iCE40 UltraPlus Breakout Board.

Note: Static electricity can severely shorten the lifespan of electronic components. Be careful when handling the iCE40 UltraPlus Breakout Board as to not damage it from ESD.

2. Features

The iCE40 UltraPlus Breakout Board includes:

- **iCE40 UltraPlus Breakout Board** – The iCE40 UltraPlus Breakout Board features the following on-board components and circuits:
  - iCE40 UltraPlus (iCE40UP5K-SG48) device in a 48-PIN QFN package.
  - Example of a board using this 0.5mm pitch QFN package.
  - High-current LED output
  - iCE40 UltraPlus Current Measurements
  - Standard USB cable for device programming.
  - RoHS-compliant packaging and process
- **Pre-loaded Demo** – The kit includes a pre-loaded demo to control the onboard RGB LED in conjunction with a software run GUI.
- **USB Connector Cable** – A mini B USB port provides power, a programming interface and communication for the software RGB LED GUI to the iCE40 UltraPlus SPI port.

Figure 2.1 shows the top side of the iCE40 UltraPlus Breakout Board indicating the specific features that are designed on the board.

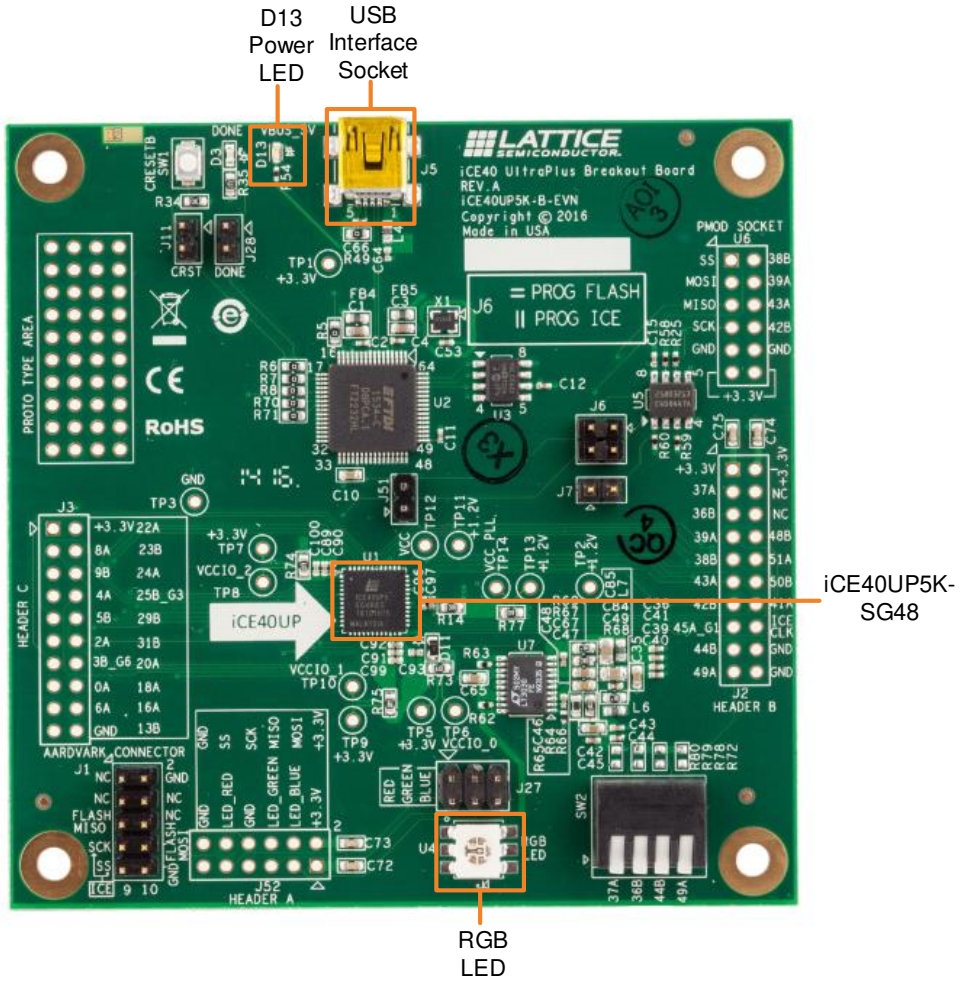

Figure 2.1. iCE40 UltraPlus Breakout Board (Top Side)

3. iCE40 UltraPlus Device

The board features an iCE40UP5K FPGA with a 1.2 V core supply. The device package is 48-PIN QFN. For a complete description of this device, see DS-1056, iCE40 UltraPlus Family Data Sheet.

4. Software Requirements

You should install the following software before you begin developing designs for the board:

- Lattice iCEcube2 2017.01 (or higher)
- Diamond Programmer 3. 9 (or higher)

These software are available at the Lattice website Design Software & IP page. Make sure you log in to www.latticesemi.com, otherwise these software downloads will not be visible. It is also recommended to download the RGB LED software GUI which interfaces with the iCE40 UltraPlus Breakout Board. This GUI allows you to control the RGB LED for color, brightness, blinking and breathing. Download the PC or MAC version of the GUI at www.latticesemi.com.

5. Demonstration Design Shunts

Lattice provides the RGB LED Driver Demo design programmed on the board. The RGB LED Driver Demo used in conjunction with the software GUI illustrates the use of a PWM driver controlling the LEDs on the board. Below is a description of the control jumpers for each LED.

- The RGB LED will transition colors
  — J27 can be used to probe RGB LED (Default shunted). If you remove J27, the RGB LED will not light up.

Figure 5.1 shows the default board shunt locations.

