Evaluating the LTC4286 High Voltage Positive Hot Swap Controller with Power Monitor and PMBus

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 MOSFETs
- LED indicated status outputs
- Wide input voltage range: 8.5 V to 80 V
- 100 V absolute maximum
- MOSFET temperature measurement capability
- I^2C/PMBus communication

EVALUATION KIT CONTENTS

- EVAL-LTC4286-A1Z evaluation board

DOCUMENTS NEEDED

- LTC4286 data sheet

ADDITIONAL HARDWARE NEEDED

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

SOFTWARE NEEDED

- LTpowerPlay, Windows-based development software (download from LTpowerPlay | Analog Devices)

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-I^2C 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.

PLEASE SEE THE LAST PAGE FOR AN IMPORTANT
WARNING AND LEGAL TERMS AND CONDITIONS.

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REVISION HISTORY

3/2023—Rev. 0 to Rev. A

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1/2023—Revision 0: Initial Version

EVAL-LTC4286-A1Z EVALUATION BOARD LAYOUT

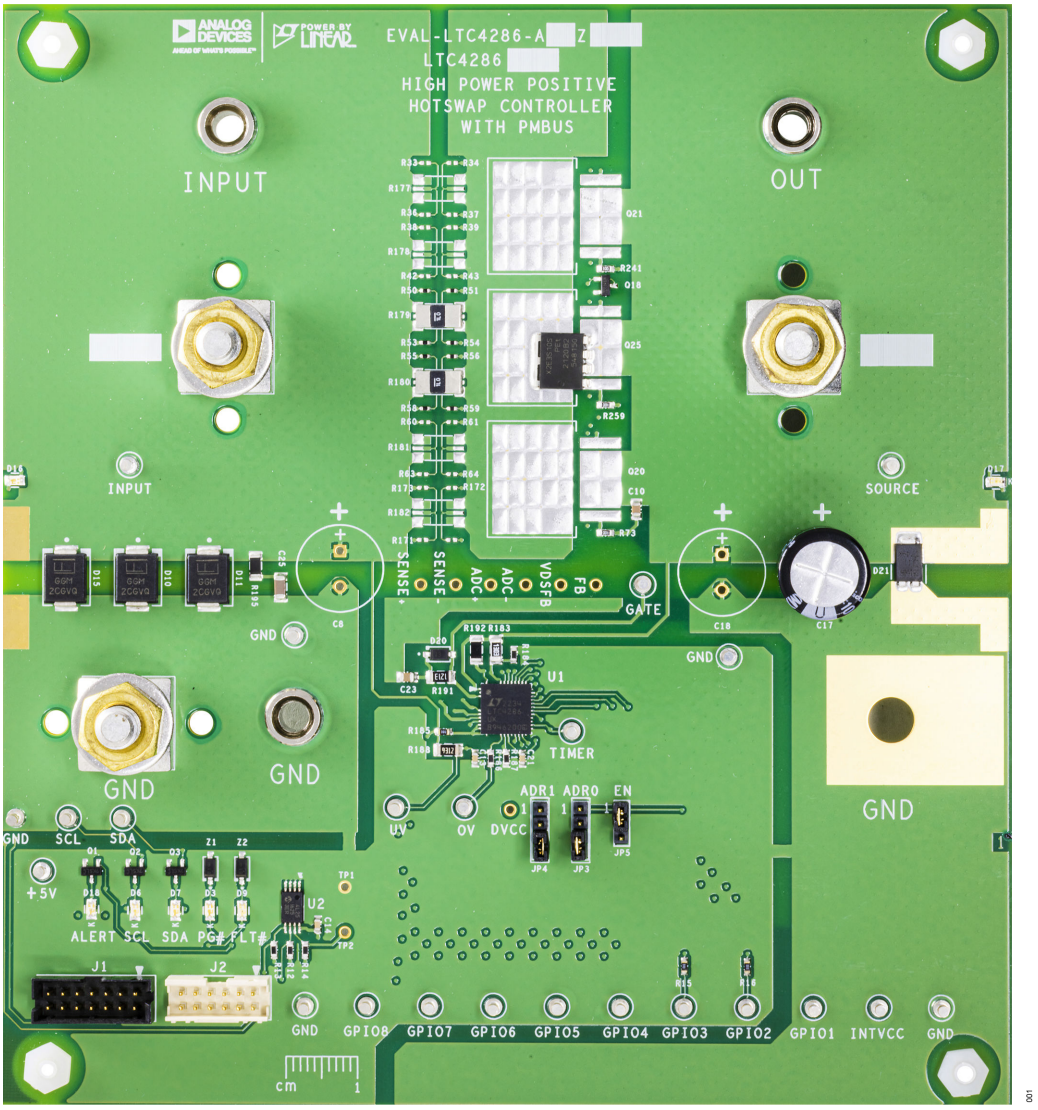

Figure 1. Evaluation Board Layout

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 grounds 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 to not allow an open ground from the power supply or load to cause 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.

If the current limit is increased or the board is operated in a high temperature environment, additional airflow is needed to keep it within safe thermal operating limits for continuous operation. If additional current is required without sufficient airflow, multiple MOSFETs must be connected in parallel with the existing MOSFETs to lower their I^2R losses.

EVAL-LTC4286-A1Z SETUP

To setup 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-I^2C controller (DC1613A).
3. Connect a power supply to the evaluation board using thick wires (10 AWG or 6^2 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 (labeled 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.

