bq24083 1-A, Single-Cell Li-Ion and Li-Polymer Charge Management IC EVM

1 Introduction

This user's guide describes the bq24083 evaluation module (EVM). The EVM provides a convenient method for evaluating the performance of a charge management solution for portable applications. 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-polymer applications using a dc power supply. The charger is programmed from the factory to deliver 0.7 A of charging current.

1.1 Background

The bq24083 is a highly integrated and flexible Li-ion linear charge and system power management device targeted at space-limited charger applications. The bq24083 integrated circuit (IC) offers an integrated power FET and current sensor, high-accuracy current and voltage regulation, charge status, and charge termination in a single monolithic device. An external resistor sets the magnitude of the charge current. The bq24083 charges the battery in three phases: conditioning, constant current, and constant voltage. The constant voltage can be programmed to 4.2 V without pullup on VBSEL and 4.1 V with a pullup (JMP5). Charge is terminated based on minimum current. An internal charge timer provides a backup safety for charge termination. The bq24083 automatically restarts the charge if the battery voltage falls below an internal threshold. The bq24083 automatically enters sleep mode when the input is 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	6.5	V
Battery charge current, $I_{O(CHG)}$			0.7	1	A
Power dissipation				1.5	W

2 Test Summary

This section shows the test setups used and the tests performed in evaluating the EVM. See the bq24083 data sheet (SLUS848) for complete details regarding the operation and specifications.

2.1 Test Setup

The bq24083EVM board requires a regulated 5-Vdc, 1-A power source to provide input power and a single-cell Li-ion or Li-polymer battery pack.

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

JACK	CONNECTION
J1-DC+	Power supply positive connection, preset to 5 Vdc, 1-A current limit.
J1-DC-	Power supply return connection, ground
J2-BAT+	Positive battery pack terminal
J2-BAT–	Negative battery pack terminal, BAT- is common with DC-
JMP1-STAT1	JMP1-2 STAT1 signal. Place shunt on **JMP1** for LED, indication.
JMP2-STAT2	JMP2-2 STAT2 signal. Place shunt on **JMP2** for LED indication.
JMP3-$\overline{PG}$	JMP3-2 $\overline{PG}$ signal. Place shunt on **JMP3** for LED indiction.
JMP4-$\overline{CE}$	Charge Enable-active low. Place shunt on **JMP4** to pull $\overline{CE}$ Hi. Remove shunt for $\overline{CE}$ = Low
JMP5-VBSEL	JMP5-2 VBSEL signal. Place shunt on **JMP5** to change output regulation from 4.2 V to 4.1 V.

2.2 Test Procedures

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 maximum power dissipation on the device is not exceeded: P_{MAX} = 1.5 W.

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

1. Turn on the power supply, which is preset to 5 Vdc, and 1 A for the current limit setting.
2. The bq24083 enters preconditioning mode if the battery is below the $V_{(LOWV)}$ threshold. In this mode, the bq24083 precharges the battery with a low current, typically

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

   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 bq24083 enters fault mode. Both LEDs turn off when in fault mode. Toggling input power or battery replacement resets fault mode. Note that the several fault conditions that can occur are described in the data sheet (SLUS848).
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 or 4.1 V with JMP5 shunt applied), the current tapers down as the battery reaches its full capacity.
5. When the current reaches the taper termination threshold, the charge current terminates.
6. After termination, if the battery discharges down to the recharge threshold, the charger starts fast charging.
7. The procedure can be repeated with the JMP5 shunt applied for a regulation of 4.1 V.

2.3 Alternative Test Procedure

The alternative methods of testing the EVM without a battery include:

- Four Quadrant Power Supply (Sinks or Source Current)
- Large Capacitor
- Dynamic Load Board

The output of the battery charger delivers varying amounts of power depending on the output voltage and load impedance. For this reason, it is difficult to test the different charge phases without a battery (using just resistors). A load resistor is required to keep the output in precharge after power up. If increased in resistance to allow the output to enter constant current fast-charge, the output voltage would quickly transition through the constant current phase into voltage regulation and then terminate. Applying a load to pull the output into fast charge would discharge the output to precharge before the refresh deglitch allows a recharge, Therefore, it is necessary to use an active load or a small battery as a load (i.e., large capacitor) that can be charged and discharged fairly quickly for timely evaluations.

2.3.1 Four Quadrant Power Supply

A source meter that can sink or source current can easily be adjusted to test each mode.

