

# ***Using the bq241xx (bqSWITCHER™)***

## ***User's Guide***

Literature Number: SLUU200A  
July 2004—Revised December 2007



# Contents

|          |                                        |           |
|----------|----------------------------------------|-----------|
| <b>1</b> | <b>Introduction.....</b>               | <b>5</b>  |
| 1.1      | Background .....                       | 5         |
| 1.2      | Performance Specification Summary..... | 5         |
| <b>2</b> | <b>Test Summary .....</b>              | <b>6</b>  |
| 2.1      | Equipment.....                         | 6         |
| 2.2      | Setup.....                             | 6         |
| 2.3      | Test Procedure .....                   | 7         |
| <b>3</b> | <b>Schematic .....</b>                 | <b>9</b>  |
| <b>4</b> | <b>Physical Layouts .....</b>          | <b>10</b> |
| 4.1      | Board Layout .....                     | 10        |
| <b>5</b> | <b>List of Materials .....</b>         | <b>13</b> |
| <b>6</b> | <b>References .....</b>                | <b>18</b> |
|          | <b>Important Notices .....</b>         | <b>19</b> |

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## List of Figures

|   |                                 |    |
|---|---------------------------------|----|
| 1 | bq241xxEVM Schematic.....       | 9  |
| 2 | bq241xxEVM Top Assembly.....    | 10 |
| 3 | bq241xxEVM Top Silk Screen..... | 11 |
| 4 | bq241xxEVM Top Layer.....       | 11 |
| 5 | bq241xxEVM Bottom Layer.....    | 12 |

## List of Tables

|   |                                                                                 |    |
|---|---------------------------------------------------------------------------------|----|
| 1 | Performance Specification Summary .....                                         | 6  |
| 2 | I/O and Jumper Connections (Factory Jumper Selections shown in Bold Text) ..... | 7  |
| 3 | bq24100EVM-001 List of Materials .....                                          | 13 |
| 4 | bq24105EVM-002 List of Materials .....                                          | 14 |
| 5 | bq24113EVM-003 List of Materials .....                                          | 15 |
| 6 | bq24115EVM-004 List of Materials .....                                          | 16 |
| 7 | bq24103EVM-005 List of Materials .....                                          | 17 |
| 8 | bq24103AEVM-006 List of Materials .....                                         | 18 |

## ***Using the bq241xx (bqSWITCHER™)***

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### **1 Introduction**

This user's guide describes the bq241xxEVM (bqSWITCHER™) Evaluation Module. The Evaluation Module provides a convenient method for evaluating the performance of a charge management solution for portable applications using the bq241xx product family. A complete designed and tested charger is presented. The charger is designed to deliver up to 2.0 A of continuous output current. The charger is programmed from the factor to deliver 1.33 A of charging current. Follow the instructions in this user's guide that pertain to the specific bq241xxEVM (one-, two- or three-cell) to be evaluated. See the bqSWITCHER data sheet ([SLUS606](#)) prior to evaluation for detailed information on the bqSWITCHER device.

#### **1.1 Background**

The bqSWITCHER series are highly integrated Li-Ion and Li-Pol switch-mode charge management devices targeted at a wide range of portable applications. The bqSWITCHER series offer integrated synchronous PWM Controller and PowerFETs, high-accuracy current and voltage regulation, charge conditioning, charge status, and charge termination, in a small thermally enhanced QFN package. The system-controlled version provides additional input for full charge management under system control.

The bqSWITCHER charges the battery in three phases: conditioning, constant current, and constant voltage. Charge is terminated based on user-selectable minimum current level. A programmable charge timer provides a backup safety for charge termination. The bqSWITCHER automatically restarts the charge if the battery voltage falls below an internal threshold. The bqSWITCHER automatically enters sleep mode when  $V_{CC}$  supply is removed.

