

bq27x10EVM Single-Cell Battery Fuel Gauge Evaluation Module

The bq27x10EVM is a complete evaluation system for the bq27x10 single-cell Li-ion and Li-polymer battery gas gauge device.

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1 Introduction

The bq27x10EVM includes one bq27x10EVM 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 bq27x10, a current sense resistor, and all other components onboard 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 bq27x10 data registers, program the on-chip configuration EEPROM, and evaluate the functions of the bq27x10 under different charge and discharge conditions.

1.1 Features

- Complete evaluation system for the bq27x10 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. bq27x10EVM 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
bq27x10EVM	USB	Li-Ion	2.6 v to 4.5 V	100 to 2000 mAh

2 bq27x10-Based Circuit Module

The bq27x10EVM-based circuit module is an example circuit for battery fuel gauging of a single-cell Li-ion/Li-polymer battery pack. The EVM module has two separate circuits. One is the active bq27x10 fuel gauging circuitry; the other is the logic and power control to program the on-chip configuration EEPROM of the bq27x10. 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 bq27x10 for the application by programming the EEPROM.

Contacts on the circuit module provide direct connection to the cell (J1-1, J2-2), and 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	Used only with bq27210 as the I2C Clock line
J1-3	SDA/HDQ	Single-wire HDQ line for bq27010 or I2C Data line for bq27210
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 bq27x10

3 bq27x10EVM Circuit Module Schematic

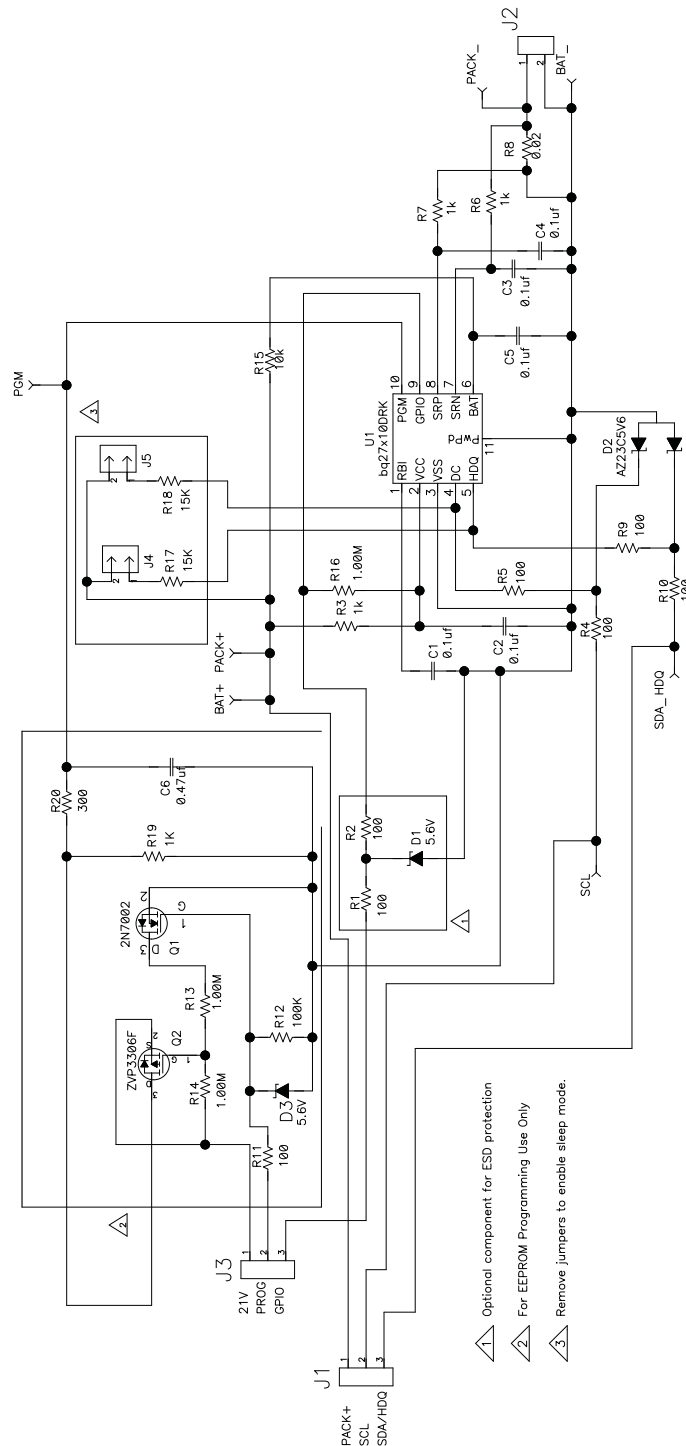


Figure 1. bq27x10EVM Schematic

4 bq27x10EVM Circuit Module Physical Layouts

Figure 2 through Figure 7 show the PCB layers and assembly drawing for the bq27x10EVM circuit module.

