bq25010/11/12/15/17 (bqHYBRID) EVM

for Single-Chip Charger and DC-DC Converter for Bluetooth Headsets and Other Portable Applications

User's Guide

June 2007

SLUU214A

bq25010/11/12/15/17 (bqHYBRID) EVM

for Single-Chip Charger and DC-DC Converter for Bluetooth Headsets and Other Portable Applications

User's Guide

Literature Number: SLUU214A
December 2004 – Revised June 2007

TEXAS INSTRUMENTS

Introduction

1.1 EVM Features

- Programmable charge current up to 500 mA for bq25010/11/12 and up to 1000 mA for bq25015/17
- Charges from both USB and ac adapter sources
- Supports single chemistry applications
- The output voltage of an integrated 1-MHz synchronized buck converter is either adjustable from 0.7 V to VBAT (bq25010/15), fixed at 3.3 V (bq25011), or fixed at 1.8 V (bq25012/17), and is capable of delivering up to 150 mA (bq25010/11/12) or 300 mA (bq25015/17) of load current.
- Power-good LED indication
- Status outputs (LED indication available): precharge, fast charge, charge done, timer fault and sleep mode
- TTL-level controls: charge enable, converter enable and forced PWM

1.2 General Description

The bq25010/11/12/15/17 evaluation module is a complete charger module for evaluating a single-chip charge solution using the bq25010/11/12/15/17 devices. It is designed to deliver up to 500 mA (bq25010/11/12) or 1000 mA (bq25015/17) of charge current to Li-Ion or Li-Pol applications.

The bq25010/11/12 has a highly integrated battery charge controller designed to work with external host commands. The charge current and other system parameters are programmable. An integrated synchronous buck converter (except the output inductor and capacitor) is incorporated in this chip as the supply from battery to system. For details, see the *bq25010, bq25011, bq25012 Single-Chip Charger and DC/DC Converter IC for Bluetooth Headsets and Other Portable Applications* data sheet (SLUS615) and *bq25015, bq25017 Single-Chip Charger and DC/DC Converter IC for Portable Applications* data sheet (SLUS721).

1.3 I/O Description

Jack	Description
J1-POS	AC adapter, positive output
J1-GND	AC adapter, negative output
J2	USB B-connector socket
J3-SYS-OUT	Positive output to system
J3-DC–	Negative output to system
J4-BAT+	Positive output to battery
J4-BAT–	Negative output to battery
J5-STAT1	STAT1 pin output voltage (when J7-2 and -3 are shorted)
J5-STAT2	STAT2 pin output voltage (when J8-2 and -3 are shorted)
J5-DC–	Connection to IC ground pin
J5-PG	PG pin output voltage (ac detection)
J7-LED	Power supply for LEDs, STAT1 monitoring
J7-EXT	STAT1 pin output voltage to external
J8-LED	Power supply for LEDs, STAT2 monitoring
J8-EXT	STAT2 pin output voltage to external
J10-LED	Power supply for LEDs, PG monitoring
J10-EXT	PG pin output voltage to external

1.4 Control and Key Parameter Settings

Jack or Resistor	Description	Factory Setting
J6-CE	CE pin output voltage	Charge enabled
J6-ISET2	Charge current limit setting when charging from USB	Set by J9
J6-DC–	Connection to IC ground pin	
J6-EN	Enable input for dc-dc converter	Dc-dc converter enabled
J9	Charge current limit setting with USB input 1–2: 0.5 A 2–3: 0.1 A	2–3 (pins 2 and 3 are shorted together)
J11	Forced PWM for dc-dc converter 1–2: forced PWM mode 2–3: power-save mode	2–3 (pins 2 and 3 are shorted together)
R7	Charge current limit setting when charging from ac adapter	1.62 kΩ (500 mA)

1.5 Recommended Operating Conditions

PARAMETER		MIN	NOM	MAX	UNIT
V_{CC_AC}	Supply voltage from ac adapter input, maximum	4.5	5	6.5	V
V_{CC_USB}	Supply voltage from USB input, maximum	4.35		6.5	V
I_{CC_AC}	Supply current from ac adapter input, maximum	0.5		1.5	A
I_{CC_USB}	Supply current from USB input, maximum (1)	100		500	mA
	Dc-dc converter output current (2)	0	100	300	mA
T_J	Operating junction temperature range	–40		125	°C

(1) When using a USB port with the current limit less than 500mA, select 100mA charge rate using ISET2 pin (J9).
(2) The typical current magnitude gives a 30% current ripple when using a 47-μH output inductor. The actual load current can be higher or lower.

1.6 Recommended Output Inductor and Capacitor Values of the DC-DC Converter

Part #	DC-DC Converter Output Voltage	Converter Load Current (mA)	Output Inductance, L (µH)	Output Capacitance, C (µF)	Inductor Peak Current (mA)
bq25010/15	0.7 V[(1)]	20	292–620	0.33–0.169	26–23
		50	220	0.47	57.5
		100	120	0.82	115
bq25011 or bq25010/15	3.3 V[(2)]	20	120	0.82	23
		50	47	2.2	57.5
		100	22	4.7	115
bq25012/17 or bq25010/15	1.8 V[(3)]	20	175	0.56	23
		50	68	1.5	57.5
		100	33	3.3	115

(1) The product of output inductance L and capacitance C is recommended to be around 10^{-10} to better match the built-in compensator.
(2) The current ripple is recommended to be about 30% to achieve a high efficiency. Therefore, the inductance can be adjusted according to the typical load current.
(3) For bq25010, the output voltage is variable over a wide range. It may require a higher inductance for the worst case to maintain 30% current ripple. Depending on specific applications, an inductance with up to 60% current ripple may be acceptable.

