Evaluating the ADM1281 Hot-Swap Controller and Digital Power and Energy Monitor with PMBus Interface

FEATURES

- Fully functional evaluation board for the ADM1281
- Populated and tested with 12 V, 73 A, and 3 mF design
- Special N-MOSFET footprint suits different packages
- Supports up to five sense resistors in parallel
- Supports up to six FETs in parallel
- LED indicated status outputs
- Wide input-voltage range of up to 20 V
- FET temperature measurement capability
- Supports cascade setup for multiple boards
- Toggle and push-button switch for easy input control
- PMBus communication supported

EVALUATION KIT CONTENTS

- EVAL-ADM1281-AZ evaluation board

ADDITIONAL HARDWARE NEEDED

- Serial I/O interface USB-SDP-CABLEZ or DC1613A (not included in the evaluation board and must be ordered separately)
- Only one interface is required in multiple board cascade setup

SOFTWARE NEEDED

- Hot-swap and power monitoring evaluation software or LTpowerPlay

DOCUMENTS NEEDED

- ADM1281 data sheet

GENERAL DESCRIPTION

The EVAL-ADM1281-AZ is a compact, full-featured evaluation board for the ADM1281. The board layout provides a clear visual of all the peripheral components and the hot-swap power path. The layout also maximizes the ability of the board to dissipate heat for some of the key components on the power path, which allows the evaluation of very high current hot-swap setups.

Five sense-resistor slots and six multipackage FET slots provide great flexibility and allow a wide range of application setups.

Multiple test points allow easy access to all critical points/pins. Seven LEDs provide direct visual indication on variations in the board status, such as supply input, output, IC power-good output, fault output, current sense output, and general-purpose outputs (GPO). An AD7291 8-channel, I^2C, 12-bit, successive approximation analog-to-digital converter (SAR ADC) allows users to measure voltages such as CSOUT and other pin voltages, as well as to read ambient board temperature through an I^2C bus in real time.

The evaluation board supports I^2C communication, which allows users to communicate with the ADM1281. The evaluation board also supports cascade setup so multiple evaluation boards can be connected together and share the same I^2C bus.

The boards are fully compatible with the hot-swap and power monitoring evaluation software and the LTpowerPlay tools, which can be downloaded from the ADM1281 product page.

Users need a USB-SDP-CABLEZ or a DC1613A USB-to-I^2C serial interface to use the evaluation software tools.

The standard evaluation board is prepopulated and tested with a 12 V, 73 A hot-swap design, which is capable of working with a 3 mF output capacitor.

Full specifications on the ADM1281 are available in the ADM1281 data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the EVAL-ADM1281-AZ evaluation board.

EVALUATION BOARD PHOTOGRAPH

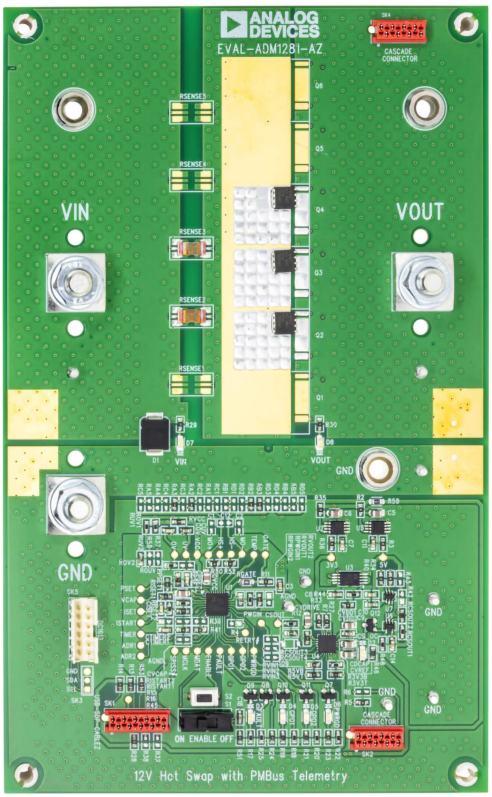

Figure 1. Evaluation Board Photograph

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REVISION HISTORY

3/2024—Revision 0: Initial Version

QUICK START GUIDE

To set up and start using the EVAL-ADM1281-AZ evaluation board, do the following steps:

1. Download the hot-swap and power monitor software from the ADM1281 product page (for more information, refer to the UG-353 user guide).
2. Connect the evaluation board to a PC through the 10-way connector and USB-SDP-CABLEZ. Alternatively, use a DC1613A connected to the 12-pin SK5 connector in conjunction with the LTpowerPlay software.
3. Connect the power supply to the evaluation board using thick wires suitable for the current levels to be observed.
4. To confirm that the boards are configured correctly, set the output of the power supply to 12 V with less than 1 A current limit and with no load capacitance. If the boards are configured correctly, the green LED, labeled PWRGD illuminates.
5. Slide the ENABLE switch to the OFF position or press the push-button. The green LED, labeled PWRGD turns off and then turns on again when re-enabled.
6. If a fault event occurs (for example, a short-circuit during operation), the red LED, labeled $\overline{\text{FAULT}}$ illuminates. To clear the fault, toggle the ENABLE pin after the fault condition is removed.
7. Before changing the controller default settings, disable the hot-swap using the **Hot Swap Control** section of the **Basic Operation** tab of the GUI. Disabling the hot-swap turns off VOUT and the associated green LEDs (VOUT and PWRGD) on the evaluation board.
8. Manually program the sense-resistor value, if required, using the options in the GUI.
9. Check that the voltage and current measurements are as expected (for example, V_{IN} = 12 V) in the **Power Monitor** tab of the software GUI.

