SBS v1.1-COMPLIANT GAS GAUGE FOR USE WITH THE bq29312

Check for Samples: bq2084-V133

FEATURES

- **Provides Accurate Measurement of Available Charge in Li-Ion and Li-Polymer Batteries**
- **Supports the Smart Battery Specification (SBS) V1.1**
- **Integrated Time Base Eliminates Need for External Crystal**
  - **Optional Crystal input**
- **Works With the TI bq29312 Analog Front-End (AFE) Protection IC to Provide Complete Pack Electronics for 7.2-V, 10.8-V or 14.4-V Battery Packs With Few External Components**
- **Based on a Powerful Low-Power RISC CPU Core With High-Performance Peripherals**
- **Integrated Flash Memory Eliminates the Need for External Configuration EEPROM**
- **Uses 16-Bit Delta Sigma Converter for Accurate Voltage and Temperature Measurements**
- **Measures Charge Flow Using a High Resolution 16-Bit Integrating Converter**
  - **Better Than 0.65-nVh of Resolution**
  - **Self-Calibrating**
  - **Offset Error Less Than 1-µV**
- **Programmable Cell Modeling for Maximum Battery Fuel Gauge Accuracy**
- **Drives 3-, 4-, or 5-Segment LED Display for Remaining Capacity Indication**
- **Available in a 38-Pin TSSOP (DBT) Package**

APPLICATIONS

- **Notebook PCs**
- **Medical and Test Equipment**
- **Portable Instrumentation**

DESCRIPTION

The bq2084-V133 SBS-compliant gas gauge IC for battery pack or in-system installation maintains an accurate record of available charge in Li-ion or Li-polymer batteries. The bq2084-V133 monitors capacity and other critical parameters of the battery pack and reports the information to the system host controller over a serial communication bus. It is designed to work with the bq29312 AFE protection IC to maximize functionality and safety and minimize component count and cost in smart battery circuits. Using information from the bq2084-V133, the host controller can manage remaining battery power to extend the system run time as much as possible.

The bq2084-V133 uses an integrating converter with continuous sampling for the measurement of battery charge and discharge currents. Optimized for coulomb counting in portable applications, the self-calibrating integrating converter has a resolution better than 0.65-nVh and an offset measurement error of less than 1-µV (typical). For voltage and temperature reporting, the bq2084-V133 uses a 16-bit A-to-D converter. With the bq29312, the onboard ADC also monitors the pack and individual cell voltages in a battery pack and allows the bq2084-V133 to generate the control signals necessary to implement the cell balancing and the required safety protection for Li-ion and Li-polymer battery chemistries.

The bq2084-V133 supports the Smart Battery Data (SBData) commands and charge-control functions. It communicates data using the System Management Bus (SMBus) 2-wire protocol. The data available include the battery's remaining capacity, temperature, voltage, current, and remaining run-time predictions.

The bq2084-V133 provides LED drivers and a pushbutton input to indicate remaining battery capacity from full to empty in 20%, 25%, or 33% increments with a 3-, 4-, or 5-segment display.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2005–2010, Texas Instruments Incorporated

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

DESCRIPTION (CONTINUED)

The bq2084-V133 contains 1k bytes of internal data flash memory, which store configuration information. The information includes nominal capacity and voltage, self-discharge rate, rate compensation factors, and other programmable cell-modeling factors used to accurately adjust remaining capacity for use-conditions based on time, rate, and temperature. The bq2084-V133 also automatically calibrates or learns the true battery capacity in the course of a discharge cycle from programmable near full to near empty levels.

The bq29312 analog front-end (AFE) protection IC is used to maximize functionality and safety and minimize component count and cost in smart battery circuits. The bq29312 AFE protection IC provides power to the bq2084-V133 from a 2-, 3-, or 4-series Li-ion cell stack, eliminating the need for an external regulator circuit.

ORDERING INFORMATION

T_A	PACKAGE
	38-PIN TSSOP (DBT)
–20°C to 85°C	bq2084DBT-V133(1)

(1) The bq2084-V133 is available taped and reeled. Add an R suffix to the device type (e.g., bq2084DBTR-V133) to order tape and reel version.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted(1)

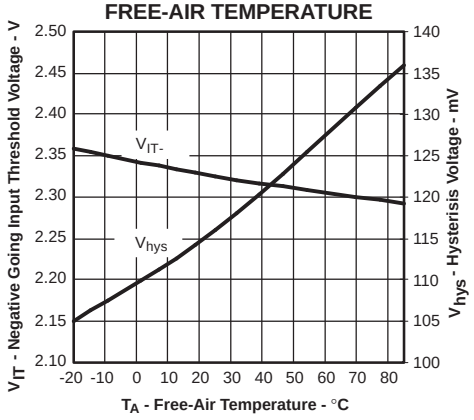
		UNIT
	Supply voltage range, V_{DD} relative to V_{SS} (2)	–0.3 V to 4.1 V
	Open-drain I/O pins, $V_{(IOD)}$ relative to V_{SS} (2)	–0.3 V to 6 V
	Input voltage range to all other pins, V_I relative to V_{Ss} (2)	–0.3 V to V_{DD} + 0.3 V
T_A	Operating free-air temperature range	–20°C to 85°C
T_{stg}	Storage temperature range	–65°C to 150°C

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) V_{SS} refers to the common node of $V_{(SSA)}$, $V_{(SSD)}$, and $V_{(SSP)}$.

Copyright © 2005–2010, Texas Instruments Incorporated

POWER ON RESET BEHAVIOR
vs
FREE-AIR TEMPERATURE



OSCILLATOR

V_{DD} = 3.0 V to 3.6 V, T_A = –20°C to 85°C (unless otherwise noted) (TYP: V_{DD} = 3.3 V, T_A = 25°C)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(eio)}$	Frequency error from 32.768 kHz	ROSC = 100k	–2%	0.5%	2%	
		XCK1 = 12 pF XTAL	–0.25%		0.25%	
$f_{(dio)}$	Frequency drift(1)	ROSC = 100k, T_A = 0°C to 50°C	–1%		1%	
$f_{(sio)}$	Start-up time(2)	ROSC = 100k			200	µs
$f_{(sxo)}$		XCK1 = 12 pF XTAL			250	ms

(1) The frequency drift is measured from the trimmed frequency at V_{DD} = 3.3 V, T_A = 25°C.
(2) The start-up time is defined as the time it takes for the oscillator output frequency to be ±1%

DATA FLASH MEMORY CHARACTERISTICS

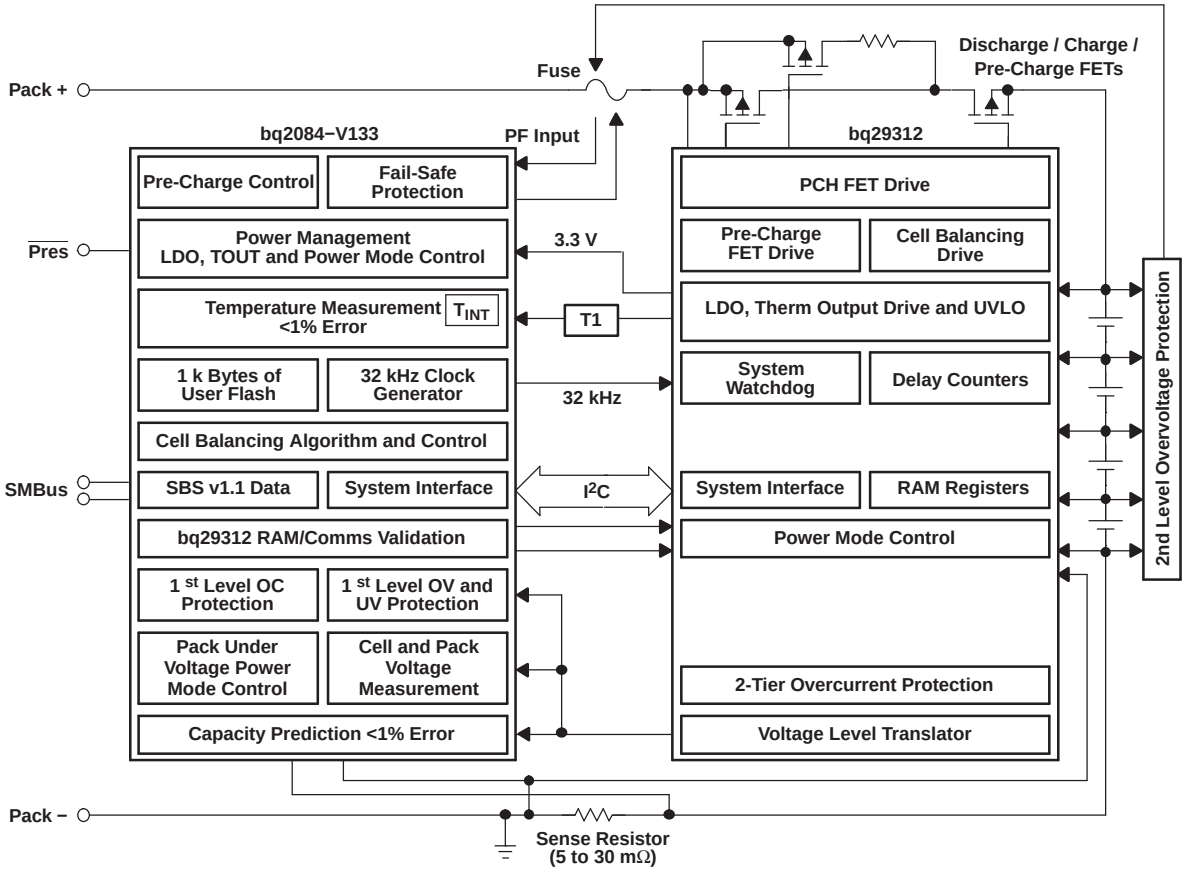
V_{DD} = 3.0 V to 3.6 V, T_A = –20°C to 85°C unless otherwise noted

PARAMETER			

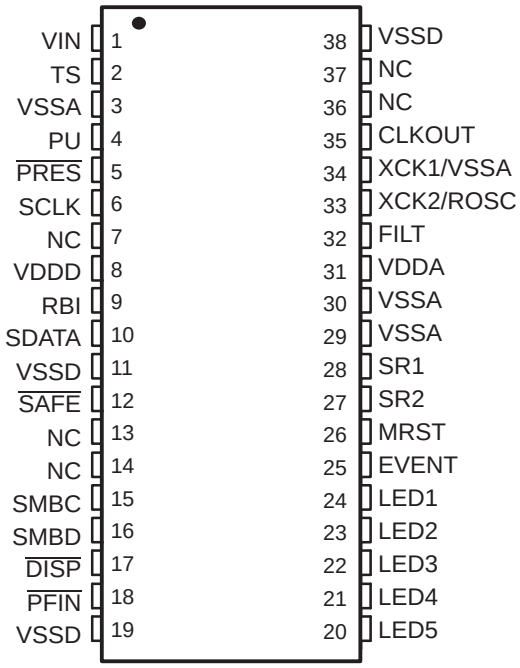
define[33.4 680 Td (UNIT)Ti /F4 BT /F2 8 Tf 1001z 0Td (define 303.9 666.8 Td (ROSC)Ti 25.51 0 Td (=)T10Td (define(100k)Ti ET BT /F2 8 Tf 100 Tz 0 0 0 rg50 0 4 BT /

SMBus TIMING DIAGRAMS

SYSTEM DIAGRAM



TSSOP (DBT)
(TOP VIEW)



MEASUREMENTS

The bq2084-V133 uses an integrating sigma-delta analog-to-digital converter (ADC) for current measurement and a second sigma-delta ADC for individual cell and battery voltage and temperature measurement. The individual cell and pack voltages, *Voltage()*, *Current()*, *AverageCurrent()* and *Temperature()* are updated every 1 s during normal operation.

CHARGE AND DISCHARGE COUNTING

The integrating ADC measures the charge and discharge flow of the battery by monitoring a small

The Discharge Count Register (DCR) is a non-accessible register that tracks discharge of the battery. The bq2084-V133 uses the DCR register to update the FCC register if the battery undergoes a qualified discharge from nearly full to a low battery level. In this way, the bq2084-V133 learns the true discharge capacity of the battery under system-use conditions.

Main Gas-Gauge Registers

RemainingCapacity() (RM)

RM represents the remaining capacity in the battery. The bq2084-V133 computes RM in units of either mAh or 10 mWh depending on the selected mode. See *Battery Mode()* (0x03) for units configuration. RM counts up during charge to a maximum value of *FullChargeCapacity()* (FCC) and down during discharge and self-discharge to a minimum of 0. In addition to charge and self-discharge compensation, the bq2084-V133 calibrates RM at three low-battery-voltage thresholds, EDV2, EDV1, and EDV0 and three programmable midrange thresholds VOC25, VOC50, and VOC75. This

charge of 10 mAh into the battery.

The bq2084-V133 sets VDQ = 1 in *PackStatus()* when qualified discharge begins. The bq2084-V133 sets VDQ = 0 if any disqualifying condition occurs. FCC cannot be reduced by more than 256 mAh or increased by more than 512 mAh during any single update cycle. The bq2084-V133 saves the new FCC value to the data flash within 4 seconds of being updated.