#### **1.2 Performance Specification Summary**

This section summarizes the performance specifications of the EVM. [Table 1](#) gives the EVM performance specifications. The TS pin has been disabled, for easier charging evaluation, by fixing its voltage to a set value. See the EVM schematic ([Figure 1](#)) and data sheet ([SLUS606](#)) for information on how to change R10 and R11 values to use with an external thermistor

**Table 1. Performance Specification Summary**

| SPECIFICATION                        |                                            | TEST CONDITIONS                                                                                        | MIN             | TYP  | MAX | UNIT |
|--------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------|------|-----|------|
| Input DC voltage, $V_{I(DC)}$        |                                            |                                                                                                        | $V_{REG} + 0.6$ | 5.0  | 16  | V    |
| Battery charge current, $I_{O(CHG)}$ |                                            |                                                                                                        |                 | 1.33 | 2.0 | A    |
| Power dissipation                    | bq24100<br>(1 cell)                        | $5\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 4.2\text{ V}$ , $I_{OUT} = 1.33\text{ A}$     |                 | 0.6  |     | W    |
|                                      | bq24103<br>bq24103A<br>bq24113<br>(1 cell) | $5\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 4.2\text{ V}$ , $I_{OUT} = 1.33\text{ A}$     |                 | 0.6  |     | W    |
|                                      | bq24103<br>bq24103A<br>bq24113<br>(2 cell) | $9\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 8.4\text{ V}$ , $I_{OUT} = 1.33\text{ A}$     |                 | 0.85 |     | W    |
|                                      | bq24105<br>bq24115<br>(1 cell)             | $5\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 4.2\text{ V}$ , $I_{OUT} = 1.33\text{ A}$     |                 | 0.0  |     | W    |
|                                      | bq24105<br>bq24115<br>(2 cell)             | $9\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 8.4\text{ V}$ , $I_{OUT} = 1.33\text{ A}$     |                 | 0.65 |     | W    |
|                                      | bq24105<br>bq24115<br>(3 cell)             | $13.5\text{ V} \leq V_{IN} \leq 16\text{ V}$ , $V_{(BAT)} = 12.6\text{ V}$ , $I_{OUT} = 1.33\text{ A}$ |                 | 1.17 |     | W    |

## 2 Test Summary

This chapter covers the test setups and tests performed, in evaluating the EVM.

### 2.1 Equipment

- **Power Source:** Current limited 15 V lab supply with its current limit set to 25% above the programmed charging current (1.7 A for setup from factory). This is basically a safety limit. The actual DC input current should be less than the charging current.
- **Two Fluke 75:** (optional) To measure input and output voltage and drop across current sense resistor.

### 2.2 Setup

The bq241xx EVM board requires a regulated supply approximately 0.3 V minimum above the regulated voltage of the battery pack (1-cell pack: 4.2 V; 2-cell pack: 8.4 V; 3-cell pack: 12.6 V) to a maximum input voltage of 16 V<sub>DC</sub>.

A one- to three-cell battery pack is needed for EVM evaluation. The EVM should be chosen and set up to charge the same numbers of cells as the evaluated (see [Table 2](#)).

Set up the EVM as shown in [Table 2](#). Preset the input supply to the desired voltage, turn off supply, and finally connect supply to J1. Set the supply's current limit 25% above the programmed charging current. The test setup connections and jumper setting selections are configured for a stand-alone evaluation and can be changed to interface with external hardware such as a microcontroller. See the EVM schematic ([Figure 1](#)) and data sheet ([SLUS606](#)) for functional information on other optional connections.

