TI Designs

Automotive ADAS Reference Design for Four Camera Hub with Integrated ISP and DVP Outputs

Design Overview

This camera hub reference design allows up to four 1.3 Megapixel cameras to be connected to a [TDA2x](#) SoC Evaluation Module (EVM). Each camera connects to the hub through a single coax cable. There are two OmniVision OV490 ISPs on the board that process the video and export it in parallel digital format (DVP). This greatly simplifies they system by combining four camera inputs into two parallel video ports.

Design Resources

TIDA-00455	D4 Camera Hub	Design Folder
DS90UB964-Q1	FPD-Link III Serializer	Product Folder
TPS55340-Q1	SEPIC Converter	Product Folder
TPS62160-Q1	Buck Converter	Product Folder
TPS1H100-Q1	High Side Switch	Product Folder
SN74LVC1G125-Q1	Single Bit Buffer	Product Folder
TS3USB221A-Q1	USB Switch	Product Folder
MSP430F2272-Q1	Microcontroller	Product Folder
TIDA-00421	Camera Module	Product Folder

Block Diagram

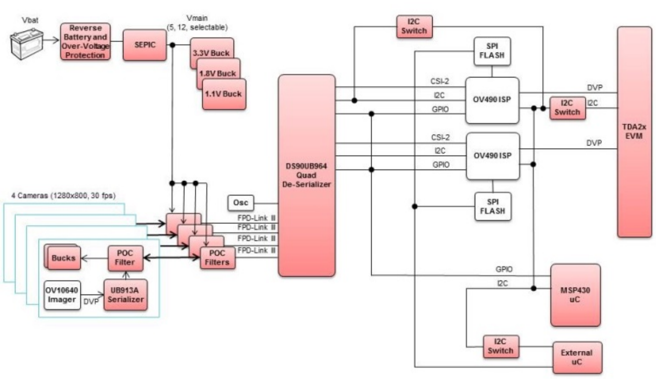


Figure 1: Surround View System Block Diagram

Design Features

- Accepts 4 camera inputs over FPD-Link III
- Utilizes two OmniVision OV490 ISPs to create DVP output to TDA2x
- Provides wide range supply voltage for Power Over Coax (4-14V)
- Connects directly to the parallel video ports on a TDA2x EVM
- Board power can come directly from car battery or TDA2x EVM
- Utilizes MSP430 uC to initialize and configure video pipeline.
- Can be used with onboard uC, without uC or with an external uC
- Optimized to work with OmniVision OV10640 imagers

Featured Applications

- ADAS Vision Systems
- Surround View Systems
- Fusion Systems

1 Key System Specifications

PARAMETER		COMMENTS	MIN	TYP	MAX	UNIT
System Input						
V_{IN}	Supply Voltage	From TDA2x EVM or External Supply	4	12	17	V
P_{TOTAL}	Total Power Consumption Without Cameras	@ 12V		1.7	2	W
P_{TOTAL}	Total Power Consumption With Four TIDA-00421 Cameras	@12V		5.5	6	W

Figure 2: Key System Specifications

2 System Description

For many automotive Advanced Driver Assistance Systems (ADAS), multiple cameras are required. This TI-Design addresses these needs by combining the outputs from four 1.3 Megapixel imagers into two digital parallel video ports (DVP). These video ports are available on an external connector that can attach to a TDA2x EVM or similar SoC/Processor.

2.1 DS90UB964A-Q1

Four input version of the Deserializer portion of a chipset that offers a FPD-Link III interface with a high-speed forward channel and a bidirectional control channel for data transmission over a single coaxial cable or differential pair. This chipset incorporates differential signaling on both the high-speed forward channel and bidirectional control channel data paths. The serializer/deserializer pair is targeted for connections between imagers and video processors in an ECU (Electronic Control Unit).

2.2 TPS55340-Q1

Monolithic non-synchronous switching converter with integrated 5-A, 40-V power switch. The device can be configured in several standard switching-regulator topologies, including boost, SEPIC and isolated flyback. The device has a wide input voltage range to support applications with input voltage from 2.9 to 38-V.

2.3 TPS62160-Q1

An easy to use synchronous step down DC-DC converter optimized for applications with high power density. A high switching frequency of typically 2.25 MHz allows the use of small inductors and provides fast transient response.

2.4 TPS1H100-Q1

Fully protected high-side power switch, with integrated NMOS power FET and charge pump, targeted for the intelligent control of the variable kinds of resistive, inductive, and capacitive loads.

2.5 SN74LVC1G125-Q1

Automotive qualified version of a single bus buffer gate with 3-state output.

2.6 TS3USB221A-Q1

High-bandwidth switch specially designed for the switching of high-speed USB 2.0 signals in handset and consumer applications, such as cell phones, digital cameras, and notebooks with hubs or controllers with limited USB I/O connections.

2.7 MSP430F2272-Q1

The Texas Instruments MSP430 family of ultra-low-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows the device to wake up from low-power modes to active mode in less than 1 µs.

2.8 TIDA-00421

An additional TI-Design that will be referenced throughout this document. It is an Automotive 1.3 MegaPixel camera module built around a DS90UB913A Serializer and an OmniVision OV10640 imager. The details of the design can be found at: TIDA-00421

Note: More information on each device and why they were chosen for this application follow in the next sections.

3 Block Diagram

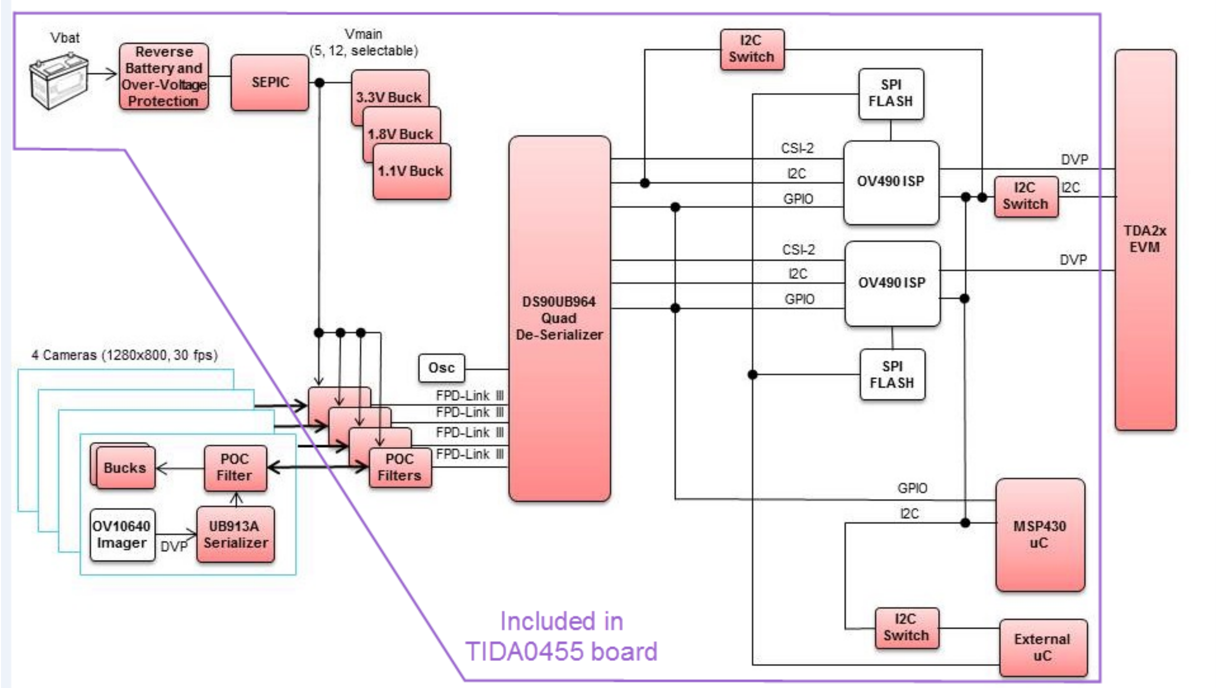


Figure 3: TIDA-0455 Block Diagram and System Partition

3.1 Highlighted Products

3.1.1 DS90UB964-Q1

Using a serializer/deserializer to combine 12-bit video with a bi-directional control signal onto one coax or twisted pair greatly simplifies system complexity, cost and cabling requirements.

The DS90UB964-Q1 four channel deserializer takes that simplification one step further. Each camera in the system is connected to the deserializer through a single coax cable. Using Power Over Coax (POC) filters, the power for each camera is also included on the single coax connection. In this way, video, I2C control, diagnostics and power can all be transmitted up to 15 meters on a single inexpensive coax cable. For more information on the cable itself, see the Cable Requirements application note at: SNLA229.

In this design, the DS90UB964-Q1 is paired with a DS90UB913A-Q1 that is on a separate camera board (TIDA-00421). The DS90UB913A-Q1 FPD-Link III 1.4 Gbit/s serializer is intended to link with mega-pixel image sensors. It transforms a parallel LVCMOS data bus (video port) along with a bidirectional control bus (I2C port) into a single high-speed differential pair. The DS90UB913A-Q1 can accept up to 12 bits of data + 2 bits (for example, HSYNC/VSYNC) + pixel clock (PCLK) in a range of 25 MHz to 100 MHz. The integrated bidirectional control channel transfers data over the same differential pair. Therefore, it eliminates the need for additional wires to program the image sensors' registers. In addition, the Serializer provides up to four GPO pins. They can act as outputs for the input signals that are fed into the Deserializer general-purpose input/output (GPIO) pins triggering the image sensor's logic. For example, the Deserializer and the Serializer can be configured in a way so that one GPIO pin on the Deserializer side causes one GPO pin on the Serializer side to toggle. In other words, the Serializer's output pins reflect the assigned input pins from the Deserializer. Alternatively, the GPO 2 pin can be configured to become a clock output pin when set in external oscillator mode (CLKOUT). In turn, the GPO 3 pin acts as input for an external clock source (CLKIN). It allows the Serializer to drive the image sensor's system clock input (XVCLK). Another option is for the output value of the GPO on the Serializer to be controlled directly by a register in the serializer. This allows the host uC or SoC to change this output value via I2C. An example use of this feature would be allowing the uC to control the reset of a device on the camera module.

3.1.2 TPS55340-Q1

For this design, the supply for the cameras is required to be configurable from 5V to 14V. With some of this range being above and below the input battery supply, a SEPIC is a good choice to solve this problem. With a simple jumper setting, one of the two most common camera power supplies can be chosen. (5V and 12V) For other voltages, the feedback resistor network can be modified by the user.

Camera sensor circuits usually are sensitive to noise at frequencies below 1 MHz. To avoid interference with the AM radio band, staying above 2 MHz is desirable in automotive applications. This means that the TPS55340-Q1 switching regulator operating up to 2.5MHz meets both requirements. This high switching frequency also helps to reduce the size of the discrete components in the circuit.

3.1.3 TLV62160-Q1

To generate the low voltage rails for this design, three of the TLV62160-/Q1 step down switching power supplies are tied to the main 5V or 12V rail. With a maximum input voltage of 17V, this gives the designer much flexibility in choosing the main rail. This allows the main rail to be chosen to output directly to cameras, directly supply a CAN phy or optimize efficiency in the system.

Camera sensor circuits usually are sensitive to noise at frequencies below 1 MHz. To avoid interference with the AM radio band, staying above 2 MHz is desirable in automotive applications. This means that the TPS55340-Q1 switching regulator operating up to 2.5MHz meets both requirements. This high switching frequency also helps to reduce the size of the discrete components in the circuit.

3.1.4 TPS1H100-Q1

In many applications, it is wise to limit the current available to the cameras. In this design, the current available to the four cameras is limited by the TPS1H100-Q1 switch. Controlling this switch from the uC also allow the designer to decide when power will be supplied to the camera and gives the flexibility for the host system to cycle the power to the cameras if this is ever required during startup, diagnostics or in response to a detected fault.

3.1.5 SN74LVC1G125-Q1

This one bit buffer was used in this design to allow the user to quickly determine if the power rails are present and functioning normally. Each of the buffers is connected directly to the Power Good output of the TLV62160-Q1 power supplies. The output is connected to an LED. This circuitry would likely be removed from a production system.

3.1.6 TS3USB221A-Q1

This design utilizes these high bandwidth USB switches to dynamically configure the I2C bus on the board. These parts are much faster than what is required, but they work well and are very simple to implement. For more information on the configuration of the I2C bus, see the uC section below.

3.1.7 MSB430F2272

This MSP430 is used in this design as a housekeeping and configuration microcontroller (uC). This allows the main SoC in the system to boot in parallel with the configuration of the SER/DES links, the initialization of the ISPs and camera imagers. More on this will be covered in the Board Boot Sequence section.

3.1.8 OV490 ISP

The OV490 integrates a high performance ISP with advanced HDR capabilities in order to achieve high quality images. In addition, it can output RAW data for machine vision processing and fully processed YUV data for display concurrently. Through its MIPI CSI-2 interfaces, it is able to receive, process and output two independent video streams at the same time. To accomplish this, MIPI standard offers up to four virtual channels to separate the streams within the physical layer of the interface. The streams arrive separated in long (L), short (S) and very short (VS) exposure channels indicated by the MSB of each value. After multiple pre-processing steps such as lens correction, white balancing or defective pixel correction, the ISP combines the channels with different exposures to generate high dynamic range output. Therefore, dark areas of the image will be filled with pixels from L exposure channel while bright areas will be filled with pixels from either S or VS channel. It results in images providing extended dynamic range. The weighted output of the combination feeds back into the blocks automatic gain control (AGC), automatic exposure control (AEC) and HDR block in order to calculate statistics. The statistics including histogram can be transferred to the host as part of idle rows within the video stream. The OV490 features a RISC processor to control the filter blocks and for configuration. Through its 4-wire serial interface the ISP needs to boot up from an external code provider. When configured using the boot mode pins: FSIN0, FSIN1,the OV490 allows booting from an external SPI Flash memory device. Doing so, the RISC processor loads the firmware into its on-chip memory and begins to execute. To obtain customized firmware, contact www.ovt.com. There are two sets of SCCB master/slave and one of SCCB slave interfaces on the chip (I2C interface). The master SCCB port configures the image sensors and optimizes its performance during runtime. The slave SCCB port receives configurations for ISP registers from an external master.

4 System Design Theory

Below we will discuss the considerations behind the design of each subsection of the system.

4.1 PCB / Form Factor

This design is to be primarily used in connection with the TDA2x EVM. The PCB was designed to match the outline of the TDA2x EVM and to connect to allow standoffs to be installed between the TIDA-00455 board and the TDA2x EVM. The design could certainly have been placed on a much smaller board. On the revision E2 PCB, the mounting holes were inadvertently removed from the design. Suitable non-conductive spacers should always be used between the two boards to avoid circuit damage.

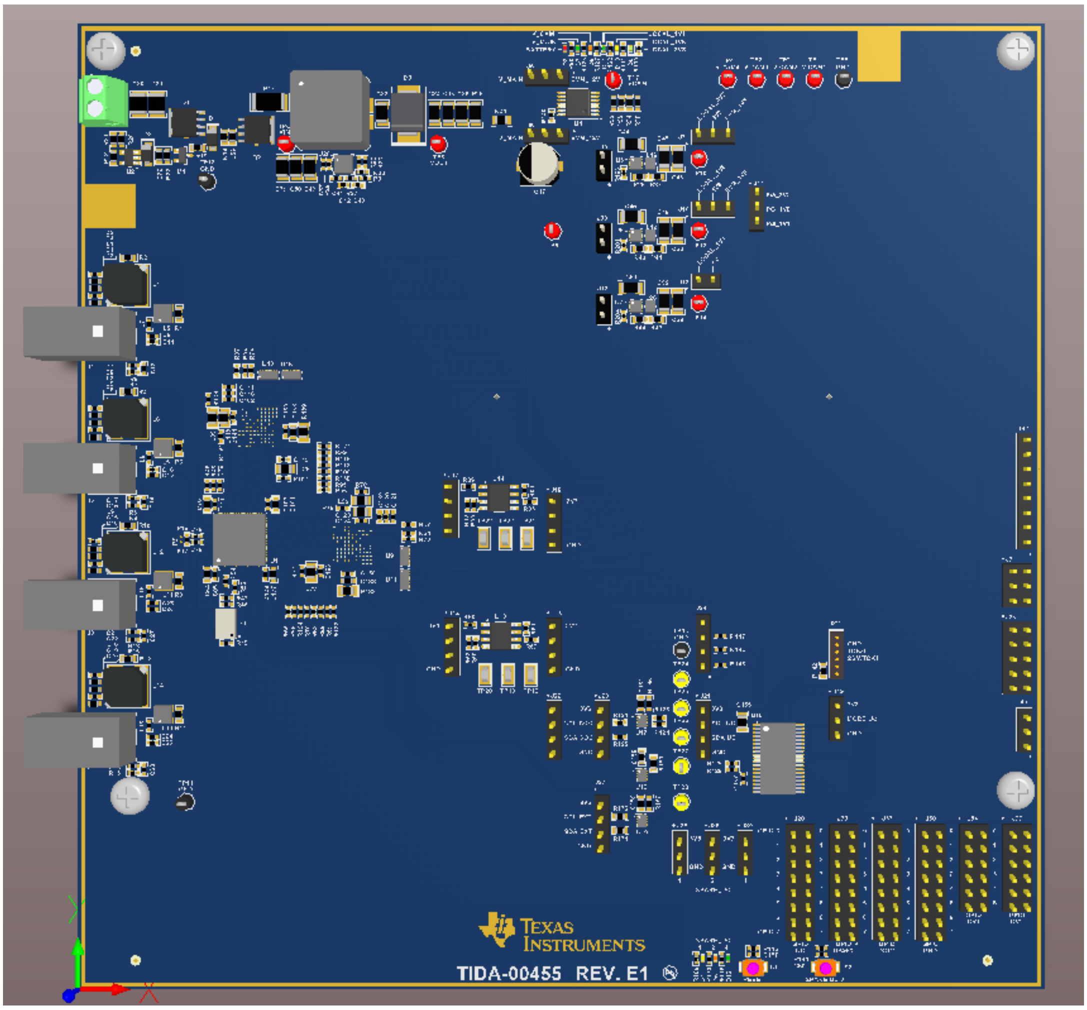


Figure 4: Board, Top View

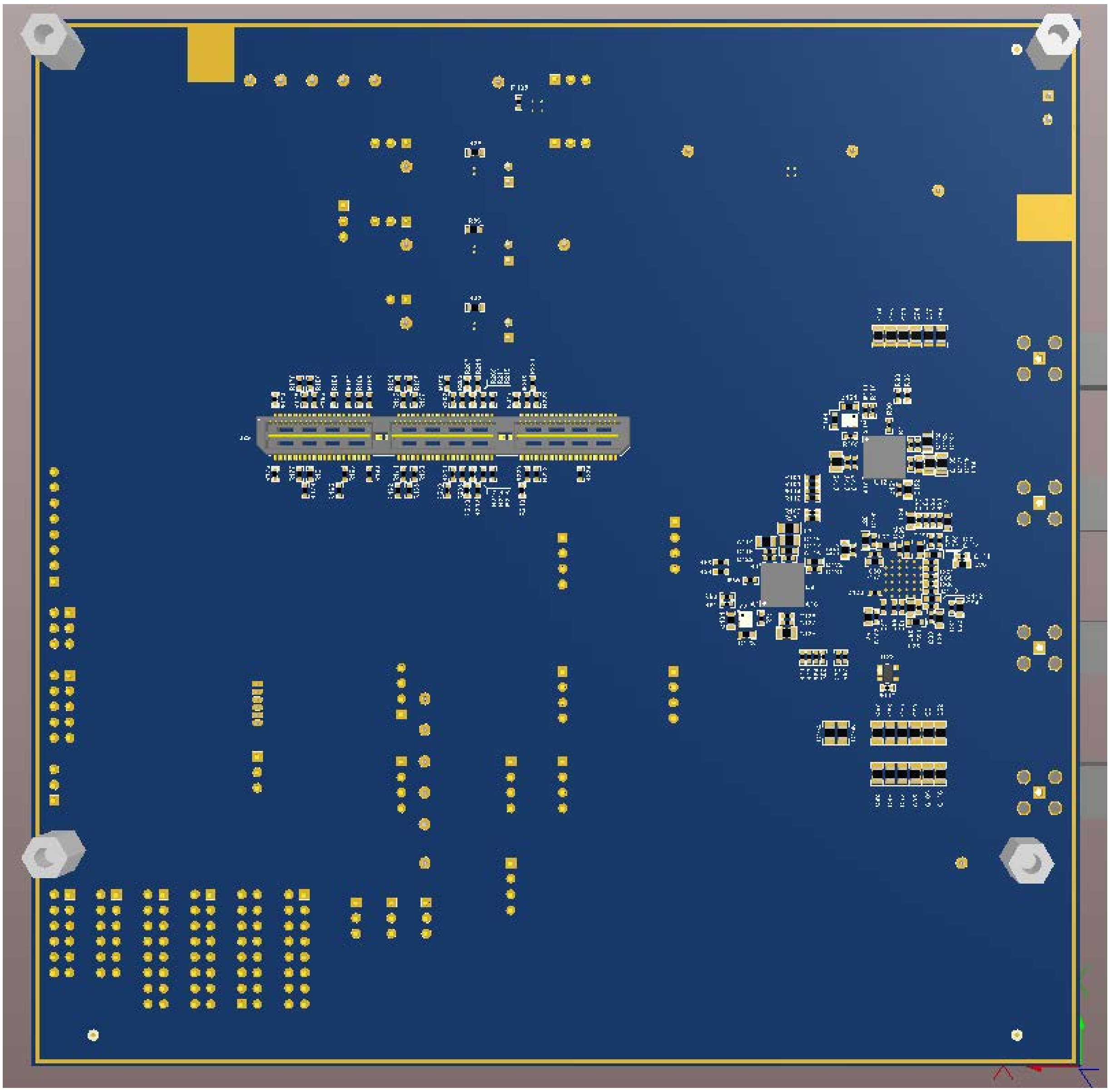


Figure 5: Board, Bottom View

4.2 I2C Addressing

4.2.1 Multiple Device Addressing (Aliasing)

Surround View applications require several cameras in a single system. Often, it is desirable for the multiple camera devices to be built alike, and therefore fixed to the same physical I2C address.