EVALUATION BOARD DESCRIPTION

The EVAL-ADM1281-AZ is designed to demonstrate several features of the ADM1281. A simplified drawing of the evaluation board is shown in Figure 5.

The EVAL-ADM1281-AZ is connected to a PC using a USB-SDP-CABLEZ serial interface for I^2C communication. Alternatively, a DC1613A USB-to-PMBus controller can be used with LTpowerPlay.

The EVAL-ADM1281-AZ photograph is shown in Figure 1. To minimize inductance, use thick wires between the power supply and the EVAL-ADM1281-AZ board connector. The PWRGD, VIN, and VOUT LEDs illuminate green after the board is powered.

The EVAL-ADM1281-AZ is intended to be plugged into a system where load capacitance already exists. Two through-hole vias are provided to allow the placement of a load capacitor on the board when testing the board outside of a real system. All testing performed on the board is done with a 3 mF load capacitor.

The EVAL-ADM1281-AZ uses a 10 nF CTIMER1 capacitor to maintain a 1 ms FET safe operating area (SOA). The undervoltage and overvoltage thresholds are set using resistor-dividers. A resistor-divider is also used on the ISET pin to set the current limit to approximately 73 A. The constant power level is set to 180 W to allow the board to power up while maintaining the FET SOA at all times. These values can all be fine-tuned further if necessary.

The EVAL-ADM1281-AZ has the capability to mimic power throttling by allowing the user to set a programmable threshold on CSOUT through the hot-swap and power monitoring evaluation software. There is a resistor-divider on the board to set the CSOUT within the input threshold range of the ADC, and another resistor-divider is used to set it within the input threshold range of the comparator. When the CSOUT voltage exceeds the comparator threshold programmed by the AD5622 digital-to-analog converter (DAC) (through the evaluation software), an alert signal is asserted. The yellow LED (D2) illuminates to mimic this alert signal. The fast response time of the CSOUT pin to a load step (typically 10 µs) makes it suitable for fast alerts to overcurrent events. For example, it can be used to drive the fast PROCHOT pin of an Intel® processor for power throttling.

The EVAL-ADM1281-AZ uses a custom MOSFET footprint as shown in Figure 3 to accommodate a variety of common MOSFET packages, which includes D2PAK, DPAK, LFPAK, and other 8-lead SOIC variants.

For the best current sensing accuracy with the footprint shown in Figure 4, chip resistors without a nickel barrier layer (usually green in color) are recommended. The data in this user guide may not be applicable to all resistors, and results may vary depending on resistor composition and size. Alternative resistors should be tested independently. It is the responsibility of the user to ensure the layout dimensions and structure of the footprint comply with individual SMT manufacturing requirements. Note that Analog Devices does not accept responsibility for any issues that may arise as a result of using this footprint.