**Table 2. I/O and Jumper Connections (Factory Jumper Selections shown in Bold Text)**

| ASSEMBLY |                                 | -001                                               | -002                                               | -003                                               | -004                                               | -005                                               | -006                                               |
|----------|---------------------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|
| U1       | Device                          | bq24100                                            | bq24105 <sup>(1)</sup>                             | bq24113 <sup>(2)</sup>                             | bq24115 <sup>(1)</sup>                             | bq24103 <sup>(2)</sup>                             | bq24103A <sup>(2)</sup>                            |
| J1       | DC+/DC-:Input voltage range (V) | <b>5 to 16</b>                                     | <b>V<sub>REG</sub>+0.8 to 16</b> <sup>(1)</sup>    | <b>5 to 16</b>                                     | <b>V<sub>REG</sub>+0.8 to 16</b> <sup>(1)</sup>    | <b>5 to 16</b> <sup>(2)</sup>                      | <b>5 to 16</b> <sup>(2)</sup>                      |
| J2       | BAT+/BAT-No. cell in series     | <b>1</b>                                           | <b>1</b>                                           | <b>1</b>                                           | <b>1</b>                                           | <b>1</b>                                           | <b>1</b>                                           |
|          | Output regulation voltage (V)   | <b>4.2</b>                                         | <b>4.2</b> <sup>(1)</sup>                          | <b>4.2</b> <sup>(2)</sup>                          | <b>4.2</b> <sup>(1)</sup>                          | <b>4.2</b> <sup>(2)</sup>                          | <b>4.2</b> <sup>(2)</sup>                          |
| J5       | $\overline{\text{PG}}$          | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  |
| J6       | STAT1                           | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  |
| J7       | STAT2                           | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  | <b>N/C no jumper</b>                               | <b>N/C no jumper</b>                               | <b>LED or EXT</b>                                  | <b>LED or EXT</b>                                  |
| J8       | TTC or CMOD                     | <b>TTC no jumper</b>                               | <b>TTC no jumper</b>                               | <b>CMOD jumper HI</b>                              | <b>CMOD jumper HI</b>                              | <b>TTC no jumper</b>                               | <b>TTC no jumper</b>                               |
| J9       | $\overline{\text{CE}}$          | <b><math>\overline{\text{CE}}</math> jumper LO</b> | <b><math>\overline{\text{CE}}</math> jumper LO</b> | <b><math>\overline{\text{CE}}</math> jumper LO</b> | <b><math>\overline{\text{CE}}</math> jumper LO</b> | <b><math>\overline{\text{CE}}</math> jumper LO</b> | <b><math>\overline{\text{CE}}</math> jumper LO</b> |
| J10      | Cells or FB                     | <b>No jumper</b>                                   | <b>No jumper</b>                                   | <b>Cells jumper LO</b>                             | <b>No jumper</b>                                   | <b>Cells jumper LO</b>                             | <b>Cells jumper LO</b>                             |

<sup>(1)</sup> R5 and R7 can be changed to regulate output between approximately 3.2 V to 15.5 V. Adjust the input voltage as required. Output set to operate at 4.2 VDC from the factory.

<sup>(2)</sup> To operate as a two cell version (8.4V), replace battery with a two-series cell pack, set J10 to High and adjust the Input voltage between 9.2 V to 16 V.

## 2.3 Test Procedure

Set up the evaluation board as described above, by making the necessary I/O connections and jumper selections.

### **WARNING**

**Prior to test and evaluation, it is important to verify that the EVM selected is set up correctly for the battery pack to be charged; several evaluation modules have a CELLS option that can be programmed for two different size – number of series cells. TI highly recommends that the battery pack to be charged, has internal protection as a safety backup.**

1. Apply power to the board with the power supply, preset to the suggested value in [Table 2](#), and use approximately 1.7 A for the current limit setting.
2. The  $\overline{\text{PG}}$  LED and STAT1 should light, if the battery is charging.
3. The bq241xx enters pre-conditioning mode if the battery is below the  $V_{(\text{LOWV})}$  threshold. In this mode, the bq241xx pre-charges the battery with a low current programmed by the ISET2 pin. If the  $R_{\text{SET1}}$  and  $R_{\text{SET2}}$  resistors are the same value then the precharge is one tenth the fast charge current ( $I_{\text{PRE-CHG}} = 1.33 \text{ A}/10 = 133 \text{ mA}$ ) until the battery voltage reaches the  $V_{(\text{LOWV})}$  threshold or until the precharge timer expires. If the timer expires then the charge current is terminated and the bq241xx enters fault mode. STAT1 and STAT2 (if available) LEDs go dark when in fault mode.

**Note:** There are several non-charging modes that share this status state. Toggling input power or battery replacement resets fault mode.

4. Once the battery voltage is above the  $V_{(\text{LOWV})}$  threshold, the battery enters fast charge mode. This EVM is programmed for approximately 1.3 A of fast charging current. The  $\overline{\text{PG}}$  and STAT1 LEDs should be on.
5. Once the battery reaches voltage regulation (4.2 V) the current tapers down as the battery reaches its full capacity. The  $\overline{\text{PG}}$  and STAT1 LEDs should light.

