

# ***bq24022/7EVM***

***1-A Single-Chip Li-Ion and Li-Pol Charge Management IC  
with Autonomous USB-Port and AC-Adapter Supply  
Management Evaluation Module***

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



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# bq24022/7 (bqTINY™-II) Evaluation Module

## 1 Introduction

This user's guide describes the bq24022/7 (bqTINY™-II) Evaluation Module. The EVM provides a convenient method for evaluating the performance of a charge management solution for portable applications using the bq24022/7 product family. A complete designed and tested charger is presented. The charger is designed to deliver up to 1 A of continuous charge current for single-cell Li-Ion or Li-Pol applications using a dc power supply. The charger is programmed from the factor to deliver 0.7 A of charging current.

### 1.1 Background

The bqTINY™-II series are highly integrated and flexible Li-Ion linear charge and system power management devices targeted at space limited charger applications. The bqTINY-II series offer integrated USB-port and ac-adapter supply management with autonomous power-source selection, power FET and current sensor, high-accuracy current and voltage regulation, charge status, and charge termination, in a single monolithic device. The bqTINY-II automatically selects the USB-port or the ac-adapter as the power source for the system. In the USB configuration, the host can select from the two preset charge rates of 100 mA and 500 mA. In the ac-adapter configuration an external resistor sets the magnitude of the system or charge current. The bqTINY-II charges the battery in three phases: conditioning, constant current, and constant voltage. Charge is terminated based on minimum current. An internal charge timer provides a backup safety for charge termination. The bqTINY-II automatically restarts the charge if the battery voltage falls below an internal threshold. The bqTINY-II automatically enters sleep mode when both supplies are removed.

### 1.2 Performance Specification Summary

**Table 1. Performance Specification Summary**

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input DC voltage, $V_{I(DC)}$		$V_{(REG)} + 0.5$	5	5.2	V
Battery charge current <sup>(1)</sup> , $I_{O(CHG)}$			0.7	1	A
Power dissipation				1.5	W

(1) This input voltage maximum is a function of the maximum allowable power dissipation on the device. The current level is programmed for 0.7 A. If the programmed charge is changed, then the maximum input voltage needs to be adjusted.  $P_{MAX(IC)} = 1.5 W = I_{CHG} (V_{(DC+)} - V_{(BAT+)})$ . The device has a maximum recommended operation of 6.5 VDC.

## 2 Test Summary

This section shows the test setups used, and the tests performed, in evaluating the EVM. See the bq24022/27 datasheet ([SLUS549](#)) for complete details regarding the operation and specifications.

## 2.1 Test Setup

The bq24022/7 EVM board requires a regulated 5-VDC, 1-A power source or a USB, 0.5-A port maximum), to provide input power and a single-cell Li-Ion or Li-Pol battery pack.

**CAUTION**

**If powered from an USB, 0.1-A port, make sure ISET2 is pulled low to program the board for the 100-mA charge. Skip any test steps that program the UUT to 0.5 A.**

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.

**Table 2. I/O and Jumper Connections<sup>(1)</sup>**

JACK	CONNECTION
J1-DC+	Power supply positive connection, preset to 5 Vdc, 1.2-A current limit. Can also be powered by J2 (USB) if J1 power is absent.
J1-DC-	Power supply return connection, ground
J2-USB plug	USB 0.5-A port — source for charging when J1 source is absent.
J5-BAT+	Positive battery pack terminal
J5-BAT-	Negative battery pack terminal, BAT—is common with DC-
J5- $\overline{CE}$	NC - R4 is a pull down resistor, set to 20 k $\Omega$ , to enable charging. J5- $\overline{CE}$ can be used as an external control.
J5-BAT-	N/C, optional external use
J3 (jumper)	ISET2 program — 0.5 A (HIGH)   <b>0.1 A (LOW)</b>
J4 (jumper)	Power good Indication location — <b>LED (EVM)</b>   EXT
J6 (jumper)	BIAS power for EVM (jumper to active source) — <b>DC+</b>   USB
J7 (jumper)	STAT1 indication location — <b>LED (EVM)</b>   EXT
J9 (jumper)	STAT2 indication location — <b>LED (EVM)</b>   EXT
J8-STAT1	External monitor hardware if J7—EXT is jumpered (not jumpered from factory)
J8-STAT2	External monitor hardware if J9—EXT is jumpered (not jumpered from factory)
J10- $\overline{PG}$	External monitor hardware if J4—EXT is jumpered (not jumpered from factory)
J10-ISET2	External USB load control (TTL) — HIGH (500 mA)   LOW (100 mA) (remove jumper J3 when using J10-ISET2. <b>EVM set up for local control with jumper J3-0.1 A installed.</b>

