TEXAS INSTRUMENTS

bq24010/2 (bqTINY™)

1-A Single-Chip Li-Ion and Li-Pol Charge Management IC With Integrated PowerFET and Current Sense Evaluation Module

User's Guide

January 2003

PMP Portable Power

SLUU125A

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 5.6 V and the output voltage range of 0 V and 4.25 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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Chapter 1

Introduction

This user's guide describes the bq24010/2 (bqTINY™) evaluation module. The EVM provides a convenient method for evaluating the performance of a charge-management solution for portable applications using the bq24010/2 product family. A complete designed and tested charger is presented. The charger is designed to deliver up to 1.0 A of continuous charge current, but is programmed for 0.7 A, for single-cell Li-Ion or Li-Pol applications using a dc power supply.

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bqTINY is a trademark of Texas Instruments.

1.1 Background

The bqTINY series are highly integrated Li-Ion and Li-Pol linear charge management devices targeted at space limited portable applications. In a small package, the bqTINY series offer integrated PowerFET and current sensor, reverse blocking diode, high accuracy current and voltage regulation, charge status, and charge termination.

The bqTINY charges the battery in three phases: conditioning, constant current, and constant voltage. Charge is terminated on the basis of minimum current. An internal charge timer provides backup safety for charge termination. The bqTINY automatically restarts the charge if the battery voltage falls below an internal threshold. The bqTINY automatically enters sleep mode when V_{CC} supply is removed.

In addition to the standard features, different versions of the bqTINY offer a multitude of additional features. These include temperature-sensing input for detecting hot or cold battery packs, power good ($\overline{PG}$) output indicating the presence of the ac adapter, a TTL-level charge enable input ($\overline{CE}$) to disable or enable the charge process, and a TTL-level timer and termination-enable ($\overline{TTE}$) input to disable or enable the fast-charge timer and charge termination.

1.2 Performance Specification Summary

This section summarizes the performance specifications of the EVM. Table 1–1 gives the performance specifications of the EVM.

Table 1–1. Performance Specification Summary

Specification	Test Conditions	Min	Typ	Max	Units
Input dc voltage, $V_{I(DC)}$		V_{REG} +0.5	5.0	5.2†	V
Battery charge current, $I_{O(CHG)}$	See note			0.7†	A
Power dissipation	$(V_{(DC+)} – V_{(BAT+)})*I_{(CHG)}$			1.5	W

† This input voltage maximum is a function of the maximum allowable power dissipation on the IC. The current level is programmed for 0.7 amps. If the programmed charge is changed, then the maximum input voltage needs to be adjusted. P_{maxIC} = 1.5 Watt = $I_{CHG}(V_{DC+} – V_{BAT+})$.

Chapter 2

Test Summary

This chapter shows the test setups used and the tests performed in evaluating the EVM.

Setup: The bq24010/2 EVM board requires a 5-VDC, 1-A power source to provide input power and a single-cell Li-Ion or Li-Pol battery pack. The test set-up 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.

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2.1 I/O and Jumper Connections

Jack	Connect To:
J1–DC+	Power supply positive, preset to 5.0VDC, 1-A current limit.
J1–DC–	Power supply ground
J2–BAT+	Positive battery pack terminal
J2–BAT–	Negative battery pack terminal
J2–TS	NC
J2–BAT–	NC
J3–STAT1	External hardware if J4-EXT is jumpered (Not jumpered from factory)
J3–STAT2	External hardware if J5-EXT is jumpered (Not jumpered from factory)
J3–DC–	Return for J3 signals
J3–$\overline{PG}$	External hardware if J6–EXT if jumpered (Not jumpered from factory)
J4 (Jumper)	STAT1 indication location – **LED** (EVM) | EXT
J5 (Jumper)	STAT2 indication location – **LED** (EVM) | EXT
J6 (Jumper)	PG indication location – **LED** (EVM) | EXT

Note: Factory jumper selections shown in bold.

