



**THE DATASHEET OF
TL431ACDBZRG4**



UCD9112 Dual-Phase Synchronous Buck Digital Controller Evaluation Module

The [UCD9112](#) is a synchronous buck digital PWM controller designed for point of load power applications. This device integrates dedicated circuitry for dc/dc loop management with a microcontroller core, flash memory and a PMBus™ interface. The UCD9112 does not require programming, and device parameters are configurable through the [TI-Fusion-Digital-Power-Designer](#), a graphical user interface (GUI) configuration software program. The evaluation module (EVM) is a dual-phase, single rail converter with the capability of 40-A load current at nominal 1-V output. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the UCD9112EVM. This user's guide also includes information regarding operating procedures and input/output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

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1 Evaluation Kit Contents

The evaluation kit includes the following items:

1. UCD9112 dual phase point of load EVM
2. Universal serial bus (USB) interface adapter
3. Ribbon cable
4. USB cable
5. CD including the *TI-Fusion-Digital-Power-Designer* program and references
6. User's guide (this document)

2 Short Introduction to EVM Functionality

The UCD9112EVM board is designed for 40-A synchronous buck converters. The output voltage range is from 0.4 V to 4 V. The operating input voltage range is from 5 V to 14 V. The UCD9112EVM is able to regulate output voltage, configure operation parameters, monitor the power-supply status, and communicate with the host through the *Fusion-Digital-Power-Designer* GUI.

2.1 Features

- 5-V to 14-V input voltage range
- 0.4-V to 4-V configurable output voltage range
- Dual phase with maximum 40-A output current
- Implementation of PMBus commands
- Configurable software GUI
- Digital Port_ID (PID) compensation
- Convenient test points

2.2 Applications

- Telecommunication equipment
- Server power
- Networking equipment
- Datacom
- DC power distributed systems
- Storage systems

3 UCD9112EVM Electrical Performance Specifications

Table 1. UCD9112EVM Electrical Performance Specification Summary

| PARAMETER | TEST CONDITIONS | UCD9112EVM | | | UNIT |
|-------------------------------|---|------------|-------|-----|------|
| | | MIN | TYP | MAX | |
| INPUT CHARACTERISTICS | | | | | |
| Input voltage range | $I_{OUT} = 30\text{ A}$, $V_{OUT} = 1\text{ V}$, $T_A = +25^\circ\text{C}$ | 5 | 12 | 14 | V |
| OUTPUT CHARACTERISTICS | | | | | |
| Output voltage range | $V_{IN} = 12\text{ V}$; $I_{OUT} = 20\text{ A}$ | 0.4 | 1.0 | 4 | V |
| Output current | $V_{IN} = 12\text{ V}$; $V_{OUT} = 1\text{ V}$ | 0 | | 40 | A |
| Output voltage ripple | $V_{IN} = 12\text{ V}$; BW = 20 kHz; $I_{OUT} = 30\text{ A}$ | | ±10 | | mV |
| Undershoot/overshoot | $V_{OUT} = 1\text{ V}$, $V_{IN} = 12\text{ V}$, SR = 2.5 A/μs, 10 A-30 A-10 A | | ±30 | | mV |
| Recovery time | | | 30 | | μs |
| Setting accuracy | $V_{IN} = 12\text{ V}$, $V_{OUT} = 1\text{ V}$, $I_{OUT} = 10\text{ A}$ | | ±0.5% | | |
| Load regulation | $V_{IN} = 12\text{ V}$, $V_{OUT} = 1\text{ V}$ (from 0 A to 40 A) | | ±5 | | mV |
| Line regulation | $V_{OUT} = 1\text{ V}$, $I_{OUT} = 20\text{ A}$ (from 5 V to 14 V) | | ±2 | | mV |
| Phase current balancing | $V_{OUT} = 1\text{ V}$, $I_{OUT} = 30\text{ A}$; phase current difference | | 1.5 | | A |
| SYSTEM CHARACTERISTICS | | | | | |
| Efficiency | $V_{IN} = 12\text{ V}$, $V_{OUT} = 1\text{ V}$, $I_{OUT} = 30\text{ A}$, $f_{SW} = 500\text{ kHz}$ | | 85 | | % |
| Switching frequency | $V_{IN} = 12\text{ V}$, $V_{OUT} = 1\text{ V}$ | | 500 | | kHz |
| Operating temperature range | V_{IN} from 5 V to 14 V, $V_{OUT} = 1\text{ V}$, $I_{OUT} = 40\text{ A}$ | -40 | | +85 | C |

4 Inspection of UCD9112EVM

4.1 Description of Jumpers

Table 2. Description of EVM Jumpers

| Reference Designator | Functions | | Default Connection |
|----------------------|-----------------|--|--------------------|
| J5 | Pin 1 to Pin 2 | Select 3.3 V from USB to the controller | |
| | Pin 3 to Pin 2 | Select 3.3 V from UCD7230 to the controller | ü |
| J6 | Pin 1 to Pin 2 | Select 3.3 V from UCD7230 of Phase 1 | |
| | Pin 3 to Pin 2 | Select 3.3 V from UCD7230 of Phase 2 | ü |
| J7 | Pin 1 to Pin 2 | Select regulator (8.0 V) to drive UCD7230 of Phase 2 | |
| | Pin 3 to Pin 2 | Select dc input power to drive UCD7230 of Phase 2 | ü |
| J8 | Pin 1 to Pin 2 | Select regulator (8.0 V) to drive UCD7230 of Phase 1 | |
| | Pin 3 to Pin 2 | Select dc input power to drive UCD7230 of Phase 1 | ü |
| J9 | Pin 9 to Pin 10 | Select control line to be used for PMBus | ü |
| J10 | Pin 1 to Pin 2 | Select internal USB 3.3 V as pull-up for power good | ü |
| | Pin 3 to Pin 2 | Select external bias as pull-up for power good | |

4.2 Description of Test Points

The EVM board contains several test points to allow users to measure input voltage, output voltages, pulse-width modulation (PWM) waveforms, apply tracking voltages, and for other evaluation purposes.

Table 3. Description of Test Points

| Reference Designator | Symbol Name | Description |
|----------------------|-------------|--|
| TP1 | VIN | Input dc power plus polarity |
| TP2 | PGND_IN | Input dc power ground |
| TP3 | AO_2 | Phase 2 current output from UCD7230 |
| TP4 | VOUT | Output dc power plus polarity |
| TP5 | VOUT | Output voltage measurement (probe) |
| TP6 | CLF_2 | Phase 2 CLF from UCD7230 |
| TP7 | PGND_OUT | Output dc power ground |
| TP8 | AO_1 | Phase 1 current output from UCD7230 |
| TP9 | V_Track+ | Parent voltage input for tracking |
| TP10 | Rmt_Anode | Remote temperature sensing |
| TP11 | Vrs+ | Output voltage positive remote sensing |
| TP12 | DATA | PMBus data line |
| TP13 | CLK | PMBus clock line |
| TP14 | Vrs- | Output voltage negative remote sensing |
| TP15 | Alert | PMBus alert line |
| TP16 | PGOOD | Internal open connector |
| TP17 | DPWM_A0 | DPWM for Phase 1 Upper FET |
| TP18 | SR1 | SRE for phase 1 |
| TP19 | DPWM_A1 | DPWM for Phase 2 Upper FET |
| TP20 | SR2 | SRE for phase 2 |
| TP21 | V_PGOOD | External open connector |
| TP22 | CLF_1 | Phase 1 CLF from UCD7230 |
| TP23 | FAN_TACH | FAN TACH input for monitoring |
| TP24 | GND | Signal ground |
| TP25 | ILIM | Current limit to UCD7230 for peak current protection |
| TP26 | FAN_PWM | FAN PWM output for speed drive |

4.3 Description of LEDs

4.3.1 Input Power LED

The green LED (D1) is lit when the input voltage is sufficient to supply power for the EVM board. The operating input voltage range is from 5 V to 14 V.

4.3.2 USB LED

The green LED (D6) indicates that the PMBus is connected to the EVM board.

4.3.3 Alert LED

The red LED (D7) indicates when a fault has occurred. When faults occur, the EVM turns off. This LED is also lit if there are communication errors.

5 Installation of Fusion-Digital-Power-Designer

The GUI is a software application interface between the host computer and the EVM. The user must first install the software on a personal computer. Without the software, the EVM cannot communicate with the host. The GUI application firmware, *TI-Fusion-Digital-Power-Designer*, is located on the CD shipped with the kit. It can also be downloaded from the [UCD9112 product folder](#) on the TI web site (at www.ti.com). Copy the file to your computer and unzip it. Execute *TI-Fusion-Digital-Power-Designer xx.exe* (**xx** is the firmware version) to start the installation. Follow the on-screen instructions to complete the installation.

Once the installation finishes, a shortcut with the GUI icon appears on the desktop. Refer to the *Fusion Digital Power Designer User Manual* for more information. The Manual is available for review when the software is first initialized; it is also available through the **Help** menu.

6 Test Setup

6.1 Recommended PC Workstation

The GUI software *TI-Fusion-Digital-Power-Designer* and the EVM hardware require the following workstation platform (host):

- A personal computer with Microsoft Windows® XP (or later) operating system
- At least one available USB port
- Microsoft .NET Framework version 2

Microsoft .NET is the runtime application framework that the GUI uses. The GUI installer checks to see if the PC has version 2.0 of .NET installed, and install it if necessary.

6.2 Recommended Test Equipment

6.2.1 DC Power Supply

The voltage range of the input power supply should be from 0 V to 15 V, and the maximum output current should be set to 20 A.

6.2.2 Load

If an electronic load is used as a constant current load, it should be rated to more than 40 A up to 5 V. A resistive load can also be used.

6.2.3 Meters and Shunt

- V1: input voltage meter, 0 V to 15 V
- V2: Output voltage meter, 0 V to 5 V

To measure input current and output current precisely, a current shunt is recommended. A third voltage meter, V3, measures the voltage across the shunt.

6.2.4 Oscilloscope

To measure output ripple and step response, an analog or digital oscilloscope is required. The scope probe should have 1-M Ω impedance, and the scope should be set for 20-MHz bandwidth.

6.2.5 Other Equipment

To test tracking, an additional dc power supply is needed.

To test fan functions, a PWM fan is needed. There are normally four terminals in a PWM fan: input power, ground, tach signal, and PWM input. More details can be found on the respective fan vendor product data sheet.

6.3 Equipment Connection

The basic test setup is shown in Figure 1. The EVM board should be used at an approved electrostatic discharge (ESD) workstation. Before powering on the EVM board, make sure that a wrist strap, boot straps, or mats are connected to reference the user to earth ground. ESD-rated smocks and safety glasses must also be worn.

6.3.1 Input Voltage Connection

There are four steps to complete the input connection. The input connection is shown in Figure 1.

- Step 1. Before connecting the dc input power supply, make sure that V_{IN} is initially set to 0 V.
- Step 2. For more accurate current measurement, it is recommended to use a current shunt to sense the input current. Connect the wire from the positive V_{IN} source to one end of the shunt, then connect the other end of the shunt to J1 with AWG #16 wire.
- Step 3. Connect voltmeter V3 across the shunt.
- Step 4. Connect J2 to the negative V_{IN} source with AWG #16 wire.

