bq2084EVM-001

SBS 1.1 Battery Management Solution Evaluation Module

User's Guide

March 2004

High Performance Analog

SLUU184

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 6 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.

Mailing Address:

Texas Instruments
Post Office Box 655303
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Chapter 1

Introduction

This EVM is a complete evaluation system for the bq2084/bq29312/bq29401 battery management system. The EVM includes one bq2084/bq29312/bq29401 circuit module, a current sense resistor, a thermistor, an EV2300 PC interface board for gas gauge interface, a PC USB cable, and Windows™-based PC software. The circuit module includes one bq2084 IC, one bq29312 IC, one bq29401 IC, and all other onboard components necessary to monitor and predict capacity, perform cell balancing, monitor critical parameters, protect the cells from overcharge, over discharge, short circuit, and overcurrent in 2-, 3- or 4-series cell Li-Ion or Li-Polymer battery packs. The circuit module connects directly across the cells in a battery. With the EV2300 interface board and software, the user can read the bq2084 data registers, program the chipset for different pack configurations, log cycling data for further evaluation and evaluate the overall functionality of the bq2084/bq29312/bq29401 solution under different charge and discharge conditions.

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1.1 Features

- ❑ Complete evaluation system for the bq2084 SBS 1.1-compliant advanced gas gauge, bq29312 analog front end and protection IC, and bq29401 independent overvoltage protection IC
- ❑ Populated circuit module for quick setup
- ❑ PC software and interface board for easy evaluation
- ❑ Software that allows data logging for system analysis

1.2 Kit Contents

- ❑ bq2084/bq29312/bq29401 circuit module
- ❑ EV2300 PC interface board
- ❑ Software CD with the evaluation software
- ❑ Connection cable to interface board
- ❑ Set of support documentation
- ❑ EV2300 USB interface board

1.3 Ordering Information

Table 1−1. Ordering Information

EVM Part Number	Chemistry	Configuration	Capacity
bq2084EVM-001	Li-Ion	2, 3, or 4 cell	Any

Chapter 2

bq2084/bq29312-Based Circuit Module

The bq2084/bq29312/bq29401-based circuit module is a complete and compact example solution of a bq2084 and bq29312 circuit for battery management and protection of Li-Ion or Li-Polymer packs. The circuit module incorporates a bq2084 battery monitor IC, bq29312 AFE and protection IC, bq29401 independent overvoltage protection IC, and all other components necessary to accurately predict the capacity of 2-, 3-, or 4-series cells.

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2.1 Circuit Module Connections

Contacts on the circuit module provide the following connections:

- ❑ Direct connection to the cells: 1N (BAT−), 1P, 2P, 3P, 4P (BAT+)
- ❑ To the serial communications port (SMBC, SMBD).
- ❑ The system load and charger connect across PACK+ and PACK−.
- ❑ To the *system present* pin (SYS PRES)
- ❑ To the *sleep* pin (SLEEP)

2.2 Pin Descriptions

1N	–ve connection of first (bottom) cell
1P	+ve connection of first (bottom) cell
2P	+ve connection of second cell
3P	+ve connection of third cell
4P	+ve connection of fourth (top) cell
SMBC	Serial communication port clock
SMBD	Serial communication data port
SYS PRES	System present pin (if low, system is present)
SLEEP	Sleep mode pin (if high, AFE enters sleep mode)
PACK−	Pack negative terminal
VSS	Pack negative terminal
PACK+	Pack positive terminal

Chapter 3

bq2084/bq29312 Circuit Module Schematic

This chapter contains a preview schematic (thumbnail) of the circuit for the bq2084/bq29312/bq29401 implementation.

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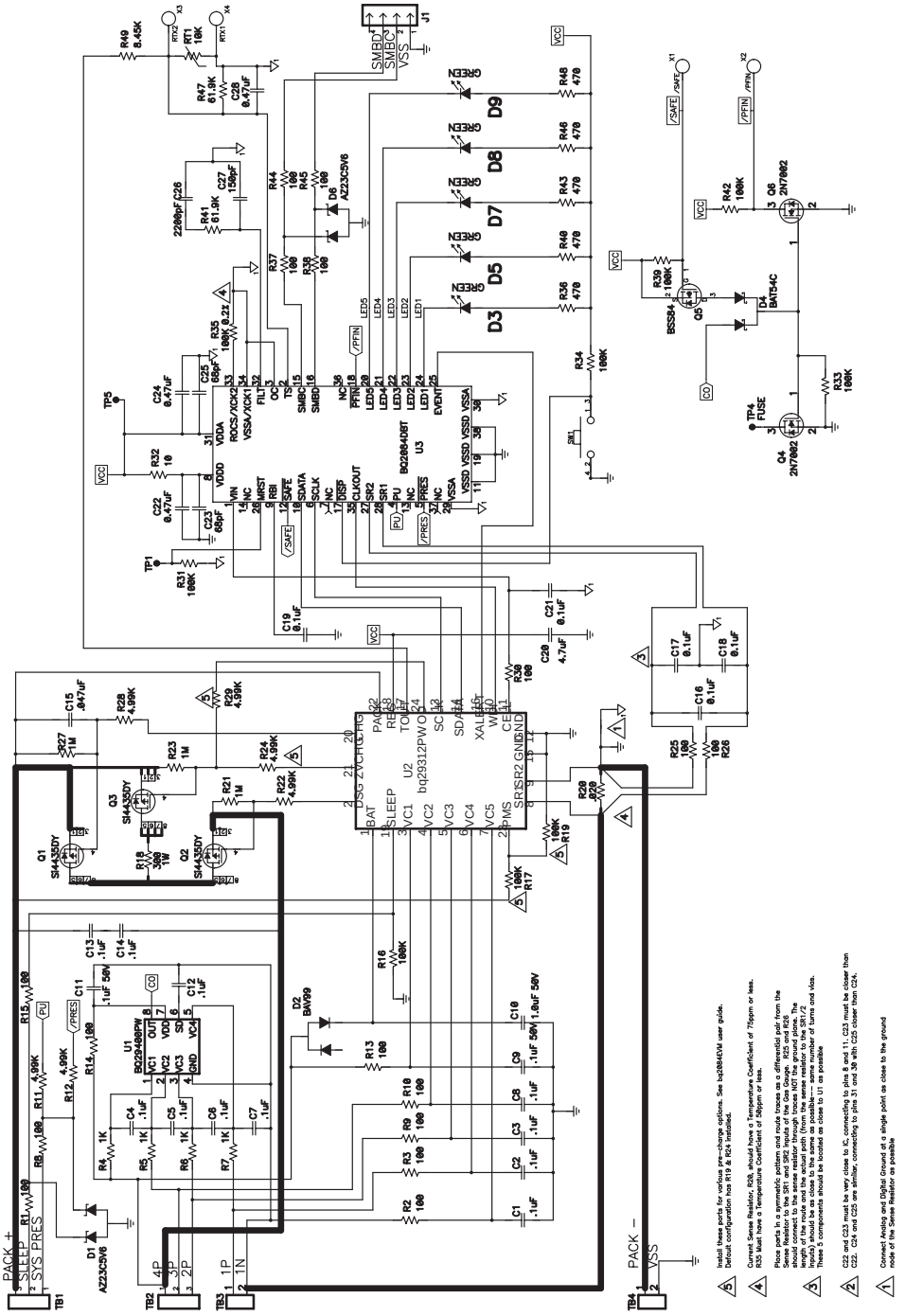
3.1 Preview Schematic