2.2 Test Procedure

Set up the evaluation board as described above, by making the necessary I/O connections and jumper selections. **Before test and evaluation, it is important to verify that the maximum power dissipation on the IC is not exceeded: $P_{(MAX)}$ = 1.5 watts.**

1) Turn on the power supply, which was preset to 5.0 VDC and 1 A for the current limit setting.

2) The bq24010/2 enters preconditioning mode if the battery is below the $V_{(LOWV)}$ threshold. In this mode, the bq24010/2 precharges the battery with a low current (typically $I_{O(CHG)}$/10 = 0.7A/10 = 70 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, the bq24010/2 enters fault mode, and both LEDs turn off. Toggling input power or battery replacement resets fault mode.

3) Once the battery voltage is above the $V_{(LOWV)}$ threshold, the battery enters fast-charge mode. This EVM is programmed for 0.7 amps of fast charging current.

4) Once the battery reaches voltage regulation (4.2 V), the current tapers down as the battery reaches its full capacity.

5) The battery remains at the fast-charge mode until the fast-charge timer expires, the charge taper time expires, or the charge termination threshold is reached.

6) If the battery discharges to the recharge threshold, the charger starts fast charging.

In place of a battery, a source meter that can sink current can easily be adjusted to test each mode.

Another way to briefly see each mode on a scope is to connect a 1-mF capacitor and a 10-kΩ resistor on the output in place of a battery to observe the power-up and cycling between voltage regulation and fast charge via the refresh threshold.

The difference between the bq2401x parts, where x is a 0 or 2, is as follows: The functions on the 0 part are power good output ($\overline{PG}$) for pin 7 and temperature sense Input (TS) for pin 8. On part 2, pin 8 is charge enable ($\overline{CE}$). From the factory, the $\overline{CE}$ pin has a pulldown resistor and the TS pin is set at 50% of V_{CC}, where applicable. These signals, if applicable, are available at the connectors for external control.

Note:

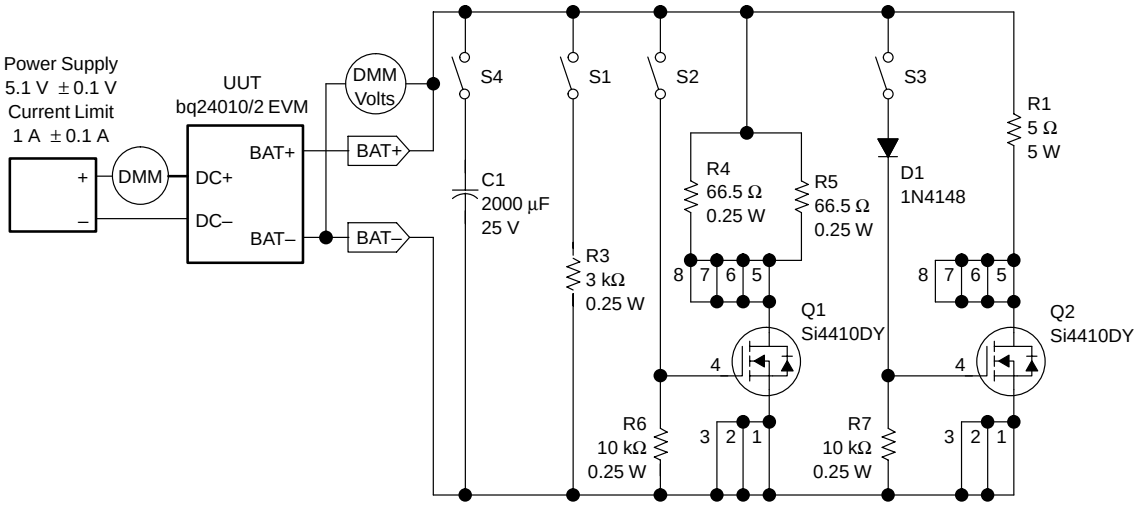
Because of the battery-detection circuit, it is not possible to switch-in static load resistors to jump between regulation and constant-current modes. An alternate procedure described below uses a dynamic load to replace the battery circuit. That procedure allows testing of each mode.

