TEXAS INSTRUMENTS

bq2060EVM-001 and bq2060EVM-002
SBS 1.1 Battery Management Solution Evaluation Module

User's Guide

June 2003 *High Performance Analog*

SLUU063A

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 3 V and 25 V, with a maximum voltage drop across the sense resistor of ±250 mV (1-W power dissipation).

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 60°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.

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Read This First

About This Manual

This user's guide describes the characteristics, operation, and use of the bq2060EVM-001 and bq2060EVM-002 evaluation module (EVM). It covers all pertinent areas involved to properly use the EVM with the devices it supports. The physical PCB layout, schematic diagram, and circuit descriptions are included.

How to Use This Manual

This document contains the following chapters:

- Chapter 1—Introduction
- Chapter 2—bq2060-Based Circuit Module
- Chapter 3—bq2060 Circuit Module Schematic and Performance Specification Summary
- Chapter 4—Circuit Module Physical Layout and BoM
- Chapter 5—EVM Hardware and Software Setup
- Chapter 6—Operation

Related Documents From Texas Instruments

To obtain a copy of any of the following TI documents, call the Texas Instruments Literature Response Center at (800) 477-8924, or the Product Information Center (PIC) at (972) 644-5580. When ordering, identify this manual by its title and literature number. Updated documents can also be obtained through our website at www.ti.com.

Data Sheet:	**Literature Number:**
bq2060	SLUS035

FCC Warning

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.

Contents

Figures

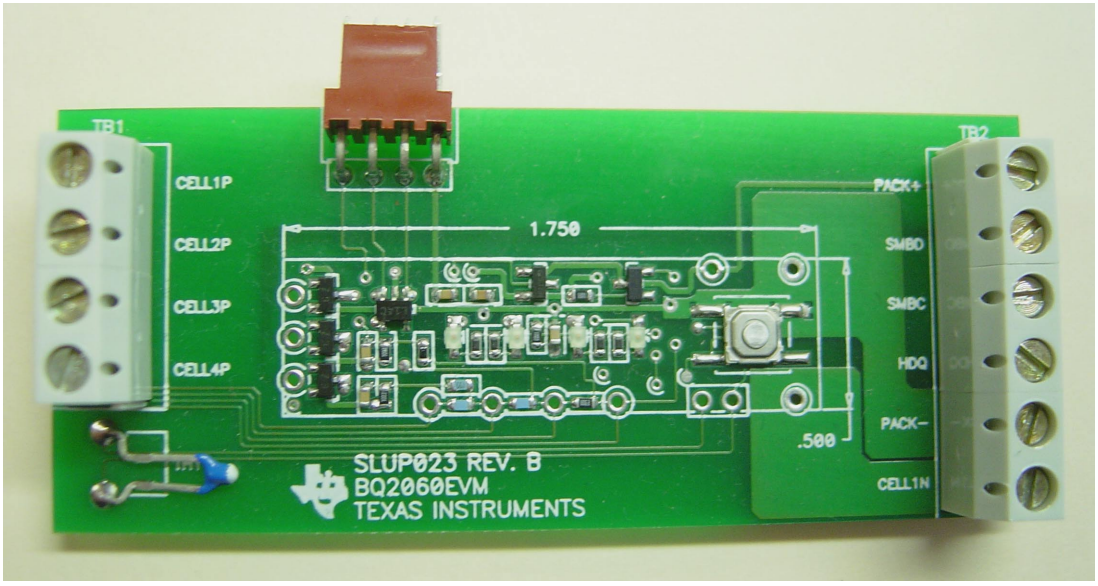
Tables

Chapter 1

Introduction

1.1 bq2060 Evaluation Module

Figure 1-1. bq2060EVM



This EVM is a complete evaluation system for the bq2060 Battery Management System. The EVM includes one bq2060 circuit module, a current sense resistor, a thermistor, an EV2200 PC Interface Board for Gas Gauge Interface, a PC serial cable, and an EEPROM connector. The latest windows based EV2200-60 PC software can be downloaded from the TI web site. The circuit module includes one bq2060 IC, and all other components on-board necessary to monitor and predict capacity of Li-Ion or Li-Polymer (bq2060EVM-001) or NiMH (bq2060EVM-002) cells. Protection for Li-Ion or Li-Polymer cells is not included on this module. The circuit module connects directly across the cells in a battery. With the EV2200 interface board and software, the user can read the bq2060 data registers, program the chipset for different pack configurations, log cycling data for further evaluation and evaluate the overall functionality of the bq2060 solution under different charge and discharge conditions.

NOTE: For this document, bq2060EVM-00X is used for both the bq2060EVM-001 and the bq2060EVM-002.

1.2 Features

- ❑ Complete evaluation system for the bq2060 SBS 1.1 compliant advanced gas gauge.
- ❑ Populated circuit module for quick setup
- ❑ PC software and interface board for easy evaluation
- ❑ Software that allows data-logging for system analysis

1.3 Kit Contents

1 bq2060 circuit module

1 EEPROM Interface connector with wires

1 Sense resistor

1 EV2200 PC interface board

1 PC serial cable

1 Set of support documentation

1 Set of evaluation software disks entitled EV2200-60

To download the latest EVM software:

1. Go to www.ti.com
2. Search for bq2060, and open the product folder
3. Click on | Development Tools |
4. Click the appropriate EVM (Li-Ion -001 or NiMH -002) and download the EV2200-60 software under the “Contents” section.
5. Find hardware and software setup guidelines in Chapter 5 of this EVM user’s guide

1.4 Ordering Information

Table 1-1. Ordering Information

EVM Part Number	Chemistry	Configuration	Capacity
bq2060EVM-001	Li-Ion	3 or 4 cell	Any
bq2060EVM-002	NiMH	4 to 10 cell	Any

Chapter 2

bq2060-Based Circuit Module

2.1 Overview

The bq2060-based circuit module includes all components required for a complete battery management solution. It includes the bq2060 gas gauge IC, 24LC01 EEPROM and other components to accurately predict and monitor capacity of NiMH, Li-Ion, and Li-Polymer cells.

Contacts on the circuit module provide direct connection to the cells (BAT-, 1P, 2P, 3P, BAT+) and the serial communications port (SMBC, SMBC). The system load and charger connect across PACK+ and PACK-.

The /SAFE output reflects the state of the safety output from the bq2060 and has extra ESD protection just for evaluation purposes.

2.2 Pin Descriptions

BAT-	Negative connection of first (bottom) cell
1P	Positive connection of first (bottom) cell
2P	Positive connection of second cell
3P	Positive connection of third cell
4P	Positive connection of fourth (top) cell
SMBC	Serial communication port clock
SMBD	Serial communication data port
SAFE	bq2060 safety output
PACK-	Pack negative terminal
VSS	Pack negative terminal
PACK+	Pack positive terminal. Used by bq2060 to derive VCC.

