

bq24070/1 1.5-A Single-Chip Li-Ion and Li-Pol Charge Management IC EVM

This user's guide describes the bq24070/1 evaluation module (EVM). The EVM provides a convenient method for evaluating the performance of a charge management and system power solution for portable applications using the bq24070/1 product family. A completely designed and tested module is presented. The charger is designed to deliver up to 1.5 A of continuous current to the system or charger for one-cell Li-ion or Li-polymer applications using a dc power supply. The charger is programmed from the factory to deliver 1 A of charging current.

Contents

1	Introduction	2
2	Considerations When Testing and Using bq24070/1 ICs	2
3	Performance Specification Summary	3
4	Test Summary	3
5	Schematic	6
6	Physical Layouts.....	7
7	Bill of Materials	11
8	References.....	12

List of Figures

1	Test Diagram	3
2	bq24070/1 EVM Schematic	6
3	Top Assembly View	7
4	Top Silkscreen	8
5	Board Layout – Top Etch Layer	8
6	Board Layout – Second Etch Layer	9
7	Board Layout – Third Etch Layer	9
8	Board Layout – Bottom Etch Layer	10

List of Tables

1	Performance Specification Summary For bq24070/1 EVM	3
2	Bill of Materials	11

1 Introduction

The bq24070/1 powers the system while independently charging the battery. This feature reduces the charge and discharge cycles on the battery, allows for proper charge termination, and allows the system to run with an absent or defective battery pack. This feature also allows for the system to turn on instantaneously from an external power source even when using a deeply discharged battery pack.

The IN pin can be programmed to perform like a USB input by pulling the MODE pin low or like an adapter input if the MODE pin is pulled high. An external resistor, RSET1, sets the magnitude of the charge current. If the charge current exceeds the available input current, the voltage on the OUT pin drops to the $DPPM_{OUT}$ threshold or the battery voltage, whichever is higher. The charging current is reduced to what current is available ($I_{BAT} = I_{IN} - I_{OUT}$).

The bq24070/1 charges the battery in three phases: conditioning, constant-current, and constant-voltage. Charge is terminated based on minimum current. A resistor-programmable charge timer provides a backup safety for charge termination. The bq24070/1 automatically restarts the charge if the battery voltage falls below an internal threshold. The bq24070/1 automatically enters sleep mode when both supplies are removed (a drop to the battery voltage).

The bq24070 regulates the OUT pin at 4.4 VDC whereas the BQ24071 regulates the output at 6 VDC if the input is greater than $6\text{ VDC} + V_{DO}$ (V_{DO} = dropout voltage between IN and OUT). For lower input voltages, the OUT pin is $V_{IN} - V_{DO}$.

2 Considerations When Testing and Using bq24070/1 ICs

It is recommended to read the bq24070/1 data sheet prior to evaluating this EVM. Consider the following noteworthy items while testing and using the bq24070/1 IC.

The two potential sources to power the system (V_{OUT}) are: IN (adapter or USB source) and the battery. The IC is designed to power the system continuously. The battery, in most cases, is the last line of backup. If the adapter or USB input is not available (or disabled), the battery connects to the system.

In thermal regulation condition ($T_J = 125^\circ\text{C}$ —not a first-choice design mode of operation), the charge current is reduced to the battery, and the system still gets its power from the input. The battery supplement is still available in thermal regulation if V_{OUT} falls to V_{BAT} . In thermal cutoff ($\sim 155^\circ\text{C}$), the input sources are disconnected, but the internal battery FET connects the battery to V_{OUT} .

There are two types of OUT-pin short circuit, one associated with the input IN pin ($V_{OUT} < 1\text{ V}$) and the other associated with the BAT pin ($V_{BAT} - V_{OUT} > 200\text{ mV}$). For the BAT short circuit, the battery FET opens if a short on V_{OUT} pulls more than $\sim 4\text{ A}$ of current ($>200\text{-mV}$ drop across the BAT FET) from the battery. The recovery method is from a 10-mA current source between the BAT and OUT pins, so the short and any system load must be removed before the OUT pin can recover within 200 mV of V_{BAT} . Note that the current source is $\sim 10\text{ mA}$ with the OUT pin near 0 V, but falls off to $\sim 2\text{ mA}$ as the OUT pin goes above 1 V. For the IN-to-OUT short-circuit case where the OUT pin is less than 1 V, the recovery method is by a 500- Ω pullup resistor from IN to OUT. The system load must be reduced ($>200\ \Omega$) such that the pullup can pull V_{OUT} above 1 V.