Basic Functions Evaluation

2.1 Equipment

2.1.1 POWER SUPPLIES

Two power supplies capable of supplying 6 V at 1 A are required.

2.1.2 METERS

Three Fluke 75 (equivalent or better) or

Two equivalent voltmeters and an equivalent ammeter

2.1.3 OSCILLOSCOPE

An oscilloscope and a single voltage probe are required.

2.1.4 COMPUTER

A computer with at least one USB port and a USB cable

2.1.5 COMPONENTS

A 5-Ω, 50-W resistor

A 12-Ω, 0.5-W resistor

A 36-Ω, 0.25-W resistor

A 500-Ω, 0.25-W resistor

2.2 EQUIPMENT SETUP

The original test setup is shown in Figure 2-1.

1. Set power supply #1 for 5.0 ±0.1 VDC, 1.0 ±0.1-A current limit, and then turn off the supply. Connect J1 (DC+, DC–) to power supply #1.
2. Plug one end of the USB cable into the computer USB port. Plug the other end into the USB input socket J2 on the bqHYBRID EVM.
3. Connect the output of power supply #2 in series with a current meter (multimeter) to J4 (BAT+, BAT–).
4. Connect the 12-Ω, 0.5-W resistor across J3 (SYS, DC–).
5. Shunt jumpers should be installed on J7-LED, J8-LED, J9-0.1, and J10-LED, J11-1 (VBAT).
6. Short J6 pin 1 (EN) and pin 2 (DC–).

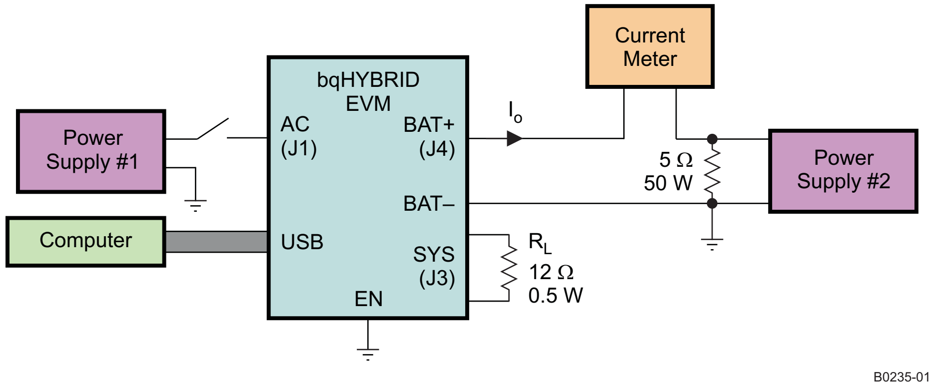

Figure 2-1. Original Test Setup (Setup A)

2.3 PROCEDURE

1. Make sure the *Equipment Setup* steps are followed. Turn on power supply #2. Then turn on the computer.
2. **USB Input Precharge.** Verify output voltage, BAT+, is about 2 VDC. Verify the red LED (D3) and green LED (D2) are lit while the green LED (D4) is off. Verify I_O, the output current from BAT+, is between 40 mA and 60 mA.
3. **USB Input Fast Charge.** Increase the output voltage of power supply #2 slowly to 3.5 V. Verify the red LED (D3) is on and the green LEDs (D2 and D4) are off. Verify I_O is between 80 mA and 120 mA. Verify the voltage of SYS (J3) is below 100 mV.
4. **USB Input Sleep Mode.** Increase the output voltage of power supply #2 slowly to 6 V. Verify both the red LED (D3) and the green LED (D2) are off.
5. **AC Adapter Input Precharge.** Reduce the output voltage of power supply #2 slowly to 2 V. Turn on power supply #1. Verify output voltage, BAT+, is about 2 VDC. Verify all the three LEDs (D3, D2, D4) are lit. Verify I_O, the output current from BAT+, is between 40 mA and 60 mA.
6. Disconnect USB cable from J2. Make sure the setup has been changed to that shown in Figure 2-2.

