

# ANALOG DEVICES EVAL-LTC4286 Power Management Development Boards and Kits User Guide

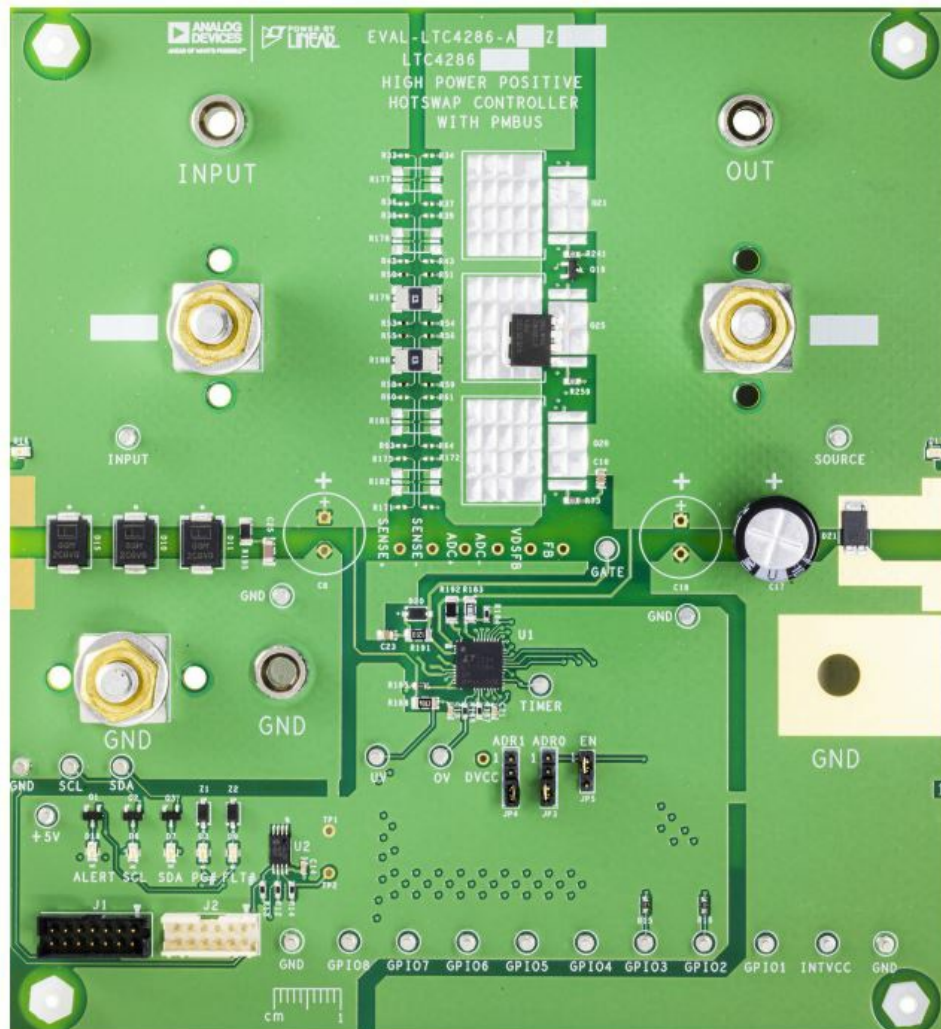
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**ANALOG DEVICES EVAL-LTC4286 Power Management Development Boards and Kits**



## FEATURES

- Fully functional evaluation kit board for the LTC4286
- Populated with 54 V, 36 A, 1 mF design
- 40 V undervoltage and 60 V overvoltage settings
- Flexible N channel MOSFET footprint suits different packages
- Supports up to 12 parallel sense resistors and six parallel MOS-FETs
- LED indicated status outputs
- Wide input voltage range: 8.5 V to 80 V
- 100 V absolute maximum
- MOSFET temperature measurement capability
- I2C/PMBus communication

## EVALUATION KIT CONTENTS

- EVAL-LTC4286-A1Z evaluation board

## DOCUMENTS NEEDED

- LTC4286 datasheet

## **ADDITIONAL HARDWARE NEEDED**

- USB-to-PMBus controller for use with LTpowerPlay, DC1613A (not included, must be ordered separately)

## **GENERAL DESCRIPTION**

The EVAL-LTC4286-A1Z is a fully featured evaluation board for the LTC4286. The board layout provides a clear example 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, allowing the evaluation of high-current hot-swap setups.

- Twelve sense resistor footprints and six (three on the bottom side) multipackage metal-oxide-semiconductor field-effect transistor (MOSFET) footprints provide great flexibility and allow a wide range of application setups.
- Multiple test points allow easy access to all critical points and pins. Seven light-emitting diodes (LEDs) provide direct visual indication of board status, such as supply input, output, SDA, SCL, ALERT, power good, and fault.
- The board supports PMBus communication, allowing the user to communicate with the LTC4286.
- The board is fully compatible with the LTpowerPlay® evaluation software, which can be downloaded from the LTpowerPlay page.
- A USB-to-I2C controller (DC1613A) is required to use the evaluation software.
- The standard evaluation kit is prepopulated and tested with a 54 V, 36 A hot-swap design capable of working with a 1 mF output capacitor.
- The full specifications of the LTC4286 are available in the LTC4286 data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the EVAL-LTC4286-A1Z evaluation board.

