



# **iCE40 UltraPlus Breakout Board**

## **User Guide**

FPGA-UG-02001 Version 1.1

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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.

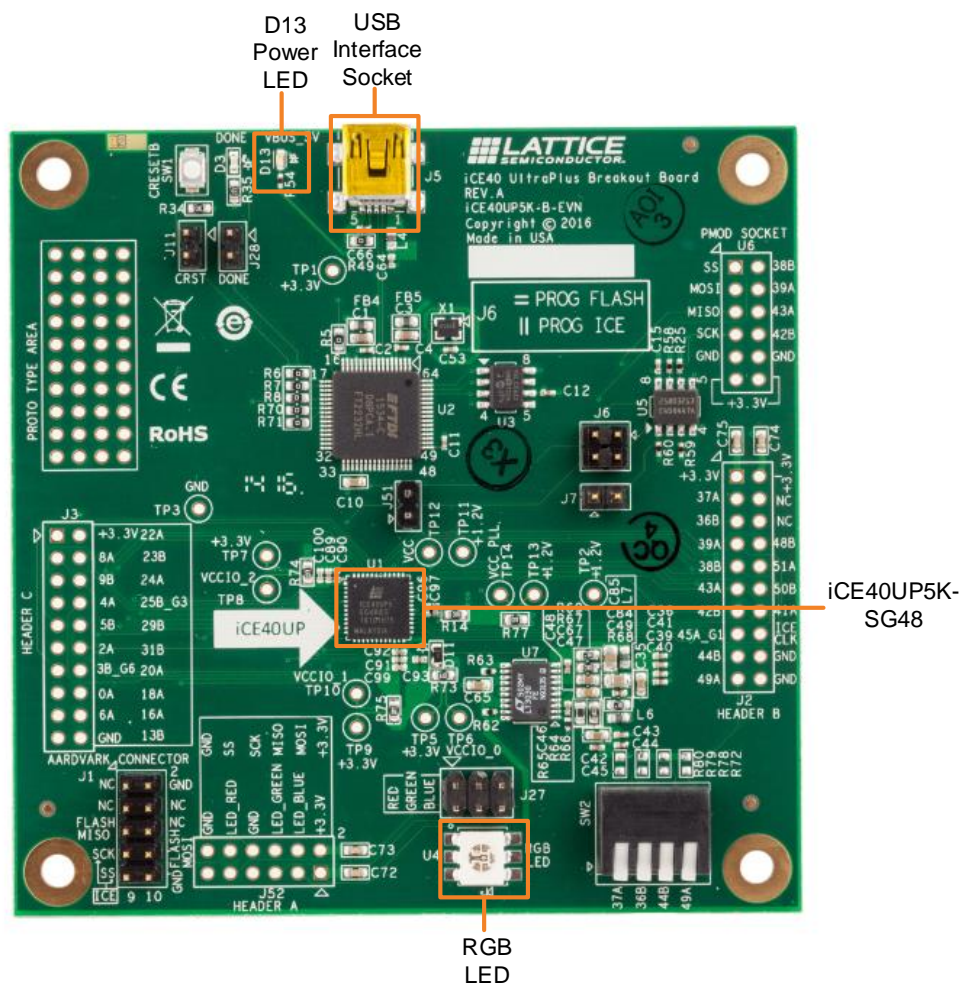
**Note:** Static electricity can severely shorten the lifespan of electronic components. Be careful when handling the iCE40 UltraPlus Breakout Board as to not damage it from ESD.

## 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.



### 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](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 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](http://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.

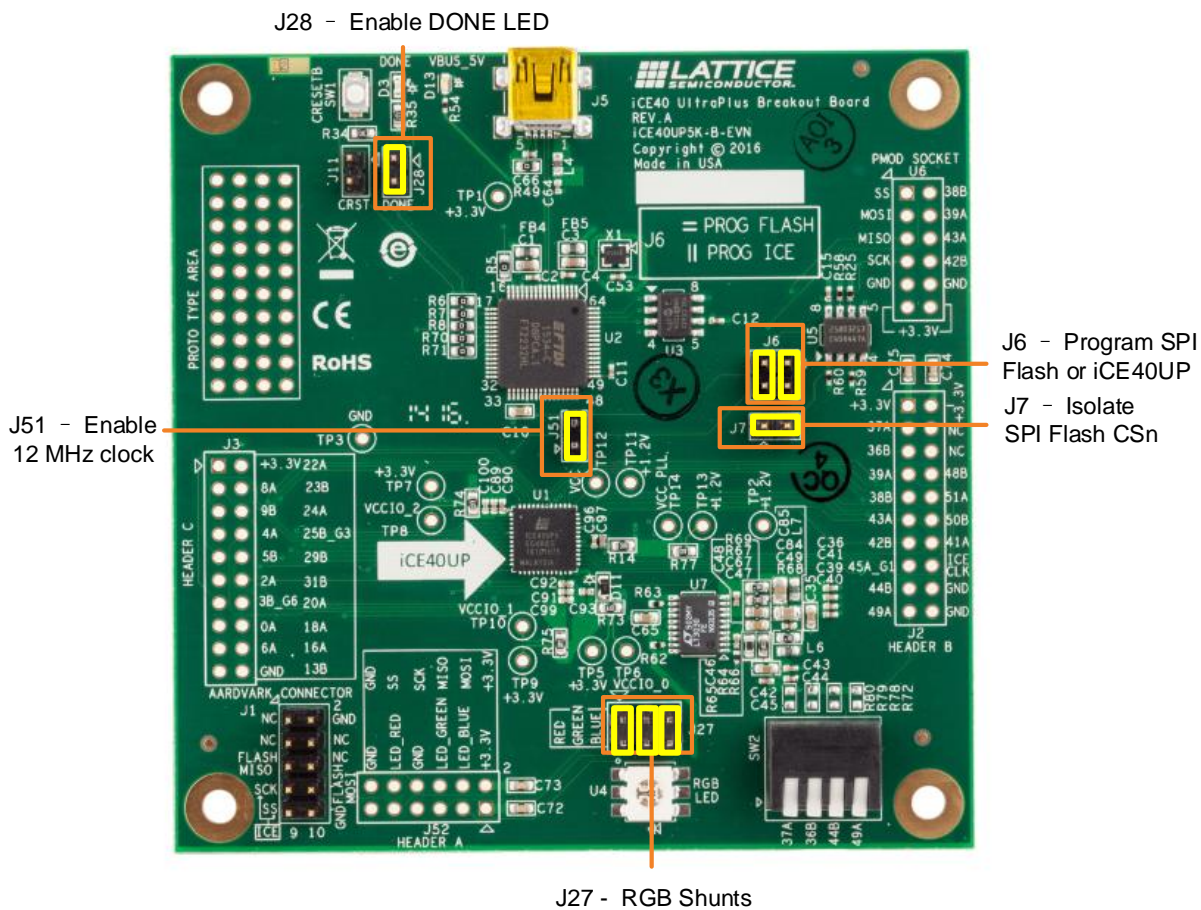


Figure 5.1. Default Shunt Locations

## 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  $\Omega$ ) at TP11 and TP12
  - ICC\_PLL can be measured across the series resistor R77 (1  $\Omega$ ) at TP13 and TP14
- iCE40 UltraPlus VCCIO
  - Onboard 3.3 V supply
  - ICC0 can be measured across the series resistor R73 (1  $\Omega$ ) at TP5 and TP6
  - ICC1 can be measured across the series resistor R75 (1  $\Omega$ ) at TP9 and TP10
  - ICC2 can be measured across the series resistor R74 (1  $\Omega$ ) at TP7 and TP8