When there is no power to the system and the battery is hot-plugged, the BAT-pin voltage leads the OUT-pin voltage due to the system capacitance, and the output may go into BAT short-circuit mode. To avoid this, a feature was added to the DPPM pin. If the voltage on the DPPM pin is held below 1 V, then the short-circuit feature is disabled. Therefore, placing a small capacitor ($\sim 1\text{ nF}$ to 10 nF) across the DPPM resistor delays the short-circuit protection on input power-up by a few microseconds.

Another feature that protects system integrity is dynamic power path management (DPPM). The voltage on the DPPM pin ($DPPM_{IN}$) times a scaling factor of ~ 1.15 is the $DPPM_{OUT}$ voltage. The $DPPM_{OUT}$ voltage is the critical voltage, determined by the designer, where battery charging current is reduced to keep the system voltage (V_{OUT}) from further decay. A special feature to keep in mind is that when in DPPM mode, the internal oscillator timer is slowed in proportion to the reduction in programmed charger current. This allows the timers (safety and others) to be appropriately adjusted during operation. Therefore, when performing any test where time is measured, keep in mind this adjustment factor.

The MODE (High/Low) sets which input source is present (adapter or USB). The CE pin (going high) immediately enables the chip; disabling it (going low) delays handoff for 5 ms.

3 Performance Specification Summary

Table 1 summarizes the performance specifications of the EVM.

Table 1. Performance Specification Summary For bq24070/1 EVM

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input dc voltage, $V_{I(AC)}$		4.8	5	6.5	V
Input dc USB voltage, $V_{I(USB)}$			5		
Battery charge current, $I_{O(CHG)}$			1	2+	A
Power dissipation, bq24070/1 IC, 1 cell	$P_{DISS} = (V_{IN} - V_{OUT})I_{out} + (V_{IN} - V_{BAT})I_{BAT} + (V_{IN} - V_{LDO})I_{LDO}$			See ⁽¹⁾	W

(1) The HPA180 (bq24070/1) thermal design is optimized (8+ vias, 0.031-inch PWB, 2 oz. copper) to give $\theta_{JA} \sim 27^{\circ}\text{C/W}$.

4 Test Summary

This section covers the setup and tests performed in evaluating the EVM.

4.1 Equipment

- Power supply (5.25 ± 0.25 VDC), current limit set to 2.0 A ± 0.2 A for AC input to the UUT
- Three Fluke 75 DMMs (equivalent or better)
- Oscilloscope, Model TDS220 (equivalent or better)

4.2 Equipment Setup

- Preset the UUT power supply voltage and current prior to connection to UUT; turn off the power supply and connect the supply to J1-IN/GND (+ to IN and – to GND).
- Connect a 10-Ω to 30-Ω load to J4-OUT/GND.
- Connect a fully discharged (< 2.8-VDC) single-cell Li-ion or Li-polymer battery to J2-BAT+/BAT–.
- Connect the DMMs as shown in Figure 1.