<sup>(1)</sup> Factory jumper selections are shown in BOLD

## 2.2 Test Procedures

Setup the evaluation board as described above, by making the necessary I/O connections and jumper selections. Prior to test and evaluation, it is important to verify that the maximum power dissipation on the device is not exceeded:  $P_{MAX} = 1.5 \text{ W}$ .

$$P_{MAX} = (V_{(DC+)} - V_{(BAT+)}) \times I_{(CHG)} \quad (1)$$

1. Turn on the power supply, which is preset to 5 VDC, and 1 A for the current limit setting.
2. The bq24022/7 enters preconditioning mode if the battery is below the  $V_{(LOWV)}$  threshold. In this mode, the bq24022/7 precharges the battery with a low current, typically

$$\frac{I_{O(CHG)}}{10} = \frac{0.7 \text{ A}}{10} = 70 \text{ mA} \quad (2)$$

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 bq24022/7 enters fault mode. Both LEDs turn off when in fault mode. Toggling input power or battery replacement resets fault mode. Note that there are several fault conditions. They are described in the data sheet (SLUS549).

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. When the current reaches the taper termination threshold, the charge current terminates for the bq24027 and a taper timer is set for the bq24022 which allows approximately 30 minutes of additional charging time. If the charge current increases above the taper threshold for any reason, the taper timer is reset. If the current drops below the termination threshold, valid only for the bq24022, (design for detecting removal of battery,  $\approx I_{pgm}/140$ ) charging immediately terminates.
6. After termination, if the battery discharges down to the recharge threshold, the charger starts fast charging.
7. The same procedure may be performed using the USB 0.5-A plug source in place of the J1 power source. The precharge current is approximately 10% of the programmed fast charge. The fast charge current is either 0.1 A or 0.5 A depending on the ISET being low or high.

**CAUTION**  
 If powered from an USB, 0.1-A port, make sure ISET2 is pulled low to program the board for the 100-mA charge.

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

Another alternative to view each mode, on a scope, is to connect a 1000- $\mu$ F or larger capacitor and a parallel 10-k $\Omega$  resistor on the output in place of a battery to observe the charging cycling.

