bq27000 Single Cell Battery Fuel Gauge Evaluation Module

The bq27000EVM is a complete evaluation system for the bq27000 single cell Li-Ion and Li-Polymer battery gas gauge device.

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1 Introduction

The bq27000EVM includes one bq27000 circuit module, an EV2300 PC interface board for gas gauge evaluation, a USB cable, CD ROM including windows-based PC software and support documentation. The circuit module includes one bq27000, a current sense resistor and all other components on-board necessary to calculate remaining battery capacity and predict system run-time to empty. The circuit module connects directly across the cell in a battery. With the PC interface board and software, the user can read the bq27000 data registers, program the on-chip configuration EEPROM, and evaluate the functions of the bq27000 under different charge and discharge conditions.

1.1 Features

- Complete evaluation system for the bq27000 battery gas gauge
- Populated circuit module for quick setup
- PC software and interface board for easy evaluation
- Software allows EEPROM programming and data logging for system analysis

1.2 Kit Contents

1. bq27000 circuit module with sense resistor
2. PC interface board (EV2300 for USB interface)
3. CD ROM including windows-based PC software and support documentation
4. USB cable
5. Set of support documentation

1.3 Ordering Information

Table 1. Ordering Information

EVM PART NUMBER	PC INTERFACE BOARD	CHEMISTRY	PACK VOLTAGE	CAPACITY
BQ27000EVM	USB	Li-Ion	2.6 v to 4.5 V	100 to 2000 mah

2 bq27000EVM Based Circuit Module

The bq27000EVM based circuit module is an example circuit for battery fuel gauging of a single cell Li-Ion/Li-Polymer battery pack. There are two separate circuits on the EVM module. One is the active bq27000 fuel gauging circuitry; the other is the logic and power control to program the on-chip configuration EEPROM of the bq27000. In a typical application, only the active fuel gauging circuitry is required. The EEPROM programming circuitry would be required in a test setup to configure the bq27000 for the application by programming the EEPROM.

Contacts on the circuit module provide direct connection to the cell (J1-1, J2-2), the serial communications port (J1-3). The system load and charger connect across J1-1 and J2-1.

Table 2. Test Points

TEST POINT	SIGNAL NAME	DESCRIPTION
J1-1	PACK+	Cell positive/pack positive
J1-2	SCL	Not used with this product
J1-3	SDA/HDQ	Single-wire HDQ line
J2-1	PACK–	Pack negative
J2-2	BAT–	Cell negative
J3-1	21V	High voltage for EEPROM programming
J3-2	PROG	Input for timing of EEPROM programming pulse
J3-3	GPIO/ADIN	GPIO pin of bq27000

3 bq27000EVM Circuit Module Schematic

Figure 1 shows the bq27000EVM circuit module schematic diagram.

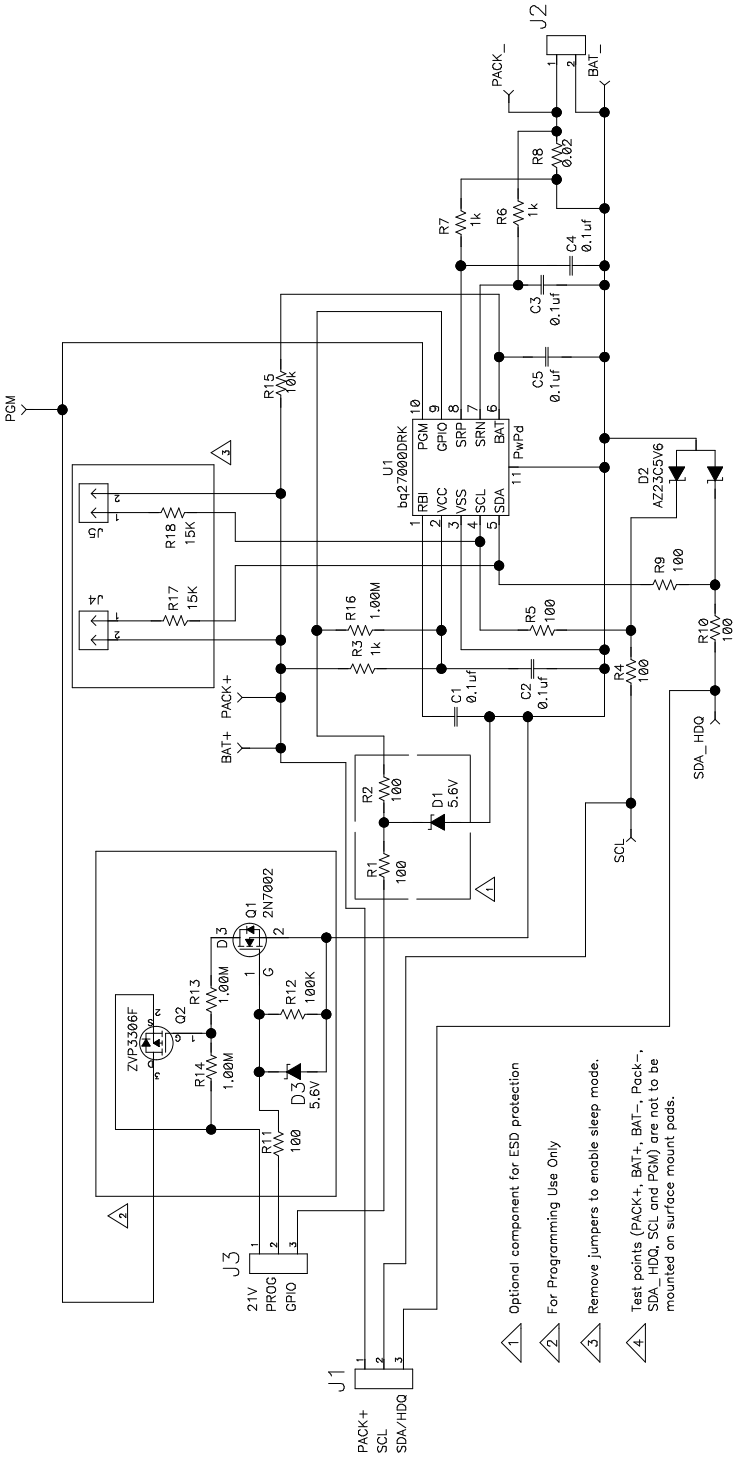

Figure 1. bq27000EVM Schematic

4 Circuit Module Physical Layouts

Figure 2, Figure 3, Figure 4, Figure 5,Figure 6, and Figure 7 shows the PCB layers and assembly drawing for the bq27000EVM circuit module.