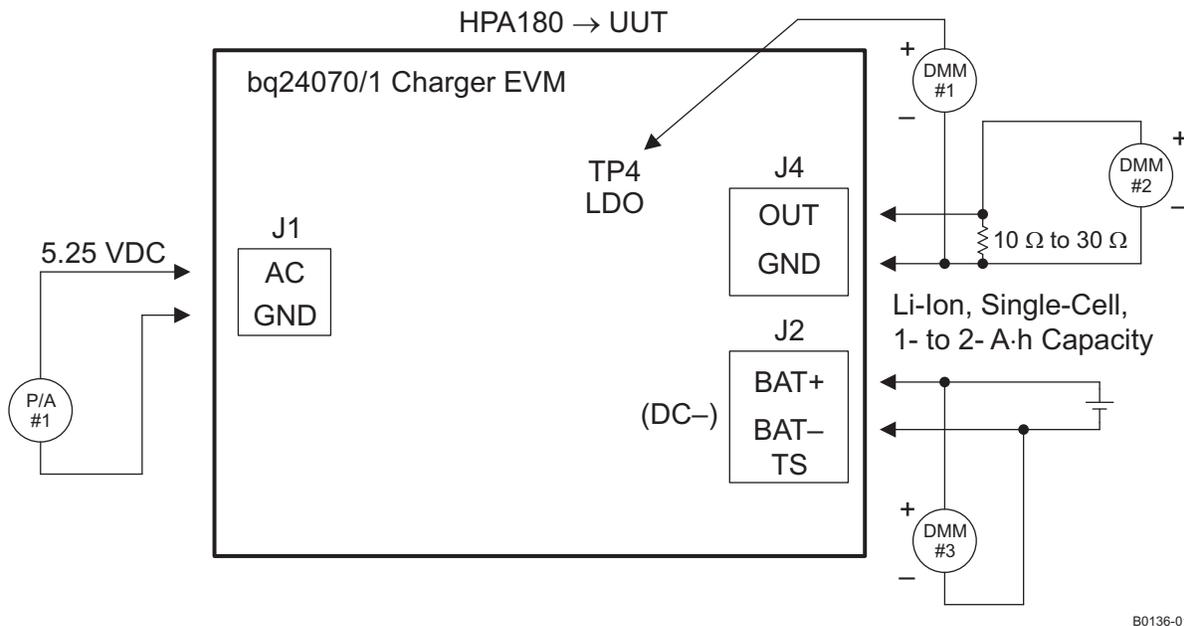


Figure 1. Test Diagram

B0136-01

4.3 Test Procedure

1. Verify that the equipment is set up according to *Equipment Setup*, [Section 4.2](#).
2. Set jumpers on the UUT as follows: JMP1 to 0.5; JMP2 to HI; JMP3 to EN; install jumpers on JMP4 through JMP6.
3. Adjust **R_DPPM** until TP1 is **35.7 kΩ ±0.1 kΩ** with respect to GND, and adjust **R_TMR** until TP2 is 50 kΩ with respect to GND.
4. Verify that **V_{OUT}** is approximately equal to **V_{BAT}** (if **V_{OUT}** < 1.1 V, the output is in short-circuit mode. To get out of this mode, momentarily disconnect the load on the OUT pin).
5. Power up the **5.25-VDC supply** to the UUT.
6. Verify **V_{BAT}** is between 2.4 VDC and 3 VDC, and the charger is in pre-charge state: LEDs STAT1 (D2), STAT2 (D3), and ACPG (D1) are on.
If **V_{BAT}** is above the low-voltage threshold (**V_(LOWV)** ~3 V), then the IC is in fast-charge mode [STAT2 (D3) is off (High)]. If the IC is in fast charge, skip to step 10.
7. Verify **I_{BAT}** is ~0.1 A (**I_{BAT}** ~ **I_{IN}** - (**V_{OUT}** / **R_{OUT}**) - 0.01 A)
8. Verify **V_{OUT}** is between 4.3 VDC and 4.5 VDC for the bq24070 IC and between 4.8 VDC and 5.5 VDC (**V_{IN}** - **V_{DO}**) for the bq24071 IC.
9. Verify **V_{LDO}** (TP4) is between 3.2 VDC and 3.4 VDC.
10. Allow the battery to charge until **V_{BAT}** is between 3.2 VDC and 4.0 VDC. The charger should deliver the programmed constant current to the battery unless the input cannot source the required current.
11. Verify **D3** (STAT2) has turned off.
12. Verify **I_{BAT}** is ~1.0 A [for a 10-kΩ resistor on *ISET1*, **I_{BAT}** ~ **I_{IN}** - (**V_{OUT}** / **R_{OUT}**) - 0.01 A].
13. Apply a short between J3-4 (CE) and J3-3 (GND) on the UUT. This overrides the JMP3 100-kΩ pullup, disables the charging, puts the IC in low-power mode, and connects the battery to the OUT pin. Note that if CE is floated (JMP3 is removed and J3-3 to 4 connection is removed), the IC may bounce between the charging and disabled states. Verify on the scope that **V_{OUT}** does not drop out when switching between the input source and the battery source.
14. Verify **D2** (STAT1) has turned off.
15. Verify **I_{IN}** drops below 10 mA [should be < 200 μA into the IC if **P_G** LED (current) JMP6 is removed].
16. Verify **V_{OUT}** is within -50 mV of **V_{BAT}**.