QUICK START GUIDE

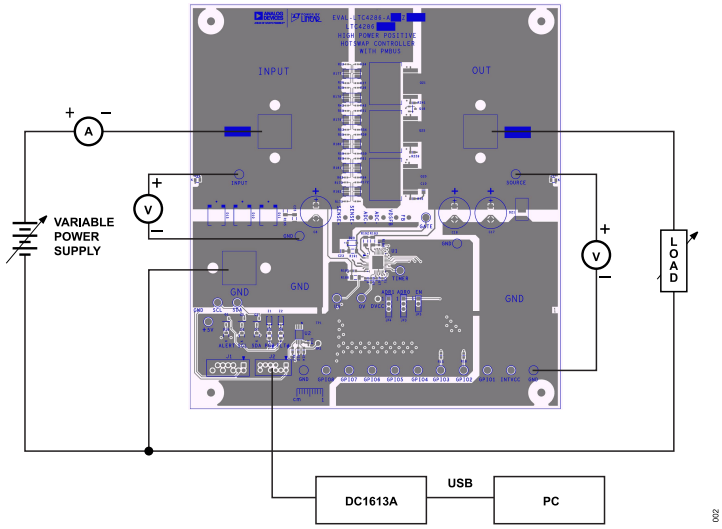

Figure 2. Basic EVAL-LTC4286-A1Z Connection Diagram

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 I^2C 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 I^2C bus. Use it during board bring up to tune and optimize the power system parameters and during system debug 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.

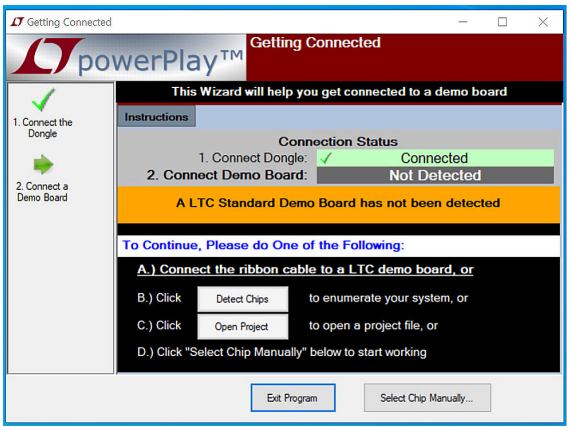

Figure 3. LTpowerPlay—Getting Connected Window

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

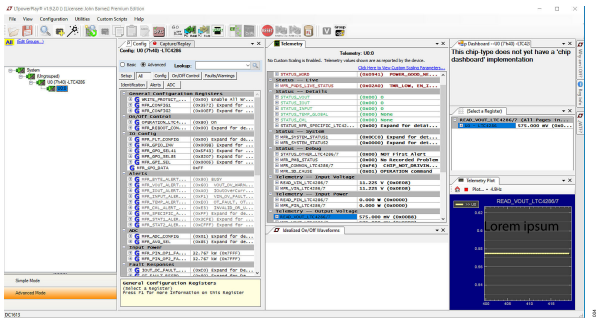

Figure 4. LTpowerPlay—Main Window

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.

QUICK START GUIDE

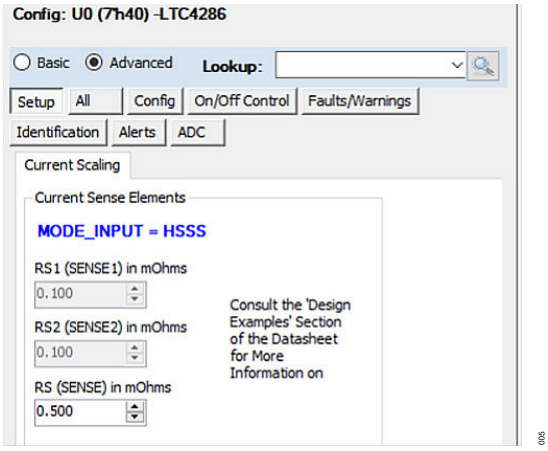

Figure 5. LTpowerPlay Setting RS (SENSE)

To update the registers 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 I^2C bus and updates the telemetry contents in real time, along with a user-friendly interpretation of the bits.

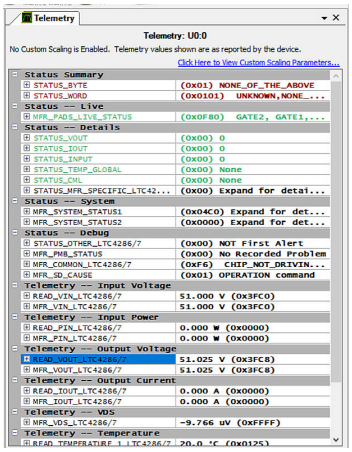

Figure 7. LTpowerPlay—Telemetry Pane Window

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, LFPAK, and other 8-lead SOIC variants.

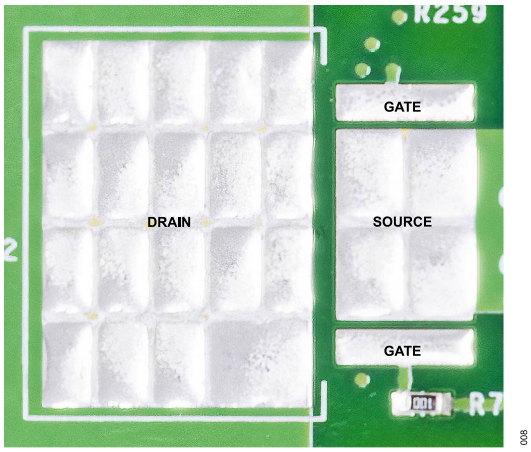

Figure 8. Multipackage N-Channel MOSFET Footprint

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 center 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 (labeled 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.

QUICK START GUIDE

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 inaccurate telemetry.