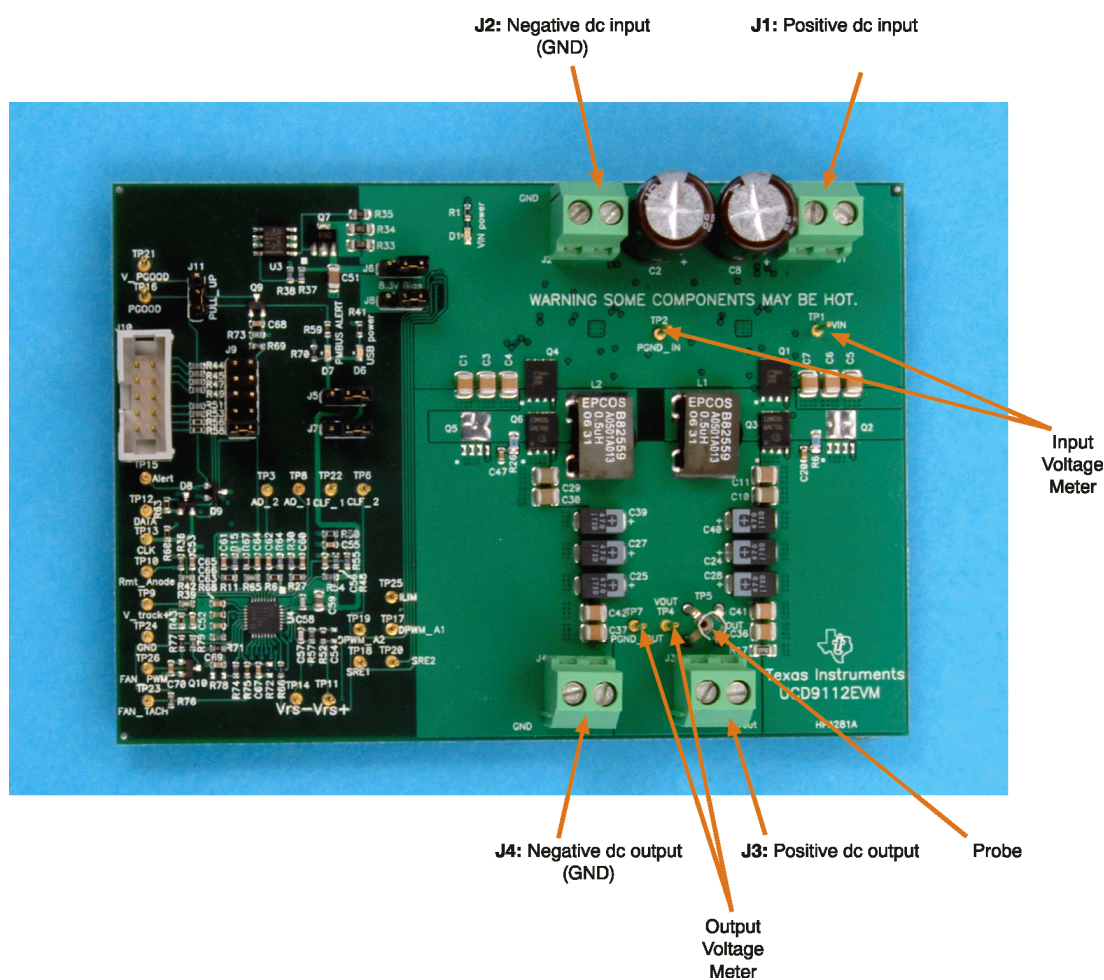


Figure 1. DC Input Power and Output Power Connection

6.3.2 Output Load Connections

Set the output load connections in the following manner:

1. Set the load to constant current mode, with a load current of 0 A.
2. Connect J3 to the positive terminal of the load using AWG #14 wire.
3. Connect J4 to the negative terminal of the load using AWG #14 wire. This connection is shown in [Figure 1](#).

6.3.3 Meters and Probe Connection

One voltage meter (V1) should be connected to TP1 and TP2 to measure the input voltage. The second meter (V2) should be connected to TP4 and TP7 to measure the output voltage.

Use a probe to plug into TP5 to measure the output voltage ripple through the oscilloscope. These connections are shown in [Figure 1](#).

6.3.4 USB Adapter Connection

The USB adapter is connected in the following manner:

1. Connect one end of the ribbon cable to J10; connect the other end to the USB interface adapter.
2. Connect the mini-connector on the USB cable to the USB interface adapter, and connect the A connector to the USB port of the host. This connection is shown in [Figure 2](#).

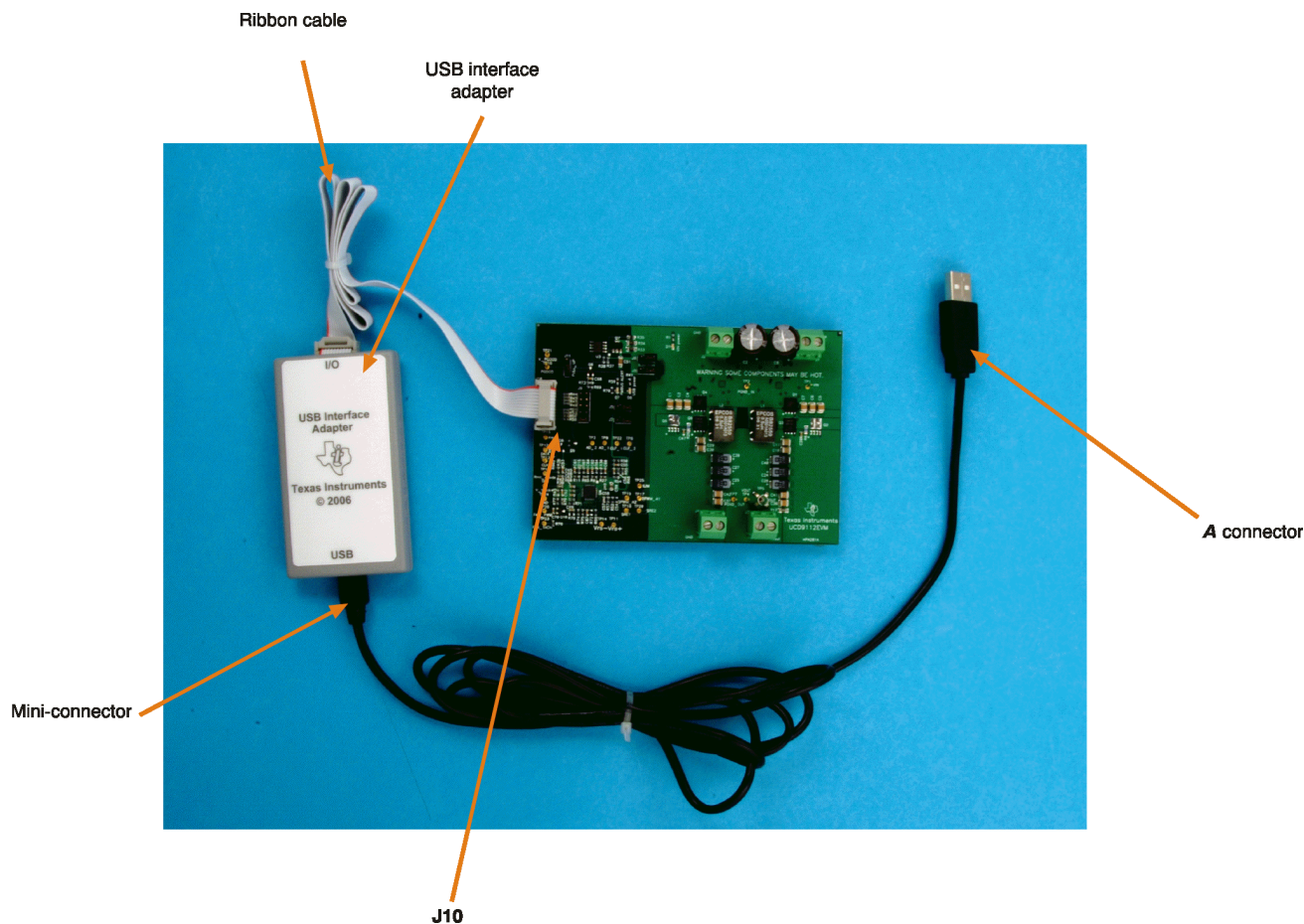


Figure 2. Connection Between EVM and Host

7 Test and Evaluation Procedures

7.1 EVM Startup

1. Follow the procedures discussed in the [Equipment Connection](#) section to make proper connections before starting up the EVM.
2. Turn on the input dc power supply, and set the input voltage to 12 V. Two green LEDs should be lit to indicate that the EVM is working.
3. Double-click the GUI icon on the host. The GUI interface screen appears, as shown in [Figure 3](#).
4. Refer to the Texas Instruments application report, [PMBus Support in UCD911X Family of Digital Power Controllers \(SLUA427\)](#) for more details. This application note is available on the CD shipped with the kit or it can be downloaded from the [TI web site](#).

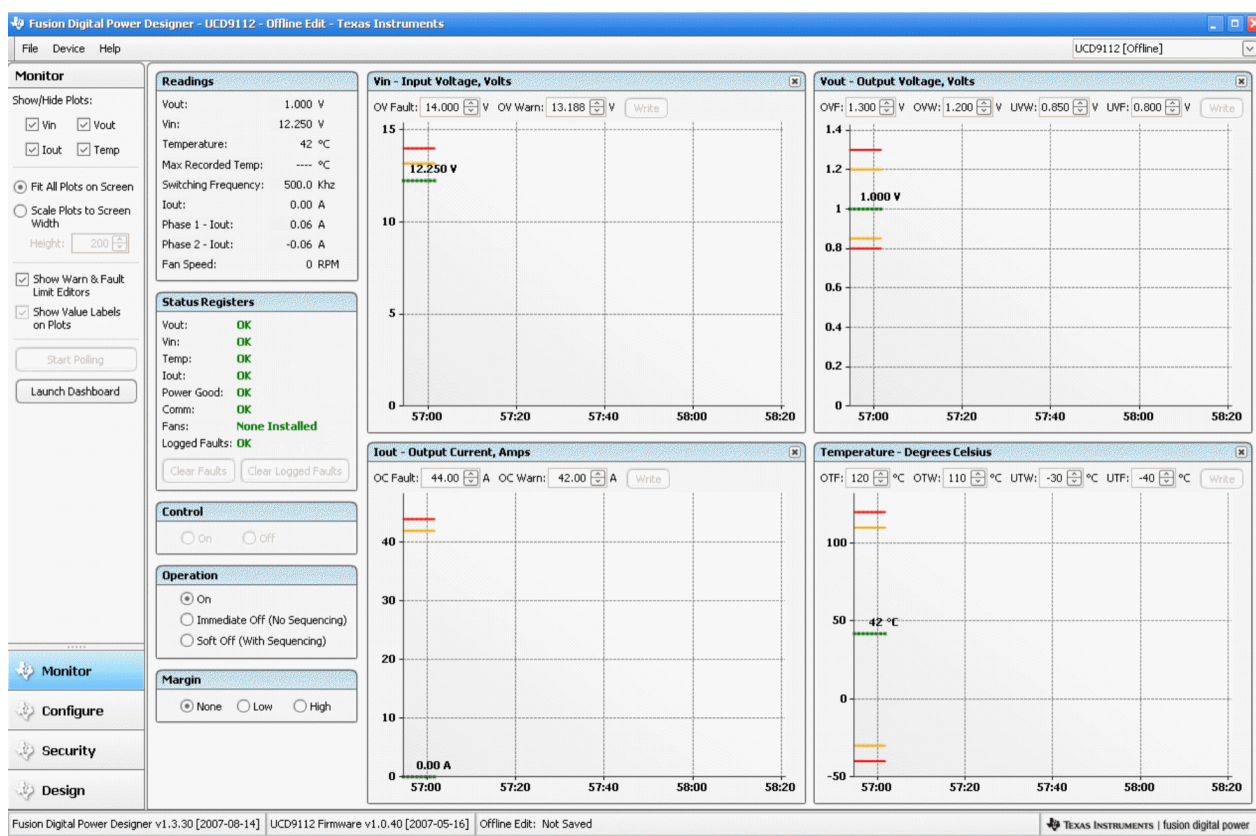


Figure 3. Graphical User Interface (GUI) Display

7.2 EVM Evaluation Procedure

7.2.1 Load Regulation

Turn on the output voltage (by default, set to 1 V) by clicking **ON** under the *Control* section as shown in [Figure 3](#). Use the meter V2 to measure the output voltage as described in [Section 6.3.3](#). Change the load current from 0 A to 40 A. If you record the voltage readings from V2, you can then calculate the load regulation.

