

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

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Literature Number: SLUU214A
December 2004 – Revised June 2007



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 k Ω (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 | $^{\circ}\text{C}$ |

⁽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

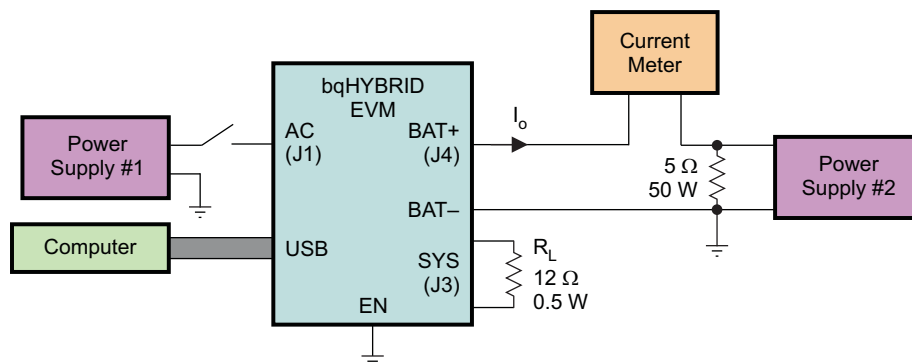
2.1.5 COMPONENTS

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 \pm 0.1 VDC, 1.0 \pm 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-).

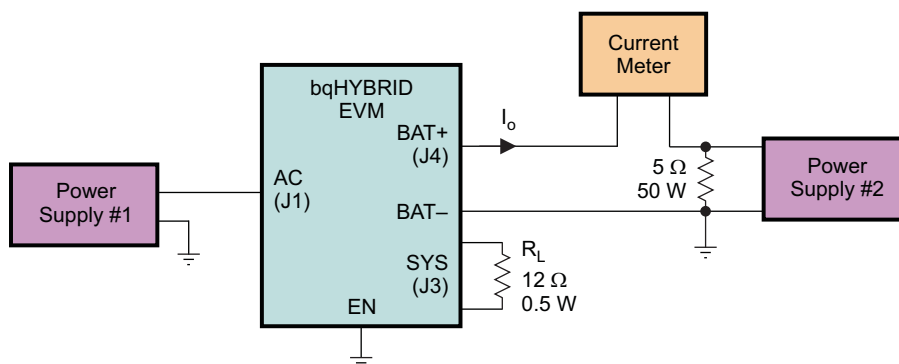


B0235-01

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](#).

