



# **iCE40 UltraPlus Mobile Development Platform**

## **Evaluation Board User Guide**

FPGA-EB-02007 Version 1.1

April 2018

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# 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.

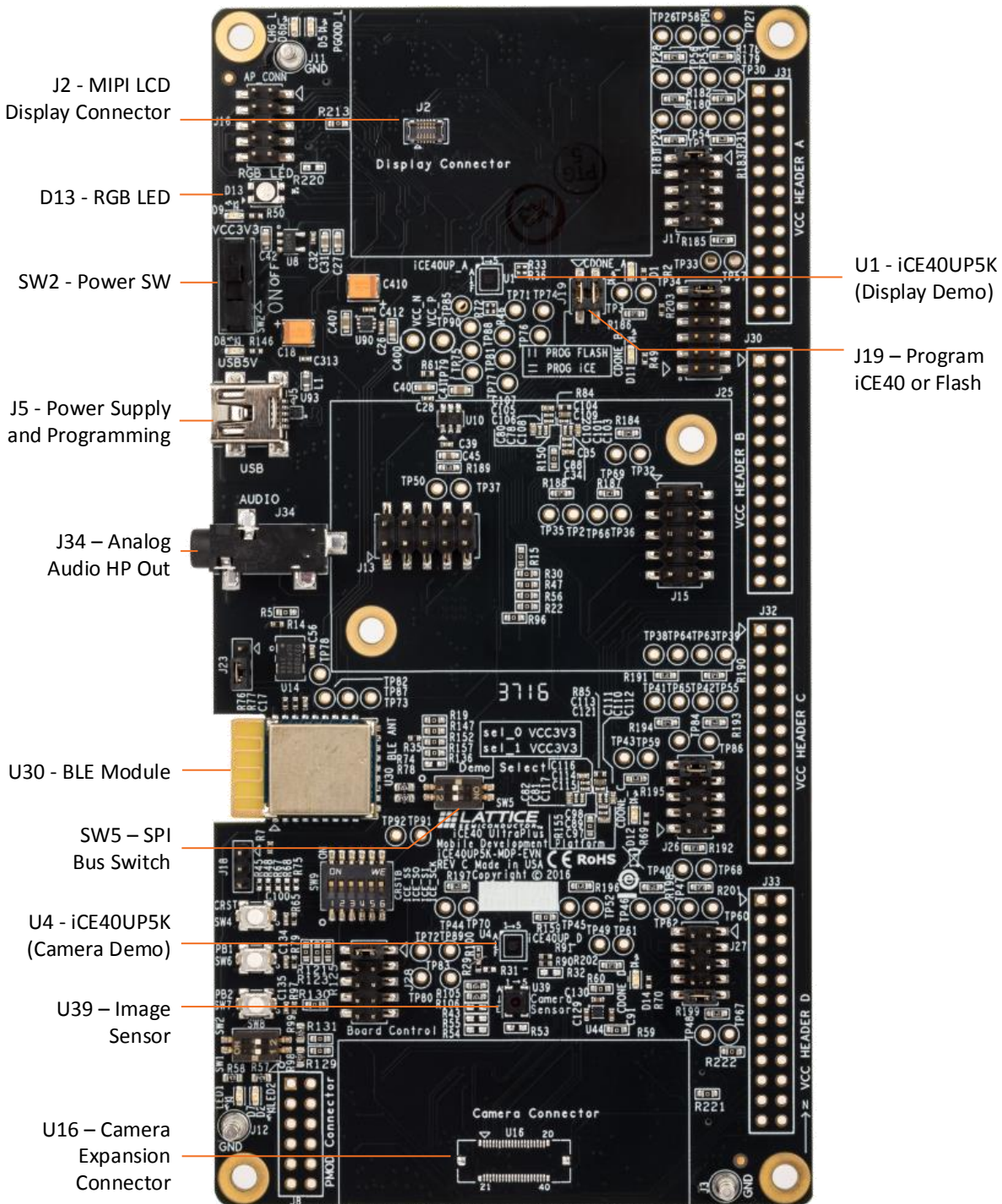


Figure 2.1. iCE40 UltraPlus Mobile Development Platform Board (Top Side)

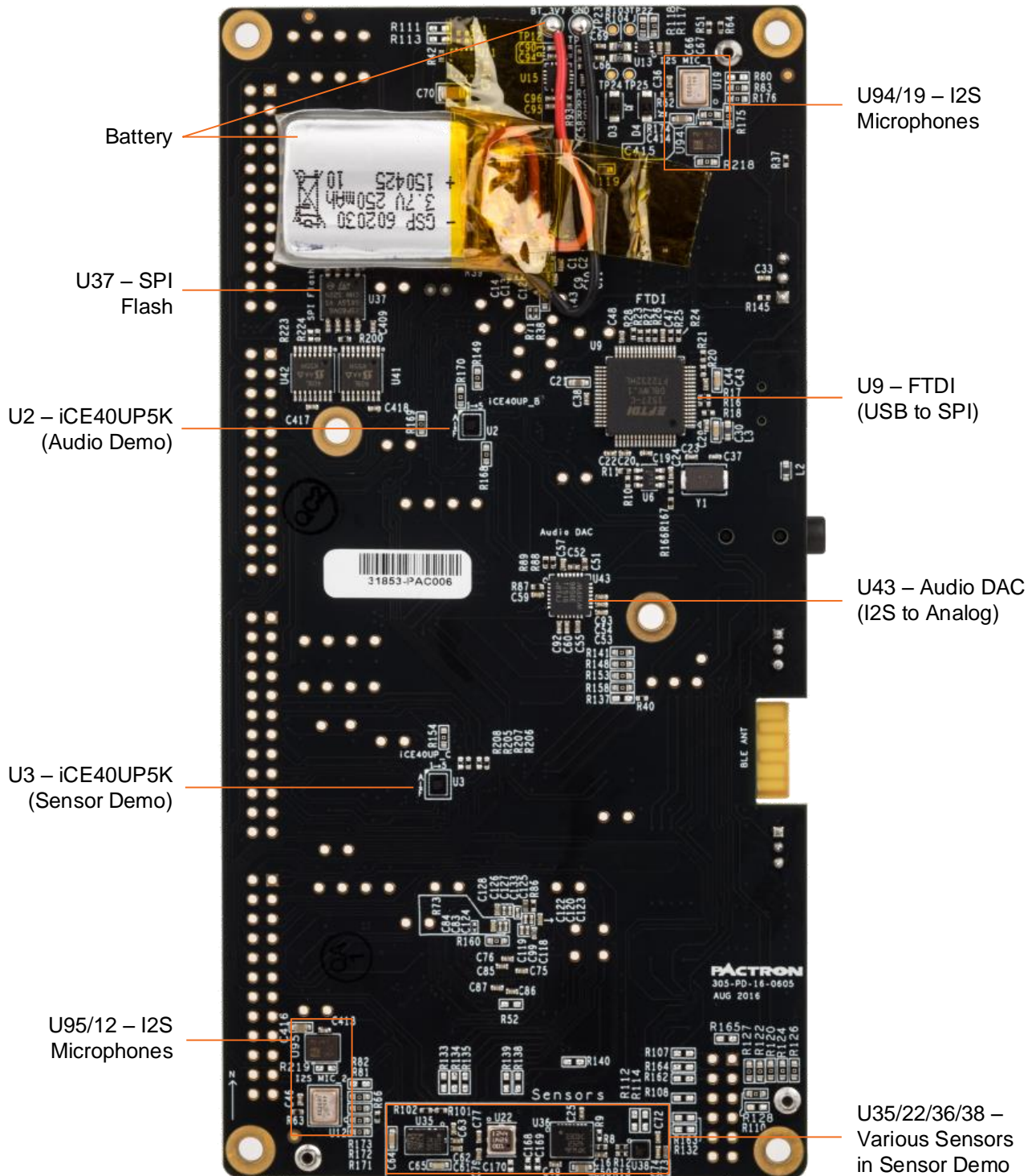


Figure 2.2. iCE40 UltraPlus Mobile Development Platform Board (Bottom Side)

## 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.

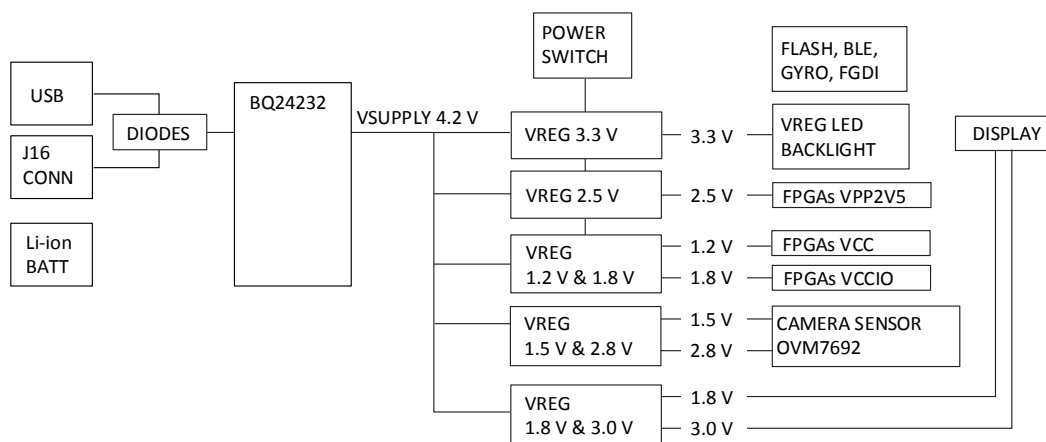


Figure 3.1. Power Block Diagram

### 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

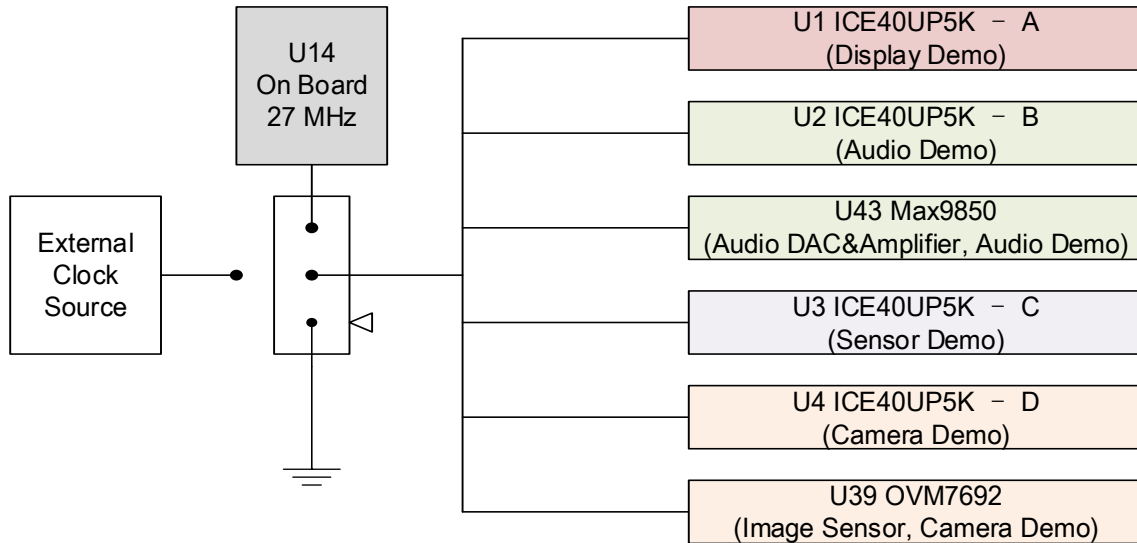


## 4. Clock Sources

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](http://www.latticesemi.com/software). Make sure you log in to [www.latticesemi.com](http://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](http://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  $\Omega$  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.