## **EVAL-LTC4286-A1Z EVALUATION BOARD LAYOUT**

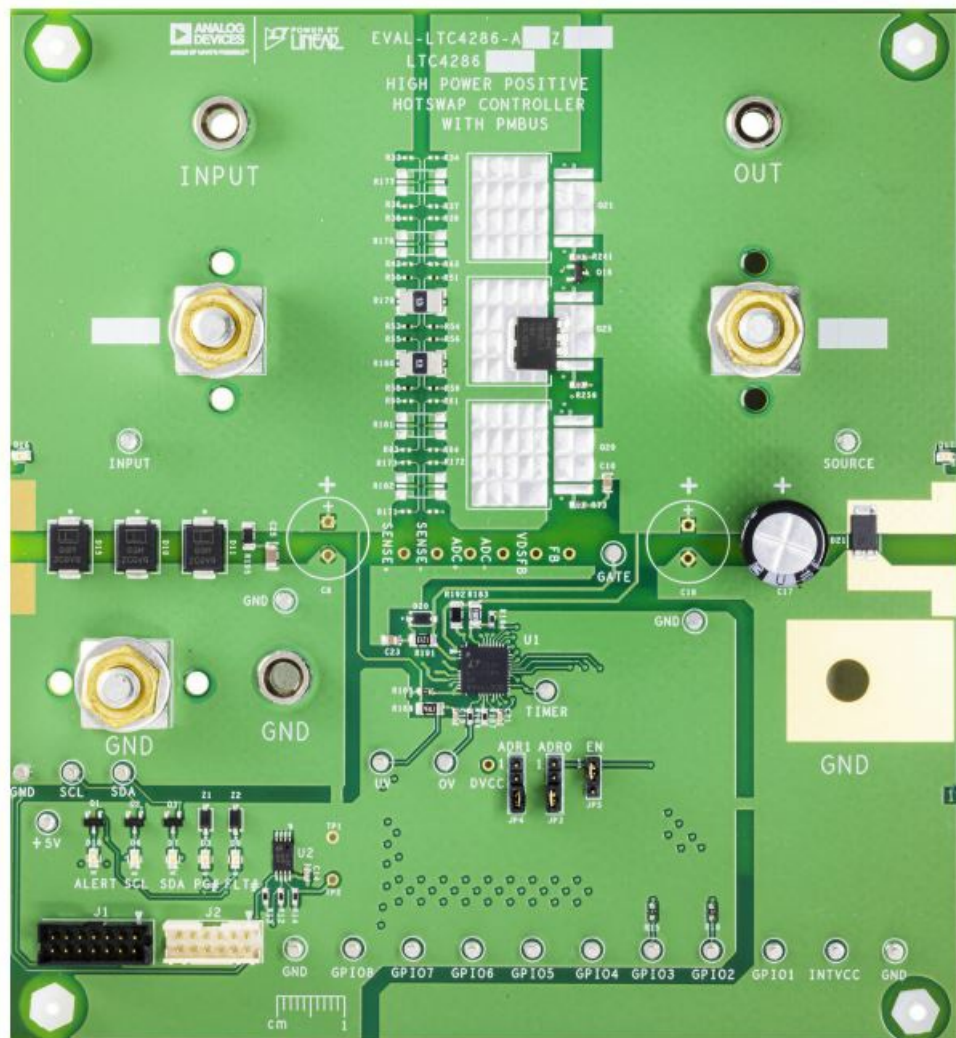


Figure 1. Evaluation Board Layout

## QUICK START GUIDE

The EVAL-LTC4286-A1Z evaluation board is easy to setup to evaluate the performance of the LTC4286. See Figure 2 for the proper measurement equipment setup and refer to the following procedures.

## WARNING AND MEASUREMENT TECHNIQUES

- The EVAL-LTC4286-A1Z is capable of operation in excess of 40 A. At this current and power level, there is a danger of serious personal injury and equipment damage if proper techniques are not used. All cabling between the power supply and the load must be capable of handling the current levels used, including the GND connection to the EVAL-LTC4286-A1Z.
- Additionally, the high currents and fast transients can cause unexpected voltage drops in cables connecting the test equipment to the EVAL-LTC4286-A1Z due to parasitic resistance and inductance. The cable drops may cause ground loops for the current through various cables and scope probes. This causes unexplained ringing, distorted oscilloscope waveforms, voltage and current spikes, and signals appearing to be below ground.
- A common sneak path for current is the third wire ground used on power cords of test equipment in use. Using ground lifting connectors at the wall outlet do not necessarily alleviate these effects since most equipment has line bypassing capacitors between the mains voltage and local chassis ground. Isolating test equipment using line isolation transformers with low primary to secondary capacitance is recommended. Probe ground leads may intercept induced fields from the high current paths and should be minimized or avoided.

- Another method to remove these artifacts is the use of a differential scope probe connected between the signal to be observed and a ground connection located close to the point of measurement.
- A very large, low-effective series resistance (ESR) capacitor from INPUT to GND can reduce supply droop and ground bounce during testing.
- Also be careful not to allow an open ground from the power supply or load to cause a return current through the grounds of the various devices connected to the demo board. This can present a fire hazard or cause damage to the test equipment.

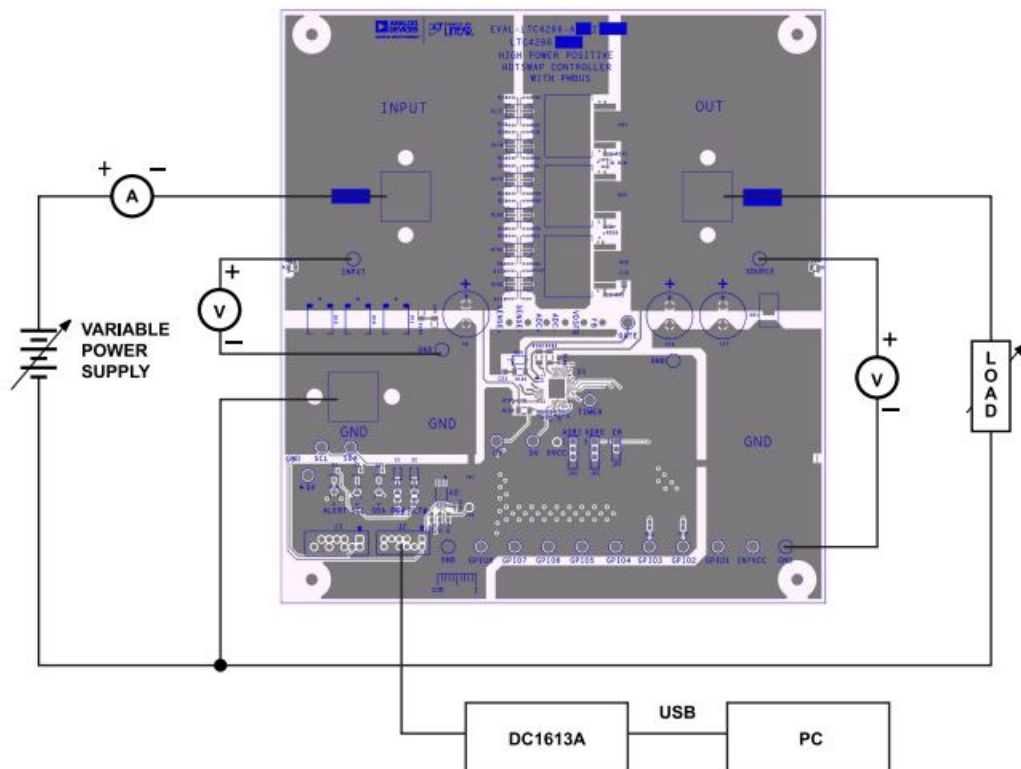
The EVAL-LTC4286-A1Z is set up to operate in a 54 V system at current levels up to 36 A. The board is designed to work at 36 A in a normal laboratory environment with natural convection. Suppose the current limit is increased or the board is operated in a high-temperature environment. In that case, additional airflow is needed to keep it within safe thermal operating limits for continuous operation. If additional current is required without sufficient airflow, multiple MOS-FETs must be connected in parallel with the existing MOSFETs to lower their I<sup>2</sup>R losses.

### **EVAL-LTC4286-A1Z SETUP**

To set up and start using the evaluation board, take the following steps:

1. On a Windows PC, download and install the LTpowerPlay application from <https://www.analog.com/en/design-center/ltpower-play.html>.
2. Connect the evaluation board (EVAL-LTC4286-A1Z) to the PC through the 12-way connector, J2, and the USB-to-I2C controller (DC1613A).
3. Connect a power supply to the evaluation board using thick wires (10 AWG or 62 mm) 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 54 V with less than 1 A current limit and with no load capacitance. If the boards are configured correctly, the green LED (labeled PG#) on the evaluation board illuminates.
5. Move the EN jumper, JP5, to the lower position. The green LED (labelled PG#) turns off and then turns back on again when JP5 is moved back to the upper position.
6. If a fault event occurs (for example, a short circuit during operation), the red LED (labeled FLT#) illuminates. This fault can be cleared by toggling the ENABLE pin after the fault condition has been removed.
7. Disable the hot-swap using the Hot-Swap Control section in the Basic Operation tab of the software graphical user interface (GUI). Disabling the hot swap turns off the green LED (labeled PG#) on the evaluation board.