7.2.2 Line Regulation

Set the load current to a fixed value. Increase the input voltage from 5 V to 14 V, and record the output voltage readings from meter V2. Calculate the line regulation from this data.

7.2.3 Output Voltage Ripple

Use the scope jack marked as TP5 to measure the output ripple. TP5 has a very short ground loop to minimize noise coupling. The tip of the probe must be connected to the positive output voltage present at the ferrule on the board, and the metal ground barrel connected to the ground present at the metal ring above the board. The scope should be triggered with ac coupling at 20-MHz bandwidth. If the probe does not fit into TP5, make the ground loop as small as possible; do not use the ground clip normally connected to the probe. Using the ground clip in this manner causes false readings.

7.2.4 Transient Response

Use the same probe setup as specified in [the previous section](#). Select the expected step load for transient test, and set a proper slew rate.

7.2.5 Efficiency Measurement

In order to evaluate efficiency, both input power and output power must be measured very accurately. Use the current shunt to measure the input current; read the voltage across the shunt in mV, and then translate this result into the current measurement. For example, if a 2 mV/A shunt is used, and the voltage reading from the meter is 20 mV, the input current is approximately 10 A. The output current can be measured from a current shunt, or the load current meter if it is set to constant current load and has Kelvin connectors. Efficiency is calculated with the following formula:

$$\text{Efficiency } \eta = \frac{I_{\text{OUT}} \times V_{\text{OUT}}}{V_{\text{IN}} \times I_{\text{IN}}} \quad (1)$$

7.2.6 Output Voltage Set Point

Output voltage can be changed using the GUI configuration program. The following procedure provides an example of using the GUI to change the output voltage from 1 V to 1.5 V.

Example 1. Changing the Output Voltage Using the GUI

- Step 1. Click *Configure* on the lower left portion of the screen (see [Figure 3](#)).
- Step 2. Click *Basic Configuration*, where some parameters can be changed. First, enter **1.6** in the *Over Voltage Warning* box; then enter 1.7 in the *Over Voltage Fault* box; finally, enter **1.5** in the *Vout* box.
- Step 3. Click *Write to Hardware* to confirm all these changes. If this configuration must be kept in nonvolatile memory, click *Store RAM to Flash*.

Note: If the last step is applied, then the new settings will be the new start-up default values.

For other configurations, refer to the *Fusion Digital Power Designer User Manual* for more information.

7.2.7 Fan Speed Test

The UCD9112 supports fan speed adjustment and monitoring. [Example 2](#) outlines the steps needed to evaluate a PWM fan with four wires supplied by SanyoDenki [109P0412P3033] that can be used for this test. (Other equivalent fans can also be used). The fan speed is adjusted by the PWM duty cycle that is controlled by the FAN_PWM pin (TP26) of the UCD9112. The fan speed is measured by counting the fan tach pulses with the fan tach output connected to the FAN_TACH pin (TP23) of the UCD9112 device.

Example 2. Fan Speed Monitoring Example

- Step 1. Connect the ground (black) to GND (TP24); connect the fan tach signal (yellow) to the FAN_TACH pin (TP23); connect the fan PWM input (brown) to the FAN_PWM pin (TP25). Finally, connect a 12-V power supply to the fan power (red).
- Step 2. Click on *Advanced Configuration* from the *Configure* page, where two relevant parameters must be changed. The first parameter is **FAN_CONFIG_1_2**; the default setting for this parameter is that the fan is not installed (with 0x10). This parameter must be changed to 0x90 to install the fan. The second command is **FAN_COMMAND_1**. This parameter is used to change the fan speed by changing the PWM duty cycle.
- Step 3. The fan speed reading (in RPM) is shown under the *Monitor* page. If the fan speed is less than the limit set by the command `FAN_SPEED_FAULT_LIMIT [MFR24]`, a fan fault is triggered and appears on the GUI.

7.2.8 Tracking Test

The UCD9112EVM provides the capability to evaluate the tracking function of the UCD9112. Follow this procedure to test the tracking function operation.

- Step 1. Connect the positive output of a dc power supply to the V_track+ pin (TP9), and connect the negative output of the supply to the GND pin (TP24).
- Step 2. Click on *Advanced Configuration* from the *Configure* page. Select ENABLE from **TRACKING_ENABLE [MFR 19]** box. The output voltage follows the voltage applied to the V_track+ pin (TP9). The voltage on this pin should be less than 4 V. Refer to the application note, *Fusion Digital Power Designer User Manual* for more information. This document is available through the **Help** menu in the GUI.

7.2.9 Control Loop Gain and Phase Margin Measurement

Follow the procedure presented in [Example 3](#) to create Bode diagrams of the loop transfer function; it is recommended to use a network analyzer when doing so.

Example 3. Creating Bode Plots of the Loop Transfer Function

- Step 1. Connect the input signal amplitude measurement probe of the network analyzer (channel A) to TP4 or TP11.
- Step 2. Connect the output signal amplitude measurement probe of the network analyzer (channel B) to TP11 or TP4.
- Step 3. Connect the ground lead of channel A and channel B to signal ground (TP24).
- Step 4. Inject 25 mV across the resistor R46 via the isolation transformer.
- Step 5. Sweep the frequency from 500 Hz to 1 MHz with a 10 Hz or smaller post filter.

Gain and phase plots are then generated by the network analyzer. Measuring phase margin, gain margin, and the crossover frequency are now possible. To redesign the compensation loop, refer to the application note, *Designing the Digital Compensator for UCD91xx-based Digital Power Supply*, ([SLUA416](#)) for more details.

7.2.10 EVM Configuration

The EVM operating parameters are configurable through the GUI. One example is given in [Section 7.2.6](#). Refer to the *Fusion Digital Power Designer User Manual* for more details.

7.2.11 EVM Shutdown

After the evaluation is finished, select **OFF** to turn off the output voltage through the *Control* command; shut down the input voltage, and disconnect the other equipment.