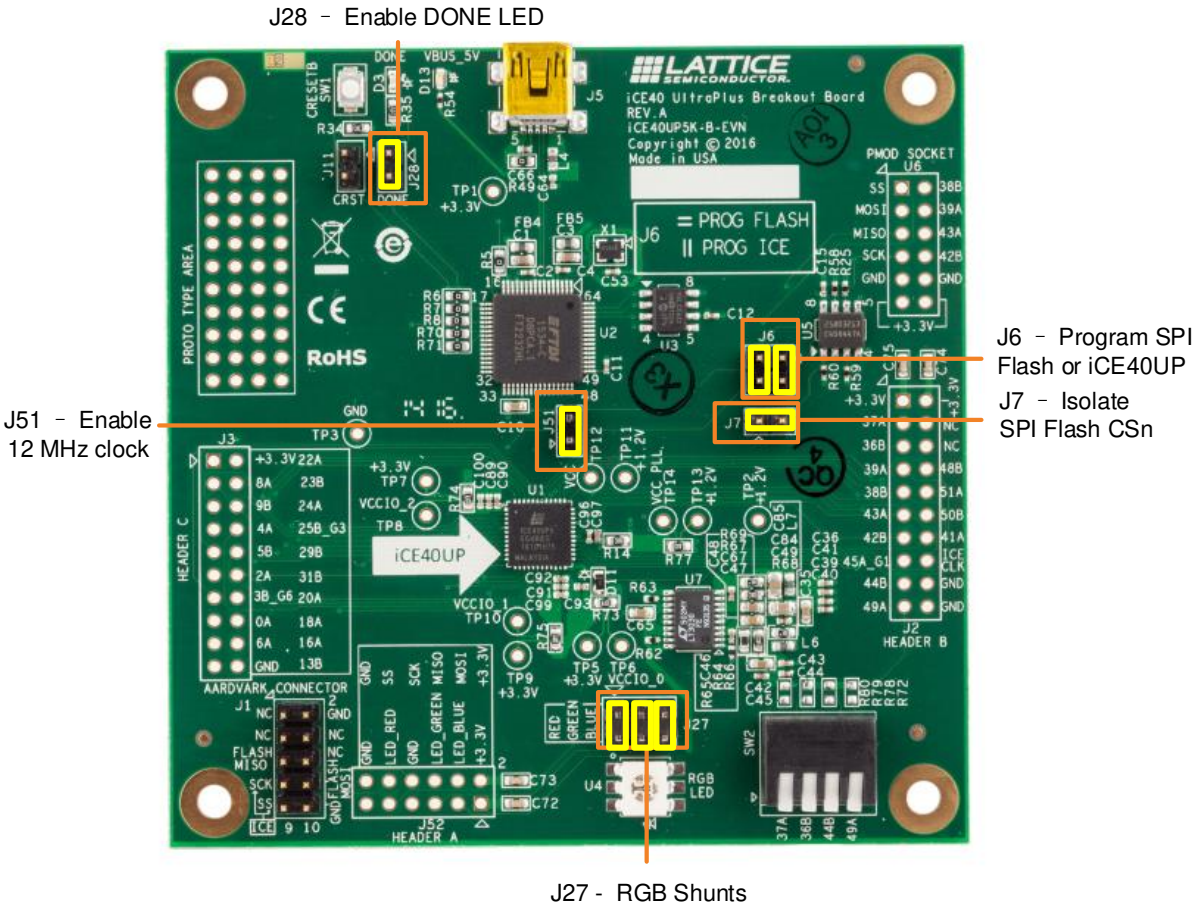

Figure 5.1. Default Shunt Locations

6. Clock Sources

The board has a single 12 MHz clock source. The 12 MHz clock drives both the FTDI USB interface device, and the iCE40UP5K device. The iCE40UP5K can be disconnected from the 12 MHz oscillator using J51. This is necessary, for example, when iCE40UP5K device pin35 is mistakenly programmed as an output and prevents the FTDI USB interface from operating.

7. Board Power

The board provides the following power features:

- Board Power
  - Board power is derived from the USB connection.
  - D13 Blue LED indicates Board Power
- iCE40 UltraPlus VCC/VCC_PLL
  - Onboard 1.2 V supply
  - ICC can be measured across the series resistor R76 (1 Ω) at TP11 and TP12
  - ICC_PLL can be measured across the series resistor R77 (1 Ω) at TP13 and TP14
- iCE40 UltraPlus VCCIO
  - Onboard 3.3 V supply
  - ICC0 can be measured across the series resistor R73 (1 Ω) at TP5 and TP6
  - ICC1 can be measured across the series resistor R75 (1 Ω) at TP9 and TP10
  - ICC2 can be measured across the series resistor R74 (1 Ω) at TP7 and TP8

The power supplies on the iCE40 UltraPlus Breakout Board are simplified and suitable for booting from the external SPI flash. The power supply sequencing does not conform to the NVCM boot requirements as specified in DS1056, iCE40 UltraPlus Family Data Sheet. The user may encounter intermittent boot success and/or higher than specified startup currents when attempting to boot from NVCM.

8. Board Configuration and Programming

The board allows for programming of the iCE40 UltraPlus or the SPI Flash:

- SPI Flash Programming J6 shunt pins 1-3 and 2-4 (Default shunted)
  - U5 Micron Technology Inc. part number N25Q032A13ESC40F
- iCE40 UltraPlus Configuration or Programming J6 shunt pins 1-2 and 3-4
  - U1 iCE40UP5K – SG48
- CRESETB can be asserted by pushing SW1
  - Can be probed with J11
- Done LED D2
  - Can be probed with J28 (Default shunted)

Details of the iCE40 UltraPlus Board for SPI flash programming are shown in Figure 8.1.