### Test Summary

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6. When the current reaches the taper termination threshold, set by the  $R_{SET2}$  resistor, the charge is terminated. The  $\overline{PG}$  LED should be still lit and the STAT1 LED should turn off and STAT2 LED lights.
7. If the battery discharges down to the recharge threshold, the charger starts fast charging. The  $\overline{PG}$  LED should remain lit, the STAT2 LED should turn off and STAT1 LED lights.

An alternative method of testing the EVM is with a source meter, that can sink or source current. This can easily be adjusted to test each mode, in place of a battery.

### 3 Schematic

Figure 1 shows the schematic diagram for the EVM.

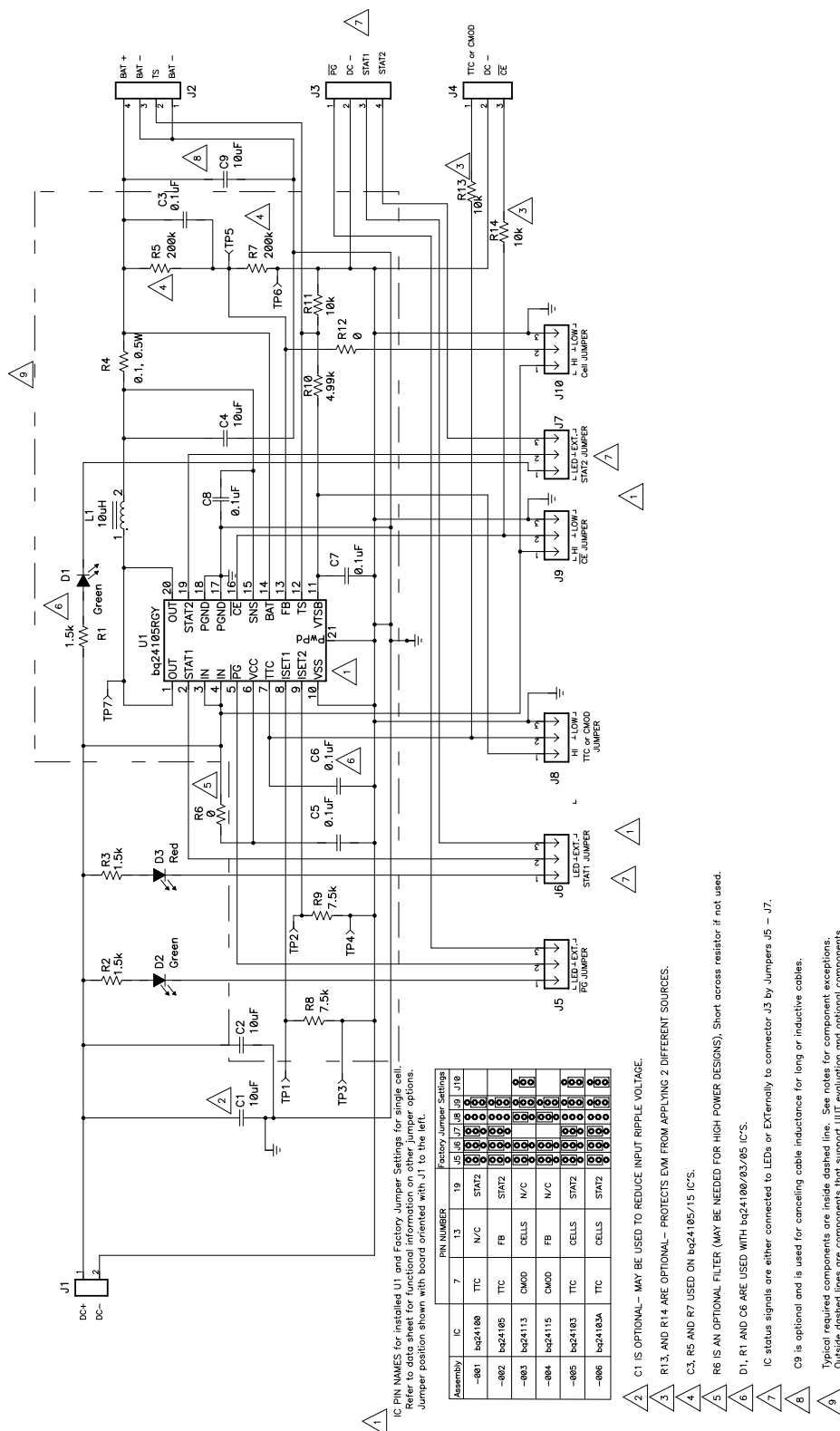


Figure 1. bq241xxEVM Schematic

## 4 Physical Layouts

This chapter contains the board layout and assembly drawings for the EVM.