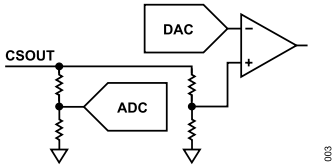

Figure 2. CSOUT Circuitry

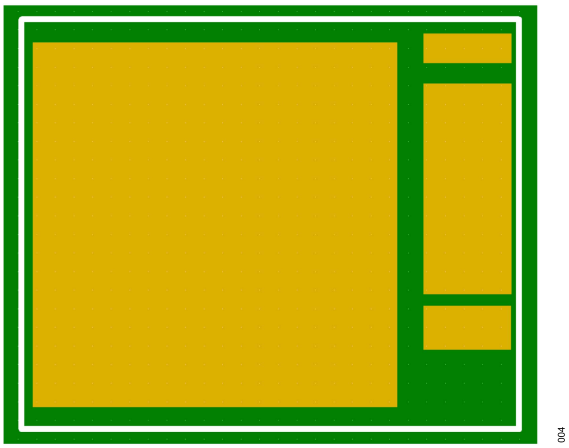

Figure 3. Multipackage N-MOSFET Footprint

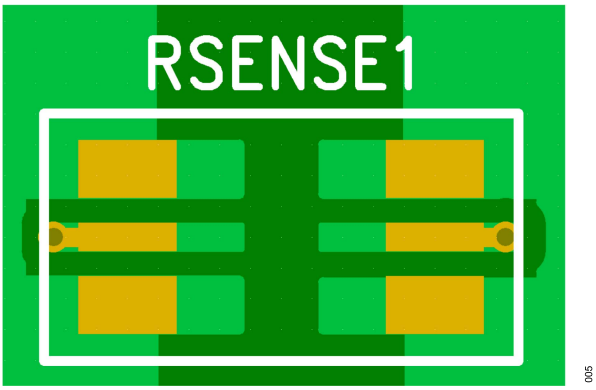

Figure 4. Recommended Sense-Resistor Footprint

EVALUATION BOARD DESCRIPTION

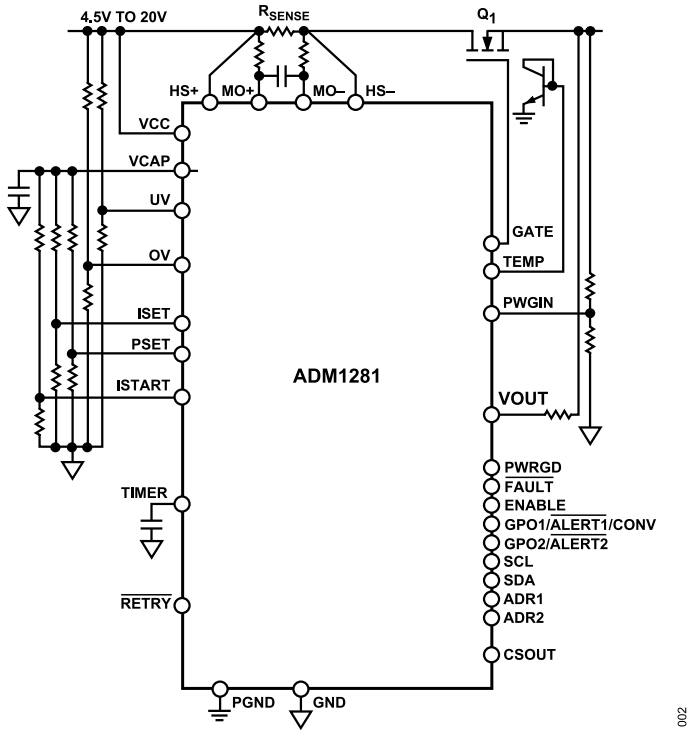

Figure 5. Basic Block Diagram

EVALUATION BOARD SPECIFICATIONS

Table 1 shows the evaluation board specifications.

Table 1. Evaluation Board Specifications

Parameter	Typical Value	Unit
Load Capacitance	3000	µF
Circuit-Breaker Current	69.5	A
Regulation Current	73	A
Start-Up Current Limit	8.0	A
Constant Power Foldback	180	W
Ambient Temperature	60	°C
UV Falling Threshold	9.26	V
UV Rising Threshold	9.81	V
OV Rising Threshold	16.4	V
PWRGD Falling Threshold	10.3	V
TIMER Regulation	167	µs

EVALUATION BOARD HARDWARE

SWITCH, JUMPER, AND LED FUNCTIONS

Table 2. Connector Functions

Connector	Description
VIN	Hot-swap line voltage input, which also powers the board. Input voltage is 4.5 V to 20 V (after removing D1 TVS).
VOUT	Hot-swap line voltage output.
GND	Board common ground.
SK1	10-way connector for USB-SDP-CABLEZ.
SK2	Bottom cascade connector; connect with the Micro-MaTch ribbon cable to link with another EVAL-ADM1281-AZ board.
SK4	Top cascade connector; connect with the Micro-MaTch ribbon cable to link with another EVAL-ADM1281-AZ board.
SK5	12-pin connector for DC1613A when using LTpowerPlay.

Table 3. Switch Functions

Switch	Description
S1	Toggle switch for the ENABLE pin.
S2	Push-button switch for the ENABLE pin.

Table 4. LED Functions

LED	Description
D2	CSOUT comparator output, active high; yellow.
D3	$\overline{\text{FAULT}}$, active low; red.
D4	GPO1, active high; blue.
D5	GPO2, active high; blue.
D6	Power good, active high; green.
D7	Board input power; green.
D8	Board output power; green.

Table 5. On-Board ICs

IC	Description
U1	ADM1281, main IC.
U2	ADP1720ARMZ-3.3, 4 V to 28 V input, 3.3 V, 50 mA output LDO; powering EEPROM.
U3	64 Kb I^2C EEPROM.
U4	AD7291, ±1°C accurate, 8-channel, I^2C, 12-bit SAR ADC with temperature sensor.
U5	ADP1720ARMZ-5, 4 V to 28 V input, 5 V, 50 mA output LDO; powering U6 and U7.
U6	ADCMP370AKSZ, general-purpose comparator with open-drain output.
U7	AD5622YKSZ, 2.7 V to 5.5 V, 12-bit *nano*DAC® with I^2C-compatible interface.