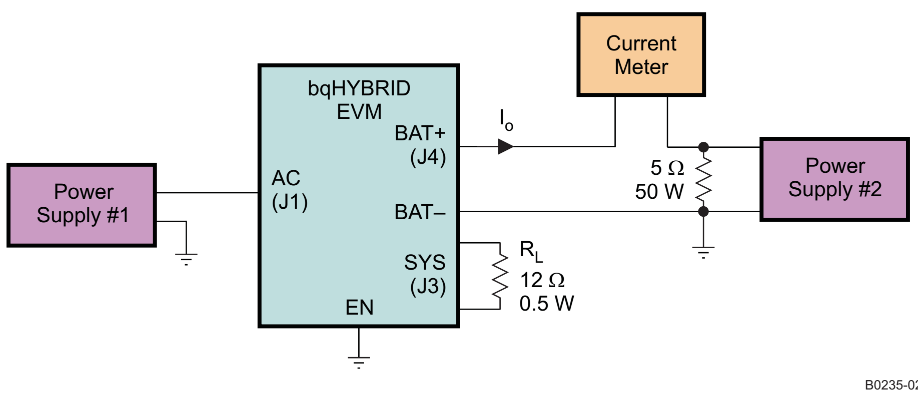

Figure 2-2. Test Setup B

7. **AC Adapter Input Fast Charge.** Increase the output voltage of power supply #2 slowly to 3.5 V. Verify the red LED (D3) and green LED (D4) are on and the green LED (D2) is off. Verify I_O is between 450 mA and 550 mA (NOTE: If a Fluke 75 multimeter is used as the current meter, make sure the meter is switched to *A* and the *A* socket is used instead of *mA* for this measurement). Verify the voltage of SYS (J3) is below 100 mV.
8. **AC Adapter Input Sleep Mode.** Increase the output voltage of power supply #2 slowly to 6 V. Verify both the red LED (D3) and the green LED (D2) are off.
9. **DC-DC Converter Under Full-Load Condition (bq25012 as an Example).** Increase the output

voltage of power supply #2 slowly to 4.2 V. Disconnect J6 pin 1 (EN) from pin 2 (DC–). Make J6 pin 1 (EN) open. Verify the voltage across R_L (SYS to DC–) is regulated between 1.75 V and 1.85 V. Verify the voltage at the SW pin, or terminal 1 of L1, is like that shown in Figure 2-3. Verify that its frequency is about 1 MHz and the duty cycle is stable at some value between 0.38 and 0.5.

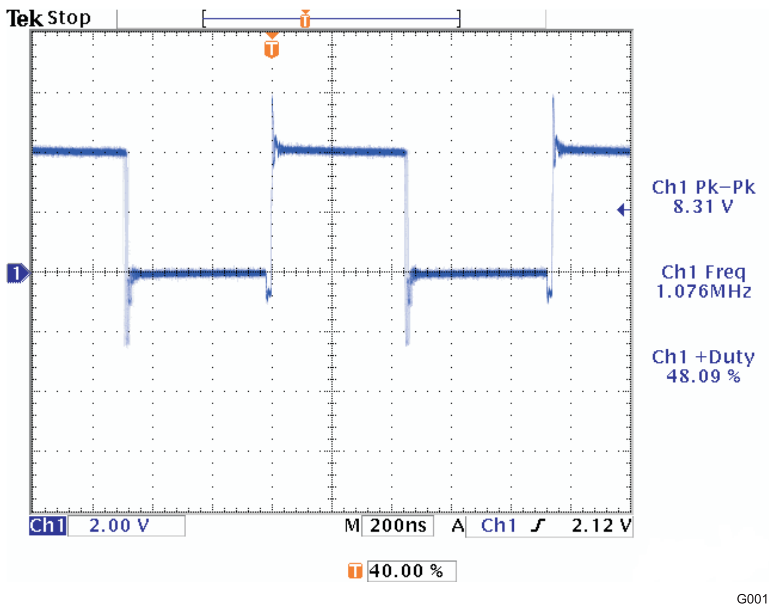

Figure 2-3. Waveform at Pin SW

10. **DC-DC Converter Under Light-Load Condition (bq25012 as an Example).** Change R_L to the 36-Ω, 0.25-W resistor. Make sure the setup has been changed to that shown in Figure 2-4. Verify the voltage across R_L (SYS to DC–) is regulated between 1.75 V and 1.85 V. Verify the voltage at the SW pin, or terminal 1 of L1, is like that shown in Figure 2-5. Verify that its frequency is about 1 MHz and the duty cycle is stable at some value between 0.38 and 0.5.