### 4.1 Board Layout

Figure 2 shows the top assembly of the EVM. Figure 3 shows the top silk screen. Figure 4 shows the top layer. Figure 5 shows the bottom layer view.

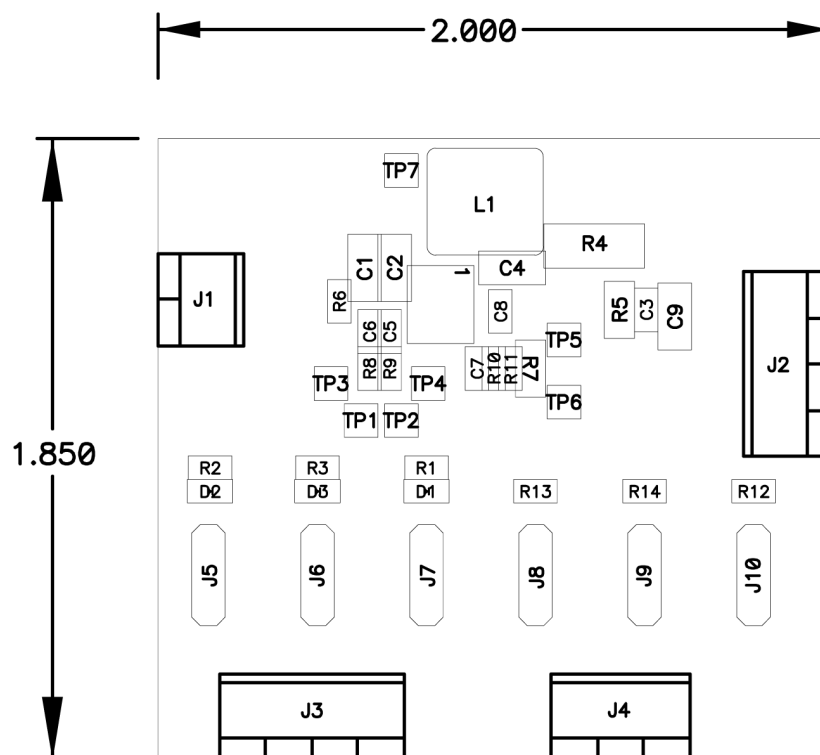