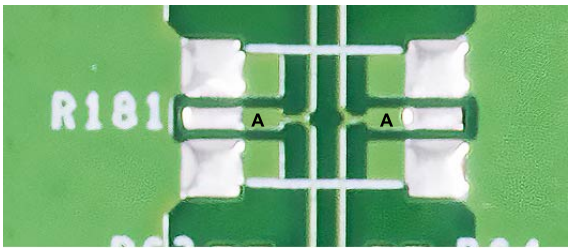

Figure 9. Sense Resistor—Kelvin Footprint

QUICK START GUIDE

BOARD SPECIFICATIONS

Table 1. Board Specifications

Parameter	Typical Value
Load Capacitance	1000 µF
Severe Circuit Breaker Current	108 A
Normal Current Limit	36 A
Start-Up Time	100 ms
Maximum T_A	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
+V Input	M6 stud, E30 (banana)	Power input
+V Output	M6 stud, E31 (banana)	Power output
GND	M6 stud, E21 (banana)	Power supply common
DC1613A	J2	I^2C/SMBus/PMBus
DC590B or DC2026C (Optional)	J1	I^2C

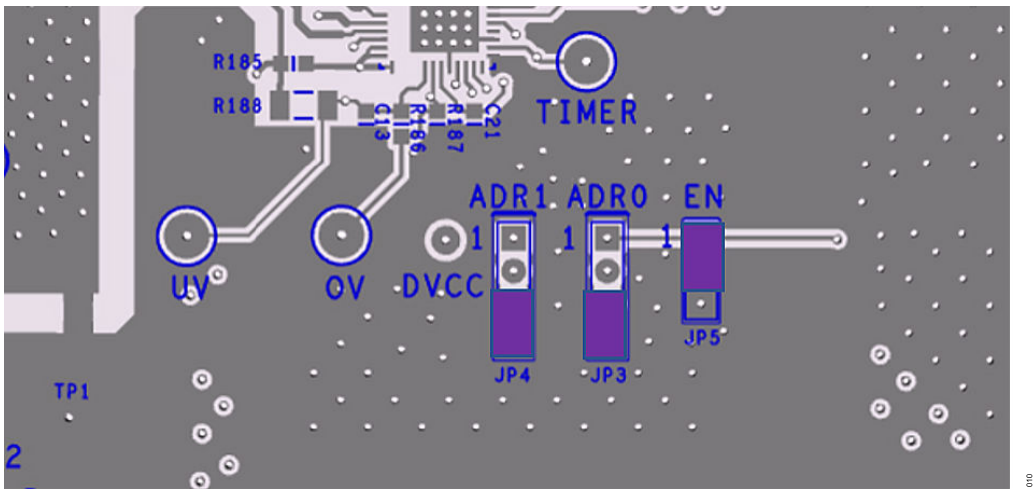

Figure 10. Jumper Configuration

Table 3. Default Jumper Configuration

Jumper Name	Description	Default
JP3, JP4	ADR0 and ADR1	3 to 4 (Address 7h40)
JP5	EN	1 to 2 (enabled)

EVALUATION BOARD HARDWARE

Table 4. Test Points, Turrets

Nomenclature	Description
INPUT	+V input test point
SOURCE	+V output test point
GND	Multiple GND test points
$INTV_{CC}$	Internal $INTV_{CC}$ pin
UV	UV input pin
OV	OV input pin
TIMER	Current-limit TMR pin
GATE1	GATE1 pin
SCL	I^2C clock
SDA	I^2C data
GPIO1	Power good, PG#[1]
GPIO2	Fault, FLT#[1]
GPIO3	Temp sensor (Q18)[1]
GPIO4	IOUT_OC_STATUS[1]
GPIO5	Reserved
GPIO6	Reserved
GPIO7	Reserved
GPIO8	OP1_STATUS, overpower[1]

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

Table 5. Other Test Points

Nomenclature	Description
$INTV_{CC}$	LTC4286
DV_{CC}	LTC4286 internal logic supply
SENSE+1	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
INPUT	D14 (green)	Input power indicator
OUTPUT	D17 (green)	Output indicator
PG#	D3 (green)	Power good[1]
SCL	D6 (green)	I^2C clock
SDA	D7 (green)	I^2C 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