End-of-Discharge Thresholds and Capacity Correction

The bq2084-V133 monitors the battery for three low-voltage thresholds, EDV0, EDV1, and EDV2. The EDV thresholds can be programmed for determination based on the overall pack voltage or an individual cell level. The EDVV bit in *Pack Configuration* DF 0x28 configures the bq2084-V133 for overall voltage or single-cell EDV thresholds. If programmed for single-cell EDV determination, the bq2084-V133 determines EDV on the basis of the lowest single-cell voltage. Fixed EDV thresholds must be programmed in *EMF/EDV0* DF 0x95-0x96, *EDV C0 Factor/EDV1* DF 0x97-0x98, and *EDV R Factor/EDV2* DF 0x99-0x9a.

If the CEDV bit in *Gauge Configuration* DF 0x29 is set, automatic compensated EDVs are enabled and the bq2084-V133 computes the EDV0, EDV1, and EDV2 voltage thresholds based on the values in DF 0x95-0xa0 and the battery's current discharge rate and temperature. The bq2084-V133 disables EDV detection if Current( ) exceeds the *Overload Current* threshold programmed in DF 0x5b-DF 0x5c. The bq2084-V133 resumes EDV threshold detection after *Current()* drops below the *Overload Current* threshold. Any EDV threshold detected is reset after charge is detected and VDQ is cleared after 10 mAh of charge.

The bq2084-V133 uses the EDV thresholds to apply voltage-based corrections to the RM register according to Table 2.

Table 2. State-of-Charge Based on Low Battery Voltage

THRESHOLD	RELATIVE STATE OF CHARGE
EDV0	0%
EDV1	3%
EDV2	Battery Low %

The bq2084-V133 performs EDV-based RM adjustments with *Current()* • C/32. No EDV flags are set if current < C/32.

The bq2084-V133 adjusts RM as it detects each threshold. If the voltage threshold is reached before the corresponding capacity on discharge, the bq2084-V133 reduces RM to the appropriate amount as shown in Table 2.

If an RM % level is reached on discharge before the voltage reaches the corresponding threshold, then RM is held at that % level until the threshold is reached. RM is only held if VDQ = 1, indicating a valid learning cycle is in progress. If *Battery Low* % is set to zero, EDV1 and EDV0 corrections are disabled.

EDV Thresholds and Near-Full Programming

The bq2084-V133 uses the values stored in data flash for the EDV0, EDV1, and EDV2 values or calculates the three thresholds from a base value and the temperature, capacity, and rate adjustment factors stored in data flash. If EDV compensation is disabled, then EDV0, EDV1, and EDV2 are stored directly in mV in DF 0x95-0x96, DF 0x97-0x98, and DF 0x99-0x9a, respectively.

For capacity correction at EDV2, *Battery Low %* DF 0x2f can be set at a desired state-of-charge, *STATEOFCHARGE%*, in the range of 3-19%. Typical values for *STATEOFCHARGE%* are 5-7%, representing 5-7% capacity.

Battery Low % = (*STATEOFCHARGE%* x 2.56)

The bq2084-V133 updates FCC if a qualified discharge occurs from a near-full threshold of FCC - *Near Full*, until EDV2 condition is reached. The desired near-full threshold window is programmed in *Near Full* (DF 0x30, 0x31) in mAh.

Copyright © 2005–2010, Texas Instruments Incorporated

Table 3. bq2084-V133 Register Functions

FUNCTION	COMMAND CODE	ACCESS	UNITS
ManufacturerAccess	0x00	Read/write	NA
RemainingCapacityAlarm	0x01	Read/write	mAh, 10 mWh
RemainingTimeAlarm	0x02	Read/write	minutes
BatteryMode	0x03	Read/write	NA
AtRate	0x04	Read/write	mA, 10 mW
AtRateTimeToFull	0x05	Read	minutes
AtRateTimeToEmpty	0x06	Read	minutes
AtRateOK	0x07	Read	Boolean
Temperature	0x08	Read	0.1°K
Voltage	0x09	Read	mV
Current	0x0a	Read	mA
AverageCurrent	0x0b	Read	mA
MaxError	0x0c	Read	percent
RelativeStateOfCharge	0x0d	Read	percent
AbsoluteStateOfCharge	0x0e	Read	percent
RemainingCapacity	0x0f	Read	mAh, 10 mWh
FullChargeCapacity	0x10	Read	mAh, 10 mWh
RunTimeToEmpty	0x11	Read	minutes
AverageTimeToEmpty	0x12	Read	minutes
AverageTimeToFull	0x13	Read	minutes
ChargingCurrent	0x14	Read	mA
ChargingVoltage	0x15	Read	mV
Battery Status	0x16	Read	NA
CycleCount	0x17	Read	cycles
DesignCapacity	0x18	Read	mAh, 10 mWh
DesignVoltage	0x19	Read	mV
SpecificationInfo	0x1a	Read	NA
ManufactureDate	0x1b	Read	NA
SerialNumber	0x1c	Read	integer
Reserved	0x1d-0x1f	0	0
ManufacturerName	0x20	Read	string
DeviceName	0x21	Read	string
DeviceChemistry	0x22	Read	string
ManufacturerData	0x23	Read	string
Pack status	0x2f (LSB)	Read	NA
Pack configuration	0x2f (MSB)	Read	NA
VCELL4	0x3c	Read	mV
VCELL3	0x3d	Read	mV
VCELL2	0x3e	Read	mV
VCELL1	0x3f	Read	mV
VPACK	0x45	Read	mV
AFEData	0x46	Read	hex

Copyright © 2005–2010, Texas Instruments Incorporated

Self-Discharge

The bq2084-V133 estimates the self-discharge of the battery to maintain an accurate measure of the battery capacity during periods of inactivity. The bq2084-V133 makes self-discharge adjustments to RM every 1/4 s when awake and periodically (determined by *Sleep Timer* DF 0xfe) when in sleep mode. The self-discharge estimation rate for 25°C is doubled for each 10 degrees above 25°C or halved for each 10 degrees below 25°C. Table 4 shows the relation of the self-discharge estimation at a given temperature to the rate programmed for 25°C (Y% per day programmed in DF 0x2d).

Table 4. Self-Discharge for Rate Programmed

TEMPERATURE (°C)	SELF-DISCHARGE RATE
Temp < 10	1/4 Y% per day
10 ” Temp <20	1/2 Y% per day
20 ” Temp <30	Y% per day
30 ” Temp <40	2Y% per day
40 ” Temp <50	4Y% per day
50 ” Temp <60	8Y% per day
60 ” Temp <70	16Y% per day
70 ” Temp	32Y% per day

The nominal self-discharge rate, %PERDAY (% per day), is programmed in an 8-bit value *Self-Discharge Rate* (DF 0x2d) by the following relation:

Self-Discharge Rate = %PERDAY ÷ 0.01

Battery Electronic Load Compensation

The bq2084-V133 can be configured to compensate for a constant load (as from battery electronics) present in the battery pack at all times. The bq2084-V133 applies the compensation continuously when the charge or discharge is below the digital filter. The bq2084-V133 applies the compensation (BEL) in addition to self-discharge. The compensation occurs at a rate determined by the value stored in *Electronics Load* (DF 0x2e). The compensation range is 0 µA-765 µA in steps of approximately 3 µA. The data is stored as follows:

Electronics Load = BEL ÷ 3

Midrange Capacity Corrections

The bq2084-V133 applies midrange capacity corrections when the VCOR bit is set in *Ga0 Td (v*

isThecompensation

Table 5. Midrange Corrections

	CONDITION	RESULT
Voltage()	• VOC75 and RelativeStateOfCharge() ” 63%	RelativeStateOfCharge() : 75%
	< VOC75 and RelativeStateOfCharge() • 87%	RelativeStateOfCharge() : 75%
	• VOC50 and RelativeStateOfCharge() <38%	RelativeStateOfCharge() : 50%
	<VOC50 and RelativeStateOfCharge() • 62%	RelativeStateOfCharge() : 50%
	• VOC25 and RelativeStateOfCharge() ” 13%	RelativeStateOfCharge() : 25%
	< VOC25 and RelativeStateOfCharge() • 37%	RelativeStateOfCharge() : 25%

Three voltage-based thresholds, *VOC25* (DF 0x88-0x89), *VOC50* (DF 0x83-0x84), and *VOC75* (DF 0x7e-0x7f), are stored in the data flash in mV.

Charge Control

The bq2084-V133 internal charge control is compatible with the constant current/constant voltage profile for Li-ion. The bq2084-V133 detects primary charge termination on the basis of the tapering charge current during the constant-voltage phase.

Charging Voltage Broadcasts

The bq2084-V133 supports SBS charge control by broadcasting the *ChargingCurrent()* and *ChargingVoltage()* to the Smart Charger address. The bq2084-V133 broadcasts the requests every 10 seconds. The bq2084-V133 updates the values used in the charging current and voltage broadcasts based on the battery's state of charge, voltage, and temperature.

The 16-bit value (mV) for charging voltage is programmed in *Charging Voltage* (DF 0x03a-0x3b) although it can be set to 0 in different operating conditions. It also sets the base value for determining overvoltage conditions during charging and voltage compliance during a constant-voltage charging methodology.

The 16-bit value, *Over Voltage Margin* (DF 0x5d-0x5e), sets the limit over *ChargingVoltage()* in mV that is to be considered as an overvoltage charge-suspension condition.

Charging Current Broadcasts

ChargingCurrent() values are either broadcast to a Level 2 smart battery charger or read from the bq2084-V133 by a Level 3 smart battery charger. The *ChargingCurrent()* may take any of four different values: *Fast-Charging Current* DF (0x3e-0x3f), *Maintenance Charging Current* (DF 0x40-0x41), *Precharge Current* (DF 0x42-0x43) or 0 depending on charge state and operating conditions.

When fast charge is allowed, the bq2084-V133 sets *ChargingCurrent()* to the rate programmed in *Fast-Charging Current* DF 0x3e-0x3f. *Fast-Charging Current* is stored in mA.

When fast charge terminates, the bq2084-V133 sets *ChargingCurrent()* to zero and then to the *MaintenanceCharging Current* (DF 0x40-0x41) when the termination condition ceases. The desired maintenance current is stored in mA.

When *Voltage()* is less than EDV0, the bq2084-V133 sets *ChargingCurrent()* to *Precharge Current* (DF 0x42-0x43). Typically this rate is larger than the maintenance rate to charge a deeply depleted pack up to the point where it may be fast charged. 1.22 0 Td [(1.22 0 Td 0 TTd (1. 24.9 0 Td (ChargingCurrent())Tj /F2 a1F2 10 Tf1 (Ch

Alarm Broadcasts to Smart Charger and Host

If any of the bits 8-15 in *BatteryStatus()* are set, the bq2084-V133 broadcasts an *AlarmWarning()* message to the Host address. If any of the bits 12-15 in *BatteryStatus()* are set, the bq2084-V133 also sends an *AlarmWarning()* message to the Smart Charger address. The bq2084-V133 repeats the *AlarmWarning()* messages every 10 seconds until the alarm bits are cleared. All broadcasts can be disabled by setting *SM* (bit 2) in *Pack Configuration* (DF 0x28).

Precharge Qualification

The bq2084-V133 sets *ChargingCurrent()* to the precharge rate as programmed in *Precharge Current* (DF 0x42-0x43) under the following conditions:

- Voltage: The bq2084-V133 requests the precharge charge rate when any cell voltage drops below the precharge threshold or when the EDV0 threshold is detected. Once requested, a precharge rate remains until all cell voltages increase above the precharge threshold and the EDV0 condition does not exist. The precharge threshold is programmed in *Precharge Voltage* (DF 0x3c-0x3d).
- Temperature: The bq2084-V133 requests the precharge rate when *Temperature()* is between *Charge Inhibit Temp Low* (DF 0x46) and the precharge threshold programmed in *Precharge Temp* (DF 0x44). *Temperature()* must be equal to or greater than the precharge threshold + 3°C to allow the fast-charge rate.

Charge Suspension

The bq2084-V133 may temporarily suspend charge if it detects a charging fault. A charging fault includes the following conditions.