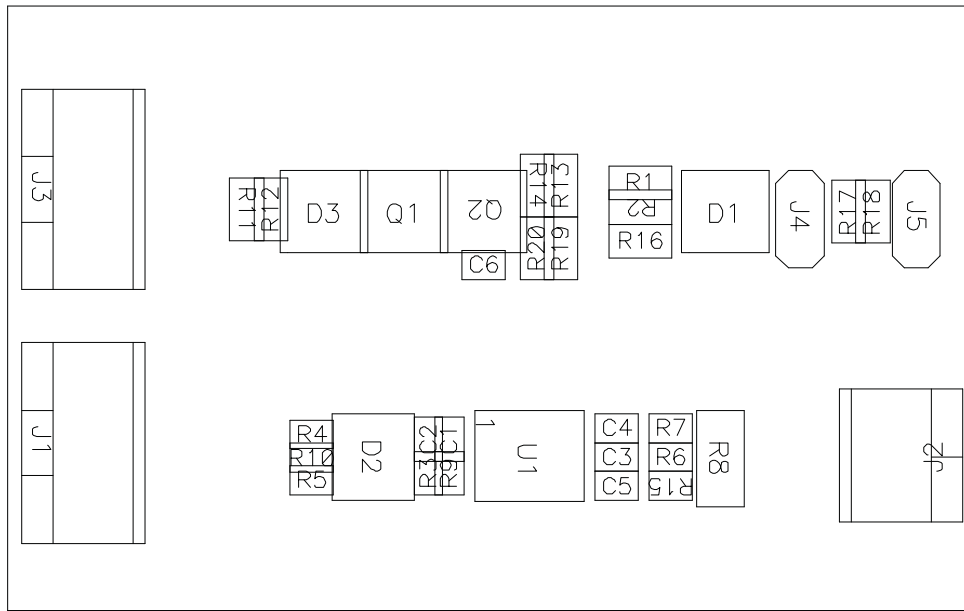


Figure 2. bq27x10EVM Topside Assembly

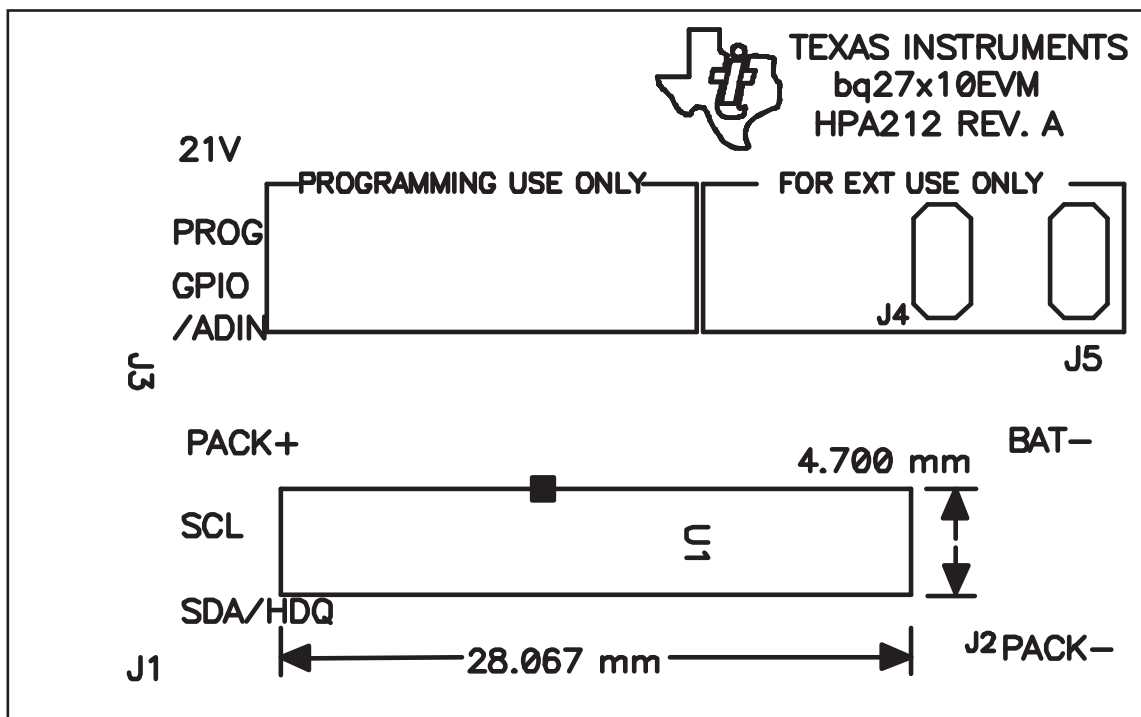


Figure 3. bq27x10EVM Silkscreen

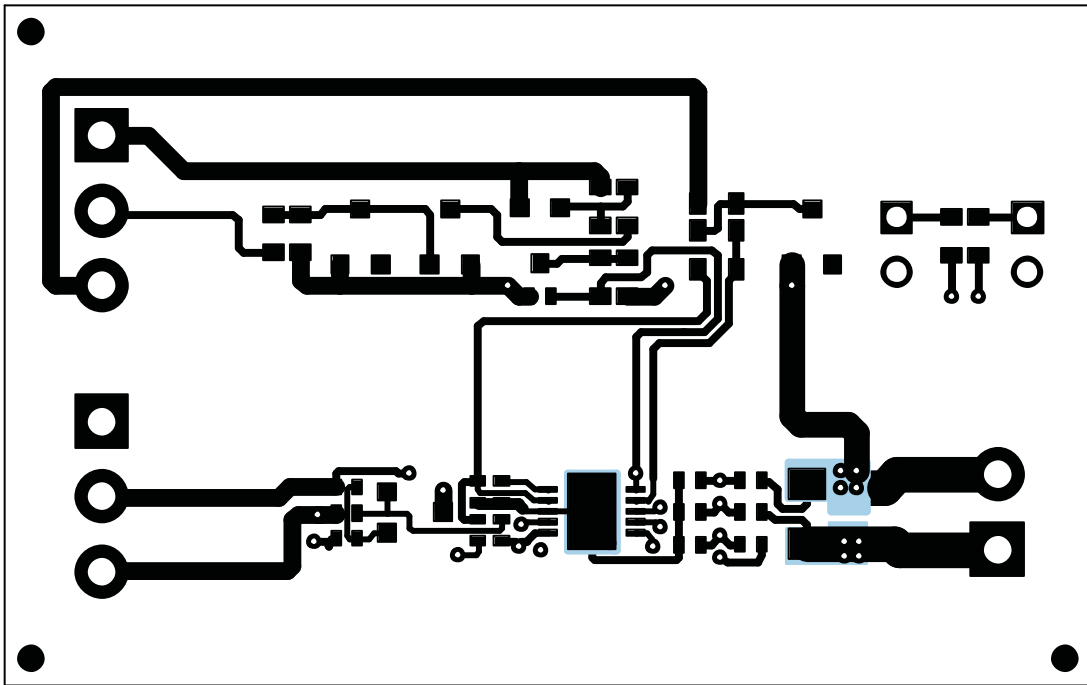


Figure 4. bq27x10EVM Layer 1 Layout

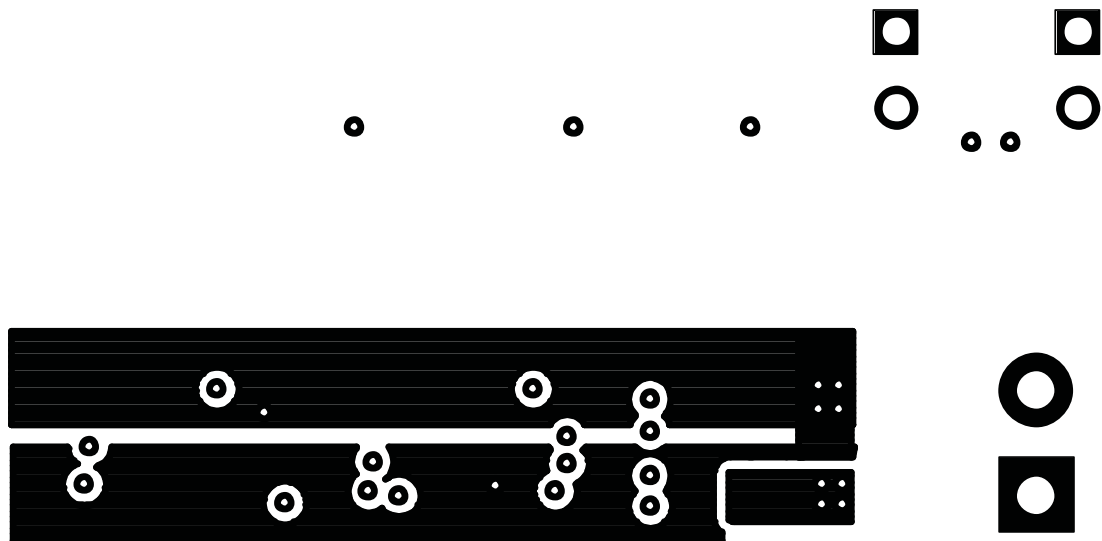


Figure 5. bq27x10EVM Layer 2 Layout

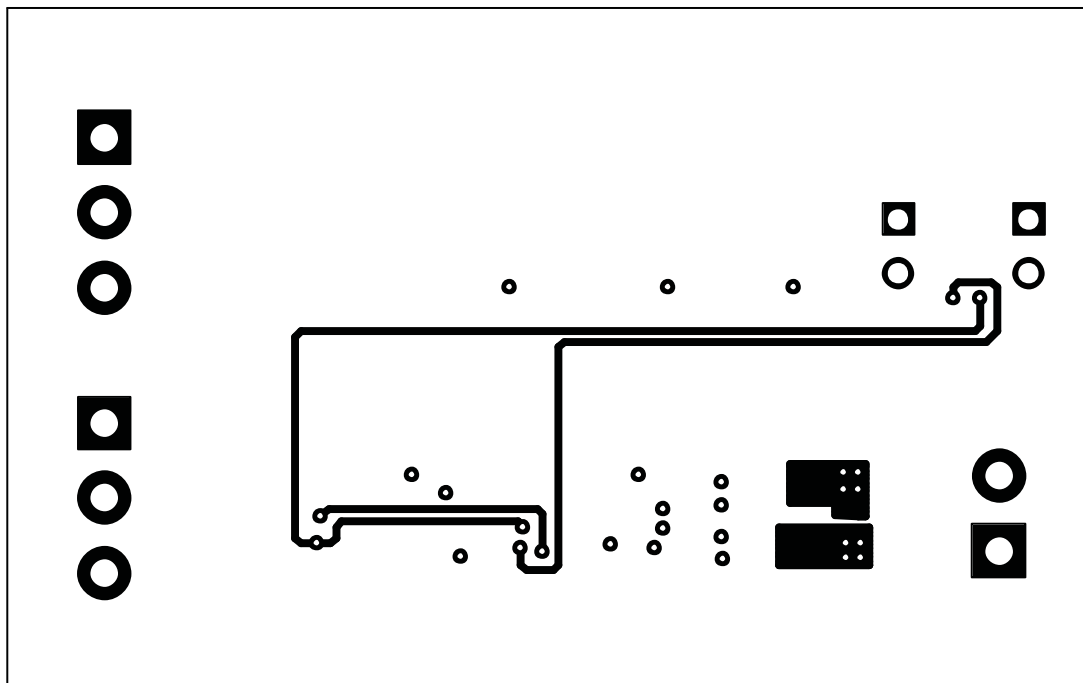


Figure 6. bq27x10EVM Layer 3 Layout

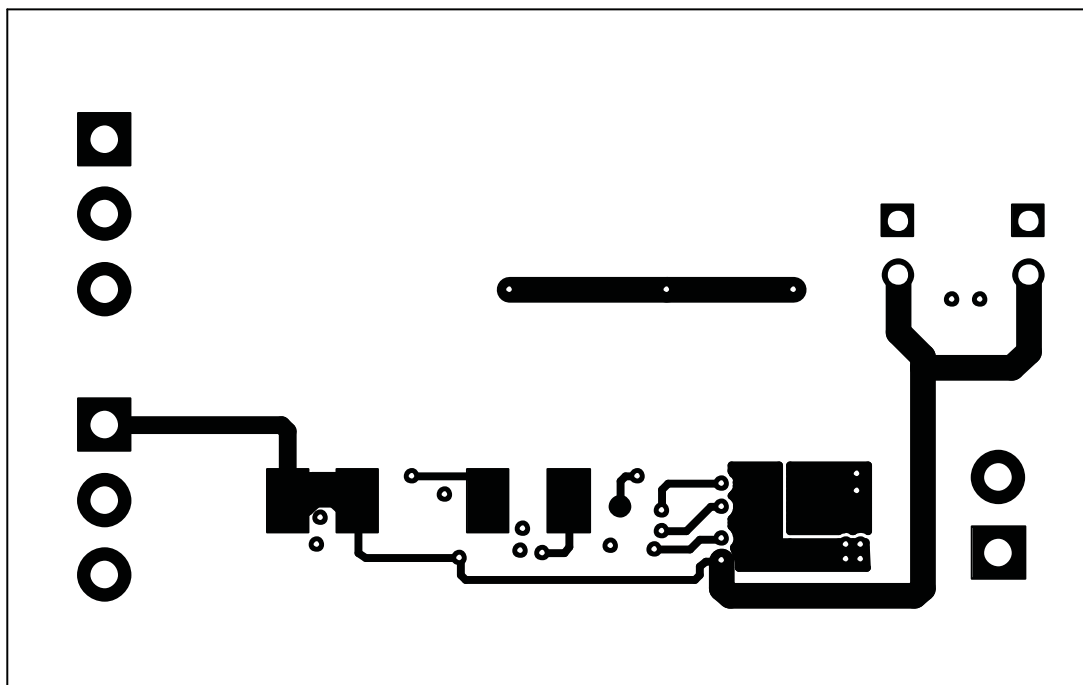


Figure 7. bq27x10EVM Layer 4 Layout

5 bq27x10EVM Circuit Module List of Materials

Table 3 contains the list of materials required for the bq27x10EVM circuit module.

Table 3. List of Materials

REF DES	27010	27210	DESCRIPTION	MFR	PART NUMBER
	QTY	QTY			
C1, C2, C3, C4, C5	5	5	Capacitor, ceramic, 0.1 μ F, 10 V, X5R, 402	Murata	GRM155R61A104KA01D