TEST PLOTS

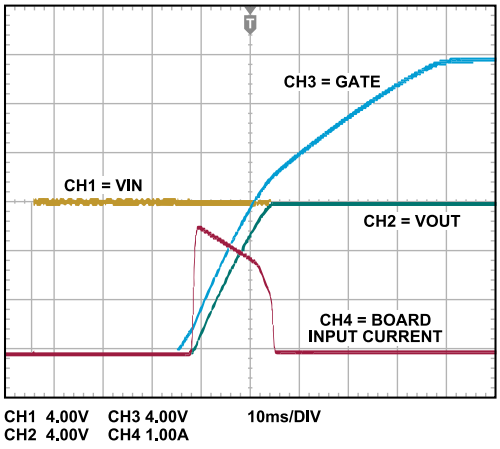

Figure 6. Power Up with 3 mF Load Capacitor and No DC Load

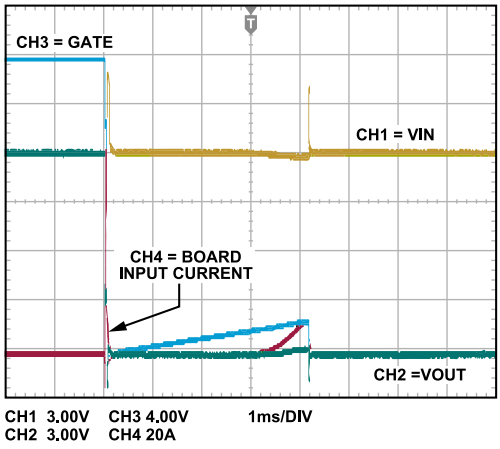

Figure 9. Output Short-Circuit

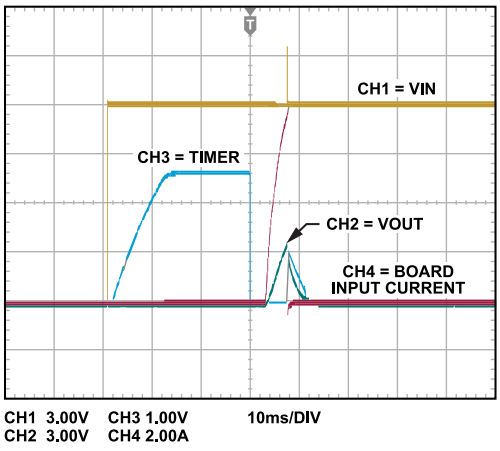

Figure 7. Failed Power Up Into 0.6 Ω DC Load with 8 A Start-Up Current Limit

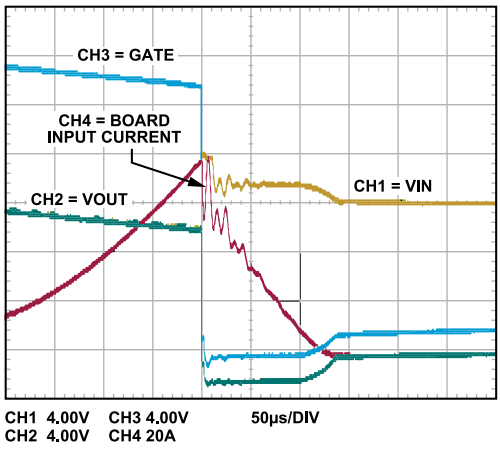

Figure 10. Output Short-Circuit Zoom-In

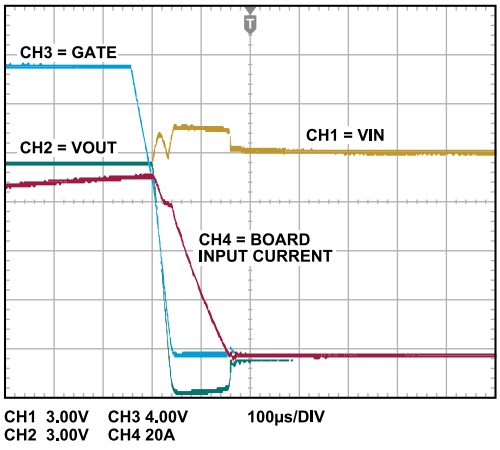

Figure 8. Overcurrent Shutdown

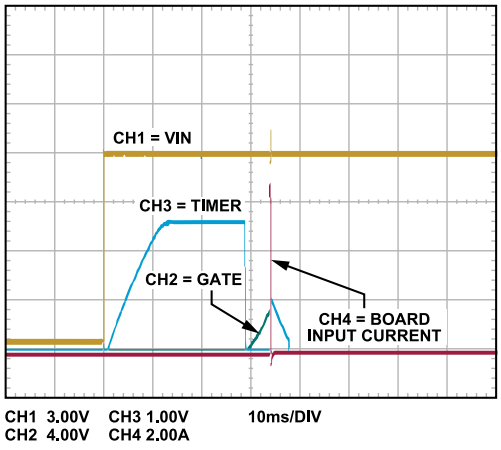

Figure 11. Power Up Into an Output Short-Circuit

TEST PLOTS

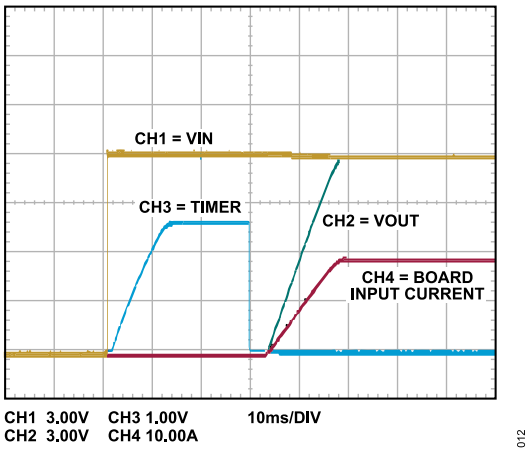

Figure 12. Power Up Into 0.6 Ω DC Load with Start-Up Current Limit Disabled

EVALUATION BOARD SCHEMATIC AND ARTWORK

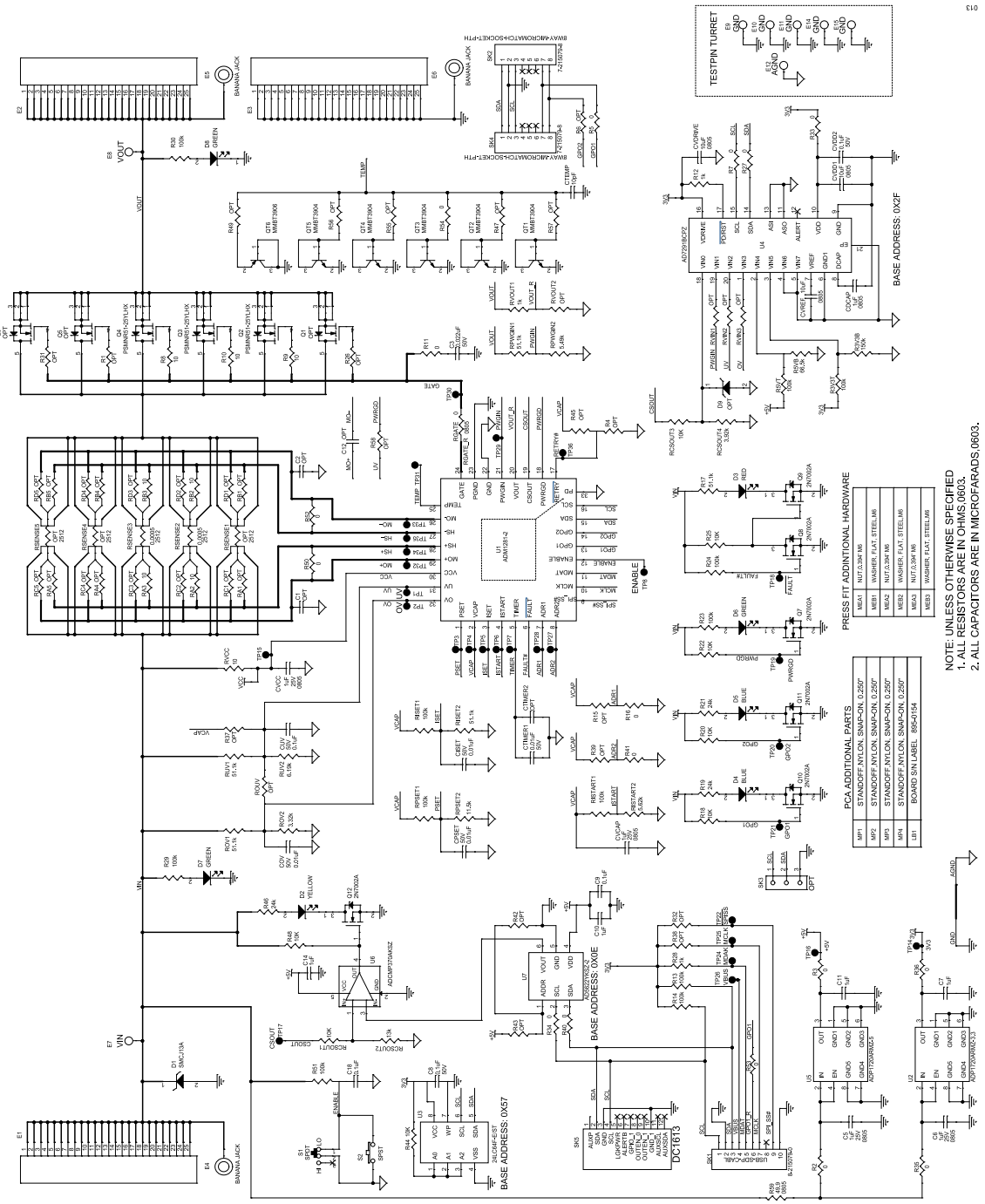

Figure 13. EVAL-ADM1281-AZ Evaluation Board Schematic

EVALUATION BOARD SCHEMATIC AND ARTWORK

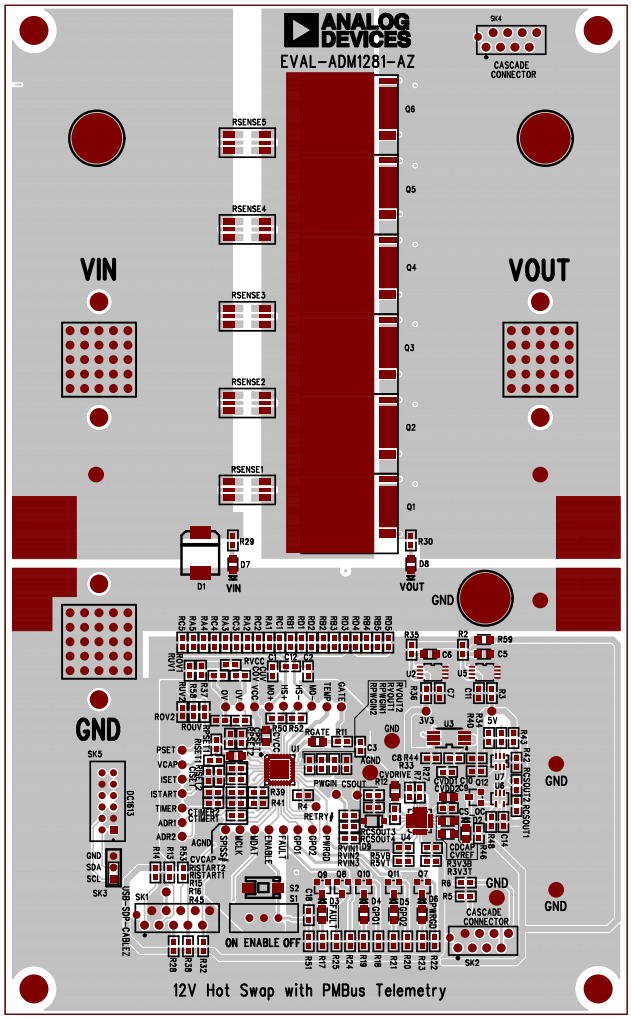

Figure 14. EVAL-ADM1281-AZ Evaluation Board Top Layer

EVALUATION BOARD SCHEMATIC AND ARTWORK

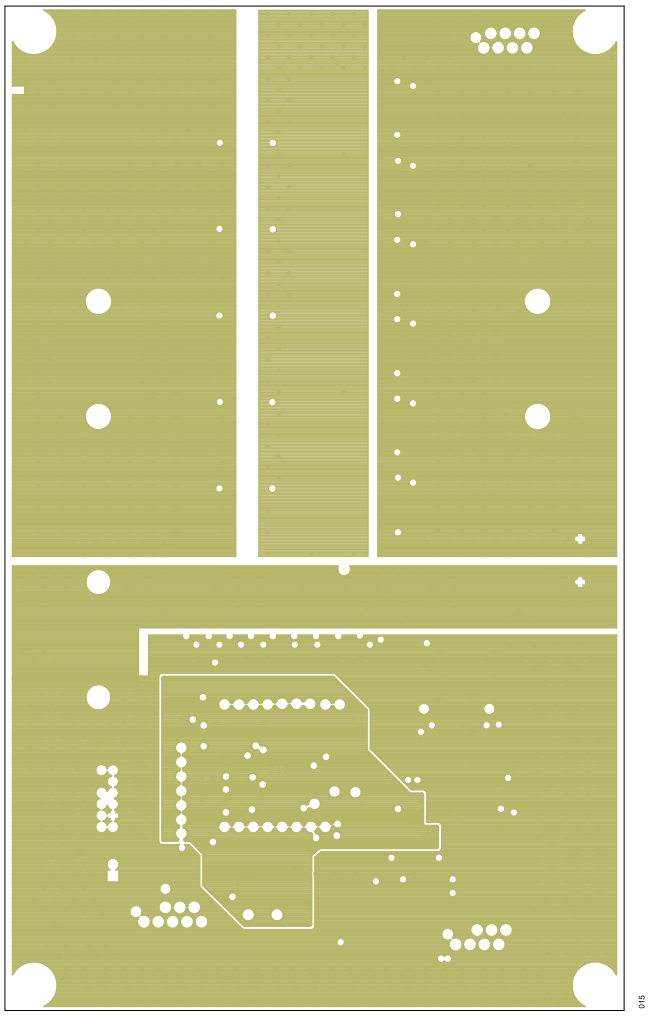

Figure 15. EVAL-ADM1281-AZ Evaluation Board Inner Layer 2

EVALUATION BOARD SCHEMATIC AND ARTWORK

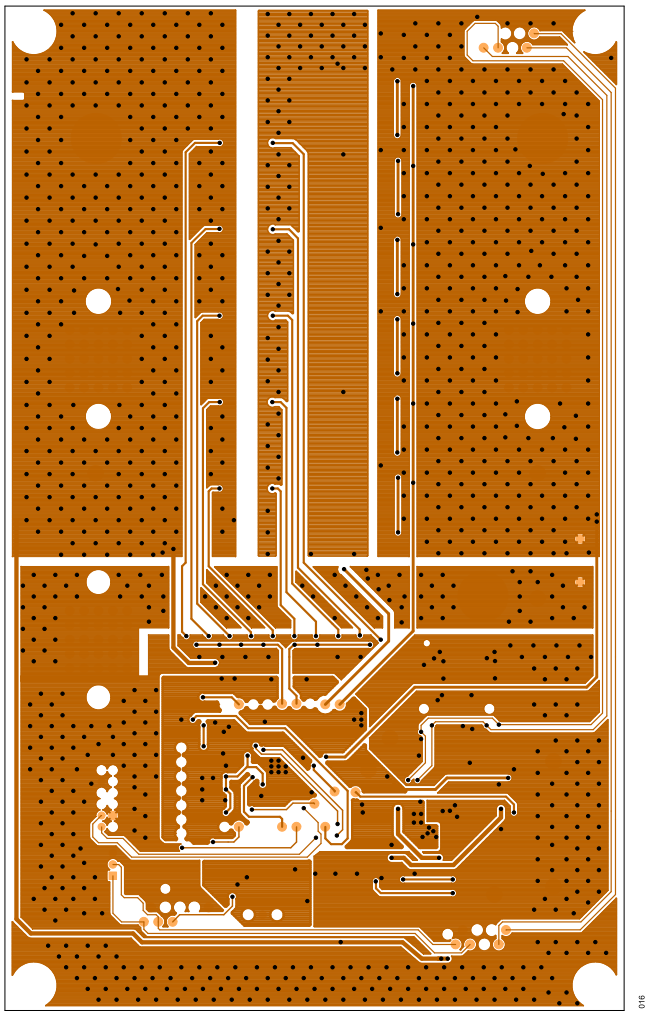

Figure 16. EVAL-ADM1281-AZ Evaluation Board Inner Layer 3

EVALUATION BOARD SCHEMATIC AND ARTWORK