This is an alternative way of testing the EVM using a dynamic load board in place of a battery. The circuit is adjusted to work with the displayed parts and their inherent thresholds. The sequence of the test procedure is important because of the active battery-detection circuit, refresh feature, and precharge and fast-charge current levels. (Switching load in or out has different results in different modes.) No damage should occur, but results might be different than anticipated if procedure is altered.

2.2.1 Equipment

1) Power source: current-limited 5-V lab supply with its current limit set to 1.0 A ±0.1 A
2) Two Fluke 75, equivalent or better
3) Oscilloscope – TDS220 or better
4) Load test board (See Figure 2–1.)

Figure 2–1. Load Test Board



2.2.2 Equipment Setup

1) Connect the load board to the BAT+ and BAT–. Set SW1 through SW4 in the closed position.
2) Connect a voltage meter to the BAT+/BAT– output to monitor the output voltage (Range is 0 to 5 V).
3) Set the lab supply for 5.1 V ±0.1VDC, 1.0 ±0.1 A current limit and then turn off supply. Connect the source supply to a current meter and to J1, noting polarity. (You may use an internal source current meter if it has 5% or better accuracy.)
4) Install shunt jumpers on the LED pins 1 and 2 of each header J4, J5, and J6.
5) Connect the scope to the output, BAT+.

2.2.3 Procedure

1) Ensure that equipment setup steps are followed. (Switches should be in the closed position, shunts installed, and power source set to 5.1V/-0.1V. Turn on the power source.
2) Verify that output voltage BAT+ charges up to between 2.5 V and 2.9 V, and the red LED (D1) and green LED (D3) are lit.
3) Open switch SW2, and then close switch SW2.

4) Verify that output voltage BAT+ settles between 3.2 V and 3.95 V.
5) Verify that the input current is between 0.69 A and 0.75 A.
6) Open switch SW3.
7) Verify that the input current is between 100 mA and 150 mA.
8) Verify the output voltage BAT+ is between 4.150 VDC and 4.250 VDC.
9) Open switch SW2.
10) Verify with a scope (250 ms/div, 1 V/div) that output BAT+ charges and discharges are between the maximum limits of 3 V and 4.35 V, with a period between 600 ms and 850 ms.
11) Verify that the LEDs flash between RED (D1) and GREEN (D2, mostly on green).
12) Open switch SW4 and verify that D1 and D2 are off and D3 is on.
13) Verify, with a scope on BAT+, a square wave between the maximum limits of 1.3 and 4.35 VDC and a frequency between 3.5 and 4.5 Hz.
14) Close switches SW2, SW3, and SW4 (all switches should be closed now) and power down the supply.
15) The EVM is good if all tests are passed.

Chapter 3

Schematic, Physical Layouts, and Bill of Materials

This chapter contains the schematic diagram, the board layouts and assembly drawings, and the bill of materials required for the EVM.

