

# ***bq24351EVM for Li-Ion Charger Front-End Protection IC***

---



---

This user's guide describes the features, setup, and operation of the bq24351EVM evaluation module. Included are the bill of materials, board layout, and schematic.

## **Contents**

1	Introduction .....	2
1.1	General Description .....	2
1.2	EVM Features .....	2
1.3	I/O Description .....	2
1.4	Controls and Key Parameters Setting .....	3
1.5	Recommended Operating Conditions .....	3
2	Test Summary .....	3
2.1	Definitions .....	3
2.2	Equipment .....	3
2.3	Equipment Setup .....	4
2.4	Procedure .....	5
3	PCB Layout Guideline .....	5
4	Bill of Materials, Board Layout, and Schematic .....	6
4.1	Bill of Materials .....	6
4.2	Board Layout .....	7
4.3	Schematic .....	11

## **List of Figures**

1	Original Test Setup for HPA666 (bq24351 DSG EVM) .....	4
2	Top Layer .....	7
3	Bottom Layer .....	8
4	Top Silk Screen .....	9
5	Top Assembly .....	10
6	bq24351 Schematic .....	11

## **List of Tables**

1	Bill of Materials .....	6
---	-------------------------	---

## 1 Introduction

### 1.1 General Description

The bq24351 evaluation module (EVM) is a complete charger module for evaluating a charger front-end protection and charger solution using the bq24351 and bq2057C devices. It is designed to deliver up to 560 mA of charge current to Li-ion or Li-polymer applications. The charger front-end protection current is designed to 1.2 A.

The bq24351 protects the charging system against three types of failures: input overvoltage when the ac adapter fails to regulate its voltage, load overcurrent when failures such as a short circuit occur in the charging system, and battery overcharge.

For details, see the bq24351 data sheet ([SLUSA62](#)).

### 1.2 EVM Features

- Evaluation module for bq24351 DSG
- Evaluation module for bq2057C charger integrated circuit (IC)
- Input operating range for bq24351 4.5 V–26 V
- Input overvoltage protection.
- Input overcurrent protection.
- Battery overvoltage protection.
- LED indication for status signals.
- Test points for key signals available for testing purposes. Easy probe hook-up
- Jumpers available. Easy to change connections

### 1.3 I/O Description

Jack	Description
J1–DC+	AC adapter, positive output
J1–DC–	AC adapter, negative output, ground
J2–FAULT	Reserved for other ICs
J2–VBAT	bq24351 VBAT pin
J2–GATDRV	bq24351 GATDRV pin
J2–CHGIN	bq24351 CHGIN pin
J3–BATEN	Reserved for other ICs
J3–OUT	bq24351 OUT pin
J3–BAT+	Battery positive output
J3–GND	Ground
J4–BAT+	Connect to battery positive output
J4–BAT–	Connect to battery negative output, ground

## 1.4 Controls and Key Parameters Setting

Jack <sup>(1)</sup>	Description	Factory Setting
JP1	If on, high-side sensing resistor is disabled	Jumper on
JP2	Reserved for other ICs	Jumper (BATEN, GND) on
JP3	bq24351 GATDRV pin	Jumper off
JP4	bq2057C BAT pin connection to bq24351	Jumper on
JP5	bq2057C VCC pin connection to bq24351	Jumper on
JP6	bq2057C CC pin connection to bq24351	Jumper on
JP7	If on, low-side current-sensing resistor is disabled	Jumper off

<sup>(1)</sup> Short JP1, JP4, JP5, and JP6, and disconnect JP7 to use onboard bq2057C as charger; to use external charger to control bq24351, disconnect JP1, JP4, JP5, and JP6 and short JP7.

## 1.5 Recommended Operating Conditions

Symbol	Description	MIN	TYP	MAX	Unit
Supply voltage, $V_{IN}$	Input voltage from ac adapter input	4.5	5	26	V
Battery voltage, $V_{BAT}$	Voltage applied at VBAT terminal of J4	0	3–4.2	5	V
Supply current, $I_{AC}$	Maximum input current from ac adapter input	0		1.5	A
Charge current, $I_{chg}$	Battery charge current	0.05	0.56	1	A
Operating junction temperature range, $T_J$		0		125	°C

## 2 Test Summary

### 2.1 Definitions

This procedure details how to configure the evaluation board. On the test procedure, the following naming conventions are followed. See the schematic for details.