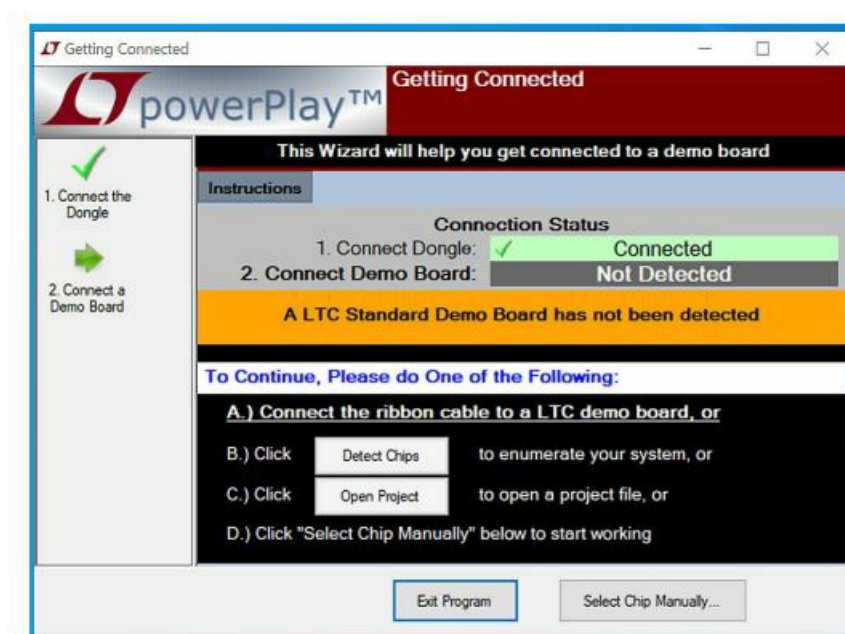


**Figure 2. Basic EVAL-LTC4286-A1Z Connection Diagram**

### CONTROL WITH LTpowerPlay

LTpowerPlay is a convenient PC GUI that gives complete access to the registers of the LTC4286 and many other Analog Devices' power system management devices. It can be used to configure and debug the application. LTpowerPlay communicates using the I2C bus in the demo system (covered in this user guide) or in a real-world product environment. It provides unprecedented control over the Analog Devices chips on the I2C bus. Use it during board bring up to tune and optimize the power system parameters and during system debugging to view critical system information and troubleshoot board design or manufacturing issues. LTpowerPlay includes extensive help and documentation under the Help menu. Online help includes quick-start videos and tutorials, and detailed technical documentation from the Analog Device website.

Launch the LTpowerPlay GUI on the PC. The software identifies the DC1613A controller. Click the Detect Chips button.



**Figure 3. LTpowerPlay—Getting Connected Window**

LTpowerPlay searches the PMBus for all supported devices. After establishing communication with the LTC4286, the GUI displays the main window shown in Figure 4.

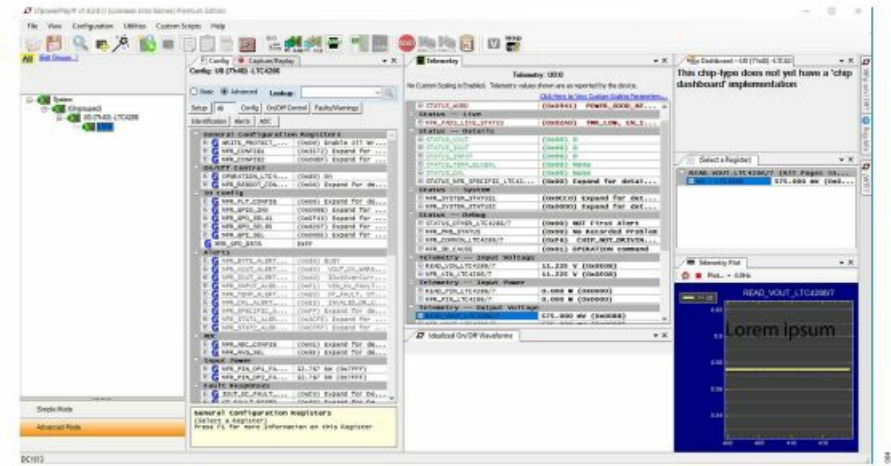


Figure 4. LTpowerPlay—Main Window

SETUP

The value of the current-sense resistor must be set RS (SENSE) in LTpowerPlay. Click the Setup button. Locate the setting for RS (SENSE). Enter the value of the current-sense resistor. For the EVAL-LTC4286-A1Z, enter 0.500 as shown in Figure 5. It is necessary to set the value of RS each time LTpowerPlay is launched. The value of RS is used in the calculation of current and power.

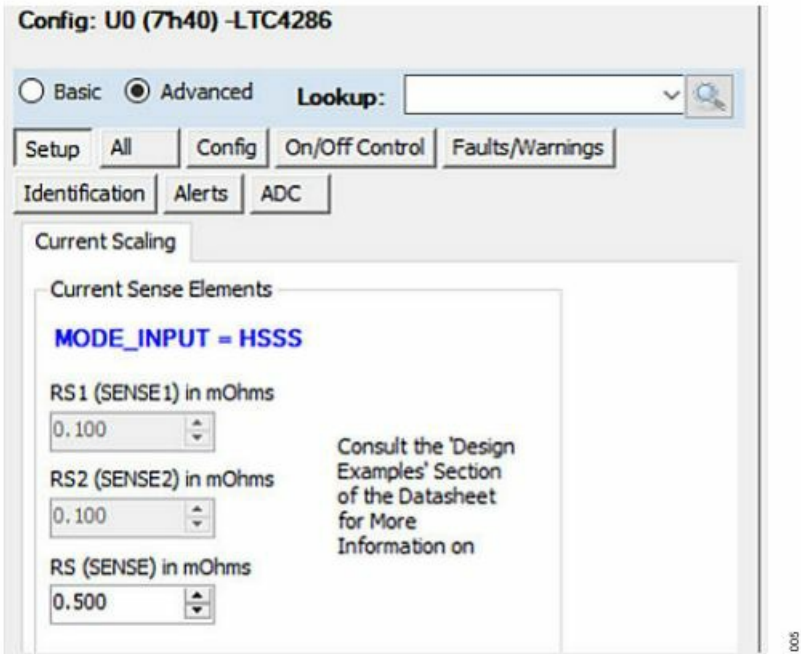


Figure 5. LTpowerPlay Setting RS (SENSE)

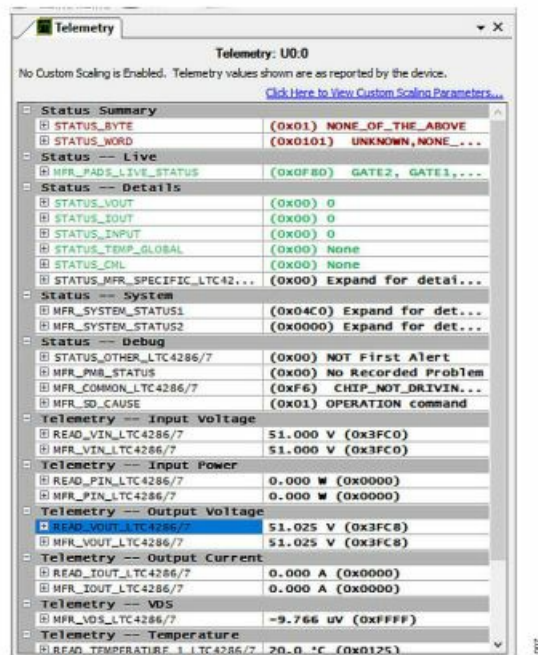
To update the register’s contents, click or type to change the required registers, then in the top toolbar, click the PC to RAM button. LTpowerPlay writes changes to the updated registers.