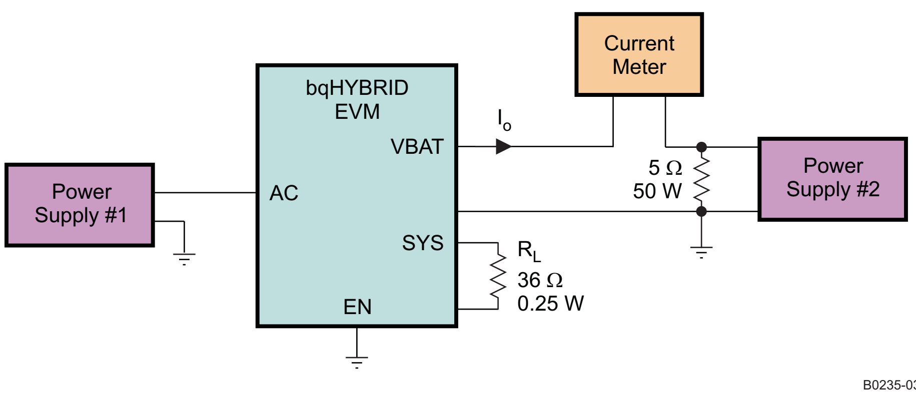

Figure 2-4. Test Setup C

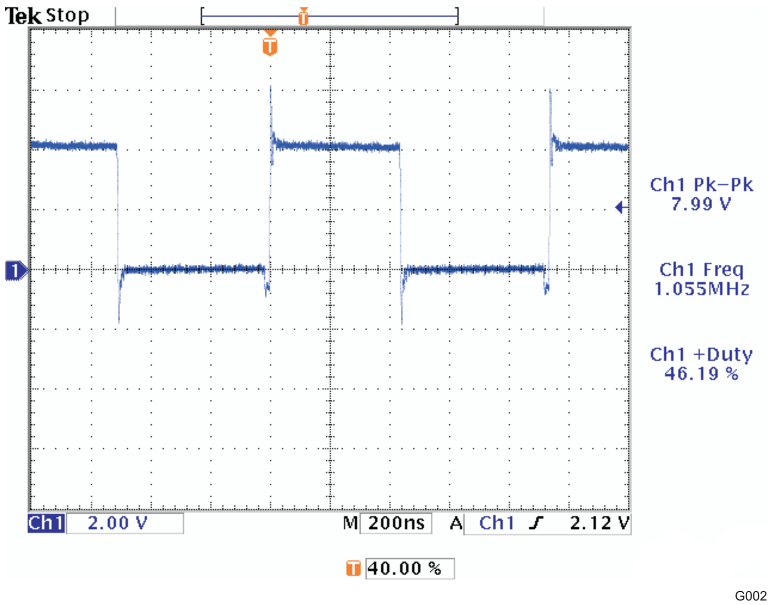

Figure 2-5. Waveform at Pin SW

11. **Converter Enable and Disable.** Disconnect the current meter, the 5-Ω, 50-W resistor, and power supply #2 from J4. Short J6 pin 1 (EN) and pin 2 (DC–). Verify the voltage of SYS (J3) is below 100 mV.
12. **No Battery Load With DC-DC Converter Disabled, Switch From** Charge **to** Charge Done **to** Recharge**, Back and Forth.** Make sure the setup has been changed to setup D, as shown in Figure 2-6. Verify that the LEDs, D3 and D2, alternate being lit. Measure the voltage at BAT+ with the oscilloscope. Verify the waveform is like that in Figure 2-7. It is actually

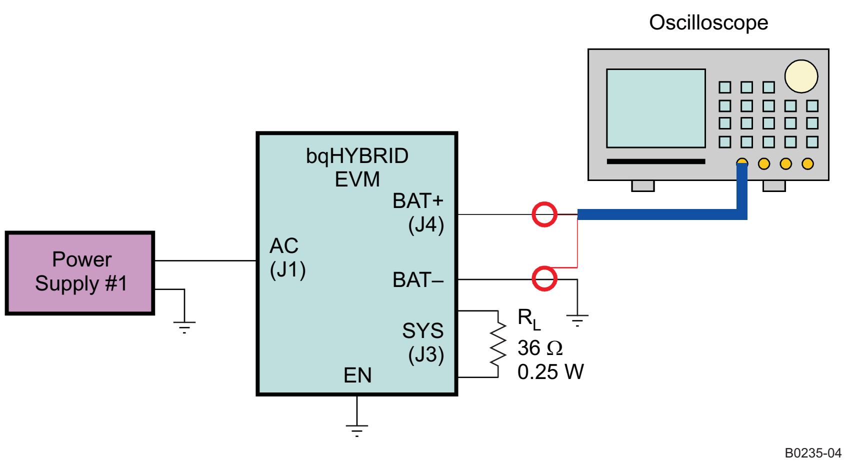

Figure 2-6. Test Setup D

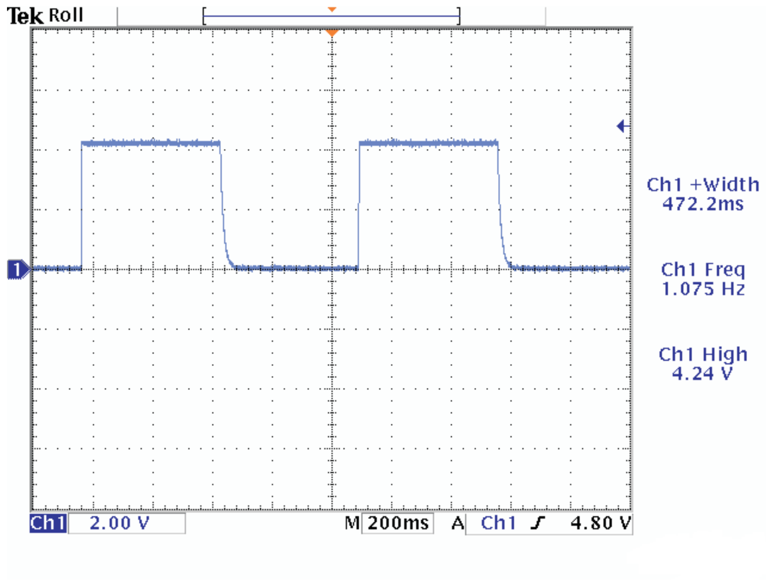

Figure 2-7. BAT+ Waveform at No Load

13. **No Battery; Charger Connected to System Directly.** Connect the 500-Ω, 0.25-W resistor across J4 (BAT+ and BAT–). Make sure the test setup has been changed to setup E, as shown in Fig. 8. Verify the red LED (D3) and green LED (D4) are on and the green LED (D2) is off. Verify the voltage across BAT+ and BAT– is regulated between 4.160 V and 4.240 V.