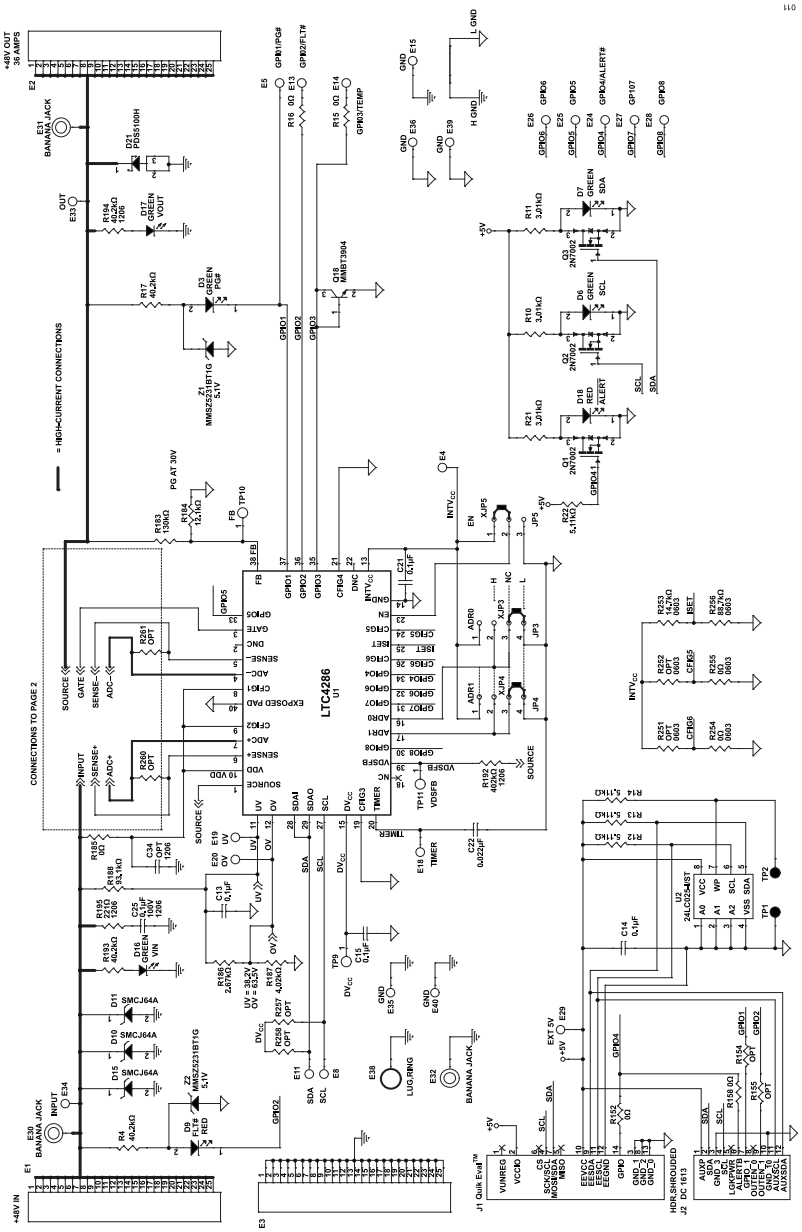

Figure 11. EVAL-LTC4286-A1Z Schematic Part 1

EVALUATION BOARD SCHEMATICS AND ARTWORK

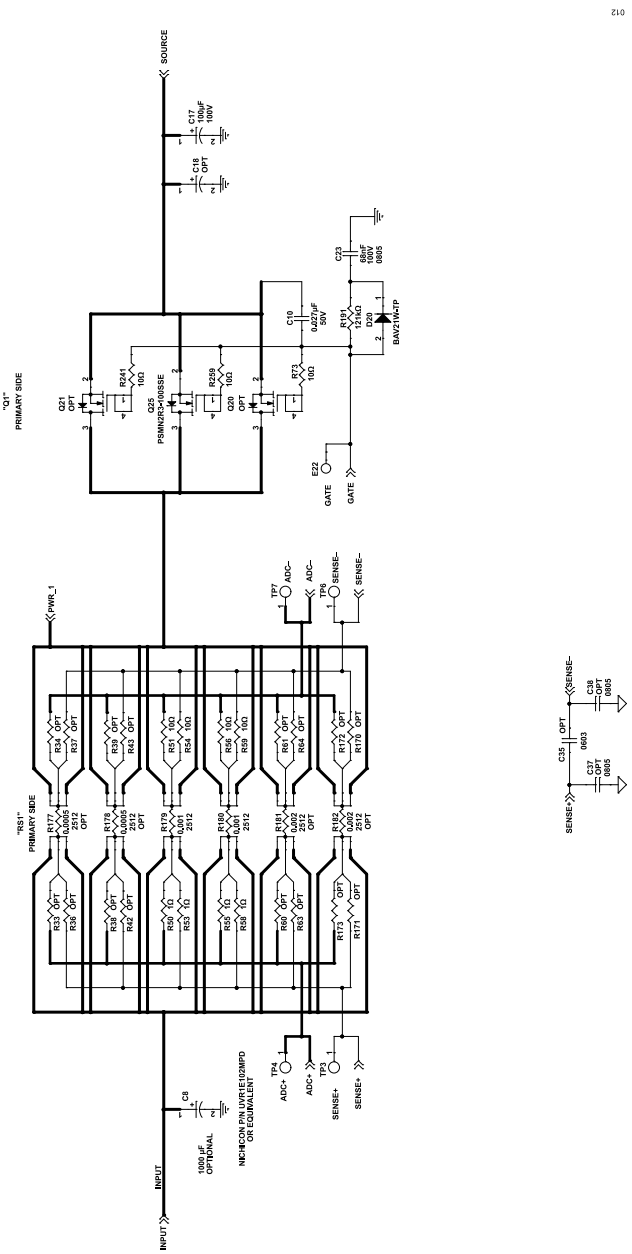

Figure 12. EVAL-LTC4286-A1Z Schematic Part 2

EVALUATION BOARD SCHEMATICS AND ARTWORK

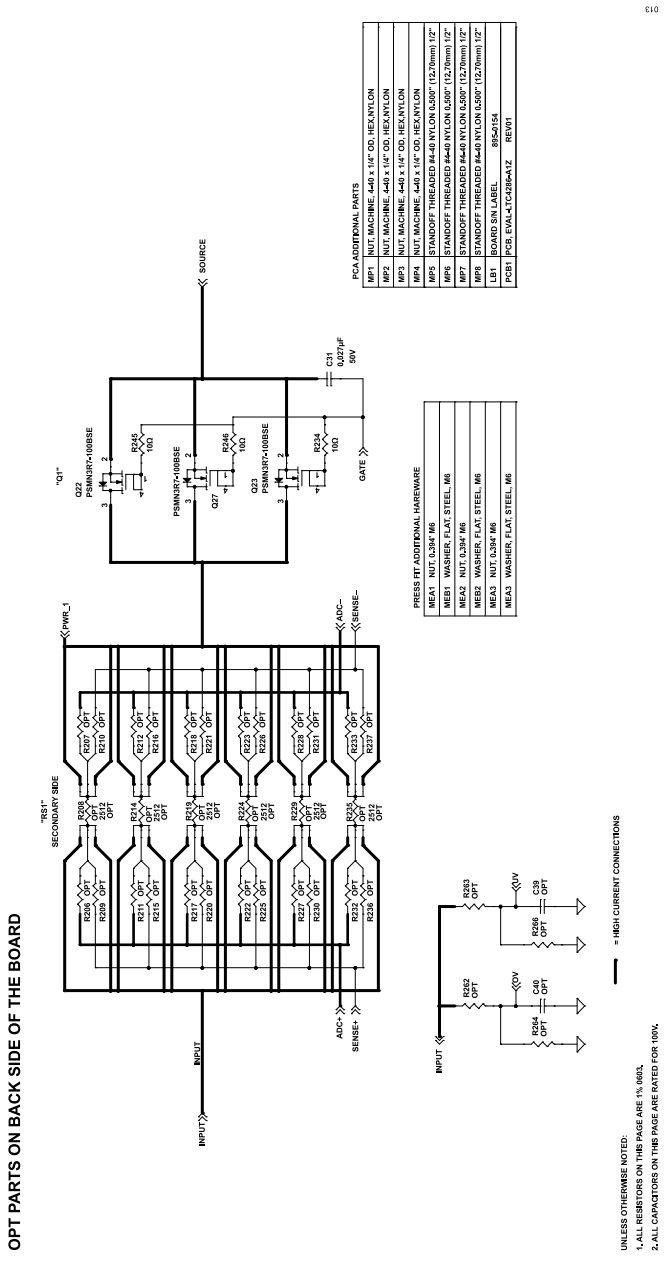

Figure 13. EVAL-LTC4286-A1Z Schematic Part 3

EVALUATION BOARD SCHEMATICS AND ARTWORK

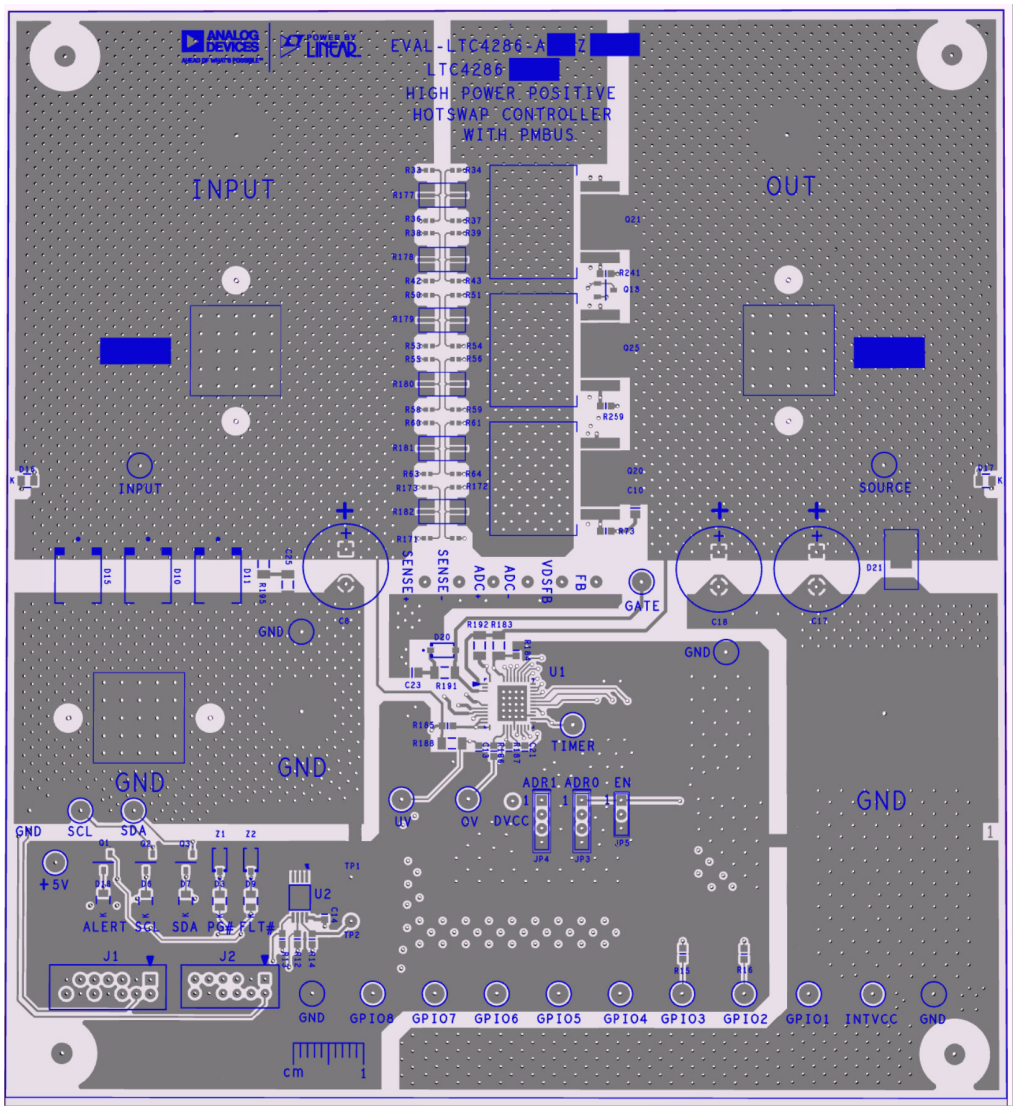

Figure 14. EVAL-LTC4286-A1Z Top Layer 1

EVALUATION BOARD SCHEMATICS AND ARTWORK

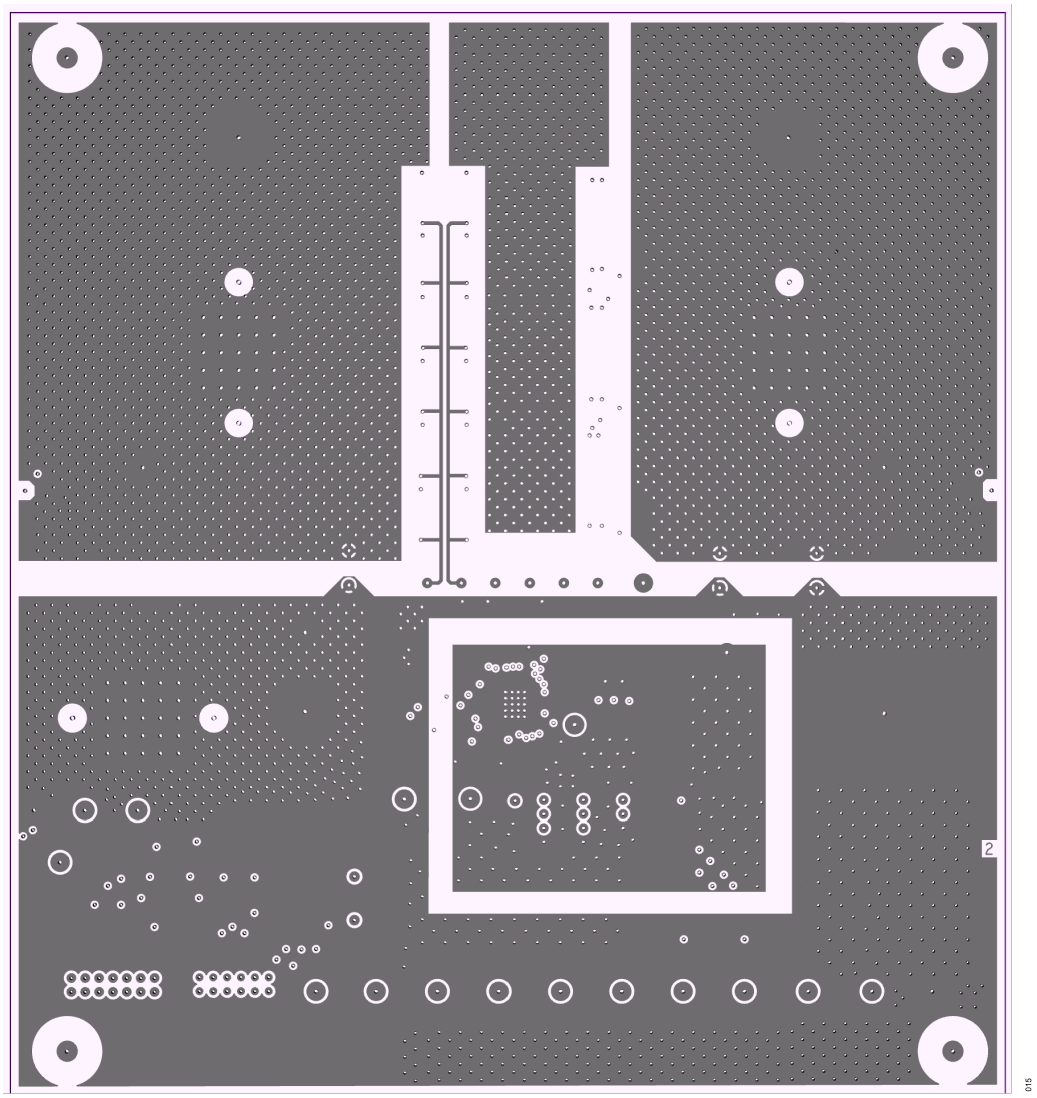

Figure 15. EVAL-LTC4286-A1Z Inner Layer 2

EVALUATION BOARD SCHEMATICS AND ARTWORK

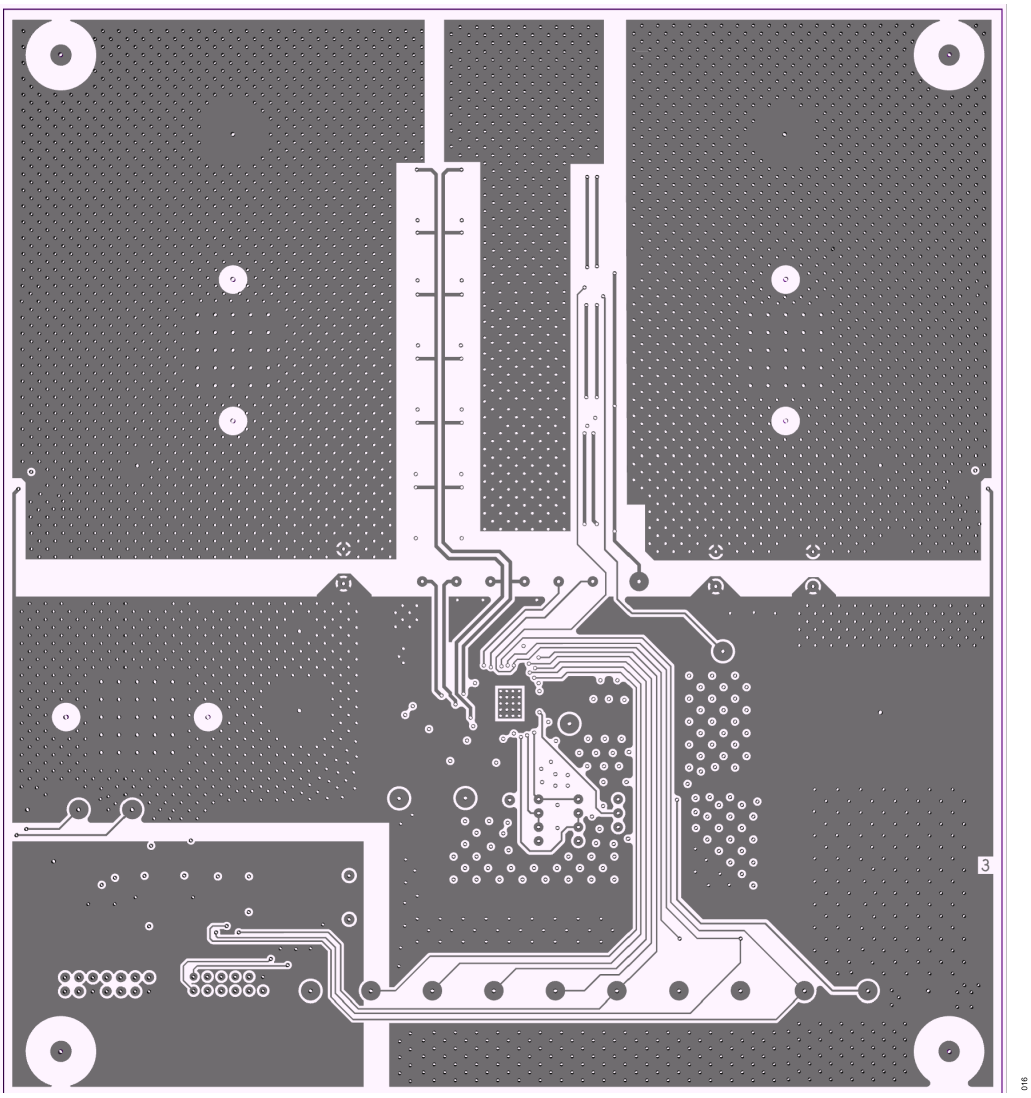

Figure 16. EVAL-LTC4286-A1Z Inner Layer 3

EVALUATION BOARD SCHEMATICS AND ARTWORK

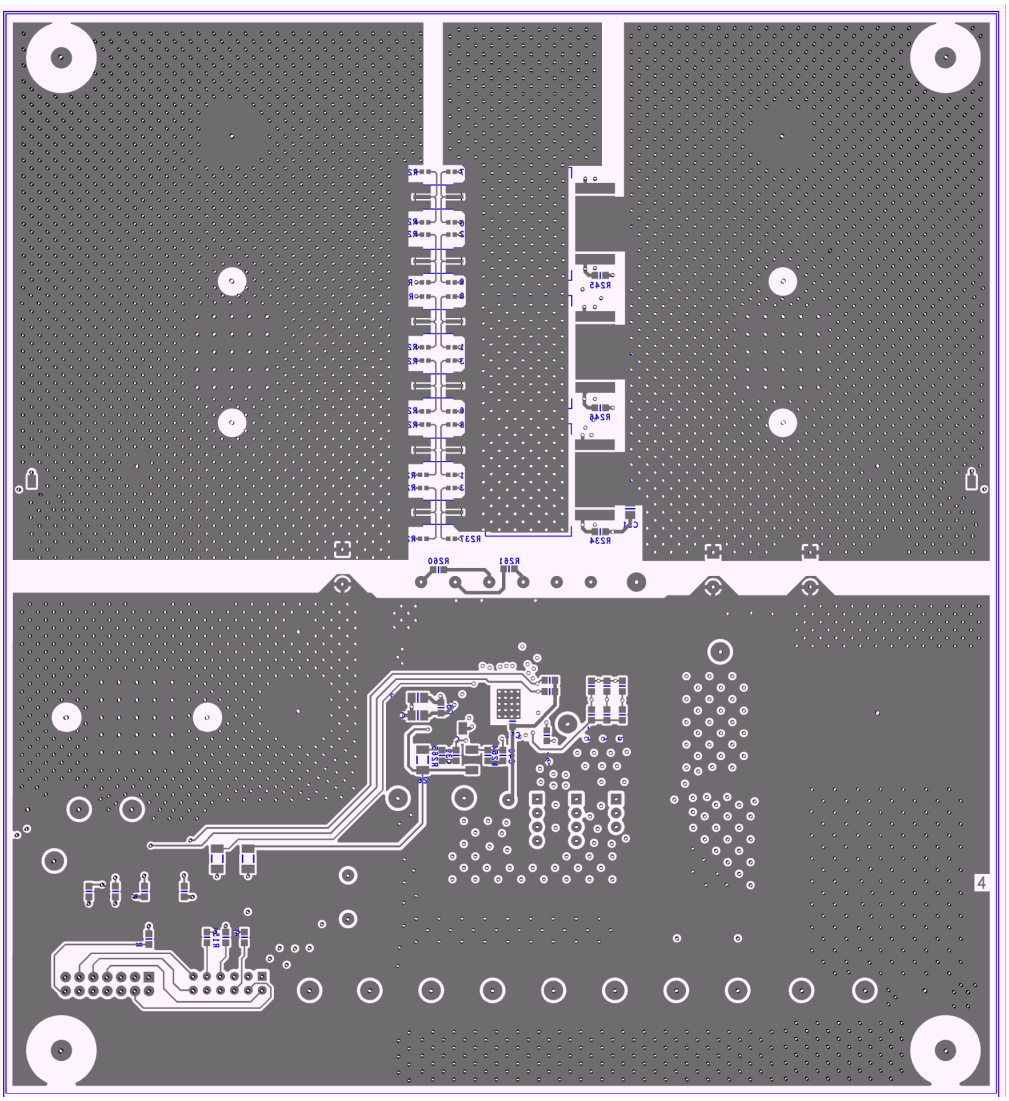

Figure 17. EVAL-LTC4286-A1Z Bottom Layer

ORDERING INFORMATION

BILL OF MATERIALS

Table 7. Bill of Materials

Reference Designator	Description	Manufacturer	Part Number[1]