- Overcurrent: An overcurrent condition exists when the bq2084-V133 measures the charge current to be greater than *Charge OC Threshold (*DF 0x12a-0x12b) for a time greater than *Charge OC Time* (DF 0x12c). On detecting an overcurrent condition, the bq2084-V133 turns off the Charge FET. If the Nonremovable Battery bit is not set in *Misc Configuration* (DF 0x2a), then the Discharge FET is turned off also. This condition is cleared when the pack is removed or if the Nonremovable Battery bit is set in *Misc Configuration* (DF 0x2a) and when a discharge current is detected or when *SBS AverageCurrent()* is less than the *ClearFailCurrent* (DF 0x61-0x62) for *FaultResetTime* (DF 0x130).
- Overtemperature: During charging, an overtemperature condition exists when *Temperature()* is greater than the *Charge Suspend Temp High* value programmed in DF 0x6d, 0x6e. On detecting an overtemperature condition, if enabled by the *OT* bit in *Misc Configuration* (DF 0x2a), the bq2084-V133 turns off the Charge and Discharge FETs. The overtemperature condition is cleared when *Temperature()* is equal to or below *Charge Suspend Temp High Reset* (DF 0x6f-0x70). The condition is also cleared if the pack is removed.
- Undertemperature: During charging, an undertemperature condition exists when *Temperature()* is less than the *Charge Suspend Temp Low* (DF 0x79) or *Charge Inhibit Temp Low* (DF 0x46). On detecting an undertemperature condition the bq2084-V133 turns off the Charge FET. The undertemperature condition is cleared when *Temperature()* is greater than *Charge Suspend Temp Low* DF 0x79*.* The condition is also cleared if the pack is removed. The maximal value of *Charge Suspend Temp Low* setting is 12.7°C.
- Charging exceeds *Maximum Charging Time* (DF 0x10f-0x110). If charging time reaches *Maximum Charge*

The bq2084-V133 detects a current taper termination when the pack voltage is greater than *Charging Voltage* (DF 0x3a-0x3b) minus *Current Taper Qualification Voltage* (DF 0x4d-0x4e) and the *AverageCurrent()* is below the *Current Taper Threshold* (DF 0x4b-0x4c), but greater than the *Charge Detection Current* (DF 0x113-0x114), for a period of *Current Taper Window* (DF 0x4f).

Once the bq2084-V133 detects a Primary Charge Termination, the bq2084-V133 sets the *TERMINATE_CHARGE_ ALARM* and *FULLY_CHARGED* bits in *BatteryStatus()*, and turns off the charge FET via the bq29312. The charge FET is turned on when discharge current is detected and is greater than *Discharge Detection Current* (DF 0x115-0x116), to minimize IR losses. The *TERMINATE_CHARGE_ ALARM* charge current is no longer detected or the pack is removed, but returns if charging is attempted while the *FULLY_CHARGED* bit is set.

The bq2084-V133 clears the *FULLY_CHARGED* and *TERMINATE_CHARGE_ALARM* bit when *RelativeStateOfCharge()* is less than the programmed *Fully Charged Clear %*. See Table 13 for a summary of *BatteryStatus()* alarm and status bit operation.

Cell Balancing

The bq2084-V133 balances the cells during charge by discharging those cells above the threshold set in *Cell Balance Threshold* (DF 0xe8-0xe9), if the maximum difference in cell voltages exceeds the value programmed in *Cell Balance Min* (DF 0xec). For cell balancing, the bq2084-V133 measures the cell voltages at an interval set in *Cell Balance Interval* (DF 0xed). On the basis of the cell voltages, the bq2084-V133 either selects the appropriate cell to discharge or adjusts the cell balance threshold up by the value programmed in *Cell Balance Window* (DF 0xea-0xeb) when all cells exceed the cell balance threshold or the highest cell exceeds the cell balance threshold by the cell balance window.

Cell balancing only occurs when charging current is detected and the cell balance threshold is reset to the value in *Cell Balance Threshold* at the start of every charge cycle. The threshold is only adjusted once during any balance interval.

If the cells are severely imbalanced during charging, where $VCELL_{(MAX)}$ - $VCELL_{(MIN)}$ > *Cell Imbalance Threshold* AND SBS. Current()> *Balance IMAX* for a period of *Cell Imbalance time* then the CIM bit in *PF Status* is set.

Table 6. Cell Balancing and Cell Imbalance Programming

NAME	DF ADDRESS	DESCRIPTION
Cell Balance Threshold	0xe8-0xe9	Sets the maximum voltage E2r the 0 00.32 0 mustl

Activation

The display may be activated at any time by a high-to-low transition on the DISP input. This is usually accomplished with a pullup resistor and a pushbutton switch. Detection of the transition activates the display and starts a 4-s display timer. Reactivation of the display requires that the DISP input return to a logic-high state and then transition low again. The second high-to-low transition can be detected only after the display timer expires. If unused, the DISP input must be pulled up to VCC. If the EDV0 bit is set, the bq2084-V133 disables the LED display.

Display Modes

In relative mode, each LED output represents 20%, 25%, or 33% of the *RelativeStateOfCharge()* value. In absolute mode, each LED output represents 20%, 25% or 33% of the *AbsoluteStateOfCharge()* value. Table 7 shows the display options for 5 LEDs, for 4 LEDs, Table 8 and Table 9 for 3 LEDs. In either mode, the bq2084-V133 blinks the LED display if *RemainingCapacity()* is less than *Remaining CapacityAlarm()*. The display is disabled if EDV0 = 1.

Table 7. Display Mode for Five LEDs

CONDITION RELATIVE OR ABSOLUTE	FIVE-LED DISPLAY OPTION				
StateOfCharge()	**LED1**	**LED2**	**LED3**	**LED4**	**LED5**
EDV0 = 1	OFF	OFF	OFF	OFF	OFF
<20%	ON	OFF	OFF	OFF	OFF
•20%, < 40%	ON	ON	OFF	OFF	OFF
•40%, < 60%	ON	ON	ON	OFF	OFF
•60%, < 80%	ON	ON	ON	ON	OFF
•80%	ON	ON	ON	ON	ON

Table 8. Display Mode for Four LEDs

CONDITION RELATIVE OR ABSOLUTE	FOUR-LED DISPLAY OPTION			
StateOfCharge()	**LED1**	**LED2**	**LED3**	**LED4**
EDV0 = 1				

The bq29312 can independently detect and protect the load from an overload (OL) or short circuit in charge (SCC) or discharge (SCD). The bq29312 sets the appropriate FET state and then alerts the bq2084-V133 with the XALERT output whenever a protection threshold is breached and its associated delay time has expired. The bq2084-V133 then determines if and when the FETs should be turned back on.

Table 10. CVOV and CVUV Flags in PackStatus()

FLAG	SET CONDITION	DSG FET	CHG FET	CLEAR CONDITION(1)
CVOV	Voltage() = ChargingVoltage() + *Over Voltage Margin*	ON	OFF(2)	Voltage() < ChargingVoltage()
	$VCELL_{(ANY)}$ • *Cell Over Voltage*	ON	OFF(2)	$VCELL_{(ALL)}$ < *Cell Over Voltage Reset*
CVUV	$VCELL_{(ANY)}$ ” *Cell Under Voltage*		(3)ON	$VCELL_{(ALL)}$ > *Cell Under Voltage Reset*
	AverageCurrent() ” *Over Load Current*	OFF (3)	ON	AverageCurrent() ” *Current Fault Clear Threshold*

(1) Clear is detected and controlled by the bq2084-V133.
(2) On if there is a discharge current • *Discharge Detection Current*
(3) On if there is a charge current • Charge Detection Current

Protection Configuration

1st Level Cell Voltage Thresholds

Cell under voltage is detected when any cell voltage is measured equal to or below the value programmed in *Cell Under Voltage* for a minimum of 1s and maximum of 2s and recovers when all cell voltages are above *Cell Under Voltage Reset*. Cell over voltage is detected when any cell voltage is measured equal to or above the value programmed in *Cell Over Voltage* for a minimum of 1s and maximum of 2s and recovers when all cell voltages are below *Cell Over Voltage Reset*.

The cell undervoltage (VUV) and overvoltage (VOV) limits are programmed in *Cell Under Voltage* and *Cell Over Voltage* (DF 0x65-0x66, DF 0x63-0x64, (respectively). Both values are stored in mV. *Cell Over Voltage Rese*t (DF 0xe0-0xe1) and *Cell Under Voltage Reset* (DF 0xe2-0xe3) set the reset points in mV for these safety parameters

Safety Overvoltage Threshold

The safety voltage threshold is programmed in *Safety Over Voltage* (DF 0x6b-0x6c). It is stored in mV. Exceeding the Safety Voltage for a period determined by the MISC Config VOD bit causes permanent failure if enabled by PFConfig.

Overcurrent Thresholds

A discharge over current fault is detected when the measured current is more negative than the value programmed in *Discharge OC Threshold* for a period equal to of greater than the time programmed into *Discharge OC Time*. When the fault is detected the DSG FET is turned OFF.

The DSG FET is turned back on when SBS.AverageCurrent( ) is less negative than the value programmed in *Current Fault Clear Threshold* (DF 0x61, 0x62).

A charge over current fault is detected when the measured current is greater than the value programmed in *Charge OC Threshold* for a period equal to of greater than the time programmed into *Charge OC Time*. When the fault is detected the CHG FET is turned OFF.

The CHG FET is turned back on when SBS.AverageCurrent( ) is less than the value programmed in *Current Fault Clear Threshold* (DF 0x61, 0x62).

Discharge current threshold is programmed in *Discharge OC Threshold* (DF 0x12d-0x12e). The discharge overcurrent must exist for time programmed in Discharge OC Time (DF 0x12f). When a discharge overcurrent condition is detected the discharge FET is turned off. Similarly, a charge overcurrent is programmed in *Charge OC Threshold* (DF 0x12a-0x12b). The charge overcurrent must exist for the time programmed in *Charge OC Time* (DF 0x12c) or Charge OC Time (DF 0x12c).

Note: See Table 10 for some special FET state conditions.

Copyright © 2005–2010, Texas Instruments Incorporated

Temperature Thresholds

The Safety Over Temperature in Charge (SOTC) threshold is programmed in *Safety Over Temperature in Charge* (DF 0x75-0x76) and Safety Over Temperature in Discharge (SOTD) threshold is programmed in *Safety Over Temperature in Discharge* (DF 0x77-0x78).

SOTC is stored as *Safety Over Temperature in Charge* = SOTC ÷ 0.1 (°C) as an unsigned integer

SOTD is stored as *Safety Over Temperature in Discharge* = SOTD ÷ 0.1 (°C) as an unsigned integer. Exceeding the Safety Temperatures causes permanent failure if enabled by PFConfig.

There are also temperature thresholds to disable both charge and discharge FETs and to set the SBS Battery Status Overtemperature bit. The thresholds are set according to whether discharge or charge is detected. The *Charge Suspend Temp High* threshold is stored in DF 0x6d-0x6e with the reset threshold stored in DF 0x6f-0x70. Likewise, the *Over Temperature Discharge* threshold is stored in DF 0x71-0x72 with the reset threshold stored in DF 0x73-0x74.

The *Charge Suspend Temp Low* threshold (CSTL) is stored in *Charge Suspend Temp Low* (DF 0x79-0x7a) and is stored as *Charge Suspend Temp Low* = CSTL ÷ 0.1 (°C) as a signed integer. A *Charge Suspend Temp Low* turns off the charge FET. The maximal value of *Charge Suspend Temp Low* setting is 12.7 °C.

AFE Configuration

The AFE protection limits are programmed as specified in the bq29312 data sheet.

AFE Over Load (DF 0xc5) sets the AFE overload protection threshold.

AFE Over Load Delay (DF 0xc6) sets the delay timing for overload protection.

AFE Short Circuit in Charge (DF 0xc7) sets the AFE short circuit in charge protection threshold and delay time.

AFE Short Circuit in Discharge (DF 0xc8) sets the AFE short circuit in discharge protection threshold and delay time.

SMBus command 0x46 can be used to string-read the AFE RAM with the AFE address 0x00 first, if the bq2084-V133 is not sealed as indicated by bit 5 of PackStatus.

Table 11. Overcurrent Protection

FAILURE	FET STATUS	CLEAR CONDITIONS
NR=1		
AFE OLV	CHG on, ZVCHG off, DSG off	Same AFE SCD
AFE SCC	CHG off, ZVCHG off, DSG on	Average Current ()< Clear Fail Current (DF 0x61/2) for Fault Reset Time (DF 0x130), or disharge current > discharge detection current (DF 0x115/6)
AFE SCD	CHG on, ZVCHG off, DSG off	Average Current () • -Clear Fail Current (DF 0x61/2) for Fault Reset Time (DF 0x130), or charge current > charge detection current (DF 0x113/4)
GG Charge OC (set by DF 0x12a to 0x12c)	CHG off, ZVCHG off, DSG on	Same AFE SCC
GG Discharge OC (set by DF 0x12d to 0x12f)	CHG on, ZVCHG off, DSG off	Same AFE SCD
NR=0		
FAILURE	**FET STATUS**	**EXIT CONDITIONS**
AFE OLV	All FETs off	RRES=high
AFE SCC	[illegible]	[illegible]

AFE Integrity Check

The bq2084-V133 checks the programming of the AFE registers at a period determined by *AFE Check Time* (DF 0xfb). The units of the check period are seconds unless the bq2084-V133 is in sleep mode, in which case the period is *AFE Check Time* x *Sleep Current Multiplier* (DF 0xfd). If the data is not correct, the bq2084-V133 increments an internal counter until it reaches the *AFE Fail Limit* (DF 0xe4). Setting *AFE Check Time* to 0 disables this function.

The SOTC bit indicates a safety overtemperature in charge occurred which if enabled by PF Config would cause the SAFE output to activate.

