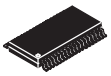


SBS v1.1-COMPLIANT GAS GAUGE FOR USE WITH THE bq29312

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 Removes Need for External Crystal with 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 LEDent**

DESCRIPTION

The bq2084-V143 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-V143 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-V143, the host controller can manage remaining battery power to extend the system run time as much as possible.

The bq2084-V143 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-V143 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-V143 to generate the control signals necessary to implement the cell balancing and the required safety protection for Li-ion and Li-polymer battery chemistries.

APPLICATIONS

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-V143 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-V143 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-V143 from a 2-, 3-, or 4-series Li-ion cell stack, eliminating the need for an external regulator circuit.

ORDERING INFORMATION

T_A	PACKAGE(1)	
	38-PIN TSSOP (DBT)(2)	36-PIN QFN (RTT)(3)
–20°C to 85°C	bq2084DBT-V143	bq2084RTT-V143

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at www.ti.com.
(2) The bq2084DBT-V141 is available in tape and reel. Add an R suffix to the device type (e.g., bq2084DBTR-V141) to order tape and reel version.
(3) The bq2084RTT-V140 is available in tape and reel only. Add an T suffix to the device type (e.g., bq2084RTTT-V140) to order mini tape and reel version.

ABSOLUTE MAXIMUM RATINGS

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

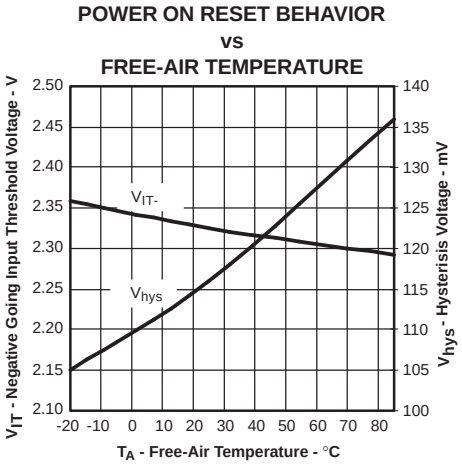
		UNIT
	Supply voltage range, V_{DD} relative to V_{SS} (2)	–0.3 V to 4.1 V
	Open-drain I/O pins, $V_{(IOD)}$ relative to V_{SS}(2)	–0.3 V to 6 V
	Input voltage range to all other pins, V_I relative to V_{Ss}(2)	–0.3 V to V_{DD} + 0.3 V
T_A	Operating free-air temperature range	–20°C to 85°C
T_{stg}	Storage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

ELECTRICAL CHARACTERISTICS

V_{DD} ≡ 3 V to 3.6 V, T_A = –20°C to 85°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{DD}	Supply voltage	VDDA and VDDD	3	3.3	3.6	V
I_{DD}	Operating mode current	No flash programming or LEDs active		380		µA
$I_{(SLP)}$	Low-power storage mode current	Sleep mode		8		µA
V_{OL}	Output voltage low SMBC, SMBD, SDATA, SCLK, $\overline{SAFE}$, PU	I_{OL} = 0.5 mA			0.4	V
	LED1-LED5	I_{OL} = 10 mA			0.4	
V_{IL}	Input voltage low SMBC, SMBD, SDATA, SCLK, EVENT, PU, $\overline{PRES}$, $\overline{PFIN}$		–0.3		0.8	V
	DISP		–0.3		0.8	
V_{IH}	Input voltage high SMBC, SMBD, SDATA, SCLK, EVENT, PU, $\overline{PRES}$, $\overline{PFIN}$		2		6	V
	DISP		2		V_{DD} + 0.3	
$V_{(AI1)}$	Input voltage range VIN, TS		V_{SS} – 0.3		1.0	V
$V_{(AI2)}$	Input voltage range SR1, SR2		V_{SS} – 0.25		0.25	V
$Z_{(AI1)}$	Input impedance SR1, SR2	–0.25 V to 0.25 V	2.5			MΩ
$Z_{(AI2)}$	Input impedance VIN, TS	0 V–1 V	8			MΩ
POWER-ON RESET						
V_{IT+}	Negative-going voltage					



INTEGRATING ADC CHARACTERISTICS

PLL SWITCHING CHARACTERISTICS

V_{DD} = 3 V to 3.6 V, T_A = –20°C to 85°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{(SP)}$	Start-up time (1)	±0.5% frequency error		2	5	ms

(1) The frequency error is measured from the trimmed frequency of the internal system clock, which is 128 x oscillator frequency, nominally 4.194 MHz.

OSCILLATOR

V_{DD} = 3 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 V to 3.6 V, T_A = –20°C to 85°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{DR}	Data retention	See (1)	10			Years
	Flash programming write-cycles	See (1)	20k			Cycles
$t_{(WORDPROG)}$	Word programming time	See (1)			2	ms
$I_{(DDPROG)}$	Flash-write supply current	See (1)		8	12	mA

(1) Specified by design. Not production tested.