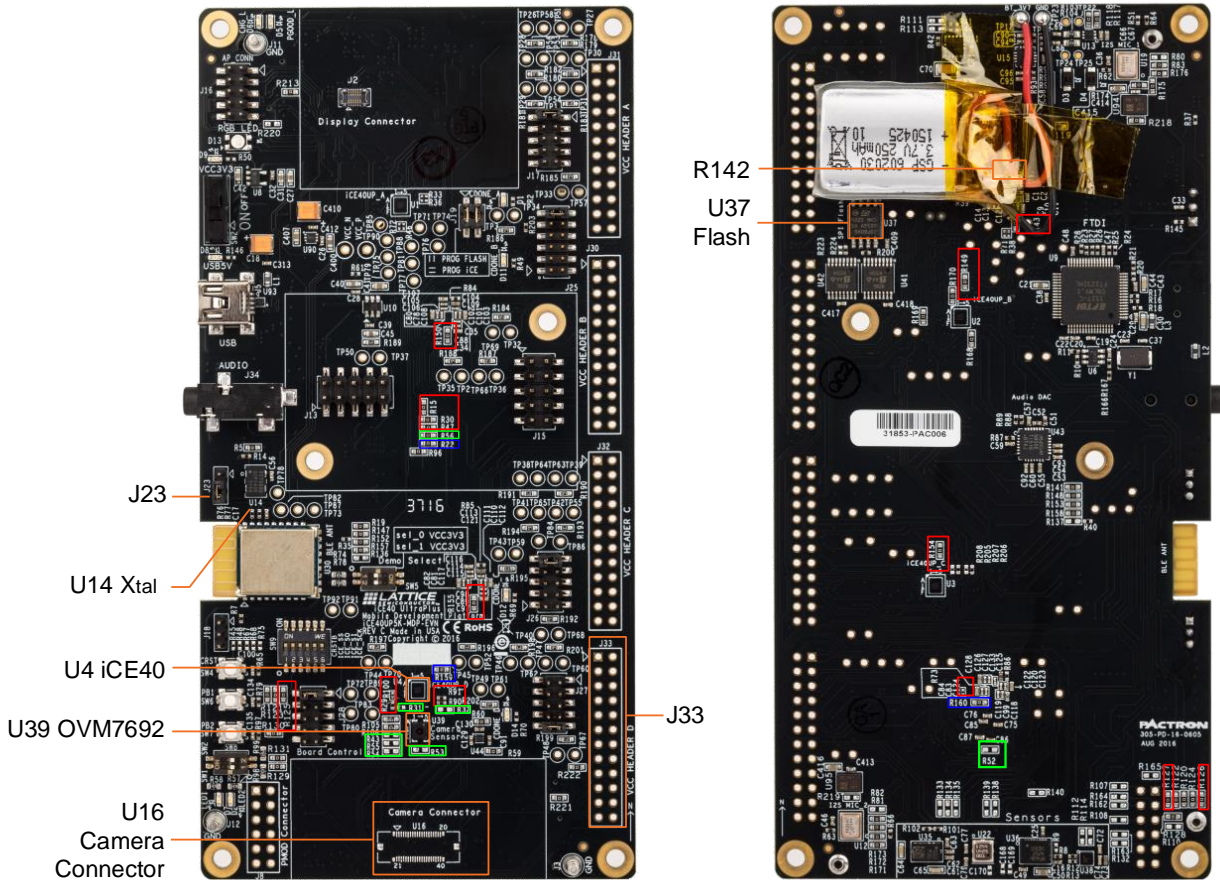


Figure 6.1. Rework Resistor Positions Described in Parallel Video Bus Configuration

## 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

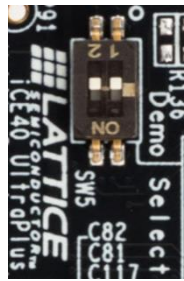
The iCE40 UltraPlus Mobile Development Board has the following jumpers:

- **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.

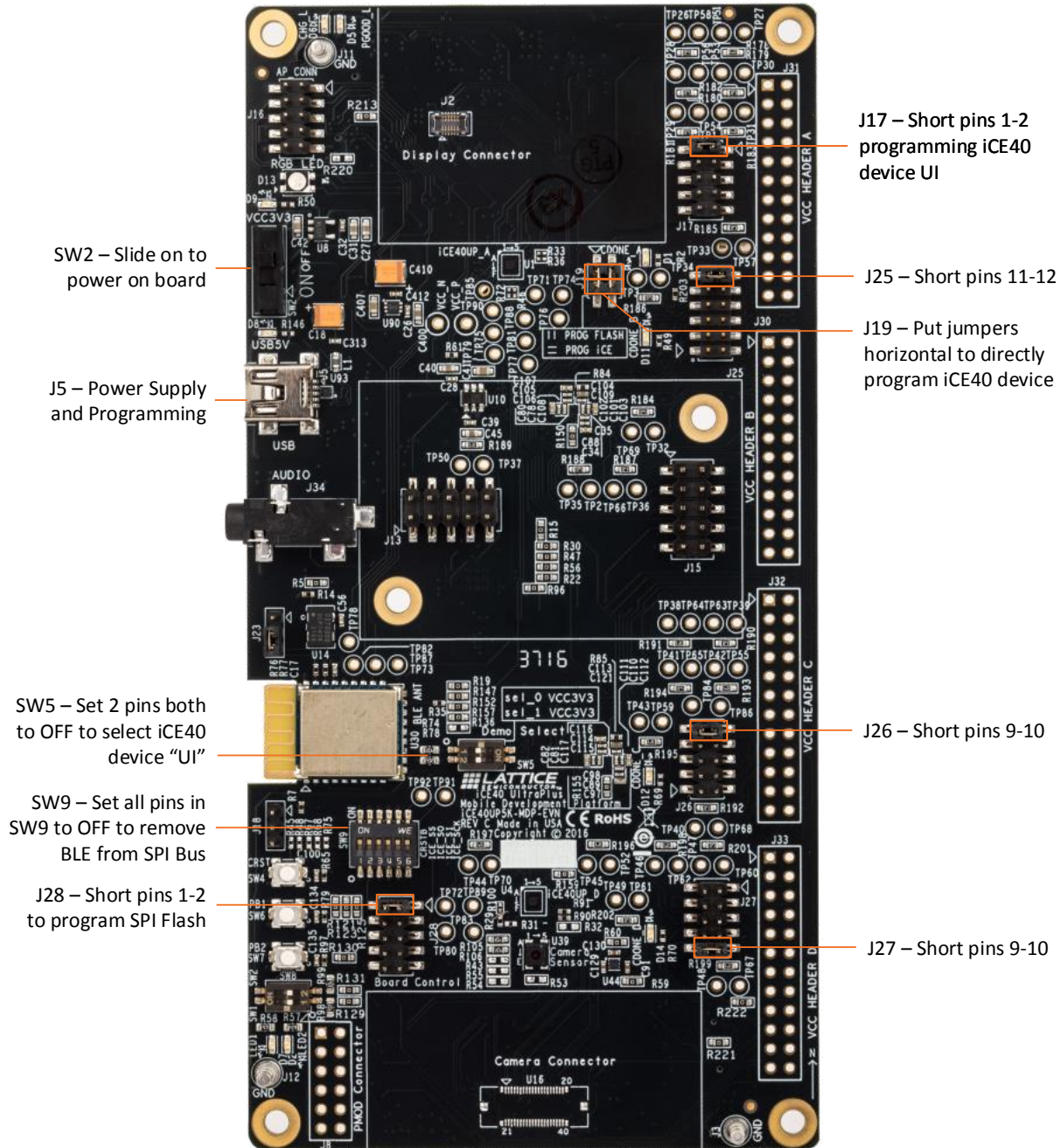


Figure 7.1. Board Configuration for Programming ICE40 UltraPlus Device “U1”

**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.

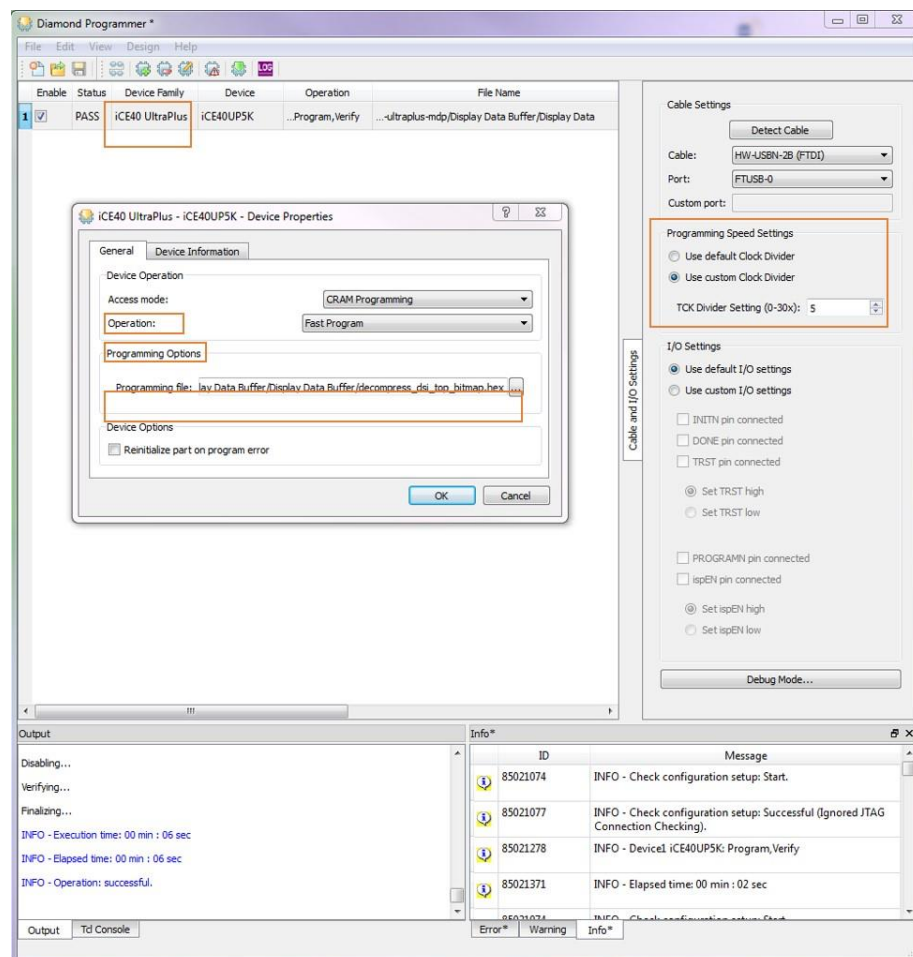


Figure 7.2. Programming iCE40 Devices on Board

### 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 custom 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”.

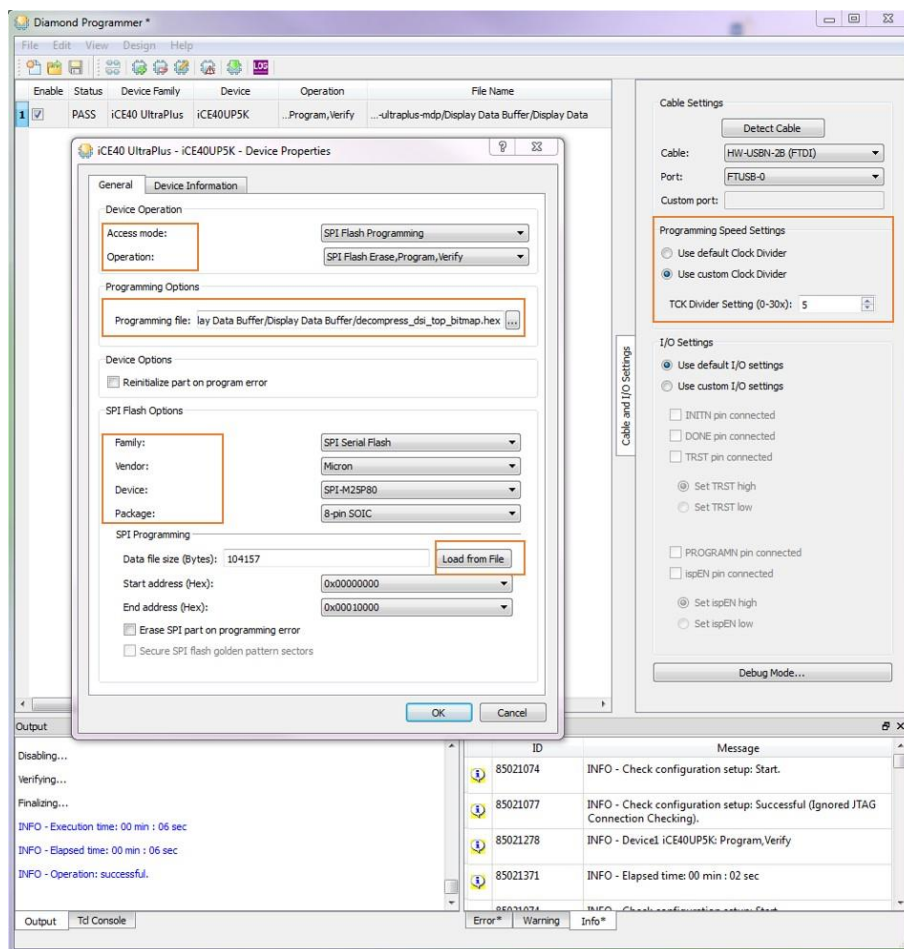
**Operation:** set to “SPI Flash Erase, Program, Verify” mode.