Figure 3−1. bq2084/bq29312/bq29401 EVM Schematic

Refer to the back of the user's guide for the full-size schematic.



3.2 Modifications for Choosing Particular Precharge Mode

In order to charge, the charge FET (CHG-FET) must be turned on to create a current path. When the V(BAT) is 0 V and CHG-FET = ON, the V(PACK) is as low as the battery voltage. In this case, the supply voltage for the device is too low to operate. There are 3 possible configurations for this function, and the bq29312 can be easily configured according to the application needs. The 3 modes are 0-V Charge FET Mode, Common FET Mode, and Precharge FET Mode.

1) 0-V Charge FET Mode − Dedicates a precharge current path using an additional FET (ZVCHG−FET) to sustain the PACK+ voltage level. The host charger is expected to provide a precharge function.

2) Common FET Mode − Does not use a dedicated precharge FET. The charge FET (CHG−FET) is set to ON state as default. The charger is expected to provide a precharge function.

3) Precharge FET Mode − Dedicates a precharge current path using an additional open drain (OD) pin drive FET (PCHG−FET) FET to sustain the PACK+ voltage level. The charger does not provide any precharge function.

To use a particular mode of charging with the EVM, add or remove some elements shown in Table 3−1, and use the given settings of Flash memory, Misc Configuration DF 0x2a (high) and 0x2b (low), bits PFET1, PFET0.

Table 3−1. Components and Flash-Memory Settings for Different Precharge Modes

Mode	Resistors	FET	PFET1	PFET0
1(default)	R19,R24	Q3, SI4435DY	0	0
2	R17	–	0	1
3	R19,R24	Q3, open drain FET	1	0

For more details about precharge operation and mode choices, see the bq29312 data sheet at http://www−s.ti.com/sc/ds/bq29312.pdf.

3.3 Testing Fuse-Blowing Circuit

To prevent the loss of board functionality during the fuse-blowing test, the actual chemical fuse is not provided in the circuit. FET Q4 drives TP4 low if a *fuse blow* condition occurs, so monitoring TP4 can be used to test this condition. Fuse placement on the application board is shown in the bq2084 data sheet reference-board schematic.

Chapter 4

Circuit Module Physical Layouts and Bill of Materials

This chapter contains the board layout, bill of materials, and assembly drawings for the bq2084/ bq29312/ bq29401 circuit module.

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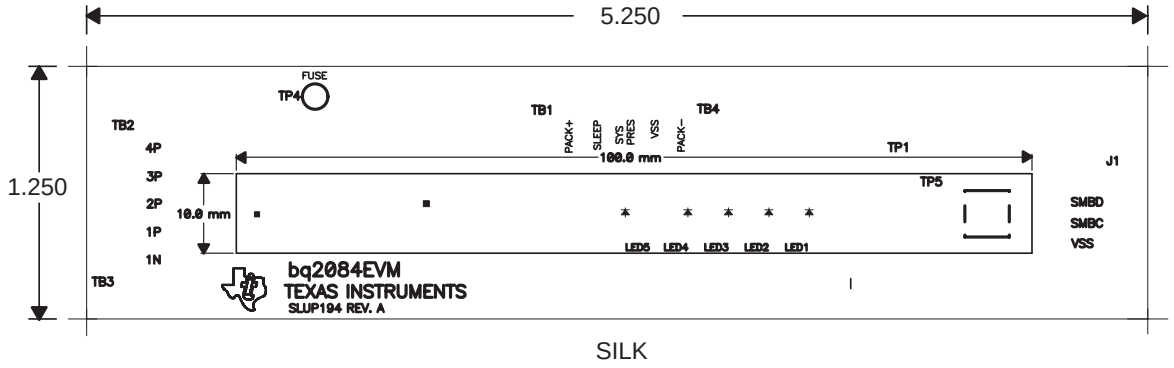
4.1 Board Layout

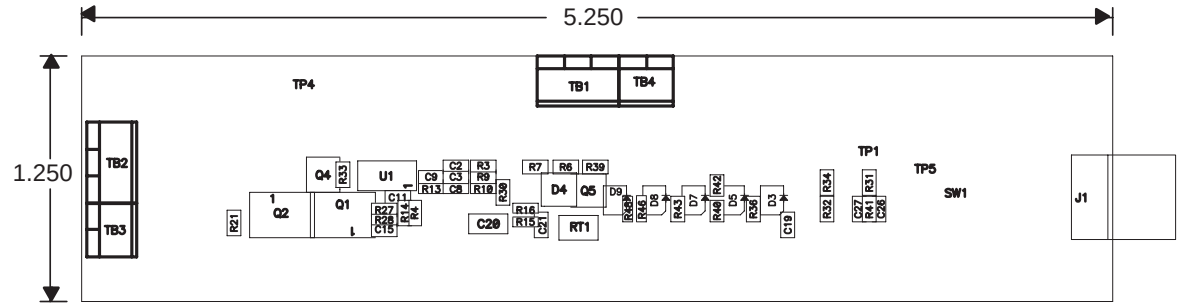
Figure 4−1 shows the dimensions, PCB layers, and assembly drawing for the bq2084/bq29312 module.

