Using the bq2412x (bqSWITCHER™) EVM

User's Guide

Literature Number: SLUU236A
March 2006–Revised November 2007

TEXAS INSTRUMENTS

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1 Introduction

This user's guide describes the bq2412x (bqSWITCHER™) evaluation module (EVM) for part numbers bq24120, bq24123, and bq24125. The EVM helps you evaluate the performance of a charge management solution for portable applications using the bq24120x product family. A complete, designed, and tested charger is presented. The charger can deliver up to 2 A of continuous output current and is programmed from the factory to deliver 1.33 A of charging current. Follow the instructions in this user's guide that pertain to the specific bq2412x EVM to be evaluated (one-, two- or three-cell). See the bqSWITCHER data sheet (SLUS688) prior to evaluation for detailed information on the bqSWITCHER devices.

1.1 Background

The bqSWITCHER™ series are highly integrated Li-ion and Li-polymer switch-mode charge management devices targeting a wide range of portable applications. The bqSWITCHER series offers integrated synchronous PWM controller and power FETs, 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-selected 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 is a bq24120x EVM performance specifications summary (Table 1). 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 SLUS688 for information about changing the 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	16	V
Battery charge current, $I_{O(CHG)}$				1.33	2	A
Power dissipation	bq24120 (1 cell)	4.5 V ≤ V_{IN} ≤ 16 V, $V_{(BAT)}$ = 4.2 V, I_{OUT} = 1.33 A		0.6		W
	bq24123 (1 cell)	4.5 V ≤ V_{IN} ≤ 16 V, $V_{(BAT)}$ = 4.2 V, I_{OUT} = 1.33 A		0.6		W
	bq24123 (2 cells)	9 V ≤ V_{IN} ≤ 16 V, $V_{(BAT)}$ = 8.4 V, I_{OUT} = 1.33 A		0.85		W
	bg24125 (1 cell)	4.5 V ≤ V_{IN} ≤ 16V, $V_{(BAT)}$ = 4.2V, I_{OUT} = 1.33A		0.6		W
	bg24125 (2 cells)	9 V ≤ V_{IN} ≤ 16V, $V_{(BAT)}$ = 8.4V, I_{OUT} = 1.33A		0.85		W
	bg24125 (3 cells)	13.5 V ≤ V_{IN} ≤ 16V, $V_{(BAT)}$ = 12.6V, I_{OUT} = 1.33A		1.17		W

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2 Test Summary

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

2.1 Equipment

- Power Source: Current-limited, 15-V laboratory power 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 digital multimeters: (optional) To measure input and output voltage and voltage drop across current-sense resistor.

2.2 Setup

The bq2412x EVM board requires a regulated supply approximating 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_{DC}.

A 1- to 3-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 battery pack to be evaluated (see Table 2).

Set up the EVM as shown in Table 2. Preset the input supply to the desired voltage, turn off the supply, and then connect the 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 but can be changed to interface with external hardware such as a microcontroller. See the EVM schematic (Figure 1) and SLUS688 data sheet for additional functional information on other optional connections.

Table 2. I/O and Jumper Connections

ASSEMBLY		**–001**	**–002**	**-003**
U1	Device	bq24120	bq24123(1)	bq24125(2)
J1	DC+/DC-:Input voltage range (V)	**5 to 16**(3)	**5 to 16**	**5 to 16**
J2	BAT+/BAT-No. cell in series	**1**	**1**	**1**
	Output regulation voltage (V)	**4.2**	**4.2**	**4.2**
J5	$\overline{PG}$	**LED** or EXT	**LED** or EXT	**LED** or EXT
J6	STAT1	**LED** or EXT	**LED** or EXT	**LED** or EXT
J7	STAT2	**LED** or EXT	**LED** or EXT	**LED** or EXT
J8	TTC or CMOD	**TTC no jumper**	**TTC no jumper**	**TTC no jumper**
J9	$\overline{CE}$	**$\overline{CE}$ jumper LO**	**$\overline{CE}$ jumper LO**	**$\overline{CE}$ jumper LO**
J10	Cells or FB	**No jumper**	**Cells jumper LO**	**No jumper**

(1) To operate as a 2-cell version (8.4 V), replace battery with a 2-series cell pack, set J10 to High, and adjust the input voltage between 9.2 V to 16 V.
(2) 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.
(3) Factory jumper selections display in bold text.

