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## **iCE40 UltraLite™ Breakout Board User Guide**

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EB96 Version 1.1, March 2017

## Introduction

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

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

The contents of this user's guide include demo operation, top-level functional descriptions of the various portions of the evaluation board, descriptions of the on-board connectors, jumpers, a complete set of schematics and the bill of material for the iCE40 UltraLite Breakout Board.

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

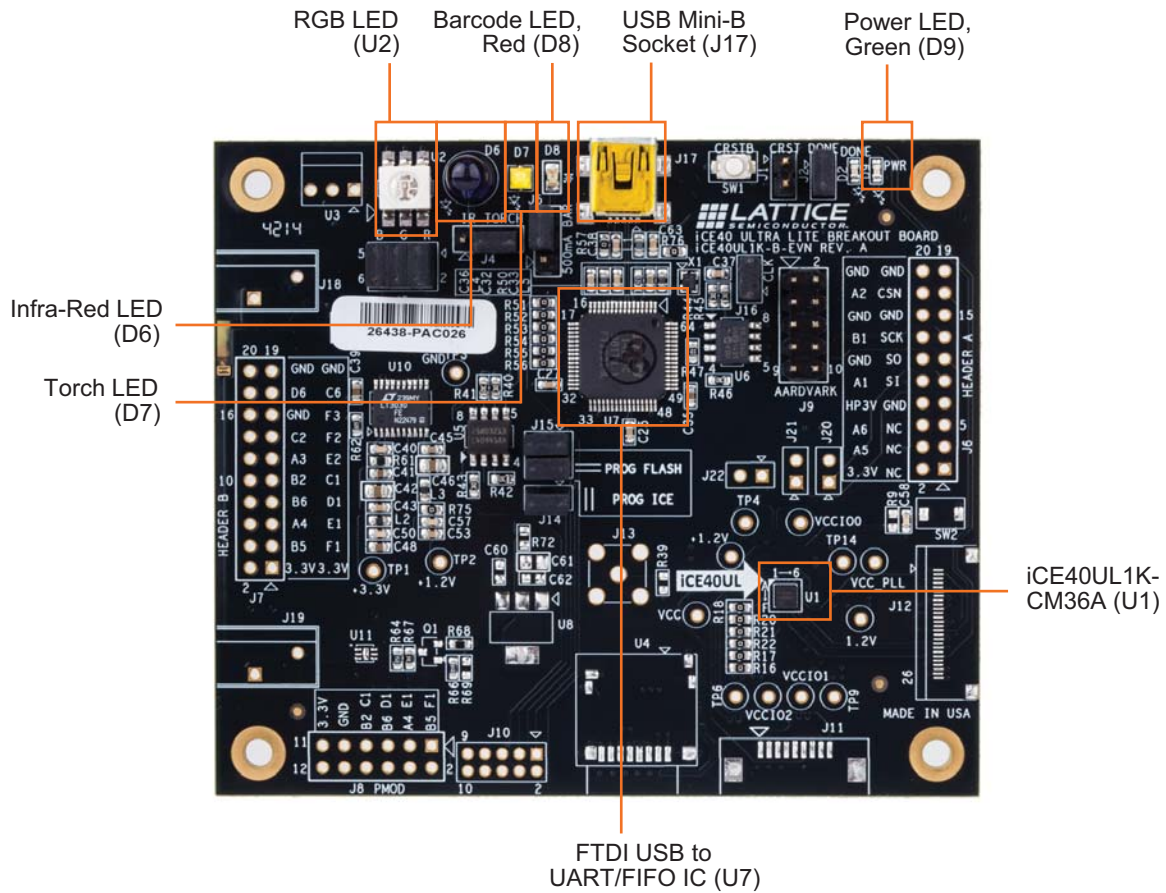
## Features

The iCE40 UltraLite Breakout Board includes:

- **iCE40 UltraLite Breakout Board** – The iCE40 UltraLite Breakout Board features the following on-board components and circuits:
  - iCE40 UltraLite (iCE40UL1K-CM36A) device in a 36-ball WLCSP package.
  - Example of a board using this 0.35-pitch WLCSP package.
  - High-current LED output
  - Infrared transmit
  - iCE40 UltraLite 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 UltraLite SPI port.

Figure 1 shows the top side of the iCE40 UltraLite Breakout Board indicating the specific features that are designed on the board.

**Figure 1. iCE40 UltraLite Breakout Board (Top Side)**



## iCE40 UltraLite Device

The board features an iCE40UL1K FPGA with a 1.2 V core supply. The device is packaged in a 36-ball WLCSP. For a complete description of this device, see DS1050, [iCE40 UltraLite Family Data Sheet](#).

## Software Requirements

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

- iCEcube2 2014.04 (or higher)
- Diamond Programmer 3.3 (or higher)

These software are available at the Lattice website [Design Software & IP](#) page. Make sure you log in to [www.latticesemi.com](http://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 UltraLite 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](http://www.latticesemi.com).

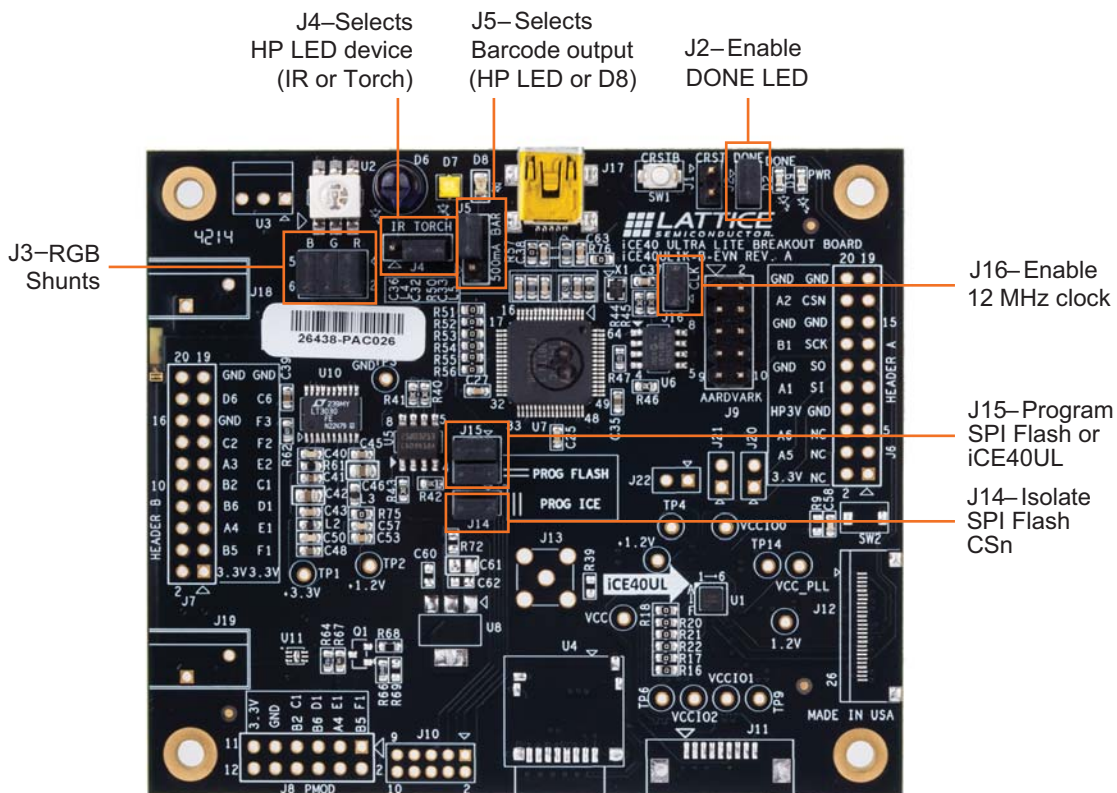
## Demonstration Design Jumpers

Lattice provides the RGB LED Driver Demo design programmed in 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 (U2) will transition colors
  - J3 can be used to probe RGB LED (Default shunted). If you remove J3, the RGB LED will not light up.
- The IR LED (D6) is controlled when a jumper is placed across J4 pins 1-2
- The HP Torch LED (D7) is controlled when a jumper is placed across J4 pins 2-3
- The BARCODE LED (D8) is under FPGA control when a jumper is placed across J5 pins 2-3
  - The IRLED FPGA output is 400 mA. This can be combined with 100 mA BARCODE FPGA output for a total of 500 mA of drive current. This is performed when a jumper is placed across J5 pins 1-2.  
*Note: This capability is not supported in the Demonstration Design*

Figure 2 shows the default jumper locations.

**Figure 2. Default Jumper Locations**



## Clock Sources

The board has a single 12 MHz clock source. The 12 MHz clock drives both the FTDI USB interface device, and the iCE40UL1K device. The iCE40UL1K device can be disconnected from the 12 MHz oscillator using J16. This is necessary, for example, when iCE40 Ultra Lite device ball D2 is mistakenly programmed as an output and prevents the FTDI USB interface from operating.