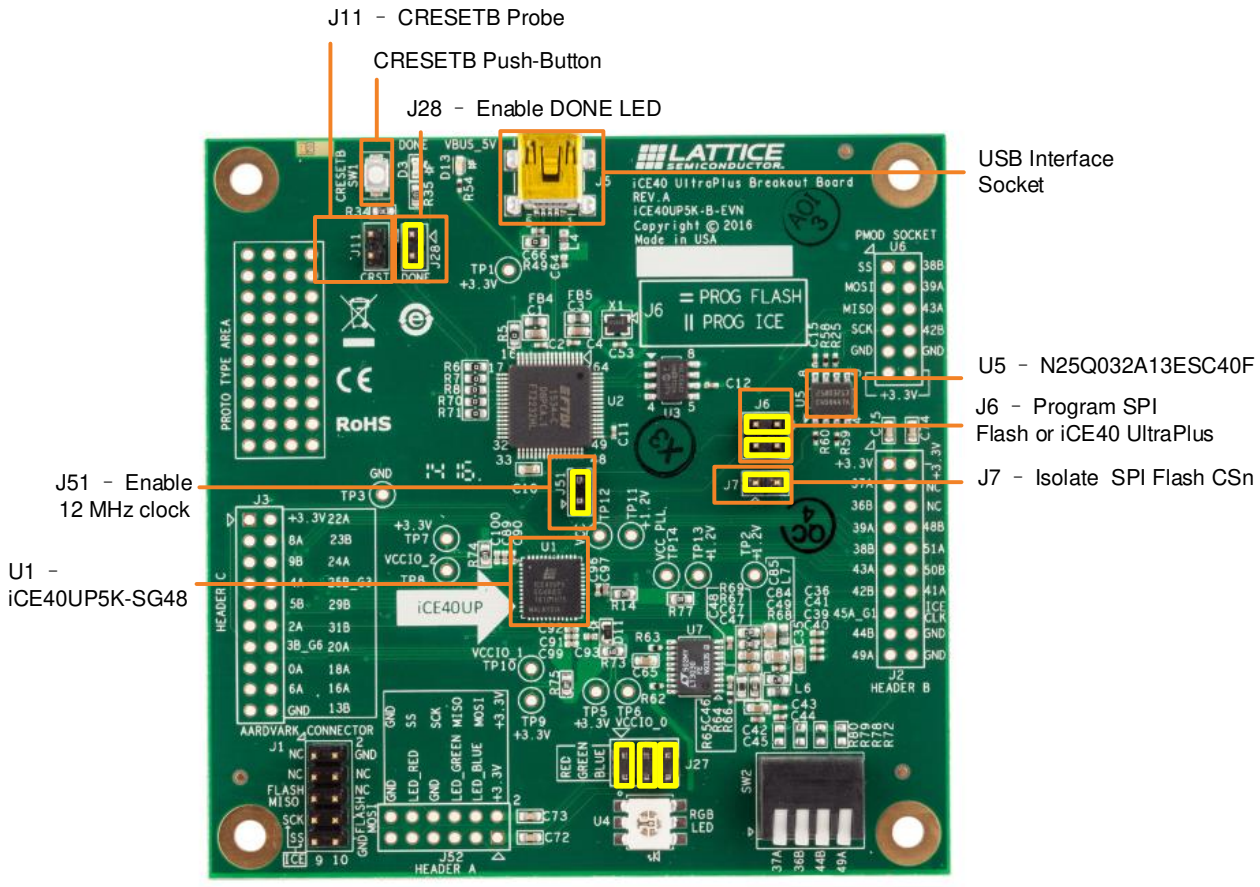

Figure 8.1. Board Configuration for Programming Flash

To program SPI flash in Diamond Programmer:

1. Make sure that the Standalone Diamond Programmer is installed.
2. Connect the iCE40 UltraPlus breakout board via the USB cable to a PC or MAC.
3. Start Diamond Programmer.
4. Set **Device Family** to iCE40 UltraPlus" and **Device** to "iCE40UP5K". Refer to Figure 8.3.
5. Open the Device Properties dialog. Apply the settings highlighted in Figure 8.2.

   Programming file is the bitmap file that will be programmed into the iCE40 UltraPlus breakout board.

Load from File button should be used to refresh fields such as “Data file size” and “End address(Hex)”.

6. Click **OK** to exit Device Properties dialog.
7. Click the **Program** button in Diamond Programmer to download the bitstream file.

