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iCE40 UltraPlus Mobile Development Platform

Evaluation Board User Guide

FPGA-EB-02007 Version 1.1

April 2018

Contents

1.	Introduction	4
2.	Features	5
3.	Power and Battery	8
3.1.	Power Source	8
3.2.	Current Measurement Test Points	8
3.3.	Battery Management and 4.2 V Regulator	8
4.	Clock Sources	9
5.	Software Requirements	10
6.	Demonstrations	11
6.1.	Mobile Display Demonstration on U1	11
6.2.	Audio Microphone Demonstrations on U2	11
6.3.	RGB LED Demonstration on U3	11
6.4.	Sensor Demonstrations on U3	12
6.5.	Face Recognition Demonstration on U4	12
7.	Board Configuration and Programming	14
7.1.	Jumpers and Switches	14
7.2.	Programming the iCE40 Devices Configuration Memory (CRAM)	17
7.3.	Programming Onboard SPI Flash	18
8.	Communication Channels	20
8.1.	USB	20
8.2.	Bluetooth	20
9.	Ordering Information	20
10.	PCB Revision History	20
	References	21
	Standards Documents	21
	Lattice Semiconductor Documents	21
	Technical Support Assistance	21
	Appendix A. iCE40 UltraPlus Mobile Development Board Schematics	22
	Appendix B. iCE40 UltraPlus Mobile Development Board Bill of Materials	36
	Accessories	42
	Revision History	43

Figures

Figure 2.1. iCE40 UltraPlus Mobile Development Platform Board (Top Side)	6
Figure 2.2. iCE40 UltraPlus Mobile Development Platform Board (Bottom Side)	7
Figure 3.1. Power Block Diagram	8
Figure 4.1. Clock Sources for the iCE40 UltraPlus MDP Board	9
Figure 6.1. Rework Resistor Positions Described in Parallel Video Bus Configuration	13
Figure 7.1. Board Configuration for Programming iCE40 UltraPlus Device “U1”	15
Figure 7.2. Programming iCE40 Devices on Board	17
Figure 7.3. Programming SPI Flash on Board	18
Figure A.1. Block Diagram	22
Figure A.2. iCE40UP5K FPGA A - Display	23
Figure A.3. iCE40UP5K FPGA B - Audio	24
Figure A.4. iCE40UP5K FPGA C - Sensor	25
Figure A.5. iCE40UP5K FPGA D - Camera	26
Figure A.6. Common Components- SPI	27
Figure A.7. Display Circuitry	28
Figure A.8. Audio Circuitry	29
Figure A.9. Sensor & RGB Circuitry	30
Figure A.10. Camera Circuitry	31
Figure A.11. USB Programming	32
Figure A.12. Power Supplies	33
Figure A.13. Common Components	34
Figure A.14. Battery Connector & Charger	35

Tables

Table 7.1. iCE40 UltraPlus Device Selection	14
Table 7.2. iCE40 UltraPlus Device Selection Summary	16

1. Introduction

Thank you for choosing the Lattice iCE40 UltraPlus™ Mobile Development Platform (MDP) Board.

This MDP board is an easy-to-use platform for demonstrating various features of the iCE40 UltraPlus for mobile applications. The MDP form-factor is similar to a mobile device (cell phone), with various sensors, display, Bluetooth communication, and others. The board contains four individual iCE40 UltraPlus devices, each configured with a unique set of interfaces to support multiple demonstrations.

Features that can be demonstrated using this board include:

- Mobile Display (Onboard 1.54 inch 240 x 240 RGB wearable type display with MIPI DSI interface)
- Camera (Onboard VGA 640 x 480 sensor with CSI and parallel video interface option)
 - Image and facial recognition
- Microphones (Onboard Dual I2S and Dual PDM microphones with audio amp, 3.5 mm and expansion connectors)
 - Voice recognition
 - Audio beam forming capabilities
- Sensors (Various Mobile Type Sensors with expansion connector)
 - RGB LED
 - Pressure Sensor
 - Compass Sensor
 - Gyroscope Sensor
 - Accelerometer Sensor

This guide describes how to begin using the MDP. The contents of this user guide include top-level functional descriptions of the various portions of the evaluation board, a summary of demonstrations, descriptions of the onboard connectors, switches, jumpers, configuration options, along with a complete set of schematics and the bill of materials.

Note: Static electricity can severely shorten the lifespan of electronic components. Be careful to follow proper ESD prevention handling standards when handling and using the iCE40 UltraPlus Mobile Development Platform Board.

2. Features

The iCE40 UltraPlus Mobile Development Platform development kit includes the items below.

- iCE40 UltraPlus Mobile Development Platform– PCB, case, and integrated Li-ion battery featuring:
 - Four iCE40 UltraPlus devices (U1-U4 iCE5UP5K-WLCSP30) in 30-Ball WLCSP packages
 - Large capacity of onboard SPI Flash memory (U37 Micron M25P80 8Mb) to store the FPGA demo bitstream for all four iCE40 UltraPlus devices
 - Example of a PCB design using 0.40 mm Ball Pitch package
 - Control switches to select which of the four devices is active (only one device is active at a time)
 - Standard USB cable for device programming (Lattice part number HW-USBN-2A, HW-USBN-2B or equivalent)
 - RoHS-compliant packaging and process
- Key Components
 - iCE40UP5K-30WLCSP (4 pieces)
 - Power Regulation
 - Bluetooth module
 - MIPI LCD Mobile Display (1.54 inch 240 x 240 RGB LH154Q01)
 - Camera image sensor OVM7692 VGA 640 x 480 (CSI and parallel video interface option)
 - Microphones (Dual I2S and Dual PDM microphones with audio amp, connectors for 3.5 mm and expansion)
 - RGB LED
 - Sensors that include:
 - Barometric pressure sensor
 - Compass sensor
 - 3D accelerometer and 3D gyroscope sensor
 - Three-axis linear accelerometer sensor
- Pre-loaded Demo – The kit includes a pre-loaded MIPI LCD Mobile Display demo.
- USB Connector Cable – A mini-B USB port provides power, a programming interface and communication channel for a PC to communicate directly to iCE40 devices.

Figure 2.1 shows the top side while Figure 2.2 on the next page shows the bottom side of the iCE40 UltraPlus Mobile Development Platform Board indicating the specific features that are designed on the board.