**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<br>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<br>Implements the wires from Rev C as PCB traces.<br>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   | <a href="http://www.mipi.org">http://www.mipi.org</a> |

### Lattice Semiconductor Documents

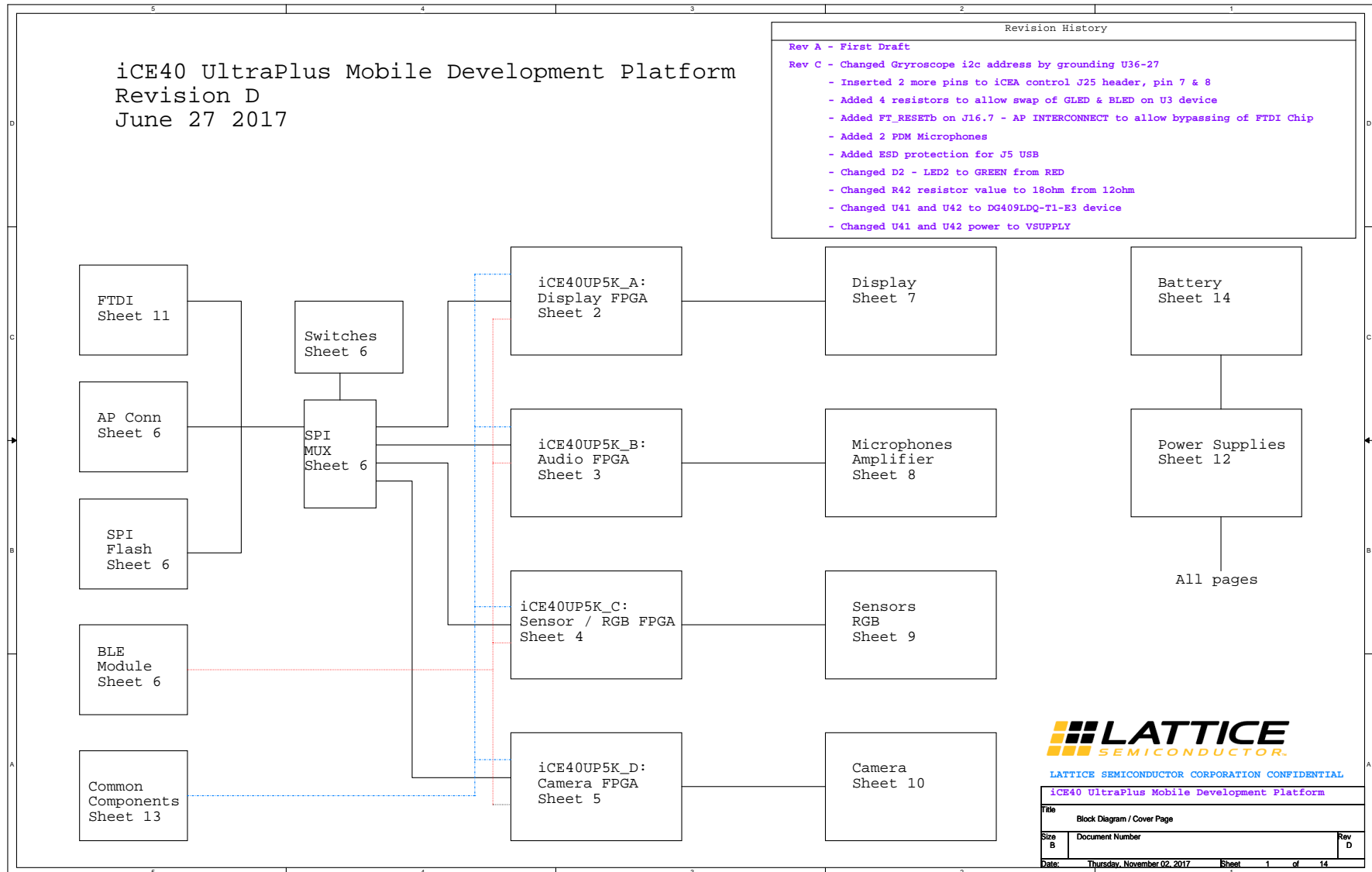
Related documents available from your Lattice Semiconductor sales representative are listed on the table below.

| 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](http://www.latticesemi.com/techsupport).