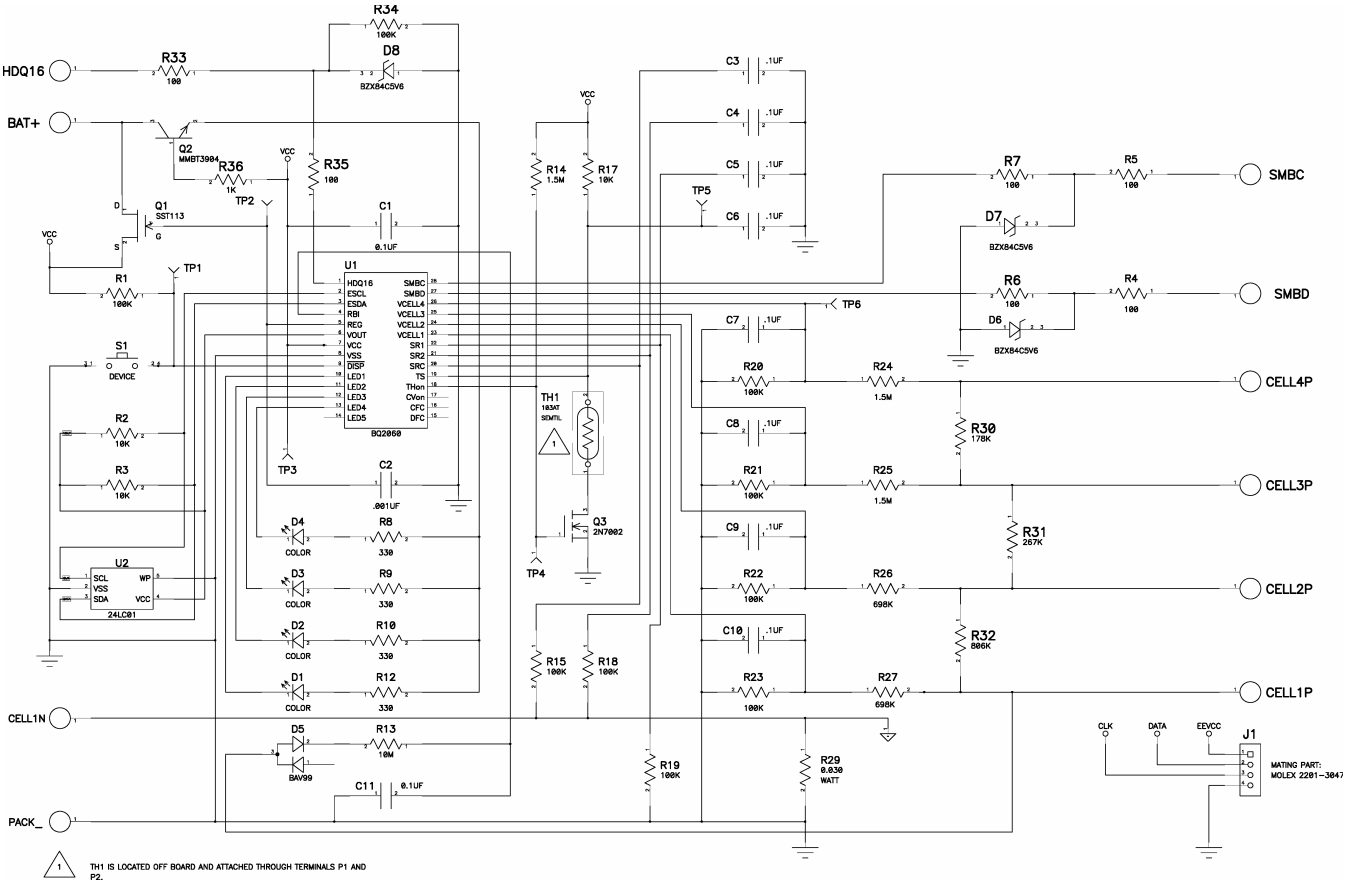
Chapter 3

bq2060 Circuit Module Schematic and Performance Specification Summary

3.1 Schematic

The schematic shows the circuit for bq2060 implementation.

Figure 3-1. bq2060EVM-00X Schematic



3.2 Performance Specifications of the bq2060 Circuit Module

Table 3-1. Performance Specification Summary

Specification	Min	Typ	Max	Units
Input Voltage Pack+ to Pack-	3.0		25	V
Charge and Discharge Current*			Note 1	A

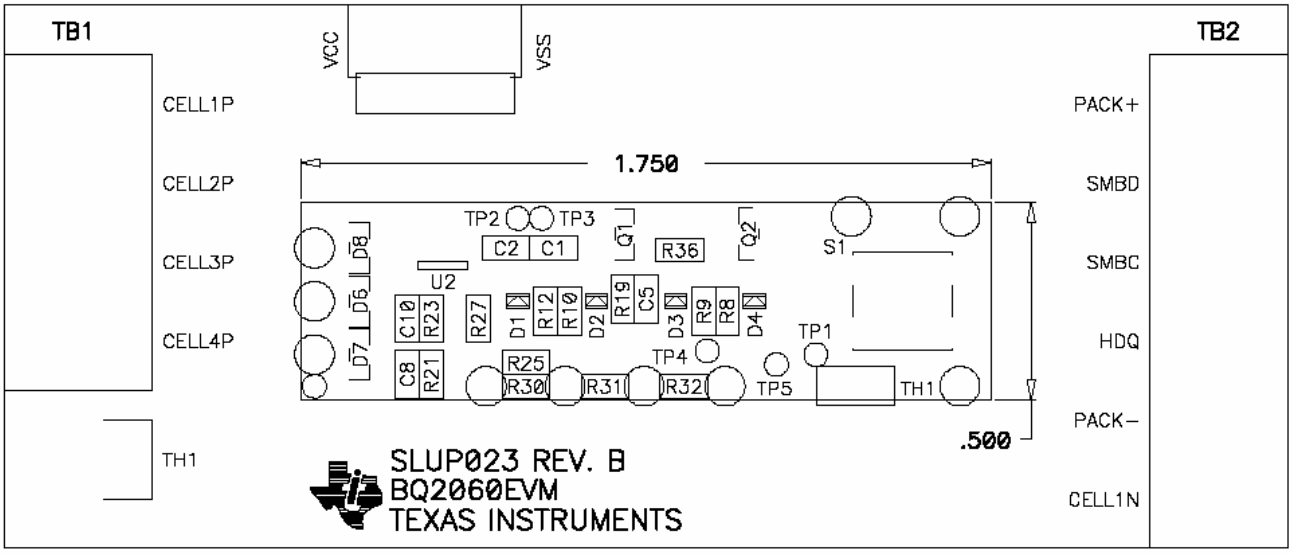
Note 1: Maximum currents are determined by the value of the sense resistor used. Do not exceed ± 250 mV across sense resistor. For the supplied sense resistor, do not exceed 1 Watt.