## Board Power

The board provides the following power features:

- Board Power
  - Board power is derived from the USB connection.
  - D9 Green LED indicates Board Power
- iCE40 UltraLite VCC
  - Onboard 1.2 V supply
  - ICC can be measured across the series resistor R4 (1 Ohm) at test points +1.2 V and VCC
- iCE40 UltraLite VCCIO
  - Onboard 3.3 V supply
  - ICC0 can be measured across the series resistor R2 (10Ohm) at test points TP4 and VCCIO0
  - ICC1 can be measured across the series resistor R3 (10Ohm) at test points TP9 and VCCIO1
  - ICC2 can be measured across the series resistor R5 (10Ohm) at test points TP6 and VCCIO2

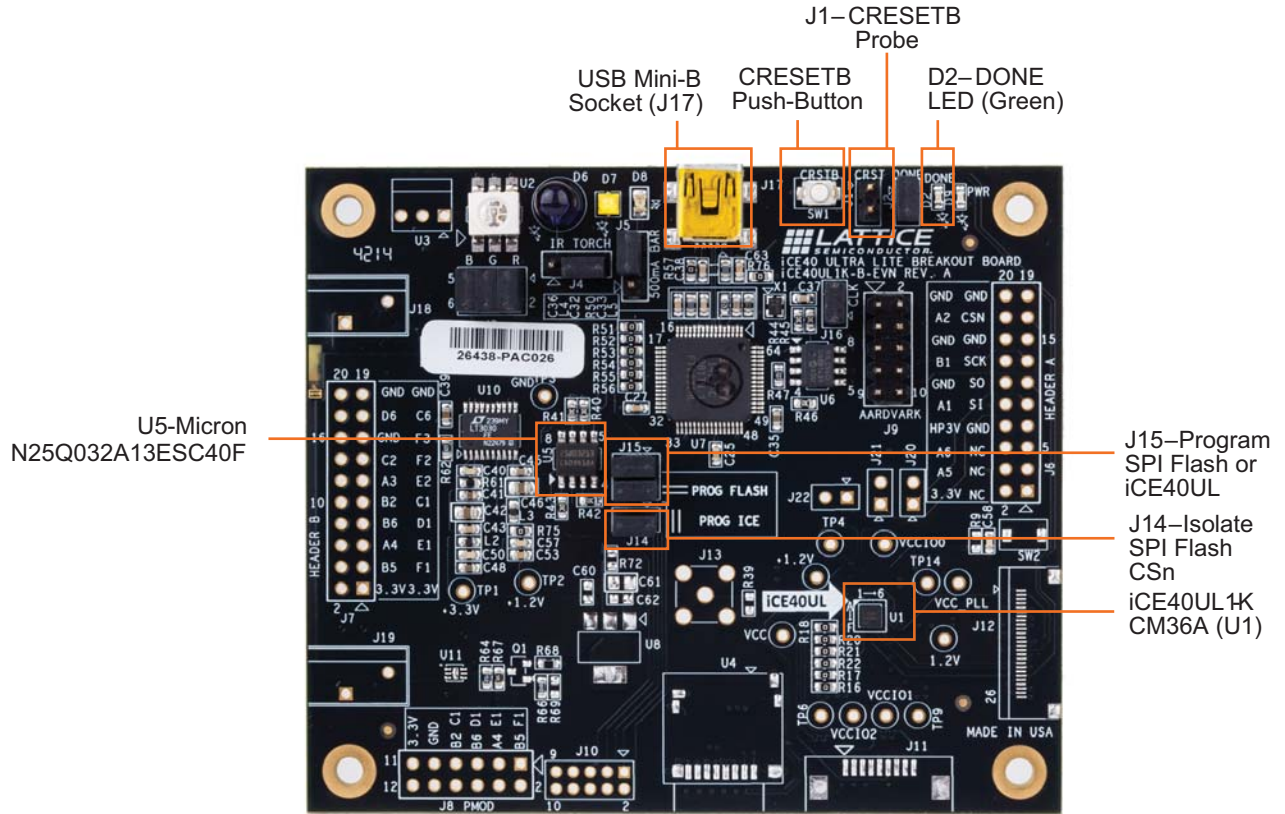
## Board Configuration and Programming

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

- SPI Flash Programming J15 shunt pins 1-3 and 2-4 (Default shunted)
  - U5 Micron Technology Inc part number N25Q032A13ESC40F
- iCE40 Ultra Configuration or Programming J15 shunt pins 1-2 and 3-4
  - U1 iCE40UL1K-CM36A
- CRESETB can be asserted by pushing SW1
  - Can be probed with J1
- DONE LED D2
  - Can be probed with J2 (default shunted)

Details of the iCE40 UltraLite Board for use in programming are shown in Figure 3.

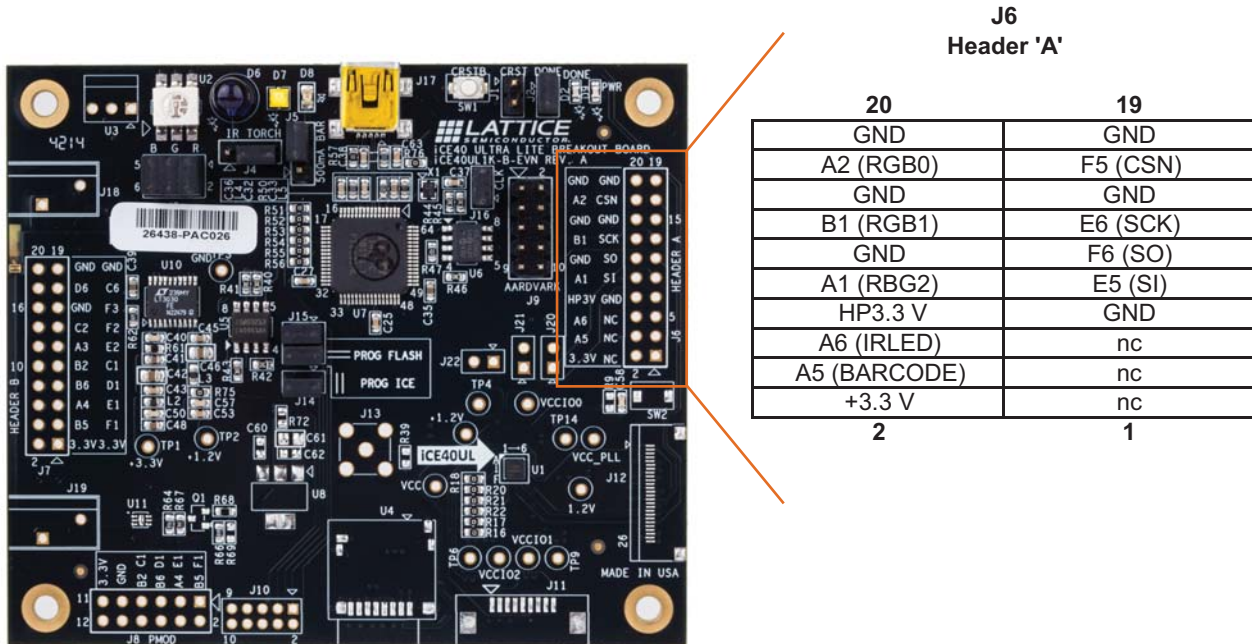
**Figure 3. Configuration and Programming Details**



## Headers and Test Connections

The board features a number of headers and test connections which provide access to the iCE40 Ultra-Lite I/Os, as shown in Figure 4, Figure 5 and Figure 6 below:

**Figure 4. J6 Header 'A' Breakouts**



**Figure 5. J7 Header 'B' Breakouts**

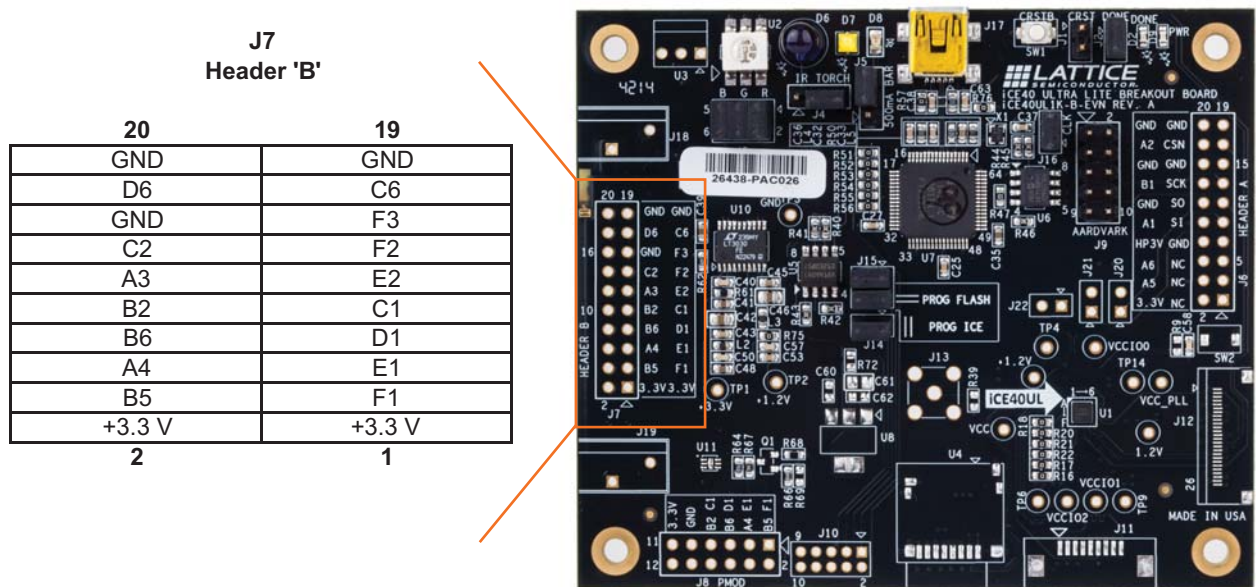
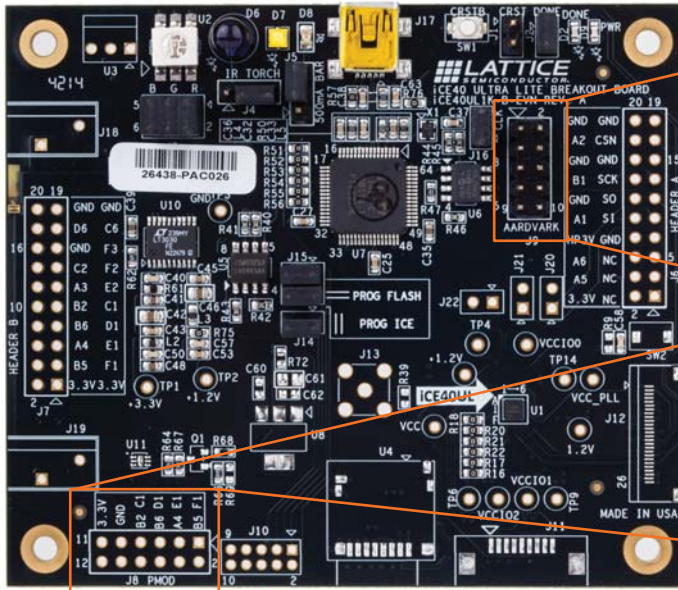




Figure 6. J9 Aardvark and J8 PMOD Connector



**J9  
Aardvark**

| 1          | 2          |
|------------|------------|
| nc         | GND        |
| nc         | nc         |
| FLASH_MISO | nc         |
| ICE_SCK    | FLASH_MOSI |
| ICE_CSN    | GND        |
| 9          | 10         |

**J8  
PMOD**

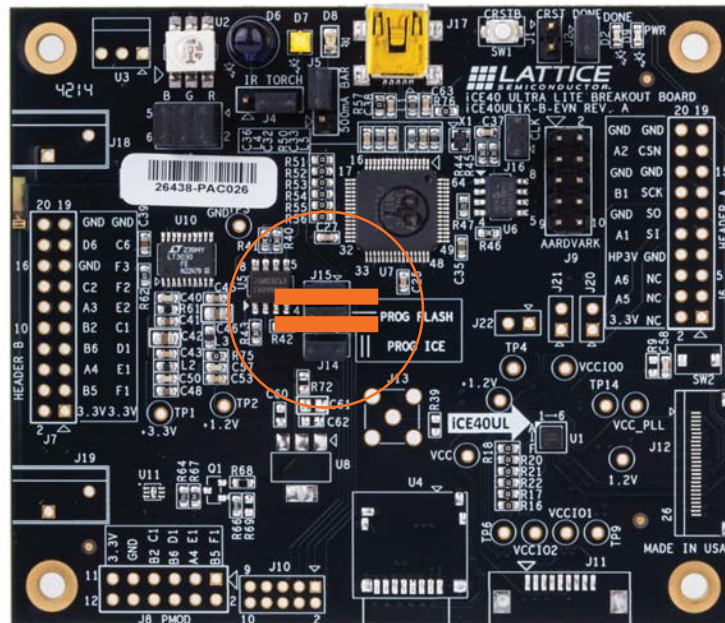
| 12     | 11     |
|--------|--------|
| +3.3 V | +3.3 V |
| GND    | GND    |
| B2     | C1     |
| B6     | D1     |
| A4     | E1     |
| B5     | F1     |
| 2      | 1      |

## RGB LED Demonstration Design and Software GUI

The iCE40 UltraLite Breakout Board can demonstrate a complete controller for an RGB LED. These are the steps necessary to run the demonstration.

1. Ensure that the RGB LED GUI is installed.
2. Make sure the jumpers on J15 are both in the horizontal position. This is the default pins 1-3 and 2-4 shorted together.

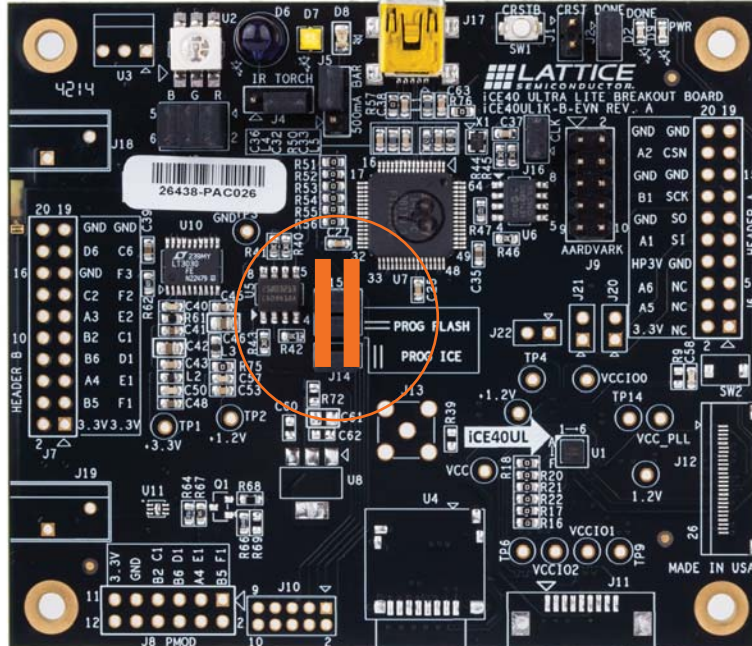
**Figure 7. SPI Flash Selection (Horizontal) for J15**



3. Connect the iCE40 UltraLite breakout board via the USB cable to a PC or MAC.

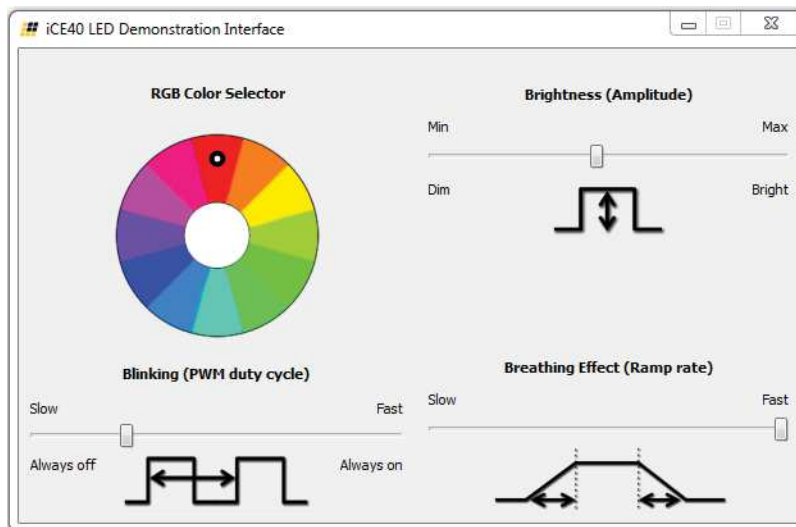
- After the iCE40 UltraLite device has initialized and the RGB LED is illuminated RED, change the J15 jumper positions to vertical, shorting pins 1-2 and 3-4. This is required to allow the USB port to communicate with the iCE40 UltraLite device.

**Figure 8. iCE Selection (Vertical) for J15**



- Start the RGB GUI on the PC or MAC.

**Figure 9. iCE40 UltraLite LED Demonstration Interface**



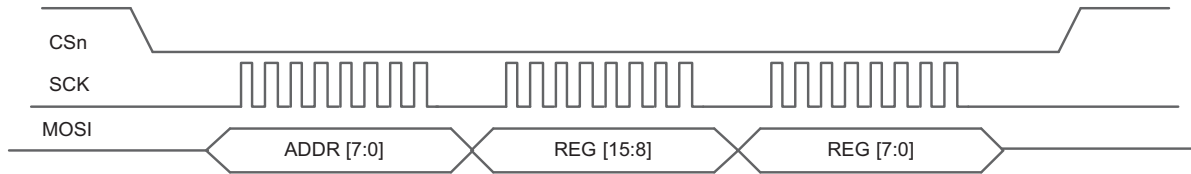
Now you can control the RGB LED on the iCE40 UltraLite Breakout Board. You can set the color, brightness, blinking rate as well as breathing.

## GUI Serial Communication Interface

### LED Control via SPI

The Software GUI demonstration program communicates with the iCE40 UltraLite device using a SPI serial communication channel. The SPI interface (mode 0) control link is implemented using a simple write-only protocol (see Figure 10).