Figure 4−1. bq2084EVM-001 Layout



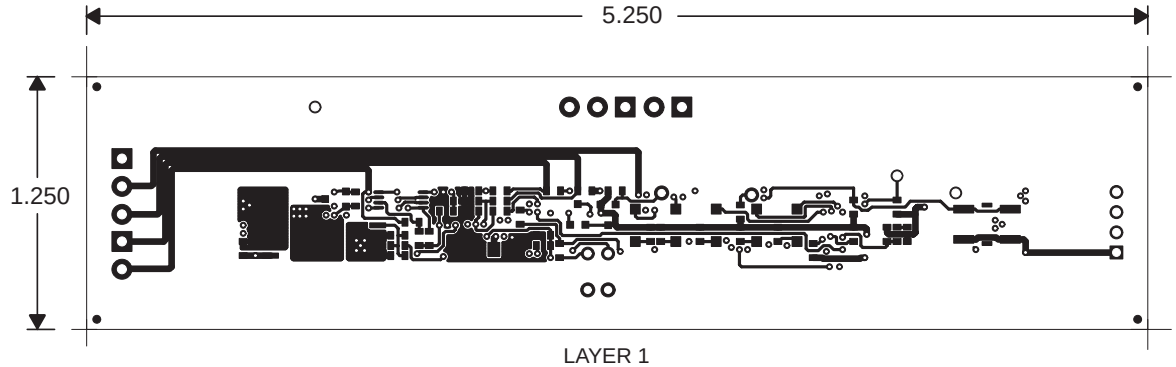
SILK

Figure 4−2. Top Assembly



SLUP194 REV. A TOP ASSY

Figure 4−3. Layer 1



LAYER 1

Figure 4−4. Layer 2 (Internal 1)

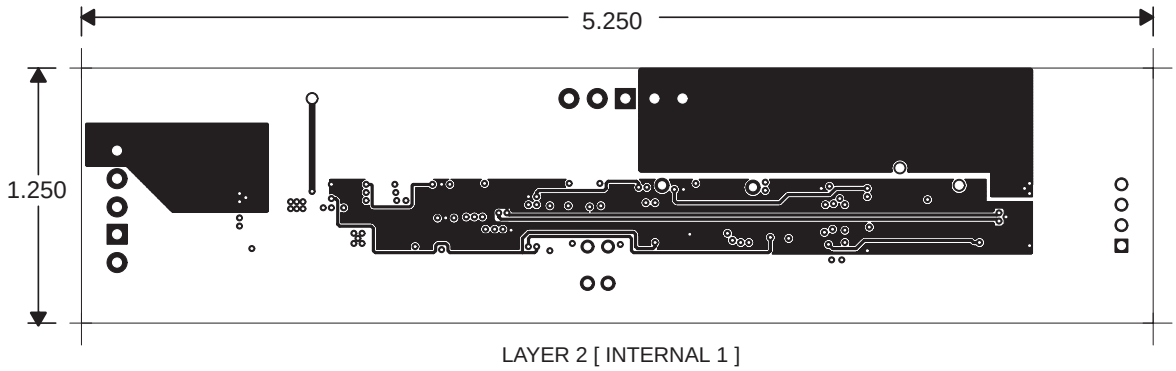


Figure 4−5. Layer 3 (Internal 2)

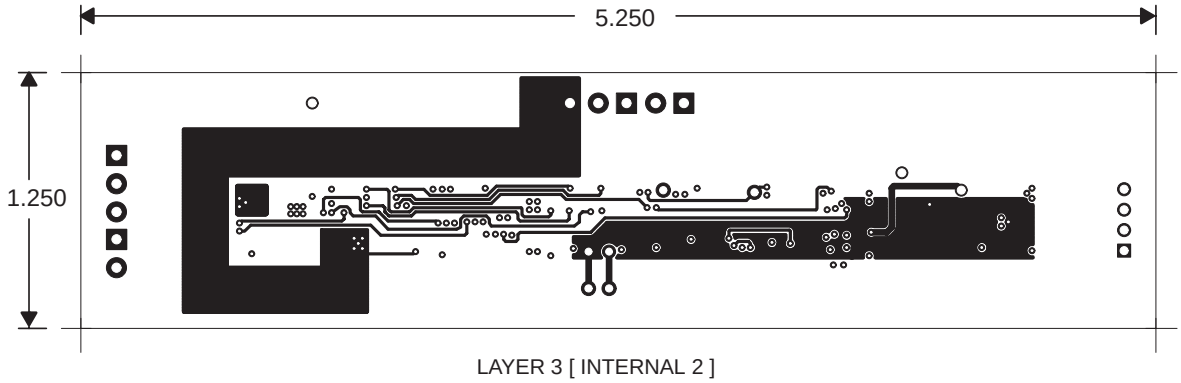


Figure 4−6. Layer 4

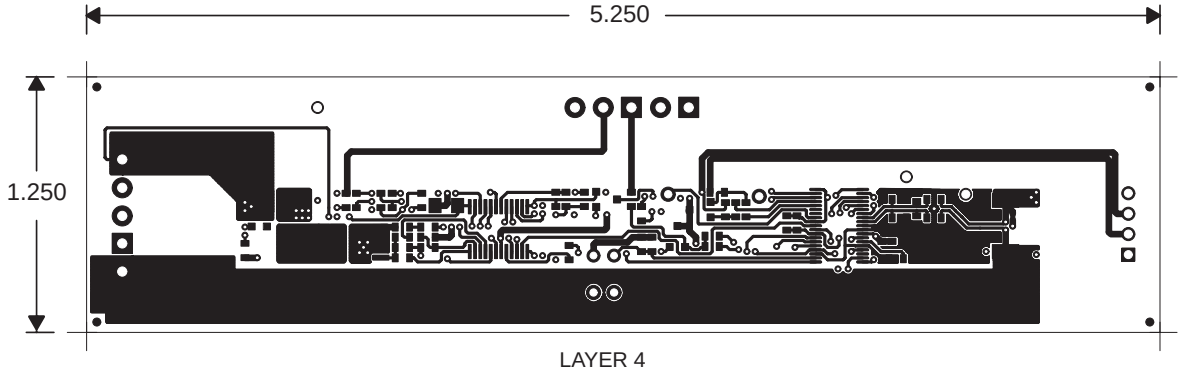
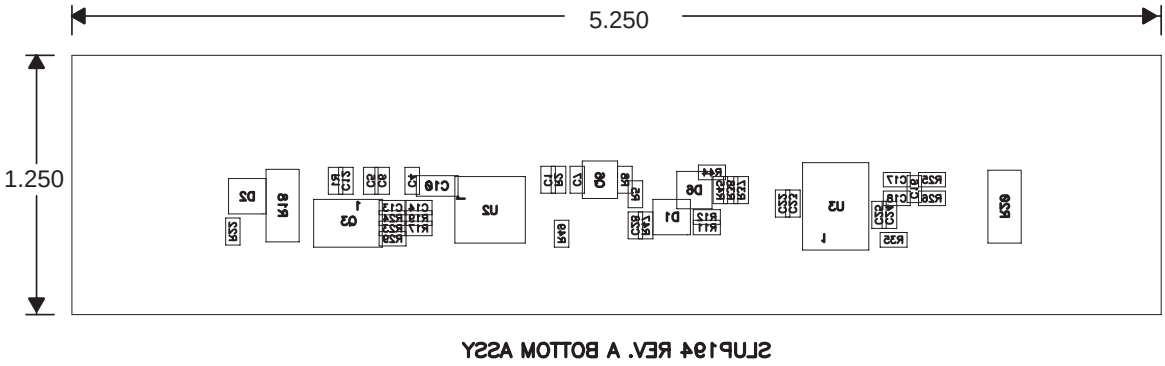