If these cameras are all to be accessed on the same I2C bus, there must be a method of assigning each camera an alias that will be used to address them. The FPD-Link SER/DES parts provide this functionality to assign a slave ID (alias) to each camera. This allows the slave devices to be independently addressed. These physical address of the slave and its associated alias IDs are configured by programming the “Slave ID” and “Slave Alias” registers on Deserializer. From the I2C host perspective, this will remap the address of each slave to its slave alias.

For this design, the most common imager that will be used in the system is the OV10640. This imager default address is 0x30 (0110000x). For a system utilizing more than one imager, GPIO 2/1 can be used to select different addresses for each imager. However, this would require that each camera in the system be built differently. Each system would have to be built with one of each unique camera. In a production environment, this is not desirable.

Instead, we can use the aliasing feature of the DS90UB964. In the deserializer, unique addresses are assigned to each imager. These aliases are used to refer to the imagers that are all addressed at 0x30 (0110000x). The host microprocessor can now communicate with each imager by using its alias, even though the imagers in each camera are physically addressed identically.

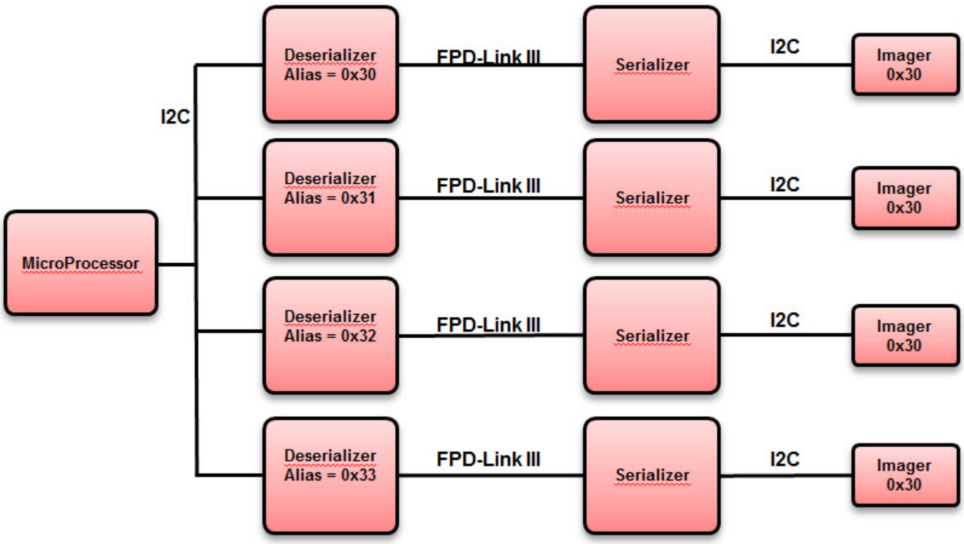


Figure 6: I2C Address Aliasing

4.2.2 I2C Bus Switches and Connections

There are six possible I2C hosts in this system. They each have a role to play, and a slave that they need to configure. This complicates the I2C bus connections. In figure 7, there are three I2C switches shown. These are used to configure the I2C bus to accomplish all of the tasks required for initialization of the system. There is a GPIO on the uC connected to the control pin of each switch. These are labeled with red text under the switch in figure 7. Their functionality could be described as:

I2C_SW_EXT
When this switch is open, either the MSP430 or the SOC will be the I2C host in the system. When this switch closes, it allows the external uC to take over as host of the I2C bus. If an external uC is used, the MSP430 should be placed into external uC mode by setting the jumper J19.

I2C_SW_SOC
When this switch is open, all SOC I2C traffic is isolated from the TIDA-00455 board. This allows either the local uC or the external uC to be the host. Depending on when this switch is closed, the SOC can either initialize the board, or just control the camera after one of the uC's has initialized the board. Control of the cameras is done by writing I2C commands into the two OV490's during normal operation.

I2C_SW_UB960
When this switch is closed, the main I2C bus on the UB96x is connected to the main I2C bus on the board. This switch must be open when the OV490 (OV1) begins to configure the OV10640 over the FPD-Link.

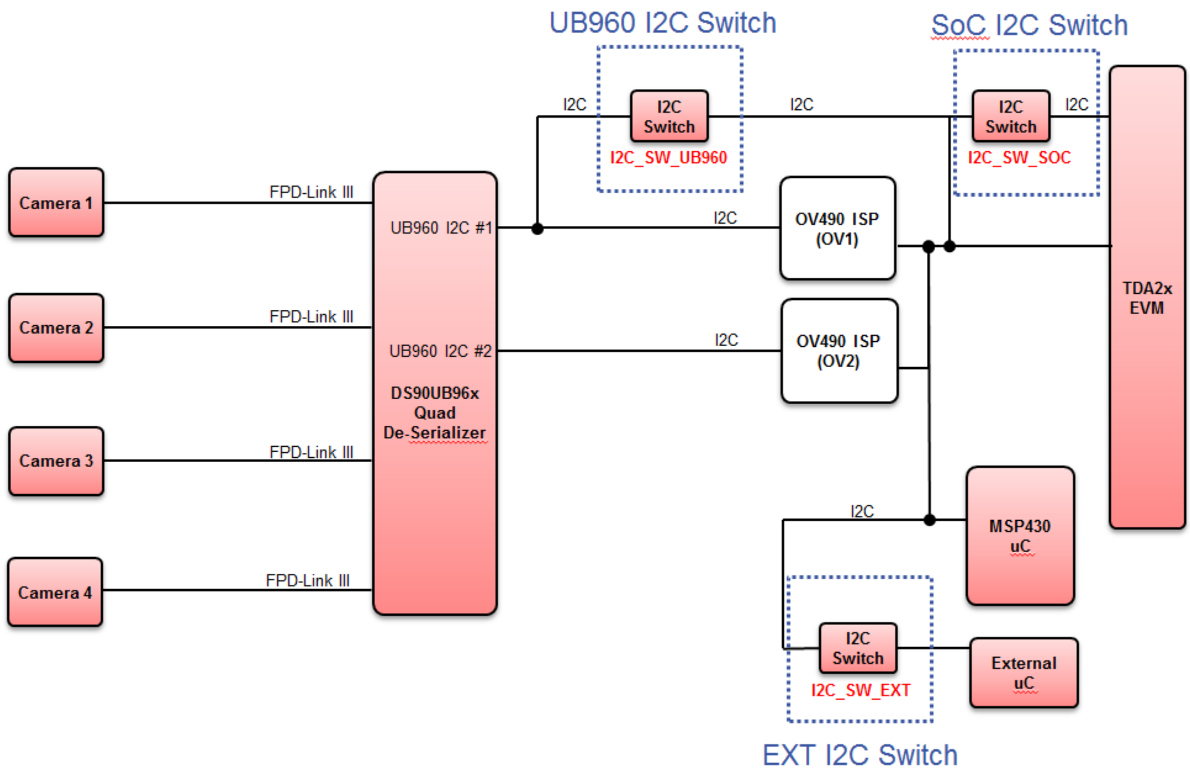


Figure 7: I2C Bus Diagram

4.2.3 Power Over Coax (POC) Filter

One of the most critical portions of a design which uses Power over Coax is the filter circuitry. The goal is twofold: 1) deliver a clean DC supply to the input of the switching regulators, and 2) protect the FPDLink communication channels from noise coupled backwards from the rest of the system.

The DS90UB964-Q1 and DS90UB913/914 SerDes devices used in this system communicate over two carrier frequencies, 700MHz at full speed ("forward channel") and a lower frequency between 1.75 and 3.25MHz ("back channel") determined by the deserializer device. The filter should attenuate this rather large band spanning both carriers, hoping to pass only DC. Luckily, by filtering the back channel frequency, we will also be filtering the frequencies from the switching power supplies on the board.

An ideal series 100 µH inductor could work as a low pass filter, with impedance >1KΩ at frequencies starting at 1MHz. However, due to parasitic capacitances, a real 100 µH inductor would cease to have high impedance around 70MHz. To cover the higher frequency band, we need another series inductor. A 10 µH inductor will ensure we have high impedance up to frequencies well above the 700MHz forward channel. See application note for more details: SNLA224

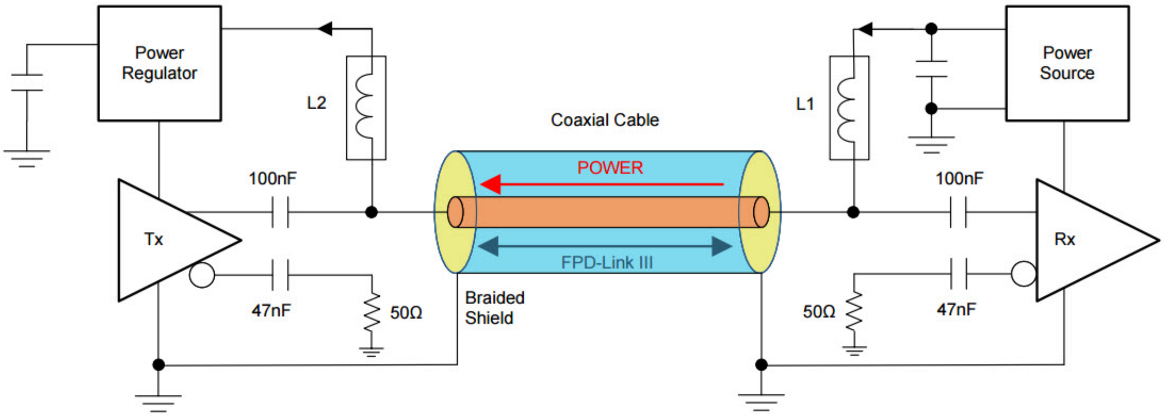


Figure 8: Power Over Coax

4.3 Step Down Converter

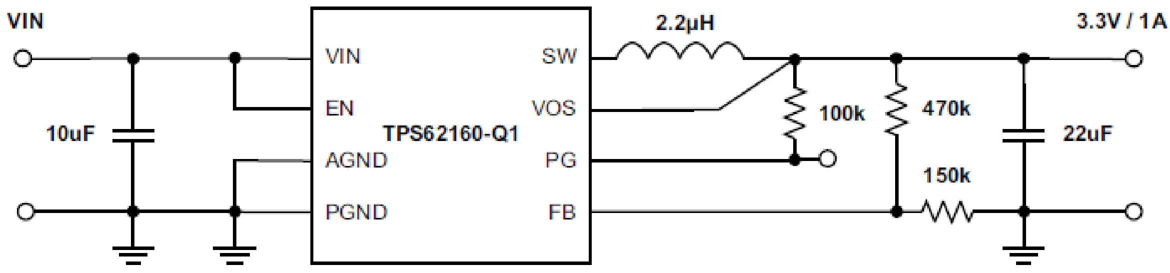


Figure 9: Typical Application Circuit

Much of the component selection and design theory can be found in the Application Information section of the datasheet.

There are very few external components to choose.

Choosing the Output Inductor:
As mentioned above, it is important in this design that the switching frequency of the converter remain above 2 MHz. This means that the converter must always operate in continuous mode. Since input voltage and output voltage are fixed and the output current is almost constant and can be predicted easily, the minimum inductance, L, for the converter to operate with continuous inductor current can be calculated using this equation:

$$L = \frac{V_{out}(V_{in} - V_{out})}{2 * V_{in} * I_{out} * f} = \frac{3.3V(12V - 3.3V)}{2 * 12V * 0.250A * 2.1MHz} = 2.27uH$$

There is a safety margin in the 250mA current budget. So, a 2.2uH should work nicely for this application.

Choosing the Output Capacitor:
Since the device is internally compensated, it is only stable for certain component values in the LC output filter. From the application note on optimizing the output filter, SLVA463A, we have the chart of stable values shown below in figure 10. Our chosen 2.2uH inductor paied with a 22uF capacitor will yield a 32.4kHz corner frequency. This is well within the recommended stable range for the TPS6216x family.

Nominal Inductance Value	Nominal Ceramic Capacitance Value (effective = 1/2 nominal)								
	4.7 µF	10.0 µF	22 µF	47 µF	100 µF	200 µF	400 µF	800 µF	1600 µF
	Effective Corner Frequencies								
0.47 µH	151.4 kHz	103.8 kHz	70.0 kHz	47.9 kHz	32.8 kHz	23.2 kHz	16.4 kHz	11.6 kHz	8.2 kHz
1.00 µH	103.8 kHz	71.2 kHz	48.0 kHz	32.8 kHz	22.5 kHz	15.9 kHz	11.3 kHz	8.0 kHz	5.6 kHz
2.2 µH	70.0 kHz	48.0 kHz	32.4 kHz	22.1 kHz	15.2 kHz	10.7 kHz	7.6 kHz	5.4 kHz	3.8 kHz
3.3 µH	57.2 kHz	39.2 kHz	26.4 kHz	18.1 kHz	12.4 kHz	8.8 kHz	6.2 kHz	4.4 kHz	3.1 kHz
4.7 µH	47.9 kHz	32.8 kHz	22.1 kHz	15.1 kHz	10.4 kHz	7.3 kHz	5.2 kHz	3.7 kHz	2.6 kHz
10.0 µH	32.8 kHz	22.5 kHz	15.2 kHz	10.4 kHz	7.1 kHz	5.0 kHz	3.6 kHz	2.5 kHz	1.8 kHz

(white)	Recommended for TPS6213x/4x/5x/6x/7x
(blue)	Recommended for TPS6213x/4x/5x only
(green)	Stable without Cff (within recommended LC corner frequency range)
(grey)	Stable without Cff (outside recommended LC corner frequency range)
(yellow)	Unstable

Figure 10: Stability vs Effective LC Corner Frequency

With our inductance value chosen, we now need an inductor with a proper saturation current. This is going to be the combination of the steady state supply current, as well as the inductor ripple current. We want the current rating to be sufficiently high, but minimize it as much as possible to reduce the physical size of the inductor. The following is the equation used to calculate the inductor ripple current (from the datasheet):

$$\Delta I_L = V_{out} * \left(\frac{\left(1 - \frac{V_{out}}{V_{in}}\right)}{L * f_{sw}} \right)$$

Here are the parameters for our design using the TPS62160:

$$V_{out} = 3.3V, V_{in} = 12V, L = 2.2\mu H, f_{sw} = 2.25MHz$$

Which yields an inductor ripple current of ΔI_L = 483mA. The maximum current draw of the system through this regulator is 250mA. Finally, the following equation gives us our minimum saturation :

$$L_{sat} \geq \left(I_{max} + \frac{I_{ripple}}{2} \right) * 1.2 = \left(250mA + \frac{483mA}{2} \right) * 1.2 = \mathbf{589mA}$$

We chose a TDK VLS201610HBX-2R2M which has a saturation current of 1700mA with only a 10% drop in inductance. This part comes in a 2 mm x 1.6 mm package.

The output voltage is determined by the resistor divider to the feedback pin. The following is the calculation for our output voltage. We aim for 3.3V out, but wanted to work with readily available resistor values:

$$R_1 = R_2 * \left(\frac{V_{out}}{V_{ref}} - 1 \right) \rightarrow V_{out} = \left(\frac{R1}{R2} + 1 \right) * V_{ref} = \left(\frac{316k\Omega}{100k\Omega} + 1 \right) * 0.8V = 3.328V$$

This gives us a close enough output voltage to the desired 3.3V. For improved accuracy, all feedback resistor dividers should use components with 1% or better tolerance.

5 Getting Started Hardware

5.1 Configuration

The TIDA-00455 needs to be configured before use. The configuration steps that follow should be done in order, to avoid damage to system components. The following configuration is for a 4 camera surround view system using TIDA-00421 cameras and a TDA2x EVM. The EVM will be powered from the included power supply, while the TIDA-00455 will be powered from a supply similar to a car battery.

1. Configure the GPIO (see below for more detail) Add/Verify jumpers in the following locations: (see figure 11)
   a. J28 pins 1-2, 3-4, 5-6, 7-8, 9-10
   b. J33 pins 1-2, 3-4, 7-8, 9-10
   c. J34 pins 5-6
   d. J35 pins 5-6
2. Configure the power supply. Add/Verify jumpers in the following locations: (see figure 12)
   a. J6 pins 2-3 (Connects output of SEPIC to the high side switch for cameras)
   b. J8 pins 2-3 (Connects output of SEPIC to input of Buck Converters)
   c. Do not install J13 (Sets SEPIC output to 12V)
   d. J7 pins 1-2 (selects output from 3.3V buck instead of supply from TDA2x EVM)
   e. J9 pins 1-2 (enables 3.3V buck supply)
   f. J10 pins 1-2 (selects output from 1.8V buck instead of supply from TDA2x EVM)
   g. J30 pins 1-2 (enables 1.8V buck supply)
   h. J12 pins 1-2 (selects output from 1.1V buck)
   i. J15 pins 1-2 (enables 1.1V buck supply)
3. Set the uC mode by setting J19. Pin 1,2 will place the board in local uC mode and it will use the MSP430 for initialization.
4. Remove any/all jumpers from J31. (may be left from programming OV490s)
5. Connect TIDA-00455 to TDA2x EVM
6. Connect 4 TIDA-00421 cameras using FAKRA coax cables
7. Connect HDMI out on TDA2x EVM to monitor using HDMI cable
8. Connect power supply provided with TDA2x EVM to input power connector on the EVM.
9. Connect 12V input power to J5. Pin 1 is marked VIN. Pin 2 is marked GND. The board is protected against reversing the input voltage. If the polarity of the input voltage is reversed, LED D6 will illuminate and Q1 will prevent damage to the board.
10. Press MSP430 RESET button (S1) on TIDA-00455 board.

GPIO Configuration:
There are headers on eight of the GPIO for the microcontroller, ISPs, Deserializer and Host Processor (SoC). This allows for maximum flexibility in utilizing these GPIO as needed in each application. This also means that for any configuration, the jumpers must be set correctly. In this case, we have installed jumpers on GPIO 0, 2, 3, 4 that connect the uC to the DS90UB964-Q1. Also, GPIO 2 jumpers have been installed to connect the uC to OV1 and OV2 serial FLASH devices. This allows the uC to control the Write Protect pin on the FLASH when in flash write mode. See section on Board Programming or Re-Programming for more details.