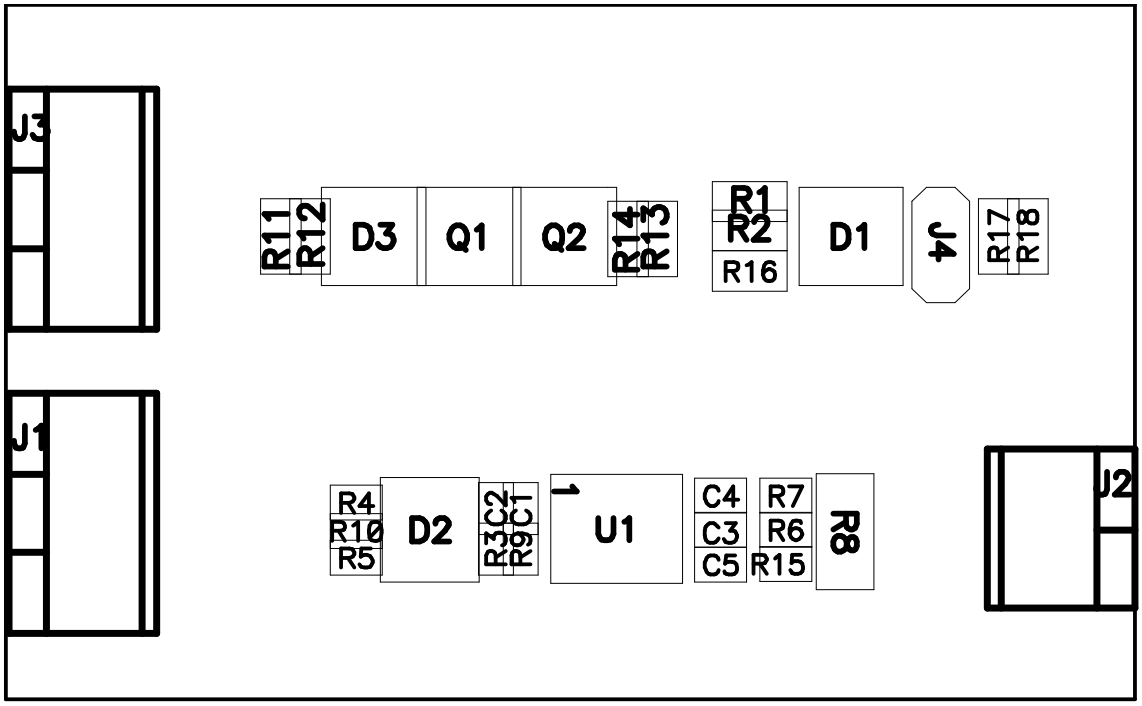

Figure 2. bq27000EVM Topside Assembly

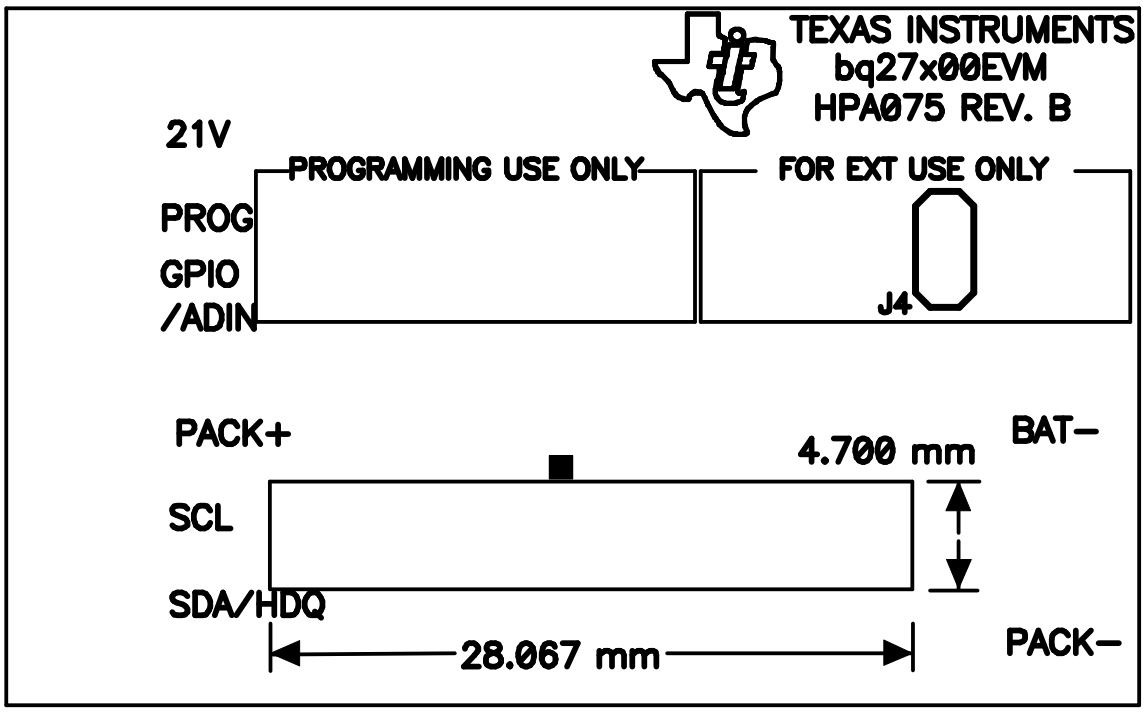

Figure 3. bq27000EVM Silkscreen

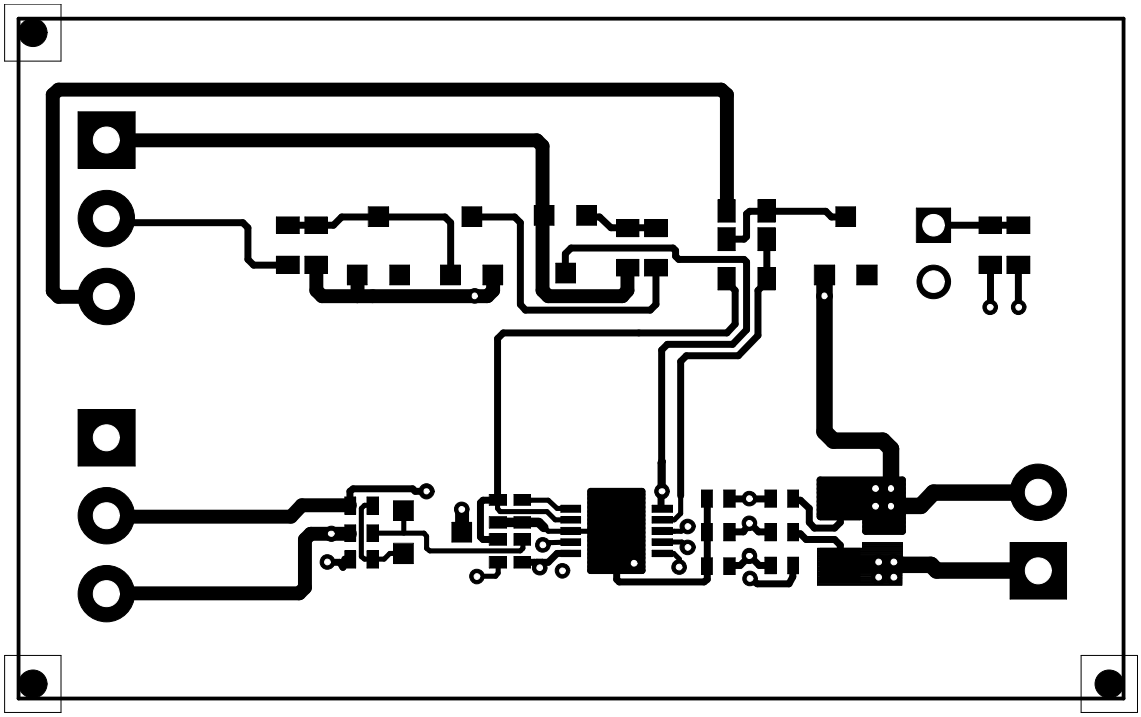

Figure 4. bq27000EVM Layer 1 Layout

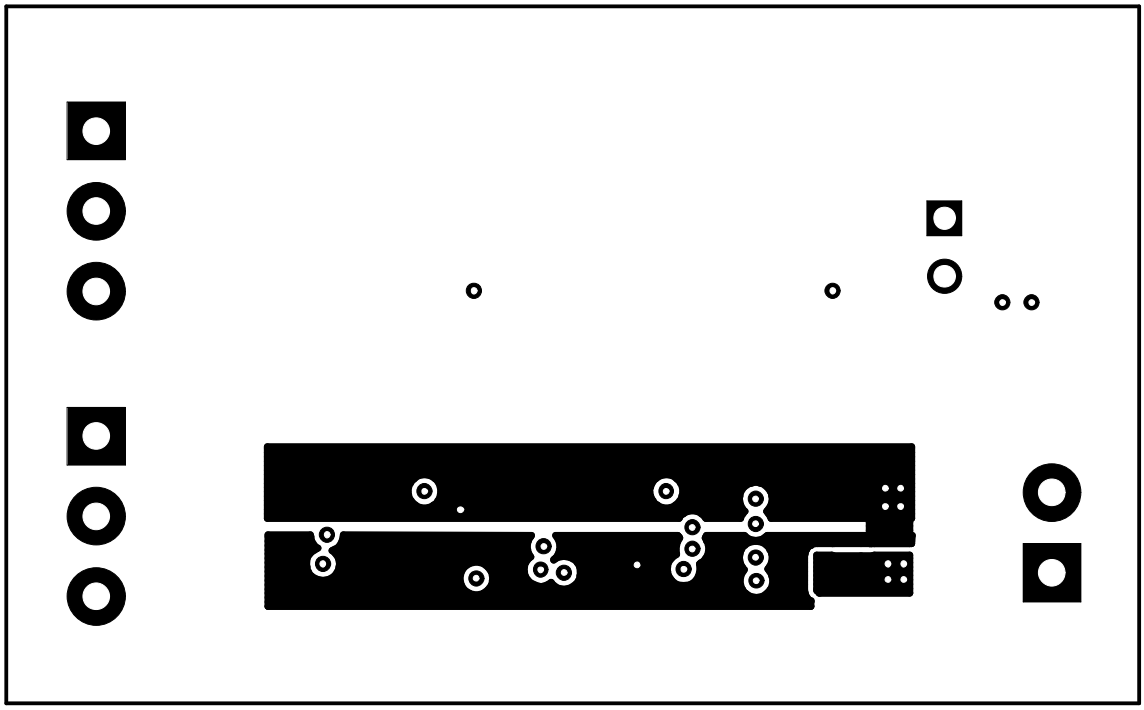

Figure 5. bq27000EVM Layer 2 Layout

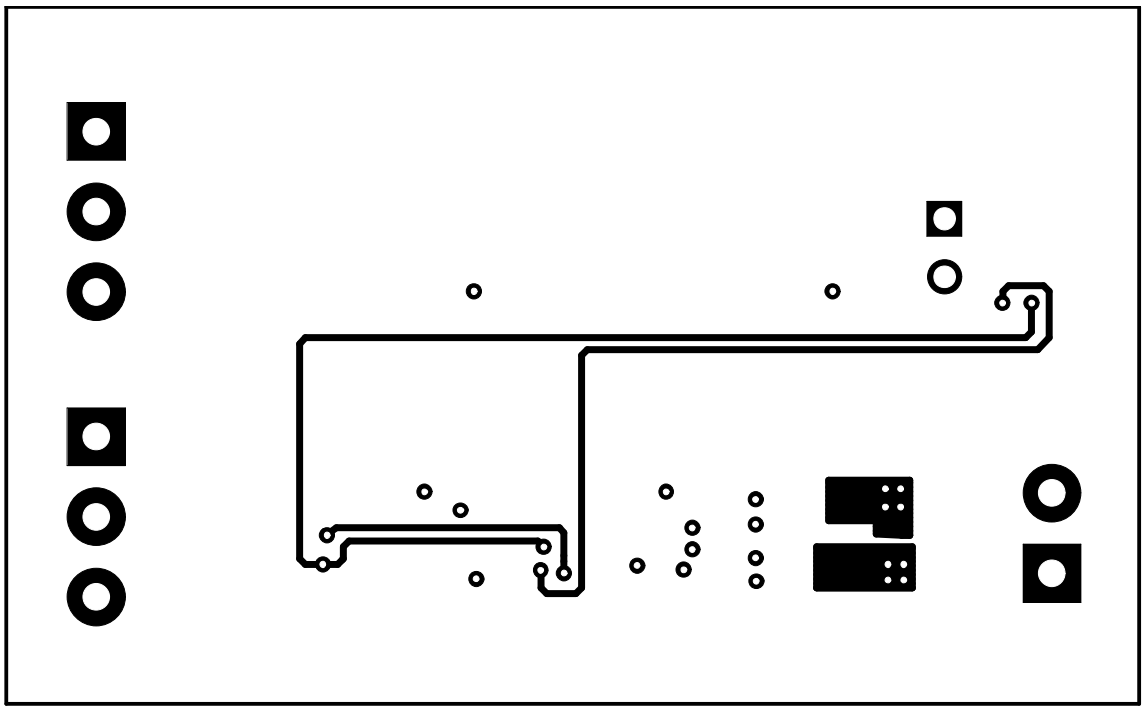

Figure 6. bq27000EVM Layer 3 Layout

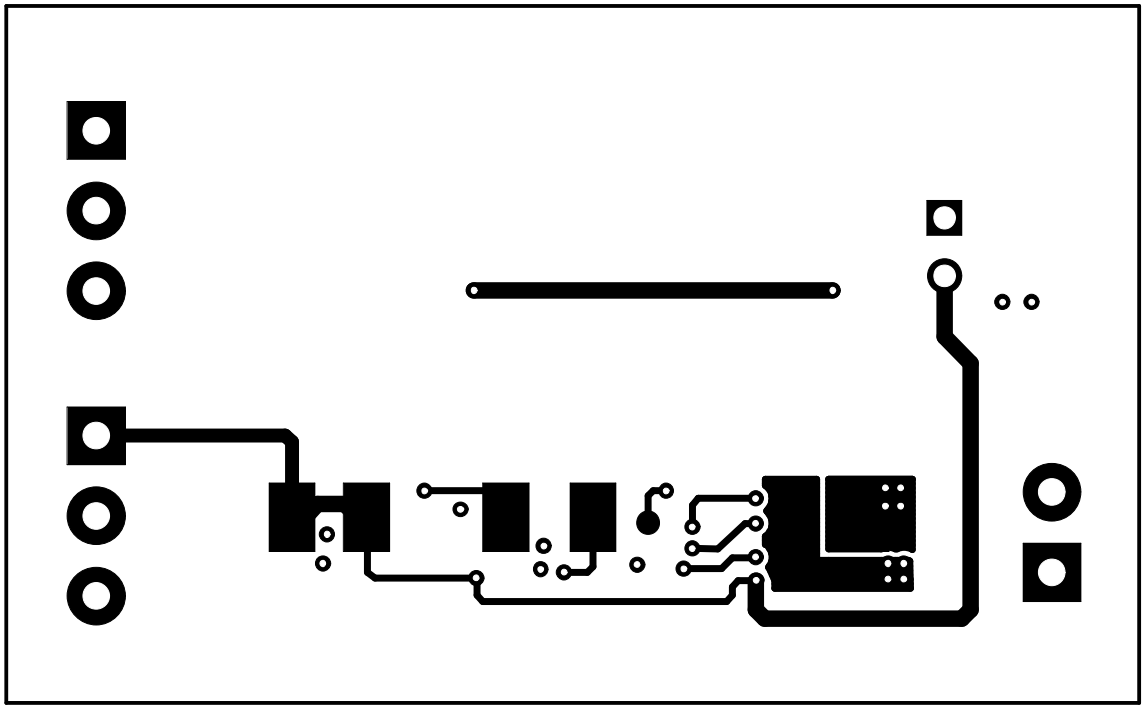

Figure 7. bq27000EVM Layer 4 Layout

5 bq27000EVM Circuit Module List of Materials

Table 3 contains the list of materials required for the bq27000EVM circuit module.

Table 3. List of Materials

REF DES	QTY	DESCRIPTION	MFR	PART NUMBER
C1, C2, C3, C4, C5	5	Capacitor, ceramic, 0.1 µF, 10 V, X5R, 402	Murata	GRM155R61A104KA01D
D1, D3	2	Diode, Zener, 5.6 V, 350 mW, SOT23	Diodes, Inc.	BZX84C5V6T
D2	1	Diode, Dual, Zener, 5.6 V, 300 mW, SOT23	Diodes, Inc.	AZ23C5V6
Q1	1	MOSFET, N-channel, 2N7002, 60 V, 250 mA, 3 Ω, SOT23	Vishay-Siliconix	2N7002E