C10	Capacitor, 0.027 µF, X7R, 50 V, 10%, 0805	Kemet	C0805C273J5RAC7800
C13, C14, C15, C21	Capacitors, 0.1 µF, X7R, 25 V, 20%, 0603	AVX	06033C104MAT2A
C18	Capacitor, 100 µF, aluminum electrolytic, 100 V	Nichicon	URZ2A101MHD1TO
C22	Capacitor, 0.022 µF, X7R, 50 V, 5%, 0603	AVX	06035C223JAT2A
C23	Capacitor, 68 nF, X7R, 100 V, 10%, 0805	Kemet	C0805C683K1RECAUTO
C25	Capacitor, 0.1 µF, 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, DO-214AB	Littelfuse	SMCJ64A
D20	Diode, switching, 200 V, 200 mA, SOD-123	Micro Commercial Co.	BAV21W-TP
D21	Diode, Schottky, 100 V, 5 A, POWERDI5, AEC-Q101	Diodes Inc.	PDS5100H-13
E1, E2, E3	Connectors, TERM., shank, red cube, M6, 25 pin, press-fit, THT, brass, TIN	Wurth Elektronik	7461098
E4, E5, E8, E11, E13, E14, E15, E18, E19, E20, E22, E24, E25, E26, E27, E28, E29, E33, E34, E35, E36, E39, E40	Test points, turret, 0.064" MTG. hole, PCB 0.125" THK	Mill-max	2308-4-00-80-00-00-07-0