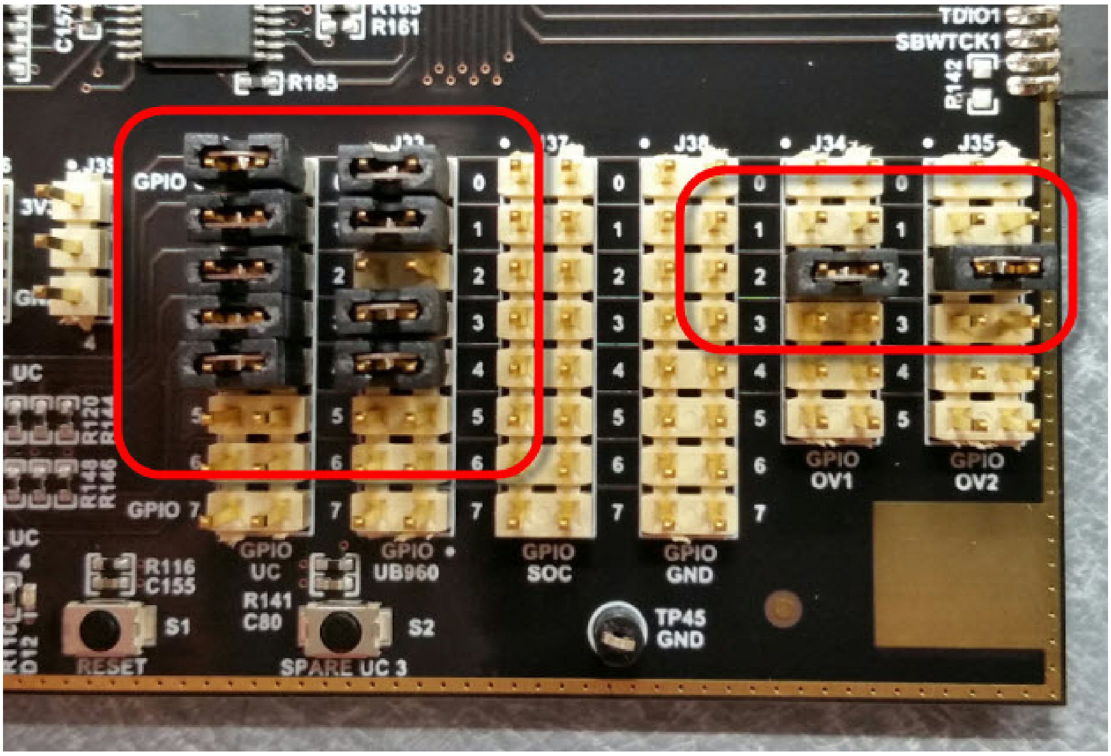


Figure 11: GPIO Jumpers

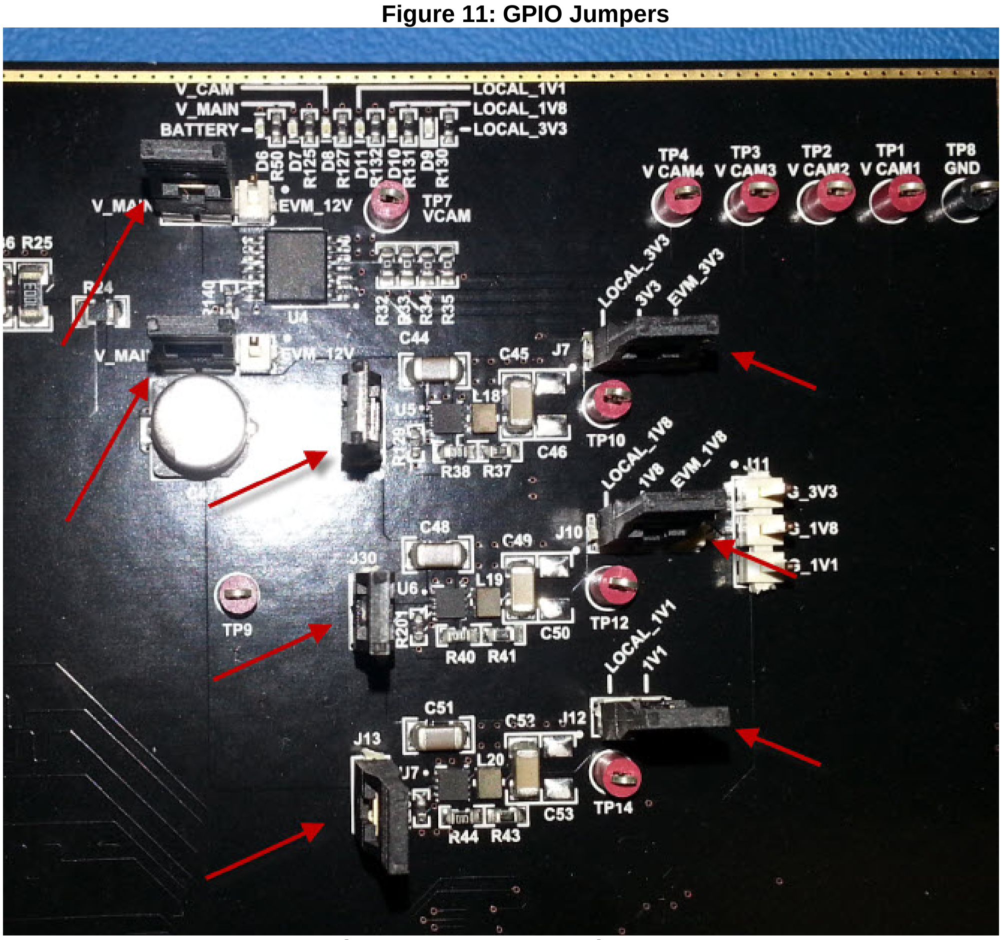


Figure 12: Power Supply Jumpers

6 Getting Started Firmware

6.1 Board Boot Sequence

If the board is placed into local uC mode (J19), the MSP430 microcontroller is in control of the startup sequence of the board. At startup, pulldown resistors hold the UB964 and the OV490's in RESET. Once the uC has started, it begins the startup of the rest of the board. The configuration sequence is:

1. uC (MSP430) boot
2. uC opens External I2C switch using: I2C_SW_EXT
3. uC opens SoC I2C switch using: I2C_SW_SOC
4. uC closes UB960 I2C switch using: I2C_SW_UB960
5. uC releases reset (PDB) pin on UB964 Deserializer
6. The deserializer is configured by the uC over I2C
7. The serializer is configured for address aliasing by the uC over I2C, through the FPD-Link
8. uC opens UB960 I2C switch using: I2C_SW_UB960
9. The uC releases the RESET on the OV490's and allows them to boot from FLASH via SPI.
10. Each OV490 configures the two imagers that are connected via the Deserializer.
    a. Firmware loaded in each OV490 ISP is identical. The aliased addresses of their slave imagers are not. However each OV490 has a different physical I2C address. This address is read from an OV490 register and causes the code in the OV490 to choose the correct imager addresses for OV1 and OV2.
11. uC closes External I2C switch using: I2C_SW_EXT (to allow SOC to have control)
12. uC changes I2C pins to inputs (high Z) and loops infinitely

The board is now configured, the imagers are running and the SoC has control of the imagers through the OV490 ISP's.

7 Test Setup

For the following tests, the TIDA-00455 board was connected to multiple TIDA-00421 cameras and a TDA2x EVM to create a surround view system.

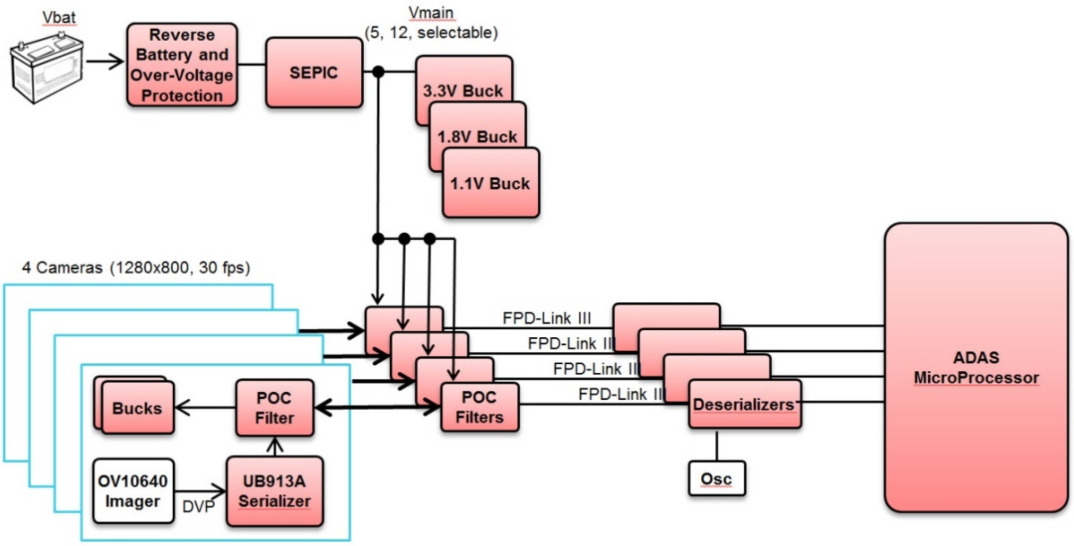


Figure 13: Simplified Surround View Block Diagram

7.1 Setup for Verifying Power Supply Startup - Vin, 3.3V, 1.8V and 1.5V Rails

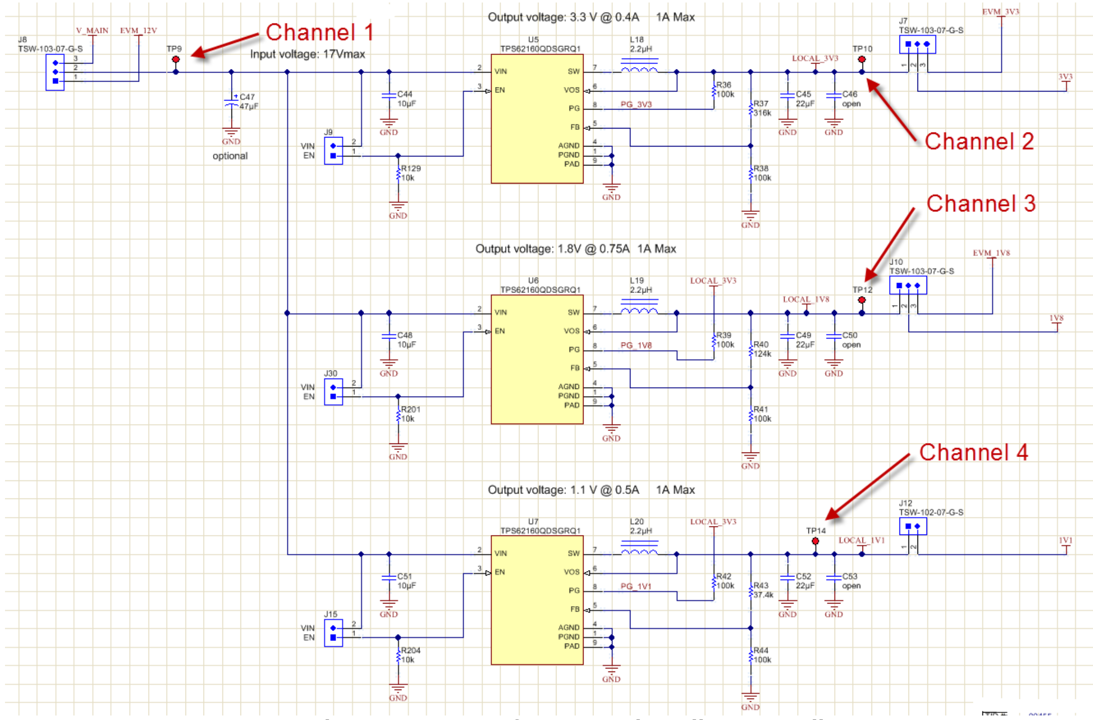


Figure 14: Setup for measuring all power rails

7.2 Setup for Verifying I2C Communications

For this test, a logic analyzer with I2C decode is used to monitor the I2C traffic on the buses. The two busses of interest are:

1. I2C connection from serializer to imager (shown as I2C_camera)
2. I2C connection from microprocessor to deserializer (shown as I2C_uC)

Connections must be made to both the clock and data lines of each bus.

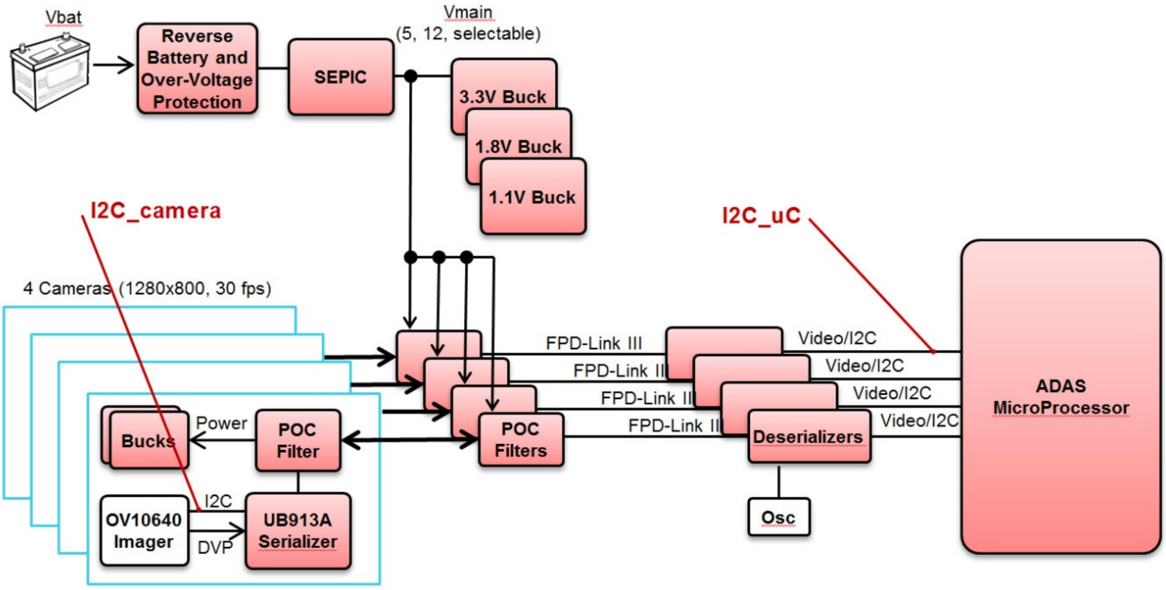


Figure 15: Setup for monitoring I2C transactions

8 Test Data

The following sections show the test data from verifying the functionality of the camera design.

8.1 Power Supply Startup - Vin, 3.3V, 1.8V and 1.5V Rails

The power supply startup waveforms are shown below.

- Channel 1 (yellow) 12V, Regulated Power Out From SEPIC Supply (TP9)
- Channel 2 (blue) 3.3V Switching Converter Output (TP10)
- Channel 3 (pink) 1.8V Switching Converter Output (TP12)
- Channel 4 (green) 1.1V Switching Converter Output (TP14)

All channels are displayed at 1V/division. The time scale is 100uS/division.

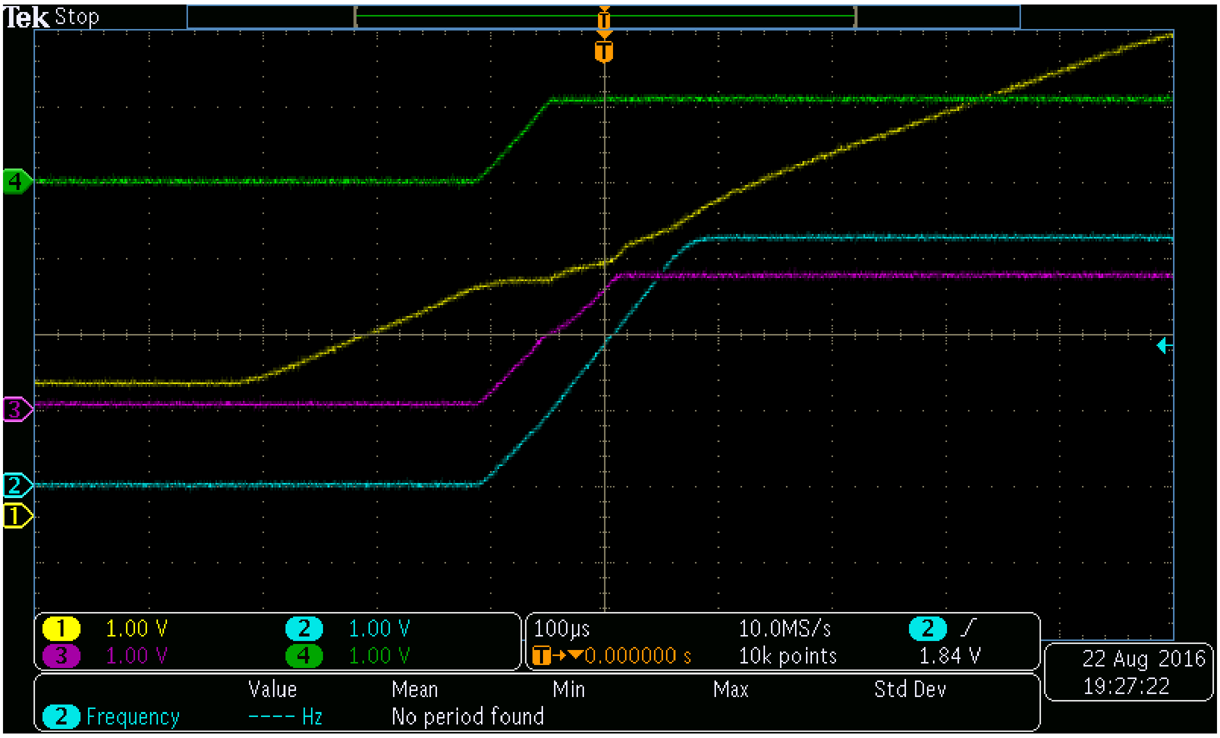


Figure 16: Power Supply Startup

8.2 I2C Communications

With the supplies up and running, we can now check the FPD-Link connection, the I2C aliasing and the state of the camera/imager in one step. The image below shows the initial communication between the microprocessor and the imager. This occurs after the microprocessor configures the deserializer, serializer, ISP and imager on the other end of the link. Since this communication comes from the uC on the TIDA-00455 board and is acknowledged by the camera(imager) on the TIDA-00421 board, this shows that the communication through the FPD-Link III is working. See figure 19.

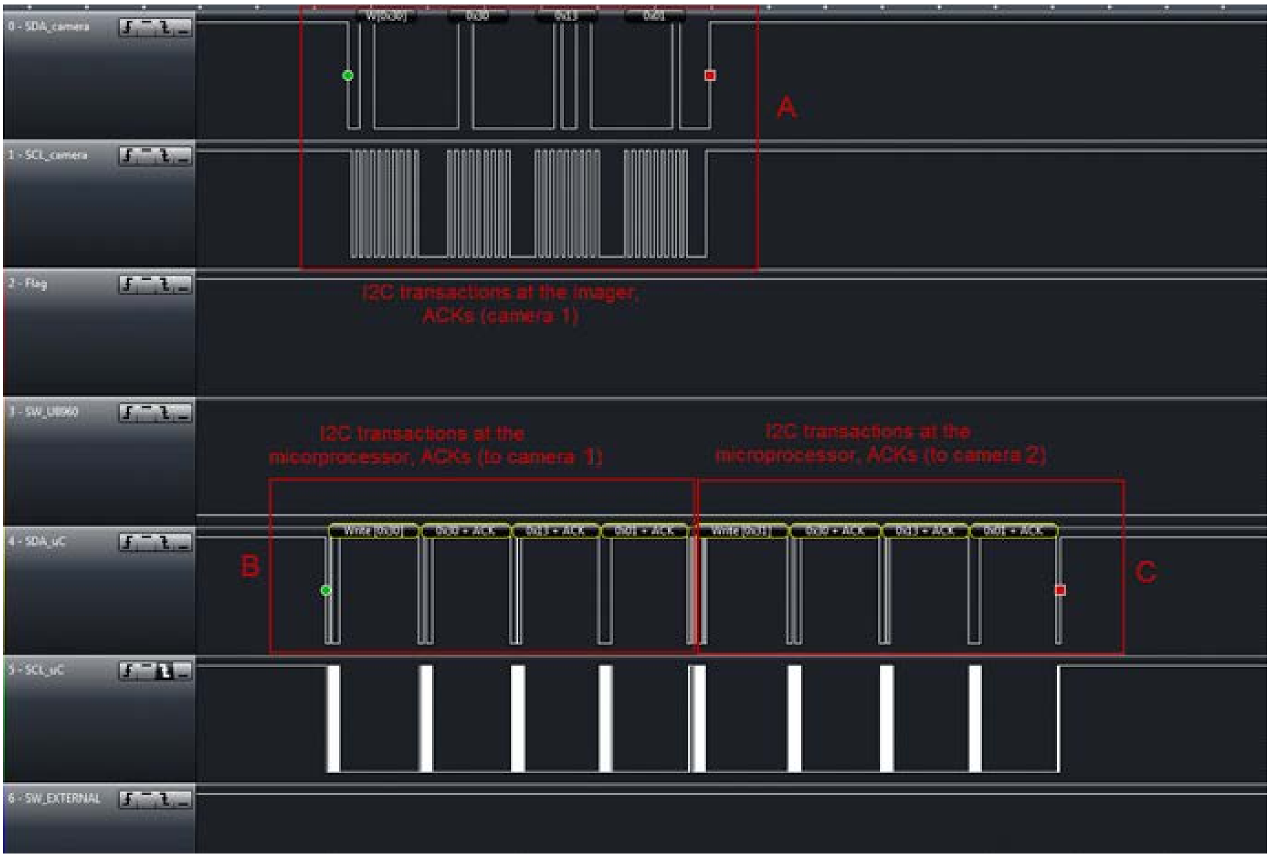


Figure 17: I2C Transactions

In figure 19, the box labeled B contains the first write from the microprocessor. It is addressed to address 0x30, the register address is 0x3013 and the data to be written is 0x1. Since the address is 0x30, the logic on the deserializer passes this transaction to the first camera in the system. It is routed to the imager, and the address is aliased to 0x30.

In box A, you can see the same communication, slightly delayed. This is the communication present on the camera 1 I2C bus, measured at the imager.

The write to address 0x31 in box C is for camera 2. (see figure 20) The deserializer passes this transaction to camera 2 and the address is aliased to 0x30. As you can see, this transaction is not present on the camera 1 I2C bus, because it is not intended for this camera.

By acknowledging the I2C write (ACK in box B), the imager on camera 1 has confirmed that it is present and alive. Similarly, the ACK in box C shows that the imager in camera 2 is responding.

Reading the status registers can confirm the status of the imager as well as verify that the correct imager was installed during assembly.

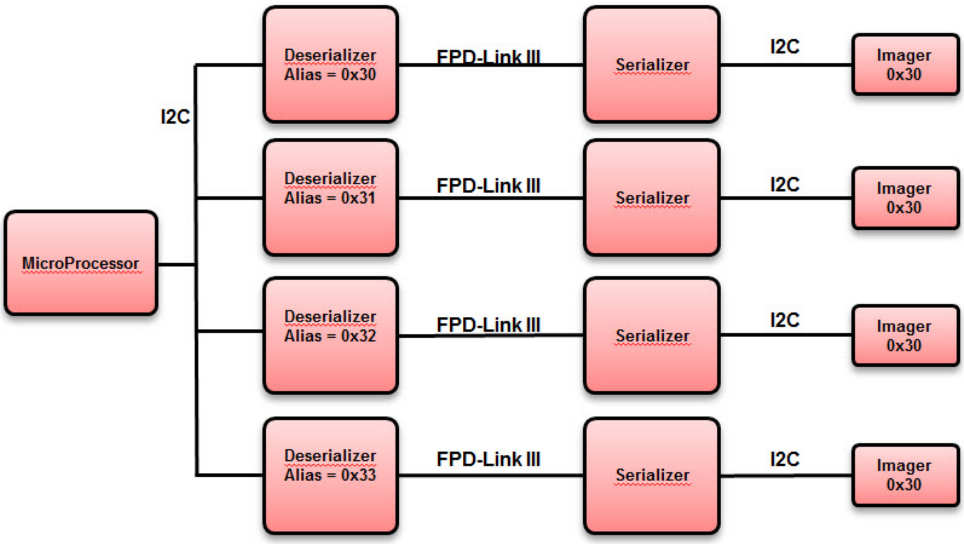


Figure 18: I2C Address Aliasing

8.3 Surround View Video

In this image, you can see the cameras mounted to a toy jeep. The video showing the 4 separate images as well as a combined view from the "top" is displayed on the LCD screen.