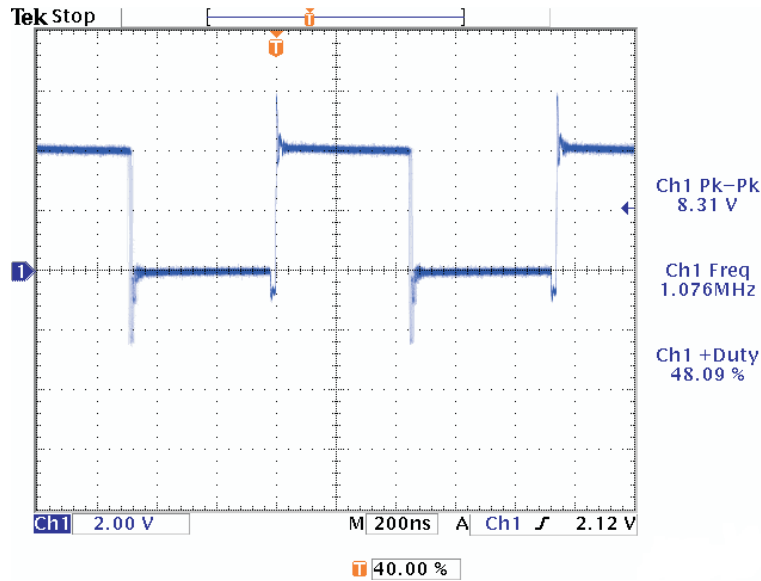


B0235-02

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

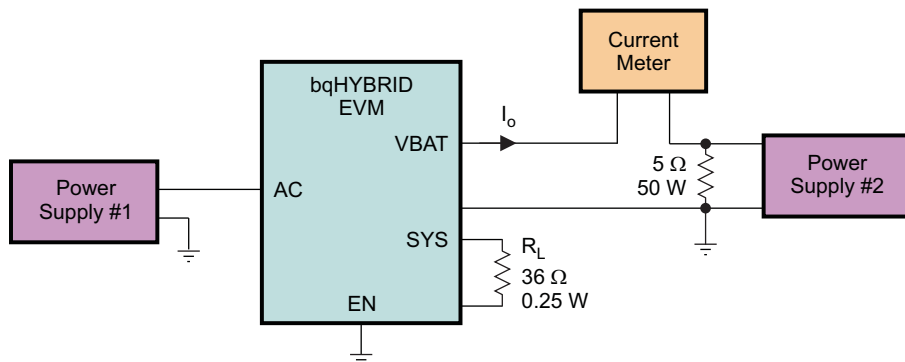
voltage of power supply #2 slowly to 4.2 V. Disconnect J6 pin 1 (EN) from pin 2 (DC-). Make J6 pin 1 (EN) open. Verify the voltage across R_L (SYS to DC-) is regulated between 1.75 V and 1.85 V. Verify the voltage at the SW pin, or terminal 1 of L1, is like that shown in [Figure 2-3](#). Verify that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



G001

Figure 2-3. Waveform at Pin SW

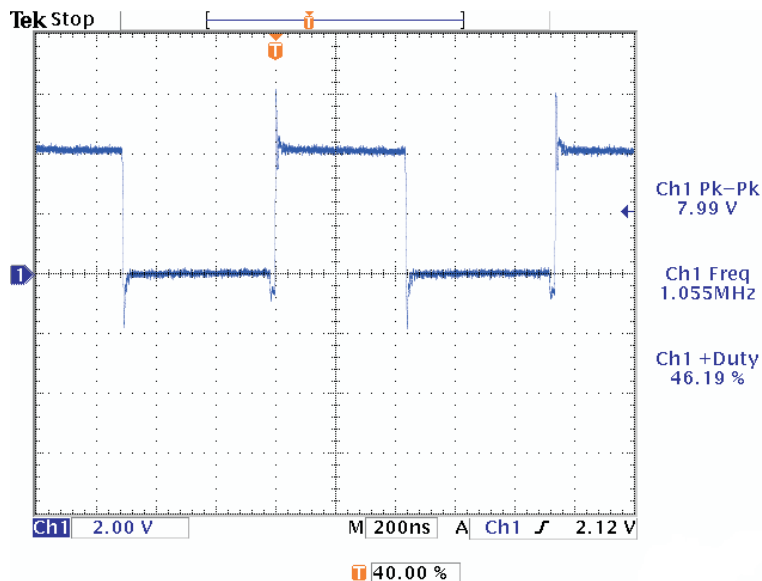
- DC-DC Converter Under Light-Load Condition (bq25012 as an Example).** Change R_L to the 36- Ω , 0.25-W resistor. Make sure the setup has been changed to that shown in [Figure 2-4](#). Verify the voltage across R_L (SYS to DC-) is regulated between 1.75 V and 1.85 V. Verify the voltage at the SW pin, 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.