Figure 6. PC to RAM Button Transfers Data Programmed from the GUI to the LTC4286 Volatile Registers

**Note** that to program the registers in the LTC4286, turn off the pass MOSFET.

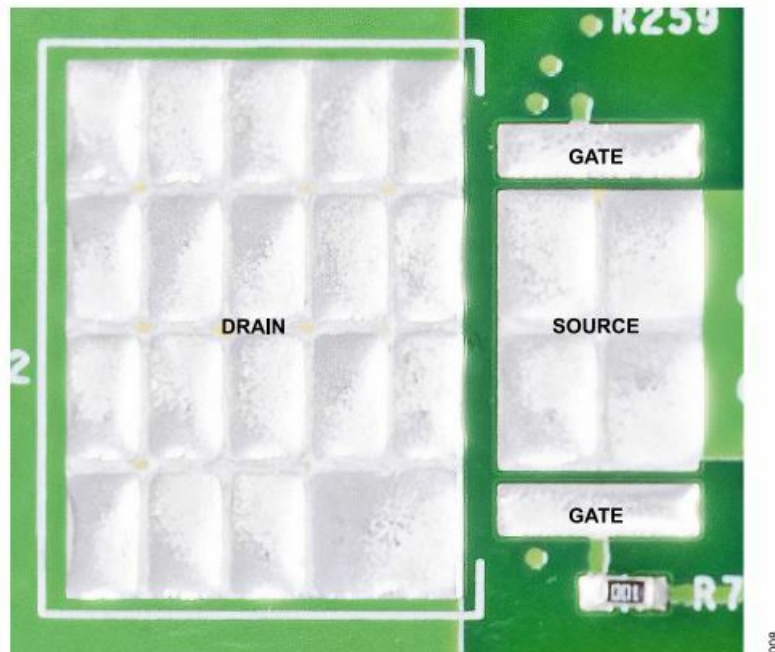
Most of the registers have immediate control over their respective chip functions. Changing them while the MOSFET is on has unpredictable and adverse effects. LTpowerPlay implements limits to writing some registers, based upon the device state, and pops up warnings when necessary. In the LTpowerPlay main window (see Figure 4), there is the Telemetry pane window (see Figure 7) that displays read-only information contained in the status registers of the selected part. The GUI periodically polls the I2C bus and updates the telemetry contents in real-time, along with a user-friendly interpretation of the bits.



**Figure 7. LTpowerPlay—Telemetry Pane Window**

## MOSFETS

The EVAL-LTC4286-A1Z uses a custom MOSFET footprint as shown in Figure 8 to accommodate a variety of common MOSFET packages, including D2PAK, DPAK, LPAK, and other 8-lead SOIC variants.



**Figure 8. Multipackage N-Channel MOSFET Footprint**

## SENSE RESISTORS

For optimum current sensing accuracy with standard 2512 sense resistors, the footprint shown in Figure 9 is preferred. This footprint may not be optimized to all resistors, and results may vary depending on resistor composition and size. The centre pads are used as the Kelvin connection to sense the voltage at the resistor.



Some resistors provide more accurate results if sensed at the inner edge of the resistor (labelled A as shown in Figure 9). Consult and follow the guidance provided by the resistor manufacturer. The board can be configured with up to 12 current-sense resistors. The Kelvin connections are combined using a resistive network made with 0402 resistors.

If replacing the current-sense resistors, it is the responsibility of the user to ensure that the layout dimensions and structure of the footprint comply with individual SMT manufacturing requirements. Failure to do this may result in inaccurate telemetry.

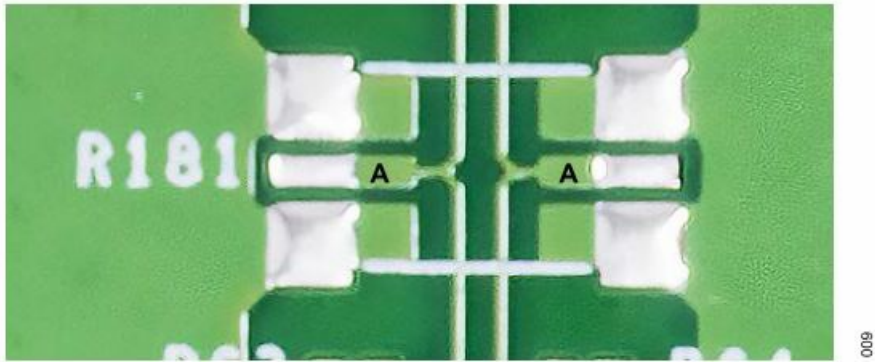


Figure 9. Sense Resistor—Kelvin Footprint

BOARD SPECIFICATIONS

Table 1. Board Specifications

Parameter	Typical Value
Load Capacitance	1000 $\mu$ F
Severe Circuit Breaker Current	108 A
Normal Current Limit	36 A
Start-Up Time	100 ms
Maximum T <sub>A</sub>	60°C
UV (Falling) Threshold	32 V
OV (Rising) Threshold	63 V
PG# Falling Threshold	30 V

EVALUATION BOARD HARDWARE

CONNECTOR AND LED FUNCTIONS

Table 2. Power Input and Signal Connections

Nomenclature	Connector	Description
--------------	-----------	-------------



INPUT	+V input test point
SOURCE	+V output test point
GND	Multiple GND test points
INTV <sub>CC</sub>	Internal INTV <sub>CC</sub> pin
UV	UV input pin
OV	OV input pin
TIMER	Current-limit TMR pin
GATE1	GATE1 pin
SCL	I2C clock
SDA	I2C data
GPIO1	Power good, PG#1
GPIO2	Fault, FLT#1
GPIO3	Temp sensor (Q18)1
GPIO4	IOOUT_OC_STATUS1
GPIO5	Reserved
GPIO6	Reserved
GPIO7	Reserved
GPIO8	OP1_STATUS, overpower1

1. With the default EVAL-LTC4286-A1Z settings.

**Table 5.** Other Test Points

Nomenclature	Description
INTV <sub>CC</sub> DV <sub>CC</sub>	LTC4286
SENSE+1	LTC4286 internal logic supply Positive current-limit input
SENSE–1	Negative current-limit input
ADC+	Positive sense input to the ADC
ADC–	Negative sense input to the ADC