9 Board Programming or Re-Programming

If the board has not been programmed or the software needs to be updated, please use the following procedure.

OV490 Firmware

1. Follow the instructions in section 5, Getting Started with the Hardware
2. Add 3 jumpers to J31. This bridges the SPI MISO, MOSI and clock signals for the two OV490 devices allowing them to both be driven from one source.
3. Install jumper on pins 1 and 2 of J40. This sets the chip select to OV490 number.
4. Connect SPI to USB device to J25. The following steps will assume the use of a TotalPhase AARDVARK.
5. Connect AARDVARK to PC via USB cable.
6. Open TotalPhase Flash Center. Available here: http://www.totalphase.com/products/flash-center/
7. Click ***Add Adapter***, choose ***AARDVARK***
8. In the ***operations*** menu, select ***choose target***.
9. When the ***select target*** box comes up, click ***Load part file***.
10. Find and select file: ***winbond-spi-flash_TIDA_00455.xml***
11. Under device type, select ***SPI Flash***
12. Under Manufacturer, select ***Winbond / NexFlash***
13. Under Part Number, select ***W25Q128***
14. Click OK
15. Under the ***file*** menu, select ***load file*** change file type to ***binary***.
16. Select correct file to load into OV490 ISP
17. Erase part
18. Program Part
19. Once this is successful, move jumper on J40 to pins 2 and 3. This selects the second OV490 for programming.
20. Repeat steps 17 and 18 to program the second OV490
21. Remove all jumpers from J31
22. Press MSP430 RESET button (S1) on TIDA-00455 board.

MSP430 Code

1. Connect EZ430 development tool to J23
2. Connect USB cable to PC and to EZ430 development tool
3. Open ***Code Composer Studio***
4. Open project files for software to be loaded
5. Select ***Debug*** to load and software into MSP430
6. Press ***run*** to run in a debug environment, or remove EZ430 and
7. Press MSP430 RESET button (S1) on TIDA-00455 board.
8. Your software should now be running on the board.

TDA2x Software

1. See TDA2x EVM documentation for details.

10 Design Files

10.1 Schematics

The schematics that follow have been reduced to fit on the page. To download the Schematics or to view them as a high resolution PDF file, see http://www.ti.com/tool/tida-00455