0 SOTC fault (default) detected (default)

1 SOTC fault detected

SFtF/kjfEnabled ((Tej ET))Tj ET (wh (,(default1Td (indi)Tj 38.58 0 Td (by)Tj 13.56 0 Td (PF)Tj 15.78 0 Td (Config)Tj 31.9 0 Td (would)T

The SOTD bit indicates a safety overtemperature in discharge occurred which if enabled by PF Config would cause the SAFE output to activate.

0 SOTD fault (default) detected (default)

1 SOTD fault detected

AFE

The AFE bit indicates an AFE integrity fault state occurred which if enabled by PF Config would cause the SAFE output to activate.

0 AFE is operating correctly (default)

output 1 AFE Integrity

AFE

bitX 6\ Tj ET BT /F2 10 Tf 100 Tz 0 0 7582.2 601.2

1 Activation enabled

XSOTC

The XSOTC bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* SOTC is set.

0 Activation disabled (default)

1 Activation enabled

XSOTD

The XSOTD bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* SOTD is set.

0 Activation disabled (default)

1 Activation enabled

XAFE

The XAFE bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* AFE is set. Bit 13 of *Miscellaneous Config* DF 0x2a also needs to be set for activation.

0 Activation disabled (default)

1 Activation enabled

XCIM

The XCIM bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* CIM is set.

0 Activation disabled (default)

1 Activation enabled

XFETF

The XFETF bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* FETF is set.

0 Activation disabled (default)

1 Activation enabled

XPFIN

The XPFIN bit enables or disables the activation of $\overline{\text{SAFE}}$ and the setting of the PF Flag when *PF Status* PFIN is set.

0 Activation disabled (default)

1 Activation enabled

Permanent Failure Flag (PF Flag)

PF Flag DF 0x11e contains the flag indicating if the /SAFE output has been activated.

STATE	b7	b6	b5	b4	b3	b2	b1	b0
Clear	0	0	0	0	0	0	0	0
Set	0	1	1	0	0	1	1	0

PF FLAG

The PF Flag indicates that the $\overline{\text{SAFE}}$ output of the bq2084-V133 has been activated.

0x00 $\overline{\text{SAFE}}$ output high (default)

0x66 $\overline{\text{SAFE}}$ output activated

An example circuit using the $\overline{\text{SAFE}}$ output to blow a fuse is shown in Figure 2.

Copyright © 2005–2010, Texas Instruments Incorporated

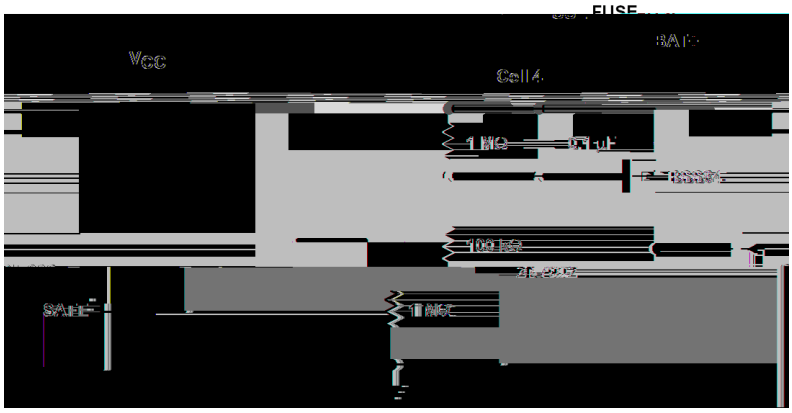
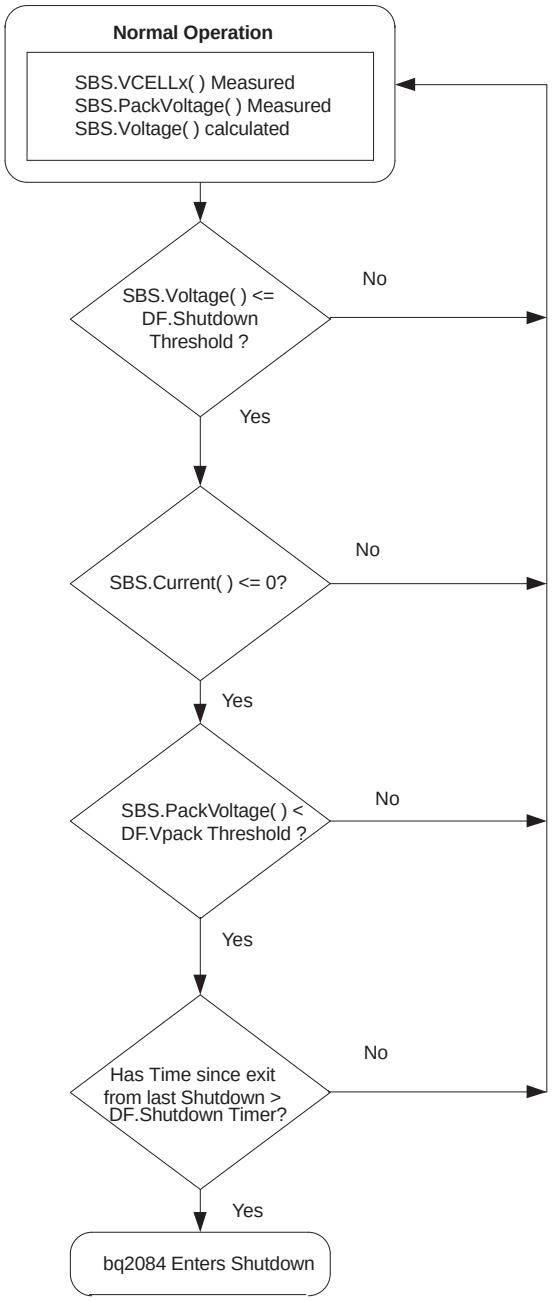


Figure 2. Example $\overline{\text{SAFE}}$ Circuit Implementation

Low-Power Modes

The bq2084-V133 enters sleep mode when the charge and discharge current is less than the threshold programmed in *Sleep Current Threshold* (DF 0xfc), the SMBus lines are low for at least 2s, and bit 12 of *Misc. Configuration* DF 0x2a is set to zero. Additionally, PRES must be pulled high if the NR bit in Misc Config is set to 0. The bq2084-V133 wakes up periodically to monitor voltage and temperature and to apply self-discharge adjustment. The sleep period is set in *Sleep Timer* DF 0xfe. The bq2084-V133 wakes up at a period set by *Sleep Current Multiplier* DF 0xfd multiplied by *Sleep Time* to measure current. The bq2084-V133 comes out of sleep when either of the SMBus lines go high or when the current is measured ge

After exiting shutdown mode, the bq2084-V133 does not enter the shutdown mode again until the *Shutdown Timer* (DF 0x133, units are seconds) has expired even if the correct conditions are present. After the *Shutdown Timer* has expired, Shutd. 0 Td 3 10 Tf6o1Tj 1917.3F3 10 TfMBus.18 0 T33 0 Td (armmand95 0 T 0 Td (o(has)12.9 (if)Tj volta



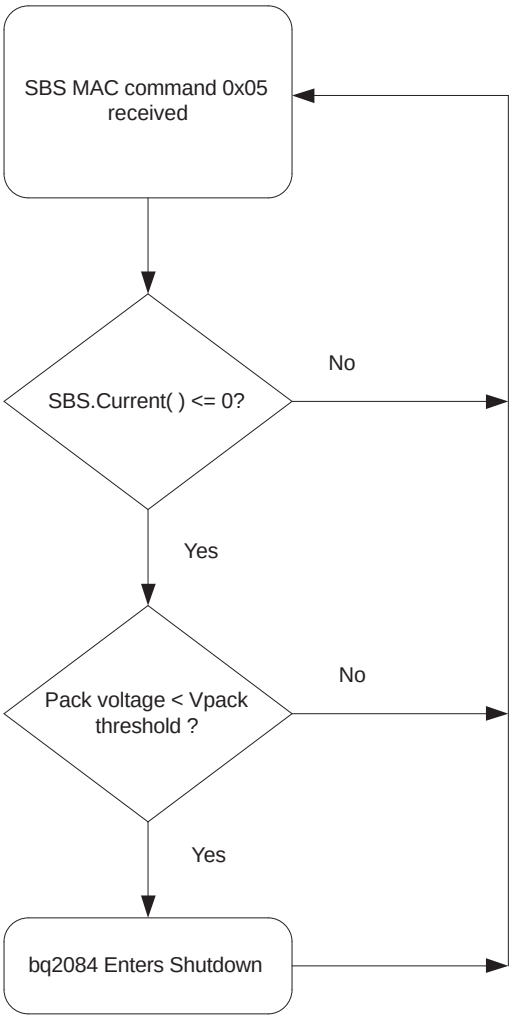


Figure 4. Shutdown Flow Chart in SBS MAC

Reset Conditions

On power up, the entire IC is reset and data is loaded from Data Flash to configure the SBS Data and the battery management solution. On a partial reset (loss of VCC but RBI holds RAM valid), a limited number of locations are taken. These actions are the following:

- The AFE registers are rewritten.
- *PackStatus()* EDV2 flag is cleared.
- *BatteryStatus()* DISCHARGING flag is cleared.
- The charger and alarm broadcast period is set to 10 seconds between broadcasts.

COMMUNICATION

The bq2084-V133 includes an SMBus communication port. The SMBus interface is a 2-wire bidirectional protocol using the SMBC (clock) and SMBD

SMBus

The SMBus interface is a command-based protocol. A processor acting as the bus master initiates communication to the bq2084-V133 by generating a start condition. A start condition consists of a high-to-low transition of the SMBD line while the SMBC is high. The processor then sends the bq2084-V133 device address