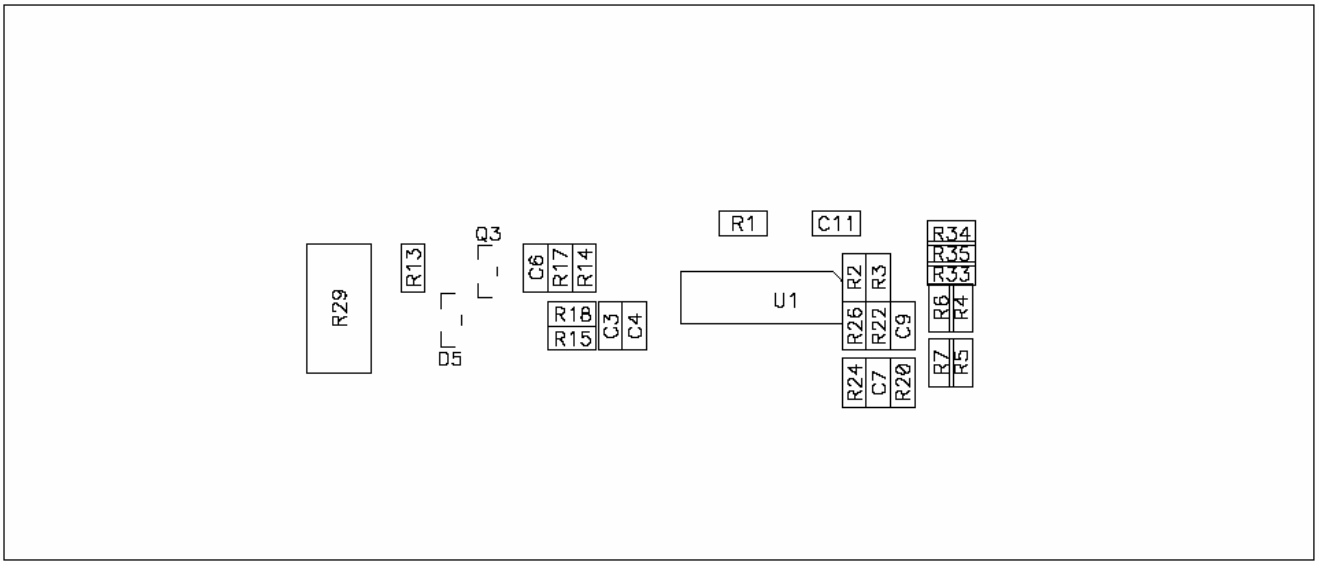
Chapter 4

Circuit Module Physical Layout and BoM

4.1 Board Layout

Figure 4-1. bq2060EVM-00X Layout





4.2 Bill of Materials

Count	Count	RefDes	Description	Size	Part Number	MFG
EVM-001	EVM-002					
10	10	C1, C11, C3, C4, C5, C6, C7, C8, C9, C10	Capacitor, ceramic, 0.1 μF, X7R, 25 V	603	VJ0603Y104KXXX	Vishay
1	1	C2	Capacitor, ceramic, 0.001 μF, X7R, 25 V	603	VJ0603Y102KXXX	Vishay
4	4	D1, D2, D3, D4	Diode, LED, LN1371G, green, gullwing	SMT Gullwing	LN1371G	Panasonic
1	1	D5	Diode, dual, BAV99, SOT23	SOT23	BAV99	Zetex
3	3	D6, D7, D8	Diode, Zener, 5.6 V, BZX84C5V6,SOT23	SOT23	BZX84C5V6	On Semi
1	1	Q1	Transistor, JFET, N-Channel, SST113, SOT23	SOT23	SST113	Vishay Siliconix
1	1	Q2	Transistor, NPN, MMBT3904, SOT23	SOT23	MMBT3904	On Semi
1	1	Q3	Transistor, N-Channel, 2N7002, SOT23	SOT23	2N7002	Zetex
9	9	R1, R15, R18, R19, R20, R21, R22, R23, R34	Resistor, chip, 100 KΩ, 5%, 0603	603	CRCW0603104J	Vishay
1	1	R13	Resistor, chip, 10 MΩ, 5%, 0603	603	CRCW0603106J	Vishay
3	3	R14, R24, R25	Resistor, chip, 1.5 MΩ, 5%, 0603	603	CRCW0603155J	Vishay
3	3	R17, R2, R3	Resistor, chip, 10 KΩ, 5%, 0603	603	CRCW0603103J	Vishay
2	2	R26, R27	Resistor, chip, 698 KΩ, 1%, 0603	603	CRCW06036983F	Vishay
1	1	R29	Resistor, chip, 0.03 Ω, 2%, 1 W, 2512	2512	WSL-2512 .03 1%	Vishay
0	1	R30	Resistor, chip, 178 KΩ 1%, 0603	603	CRCW06031783F	Vishay
1	0	R30	Resistor, chip, 0 Ω, 5%, 0603	603	CRCW0603000Z	Vishay
1	1	R31	Resistor, chip, 267 KΩ 1%, 0805	805	CRCW08052673F	Vishay
1	1	R32	Resistor, chip, 806 KΩ 1%, 0603	603	CRCW06038063F	Vishay
1	1	R36	Resistor, chip, 1 KΩ, 5%, 0603	603	CRCW0603102J	Vishay
6	6	R6, R7, R33, R35, R4, R5	Resistor, chip, 100 Ω, 5%, 0603	603	CRCW0603101J	Vishay
4	4	R8, R9, R10, R12	Resistor, chip, 330 Ω, 5%, 0603	603	CRCW0603331J	Vishay
1	1	S1	Switch, Momentary, bush button, EVQPLHA	SMT	EVQ-PLHA15	Panasonic
1	1	TH1	Thermistor, 103AT-2, radial	Radial	103AT-2	Semitec
1	1	U1	IC, Gas Gauge, bq2060SS-E411	28P-SSOP	bq2060SS-E411	Texas Instruments
1	1	U2	IC, EEPROM, 24LC01BI/OT, 128 byte	SOT23-5	24LC01BI/OT	Micro Chip, Atmel
1	1	J1	Connector, header, right angle, Male,4 pin, .100-inch centers		22-12-2044	Molex
1	1	J1 mate	Connector, female, .100-inch centers		22-01-3047	Molex
4	4	N/A	Terminals, crimp, tin		08-50-0114	Molex
1	1	N/A	Wire, Insulated 22 Awg, red, 8 inches (VCC)		Any	Any
1	1	N/A	Wire, insulated 22 Awg, white, 8 inches (SMBC)		Any	Any

Count	Count	RefDes	Description	Size	Part Number	MFG
1	1	N/A	Wire, insulated 22 Awg, black, 8 inches (GND)		Any	Any
1	1	N/A	Wire, insulated 22 Awg, brown, 8 inches (SMBD)		Any	Any
1	1	TB1	Terminal block, .200-inch centers, 4 position, 90 deg		ED120/4DS	On Shore Technology
1	1	TB2	Terminal block, .200-inch centers, 6 position, 90 deg		ED120/6DS	On Shore Technology

Chapter 5

EVM Hardware and Software Setup

This chapter describes how to install the bq2060EVM-00X PC software and how to connect the various components on the EVM.

5.1 Software Installation

5.1.1 The following steps install the EV2200-60 software from the included disks:

1. Insert disk 1 into a 3 ½ inch floppy drive.
2. Select the 3 ½ inch drive using My Computer or File Manager.
3. Double-click on the Setup.exe icon.
4. The setup program prompts for the remaining disks and installs a Windows application group.

5.1.2 Use the following steps to install the latest EV2200-60 software downloaded from the TI website listed in Chapter 1, Section 1.2:

1. Unzip the self-extracting EXE file to a temporary directory.
2. Double-click on the Setup.exe icon.
3. Follow the on screen instructions and the setup program will install a Windows application group.

5.2 Hardware Connection

There are four hardware components to the bq2060EVM-00X: the bq2060 circuit module, the EEPROM interface connector, the EV2200 PC interface board, and the PC.

5.2.1 Connecting the bq2060 circuit module to a battery pack

Figures 5-1 and 5-2 show how to connect the bq2060 circuit module to the cells, and system load/charger. The cells should be connected in the following order.

4-Cell Pack: Connect PACK+ and 4P together. BAT-, 4P, 1P, 2P and then 3P (see Chapter 2, Section 2.2 for pin descriptions)

3-Cell Pack: Connect PACK+ and 4P together. BAT-, 4P, 1P, 2P and then connected 4P and 3P together.

2-Cell Pack: Connect PACK+ and 4P together. BAT-, 4P, 1P, 2P and then connected 4P, 3P, and 2P together.

No Individual Cell voltages: If no individual cell voltages are required then Connect PACK+ and 4P together. Then connect BAT-, and then 4P.

Figure 5-1. bq2060 Circuit Module Connection to Li-Ion Cells and System Load/Charger