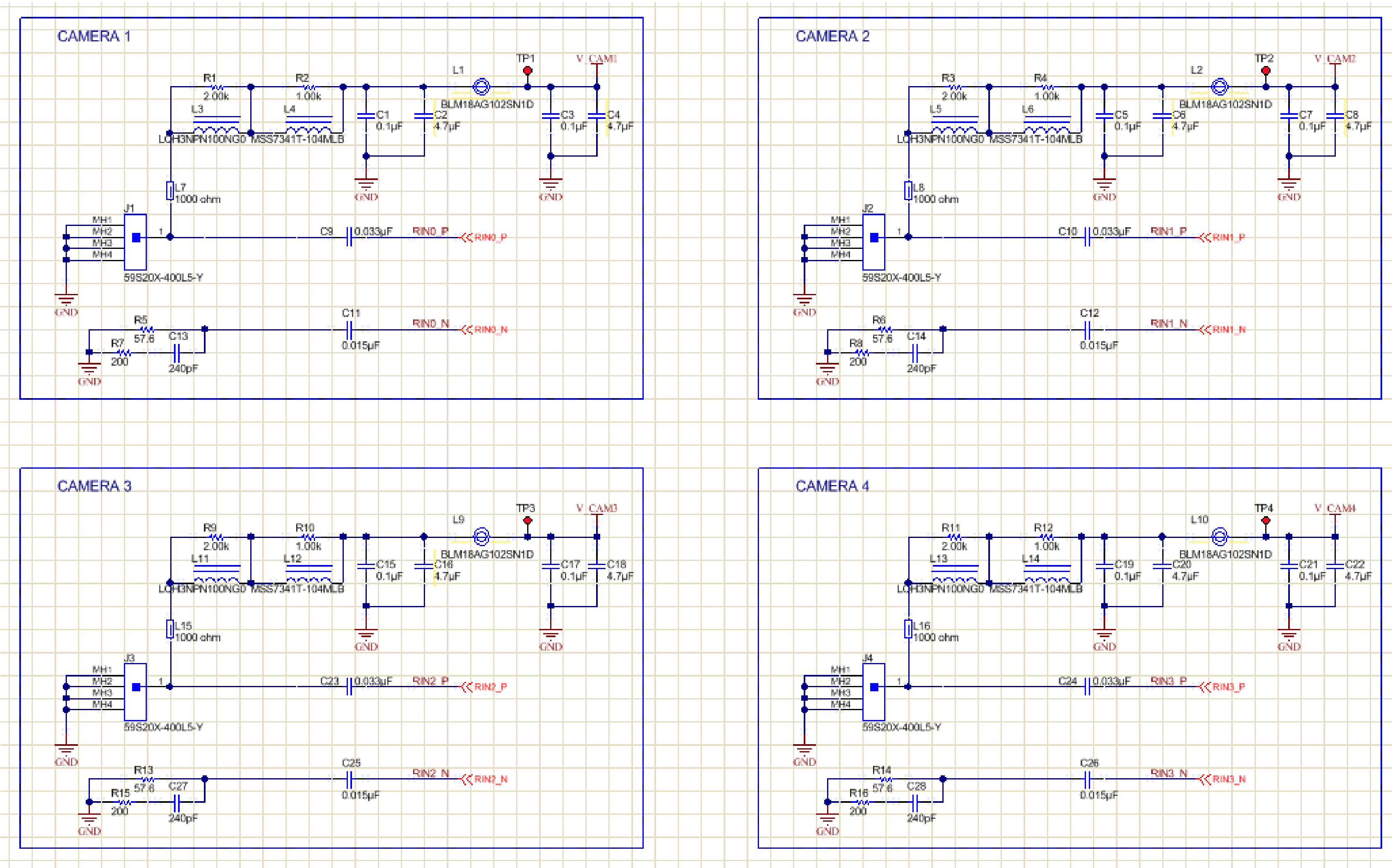


Figure 19: Camera Connections Schematic

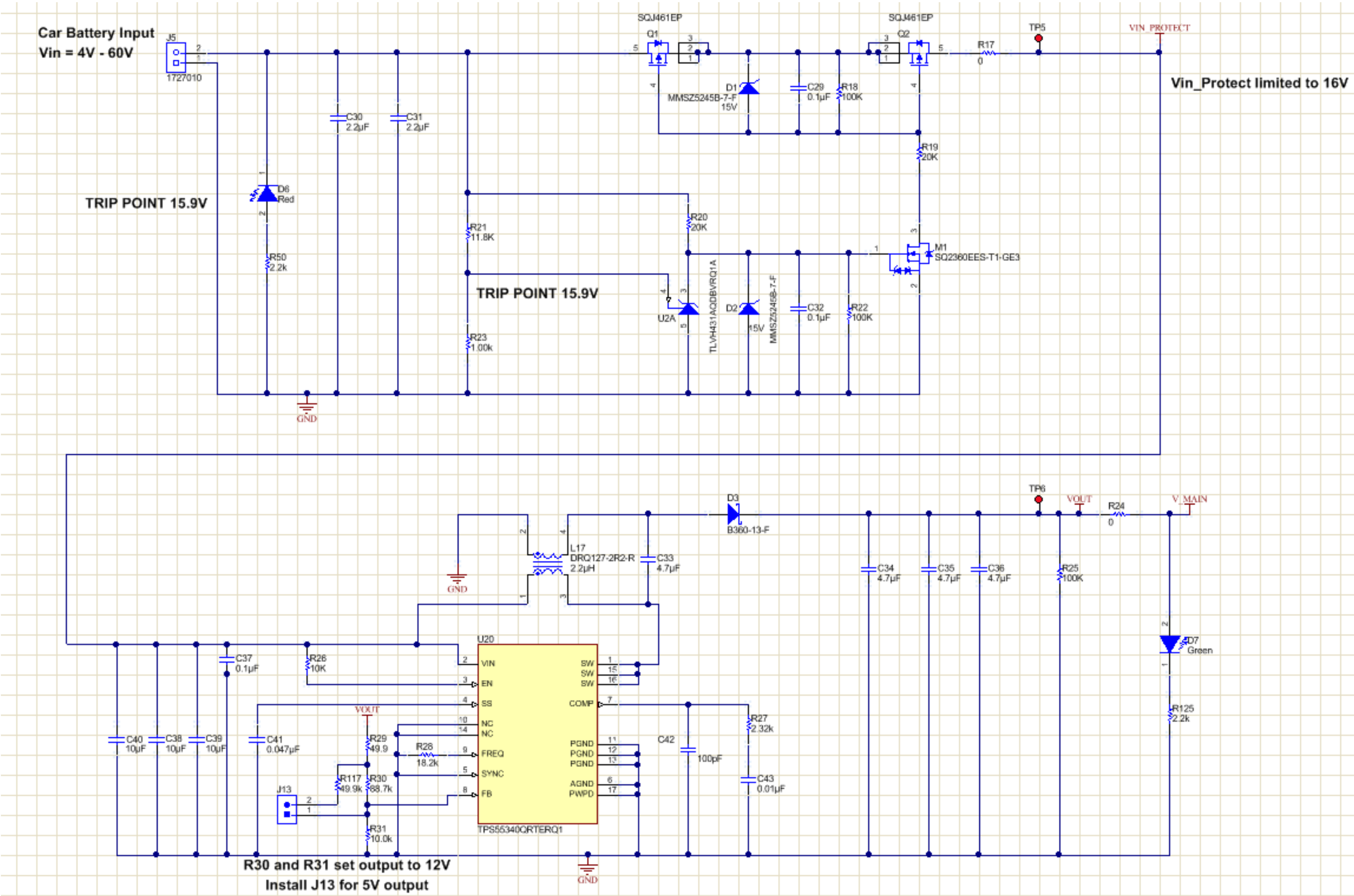


Figure 20: V Battery Power Supply Schematic

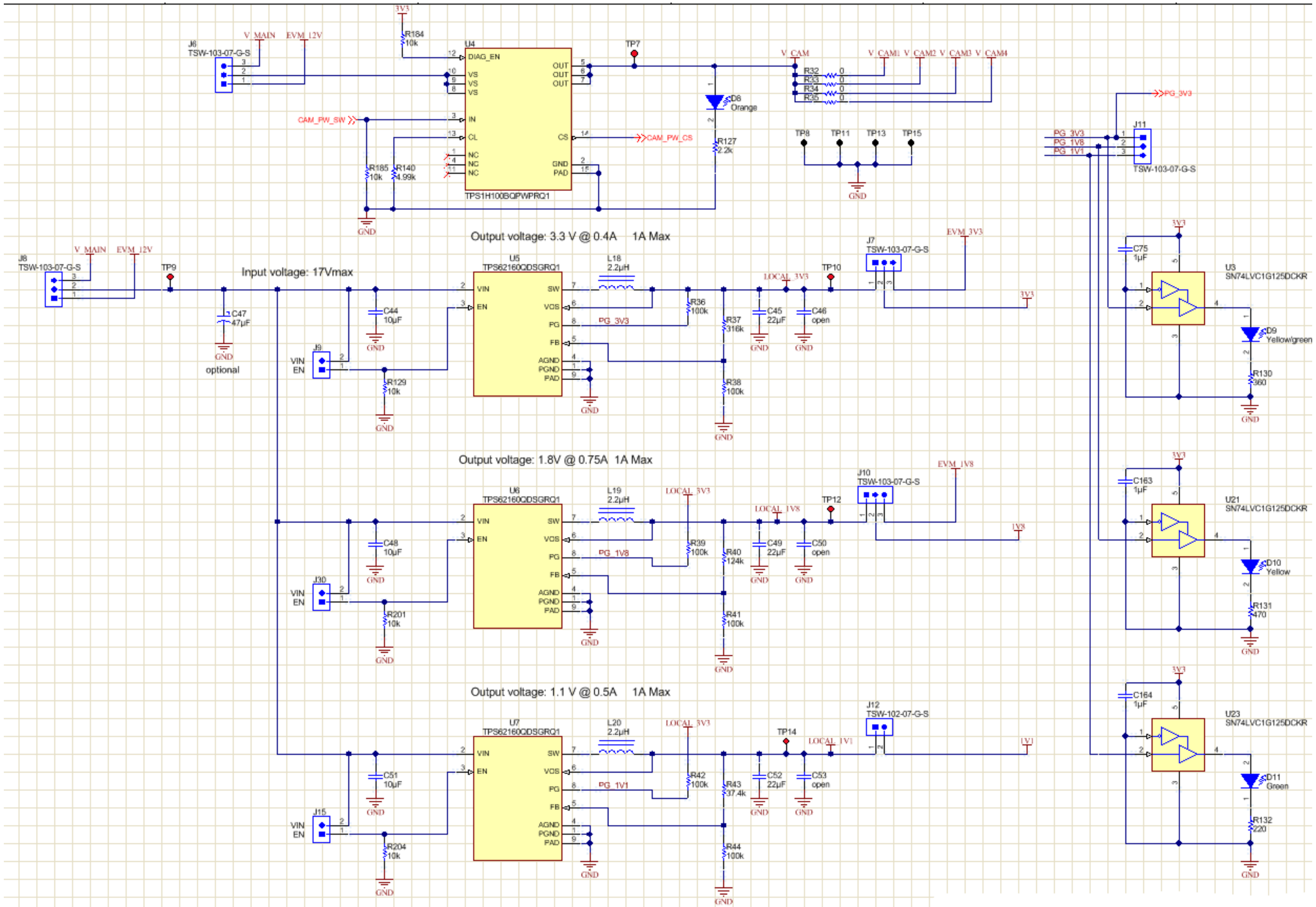


Figure 21: Camera Power Switch Buck Supplies Schematic

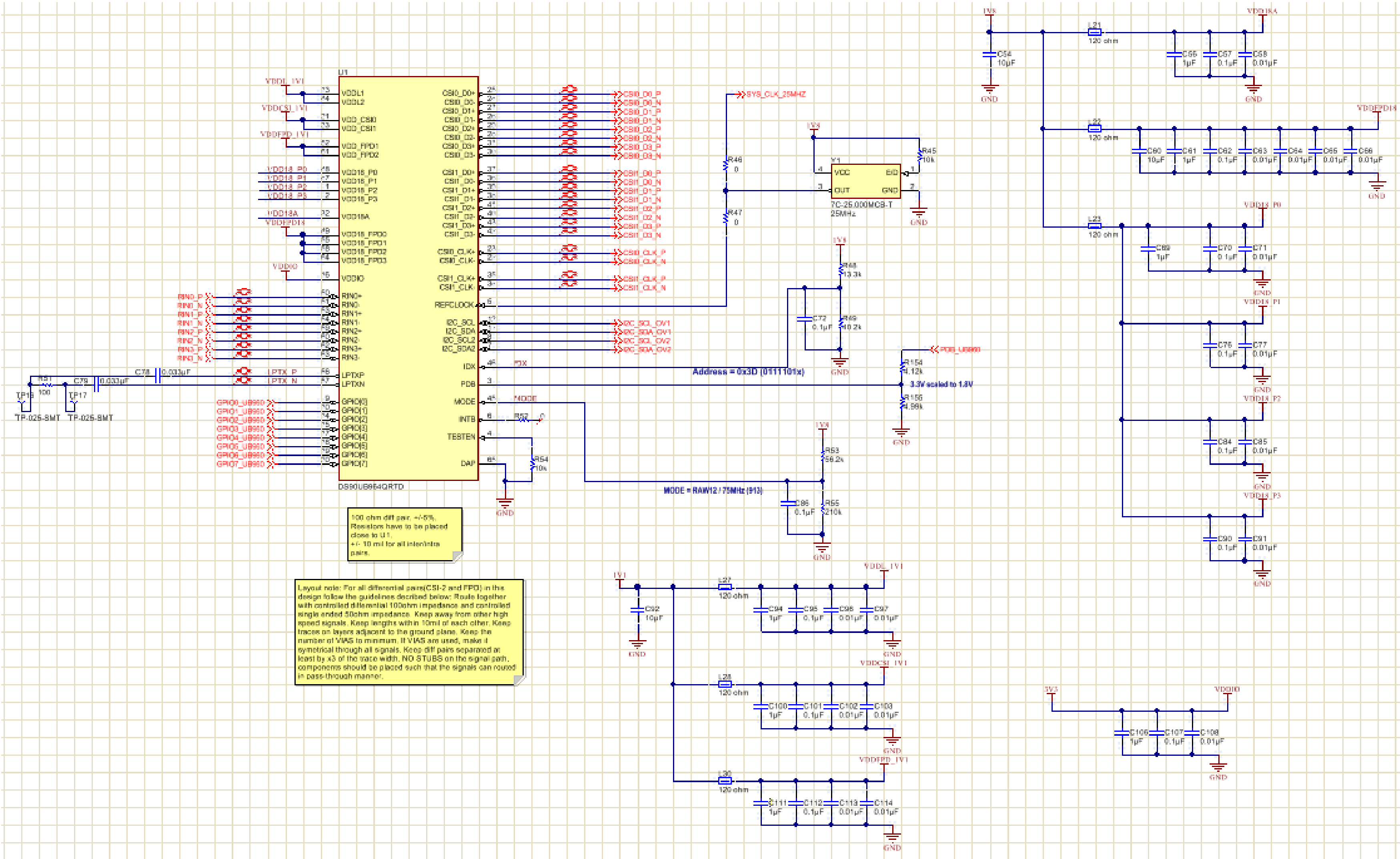


Figure 22: Deserializer Schematic

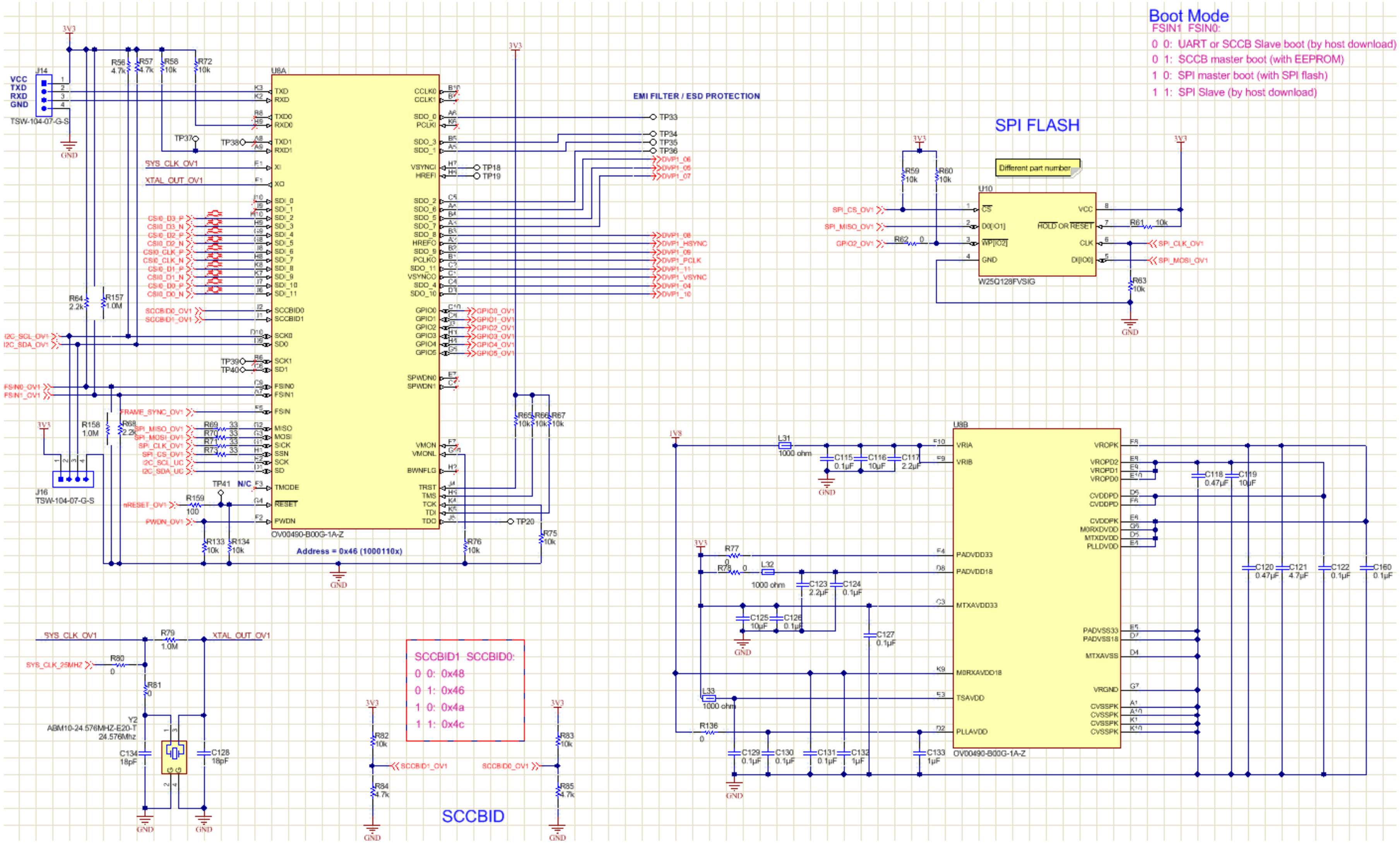


Figure 23: OV490 #1 Schematic

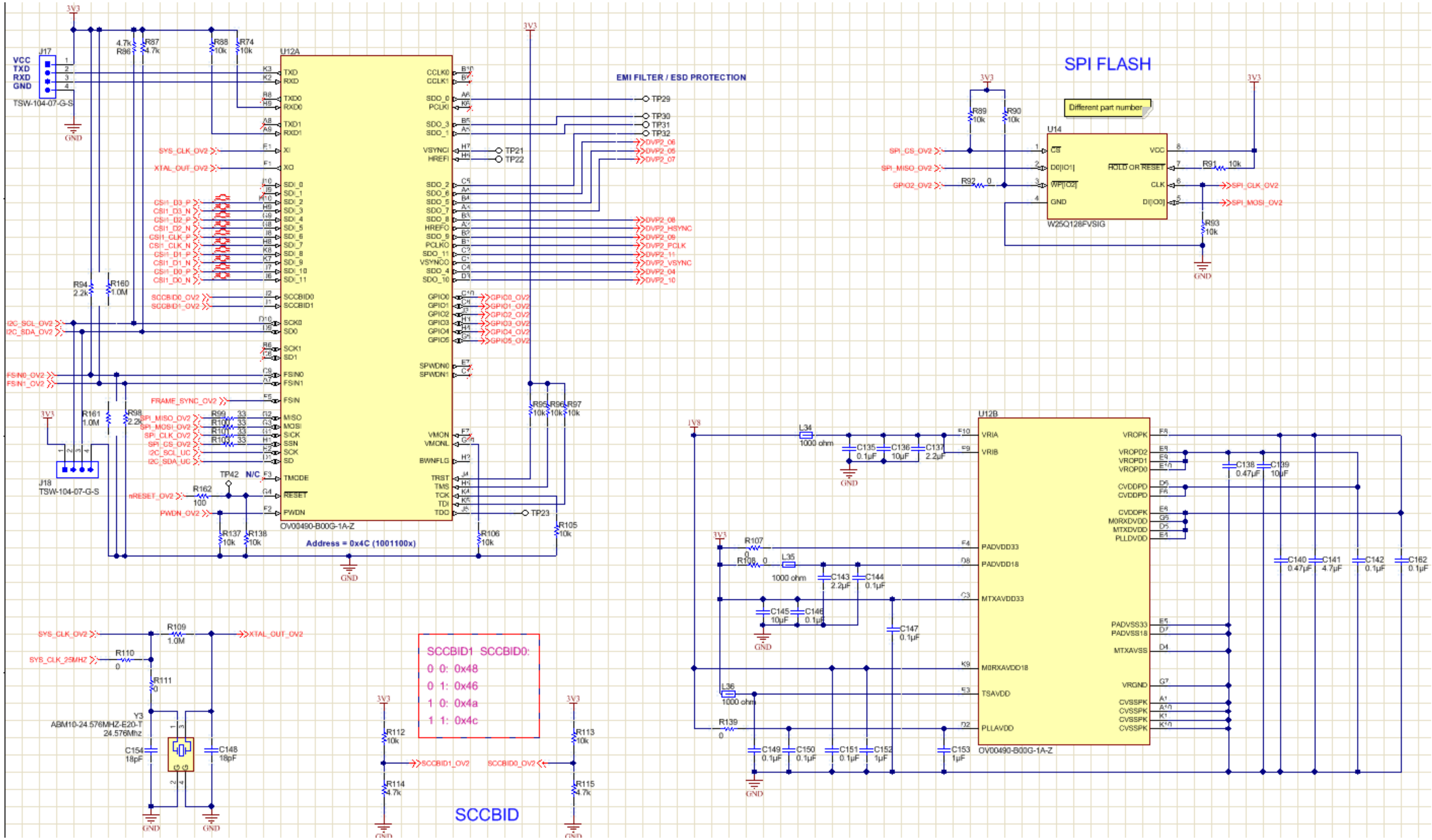


Figure 24: OV490 #2 Schematic

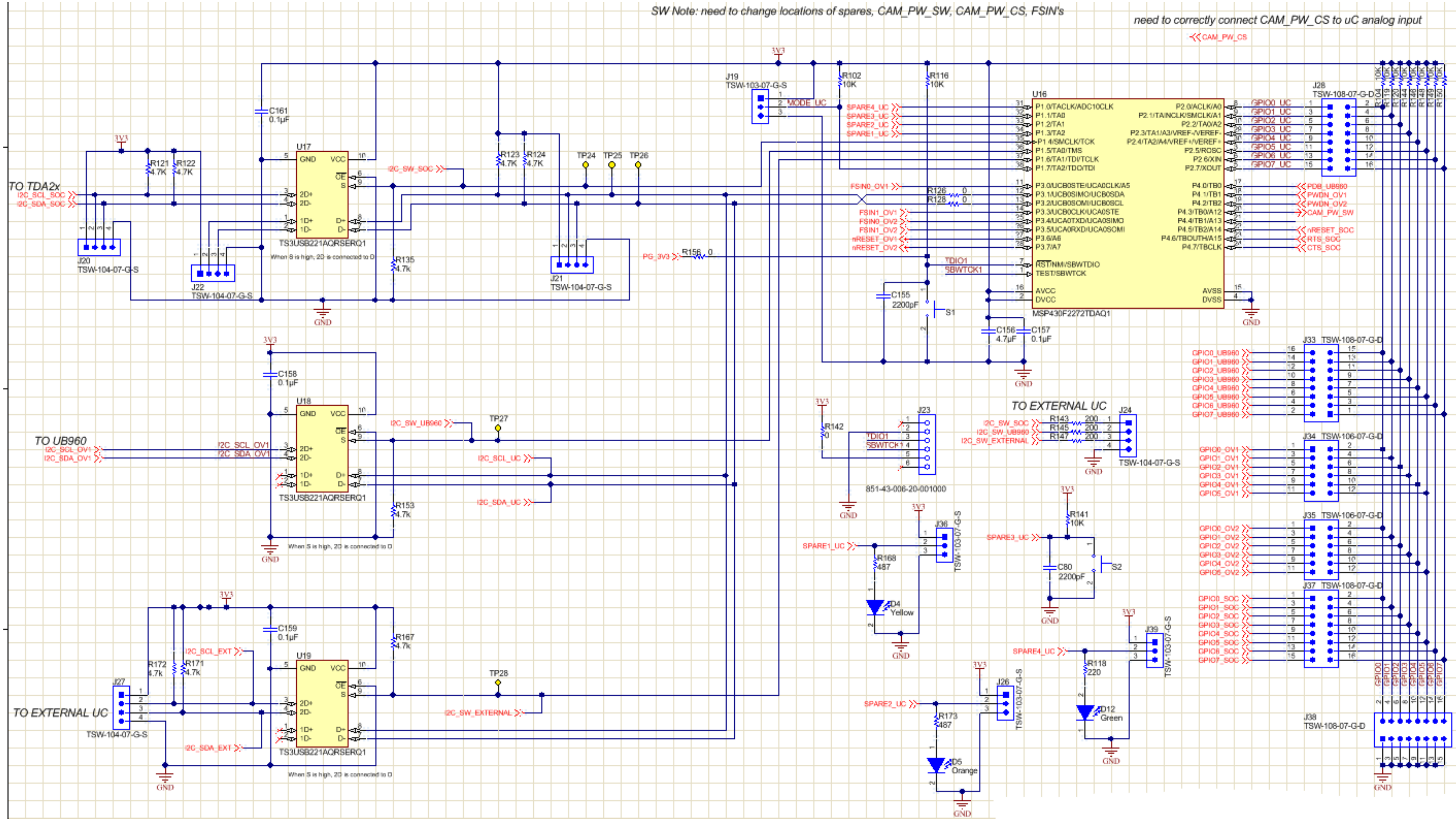


Figure 25: uC and I2C Switches Schematic

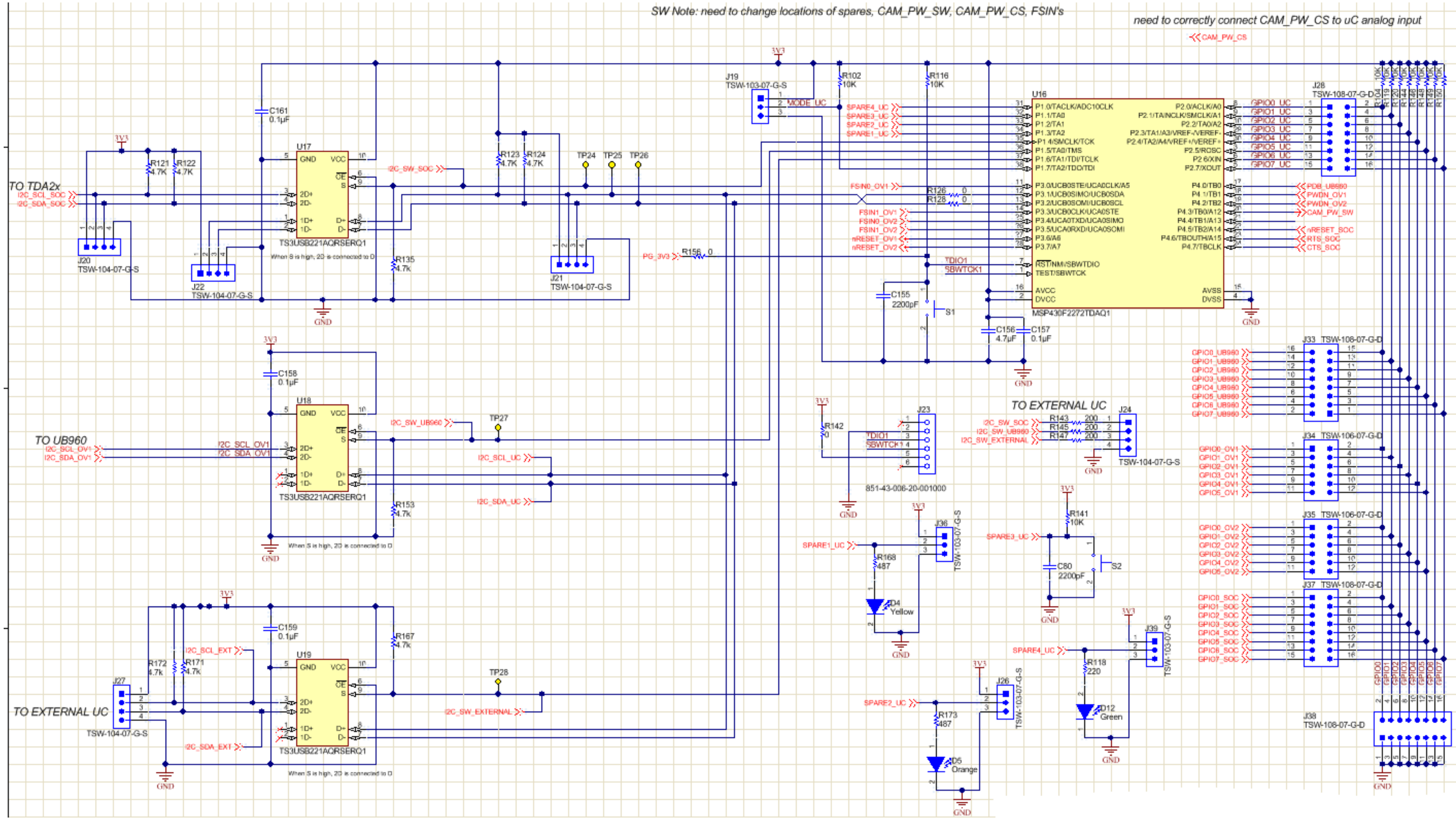


Figure 26: Connectors Schematic

10.2 Bill of Materials

To download the Excel version of the Bill of Materials for this board, see the design files at http://www.ti.com/tool/tida-00455

Filename: TIDA-00455E2.0(001)_BOM.xls
Variant: 001
Generated: 6/10/2015 3:08:29 PM
TID #: 00455

TIDA-00455 REV E2.0 Bill of Materials

Item #	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReferenc
1	!PCB1	1		TIDA-00455	Any	Printed Circuit Board	
2	C1, C3, C5, C7, C15, C17, C19, C21, C115, C122, C124, C126, C127, C129, C130, C131, C135, C142, C144, C146, C147, C149, C150, C151, C160, C162	26	0.1uF	C1005X7R1H104K050BB	TDK	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0402	0402
3	C2, C4, C6, C8, C16, C18, C20, C22	8	4.7µF	GRM188R61E475KE11D	Murata Electronics North Ame	CAP CER 4.7UF 25V 10% X5R 0603	0603 (1608 Metric)
4	C9, C10, C23, C24, C78, C79	6	0.033uF	CGA2B3X7R1H333K050BB	TDK	CAP, CERM, 0.033 µF, 50 V, +/- 10%, X7R, 0402	0402
5	C11, C12, C25, C26	4	0.015uF	CGA2B3X7R1H153K050BB	TDK	CAP, CERM, 0.015 µF, 50 V, +/- 10%, X7R, 0402	0402
6	C13, C14, C27, C28	4	240pF	GRM1555C1H241JA01D	MuRata	CAP, CERM, 240 pF, 50 V, +/- 5%, C0G/NP0, 0402	0402
7	C30, C31	2	2.2uF	GRM32ER72A225KA35L	MuRata	Cap, Cer-X7R, 2.2uF, 100V, 10%, 1210	1210
8	C32	1	0.1uF	C1608X7R1H104K	TDK	CAP, CERM, 0.1uF, 50V, +10%, X7R, 0603	0603
9	C33, C34, C35	3	4.7uF	C3216X7R1E475M	TDK	CAP, CERM, 4.7uF, 25V, +/-20%, X7R, 1206	1206
10	C37, C157	2		GRM155R70J104KA01D	MuRata	Cap, Cer-X7R, 0.1uF, 6.3V, 10%, 0402	0402
11	C38, C40	2		GRM31CR71E106KA12L	MuRata	Cap, Cer-X7R, 10uF, 25V, 10%, 1206	1206
12	C41	1		GRM155R70J473KA01D	MuRata	Cap, Cer-X7R, 0.047uF, 6.3V, 10%, 0402	0402
13	C42	1	100pF	CC0402KRX7R9BB101	Yageo America	Cap, Cer-X7R, 100pF, 50V, 10%, 0402	0402
14	C43	1		GRM155R71C103KA01D	MuRata	Cap, Cer-X7R, 10000pF, 16V, 10%, 0402	0402
15	C44, C48, C51	3		GRM31CR71C106KAC7L	MuRata	Cap, Cer-X7R, 10uF, 16V, 10%, 1206	1206
16	C45, C49, C52	3	22uF	GRM31CR61C226KE15L	MuRata	CAP, CERM, 22 µF, 16 V, +/- 10%, X5R, 1206	1206
17	C47	1	47uF	EEE-FK1E470P	Panasonic	CAP, AL, 47 µF, 25 V, +/- 20%, 0.36 ohm, SMD	SMT Radial D
18	C54, C60, C92	3	10uF	CL21A106KAFN3NE	Samsung	CAP, CERM, 10 µF, 25 V, +/- 10%, X5R, 0805	0805
19	C56, C61, C69, C75, C94, C100, C106, C111, C163, C164	10	1uF	C1005JB1V105K050BC	TDK	CAP, CERM, 1 µF, 35 V, +/- 10%, JB, 0402	0402
20	C57, C62, C70, C76, C84, C90, C95, C101, C107, C112	10	0.1uF	CGA2B3X7R1H104K050BB	TDK	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0402	0402
21	C58, C63, C64, C65, C66, C71, C77, C85, C91, C96, C97, C102, C103, C108, C113, C114	16	0.01uF	GCM155R71H103KA55D	MuRata	CAP, CERM, 0.01uF, 50V, +/-10%, C0G/NP0, 0402	0402
22	C72, C86	2	0.1uF	C1005X7R1H104M	TDK	CAP, CERM, 0.1uF, 50V, +/-20%, C0G/NP0, 0402	0402
23	C80, C155	2	2200pF	UMK105B7222KV-F	Taiyo Yuden	Cap, Cer-X7R, 2200pF, 50V, 10%, 0402	0402 (1005 Metric)
24	C116, C119, C125, C136, C139, C145	6	10uF	C2012X7R0J106M125AB	TDK	CAP, CERM, 10 µF, 6.3 V, +/- 20%, X7R, 0805	0805
25	C117, C137	2	2.2uF	C0603C225M8PACTU	Kemet	CAP, CERM, 2.2 µF, 10 V, +/- 20%, X5R, 0603	0603
26	C118, C120, C138, C140	4	0.47uF	C1005X5R1A474K050BB	TDK	CAP, CERM, 0.47 µF, 10 V, +/- 10%, X5R, 0402	0402
27	C121, C141	2	4.7uF	C1005X5R1A475K050BC	TDK	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0402	0402
28	C123, C143	2	2.2uF	C2012X5R1A225K/0.85	TDK	CAP, CERM, 2.2 µF, 10 V, +/- 10%, X5R, 0805	0805
29	C128, C134, C148, C154	4	18pF	GRM1885C2A180JA01D	MuRata	CAP, CERM, 18 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603
30	C132, C133, C152, C153	4	1uF	C0603C105K4PACTU	Kemet	CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0603	0603
31	C156	1	4.7uF	LMK212B7475KG-T	Taiyo Yuden	Cap, Cer-X7R, 4.7uF, 10V, 10%, 0805	0805
32	C158, C159, C161	3	0.1uF	0603YC104JAT2A	AVX	CAP, CERM, 0.1uF, 16V, +/-5%, X7R, 0603	0603

Item #	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReferenc
33	D1, D2	2	15V	MMSZ5245B-7-F	Diodes Inc.	Diode, Zener, 15 V, 500 mW, SOD-123	SOD-123
34	D3	1		B360-13-F	Diodes Inc.	Diode, Schottky, 3A, 60V, SMC	SMC
35	D4, D10	2	Yellow	SML-P12YTT86	Rohm	LED, Yellow, SMD	Yellow LED
36	D5, D8	2	Orange	SML-P12DTT86	Rohm	LED, Orange, SMD	Orange LED
37	D6	1	Red	SML-P12UTT86	Rohm	LED, Red, SMD	LED, 1x.2x.6mm
38	D7, D11, D12	3	Green	SML-P12PTT86	Rohm	LED, Green, SMD	LED, 1x.2x.6mm
39	D9	1	Yellow/green	SML-P12MTT86	Rohm	LED, Yellow/green, SMD	0402 LED
40	H1, H2, H3, H4	4		24430	Keystone	HEX Standoff M3 Aluminum 5 MM	
41	J1, J2, J3, J4	4		59S20X-400L5-Y	Rosenberger	RIGHT ANGLE PLUG FOR PCB	16.6x11.6x8.5mm
42	J5	1	2x1	1727010	Phoenix Contact	Conn Term Block, 2POS, 3.81mm, TH	2POS Terminal Block
43	J6, J7, J8, J10, J11, J19, J26, J36, J39, J40	10		TSW-103-07-G-S	Samtec	Header, 100mil, 3x1, Gold, TH	3x1 Header
44	J9, J13, J15, J30	4		PEC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin
45	J12	1		TSW-102-07-G-S	Samtec	Header, 100mil, 2x1, Gold, TH	2x1 Header
46	J14, J16, J17, J18, J20, J21, J22, J24, J27	9		TSW-104-07-G-S	Samtec	Header, 100mil, 4x1, Gold, TH	4x1 Header
47	J23	1		851-43-006-20-001000	Mill-Max	Receptacle, 50mil, 6x1, Gold, R/A, TH	Receptacle, 6x1, 50mil pitch, R/A
48	J25	1		TSW-105-07-G-D	Samtec	Header, 100mil, 5x2, Gold, TH	5x2 Header
49	J28, J33, J37, J38	4		TSW-108-07-G-D	Samtec	Header, 100mil, 8x2, Gold, TH	8x2 Header
50	J29	1		QTE-060-01-F-D-A	Samtec	Header, 0.8mm, 60x2, Gold, SMT	Header, 0.8mm, 60x2, SMT
51	J31	1		TSW-103-07-G-D	Samtec	Header, 100mil, 3x2, Gold, TH	3x2 Header
52	J32	1		TSW-108-07-G-S	Samtec	Header, 100mil, 8x1, Gold, TH	8x1 Header
53	J34, J35	2		TSW-106-07-G-D	Samtec	Header, 100mil, 6x2, Gold, TH	6x2 Header
54	L1, L2, L9, L10	4		BLM18AG102SN1D	Murata Electronics North Ame	FERRITE CHIP 1000 OHM 400MA 0603	0603 (1608 Metric)
55	L3, L5, L11, L13	4	10uH	LQH3NPN100NG0	MuRata	Inductor, Wirewound, Ferrite, 10 µH, 0.5 A, 0.57 ohm, SMD	3.0x0.9x3.0mm
56	L4, L6, L12, L14	4	100uH	MSS7341T-104MLB	Coilcraft	Inductor, Shielded Drum Core, Ferrite, 100 µH, 0.7 A, 0.28 ohm, SMD	MSS7341
57	L7, L8, L15, L16	4	1000 ohm	BLM15HG102SN1D	MuRata	Ferrite Bead, 1000 ohm @ 100 MHz, 0.25 A, 0402	0402
58	L17	1		DRQ127-2R2-R	Coiltronics	Ind, Dual, 2.2uH, 20%, 6.23A, 8.05mE, Shielded, SMD	12.5x8.0x12.5mm
59	L18, L19, L20	3	2.2uH	VLS201610HBX-2R2M	TDK	Inductor, Shielded, Ferrite, 2.2 µH, 1.45 A, 0.170 ohm, SMD	2.0x0.95x1.6mm
60	L21	1	120 ohm	BLM18SG121TN1D	MuRata	Ferrite Bead, 120 ohm @ 100 MHz, 3 A, 0603	0603
61	L22, L23, L27, L28, L30	5	120 ohm	BLM18SG121TN1D	MuRata	1.5A Ferrite Bead, 330 ohm @ 100MHz, SMD	0603
62	L31, L32, L33, L34, L35, L36	6	1000 ohm	BK2125HS102-T	Taiyo Yuden	Ferrite Bead, 1000 ohm @ 100 MHz, 0.3 A, 0805	0805
63	M1	1	60V	SQ2360EES-T1-GE3	Vishay-Siliconix	MOSFET, N/P-CH, 60 V, 4.4 A, SOT-23	SOT-23
64	Q1, Q2	2	-60V	SQJ461EP	Vishay-Siliconix	MOSFET, P-CH, -60V, 30A, PowerPAK_SO-8L	PowerPAK_SO-8L
65	R1, R3, R9, R11	4	2.00k	CRCW06032K00FKEA	Vishay-Dale	RES, 2.00 k, 1%, 0.1 W, 0603	0603
66	R2, R4, R10, R12	4	1.00k	ERJ-3EKF1001V	Panasonic	RES, 1.00 k, 1%, 0.1 W, 0603	0603
67	R5, R6, R13, R14	4	57.6	CRCW040257R6FKED	Vishay-Dale	RES, 57.6, 1%, 0.063 W, 0402	0402
68	R7, R8, R15, R16, R143, R145, R147	7	200	CRCW0402200RJNED	Vishay-Dale	RES, 200, 5%, 0.063 W, 0402	0402
69	R17	1	0	CRCW20100000Z0EF	Vishay-Dale	RES, 0, 5%, 0.75 W, 2010	2010
70	R18, R22	2	100K	ERJ-3EKF1003V	Panasonic Electronic Compor	Res, Chip, 100K, 1/10W, 1%, 0603	0603 (1608 Metric)
71	R19, R20	2	20K	RC0603FR-0720KL	Yageo America	Res, Chip, 20K, 1/10W, 1%, 0603	0603
72	R21	1	11.8K	CRCW060311K8FK	Vishay-Dale	RES, 11.8 ohm, 1%, 0.1W, 0603	0603
73	R23	1	1.00k	CRCW06031K00FKEA	Vishay-Dale	RES, 1.00k ohm, 1%, 0.1W, 0603	0603
74	R24, R136, R139	3	0	CRCW08050000Z0EA	Vishay-Dale	Res, Chip, 0E, 1/8W, JUMP, 0805	0805
75	R26, R102, R104, R116, R119, R120, R141, R144, R146, R148, R149, R150	12	10K	CRCW040210K0JNED	Vishay-Dale	Res, Chip, 10K, 1/16W, 5%, 0402	0402
76	R27	1	2.32k	CRCW04022K32FKED	Vishay-Dale	RES, 2.32k ohm, 1%, 0.063W, 0402	0402
77	R28	1	18.2k	CRCW040218K2FKED	Vishay-Dale	RES, 18.2k ohm, 1%, 0.063W, 0402	0402
78	R29	1	49.9	CRCW040249R9FKED	Vishay-Dale	RES, 49.9 ohm, 1%, 0.063W, 0402	0402