VXXX	External voltage supply name ( $V_{IN}$ , $V_{BAT}$ , $V_{OUT}$ )
LOADW	External load name (LOADR, LOADI)
V(TPyyy)	Voltage at internal test point TPyyy. For example, V(TP1) means the voltage at TP1.
V(Jxx):	Voltage at jack terminal Jxx.
V(TP(XXXXX))	Voltage at test point XXXXX. For example, V(ACDET) means the voltage at the test point which is marked as <i>ACDET</i> .
V(XXX, YYY)	Voltage across points XXX and YYY.
I(JXX(YYY))	Current going out from the YYY terminal of jack XX.
Jxx(BBB)	Terminal or pin BBB of jack xx
Jxx ON	Internal jumper Jxx terminals are shorted
Jxx OFF	Internal jumper Jxx terminals are open
Jxx (-YY-) ON	Internal jumper Jxx adjacent terminals marked as YY are shorted
Measure → A,B	Check specified parameters A, B. If measured values are not within specified limits, the unit under test has failed.
Observe → A,B	Observe if A, B occur. If they do not occur, the unit under test has failed.

Assembly drawings show locations for jumpers, test points, and individual components.

### 2.2 Equipment

#### 2.2.1 Power Supplies

Power supply 1 (PS 1): a power supply capable of supplying 15 V at 2 A is required.

### 2.2.2 Load 1

A 10-V (or above), 2-A (or above) electronic load that can operate in constant-current mode.

### 2.2.3 Load 2

A 10-V (or above), 2-A (or above) electronic load that can operate in constant-voltage mode.

### 2.2.4 Meters

Four Fluke 75 multimeters (equivalent or better)

Or:

Three equivalent voltage meters and one equivalent current meter

The current meter must be capable of measuring 2-A+ current.

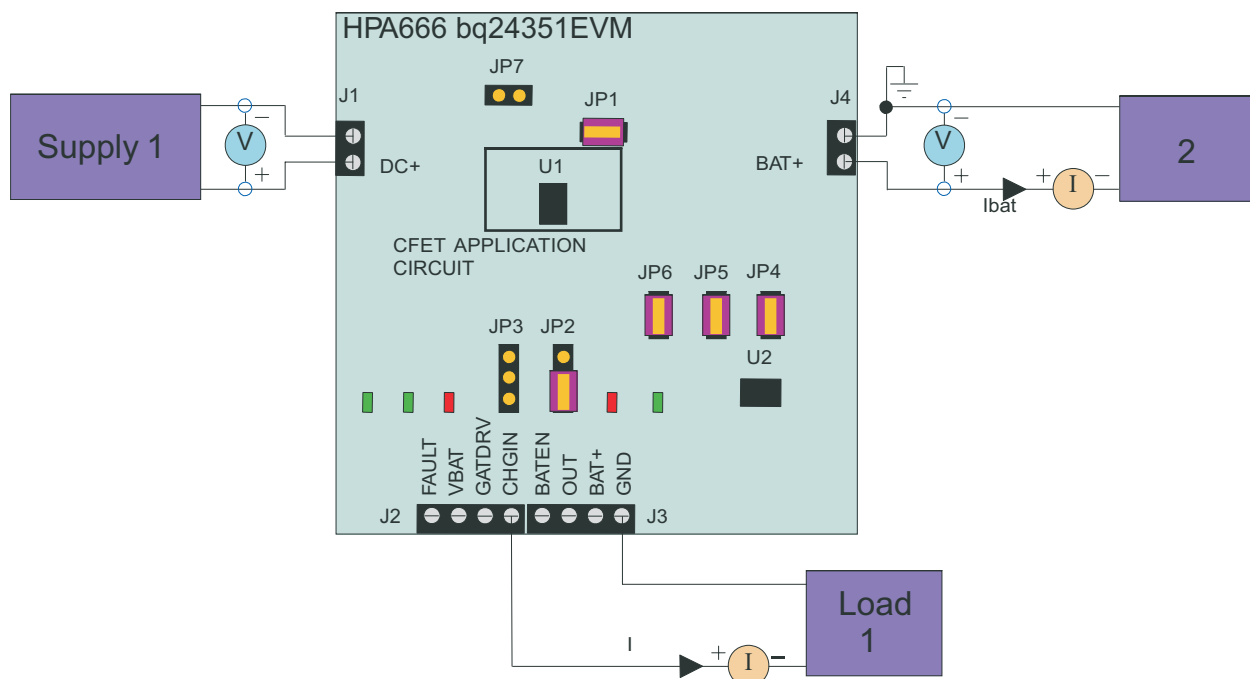
### 2.2.5 Wire Gauge

All wires connected to the EVM input power supply and output load must be at least AWG 22. The maximum current is up to 1 A.