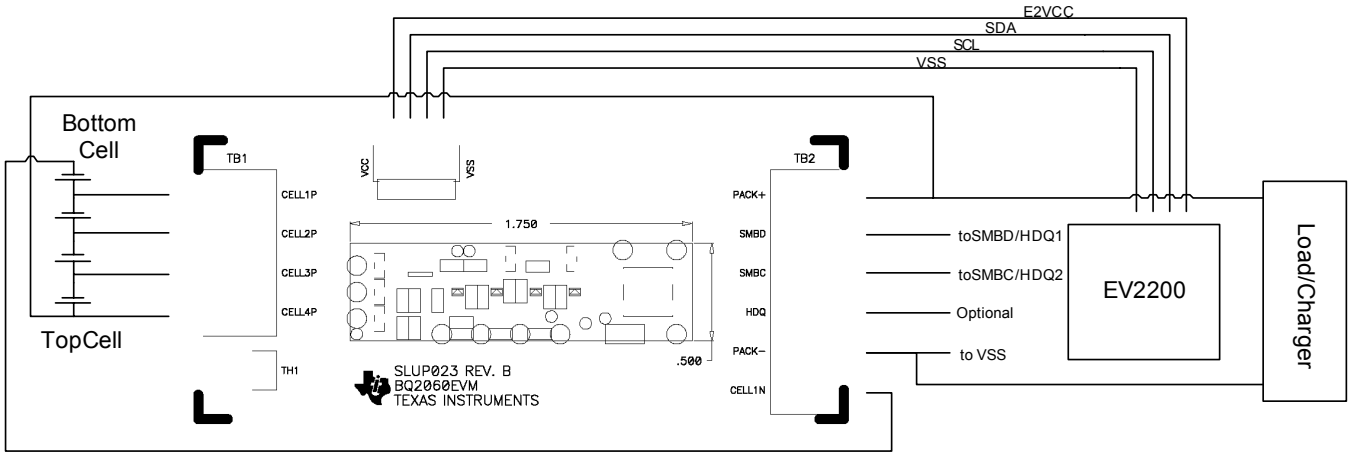
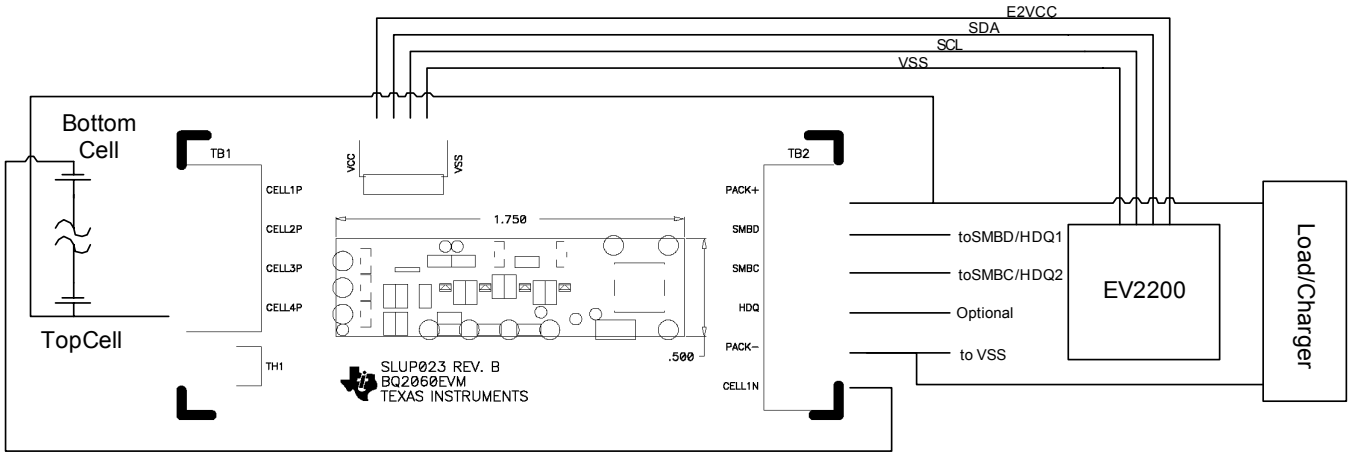


Figure 5-2. Circuit Module Connection to NiMH Cells and System Load/Charger



5.2.2 PC interface connection

1) Configure the hardware interface to the PC by connecting the bq2060-based smart battery (bq2060EVM-00X) to the EV2200 using wire leads according to the following table.

Table 5-1. Circuit Module to EV2200 Connections

bq2060EVM-00X	EV2200
SMBD	SMBD/HDQ1
SMBC	SMBC/HDQ2
PACK-	VSS

2) Connect the EEPROM connector to the bq2060EVM-00X and the wire leads of the EEPROM connector to the EV2200 according to the following table.

Table 5-2. Circuit Module EEPROM Connector to EV2200 Connections

bq2060EVM-00X	EV2200
VCC	E2 VCC
EEPROM data	SDA
EEPROM Clock	SCL
VSS	VSS

3) Connect the PC serial cable to the EV2200 and the PC COM port.

The bq2060EVM-00X is now set up for operation.

Chapter 6

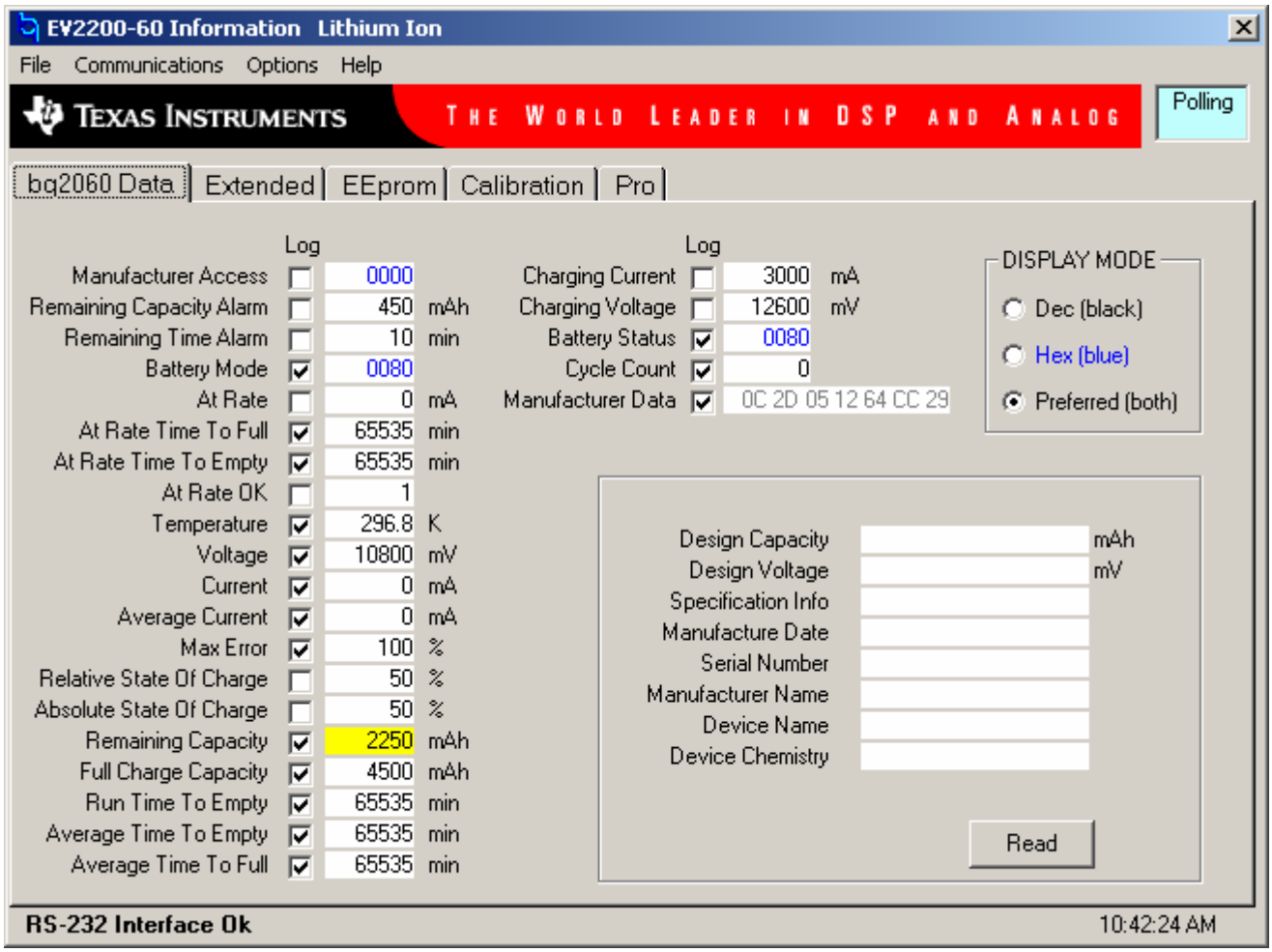
Operation

This chapter describes the operation of the EVM2200-60 software.

6.1 Starting the Program

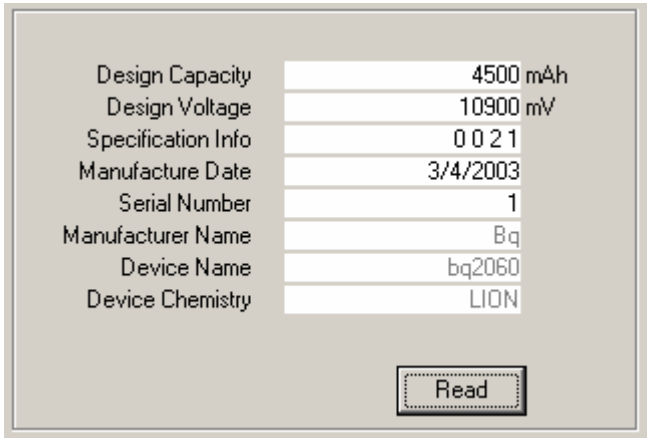
Run EV2200-60 from the ‘Start | Programs | Texas Instruments | EV2200-60’ menu sequence. The SBS Data screen appears, and the data fields begin to populate as the indicator scans down the screen. ‘Remaining Capacity’ is highlighted in Figure 6-1. To disable the scan feature select | Options | Poll BQ Registers | Stop |.