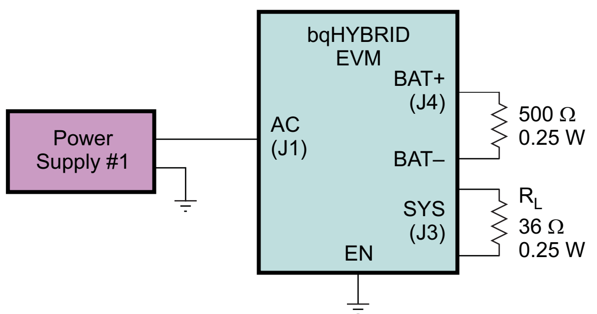

Figure 2-8. Test Setup E

Bill of Materials, Board Layout, and Schematic

3.1 Bill of Materials

bq2501x					RefDes	DESCRIPTION	SIZE	MFR	Part Number
x = 0 -001	x = 1 -002	x = 2 -003	x = 5 -004	x = 7 -005					
1	1	1	0	0	C1	Capacitor, ceramic, 2.2-µF, 6.3-V, X5R, 10%	805	Panasonic	ECJ-2YB0J225K
0	0	0	1	1	C1	Capacitor, ceramic, 10-µF, 6.3-V, X5R, 20%	805	Panasonic	ECJ-2FB0J106M
2	2	2	2	2	C4, C6	Capacitor, ceramic, 10-µF, 6.3-V, X5R, 20%	805	Panasonic	ECJ-2FB0J106M
1	0	0	1	0	C2	Capacitor, ceramic, 68 pF, 50-V, NPO	603	Panasonic	ECJ-1VC1H680J
1	0	0	1	0	C3	Capacitor, ceramic, 100-pF, 50-V, NPO	603	Panasonic	ECJ-1VC1H101J
1	1	1	1	1	C5	Capacitor, ceramic, 4.7-µF, 10-V, X5R, 10%	805	Panasonic	ECJ-2FB1A475K
1	1	1	1	1	D1	Diode, dual Schottky, 200-mA, 30-V	SOT23	Vishay-Liteon	BAT54C
2	2	2	2	2	D2, D4	Diode, LED, green, 2.1-V, 20-mA, 6-mcd	603	Liteon	160-1183-1-ND
1	1	1	1	1	D3	Diode, LED, red, 1.8-V, 20-mA, 20-mcd	603	Liteon	160-1181-1-ND
2	2	2	2	2	J1, J3	Terminal block, 2-pin, 6-A, 3.5-mm	0.27 × 0.25	OST	ED1514
1	1	1	1	1	J2	Connector, USB upstream (type B)	0.47 × 0.67	Molex	67068-1000
3	3	3	3	3	J4, J5, J6	Terminal block, 4-pin, 6-A, 3.5-mm	0.55 × 0.25	OST	ED1516
5	5	5	5	5	J7, J8, J9, J10, J11	Header, 3-pin, 100-mil spacing, (36-pin strip)	0.100 × 3	Sullins	PTC36SAAN
5	5	5	5	5	--	Shunt, 100-mil, black	0.100	3M	929950-00
1	1	1	0	0	L1	Inductor, SMT, 47-µH, 0.48-A, 435-mΩ	0.185 × 0.185	Sumida	CDRH4D28-470
0	0	0	1	1	L1	Inductor, SMT, 10-µH, 1-A, 95-mΩ	0.185 × 0.185	Sumida	CDRH4D28-100
1	0	0	1	0	R1	Resistor, chip, 261-kΩ, 1/16-W, 1%	603	Std	Std
0	1	1	0	1	R1	Resistor, chip, 0-Ω, 1/16-W, 1%	603	Std	Std
1	0	0	1	0	R2	Resistor, chip, 100-kΩ, 1/16-W, 1%	603	Std	Std
1	1	1	1	1	R3	Resistor, chip, 100-kΩ, 1/16-W, 1%	603	Std	Std
1	1	1	1	1	R10	Resistor, chip, 10-kΩ, 1/16-W, 1%	603	Std	Std

bq2501x					RefDes	DESCRIPTION	SIZE	MFR	Part Number
x = 0 -001	x = 1 -002	x = 2 -003	x = 5 -004	x = 7 -005					
3	3	3	3	3	R4, R5, R6	Resistor, chip, 1.5-kΩ, 1/16-W, 1%	603	Std	Std
1	1	1	1	1	R7	Resistor, chip, 1.62-kΩ, 1/16-W, 1%	603	Std	Std
2	2	2	2	2	R8, R9	Resistor, chip, 1-kΩ, 1/16-W, 1%	603	Std	Std
1	0	0	0	0	U1	IC	QFN-20	TI	bq25010RHL
0	1	0	0	0	U1	IC	QFN-20	TI	bq25011RHL
0	0	1	0	0	U1	IC	QFN-20	TI	bq25012RHL
0	0	0	1	0	U1	IC	QFN-20	TI	bq25015RHL
0	0	0	0	1	U1	IC	QFN-20	TI	bq25017RHL
1	1	1	1	1	–	PCB, 2.3-in. × 2.2 in. × 0.031 in. (5.88-cm × 5.59-cm × 0.787-mm)		Any	HPA036