**Figure 10. SPI Physical Transaction**



### 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: Unspecified REG bits must be written, but are ignored.

| 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.

| 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]   |

## Register Definitions

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    |


| Brightness[3:0] | Level (%)    |
|-----------------|--------------|
| 0000            | 6.25(dim)    |
| 0001            | 12.5         |
| 0010            | 18.75        |
| 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) |

| <b>Breathe Ramp [3:0]</b> | <b>Factor</b> |
|---------------------------|---------------|
| 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                      | —             |

| <b>Blink Rate [3:0]</b> | <b>Off Time (s)<sup>1</sup></b> |
|-------------------------|---------------------------------|
| 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                    | —                               |

1. By default, the LED "On-Time" is fixed at approximately one second.

## Ordering Information

| Description                    | Ordering Part Number | China RoHS Environment-Friendly Use Period (EFUP)                                   |
|--------------------------------|----------------------|---|
| iCE40 UltraLite Breakout Board | ICE40UL1K-B-EVN      |  |

## Technical Support Assistance

Submit a technical support case via [www.latticesemi.com/techsupport](http://www.latticesemi.com/techsupport).

## Revision History

| Date          | Version | Change Summary  |
|---------------|---------|---|
| March 2017    | 1.1     | Updated <a href="#">Appendix A. Schematic Diagrams</a> section. Indicated “Bank 2” in Figure 12, iCE40 ULtraLite. |
|               |         | Updated <a href="#">Technical Support Assistance</a> information.   |
|               |         | Updated document template.  |
| December 2014 | 1.0     | Initial release.  |

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Appendix A. Schematic Diagrams