E30, E31, E32	Connectors, banana jack, female, through-hole, noninsulated, swage, 0.218"	Keystone	575-4
E38	Lug, ring, 1/4" stud, crimp, 4 AWG, 1.30"L, noninsulated	Panduit	S4-14R-E
J1	Connector, header, shrouded, plug, male, 2 × 7, 2 mm, vertical, straight, through-hole, KEYED	Molex	87831-1420
J2	Connector, header, shrouded, male, 2 × 6, 2 mm, vertical, straight, through-hole	Amphenol	98414-G06-12ULF
JP3, JP4	Connectors, header, male,1 4, 2 mm, vertical, straight, through-hole	Samtec	TMM-104-02-L-S
JP5	Connector, header, male, 1 × 3, 2 mm, vertical, straight, through-hole, 10 µ" Au	Samtec	TMM-103-02-L-S
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 approved supplier	600-EVAL-LTC4286-A1Z
Q1, Q2, Q3	Transistors, MOSFET, N channel, 60 V, 300 mA, SOT-23-3 (TO-236)	Vishay	2N7002K-T1-GE3
Q18	Transistor, NPN, 40 V, 200 mA, SOT23-3, AEC-Q101	Diodes Inc.	MMBT3904-7-F
Q25	Transistors, MOSFET, N channel, 40 V, 425 A, LFPAK88	Nexperia	PSMN2R3-100SSE