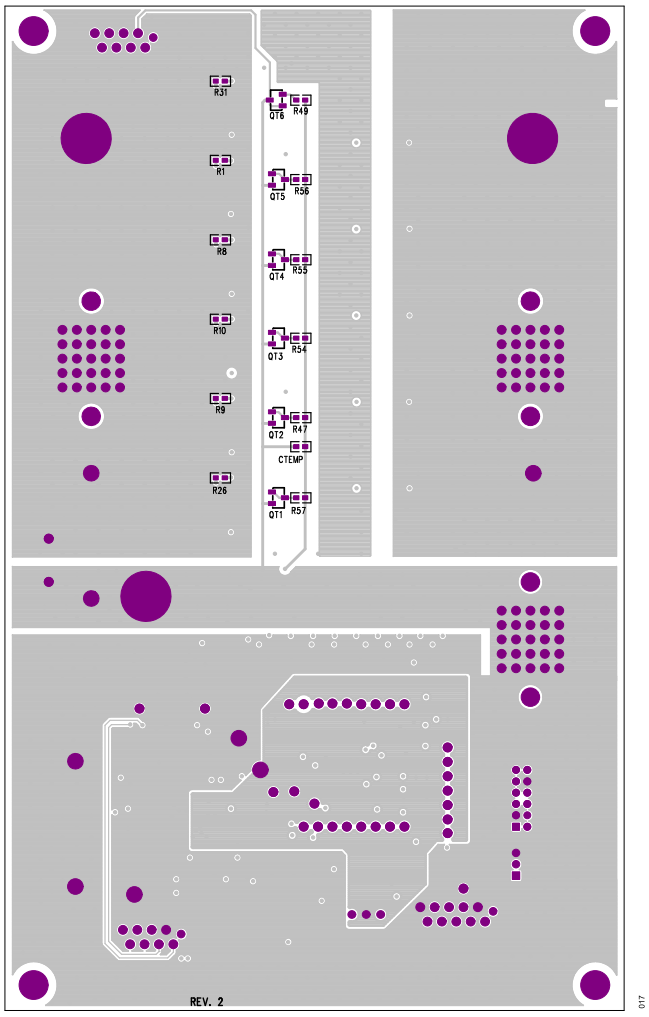

Figure 17. EVAL-ADM1281-AZ Evaluation Board Bottom Layer

ORDERING INFORMATION

BILL OF MATERIALS

Table 6. Bill of Materials for EVAL-ADM1281-AZ

Reference Designator	Description	Manufacturer	Part Number
C3	Capacitor, 0.022 µF, X7R, 50 V, 10%, 0603	AVX	06035C223KAT2A
C5, C6, CDCAP, CVCAP, CVCC	Capacitors, 1 µF, X7R, 25 V, 10%, 0805, AEC-Q200	TDK	CGA4J3X7R1E105K125AB
C7, C10, C11, C14	Capacitors, 1 µF, X5R, 16 V, 10%, 0603	AVX	0603YD105KAT2A
C8, C9, C18, CUV, CVDD2	Capacitors, 0.1 µF, X7R, 50 V, 10%, 0603	AVX	06035C104KAT2A
CISET, COV, CPSET, CTIMER1	Capacitors, 0.01 µF, X7R, 50 V, 10%, 0603	AVX	06035C103KAT2A
CTEMP	Capacitor, 10 pF, C0G, 50 V, 5%, 0603	AVX	06035A100JAT2A
CVDD1, CVDRIVE, CVREF	Capacitors, 10 µF, X7R, 6.3 V, 20%, 0805	AVX	08056C106MAT2A
D1	Diode, transient voltage suppressors (TVS), unidirectional, 13 V, 1.5 kW, SMC, 5%	Littelfuse Inc.	SMCJ13A
D2	LED, yellow, water clear, 0805	Wurth Elektronik	150080YS75000
D3	LED, red, water clear, 0805	Wurth Elektronik	150080RS75000
D4, D5	LEDs, blue, water clear, 0805	Wurth Elektronik	150080BS75000
D6, D7, D8	LEDs, green, water clear, 0805	Wurth Elektronik	150080GS75000
E1, E2, E3	Connectors, REDCUBE, M6, 25-pin, press-fit, through hole technology (THT), brass, tin	Wurth Elektronik	7461098