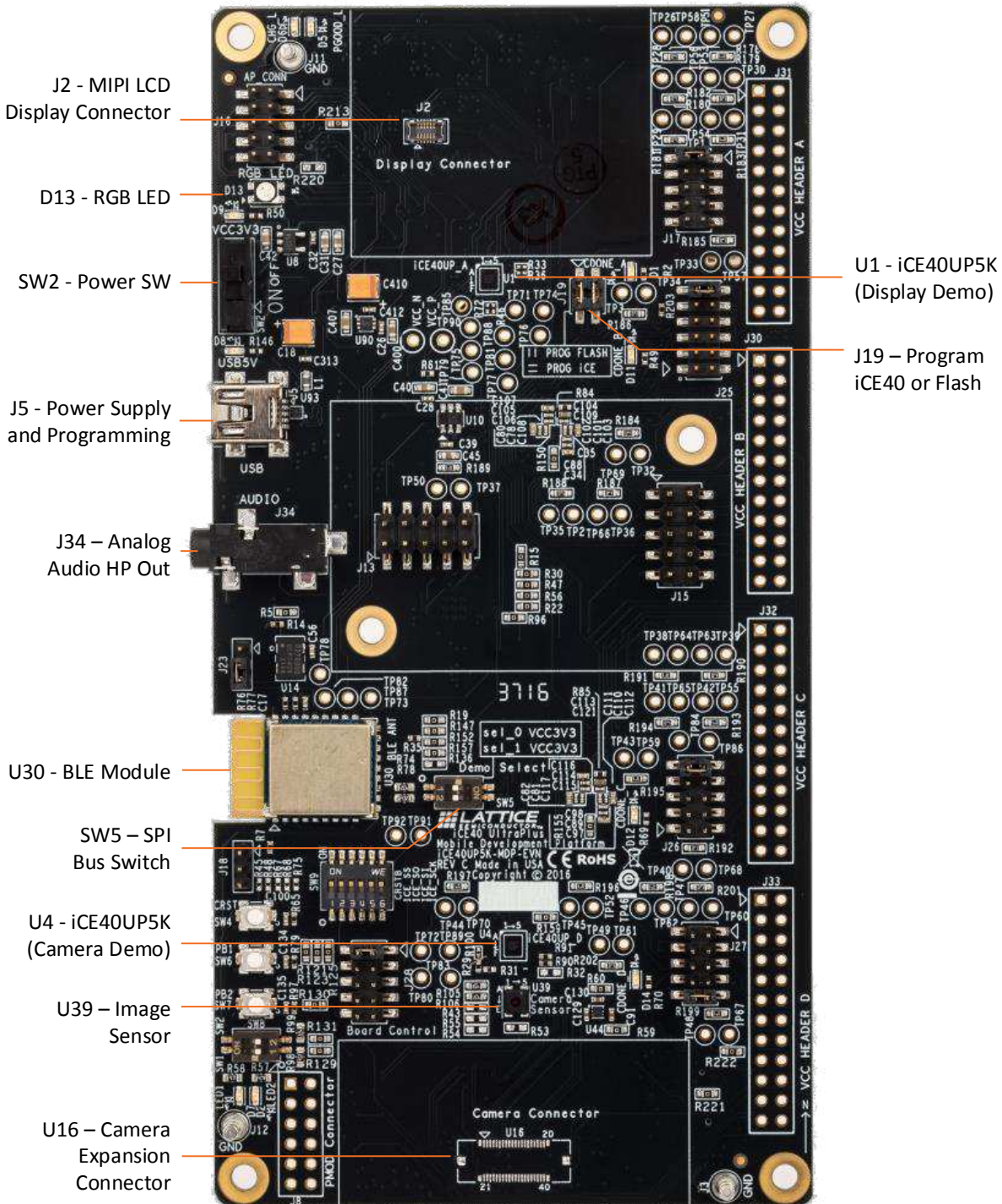


Figure 2.1. iCE40 UltraPlus Mobile Development Platform Board (Top Side)

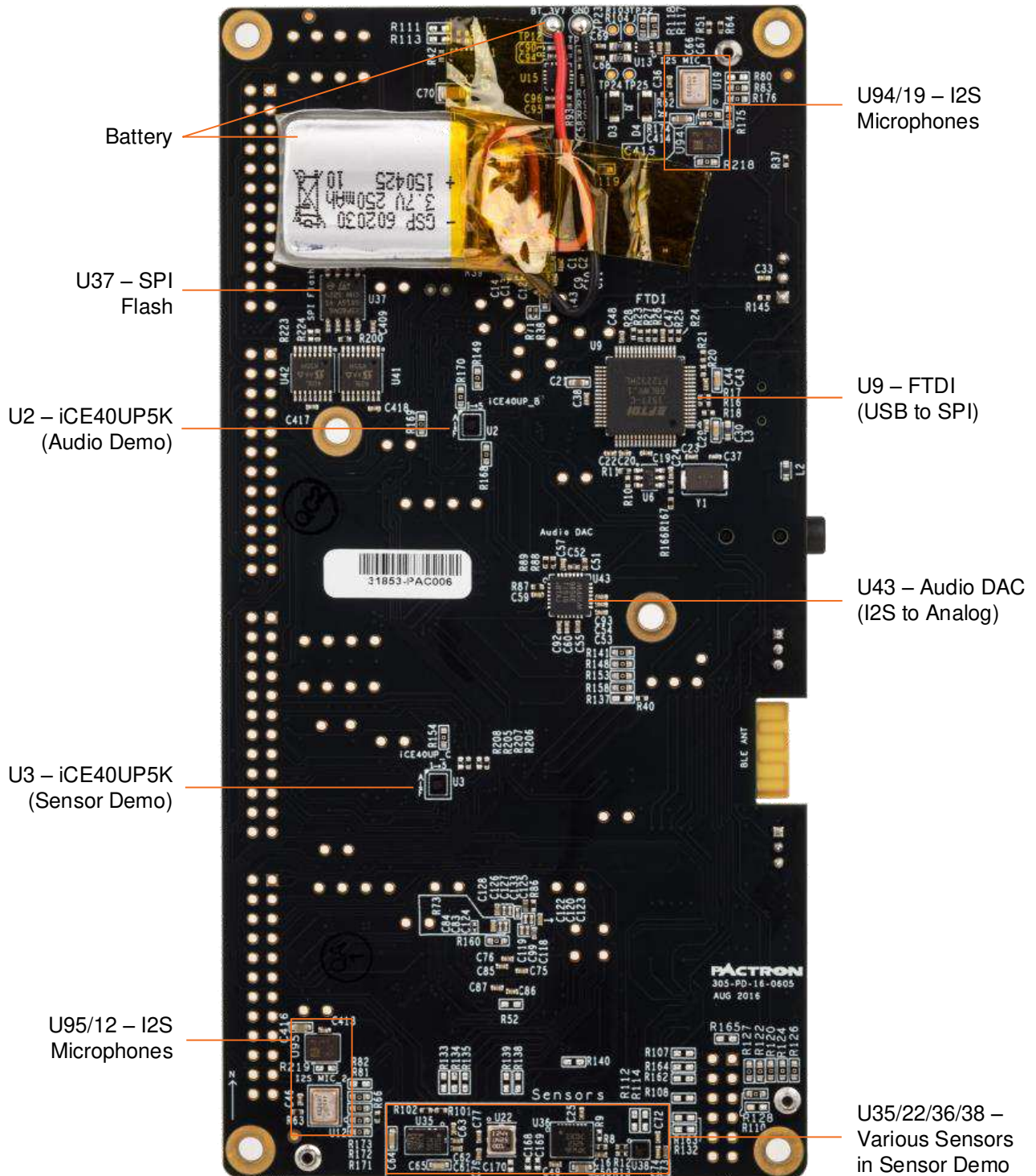


Figure 2.2. iCE40 UltraPlus Mobile Development Platform Board (Bottom Side)

3. Power and Battery

3.1. Power Source

The MDP board can be powered by three sources:

- External USB Connector J5 (5 V). Green LED D8 and Yellow LED D5 lights up when power is supplied.
- External AP Header Connector J16-8 (5 V) and J16-9 (GND). Yellow LED D5 lights up when power is supplied.
- Internal 250 mA Li-ion battery contained internal to the MDP case.

External power from USB connector J5 and AP header connector J16 are 'Diode-ORd'. If power is supplied to both connectors, the higher voltage powers the board. When external power is not supplied, the internal Li-ion battery contained in the case powers the board.

Power switch SW2 turns the board ON and OFF by enabling/disabling the main voltage regulator outputs of 3.3 V, 2.5 V, and 1.2 V. Green LED D9 lights up when the 3.3 V rail is active and indicates that the board is powered ON.