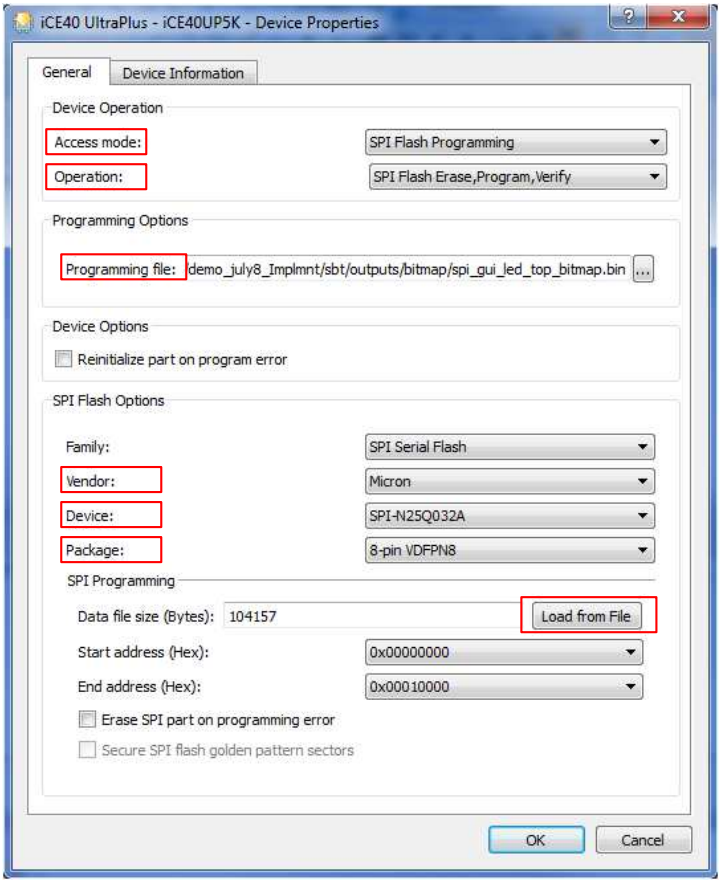

Figure 8.2. Device Property Settings for Programming Flash

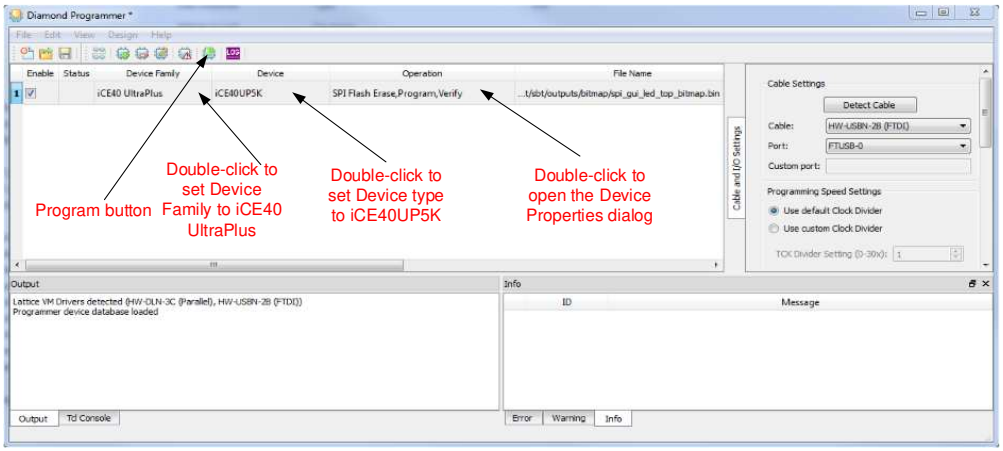

Figure 8.3. Setting Status in Diamond Programmer for Programming Flash

The differences between programming ICE40 UltraPlus and programming flash are described below.

To program ICE40 UltraPlus in Diamond Programmer:

1. Change jumpers on J6, shunt pins 1-2 and 3-4.
2. Apply the settings in the Device Properties dialog as shown in Figure 8.4.

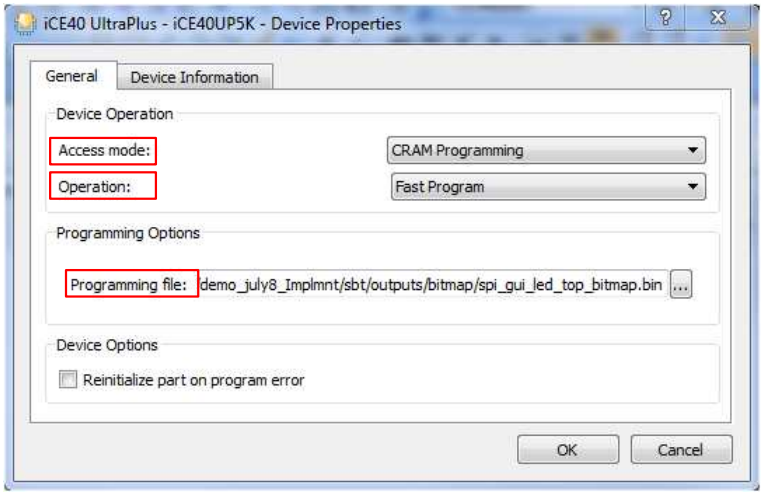

Figure 8.4. Device Property Settings for Programming iCE40 UltraPlus

For more information on Diamond Programmer, please refer to its user guide.

9. Test Points

The board features a number of headers and test connections which provide access to the iCE40 UltraPlus I/Os:

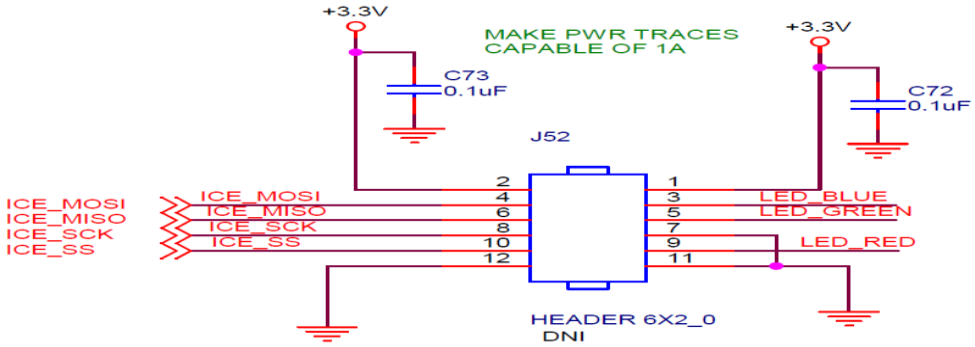

Figure 9.1. J52 Header 'A' Breakouts

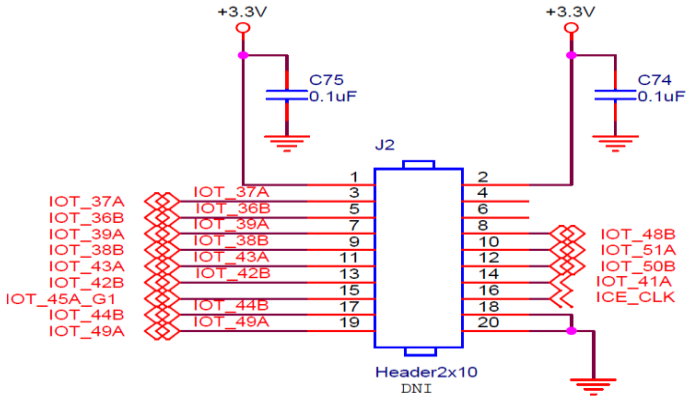

Figure 9.2. J2 Header 'B' Breakouts

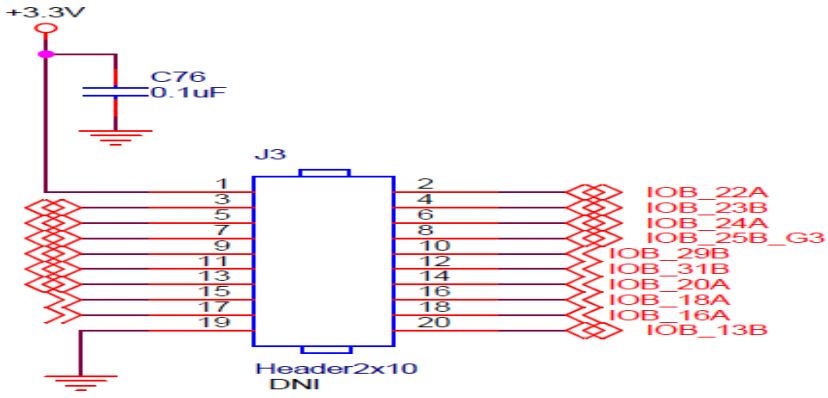

Figure 9.3. J3 Header 'C' Breakouts

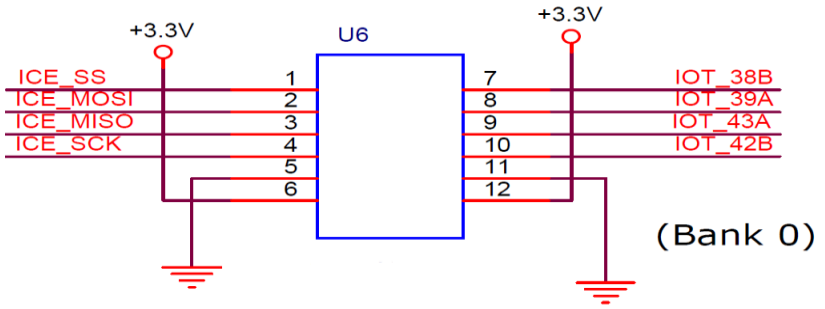

Figure 9.4. U6 PMOD Connector

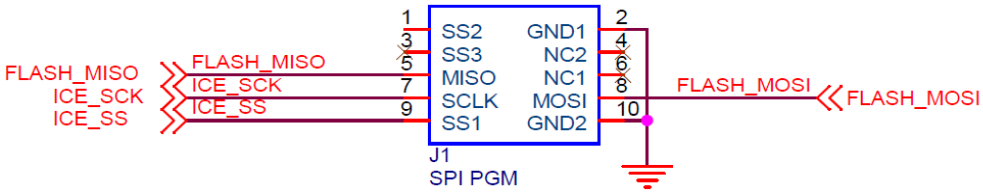

Figure 9.5. J1 Adardvark Connector

The break-out headers and test connectors are shown in Figure 9.6.

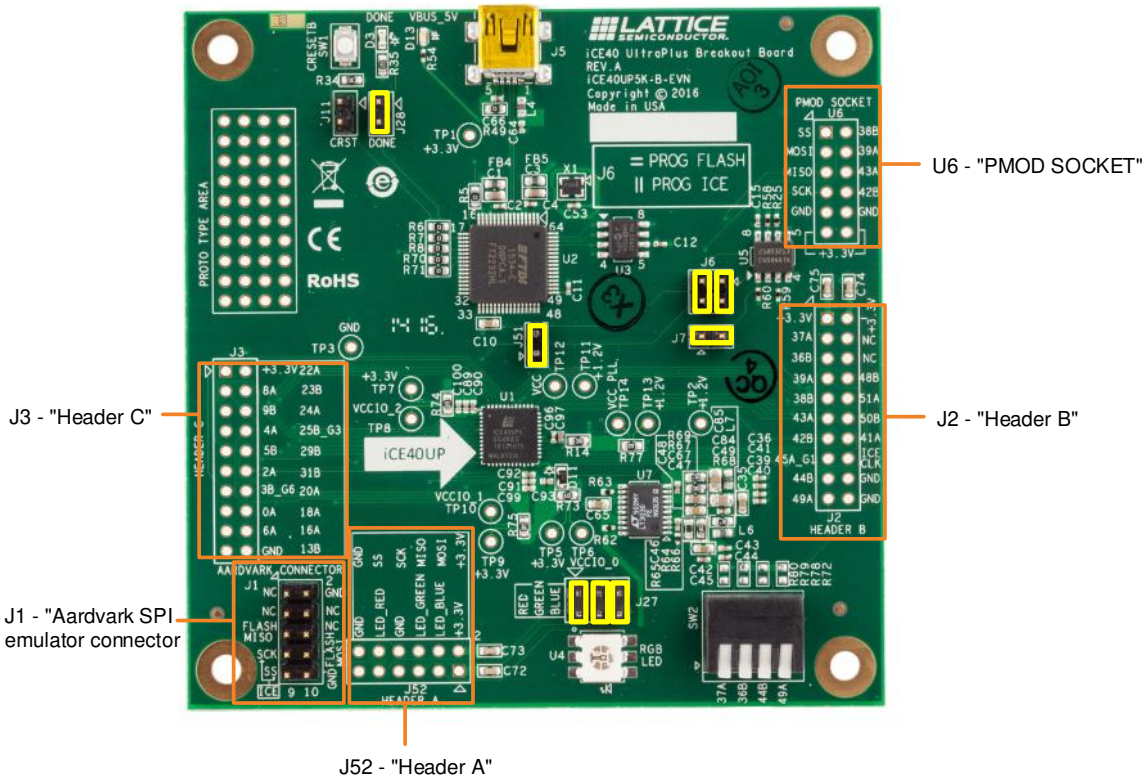

Figure 9.6. Breakout Headers

10. RGB LED Demonstration Design and Software GUI

The iCE40 UltraPlus Breakout Board can demonstrate a complete controller for an RGB LED. Following are the steps to run the demonstration. The Software GUI tool used here is the same as the one used with the iCE40 Ultra Breakout Board. You can refer to the Lattice website iCE40 Ultra Breakout Board page.

To run the demonstration:

1. Ensure that the RGB LED GUI is installed.
2. Make sure the jumpers on J6 are both in the horizontal position. This is the default pins 1-3 and 2-4 shorted together.