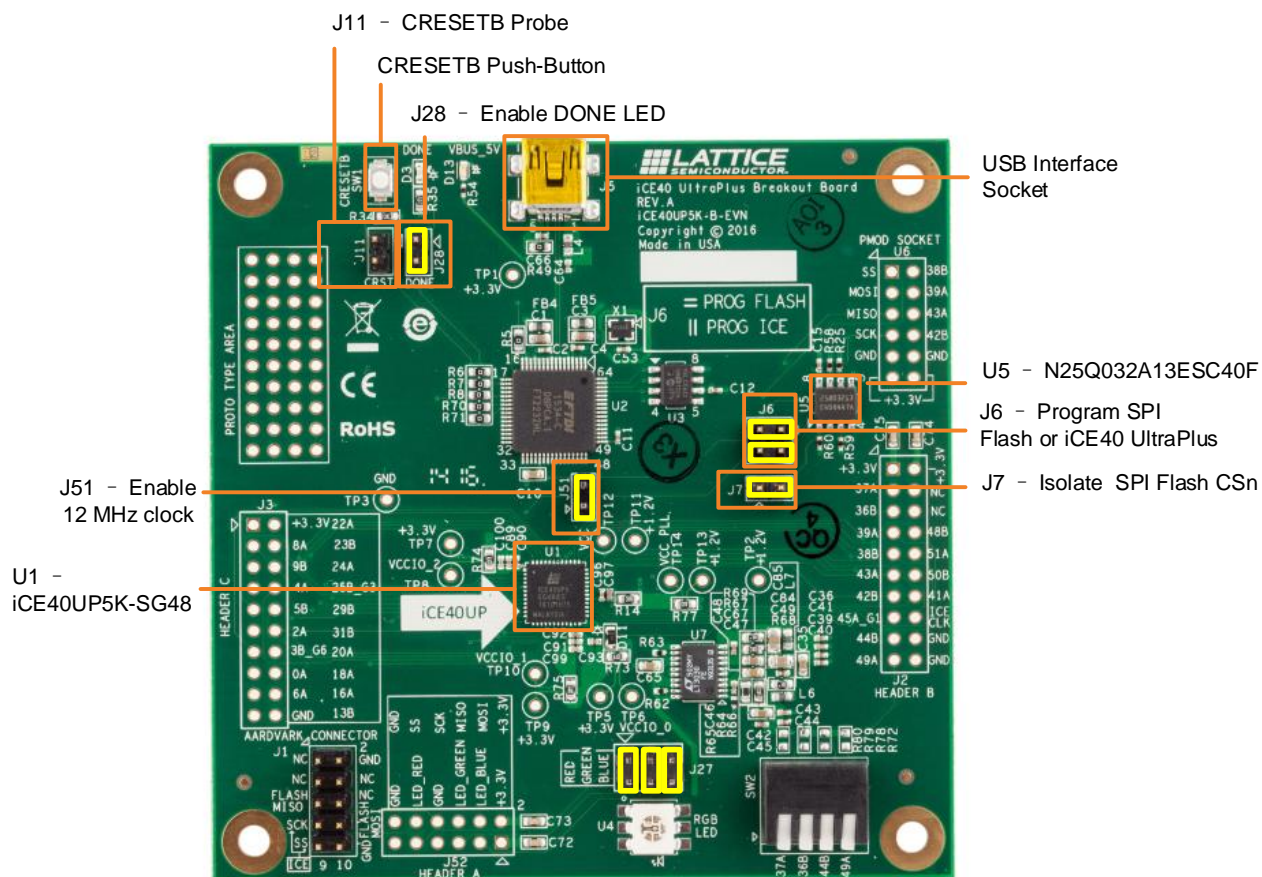
The power supplies on the iCE40 UltraPlus Breakout Board are simplified and suitable for booting from the external SPI flash. The power supply sequencing does not conform to the NVCM boot requirements as specified in DS1056, [iCE40 UltraPlus Family Data Sheet](#). The user may encounter intermittent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

## 8. Board Configuration and Programming

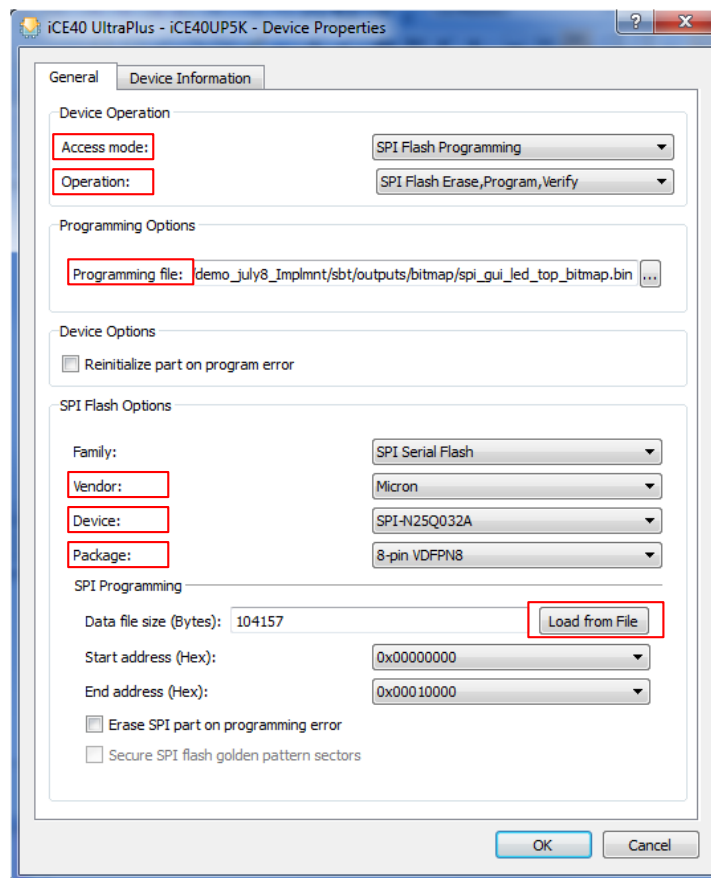
The board allows for programming of the iCE40 UltraPlus or the SPI Flash:

- 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)

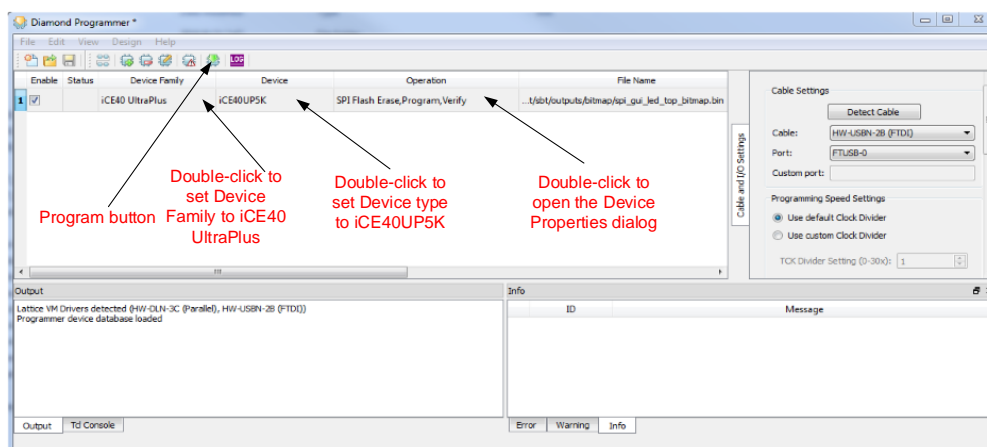
Details of the iCE40 UltraPlus Board for SPI flash programming are shown in Figure 8.1.