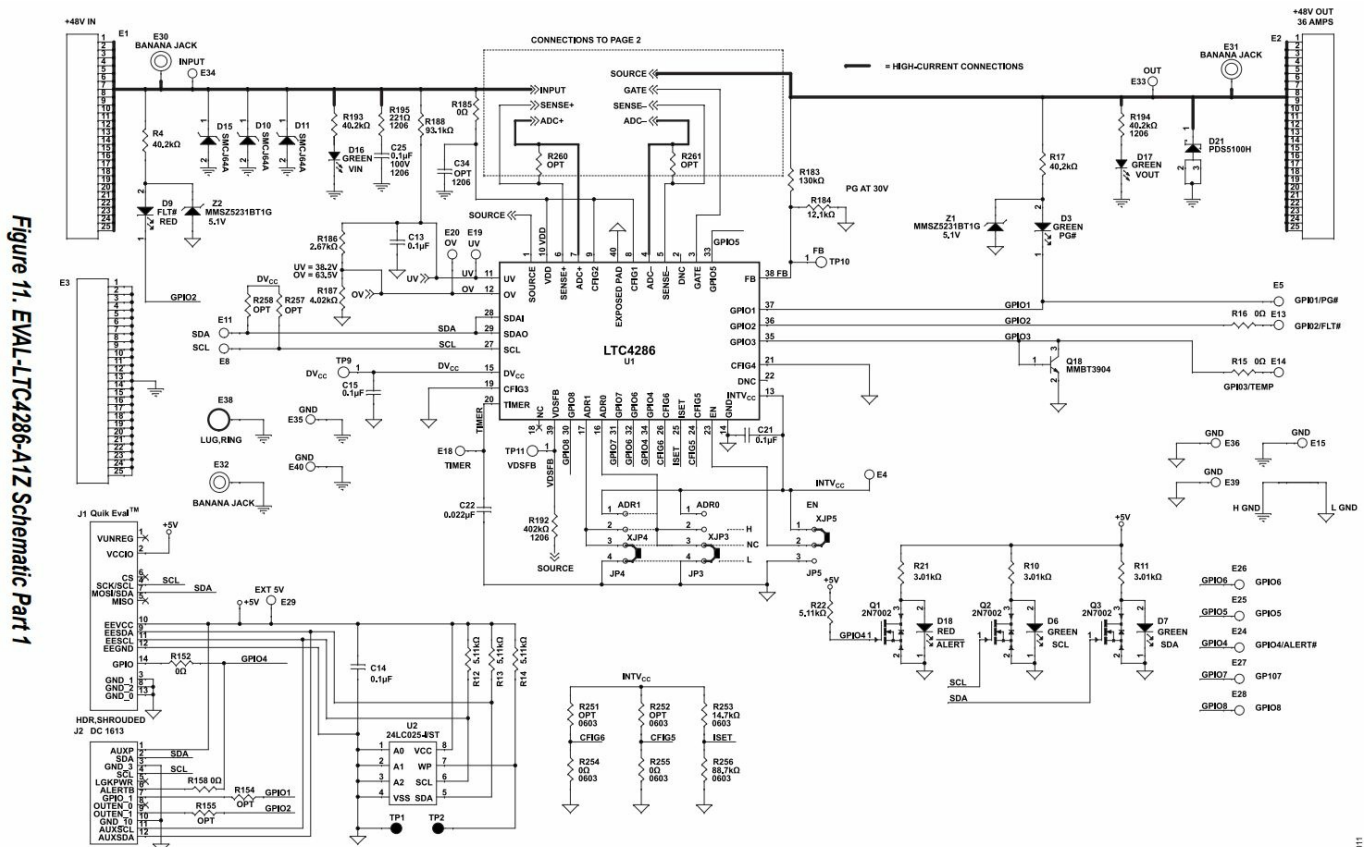
**Table 6.** LED Indicators

Nomenclature	Designation	Description
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INPUT	D14 (green)	Input power indicator
OUTPUT	D17 (green)	Output indicator
PG#	D3 (green)	Power good1
SCL	D6 (green)	I2C clock
SDA	D7 (green)	I2C data
FLT#	D9 (red)	FLT#1
ALERT	D16 (red)	ALERT [2]2

1. With the default EVAL-LTC4286-A1Z settings.
2. The ALERT LED is driven by the IOUT\_OC\_STATUS OUTPUT in the default configuration, which can be changed by writing to the registers.

## EVALUATION BOARD SCHEMATICS AND ARTWORK





PCA ADDITIONAL PARTS		
MP1	NUT, MACHINE, 4-40 x 1/4" OD, HEX,NYLON	
MP2	NUT, MACHINE, 4-40 x 1/4" OD, HEX,NYLON	
MP3	NUT, MACHINE, 4-40 x 1/4" OD, HEX,NYLON	
MP4	NUT, MACHINE, 4-40 x 1/4" OD, HEX,NYLON	
MP5	STANDOFF THREADED #4-40 NYLON 0.500" (12.70mm) 1/2"	
MP6	STANDOFF THREADED #4-40 NYLON 0.500" (12.70mm) 1/2"	
MP7	STANDOFF THREADED #4-40 NYLON 0.500" (12.70mm) 1/2"	
MP8	STANDOFF THREADED #4-40 NYLON 0.500" (12.70mm) 1/2"	
LB1	BOARD S/N LABEL	895-0154
PCB1	PCB, EVAL-LT4286-A12	REV01