REGISTER BACKUP

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(RBI)}$	RBI data-retention input current	V_{RBI} > 2 V, V_{DD} < V_{IT}		10	100	nA
$V_{(RBI)}$	RBI data-retention voltage (1)		1.3			V

(1) Specified by design. Not production tested.

SMBus TIMING SPECIFICATIONS

V_{DD} = 3 V to 3.6 V, T_A = -20°C to 85°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(SMB)}$	SMBus operating frequency	Slave mode, SMBC 50% duty cycle	10		100	kHz
$f_{(MAS)}$	SMBus master clock frequency	Master mode, no clock low slave extend		51.2		kHz
$t_{(BUF)}$	Bus free time between start and stop		4.7			µs
$T_{(HD:STA)}$	Hold time after (repeated) start		4			µs
$t_{(SU:STA)}$	Repeated start setup time		4.7			µs
$t_{(SU:STO)}$	Stop setup time		4			µs
$t_{(HD:DAT)}$	Data hold time	Receive mode	0			ns
		Transmit mode	300			
$t_{SU:DAT)}$	Data setup time		250			ns
$t_{(TIMEOUT)}$	Error signal/detect	See (1)	25		35	ms
$t_{(LOW)}$	Clock low period		4.7			µs

(1) The bq2084-V143 times out when any clock low exceeds $t_{(TIMEOUT)}$.

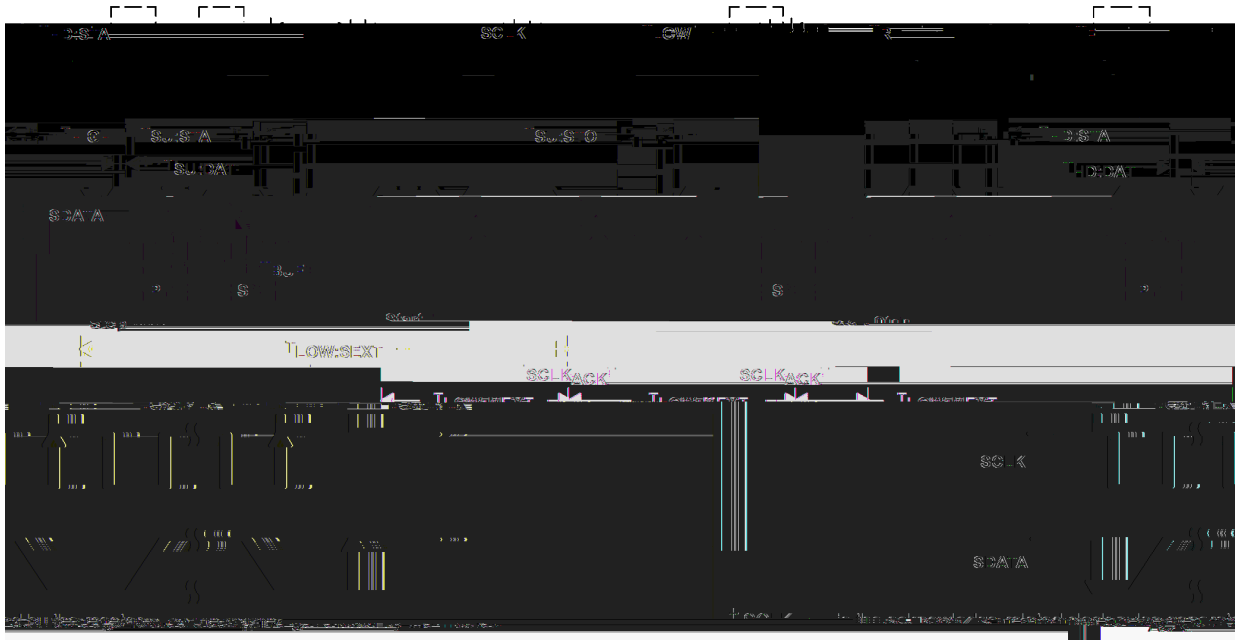
SMBus TIMING SPECIFICATIONS (continued)