Figure 6-1. SBS Data Screen



This SBS data screen shows the SBS data set, along with additional Static data shown in a box at the bottom right. By clicking on the ‘Read…’ button, the screen changes to show the static data from the bq2060.

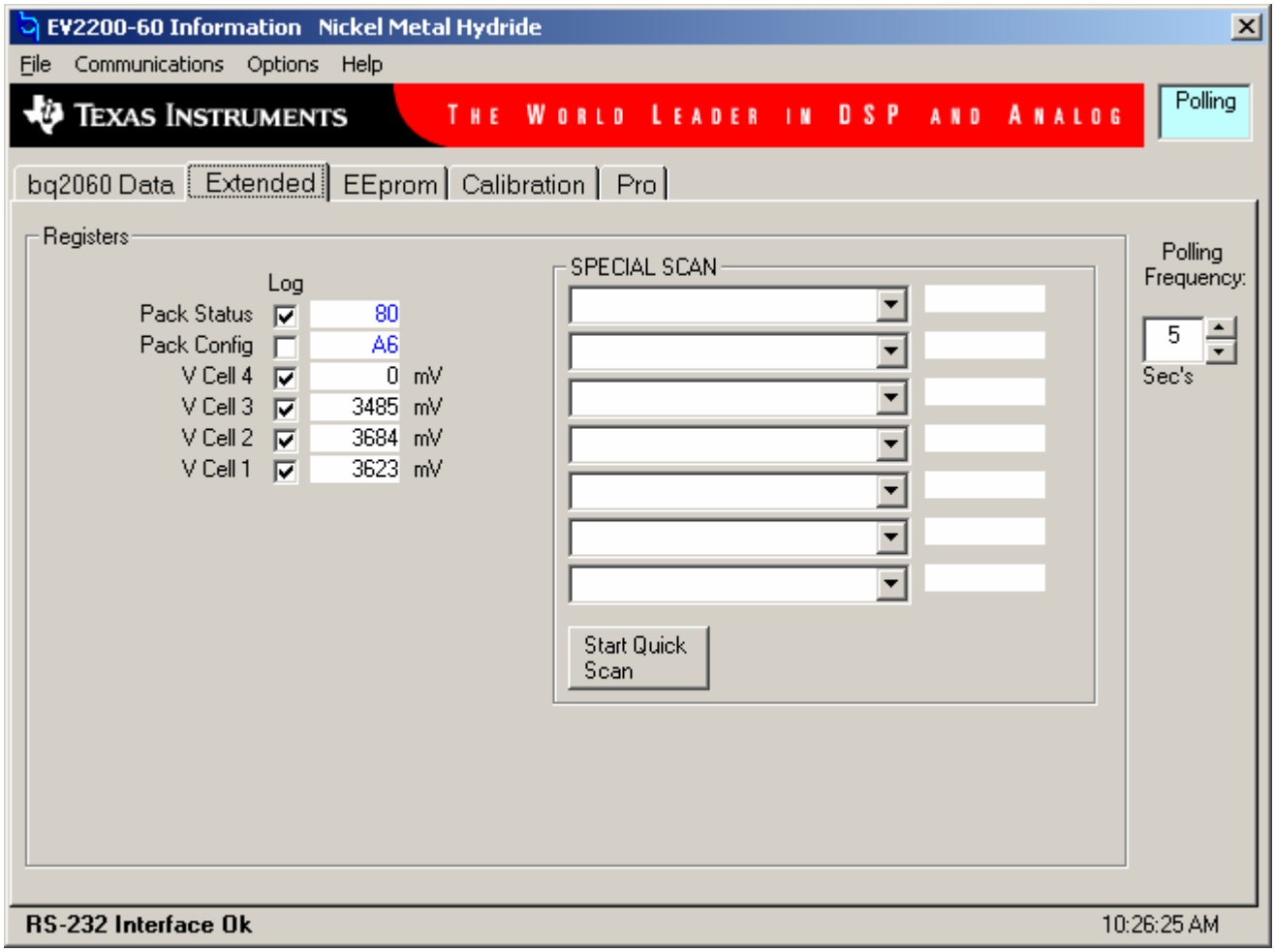
Figure 6-2. SBS Data Screen –Static Data Window



6.2 Extended Data Screen

The SBS Extended Data Screen has 2 frames. The First frame contains the SBS Extended data that continues scanning from the bq2060 Data Screen. The second frame is for high speed scanning of up to 7 SBS data values. When the | Start Quick Scan | button is clicked, these scans take precedence over all other scanning to get the highest update rate possible.

Figure 6-3. SBS Extended Data Screen



6.3 Data Logging

SBS Data can be logged for further evaluation by using the File | Start Data Log menu options. Then enter the desired file name and click on | SAVE |. A window appears asking for the desired log interval. Select a desired interval and click | CLOSE |. An example of a data log file is below. To stop the data log follow the same sequence. The log file can be customized by clicking on the check box (in the Log column) next to the data fields on the bq2060 Data and Extended screens. All the data fields that are checked are recorded in the log file. It is important to select the desired data fields prior to starting a log because check box updates made after logging starts are ignored.

Table 6-1. Example Log File

Elapsed Time(s)	Temperature	Voltage	Current	Max Error	Remaining Capacity	Full Charge Capacity
2	296.3	10797	0	100	2025	4050
5	296.3	10791	0	100	2025	4050
8	296.3	10800	0	100	2025	4050
10	296.3	10799	0	100	2025	4050
13	296.3	10800	0	100	2025	4050
15	296.3	10802	0	100	2025	4050
18	296.3	10793	0	100	2025	4050
21	296.3	10792	0	100	2025	4050
23	296.3	10794	0	100	2025	4050
26	296.4	10798	0	100	2025	4050
29	296.4	10797	0	100	2025	4050
32	296.4	10791	0	100	2025	4050
34	296.3	10797	0	100	2025	4050
37	296.3	10794	0	100	2025	4050
39	296.3	10797	0	100	2025	4050
42	296.3	10793	0	100	2025	4050
44	296.3	10795	0	100	2025	4050
47	296.3	10791	0	100	2025	4050

6.4 Setting programmable bq2060 options

The EEPROM on the EVM is configured from the factory as an example Li-Ion battery for the bq2060EVM-001, and for an example Nickel battery for the bq2060EVM-002. Special attention should be paid to make sure the settings are correctly changed for the pack, and application for the bq2060 solution being evaluated. This procedure should be done prior to calibrating the module, as described in the following section. The bq2060 must be reset after changing EEPROM data or calibration, for the changes to take effect. To reset the bq2060, click | Options | Initialize Device |.

EEPROM Data cannot be accessed on a sealed bq2060 (*Pack Configuration* bit 6 is set). To unseal the pack connect the EEPROM connector, and click | Options | Unlock Device|. Be sure to remove power from the device and re-apply to finish the unsealing procedure. To re-seal the part, click | Options | Seal | bq2060 |. Then reset the bq2060 by clicking | Options | Initialize Device |.

IMPORTANT: The correct setting of these options is essential to obtain the best performance. The settings can be configured using the EEPROM Data Screen.