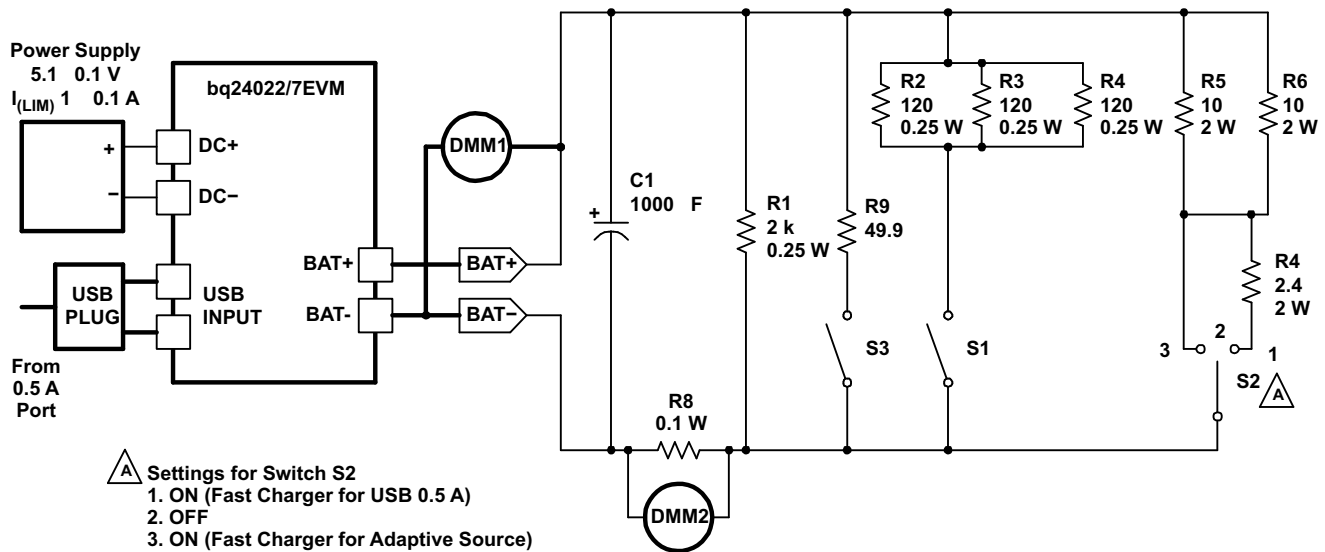
### 2.3 Alternative Test Procedure

Below is a test procedure to verify charging states without the need for a battery or expensive test equipment.

#### 2.3.1 Equipment

The procedure used to evaluate the EVM assembly with a few basic functions of the device is as follows:

1. Power source: current limited 5-V lab supply with its current limit set to 1 A  $\pm$ 0.1 A
2. Two fluke 75, equivalent or better.
3. Load test board as shown in [Figure 1](#).



UDG-03044

NOTE: R5, R6, and R7 are 5% or better. All other resistors are 1% or better.

**Figure 1. bq24022/7 Testing Setup**

### 2.3.2 Equipment Setup

1. Connect the load board to the BAT+ and BAT-. Set switches SW1 and SW3 to closed, and switch SW2 to off (center).
2. Connect a voltage meter, DMM1, to the BAT+/BAT- output to monitor the output voltage (range is 0 V to 5 V).
3. Set the lab supply for 5.1 V +0.1 VDC, 1 A ±0.1 A current limit and then turn off supply. Connect DMM2 across R8 to monitor the current (R8 should be a 1% or better resistor if it is used for current measurements).
4. Shunt jumpers should be installed on J6-DC+, J7-LED, J9-LED, J3-0.5, and J4-LED.

#### CAUTION

**If USB port is a low power port (0.1 A) and the charger is set up to draw 0.5 A, then problems or damage may occur to the USB circuitry. Therefore, when powering from a 0.1-A port, the user must set J3 to 0.1 A, and replace steps 8 through 11 of the *Procedure* section with the following:**

1. Turn off J1 power source, set jumper to J6-USB, SW2-off, and close switches SW1 and SW3. Plug in USB power source, verify output voltage, BAT+, regulates between 2.5 and 2.9 VDC and both LEDs are lit.
2. Open switch SW1 and verify output voltage, VBAT+, regulates between 4.16 and 4.24 Vdc.