Q2	1	MOSFET, P-channel, ZVP3306, –60 V, 0.09 A, 14 Ω, SOT23	Zetex	ZVP3306
R1, R2, R11	3	Resistor, chip, 100 Ω, 1/16 W, 5%, 603	Std	Std
R13, R14, R16	3	Resistor, chip, 1 MΩ, 1/16 W, 5%, 603	Std	Std
R12	1	Resistor, chip, 100 kΩ, 1/16 W, 5%, 603	Std	Std
R3	1	Resistor, chip, 1 kΩ, 1/16 W, 5%, 402	Std	Std
R4, R5, R9, R10	4	Resistor, chip, 100 Ω, 1/16 W, 5%, 402	Std	Std
R6, R7, R15	3	Resisitor, chip, 10 Ω, 1/16 W, 5%, 402	Std	Std
R8	1	Resistor, chip, 0.02 Ω, 0.25 W, 1%, 1206	Vishay	WSL1206
U1	1	Single cell Li-Ion/Polymer gas gauge device, QFN	Texas Instruments	bq27000DRK
J1, J3	2	Terminal blocks, 3 position	OST	ED1515
J2	1	Terminal blocks, 2 position	OST	ED1514
N/A	1	PCB	Any	HPA033

6 bq27000EVM Circuit Module Performance Specification Summary

Table 4 gives the performance specifications of the bq27000EVM circuit module.

Table 4. Performance Specification Summary

SPECIFICATION	MIN	TYP	MAX	UNIT
Input Voltage PACK+/BAT–	2.6		4.5	V
Charge and Discharge Current (1)			2.5	A

(1) Charge and discharge max. is limited by the PCB design and power dissipation of the 20-mΩ 1/4-W sense resistor included in the kit.

7 EVM Hardware and Software Setup

This section describes how to install the bq27000EVM PC software and how to connect the different components of the EVM.

7.1 Software Installation

The following steps install the bq27000 evaluation software:

1. Insert CD ROM into a CD ROM drive.
2. Select the CD ROM drive using **My Computer** or **File Manager**.
3. Select the ReadMeFirst.txt file.
4. Follow the instructions to install USB drivers for EV2300.
5. After installing the USB drivers for EV2300, double-click on the Setup.exe icon.
6. The setup program installs a windows application group

7.2 Hardware Connection

There are three hardware components to the bq27000EVM:

- The bq27000EVM circuit module,
- The PC interface board, (EV2300)
- And the PC.