Figure 2. bq241xxEVM Top Assembly

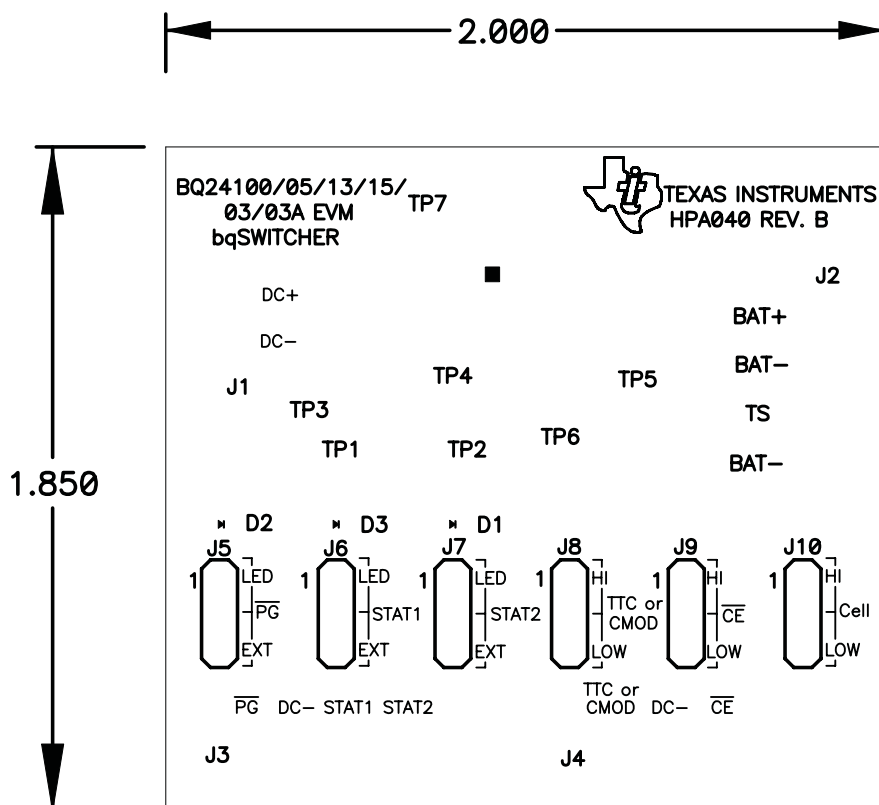


Figure 3. bq241xxEVM Top Silk Screen

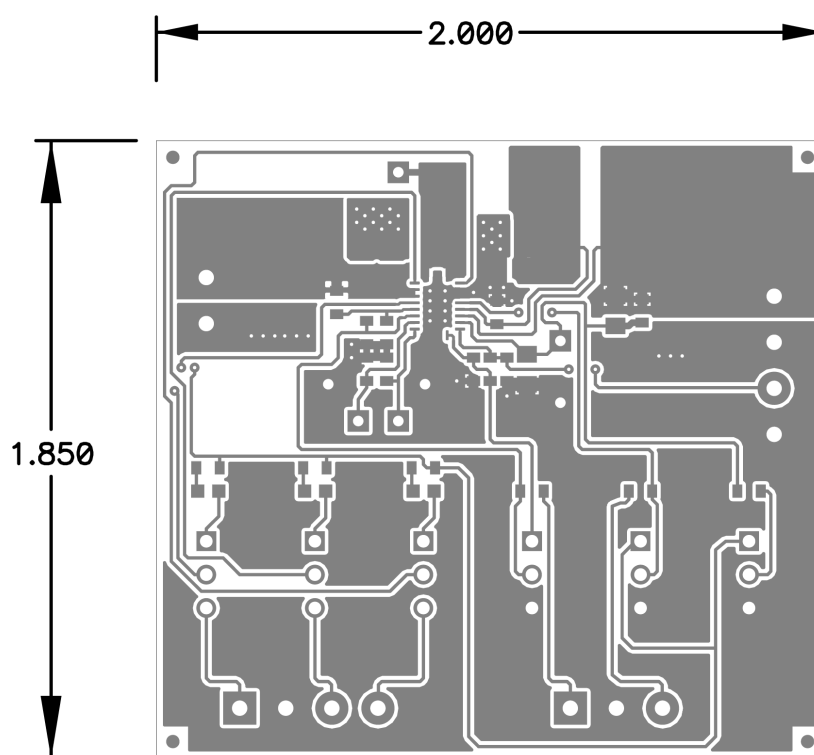
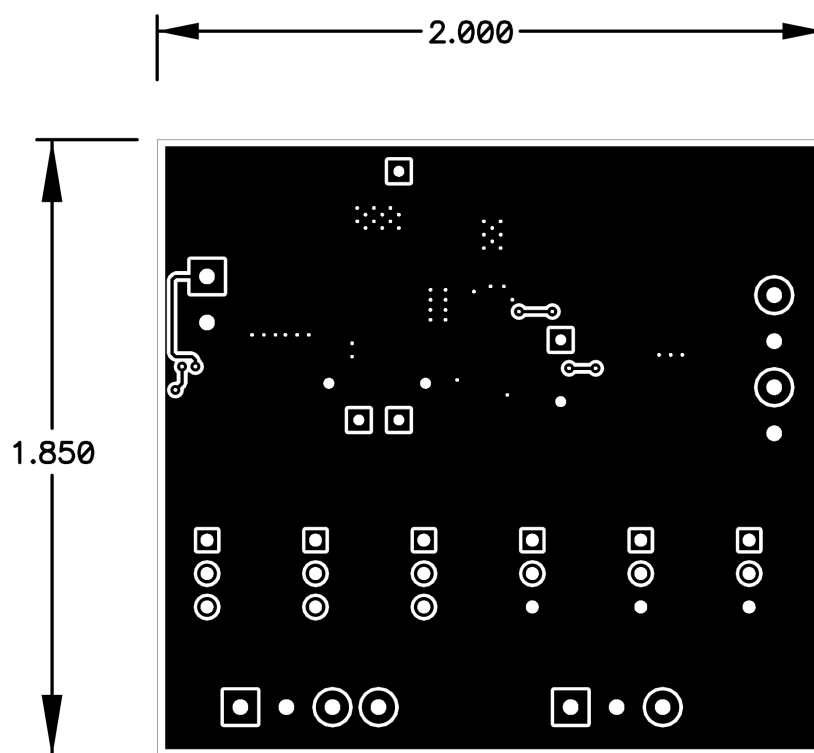