8 UCD9112EVM Typical Performance Characteristics

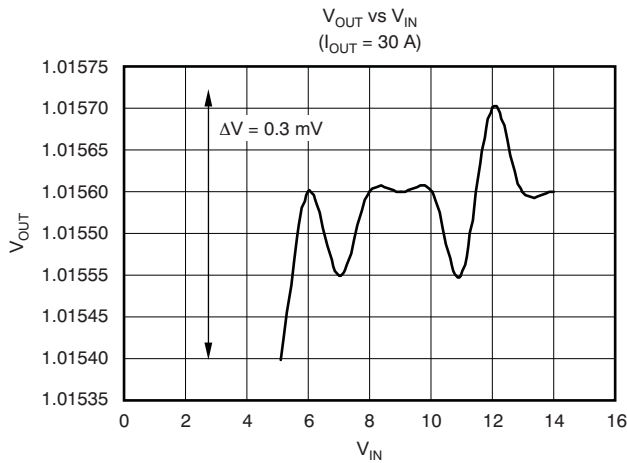


Figure 4. Line Regulation

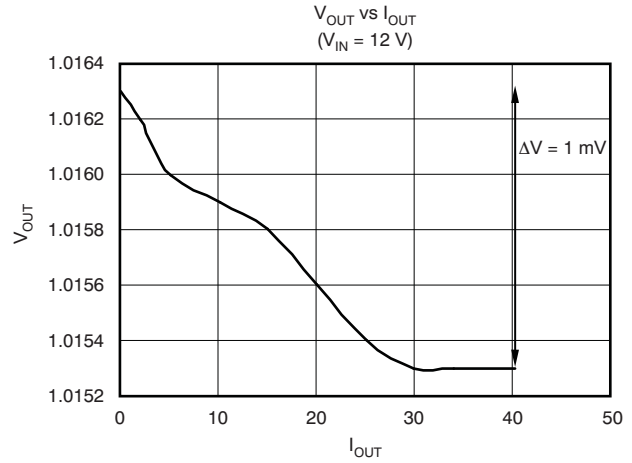


Figure 5. Load Regulation

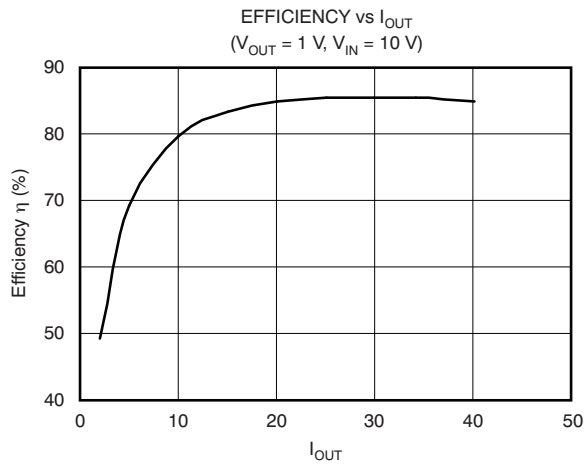


Figure 6. Efficiency η vs I_{OUT}

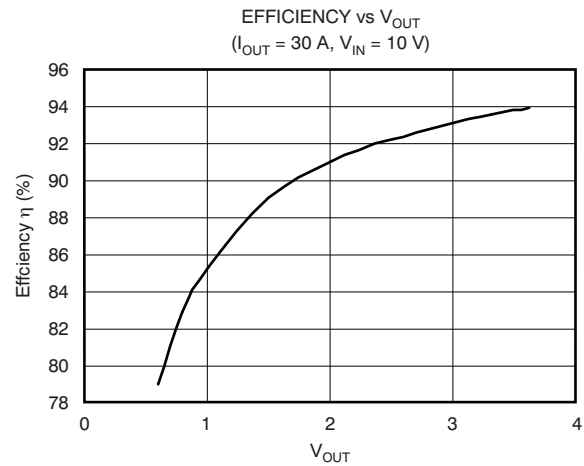


Figure 7. Efficiency η vs V_{OUT}

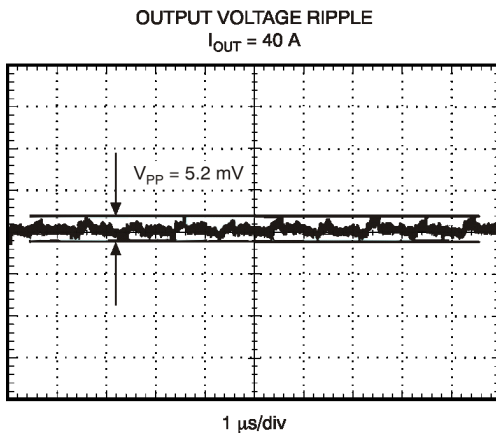


Figure 8. Output Voltage Ripple

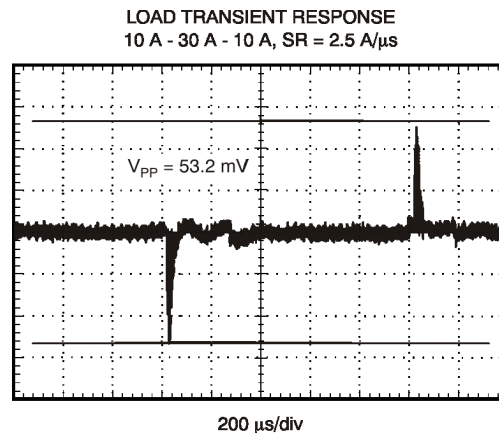


Figure 9. Load Transient Response

9 UCD9112EVM Schematics

Note: Board layouts are not to scale. These are intended to show how the board is laid out; they are not intended to be used for manufacturing UCD9112EVM PCBs.

Full-size schematics are appended to the end of this document.