Figure 4−7. Bottom Assembly



4.2 Bill of Materials

Table 4−1 is a list of materials required for the bq2084/bq29312 circuit module.

Table 4−1. Bill of Materials

Count	Ref Des	Description	Size	Value	MFG Part No.
18	C1, C2, C3, C4, C5, C6, C7, C8, C9, C11, C12, C13, C14, C16, C17, C18, C19, C21	Capacitor, ceramic, 50 V, X7R, 20%	603	0.1 µF	
1	C10	Capacitor, ceramic, 50 V, X7R, 20%	1206	1.0 µF	
1	C15	Capacitor, ceramic, 50 V, X7R, 10%	603	0.047 µF	
1	C20	Capacitor, ceramic, 16 V, X7R, 10%	1206	4.7 µF	
3	C22, C24, C28	Capacitor, ceramic, 16 V, X7R, 10%	603	0.47 µF	
2	C23, C25	Capacitor, ceramic, 16 V, COG, 10%	603	68 pF	
1	C26	Capacitor, ceramic, 16 V, COG, 10%	603	2200 pF	
1	C27	Capacitor, ceramic, 16 V, COG, 10%	603	150 pF	
2	D1, D6	Diode, dual, Zener, 5.6 V, 300 mW	SOT23		AZ23C5V6
1	D2	Diode, dual ultra fast, series, 200 mA, 70 V	SOT23		BAV99
5	D3, D5, D7, D8, D9	Diode, LED, gree, Gullwing, GW type, 20 mA, 7.5 mcd Typ	Gullwing		LN1361C
1	D4	Diode, dual Schottky, 200 mA, 30 V	SOT23		BAT54C
1	J1	Header, friction lock assembly, 4-pin right angle	0.400 × 0.500		22-05-3041
3	Q1, Q2, Q3	MOSFET, P-ch, 30 V, 7.0 A, 20 mΩ	SO8		Si4435DY
2	Q4, Q6	MOSFET, N-ch, 60 V, 115 mA, 1.2 Ω	SOT23		2N7002
1	Q5	MOSFET, P-ch, 50 V, 130 mA, 10 Ω	SOT23		BSS84
16	R1, R2, R3, R8, R9, R10, R13, R14, R15, R25, R26, R30, R37, R38, R44, R45	Resistor, chip, 1/16 W, 5%	603	100 Ω	
6	R11, R12, R22, R24, R28, R29	Resistor, chip, 1/16 W, 1%	603	4.99 kΩ	
8	R16, R17, R19, R31, R33, R34, R39, R42	Resistor, chip, 1/16 W, 5%	603	100 kΩ	
1	R18	Resistor, chip, 1 W, 5%	2512	300 Ω	

Count	Ref Des	Description	Size	Value	MFG Part No.
1	R20	Resistor, chip, 1 W, 1%	2512	0.02 Ω	
3	R21, R23, R27	Resistor, chip, 1/16 W, 5%	603	1 MΩ	
1	R32	Resistor, chip, 1/16 W, 5%	603	10 Ω	
1	R35**	Resistor, chip, 1/16 W, 0.2%, 75 PPM	603	100 kΩ	
5	R36, R40, R43, R46, R48	Resistor, chip, 1/16 W, 5%	603	470 Ω	
4	R4, R5, R6, R7	Resistor, chip, 1/16 W, 5%	603	1 kΩ	
2	R41, R47	Resistor, chip, 1/16 W, 1%	603	61.9 kΩ	
1	R49	Resistor, chip, 1.16 W, 1%	603	8.45 kΩ	
1	RT1	Thermistor	0.095 × 0.150	10 kΩ	
1	SW1	Switch, push button, momentary, N.O. low profile	5 mm × 5 mm		
2	TB1, TB2	Terminal block, 3 pin, 6 A, 3,5 mm	0.41 × 0.25		ED1515
2	TB3, TB4	Terminal block, 2 pin, 6 A, 3,5 mm	0.27 × 0.25		ED1514
3	TP1, TP4, TP5	Jack, test point, cir		NA	
1	U1	IC, voltage protection for 2, 3, or 4 cell Li-Ion, 2nd protection, x.xx	TSSOP-08		bq29400PW
1	U2	IC, 2, 3, or 4 cell serie protection control AFE	TSSOP24		bq29312PW
1	U3	IC, advanced gas gauge	TSSOP38		bq2084DBT
1	—	PCB			

Notes: 1) This assembly is ESD sensitive.
2) This assembly shall comply with IPC-A-610 class 2 or better.
3) This assembly must be clean of flux residues and contaminants. Use of no-clean flux is not acceptable.
4) Reference designators marked with an asterisk (**) cannot be substituted.

4.3 bq2084/bq29312/bq29401 Circuit Module Performance Specification Summary

This section summarizes the performance specifications of the bq2084/bq29312/bq29401 circuit module.

Table 4−2. Performance Specifiction Summary

Specification	Min	Typ	Max	Units
Input Voltage Pack+ to Pack−	6.0		25	V
Charge and Discharge Current			See Note	A

Note: Maximum currents are determined by the value of the sense resistor used and the short circuit threshold setting of the bq29312. It is important to operate this EVM within the input voltage range of 6 V and 25 V, with a maximum voltage drop across the sense resistor of ±250 mV (1-W power dissipation).