2.3 Test Procedure

Set up the evaluation board as previously described by making the necessary I/O connections and jumper selections. 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). It is strongly recommended that the battery pack to be charged has internal protection as a safety backup.

1. Turn on the power supply, preset to the suggested value in Table 2 and approximately 1.7 A for the current-limit setting.
2. The $\overline{PG}$ LED should turn on along with STAT1, if the battery is charging.

3. The bq2412x enters preconditioning mode if the battery is below the $V_{(LOWV)}$ threshold. In this mode, the bq2412x precharges the battery with a low current programmed by the ISET2 pin. If the R_{SET1} and R_{SET2} resistors are the same value, then the precharge is 1/10th the fast-charge current ($I_{PRE-CHG}$ = 1.33 A/10 = 133 mA) until the battery voltage reaches the $V_{(LOWV)}$ threshold or until the precharge timer expires. If the timer expires, then the charge current is terminated and the bq24120x enters fault mode. STAT1 and STAT2 (if available) LEDs turn off when in fault mode. Note that several noncharging modes share this status state. Toggling input power or battery replacement resets fault mode.
4. Once the battery voltage is above the $V_{(LOWV)}$ threshold, the battery enters fast-charge mode. This EVM is programmed for approximately 1.3 A of fast-charging current. The $\overline{PG}$ 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 $\overline{PG}$ and STAT1 LEDs should be on.
6. When the current reaches the taper termination threshold, set by the R_{SET2} resistor, the charge is terminated. The $\overline{PG}$ LED should still be on, and the STAT1 LED should turn off and STAT2 LED turn on.
7. If the battery discharges down to the recharge threshold, the charger starts fast-charging. The $\overline{PG}$ LED should still be on, and the STAT2 LED should turn off and STAT1 LED turn on.

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.