### 2.3.3 Procedure

1. Make sure *EQUIPMENT SETUP* steps are followed (SW1–closed, SW2 and SW3–Open, shunts installed as per step 4, test board connected, and power source set to 5.1 V ±0.1 Vdc). Turn on the power source.
2. Verify output voltage, BAT+, is between 2.5 Vdc to 2.95 Vdc, and the red LED (D1) and green LEDs (D2 and D3) are lit.
3. Short J5-2 to J1-1 ( $\overline{CE}$  to DC+) and verify that charging stops (DMM2 < 0.5 mV). Remove the short and verify output voltage, BAT+, is between 2.5 Vdc and 2.95 Vdc.
4. Close switch SW3 and open switch SW1. Verify LED (D2) is off and the output voltage, BAT+, regulates between 4.16 Vdc and 4.24 Vdc.
5. Close switch SW2 (to position 1 Ω - 5 Ω) and verify output voltage, BAT+, is between 3.1 Vdc and 3.5 Vdc. Note: If output drops below 3 V and remains below 3 V, the input may be dropping below 4.9 V. Add input capacitance to the source, to keep the input in compliance.
6. Verify that the charging current is between 0.6 Amps and 0.8 Amps (DMM2 is between 60 mVdc and 80 mVdc).
7. Open switch SW3, set switch SW2 to off, and verify that the LEDs, D1 and D2, alternate being lit.
8. Turn off the J1 power source.
9. Set jumper to J6-USB, Close switch SW1. Plug in USB power source, verify output voltage, BAT+, regulates between 2.5 Vdc and 2.9 Vdc, and both LEDs are lit.
10. Close switch SW3 and open switch SW1, verify output voltage, VBAT+, regulates between 4.16 Vdc and 4.24 Vdc, and LED (D2) is off.
11. Turn off power and set jumper to J6-DC+. Set switch SW3 open and SW1 to closed. Remove the UUT from the test apparatus. Repeat setup and test procedures for other untested EVMs.

## 2.4 Ordering Information

**Table 3. Ordering Information**

EVM Part Number	Additional Devices	Chemistry	Pack Voltage	Capacity
bq24022/7EVM	None	Li-Ion / Li-Poly	2.5 V to 4.2 V	Any

### 3 Schematic

Figure 2 shows the schematic diagram for the bq24022/7EVM.