17. Remove short between J3-4 and J3-3 on UUT. Verify on the scope that **V_{OUT}** does not drop out. Verify **D2** (STAT1) has turned on, charging has resumed, and **V_{OUT}** is powered from the input.
18. Disconnect the **5.25-VDC input supply** from the UUT IN input. Verify on the scope that **V_{OUT}** does not drop out. Verify **V_{OUT}** is within -50 mV of **V_{BAT}** and **D2** (STAT1) and **D1** (**P_G**) LEDs turn off. This demonstrates battery power backup for loss of adapter power.
19. Reapply the +5.25-VDC supply to the UUT IN input. Verify on the scope that **V_{OUT}** does not drop out. Verify **D2** (STAT1) and **D1** (**P_G**) LEDs turn on.
20. Reduce the current limit on the input supply to ~ 1 A (going to the IN pin on the UUT) and verify on the scope that **V_{OUT}** has dropped to the VDPPM level of ~4.2 V [(3.57 V at TP1) × 1.15 = 4.1 V]. Note that the current into the battery is ~ 590 mA (1-A input minus 410 mA to the system for a 10-Ω load), which has been reduced to keep the output from falling below the programmed DPPM OUTPUT threshold of 4.1 V. This demonstrates DPPM operation (charging current to the battery is reduced if output drops to the DPPM OUTPUT voltage threshold attempting to keep the output voltage from dropping further).
21. Further reduce the input current limit to 250 mA. Verify on the scope that **V_{OUT}** does not drop out. Verify that **V_{OUT}** drops just below **V_{BAT}** (< 50 mV). Because the available input current is less than the system **OUT** load, reducing the battery charging current to zero is still not enough reduction in load to keep the output from dropping. Once the output drops below ~ 60 mV, the internal battery FET turns on and allows the battery to source the OUT pin system load. This demonstrates battery supplement mode.
22. Return the current limit of the 5.25-V supply to ~2 A. Verify **V_{OUT}** returns to ~4.4 V.
23. Set JMP2 (MODE) to LO (USB mode). Verify that the input current, **I_{IN}**, drops to between 400 mA and 500 mA. The programmed charge current of ~1 A and the system load of 10 Ω exceeds the USB-mode 0.5-A limit; therefore, **V_{OUT}** drops until the DPPM OUTPUT voltage threshold or battery voltage is reached (whichever is higher). If the DPPM OUTPUT threshold is higher, the charging current is reduced to keep the output voltage from dropping further. If the battery voltage is higher, the battery supplements the current to keep the output from dropping too much (20 mV to 200 mV) below the