Chapter 5

EVM Hardware and Software Setup

This chapter describes how to install the bq2084EVM-001 PC software, and how to connect the different components of the EVM.

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5.1 System Requirements

EV2300-84 software requires Windows™ 2000 or Windows™ XP. Drivers for Windows 98SE are provided, but Microsoft no longer supports Windows™ 98; and there may be issues in Windows™ 98 with USB driver support. The EV2300 USB drivers have been tested for Windows™ 98SE, but no assurance is made for problem-free operation with specific system configurations.

5.2 Software Installation

You can find the latest software version in the bq2084 tool folder on power.ti.com. The following steps install the EV2300-84 software:

If files were delivered on floppy disks:

1) Insert disk 1 into a 3-1/2-inch floppy drive.

2) Select the 3-1/2-inch drive using My Computer or File Manager. Execute setup.exe which prompts you to enter a temporary directory to extract all files. Follow the instructions of the extractor program, which prompts you to insert more disks.

3) In the temporary directory you selected, open the archive TI USB DRVRS.zip and extract its contents in a subdirectory/drivers. Choose *preserve directory structure* option when extracting.

4) Plug the EV2300 into a USB port.

5) Wait until system prompt *new hardware found* appears. Chose *select location manually* and use the *Browse* button to point to subdirectory TIUSB-Win2K-XP-1.

6) Answer *continue* to the warning that drivers are not certified with Microsoft.

7) After installation finishes, another system prompt *new hardware found* appears. Repeat procedure above, but point to subdirectory TIUSBWin2K-XP-2

8) Answer *continue* to the warning that drivers are not certified with Microsoft. Installation of drivers is now finished.

9) In case of Windows 98, point to directory TIUSBWin98.

10) Return to the temporary directory where you extracted files; double-click on the Setup.exe icon to install EV Software.

If files were delivered on a CD, copy all files to a temporary directory and follow the preceding steps 3−10.

If files were downloaded from the Web:

1) Open the archive containing the installation package and copy its contents in a temporary directory.

2) Follow the preceding steps 3−10.

5.3 Hardware Connection

The bq2084EVM-001 comprises three hardware components: the bq2084/bq29312/bq29401 circuit module, the EV2300 PC interface board, and the PC.

5.3.1 Connecting the bq2084/bq29312/bq29401 Circuit Module to a Battery Pack

Figure 5−1 shows how to connect the bq2084/bq29312/bq29401 circuit module to the cells and system load/charger.

The cells should be connected in the following order.

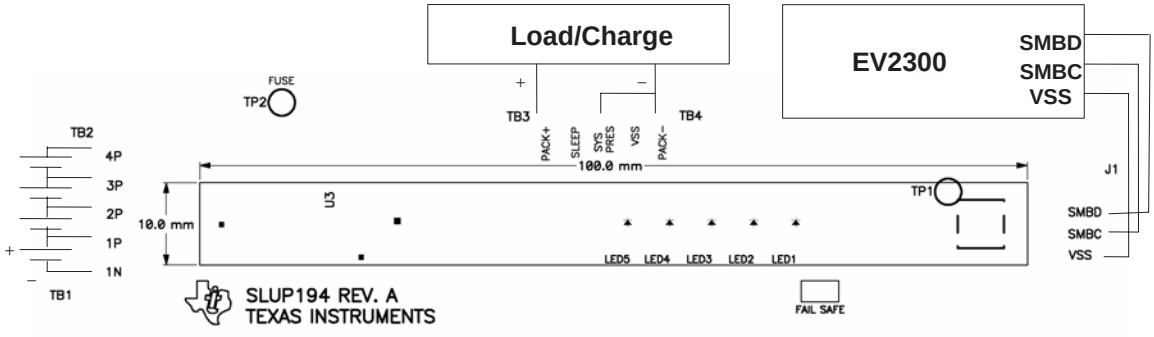
1) 4-Cell Pack: 1N (BAT−), 4P (BAT+), 1P, 2P, and then 3P. (see section 2.1 for definitions)

2) 3-Cell Pack: 1N (BAT−), 4P (BAT+), 1P, 2P, and then connect 4P and 3P together.

3) 2−Cell Pack: 1N (BAT−), 4P (BAT+), 1P, and then connect 4P, 3P, and 2P together

To start charge or discharge test, connect SYS PRES pin to PACK– pin to set SYS PRES state. To test sleep mode, disconnect SYS PRES pin.

Figure 5−1. bq2084/bq29312 Circuit Module Connection to Cells and System Load/Charger



5.3.2 PC Interface Connection

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

1) Connect the bq2084/bq29312-based smart battery to the EV2300 using wire leads as shown in Table 5−1.

Table 5−1. Circuit Module to EV2300 Connections

bq2084/bq29312−Based Battery	EV2300
SMBD	SMBD/HDQ1
SMBC	SMBC/HDQ2
VSS	VSS

2) Connect the PC USB cable to the EV2300 and the PC USB port.

The bq2084EVM-001 is now set up for operation.

Chapter 6

Operation

This chapter details the operation of the bq2084 EVSW software.

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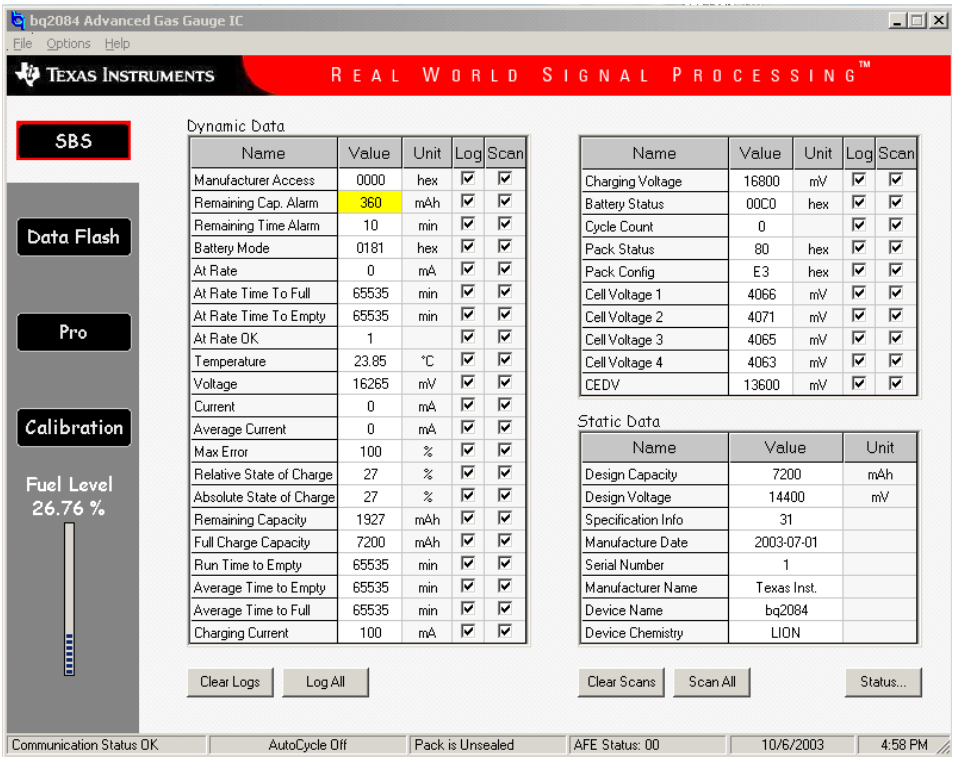
6.1 Starting the Program