B0235-03

Figure 2-4. Test Setup C

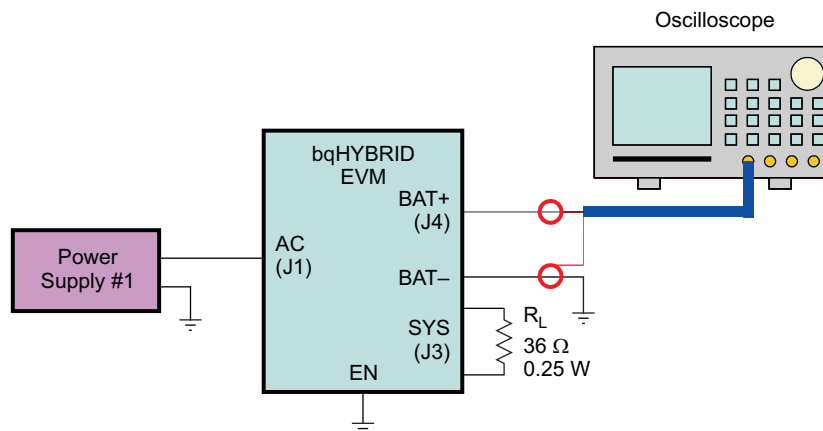
PROCEDURE



G002

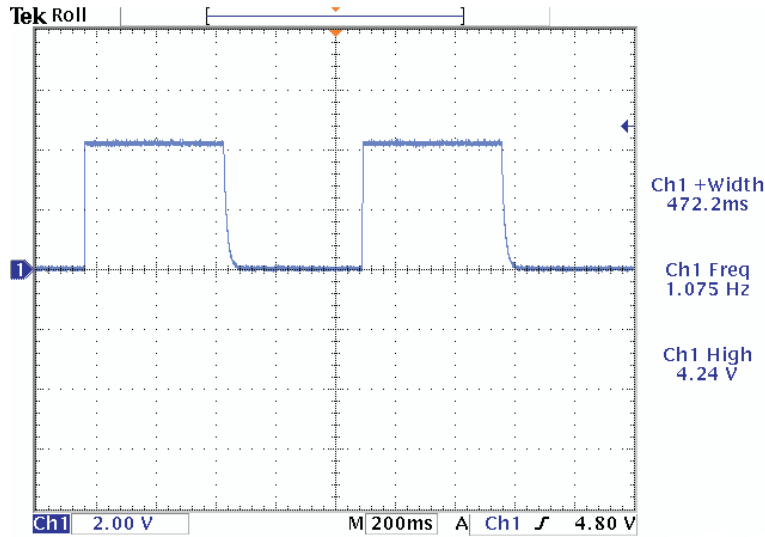
Figure 2-5. Waveform at Pin SW

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



B0235-04

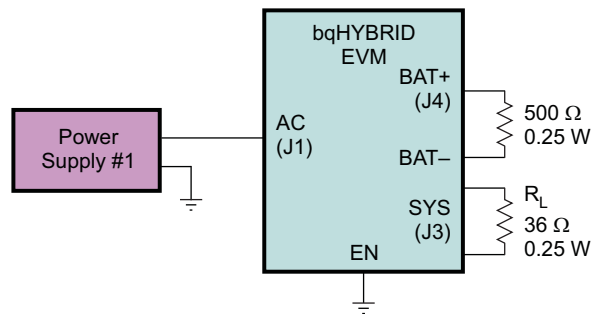
Figure 2-6. Test Setup D



G003

Figure 2-7. BAT+ Waveform at No Load

- 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.