D1, D3	2	2	Diode, Zener, 5.6 V, 350 mW, SOT23	Diodes, Inc.	BZX84C5V6T
D2	1	1	Diode, Dual, Zener, 5.6 V, 300 mW, SOT23	Diodes, Inc.	AZ23C5V6
Q1	1	1	MOSFET, N-channel, 2N7002, 60 V, 250 mA, 3 Ω , SOT23	Vishay-Siliconix	2N7002E
Q2	1	1	MOSFET, P-channel, ZVP3306, -60 V, 0.09 A, 14 Ω , SOT23	Zetex	ZVP3306
R1, R2, R11	3	3	Resistor, chip, 100 Ω , 1/16 W, 5%, 603	Std	Std
R13, R14, R16	3	3	Resistor, chip, 1 M Ω , 1/16 W, 5%, 603	Std	Std
R12	1	1	Resistor, chip, 100 k Ω , 1/16 W, 5%, 603	Std	Std
R3, R6, R7	3	3	Resistor, chip, 1 k Ω , 1/16 W, 5%, 402	Std	Std
R4, R5, R9, R10	4	4	Resistor, chip, 100 Ω , 1/16 W, 5%, 402	Std	Std
R17, R18	0	2	Resistor, chip, 15 k Ω , 1/16 W, 5%, 603	Std	Std
R15	1	1	Resistor, chip, 10k Ω , 1/16 W, 5%, 402	Std	Std
R8	1	1	Resistor, chip, 0.02 Ω , 0.25 W, 1%, 1206	Vishay	WSL1206
U1	1	0	Single cell Li-Ion/Polymer gas gauge device, QFN	Texas Instruments	bq27010DRK
U1	0	1	Single cell Li-Ion/Polymer gas gauge device, QFN	Texas Instruments	bq27210DRK
J1, J3	2	2	Terminal blocks, 3 position	OST	ED1515
J2	1	1	Terminal blocks, 2 position	OST	ED1514
J4	0	1	Header, 2-pin, 100mil spacing, (36-pin strip)	Sullins	PTC36SAAN
N/A	1	1	PCB	Any	HPA212

6 bq27x10EVM Circuit Module Performance Specification Summary

Table 4 gives the performance specifications of the bq27x10EVM 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 maximum is limited by the PCB design and power dissipation of the 20-m Ω 1/4-W sense resistor included in the kit.