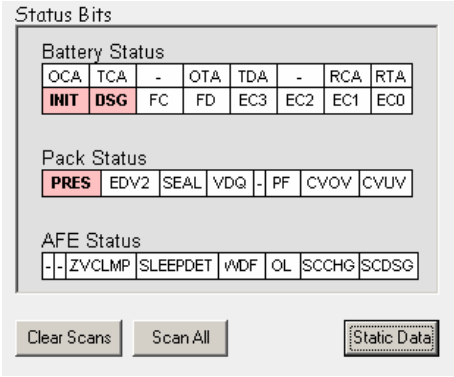
Run bq2084 EVSW from the Start | Programs | Texas Instruments | bq2084 EVSW menu sequence. The SBS Data screen appears. Data begins to appear as the indicator scans down the screen, as seen in the field *Charging Current* of Figure 6−1. To disable the scan feature, select |Options |Scan| Off|.

Figure 6−1. SBS Data Screen



This screen shows the SBS data set along with additional ManufacturersAccess() command information such as individual cell measurements. Static data is shown in a box at the bottom right which, by clicking on the Status… button, changes to show the status bits of the bq2084 and bq29312.

Figure 6−2. SBS Data Screen − Status Bit Window



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 |OK|. An example of a data log file is shown in Table 6−1. To stop the data log, follow the same sequence. The logging period can be changed via | Options | Set Logging Options |.

Table 6−1. Example Log File

10/6/2003 17:01
Design Capacity: 7200
Design Voltage: 14400
Specification Info: 31
Mfg Date (yyy−mm−dd): 2003−07−01
Serial Number: 1
Mfr Name: Texas Instruments
Device Name: bq2084
Device Chemistry: LION

Sample	Stamp	Elapsed (s)	Mf Access	Rm Cap Aln	RmTme Alr	Batt-Mode	@Rate	@Rate-Ful	@Rate Emp	@Rate OK	Temp	Voltage	Current	Avg-Curr
1	5:01:53	1	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
2	5:01:55	2	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
4	5:01:56	4	0	360	10	181	0	65535	65535	1	23.85	16267	0	0
5	5:01:57	5	0	360	10	181	0	65535	65535	1	23.85	16267	0	0
6	5:01:58	6	0	360	10	181	0	65535	65535	1	23.95	16267	0	0
7	5:01:59	7	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
8	5:02:00	8	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
9	5:02:01	9	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
10	5:02:02	10	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
11	5:02:03	11	0	360	10	181	0	65535	65535	1	23.95	16266	0	0
12	5:02:04	12	0	360	10	181	0	65535	65535	1	23.85	16266	0	0

NOTE: This is a reduced version of the log file; in addition to the data shown here, Max Error, RSOC, ASOC, RemCap, FCC, RT−Empty, AvTm2Emp, AvTm2Ful, ChgCurr, ChgVlt, Batstat, CyclCnt, PackStat, PackConf, Cell_V_1, Cell_V_2, Cell_V_3, Cell_V_4, CEDV, AFE Sts are also logged.

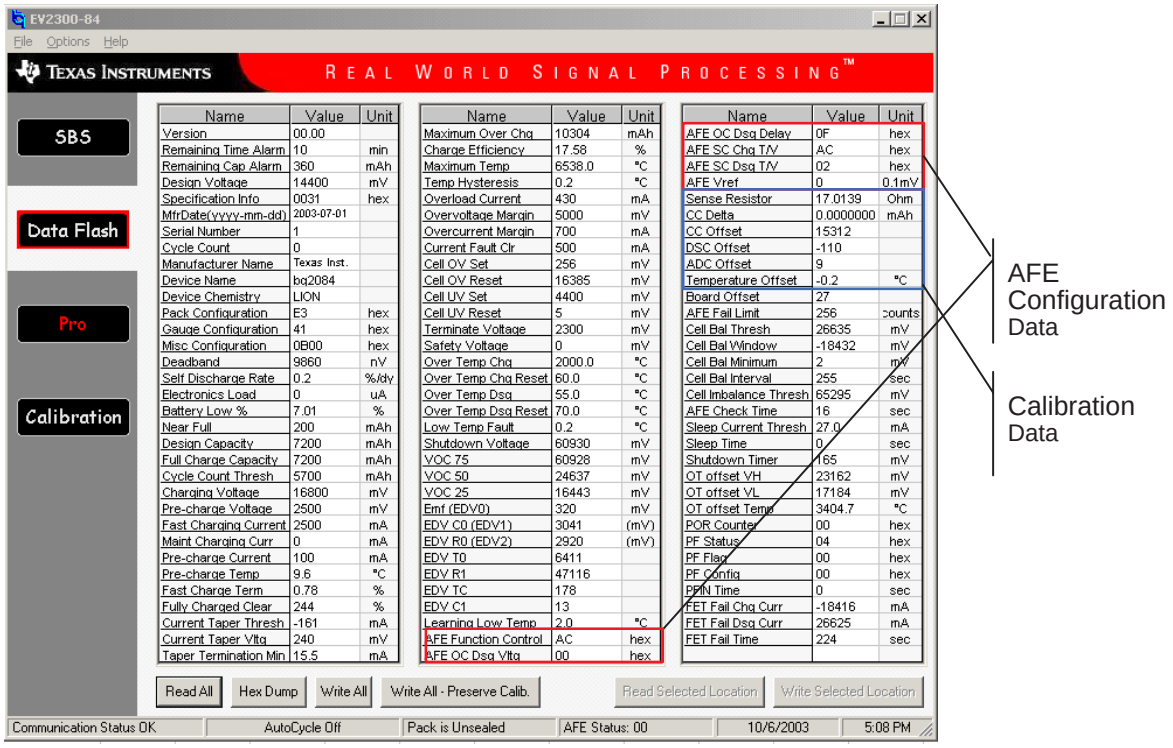
6.2 Setting Programmable bq2084 and bq29312 Options

The bq2084 data flash comes configured per the default settings detailed in the bq2084 data sheet. Ensure that the settings are correctly changed to match the pack and application for the bq2084/bq29312 solution being evaluated.