2.3.2 Large Capacitor

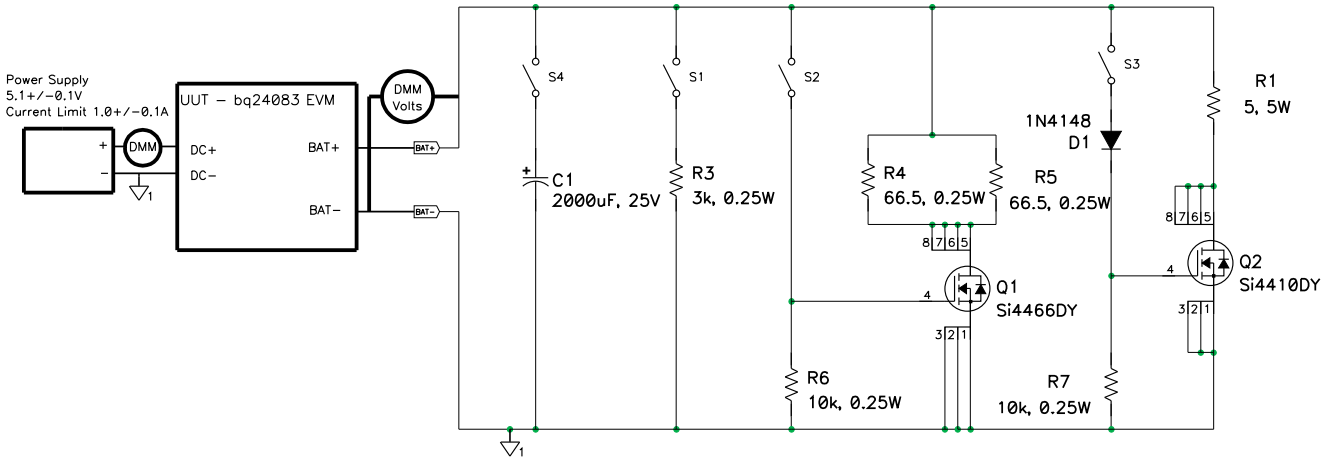
To briefly see each mode on an oscilloscope, connect a 1-mF capacitor in parallel with a 20-kΩ resistor, from the output to ground, to observe the power up, termination, and then cycling between voltage regulation and fast charge.

2.3.3 Dynamic Load Board

The loads are dynamic and automatically adjusted as a function of the output (battery) voltage. The sequence of the test procedure is important to remain in the desired mode. If altered, no damage occurs, but one might get different results than anticipated. The following test procedure applies more to verifying that the EVM was built correctly and does not test every feature. See the data sheet for an explanation of all the features.

2.3.3.1 Equipment

1. Power source: current-limited 5-V laboratory supply with its current limit set to 1 A ±0.1 A
2. Two Fluke 75 Multimeters, equivalent or better.
3. Oscilloscope – TDS220 or better
4. Load Test Board: PR694



2.3.3.2 Equipment Setup

1. Connect the load board to the BAT+ and BAT–. Set SW1 through SW4 in the ON (closed) position.
2. Connect a voltage meter to the BAT+/BAT– output to monitor the output voltage (range is 0-to-5 V).
3. Connect CH1 of scope to BAT+ and ground lead to BAT– (1 V/div and 200 ms/div).
4. Set the laboratory power supply for 5.1 V ±0.1 Vdc, 1-A ±0.1-A current limit and then turn off supply. Connect the source supply to a current meter and to J1, noting polarity (may use an internal source current meter if it has 5% or better accuracy).
5. Install shunt jumpers on the LED pins 1 and 2 of headers JMP1, JMP2, and JMP3.

2.3.3.3 Procedure

1. Ensure that the EQUIPMENT SETUP steps are followed {switches must be in the ON (closed) position, shunts installed, and power source set to 5.1 V ±0.1 Vdc}. Turn on the power source.
2. Verify output voltage, BAT+, charges up to between 2 V to 2.9 V and the red LED (D1), green LED (D2), and green LED (D3) are illuminated.
3. Open switch SW2 and then close switch SW2.

4. Verify that output voltage BAT+ settles between 3.2 V to 4 V.
5. Verify that the LED (D2) turns off.
6. Verify that the input current is between 0.65 A to 0.75 A.
7. Open switch SW3.
8. Verify that the input current is between 70 mA and 160 mA.
9. Verify the output voltage BAT+ is between 4.15 V dc and 4.25 Vdc.
10. Place shunt on JMP5 (4.1 V) and verify output voltage BAT+ is between 4 Vdc and 4.1 Vdc.
11. Place shunt on JMP4 (CHG DISABLE), and verify input current is less than 10 mA.
12. Remove JMP4 shunt (place on only one pin of JMP4 to keep from losing the shunt).
13. Open switch SW2.
14. Verify with a scope (250 ms/div, 1 V/div) that output BAT+ charges and discharges between the maximum limits of 3.3 V and 4.25 V with a period of between 600 ms to 1500 ms.
15. Verify that the LEDs flash between RED (D1) and GREEN (D2).
16. Close switches SW2 and SW3 (all switches should be closed now), and power down supply.
17. EVM is good if all tests have passed. Remove I/O connections.
18. If more EVMs are to be tested, loop back to 7.1 and continue until all units have been tested.