3.2 Board Layout

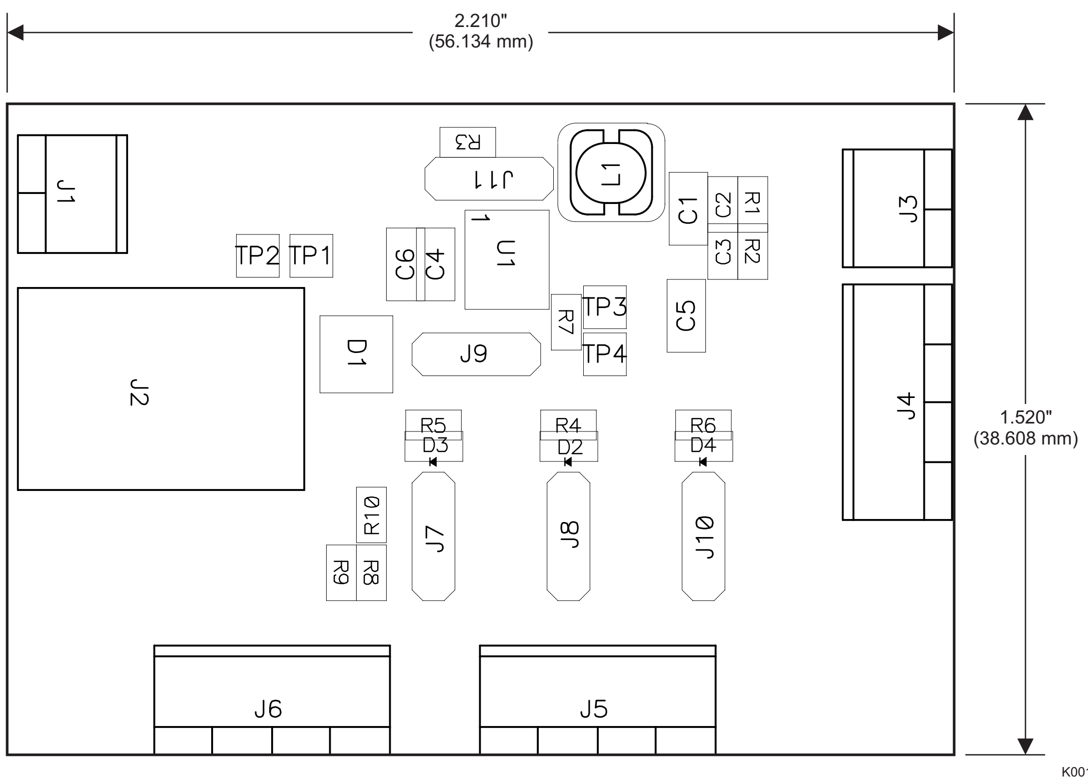

Figure 3-1. Top Assembly

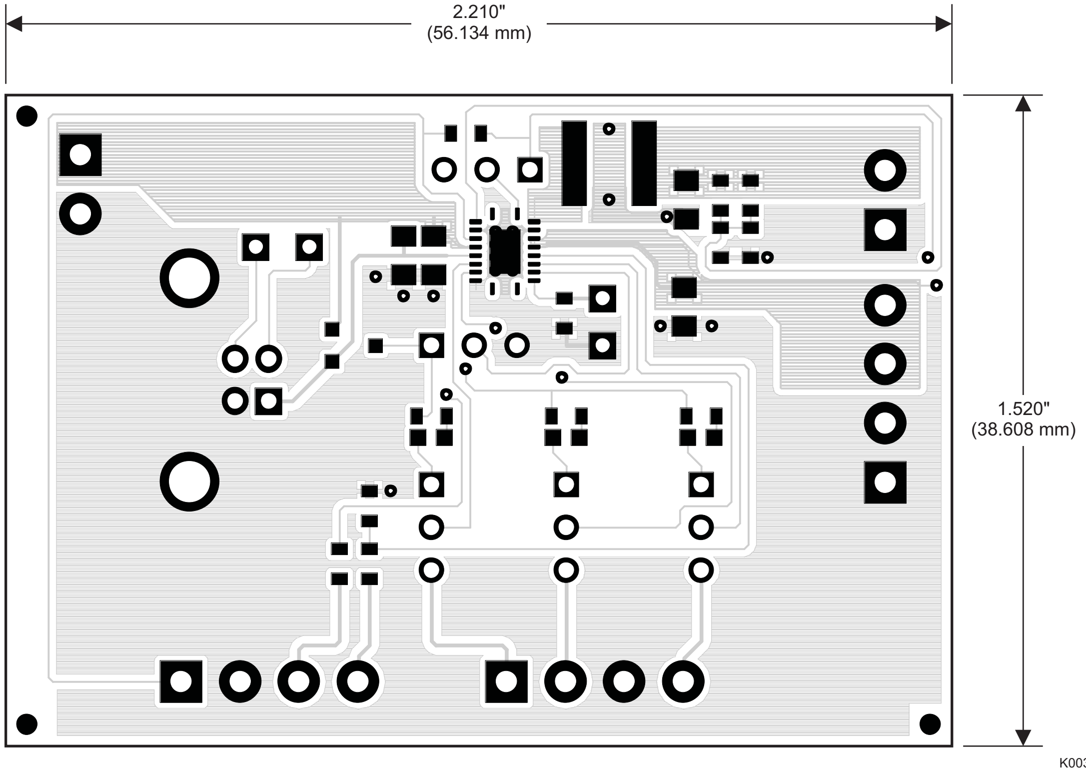

Figure 3-2. Layer 1

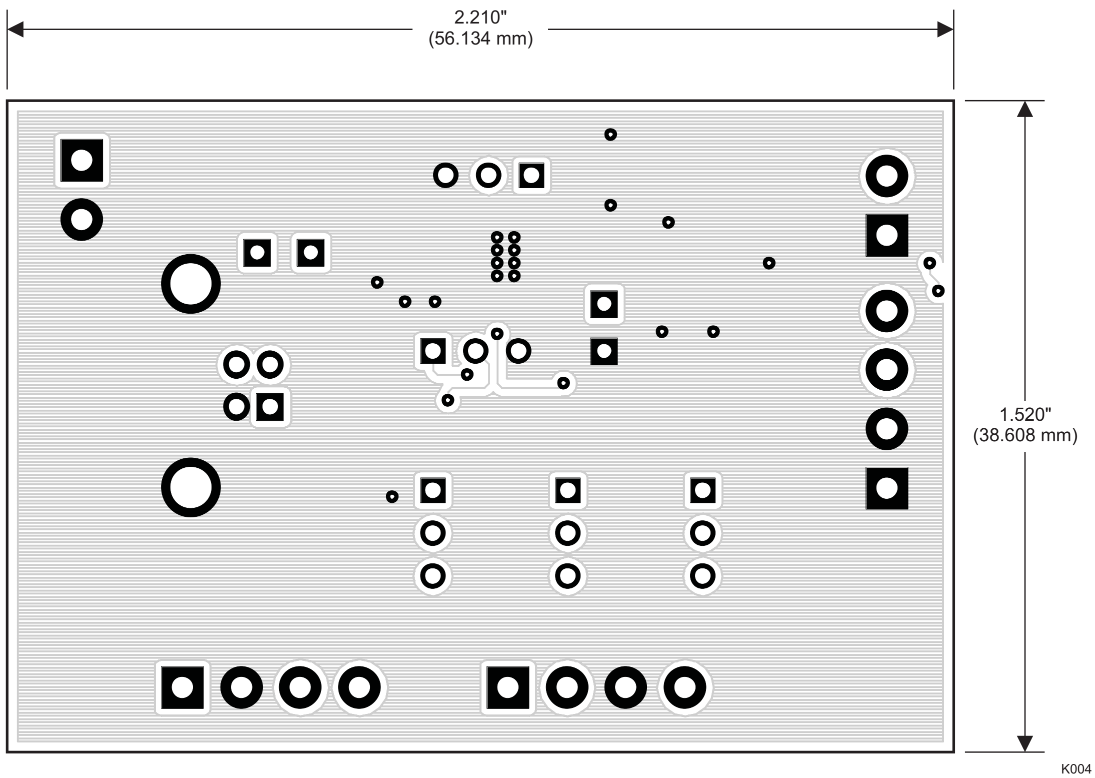

Figure 3-3. Layer 2

Figure 3-4. Mask 1

Figure 3-5. Mask 2

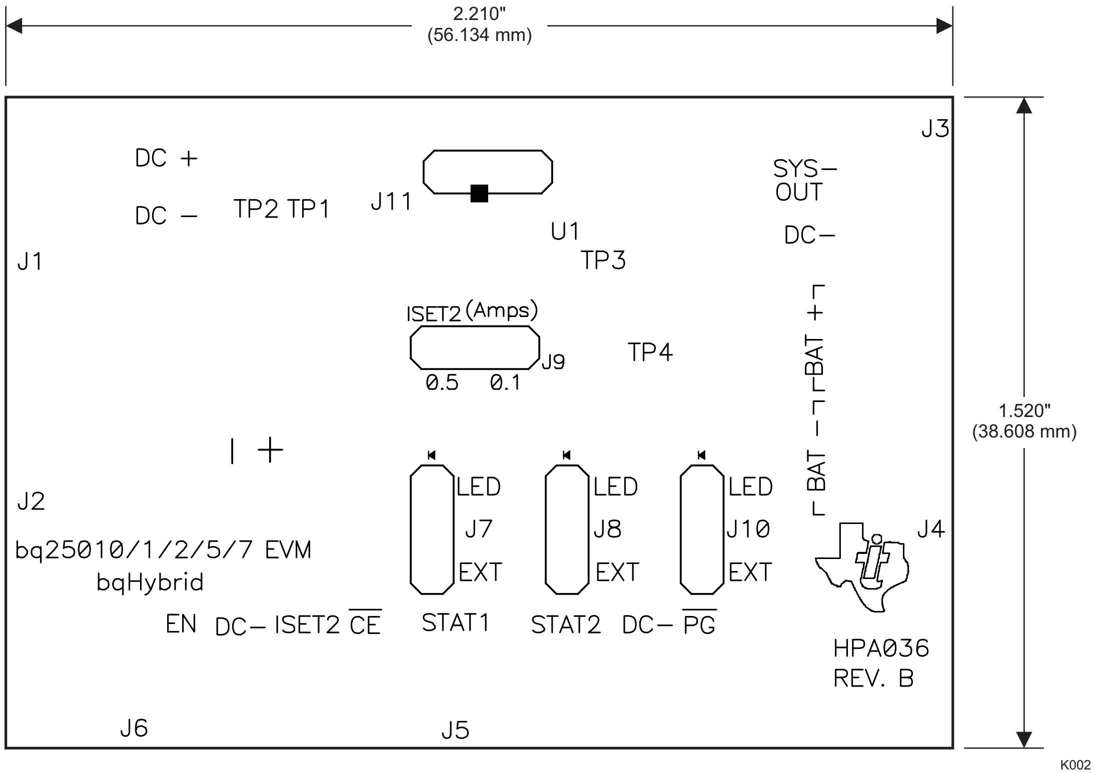

Figure 3-6. Silkscreen

3.3 Schematic