7.2.1 Connecting the bq27000EVM Circuit Module to a Battery Pack

Figure 8 shows how to connect the bq27000EVM circuit module to a Li-Ion cell and the system load/charger.

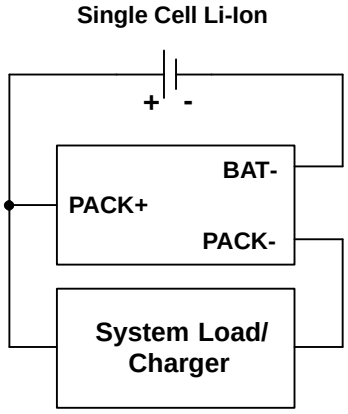

Figure 8. bq27000EVM Circuit Module Connection to Cells and System Load/Charger

7.2.2 PC Interface Connection

The following steps configure the hardware for interface to the PC:

1. Connect colored wires that are included with EV2300 to bq27000EVM using Table 5 as a guide.
2. Connect the connector with colored wires to the HDQ connector that is on EV2300. HDQ connection is located on the top right of EV2300.
3. Connect the PC USB cable to the EV2300 and the PC USB port.

The bq27000EVM is now set up for operation.

Table 5. Circuit Module-to-EV2300 Connection

bq27000EVM	COLOR
SDA/HDQ	BROWN
PACK–	BLACK
PROG	WHITE
PACK+ (1)	RED

(1) This connection is not useful when using a system load, charger or a power source (battery or external power supply). The red wire of the EV2300 connector gives access to a low power 3.3V output when connected to HDQ section of EV2300. Shield this wire when not in use to avoid contacts with other connections such as ground.

8 Operation

8.1 Starting the Program

Run the program from the **Start|Programs|Texas Instruments|bq27X00 Battery Gas Gauge** menu sequence. The software defaults to PC USB port for communication. If the EV2300 is connected to USB port, the program should load and display the initial data screen. If it is the first time that the program is used then the user will be prompted to select between bq27000 or bq27200. Select bq27000 (HDQ) and then press continue button.

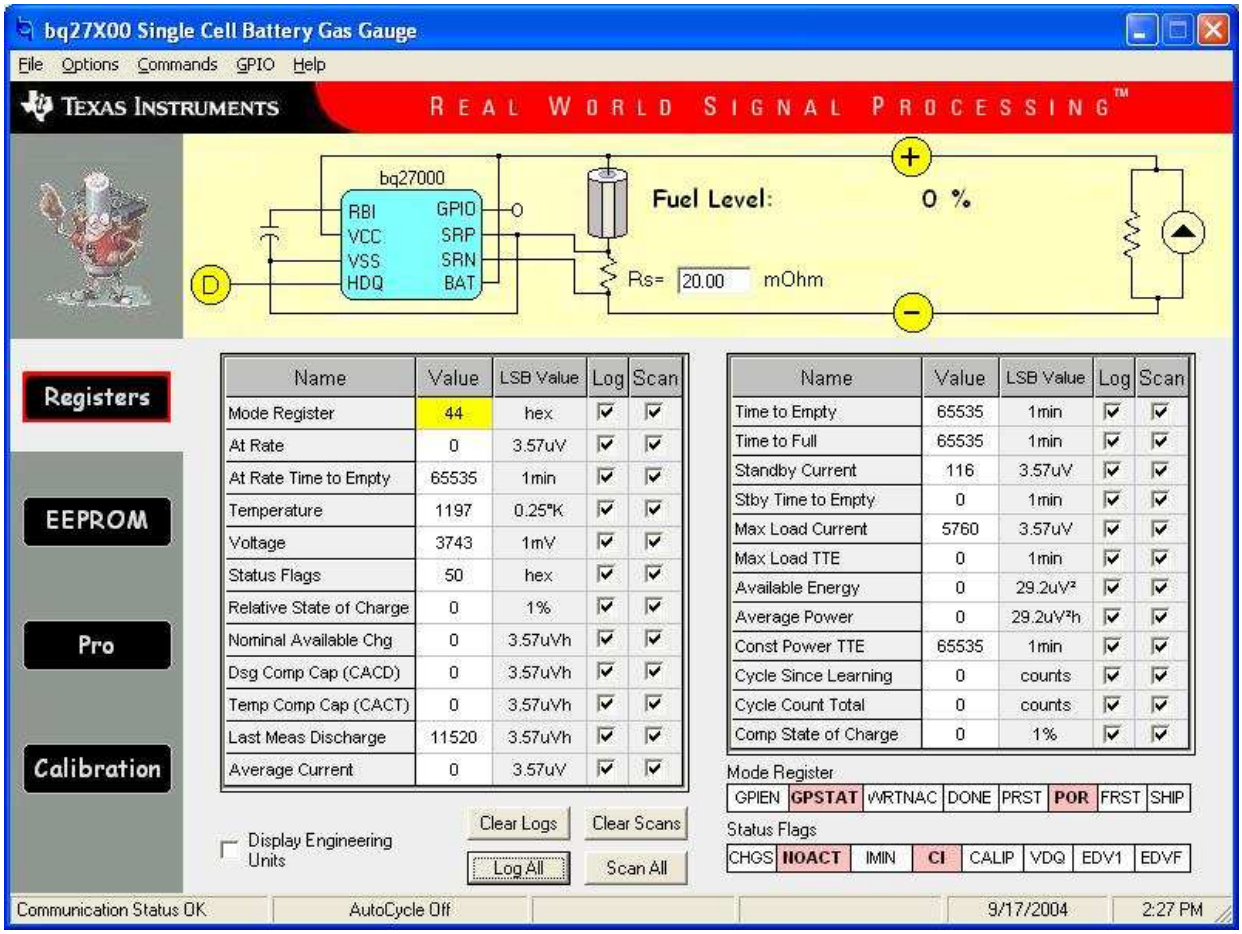

Figure 9. Initital Register Screen

If the EV2300 is not connected to a USB port, the program will display a USB error message and then display the initial data screen with no data in the register locations.

The com port can be changed by selecting the port under the options menu.

8.2 Initialization

This section describes the settings that must be made before the bq27000 is evaluated.