Figure 11. System Diagram

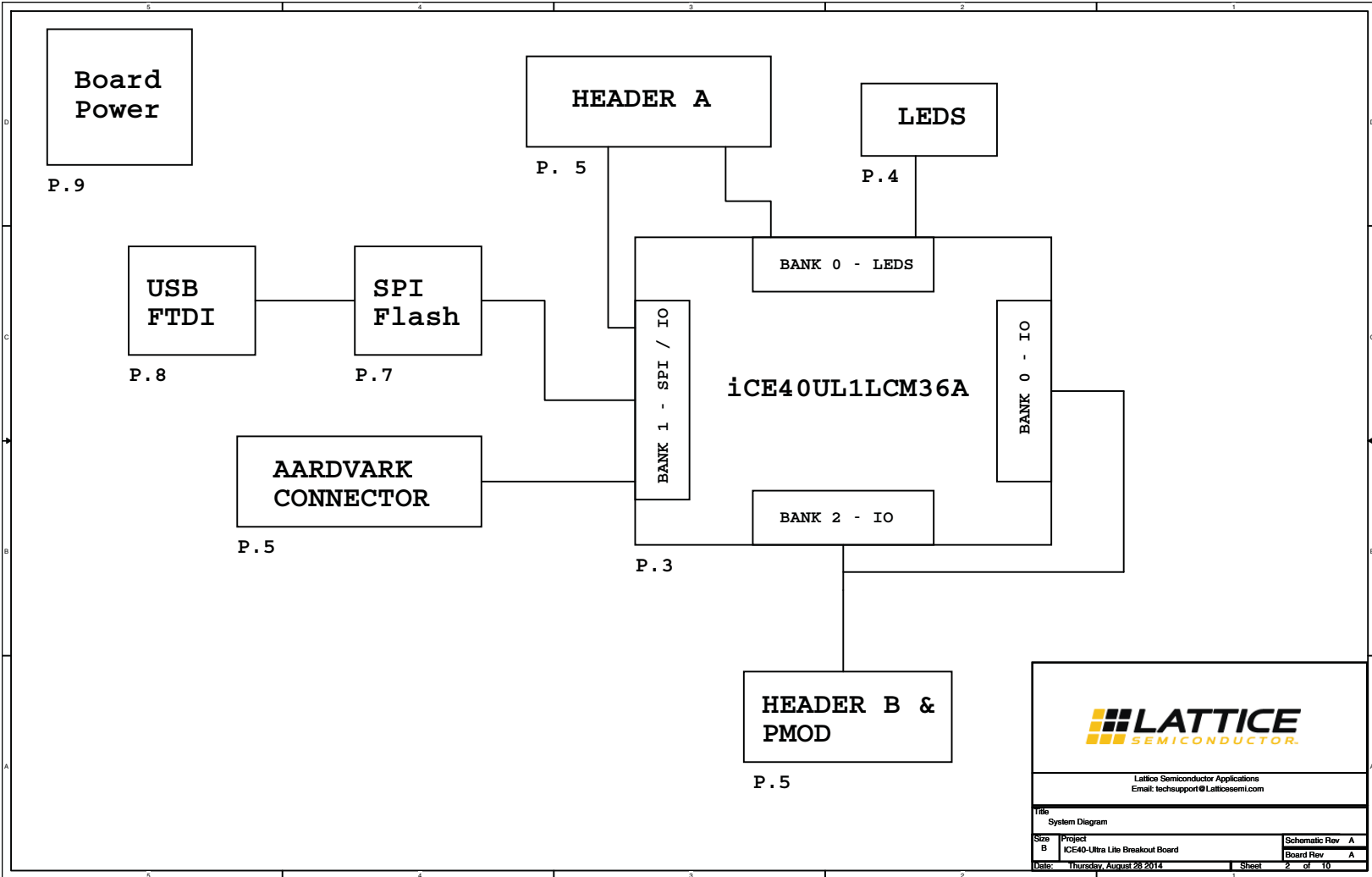




Figure 12. ICE40 UltraLite

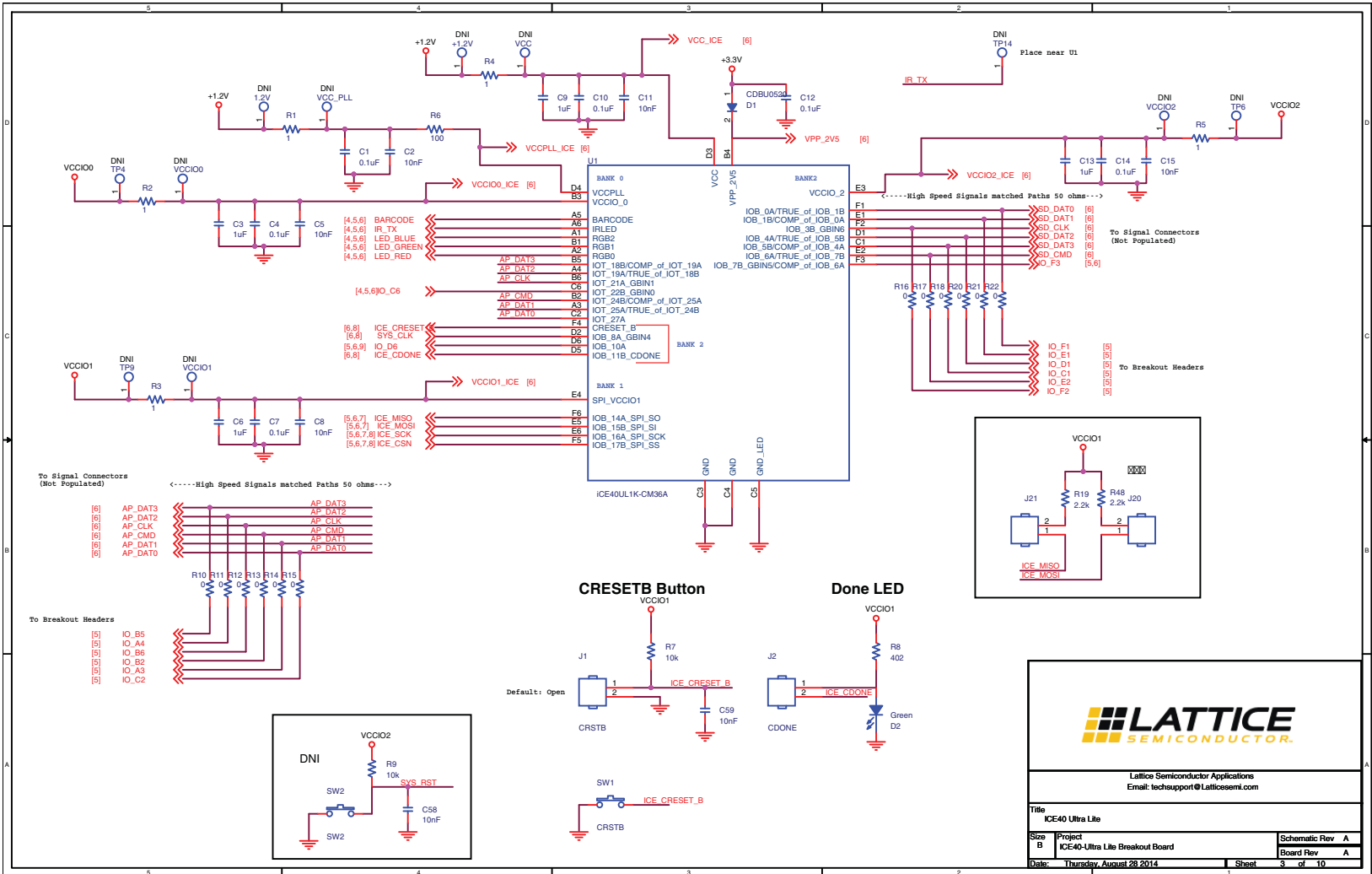


Figure 13. LEDS

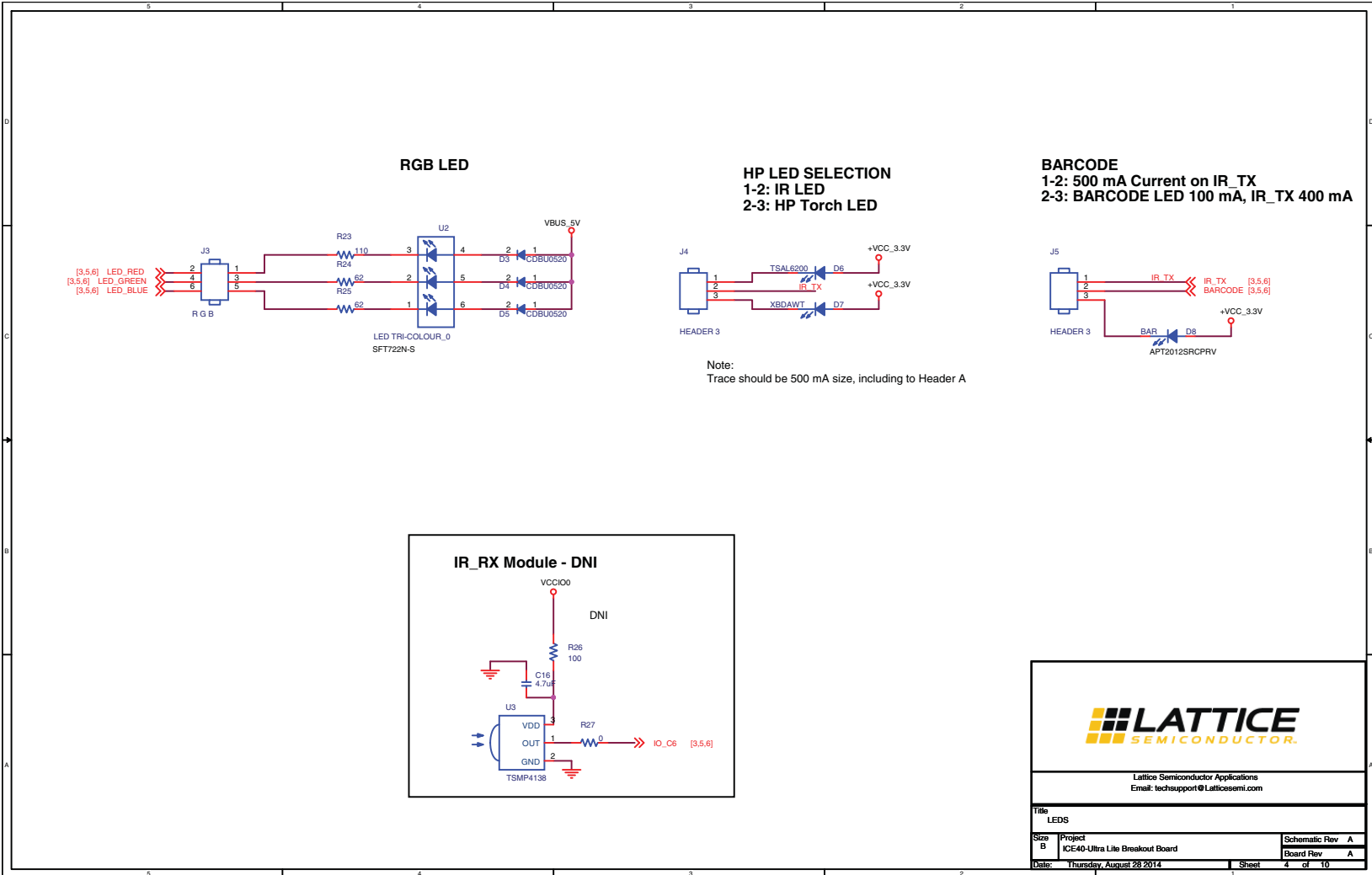