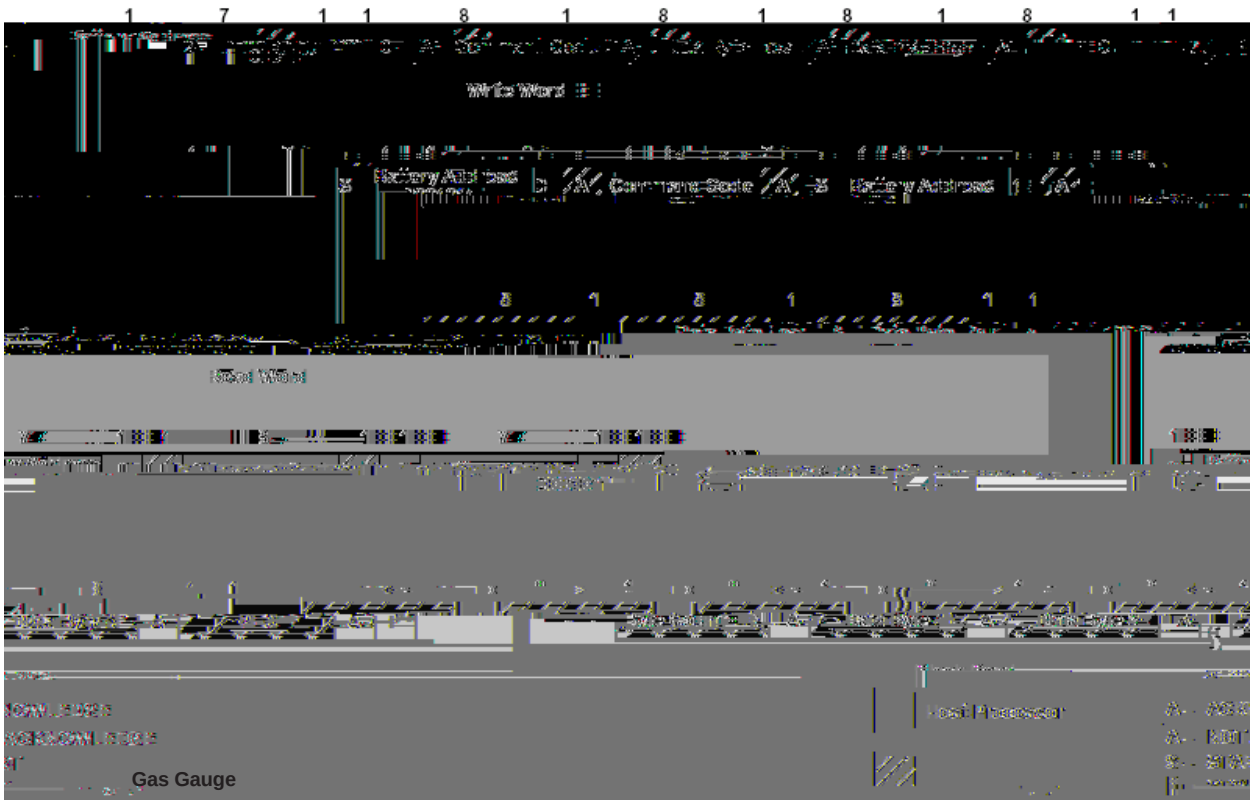


Figure 5. SMBus Communication Protocol Without PEC

Copyright © 2005–2010, Texas Instruments Incorporated

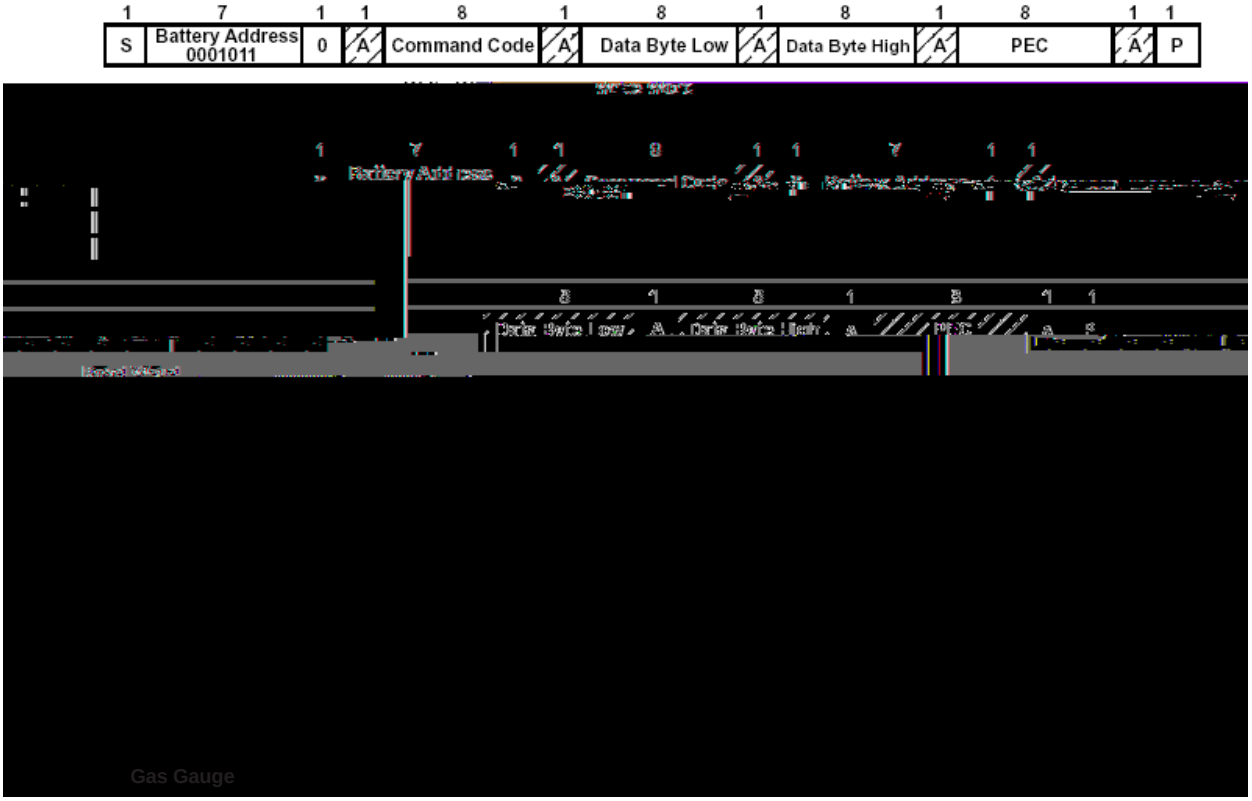


Figure 6. SMBus Communication Protocol With PEC

PEC Calculation

The basis of the PEC calculation is BT /F1 10 24.66 0 Td h

Command Codes

The SMBus command codes are in (). *Temperature()*, *Voltage()*, *Current()*, and *AverageCurrent()*, performance specifications are at bq29312 regulated VCC ($V_{(REG)}$) and a temperature of -20°C to 85°C.

Manufacturer Access() (0x00)

Description: This function provides writable command codes to control the bq2084-V133 during normal operation and pack manufacture. Writing the command code to SMB command 0x00 causes the following reads with the SMB command 0x00 to return the word indicated in the table. The following commands are available:

COMMAND CODE	NAME	DESCRIPTION
0x0001	Device Type	Returns IC part number so it can be read, i.e., 2084 (0x0824)
0x0002	Firmware Rev	Returns firmware version so it can be read
0x0003	EDV Level	Returns the pending end-of-discharge voltage level so it can be read
0x0004	Manufacturer Status	Returns the battery system status so it can read
0x0005	SHIP Command	Instructs the bq2084-V133 to instruct the bq29312 to enter ship mode
0x062b	Seal	Instructs the bq2084-V133 to restrict access to those functions listed in Table 3. The bq2084-V133 completes the seal function and clears ManufacturerAccess().

The Manufacture Status word is defined as:

b15	b14	b13	b12	b11	b10	b9	b8
FET1	FET0	PF1	PF0	STATE3	STATE2	STATE1	STATE0

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	1	0	1	0

FET1, FET0

Indicated the state of the charge and discharge FETs

- 0,0 Both charge and discharge FETs are on.
- 0,1 Charge FET is off, discharge FET is on.
- 1,0 Both charge and discharge FETs are off.
- 1,1 Charge FET is on, discharge FET is off.

PF1, PF0

Indicates permanent failure cause when permanent failure indicated by STATE3-STATE0

- 0,0 Fuse is blown
- 0,1 Cell imbalance failure
- 1,0 Safety voltage failure
- 1,1 FET failure

STATE3, STATE2, STATE1, STATE0

Indicates battery state as defined in the State and Status bit Summary.

Purpose: The *ManufacturerAccess()* function provides the system host access to bq2084-V133 functions that are not defined by the SBD.

SMBus protocol: Read or write word

Input/Output: Word

Copyright © 2005–2010, Texas Instruments Incorporated

	BATTERY MODES	
	CAPACITY_MODE BIT = 0	CAPACITY_MODE BIT = 1
Accuracy	See RemainingCapacity()	

RemainingTimeAlarm() (0x02)

Description: Sets or gets the *Remaining Time Alarm* value. Whenever the *AverageTimeToEmpty()* falls below the remaining time value, the bq2084-V133 sends *AlarmWarning()* messages to the SMBus host with the *REMAINING_TIME_ALARM* bit set. A remaining time value of 0 effectively disables this alarm. The bq2084-V133 initially sets the remaining time value to the *Remaining Time Alarm* (DF 0x00-0x01) value. The remaining time value remains unchanged until altered by the *RemainingTimeAlarm()* function.

Purpose: The *RemainingTimeAlarm()* function can be used by systems that want to adjust when the remaining time alarm warning is sent. The remaining time value can be read to verify the value in use by the bq2084-V133 *RemainingTimeAlarm()*.

SMBus protocol: Read or write word

Input/Output: Unsigned integer—the point below which remaining time messages are sent.

Units: Minutes

Range: 0 to 65,535 minutes

Granularity: Not applicable

Accuracy: See *AverageTimeToEmpty()*.

BatteryMode() (0x03)

Description: Selects the various battery operational modes and reports the battery's mode and requests.

Defined modes include

- Whether the battery capacity information is specified in units of mAh or 10 mWh (CAPACITY_MODE bit)
- Whether the *ChargingCurrent()* and *ChargingVoltage()* values are broadcast to the smart battery charger when the *CHARGER_MODE* bit is set.
- Whether all broadcasts to the smart battery charger and host are disabled

The value.is

RELEARN_FLAG bit set indicates that the bq2084-V133 is requesting a capacity relearn cycle for the battery. The bq2084-V133 sets the *RELEARN_FLAG* on a full reset and if it detects 20-cycle counts without an FCC update. The bq2084-V133 clears this flag after a learning cycle has been completed.

CHARGE_CONTROLLER_ENABLED bit is not used by the bq2084-V133. The bq2084-V133 forces this bit to zero.

PRIMARY_BATTERY bit is not used by the bq2084-V133. The bq2084-V133 forces this bit to zero.

Table 14. Battery Mode Bits and Values

Battery Mode() BITS	BITS USED	FORMAT	ALLOWABLE VALUES
INTERNAL_CHARGE_CONTROLLER	0	Read only bit flag	1 - always one
PRIMARY_BATTERY_SUPPORT	1	7 0 Td (bit)Tj 10.85 0 Td (flag)Tj ET BT /F2 8 Tf 100 Tz 0 0 0 rg 384.6 590 Td (1)Tj 6.85	

The following functions are calculated on the basis of capacity and may be calculated differently depending on the CAPACITY_MODE bit:

- *AtRateOK()*
- *AtRateTimeToEmpty()*
- *AtRateTimeToFull()*
- *RunTimeToEmpty()*
- *AverageTimeToEmpty()*
- *AverageTimeToFull()*
- *Remaining Time Alarm()*
- *BatteryStatus()*

The bq2084-V133 updates the non-AtRate related register values immediately after changing the state of the *CAPACITY_MODE* bit. The *AtRate()* values are updated after the next *AtRate()* value is written to the bq2084-V133 (or after the next 1-s scheduled refresh calculation).

AtRate() (0x04)

Description: The *AtRate()* function is the first half of a two-function call-set used to set the AtRate value used in calculations made by the *AtRateTimeToFull()*, *AtRateTimeToEmpty()*, and *AtRateOK()* functions. The *AtRate* value may be expressed in either current (mA) or power (10 mW) depending on the setting of the *BatteryMode() CAPACITY_MODE* bit.

Purpose: Because the *AtRate()* function is the first half of a two-function call-set, it is followed by the second function of the call-set that calculates and returns a value based on the *AtRate* value and the battery's present state.

- When the *AtRate()* value is positive, the *AtRateTimeToFull()* function returns the predicted time to full charge at the *AtRate* value of charge.
- When the *AtRate()* value is negative, the *AtRateTimeToEmpty()* function returns the predicted operating time at the *AtRate* value of discharge.
- When the *AtRate()* value is negative, the *AtRateOK()* function returns a Boolean value that predicts the battery's ability to supply the *AtRate* value of *additional* discharge energy (current or power) for 10 seconds.

The default value for *AtRate()* is zero.

SMBus protocol: Read or write word

Input/Output: Signed integer-charge or discharge; the *AtRate()* value is positive for charge, negative for discharge, and zero for neither (default).

	BATTERY MODES	
	CAPACITY_MODE BIT = 0	**CAPACITY_MODE BIT = 1**
Units	mA	10 mW
Charge range	1 to 32,767 mA	1 to 32,767 10 mW
Discharge range	–1 to –32,768 mA	–1 to –32,768 10 mW
Granularity	1 Unit	
Accuracy	NA	

AtRateTimeToFull() (0x05)

Description: Returns the predicted remaining time to fully charge the battery at the *AtRate()* value (mA).

Purpose: The *AtRateTimeToFull()* function is part of a two-function call-set used to determine the predicted remaining charge time at the *AtRate* value in mA. The bq2084-V133 updates *AtRateTimeToFull()* within 5 ms after the SMBus host sets the *AtRate* value. The bq2084-V133 automatically updates *AtRateTimeToFull()* based on the *AtRate()* value every 1 s.

SMBus protocol: Read word

Output: Unsigned integer—predicted time in minutes to fully charge the battery.

Copyright © 2005–2010, Texas Instruments Incorporated

Units: Minutes

Range: 0 to 65,534 min

Granularity: 2 min or better

Accuracy: ± *MaxError()* × *FullChargeCapacity()* ÷ |*AtRate()*|

Invalid Data Indication: 65,535 indicates the *AtRate* = 0.

AtRateTimeToEmpty() (0x06)

Description: Returns the predicted remaining operating time if the battery is discharged at the *AtRate()* value.

Purpose: The *AtRateTimeToEmpty()* function is part of a two-function call-set used to determine the remaining operating time at the *AtRate()* value. The bq2084-V133 updates *AtRateTimeToEmpty()* within 5 ms after the SMBus host sets the *AtRate()* value. The bq2084-V133 automatically updates *AtRateTimeToEmpty()* based on the *AtRate()* value every 1 s.

SMBus protocol: Read word

Output: Unsigned integer—estimated operating time left.

Units: Minutes

Range: 0 to 65,534 min

Granularity: 2 min or better

Accuracy: -0, +*MaxError()* × *FullChargeCapacity* ÷ |*AtRate()*|

Invalid Data Indication: 65,535 indicates *AtRate* = 0.

AtRateOK() (0x07)

Description: Returns a Boolean value that indicates whether or not the battery can deliver the *AtRate()* value of *additional* energy for 10 s. If the *AtRate* value is zero or positive, the *AtRateOK()* function ALWAYS returns OK (logic 1).

Purpose: The *AtRateOK()* function is part of a two-function call-set used by power management systems to determine if the battery can safely supply enough energy for an additional load. The bq2084-V133 updates *AtRateOK()* within 5 ms after the SMBus host sets the *AtRate()* value. The bq2084-V133 automatically updates *AtRateOK()* based on the *At Rate()* value every 1 second.

SMBus protocol: Read word

Output: Boolean—indicates if the battery can supply the *additional* energy requested.

Units: Boolean

Range: 1, 0

Granularity: Not applicable

Accuracy: Not applicable

Temperature() (0x08)

Description: Returns the temperature (K) measured by the bq2084-V133.