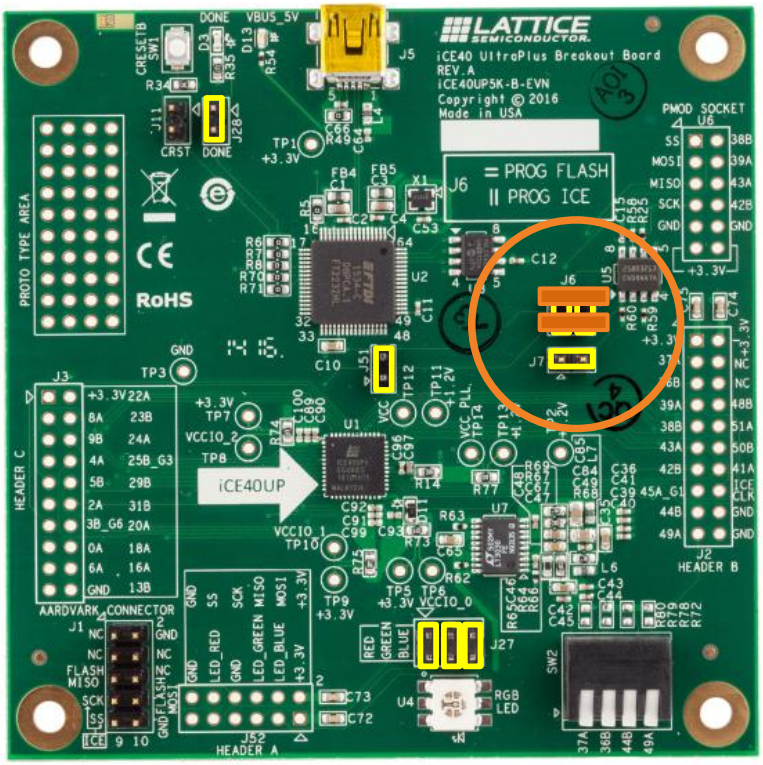

Figure 10.1. SPI Flash Selection (Horizontal) for J6

3. Connect the iCE40 UltraPlus breakout board via the USB cable to a PC or MAC.
4. After the iCE40 UltraPlus device has initialized and the RGB LED is illuminated RED, change the J6 jumper positions to vertical, shorting pins 1-2 and 3-4. This is required to allow the USB port to communicate with the iCE40UP5K device.

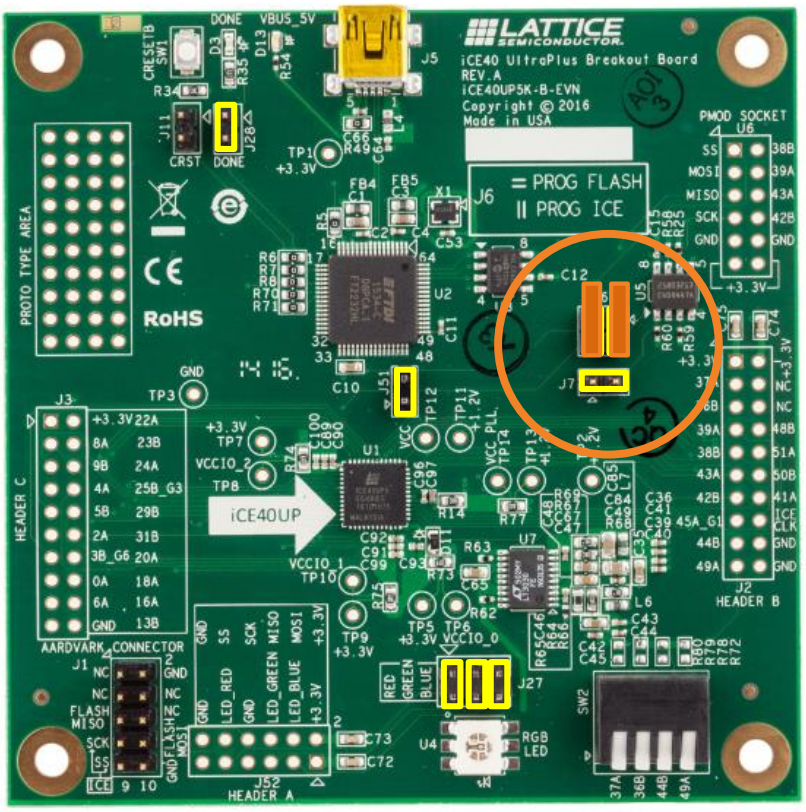

Figure 10.2. iCE40 UltraPlus Selection (Vertical) for J6

5. Start the RGB GUI on the PC or MAC.

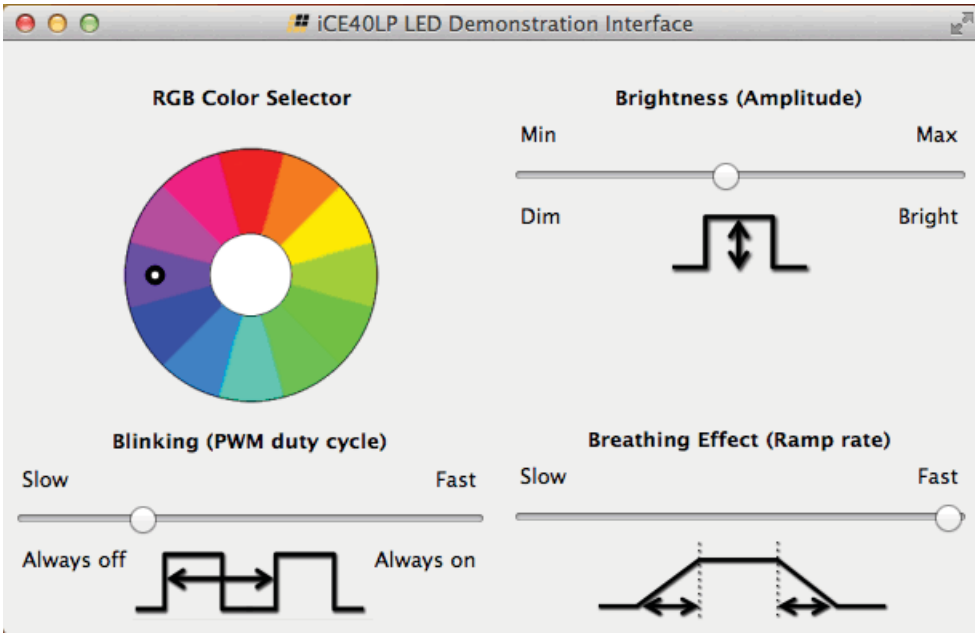

Figure 10.3. iCE40 UltraPlus LED Demonstration Interface

Now you can control the RGB LED on the iCE40 UltraPlus Breakout Board. You can set the color, brightness, blinking rate as well as breathing.