7 EVM Hardware and Software Setup

This section describes how to install the bq27x10EVM PC software and how to connect the different components of the EVM.

7.1 Software Installation

The following steps install the bq27x10EVM 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

The three hardware components to the bq27x10EVM are:

- The bq27x10EVM circuit module
- The PC interface board (EV2300)
- The PC.

7.2.1 Connecting the bq27x10EVM Circuit Module to a Battery Pack

[Figure 8](#) shows how to connect the bq27x10EVM circuit module to a Li-ion cell and the system load/charger.

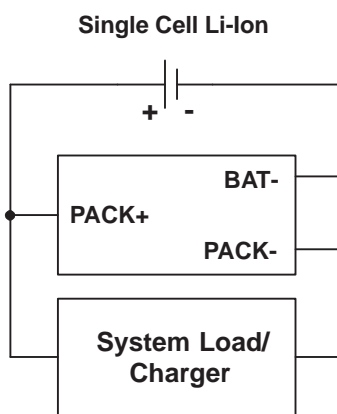


Figure 8. bq27x10EVM Circuit Module Connection to Cells and System Load/Charger

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 bq27x10EVM using [Table 5](#) as a guide.
2. For bq27010 connect the connector with colored wires to the HDQ connector that is on the EV2300. HDQ connection is located on the top right of EV2300. For the bq27210, connect the connector with colored wires to the I²C connector that is on the EV2300. The I²C connection is just below the HDQ connection on the EV2300.
3. Connect the PC USB cable to the EV2300 and the PC USB port.

The bq27x10EVM is now set up for operation.

Table 5. Circuit Module-to-EV2300 Connection

bq27x10EVM (bq27010)	bq27x10EVM (bq27210)	COLOR
SDA/HDQ	SDA/HDQ	BROWN
PACK-	PACK-	BLACK
PROG	SCL	WHITE
PACK+ ⁽¹⁾	VOUT	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, 3.3-V output when connected to HDQ section of EV2300. Shield this wire when it is 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|bq27X10 Battery Gas Gauge** menu sequence. The software defaults to the 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 is prompted to select between the bq27010 or bq27210. Select the appropriate device, and then press the continue button.