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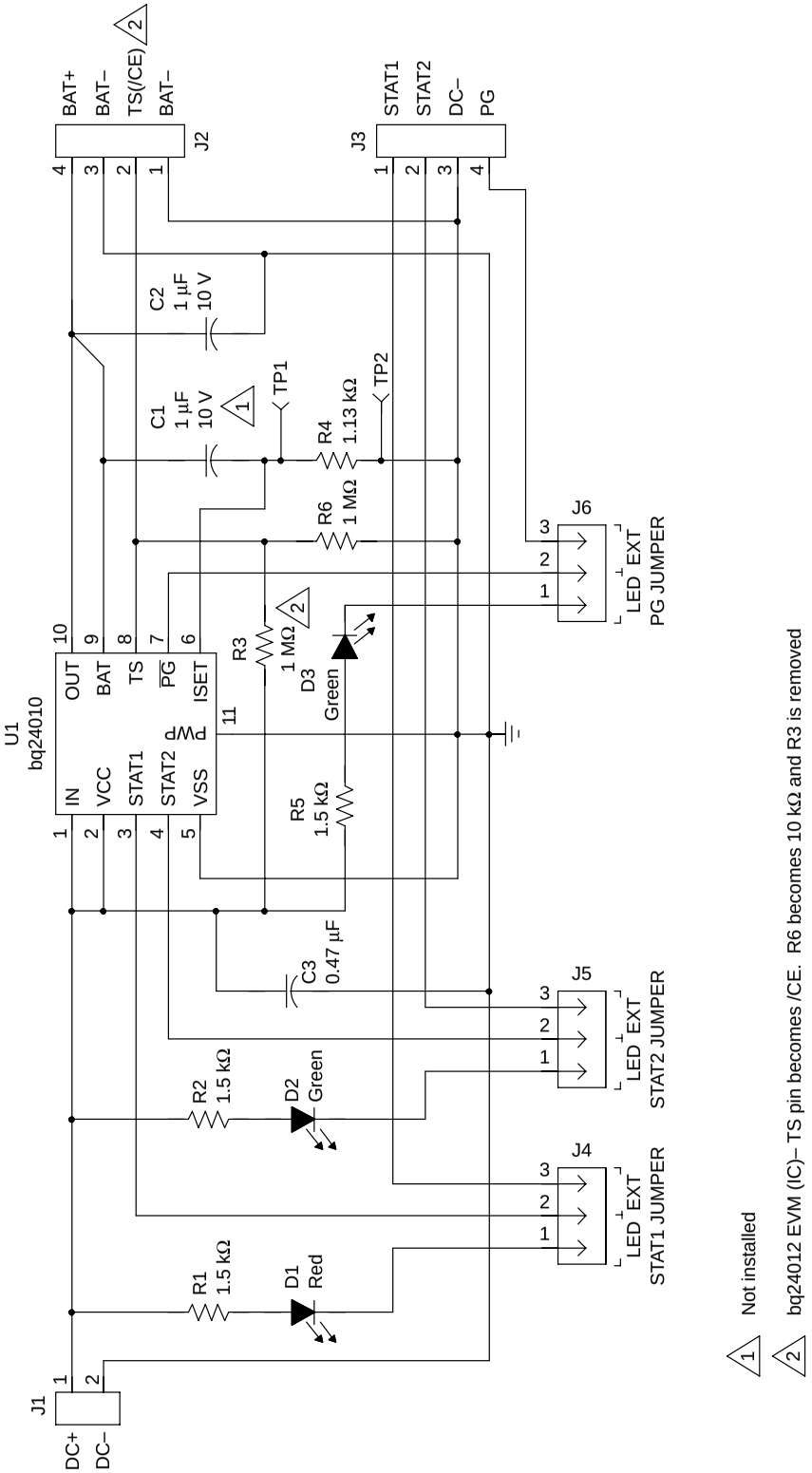
3.1 Schematic

Figure 3–1. EVM Schematic Diagram



3.2 Physical Layouts

3.2.1 Board Layout

Figure 3–2 shows the assembly view of the EVM. Figure 3–3 shows the top layer. Figure 3–4 shows the bottom layer.