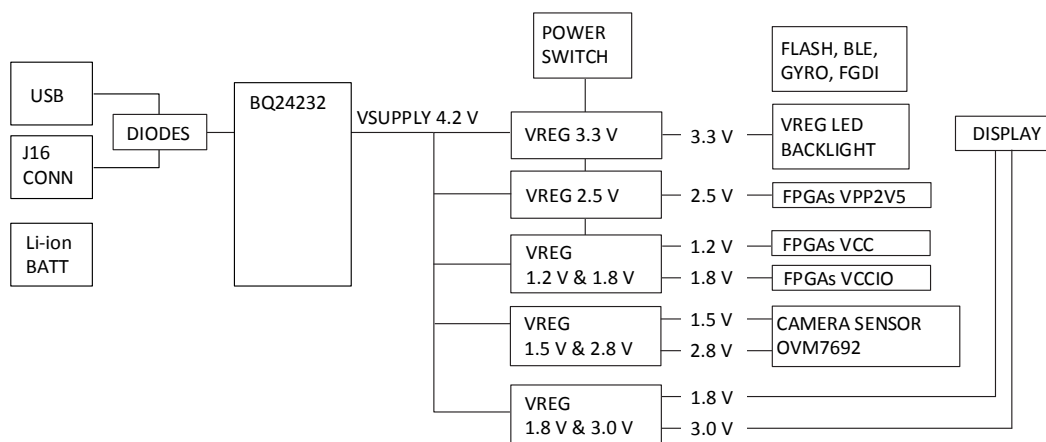


Figure 3.1. Power Block Diagram

3.2. Current Measurement Test Points

Each of the four FPGAs have six 1 Ω resistors in series with their power inputs to allow easy current measurements using a voltmeter and to ease reworking VCCIO voltage rails. See [Appendix A. iCE40 UltraPlus Mobile Development Board Schematics](#) for details.

3.3. Battery Management and 4.2 V Regulator

Chip BQ24232 U15 provides automatic battery management and the board's 4.2 V regulated voltage rail. The 4.2 V rail (VSUPPLY) is used to generate all of the board's other voltages. The management chip is always ON (not controlled by power switch SW2).

When external power is not available, the management chip uses the 250 mA Li-ion battery internal to MDP case to generate the 4.2 V rail.

When external 5 V is supplied (4.6 V to 6.0 V), the battery is automatically charged as required. The Green LED D6 lights during charging and turns OFF when charging is complete. Additionally, external power is used to generate the 4.2 V rail. The BQ24232 battery charging is configured with external resistors.

Default resistor configuration:

- 500 mA input current limit
- 200 mA charging current
- 25 mA end of charging termination current threshold
- 5-hour fast charge time and 30-minute pre-charge

4. Clock Sources

A 27 MHz oscillator is built on the Mobile Development Platform board. External clock input can also be provided to this board depending on the J23 settings.

There are six devices sharing the same clock source that are available at the same time. These include four iCE40UP5K(U1~U4) devices that are responsible for various demos, U43 which is a stereo audio DAC with direct drive headphone amplifier, and U39 which is an ultra-compact size 640 x 480 image sensor.

Short Pins 2-3 leads the onboard 27 MHz clock to these devices and provides external clock source through Pin 2 and Pin 3 (GND).

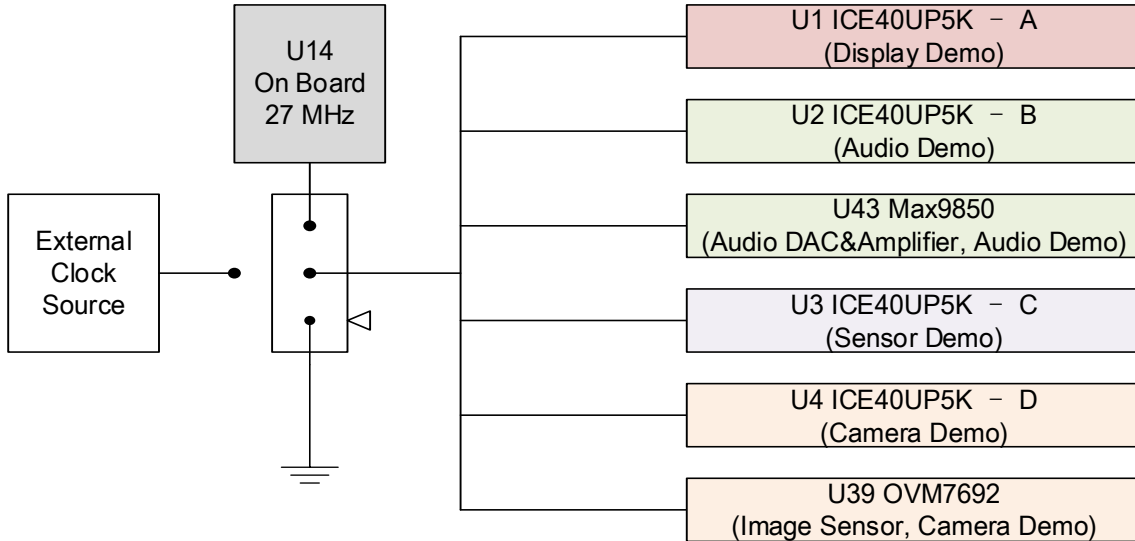


Figure 4.1. Clock Sources for the iCE40 UltraPlus MDP Board

5. Software Requirements

Install the following software before you begin developing designs for the board:

- Lattice iCEcube2 2017.01 (or higher)
Used for developing your own custom designs for the iCE40 UltraPlus FPGA.
- Diamond Programmer® 3. 8 (or higher)
Used to program the iCE40 UltraPlus FPGA.

These software programs are available at the www.latticesemi.com/software. Make sure you log in to www.latticesemi.com, otherwise these software downloads will not be visible.

6. Demonstrations

Four iCE40UP5K-30WLCSP (U1-U4) devices are used on the Mobile Development Platform board. The devices are responsible for specific demonstrations. Lattice provides separate user guides that describe each demo in detail. The documents cover board configuration and step-by-step instructions. Please refer to the relevant documents for more details.

The following sections describe the Mobile Development Platform board demos.

6.1. Mobile Display Demonstration on U1

This demo showcases the ability of iCE40 UltraPlus to drive a small wearable display and buffer one full image frame.

Key components for this demo include:

- U1 iCE40UP5K-30WLCSP
- J2 Display connector for MIPI LCD display (MIPI LCD Display, 1.4" LH154Q01 is included in the kit.)
- U11 Display backlight driver
- U13 1.8 V and 3.0 V voltage regulator

Note: Be careful with the LCD display ribbon, it is fragile and can be damaged!

6.2. Audio Microphone Demonstrations on U2

FPGA U2 is optimized for microphone related demonstrations, such as audio beam. The board contains two I2S microphones, two PDM microphones, a 3.5 mm audio jack driven by a MAX9850 headphone audio amplifier, and an expansion connector allowing up to seven microphones used in an array. This demo shows the capability of picking up human voice and driving the output on the speaker with the same quality, irrespective of where the voice is originating from within a room.

Key components for this demo include:

- U2 iCE40UP5K-30WLCSP
- U12/U19 I2S omnidirectional microphone with Bottom Port and Analog Output
- U94/U95 PDM omnidirectional microphone with Bottom Port and Analog Output
- U43 Audio DAC with headphone amplifier.
- J34 3.5 mm audio jack for analog output
- J15 Expansion connector supporting up to seven microphones.
- J25 Header used to configure FPGA to microphone connections

6.3. RGB LED Demonstration on U3

This demo showcases the capability of ICE40-UltraPlus to control and drive an RGB LED. A mobile app software GUI tool is provided to allow a user to remotely control the LED via a phone or tablet over Bluetooth. The features of the demo include:

- Ability to control the color of the LED from a color palette.
- Ability to control the brightness of the LED.
- Ability to control the ON/OFF time of the LED – thereby creating a pulsating breathing effect.

Key components for this demo include:

- U3 iCE40UP5K-30WLCSP
- D13 RGB LED
- U30 Bluetooth Module used for remote control

It is recommended to download the RGB LED software GUI which interfaces with the MDP. 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/ice40ultraplusmdp.

6.4. Sensor Demonstrations on U3

This demo showcases the capability of iCE40 UltraPlus to act as a sensor hub.