B0235-05

Figure 2-8. Test Setup E

Bill of Materials, Board Layout, and Schematic

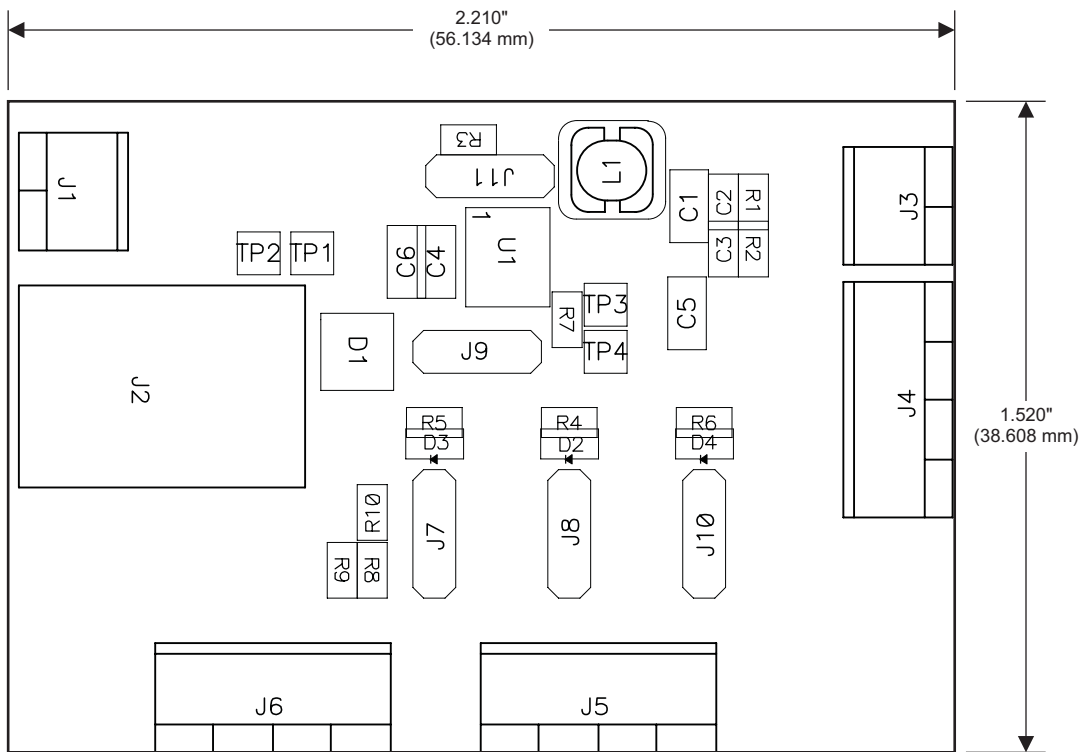
3.1 Bill of Materials

| 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- μ F, 6.3-V, X5R, 10% | 805 | Panasonic | ECJ-2YB0J225K |
| 0 | 0 | 0 | 1 | 1 | C1 | Capacitor, ceramic, 10- μ F, 6.3-V, X5R, 20% | 805 | Panasonic | ECJ-2FB0J106M |
| 2 | 2 | 2 | 2 | 2 | C4, C6 | Capacitor, ceramic, 10- μ F, 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- μ F, 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 \times 0.25 | OST | ED1514 |
| 1 | 1 | 1 | 1 | 1 | J2 | Connector, USB upstream (type B) | 0.47 \times 0.67 | Molex | 67068-1000 |
| 3 | 3 | 3 | 3 | 3 | J4, J5, J6 | Terminal block, 4-pin, 6-A, 3.5-mm | 0.55 \times 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 \times 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- μ H, 0.48-A, 435-m Ω | 0.185 \times 0.185 | Sumida | CDRH4D28-470 |
| 0 | 0 | 0 | 1 | 1 | L1 | Inductor, SMT, 10- μ H, 1-A, 95-m Ω | 0.185 \times 0.185 | Sumida | CDRH4D28-100 |
| 1 | 0 | 0 | 1 | 0 | R1 | Resistor, chip, 261-k Ω , 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-k Ω , 1/16-W, 1% | 603 | Std | Std |
| 1 | 1 | 1 | 1 | 1 | R3 | Resistor, chip, 100-k Ω , 1/16-W, 1% | 603 | Std | Std |
| 1 | 1 | 1 | 1 | 1 | R10 | Resistor, chip, 10-k Ω , 1/16-W, 1% | 603 | Std | Std |