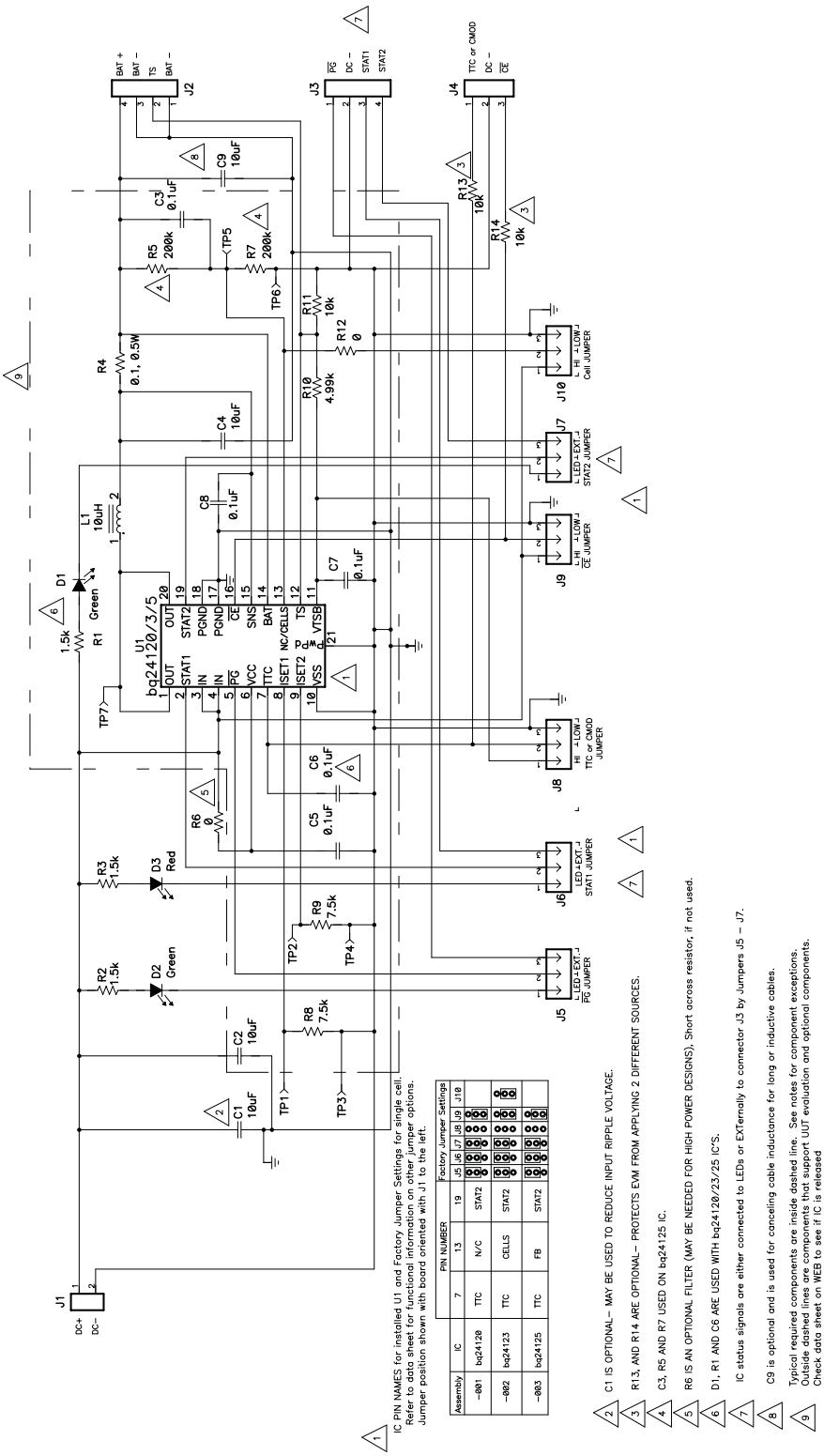

Figure 1. bq2412x Schematic

4 Physical Layouts

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

4.1 Board Layout

The EVM top assembly and the top silk screen views are shown by Figure 2 and Figure 3, respectively. Figure 4 and Figure 5 show the top layer and the bottom layer views, respectively.