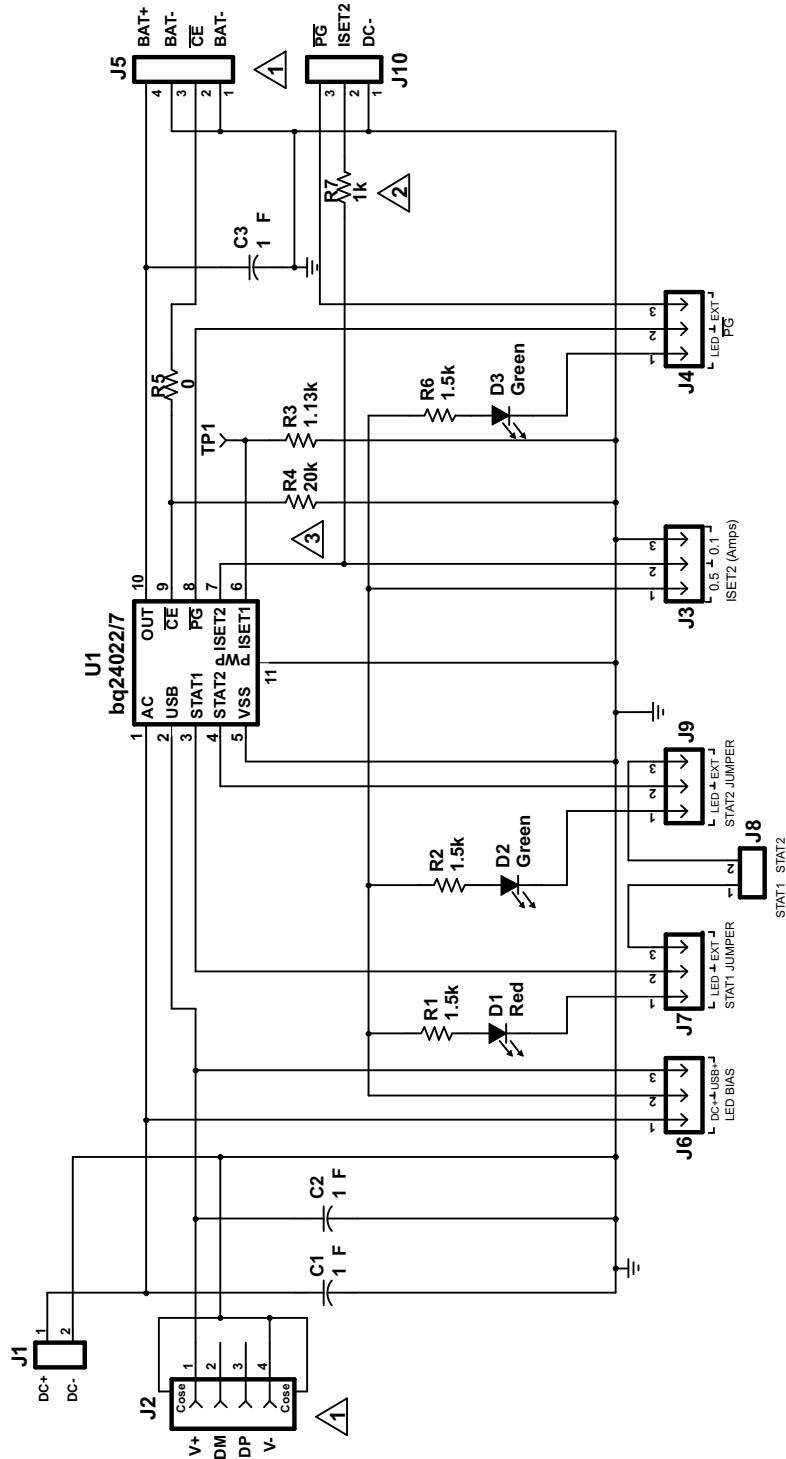





Figure 2. bq24022/7 Schematic

- 
**1** DC-, BAT-, and V- are tied together
- 
**2** R7 is optional and protects the EVM from applying two different sources.
- 
**3** R4 and R5 are optional if a thermistor is used

## 4 Physical Layouts

Figure 3 shows the top layer of the EVM. Figure 4 shows the bottom layer. Figure 5 shows the top assemble view.