IMPORTANT: The correct setting of these options is essential to get the best performance.

The settings can be configured using the *Data Flash* screen.

Figure 6−3. Data Flash Screen, AFE Configuration, and Module Calibration Locations



To read all the data from the bq2084 data flash, click on the | Read All | button. To only read a selected location, click on the desired location and the | Read Selected Location | button is activated. When this button is clicked, the data is read and the screen updated.

The same procedure can be followed for writing all the data flash or just a specific location.

The data flash configuration can be saved to a file by selecting | File | Save gas gauge constants |, and entering a file name. A data flash file can also be retrieved in this way and written to the bq2084 using the | Write All | button.

If the calibration data already in the bq2084 is required to be preserved, use the | Write All – Preserve Calibration | button.

The configuration information of the bq29312 and module calibration data is also held in the bq2084 data flash as highlighted in Figure 6−4.

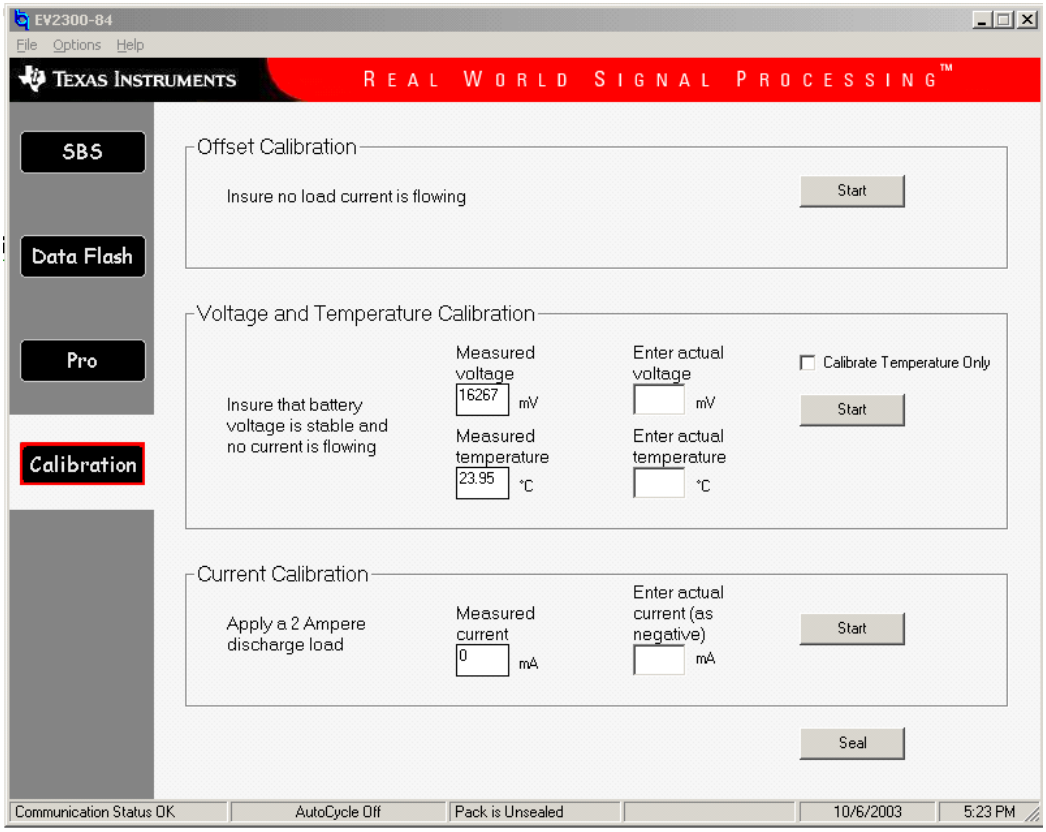
6.3 Calibration of a bq2084/bq29312/bq29401-Based Module Using the EV2300-84 Software

Part of the calibration data is a board offset parameter. The EV2300-84 software allows the board offset to be measured. An average of several modules should be taken, and then this value entered in all like modules.

The calibration screen offers a simple-to-use interface for this procedure.

Follow the on-screen instructions as shown in Figure 6−4. Click |Start| to begin the test, and additional instructions appear for that particular calibration procedure until it is complete.