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**

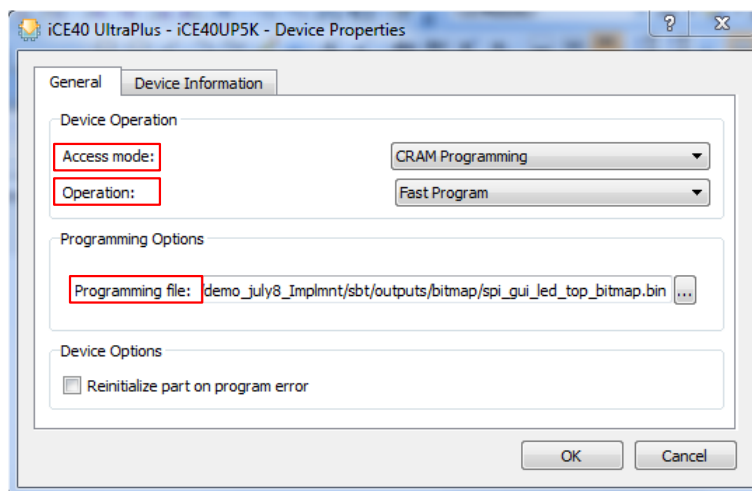


**Figure 8.3. Setting Status in Diamond Programmer for Programming Flash**

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:

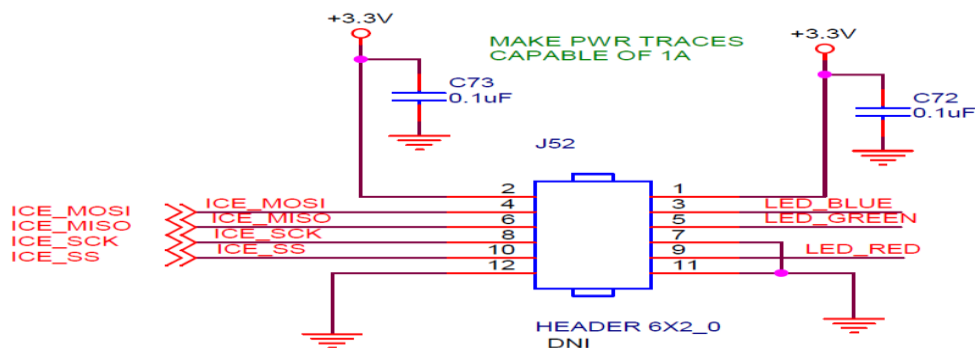


Figure 9.1. J52 Header 'A' Breakouts

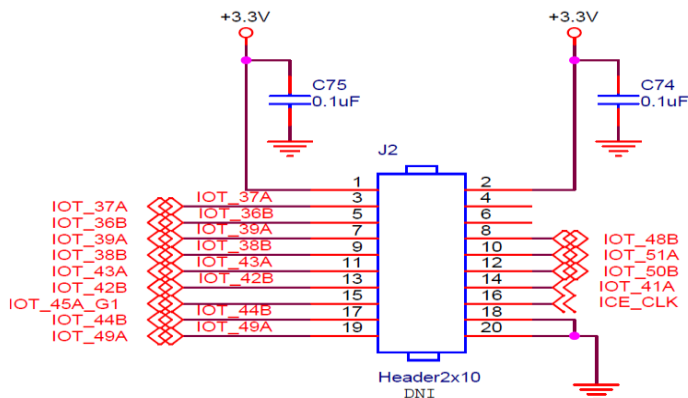


Figure 9.2. J2 Header 'B' Breakouts

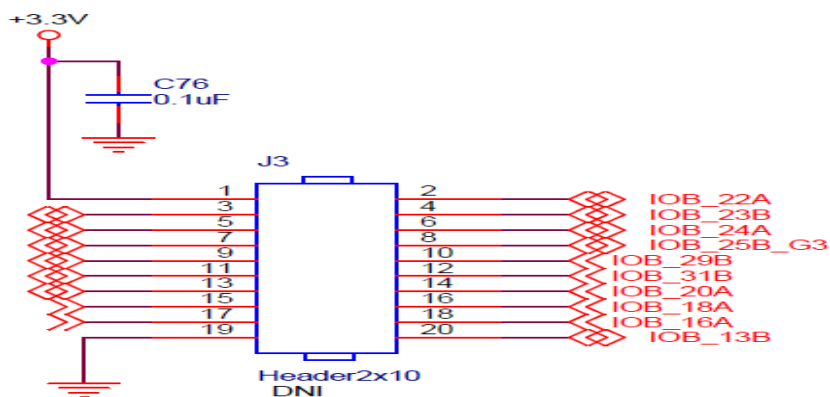


Figure 9.3. J3 Header 'C' Breakouts

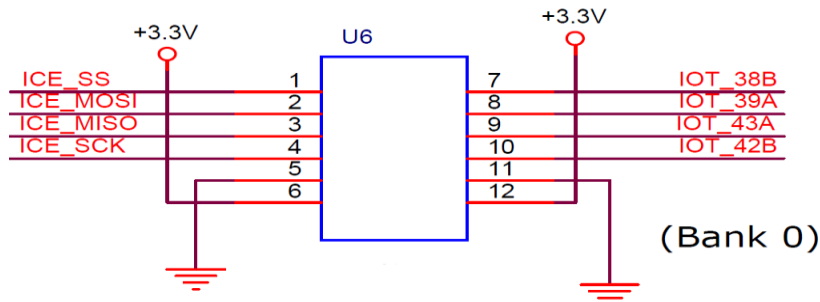


Figure 9.4. U6 PMOD Connector

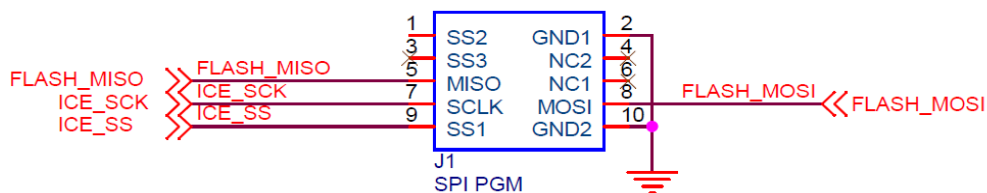


Figure 9.5. J1 Adardvark Connector

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

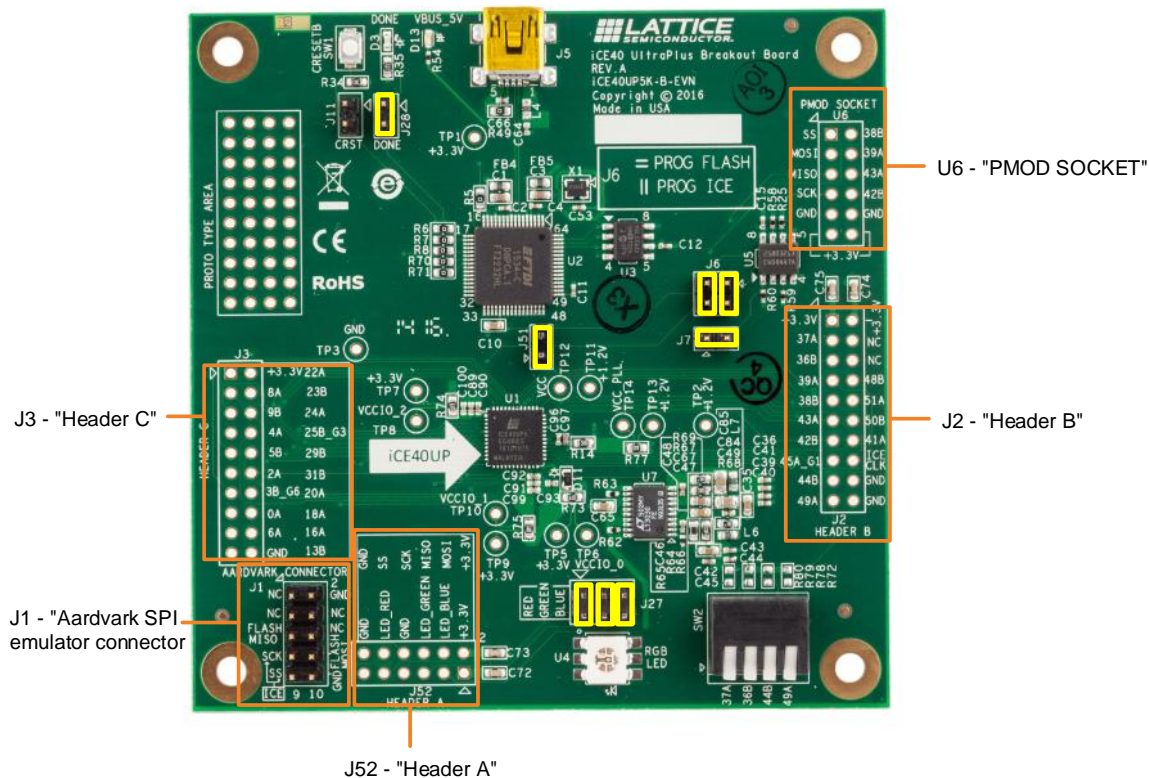


Figure 9.6. Breakout Headers

## 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](http://www.lattice.com/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.