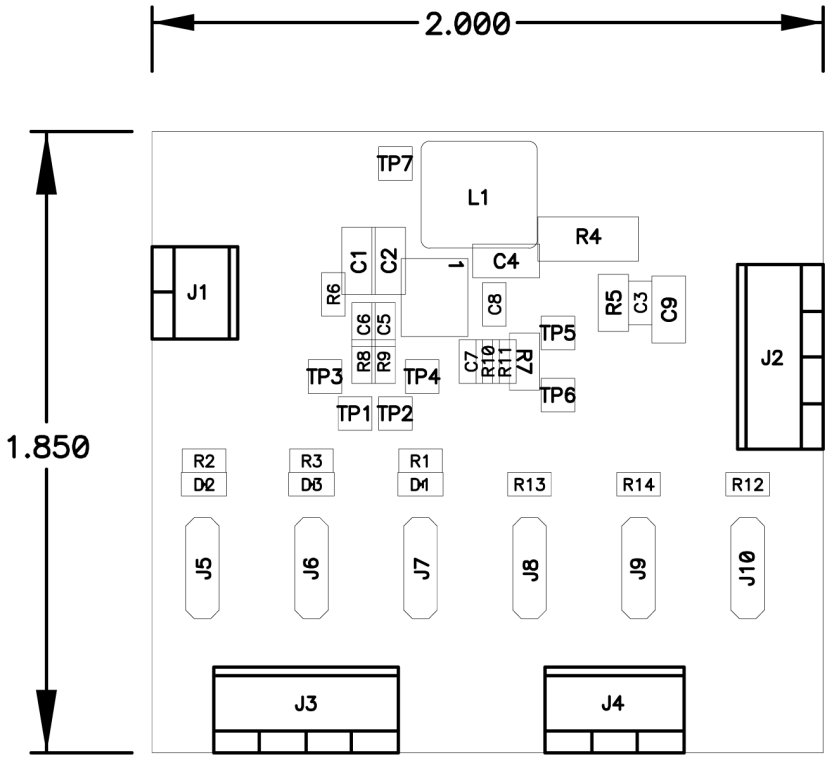

Figure 2. bq2412x EVM Top Assembly

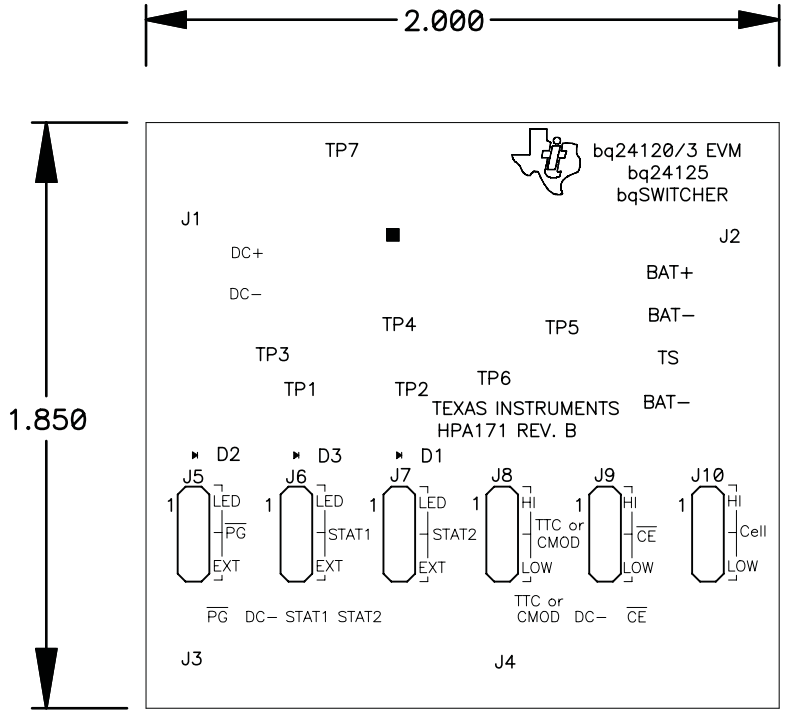

Figure 3. bq2412x EVM Top Silk Screen

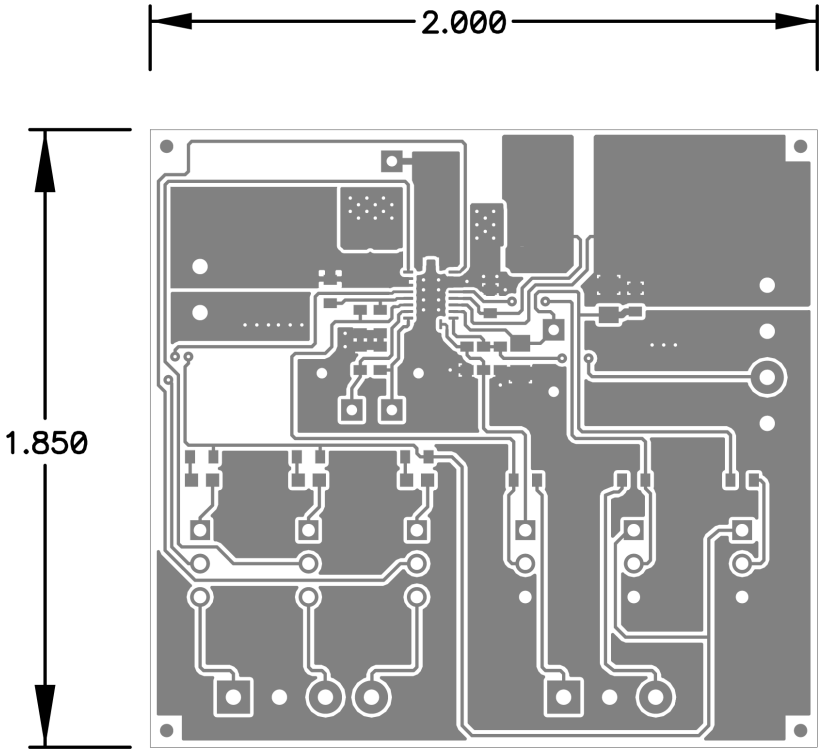

Figure 4. bq2412x EVM Top Layer

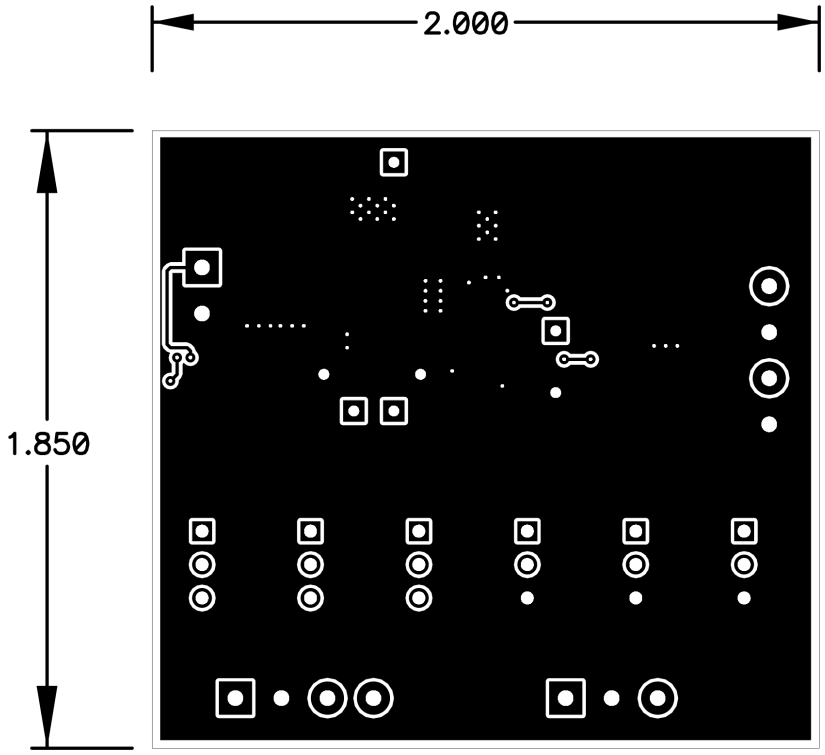

Figure 5. bq2412x EVM Bottom Layer

5 List of Materials

Table 3 through Table 5 lists the components used in this design. With minor component adjustments, this design could be modified to meet a wide range of applications.

Table 3. bq24120EVM-001 List of Materials(1) (2)

REFERENCE DESIGNATOR	QTY	DESCRIPTION	SIZE	MFR	PART NUMBER
C1, C2, C4	3	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C9	0	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C3	0	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C5, C7, C8	3	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C6	1	Capacitor, ceramic, 0.1 µF, 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 × 0.25	OST	ED1516
J4	1	Terminal block, 3-pin, 6 A, 3.5 mm	0.41 × 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 µH, 1.84 A, 49 mW	0.315 × 0.287	Vishay	CDRH74-100
R1	1	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R10	1	Resistor, chip, 4.99 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-4991-F
R11, R13, R14	3	Resistor, chip, 10 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1002-F
R12	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-0000-F
R2, R3	2	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R4	1	Resistor, chip, 0.1 Ω, W, 1%	2010	Vishay	CRCW1210-0R10F
R5, R7	0	Resistor, chip, 200 kΩ, 1/8-W, 1%	805	Vishay	CRCW0805-2003-F
R6	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-00R0-F
R8, R9	2	Resistor, chip, 7.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-7501-F
U1	1	IC, advanced Li-Ion and Li-Pol charge management	RHL-20	TI	bq24120RHL
—	1	PCB, 2.0 In × 1.9 In × 0.031 In		Any	HPA171