Key components for this demo include:

- U3 iCE40UP5K-30WLCSP.
- U22 Digital barometric pressure sensor
- U35 High performance e-compass 3D accelerometer and 3D magnetometer
- U36 3D accelerometer and 3D gyroscope
- U38 3-axis "pico" accelerometer

6.5. Face Recognition Demonstration on U4

This demo showcases the capability of ICE40-UltraPlus to detect and react to a general human face.

Key components for this demo include:

- U4 iCE40UP5K-30WLCSP.
- U39 Image Sensor OVM7692.
- U16 Camera Expansion Connector.
- U44 1.5 V and 2.8 V voltage regulator.

This demo uses the VGA (640 x 480) sensor OVM7692 U39 or the camera expansion connector U16. The default interface uses CSI2, however, the interface can be configured for 3.3 V parallel video interface to support the facial recognition demo with the following rework:

1. Remove resistors: R15, R29, R30, R47, R73, R90, R91, R100, R125, R126, R127, R142, R143, R149, R150, R154, R155.
2. Install 0 Ω resistors (or short with solder blob): R31, R32, R43, R52, R53, R54, R55, R56.
3. Verify resistors installed: R22, R159, R160.
4. If using Xtal U14 as clock source Jumper J23-2 and 3 else J23-2 should be open.

Figure 6.1 shows the resistors of the rework. Resistors highlighted in red rectangle need to be removed; resistors highlighted in green rectangle need to install 0 Ω resistors; blue highlights show the resistors needing installation verification.

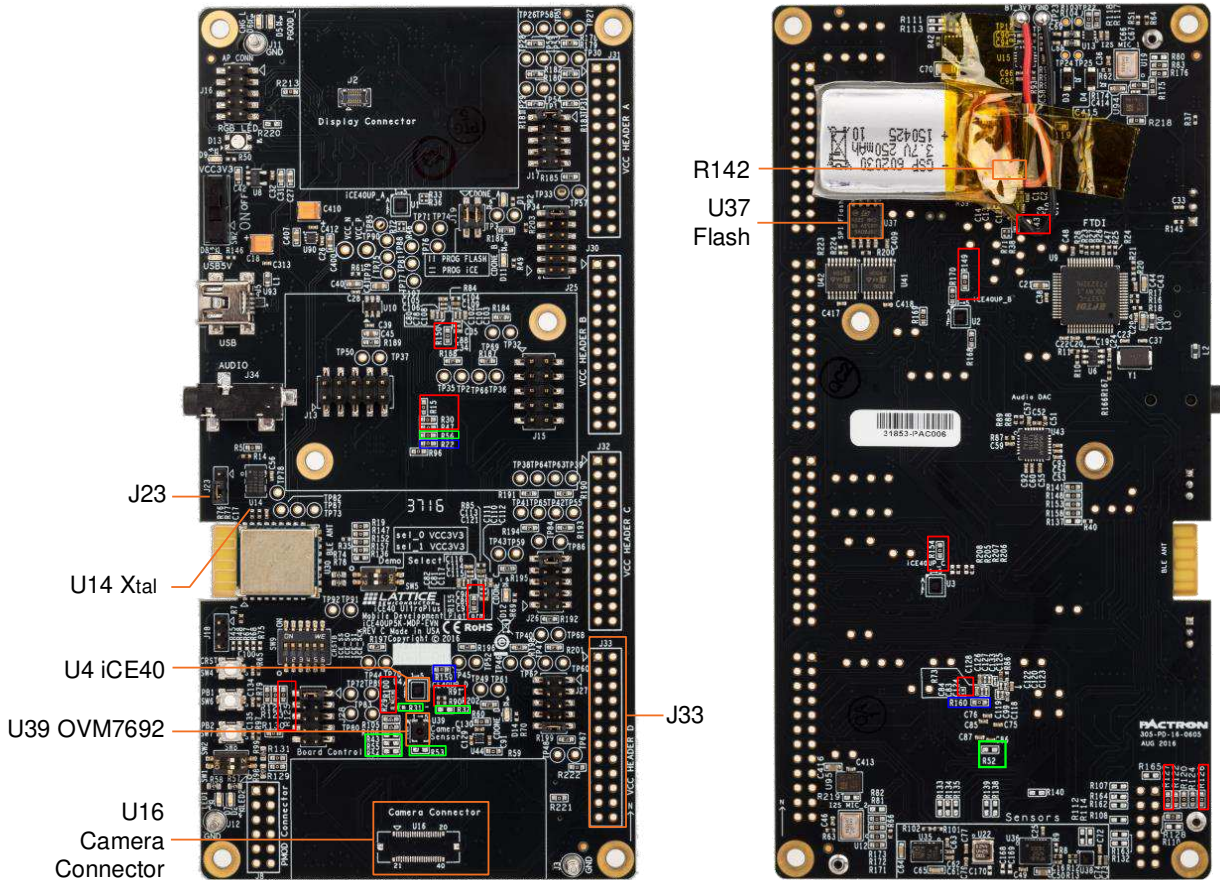


Figure 6.1. Rework Resistor Positions Described in Parallel Video Bus Configuration

7. Board Configuration and Programming

The iCE40 UltraPlus Mobile Development Board has four iCE40 devices. Each device serves specific demo purposes. As there is only one USB to SPI bridge chip used onboard, programming different iCE40 devices can be completed using combinations of jumper and switch settings. The installed jumpers used on the MDP board have a 2 mm pin-pitch, not the standard 100-mil style.

7.1. Jumpers and Switches

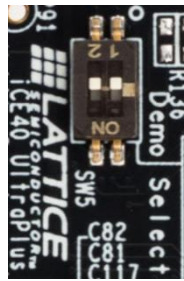
The iCE40 UltraPlus Mobile Development Board has the following jumpers:

- **J19**
Set these for either SPI Flash programming (both vertical) or SRAM (iCE40) programming (both horizontal), per the silkscreen markings on the board.
- **J17**
To program the iCE40 UltraPlus device U1, short pins 1-2. To program any other device on the board, short pins 9-10.
Note: Follow the silkscreen markings on the board, pins 1-2 are at the top of this header bank.
- **J25**
To program the iCE40 UltraPlus device U2, short pins 1-2. To program any other device on the board, short pins 11-12.
Note: Follow the silkscreen markings on the board, pins 1-2 are at the bottom of this header bank.
- **J26**
To program the iCE40 UltraPlus device U3, short pins 1-2. To program any other device on the board, short pins 9-10.
Note: Follow the silkscreen markings on the board, pins 1-2 are at the bottom of this header bank.
- **J27**
To program the iCE40 UltraPlus device U4, short pins 1-2. To program any other device on the board, short pins 9-10.
Note: Follow the silkscreen markings on the board, pins 1-2 are at the top of this header bank.
- **J28**
If you are doing SPI Flash programming, short pins 1-2. Otherwise, leave all pins open.

The iCE40 UltraPlus Mobile Development Board has the following switches:

- **SW5**
This selects the target iCE40 UltraPlus device. Refer to [Table 7.1](#) to select the correct device.

Table 7.1. iCE40 UltraPlus Device Selection

iCE40 UltraPlus FPGA	Key Supported Features	SW5 (2,1)	Reference Image
U1	Display frame buffer: 240x240 display 18-bit color (R6,G6,B6), MIPI DSI interface	OFF, OFF	
U2	On-board stereo microphones (I2S and PDM): 7-microphone expansion connector, headphone amp, audio output jack	OFF, ON	
U3	Sensors: RGB LED, Pressure Sensor, Gyroscope, Accelerometer, Compass	ON, OFF	
U4	640x480 VGA Camera, MIPI CSI interface, expansion connector utilizing single MIPI data lane	ON, ON	

Use the marking on switch to determine SW5-1 and SW5-2 orientations, including the 'ON' direction.