Purpose: The *Temperature()* function provides accurate cell temperatures for use by battery chargers and thermal management systems. A battery charger can use the temperature as a safety check. Thermal management systems may use the temperature because the battery is one of the largest thermal sources in a system.

SMBus protocol: Read word

Output: Unsigned integer—cell temperature in tenth-degree Kelvin increments.

Units: 0.1°K

Copyright © 2005–2010, Texas Instruments Incorporated

Range: 0 to +6553.5°K {real range}

Granularity: 0.1°K

Accuracy: ±1.5°K (from ideal Semitec 103AT thermistor performance, after calibration)

Voltage() (0x09)

Description: Returns the cell-pack voltage (mV).

Purpose: The *Voltage()* function provides power management systems with an accurate battery terminal voltage. Power management systems can use this voltage, along with battery current information, to characterize devices they control. This ability helps enable intelligent, adaptive power-management systems.

SMBus protocol: Read word

Output: Unsigned integer—battery terminal voltage in mV.

Units: mV

Range: 0 to 20,000 mV

Granularity: 1 mV

Accuracy: ±0.25% (after calibration)

Current() (0x0a)

Description: Returns the current being supplied (or accepted) by the battery (mA).

Purpose: The *Current()* function provides a snapshot for the power management system of the current flowing into or out of the battery. This information is of particular use in power-management systems because they can characterize individual devices and tune their operation to actual system power behavior.

SMBus protocol: Read word

Output: Signed integer—charge/discharge rate in mA increments: positive for charge, negative for discharge.

Units: mA

Range: -32,768 to 32,767 mA

Granularity: 1 mA

Accuracy: 0.25% or 5 mA, whichever is greater

AverageCurrent() (0x0b)

Description: Returns a value that approximates a one-minute rolling average of the current being supplied (or accepted) through the battery terminals (mA). *AverageCurrent()* is implemented as a single pole IIR filter with a 14.5-s time constant.

Purpose: The *AverageCurrent()* function provides the average current flowing into or out of the battery for the power management system.

SMBus protocol: Read word

Output: Signed integer—charge/discharge rate in mA increments: positive for charge, negative for discharge.

Units: mA

Range: -32,768 to 32,767 mA

Granularity: 1 mA

Accuracy: 0.25% or 5 mA, whichever is greater

Copyright © 2005–2010, Texas Instruments Incorporated

MaxError() (0x0c)

Description: Returns the expected margin of error (%) in the state of charge calculation. For example, when *MaxError()* returns 10% and *RelativeStateOfCharge()* returns 50%, the *RelativeStateOfCharge()* is more likely between 50% and 60%. The bq2084-V133 sets *MaxError()* to 100% on a full reset. The bq2084-V133 sets *MaxError()* to 2% on completion of a learning cycle, unless the bq2084-V133 limits the learning cycle to the +512/-256 mAh maximum adjustment values. If the learning cycle is limited, the bq2084-V133 sets *MaxError()* to 8% unless *MaxError()* was already below 8%. In this case, *MaxError()* does not change. The bq2084-V133 increments *MaxError()* by 1% after four increments of *CycleCount()* without a learning cycle. If voltage-based corrections are applied to the coulomb counter, *MaxError()* is set to 25%.

Purpose: The *MaxError()* function has real value in two ways: first, to give the user a confidence level about the state of charge and second, to give the power management system information about how aggressive it should be, particularly as the battery nears the end of its life.

SMBus protocol: Read word

Output: Unsigned integer—percent uncertainty for selected information.

Units: %

Range: 2-100%

Granularity: 1%

Accuracy: Not applicable

RelativeStateOfCharge() (0x0d)

Description: Returns the predicted remaining battery capacity expressed as a percentage of *FullChargeCapacity()* (%).

Purpose: The *RelativeStateOfCharge()* function is used to estimate the amount of charge remaining in the battery relative to the last learned capacity.

SMBus protocol: Read word

Output: Unsigned integer-percent of remaining capacity.

Units: %

Range: 0-100%

Granularity: 1%

Accuracy: -0, +*MaxError()*

AbsoluteStateOfCharge()(0x0e)

Description: Returns the predicted remaining battery capacity expressed as a percentage of *DesignCapacity()* (%). Note thatd ((%)5T8621/F2 1a0 Tf6 6.12 0 Td [(Units)]TJ /F1 10 Tf 5 0 Td (of)Tj /F1 10 Tf 14.454 0 Td (The)Tj /F3 1

Purpose: The

AverageTimeToEmpty() (0x12)

Description: Returns a predicted remaining battery life (minutes), based on *AverageCurrent*. The *AverageTimeToEmpty()* value is calculated based on either current or power depending on the setting of the *BatteryMode()* CAPACITY_MODE bit.

Purpose: The *AverageTimeToEmpty()* displays state-of-charge information in a more useful way. It averages the instantaneous estimations so that the remaining time does not appear to jump around.

SMBus protocol: Read word

Output: Unsigned integer—minutes of operation left.

Units: Minutes

Range: 0 to 65,534 min

Granularity: 2 min or better

Accuracy: -0, +*MaxError() * FullChargeCapacity()* / *AverageCurrent()*

Invalid Data Indication: 65,535 indicates battery is not being discharged.

AverageTimeToFull() (0x13)

Description: Returns a predicted remaining time until the battery reaches full charge (minutes), based on AverageCurrent.

Purpose: The *AverageTimeToFull()* function can be used by the SMBus host's power management system to aid in its policy. It may also be used to find out how long the system must be left on to achieve full charge.

SMBus protocol: Read word

Output: Unsigned integer—remaining time in minutes.

Units: Minutes

Range: 0 to 65,534 minutes

Granularity: 2 minutes or better

Accuracy: -0, +*MaxError() * FullChargeCapacity() ÷AverageCurrent()*

Invalid Data Indication: 65,535 indicates the battery is not being charged.

ChargingCurrent() (0x14)

A9ou3Bd(charged/F1-rent())Tj /F2 10 Tf 83.5 0 Td (function)Tj 3j 16.9.-um 10 Tf /F2 10 TTj ET BT /Fd.

Description: Returns the desired charging rate in mA.

Purpose: The *ChargingCurrent()* fu nction

ChargingVoltage() (0x15)

Description: Returns the desired charging voltage in mV.

Purpose: The *ChargingVoltage()* function sets the maximum charge voltage of the battery. The *ChargingVoltage()* value should be used in combination with the *ChargingCurrent()* value to set the charger's operating point. Together, these functions permit the bq2084-V133 to dynamically control the charging profile (current/voltage) of the battery. The charger may be operated as a constant-current source above its maximum regulated voltage range by returning a *ChargingVoltage()* value of 65,535.

SMBus protocol: Read word

Output: Unsigned integer—charger output voltage in mV.

Units: mV

Range: 0 to 65,535 mV

Granularity: 1 mV

Accuracy: Not applicable

Invalid Data Indication: 65,535 indicates the charger should operate as a current source outside its maximum regulated voltage range.

BatteryStatus() (0x16)

Description: Returns the bq2084-V133 status word (flags). Some of the *BatteryStatus()* flags (and *REMAINING_TIME_ALARM*) are calculated on the basis of either current or power depending on the setting of the *BatteryMode() CAPACITY_MODE* bit. This is important because use of the wrong calculation mode may result in an inaccurate alarm.

Purpose: The *BatteryStatus()* function is used o4 0 T18.4 /F1 s())

ALARM BITS	
0x0002	ReservedCommand
0x0001	Busy
0x0000	OK

ALARM BITS *ALARM Bits d (ts)TjERROR 10 3(1.84 0 TdCODESTS*

OVER_CHARGED_ALARM bit is set whenever the bq2084-V133 detects that the battery is being charged beyond the maximum overcharge limit, which is full capacity plus *Maximum Overcharge* (DF 0x51-0x52). This bit is cleared when the bq2084-V133 detects that the battery is no longer being charged and there are 2 mAh of continuous discharge (i.e., the bq2084-V133 detects discharge activity or no activity above the digital filter).

TERMINATE_CHARGE_ALARM bit is set when the bq2084-V133 detects a primary charge termination. This bit is cleared when the bq2084-V133 detects that the battery is no longer being charged.

OVER_TEMP_ALARM bit is set when the bq2084-V133 detects that the internal battery temperature is greater than or equal to the *OverTemperature Charge* threshold while charging or *OverTemperature Discharge* threshold while discharging. This bit is cleared when the internal temperature falls back below the *OverTemperature Charge Reset* or *OverTemperature Discharge Reset* as appropiate..

TERMINATE_DISCHARGE_ALARM bit is set when RM = 0, *Voltage()* = *Terminate Voltage* (DF 0x67-0x68), the battery temperature is less than or equal to the *Charge Suspend Temp Low* (DF 0x79) or the CVUV bit in pack status is set indicating that a Li-ion cell voltage has dropped below the limit programmed in *Cell Under*. The bit is cleared when Voltage() > *Terminate Voltage*, *RM()* > 0, and the *CVUV* bit is cleared.

REMAINING_CAPACITY_ALARM bit is set when the bq2084-V133 detects that *RemainingCapacity()* is less than that set by the *RemainingCapacityAlarm()* function. This bit is cleared when either the value set by the *RemainingCapacityAlarm()* function is lower than the *RemainingCapacity()* or when the *RemainingCapacity()* is increased by charging.

REMAINING_TIME_ALARM bit is set when the bq2084-V133 detects that the estimated remaining time at the present discharge rate is less than that set by the *RemainingTimeAlarm()* function. This bit is cleared when either the value set by the *RemainingTimeAlarm()* function is lower than the *AverageTimeToEmpty()* or when the *AverageTimeToEmpty()* is increased by charging.

STATUS BITS

The initialized bit is set when the bq2084-V133 has detected a valid load of data flash at full or partial reset. It is cleared when the bq2084-V133 detects an improper data flash load.

DISCHARGING bit is set when the bq2084-V133 determines that the battery is not being charged. This bit is cleared when the bq2084-V133 detects that the battery is being charged.

FULLY_CHARGED bit is set when the bq2084-V133 detects a primary charge termination or an Overcharge condition. It is cleared when 84 V133 2.46 0 ng

1.5Ti 13.56 0 Td (th3.) Td (limit.)Ti 23.20.32 0 Td (Under)Ti /d (charged60 36.35 0 TF28.vSCHARGI9)Ti 25.88 0 TdFULLY_Terminate%

SpecificationInfo() (0x1a)

Description: Returns the version number of the smart battery specification the battery pack supports, as well as voltage and current scaling information in a packed unsigned integer. Power scaling is the product of the voltage scaling times the current scaling. The *SpecificationInfo()* is packed in the following fashion:

(SpecID_H × 0x10 + SpecID_L) + (VScale + IPScale × 0x10) × 0x100.

The bq2084-V133 *VScale* (voltage scaling) and *IPScale* (current scaling) should always be set to zero. The bq2084-V133 sets *SpecificationInfo()* to the value programmed in *Specification Information* (DF 0x06-0x07).

Purpose: The *SpecificationInfo()* function is is

Purpose: The *ManufacturerName()* function returns the name of the smart battery manufacturer. The manufacturer's name can be displayed by the SMBus host's power management system display as both an identifier and as an advertisement for the manufacturer. The name is also useful as part of the information required to uniquely identify a battery.

SMBus protocol: Read block

Output: String—character string with maximum length of 11 characters (11 + length byte).

DeviceName() (0x21)

Description: This function returns a character string that contains the battery name. For example, a *DeviceName()* of bq2084-V133 indicates that the battery is a model bq2084-V133. The bq2084-V133 sets *DeviceName()* to the value programmed in *Device Name* (DF 0x1a-0x21).

Purpose: The *DeviceName()* function returns the battery name for identification purposes.

SMBus protocol: Read block

Output: String—character string with maximum length of 7 characters (7 + length byte).

DeviceChemistry() (0x22)

Description: This function returns a character string that contains the battery chemistry. For example, if the *DeviceChemistry()* function returns *NiMH*, the battery pack contains nickel metal hydride cells. The bq2084-V133 sets DeviceChemistry() to the value programmed in *Device Chemistry* (DF 0x22-0x26).

Purpose: The *DeviceChemistry()* function gives cell chemistry information for use by charging systems. The bq2084-V133 does not use *DeviceChemisty()* values for internal charge control or fuel gauging.

SMBus protocol: Read block

Output: String—character string with maximum length of 4 characters (4 + length byte).

The following is a partial list of chemistries and their expected abbreviations. These abbreviations are *not* case sensitive.

CHEMISTRY	ABBREVIATIONS
Lead acid	PbAc
Lithium ion	LION
Nickel	

Pack Status and Pack Configuration (0x2f)

This function returns the pack status and pack configuration registers. The pack status register contains a number of status bits relating to bq2084-V133 operation. The pack status register is the least significant byte of the word. The pack configuration register reflects how the bq2084-V133 is configured as defined by the value programmed in *Pack Configuration* in DF 0x28.

The pack status register consists of the following bits:

b7	b6	b5	b4	b3	b2	b1	b0
PRES	EDV2	SS	VDQ	AFEFAIL	PF	CVOV	CVUV

PRES

The PRES bit indicates that the bq2084-V133 has been inserted into the system.