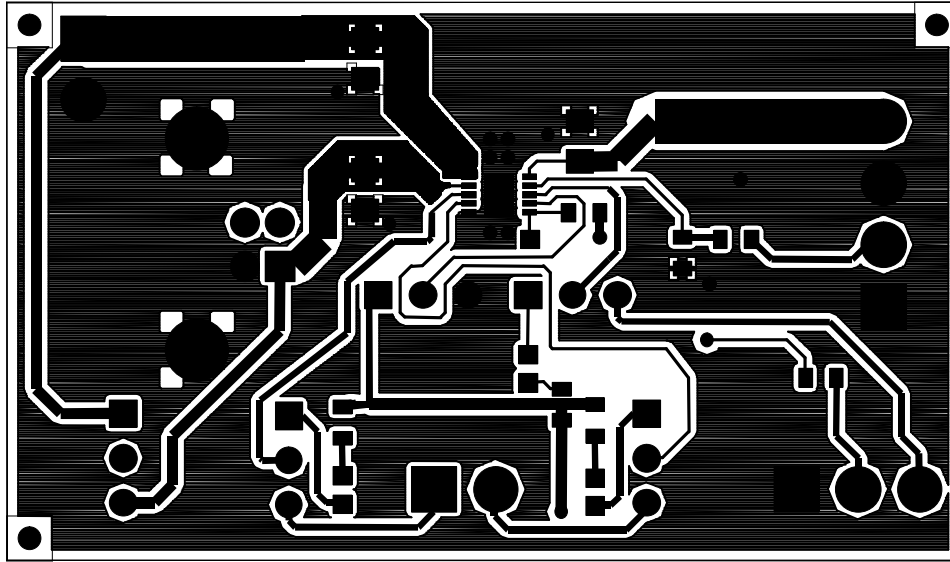


Figure 3. bq24022/7EVM Top Layer

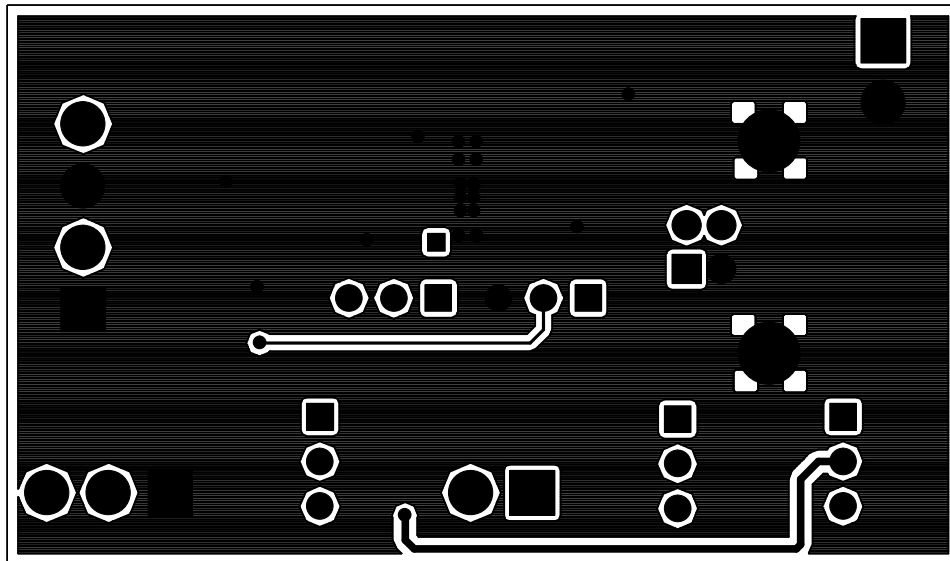


Figure 4. bq24022/7EVM Bottom Layer

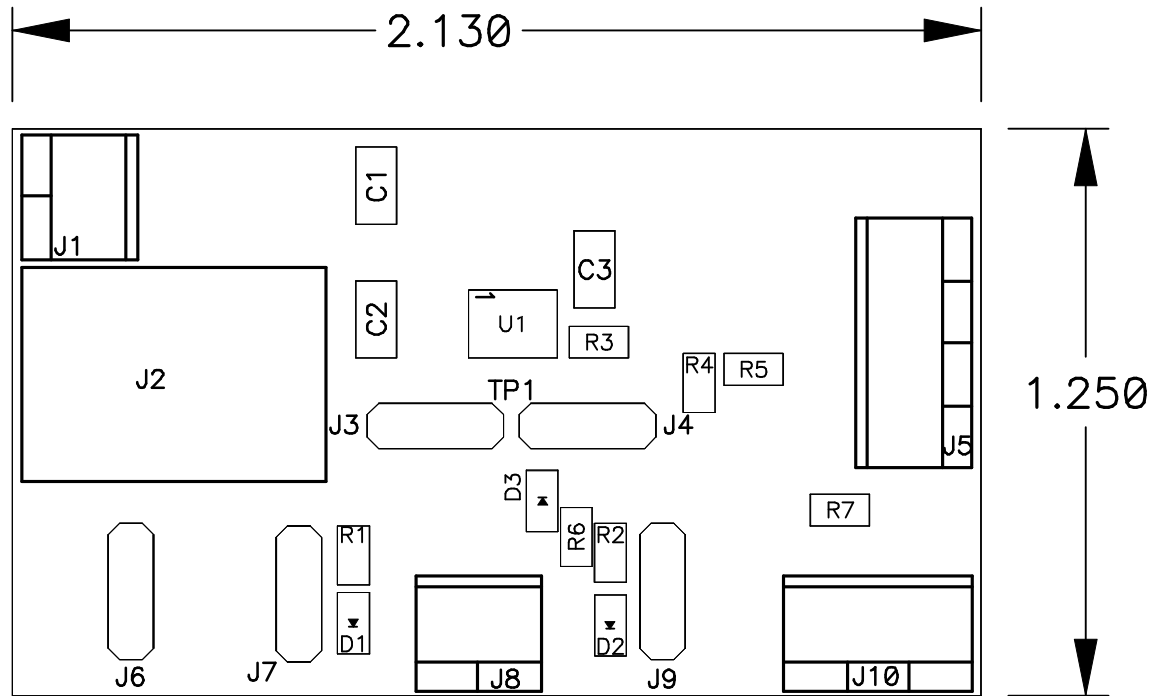


Figure 5. bq24022/7EVM Component Placement

## 5 Bill of Materials

Table 4 lists the materials required for the bq24022/7EVM.

**Table 4. Bill of Materials<sup>(1)(2)(3)(4)</sup>**

ITEM	-001	-002	REFERENCE DESIGNATOR <sup>(5)</sup>	DESCRIPTION	SIZE	MANUFACTUR E	PART NUMBER
	bq24022	bq24027					
	COUNT	COUNT					
1	3	3	C1, C2, C3	Capacitor, Ceramic, 1uF, 16-V, X7R	805	Kemet	C0805C105K4RACTU
2	1	1	D1	Diode, LED, Red, 1.8-V, 20-mA, 20-mcd	603	Liteon	160-1181-1-ND
3	2	2	D2, D3	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	603	Liteon	160-1183-1-ND
4	2	2	J1, J8	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25	OST	ED1514
5	1	1	J10	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 x 0.25	OST	ED1515
6	1	1	J2	Connector, USB Upstream (Type B)	0.47 x 0.67	Molex	67068-1000
7	5	5	J3, J4, J6, J7, J9	Header, 3-pin, 100mil spacing, (36-pin strip)	0.100 x 3	Sullins	PTC36SAAN
8	1	1	J5	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 x 0.25	OST	ED1516
9	3	3	R1, R2, R6	Resistor, Chip, 1.5k-Ohms, 1/16-W, 1%	603	Std	Std
10	1	1	R3	Resistor, Chip, 1.13k-Ohms, 1/16-W, 1%	603	Std	Std
11	1	1	R4	Resistor, Chip, 20k-Ohms, 1/16-W, 1%	603	Std	Std
12	1	1	R5	Resistor, Chip, 0-Ohms, 1/16-W, 1%	603	Std	Std