## 2.3 Equipment Setup

1. Set PS 1 for 0 V  $\pm$ 100 mVdc, 2  $\pm$  0.1 A current limit, and then disable the output.
2. Connect the output of PS 1 to J1 (DC+, DC-).
3. Connect a voltage meter across J1 (DC+, DC-).
4. Connect the output of load 1 in series with a current meter (multimeter) to J2 (CHGIN) and J3 (GND). Turn on the power of load 1. Set the load current to 1.5 A  $\pm$ 50 mA, but disable the output.
5. Connect the output of load 2 in series with a current meter (multimeter) to J4 (BAT+, BAT-).
6. Connect a voltage meter across J4 (BAT+, BAT-).
7. Set the voltage of load 2 to 3.6 V  $\pm$ 0.1 V, and disable output of load 2.
8. JP1: ON, JP2 (BATEN, GND): ON, JP3: OFF, JP4: ON, JP5: ON, JP6: ON, JP7: OFF.

After the preceding steps have been taken, the test setup for HPA666 (bq24351 DSG EVM) appears as is shown in [Figure 1](#).



**Figure 1. Original Test Setup for HPA666 (bq24351 DSG EVM)**

## 2.4 Procedure

### 2.4.1 Charger Current and Voltage Regulation

1. Ensure that steps in [Section 2.3](#) are followed.
2. Enable output of PS 1.
3. Increase the output voltage of PS 1 to 5 V  $\pm$ 0.1 V.
4. Enable the output of load 2.  
*Measure*  $\rightarrow V(J2(OUT)) = 3.6 \text{ V} \pm 200 \text{ mV}$   
*Measure*  $\rightarrow I_{bat} = 560 \text{ mA} \pm 70 \text{ mA}$   
*Observe*  $\rightarrow D2 \text{ on, } D3 \text{ on, } D6 \text{ off, } D7 \text{ on.}$

### 2.4.2 CFET Input Overvoltage Protection

1. Increase the voltage of PS 1 to 11 V  $\pm$ 0.1 V.  
*Observe*  $\rightarrow D2 \text{ on, } D3 \text{ off, } D6 \text{ off, } D7 \text{ off.}$
2. Decrease the voltage of PS 1 to 5 V  $\pm$ 0.1 V.  
*Observe*  $\rightarrow D2 \text{ on, } D3 \text{ on, } D6 \text{ off, } D7 \text{ on.}$

### 2.4.3 CFET Load Overcurrent Protection

1. Enable the output of load 1.  
*Observe*  $\rightarrow D2 \text{ on, } D3 \text{ off, } D6 \text{ off, } D7 \text{ off.}$
2. Disable the output of load 1.  
*Observe*  $\rightarrow D2 \text{ on, } D3 \text{ on, } D6 \text{ off, } D7 \text{ on.}$
3. Decrease the voltage of PS 1 to 0 V  $\pm$ 0.1 V.

## 3 PCB Layout Guideline

1. It is critical that the exposed thermal pad on the back side of the bq24351 package be soldered to the printed-circuit board (PCB) ground. Ensure that sufficient thermal vias are located underneath the IC, connecting to the ground plane on the other layers.
2. The high-current charge paths into ACIN and from the CHGIN and OUT pins must be sized appropriately for the maximum charge current in order to avoid excessive voltage drops in these traces.
3. Decoupling capacitors for ACIN and CHGIN must be placed to make the interconnections to the IC as short as possible.
4. Resistors for VBAT pin must be placed close to the corresponding IC pins and make the interconnections to the IC as short as possible.