0 bq2084-V133 is out of the system

1 bq2084-V133 is inserted into a system

Copyright © 2005–2010, Texas Instruments Incorporated

EDV2

The EDV2 bit indicates that pack or cell voltage (program option) is less than the EDV2 threshold.

0 Voltage > EDV2 threshold (discharging)

1 Voltage = EDV2 threshold

SS

The SS bit indicates the seal state of the bq2084-V133.

0 The bq2084-V133 is in the unsealed state.

1 The bq2084-V133 is in the sealed state.

AFEFAIL

The AFEFAIL bit indicates that AFE communications has failed.

0 AFE communications are okay.

1 AFE communications have failed.

VDQ

The VDQ bit indicates if the present discharge cycle is valid for an FCC update.

0 Discharge cycle not valid

1 Discharge cycle valid

PF

The PF bit indicates that the bq2084-V133 *PF Flag* has been set. It is cleared only when the *PF Flag* has been cleared.

0 bq2084-V133 *PF Flag* = 0x00

1 bq2084-V133 *PF Flag* = 0x66

CVOV

The CVOV bit indicates that a protection limit has been exceeded including Prolonged Overcurrent, Overvoltage, or Overtemperature conditions. The bit is not latched and merely reflects the present fault status.

0 No secondary protection limits exceeded

1 A secondary protection limit exceeded

CVUV

The CVUV bit indicates that a protection limit has been exceeded including overload or overdischarge conditions. The bit is not latched and merely reflects the present fault status.

0 No secondary protection limits exceeded

1 A secondary protection limit exceeded

VCELL4-VCELL1 (0x3c-0x3f)

These functions return the calculated individual cell voltages in mV.

DATA FLASH

General

The bq2084-V133 accesses the internal data flash during reset and when storing historical data. The data flash stores basic configuration information for use by the bq2084-V133. The data flash must be programmed correctly for proper bq2084-V133 operation.

Copyright © 2005–2010, Texas Instruments Incorporated

Memory Map

The following table shows the memory map for the data flash. It shows the default programming for the bq2084-V133. The default programming reflects example data for a 3s2p Li-ion battery pack with a 0.02- Ÿ sense resistor. The data flash must be reprogrammed to meet the requirements of individual applications.

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x00	0x01	*Remaining Time Alarm*	10 minutes	00	0a
0x02	0x03	*Remaining Capacity Alarm*	360 mAh	01	68
0x04	0x05	*Design Voltage*	14400 mV	38	40
0x06	0x07	*Specification Information*	v1.1/PEC	00	31
0x08	0x09	*Manufacture Date*	1/1/2003=11809	2e	21
0x0a	0x0b	*Serial Number*	1	00	01
0x0c	0x0d	*Cycle Count*	0	00	00
0x0e		*Manufacturer Name Length*	11		0b
0x0f		Character 1	T		54
0x10		Character 2	e		45
0x11		Character 3	x		58
0x12		Character 4	a		41
0x13		Character 5	s		53
0x14		Character 6			20
0x15		Character 7	I		49
0x16		Character 8	n		4e
0x17		Character 9	s		53
0x18		Character 10	t		54
0x19		Character 11	.		2e
0x1a		*Device Name Length*	6		06
0x1b		Character 1	b		42
0x1c		Character 2	q		51
0x1d		Character 3	2		32
0x1e		Character 4	0		30
0x1f		Character 5	8		38
0x20		Character 6	4		34
0x21		Character 7	—		00
0x22		*Device Chemistry Length*	4		04
0x23		Character 1	L		4c
0x24		Character 2	I		49
0x25		Character 3	O		4f
0x26		Character 4	N		4e
0x27		*Manufacturer Data Length*	9		09
0x28		*Pack Configuration*	DMODE, 4-LEDs, 4-CELL		c3
0x29		*Gauge Configuration*	CSYNC, OTVC		41
0x2a	0x2b	*Misc Configuration*	OT, VOD	0b	00
0x2c		*Digital Filter* (Dead Band)	9860 nV		22
0x2d		*Self-Discharge Rate*	0.2%		14
0x2e		*Electronics Load*	0 mA		00
0x2f		*Battery Low % (MSB)*			

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x36	0x37	*Full Charge Capacity*	7200 mAh	1c	20
0x38	0x39	*Cycle Count Threshold*	5200 mAh	14	50
0x3a	0x3b	*Charging Voltage*	16800 mV	41	a0
0x3c	0x3d	*Precharge Voltage*	2500 mV	09	c4
0x3e	0x3f	*Fast-Charging Current*	2500 mA	09	c4
0x40	0x41	*Maintenance Charging Current*	0 mA	00	00
0x42	0x43	*Precharge Current*	100 mA	00	64
0x44		*Precharge Temperature*	9.6°C		60
0x45		*Precharge Temperature Hysteresis*	3.0°C		1e
0x46		*Charge Inhibit Temp Low*	0.0°C		00
0x47	0x48	*Charge Inhibit Temp High*	50.0°C	01	f4
0x49		*Fast Charge Termination %*	100%		ff
0x4a		*Fully Charged Clear %*	95%		5f
0x4b	0x4c	*Current Taper Threshold*	240 mA	00	f0
0x4d	0x4e	*Current Taper Qual Voltage*	300 mV	01	2c
0x4f		*Current Taper Window*	40s		28
0x50		Reserved			40
0x51	0x52	*Maximum Overcharge*	300 mAh	01	2c
0x53		Reserved			02
0x54		*Charge Efficiency*	100%		ff
0x55		Reserved			64
0x56	0x57	Reserved		02	22
0x58		Reserved			32
0x59	0x5a	Reserved		01	ae
0x5b	0x5c	*Overload Current*	5000 mA	13	88
0x5d	0x5e	*Over Voltage Margin*	700 mV	02	bc
0x5f	0x60	Reserved		01	f4
0x61	0x62	*Clear Fail Current*	256 mA	01	00
0x63	0x64	*Cell Over Voltage*	4350 mV	10	fe
0x65	0x66	*Cell Under Voltage*	2300 mV	08	fc
0x67	0x68	*Terminate Voltage*	11300 mV	2c	24
0x69	0x6a	Reserved		00	00
0x6b	0x6c	*Safety Over Voltage*	20000 mV	3a	98
0x6d	0x6e	*Charge Suspend Temp High*	60°C	02	58
0x6f	0x70	*Charge Suspend Temp High Reset*	55°C	02	26
0x71	0x72	*Over Temperature Discharge*	70°C	02	bc
0x73	0x74	*Over Temperature Discharge Reset*	60°C	02	58
0x75	0x76	*Safety OverTemperature Charge*	75°C	02	ee
0x77	0x78	*Safety OverTemperature Discharge*	75°C	02	ee
0x79		*Charge Suspend Temp Low*	0°C		00
0x7a		Reserved			ef
0x7b		*Current Deadband*	3 mA		03
0x7c	0x7d	*Shutdown Voltage*	8800 mV	22	60
0x7e	0x7f	*VOC75*	15848 mV	3d	e8
0x80		Reserved			bf
0x81		Reserved			56
0x82		Reserved			40

Copyright © 2005–2010, Texas Instruments Incorporated

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x83	0x84	*VOC50*	15240 mV	3b	88
0x85		Reserved			7f
0x86		Reserved			3d
0x87		Reserved			27
0x88	0x89	*VOC25*	15024 mV	3a	b0
0x8a		Reserved			3f
0x8b		Reserved			24
0x8c		Reserved			0e
0x8d		Reserved			14
0x8e		*Voltage Average Time*	1 s		01
0x8f		*Correction Current Limit*	64 mA		40
0x90	0x91	Reserved		0b	e1
0x92	0x93	Reserved		0b	68
0x94		Reserved			19
0x95	0x96	*EMF/EDV0*	3000 mV	0b	b8
0x97	0x98	*EDV C0 Factor/EDV1*	3250 mV	0c	b2
0x99	0x9a	*EDV R0 Factor/EDV2*	3400 mV	0d	48
0x9b	0x9c	*EDV T0 Factor*	0	00	00
0x9d	0x9e				

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x10f	0x110	*Max Charge Time*	7200 s	1c	20
0x111	0x112	*Precharge Detection Current*	10 mA	00	0a
0x113	0x114	*Charge Detection Current*	100 mA	00	64
0x115	0x116	*Discharge Detection Current*	-150 mA	ff	6a
0x117	0x118	Reserved		10	68
0x119	0x11a	Reserved		10	36
0x11b	0x11c	Reserved			00
0x11d		*Permanent Fail Status*	0		00
0x11e		*Permanent Fail Flag*	0		00
0x11f		*Permanent Fail Config*	0		00
0x120		*Permanent Fail Input Time*	0		00
0x121	0x122	Reserved		17	12
0x123	0x124	Reserved		26	73
0x125	0x126	*FET Fail Charge Current*	20 mA	00	20
0x127	0x128	*FET Fail Discharge Current*	-20 mA	ff	ec
0x129		*FET Fail Time*	20 s		14
0x12a	0x12b	*Charge OC Threshold*	4000 mA	0f	a0
0x12c		*Charge OC Time*	6 s		06
0x12d	0x12e	*Discharge OC Threshold*	10970 mA	2a	da
0x12f		*Discharge OC Time*	10 s		00

CC offset

CC offset (DF 0xd2-0xd3), contains the offset for the coulomb counter. It is automatically updated when the pack has met the conditions for sleep, before it enters sleep mode.

DSC offset

DSC offset (DF 0xd4), contains the offset for the pack ground reference. It is automatically updated when the pack has met the conditions for sleep, before it enters sleep mode.

ADC offset

ADC offset (DF 0xd5), contains the offset for the a/d converter. It is automatically updated when the pack has met the conditions for sleep, before it enters sleep mode.

Digital Filter

The desired digital filter threshold, VDF (V), is set by the value stored in *Digital Filter* (DF 0x2c).

Digital Filter = VDF ÷ 290 nV

CELL AND PACK CHARACTERISTICS

Battery Pack Capacity and Voltage

Pack capacity in mAh units is stored in *Design Capacity* (DF 0x32-0x33). In mAh mode, the bq2084-V133 copies *Design Capacity* to *DesignCapacity()*. In mWh mode, the bq2084-V133 multiplies *Design Capacity* by *Design Voltage* (DF 0x04-0x05) to calculate *DesignCapacity()* scaled to 10 mWh. *Design Voltage* is stored in mV.

The initial value for *Full Charge Capacity*, in mAh, is stored in DF 0x36-0x37. *Full Charge Capacity* is modified over the course of pack usage to reflect cell aging under the particular use conditions. The bq2084-V133 updates *Full Charge Capacity* in mAh after a capacity learning cycle.

Remaining Time Alarm and Capacity Alarm

Remaining Time Alarm (DF 0x02-0x03) sets the alarm thresholds used in the SMBus command codes 0x01 and 0x02, respectively. *Remaining Time Alarm* is stored in minutes and *Remaining Capacity Alarm* in units of mAh or 10 mWh, depending on the *BatteryMode()* setting.

Cycle Count Initialization

Cycle Count (DF 0x0c-0x0d) stores the initial value for the *CycleCount()* function. It should be programmed to 0x0000.

Cycle Count Threshold

Cycle Count Threshold (DF 0x37-0x38) sets the number of mAh that must be removed from the battery to increment *CycleCount()*. Cycle Count threshold is a 16-bit value stored in mAh.

Charge Efficiency

The bq2084-V133 applies the efficiency factor, EFF%, to all charge added to the battery. EFF% is encoded in *Charge Efficiency* (DF 0x54) according to the following equation:

Charge Efficiency = (EFF% w 2.56-1)

PACK OPTIONS

Pack Configuration

Pack Configuration (DF 0x28) contains bit-programmable features.

b7	b6	b5	b4	b3	b2	b1	b0
DMODE	LED1	LED0	HPE	CPE	SM	CC1	CC0

Copyright © 2005b02005

DMODE

The DMODE bit determines whether the LED outputs indicate AbsoluteStateOfCharge() or RelativeStateOfCharge().

0 LEDs reflect AbsoluteStateOfCharge()

1 LEDs reflect RelativeStateOfCharge()

LED1–LED0

The LED bits set the number of LEDs for Remaining Capacity () indication.

0-0 Configures the bq2084-V133 for five LEDs

0-1 Configures the bq2084-V133 for three LEDs

1-0 Configures the bq2084-V133 for four LEDs

1-1 Configures the bq2084-V133 for five LEDs

HPE

The HPE bit enables/disables PEC transmissions to the smart battery host for master mode alarm messages.

0 No PEC byte on alarm warning to host

1 PEC byte on alarm warning to host

CPE

The CPE bit enables/disables PEC transmissions to the smart battery charger for master mode messages.

0 No PEC byte on broadcasts to charger

1 PEC byte on broadcasts to charger

SM

The SM bit enables/disables master mode broadcasts by the bq2084-V133.

0 Broadcasts to host and charger enabled

1 Broadcasts to host and charger disabled

If the SM bit is set, modifications to bits in BatteryMode() do not re-enable broadcasts.