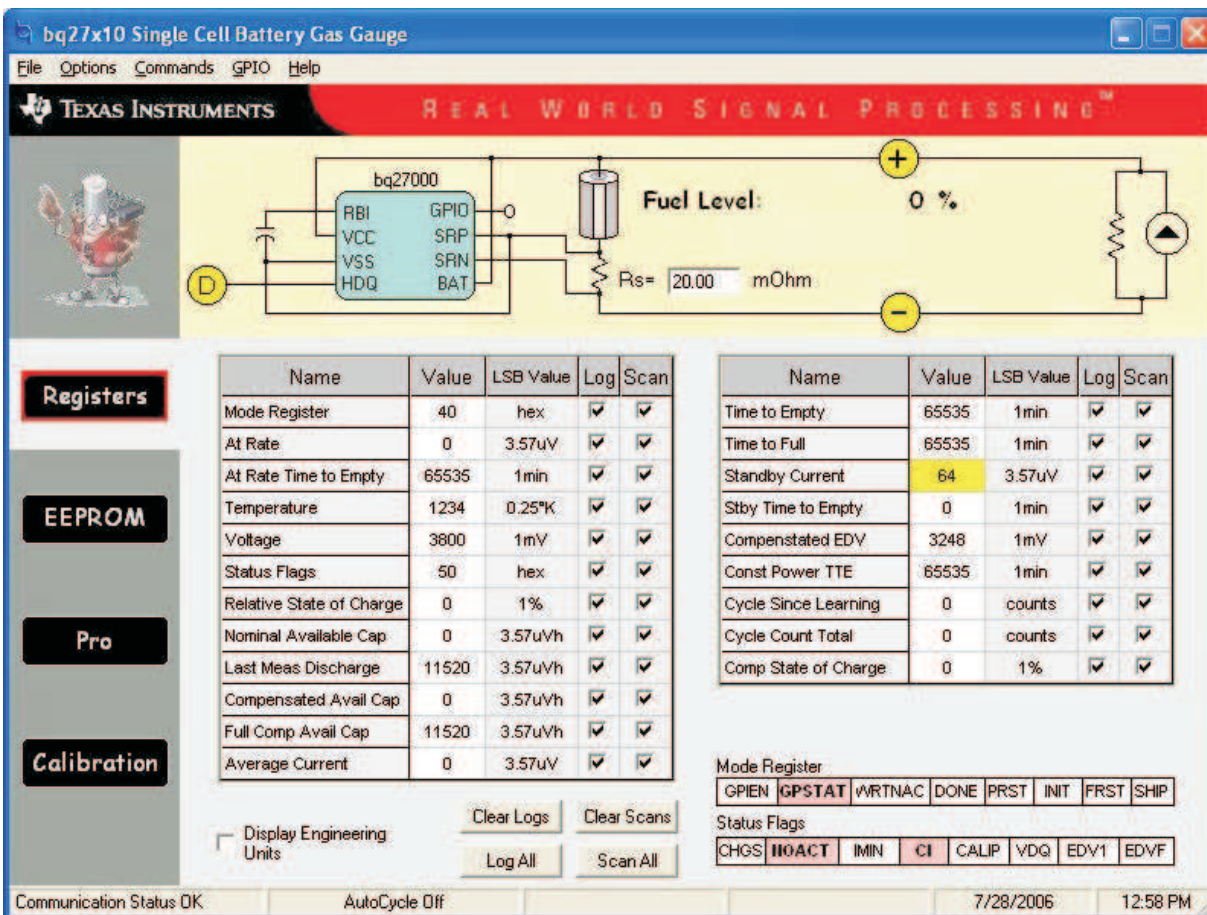


Figure 9. Initial Register Screen

Operation

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

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

8.2 Initialization

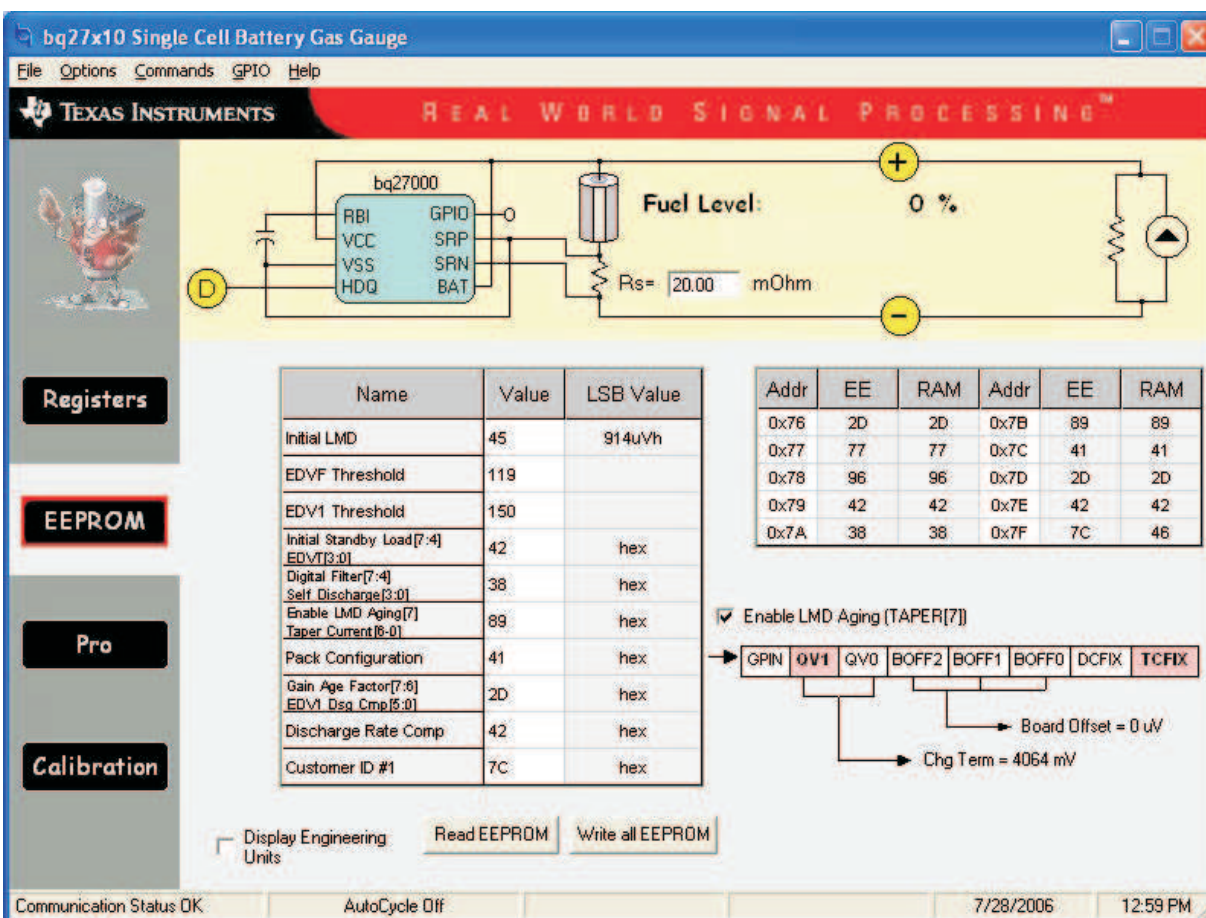
This section describes the settings that must be made before the bq27x10EVM is evaluated.

8.2.1 Loading the Sense Resistor Value

The bq27x10EVM 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 bq27x10 data set to engineering units. A check mark in the display engineering units box displays the data set in engineering units. No check mark displays the data set just as the bq27x10 calculates them, i.e., in units of 3.57-μVh counts.

8.2.2 Programming the bq27x10 EEPROM

Each bq27x10 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.