8.2.1 Loading the Sense Resistor Value

The bq27000EVM comes with a 20-mΩ sense resistor on the circuit board. Make sure the sense resistor value is entered in the RS box at the top of the initial register screen. This value is used by the PC program to convert the bq27000 data set to engineering units. Checking the display engineering units box displays the data set in engineering units. No check mark displays the data set just as the bq27000 calculates them, i.e., in units of 3.57-µVh counts.

8.2.2 Programming the bq27000 EEPROM

Each bq27000 is programmed at the factory with default values in the EEPROM. The values in EEPROM should be changed to match specific applications. The EEPROM values can be read by using the EEPROM screen.

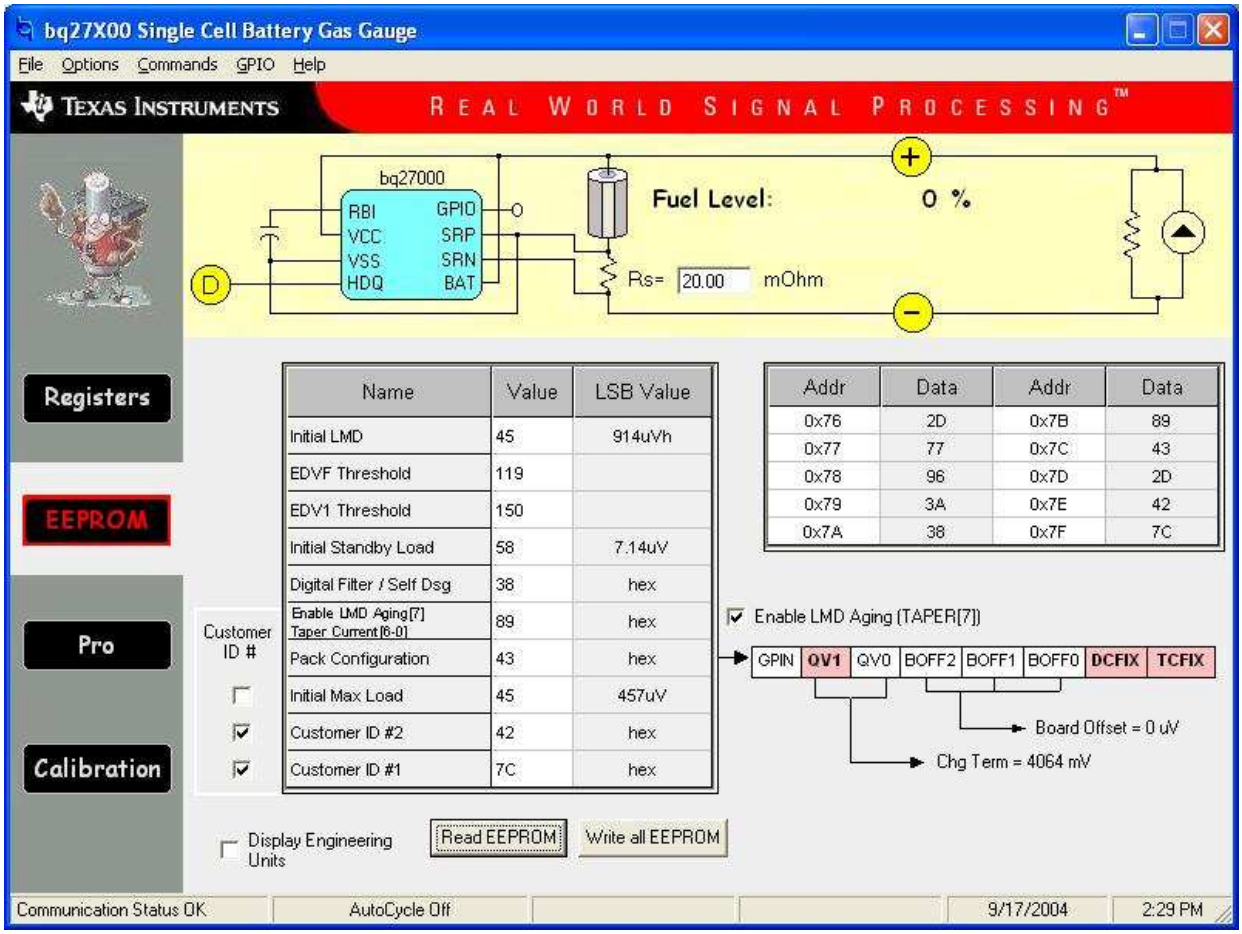

Figure 10. EEPROM Screen

The values in the EEPROM can be easily changed using the EVMs auto programming feature. To use the auto program feature:

1. Make sure VOUT of the EV2300 is connected to PROG of the EVM
2. Connect a 21-V supply across 21 V (J3-1) and BAT- (J2-2)

To change the EEPROM values simply click on the value to be changed, enter the new value, and press enter.

The EEPROM values can be stored in a file on the PC by using the **File|Save Gas Gauge Flash Constants** command from the pull down menu. Similarly, a saved file can be load by using the **File|Open Gas Gauge Flash Constants** command. Once the file is called up, the Write all EEPROM button can be used to write all the EEPROM values at once.

Note:
Changing EEPROM data affects critical aspects of the bq27000 operation. Please review the bq27000 data sheet to determine how to develop new data for the EEPROM based on your application. It is recommended to first save the default EEPROM data as a file first before changing the data. In this way, the default data programming can easily be restored.

The bq27000 automatically uses the new EEPROM in its calculations once programmed.

8.2.3 Resetting the bq27000

The bq27000 can be reset at anytime by using the **Options|Special Options|Reset bq27000** from the pulldown menu. When reset, the bq27000 loads the configuration values from EEPROM and set the remaining capacity registers to zero.

8.3 The Registers Screen

In the Registers screen all of bq27000's RAM registers are displayed.

8.3.1 Options Menu

This menu allows the user to select among different options. These options include whether or not to enable scan of registers, select the file logging time rate, select the type of communication protocol (HDQ or I2C) and select the type of communication interface (EV2300 or EV2200).

8.3.2 Commands Menu

With bq27000 there are several commands that are performed by setting the appropriate bit in the MODE register and then writing 0xA9 into address 0x00. With the Commands menu of the EVSW the user may perform the commands automatically. Among the selections are:

- WRTNAC - If a user desires to write the NAC register to a specific value, the user would write that value to the AT RATE register and then select WRTNAC from the Commands menu.
- DONE - The user selects DONE when charging is complete and the monitor is not able to detect taper current. It forces an update of internal registers to represent a full battery condition.
- PRST - This command causes a reset except that NAC, LMD and the CI bit in FLAGS register are not restored to initial values. This command is intended for manufacturing use.
- FRST - This command will re-initialize all RAM registers. This command is intended for manufacturing use.
- SHIP - Once this command is given the bq27000 will enter ship mode if the HDQ has been pulled low for at least 18 seconds. A full reset is forced when the part leaves ship mode.