Note: The RGB GUI is the same demo tool used with iCE40 Ultra Breakout board.

11. GUI Serial Communication Interface

11.1. LED Control via SPI

The Software GUI demonstration program communicates with the iCE40 UltraPlus device using an SPI serial communication channel. The SPI interface (mode 0) control link is implemented using a simple write-only protocol (see Figure 11.1.)

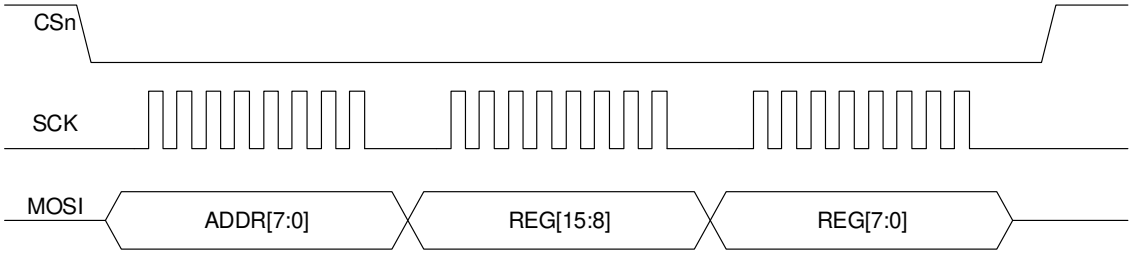

Figure 11.1. SPI Physical Transaction

11.2. SPI Protocol

Data on the MOSI serial line is transmitted MSB first.

Addr[7:0] – Controls which of the 16 bits are updated with REG data.

Note that Unspecified REG bits must be written, but are ignored.

Table 11.1. Register Address and Bit Field Allocation

Addr	Bits Written	Bit Position
0x13	REG[3:0]	----------dddd
0x14	REG[7:4]	--------cccc----
0x15	REG[11:8]	----bbbb--------
0x16	REG[15:12]	aaaa----------
0x19	REG[15:0]	aaaabbbbccccdddd

REG[15:0] – Consists of four control fields.

Table 11.2. Bit Field Functionality Definition

Field	Bit Positions	Function
aaaa	REG[15:12]	RGB Color[3:0]
bbbb	REG[11:8]	Brightness[3:0]
cccc	REG[7:4]	Breathe Ramp [3:0]
dddd	REG[3:0]	Blink Rate [3:0]

11.3. Register Definitions

Table 11.3. RGB Color Code Definition

Default setting (hardware, software) is denoted by (*).

RGB Color[3:0]	Color	Color Code
0000*	Red	#FF0000
0001	Orange	#FF7F00
0010	Yellow	#FFFF00
0011	Chartreuse	#7FFF00
0100	Green	#00FF00
0101	Spring Green	#00FF7F
0110	Cyan	#00FFFF
0111	Azure	#007FFF
1000	Blue	#0000FF
1001	Violet	#7F00FF
1010	Magenta	#FF00FF
1011	Rose	#FF007F
1100	—	—
1101	—	—
1110	—	—
1111	White	#FFFFFF

Table 11.4. LED Brightness Code Definition

Brightness[3:0]	Level (%)
0000	6.25 (dim)
0001	12.5
0010	18.78
0011	25
0100	31.25
0101	37.5
0110	43.75
0111*	50
1000	56.25
1001	62.5
1010	68.75
1011	75
1100	81.25
1101	87.5
1110	93.75
1111	100 (bright)

Table 11.5. Breathe Ramp Code Definition

Breathe Ramp[3:0]	Level (%)
0000*	.0x (fast)
0001	.063x
0010	.125x
0011	.25x
0100	.5x
0101	1x
0110	2x
0111	4x (slow)
1000	—
1001	—
1010	—
1011	—
1100	—
1101	—
1110	—
1111	—

Table 11.6. Blink Rate Code Definition

Blink Rate[3:0]	Level (%)
0000	Always On
0001	1/16 (fast)
0010	1/8
0011	1/4
0100	1/2
0101*	1
0110	2
0111	4
1000	Always Off
1001	—
1010	—
1011	—
1100	—
1101	—
1110	—
1111	—

12. Ordering Information

Description	Ordering Part Number	China RoHS Environment- Friendly Use Period (EFUP)
iCE40 UltraPlus Breakout Board	iCE40UP5K-B-EVN	