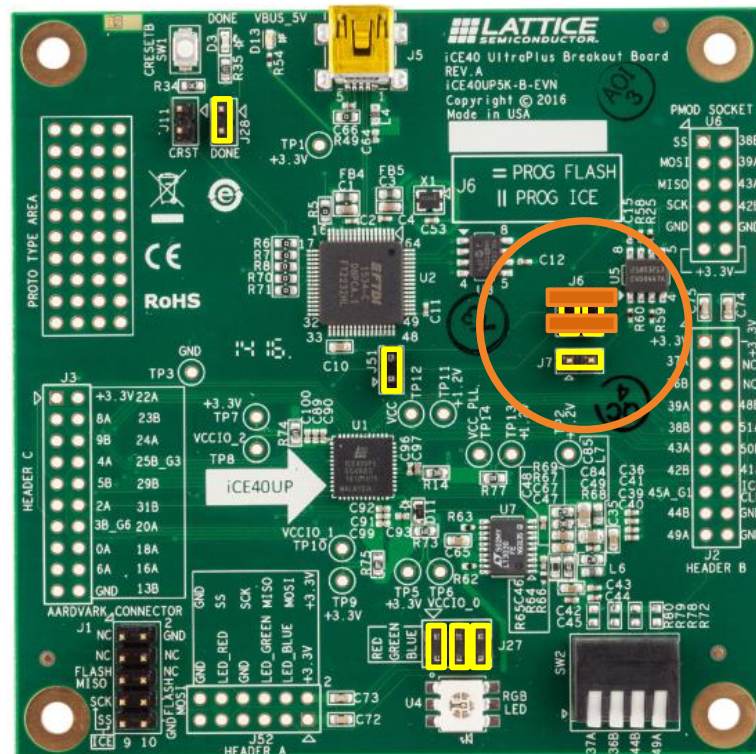


Figure 10.1. SPI Flash Selection (Horizontal) for J6

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.

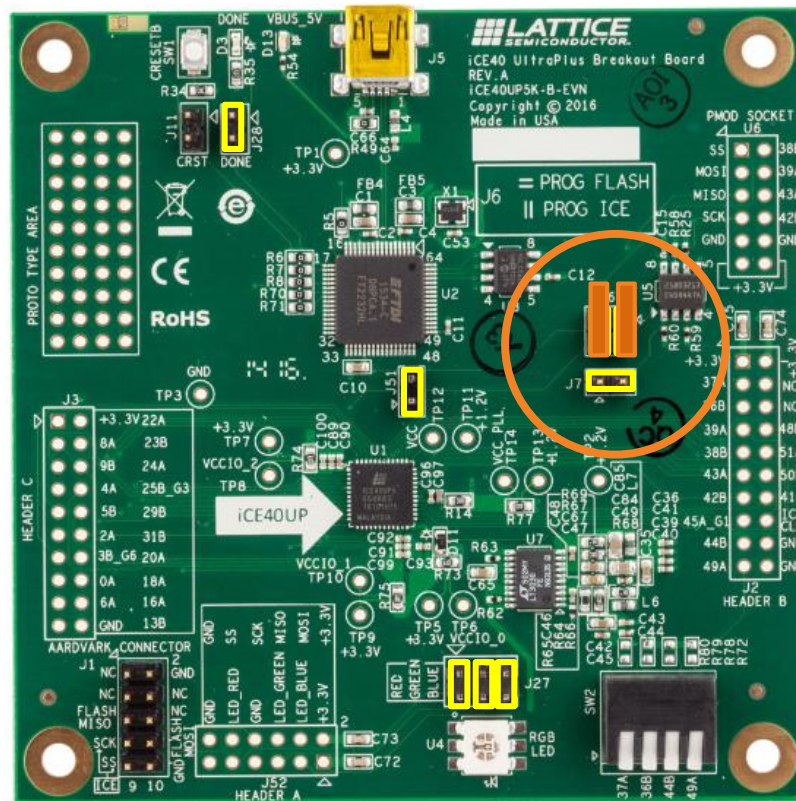


Figure 10.2. iCE40 UltraPlus Selection (Vertical) for J6

- Start the RGB GUI on the PC or MAC.

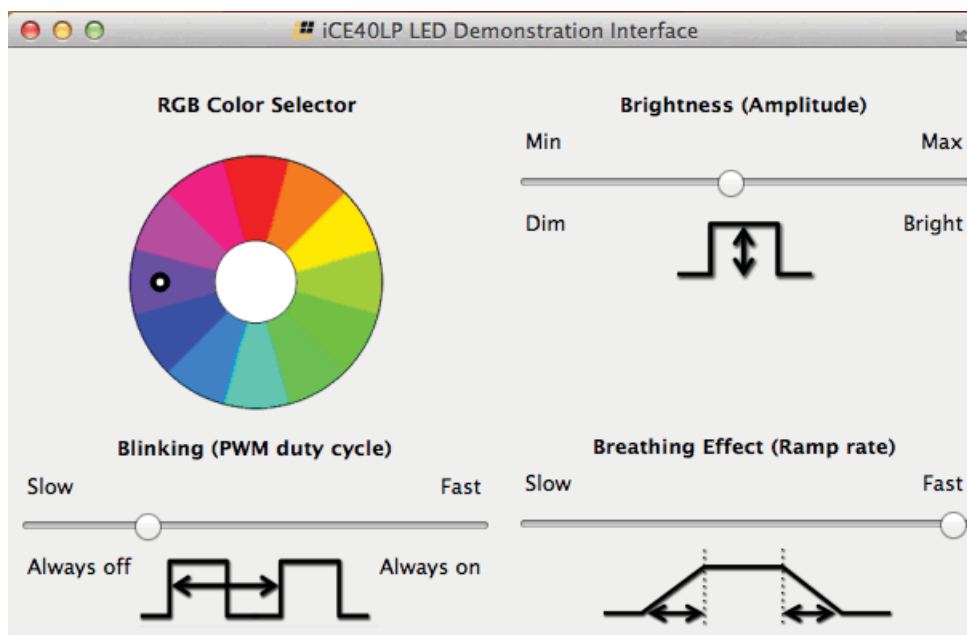


Figure 10.3. iCE40 UltraPlus LED Demonstration Interface

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.)