8.3.3 GPIO Menu

This menu selects the function of the GPIO pin as an ouptut or input. If selected as an output, the open drain output can be set to on or off.

8.4 The EEPROM Screen

The EEPROM screen allows the user to read and write the 10 EEPROM registers of bq27000. There are checkboxes (*Enable LMD Aging*, *Customer ID #*) that when its status are changed it will cause an automatic write to the EEPROM to ensure that the selections apply accordingly. Always when writing to the EEPROM ensure that the 21V pulse to PROG pin is available.

When selecting the status of Customer ID #1 (DCOMP) and Customer ID #2 (TCOMP), the DCFIX and TCFIX bits in the Pack Configuration EEPROM register will also be written. For example, if the DCOMP is set for discharge compensation then the DCFIX bit will be clear. If the DCOMP register is selected to be used as Customer ID #2 then the DCFIX bit will be set.

The Taper Current EEPROM register includes the Taper Current value (bits 0-6) and the Enable Last Measure Discharge Aging (bit 7). When registers are displayed with engineering units, the value shown for Taper Current is just taking in consideration bits 0-6. The user must rely on the *Enable LMD Aging* checkbox to determine this feature. When registers are not displayed in engineering units, the value shown for Taper Current includes all 8 bits of this register represented in hex.

8.5 The Pro Screen

The pro screens allows the data location in the bq27000 to be addressed individually by entering the address to be read or the address and data to be written.

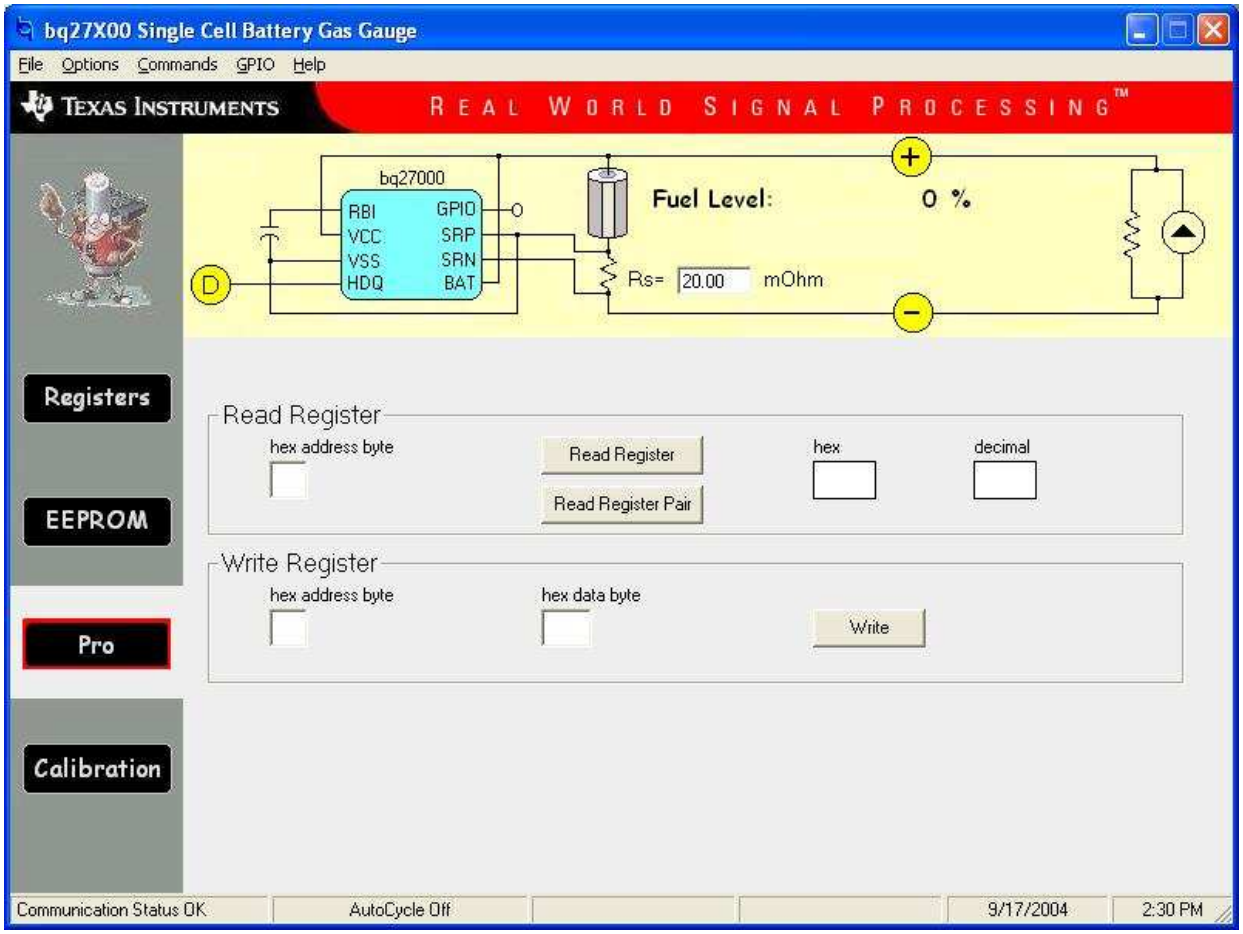

Figure 11. Pro Screen

8.6 The Calibration Screen

The Calibration screen allows the user to perform the CIO and CEO commands automatically. There are two ways to use the commands. Each command can be called individually or the board offset can be determined by selecting **Compute Board Offset** button. The result given by computing the board offset could be used to program the BOFF bits at the Pack Configuration EEPROM register.