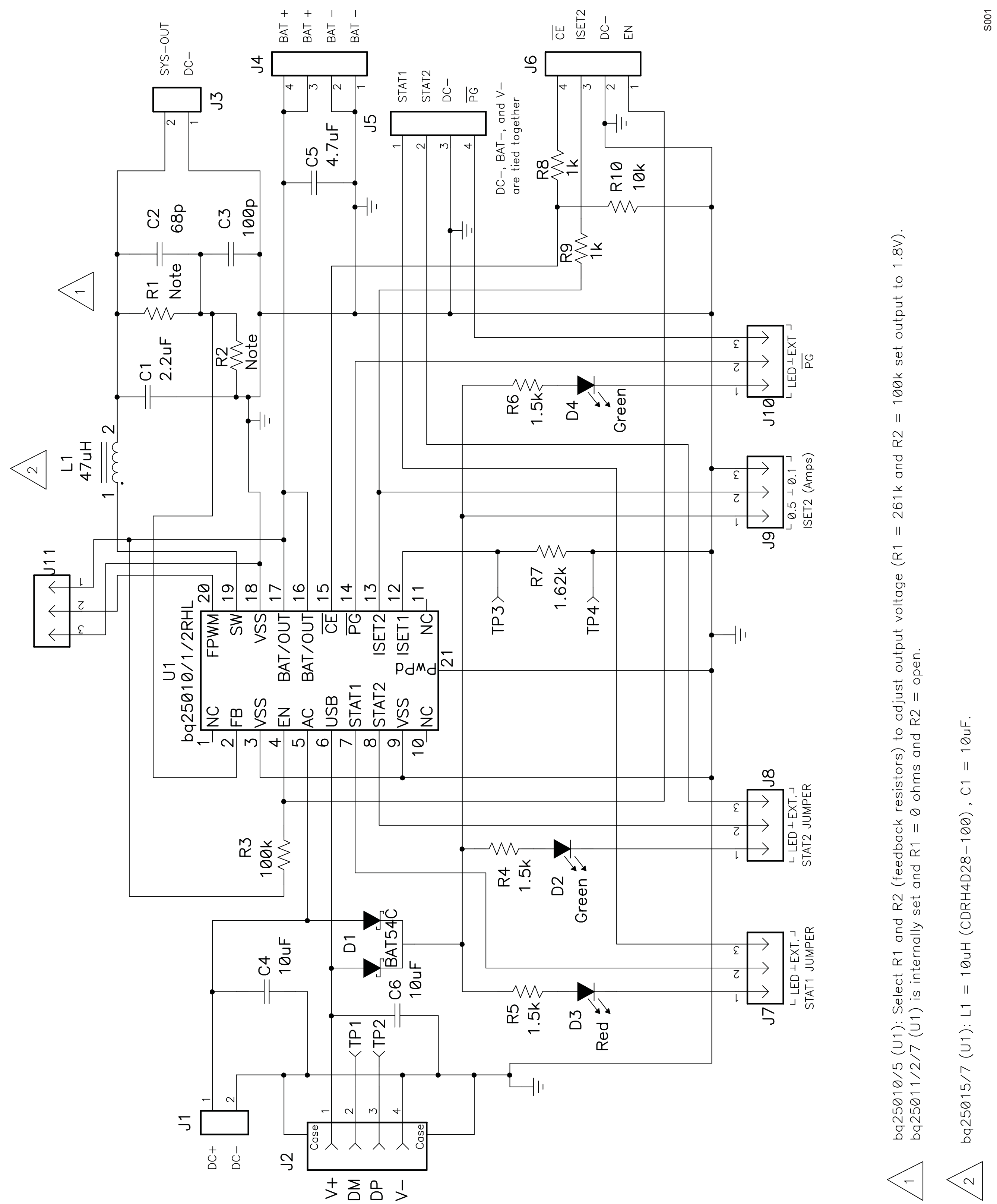

Figure 3-7. Schematic Diagram

EVALUATION BOARD/KIT IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User’s Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user’s responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User’s Guide and, specifically, the Warnings and Restrictions notice in the User’s Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI’s environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the charge regulation input voltage range of 4.35 V to 6.5 V and the adapter output voltage range of 0 V to 4.2 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
Low Power Wireless	www.ti.com/lpw	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265