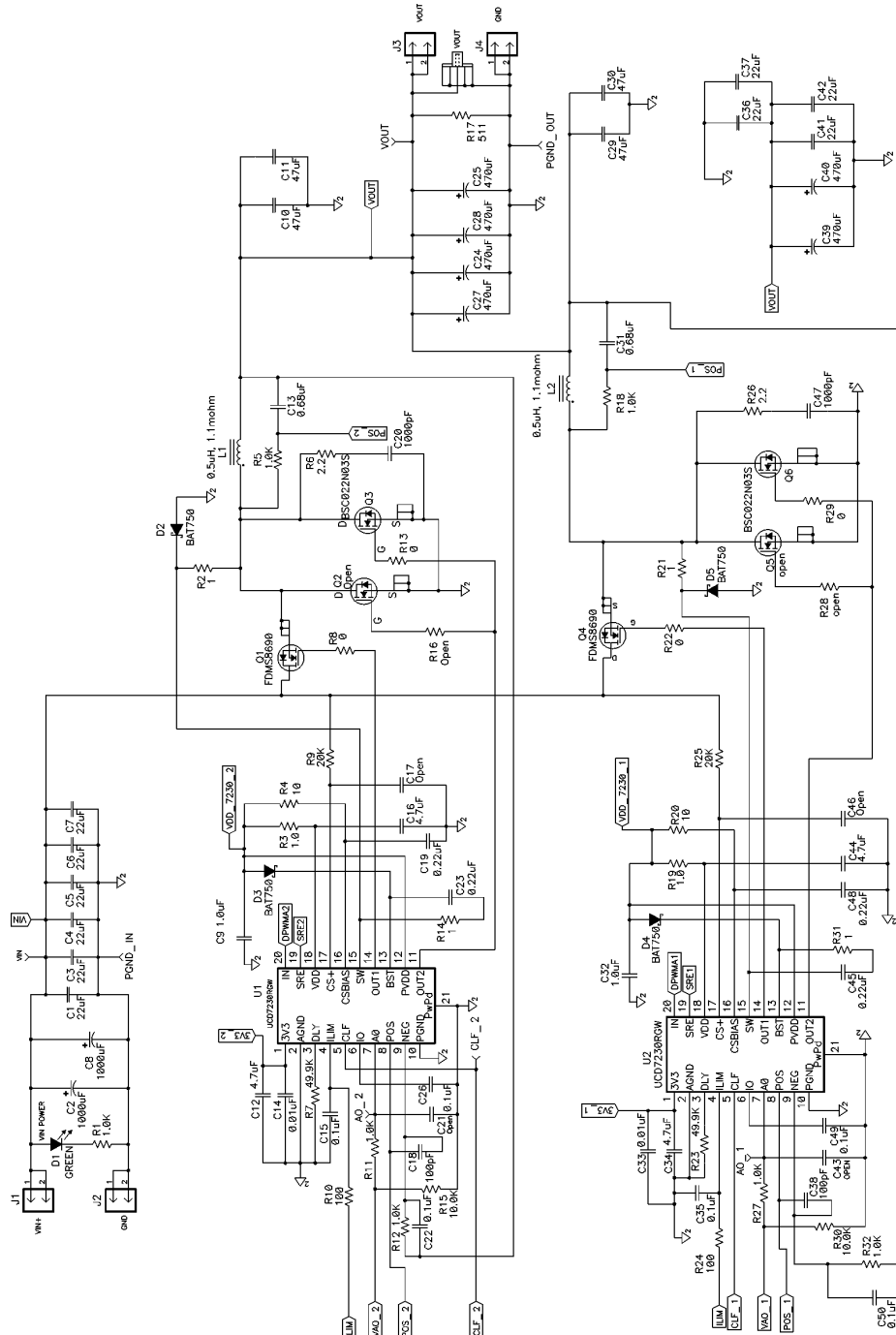


Figure 10. UCD9112EVM Schematic

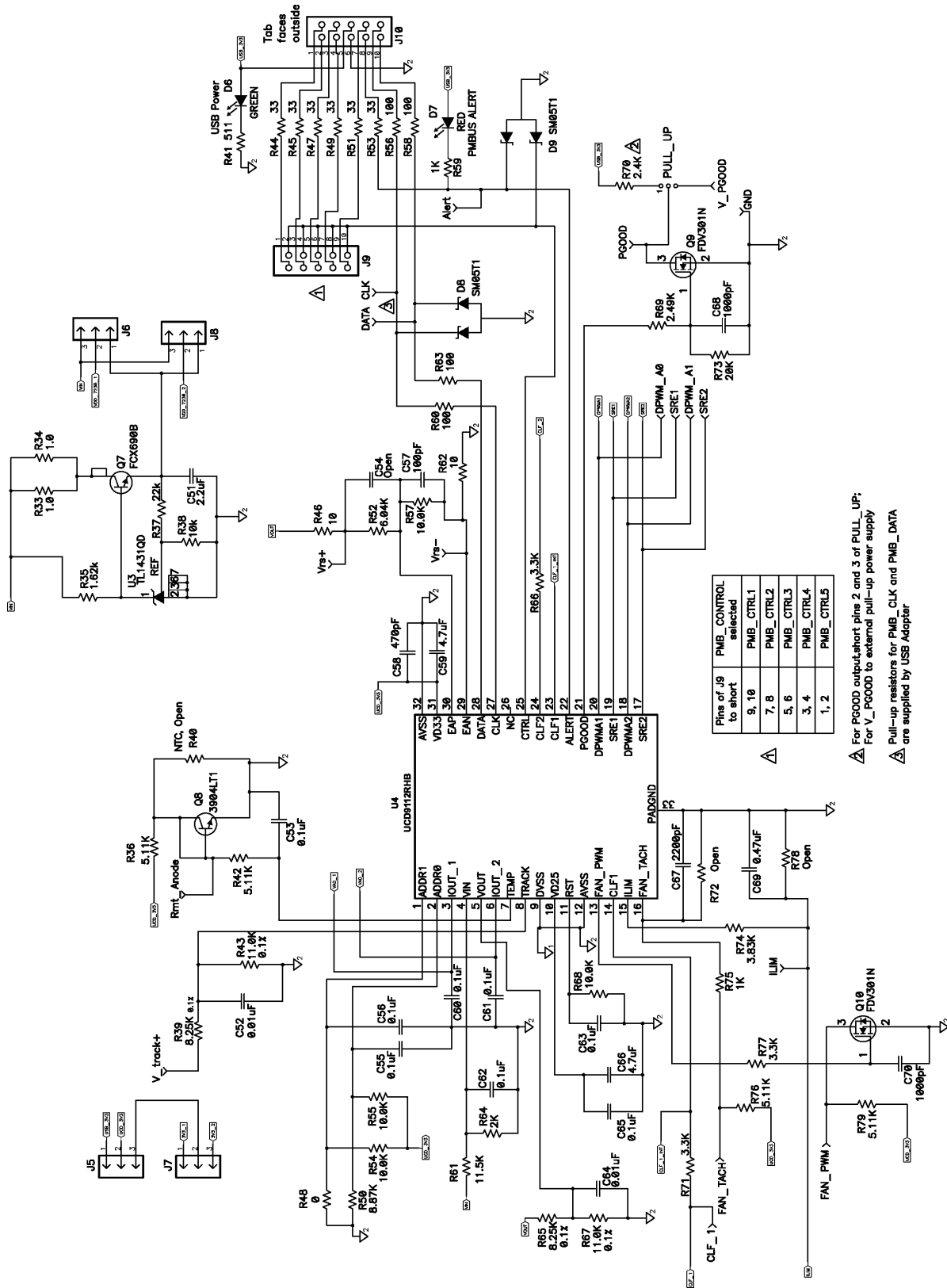


Figure 11. UCD9112EVM Schematic

10 UCD9112EVM Silkscreen and PCB Layout

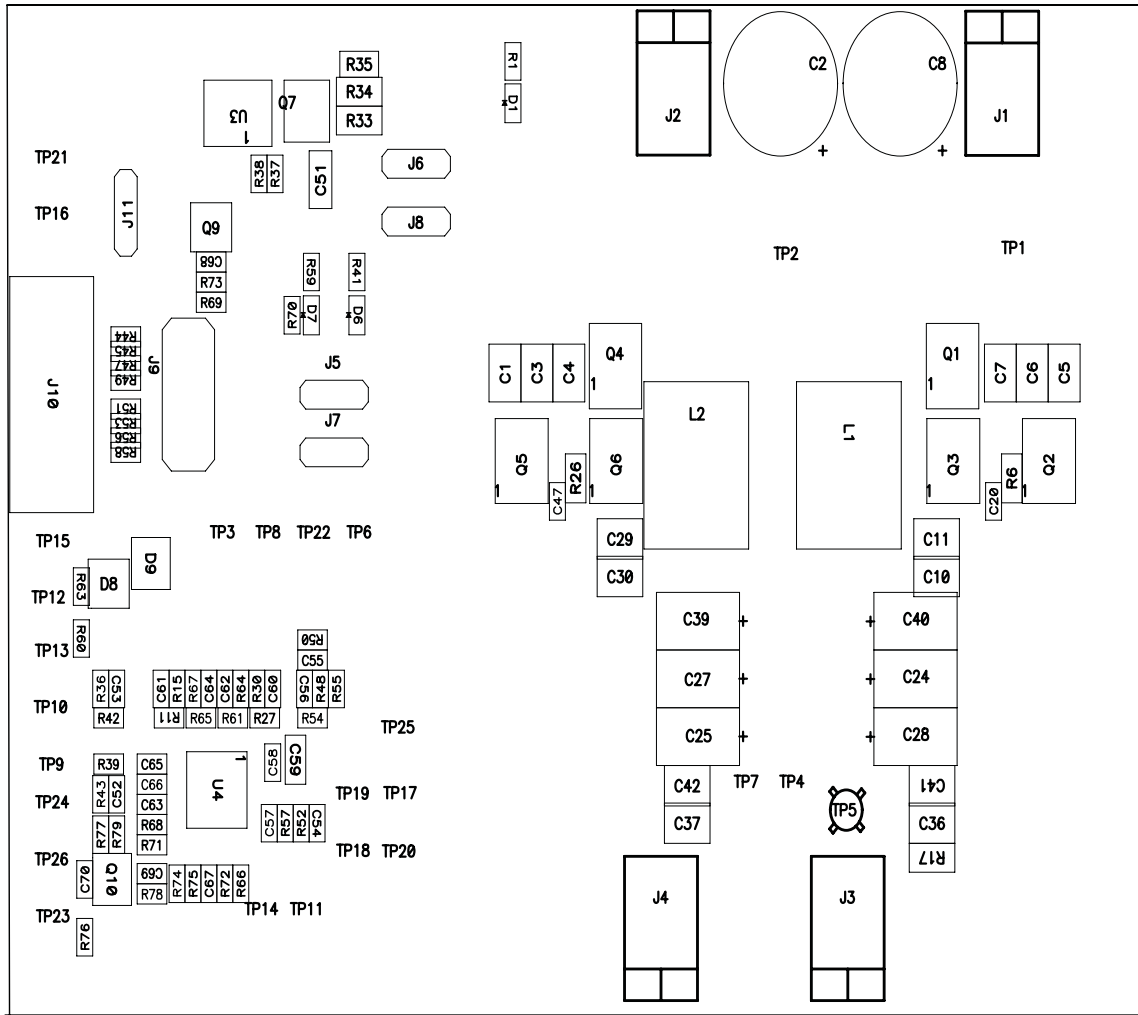


Figure 12. Top Layer Silkscreen

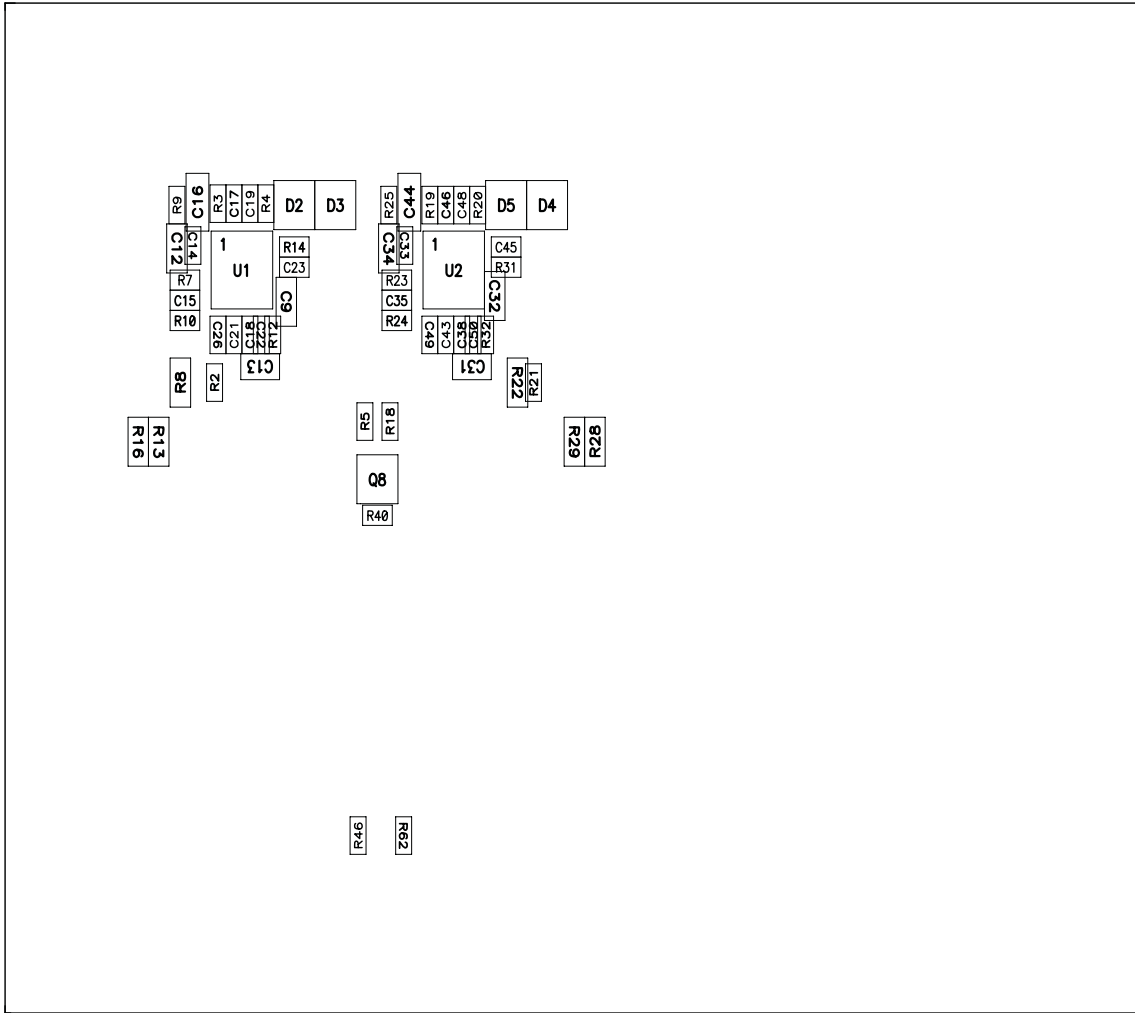


Figure 13. Bottom Layer Silkscreen

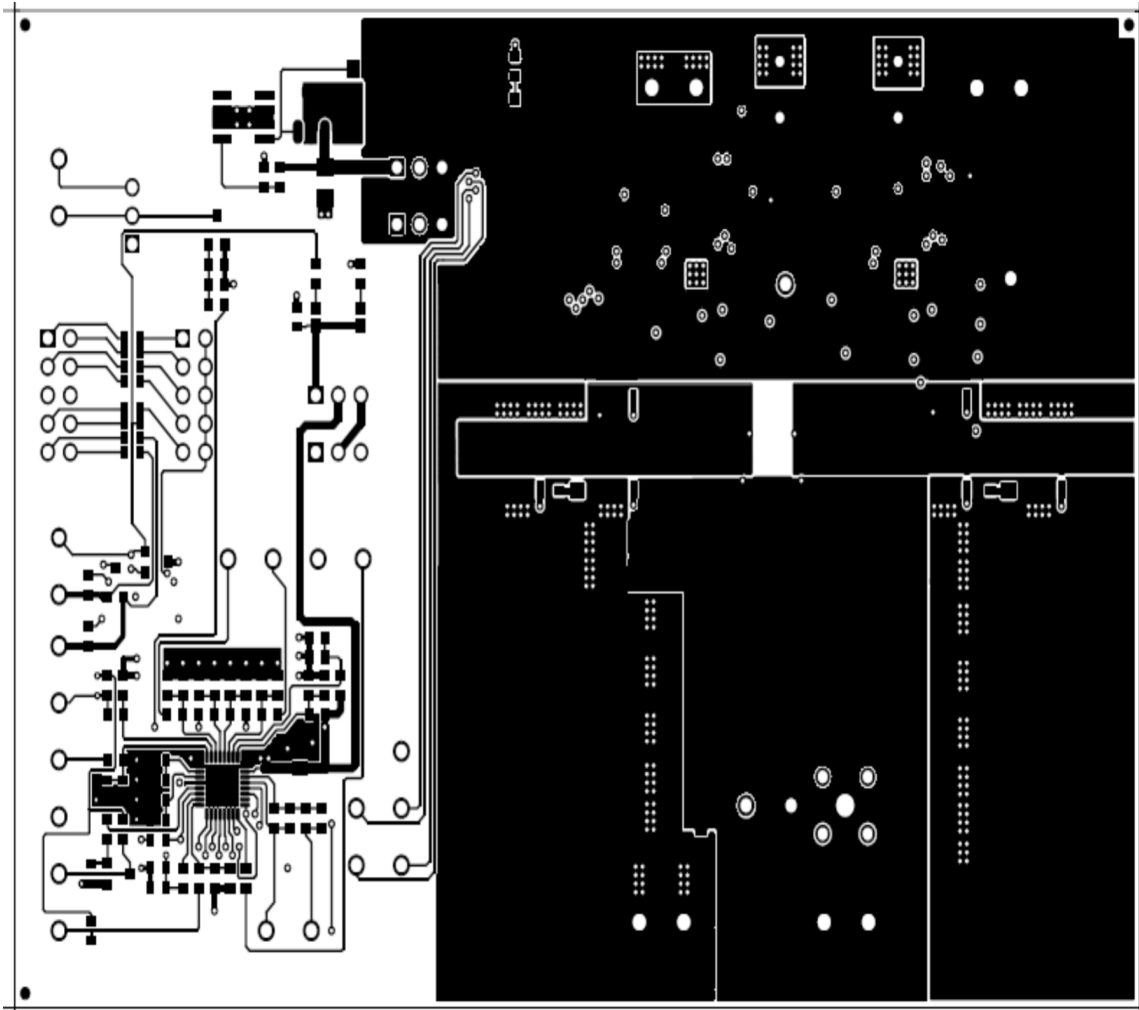


Figure 14. UCD9112EVM PCB Top Layer (Component Side)