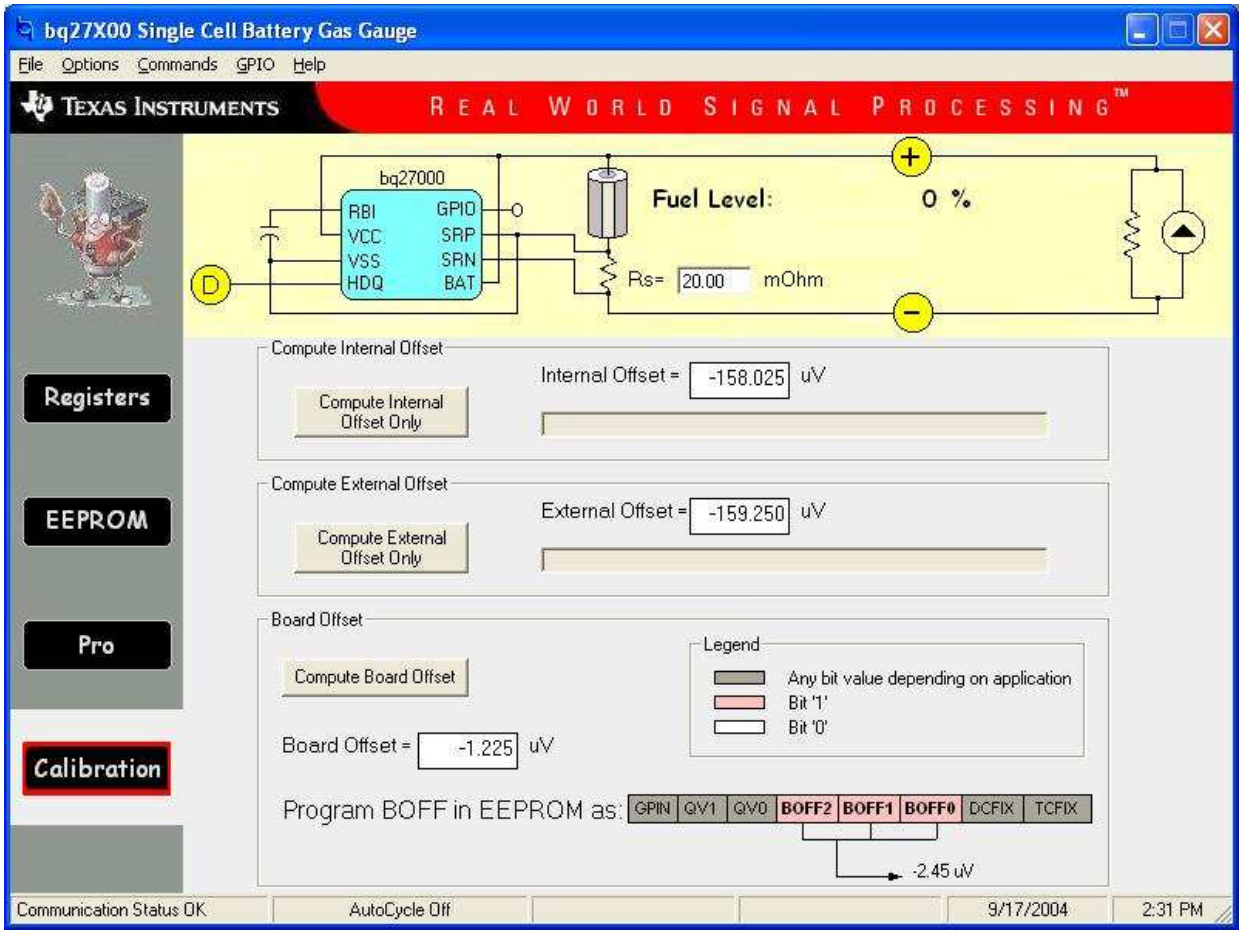

Figure 12. Calibration Screen

8.7 Data Logging

The bq27000 registers can be logged by using the data log function. To log the data and create a log file:

1. Select the registers to log by clicking on the corresponding **Log** box in each row of data.
2. **File|Start Data Log** from the pull-down menu.
3. Enter the name of the data log file in the **Name Datalog File** box
4. Click on the **Open** button
5. To stop the data logging select **File|Close Data Log** from the pull-down menu

The file can be imported into a text editor, spreadsheet, or word processor program.

Table 6. Example Data Log

SAMPLE	STAMP	ELAPSED (s)	VOLTAGE	NAC	TEMP COMP
1	3:31:30 PM	10	3829	1084.58	1084.58
2	3:31:40 PM	20	3829	1086.26	1086.26
3	3:31:50 PM	30	3832	1087.48	1087.48
4	3:32:00 PM	40	3800	1087.48	1087.48
5	3:32:10 PM	50	3786	1087.48	1087.48
6	3:32:20 PM	60	3786	1087.48	1087.48
7	3:32:30 PM	70	3630	1087.78	1087.78
8	3:32:40 PM	80	3622	1084.12	1064.91
9	3:32:50 PM	90	3614	1081.68	1062.47
10	3:33:00 PM	100	3609	1078.02	1060.03
11	3:33:10 PM	110	3603	1075.74	1033.34
12	3:33:20 PM	120	3754	1075.74	1033.34
13	3:33:30 PM	130	3762	1075.74	1033.34
14	3:33:40 PM	140	3765	1075.74	1033.34
15	3:33:50 PM	150	3767	1075.74	1033.34
16	3:34:00 PM	160	3622	1073.91	1032.73
17	3:34:10 PM	170	3609	1072.69	1032.73
18	3:34:20 PM	180	3598	1070.25	1032.73
19	3:34:30 PM	190	3593	1065.52	1032.73
20	3:34:40 PM	200	3695	1065.52	1032.73
21	3:34:50 PM	210	3810	1065.52	1032.73
22	3:35:00 PM	220	3810	1065.52	1032.73
23	3:35:10 PM	230	3813	1065.52	1032.73
24	3:35:20 PM	240	3767	1065.52	1032.73

FCC Warnings

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of 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.

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IMPORTANT: TI is providing the enclosed HPA075 evaluation module under the following conditions:

This evaluation module (EVM) being provided by Texas Instruments (TI) is intended for use for ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY and is not considered by Texas Instruments to be fit for commercial use. As such, this EVM may not be complete in terms of design and/or manufacturing related protective considerations including product safety measures typically found in the end-product incorporating the module. As a prototype, this product does not fall within the scope of the European Union Directive on electromagnetic compatibility and on low voltage and therefore may not meet the technical requirements of the directive. This EVM is not subject to the EU marking requirements.

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- The user assumes all responsibility and liability for proper and safe handling of the EVM. The user acknowledge that the use of the EVM could present serious hazards and that it is the user's responsibility to take all precautions for the handling and use of the EVMs in accordance with good laboratory practices. Please be aware that the products received may not be regulatory compliant or agency certified (FCC, UL, etc.). 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.
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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 2.6 V to 4.5 V and the output voltage range of 2.6 V to 4.5 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 25°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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