battery voltage.

24. Set JMP2 (MODE) to HI and verify that the input supply is providing ~1.5 A of current (~0.44, for a 10- Ω resistor, to the load and 1 A to the battery).
25. Set JMP1 to 0.1 on the UUT. Verify that the battery charge has dropped in half. The input current should be $\sim I_{\text{BAT}} (\sim 0.5 \text{ A}) + I_{\text{OUT}} (\sim 4.4 \text{ V}/10 \Omega = 0.44 \text{ A}) \approx 0.94 \text{ A}$.
26. Set JMP1 to 0.5. Continue to let the battery charge. Note that once the battery voltage reaches regulation (~4.2 VDC), the charging current tapers off.
27. Verify that the charging terminates when the battery current tapers to C/10 or 100 mA (1 A/10, programmed charge current divided by 10). Verify D2 (STAT1) turns off (High) and D3 (STAT2) turns on (Low).
28. If a load is applied across the battery such that the battery is discharged to ~4.1 V, the charger starts a new charging cycle.

This concludes the evaluation of the bq24070/1 EVM. Several more features implemented in the IC are not demonstrated in this user's guide. See the data sheet to learn more about thermal regulation, thermal cutoff, USB boot up, and short-circuit protection.

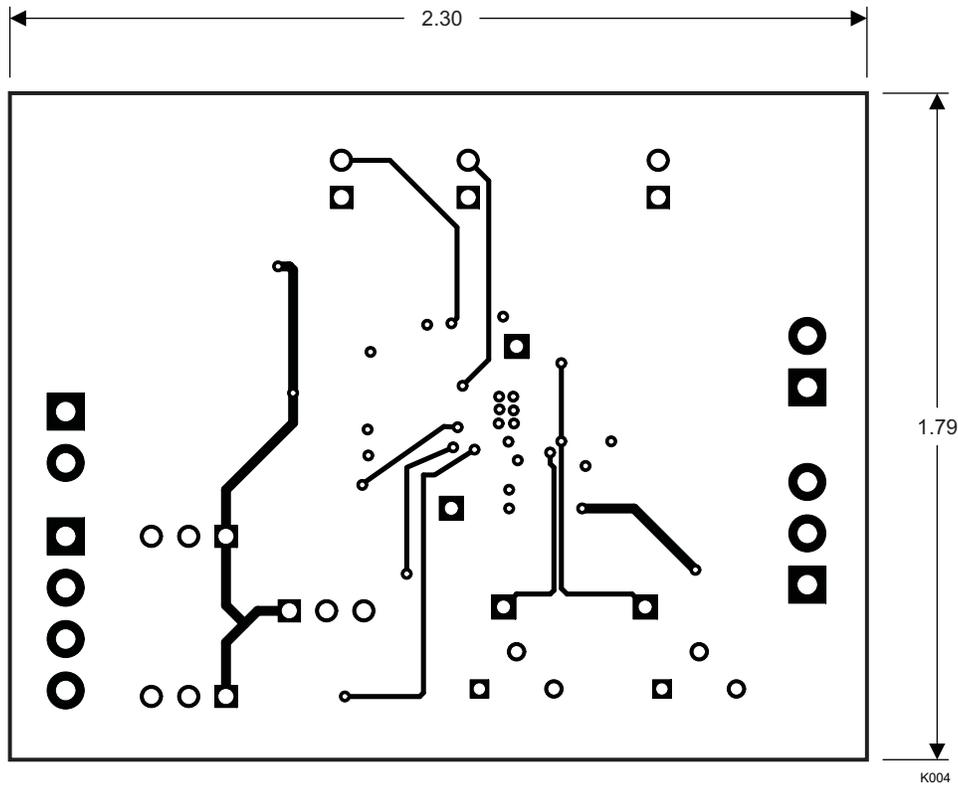


Figure 6. Board Layout – Second Etch Layer

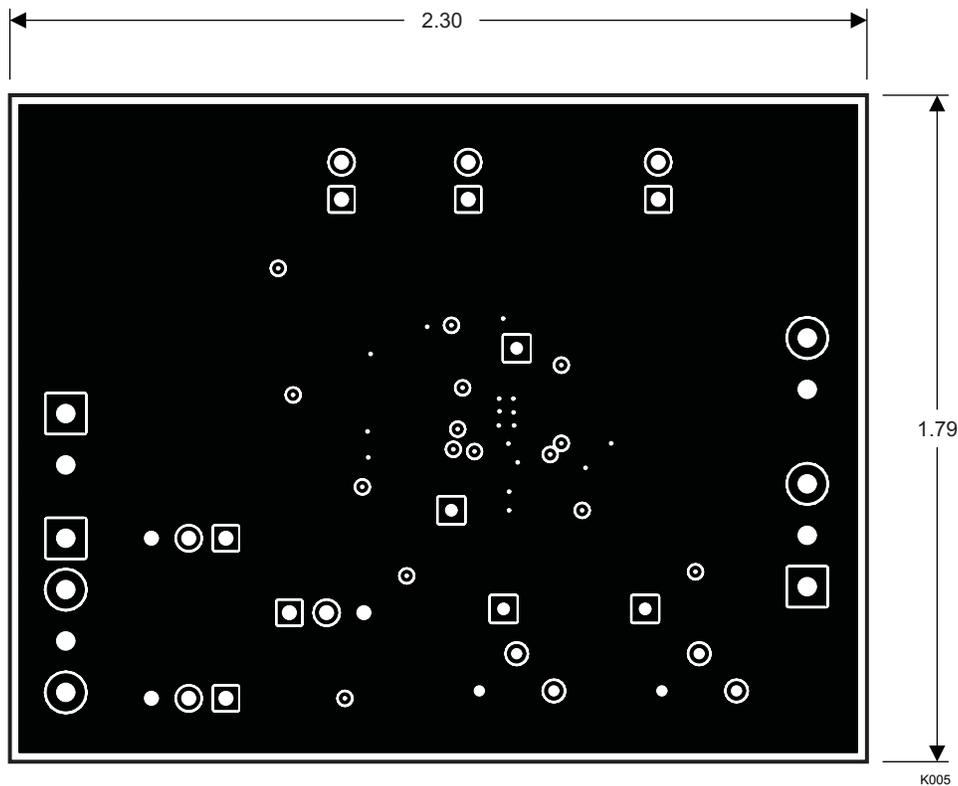


Figure 7. Board Layout – Third Etch Layer

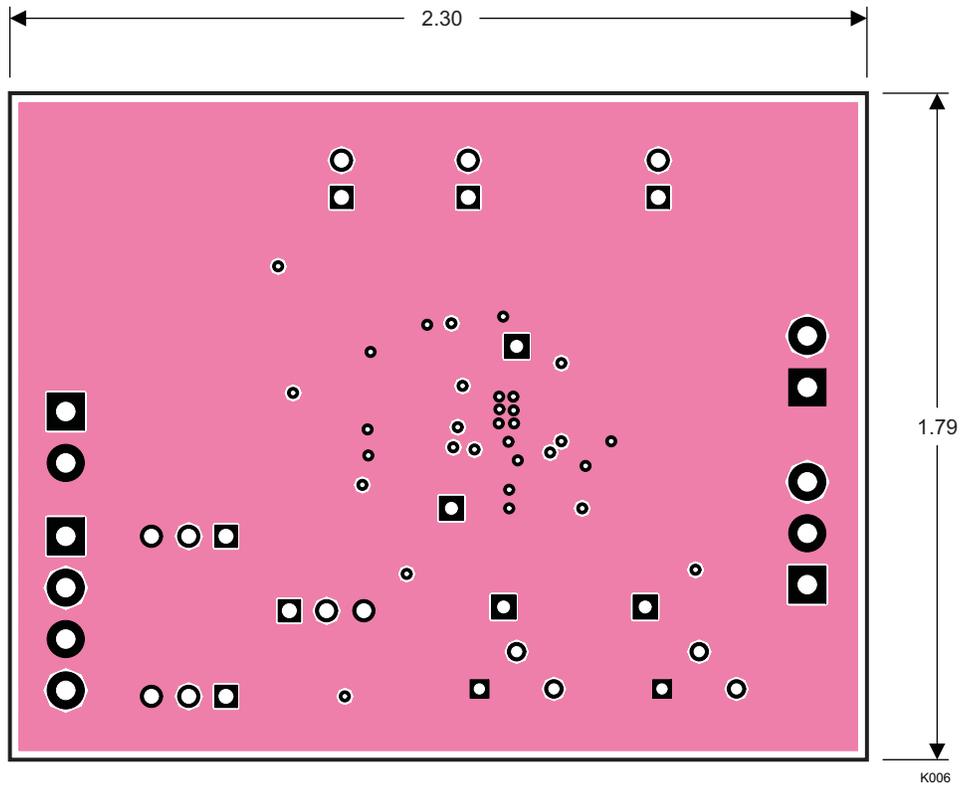


Figure 8. Board Layout – Bottom Etch Layer

7 Bill of Materials
Table 2. Bill of Materials

REFDES		QTY	VALUE	DESCRIPTION	SIZE	MFR	PART NUMBER
-001	-002						
C1	C1	1	0.01 μ F	Capacitor, ceramic, 0.01- μ F, 16-V, X7R, 10%	0603	Std	Std