Figure 14. Headers

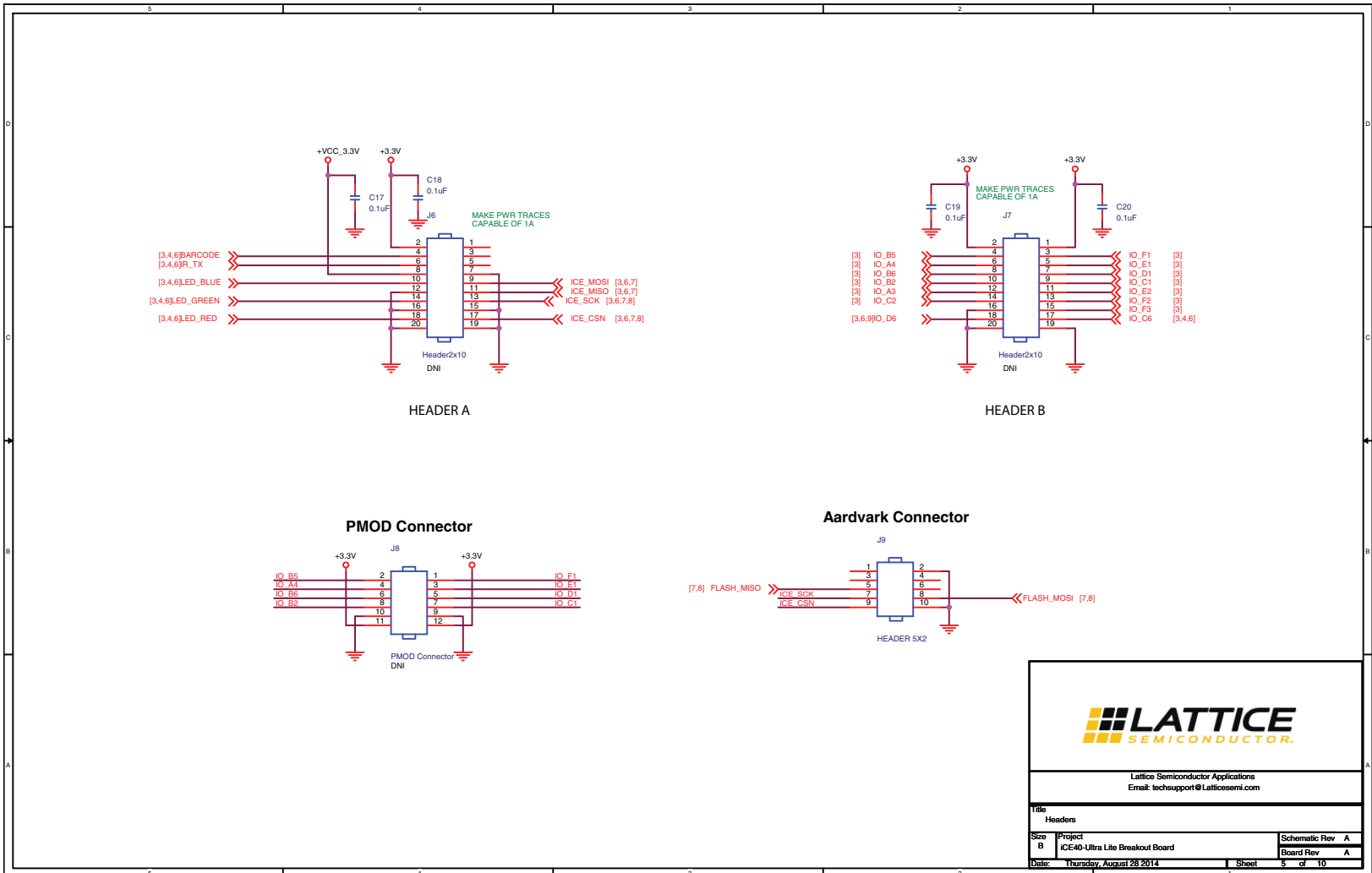


Figure 15. Connectors - DNI

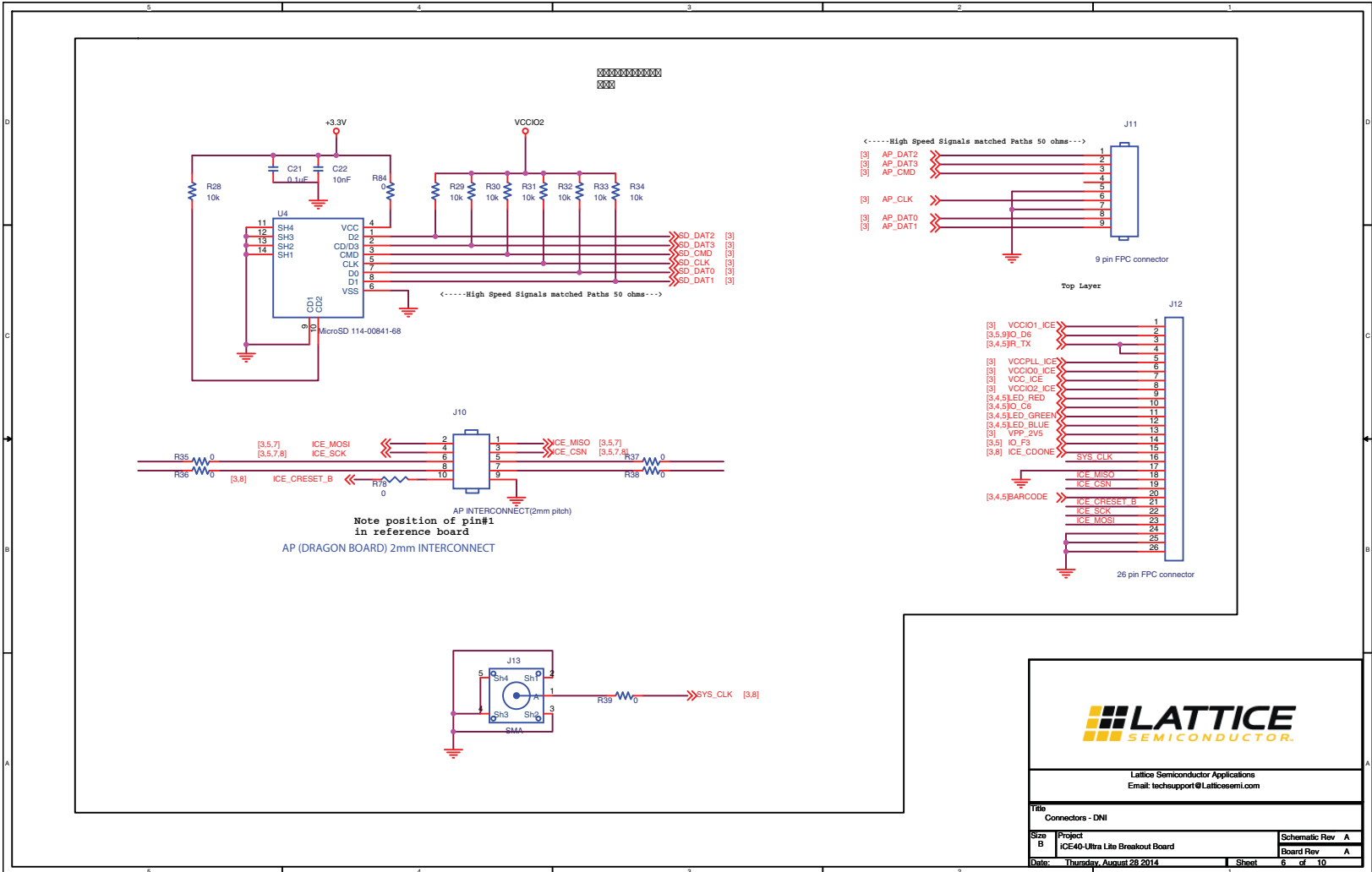


Figure 16. SPI

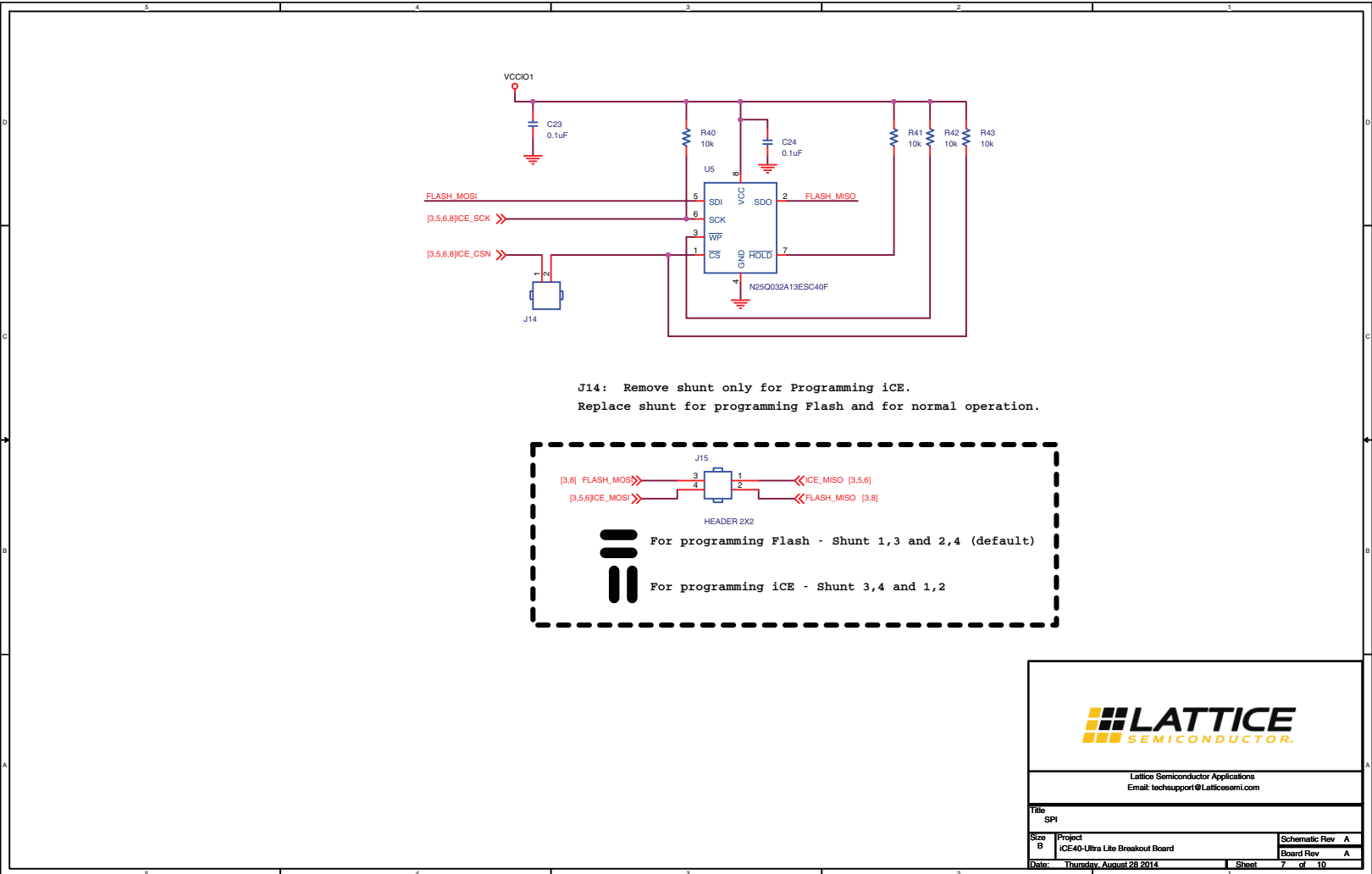