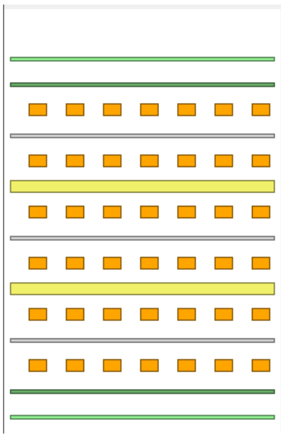
Item #	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReferenc
78	R29	1	49.9	CRCW040249R9FKED	Vishay-Dale	RES, 49.9 ohm, 1%, 0.063W, 0402	0402
79	R30	1	88.7k	CRCW040288K7FKED	Vishay-Dale	RES, 88.7 k, 1%, 0.063 W, 0402	0402
80	R31	1	10.0k	CRCW040210K0FKED	Vishay-Dale	RES, 10.0k ohm, 1%, 0.063W, 0402	0402
81	R32, R33, R34, R35, R156	5	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0 ohm, 5%, 0.1W, 0603	0603
82	R36, R38, R39, R41, R42, R44	6	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100 k, 1%, 0.1 W, 0603	0603
83	R37	1	316k	CRCW0603316KFKEA	Vishay-Dale	RES, 316 k, 1%, 0.1 W, 0603	0603
84	R40	1	124k	CRCW0603124KFKEA	Vishay-Dale	RES, 124 k, 1%, 0.1 W, 0603	0603
85	R43	1	37.4k	CRCW060337K4FKEA	Vishay-Dale	RES, 37.4 k, 1%, 0.1 W, 0603	0603
86	R45, R54	2	10k	CRCW040210K0JNED	Vishay-Dale	RES, 10k ohm, 5%, 0.063W, 0402	0402
87	R47	1	0	ERJ-2GE0R00X	Panasonic	RES, 0, 5%, 0.063 W, 0402	0402
88	R48	1	13.3k	CRCW040213K3FKED	Vishay-Dale	RES, 13.3 k, 1%, 0.063 W, 0402	0402
89	R50, R64, R68, R94, R98, R125, R127	7	2.2k	CRCW04022K20JNED	Vishay-Dale	RES, 2.2 k, 5%, 0.063 W, 0402	0402
90	R51, R159, R162	3	100	CRCW0402100RFKED	Vishay-Dale	RES, 100 ohm, 1%, 0.063W, 0402	0402
91	R52, R78, R108, R151, R152, R174, R175, R176, R177, R178, R179, R180, R181, R182, R186, R187, R188, R189, R190, R191, R192, R193, R194, R195, R196, R197, R198, R199, R200, R202, R203, R205, R206, R207, R208, R209, R210, R211, R212, R213, R214, R215, R216, R217, R218, R219, R220, R221, R222, R223, R224	51	0	ERJ-2GE0R00X	Panasonic	RES, 0 ohm, 5%, 0.063W, 0402	0402
92	R53	1	56.2k	CRCW040256K2FKED	Vishay-Dale	RES, 56.2 k, 1%, 0.063 W, 0402	0402
93	R55	1	210k	CRCW0402210KFKED	Vishay-Dale	RES, 210 k, 1%, 0.063 W, 0402	0402
94	R56, R57, R84, R86, R87	5	4.7k	CRCW04024K70JNED	Vishay-Dale	RES, 4.7 k, 5%, 0.063 W, 0402	0402
95	R58, R59, R60, R61, R63, R65, R66, R67, R72, R74, R75, R76, R83, R88, R89, R90, R91, R93, R95, R96, R97, R105, R106, R112, R113, R129, R133, R134, R137, R138, R184, R185, R201, R204	34	10k	CRCW040210K0JNED	Vishay-Dale	RES, 10 k, 5%, 0.063 W, 0402	0402
96	R62, R77, R81, R92, R107, R111	6	0	CRCW04020000Z0ED	Vishay-Dale	RES, 0, 5%, 0.063 W, 0402	0402
97	R69, R70, R71, R73, R99, R100, R101, R103	8	33	CRCW040233R0JNED	Vishay-Dale	RES, 33, 5%, 0.063 W, 0402	0402

A	B	C	D	E	F	G	H
Item #	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
98	R79, R109, R157, R158, R160, R161	6	1.0Meg	CRCW04021M00JNED	Vishay-Dale	RES, 1.0 M, 5%, 0.063 W, 0402	0402
99	R117	1	49.9k	CRCW040249K9FKED	Vishay-Dale	RES, 49.9 k, 1%, 0.063 W, 0402	0402
100	R118, R132	2	220	CRCW0402220RJNED	Vishay-Dale	RES, 220, 5%, 0.063 W, 0402	0402
101	R121, R122, R123, R124	4	4.7K	CRCW04024K70JNED	Vishay-Dale	Res, Chip, 4.7K, 1/16W, 5%, 0402	0402
102	R126, R128, R163, R164, R165, R166	6	0	CRCW04020000Z0ED	Vishay-Dale	RES, 0 ohm, 5%, 0.063W, 0402	0402
103	R130	1	360	CRCW0402360RJNED	Vishay-Dale	RES, 360, 5%, 0.063 W, 0402	0402
104	R131	1	470	CRCW0402470RJNED	Vishay-Dale	RES, 470, 5%, 0.063 W, 0402	0402
105	R135, R153, R167, R171, R172	5	4.7k	CRCW06034K70JNEA	Vishay-Dale	RES, 4.7k ohm, 5%, 0.1W, 0603	0603
106	R140, R155	2	4.99k	CRCW04024K99FKED	Vishay-Dale	RES, 4.99 k, 1%, 0.063 W, 0402	0402
107	R154	1	4.12k	CRCW04024K12FKED	Vishay-Dale	RES, 4.12 k, 1%, 0.063 W, 0402	0402
108	R168, R173	2	487	CRCW0402487RFKED	Vishay-Dale	RES, 487 ohm, 1%, 0.063W, 0402	0402
109	S1, S2	2		SKRKAEE010	Alps	Switch, Tactile, 12v, 50mA, Vertical, SMD	2.9x2x3.9mm SMD
110	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP9, TP10, TP12, TP14	11	Red	5000	Keystone	Test Point, Miniature, Red, TH	Red Miniature Testpoint
111	TP8, TP11, TP13, TP15, TP43, TP44, TP45, TP46	8	Black	5001	Keystone	Test Point, Miniature, Black, TH	Black Miniature Testpoint
112	TP24, TP25, TP26, TP27, TP28	5	Yellow	5004	Keystone	Test Point, Miniature, Yellow, TH	Yellow Miniature Testpoint
113	U1	1		DS90UB964QRTD	Texas Instruments	FPD-Link III Camera Hub Deserializer, RTD0064E	RTD0064E
114	U2	1		TLVH431AQDBVRQ1A	Texas Instruments	Automotive Catalog Low-Voltage Adjustable Precision Shunt Regulator, 80 mA, -40 to 125 degC, 5-pin SOT-23 (DBV), Green (RoHS & no Sb/Br)	DBV0005A
115	U3, U21, U23	3		SN74LVC1G125DCKR	Texas Instruments	Single Bus Buffer Gate With 3-State Output, DCK0005A	DCK0005A
116	U4	1		TPS1H100BQPWPRQ1	Texas Instruments	40V/100mO Single Channel Smart High Side Switch, Automotive Qualified, PWP0014C	PWP0014C
117	U5, U6, U7	3		TPS62160QDSGRQ1	Texas Instruments	3-V to 17-V 1-A Step-Down Converter with DCS-Control™, DSG0008A	DSG0008A
118	U8, U12	2		OV00490-B00G-1A-Z	OmniVision Technologies	Companion ISP processor, BGA100	100 pin BGA
119	U10, U14	2		W25Q128FVSIG	Winbond	3V 128M-bit Serial Flash Memory With Dual SPI&QPI, SO-8	SOIC-8, 208mil wide
120	U16	1		MSP430F2272TDA	Texas Instruments	16 MHz Mixed Signal Microcontroller with 32 KB Flash, 1024 B SARM and 32 GPIOs, -40 to 105 degC, 38-pin SOP (DA)	DA0038A
121	U17	1		TS3USB221AQRSERQ1	Texas Instruments	IC, TS3USB221A-Q1, Dual USB Switch, UQFN-10	RSE0010A
122	U18, U19	2		TS3USB221AQRSERQ1	Texas Instruments	Automotive Catalog ESD Protected, High-Speed USB 2.0 (480-Mbps) 1:2 Multiplexer / Demultiplexer Switch, 16 ohm RON, 2.5 to 3.3V, -40 to 125 degC, 10-Pin UQFN (RSE), Green (RoHS & no Sb/Br)	RSE0010A
123	U20	1		TPS55340QRTERQ1	Texas Instruments	Integrated 5-A 40-V Wide Input Range Boost/SEPIC/Flyback DC-DC Regulator, RTE0016C	RTE0016C
124	Y1	1		7C-25.000MCB-T	TXC Corporation	XO, 25.000MHz, 2.5V, SMD	5.0x1.2x3.2mm
125	Y2, Y3	2		ABM10-24.576MHZ-E20-T	Abracon Corportation	Crystal, 24.576MHz, 10pF, SMD	2.5x0.5x2.0mm
126	C29	0	0.1uF	C1608X7R1H104K	TDK	CAP, CERM, 0.1uF, 50V, +10/%, X7R, 0603	0603
127	C36	0	4.7uF	C3216X7R1E475M	TDK	CAP, CERM, 4.7uF, 25V, +/-20%, X7R, 1206	1206
128	C39	0		GRM31CR71E106KA12L	MuRata	Cap, Cer-X7R, 10uF, 25V, 10%, 1206	1206
129	C46, C50, C53	0				CAP, open, 1206	1206
130	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	Fiducial
131	R25	0	100K	CRCW1206100KJNEA	Vishay-Dale	Res, Chip, 100K, 1/4W, 5%, 1206	1206
132	R46	0	0	ERJ-2GE0R00X	Panasonic	RES, 0, 5%, 0.063 W, 0402	0402
133	R49	0	40.2k	CRCW040240K2FKED	Vishay-Dale	RES, 40.2 k, 1%, 0.063 W, 0402	0402
134	R80, R110	0	0	CRCW04020000Z0ED	Vishay-Dale	RES, 0, 5%, 0.063 W, 0402	0402
135	R82	0	10k	CRCW040210K0JNED	Vishay-Dale	RES, 10 k, 5%, 0.063 W, 0402	0402
136	R85, R114, R115	0	4.7k	CRCW04024K70JNED	Vishay-Dale	RES, 4.7 k, 5%, 0.063 W, 0402	0402
137	R142	0	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0 ohm, 5%, 0.1W, 0603	0603
138	TP16, TP17	0	STD	STD	STD	Test Point, O.025"	
139	TP18, TP19, TP20, TP21, TP22, TP23	0	SMT	5015	Keystone	Test Point, Miniature, SMT	Testpoint_Keystone_ Miniature

10.3 PCB Layout Recommendations

10.3.1 PCB Layer Stackup Recommendations

- Use at least a four layer board with a power and ground plane. Locate LVCMOS signals away from the differential lines to prevent coupling from the LVCMOS lines to the differential lines
- If using a 4 layer board, layer 2 should be a ground plane. Since most of the components/switching currents are on the top layer, this reduces the inductive effect of the vias when currents are returned through the plane.
- An additional two layers were used in this board to simplify BGA fan out and routing. Here is the 6 layer stack-up used in this board:



Layer Name	Type	Material	Thickness (mil)	Dielectric Material	Dielectric Constant	Pullback (mil)	Orientation
Top Overlay	Overlay						
Top Solder	Solder Mask/Co...	Surface Material	0.4	Solder Resist	3.5		
Layer 1 - Top Lay...	Signal	Copper	1.4				Top
Dielectric 1	Dielectric	Prepreg	5.91	370HR	4.2		
Layer 2 - GND	Signal	Copper	1.417				Not Allowed
Dielectric 2	Dielectric	Core	10	370HR	4.2		
Layer 3 - PWR	Signal	Copper	1.417				Not Allowed
Dielectric 3	Dielectric	Prepreg	20	370HR	4.2		
Layer 4 - Signal	Signal	Copper	1.417				Not Allowed
Dielectric 4	Dielectric	Core	10	370HR	4.2		
Layer 5 - GND	Signal	Copper	1.417				Not Allowed
Dielectric 5	Dielectric	Prepreg	5.91	370HR	4.2		
Layer 6 - Bottom...	Signal	Copper	1.4				Bottom
Bottom Solder	Solder Mask/Co...	Surface Material	0.4	Solder Resist	3.5		
Bottom Overlay	Overlay						

Figure 27: Layer Stackup

10.3.2 Switching DC-DC Converter

During part placement and routing, it is helpful to always consider the path the current will be taking through the circuit. The yellow line in figure 28 shows the current path in through across the input capacitor (C44), the switch in the converter (U5), Inductor (L18), and then out across the output capacitors (C45, C46). Any return currents from the input capacitor (C44) or the output capacitors (C45, C46) are joined together on the top side of the board before they are connected to the ground (return) plane (inside the green circle). This will reduce the amount of return currents in the internal ground plane, and thereby, voltage gradients seen by other circuits on the board. This may not be noticeable in the performance of the converter, but it will reduce its coupled noise into other devices. The figure below shows the layout of the switch mode power supply with the routing outlined and solid.

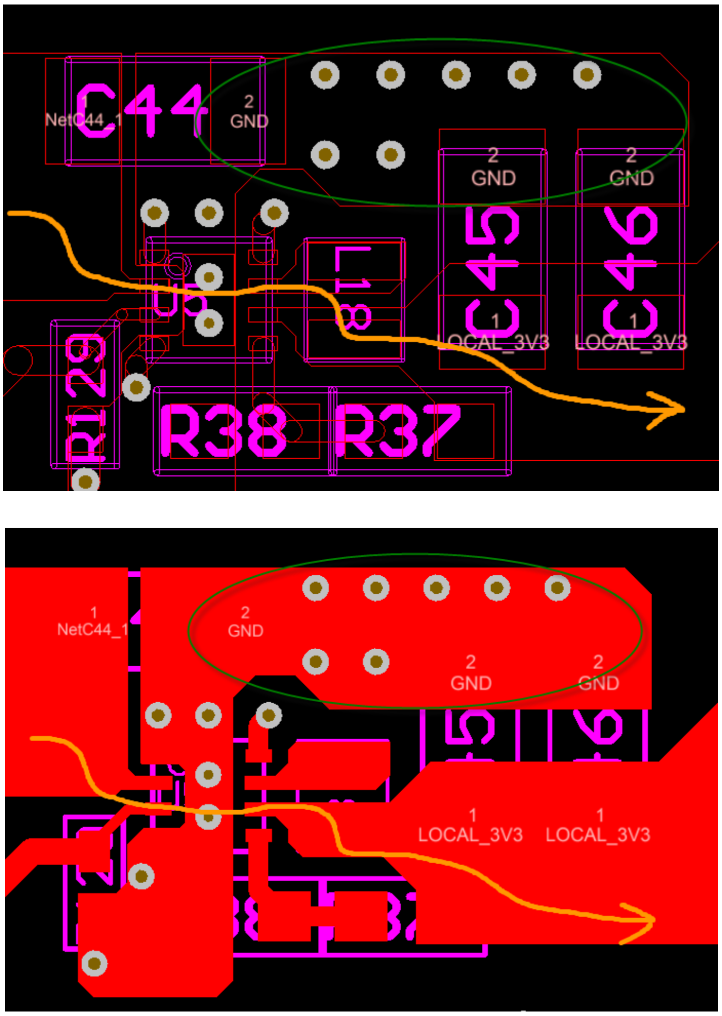


Figure 28: Step-Down Switch Mode Power Supply Routing

Input capacitors should be placed as close to the IC as possible to reduce the parasitic series inductance from the capacitor to the device it is supplying. This is especially important for DCDC converters as the inductance from the capacitor to the high-side switching FET can cause high voltage spikes and ringing on the switch node, which can be damaging to components and cause problems for EMI.

10.3.3 Deserializer Layout Recommendations

Decoupling capacitors need to be located very close to the supply pin on the serializer. Again, this requires that you consider the path of the supply current and the return current. Keeping the loop area of this connection small reduces the parasitic inductance associated with the connection of the capacitor. Due to space constraints, ideal placement is not always possible. Smaller value capacitors that provide higher frequency decoupling should be placed closest to the device.

Figure 26 shows the supply current from C85 in yellow. The green line is the return path. The cross sectional area of this loop is very small. A similar sketch for C84 would show a slightly larger loop.