Board Layout

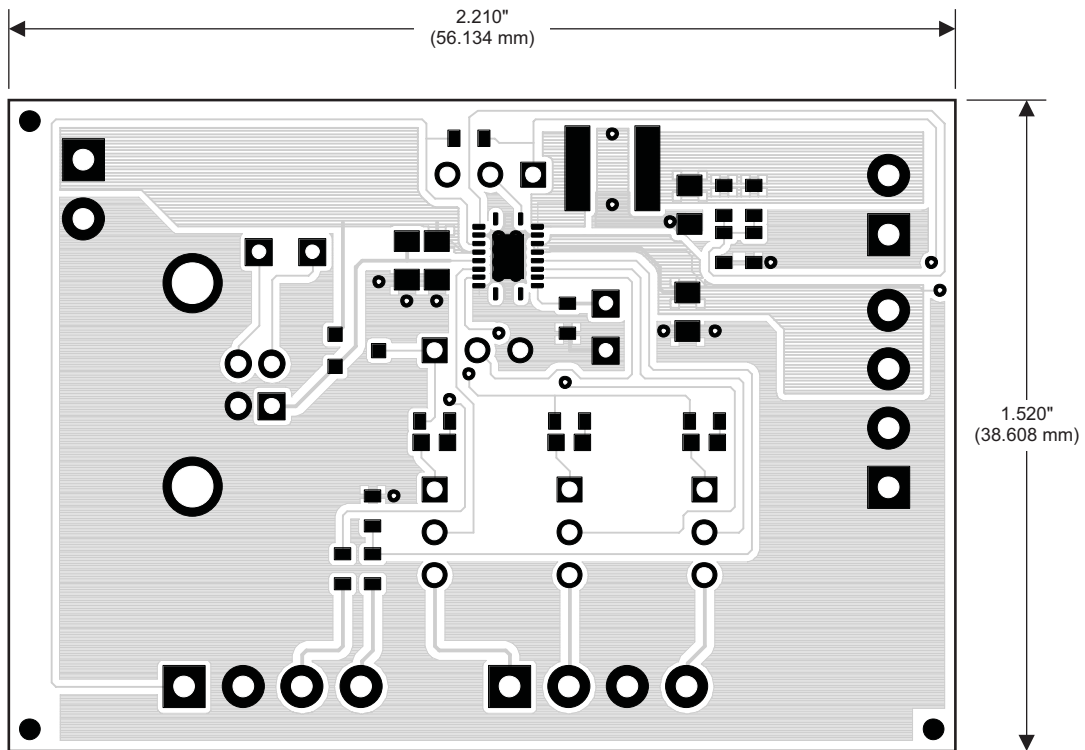
| bq2501x | | | | | RefDes | DESCRIPTION | SIZE | MFR | Part Number |
|---------------|---------------|---------------|---------------|---------------|---------------|---|--------|-----|-------------|
| x = 0 -001 | x = 1 -002 | x = 2 -003 | x = 5 -004 | x = 7 -005 | | | | | |
| 3 | 3 | 3 | 3 | 3 | R4, 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