C2, C3	C2, C3	2	10 μ F	Capacitor, ceramic, 10- μ F, 6.3-V, X5R, 20%	0805	Panasonic	ECJ-2FB0J106M
C4, C5	C4, C5	2	10 μ F	Capacitor, ceramic, 10- μ F, 25-V, X5R, 20%	1206	Panasonic	ECJ-3YB1E106M
C6	C6	1	0.47 μ F	Capacitor, ceramic, 0.47- μ F, 16-V, X7R, 10%	0805	Panasonic	ECJ-2YB1C474K
C7	C7	0	0.22 μ F	Capacitor, ceramic, 0.22- μ F, 10-V, X5R, 10%	0603	muRata	ECJ-1VB1A224K
D1, D2	D1, D2	2	Green	Diode, LED, green, 2.1-V, 20-mA, 6-mcd	0603	Liteon	160-1183-1-ND
D3	D3	1	Red	Diode, LED, red, 1.8-V, 20-mA, 20-mcd	0603	Liteon	160-1181-1-ND
J1, J4	J1, J4	2	ED1514	Terminal block, 2-pin, 6-A, 3,5-mm	0.27 inch \times 0.25 inch	OST	ED1514
J2	J2	1	ED1515	Terminal block, 3-pin, 6-A, 3,5-mm	0.41 inch \times 0.25 inch	OST	ED1515
J3	J3	1	ED1516	Terminal block, 4-pin, 6-A, 3,5-mm	0.55 inch \times 0.25 inch	OST	ED1516
JMP1, JMP2, JMP3 ⁽¹⁾	JMP1, JMP2, JMP3 ⁽¹⁾	3	PTC36SAA N	Header, 3-pin, 100-mil spacing, (36-pin strip)	0.100 inch \times 3	Sullins	PTC36SAAN
JMP4, JMP5, JMP6 ⁽¹⁾	JMP4, JMP5, JMP6 ⁽¹⁾	3	PTC36SAA N	Header, 2-pin, 100-mil spacing, (36-pin strip)	0.100 inch \times 2	Sullins	PTC36SAAN
R1, R2, R8	R1, R2, R8	3	1.5 k Ω	Resistor, chip, 1.5-k Ω , 1/16-W, 1%	0603	Std	Std
R3, R4, R5	R3, R4, R5	3	100 k Ω	Resistor, Chip, 100-k Ω , 1/16-W, 1%	0603	Std	Std
R6	R6	1	1 k Ω	Resistor, chip, 1-k Ω , 1/10W, 1%	0805	Std	Std
R7	R7	0	1 k Ω	Resistor, chip, 1-k Ω , 1/10W, 1%	0805	Std	Std
R9	R9	1	10 k Ω	Resistor, chip, 10-k Ω , 1/16W, 1%	0603	Std	Std
R10	R10	1	0	Resistor, chip, 0- Ω , 1/16-W, 1%	0603	Std	Std
R11	R11	1	22.6 k Ω	Resistor, chip, 22.6-k Ω , 1/16-W, 1%	0603	Std	Std
R12	R12	1	20 k Ω	Potentiometer, 20-k Ω , 1/4-in. Cermet, 12-turn, top-adjust	0.25 inch \times 0.17 inch	Bourns	3266W-203