Figure 3–2. Assembly View

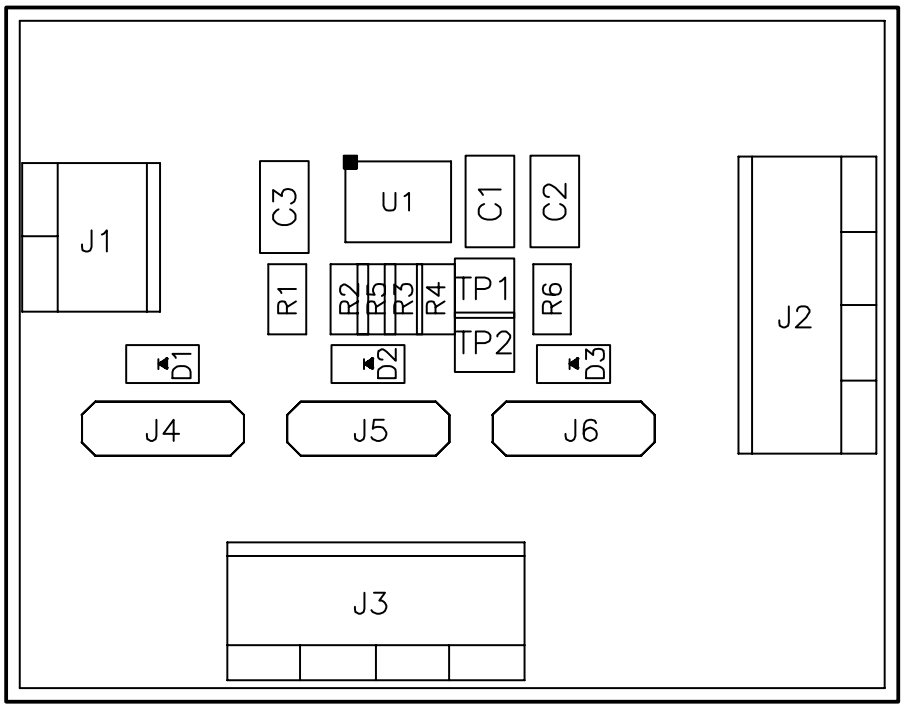


Figure 3–3. Top Layer

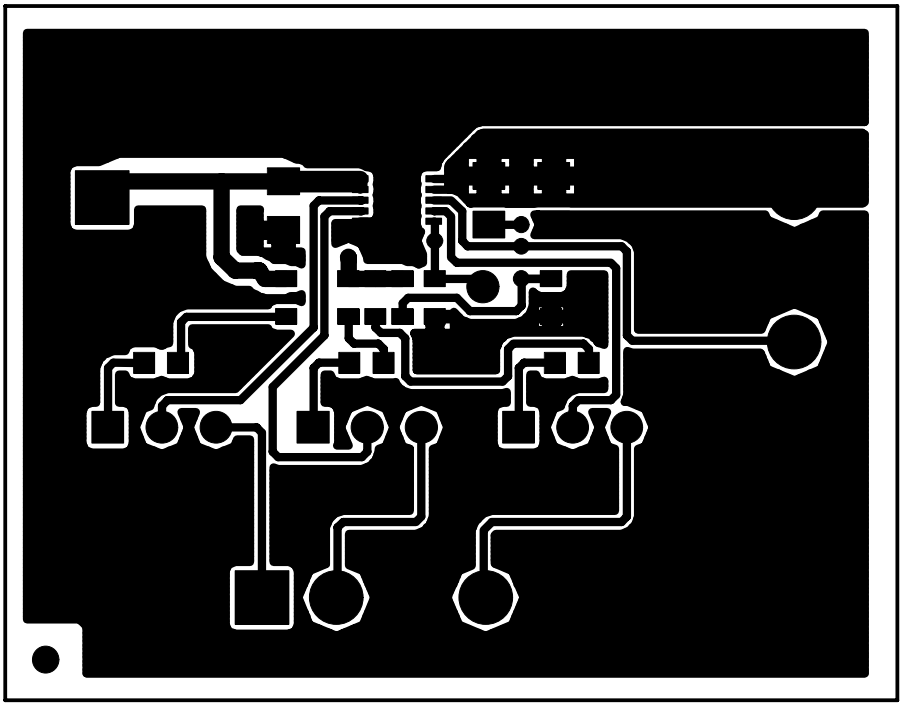
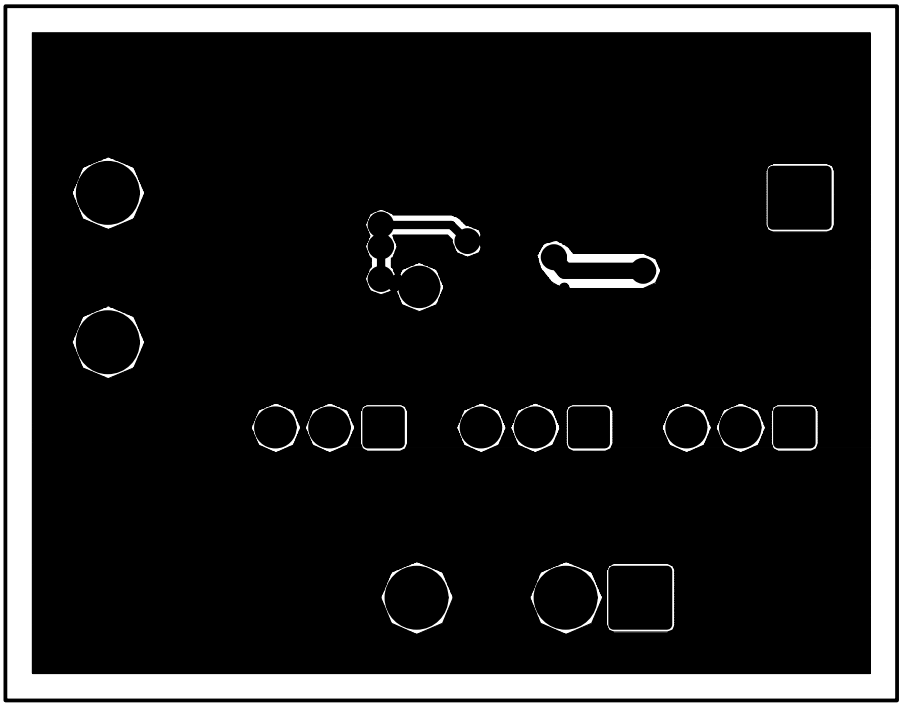