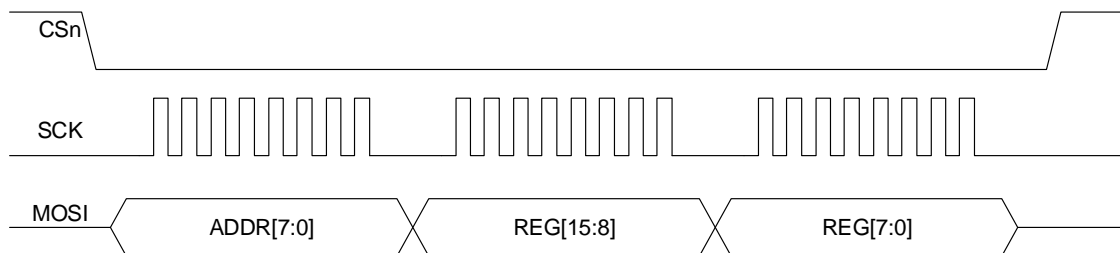


Figure 11.1. SPI Physical Transaction

### 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

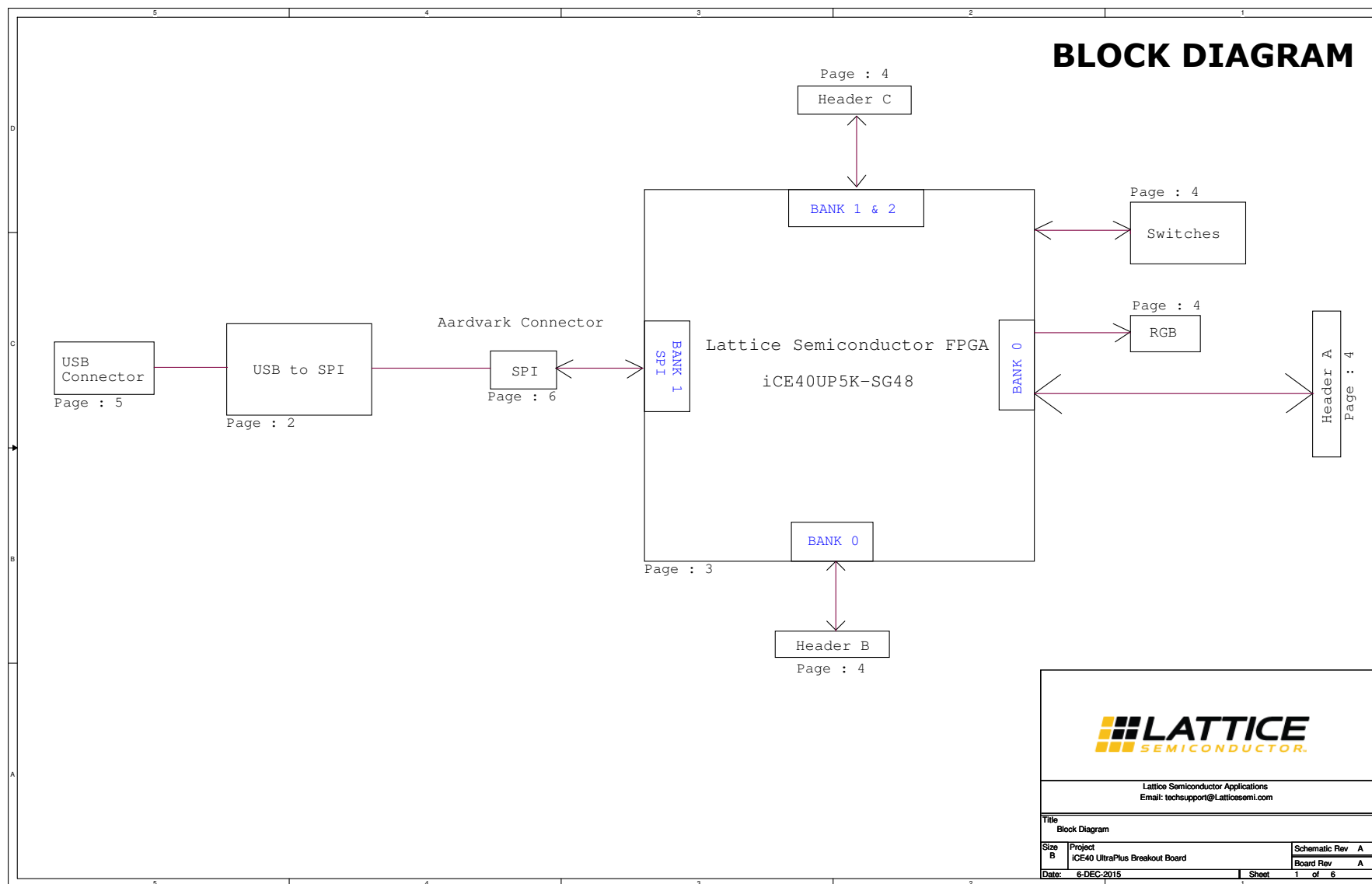


Figure A.1. Block Diagram



## DUT CONNECTION

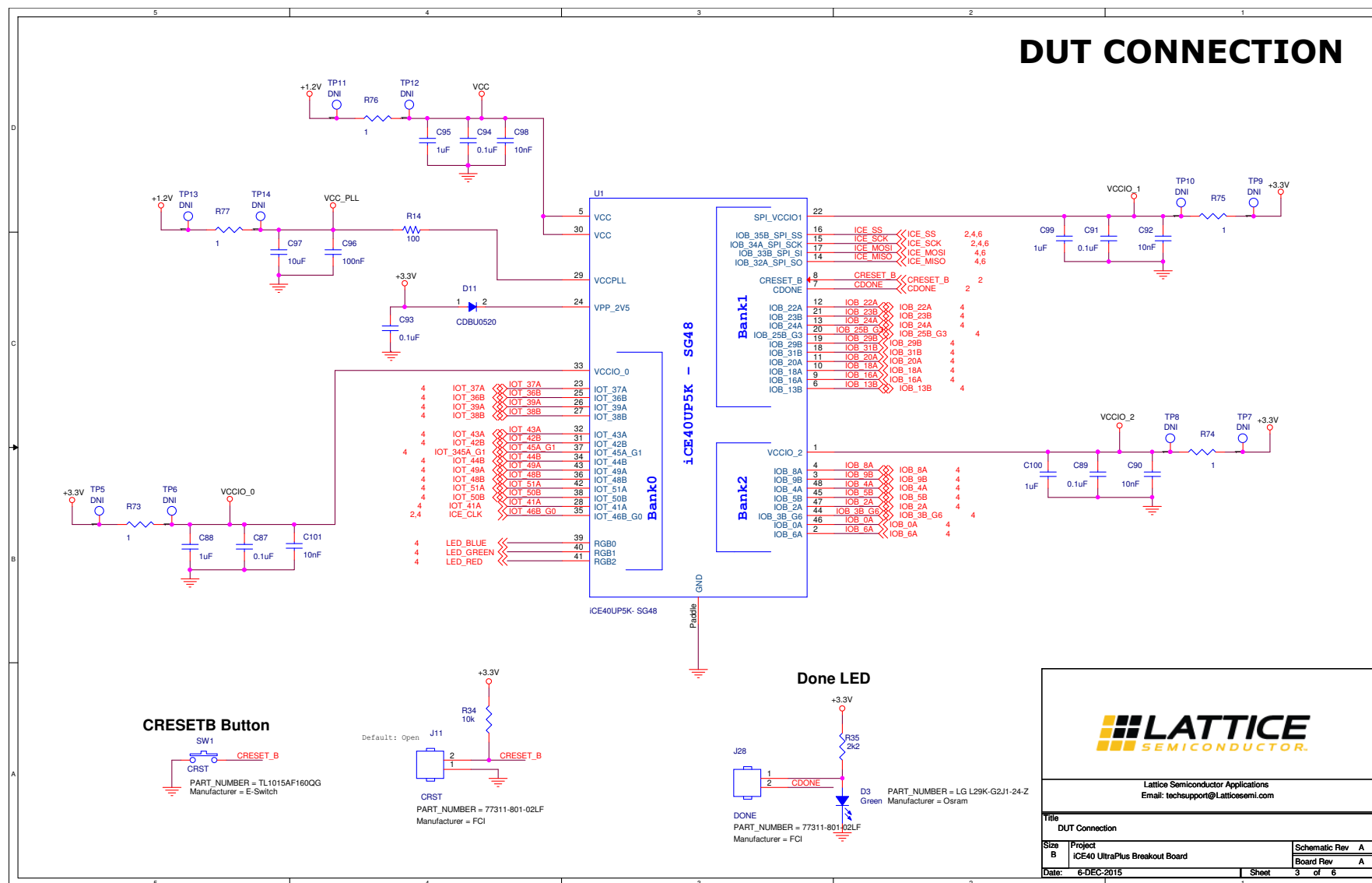


Figure A.3. DUT Connection

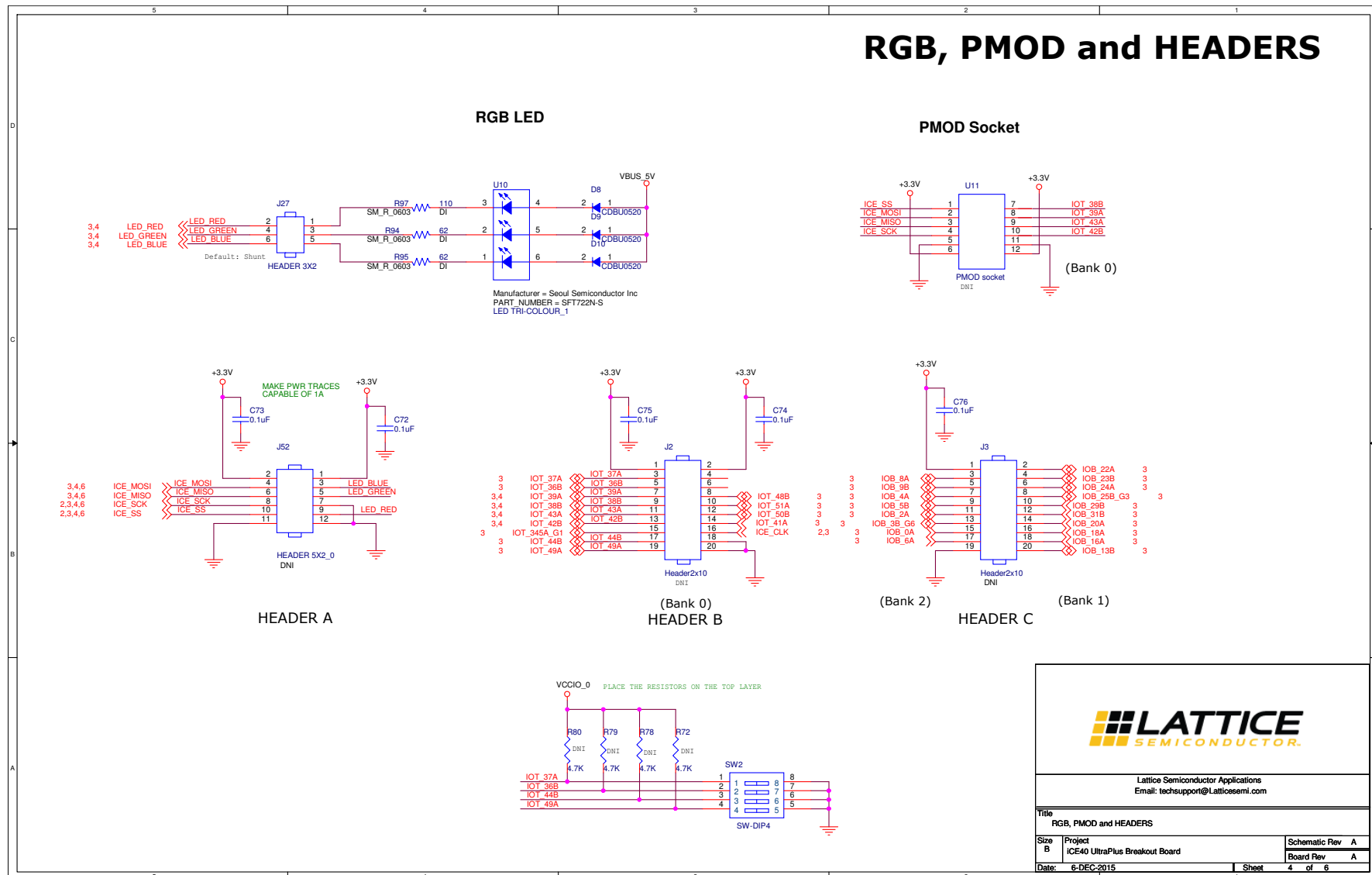


Figure A.4. RGB, PMOD and HEADERS

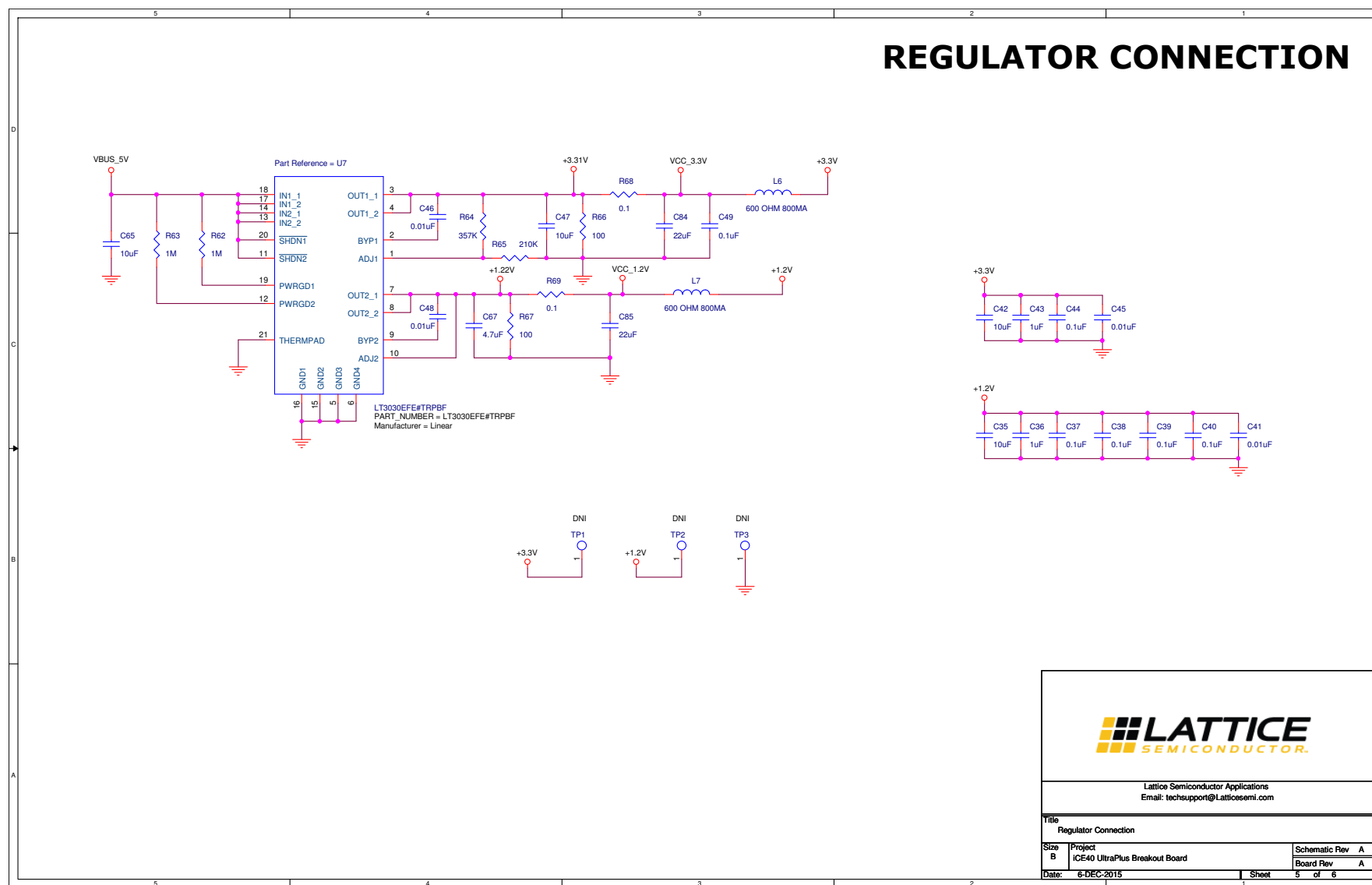


Figure A.5. Regulator Connection

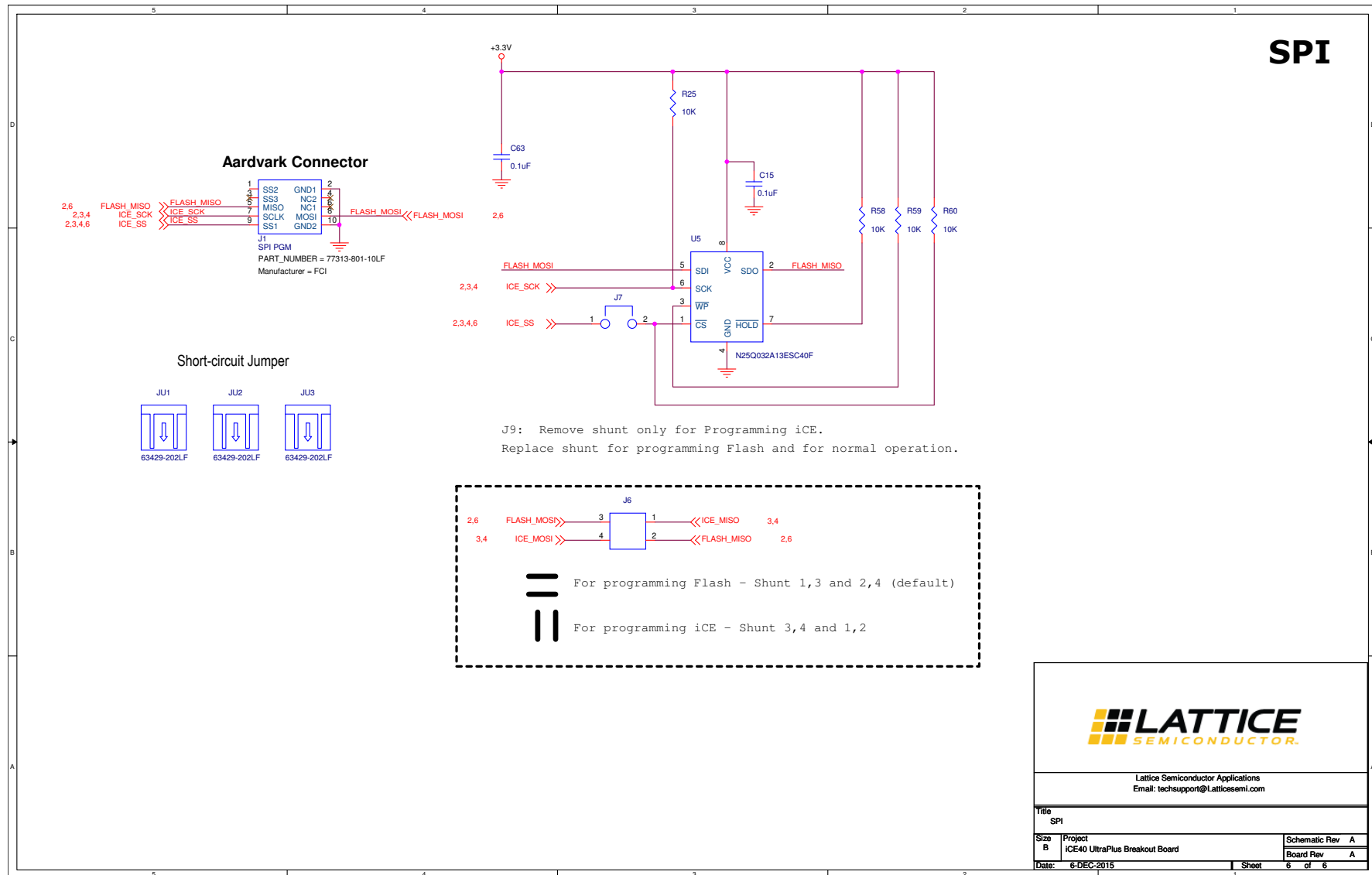


Figure A.6. SPI

## Appendix B. Bill of Materials

Item	Reference	Qty	Part	PCB Footprint	PART_NUMBER	Manufacturer	DESCRIPTION
1	C1,C3,C67	3	4.7uF	cc0603	ECJ-1VB0J475K	Panasonic	CAP CER 4.7UF 6.3V 10% X5R 0603
2	C2,C4,C5,C6,C7, C8,C9,C11,C12, C15,C37,C38,C39, C40,C44,C49,C53, C63,C64,C66,C87, C89,C91,C93,C94	25	0.1uF	cc0402	C0402C104K4RA CTU	Kemet	CAP CER 0.1UF 16V 10% X7R 0402