Figure 17. SPI

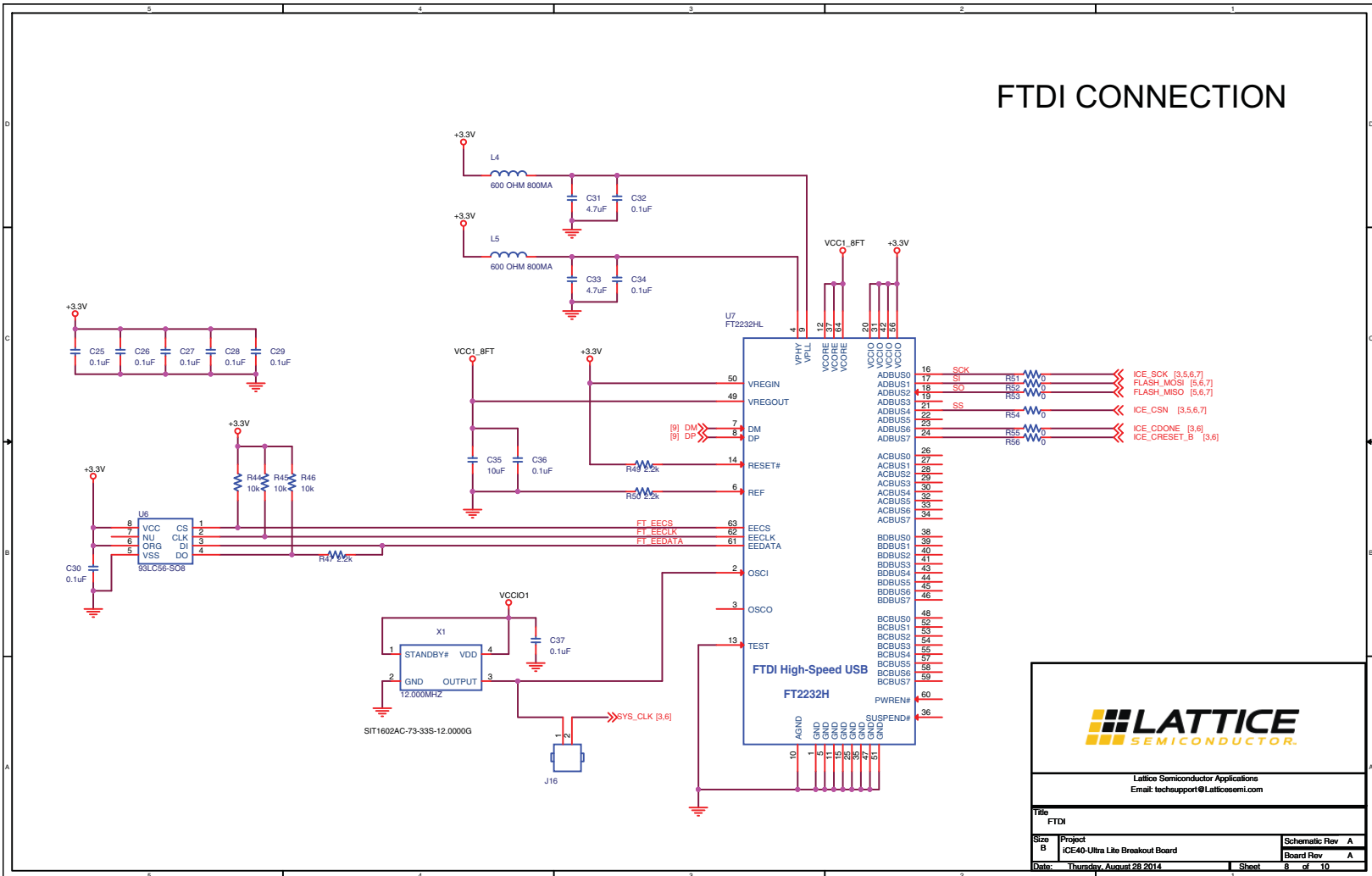


Figure 18. Voltage Regulators

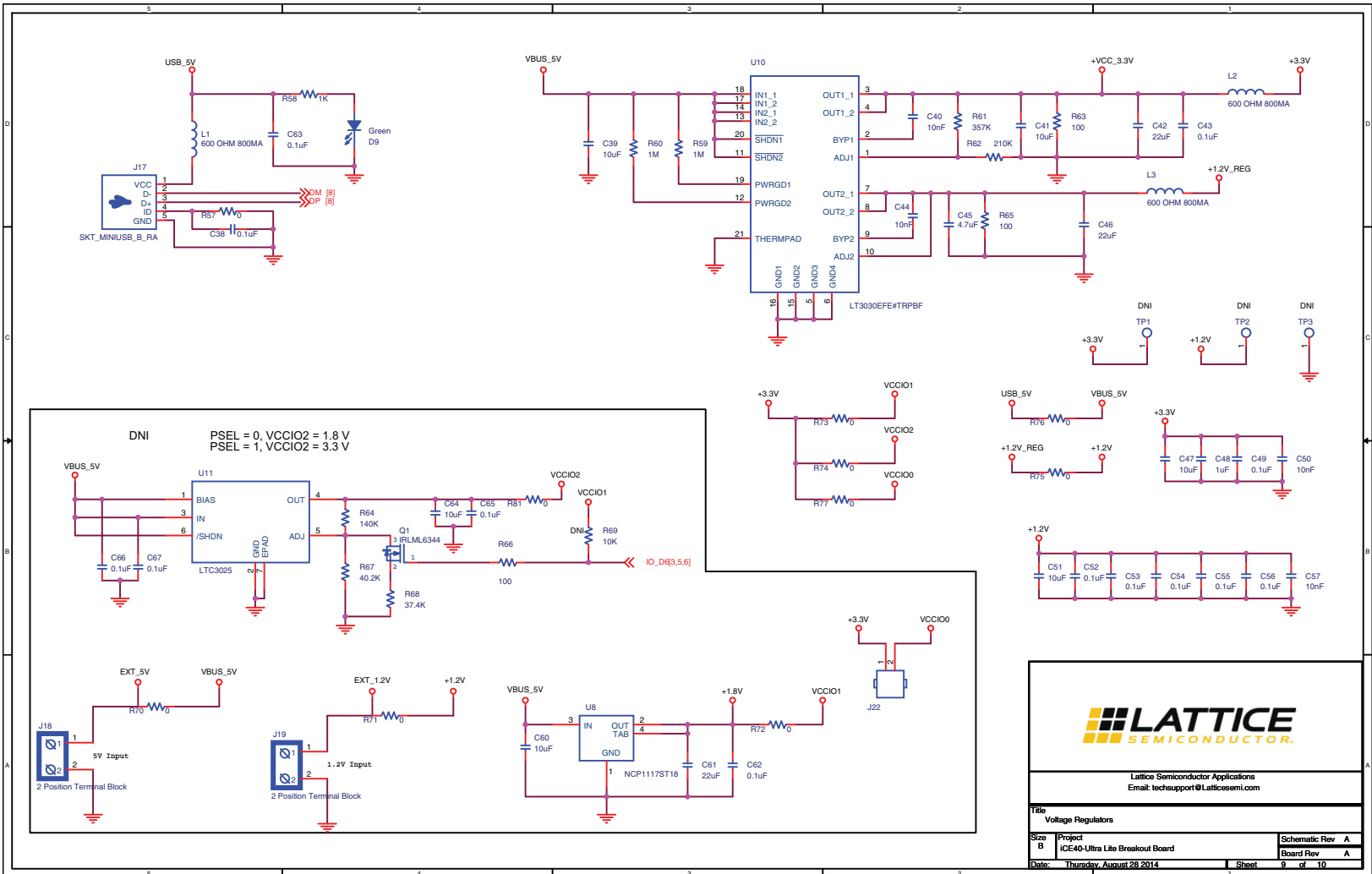
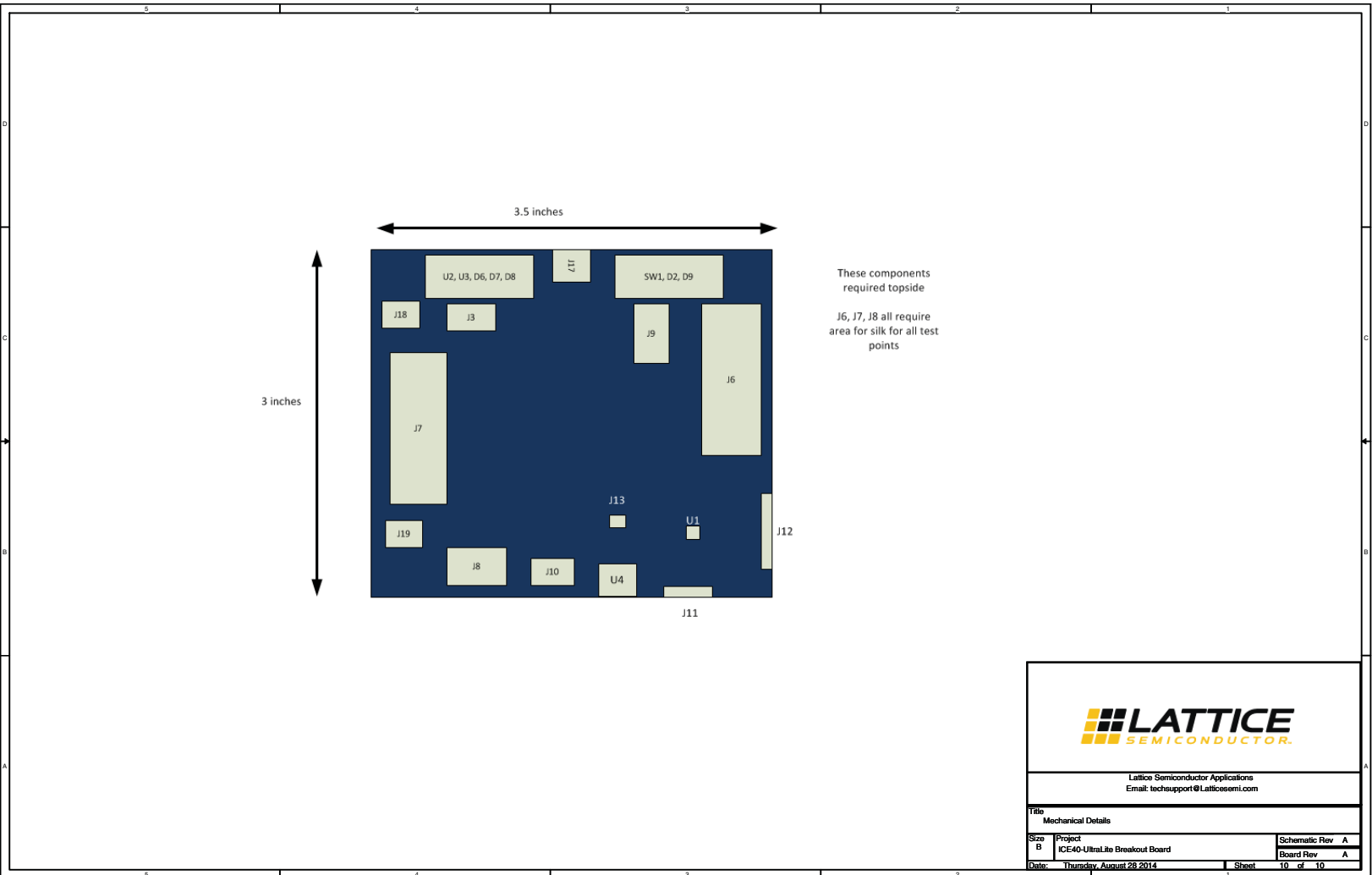