- SW9**
 This switch is used to add/remove the BLE module from the SPI bus. It is recommended that the BLE module be removed from the SPI bus when the module is not in demo use.

Figure 7.1 shows the setting of jumpers and switches while trying to program ICE40 device “U1” directly.

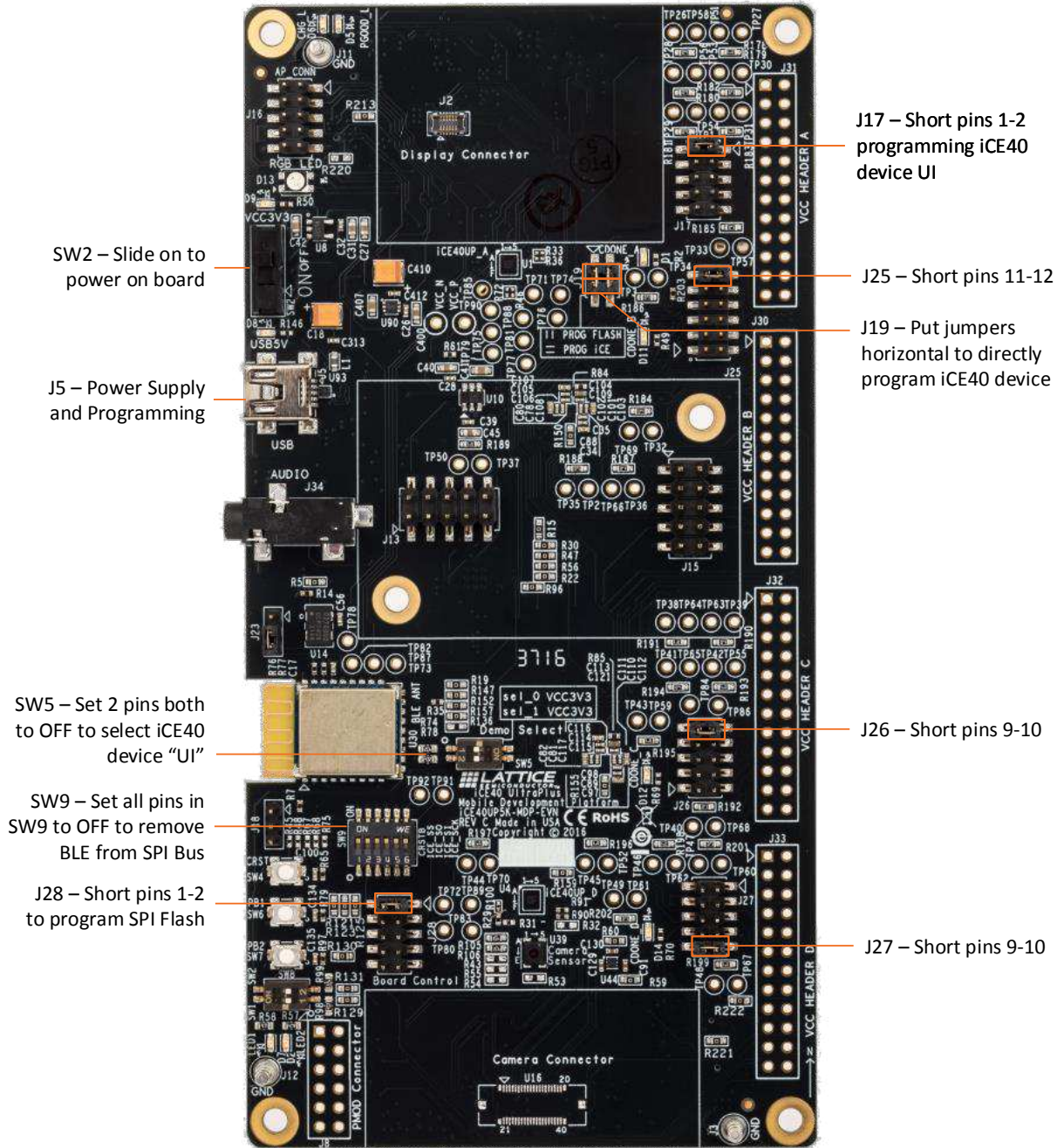


Figure 7.1. Board Configuration for Programming ICE40 UltraPlus Device “UI”

Table 7.2. iCE40 UltraPlus Device Selection Summary

		SPI Flash Demux	CRESET Boot Control Jumper Placement			
Section	iCE40 UltraPlus RefDes	SW5 (2,1)	J17	J25	J26	J27
Camera	U1	OFF,OFF	1-2	11-12	9-10	9-10
Audio	U2	OFF, ON	9-10	1-2	9-10	9-10
Sensor/RGB	U3	ON, OFF	9-10	11-12	1-2	9-10
Display	U4	ON, ON	9-10	11-12	9-10	1-2

7.2. Programming the iCE40 Devices Configuration Memory (CRAM)

To program iCE40 UltraPlus devices' CRAM in Diamond Programmer:

1. Set board jumpers on J19 horizontally for CRAM programming.
2. Remove board jumper J28: 1-2 for CRAM programming.
3. Use Diamond Programmer 3.8 or later.
4. Connect the iCE40 UltraPlus Mobile Development Platform board via the USB cable to a PC or MAC.
5. Start Diamond Programmer.
6. Set **Device Family** to "iCE40 UltraPlus" and **Device** to "iCE40UP5K". Refer [Figure 7.2](#) below.
7. Be sure to perform the "Program, Verify" operation. If you select only the "Program" operation, you may get a false positive that the device has programmed.
8. Field **Programming Speed Settings** should be set to "Use customer Clock Divider" and appropriate value "5" should be set in the text box below.
9. Open the Device Properties dialog. Apply the settings highlighted.
10. **Access mode:** set to "CRAM programming" to allow directly programming iCE40 devices.
11. **Operation:** set to "Fast Program" mode.
12. **Programming File:** load bit stream file for demo.
13. Click **OK** to exit Device Properties dialog.
14. Click the **Program** button in Diamond Programmer to download the bit stream file.