R13	R13	1	50 k Ω	Potentiometer, 50-k Ω , 1/4-in. Cermet, 12-turn, top-adjust	0.25 inch \times 0.17 inch	Bourns	3266W-503
R14	R14	1	30.1 k Ω	Resistor, chip, 30.1-k Ω , 1/16-W, 1%	0603	Std	Std
TP1, TP2, TP3, TP4	TP1, TP2, TP3, TP4	4		Test point, 0.032-inch hole		Void	None
U1		1	bq24070R HL	IC, single-IC charge and system power-path management	QFN	TI	bq24070RHL
	U1	1	bq24071R HL	IC, single-IC charge and system power-path management	QFN	TI	bq24071RHL
—	—	1		PCB, 2-inch \times 1-inch \times 0.031-inch		Any	HPA180_PCB
6	6	6	N/A	Shunt, 100-mil, black	0.100-inch	3M	929950-00

⁽¹⁾ Add shunt to JMP1-0.5, JMP2-AC, JMP3-EN, JMP4-1/2, JMP5-1/2, JMP6-1/2.

8 References

1. *bq24070 Single-Chip Charge and System Power-Path Management IC* data sheet, [SLUS694](#)
2. *bq24071 Single-Chip Charge and System Power-Path Management IC* data sheet, [SLUS713](#)

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general customer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference. - SSZZ017A - February 2006

EVALUATION BOARD/KIT IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

EVALUATION BOARD/KIT IMPORTANT NOTICE (continued)

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2006, Texas Instruments Incorporated

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 0 V to 6.5 V and the output voltage range of 0 V to 6.5 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 85°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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2006, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
Low Power Wireless	www.ti.com/lpw	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2007, Texas Instruments Incorporated