V_{DD} = 3 V to 3.6 V, T_A = -20°C to 85°C unless otherwise noted

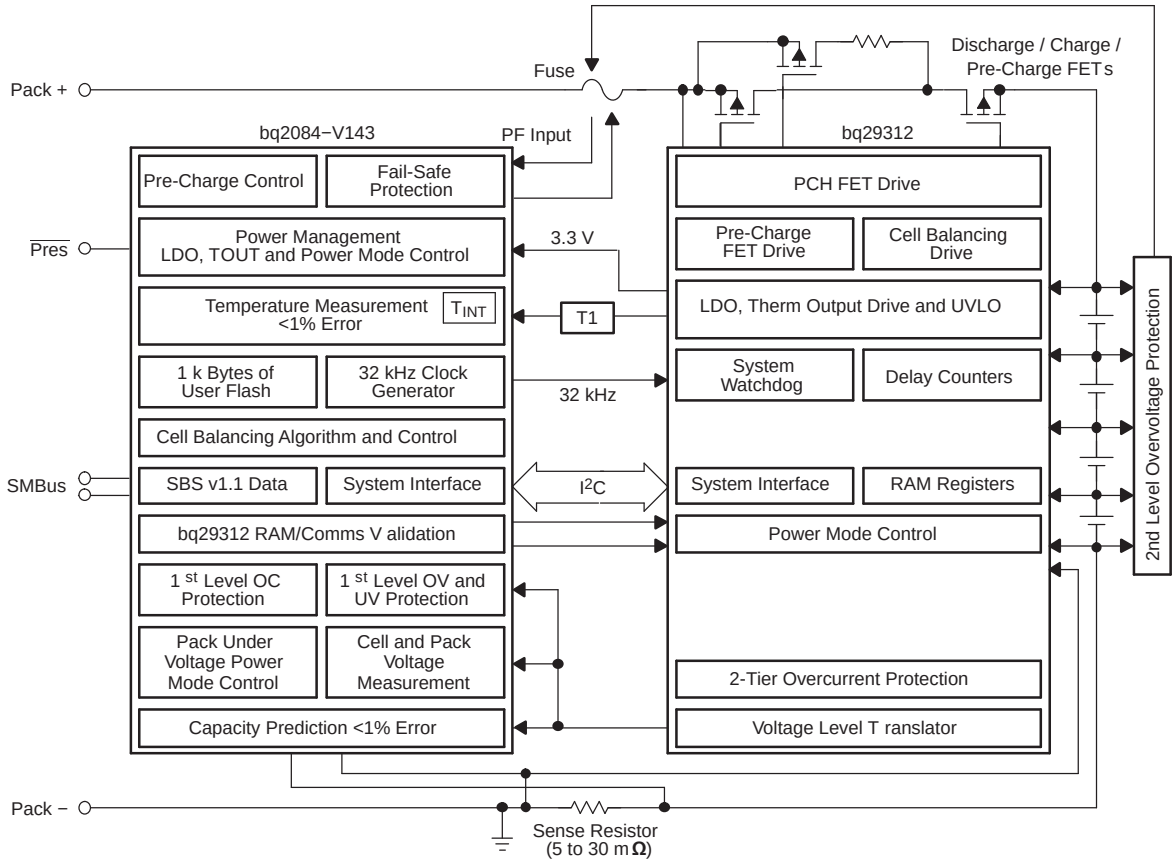
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{(HIGH)}$	Clock high period	See (2)	4		50	µs
$t_{LOW:SEXT)}$	Cumulative clock low slave extend time	See (3)			25	ms
$t_{LOW:MEXT}$	Cumulative clock low master extend time	See (4)			10	ms
t_f	Clock/data fall time	(V_{ILMAX} – 0.15 V) to (V_{IHMIN} + 0.15 V)			300	ns
t_r	Clock/data rise time	0.9 V_{DD} to (V_{ILMAX}– 0.15 V)			1000	ns

(2) $t_{(HIGH)}$ Max. is minimum bus idle time. SMBC = 1 for t > 50 ms causes reset of any transaction involving bq2084-V143 that is in progress.
(3) $t_{(LOW:SEXT)}$ is the cumulative time a slave device is allowed to extend the clock cycles in one message from initial start to the stop.
(4) $t_{(LOW:MEXT)}$ is the cumulative time a master device is allowed to extend the clock cycles in one message from initial start to the stop.

SMBus TIMING DIAGRAMS

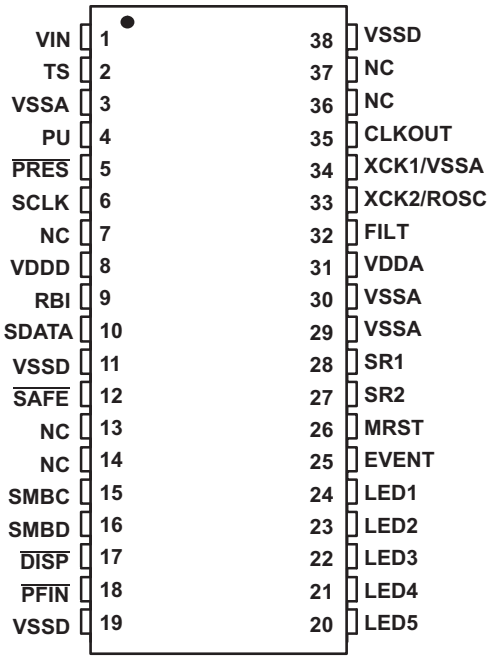


SYSTEM DIAGRAM



PIN ASSIGNMENTS

TSSOP (DBT)
(TOP VIEW)