CC1–CC0

The CC bits configure the bq2084-V133 for the number of series cells in the battery pack.

1-1 Configures the bq2084-V133 for four series cells

1-0 Configures the bq2084-V133 for three series cells

0-1 Configures the bq2084-V133 for two series cells

Gauge Configuration

Gauge Configuration (DF 0x29) contains bit-programmable features:

b7	b6	b5	b4	b3	b2	b1	b0
0	CSYNC	SC	CEDV	EDVV	OVSEL	VCOR	OTVC

CSYNC

In usual operation of the bq2084-V133, the CSYNC bit is set so that the coulomb counter is adjusted when a fast charge termination is detected. In some applications, especially those where an externally controlled charger is used, it may be desirable *not* to adjust the coulomb counter. In these cases the CSYNC bit should be cleared.

0 The bq2084-V133 does not alter RM at the time of a valid charge termination.

1 The bq2084-V133 updates RM with a programmed percentage of FCC at a valid charger termination.

Copyright © 2005–2010, Texas Instruments Incorporated

SC

The SC bit enables learning cycle optimization for a Smart Charger or independent charge.

1 Learning cycle optimized for independent charger

0 Learning cycle optimized for Smart Charger

CEDV

The CEDV bit determines whether the bq2084-V133 implements automatic EDV compensation to calculate the EDV0, EDV1, and EDV2 thresholds base on rate, temperature, and capacity. If the bit is cleared, the bq2084-V133 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the bq2084-V133 calculates EDV0, EDV1, and EDV2.

0 EDV compensation disabled

1 EDV compensation enabled

EDVV

The EDVV bit selects whether EDV termination is to be done with regard to Voltage () or the lowest single-cell voltage.

0 EDV conditions determined on the basis of the lowest single-cell voltage

1 EDV conditions determined on the basis of Voltage()

OVSEL

The OVSEL bit determines if Safety Over Voltage is based on Voltage () or highest cell voltages.

0 Safety overvoltage based on Voltage ()

1 Safety overvoltage based on highest cell voltage multiplied by the numb()

AFEDET

The AFEDET bit programs the bq2084-V133 to look for errors with I^2C communications and the AFE and enables the detection of the AFE permanent failure if bit 3 of PF Config 0x11f is set.

0 Does not verify AFE communications.

1 Does verify AFE communications.

DS

The DS bit programs the bq2084-V133 to enter sleep mode on SMBus inactivity.

0 bq2084-V133 enters sleep mode when the SMBus is low for 2 s.

1 bq2084-V133 does not enter sleep mode.

OT

The OT bit programs the bq2084-V133 to turn off the discharge FET when the bq2084-V133 detects an overtemperature condition. Charge FET is always turned off in overtemperature conditions.

0 bq2084-V133 does not turn off the discharge FET on overtemperature.

1 bq2084-V133 turns off the discharge FET on overtemperature.

ECLED

The ECLED bit programs the LED activity during charging (DSG bit = 0).

0 The LEDs are not enabled during charging.

1 The LEDs are enabled during charging.

VOD

The VOD bit enables a 1-s time delay in the setting of the CVOV and CVUV bits in PackStatus.

0 No delay

1 1-s delay

Misc Configuration (DF 0x2b, low)

b7	b6	b5	b4	b3	b2	b1	b0
LEDRCA	PFET1	PFET0	NR	CHGFET	0	0	0

LEDRCA

The LEDRCA bit programs the LED to blink when there is a RemainingCapacityAlarm.

0 The LEDs blink when there is a RemainingCapacityAlarm.

1 The LEDs do not blink when there is a RemainingCapacityAlarm.

PFET1, PFET0

The PFETx bits define the precharge FET operation.

NR

The NR bit defines whether the bq2084-V133 is to be used with a nonremovable system battery. If set to indicate a nonremovable system battery there are additional clear conditions for a battery failure due to overcharge, overcurrent, and overload. The additional conditions besides battery removal (defined as the loss system present pin going high) are either detection of an opposite current of that that caused the failure or when *AverageCurrent()* is less than *Clear Fail Current* DF 0x61, 0x62 for a time defined by Fault Reset Time DF 0x130. Also, for a nonremovable battery the charge FET is left on for discharge current failures and the discharge FET is left on for charge current failures.

0 Removable battery, battery fail conditions cleared by battery removal only.

1 Nonremovable system battery.

CHGFET

The CHGFET bit programs the charge FET to remain on even after a charge terminate condition.

0 The charge FET is turned off after a charge termination condition.

1 The charge FET is turned on after a charge termination condition.

Constants and String Data

Specification Information

Specification Information (DF 0x06-0x07) stores the default value for the *SpecificationInfo()* function. It is stored in data flash in the same format as the data returned by the *SpecificationInfo()*.

Manufacture Date

Manufacture Date (DF 0x08-0x09) stores the default value for the *ManufactureDate()* function. It is stored in data flash in the same format as the data returned by the *ManufactureDate()*.

Serial Number

Serial Number (DF 0x0a-0x0b) stores the default value for the *SerialNumber()* function. It is stored in data flash in the same format as the data returned by the *SerialNumber()*.

Manufacturer Name Data

Manufacturer Name Length (DF 0x0e) stores the length of the desired string that is returned by the *ManufacturerName()* function. Locations DF 0x0f-0x19 store the characters for *ManufacturerName()* in ASCII code.

Device Name Data

Device Name Length (DF 0x1a) stores the length of the desired string that is returned by the *DeviceName()* function. Locations DF 0x1b-0x21 store the characters for *DeviceName()* in ASCII code.

Device Chemistry Data

Device Chemistry Length (DF 0x22) stores the length of the desired string that is returned by the *DeviceChemistry()* function. Locations DF 0x23-0x26 store the characters for *DeviceChemistry()* in ASCII code.

Manufactuters Data Length

Manufacturers Data Length (DF 0x27) stores the length of the desired number of bytes that is returned by the *ManufacturersData()* function. It should be set to 9.

Temperature Limits

The limits described below are extensions to those limits detailed in the safety and charging sections of this data sheet.

Copyright © 2005–2010, Texas Instruments Incorporated

Charge Suspend Temp Low

Charge Suspend Temp Low (DF 0x45-0x49) sets the low temperature, in 0.1°C, at which normal operation is allowed. If the temperature falls below this limit, the pack goes into a temporary failure state, the charge FET is turned off, and the Not Ready status bit is set to system management. It is cleared when the pack warms, or the pack is removed.

Charge Inhibit Temp Low

Charge Inhibit Temp Low (DF 0x46) inhibits charging by setting *ChargingCurrent()* and *ChargingVoltage()* to 0 and turn off the CHG FET. It is programmed in degrees C ÷ 10, and the range of -12.8°C to 12.7°C.

Charge Inhibit Temp High

Charge Inhibit Temp High (DF 0x47-0x48) inhibits charging by setting *ChargingCurrent()* and *ChargingVoltage()* to 0

Charge Suspend Temp High

Charge Suspend Temp High (DF 0x6d-0x6e) sets

Discharge Detection Current

Discharge Detection Current (DF 0x115-0x116) sets the threshold in milliamperes for detecting discharge current. This is a signed value and is negative. This threshold is used for detecting cross-conduction and determining that the charge FET should be turned on during discharge to reduce IR losses.

FET Fail Charge Current

FET Fail Charge Current (DF 0x125-0x126) sets the threshold in milliamperes for detecting current in a charge FET which is turned off. This is a signed value and is positive.

FET Fail Discharge Current

FET Fail Discharge Current (DF 0x127-0x128) sets the threshold in milliamperes for detecting current in a discharge FET which is turned off. This is a signed value and is negative.

FET Fail Time

FET Fail Time (DF 0x129) sets the time in seconds that current must be detected in a FET which is turned off, in order to determine that the FET has failed.

Terminate Voltage

Terminate Voltage (DF 0x67-0x68) sets the threshold below which the *Terminate Discharge Alarm* bit is set. The alarm is cleared when the voltage rises above this threshold, if the *CVUV* bit in *Pack Status* is not set.

Offsets and Limits

Temperature offset

Temperature offset (DF 0xd6) contains a signed offset for the pack's temperature measurements, in degrees C/10. It is set at board test during pack calibration.

Board offset

Board offset (DF 0xd7), contains a signed offset for the pack's coulomb counter measurements. If used, it is set at board design time.

Current Deadband

Current Deadband (DF 0x7b), sets the threshold in mA below which a current measurement is not detected.

Shutdown Voltage

Shutdown Voltage (DF 0x7c-0x7d) sets the pack voltage below which the pack's electronics, including the bq2084-V133, is shut down to conserve power. All FETs are turned off by the AFE.

APPLICATION INFORMATION

Figure 7 shows a typical bq2084-V133-based battery pack application. The circuit consists of the bq29312 AFE IC, bq29400 second-level protection IC, LED, temperature measurement network, data flash connections, serial port, and the sense resistor. The data flash stores basic battery pack configuration information and measurement calibration values. The data flash must be programmed properly for bq2084-V133 operation.

Copyright © 2005–2010, Texas Instruments Incorporated

Figure 7. bq2084-V133 Based Battery Pack Schematic

Copyright © 2005–2010, Texas Instruments Incorporated

REVISION HISTORY

Changes from Revision A (June 2005) to Revision B **Page**

- Changed Table 10 CVOV entry From: $VCELL_{(ANY)}$ = *Cell Over Voltage* To: $VCELL_{(ANY)}$ • *Cell Over Voltage* 20
- Changed Table 10 CVUV entry From: $VCELL_{(ANY)}$ = *Cell Under Voltage* To: $VCELL_{(ANY)}$ ” *Cell Under Voltage* 20
- Changed Table 10 Note 2 From: On if there is a discharge current • 150mA To: On if there is a discharge current • Discharge Detection Current 20
- Changed Table 10 Note 3 From: On if there is a charge current • Charge Detection Current • 50mA To: On if there is a charge current • Charge Detection Current • Charge Detection Current 20
- Changed 1st Level Cell Voltage Thresholds section. 20
- Changed Overcurrent Thresholds section 20

Copyright © 2005–2010, Texas Instruments Incorporated

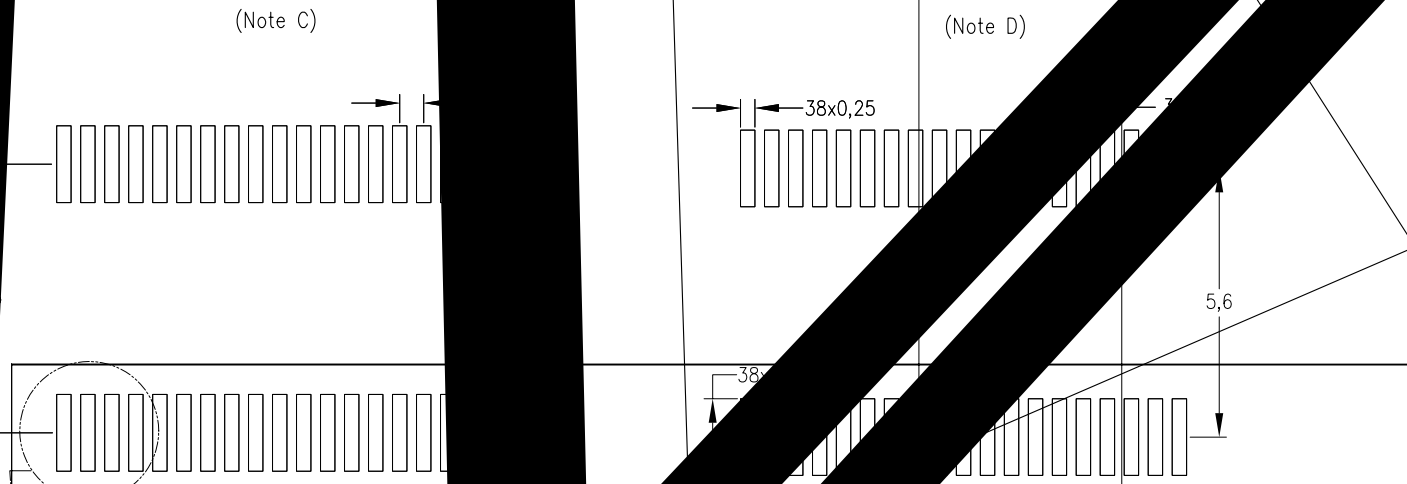
PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
BQ2084DBT-V133	NRND	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	-20 to 85	2084DBT	
BQ2084DBT-V133G4	NRND	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	-20 to 85	2084DBT	
BQ2084DBTR-V133	NRND	TSSOP	DBT	38	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-20 to 85	2084DBT	
BQ2084DBTR-V133G4	NRND	TSSOP	DBT	38	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-20 to 85	2084DBT	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

DB (R–PD

PLASTIC SMALL OUTLINE



4211881/A 06/11

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
D. Publication IPC-7351 may have alternate designs. Pin flares with trapezoidal shapes as well as rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525.
E. Falls within JEDEC MS-012 variation AB. Customers should contact their board fabrication site for solder mask t

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information Buyers subject to retriectionI.