2.4 Ordering Information

Table 3. Ordering Information

EVM Part Number	Additional Devices	Chemistry	Pack Voltage	Capacity
bq24083EVM	None	Li-Ion / Li-Poly	2.5 V to 4.2 V	Any

3 Schematic

Figure 1 shows the schematic diagram for the bq24083EVM.

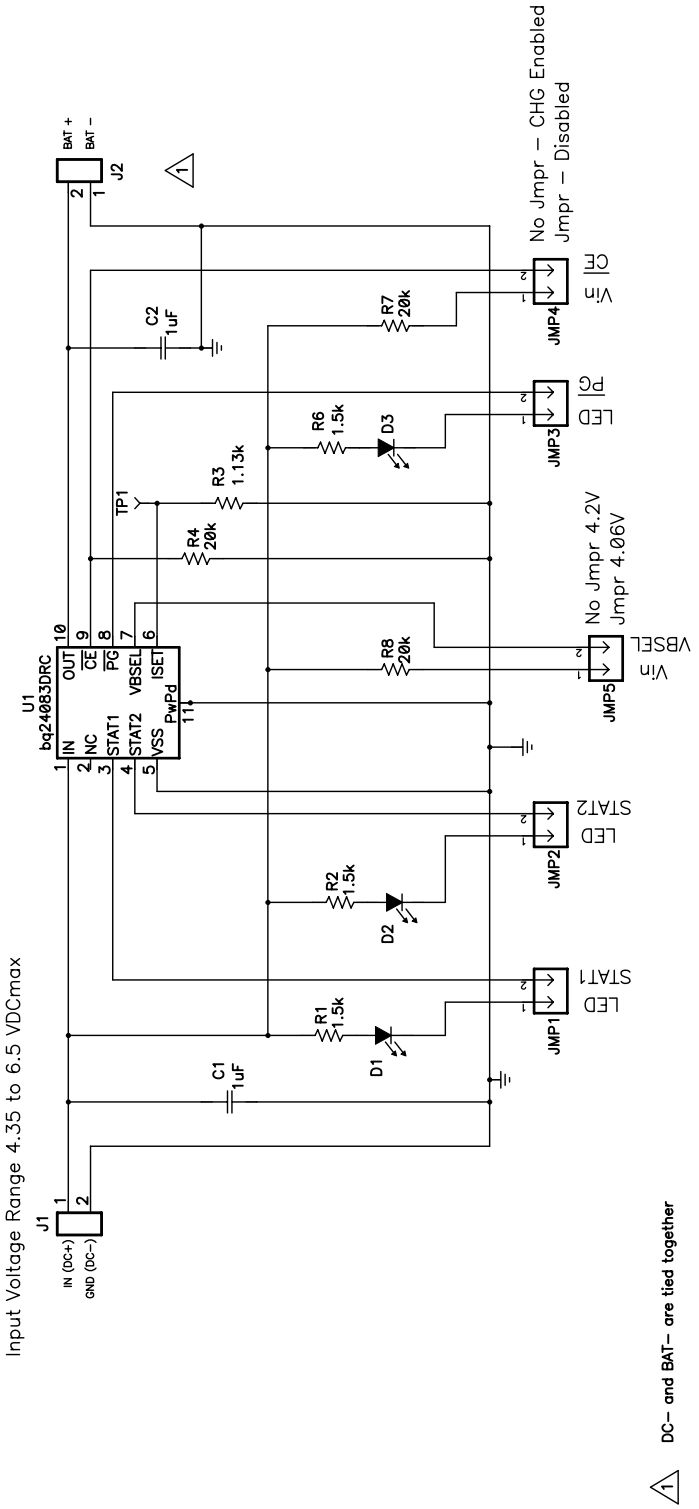


Figure 1. Schematic Diagram

4 Physical Layouts

Figure 2 and Figure 3 show the top layer and bottom layer of the EVM, respectively. Figure 3 shows the top assembly view.