## Appendix A. iCE40 UltraPlus Mobile Development Board Schematics



**Figure A.1. Block Diagram**

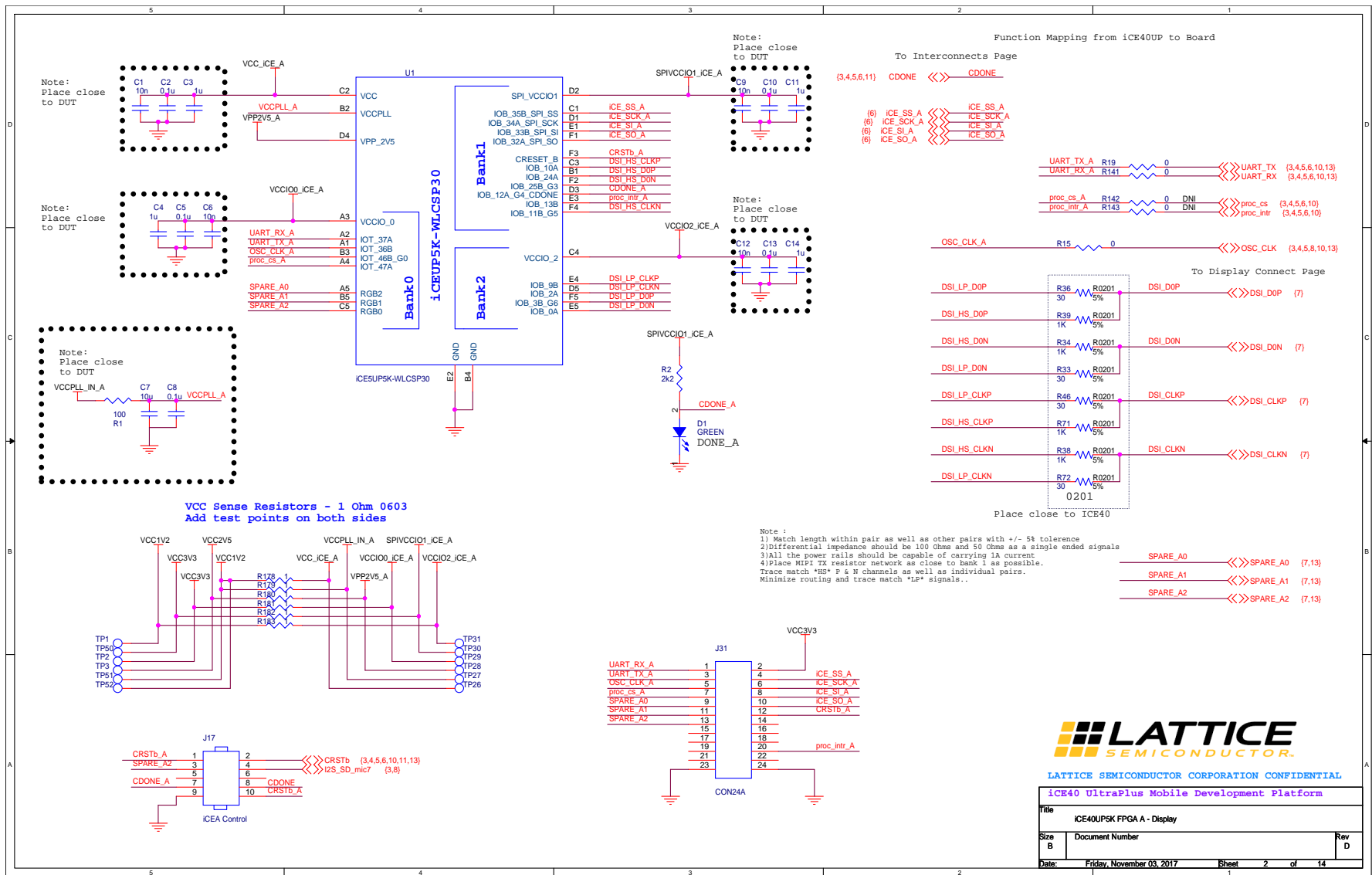


Figure A.2. ICE40UP5K FPGA A - Display

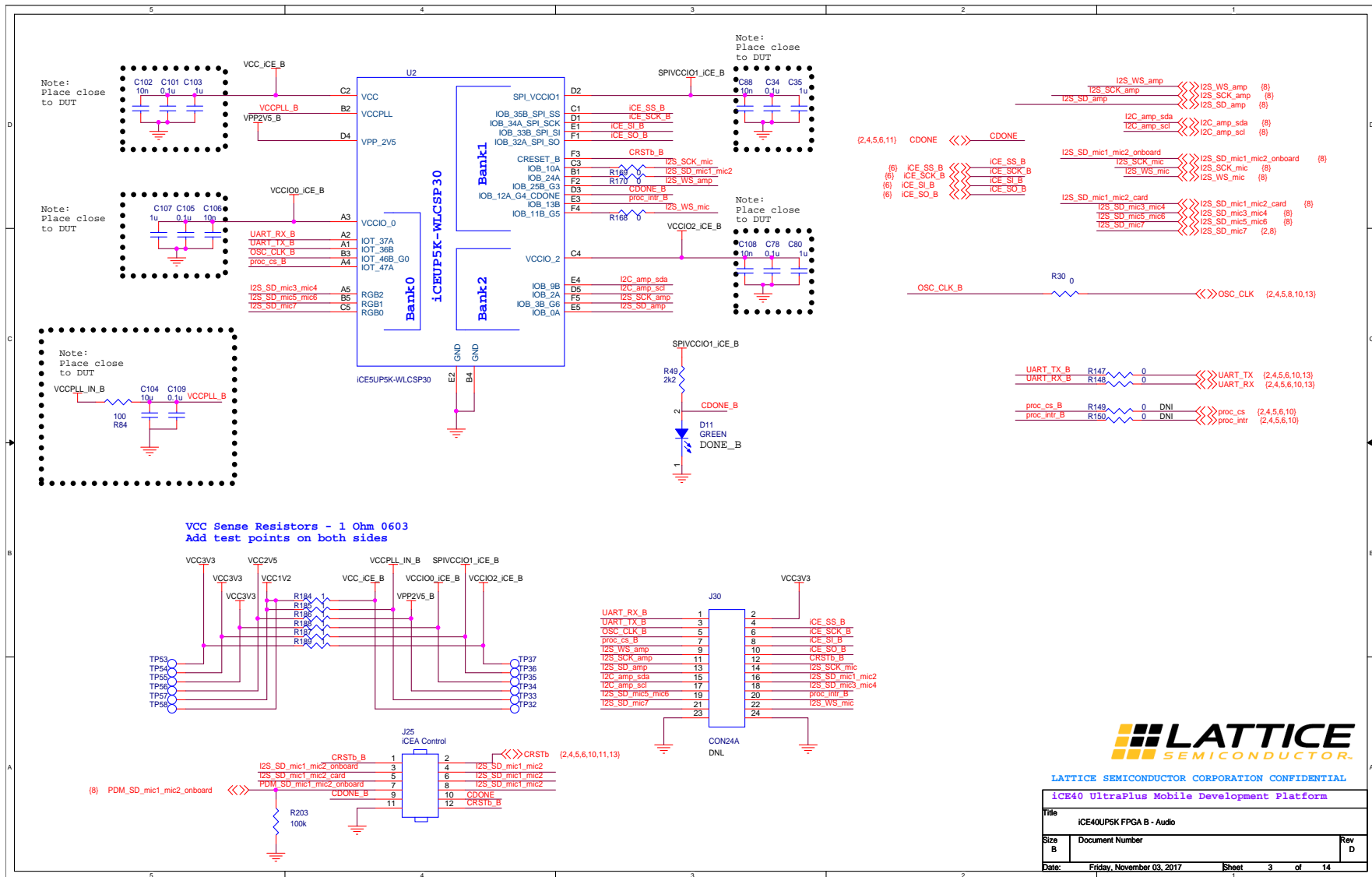


Figure A.3. iCE40UP5K FPGA B - Audio



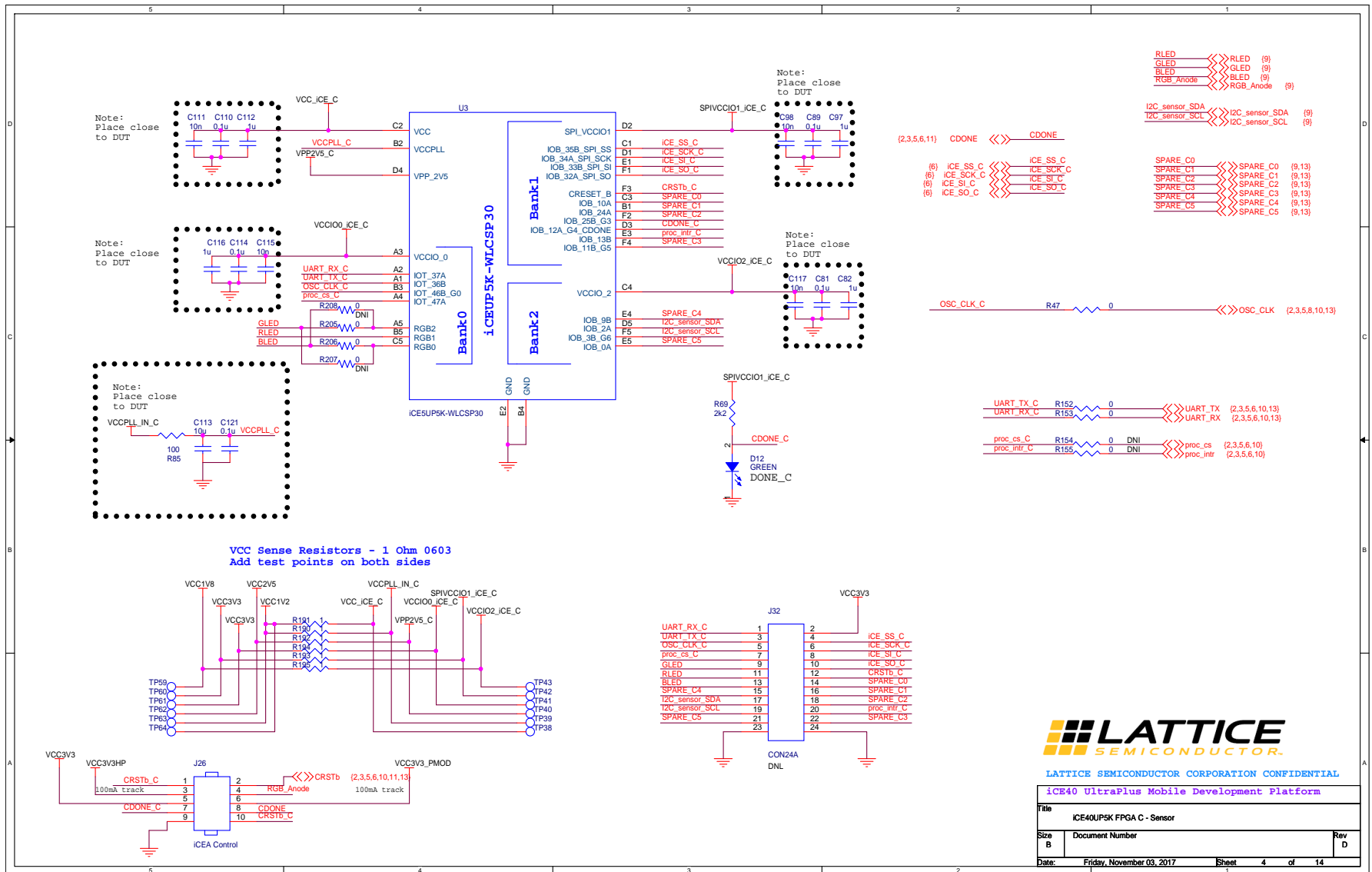


Figure A.4. ICE40UP5K FPGA C - Sensor

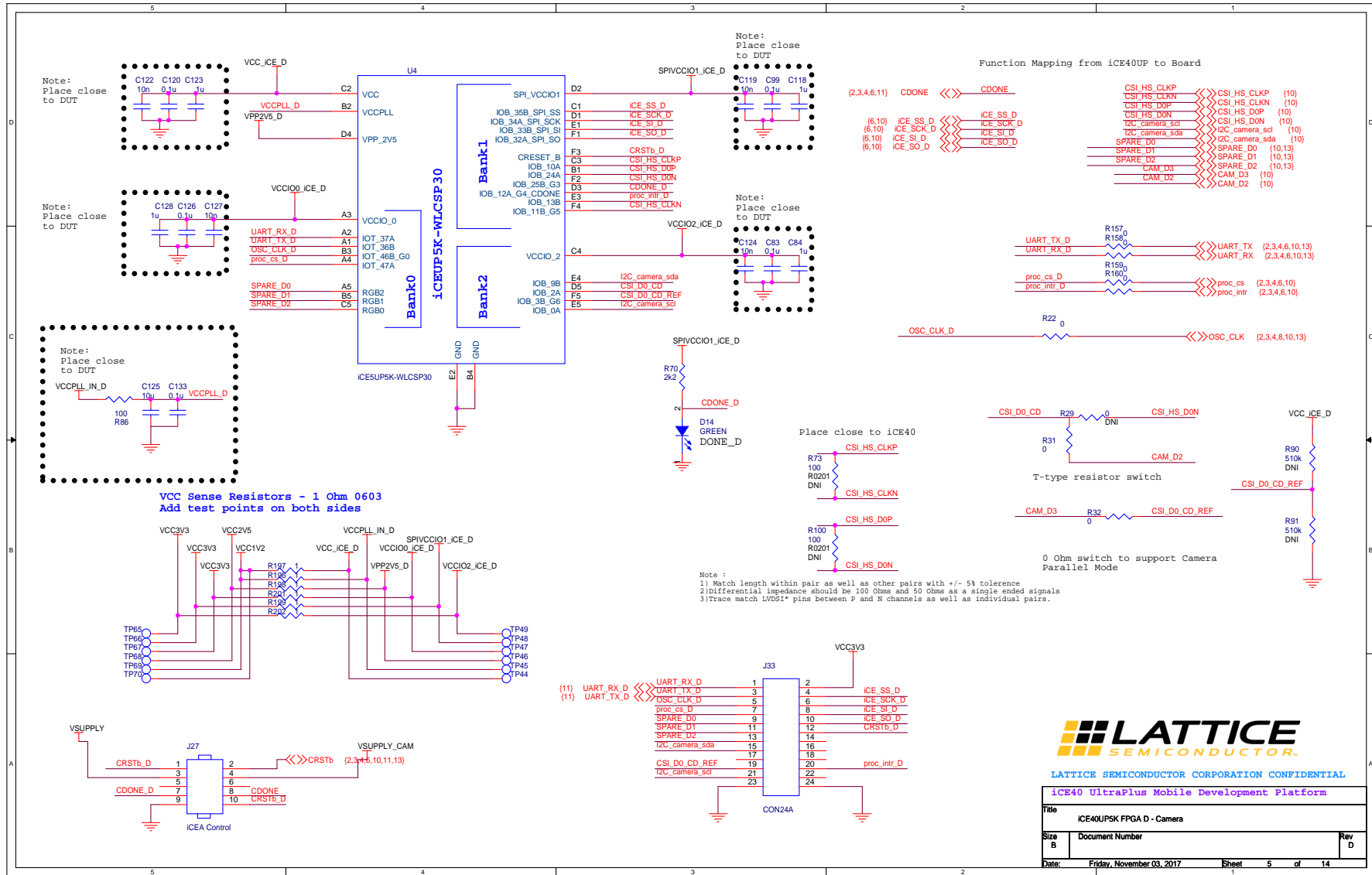


Figure A.5. ICE40UP5K FPGA D - Camera

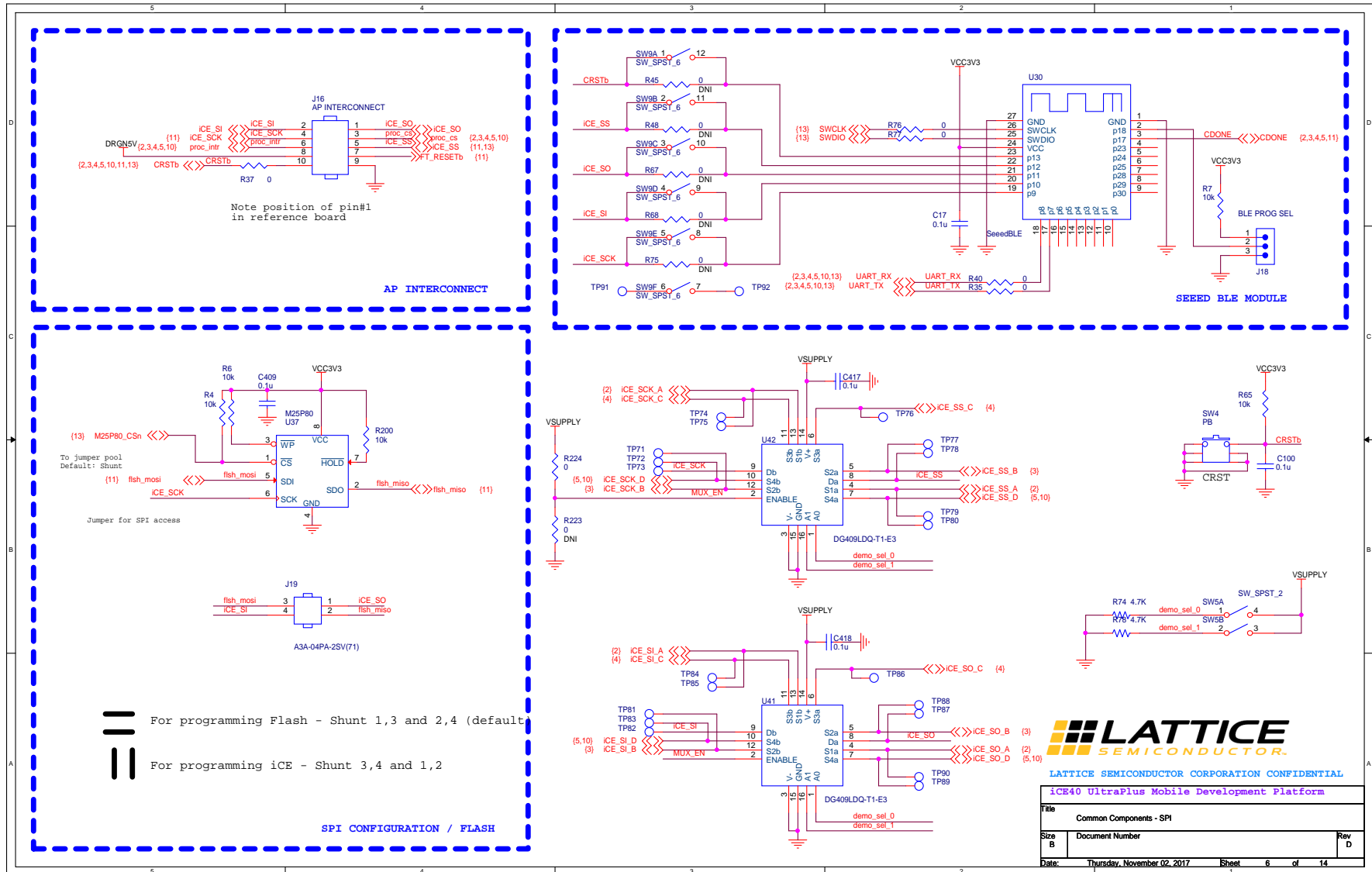


Figure A.6. Common Components- SPI

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ICE40 UltraPlus Mobile Development Platform

|       |                             |       |         |
|-------|-----------------------------|-------|---------|
| File  | Common Components - SPI     |       | Rev     |
| Size  | Document Number             |       | D       |
| Date: | Thursday, November 02, 2017 | Sheet | 6 of 14 |