Figure 3–4. Bottom Layer



3.3 Bill of Materials

Table 3–1 lists materials required for the EVM.

Table 3–1. Bill of Materials

Item#	bq24010 –1	bq24012 –2	Ref Des	Description	Size	MFR	Part Number
1	0	0	C1	Capacitor, ceramic, X5R, 1 μF, 10 V	805	Panasonic	ECJ-2YB1A105K
2	1	1	C2	Capacitor, ceramic, X5R, 1 μF, 10 V	805	Panasonic	ECJ-2YB1A105K
3	1	1	C3	Capacitor, ceramic, X7R, 0.47 μF, 16 V	805	Panasonic	ECJ-2YB1C474K
4	1	1	D1	Diode, LED, red, 1.8 V, 20 mA, 20 mcd	603	Lite-On	160-1181-1-ND
5	2	2	D2, D3	Diode, LED, green, 2.1 V, 20 mA, 6 mcd	603	Lite-On	160-1183-1-ND
6	1	1	J1	Terminal block, 2 pin, 6 A, 3,5 mm	0.27 × 0.25	OST	ED1514
7	2	2	J2, J3	Terminal block, 4 pin, 6 A, 3,5 mm	0.55 × 0.25	OST	ED1516
8	3	3	J4, J5, J6	Header, 3 pin, 100 mil spacing, (36-pin strip)	0.100 × 3	Sullins	PTC36SAAN
9	3	3	R1, R2, R5	Resistor, chip, 1.5 kΩ, 1/16 W, 1%	603	Std	Std
10	2	0	R3, R6	Resistor, chip, 1 MΩ, 1/16 W, 1%	602	Std	Std
11	0	1	R6	Resistor, chip, 10 kΩ, 1/16 W, 1%	603	Std	Std
12	1	1	R4	Resistor, chip, 1.3 kΩ, 1/16 W, 1%	603	Std	Std
13	1	0	U1	IC, single Li-Ion/Li-Poly, charge manager	MLP10	TI	bq24010DRC
14	0	1	U1	IC, single Li-Ion/Li-Poly, charge manager	MLP10	TI	bq24012DRC
15	3	3	—	Shunt, 100-mil, black	0.100	3M	929950-00
16	1	1	—	PCB, bq24010/2, 1.6 in × 1.3 in × 0.031 in		Any	SLUP162

Notes: 1) These assemblies are ESD sensitive; ESD precautions must be observed.

2) These assemblies must be clean and free from flux and all contaminants. Use of no-clean flux is not acceptable.

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

4) Reference designators marked with an asterisk (**) cannot be replaced by substitutes. All other components can be replaced with equivalent manufacturer components.

3.4 Reference

1) bq2401x data sheet (SLUS530)

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3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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