## 4 Bill of Materials, Board Layout, and Schematic

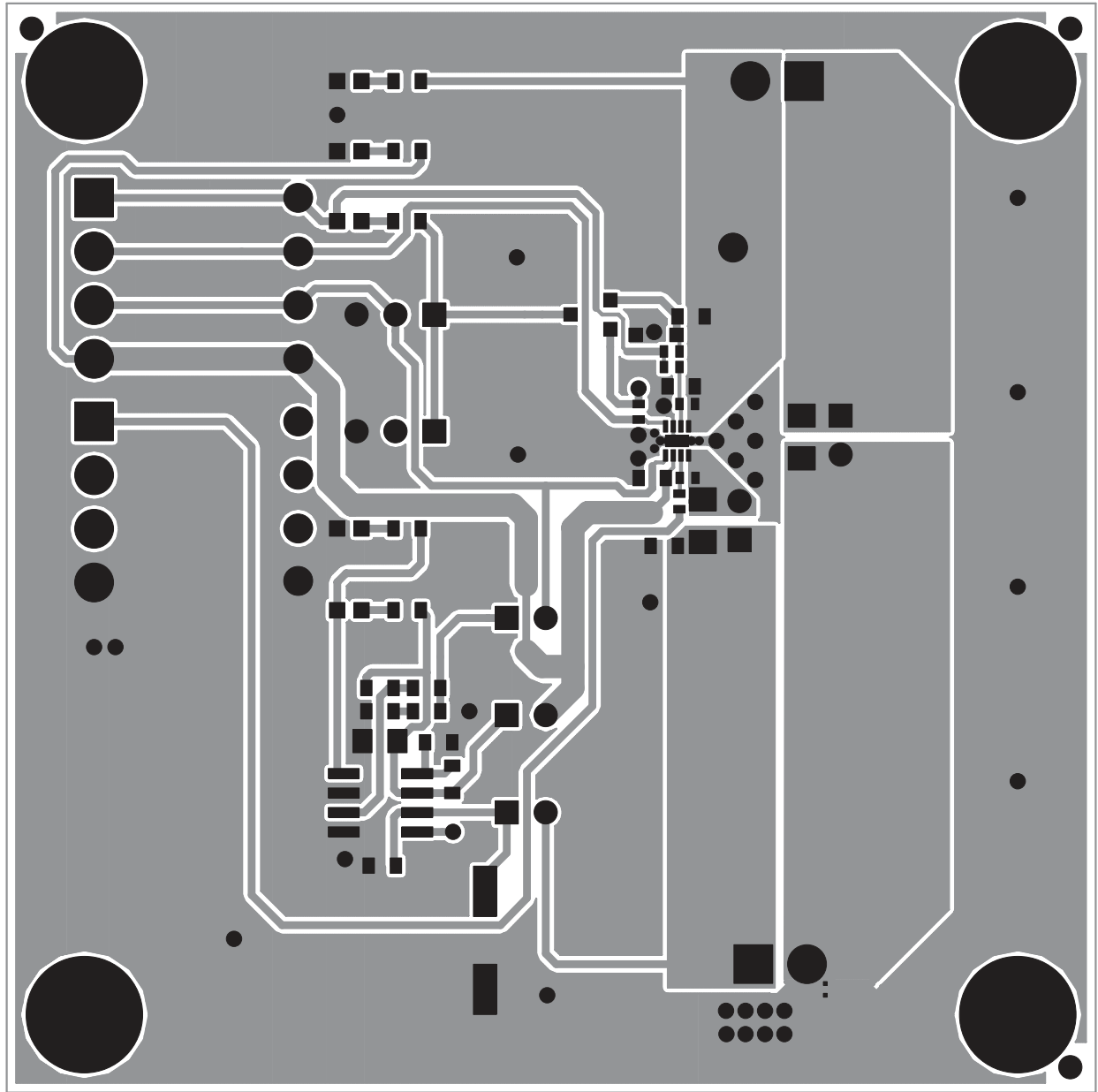
### 4.1 Bill of Materials

**Table 1. Bill of Materials**

bq24351	RefDes	Value	Description	Size	Part Number	MFR
1	C1	1 $\mu$ F	Capacitor, ceramic, 35-V, X5R, 10%	603	Std	Std
3	C2, C3, C5	1 $\mu$ F	Capacitor, ceramic, 10-V, X7R, 10%	603	Std	Std
1	C4	0.1 $\mu$ F	Capacitor, ceramic, 16-V, X7R, 10%	805	Std	Std
1	C6	0.1 $\mu$ F	Capacitor, ceramic, 10-V, X7R, 10%	603	Std	Std
1	C7	220 $\mu$ F	Capacitor, electrolytic, 25-V, 20%	0.327 inch x 0.327 inch (8.3 mm x 8.3 mm)	UUD1E221MNL1GS	Nichicon
1	D1	BZT52C6V8S	Diode, zener, 200-mW, 6.8-V	SOD-323	BZT52C6V8S	General
3	D2, D3, D6	Green	Diode, LED, green, 2.1-V, 20-mA, 6-mcd	603	LTST-C190GKT	LITE-ON
2	D4, D7	Red	Diode, LED, red, 2.1-V, 20-mA, 6-mcd	603	LTST-C190CKT	Lite-On
1	D5	BAT54C	Diode, dual Schottky, 200-mA, 30-V	SOT23	BAT54C	Vishay/LITE-ON
2	J1, J4	ED1514/2DS	Terminal block, 2-pin, 6-A, 3.5-mm	0.27 inch x 0.25 inch (6.86 mm x 6.35 mm)	ED1514/2DS	OST
