

# **bq24013 (bqTINY™)**

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

## *User's Guide*

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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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# Introduction

This user's guide describes the bq24013 (bqTINY™) evaluation module. The EVM provides a convenient method for evaluating the performance of a charge-management solution for portable applications using the bq24013 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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## 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 terminates 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 and 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 features 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 <sup>†</sup>	V
Battery charge current, $I_{O(CHG)}$	See note		0.7	1	A
Power dissipation	$(V_{(DC+)} - V_{(BAT+)}) \times I_{(CHG)}$			1.5	W

<sup>†</sup> This input voltage maximum is a function of the maximum allowable power dissipation on the IC. The current level is programmed for 0.7 A. If the programmed charge is changed, then the maximum input voltage must be adjusted.  
 $P_{maxIC} = 1.5 \text{ Watt} = I_{CHG}(V_{DC+} - V_{BAT+})$ .



# Test Summary

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

**Setup:** The bq24013 EVM board requires a single-cell Li-Ion or Li-Pol battery pack and a 5-VDC, 1-A power source to provide input power. 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.

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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-TTE	NC required—pulled down with 10 k $\Omega$ resistor on EVM
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-/CE	NC required—pulled down with 10-k $\Omega$ resistor on EVM
J4 (Jumper)	STAT1 indication location – LED (EVM)   EXT
J5 (Jumper)	STAT2 indication location – LED (EVM)   EXT

## 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 bq24013 enters preconditioning mode if the battery is below the  $V_{(LOWV)}$  threshold. In this mode, the bq24013 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 bq24013 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 A 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.

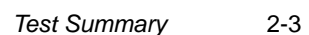
In place of a battery, a source meter that can sink current can easily be adjusted to test each mode.

**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.

### 2.2.1 Equipment

- 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 0 to 5 V).
- 3) Set the lab supply for  $5.1\text{ V} \pm 0.1\text{ VDC}$ ,  $1.0 \pm 0.1\text{ A}$  current limit, and then turn off the 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 and J5.

### 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  $5.1\text{ V} \pm 0.1\text{ V}$ .) 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) is 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 V and 4.250 V.
- 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 of 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.
- 13) Verify, with a scope on BAT+, a square wave between the maximum limits of 1.3 VDC and 4.35 VDC and a frequency between 3.5 Hz and 4.5 Hz. This step verifies operation of the battery-detect circuit and the internal-timer oscillator.
- 14) Turn off the power source and set all switches, SW1 through SW4, closed.
- 15) The EVM is good if all tests are passed.

# Schematic, Physical Layouts, and Bill of Materials

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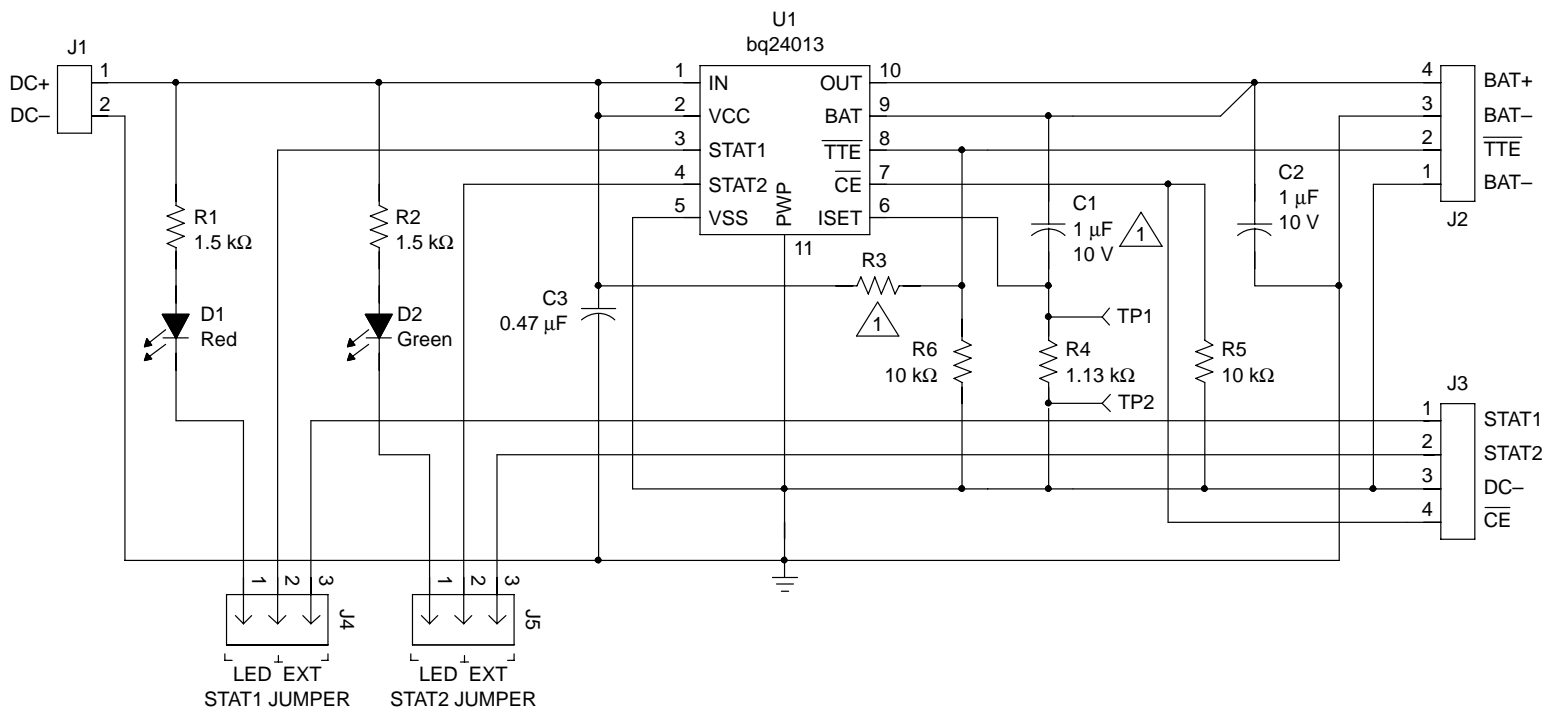
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This chapter contains the schematic diagram, the board layouts and assembly drawings, and the bill of materials required for the EVM.