R4, R17, R193, R194	Resistors, 40.2 kΩ, 1%, 1/4 W, 1206	Stackpole Electronics, Inc.	RMCF1206FT40K2
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, R61, R63, R64, R170, R171, R172, R173, R206,	Resistors, option, 0402	Not applicable	Not applicable

ORDERING INFORMATION

Table 7. Bill of Materials (Continued)

Reference Designator	Description	Manufacturer	Part Number[1]
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 Ω, 1%, 1/16 W, 0402, AEC-Q200	Vishay	CRCW04021R00FKED
R51, R54, R56, R59	Resistors, 10 Ω, 1%, 1/16 W, 0402	Yageo	RC0402FR-0710RL
R73, R241, R259	Resistors, 10 Ω, 5%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3GEYJ100V
R154, R155, R251, R252, R257, R258, R260, R261, R264, R265, R266	Resistors, option, 0603	Not applicable	Not applicable
R179, R180	Resistors, 0.001 Ω, 1%, 2 W, 2512, AEC-Q200 current sense	Yageo	PA2512FKF7W0R001E
R183	Resistor, 130 kΩ, 1%, 1/4 W, 1206, AEC-Q200	Panasonic Electronic Components	ERJ-8ENF1303V
R184	Resistor, 12.1 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF1212V
R186	Resistor, 2.67 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF1212V
R187	Resistor, 4.02 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF4021V
R188	Resistor, 93.1 kΩ, 1%, 1/4 W, 1206, AEC-Q200	NIC	NRC12F9312TRF
R191	Resistor, 121 kΩ, 1%, 1/4 W, 1206	Yageo	RC1206FR-07121KL
R192	Resistor, 402 kΩ, 1/4 W, 1206, AEC-Q200	Vishay	CRCW1206402KFKEA
R195	Resistor, 221 Ω, 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 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ3EKF1472V
R256	Resistor, 88.7 kΩ, 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	LTC4286AUK#PBF
U2	IC, memory, EEPROM, 2 Kb (256 × 8), TSSOP-8, 400 kHz	Microchip	24LC025-I/ST
Z1, Z2	Diodes, Zener, 5.1 V, 500 mW, SOD-123, AEC-Q101	On Semiconductor	MMSZ5231BT1G

[1] Equivalent devices can be substituted.

NOTES

I^2C 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.

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