2	J2, J3	ED1516/4DS	Terminal block, 4-pin, 6-A, 3.5-mm	0.55 inch x 0.25 inch (14 mm x 6.35 mm)	ED1516/4DS	OST
5	JP1, JP4, JP5, JP6, JP7	PEC02SAAN	Header, 2-pin, 100-mil (2.54-mm) spacing	0.100 inch (2.54 mm) x 2	PEC02SAAN	Sullins
2	JP2, JP3	PTC03SAAN	Header, male 3-pin, 100-mil (2.54-mm) spacing, (36-pin strip)	0.100 inch (2.54 mm) x 3	PTC03SAAN	Sullins
5		929950-00	Shorting jumpers, 2-pin, 100-mil (2.54-mm) spacing		929950-00	3M/ESD
2	R1, R2	0	Resistor, chip, 1/16-W, 1%	402	Std	Std
0	R3, R4	0	Resistor, chip, 1/16-W, 1%	402	Std	Std
2	R5, R6	200 k $\Omega$	Resistor, chip, 1/16-W, 5%	402	Std	Std
2	R7, R8	200 k $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
2	R9, R10	0.2 $\Omega$	Resistor, metal film, 1/4-W, 1%	1206	Std	Std
1	R11	20 k $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
1	R12	100 k $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
1	R13	100 $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
1	R14	6.2 k $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