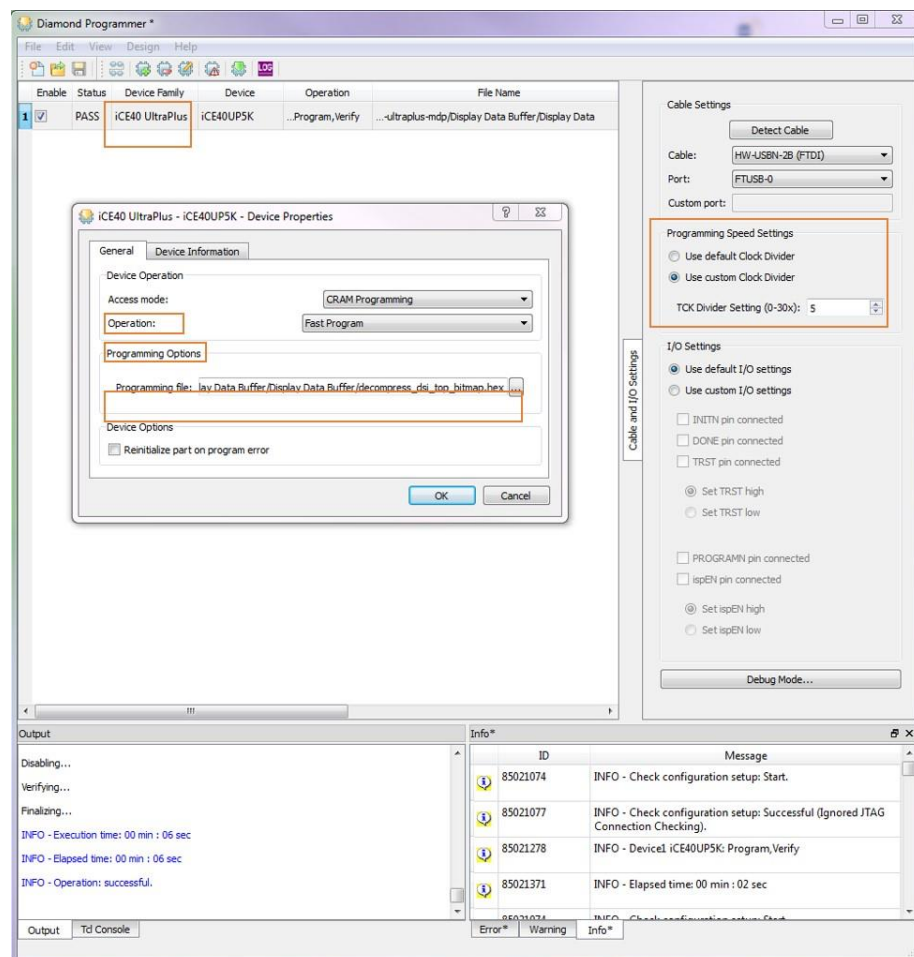


Figure 7.2. Programming iCE40 Devices on Board

7.3. Programming Onboard SPI Flash

To program SPI flash in Diamond Programmer:

1. Set board jumpers on J19 vertically for SPI Flash programming.
2. Install board jumper J28: 1-2 for SPI Flash programming.
3. Start Diamond Programmer.
4. Set Device Family to “iCE40 UltraPlus” and Device to “iCE40UP5K”.
5. Be sure to do the “Program, Verify” operation. If you select only the “Program” operation, you may get a false positive that the device has programmed.
6. Field Programming Speed Settings should be set to “Use customer Clock Divider” and appropriate value “5” should be set in the text box below.
7. Open the Device Properties dialog. Apply the settings highlighted.
 - Access mode:** set to “SPI Flash Programming”.
 - Operation:** set to “SPI Flash Erase, Program, Verify” mode.
 - Programming File:** load bit stream file for demo.
 - SPI Flash Options:** select correct Flash chip as shown in [Figure 7.3](#) blow.
 - Load from File** button should be used to refresh fields such as “Data file size” and “End address(Hex)”.
8. Click **OK** to exit Device Properties dialog.
9. Click the **Program** button in Diamond Programmer to download the bit stream file.

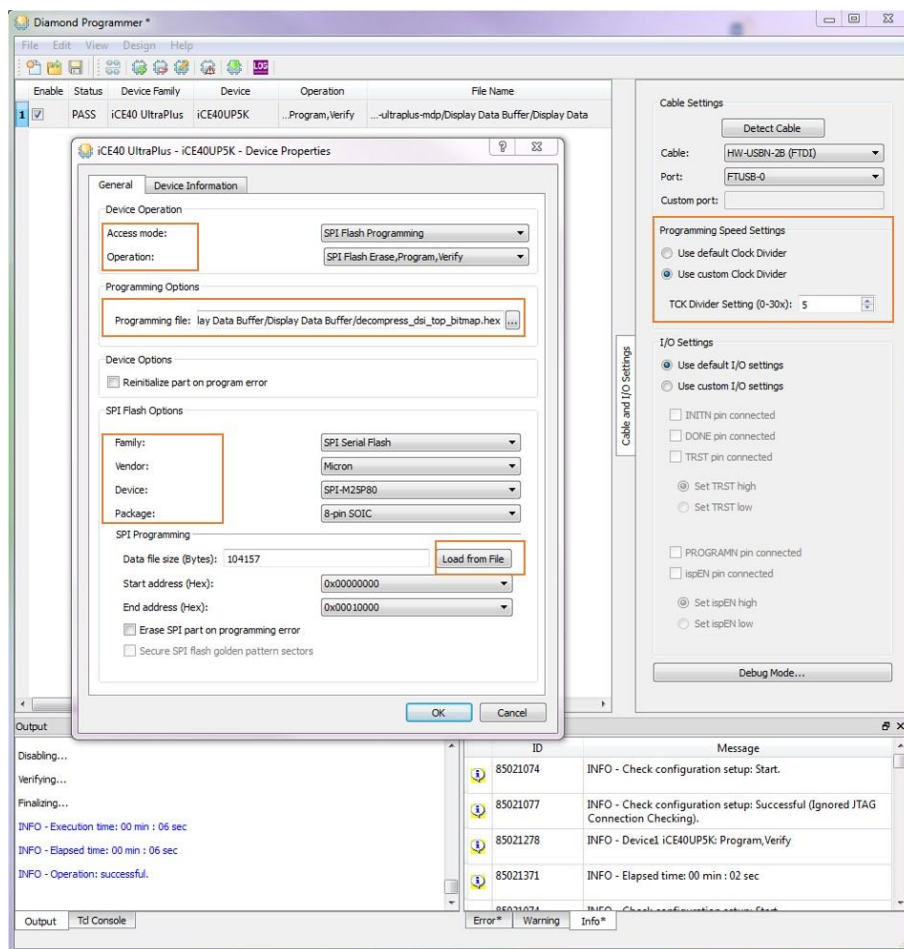


Figure 7.3. Programming SPI Flash on Board

The main differences between programming ICE40 UltraPlus devices and programming SPI Flash are:

1. Board jumpers on J19: Vertical for CRAM programming and horizontal for SPI Flash programming.
2. Board jumpers J28: 1-2: Remove for CRAM programming and install for SPI Flash programming.
3. The settings in the Device Properties dialog box in Diamond Programmer.

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

8. Communication Channels

To enable communication with external tools, devices or Apps on Smart phone, this board features a number of communication channels.

8.1. USB


A USB cable from PC needs to be connected to J5 on board. This communication channel through U9 (FT2232H) is mainly used for programming the SPI flash on board, or program the ICE devices directly depends on settings on jumper J19.

8.2. Bluetooth

This board features a Bluetooth module U30 to enable wireless communication with external devices like smart phones, which is very useful while need to run some APPs on smart phone in demos. This Bluetooth provide UART channel to communicate with ICE40 devices on board.

The operating range of the BLE module is up to 100 meters.

9. Ordering Information

Description	Ordering Part Number	China RoHS Environment- Friendly Use Period (EFUP)
ICE40 UltraPlus Mobile Development Platform	ICE40UP5K-MDP-EVN	

10. PCB Revision History

PCB Revision	Notes
Rev A, Rev B	Prototype revisions, unreleased
Rev C	Production revision Includes two wires added during assembly to connect the UART of the FT2232HL to test points. Specifically, these are U9-38 to J33-1 and U9-39 to J33-3.
Rev D	Production revision Implements the wires from Rev C as PCB traces. Rev C and Rev D schematics are identical.

References

Standards Documents

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

Abbreviation	Standards Publication, Organization, and Date
MIPI	<i>MIPI Alliance, Mobile Industry Processor Interface</i>
CSI2	<i>MIPI Alliance, Camera Serial Interface</i>

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
MIPI Alliance	http://www.mipi.org

Lattice Semiconductor Documents

Related documents available from your Lattice Semiconductor sales representative are listed on the table below.

Document	Title
Data Sheet DS1056	<i>iCE40 UltraPlus Family Data Sheet</i>

Technical Support Assistance

Submit a technical support case through www.latticesemi.com/techsupport.