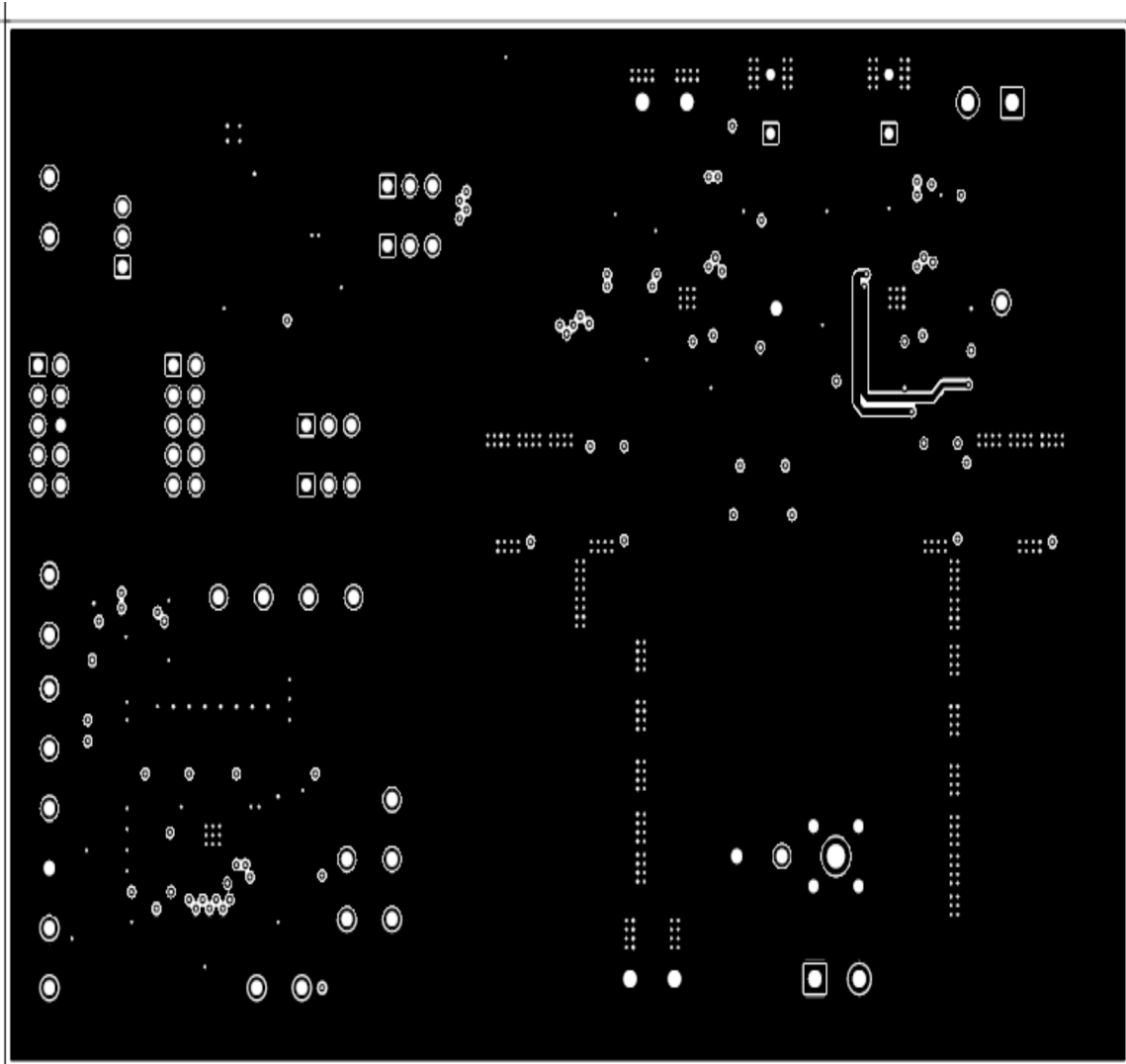


Figure 15. UCD9112EVM PCB Layer 1 (Internal)

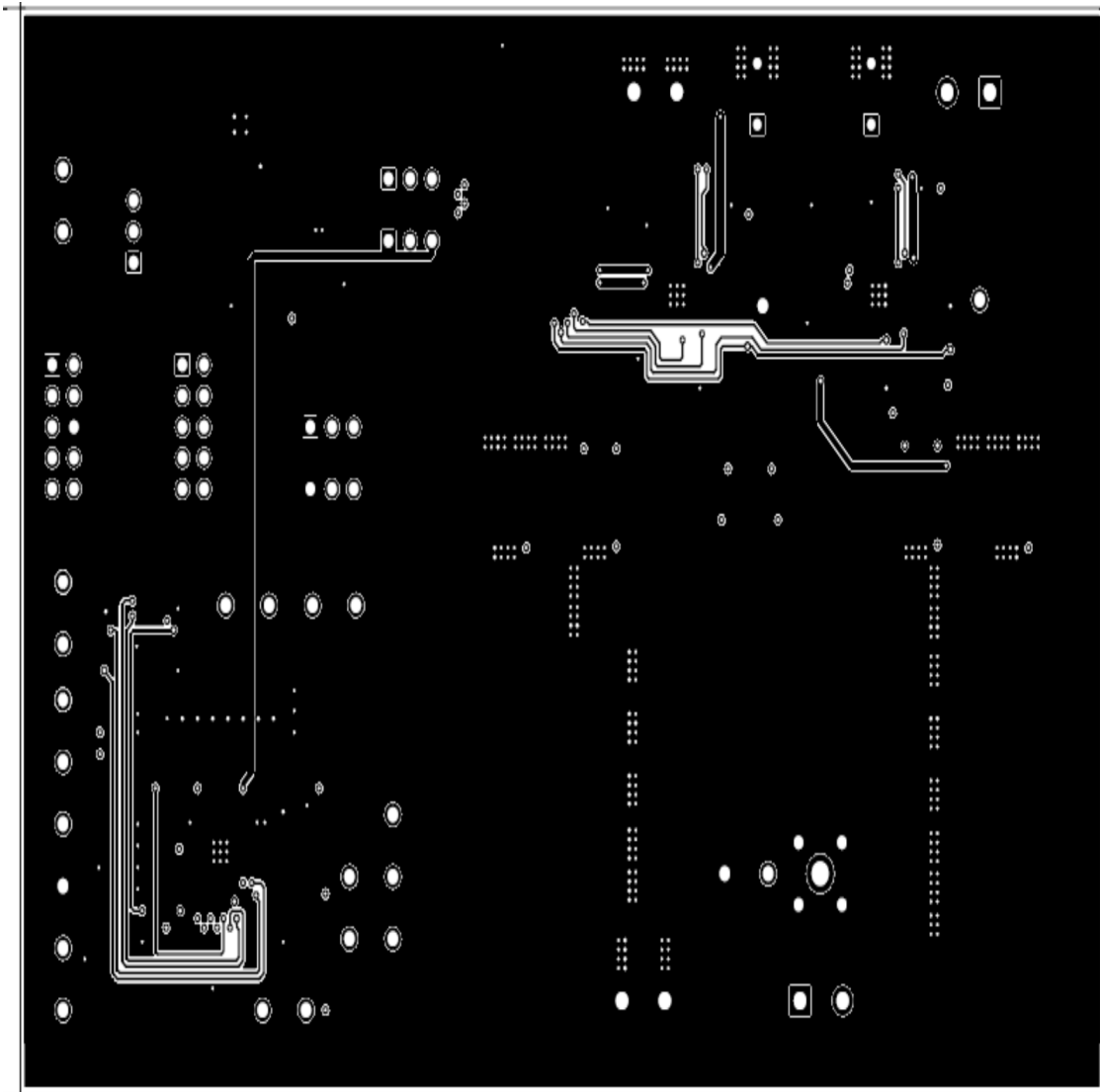


Figure 16. UCD9112EVM PCB Layer 2 (Internal)

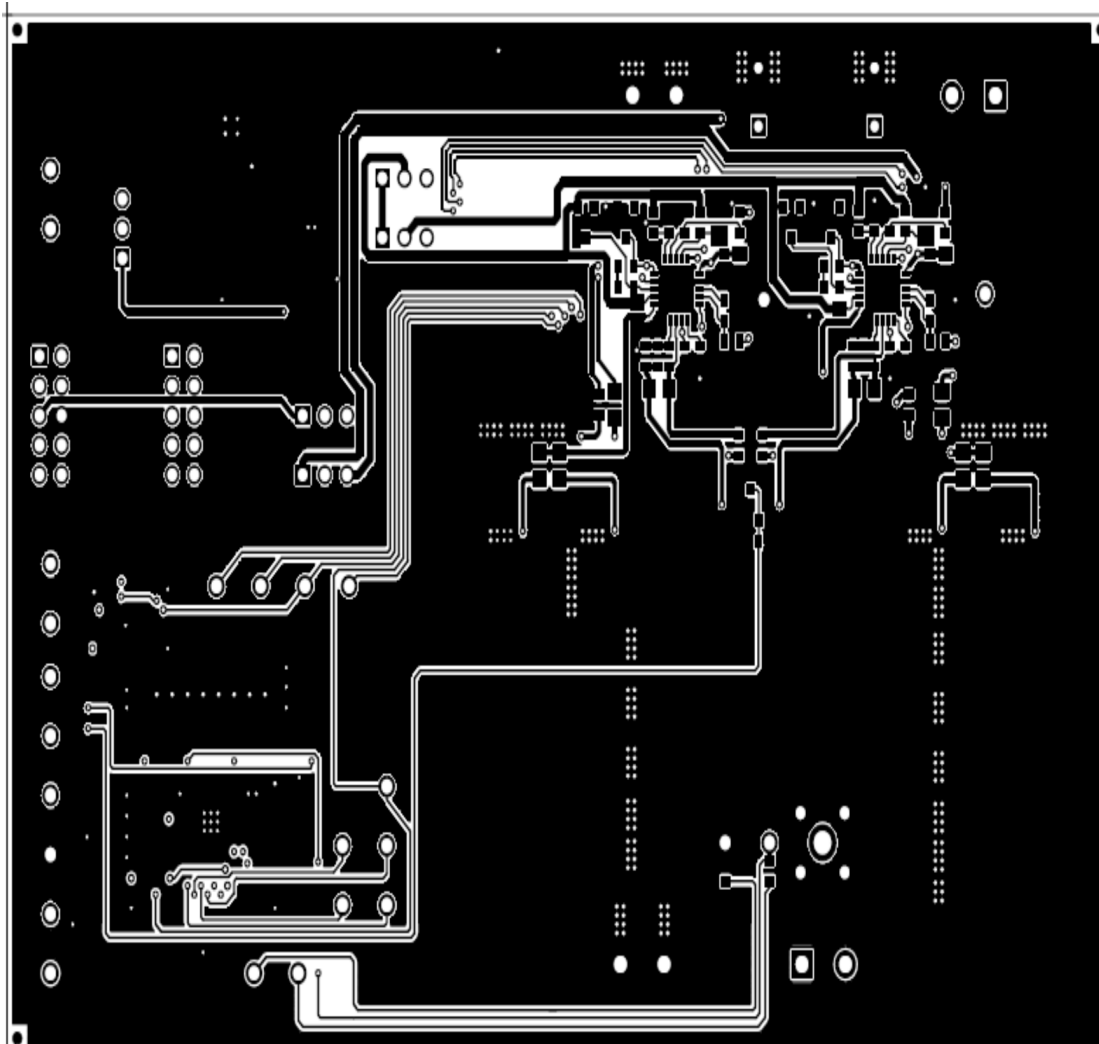


Figure 17. UCD9112EVM PCB Bottom Layer (Solder Side)