4	R15, R16, R17, R18	1.5 k $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
1	R19	51 $\Omega$	Resistor, chip, 1/16-W, 5%	603	Std	Std
4			6-32 NYL nuts	NY HN 632	H620-ND	Building Fasteners
4	ST1, ST2, ST3, ST4	4816	Standoff, M/F, hex 6-32 NYL, 0.500 inch (12.7 mm)	sf_thvt_325_rnd	4816	Keystone
8	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	White	Test point, white, thru hole, color-keyed	0.100 x 0.100 inch (2.54 mm x 2.54 mm)	5002	Keystone
1	TP9	White	Test point, white, thru hole, color-keyed	0.100 x 0.100 inch (2.54 mm x 2.54 mm)	5001	Keystone
1	U1	bq24351DSG	IC, overvoltage and overcurrent charger front-end	SON-8	bq24351DSG	TI
1	U2	bq2057CSN	IC, charge management, one- or two-cell Li-Ion or Li-Pol charger	SOIC(SN)	bq2057CSN	TI
1	—	HPA666	PCB, 2.8-inch x 2.8-inch x 0.062-inch (7.11-cm x 7.11-cm x 1.58-mm)		PCB	Any

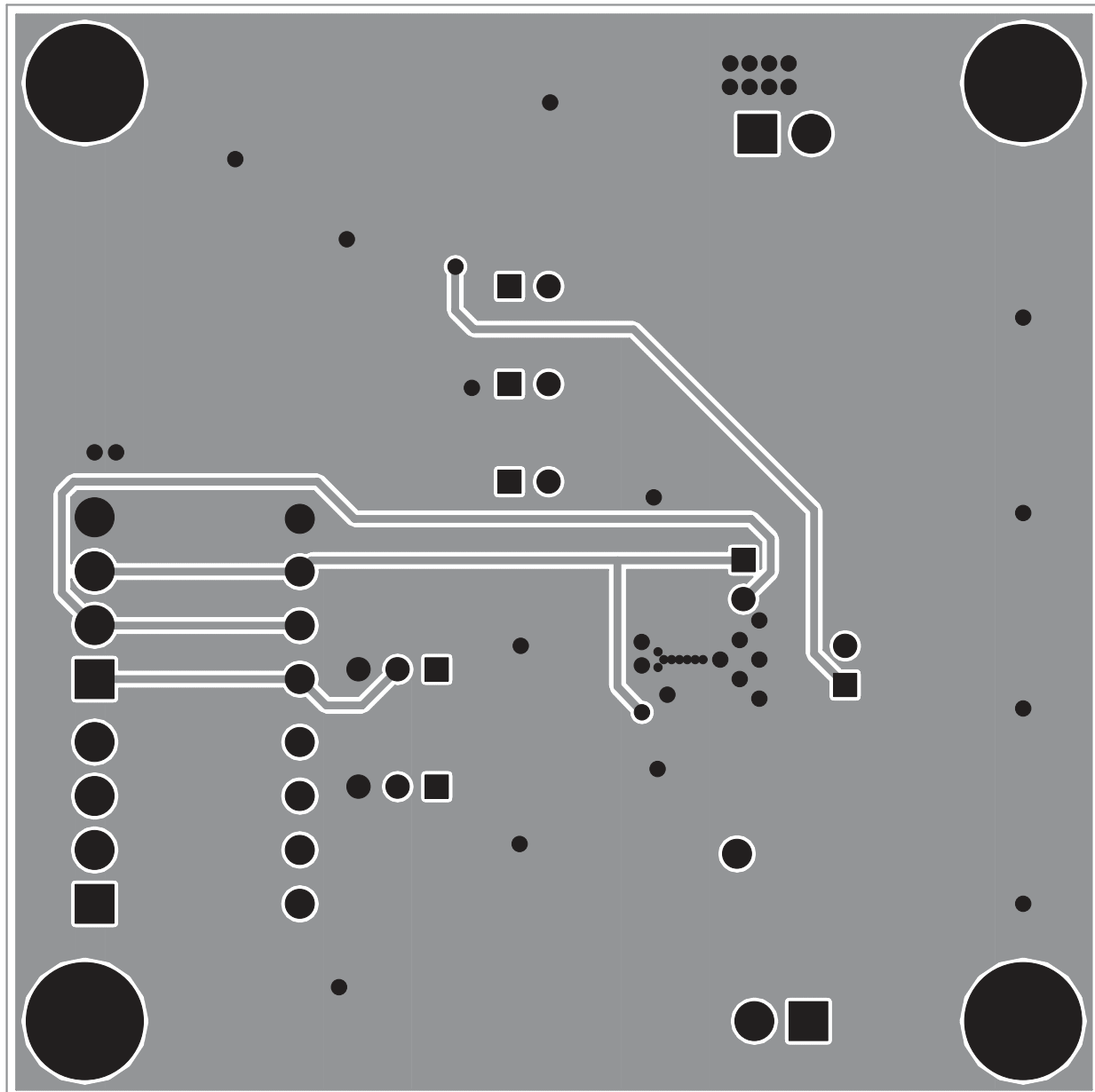
Notes: 1. Number 0 in left side columns means do not use this component.  
 2. Std in part number column means standard manufacturer's part number.