The screenshot shows the 'EEPROM' screen of the 'bq27x10 Single Cell Battery Gas Gauge' software. The interface includes a circuit diagram at the top showing the bq27000 chip connected to a battery and a sense resistor (Rs = 20.00 mOhm). The fuel level is displayed as 0%. Below the diagram is a table of EEPROM values:

Name	Value	LSB Value
Initial LMD	45	914uVh
EDVF Threshold	119	
EDV1 Threshold	150	
Initial Standby Load[7:4]	42	hex
EDVT[3:0]		
Digital Filter[7:4]	38	hex
Self Discharge[3:0]		
Enable LMD Aging[7]	89	hex
Taper Current[6:0]		
Pack Configuration	41	hex
Gain Age Factor[7:6]	2D	hex
EDV1 Dsg Cmp[5:0]		
Discharge Rate Comp	42	hex
Customer ID #1	7C	hex

To the right of the table is another table showing memory addresses and values for EE and RAM:

Addr	EE	RAM	Addr	EE	RAM
0x76	2D	2D	0x7B	89	89
0x77	77	77	0x7C	41	41
0x78	96	96	0x7D	2D	2D
0x79	42	42	0x7E	42	42
0x7A	38	38	0x7F	7C	46

Below the tables, there are buttons for 'Read EEPROM' and 'Write all EEPROM'. A checkbox for 'Display Engineering Units' is checked. At the bottom, there are status indicators: 'Communication Status OK', 'AutoCycle Dif', '7/28/2006', and '12:59 PM'.

Figure 10. EEPROM Screen

The values in the EEPROM can be easily changed using the EVM's 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 pulldown menu. Similarly, a saved file can be loaded 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 bq27x10 operation. Review the bq27x10 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 before changing the data. In this way, the default data programming can easily be restored.

The bq27x10 automatically uses the new EEPROM in its calculations once programmed.

8.2.3 Resetting the bq27x10

The bq27x10 can be reset at anytime by using the **Options|Special Options|Reset bq27x10** from the pulldown menu. When reset, the bq27x10 reinitializes all RAM registers.

8.3 The Registers Screen

In the Registers screen, all the bq27x10's RAM registers are displayed.

8.3.1 Options Menu

This menu allows the user to select among different options. These options include whether to enable scan of registers, select the file logging time rate, select the type of communication protocol (HDQ or I2C), or select the type of communication interface (EV2300 or EV2200).

8.3.2 Commands Menu

With the bq27x10, several commands are performed by setting the appropriate bit in the MODE register and then writing 0xA9 or 0x56 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 wants to write the NAC register to a specific value, the user writes that value to the AT RATE register and then selects 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 re-initializes all RAM registers. This command is intended for manufacturing use.
- SHIP - Once this command is given, the bq27x10EVM enters 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.
- WNACCI - It is identical to the WRTNAC command, but the CI bit in FLAGS is also cleared.
- WRTCYC - It is used to transfer data from the AR registers to CYCT.
- WRTLMD - It is used to transfer data from the AR registers to LMD.

8.3.3 GPIO Menu

This menu selects the function of the GPIO pin as an output 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 bq27x10. A changing of the status of the checkbox for *Enable LMD Aging* causes an automatic write to the EEPROM to ensure that the selection applies accordingly. When writing to the EEPROM, always ensure that the 21-V pulse to PROG pin is available.

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* check box 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 hexadecimal numbers.

If either the DCFIX or TCFIX bits in the Pack Configuration EEPROM register are set, then the DCOMP or TCOMP is illustrated as Customer ID # accordingly. For example, if DCFIX bit is set, then the DCOMP register is set as a customer ID and the default discharge rate compensation is used by the bq27x10 regardless of the contents of the DCOMP register.

The EEPROM screen has two grids. The one to the right is the data that is contained in the EEPROM (addresses 0x76-0x7F) and RAM registers corresponding to EEPROM (addresses 0x46-0x4F).

8.5 The Pro Screen

The Pro screen allows the data location in the bq27x10 to be addressed individually by entering the address to be read or the address and data to be written. This screen can be helpful when evaluating commands that are used in host-side gauge applications.