3	C10,C35,C42,C47, C65	5	10uF	cc0603	LMK107BJ106M ALTD	Taiyo Yuden	CAP CER 10UF 10V 20% X5R 0603
4	C36,C43	2	1uF	cc0402	C0402C105K9PA CTU	Kemet	CAP CER 1UF 6.3V 10% X5R 0402
5	C41,C45,C46,C48	4	0.01uF	cc0402	C0402C103J4RA CTU	Kemet	CAP CER 10000PF 16V 5% X7R 0402
6	C72,C73,C74,C75, C76	5	0.1uF	cc0603	C0603C104K4RA CTU	Kemet	CAP CER 0.1UF 16V 10% X7R 0603
7	C84,C85	2	22uF	cc0805	LMK212BJ226M G-T	Taiyo Yuden	CAP CER 22UF 10V 20% X5R 0805
8	C88, C95, C99, C100	4	1uF	cc0402	C0402C105K4PA C7867	Kemet	CAP CER 1UF 16V 10% X5R 0402
9	C90, C92, C98, C101	4	10nF	cc0402	C0402C103J4RA CTU	Kemet	CAP CER 10000PF 16V 5% X7R 0402
10	C96	1	100nF	cc0402	C0402C104K4RA CTU	Kemet	CAP CER 0.1UF 16V 10% X7R 0402
11	C97	1	10uF	cc0402	CL05A106MP5N UNC	Samsung	CAP CER 10UF 10V X5R 0402