QFN (RTT)
(TOP VIEW)

Terminal Functions

TERMINAL			I/O	DESCRIPTION
NAME	NO. TSSOP	NO. QFN		
$\overline{\text{DISP}}$	17	2	I	Display control for the LED drivers LED1 through LED5
CLKOUT	35	20	O	32.768-kHz output to the bq29312
FILT	32	17	I	Analog input connected to the external PLL filter
EVENT	25	10	I	Input from bq29312 XALERT output
LED1	24	9	O	LED display segments that each may drive an external LED
LED2	23	8	O	
LED3	22	7	O	
LED4	21	6	O	
LED5	20	5	O	
MRST	26	11	I	Master reset input that forces the device into reset when held high
NC	7, 13, 14, 36, 37	21, 29, 35	–	No connection
$\overline{\text{PFIN}}$	18	3	I	Active low input to detect secondary protector output status
$\overline{\text{PRES}}$	5	27	I	Active low input to sense system insertion
PU	4	26	O	Output to pull up the $\overline{\text{PRES}}$ pin for detection
RBI	9	31	I	Register backup that provides backup potential to the bq2084-V143 data registers during periods of low operating voltage. RBI accepts a storage capacitor or a battery input.
$\overline{\text{SAFE}}$	12	34	O	Active low output for additional level of safety protection; e.g., fuse blow.
SCLK	6	28	O	Communication clock to the bq29312
SDATA	10	32	I/O	Data transfer to and from bq29312
SMBC	15	36	I/O	SMBus clock open-drain bidirectional pin used to clock the data transfer to and from the bq2084-V143
SMBD	16	1	I/O	SMBus data open-drain bidirectional pin used to transfer address and data to and from the bq2084-V143
SR1	28	13	I	Connections for a small-value sense resistor to monitor the battery charge- and discharge-current flow
SR2	27	12	I	
TS	2	24	I	Thermistor voltage input connection to monitor temperature
VDDA	31	16	I	Positive supply for analog circuitry
VDDD	8	30	I	Positive supply for digital circuitry and I/O pins
VIN	1	25	I	Single-cell voltage input from the bq29312
VSSA	3, 29, 30	14, 15	I	Negative supply for analog circuitry
VSSD	11, 19, 38	4, 22, 23, 33	I	Negative supply for digital circuitry
XCK1/VSSA	34	19	I	32.768-kHz crystal oscillator input pin or connected to VSSA if the internal oscillator is used
XCK2/ROSC	33	18	O	32.768-kHz crystal oscillator output pin or connected to a 100-kΩ, 50 ppm or better resistor if the internal oscillator is used

FUNCTIONAL DESCRIPTION

OSCILLATOR FUNCTION

The oscillator of the bq2084-V143 can be set up for an internal or external operation. As the bq2084-V143 powers up it automatically attempts to start the internal oscillator, but if a 100-kΩ resistor is not connected to ROSC (pin 33), then it attempts to start the oscillator using an external 32.768-kHz crystal. Either the 100-kΩ ROSC resistor OR the 12 pF 32.768-kHz crystal should be mounted, NOT both.

The performance of the internal oscillator depends on the tolerance of the 100-kΩ resistor connected between

FUNCTIONAL DESCRIPTION (continued)

DIGITAL FILTER

The bq2084-V143 does not measure charge or discharge counts below the digital filter threshold. The digital filter threshold is programmed in the *Digital Filter* DF 0x2c and should be set sufficiently high to prevent false signal detection with no charge or discharge flowing through the sense resistor.

VOLTAGE

While monitoring SR1 and SR2 for charge and discharge currents, the bq2084-V143 monitors the individual series cell voltages through the bq29312. The bq2084-V143 configures the bq29312 to present the selected cell to the CELL pin of the bq29312, which should be connected to VIN of the bq2084-V143. The internal ADC of the bq2084-V143 then measures the voltage and scales it appropriately. The bq2084-V143 then reports the *Voltage()* and the individual cell voltages in *VCELL1()*, *VCELL2()*, *VCELL3()*, and *VCELL4()*. An additional SMBus command (0x45) returns the measured ADC Reading of the PACK input to the AFE.

CURRENT

The bq2084-V143 uses the SR1 and SR2 inputs to measure and calculate the battery charge and discharge current. This value is reported via the SBS command *Current()*. *AverageCurrent()* is implemented as a single-pole IIR filter with a 14.5-s time constant.

TEMPERATURE

The TS input of the bq2084-V143 along with an NTC thermistor measures the battery temperature as shown in the schematic. The bq2084-V143 reports temperature via the SBS command *Temperature()*.

The bq2084-V143 can also be configured to use its internal temperature sensor by setting the IT bit in *Misc Configuration* DF 0x2a-0x2b. Data flash locations DF 0xb5 through DF 0xc0 also have to be changed to prescribed values if the internal temperature sensor option is selected.