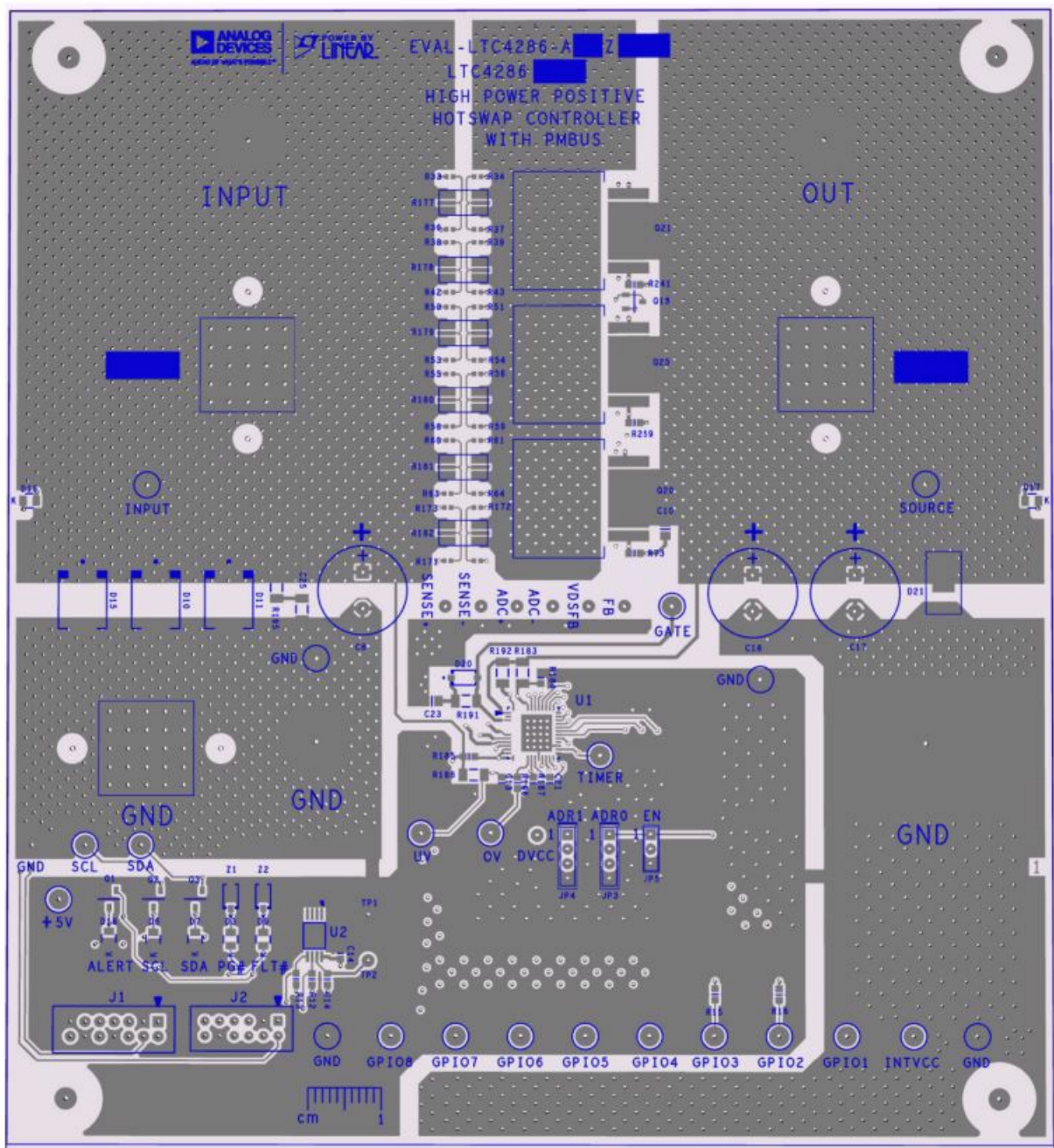
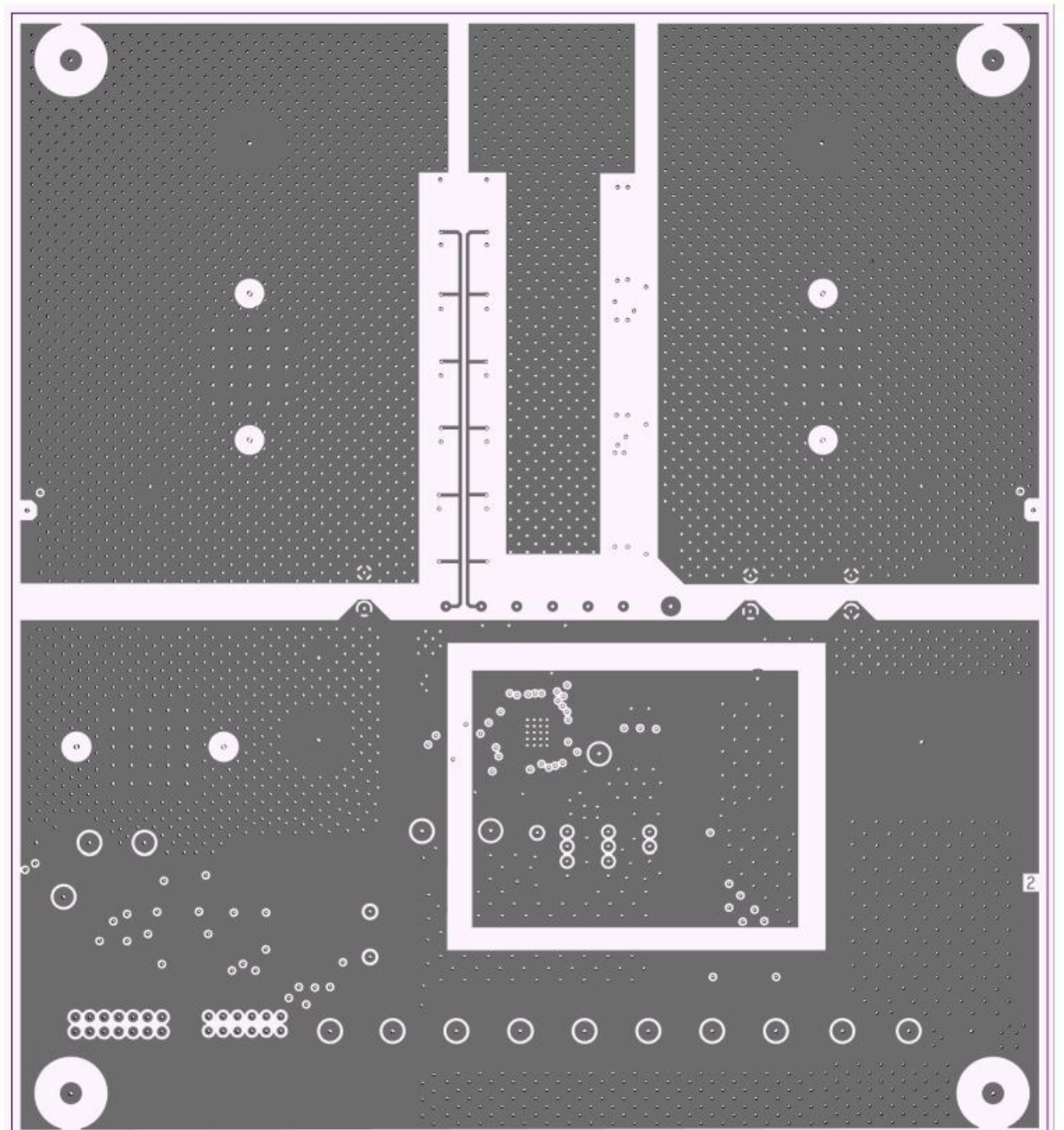
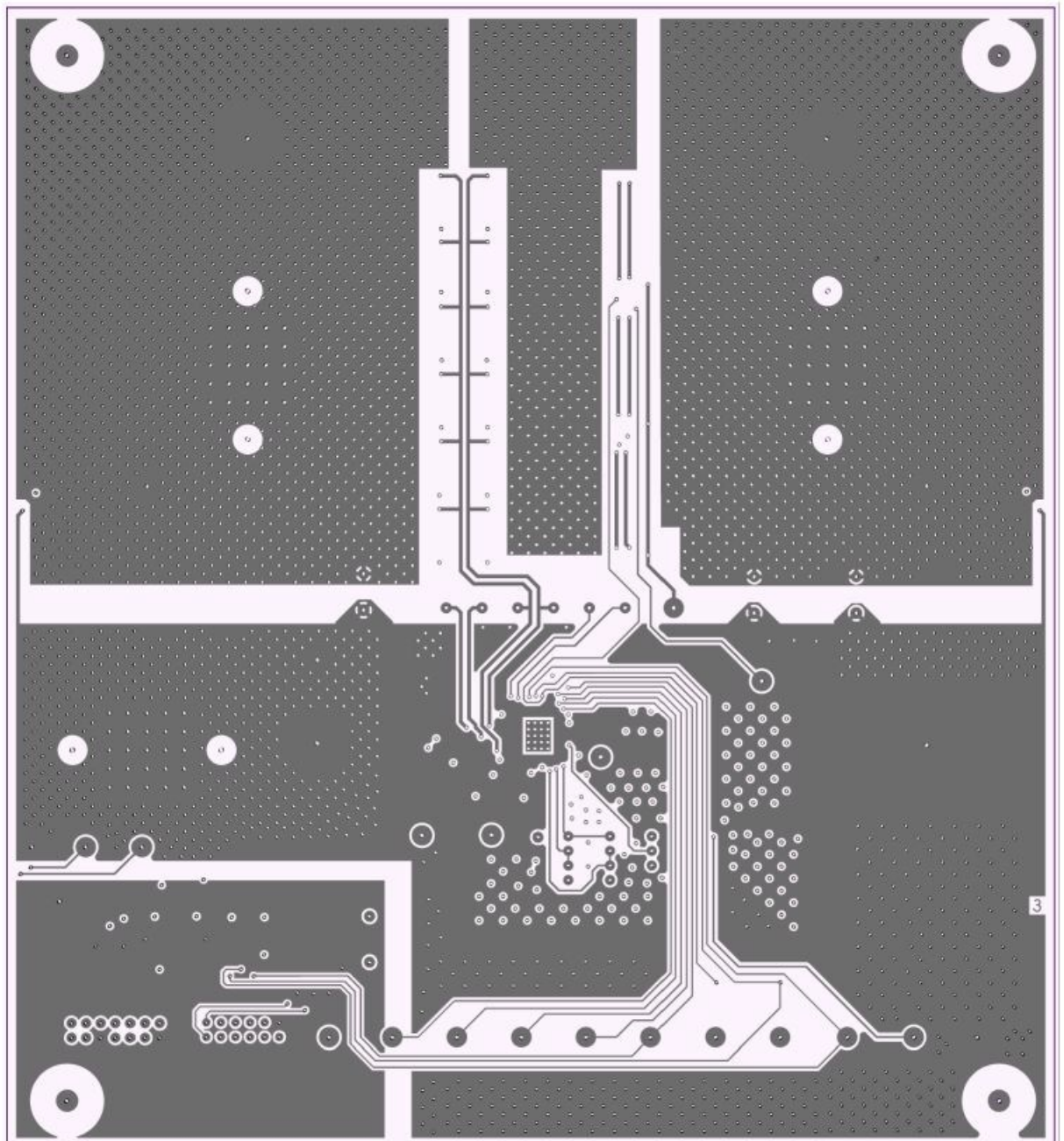