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### 3.1 Schematic

Figure 3–1. EVM Schematic Diagram



1 Not installed

## 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*

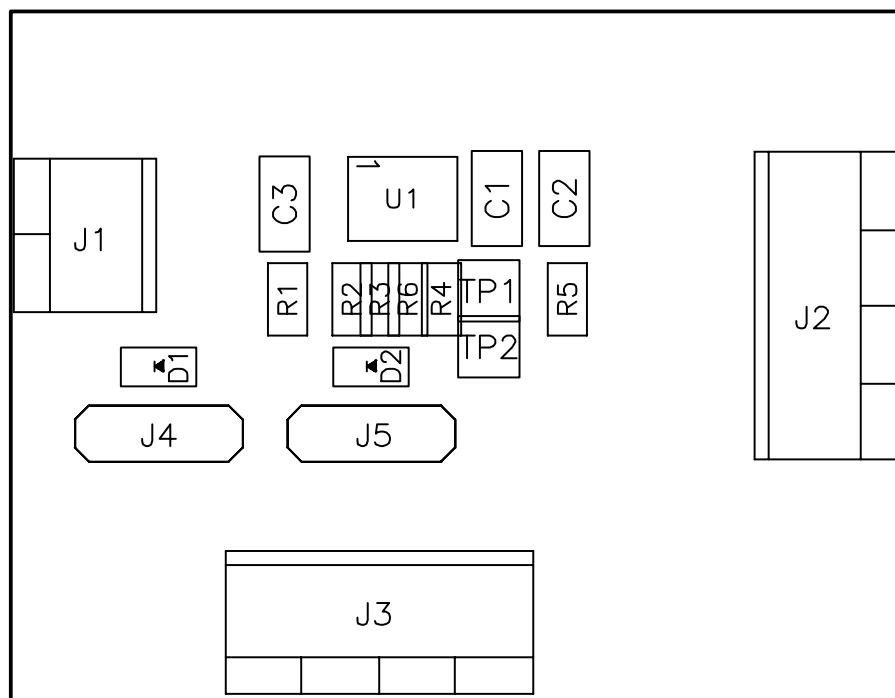


Figure 3–3. Top Layer

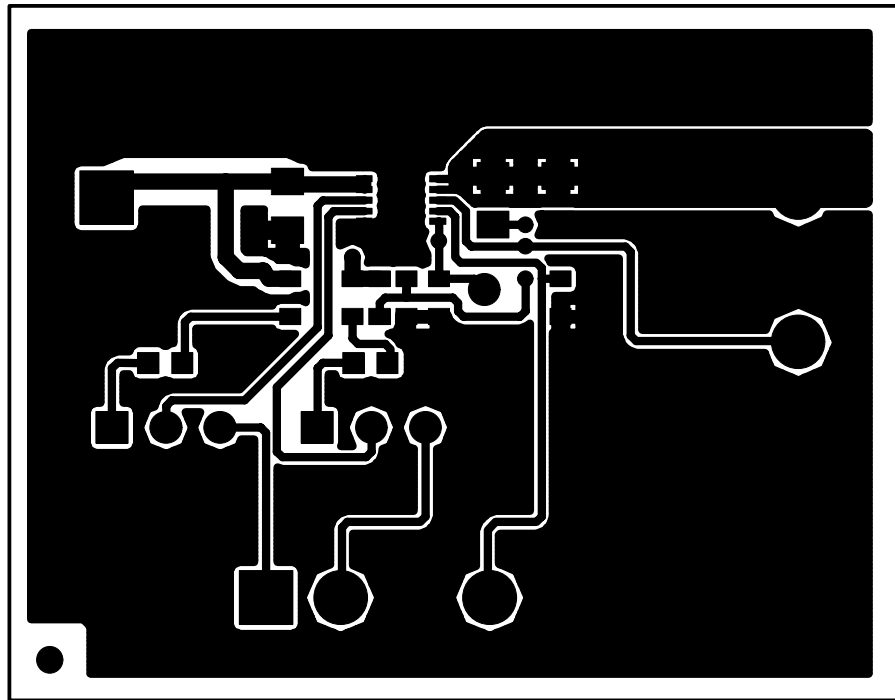
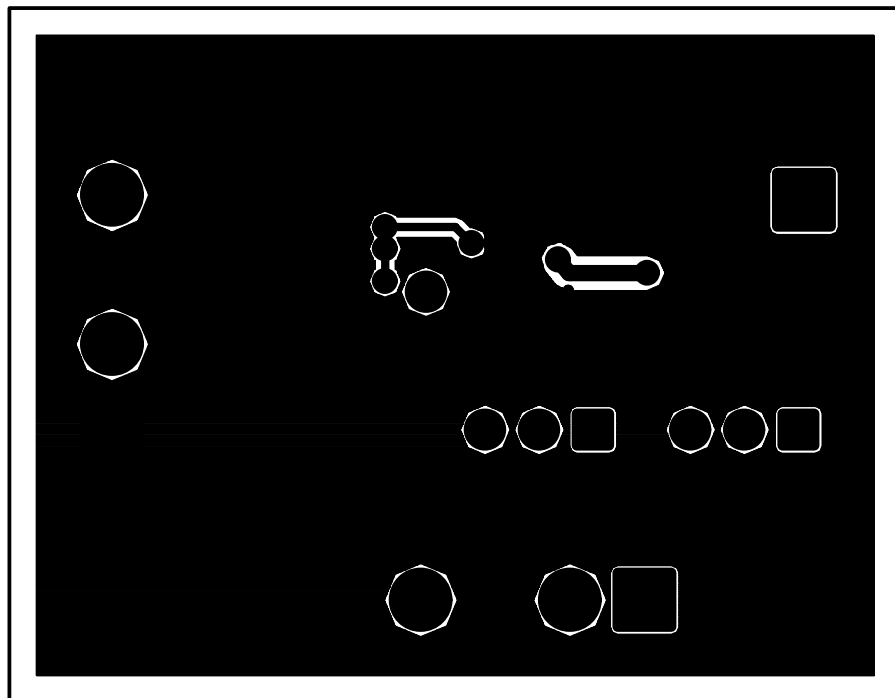


Figure 3–4. Bottom Layer





### 3.3 Bill of Materials

Table 3–1 lists materials required for the EVM.

*Table 3–1. Bill of Materials*

Item#	bq24013	Ref Des	Description	Size	MFR	Part Number
1	0	C1	Capacitor, ceramic, X5R, 1 $\mu$ F, 10 V	805	Panasonic	ECJ-2YB1A105K
2	1	C2	Capacitor, ceramic, X5R, 1 $\mu$ F, 10 V	805	Panasonic	ECJ-2YB1A105K
3	1	C3	Capacitor, ceramic, X7R, 0.47 $\mu$ F, 16 V	805	Panasonic	ECJ-2YB1C474K
4	1	D1	Diode, LED, red, 1.8 V, 20 mA, 20 mcd	603	Lite-On	160-1181-1-ND