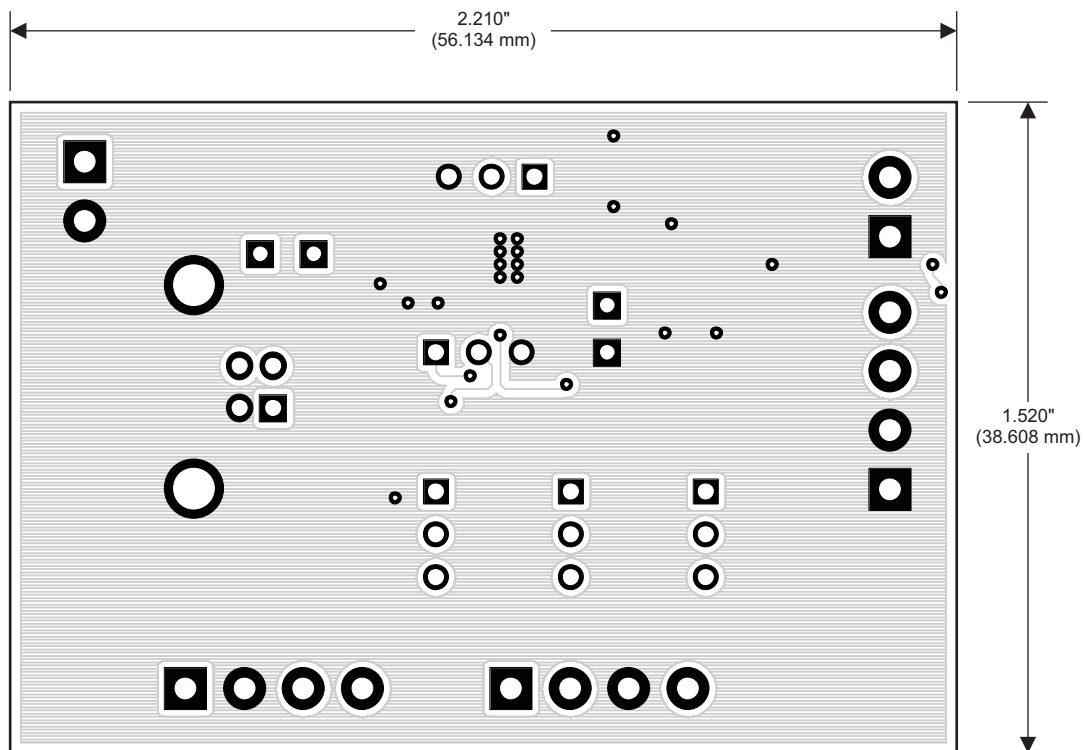
K001

Figure 3-1. Top Assembly



K003

Figure 3-2. Layer 1

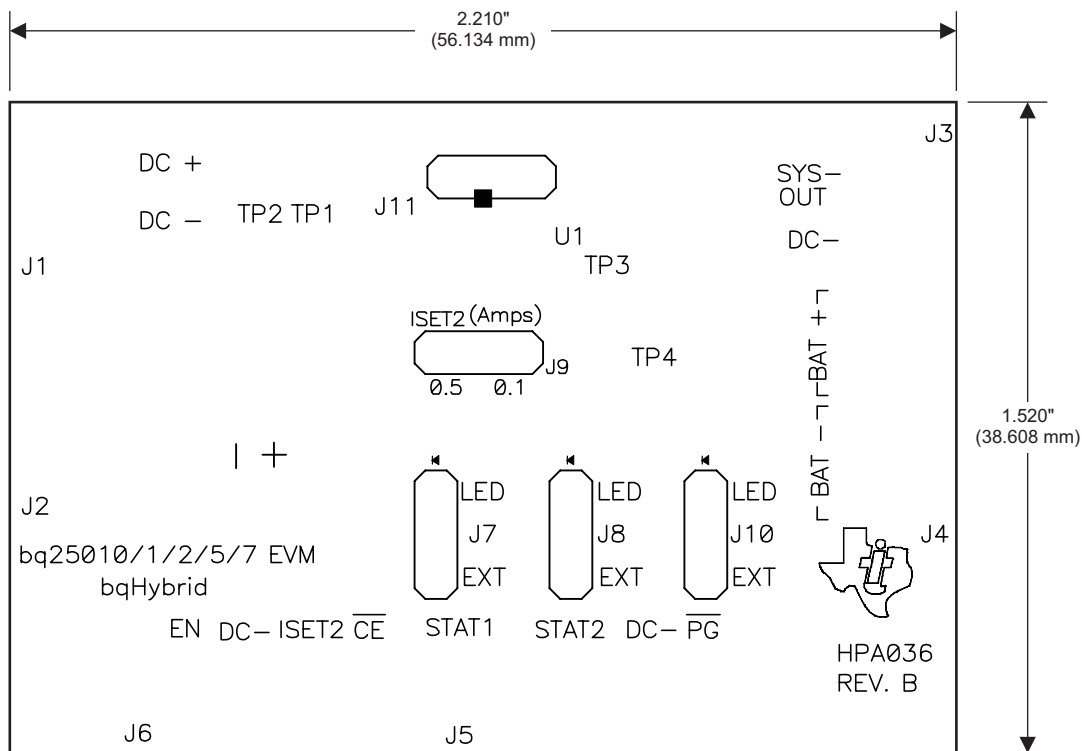


K004

Figure 3-3. Layer 2

Figure 3-4. Mask 1

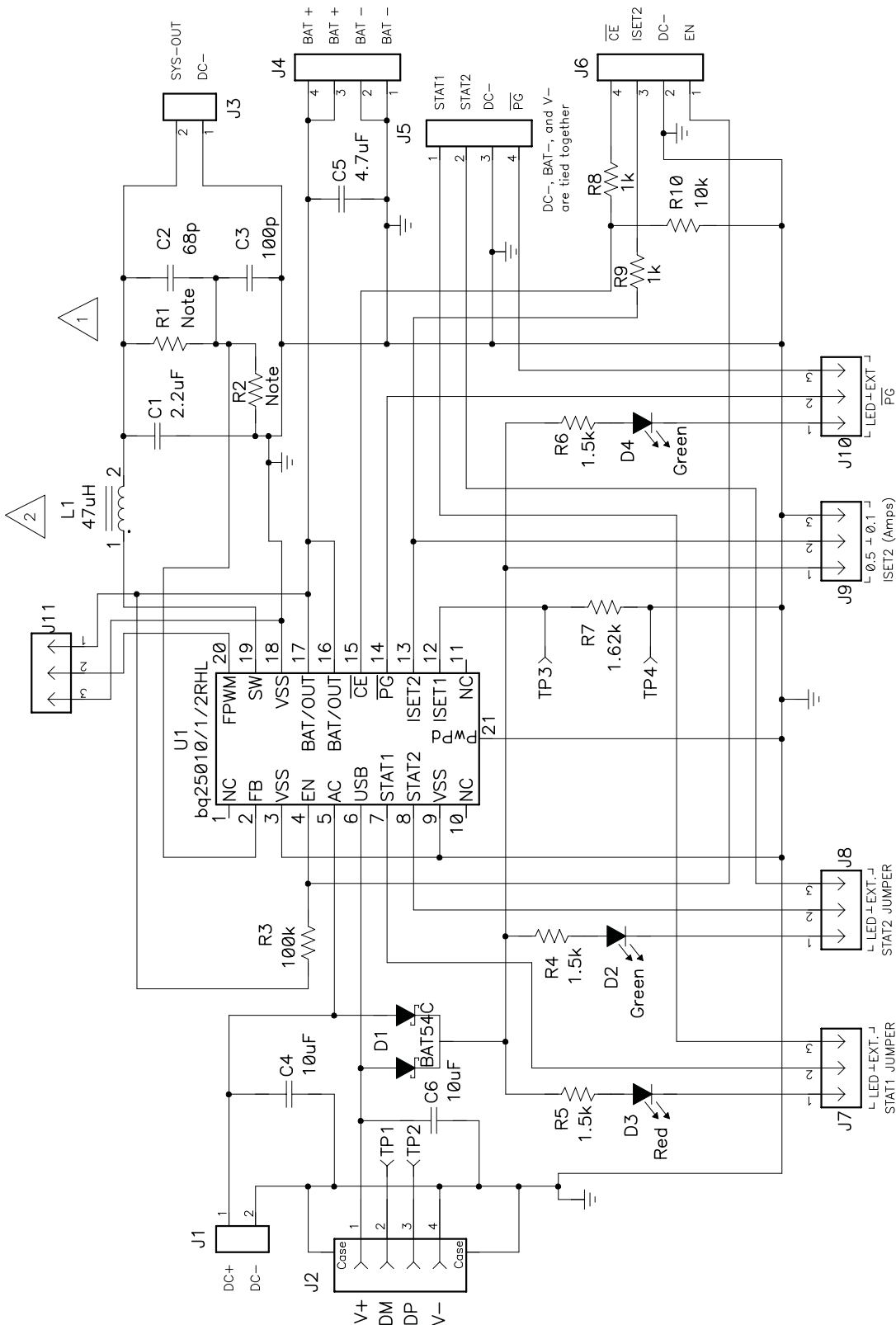
Figure 3-5. Mask 2



K002

Figure 3-6. Silkscreen

3.3 Schematic



1 Select R1 and R2 (feedback resistors) to adjust output voltage (R1 = 261k and R2 = 100k set output to 1.8V).
 bq25011/2/7 (U1) is internally set and R1 = 0 ohms and R2 = open.

2 bq25015/7 (U1): L1 = 10uH (CDRH4D28-100) , C1 = 10uF.

S001

Figure 3-7. Schematic Diagram

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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.

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