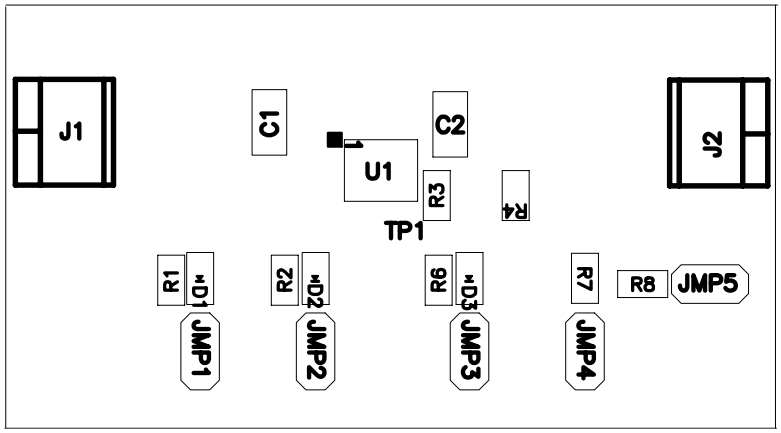


Figure 2. bq24083EVM Top Assembly Layer

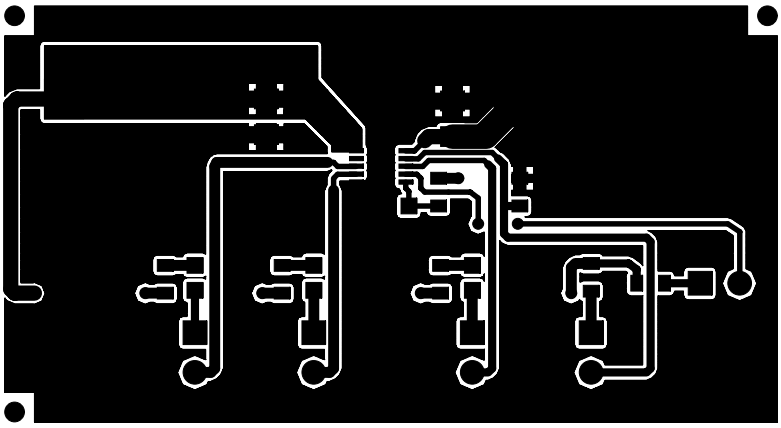


Figure 3. bq24083EVM Top Copper Layer

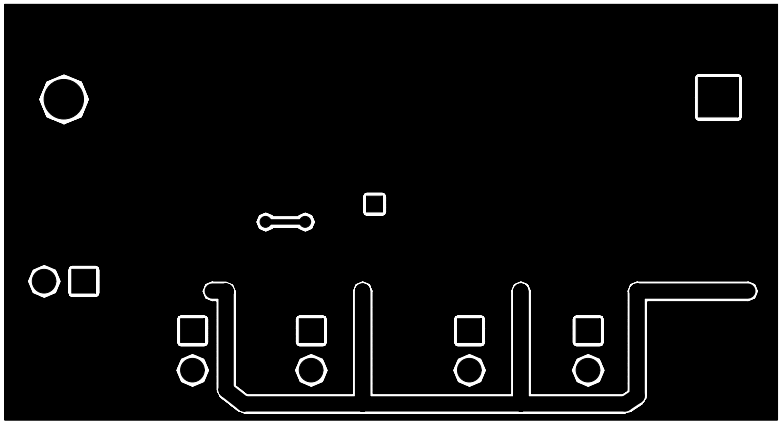


Figure 4. bq24083EVM Bottom Copper Layer

5 Bill of Materials

Table 4 lists the materials required for the bq24083EVM.

Table 4. bq24083EVM BOM

COUNT	REF DES	VALUE	DESCRIPTION	SIZE	PART NUMBER	MFR
2	C1, C2	1 μF	Capacitor, Ceramic, 16V, X5R, 10%	0805	Std	Std
1	D1	LTST-C190CKT	Diode, LED, Red, 2.1-V, 20-mA, 20-mcd	0603	LTST-C190CKT	Lite On
2	D2, D3	LTST-C190CKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190CKT	Lite On
2	J1, J2**	ED555/2DS	Terminal Block, 2-pin, 6-A, 3,5 mm	0.27 x 0.25 INCH	ED555/2DS	OST
5	JMP1–JMP5	PTC36SAAN	Header, 2-pin, 100-mil spacing, (36-pin strip)	0.100 x 2	PTC36SAAN	Sullins
3	R1, R2, R6	1.5 k	Resistor, Chip, 1/16-W, 1%	0603	Std	Std
1	R3	1.13 k	Resistor, Chip, 1/16-W, 1%	0603	Std	Std
3	R4, R7, R8	20 k	Resistor, Chip, 1/16-W, 1%	0603	Std	Std
1	U1	bq24083DRC	IC, Stand-alone linear charger	DRC10	bq24083DRC	TI
1	—		PCB, 2 In x 1 In x 0.31 In		HPA344	Any
5	Shunt (5) (6)		Shunt, 100-mil, black	0.1	929950-00	3M

Notes: 1. Shunts are placed on pins 1 and 2 for jumpers JMP1, JMP2, and JMP3.
2. For JMP4 and JMP5 place shunt on just one pin (do no short pins 1 and 2 with shunt)

6 References

bq24083, 1-A Single-Chip, Li-Ion and Li-Pol Charger IC data sheet (SLUS848).

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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.

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