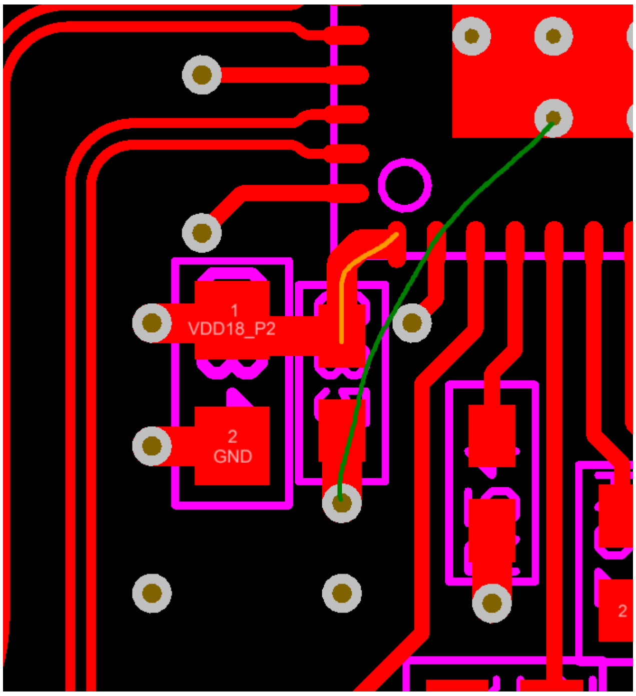


Figure 29: Decoupling Current Loop

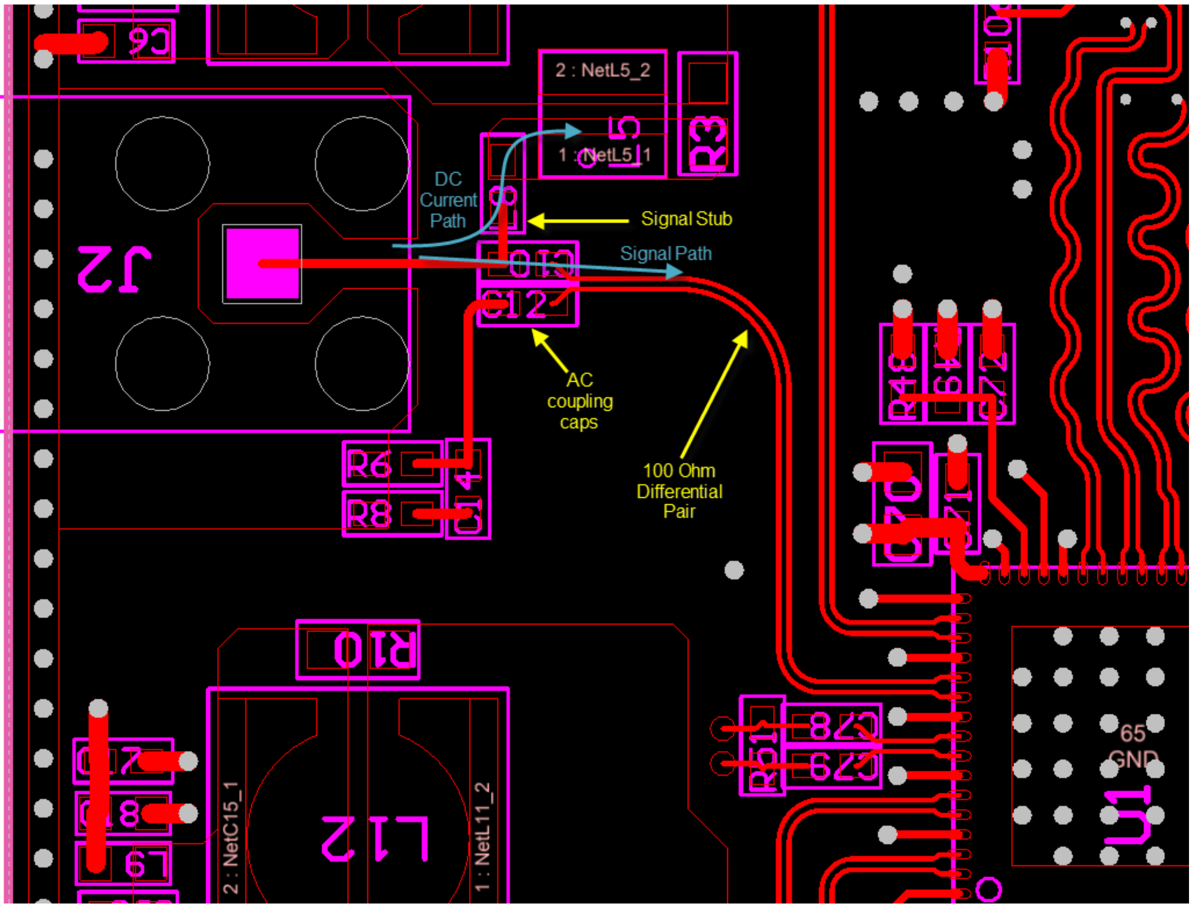


Figure 30: Decoupling Current Loop

When routing the coaxial input to the Power over Coax (POC) filter, care must be taken to reduce stubs on the LVDS nets. In figure 27, the high speed signal comes in from J2 and passes through C10 to U1. The DC current path is through L8 to L5. For the high speed signal, this path to L8/L5 is a stub. Minimizing the length of this stub will reduce reflections on the LVDS lines and lead to better signal integrity.

10.3.4 Layout Prints

To download the Layout Prints for each board, see the design files at:
http://www.ti.com/tool/tida-00455