## 4.2 Board Layout



C001

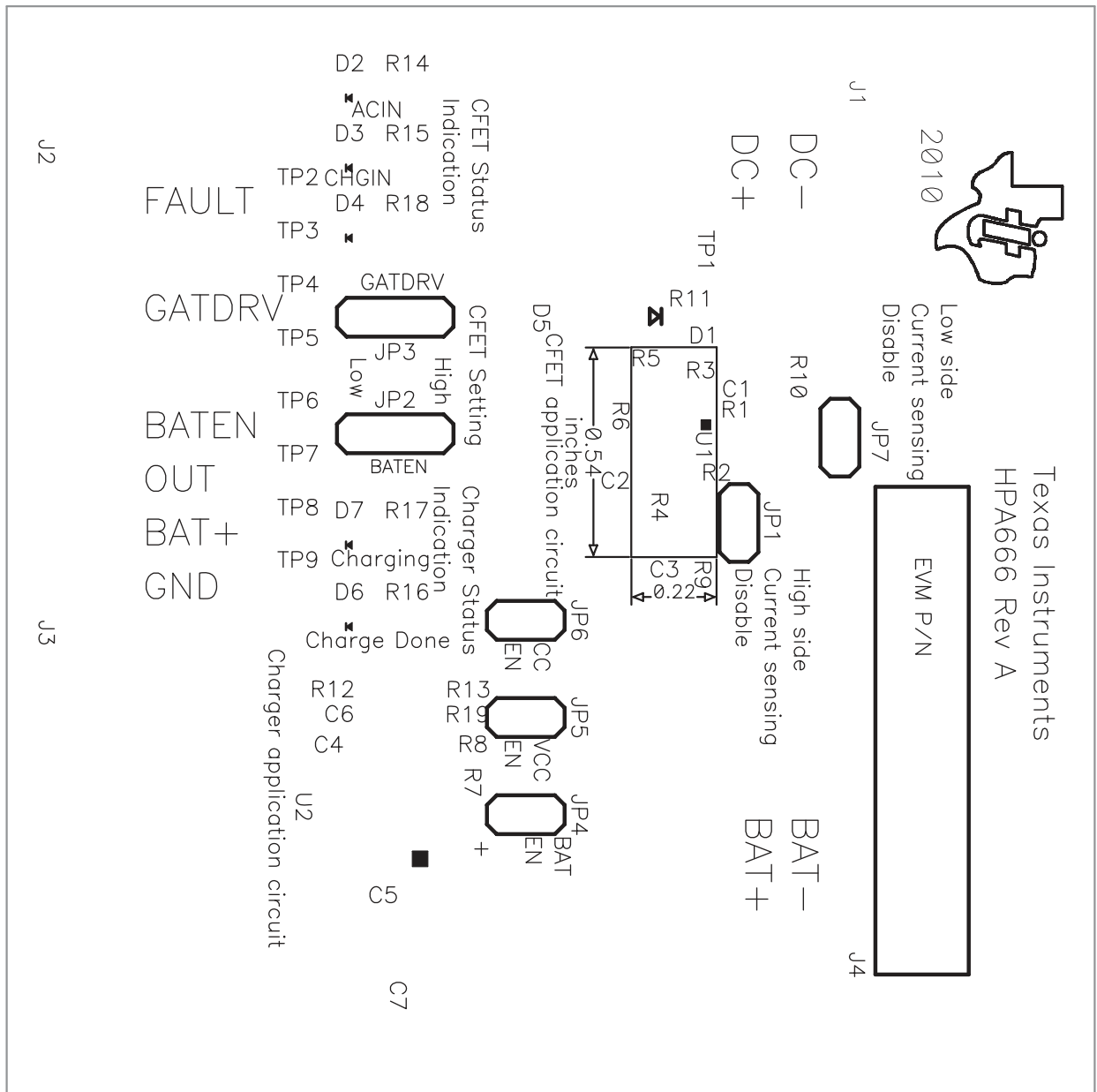
Figure 2. Top Layer



C002

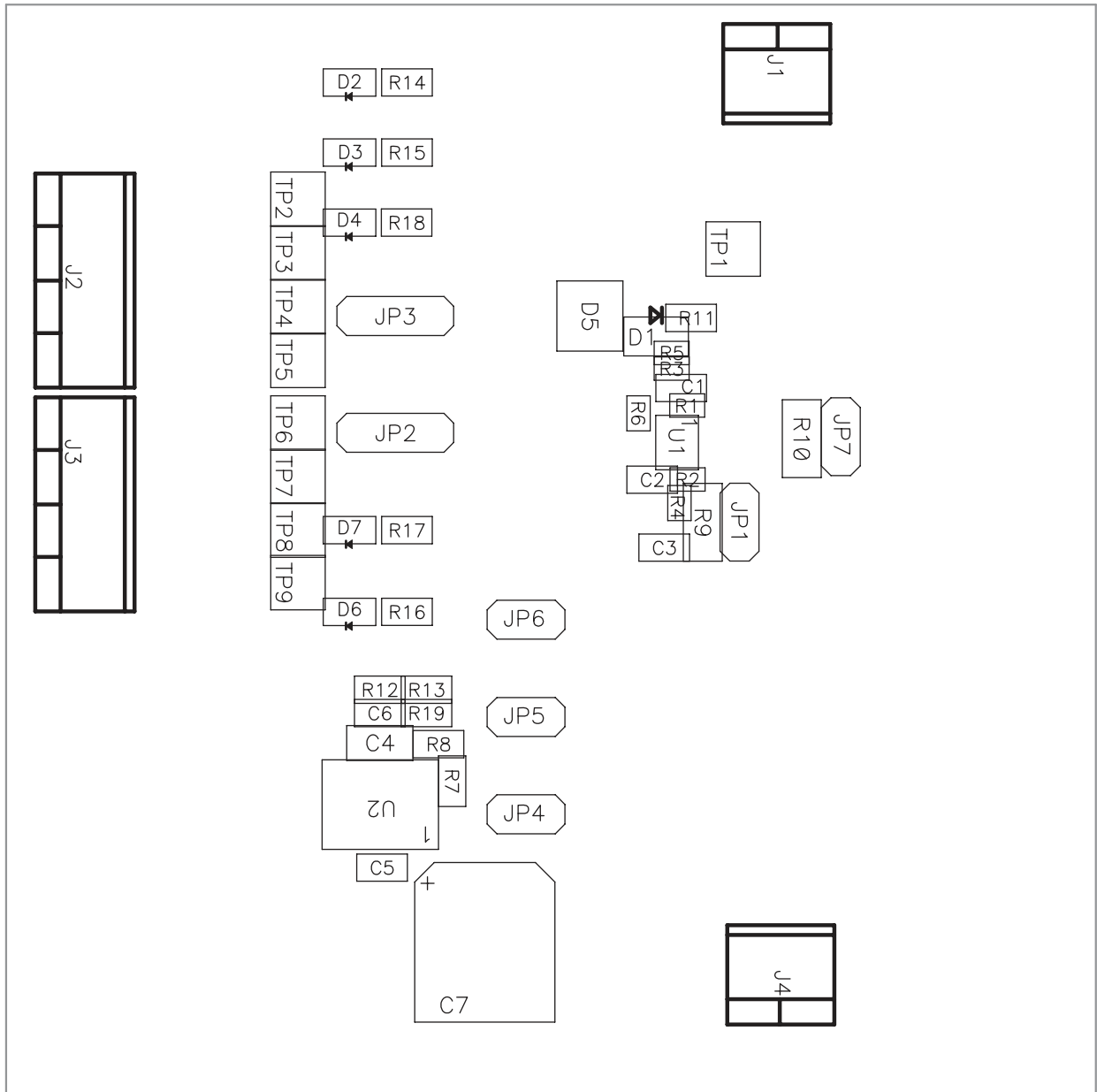
Figure 3. Bottom Layer





C003

Figure 4. Top Silk Screen



C004

Figure 5. Top Assembly

### 4.3 Schematic

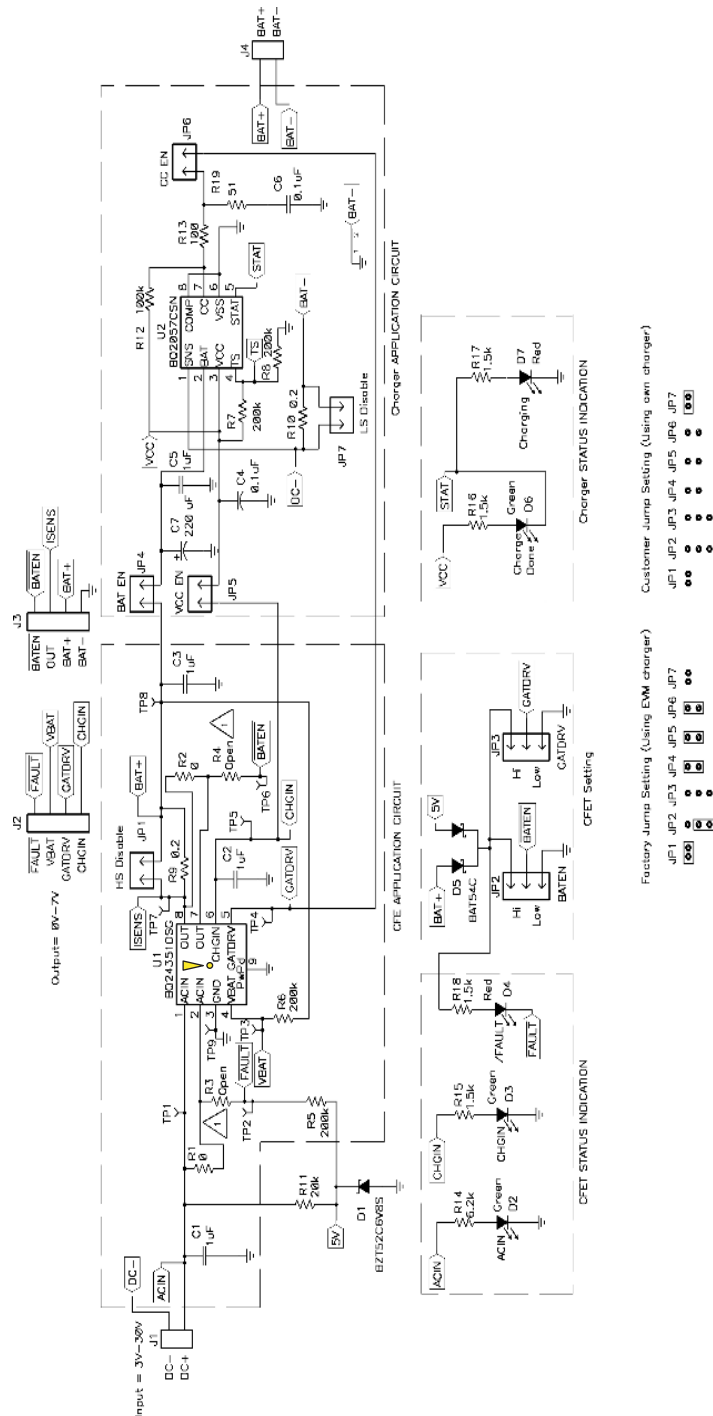


Figure 6. bq24351 Schematic

CAUTION: Device may have surface temperature in excess of 60°C when unit is operational.

Not indicated

## 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](http://www.ti.com/esh).

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.

## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 4.5 V to 26 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 125°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 © 2010, 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 TI 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. Information of third parties may be subject to additional restrictions.

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:

<b>Products</b>		<b>Applications</b>	
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</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>	Space, Avionics & Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless-apps">www.ti.com/wireless-apps</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2010, Texas Instruments Incorporated