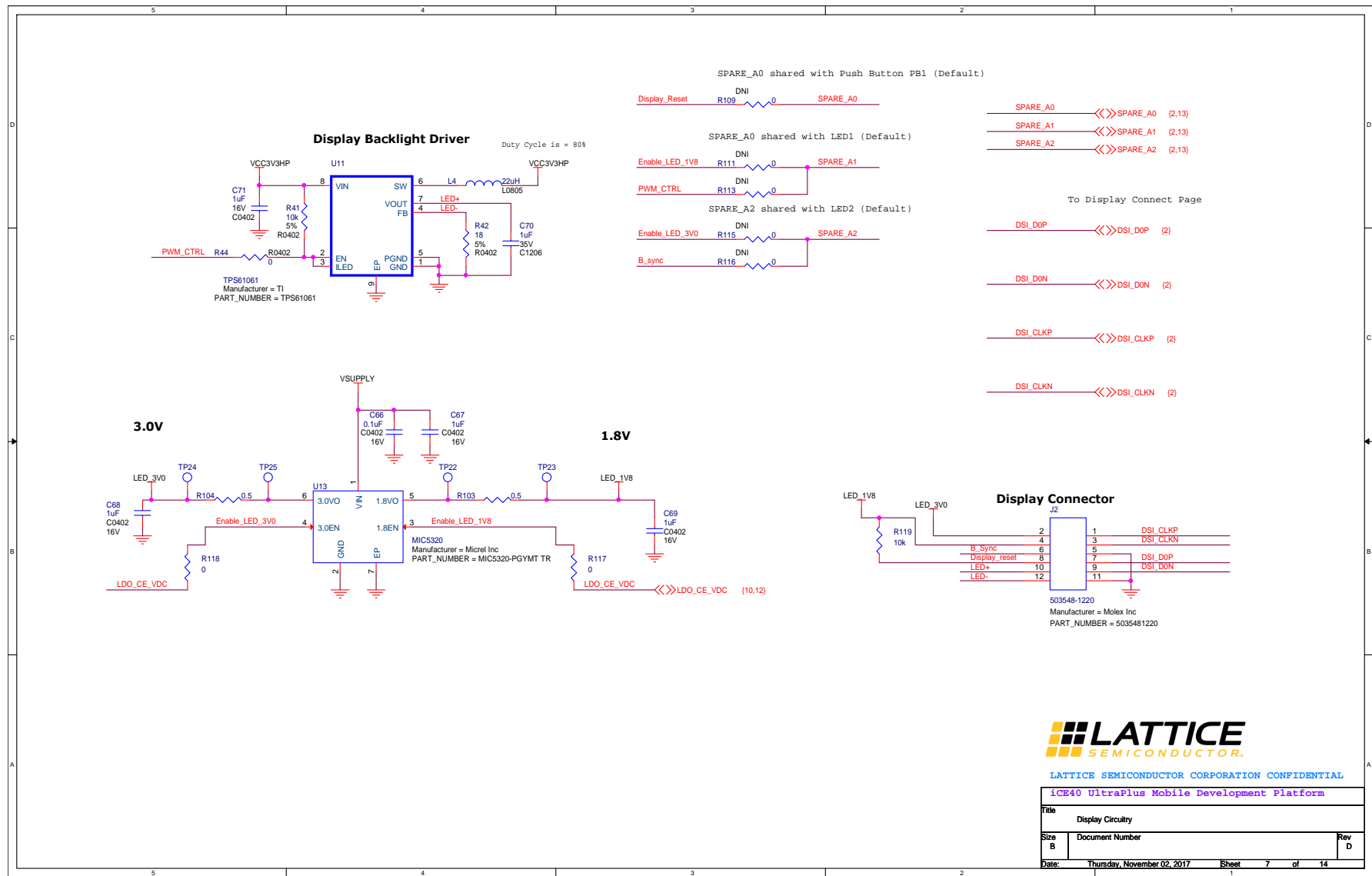


Figure A.7. Display Circuitry

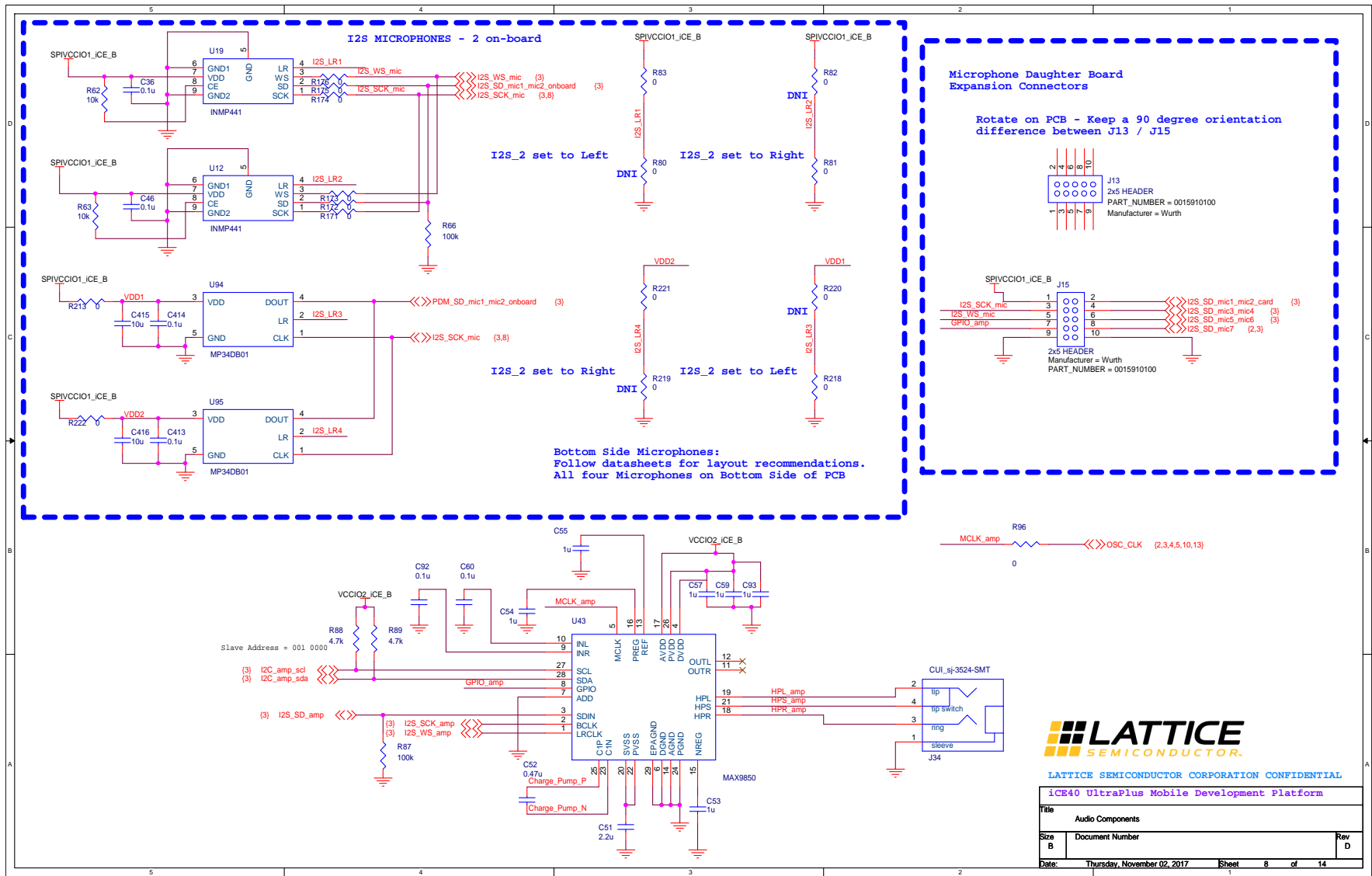


Figure A.8. Audio Circuitry

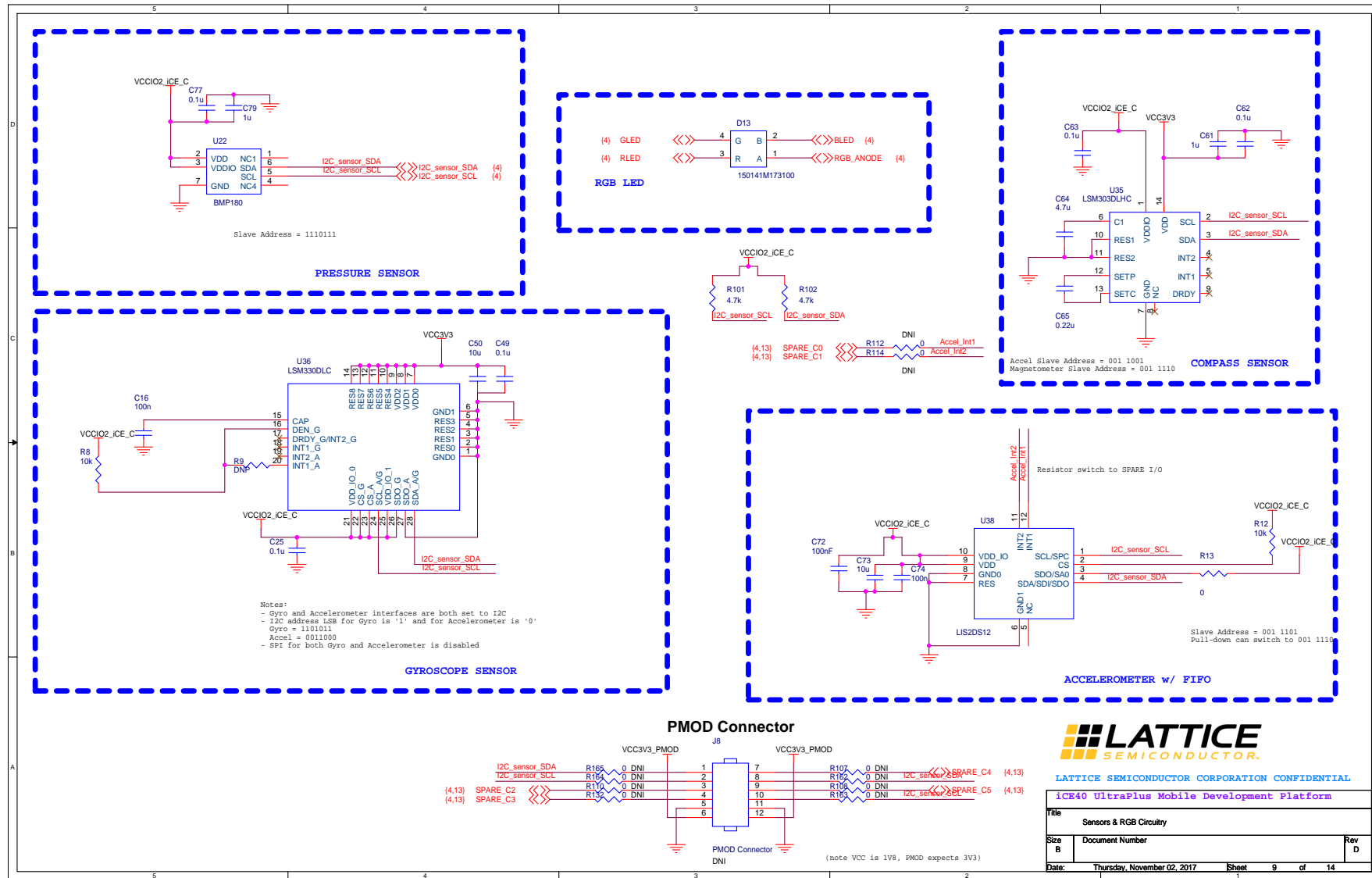


Figure A.9. Sensor & RGB Circuitry

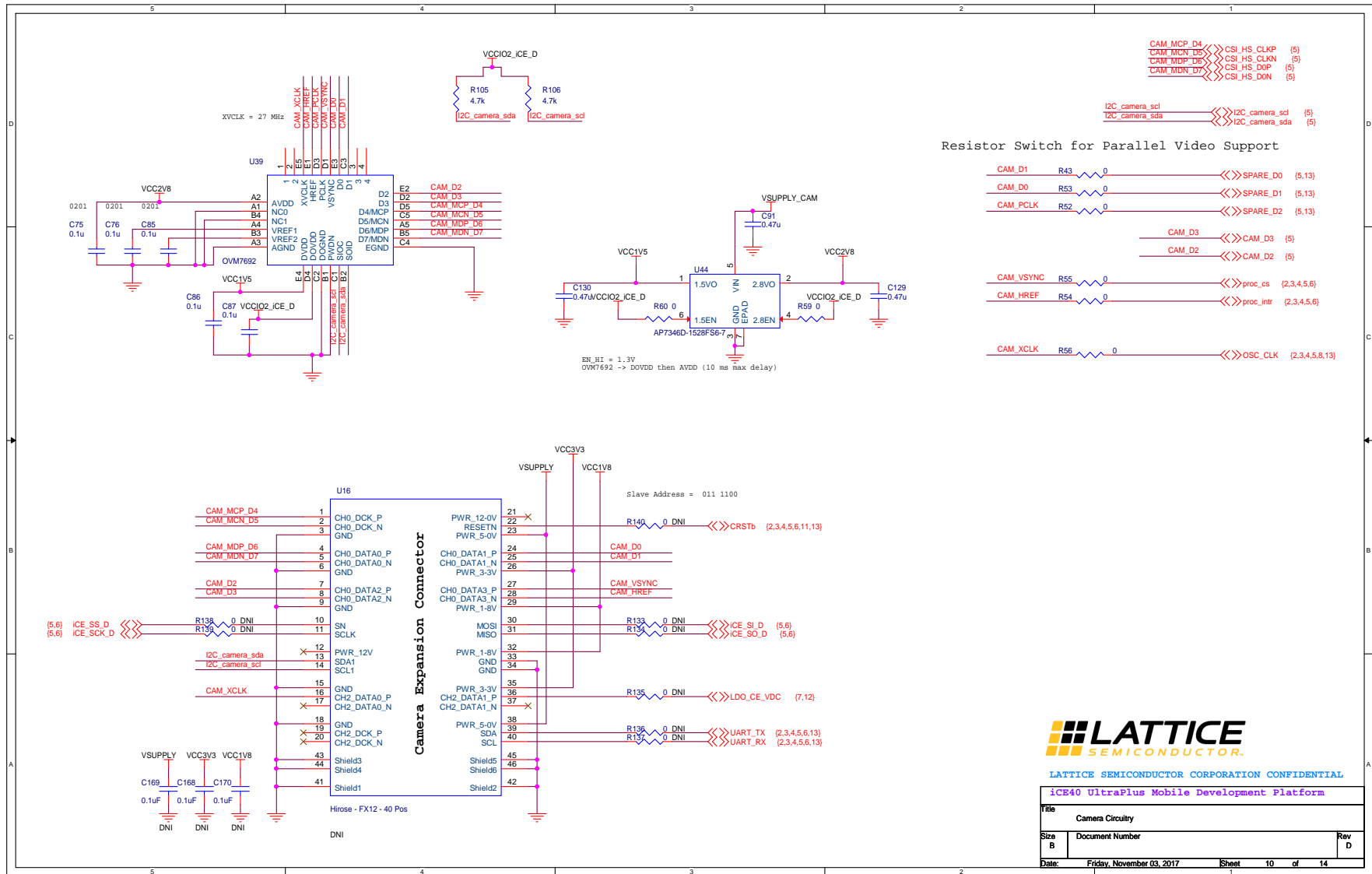


Figure A.10. Camera Circuitry

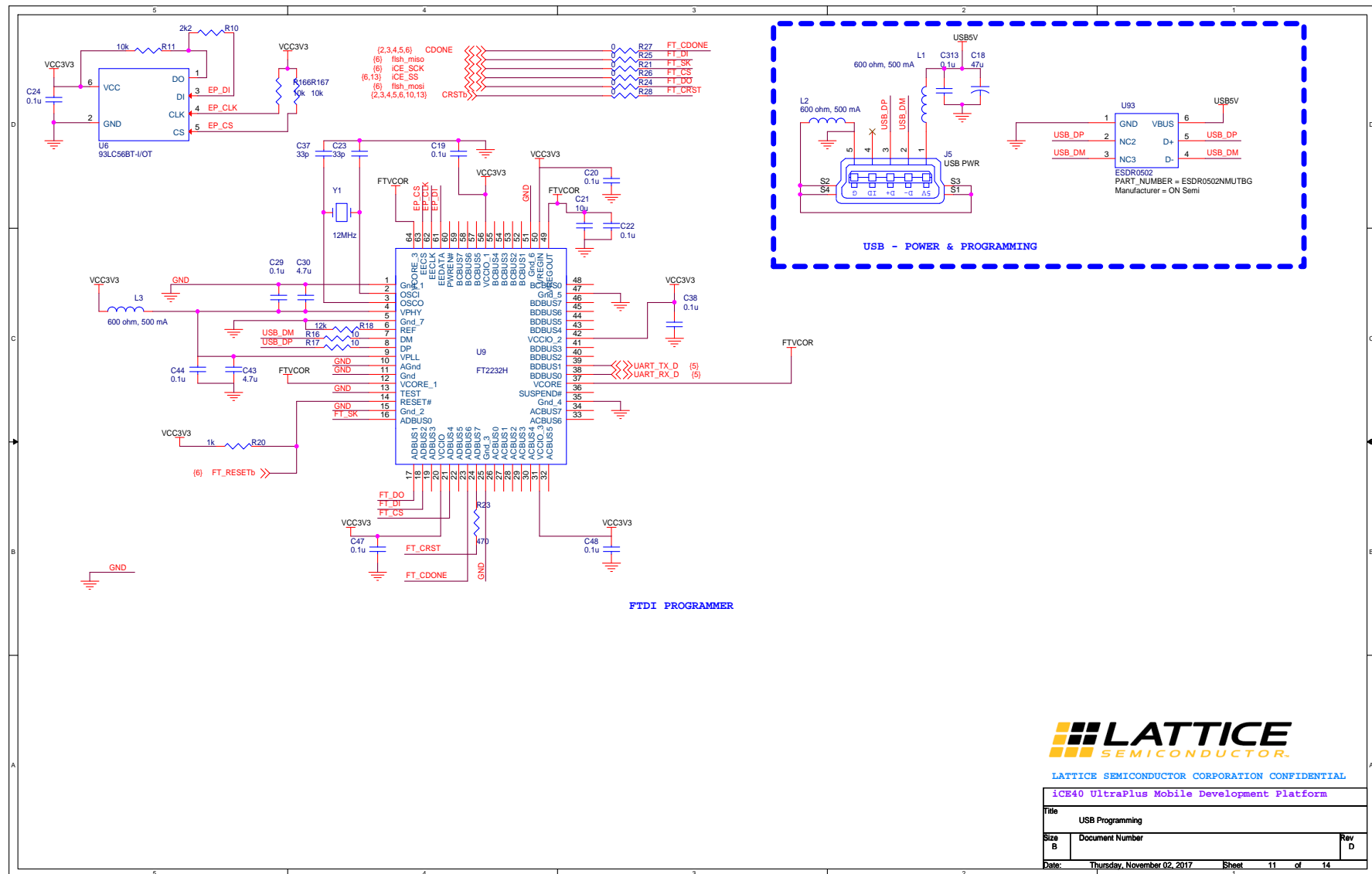


Figure A.11. USB Programming



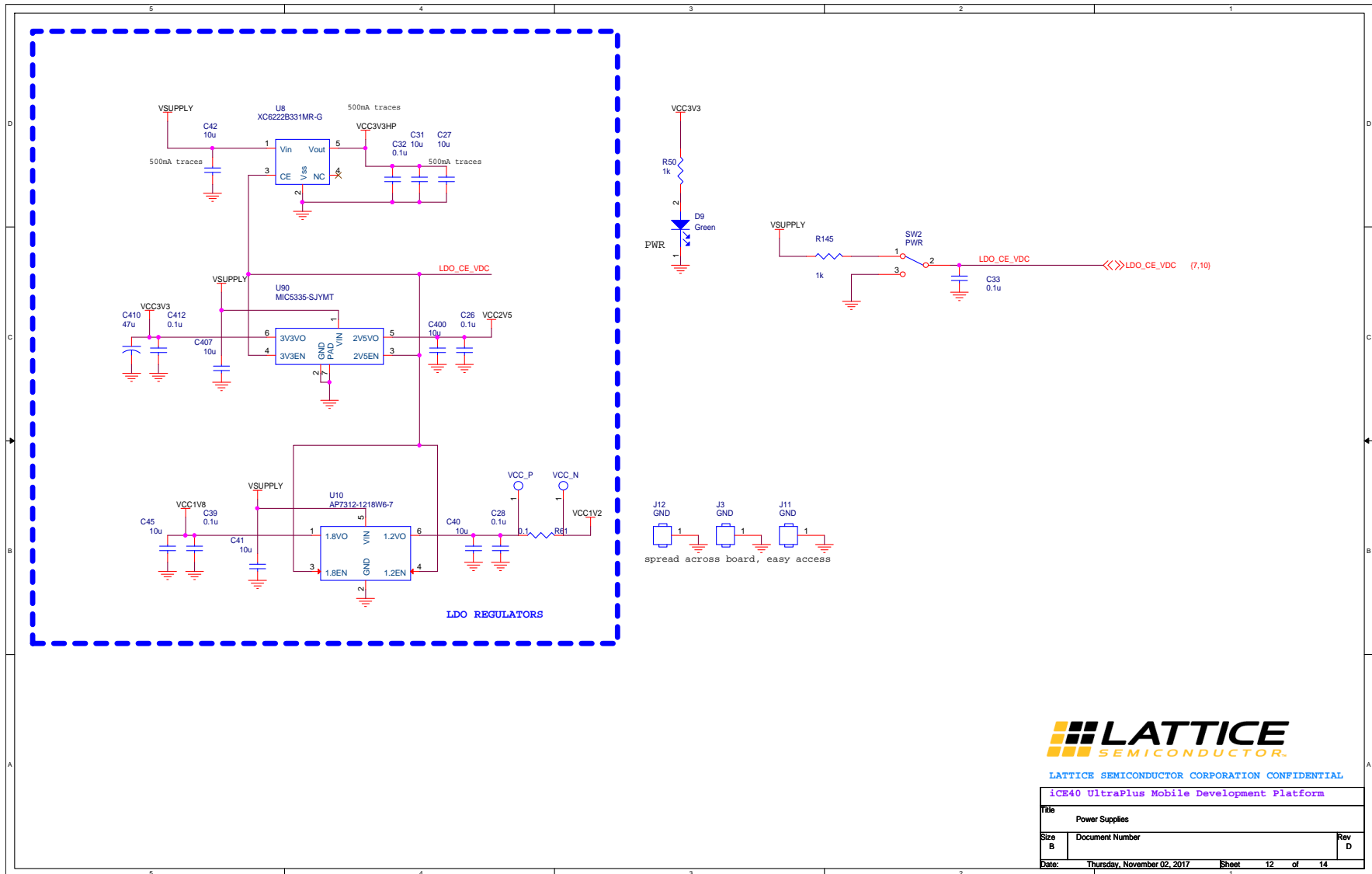


Figure A.12. Power Supplies

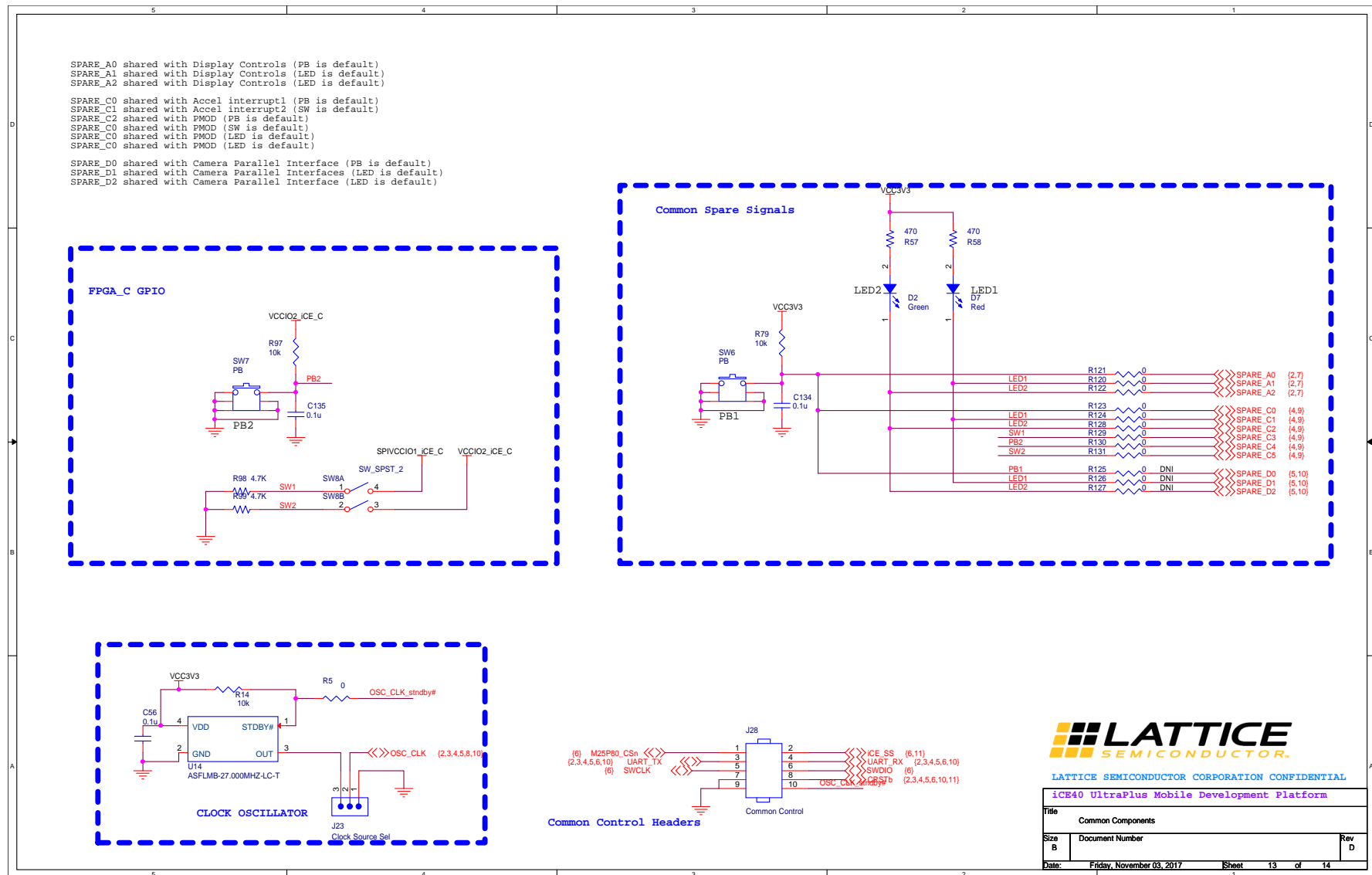


Figure A.13. Common Components

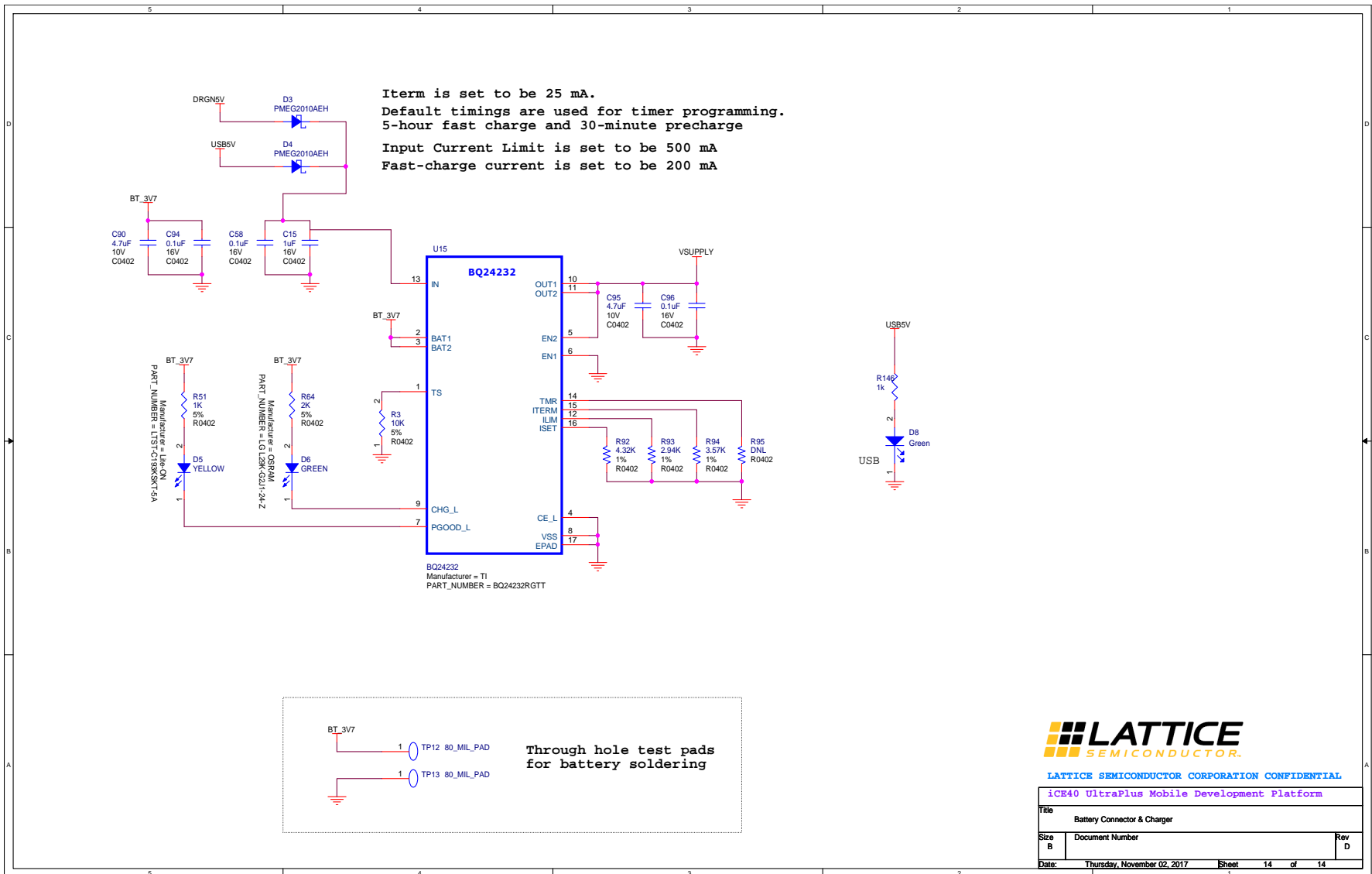


Figure A.14. Battery Connector & Charger

## Appendix B. iCE40 UltraPlus Mobile Development Board Bill of Materials

| Item | Reference   | Qty | Part | PART_NUMBER         | Manufacturer | Description                      |
|------|---|-----|------|---------------------|--------------|----------------------------------|
| 1    | C1, C6, C9, C12, C88, C98, C102, C106, C108, C111, C115, C117, C119, C122, C124, C127   | 16  | 10n  | GRM033R61C103KA12D  | Murata       | CAP CER 10000PF 16V 10% X5R 0201 |
| 2    | C2, C5, C8, C10, C13, C34, C78, C81, C83, C89, C99, C101, C105, C109, C110, C114, C120, C121, C126, C133  | 20  | 0.1u | GRM033R61A104KE15D  | Murata       | CAP CER 0.1UF 10V X5R 0201       |
| 3    | C3, C4, C11, C14, C35, C53, C54, C55, C57, C59, C61, C79, C80, C82, C84, C93, C97, C103, C107, C112, C116, C118, C123, C128   | 24  | 1u   | 885012105012        | Wurth        | CAP CER 1UF 10V X5R 0402         |
| 4    | C7, C73, C104, C113, C125   | 5   | 10u  | CL05A106MP5NUNC     | Samsung      | CAP CER 10UF 10V X5R 0402        |
| 5    | C15   | 1   | 1uF  | C1005X5R1C105K050BC | TDK          | CAP CER 1UF 16V 10% X5R 0402     |
| 6    | C16   | 1   | 100n | 885012205037        | Wurth        | CAP CER 0.1UF 16V X7R 0402       |
| 7    | C17, C19, C20, C22, C24, C25, C26, C28, C29, C32, C33, C36, C38, C39, C44, C47, C48, C49, C56, C60, C62, C63, C75, C76, C77, C85, C86, C87, C92, C100, C134, C135, C313, C409, C412, C414, C417, C418 | 38  | 0.1u | 885012105010        | Wurth        | CAP CER 0.1UF 10V X5R 0402       |
| 8    | C18, C410   | 2   | 47u  | TCJB476M010R0070    | AVX          | CAP TANT POLY 47UF 10V 1210      |
| 9    | C21, C27, C31, C40, C45, C400   | 6   | 10u  | CL10A106MQ8NNNC     | Samsung      | CAP CER 10UF 6.3V X5R 0603       |
| 10   | C23, C37  | 2   | 33p  | 885012005058        | Wurth        | CAP CER 33PF 50V NP0 0402        |
| 11   | C30, C43, C64   | 3   | 4.7u | CC0603KRX5R6BB475   | Yageo        | CAP CER 4.7UF 10V X5R 0603       |
| 12   | C41, C42, C407  | 3   | 10u  | CL10X106MP8NRNC     | Samsung      | CAP CER 10UF 10V X6S 0603        |
| 13   | C46, C413   | 2   | 0.1u | 885012105010        | Wurth        | CAP CER 0.1UF 10V X5R 0402       |
| 14   | C50   | 1   | 10u  | CL10X106MP8NRNC     | Samsung      | CAP CER 10UF 10V X6S 0603        |

| Item | Reference            | Qty | Part            | PART_NUMBER         | Manufacturer      | Description                      |
|------|----------------------|-----|-----------------|---------------------|-------------------|----------------------------------|
| 15   | C51                  | 1   | 2.2u            | C1005X5R1C225K050BC | TDK               | CAP CER 2.2UF 16V 10% X5R 0402   |
| 16   | C52, C91, C129, C130 | 4   | 0.47u           | C1005X5R1E474K050BB | TK                | CAP CER 0.47UF 25V X5R 0402      |
| 17   | C58, C94, C96        | 3   | 0.1uF           | 885012105016        | Würth             | CAP CER 0.1UF 16V X5R 0402       |
| 18   | C65                  | 1   | 0.22u           | 885012206048        | Würth             | CAP CER 0.22UF 16V X7R 0603      |
| 19   | C66                  | 1   | 0.1uF           | 885012105016        | Würth             | CAP CER 0.1UF 16V X5R 0402       |
| 20   | C67, C68, C69        | 3   | 1uF             | GRM155R61C105KE01D  | Murata            | CAP CER 1UF 16V 10% X5R 0402     |
| 21   | C70                  | 1   | 1uF             | 885012208093        | Würth             | CAP CER 1UF 50V X7R 1206         |
| 22   | C71                  | 1   | 1uF             | GRM155R61C105KE01D  | Murata            | CAP CER 1UF 16V 10% X5R 0402     |