Table 1. Data Flash Settings for Internal or External Temperature Sensor

LABEL	LOCATION	INTERNAL TEMP SENSOR SETTING	EXTERNAL TEMP SENSOR SETTING (Semitec 103AT)
	Dec (Hex)	Dec (Hex)	Dec (Hex)
Misc. Config	42 (0x2a)	Bit 7 = 1	Bit 7 = 0
TS Const1 A3	164/5 (0xb5/6)	0 (0x0000)	–28285 (0x9183)
TS Const2 A2	166/7 (0xb7/8)	0 (0x0000)	20848 (0x5170)
TS Const3 A1	168/9 (0xb9/a)	–11136 (0xd480)	–7537 (0xe28f)
TS Const4 A0	170/1 (0xbb/c)	5734 (0x1666)	4012 (0x0fac)
Min Temp AD	172/3 (0xbd/e)	0 (0x0000)	0 (0x000)
Max Temp	174/5 (0xbf/c0)	5734 (0x1666)	4012 (0x0fac)

GAS GAUGE OPERATION

General

The operational overview in Figure 1 illustrates the gas gauge operation of the bq2084-V143. Table 3 describes the bq2084-V143 registers.

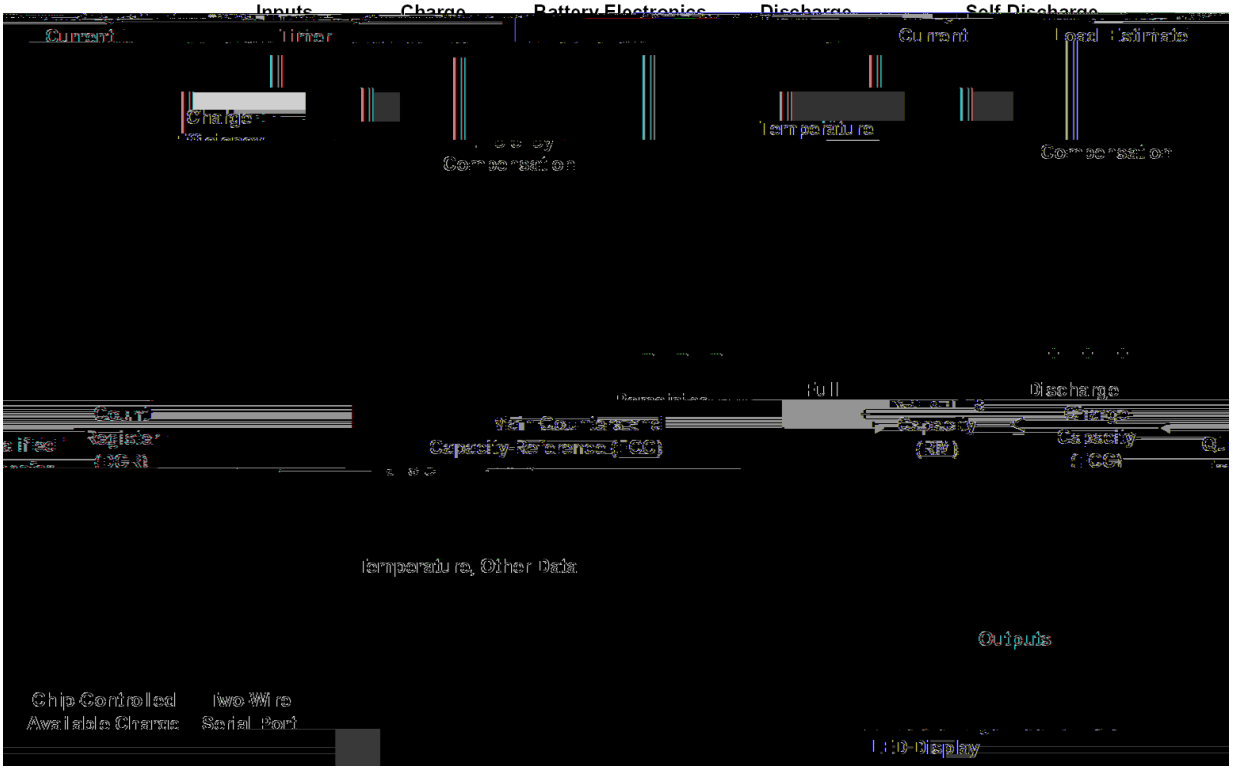


Figure 1. bq2084-V143 Gas Gauging Operational Overview

The bq2084-V143 accumulates a measure of charge and discharge currents and estimates self-discharge of the battery. The bq2084-V143 compensates the charge current measurement for temperature and state-of-charge of the battery. The bq2084-V143 also adjusts the self-discharge estimation based on temperature.

The main charge counter *RemainingCapacity()* (RM) represents the available capacity or energy in the battery at any given time. The bq2084-V143 adjusts RM for charge, self-discharge, and other compensation factors. The information in the RM register is accessible through the SMBus interface and is also represented through the LED display.