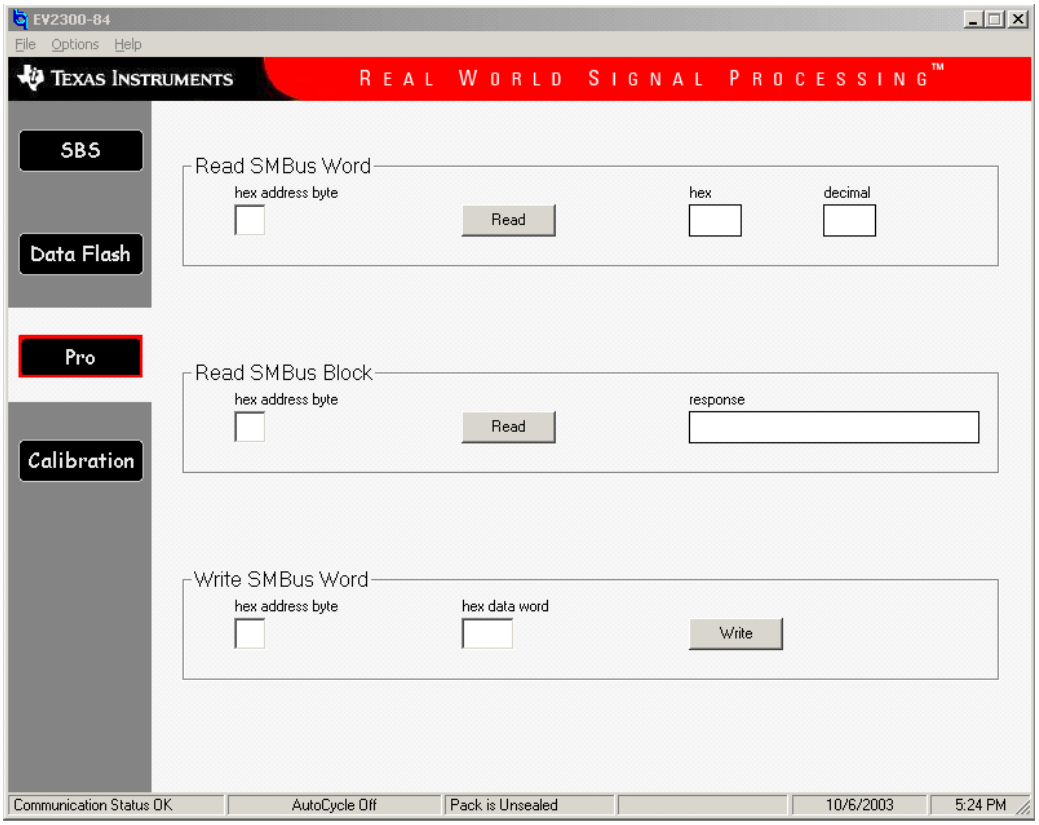
Figure 6−4. Calibration Screen

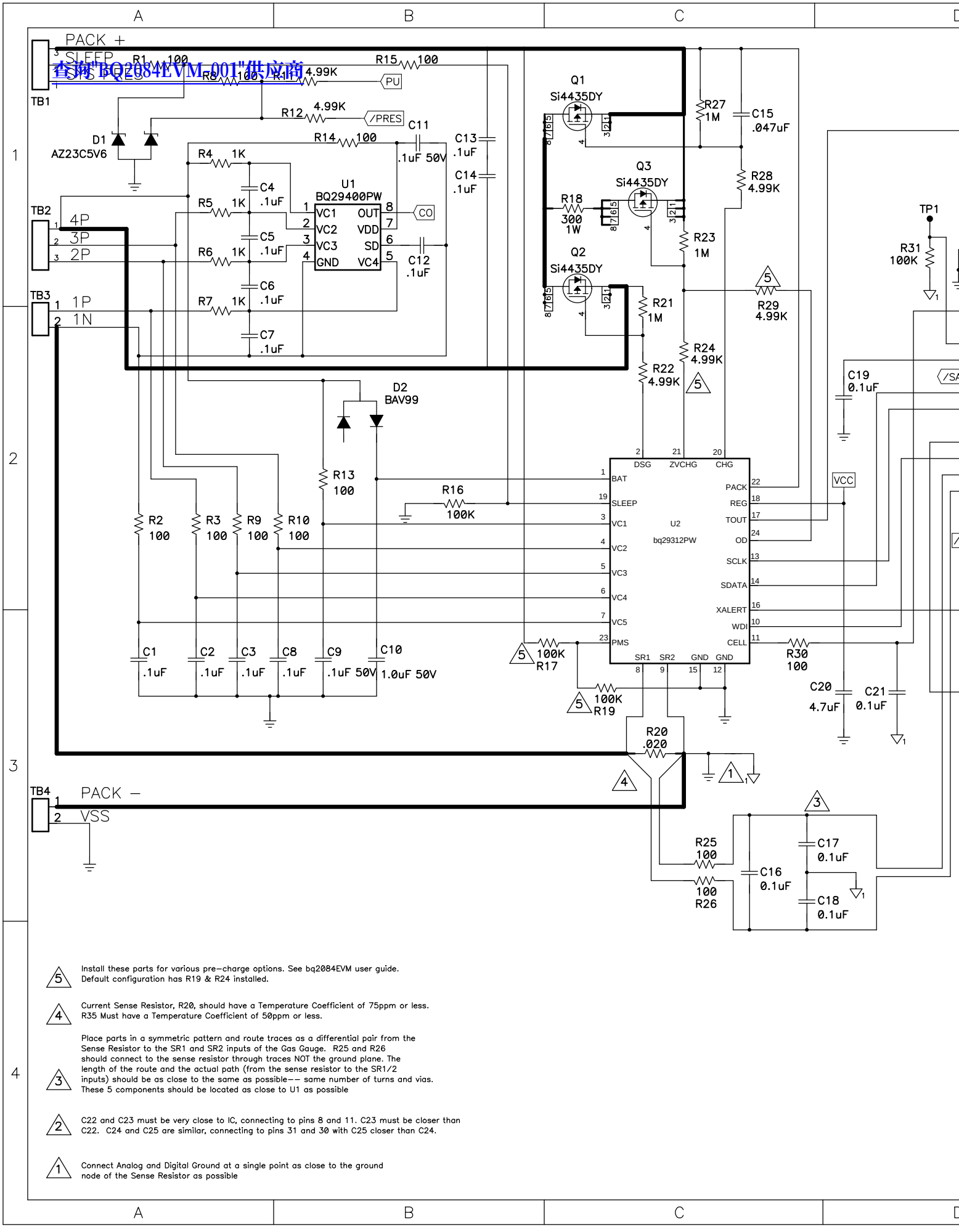


6.4 Direct Access Communication

The bq2084 allows access to the various internal registers through the Pro Screen. Here, individual byte or block reads and block writes can be performed.

Figure 6−5. Pro Screen





5 Install these parts for various pre−charge options. See bq2084EVM user guide. Default configuration has R19 & R24 installed.

4 Current Sense Resistor, R20, should have a Temperature Coefficient of 75ppm or less. R35 Must have a Temperature Coefficient of 50ppm or less.

3 Place parts in a symmetric pattern and route traces as a differential pair from the Sense Resistor to the SR1 and SR2 inputs of the Gas Gauge. R25 and R26 should connect to the sense resistor through traces NOT the ground plane. The length of the route and the actual path (from the sense resistor to the SR1/2 inputs) should be as close to the same as possible−− same number of turns and vias. These 5 components should be located as close to U1 as possible

2 C22 and C23 must be very close to IC, connecting to pins 8 and 11. C23 must be closer than C22. C24 and C25 are similar, connecting to pins 31 and 30 with C25 closer than C24.

1 Connect Analog and Digital Ground at a single point as close to the ground node of the Sense Resistor as possible