| 23   | C72                  | 1   | 100nF           | 885012105016        | Würth             | CAP CER 0.1UF 16V X5R 0402       |
| 24   | C74                  | 1   | 100n            | 885012105016        | Würth             | CAP CER 0.1UF 16V X5R 0402       |
| 25   | C90, C95             | 2   | 4.7uF           | C1005X5R1A475K050BC | TDK               | CAP CER 4.7UF 10V 10% X5R 0402   |
| 26   | C168, C169, C170     | 3   | 0.1uF           | 885012105016        | Würth             | CAP CER 0.1UF 16V X5R 0402       |
| 27   | C415, C416           | 2   | 10u             | CL10X106MP8NRNC     | Samsung           | CAP CER 10UF 10V X6S 0603        |
| 28   | D1, D11, D12, D14    | 4   | GREEN           | 150060GS75000       | Würth             | LED GREEN CLEAR 0603 SMD         |
| 29   | D2                   | 1   | Green           | 150060GS75000       | Würth             | LED GREEN CLEAR 0603 SMD         |
| 30   | D3, D4               | 2   | PMEG2010AEH     | PMEG2010AEH, 115    | NXP Semiconductor | DIODE SCHOTTKY 20V 1A SOD123F    |
| 31   | D5                   | 1   | YELLOW          | 150060YS75000       | Würth             | LED YELLOW RECT CLEAR 0603       |
| 32   | D6                   | 1   | GREEN           | 150060GS75000       | Würth             | LED SMARTLED GREEN 570NM 0603    |
| 33   | D7                   | 1   | Red             | 150060SS75000       | Würth             | LED RED CLEAR 0603 SMD           |
| 34   | D8, D9               | 2   | Green           | 150060VS75000       | Würth             | LED SUPER GREEN CLEAR 0603 SMD   |
| 35   | D13                  | 1   | 150141M173100   | 150141M173100       | Würth             | LED RGB CLEAR 1411 SMD           |
| 36   | J2                   | 1   | 503548-1220     | 5035481220          | Molex Inc         | CONN RCPT BTB 12POS DL VERT SMD  |
| 37   | J3, J11, J12         | 3   | GND             | 608001162100        | Würth             |                                  |
| 38   | J5                   | 1   | USB PWR         | 65100516121         | Würth             | CONN COM TYPE B MINI USB SMD 5P  |
| 39   | J8                   | 1   | PMOD Connector  | -                   | -                 | CONN HEADER .100 DUAL STR 10POS  |
| 40   | J13, J15             | 2   | 2x5 HEADER      | 61001021121         | Würth             | CONN HEADER VERT DUAL 10POS 2.54 |
| 41   | J16                  | 1   | AP INTERCONNECT | 62101021921         | Würth             | 2.00 mm SMT Dual Pin Header      |
| 42   | J17, J26, J27        | 3   | iCEA Control    | 62101021921         | Würth             | 2.00 mm SMT Dual Pin Header      |
| 43   | J18                  | 1   | BLE PROG SEL    | 62000311121         | Würth             | 2.00 mm THT Pin Header           |

| Item | Reference   | Qty | Part             | PART_NUMBER        | Manufacturer        | Description  |
|------|---|-----|------------------|--------------------|---------------------|--|
| 44   | J19   | 1   | A3A-04PA-2SV(71) | A3A-4PA-2SV(71)    | Hirose              | CONN HEADER 2mm DUAL STR 4POS SMT  |
| 45   | J23   | 1   | Clock Source Sel | 62000311121        | Würth               | 2.00 mm THT Pin Header   |
| 46   | J25   | 1   | iCEA Control     | 57202-G52-06LF     | Amphenol FCI        | 12 Positions Header, Unshrouded Connector 0.079" (2.00mm) Surface Mount Gold, GXT™ |
| 47   | J28   | 1   | Common Control   | 62101021921        | Würth               | 2.00 mm SMT Dual Pin Header  |
| 48   | J30, J32  | 2   | CON24A           | —                  | —                   | —  |
| 49   | J31, J33  | 2   | CON24A           | —                  | —                   | —  |
| 50   | J34   | 1   | CUI_sj-3524-SMT  | SJ-3524-SMT-TR     | CUI Inc.            | CONN AUDIO JACK 3.5MM STEREO SMD   |
| 51   | L1, L2, L3  | 3   | 600 Ohm, 500 mA  | MMZ1608R601A       | TDK                 | FERRITE BEAD 600 OHM 0603 1LN  |
| 52   | L4  | 1   | 22uH             | AIML-0805HC-220M-T | Abrakon Corporation | HIGH CURRENT CHIP IND 22.0UH 20%   |
| 53   | R1, R84, R85, R86   | 4   | 100              | RC1005J101CS       | Samsung             | RES 100 OHM 1/16W 5% 0402  |
| 54   | R2, R49, R69, R70   | 4   | 2k2              | RC1005J222CS       | Samsung             | RES 2.2K OHM 1/16W 5% 0402   |