Appendix A. iCE40 UltraPlus Mobile Development Board Schematics

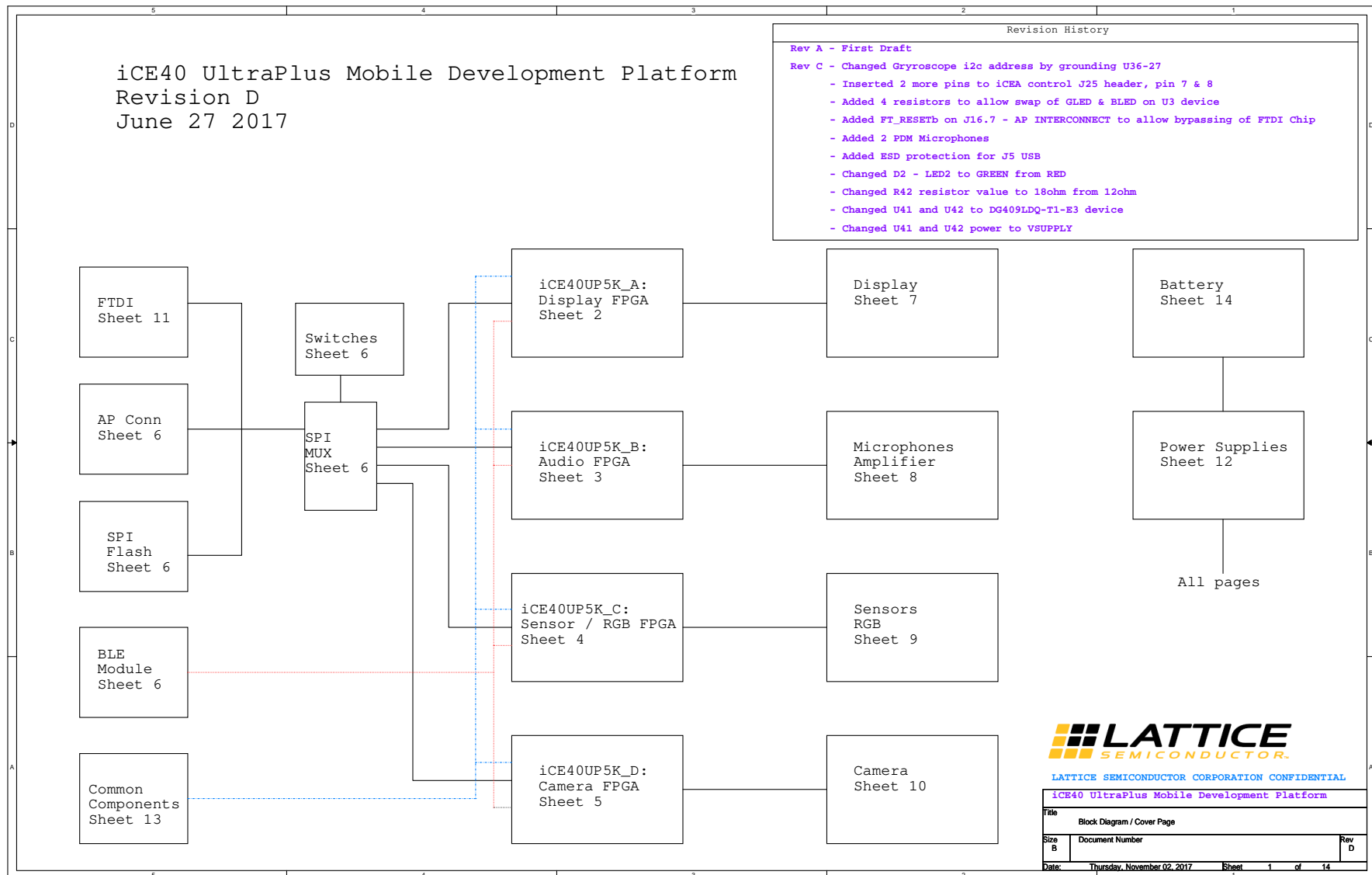


Figure A.1. Block Diagram

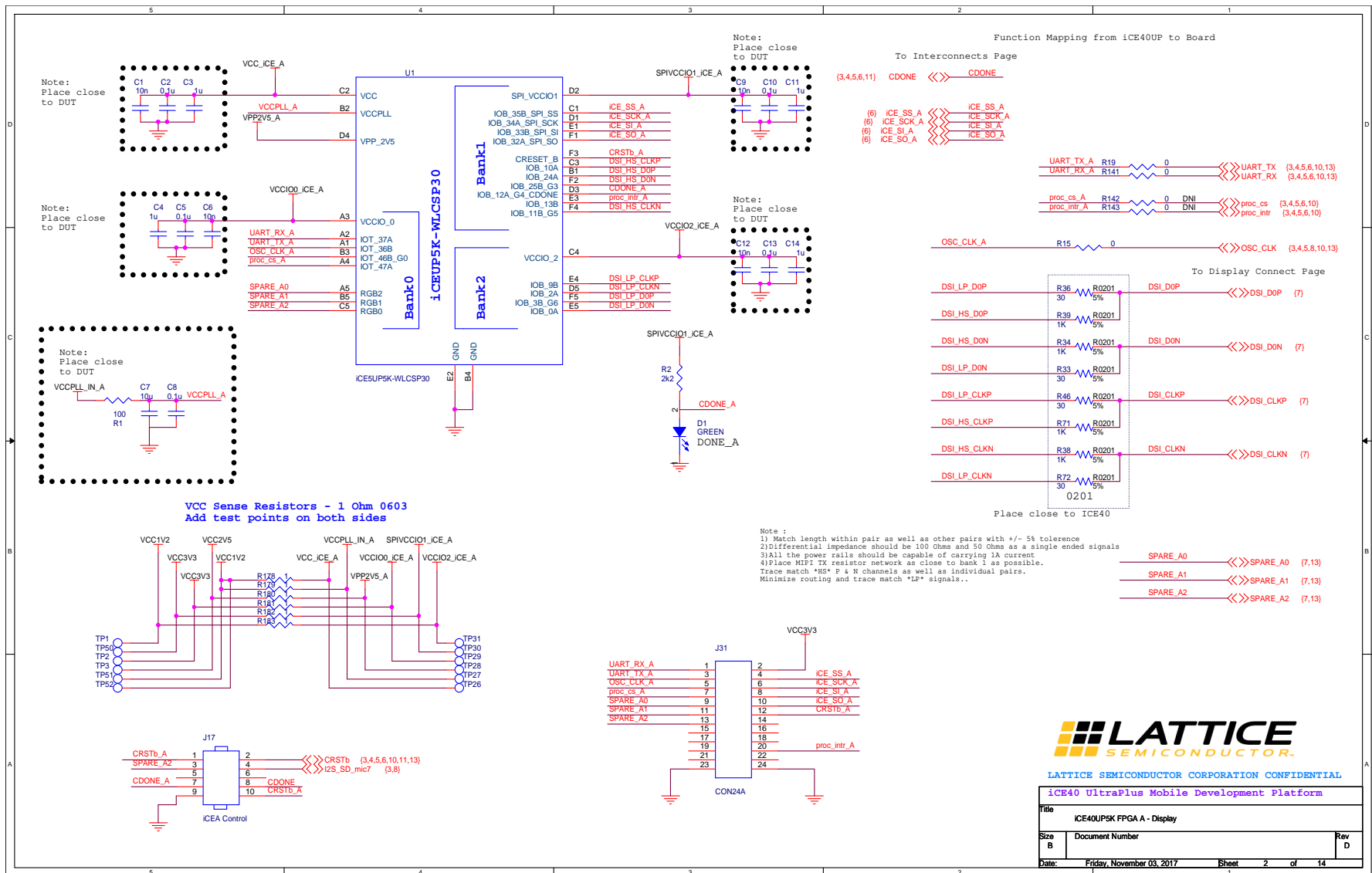