Appendix A. Schematic Diagrams

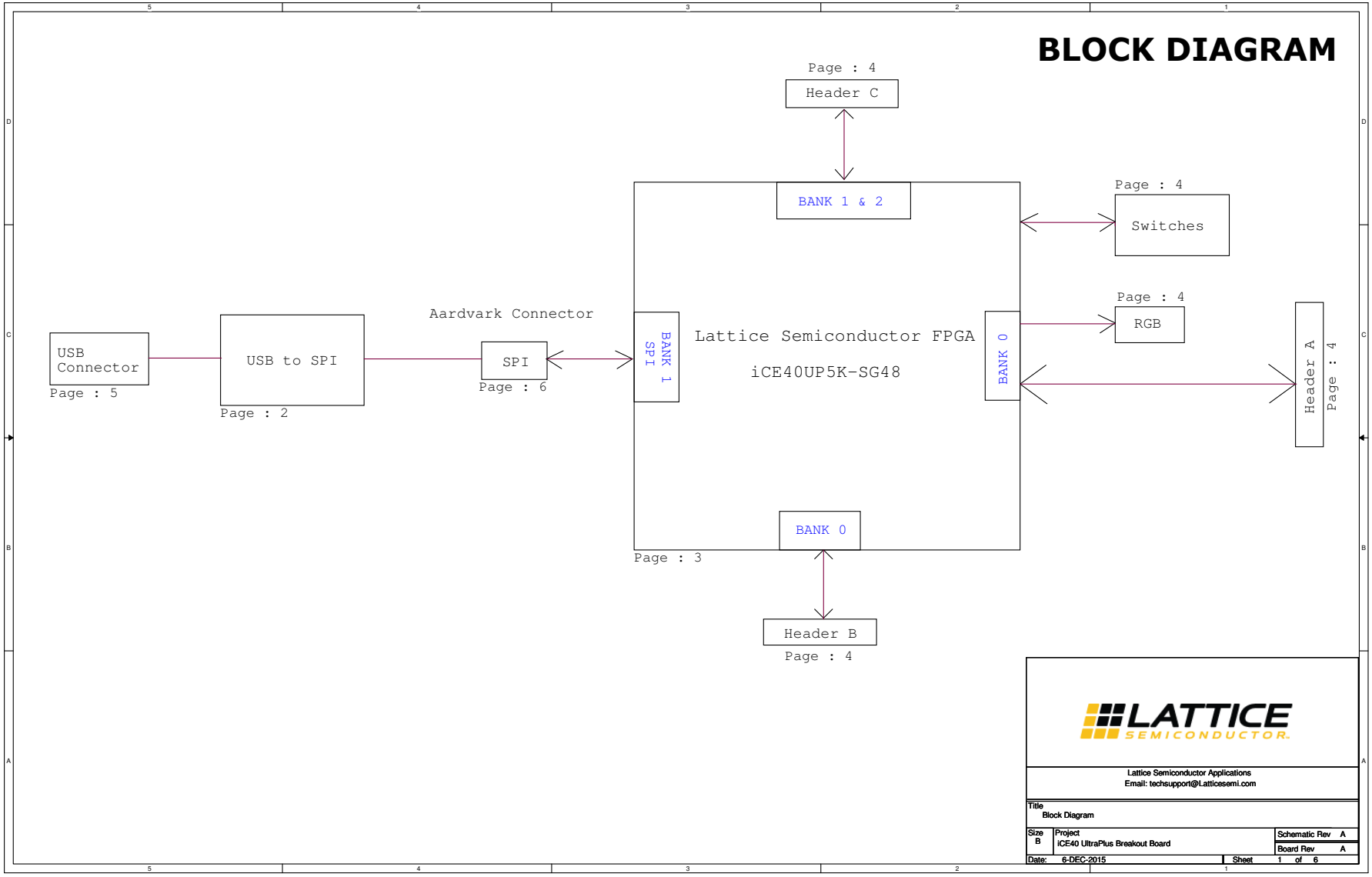

Figure A.1. Block Diagram

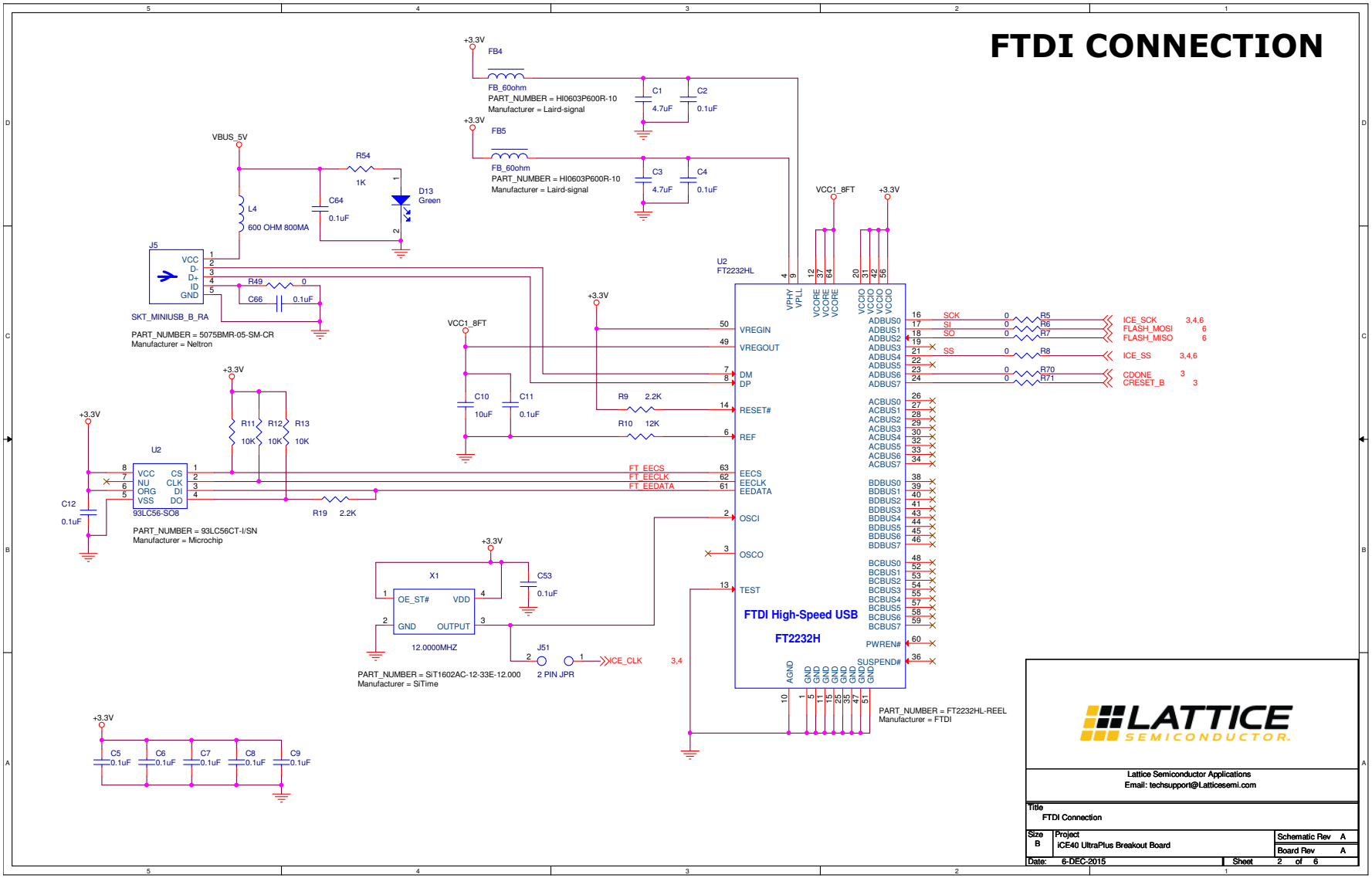

Figure A.2. FTDI Connection