5	1	D2	Diode, LED, green, 2.1 V, 20 mA, 6 mcd	603	Lite-On	160-1183-1-ND
6	1	J1	Terminal block, 2 pin, 6 A, 3.5 mm	0.27 $\times$ 0.25	OST	ED1514
7	2	J2, J3	Terminal block, 4 pin, 6 A, 3.5 mm	0.55 $\times$ 0.25	OST	ED1516
8	2	J4, J5	Header, 3 pin, 100 mil spacing, (36-pin strip)	0.100 $\times$ 3	Sullins	PTC36SAAN
9	2	R1, R2	Resistor, chip, 1.5 k $\Omega$ , 1/16 W, 1%	603	Std	Std
10	0	R3	Resistor, chip, 1 M $\Omega$ , 1/16 W, 1%	602	Std	Std
11	2	R5, R6	Resistor, chip, 10 k $\Omega$ , 1/16 W, 1%	603	Std	Std
12	1	R4	Resistor, chip, 1.3 k $\Omega$ , 1/16 W, 1%	603	Std	Std
13	1	U1	IC, single Li-Ion/Li-Polymer, charge manager	MLP10	TI	bq24013DRC
14	2	—	Shunt, 100-mil, black	0.100	3M	929950-00
15	1	—	PCB, bq24010/2, 1.6 in $\times$ 1.3 in $\times$ 0.031 in		Any	SLUP185

- 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)