13	1	1	R7	Resistor, Chip, 1k-Ohms, 1/16-W, 1%	603	Std	Std
14	1	0	U1	IC, Single Li -ION/Li-POLY, Charge Manager	MLP10	TI	bq24022DRC
15	0	1	U1	IC, Single Li -ION/Li-POLY, Charge Manager	MLP10	TI	bq24027DRC
16	5	5	--	Shunt, 100 mill, Black	0.1	3M	929950-00
17	1	1	--	PCB, 2.13 In x 1.25 In x .31 In		Any	HPA004

- (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) Install shunts on J6-DC+, J7-LED, J9-LED, J3-0.5, and J4-LED.
- (5) Reference designators marked with an asterisk (\*\*\*) cannot be substituted. All other components can be substituted with equivalent MFG's components.

## 6 References

Single-Chip Li-Ion and Li-Pol Charger IC with Autonomous USB-Port and AC Adapter Supply Management (bqTINY™-II) bq24022/27 data sheet ([SLUS549](#))

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## EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of VREG + 0.5 V to 5.2 V and the output voltage range of 0 V to 4.2 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 70°C. The EVM is designed to operate properly with certain components above 70°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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Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Low Power Wireless	<a href="http://www.ti.com/lpw">www.ti.com/lpw</a>	Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
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