| 55   | R3  | 1   | 10K              | ERJ-2RKF1002X      | Panasonic           | RES 10K OHM 1/10W 1% 0402 SMD  |
| 56   | R4, R6, R7, R8, R12, R62, R63, R65, R200  | 9   | 10k              | ERJ-2RKF1002X      | Panasonic           | RES 10K OHM 1/10W 1% 0402 SMD  |
| 57   | R5  | 1   | 0                | ERJ-3GEY0R00V      | Panasonic           | RES SMD 0.0 OHM JUMPER 1/10W 0603  |
| 58   | R9  | 1   | DNP              | —                  | —                   | —  |
| 59   | R10   | 1   | 2k2              | RC1005J222CS       | Samsung             | RES 2.2K OHM 1/16W 5% 0402   |
| 60   | R11, R14, R79, R97, R166, R167  | 6   | 10k              | ERJ-2RKF1002X      | Panasonic           | RES 10K OHM 1/10W 1% 0402 SMD  |
| 61   | R13, R29, R35, R37, R40, R76, R77, R205, R206, R224   | 10  | 0                | ERJ-2GE0R00X       | Panasonic           | RES 0.0 OHM 1/10W 0402 SMD   |
| 62   | R15, R19, R22, R30, R47, R56, R59, R60, R81, R83, R96, R141, R142, R143, R147, R148, R149, R150, R152, R153, R154, R155, R157, R158, R159, R160, R168, R169, R170, R171, R172, R173, R174, R175, R176, R213, R218, R221, R222 | 39  | 0                | ERJ-3GEY0R00V      | Panasonic           | RES SMD 0.0 OHM JUMPER 1/10W 0603  |

| Item | Reference   | Qty | Part | PART_NUMBER    | Manufacturer | Description                          |
|------|---|-----|------|----------------|--------------|--------------------------------------|
| 63   | R16, R17  | 2   | 10   | RC1005J100CS   | Samsung      | RES 10 OHM 1/16W 5% 0402             |
| 64   | R18   | 1   | 12k  | RC1005F123CS   | Samsung      | RES 12K OHM 1/16W 1% 0402            |
| 65   | R20, R50, R145,<br>R146   | 4   | 1k   | RC1005J102CS   | Samsung      | RES 1K OHM 1/16W 5% 0402             |
| 66   | R21, R24, R25,<br>R26, R27, R28   | 6   | 0    | RC1005J000CS   | Samsung      | RES 0.0 OHM 1/16W JUMP 0402          |
| 67   | R23   | 1   | 470  | RC1005J471CS   | Samsung      | RES 470 OHM 1/16W 5% 0402            |
| 68   | R31   | 1   | 0    | ERJ-2GE0R00X   | Panasonic    | RES 0.0 OHM 1/10W 0402 SMD           |
| 69   | R32, R43, R52,<br>R53, R54, R55,<br>R107, R108, R110,<br>R132, R133, R134,<br>R135, R136, R137,<br>R138, R139, R140,<br>R162, R163, R164,<br>R165 | 22  | 0    | ERJ-3GEY0R00V  | Panasonic    | RES SMD 0.0 OHM JUMPER<br>1/10W 0603 |
| 70   | R33, R36, R72   | 3   | 30   | ERJ-1GEJ300C   | Panasonic    | RES 30 OHM 1/20W 5% 0201<br>SMD      |
| 71   | R34, R38, R39, R71  | 4   | 1K   | ERJ-1GEF1001C  | Panasonic    | RES SMD 1K OHM 1% 1/20W<br>0201      |
| 72   | R41   | 1   | 10k  | ERJ-2GEJ103X   | Panasonic    | RES SMD 10K OHM 5% 1/10W<br>0402     |
| 73   | R42   | 1   | 18   | ERJ-2GEJ180X   | Panasonic    | RES SMD 18 OHM 5% 1/10W<br>0402      |
| 74   | R44   | 1   | 0    | ERJ-2GE0R00X   | Panasonic    | RES SMD 0.0 OHM JUMPER<br>1/10W 0402 |
| 75   | R45, R48, R67,<br>R68, R75, R223  | 6   | 0    | ERJ-2GE0R00X   | Panasonic    | RES 0.0 OHM 1/10W 0402 SMD           |
| 76   | R46   | 1   | 30   | ERJ-1GEJ300C   | Panasonic    | RES 30 OHM 1/20W 5% 0201<br>SMD      |
| 77   | R51   | 1   | 1K   | ERJ-2GEJ102X   | Panasonic    | RES SMD 1K OHM 5% 1/10W<br>0402      |
| 78   | R57, R58  | 2   | 470  | ERJ-3GEYJ471V  | Panasonic    | RES SMD 470 OHM 5% 1/10W<br>0603     |
| 79   | R61   | 1   | 0.1  | RUT1005FR100CS | Samsung      | RES SMD 0.1 OHM 1% 1/10W<br>0402     |
| 80   | R64   | 1   | 2K   | ERJ-2GEJ202X   | Panasonic    | RES SMD 2K OHM 5% 1/10W<br>0402      |
| 81   | R66, R87, R203  | 3   | 100k | RC1005J104CS   | Samsung      | RES SMD 100K OHM 5% 1/16W<br>0402    |
| 82   | R73, R100   | 2   | 100  | ERJ-1GEF1000C  | Panasonic    | RES SMD 100 OHM 1% 1/20W<br>0201     |
| 83   | R74, R78, R98, R99  | 4   | 4.7K | ERJ-3EKF4701V  | Panasonic    | RES SMD 4.7K OHM 1% 1/10W<br>0603    |
| 84   | R80, R82  | 2   | 0    | ERJ-3GEY0R00V  | Panasonic    | RES SMD 0.0 OHM JUMPER<br>1/10W 0603 |
| 85   | R88, R89, R101,<br>R102   | 4   | 4.7k | ERJ-2RKF4701X  | Panasonic    | RES SMD 4.7K OHM 1% 1/10W<br>0402    |
| 86   | R90, R91  | 2   | 510k | ERJ-2RKF5103X  | Panasonic    | RES SMD 510K OHM 1% 1/10W<br>0402    |