The *FullChargeCapacity()* (FCC) register represents the last measured learned full discharge of the battery. It is used as the battery full-charge reference for relative capacity indication. The bq2084-V143 updates FCC after the battery undergoes a qualified discharge from nearly full to a low battery level. FCC is accessible through the SMBus interface.

The Discharge Count Register (DCR) is a non-accessible register that tracks discharge of the battery. The bq2084-V143 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-V143 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-V143 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-V143 calibrates RM at three low-battery-voltage thresholds, EDV2, EDV1, and EDV0 and three programmable midrange thresholds VOC25, VOC50, and VOC75. This provides a voltage-based calibration to the RM counter.

DesignCapacity () (DC)

DC is the user-specified battery full capacity. It is calculated from *Pack Capacity* DF 0x32-0x33 and is represented in units of mAh or 10 mWh. It also represents the full-battery reference for the absolute display mode.

FullChargeCapacity() (FCC)

FCC is the last learned measured discharge capacity of the battery. It is represented in units of either mAh or 10 mWh, depending on the selected mode. On initialization, the bq2084-V143 sets FCC to the value stored in *Full Charge Capacity* DF 0x36-0x37. During subsequent discharges, the bq2084-V143 updates FCC with the last learned measured discharge capacity of the battery. The last learned measured discharge of the battery is based on the value in the Discharge Count Register (DCR) after a qualified discharge occurs. Once updated, the bq2084-V143 writes the new FCC value to data flash in mAh to *Full Charge Capacity*. FCC represents the full-battery reference for the relative display mode, relative state of charge and AtRate() calculations.

Discharge Count Register (DCR)

The DCR register counts up during discharge, independent of RM. DCR counts discharge activity, battery load estimation, and self-discharge increments. The bq2084-V143 initializes DCR, at the beginning of a discharge, to FCC - RM when FCC - RM is within the programmed value in *Near Full* DF 0x30. The DCR initial value of FCC - RM is reduced by FCC/128 if SC = 1 (bit 5 in *Gauge Configuration*) and is not reduced if SC = 0. DCR stops counting when the battery voltage reaches the EDV2 threshold on discharge.

Capacity Learning (FCC Update) and Qualified Discharge

The bq2084-V143 updates FCC with an amount based on the value in DCR if a qualified discharge occurs. The new value for FCC equals the DCR value plus the programmable nearly full and low battery levels, according to the following equation:

FCC (new) = DCR (final) = DCR (initial) + Measured Discharge to EDV2 + (FCC x *Battery Low%*)

here Battery Low % = (value stored in DF 0x2f) ÷ 2.56

A qualified discharge occurs if the battery discharges from RM = FCC - *Near Full* to the EDV2 voltage threshold with the following conditions:

- No more than 256 mAh of self-discharge or battery load estimation occurs during the discharge period.
- The temperature does not drop below the low temperature threshold programmed in *Learning Low Temp* DF 0xac during the discharge period.
- The battery voltage reaches the EDV2 threshold during the discharge period, and the voltage is greater than or equal to the EDV2 threshold minus 256 mV when the bq2084-V143 detects EDV2.
- No midrange voltage correction occurs during the discharge period.
- Current remains ≤ 3C/32 when EDV2 or *Battery Low* % level is reached.
- No overload condition exists when EDV2 threshold is reached, or if *RM()* has dropped to *Battery Low%* x FCC,
- No valid charge activity occurs during the discharge period. A valid charge is defined as an uninterrupted charge of 10 mAh into the battery.

The bq2084-V143 sets VDQ = 1 in PackStatus() when qualified discharge begins. The bq2084-V143 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-V143 saves the new FCC value to the data flash within 4 seconds of being updated.

End-of-Discharge Thresholds and Capacity Correction

The bq2084-V143 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-V143 for overall voltage or single-cell EDV thresholds. If programmed for single-cell EDV determination, the bq2084-V143 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-V143 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. If FEDV0 in *Gauge Configuration* is also set then EDV0 is not compensated. The bq2084-V143 disables EDV detection if Current( ) exceeds the *Overload Current* threshold programmed in DF 0x5b-DF 0x5c. The bq2084-V143 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-V143 uses the EDV thresholds to apply voltage-based corrections to the RM register according to Table 2

EDV Thresholds and Near-Full Programming

EDV Discharge Rate and Temperature Compensation Programming

C (either 0%, 3%, or *Battery Low %* for EDV0, EDV1, and EDV2, respectively) and C0 are the capacity-related EDV adjustment factors. C0 is programmed in *EDV C0 Factor/EDV1* DF 0x97-98. C1 is the desired residual battery capacity remaining at EDV0 (RM = 0). The C1 factor is stored in *EDV C1 Factor* DF 0xa0.

T is the current temperature in °K.