Figure 4. bq241xxEVM Top Layer



**Figure 5. bq241xxEVM Bottom Layer**

## 5 List of Materials

Table 3 through Table 7 list the components used in this design. With minor component adjustments this design could be modified to meet a wide range of applications.

**Table 3. bq24100EVM-001 List of Materials**<sup>(1) (2) (3) (4) (5)</sup>

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 0   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 5   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 1   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 0   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 0   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24100RHL      |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

<sup>(1)</sup> These assemblies are ESD sensitive, ESD precautions shall be observed.

<sup>(2)</sup> These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.

<sup>(3)</sup> These assemblies must comply with workmanship standards IPC-A-610 Class 2.

<sup>(4)</sup> C9 can be installed by the customer if using long cables (inductive load)

<sup>(5)</sup> Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J5, J6, J7-1/2 (LED); J9-2/3 (LOW); J8-2 (optional)

**Table 4. bq24105EVM-002 List of Materials** <sup>(1) (2) (3) (4) (5)</sup>

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 0   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 5   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 1   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 0   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 2   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24105RHL      |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

(1) These assemblies are ESD sensitive, ESD precautions shall be observed.

(2) These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.

(3) These assemblies must comply with workmanship standards IPC-A-610 Class 2.

(4) C9 can be installed by the customer if using long cables (inductive load)

(5) Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J5, J6, J7-1/2 (LED); J9-2/3 (LOW); J8-2 (optional)

**Table 5. bq24113EVM-003 List of Materials**<sup>(1) (2) (3) (4) (5)</sup>

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 0   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 0   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 5   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 0   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 0   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24113RHL      |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

<sup>(1)</sup> These assemblies are ESD sensitive, ESD precautions shall be observed.

<sup>(2)</sup> These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.

<sup>(3)</sup> These assemblies must comply with workmanship standards IPC-A-610 Class 2.

<sup>(4)</sup> C9 can be installed by the customer if using long cables (inductive load)

<sup>(5)</sup> Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J8-1/2 (Hi), J5 & J6-1/2 (LED), J9-2/3 (LOW). Place shunts on J10-2/3 (LOW).

**Table 6. bq24115EVM-004 List of Materials**<sup>(1) (2) (3) (4) (5)</sup>

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 0   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 0   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 0   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 4   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 0   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 0   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 2   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24115RHL      |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

<sup>(1)</sup> These assemblies are ESD sensitive, ESD precautions shall be observed.

<sup>(2)</sup> These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.

<sup>(3)</sup> These assemblies must comply with workmanship standards IPC-A-610 Class 2.

<sup>(4)</sup> C9 can be installed by the customer if using long cables (inductive load)

<sup>(5)</sup> Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J8-1/2 (Hi), J5 & J6-1/2 (LED), J9-2/3 (LOW).

**Table 7. bq24103EVM-005 List of Materials**<sup>(1) (2) (3) (4) (5)</sup>

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 6   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 1   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 0   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24103RHL      |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

<sup>(1)</sup> These assemblies are ESD sensitive, ESD precautions shall be observed.

<sup>(2)</sup> These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.

<sup>(3)</sup> These assemblies must comply with workmanship standards IPC-A-610 Class 2.

<sup>(4)</sup> C9 can be installed by the customer if using long cables (inductive load)

<sup>(5)</sup> Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J5, J6, J7-1/2 (LED); J9-2/3 (LOW); J8-2 (optional). Place shunts on J10-2/3 (LOW).