Figure 6-4. Li-Ion EEPROM Data Screen

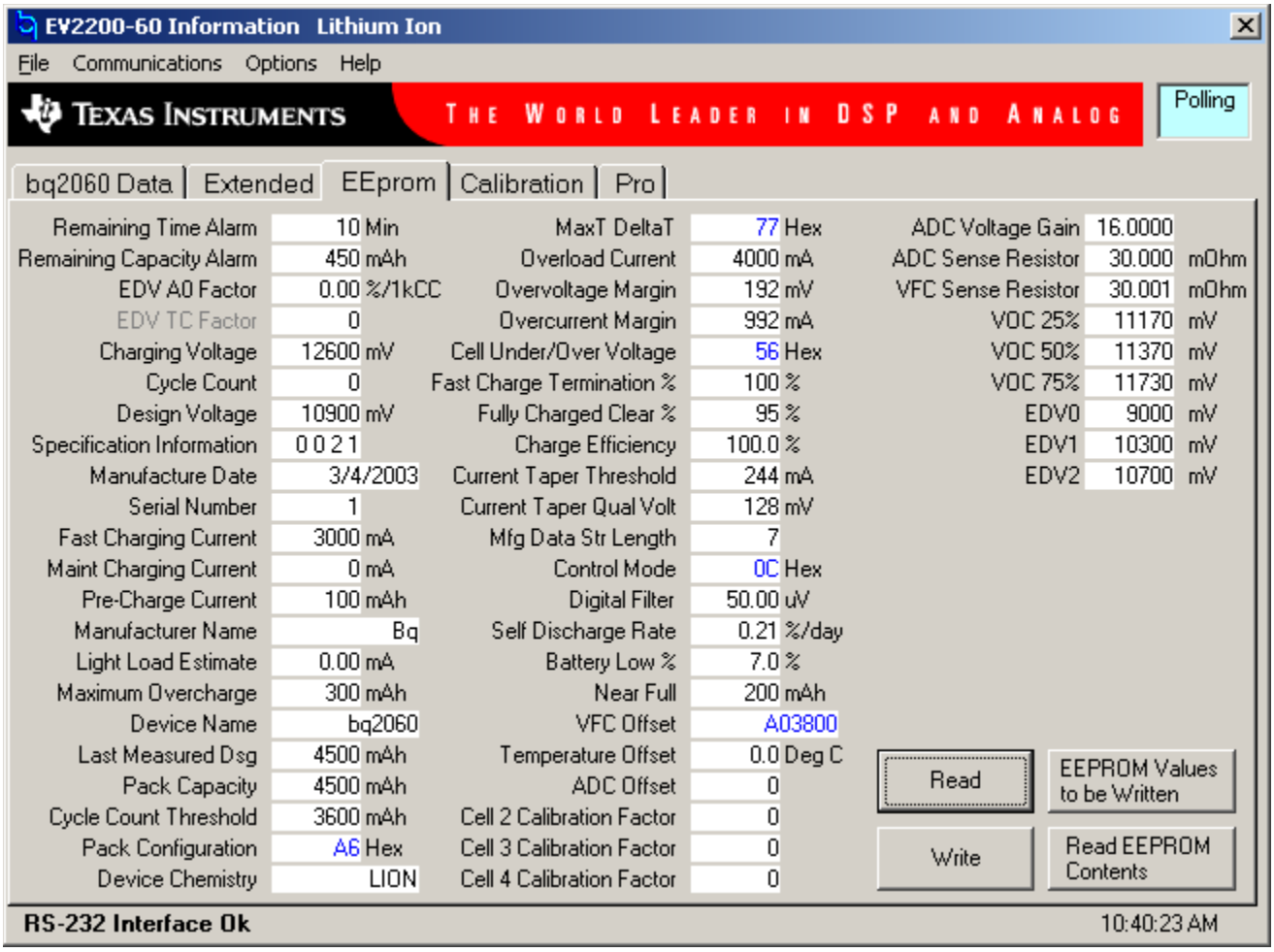
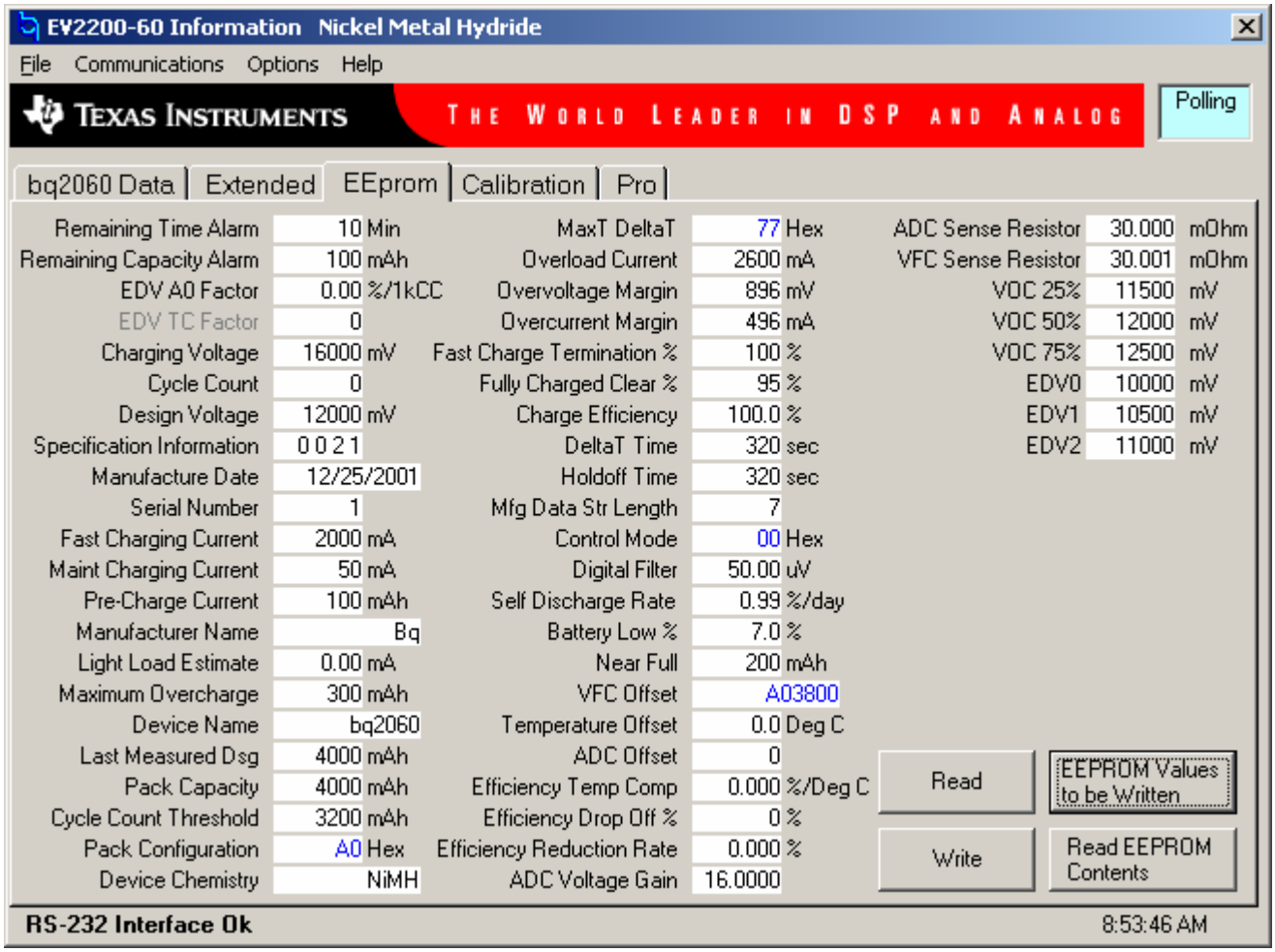


Figure 6-5. NiMH EEPROM Data Screen

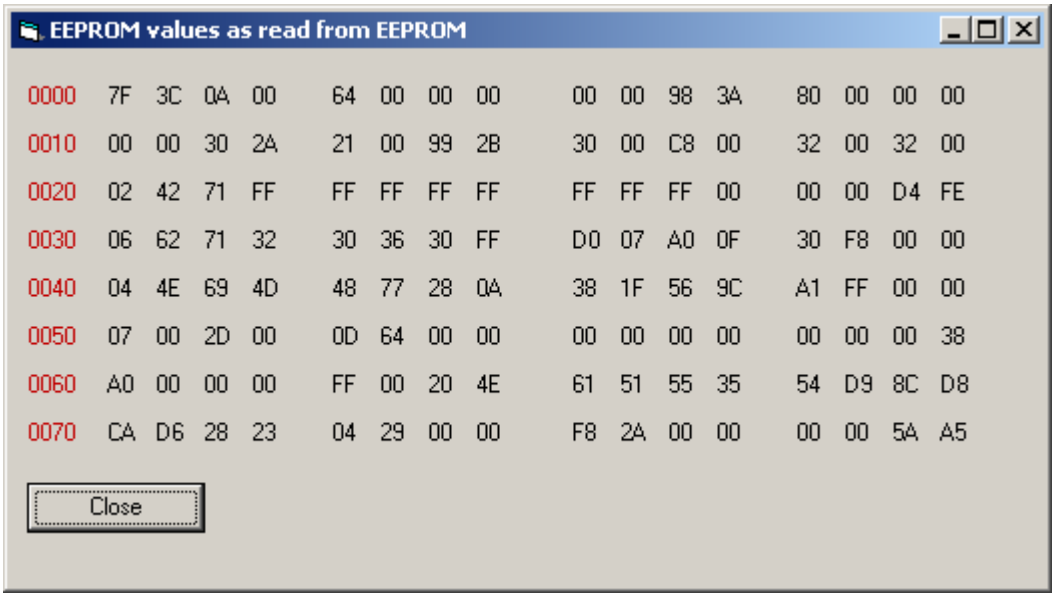


To read all the data from the bq2060 EEPROM, click on | Read |. To write to a selected location click on the desired location, type in the desired data, and hit the ENTER key. After a moment the next location will be highlighted. The entire EEPROM can be written this way.