Figure 14. EVAL-LTC4286-A1Z Top Layer 1



**Figure 15. EVAL-LTC4286-A1Z Inner Layer 2**





**Figure 16. EVAL-LTC4286-A1Z Inner Layer 3**

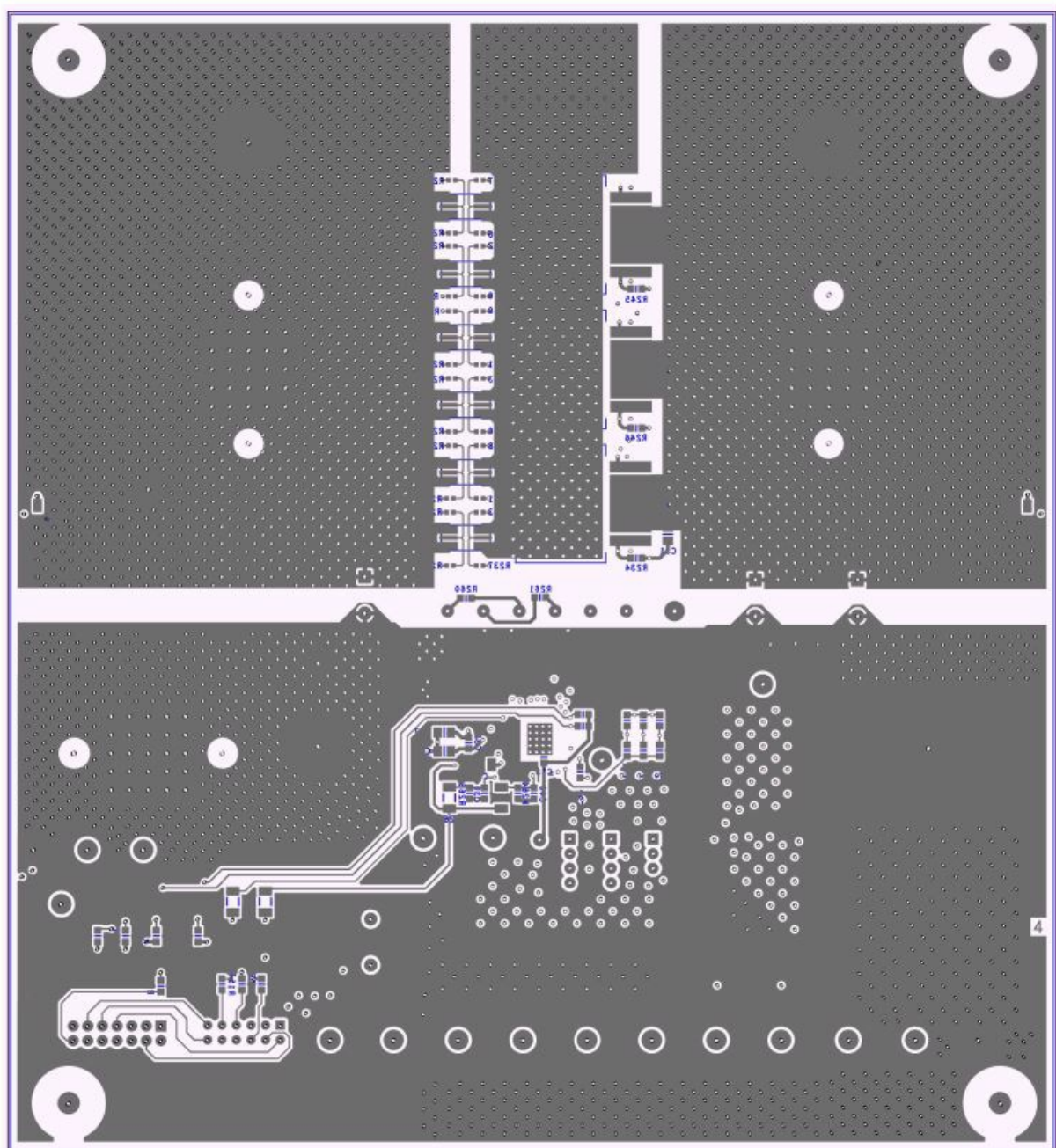


Figure 17. EVAL-LTC4286-A1Z Bottom Layer

## ORDERING INFORMATION

### BILL OF MATERIALS

Table 7. Bill of Materials

Reference Designator Part Number1	Description	Manufacturer
C10	Capacitor, 0.027 $\mu$ F, X7R, 50 V, 10%, 0805	Kemet
C13, C14, C15, C21	Capacitors, 0.1 $\mu$ F, X7R, 25 V, 20%, 0603	AVX
C18	Capacitor, 100 $\mu$ F, aluminum electrolytic, 100 V	Nichicon