R0 × FTZ represents the resistance of a cell as a function of temperature and capacity.

FTZ = f (R1, T0, T, C + C1, TC)

R0 is the first order rate dependency factor stored in *EDV R0 Factor/EDV2* DF 0x99-0x9a.

T is the current temperature; C is the battery capacity relating to EDV0, EDV1, and EDV2.

R1 adjusts the variation of impedance with battery capacity. R1 is programmed in *EDV R1 Rate Factor* DF 0x9d-0x9e.

T0 adjusts the variation of impedance with battery temperature. T0 is programmed in *EDV T0 Rate Factor* DF 0x9b-0x9c.

TC adjusts the variation of impedance for cold temperatures (T < 23°C). TC is programmed in *EDV TC* DF 0x9f.

Typical values for the EDV compensation factors, based on overall pack voltages for a Li-ion 3s2p 18650 pack, are:

EMF = 11550/3

T0 = 4475

C0 = 235

C1 = 0

R0 = 5350/3

R1 = 250

TC = 3

Table 3. bq2084-V143 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
Tem15.2 Tm /F4 -8 Tf (Tem15.2	Tm /F4 -88 Tf (Tem15.2	T /F4 -8 Tf (Tem15.2	T /F4 2 Tm /F42 Tm /F4 4 2 Tm /F42 Tm /F4 4 Tm /F425

Aging Factor

specific applications, this new aging factor may be required. In those cases, experimental data must be taken at the 0, 100, 200, and 300 cycle read points using a typical discharge rate while at ambient temperature. Entering this data into a TI provided MathCAD program will yield the appropriate *DF: Age Factor* value. Contact TI Applications Support @ http://www-k.ext.ti.com/sc/technical-support/email-tech-support.asp?AAP for more detailed information.

Watch Dog Re-Initialization

The bq2084-V143 adds a new feature which periodically tests the state of two registers required to produce the 32kHz signal to the AFE.

The two registers which configure a 32kHz clock output to the AFE are checked once per second in normal operation, sleep mode,10 1 0 0 1 131.o1 131.1 0 1 162.06 le1432 95.2 Tm /F4 -8/F4 131.1 0 1 162.06 le14 0 man 0 0 1 520.

Self-Discharge

Battery Electronic Load Compensation

Midrange Capacity Corrections

For the midrange corrections to occur, the temperature must be in the range of 19°C to 31°C inclusive and Current() and AverageCurrent() must both report between -64 mA and 0. The bq2084-V143 makes midrange corrections as shown in Table 5. For a correction to occur, the bq2084-V143 must detect the need for correction twice during subsequent 20-s intervals. With the VCOR bit set, the bq2084-V143 makes midrange corrections whenever conditions permit.

If the OTVC bit in *Gauge*

Charge Control

Charging Voltage Broadcasts

Charging Current Broadcasts

If temperature is between the *Charge Inhibit Temp Low* (DF0x46) and the precharge threshold PC (°C), the bq2084-V143 sets ChargingCurrent() to *Precharge Current.* The threshold is programmed in the *Precharge Temp* DF 0x44. The maximal value of precharge temperature threshold setting is 12.7°C.

- *Precharge Temp* = PC (°C) / 0.1

The bq2084-V143 also sets *ChargingCurrent()* to the precharge rate if *Voltage()* is less than the value programmed in *Precharge Voltage* DF 0x3c-0x3d. *Precharge Voltage* is programmed in mV.

Alarm Broadcasts to Smart Charger and Host

If any of the bits 8-15 in *BatteryStatus()* are set, the bq2084-V143 broadcasts an *AlarmWarning()* message to the Host address. If any of the bits 12-15 in *BatteryStatus()* are set, the bq2084-V143 also sends an *AlarmWarning()* message to the Smart Charger address. The bq2084-V143 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-V143 sets ChargingCurrent() to the precharge rate as programmed in *Precharge Current* DF 0x42-0x43 under the following conditions:

- Voltage: The bq2084-V143 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-V143 requests the precharge rate when Temperature() is between *Charge Inhibit Temp Low* (DF0x46) and the precharge threshold programmed in *Precharge Temp* 0x44. *Temperature( )* must be equal to or greater than the precharge threshold + 3°C to allow the fast-charge rate.

Charge Suspension

The bq2084-V143 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-V143 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-V143 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-V143 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* in DF 0x79 or *Charge Inhibit Temp Low* in DF 0x46. On detecting an undertemperature condition the bq2084-V143 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 *Max Charging Time* in DF 0x10f-0x110. If charging time reaches DF: *Max Charge Time*, the Charge FET is turned off. This condition is cleared when the pack detects discharge current or is removed. In version bq2084-V143 setting *Max Charge Time* to 0 will disable this feature. Also in version bq2084-V143, setting Bit 7 (0x80) of *DF:MiscConfig2* will suspend the Charge Timer when the SBS. Current < *DF:Chg Detection* threshold.