The EEPROM configuration data can be saved to a file by selecting | File | Store EEPROM |, and entering a file name. An EEPROM file can also be retrieved in this way and written to the bq2060 using the | Write | button.

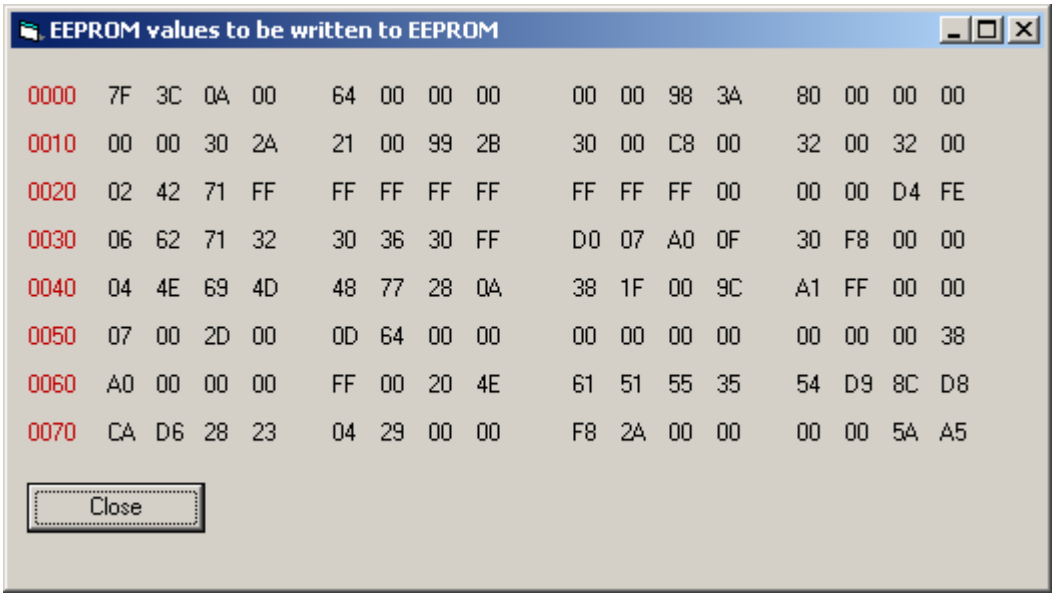
To read the raw hex data in the EEPROM click on | Read EEPROM Contents |. This reads the entire EEPROM contents and displays it in a new window.

Figure 6-6. Read EEPROM Values Screen



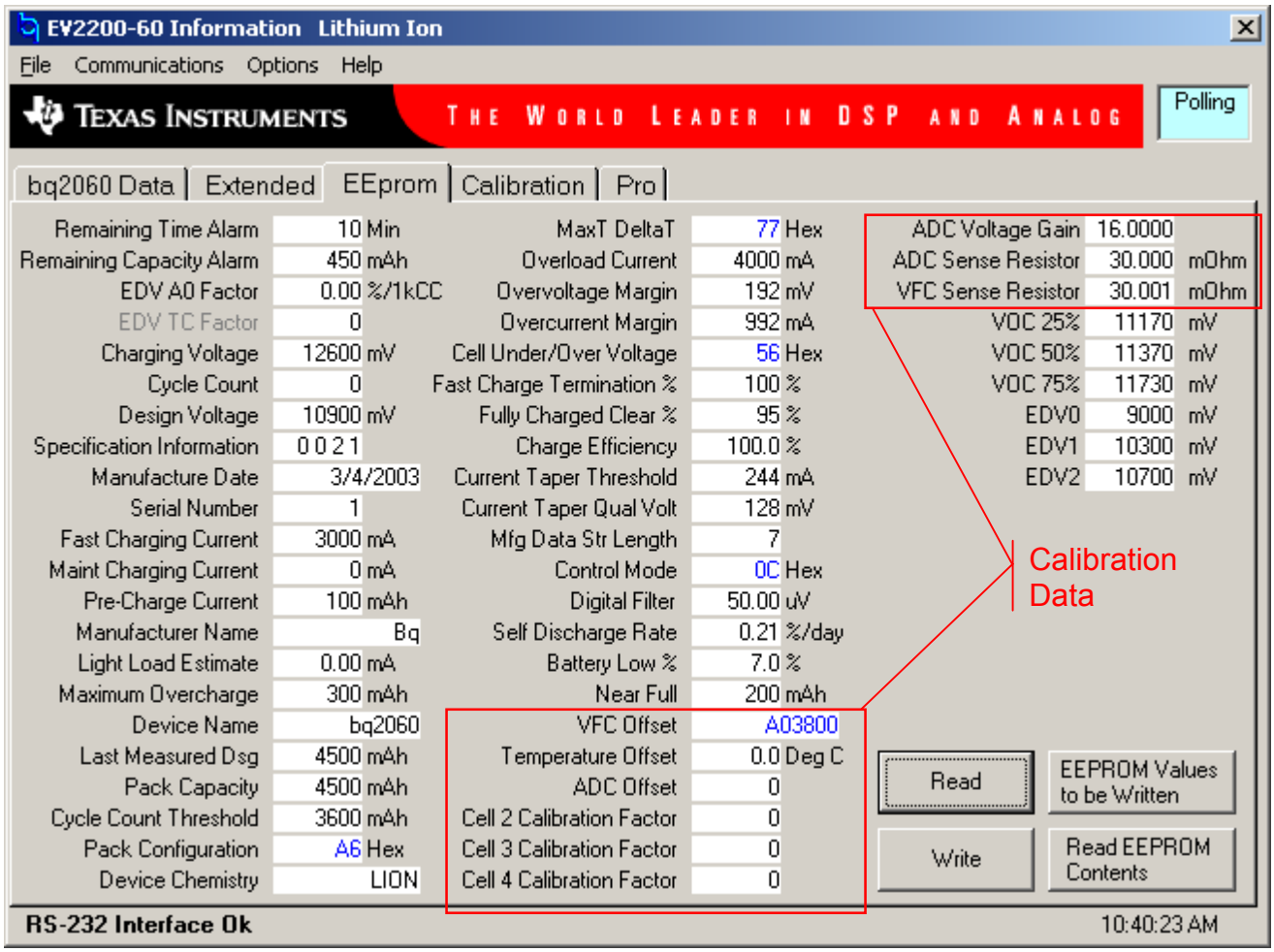
To view the raw hex data prior to writing it to the EEPROM click on | EEPROM Values to be Written |. This does not read from the EERPOM but from the locations as they are displayed. It translates all locations to a raw hex EEPROM map that will be displayed in a new window exactly as it would go into the EEPROM once written.

Figure 6-7. EEPROM Values to be Written Screen



All data required for calibration is also held in the EEPROM for the bq2060, as highlighted in the following figure.