Figure A.2. ICE40UP5K FPGA A - Display

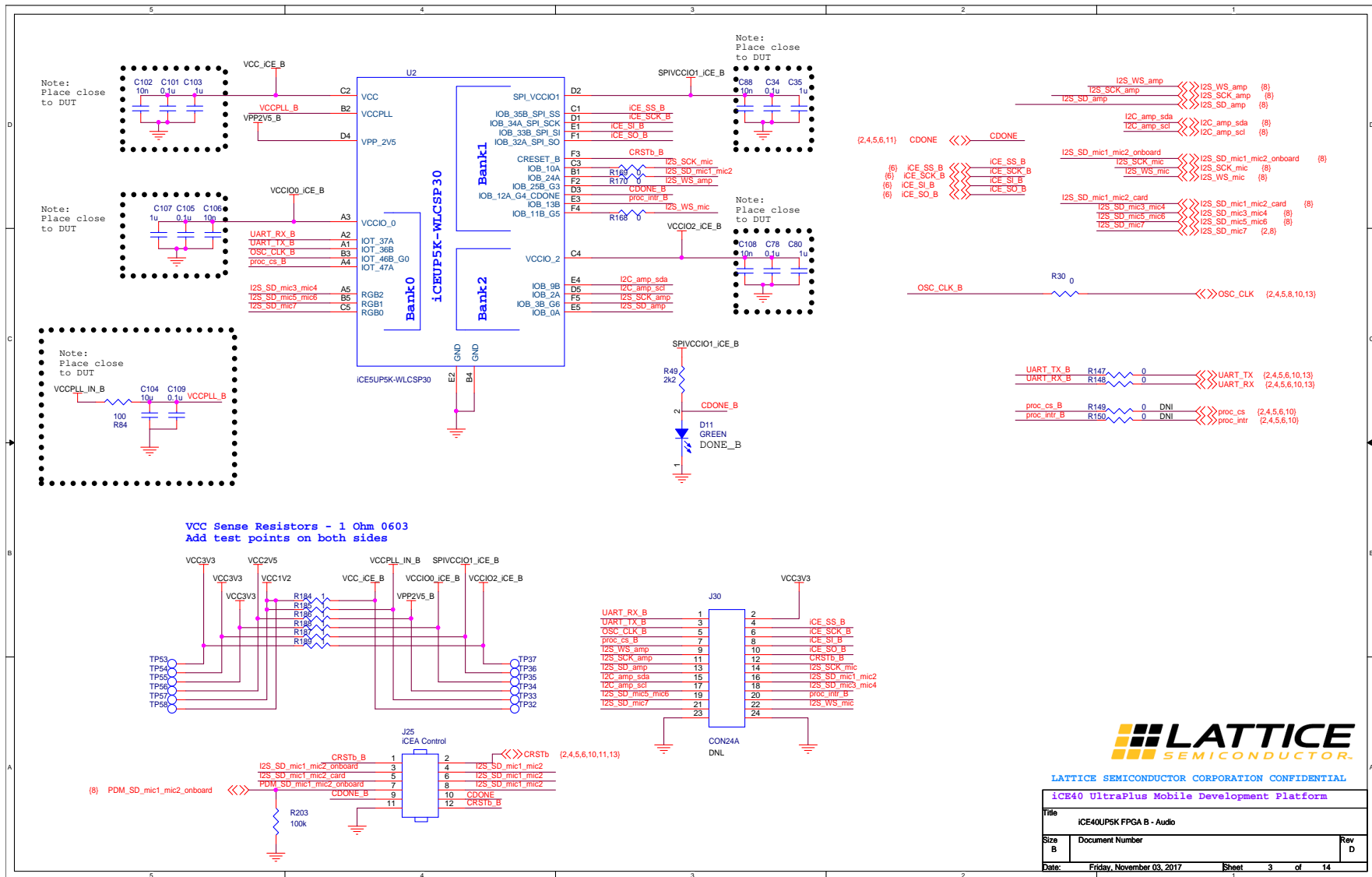


Figure A.3. iCE40UP5K FPGA B - Audio

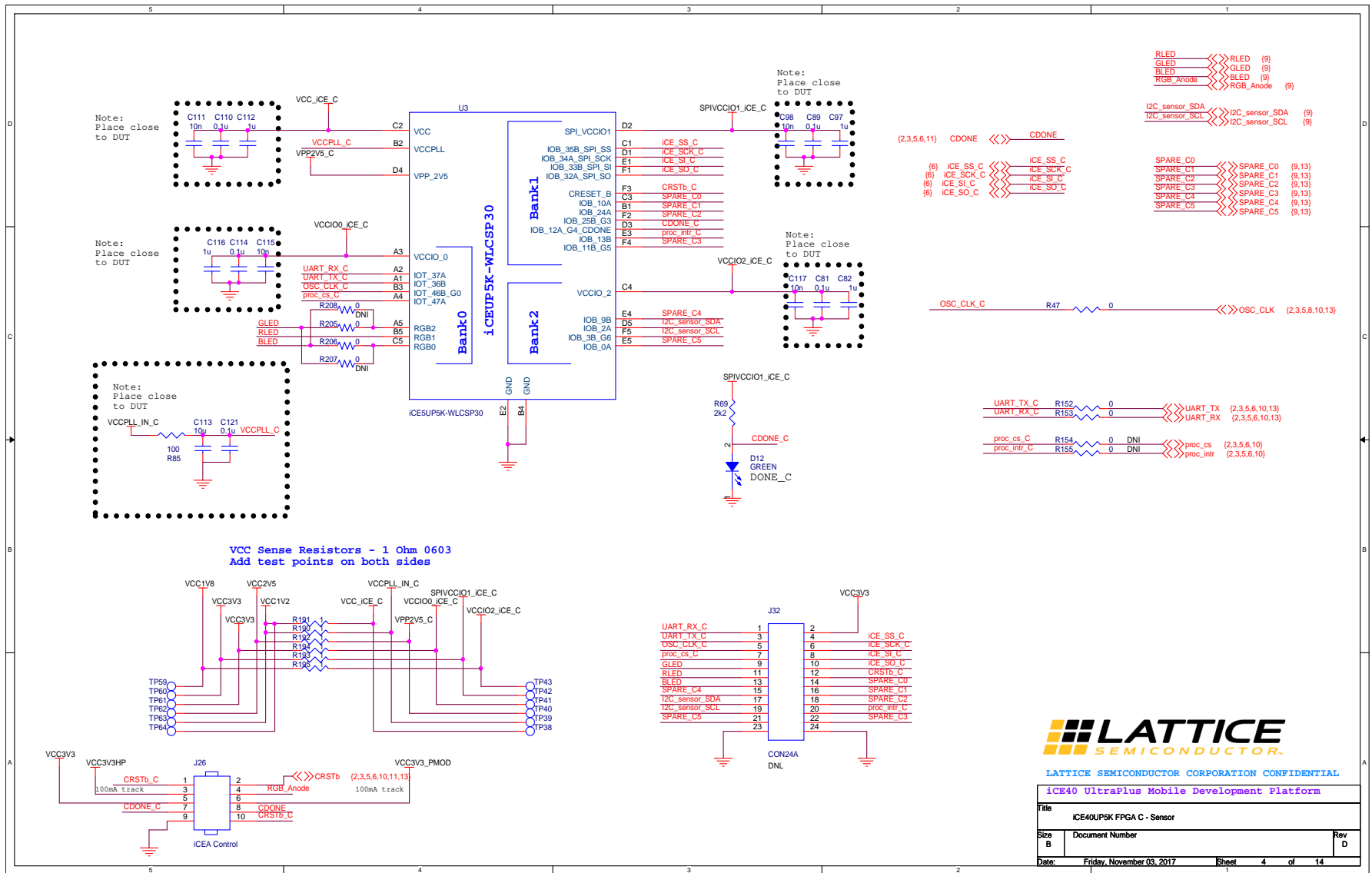


Figure A.4. ICE40UP5K FPGA C - Sensor