E4, E5, E6	Connectors, banana jack, female, THT, noninsulated, swage, 0.218"	Keystone	575-4
E7, E8, E9, E10, E11, E12, E14, E15	Test points, turret, mounting hole diameter 0.064", PCB thickness 0.125"	Mill-Max	2308-4-00-80-00-00-07-0
MEA1, MEA2, MEA3	Nuts, width 0.394", M6	B&F Fastener Supply	MHNZ 006
MEB1, MEB2, MEB3	Washers, flat, steel, M6	B&F Fastener Supply	MFWZ 006
MP1, MP2, MP3, MP4	Standoffs, nylon, snap-on, 0.250"	Keystone	8831
Q2, Q3, Q4	NMOSFET, 25 V, 380 A, LFPAK56E (Power-SO8)	Nexperia	PSMNR51-25YLHX
Q7, Q8, Q9, Q10, Q11, Q12	NMOSFET, 60 V, 220 mA, SOT23-3, AEC-Q101	Diodes Inc.	2N7002A-13
QT1, QT2, QT3, QT4, QT5	NPN, 40 V, 200 mA, SOT23-3, AEC-Q101	Diodes Inc.	MMBT3904-7-F
QT6	PNP, 40 V, 200 mA, SOT-23, AEC-Q101	Diodes Inc.	MMBT3906-7-F
R2, R3, R5, R7, R11, R16, R27, R33, R34, R35, R36, R40, R41, R50, R52, R53, R54	Resistors, 0 Ω, 1/10 W, 0603	Bourns Inc.	CR0603-J/-000ELF
R3V3B	Resistor, 150 kΩ, 1%, 1/10 W, 0603	Panasonic	ERJ3EKF1503V
R3V3T, R5VT, R13, R14, R23, R24, R29, R30, R51, RISET1, RISTART1, RPSET1	Resistors, 100 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW0603100KFKEA
R5VB	Resistor, 66.5 kΩ, 1%, 1/10 W, 0603	NIC	NRC06F6652TRF