| Item | Reference  | Qty | Part      | PART_NUMBER     | Manufacturer | Description                       |
|------|--|-----|-----------|-----------------|--------------|-----------------------------------|
| 87   | R92  | 1   | 4.32K     | ERJ-2RKF4321X   | Panasonic    | RES SMD 4.32K OHM 1% 1/10W 0402   |
| 88   | R93  | 1   | 2.94K     | ERJ-2RKF2941X   | Panasonic    | RES SMD 2.94K OHM 1% 1/10W 0402   |
| 89   | R94  | 1   | 3.57K     | ERJ-2RKF3571X   | Panasonic    | RES SMD 3.57K OHM 1% 1/10W 0402   |
| 90   | R95  | 1   | DNL       | —               | —            | —                                 |
| 91   | R103, R104   | 2   | 0.5       | RL0603FR-070R5L | Yageo        | RES SMD 0.5 OHM 1% 1/10W 0603     |
| 92   | R105, R106   | 2   | 4.7k      | ERJ-3EKF4701V   | Panasonic    | RES SMD 4.7K OHM 1% 1/10W 0603    |
| 93   | R109, R111, R113, R115, R116   | 5   | 0         | ERJ-3GEY0R00V   | Panasonic    | RES SMD 0.0 OHM JUMPER 1/10W 0603 |
| 94   | R112, R114   | 2   | 0         | ERJ-3GEY0R00V   | Panasonic    | RES SMD 0.0 OHM JUMPER 1/10W 0603 |
| 95   | R117, R118, R120, R121, R122, R123, R124, R125, R126, R127, R128, R129, R130, R131   | 14  | 0         | ERJ-3GEY0R00V   | Panasonic    | RES SMD 0.0 OHM JUMPER 1/10W 0603 |
| 96   | R119   | 1   | 10k       | ERJ-3EKF1002V   | Panasonic    | RES SMD 10K OHM 1% 1/10W 0603     |
| 97   | R178, R179, R180, R181, R182, R183, R184, R185, R186, R187, R188, R189, R190, R191, R192, R193, R194, R195, R196, R197, R198, R199, R201, R202   | 24  | 1         | ERJ-3GEYJ1R0V   | Panasonic    | RES SMD 1 OHM 5% 1/10W 0603       |
| 98   | R207, R208   | 2   | 0         | ERJ-2GE0R00X    | Panasonic    | RES SMD 0.0 OHM JUMPER 1/10W 0402 |
| 99   | R219, R220   | 2   | 0         | ERJ-3GEY0R00V   | Panasonic    | RES SMD 0.0 OHM JUMPER 1/10W 0603 |
| 100  | SW2  | 1   | PWR       | EG1218          | E-Switch     | SWITCH SLIDE SPDT 30V.2A PC MNT   |
| 101  | SW4, SW6, SW7  | 3   | PB        | TL1015AF160QG   | E-Switch     | SWITCH TACTILE SPST-NO 0.05A 12V  |
| 102  | SW5, SW8   | 2   | SW_SPST_2 | 416131160802    | Würth        | DIP SWITCH 1.27MM PITCH 2POL 24V  |
| 103  | SW9  | 1   | SW_SPST_6 | 416131160806    | Würth        | DIP SWITCH 1.27MM PITCH 6POL 24V  |
| 104  | TP1, TP2, TP3, TP26, TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP34, TP35, TP36, TP37, TP38, TP39, TP40, TP41, TP42, TP43, TP44, TP45, TP46, TP47, TP48, TP49, TP50, TP51, TP52, TP53, TP54, TP55, TP56, TP57, TP58, | 70  | T POINT R | —               | —            | —                                 |



| Item | Reference  | Qty | Part                   | PART_NUMBER           | Manufacturer            | Description  |
|------|--|-----|------------------------|-----------------------|-------------------------|--|
|      | TP59, TP60, TP61, TP62, TP63, TP64, TP65, TP66, TP67, TP68, TP69, TP70, TP71, TP72, TP73, TP74, TP75, TP76, TP77, TP78, TP79, TP80, TP81, TP82, TP83, TP84, TP85, TP86, TP87, TP88, TP89, TP90, TP91, TP92 |     |                        |                       |                         |  |
| 105  | TP12, TP13   | 2   | 80_MIL_PAD             | —                     | —                       | TEST POINT PC MINIATURE SMT                                      |
| 106  | TP22, TP23, TP24, TP25   | 4   | T POINT R              | —                     | —                       | —  |
| 107  | U1, U2, U3, U4   | 4   | iCE5UP5K-WLCSP30       | iCE5UP5K-UWG30        | Lattice                 | —  |
| 108  | U6   | 1   | 93LC56BT-I/OT          | 93LC56BT-I/OT         | Microchip Technology    | IC EEPROM 2KBIT 2MHZ SOT23-6                                     |
| 109  | U8   | 1   | XC6222B331MR-G         | XC6222B331MR-G        | Torex Semiconductor Ltd | IC REG LDO 3.3V 0.7A SOT25                                       |
| 110  | U9   | 1   | FT2232H                | FT2232HL              | FTDI                    | IC USB HS DUAL UART/FIFO 64-LQFP                                 |
| 111  | U10  | 1   | AP7312-1218W6-7        | AP7312-1218W6-7       | Diodes Inc              | IC REG LDO 1.2V/1.8V 0.15A SOT26                                 |
| 112  | U11  | 1   | TPS61061               | TPS61061DRBR          | TI                      | IC LED DRIVER WHITE BCKLGT 8SON                                  |
| 113  | U12, U19   | 2   | INMP441                | INMP441ACEZ           | Invensense              | Omnidirectional Microphone with bottom port and I2S digital port |
| 114  | U13  | 1   | MIC5320                | MIC5320-PGYMT TR      | Micrel Inc              | IC REG LDO 3V/1.8V 0.15A 6TMLF                                   |
| 115  | U14  | 1   | ASFLMB-27.000MHZ-LC-T  | ASFLMB-27.000MHZ-LC-T | ABRACON                 | OSC MEMS 27.000MHZ CMOS SMD                                      |
| 116  | U15  | 1   | BQ24232                | BQ24232RGTT           | TI                      | IC LI+ CHARGER PWR MGMT 16QFN                                    |
| 117  | U16  | 1   | Hirose - FX12 - 40 Pos | FX12B-40P-0.45V       | Hirose                  | CONN PLUG 40POS 0.4MM SMD SHIELD                                 |
| 118  | U22  | 1   | BMP180                 | BMP180                | Bosch                   | SENSOR PRESSURE ABS  |
| 119  | U30  | 1   | SeeedBLE               | 113050012             | Seeed                   | Low cost ARM cortex-m0 based module for Bluetooth module         |
| 120  | U35  | 1   | LSM303DLHC             | LSM303DLHC            | ST Micro                | ACCELEROMETER/MAGNETOMETER 14LGA                                 |
| 121  | U36  | 1   | LSM330DLC              | LSM330DLC             | ST Micro                | ACCELEROMETER/MAGNETOMETER 28LGA                                 |
| 122  | U37  | 1   | M25P80                 | M25P80-VMW6G          | Micron                  | IC FLASH 8MBIT 75MHZ 8SOW  |
| 123  | U38  | 1   | LIS2DS12               | LIS2DS12TR            | STMicroelectronics      | MEMS DIGITAL OUTPUT MOTION SENSOR                                |
| 124  | U39  | 1   | OVM7692                | OVM7692-RAAA          | OmniVision              | SENSOR IMAGE   |
| 125  | U41, U42   | 2   | DG409LDQ-T1-E3         | DG409LDQ-T1-E3        | Vishay                  | 2 Circuit IC Switch 4:1 29 Ohm 16-TSSOP                          |

| Item | Reference                                     | Qty | Part              | PART_NUMBER         | Manufacturer       | Description  |
|------|---|-----|-------------------|---------------------|--------------------|--|
| 126  | U43   | 1   | MAX9850           | MAX9850ETI+T        | Maxim Integrated   | IC AMP AUDIO .095W STER 28TQFN   |
| 127  | U44   | 1   | AP7346D-1528FS6-7 | AP7346D-1528FS6-7   | Diodes             | IC REG LDO 1.5V/2.8V X2-DFN1212  |
| 128  | U90   | 1   | MIC5335-SJYMT     | MIC5335-SJYMT       | Micrel             | IC REG LDO 3.3V/2.5V 0.3A 6TMLF  |
| 129  | U93   | 1   | ESDR0502          | ESDR0502NMUTBG      | ON Semi            | TVS DIODE 5.5VVM 6UDFN   |
| 130  | U94, U95                                      | 2   | MP34DB01          | MP34DB01            | STMicroelectronics | 20Hz ~ 20kHz Digital, PDM Microphone MEMS (Silicon) 1.8V Omnidirectional (-26dB ±3dB @ 94dB SPL) Solder Pads |
| 131  | VCC_P, VCC_N                                  | 2   | TP_S_40_63        | —                   | —                  | Square test point, 40mil inner diameter, 63mil outer diameter  |
| 132  | Y1  | 1   | 12MHz             | ABM3-12.000MHZ-B2-T | Abracon Corp       | CRYSTAL 12MHZ 18PF SMD   |
| 133  | iCE40UP Mobile Development Platform Board PCB | 1   | —                 | 305-PD-16-0605      | PACTRON            | —  |

## Accessories

| Item | Reference                    | Qty Per Board | Recommended Purchase Source   | PART_NUMBER       | Manufacturer                | Description   |
|------|------------------------------|---------------|---|-------------------|-----------------------------|---|
| 1    | LCD Display                  | 1             | <a href="http://www.vcdisplay.com">www.vcdisplay.com</a> - David Fontano / david@vcdisplay.com  | LH154Q01-TD01     | LG                          | <a href="http://vcdisplay.com/index.php/inventory/lg-display/lh154q01-td01-detail">http://vcdisplay.com/index.php/inventory/lg-display/lh154q01-td01-detail</a> |
| 2    | Battery                      | 1             | <a href="http://www.ebay.com/itm/251766536585?_trksid=p2057872.m2749.l2649&amp;ssPageName=STRK%3AMEBIDX%3AIT">http://www.ebay.com/itm/251766536585?_trksid=p2057872.m2749.l2649&amp;ssPageName=STRK%3AMEBIDX%3AIT</a> | S107-19 or 652030 | Syma                        | 3.7V 240mAh Li-Po Battery for SYMA S026 RC Remote Quadcopter  |
| 3    | J17, J19, J25, J26, J27, J28 | 30            | -   | SPN02SXCN-RC      | Sullins Connector Solutions | CONN JUMPER SHORTING 2MM GOLD   |

## Revision History

| Date       | Version | Change Summary   |
|------------|---------|--|
| April 2018 | 1.1     | Updated <a href="#">Jumpers and Switches</a> section. <ul style="list-style-type: none"> <li>Corrected J25 description</li> <li>Added J27</li> </ul>   |
|            |         | Updated jumpers in <a href="#">Figure 7.1. Board Configuration for Programming iCE40 UltraPlus Device “UI”</a> .   |
|            |         | Added <a href="#">Table 7.2. iCE40 UltraPlus Device Selection Summary</a> .  |
|            |         | Corrected step 1 (J19 setting changed to “vertically”) in <a href="#">Programming the iCE40 Devices Configuration Memory (CRAM)</a> section.   |
|            |         | Updated <a href="#">Programming the iCE40 Devices Configuration Memory (CRAM)</a> section. <ul style="list-style-type: none"> <li>Corrected step 1 (J19 setting changed to “horizontally”)</li> <li>Corrected step 7 figure reference for SPI Flash Options</li> </ul>                             |
|            |         | Indicated operating range of BLE module in <a href="#">Bluetooth</a> section.  |
|            |         | Added <a href="#">PCB Revision History</a> section.  |
|            |         | Updated <a href="#">Appendix A. iCE40 UltraPlus Mobile Development Board Schematics</a> . <ul style="list-style-type: none"> <li>Changed schematics from Rev C to Rev D</li> <li>Restored missing Sheet 13</li> <li>Changed figure numbering format</li> <li>Made schematics searchable</li> </ul> |
|            |         | Improved table format in <a href="#">Appendix B. iCE40 UltraPlus Mobile Development Board Bill of Materials</a>  |
|            |         | Updated numbering of headings.<br>Enhanced resolution of figures.  |
| May 2017   | 1.0     | Initial release.   |



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