(1) C9 can be installed by the customer if using long cables (inductive load)
(2) 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. bq24123EVM-002 List of Materials(1) (2)

REFERENCE DESIGNATOR	QTY	DESCRIPTION	SIZE	MFR	PART NUMBER
C1, C2, C4	3	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C9	0	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C3	0	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C5, C7, C8	3	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C6	1	Capacitor, ceramic, 0.1 µF, 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 × 0.25	OST	ED1516
J4	1	Terminal block, 3-pin, 6 A, 3.5 mm	0.41 × 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 µH, 1.84 A, 49 mW	0.315 × 0.287	Vishay	CDRH74-100
R1	1	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R10	1	Resistor, chip, 4.99 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-4991-F
R11, R13, R14	3	Resistor, chip, 10 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1002-F
R12	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-0000-F
R2, R3	2	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R4	1	Resistor, chip, 0.1 Ω, W, 1%	2010	Vishay	CRCW1210-0R10F
R5, R7	0	Resistor, chip, 200 kΩ, 1/8-W, 1%	805	Vishay	CRCW0805-2003-F
R6	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-00R0-F
R8, R9	2	Resistor, chip, 7.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-7501-F
U1	1	IC, advanced Li-Ion and Li-Pol charge management	RHL-20	TI	bq24123RHL
—	1	PCB, 2.0 In × 1.9 In × 0.031 In		Any	HPA171

(1) C9 can be installed by the customer if using long cables (inductive load)
(2) 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. bq24125EVM-003 List of Materials(1) (2)

REFERENCE DESIGNATOR	QTY	DESCRIPTION	SIZE	MFR	PART NUMBER
C1, C2, C4	3	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C9	0	Capacitor, ceramic, 10 µF, 25 V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C3	1	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C5, C7, C8	3	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%	603	Panasonic	ECJ-1VB1C104K
C6	1	Capacitor, ceramic, 0.1 µF, 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 × 0.25	OST	ED1516
J4	1	Terminal block, 3-pin, 6 A, 3.5 mm	0.41 × 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 µH, 1.84 A, 49 mW	0.315 × 0.287	Vishay	CDRH74-100
R1	1	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R10	1	Resistor, chip, 4.99 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-4991-F
R11, R13, R14	3	Resistor, chip, 10 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1002-F
R12	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-0000-F
R2, R3	2	Resistor, chip, 1.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-1501-F
R4	1	Resistor, chip, 0.1 Ω, W, 1%	2010	Vishay	CRCW1210-0R10F
R5, R7	2	Resistor, chip, 200 kΩ, 1/8-W, 1%	805	Vishay	CRCW0805-2003-F
R6	1	Resistor, chip, 0 Ω, 1/16-W, 1%	603	Vishay	CRCW0603-00R0-F
R8, R9	2	Resistor, chip, 7.5 kΩ, 1/16-W, 1%	603	Vishay	CRCW0603-7501-F
U1	1	IC, advanced Li-Ion and Li-Pol charge management	RHL-20	TI	bq24125RHL
—	1	PCB, 2.0 In × 1.9 In × 0.031 In		Any	HPA171

(1) C9 can be installed by the customer if using long cables (inductive load)
(2) 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)

6 References

1. *bq2412x, Single-Chip Switchmode, Li-Ion and Li-Polymer Charge-Management IC With Enhanced EMI Performance (bqSWITCHER™)* data sheet (SLUS688)

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0.6 V to 16 V and the output voltage range of 0.6 V to 16 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 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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