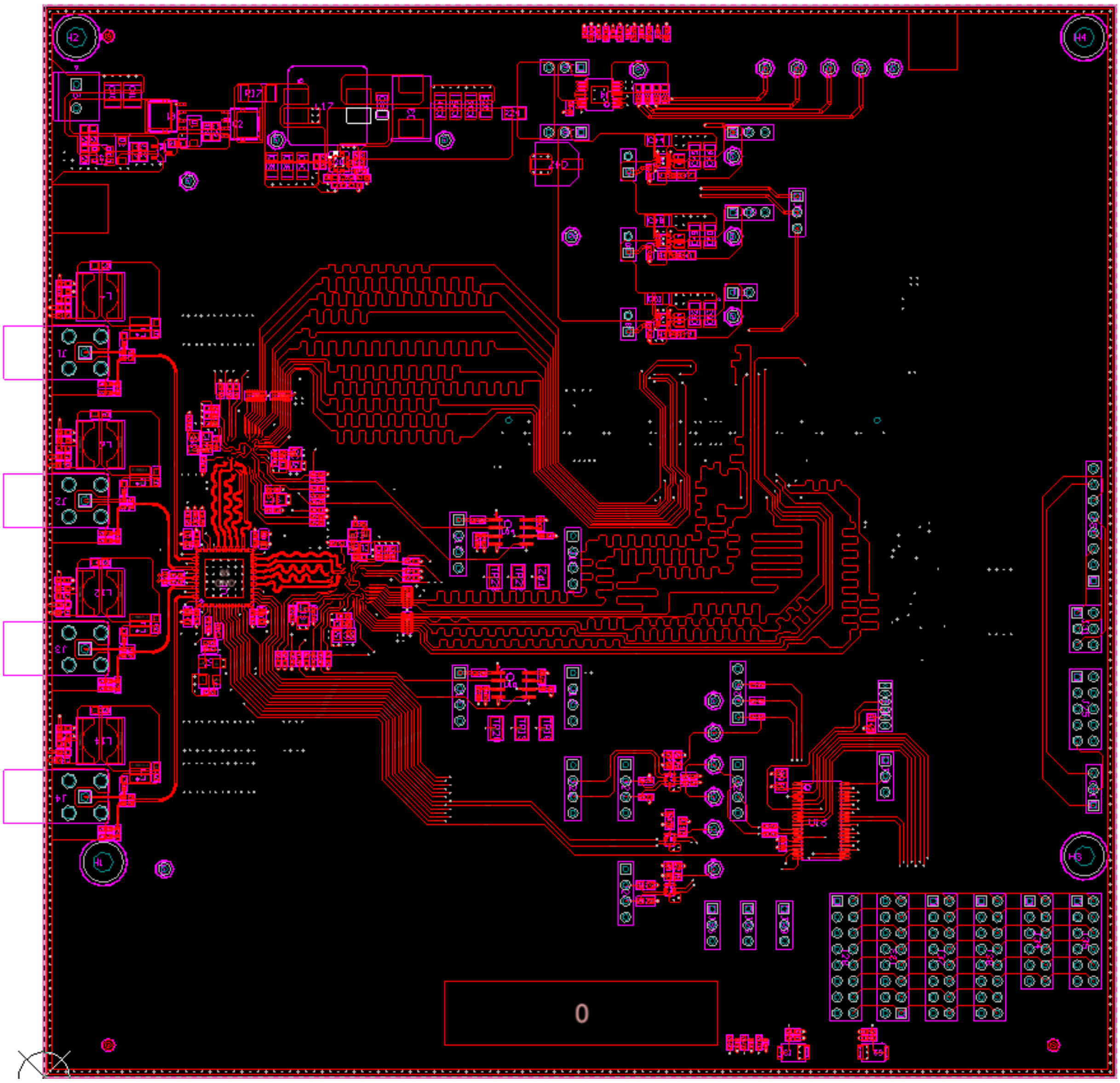


Figure 31: Layer 1: Top

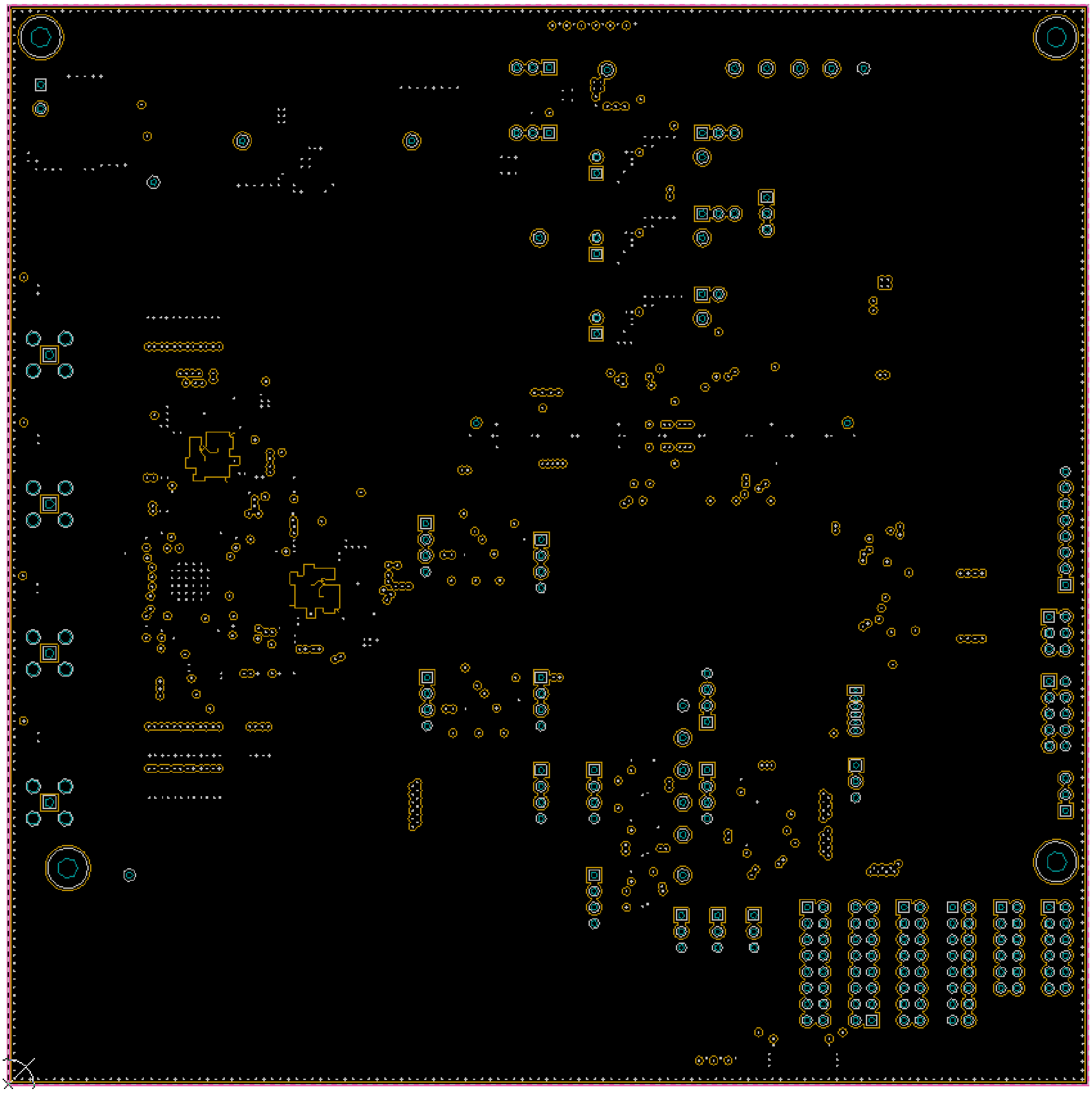


Figure 32: Layer 2: Ground

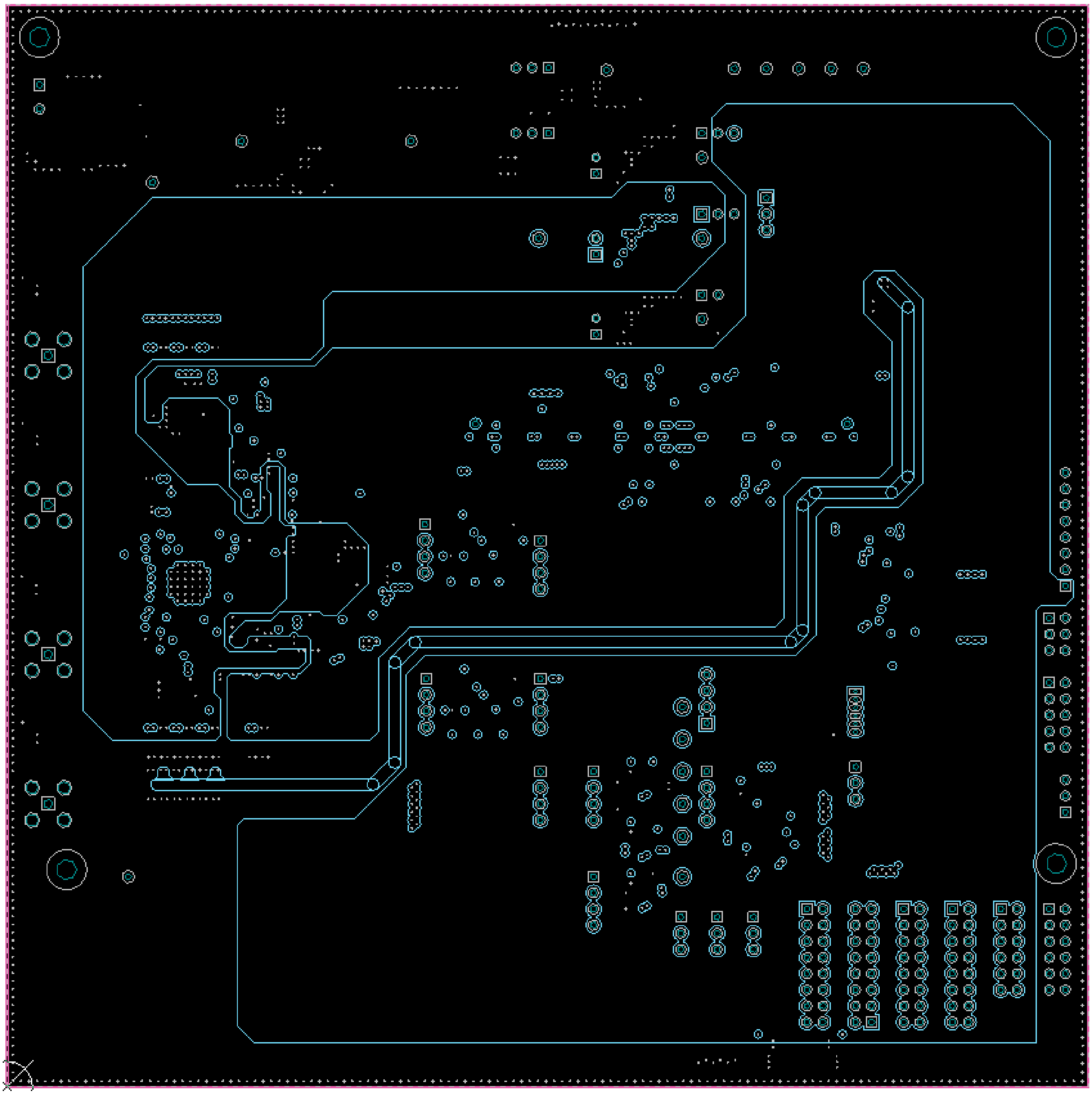


Figure 33: Layer 3: Power

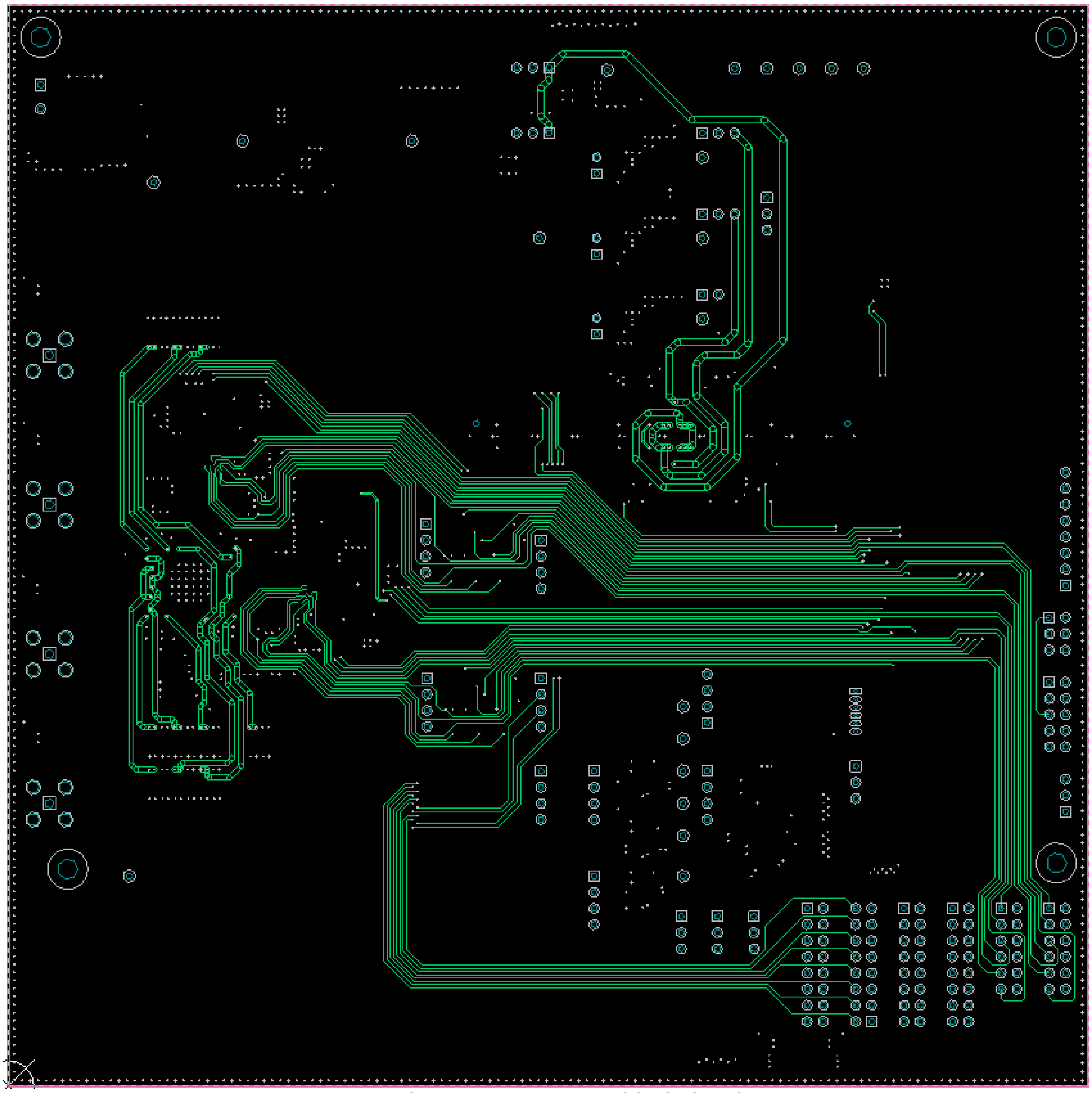


Figure 34: Layer 4: Critical Signal

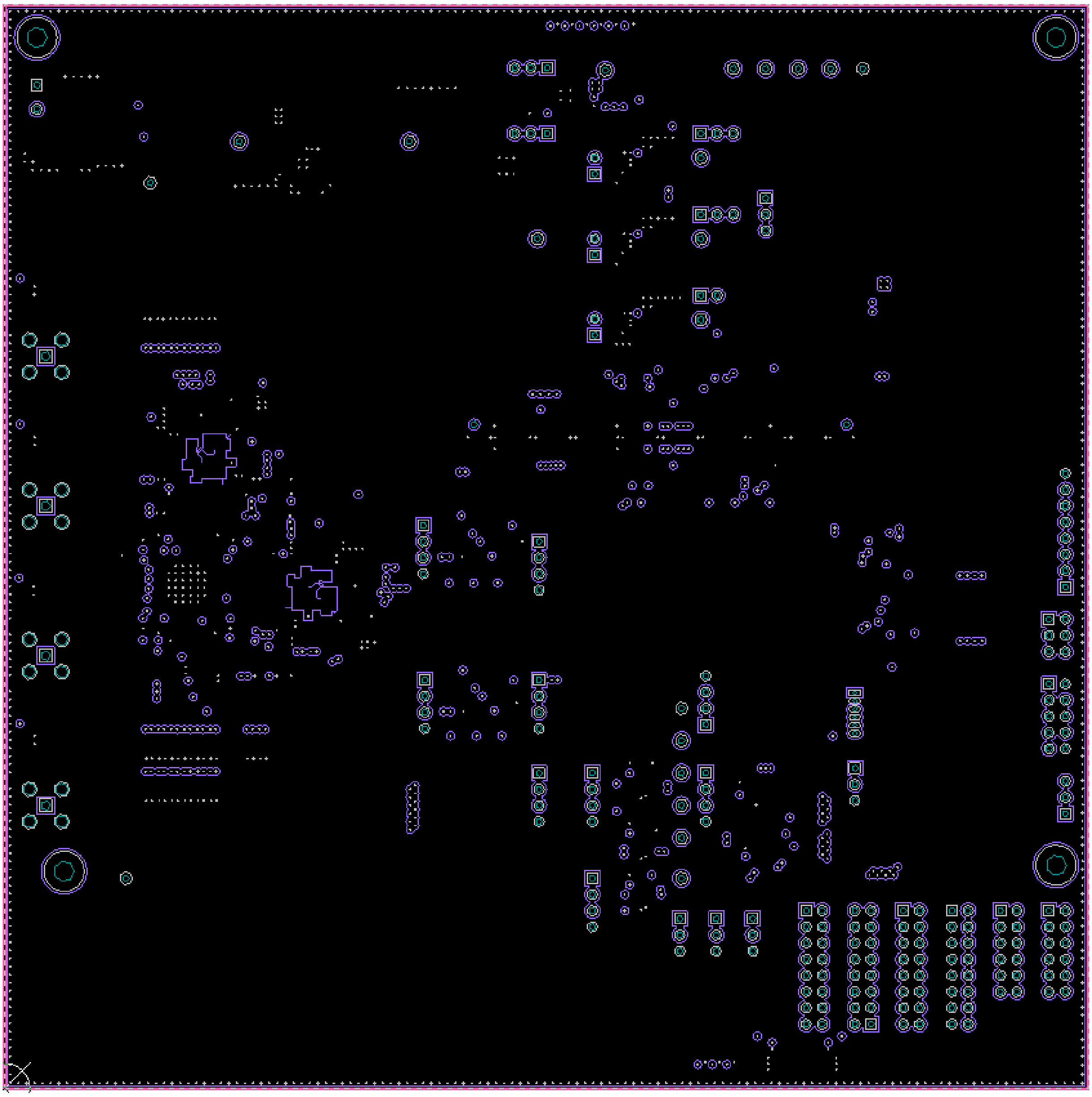


Figure 35: Layer 5: Ground

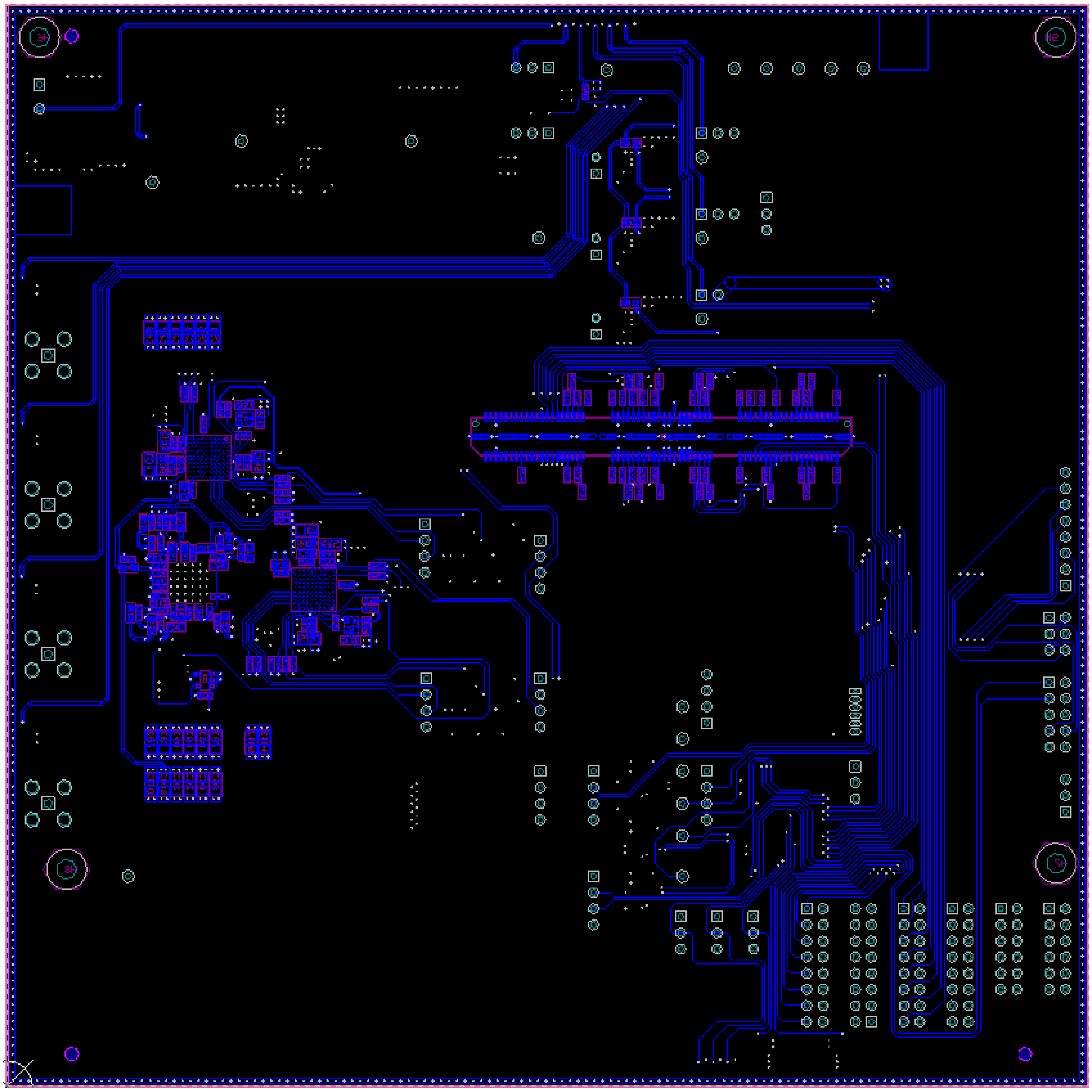


Figure 36: To Layer 6: Bottom

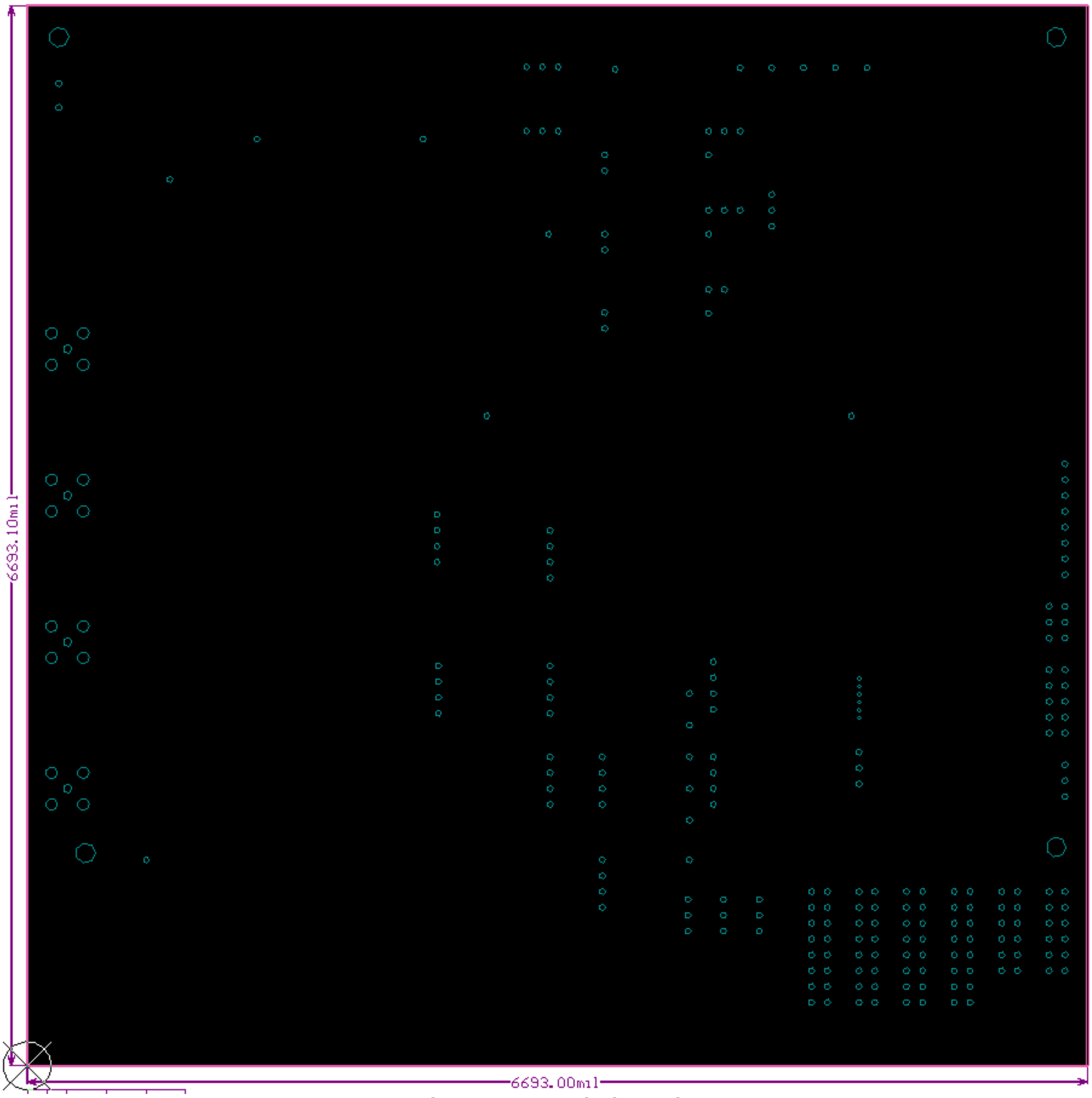


Figure 37: Board Dimensions

10.4 Gerber files

To download the Gerber files for each board, see the design files at http://www.ti.com/tool/tida-00455

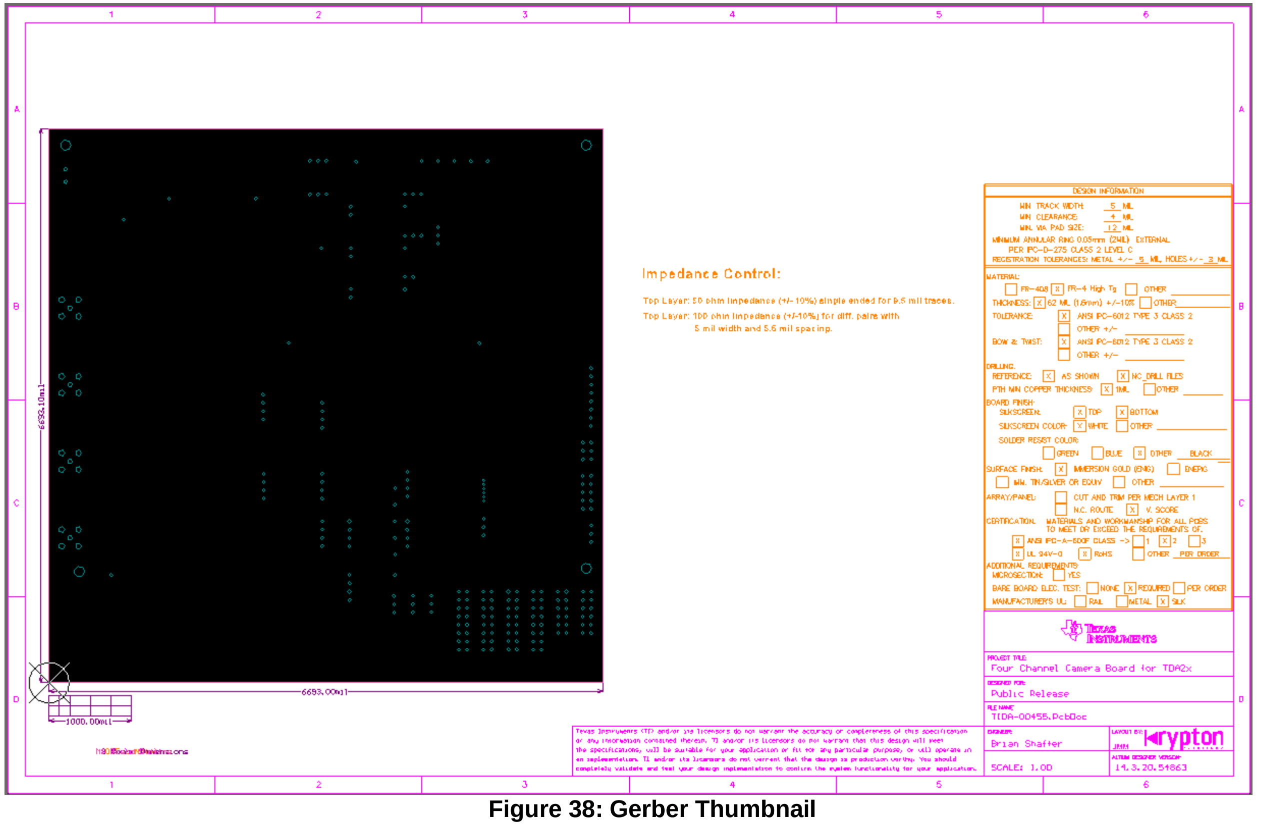
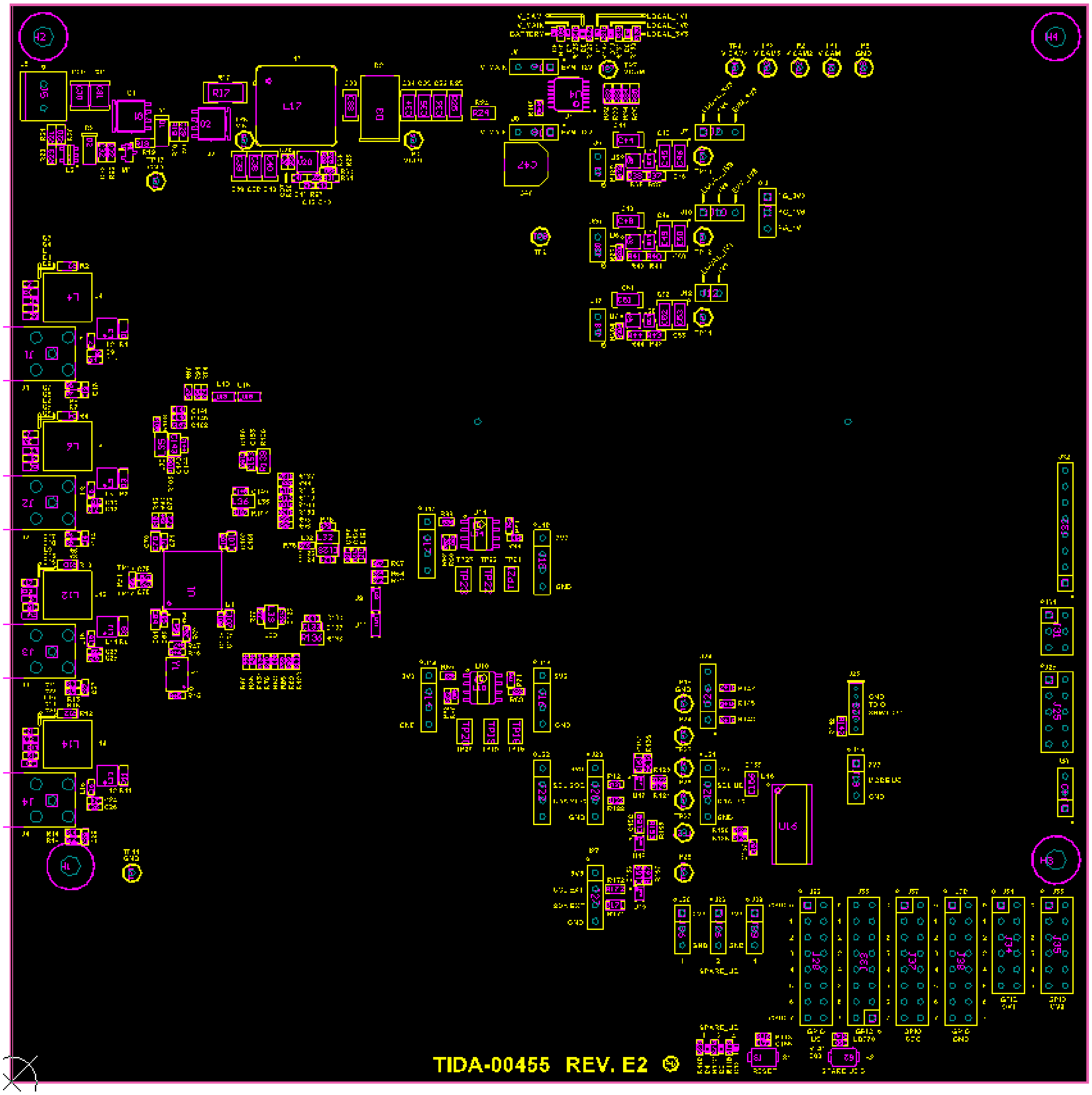


Figure 38: Gerber Thumbnail

10.5 Assembly Drawings

To download the Assembly Drawings for each board, see the design files at:
http://www.ti.com/tool/tida-00455


TIDA-00455 REV. E2

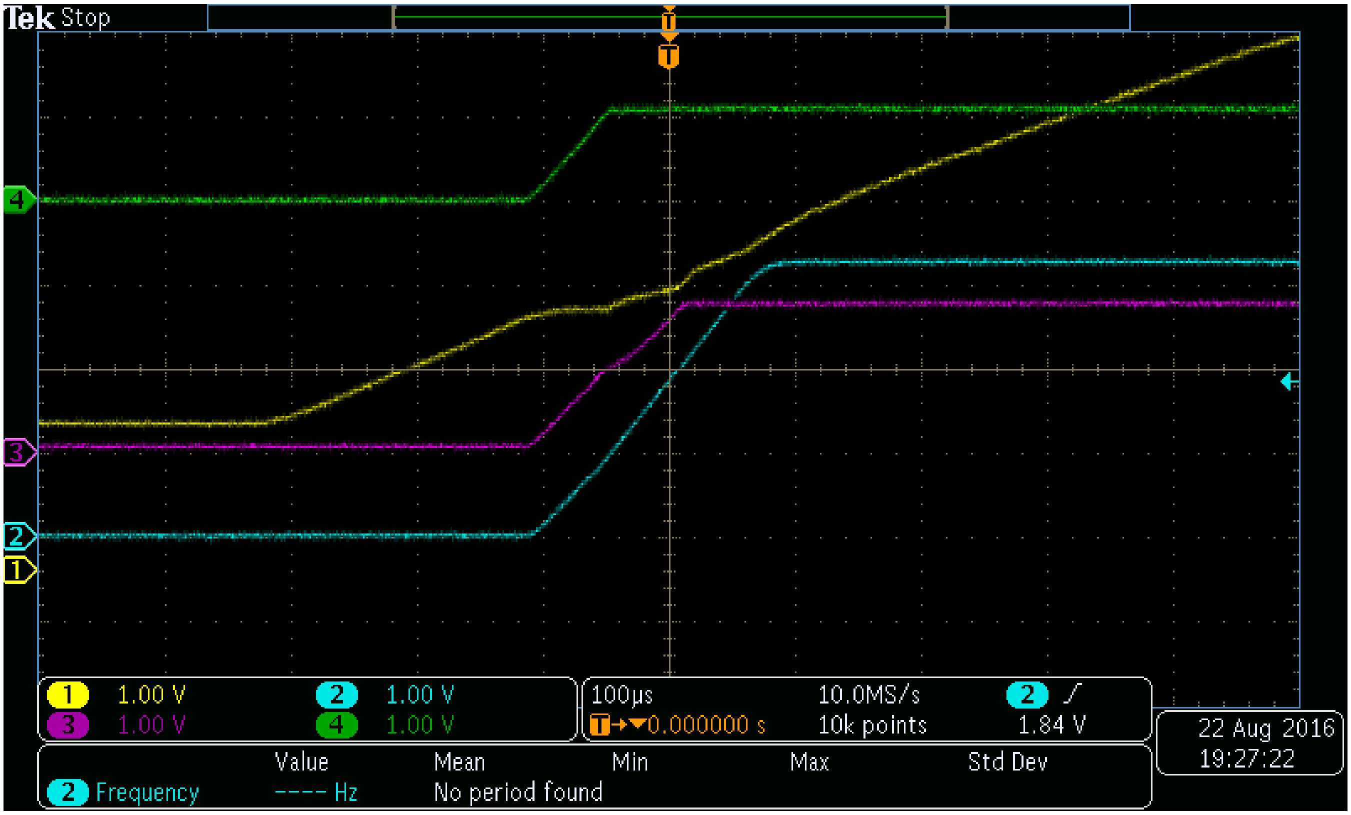


Figure 39: Top Level Assembly Thumbnail

11 Software Files

To download the software files for this reference design, please see the link at:
http://www.ti.com/tool/tida-00455

12 References

1. DS90UB913A-Q1 datasheet (http://www.ti.com/product/DS90UB913A-Q1)
2. TPS62170-Q1 datasheet (http://www.ti.com/product/tps62170-q1)
3. TLV70215-Q1 datasheet (http://www.ti.com/product/TLV702-Q1)
4. TLV70218-Q1 datasheet (http://www.ti.com/product/TLV702-Q1)
5. "Sending Power Over Coax in DS90UB913A Designs", Texas Instruments Application Note, literature number SNLA224. (http://www.ti.com/lit/an/snla224/snla224.pdf)
6. "Cable Requirements for the DS90UB913A & DS90UB914A", Texas Instruments Application Note, literature number SNLA229. (http://www.ti.com/lit/an/snla229/snla229.pdf)
7. "Optimizing the TPS62130/40/50/60/70 Output Filter", Texas Instruments Application Note, literature number SLVA463. (http://www.ti.com/lit/an/slva463a/slva463a.pdf)

13 About the Author

Brian Shaffer is a Systems Engineer at Texas Instruments. As a member of the Automotive Systems Engineering team, Brian focuses on ADAS (Advanced Driver Assistance Systems) end-equipments, creating reference designs for top automotive OEM and Tier 1 manufacturers. He brings to this role, his experience in high reliability infrared cameras, power supplies for portable devices, cameras for automotive platforms, and embedded systems design. Brian earned his Bachelor of Science in Electrical Engineering from Kansas State University in Manhattan, KS.

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