## References

**Table 8. bq24103AEVM-006 List of Materials<sup>(1) (2) (3) (4) (5)</sup>**

| REFERENCE DESIGNATOR | QTY | DESCRIPTION                                      | SIZE                 | MFR       | PART NUMBER     |
|----------------------|-----|--------------------------------------------------|----------------------|-----------|-----------------|
| C1, C2, C4           | 3   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C9                   | 0   | Capacitor, ceramic, 10 $\mu$ F, 25 V, X5R, 20%   | 1206                 | Panasonic | ECJ-3YB1E106M   |
| C3                   | 0   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C5, C7, C8           | 3   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | ECJ-1VB1C104K   |
| C6                   | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 16 V, X7R, 10%  | 603                  | Panasonic | 160-1183-1-ND   |
| D1                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D2                   | 1   | Diode, LED, green, 2.1 V, 20 mA, 6 mcd           | 603                  | Liteon    | 160-1183-1-ND   |
| D3                   | 1   | Diode, LED, red, 1.8 V, 20 mA, 20 mcd            | 603                  | Liteon    | 160-1181-1-ND   |
| J1                   | 1   | Terminal block, 2-pin, 6 A, 3.5 mm               | 75525                | OST       | ED1514          |
| J2, J3               | 2   | Terminal block, 4-pin, 6 A, 3.5 mm               | 0.55 $\times$ 0.25   | OST       | ED1516          |
| J4                   | 1   | Terminal block, 3-pin, 6 A, 3.5 mm               | 0.41 $\times$ 0.25   | Sullins   | ED1515          |
| J5, J6, J8, J9       | 4   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J7                   | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | Sullins   | PTC36SAAN       |
| J10                  | 1   | Header, 3-pin, 100 mil spacing, (36-pin strip)   | 34100                | 3M        | PTC36SAAN       |
|                      | 6   | Shunt, 100 mil, black                            | 0.100                | Sumida    | 929950-00       |
| L1                   | 1   | Inductor, SMT, 10 $\mu$ H, 1.84 A, 49 mW         | 0.315 $\times$ 0.287 | Vishay    | CDRH74-100      |
| R1                   | 1   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R10                  | 1   | Resistor, chip, 4.99 k $\Omega$ , 1/16-W, 1%     | 603                  | Vishay    | CRCW0603-4991-F |
| R11, R13, R14        | 3   | Resistor, chip, 10 k $\Omega$ , 1/16-W, 1%       | 603                  | Vishay    | CRCW0603-1002-F |
| R12                  | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-0000-F |
| R2, R3               | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-1501-F |
| R4                   | 1   | Resistor, chip, 0.1 $\Omega$ , W, 1%             | 2010                 | Vishay    | CRCW1210-0R10F  |
| R5, R7               | 0   | Resistor, chip, 200 k $\Omega$ , 1/8-W, 1%       | 805                  | Vishay    | CRCW0805-2003-F |
| R6                   | 1   | Resistor, chip, 0 $\Omega$ , 1/16-W, 1%          | 603                  | Vishay    | CRCW0603-00R0-F |
| R8, R9               | 2   | Resistor, chip, 7.5 k $\Omega$ , 1/16-W, 1%      | 603                  | Vishay    | CRCW0603-7501-F |
| U1                   | 1   | IC, advanced Li-Ion and Li-Pol charge management | RHL-20               | TI        | bq24103ARHL     |
| —                    | 1   | PCB, 2.0 In $\times$ 1.9 In $\times$ 0.031 In    |                      | Any       | HPA040          |

- (1) These assemblies are ESD sensitive, ESD precautions shall be observed.  
 (2) These assemblies must be clean and free from flux and all contaminants. Refrain from using "no clean" flux on these assemblies.  
 (3) These assemblies must comply with workmanship standards IPC-A-610 Class 2.  
 (4) C9 can be installed by the customer if using long cables (inductive load)  
 (5) Place shunts as follows (Jumper pin orientation: pin 1: top (toward RD), pin 2: center, pin 3-bottom). Place shunts on J5, J6, J7-1/2 (LED); J9-2/3 (LOW); J8-2 (optional). Place shunts on J10-2/3 (LOW).

## 6 References

1. bq241xx Synchronous Switchmode Li-Ion and Li-Pol Charge Management IC With Integrated PowerFETs (bqSWITCHER™) data sheet ([SLUS606](#)).

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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.

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During normal operation, some circuit components may have case temperatures greater than 125° C. The EVM is designed to operate properly with certain components above 125° 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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