12	D3	1	Green	SM_D_0603	LG L29K-G2J1- 24-Z	Osram	LED SMARTLED GREEN 570NM 0603
13	D8,D9,D10,D11	4	CDBU0130R	diode_sod523f	CDBU0130R	Comchip	DIODE SCHOTTKY 30V 100MA 0603
14	D13	1	Blue	led_0603	LTST-C190TBKT	LITE-On Inc.	LED BLUE CLEAR 0603 SMD
15	FB4,FB5	2	FB_60ohm	L0603	HI0603P600R-10	Laird-signal	FERRITE CHIP POWER 60 Ω SMD
16	J1	1	SPI PGM	hdr5x2	77313-801-10LF	FCI	CONN HEADER .100 DUAL STR 10POS
17	J2,J3	2	Header2x10	hdr_samtec_mts w_2x10_100	MTSW-110-08-T- D-300	Samtec	CONN HEADER 20POS .100" TH DUAL
18	J5	1	SKT_MINIUSB_ B_RA	skt_miniusb_b_r a	5075BMR-05- SM-CR	Neltron	CONN MINI USB RCPT RA TYPE B SMD
19	J6	1	TSW-102-07-F- D	hdr_samtec_tsw _2x2_100	TSW-102-07-F-D	Samtec	CONN HEADER 4POS .100" DBL
20	J7	1	TSW-102-07-G- S	hdr_samtec_tsw _1x2_100	TSW-102-07-G-S	Samtec	CONN HEADER 2POS .100" SGL GOLD
21	J11	1	CRST	HDR1X2-40	77311-801-02LF	FCI	CONN HEADER