Figure 19. Mechanical Details





**Appendix B. Bill of Materials**

| Item | Quantity | Reference   | Value                      | Manufacturer    | Mfg P/N                  | Populated |
|------|----------|---|----------------------------|-----------------|--------------------------|-----------|
| 1    | 5        | C1,C4,C7,C10,C14  | 0.1 uF                     | Kemet           | C0603C104K4RACTU         | Yes       |
| 2    | 5        | C2,C5,C8,C11,C15  | 10 nF                      | Kemet           | C0603C103K4RACTU         | Yes       |
| 3    | 4        | C3,C6,C9,C13  | 1 uF                       | Murata          | GRM188R61A105KA61D       | Yes       |
| 4    | 17       | C12,C17,C18,C19,C20,C23,C24,C37,C38,C43,C49,C52,C53,C54,C55,C56,C63 | 0.1 uF                     | Kemet           | C0603C104K4RACTU         | Yes       |
| 5    | 1        | C16   | 4.7 uF                     | Murata          | GRM188R60J475KE19D       | —         |
| 6    | 1        | C21   | 0.1 uF                     | Kemet           | C0603C104K4RACTU         | —         |
| 7    | 1        | C22   | 10 nF                      | Kemet           | C0603C103K4RACTU         | —         |
| 8    | 9        | C25,C26,C27,C28,C29,C30,C32,C34,C36                                 | 0.1 uF                     | Kemet           | C0603C104K4RACTU         | Yes       |
| 9    | 2        | C31,C33   | 4.7 uF                     | Murata          | GRM188R60J475KE19D       | Yes       |
| 10   | 1        | C35   | 10 uF                      | Taiyo Yuden     | LMK107BBJ106MAHT         | Yes       |
| 11   | 4        | C39,C41,C47,C51   | 10 uF                      | Taiyo Yuden     | LMK107BBJ106MAHT         | Yes       |
| 12   | 6        | C40,C44,C50,C57,C58,C59   | 10 nF                      | Kemet           | C0603C103K4RACTU         | Yes       |
| 13   | 2        | C42,C46   | 22 uF                      | TDK             | C2012X5R1A226M125AB      | Yes       |
| 14   | 1        | C45   | 4.7 uF                     | Murata          | GRM188R60J475KE19D       | Yes       |
| 15   | 1        | C48   | 1uF                        | Murata          | GRM188R61A105KA61D       | Yes       |
| 16   | 2        | C60,C64   | 10 uF                      | Taiyo Yuden     | LMK107BBJ106MAHT         | —         |
| 17   | 1        | C61   | 22 uF                      | TDK             | C2012X5R1A226M125AB      | —         |
| 18   | 4        | C62,C65,C66,C67   | 0.1 uF                     | Kemet           | C0603C104K4RACTU         | —         |
| 19   | 4        | D1,D3,D4,D5   | CDBU0520                   | Comchip         | CDBU0520                 | Yes       |
| 20   | 2        | D2,D9   | Green                      | Osram           | LG L29K-G2J1-24-Z        | Yes       |
| 21   | 1        | D6  | TSAL6200                   | Vishay          | TSAL6200                 | Yes       |
| 22   | 1        | D7  | XBDAWT                     | Cree            | XBDAWT-00-0000-00000LCE3 | Yes       |
| 23   | 1        | D8  | BAR                        | Kingbright Corp | APT2012SRCPRV            | Yes       |
| 24   | 1        | J1  | CRSTB                      | FCI             | 77311-801-02LF           | Yes       |
| 25   | 1        | J2  | CDONE                      | FCI             | 77311-801-02LF           | Yes       |
| 26   | 1        | J3  | 0.1" Header<br>3 x 2       | —               | —                        | Yes       |
| 27   | 2        | J4,J5   | 0.1" Header<br>3 x 1       | —               | —                        | Yes       |
| 28   | 2        | J6,J7   | 0.1" Header<br>10 x 2      | Samtec          | MTSW-110-08-G-D-265      | —         |
| 29   | 1        | J8  | 0.1" Header<br>6 x 2       | —               | —                        | —         |
| 30   | 1        | J9  | 0.1" Header<br>5 x 2       | —               | —                        | Yes       |
| 31   | 1        | J10   | Header 5x2<br>(2 mm pitch) | Molex           | 087758-1016              | —         |
| 32   | 1        | J11   | 9 pin FPC<br>connector     | Molex Inc       | 522070960                | —         |
| 33   | 1        | J12   | 26 pin FPC<br>connector    | Omron           | XF2M-2615-1A             | —         |

| Item | Quantity | Reference   | Value                           | Manufacturer    | Mfg P/N                            | Populated |
|------|----------|---|---------------------------------|-----------------|------------------------------------|-----------|
| 34   | 1        | J13   | SMA                             | Molex Inc       | 733910060                          | —         |
| 35   | 2        | J14,J16   | 0.1" Header<br>2 x 1            | FCI             | 77311-801-02LF                     | Yes       |
| 36   | 1        | J15   | 0.1" Header<br>2 x 2            | —               | —                                  | Yes       |
| 37   | 1        | J17   | SKT_MINIU<br>SB_B_RA            | Neltron         | 5075BMR-05-SM-CR                   | Yes       |
| 38   | 2        | J18,J19   | 2 Position<br>Terminal<br>Block | Phoenix Contact | 1990009                            | —         |
| 39   | 3        | J20,J21,J22   | 0.1" Header<br>2 x 1            | FCI             | 77311-801-02LF                     | —         |
| 40   | 3        | L1,L2,L3  | 600 Ohm<br>800 mA               | Murata          | BLM18HE601SN1D /<br>BLM18AG601SN1D | Yes       |
| 41   | 2        | L4,L5   | 600 Ohm<br>800 mA               | Murata          | BLM18HE601SN1D /<br>BLM18AG601SN1D | Yes       |
| 42   | 1        | Q1  | IRLML6344                       | IR              | IRLML6344TRPBF                     | —         |
| 43   | 2        | R1,R4   | 1                               | Panasonic       | ERJ-3RQF1R0V                       | Yes       |
| 44   | 3        | R2,R3,R5  | 1                               | Panasonic       | ERJ-3RQF1R0V                       | Yes       |
| 45   | 1        | R6  | 100                             | Vishay Dale     | CRCW0603100RFKEAHP                 | Yes       |
| 46   | 5        | R7,R40,R41,R42,R43  | 10k                             | Panasonic       | ERJ-3EKF1002V                      | Yes       |
| 47   | 1        | R8  | 402                             | Panasonic       | ERJ-3EKF4020V                      | Yes       |
| 48   | 1        | R9  | 10k                             | Panasonic       | ERJ-3EKF1002V                      | —         |
| 49   | 18       | R10,R11,R12,R13,R14,R15,R16,R17,R18,R20,R21,R22,R51,R52,R53,R54,R55,R56 | 0                               | Panasonic       | ERJ-3GEY0R00V                      | Yes       |
| 50   | 2        | R19,R48   | 2.2 k                           | Yageo           | RC0603FR-072K2L                    | —         |
| 51   | 1        | R23   | 110                             | Panasonic       | ERJ-3EKF1100V                      | Yes       |
| 52   | 1        | R24   | 62                              | Panasonic       | ERJ-3EKF62R0V                      | Yes       |
| 53   | 1        | R25   | 62                              | Panasonic       | ERJ-3EKF62R0V                      | Yes       |
| 54   | 1        | R26   | 100                             | Panasonic       | ERJ-3EKF1000V                      | —         |
| 55   | 10       | R27,R35,R36,R37,R38,R39,R70,R71,R72,R81                                 | 0                               | Panasonic       | ERJ-3GEY0R00V                      | —         |
| 56   | 7        | R28,R29,R30,R31,R32,R33,R34   | 10 k                            | Panasonic       | ERJ-3EKF1002V                      | —         |
| 57   | 3        | R44,R45,R46   | 10 k                            | Panasonic       | ERJ-3EKF1002V                      | Yes       |
| 58   | 3        | R47,R49,R50   | 2.2 k                           | Yageo           | RC0603FR-072K2L                    | Yes       |
| 59   | 3        | R57,R75,R76   | 0                               | Panasonic       | ERJ-3GEY0R00V                      | Yes       |
| 60   | 1        | R58   | 1 K                             | Vishay Dale     | CRCW06031K00FKEA                   | Yes       |
| 61   | 2        | R59,R60   | 1 M                             | Vishay Dale     | CRCW04021M00JNED                   | Yes       |
| 62   | 1        | R61   | 357 K                           | Panasonic       | ERJ-3EKF3573V                      | Yes       |
| 63   | 1        | R62   | 210 K                           | Panasonic       | ERJ-3EKF2103V                      | Yes       |
| 64   | 3        | R63,R65,R66   | 100                             | Panasonic       | ERJ-3EKF1000V                      | Yes       |
| 65   | 1        | R64   | 140 K                           | Yageo           | RC0603FR-07140KL                   | Yes       |
| 66   | 1        | R67   | 40.2 K                          | Panasonic       | ERJ-3EKF4022V                      | Yes       |