R8, R9, R10, RA2, RA3, RB2, RB3, RVCC	Resistors, 10 Ω, 1%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW060310R0FKEA
R12, R28, RVOUT1	Resistors, 1 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW06031K00FKEA
R17, RISET2, ROV1, RPWGIN1, RUV1	Resistors, 51.1 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF5112V
R18, R20, R22, R25, R44, R48, RCSOUT1, RCSOUT3	Resistors, 10 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF1002V
R19, R21, R46	Resistors, 24 kΩ, 5%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW060324K0JNEA
R59	Resistor, 49.9 Ω, 1%, 1/8 W, 0805, AEC-Q200	Panasonic	ERJ6ENF49R9V
RCSOUT2	Resistor, 13 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW060313K0FKEA
RCSOUT4	Resistor, 3.92 kΩ, 1%, 1/10 W, 0603	NIC	NRC06F3921TRF
RGATE	Resistor, 0 Ω, 1/8 W, 0805, AEC-Q200	Panasonic	ERJ6GE0R00V
RISTART2	Resistor, 5.62 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF5621V
ROV2	Resistor, 3.32 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF3321V
RPSET2	Resistor, 11.5 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Vishay	CRCW060311K5FKEA
RPWGIN2	Resistor, 5.49 kΩ, 1%, 1/10 W, 0603, AEC-Q200	NIC	NRC06F5491TRF
RSENSE2, RSENSE3	Resistors, 0.0005 Ω, 1%, 6 W, 2512, metal, sense, AEC-Q200	Bourns Inc.	CSS2H-2512R-L500F

ORDERING INFORMATION