Item	Reference	Qty	Part	PCB Footprint	PART_NUMBER	Manufacturer	DESCRIPTION
							.100 SINGL STR 2POS
22	J27	1	HEADER 3X2	HDR3x2	—	—	—
23	J28	1	DONE	HDR1X2-40	77311-801-02LF	FCI	CONN HEADER .100 SINGL STR 2POS
24	J51	1	2 PIN JPR	2PIN_100MIL	—	—	—
25	J52	1	HEADER 6X2_0	HDR_6X2	—	—	—
26	L4,L6,L7	3	600 OHM 800MA	fb0603	BLM18HE601SN 1D	Murata	FERRITE CHIP 600 Ω 800MA 0603
27	R5,R6,R7,R8,R49, R70,R71	7	0	cr0603	RC0603JR-070RL	Yageo	RES 0.0 Ω 1/10W JUMP 0603 SMD
28	R9,R19	2	2.2K	cr0402	RC0402FR- 072K2L	Yageo	RES 2.20 K Ω 1/16W 1% 0402 SMD
29	R10	1	12K	cr0402	RC0402FR- 0712KL	Yageo	RES 12.0 K Ω 1/16W 1% 0402 SMD
30	R11,R12,R13,R25, R58,R59,R60	7	10K	cr0402	RC0402FR- 0710KL	Yageo	RES 10.0 K Ω 1/16W 1% 0402 SMD
31	R14	1	100	R0603	CRCW0603100R FKEAHP	Vishay	RES 100 Ω 0.25W 1% 0603 SMD
32	R34	1	10k	R0603	ERJ-3EKF1002V	Panasonic	RES 10 K Ω 1/10W 1% 0603 SMD
33	R35	1	2k2	R0603	ERJ-3EKF2201V	Panasonic	RES 2.2 K Ω 1/10W 1% 0603 SMD
34	R54	1	1K	cr0402	ERJ-2GEJ102X	Panasonic	RES SMD 1 K Ω 5% 1/10W 0402
35	R62,R63	2	1M	cr0402	RC0402JR- 071ML	Yageo	RES 1.0M Ω 1/16W 5% 0402 SMD
36	R64	1	357K	cr0603	ERJ-3EKF3573V	Panasonic	RES SMD 357 K Ω 1% 1/10W 0603
37	R65	1	210K	cr0402	ERJ-2RKF2103X	Panasonic	RES SMD 210 K Ω 1% 1/10W 0402
38	R66,R67	2	100	cr0603	RC0603FR- 07100RL	Yageo	RES 100 Ω 1/10W 1% 0603 SMD
39	R68,R69	2	0.1	cr0603	ERJ-3RSFR10V	Panasonic	RES .10 Ω 1/10W 1% 0603 SMD
40	R72,R78,R79,R80	4	4.7K	cr0603	CRCW06034K70 FKEA	Vishay	RES 4.70 K Ω 1/10W 1% 0603 SMD
41	R73,R74,R75,R76, R77	5	1	cr0603	RC0603FR-071RL	Yageo	RES SMD 1 Ω 1% 1/10W 0603
42	R94,R95	2	62	SM_R_0603	ERJ-3EKF62R0V	Panasonic	RES 62 Ω 1/10W 1% 0603 SMD
43	R97	1	110	SM_R_0603	ERJ-3EKF1100V	Panasonic	RES 110 Ω 1/10W 1% 0603 SMD
44	SW1	1	CRST	2psmd_eswitch	TL1015AF160QG	E-Switch	SWITCH TACTILE SPST-NO 0.05 A 12V
45	SW2	1	SW-DIP4	sw_sp_st_cts_19	195-4MST	CTS	SWITCH SIDE

Item	Reference	Qty	Part	PCB Footprint	PART_NUMBER	Manufacturer	DESCRIPTION
				5-4mst		Electrocomponents	ACTUATED 4 SEC 50V
46	TP1,TP2,TP3	3	TP_S_40_63	tp_s_40_63	—	—	Square test point, 40mil inner diameter, 63mil outer diameter
47	TP5,TP6,TP7,TP8,TP9,TP10,TP11,TP12,TP13,TP14	10	DNI	tp_s_40_63	—	—	Square test point, 40mil inner diameter, 63mil outer diameter
48	U1	1	iCE40UP5K/3K-SG48	iCE40UP5K_SG48	—	—	—
49	U2	1	FT2232HL	tqfp64_0p5_12p2x12p2_h1p6	FT2232HL-REEL	FTDI	IC USB HS DUAL UART/FIFO 64-LQFP
50	U3	1	93LC56-SO8	so8_50_244	93LC56CT-I/SN	Microchip	IC EEPROM 2KBIT 3MHZ 8SOIC
51	U4	1	LED TRI-COLOUR_1	6-PLCC	SFT722N-S	Seoul Semiconductor Inc.	LED RED/GRN/BLU CLEAR LENS 6PLCC
52	U5	1	N25Q032A13ESC40F	so8_50_244	N25Q032A13ESC40F	Micron	IC Flash Mem Serial-SPI 3V/3.3V 32M-Bit 4M 7ns 8-Pin SO T/R
53	U6	1	PMOD socket	HDR_2X6	—	—	—
54	U7	1	LT3030EFE#TRPBF	tssop20_26_260_thrm_pad	LT3030EFE#TRPBF	Linear	IC REG LDO ADJ 20TSSOP
55	X1	1	12.0000MHZ	2_5mmx2mm	SiT1602AC-12-33E-12.000	SiTime	OSC MEMS 12MHZ H/LV-CMOS SMD
57	iCE40 ULTRAPLUS BREAKOUT BOARD PCB	1	—	—	305-PD-16-0084	PACTRON	—

## References

### Standards Documents

The standards used in this document and their abbreviations are listed on the table below.

Abbreviation	Standards Publication, Organization, and Date
HDMI	<i>High Definition Multimedia Interface</i> , Revision 1.4a, HDMI Licensing LLC., March 2010
HCTS	<i>HDMI Compliance Test Specification</i> , Revision 1.4a, HDMI Licensing LLC., March 2010
HDCP	<i>High-bandwidth Digital Content Protection</i> , Revision 2.2, Digital Content Protection, LLC; February 2013 <i>High-bandwidth Digital Content Protection</i> , Revision 1.4, Digital Content Protection, LLC; July 2009
DVI	<i>Digital Visual Interface</i> , Revision 1.0, Digital Display Working Group, April 1999
E-EDID	<i>Enhanced Extended Display Identification Data Standard</i> , Release A Revision 1, VESA; February 2000
CEA-861-D	<i>A DTV Profile For Uncompressed High Speed Digital Interfaces</i> , EIA/CEA, July 2006
EDDC	<i>Enhanced Display Data Channel Standard</i> , Version 1, VESA, September 1999
MHL	<i>MHL (Mobile High-definition Link) Specification</i> , Version 3.0, MHL, LLC, August 2013

For more information on the specifications that are applied in this document, contact the responsible standards groups listed on the table below.

Standards Group	Web URL
ANSI/EIA/CEA	<a href="http://global.ihs.com">http://global.ihs.com</a>
VESA	<a href="http://www.vesa.org">http://www.vesa.org</a>
HDCP	<a href="http://www.digital-cp.com">http://www.digital-cp.com</a>
DVI	<a href="http://www.ddwg.org">http://www.ddwg.org</a>
HDMI	<a href="http://www.hdmi.org">http://www.hdmi.org</a>
MHL	<a href="http://www.mhlconsortium.org">http://www.mhlconsortium.org</a>

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Email: [techsupport@latticesemi.com](mailto:techsupport@latticesemi.com)

## Revision History

Date	Version	Change Summary
March 2017	1.1	<ul style="list-style-type: none"><li>— Corrected document status; removed “Preliminary”.</li><li>— iCE40 UltraPlus Family Data Sheet document number changed to DS1056.</li><li>— Update Lattice iCEcube2 to version 2017.01.</li><li>— Updated Diamond Programmer version to 3.9.</li><li>— Updated <a href="#">Appendix A. Schematic Diagrams</a>.</li><li>— Removed Lattice Semiconductor Documents section.</li></ul>
September 2016	1.0	Initial release.



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