11 UCD9112EVM Bill of Materials

Table 4. UCD9112EVM Bill of Materials

| RefDes | Description | Value | Size | Part Number | MFR |
|--|---|--------------------------------|--------------------------------|--------------------|------------------|
| C1, C3–C7, C36, C37, C41, C42 | Capacitor, Ceramic, 25-V, X7R, 10% | 22 μ F | 1210 | GRM32ER71E226KE15L | Murata |
| C10, C11, C29, C30 | Capacitor, Ceramic, 6.3-V, X7R, 10% | 47 μ F | 1210 | GRM32ER71E476KE15L | Murata |
| C12, C34, C59 | Capacitor, Ceramic, 4.7 μ F, 16V, X7R, 20% | 4.7 μ F | 0805 | 0805YC475MAT2A | AVX |
| C13, C31 | Capacitor, Ceramic, 0.68 μ F, 25V, X7R, 5% | 0.68 μ F | 0805 | 08053C684JAT2A | AVX |
| C14, C33, C52 | Capacitor, Ceramic, 0.01- μ F, 16-V, X7R, \pm 10% | 0.01 μ F | 0603 | GRM188R71C103KA01D | Murata |
| C15, C26, C35, C49, C53, C55, C56, C63 | Capacitor, Ceramic, 0.1- μ F, 16-V, X7R, \pm 10% | 0.1 μ F | 0603 | GRM188R71C104KA01D | Murata |
| C16, C44 | Capacitor, Ceramic, 4.7- μ F, 25-V, X7R, \pm 10% | 4.7 μ F | 1206 | GRM31CR71E475KA88L | Murata |
| C17, C46 | Capacitor, Ceramic, 100-pF, 50V, NPO | Open | 0603 | C1608C0G1H101J | TDK |
| C18, C38, C57 | Capacitor, Ceramic, 100-pF, 50V, NPO | 100 pF | 0603 | C1608C0G1H101J | TDK |
| C19, C23, C45, C48 | Capacitor, Ceramic, 0.22- μ F, 25-V, X7R, \pm 10% | 0.22 μ F | 0603 | GRM188R71E224KA88D | Murata |
| C2, C8 | Capacitor, Electrolytic, 25V, Temp -55°C to 105°C \pm 20% | 1000 μ F | 12.5 \times 20 mm | UPW1E102MHD | Rubycon/Nichicon |
| C20, C47 | Capacitor, Ceramic, 1000pF, 50V, X7R, 10% | 1000 pF | 0603 | GRM188R71H102KA01D | Murata |
| C21 | Capacitor, Ceramic, 100 pF, 16-V, X7R, \pm 10%, Open | Open | 0603 | GRM188R71C104KA01D | Murata |
| C22, C50 | Capacitor, Ceramic, 0.1 μ F 50V, NPO | 0.1 μ F | 0603 | C1608C0G1H104J | TDK |
| C24, C25, C27, C28, C39, C40 | Capacitor, POS-Cap, 470 μ F, 6.3V, 0.010 Ω , 20%, 7343 | 470 μ F | 7343 | 6TPD470M | Sanyo |
| C43 | Capacitor, Ceramic, 100 pF, 16-V, X7R, \pm 10%, Open | OPEN | 0603 | | Murata |
| C51 | Capacitor, Ceramic, 2.2- μ F, 25-V, X7R, \pm 10% | 2.2 μ F | 1206 | GRM31CR71E225KA88L | Murata |
| C54 | Capacitor, Ceramic, Open, 50V, NPO | Open | 0603 | | TDK |
| C58 | Capacitor, Ceramic, 470 pF, 50V, NPO | 470 pF | 0603 | C1608C0G1H471J | TDK |
| C60–C62, C65 | Capacitor, Ceramic, 16V, X7R, 0.1 μ F, 10% | 0.1 μ F | 0603 | GRM188R71C104KA01D | Murata |
| C64 | Capacitor, Ceramic, 16V, X7R, 0.01 μ F, 10% | 0.01 μ F | 0603 | GRM188R71C103KA01D | Murata |
| C66 | Capacitor, Ceramic, 4.7- μ F, 6.3-V, X5R, \pm 10% | 4.7 μ F | 0603 | GRM188R70J475KA01D | Murata |
| C67 | Capacitor, Ceramic, 2200pF, 16-V, X7R, \pm 10% | 2200 pF | 0603 | GRM188R71C222KA01D | Murata |
| C68, C70 | Capacitor, Ceramic, 1000pF, 16-V, X7R, \pm 10% | 1000 pF | 0603 | GRM188R71C102KA01D | Murata |
| C69 | Capacitor, Ceramic, 0.47- μ F, 16-V, X7R, \pm 10% | 0.47 μ F | 0603 | GRM188R71C474KA01D | Murata |
| C9, C32 | Capacitor, Ceramic, 1.0 μ F, 25V, X7R, 20% | 1.0 μ F, 25V | 0805 | 08053C105MAT2A | AVX |
| D1, D6 | Diode, LED, Green, 2.1-V, 20-mA, 6-mcd | GREEN | 0603 | LTST-C190GKT | Liteon |
| D2–D5 | Diode, Schottky, 750-mA, 40-V | BAT750 | SOT23 | BAT750 | Vishay-Liteon |
| D7 | Diode, LED, Red, 1.8-V, 20-mA, 20-mcd | RED | 0603 | LTST-C190CKT | Lite On |
| D8, D9 | Dual Zener, ESD TVS, 6.5 V | SM05T1 | SOT23 | SM05T1 | On-Semi |
| J1–J4 | Header, Side Entry 2-pin, 5mm spacing | 1711026 | 0.441 \times 0.200 in | 1711026 | Phoenix Contact |
| J10 | Connector, Male Straight 2 \times 5 pin, 100mil spacing, 4 Wall | 2510-6002UB | 0.338 \times 0.788 in | 2510-6002UB | 3M |
| J11 | Header, 3-pin, 100mil spacing, (36-pin strip) | PULL_UP | 0.100 \times 3 | PTC36SAAN | Sullins |
| J5–J8 | Header, 3-pin, 100mil spacing, (36-pin strip) | PTC36SAAN | 0.100 in \times 3 | PTC36SAAN | Sullins |
| J9 | Header, 2 \times 5-pin, 100mil spacing (36-pin strip) | PTC36DAAN | 0.100 in \times 5 \times 2 | PTC36DAAN | Sullins |
| Jumper | Shunt, 100-mil | | 0.1 | 929957-08-ND | |
| L1, L2 | Inductor, Power SMT, 0.5 μ H, 30A, 1.1 m Ω | 0.5 μ H, 1.1 m Ω | 0.433 \times 0.516 in | B82559A0501A013 | Epcos |
| Q1, Q4 | MOSFET, NChan, 30V, 27A, 9 m Ω | FDMS8690 | POWER 56 | FDMS8690 | Fairchild |
| Q2 | MOSFET, Nch, 30V, 50A, 2.2 m Ω | Open | TDSON-8 | BSC022N03S | Infineon |
| Q3, Q6 | MOSFET, Nch, 30V, 50A, 2.2 m Ω | BSC022N03S | TDSON-8 | BSC022N03S | Infineon |
| Q5 | MOSFET, Nch, 30V, 50A, 2.2 m Ω | open | TDSON-8 | BSC022N03S | Infineon |
| Q7 | Transistor, NPN High Current, VCE 30V, VCB 80V, VEB6V, IC 7A | FCX690B | SOT89 | FCX690B | Zetex |

Table 4. UCD9112EVM Bill of Materials (continued)

| RefDes | Description | Value | Size | Part Number | MFR |
|---------------------------------------|--|------------|------------|-------------|-----------|
| Q8 | Bipolar, NPN, xx-V, yy-mA, zz-W | 3904LT1 | SOT23 | MMBT3904LT1 | On Semi |
| Q9, Q10 | MOSFET, Nch, 25V, 220-mA, 5 Ω | FDV301N | SOT23 | FDV301N | Fairchild |
| R1, R5, R11, R12, R18, R27, R32 | Resistor, Chip, 1.0K, 1/16-W, 1% | 1.0K | 0603 | Std | Std |
| R10, R24 | Resistor, Chip, 100, 1/16-W, 1% | 100 | 0603 | Std | Std |
| R13 | Resistor, Chip, 1/10W, 1%, 0 Ω | 0805 | 0805 | Std | Std |
| R15, R30, R54, R55, R57, R68 | Resistor, Chip, 10 kΩ, 1/10-W, 1% | 10.0K | 0603 | Std | Std |
| R16 | Resistor, Chip, 1/10W, 1%, 1 Ω, 805 | Open | 0805 | Std | Std |
| R17 | Resistor, Chip, 511-Ω, 1/8W, 5% 511 | | 1206 | Std | Std |
| R2, R3, R14, R19, R21, R31 | Resistor, Chip, 1.0-Ω, 1/16-W, 5% | 1 | 0603 | Std | Std |
| R23 | Resistor, Chip, 49.9 kΩ, 1/10-W, ±1% | 49.9K | 0603 | Std | Std |
| R25, R9 | Resistor, Chip, 20 kΩ, 1/16-W, 1% | 20K | 0603 | Std | Std |
| R28 | Resistor, Chip, 1/10W, 1%, 0 ohm, 805 | open | 0805 | Std | Std |
| R29 | Resistor, Chip, 1/10W, 1%, 0 ohm, | 0805 | 0805 | Std | Std |
| R33, R34 | Resistor, Chip, 1-Ω, 1/4W, 5% | 1 | 1206 | Std | Std |
| R35 | Resistor, Chip, 1/10W, 1.62K, 5% | 1.62k | 0805 | Std | Std |
| R36, R42 | Resistor, Chip, 5.11 kΩ, 1/10-W, ±1% | 5.11K | 0603 | Std | Std |
| R37 | Resistor, Chip, 22 kΩ, 1/10-W, 1% | 22k | 0603 | Std | Std |
| R38 | Resistor, Chip, 10 kΩ, 1/10-W, 1% | 10k | 0603 | Std | Std |
| R39, R65 | Resistor, Chip, 8.25 kΩ, 1/16-W, ±0.1% | 8.25K | 0603 | Std | Std |
| R4, R20 | Resistor, Chip, 10-Ω, 1/10-W, ±1% | 10 | 0603 | Std | Std |
| R40 | Resistor, Chip, 10.7 kΩ, 1/10-W, ±1% NTC | Open | 0603 | Std | Std |
| R41 | Resistor, Chip, 511, 1/16-W, 5% | 511 | 0603 | Std | Std |
| R43, R67 | Resistor, Chip, 11.0 kΩ, 1/16-W, ±0.1% | 11.0K | 0603 | Std | Std |
| R44, R45, R47, R49, R51, R53 | Resistor, Chip, 33-Ohms, 1/16-W, 5% | 33 | 0603 | Std | Std |
| R46, R62 | Resistor, Chip, 10-Ω, 1/10-W, 1% | 10 | 0603 | Std | Std |
| R48 | Resistor, Chip, 0-Ω, 1/16-W, 5% | 0 | 0603 | Std | Std |
| R50 | Resistor, Chip, 8.87 kΩ, 1/16-W, 1% | 8.87K | 0603 | Std | Std |
| R52 | Resistor, Chip, 6.04 kΩ, 1/10-W, 1% | 6.04K | 0603 | Std | Std |
| R56, R58, R60, R63 | Resistor, Chip, 100-Ω, 1/16-W, 5% | 100 | 0603 | Std | Std |
| R59 | Resistor, Chip, 1K, 1/16-W, 5% | 1K | 0603 | Std | Std |
| R6, R26 | Resistor, Chip, 1/10W, 1%, 2.2Ω, 805 | 2.2 | 0805 | Std | Std |
| R61 | Resistor, Chip, 11.5 kΩ, 1/10-W, ±1% | 11.5K | 0603 | Std | Std |
| R64 | Resistor, Chip, 2 kΩ, 1/10-W, ±1% | 2K | 0603 | Std | Std |
| R66, R71, R77 | Resistor, Chip, 3.3 kΩ, 1/10-W, 5% | 3.3K | 0603 | Std | Std |
| R69 | Resistor, Chip, 2.49 kΩ, 1/10-W, 1% | 2.49K | 0603 | Std | Std |
| R7 | Resistor, Chip, 49.9 kΩ, 1/10-W, ±1% | 49.9K | 0603 | Std | Std |
| R70 | Resistor, Chip, 2.4 kΩ, 1/10-W, ±5% | 2.4K | 0603 | Std | Std |
| R72 | Resistor, Chip, 5.11 kΩ, 1/10-W, ±1% | Open | 0603 | Std | Std |
| R73 | Resistor, Chip, 20 kΩ, 1/10-W, 1% | 20K | 0603 | Std | Std |
| R74 | Resistor, Chip, 3.83 kΩ, 1/10W, ±1% | 3.83K | 0603 | Std | Std |
| R75 | Resistor, Chip, 1 kΩ, 1/10-W, 5% | 1K | 0603 | Std | Std |
| R76, R79 | Resistor, Chip 5.11 kΩ, 1/10-W, 5% | 5.11K | 0603 | Std | Std |
| R78 | Resistor, Chip, 4.99 kΩ, 1/10W, ±1% | Open | 0603 | Std | Std |
| R8, R22 | Resistor, Chip, 1/10W, 1%, 0 Ω, | 0805 | 0805 | Std | Std |
| TP1–TP26 | Pin, Thru Hole, Tin Plate, for 0.062 PCB's | | 0.039 inch | K24A/M | Vector |
| TP5 | Adaptor, 3.5-mm probe clip (or 131-5031-00) | VOUT | 0.2 | 131-4244-00 | Tektronix |
| U1, U2 | IC, Power Stage (Analog Stuff) | UCD7230RGW | QFN-20 | UCD7230RGW | TI |