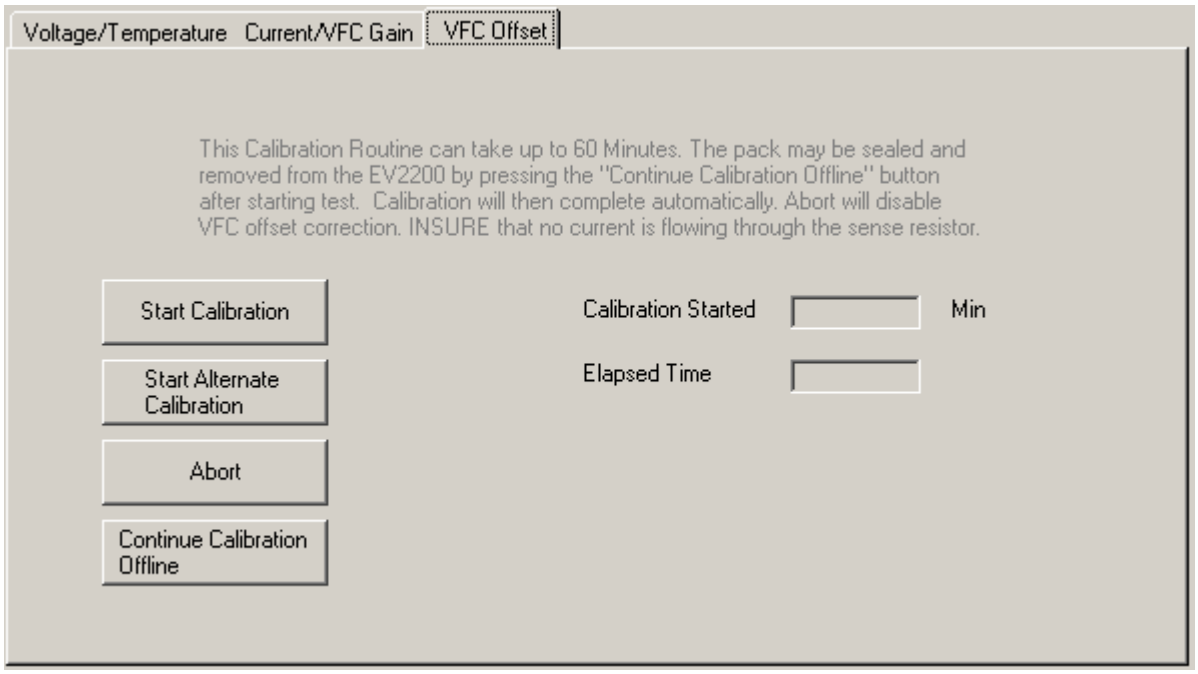
Figure 6-8. EEPROM Data Screen – bq2060 Module Calibration Locations



6.5 Calibration of a bq2060 Based Module Using the EV2200-60 Software

As part of the calibration data there is a VFC Offset tab. The VFC Offset screen offers a simple to use interface for calibrating the Offset of the VFC. There are two different types of offset to choose from.

Figure 6-9. VFC Offset Screen



Default VFC Offset: To select this offset method click on | Start Calibration |. This method will apply an internal short (inside the bq2060) across the sense resistor. With the sense resistor shorted inside the bq2060 there is less chance that an external current can cause a poor offset calculation. This method does not compensate for slight offsets induced by the circuit board.

Alternate VFC Offset: To select this offset method click on | Start Alternate Calibration |. This method does not apply an internal short across the sense resistor. Care must be taken that no current is flowing through the sense resistor. If there is current, the bq2060 applies this current to its calculations, resulting in an inaccurate VFC offset. With no short across the sense resistor, this method compensates for board offset, as long as no current is flowing.

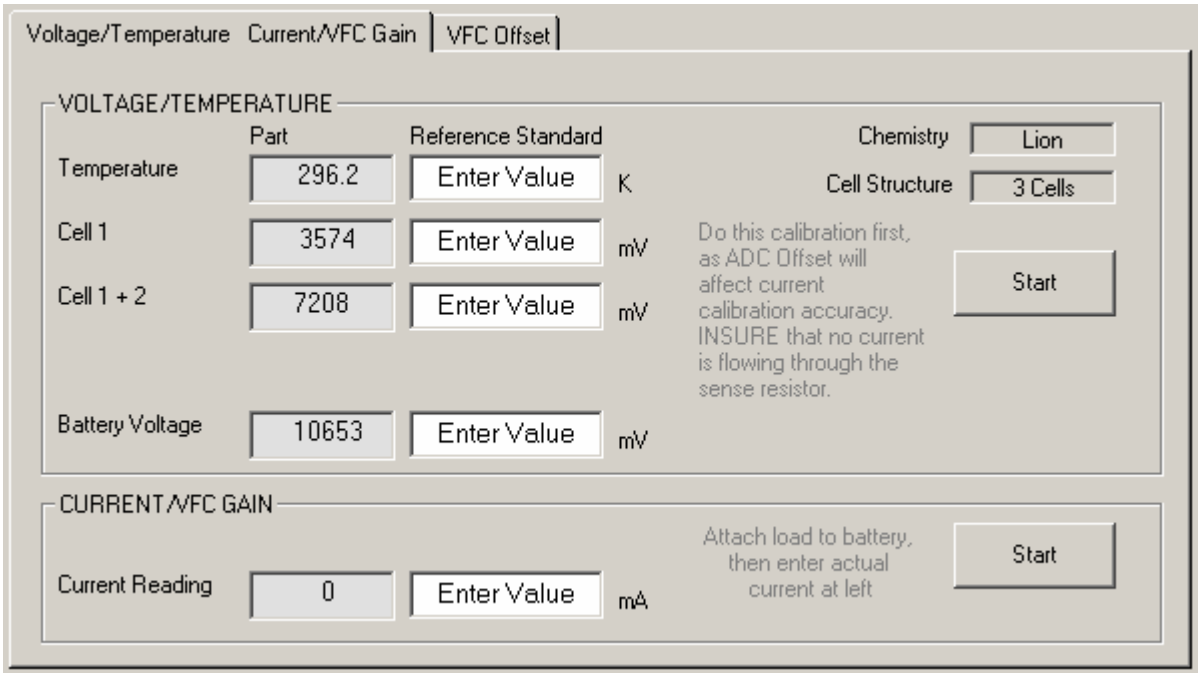
Once calibration is started, the Calibration Started Field displays the time when the calibration was initiated. The Elapsed Time continually updates the amount of time in minutes from the time calibration began.

To abort the offset attempt, click on | Abort |. This halts the offset calculation process and stores a value of 0x003800 into the EEPROM.

If this module is installed on a pack where VCC is present to the bq2060 after disconnecting from the EV2200, then you can click | Continue Calibration Offline | and the bq2060 automatically finishes the calibration, and stores the final result in the EEPROM

when it is complete. When this option is selected, a popup window appears asking if you wish to seal the pack after the calibration is complete. Click | Yes | to seal the pack after calibration, or | No | to finish calibration without sealing the pack. This also is automatically done by the bq2060 after it completes calibration.

Figure 6-10. 3 Cell Li-Ion Calibration Screen



The Li-Ion Calibration screen differs from the NiMH calibration screen by the individual cell voltages and cell structure. If the Chemistry or Cell Structure fields do not show the proper configuration in their respective fields, then select the bq2060 Data Screen Tab, select | Options | Initialize Device |, wait 5 seconds and then Return to the Calibration Tab.

The Voltage/Temperature and Current/VFC Gain screen has two frames. The top frame is for calibrating Voltage and Temperature. This calibration procedure should be performed prior to the Current/VFC Gain calibration.

To perform the Voltage/Temperature calibration, enter values in the Reference Standard column recorded using a traceable calibrated standard. Be sure to make the voltage measurements at the connections to the bq2060EVM-00X module to get the most accurate results. Also be sure that you add the cells together at each individual cell field for all the cells below it. The Battery Voltage Field should be derived from all the cells added together. If this application does not have individual cell voltage monitoring, then only the Battery Voltage field will be displayed. Enter the temperature in the appropriate field in the Reference Standard column. Click on the | Start | button to finish the Voltage/Temperature calibration.

To perform the Current/VFC Gain calibration, connect a traceable calibrated load to the bq2060EVM-00X module as shown in Figure 5-1 or Figure 5-2. Then enter the Load current in the Reference Standard column and click | Start | to finish the Current/VFC Gain calibration.

6.6 Direct Access Communication

The Pro Screen allows direct access to all the memory in the bq2060 including the memory above the SMBus locations provided the bq2060 is unsealed. There is also a scan tool called Dwell that can be useful for scanning a specific location.

Figure 6-11. Pro Screen