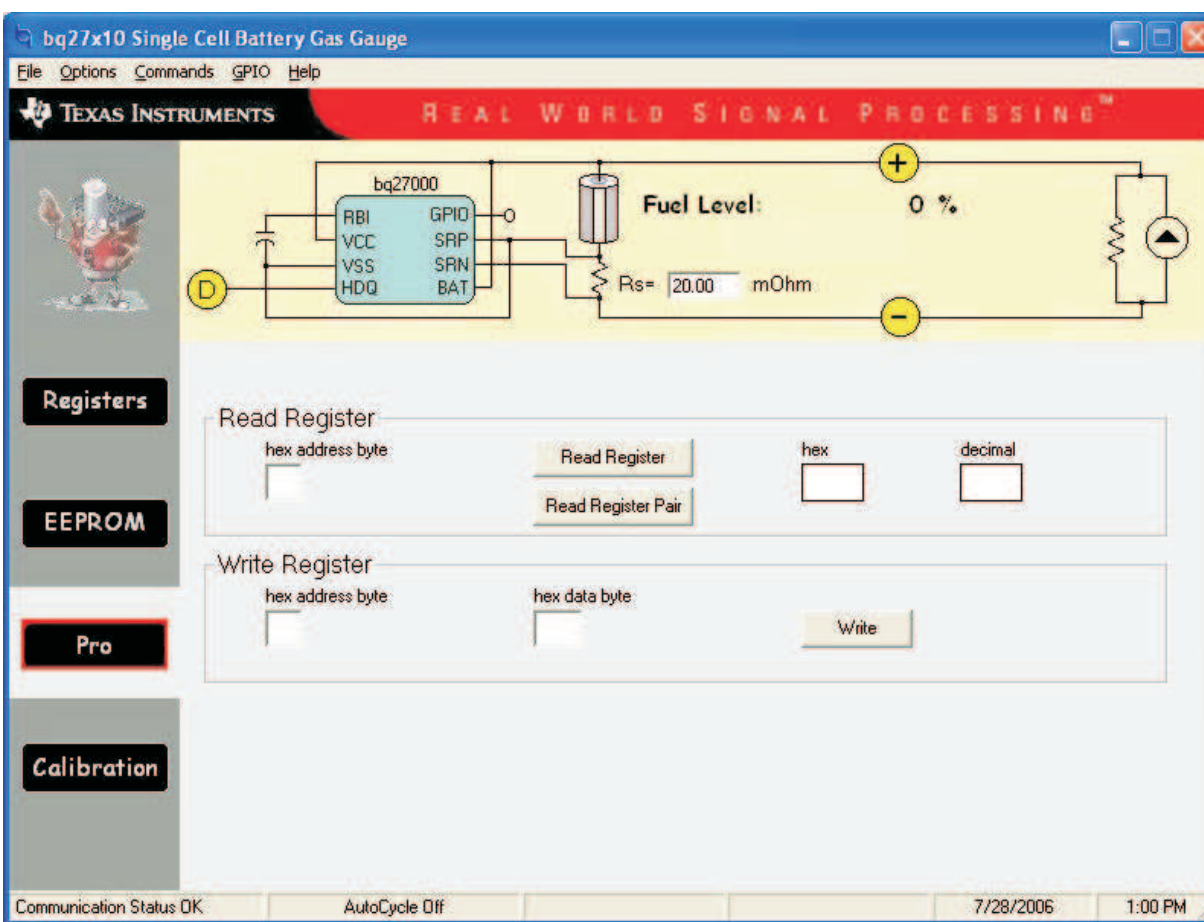


Figure 11. Pro Screen

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.

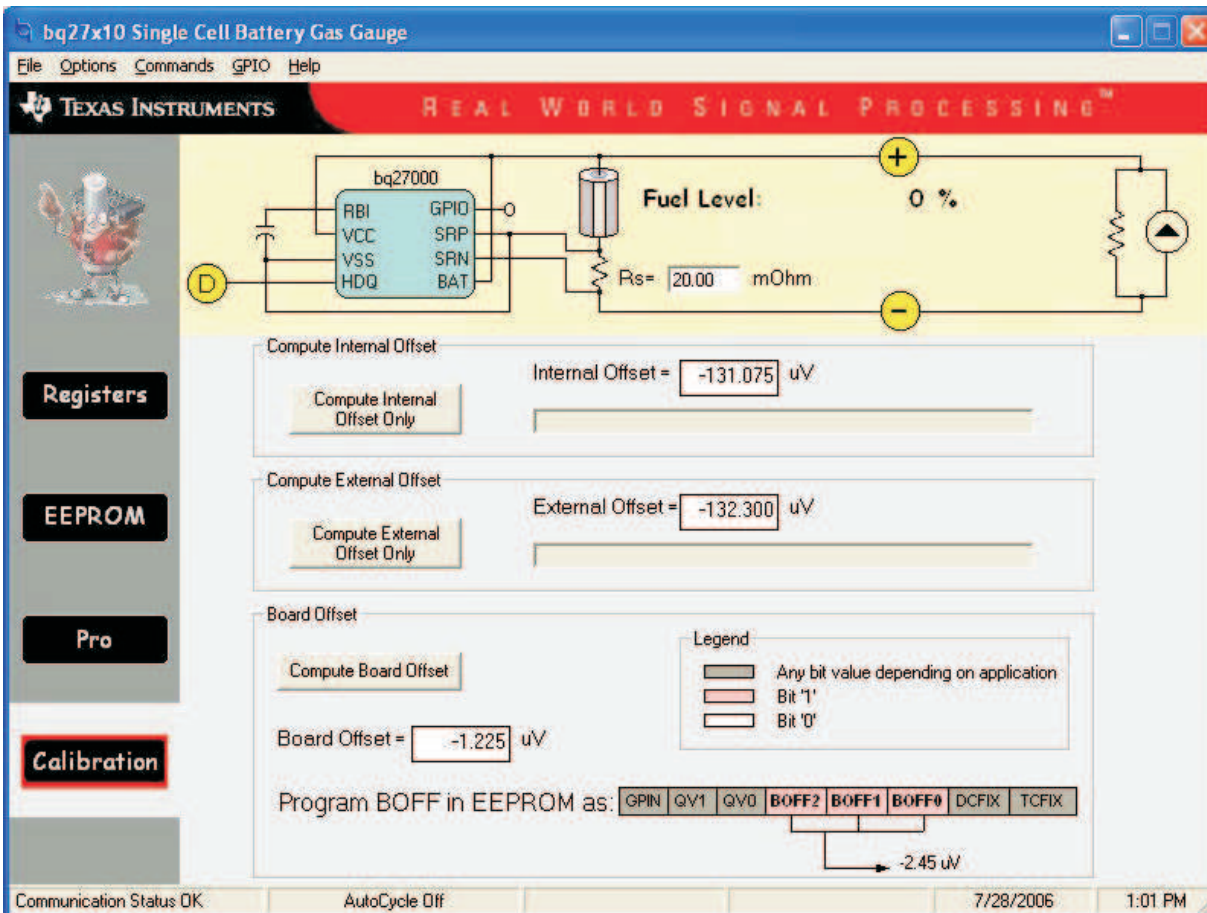


Figure 12. Calibration Screen

8.7 Data Logging

The bq27x10 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. Select **File|Start Data Log** from the pulldown 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 pulldown 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 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

EVM IMPORTANT NOTICE (CATEGORY B)

IMPORTANT: TI is providing the enclosed HPA212 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.

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