Table 6. Bill of Materials for EVAL-ADM1281-AZ (Continued)

Reference Designator	Description	Manufacturer	Part Number
RUV2	Resistor, 6.19 kΩ, 1%, 1/10 W, 0603	Yageo	RC0603FR-076K19L
S1	Switch, slide, SPDT, 0.2 A, 30 V, THT	E-Switch	EG1218
S2	Switch, light touch, tactile, SPST, 0.05 A, 12 V, J-bent, SMD, 6.0 mm × 3.5 mm, height 5 mm, black	Panasonic	EVQPE105K
SK1	Connector, receptacle, 10POS 0.1, Tin, PCB	TE Connectivity	8-215079-0
SK2, SK4	Connectors, receptacle, 8POS 0.1, Tin, PCB	TE Connectivity	7-215079-8
SK5	Connector, headers, shrouded, male, 2 × 6, 2 mm, vertical, straight, THT	Amphenol	98414-G06-12ULF
U1	IC, hot-swap controller and digital power and energy monitor, LFCSP 32-Lead	Analog Devices, Inc.	ADM1281-2A
U2	IC, low noise, CMOS LDO, 3.3 V, 8-Lead MSOP	Analog Devices, Inc.	ADP1720ARMZ-3.3-R7
U3	IC, EEPROM, I^{2}C, TSSOP-8, 64 kb, 400 kHz	Microchip Technology	24LC64F-E/ST
U4	IC, 8-channel, I^{2}C, 12-bit SAR ADC	Analog Devices, Inc.	AD7291BCPZ
U5	IC, low noise, CMOS LDO, 5 V, 8-Lead MSOP	Analog Devices, Inc.	ADP1720ARMZ-5-R7
U6	General-purpose comparator, 5-Lead SC70	Analog Devices, Inc.	ADCMP370AKSZ
U7	IC, 12-bit DAC with I^{2}C, 6-Lead SC70	Analog Devices, Inc.	AD5622YKSZ-2

I^{2}C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.