C22	Capacitor, 0.022 $\mu$ F, X7R, 50 V, 5%, 0603	AVX	06035C223JAT2A
C23	Capacitor, 68 nF, X7R, 100 V, 10%, 0805	Kemet	C0805C683K1RECAUTO
C25	Capacitor, 0.1 $\mu$ F, X5R, 100 V, 20%, 1206	Taiyo Yuden	HMK316BJ104ML-T
C34	Capacitor, option, 1206	Not applicable	Not applicable
C35, C39	Capacitors, option, 0603	Not applicable	Not applicable
C37, C38	Capacitors, option, 0805	Not applicable	Not applicable
D3, D6, D7, D16, D17	LEDs, green, water-clear, 0805	Wurth Elektronik	150080GS75000
D9, D18	LEDs, red, water-clear, 0805	Wurth Elektronik	150080RS75000
D10, D11, D15	Diodes, TVS, ESD suppressor, 64 V, 1500 W,	Littelfuse	SMCJ64A
	DO-214AB		
D20	Diode, switching, 200 V, 200 mA, SOD-123	Micro Commercial Co.	BAV21W-TP
D21	Diode, Schottky, 100 V, 5 A, POWERDI5, AEC-	Diodes Inc.	PDS5100H-13
	Q101		
E1, E2, E3	Connectors, TERM., shank, red cube, M6, 25	Wurth Elektronik	7461098
	pin, press-fit, THT, brass, TIN		
E4, E5, E8, E11, E13, E14, E15, E18, E19, E20,	Test points, turret, 0.064" MT G. hole, PCB	Mill-max	2308-4-00-80-00-00-07-0
E22, E24, E25, E26, E27, E28, E29, E33, E34,	0.125" THK		
E35, E36, E39, E40			
E30, E31, E32	Connectors, banana jack, female, through-hole,	Keystone	575-4
	noninsulated, swage, 0.218"		
E38	Lug, ring, 1/4" stud, crimp, 4 AWG, 1.30"L,	Panduit	S4-14R-E
	noninsulated		
J1	Connector, header, shrouded, plug, male, 2 $\times$ 7,	Molex	87831-1420



	2 mm, vertical, straight, through-hole, KEYED		
J2	Connector, header, shrouded, male, 2 × 6, 2	Amphenol	98414-G06-12ULF
	mm, vertical, straight, through-hole		
JP3, JP4	Connectors, header, male, 1 4, 2 mm, vertical,	Samtec	TMM-104-02-L-S
	straight, through-hole		
JP5	Connector, header, male, 1 × 3, 2 mm, vertical,	Samtec	TMM-103-02-L-S
	straight, through-hole, 10 μ" A u		
LB1	Label specification, demo board serial number	Brady	THT-96-717-10
MP1, MP2, MP3, MP4	Standoff, nylon, snap-ons, 0.25" (6.4 mm)	Keystone	8831
PCB1	PCB, EVAL-LTC4286-A1Z	Analog Devices	600-EVAL-LTC4286-A1Z
		approved supplier	
Q1, Q2, Q3	Transistors, MOSFET, N channel, 60 V, 300	Vishay	2N7002K-T1-GE3
	mA, SOT-23-3 (TO-236)		
Q18	Transistor, NPN, 40 V, 200 mA, SOT23-3, AEC-	Diodes Inc.	MMBT3904-7-F
	Q101		
Q25	Transistors, MOSFET, N channel, 40 V, 425 A,	Nexperia	PSMN2R3-100SSE
	LFPK88		
R4, R17, R193, R194	Resistors, 40.2 kΩ, 1%, 1/4 W, 1206	Stackpole Electronics,	RMCF1206FT40K2
		Inc.	
R10, R11, R21	Resistors, 3.01 kΩ, 1%, 1/10 W, 0603	Vishay	CRCW06033K01FKEA
R12, R13, R14, R22	Resistors, 5.11 kΩ, 1%, 1/10 W, 0603	Panasonic	ERJ3EKF5111V
R15, R16, R152, R158, R185, R254, R255	Resistors, 0 Ω, 1/10 W, 0603, AEC-Q200	Vishay	CRCW06030000Z0EA
R33, R34, R36, R37, R38, R39, R42, R43, R60,	Resistors, option, 0402	Not applicable	Not applicable

R61, R63, R64, R170, R171, R172, R173, R206,			
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R207, R209, R210, R211, R212, R215, R216,			
R217, R218, R220, R221, R222, R223, R225,			
R226, R227, R228, R230, R231, R232, R233,			
R236, R237			
R50, R53, R55, R58	Resistors, 1 $\Omega$ , 1%, 1/16 W, 0402, AEC-Q200	Vishay	CRCW04021R00FKED
R51, R54, R56, R59	Resistors, 10 $\Omega$ , 1%, 1/16 W, 0402	Yageo	RC0402FR-0710RL
R73, R241, R259	Resistors, 10 $\Omega$ , 5%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3GEYJ100V
R154, R155, R251, R252, R257, R258, R260,	Resistors, option, 0603	Not applicable	Not applicable
R261, R264, R265, R266			
R179, R180	Resistors, 0.001 $\Omega$ , 1%, 2 W, 2512, AEC-Q200	Yageo	PA2512FKF7W0R001E
	current sense		
R183	Resistor, 130 k $\Omega$ , 1%, 1/4 W, 1206, AEC-Q200	Panasonic Electronic	ERJ-8ENF1303V
		Components	
R184	Resistor, 12.1 k $\Omega$ , 1%, 1/10 W, 0603, AEC-	Panasonic	ERJ3EKF1212V
	Q200		
R186	Resistor, 2.67 k $\Omega$ , 1%, 1/10 W, 0603, AEC-	Panasonic	ERJ3EKF1212V
	Q200		
R187	Resistor, 4.02 k $\Omega$ , 1%, 1/10 W, 0603, AEC-	Panasonic	ERJ3EKF4021V
	Q200		
R188	Resistor, 93.1 k $\Omega$ , 1%, 1/4 W, 1206, AEC-Q200	NIC	NRC12F9312TRF
R191	Resistor, 121 k $\Omega$ , 1%, 1/4 W, 1206	Yageo	RC1206FR-07121KL
R192	Resistor, 402 k $\Omega$ , 1/4 W, 1206, AEC-Q200	Vishay	CRCW1206402KFKEA

R195	Resistor, 221 $\Omega$ , 1%, 1/4 W, 1206, AEC-Q200	Vishay	CRCW1206221RFKEA
R208, R214, R219, R224, R229, R235	Resistors, option, 2512	Not applicable	Not applicable
R253	Resistor, 14.7 k $\Omega$ , 1%, 1/10 W, 0603, AEC-	Panasonic	ERJ3EKF1472V
	Q200		
R256	Resistor, 88.7 k $\Omega$ , 1%, 1/10 W, 0603	Yageo	RC0603FR-0788K7L
R262, R263	Resistor, option, 1206	Not applicable	Not applicable
U1	IC, power controller, QFN-40	Analog Devices	<a href="#">LTC4286AUK#PBF</a>
U2	IC, memory, EEPROM, 2 Kb (256 $\times$ 8),	Microchip	24LC025-I/ST
	TSSOP-8, 400 kHz		
Z1, Z2	Diodes, Zener, 5.1 V, 500 mW, SOD-123, AEC-	On Semiconductor	MMSZ5231BT1G
	Q101		

## NOTES

I2C 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.

## Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants.

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User Guide

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