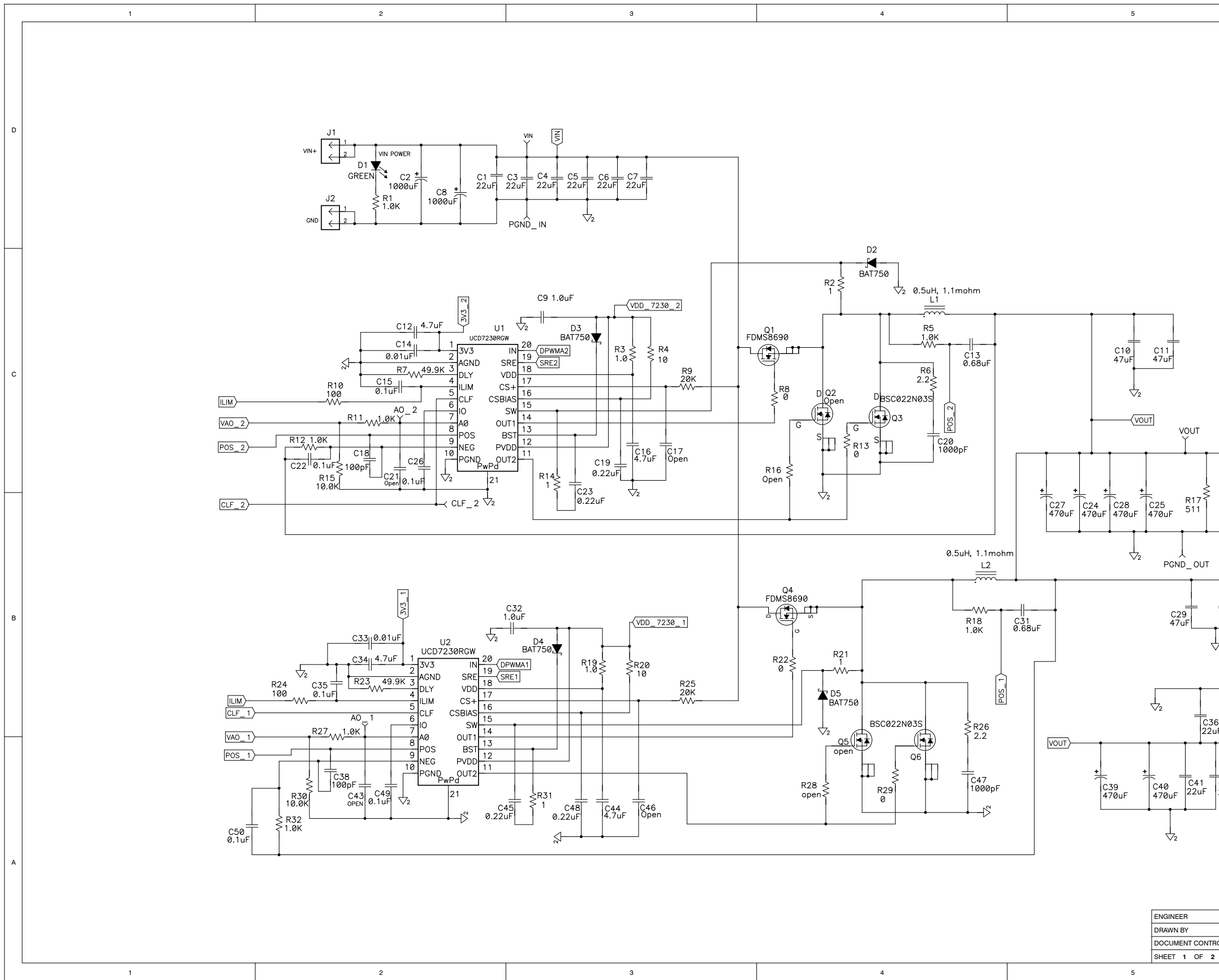
Table 4. UCD9112EVM Bill of Materials (continued)

| RefDes | Description | Value | Size | Part Number | MFR |
|--------|--|------------|-----------|----------------------|-----|
| U3 | IC, Precision Programmable Reference | TL1431QD | S08 | TL1431QD or TL1431CD | TI |
| U4 | IC, Digital Dual Phase Sync. Buck Controller | UCD9112RHB | QFN-32 | UCD9112RHB | TI |
| | PCB | | | HPA281 | Any |
| | Bumpers | 2563 | 0.25x0.50 | 2563 | SPC |

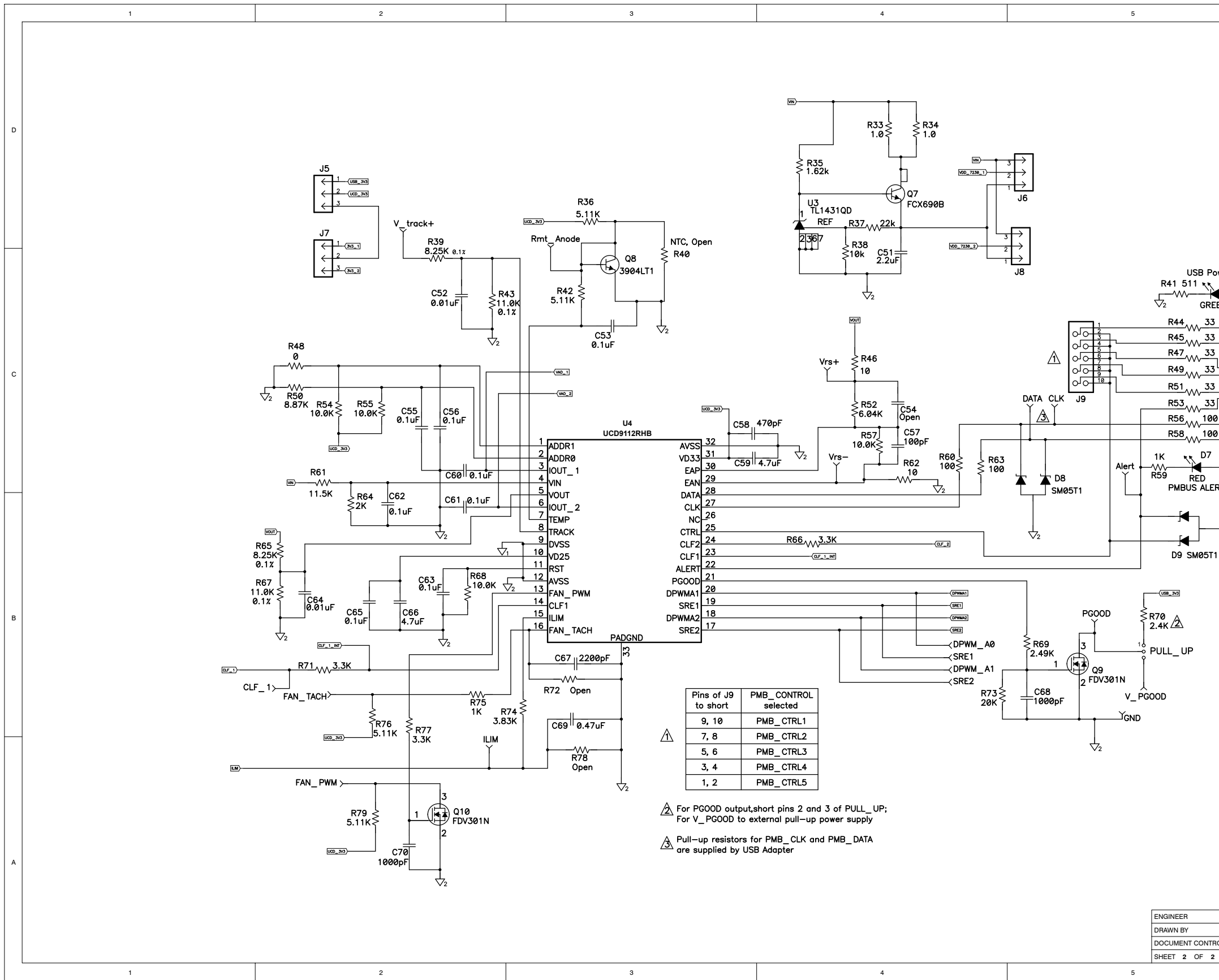
12 References

The following documents are available for download through the Texas Instruments web site (www.ti.com).

1. *Designing the Digital Compensator for UCD91xx Based Digital Power Supply* ([SLUA416](#))
2. *PMBus Support in UCD911x Family of Digital Power Controllers* ([SLUA427](#))
3. *Configuration Security for UCD91xx Digital Controllers* ([SLUA428](#))
4. *Fusion Digital Power Designer User Manual* (available with the TI-Fusion-Digital-Power-Designer Software program, [SLVC118](#))



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 SHEET 1 OF 2



| Pins of J9 to short | PMB_CONTROL selected |
|---------------------|----------------------|
| 9, 10 | PMB_CTRL1 |
| 7, 8 | PMB_CTRL2 |
| 5, 6 | PMB_CTRL3 |
| 3, 4 | PMB_CTRL4 |
| 1, 2 | PMB_CTRL5 |

- ⚠ For PGGOOD output, short pins 2 and 3 of PULL_UP; For V_PGGOOD to external pull-up power supply
- ⚠ Pull-up resistors for PMB_CLK and PMB_DATA are supplied by USB Adapter

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