When charging begins on a depleted battery pack, the voltage is below *Voff*, and may even stay below *Von* for some time. This means the pack is under constant charge, with no pulsing, for some part of the charge cycle. As the voltage on the cells rises, it crosses the *Voff* threshold (or the *Vmax* threshold if *Voff* is disabled), and the charge FET turns off. Initially, the off time is short, because the cells are only barely over the threshold and is quickly relaxed to below *Von*. As the cell voltages rises,

Primary Charge Termination

Cell Balancing

DISPLAY PORT

General

The display port drives a 3-, 4-, or 5-LED bar-graph display. The display is activated by a logic signal on the DISP input. The bq2084-V143 can display RM in either a relative or absolute mode with each LED representing a percentage of the full-battery reference. In relative mode 616.4 m 131 4 -10 Tf (ea/F4 -10 Tf (mo 1 0 0 0 g ET 131 721.8

Activation

Display Modes

Table 9. Display Mode for Three LEDs (continued)

CONDITION RELATIVE OR ABSOLUTE	THREE-LED DISPLAY OPTION		
StateOfCharge()			

LI-ION PROTECTION

Protection Configuration

The AFE protection features can also recover automatically after *AFE Recovery Time* (DF 0x160) if the AFE Recovery Time is set to a nonzero value. When the protection feature is recovered in this manner, it does not re-trigger for *AFE Hold Off Time* (DF 0x161).

AFE Integrity Check

The bq2084-V143 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-V143 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-V143 increments an internal counter until it reaches the *AFE Fail Limit* (DF 0xe4). Setting *AFE Check Time* to 0 disables this function.

When the internal AFE Fail counter reaches *AFE Fail Limit*, then the AFE bit in PF Status is set.

AFE Watchdog Fault and Clear

The bq29312 has a feature where the 32-kHz output (CLKOUT, pin 35) of the bq2084-V143 is used to drive its internal clock. If this clock fails, a fault is declared in the AFE. See the bq29312 data sheet for further details.

The fault is cleared automatically on return of the 32-kHz input via the bq2084-V143 CLKOUT pin.

Permanent Failure Mode ($\overline{\text{SAFE}}$ Output)

The $\overline{\text{SAFE}}$ output of the bq2084-V143 provides an additional level of safety control. The active low safety output can blow a fuse or control another switch on the basis of temperature, pack-voltage cell-voltage, CHG FET Failure, severe cell imbalance, or an integrity check of the AFE and Data Flash configuration registers.

The bq2084-V143 can also activate the $\overline{\text{SAFE}}$ output and set the PF Flag based on the $\overline{\text{PFIN}}$ input. If this pin is low for *PFIN Time* seconds ±1 s, then the $\overline{\text{PFIN}}$ bit in PF Status is set.

The $\overline{\text{SAFE}}$ output can be driven low in any of the following conditions, and the bq2084-V143 sets the *PF Flag* register (DF 0x11e) to 0x66 (011001100). The activation ofbq2084 /F4 -170 0 1 313.34 39210 13.34 1 313m 0 g ET 56.6 7 3

Permanent Failure Status (PF Status)

SOV

The SOV bit indicates a safety overvoltage occurred which if enabled by PF Config would cause the $\overline{\text{SAFE}}$ output to activate.

0 SOV fault not detected (default)

1 SOV fault detected

SOTC

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

0 SOTC fault not detected (default)

1 SOTC fault detected

SOTD

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

0 SOTD fault not 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 $\overline{\text{SAFE}}$ output to activate.

0 AFE is operating correctly (default)

1 AFE Integrity check fail limit reached

CIM

The CIM bit indicates that a severe cell imbalance occurred during charging, which if enabled by PF Config, would cause the $\overline{\text{SAFE}}$ output to activate.

0 All cells are within the *Cell Imbalance Threshold* (default)

1 There is a severe cell imbalance

FETF

The FETF bit indicates a FET or FET driver failure occurred, which if enabled by PF Config would cause the $\overline{\text{SAFE}}$ output to activate.

0 The FETs are operating normally (default)

1 The FETs or FET drivers have a fault

PFIN

The PFIN bit is used to indicate that the output of the 2nd level protector has activated.

0 The PFIN input is high (default)

1 The PFIN input drive and held low by 2nd level protector output

FPP

The FPP bit is used to indicate that current has been detected when the fuse has been set to be blown.

0 Current not detected with fuse blown

1 Current detected with fuse blown

Permanent Failure Configuration (PF Config)

PF Config DF 0x11f contains the enable/disable configuration that determines if the $\overline{\text{SAFE}}$ output is activated and the PF Flag set for each possible failure mode.

b7	b6	b5	b4	b3	b2	b1	b0
-	XPFIN	XFETF	XCIM	XAFE	XSOTD	XSOTC	XSOV

XSOV

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

0 Activation disabled (default)

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-V143 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.

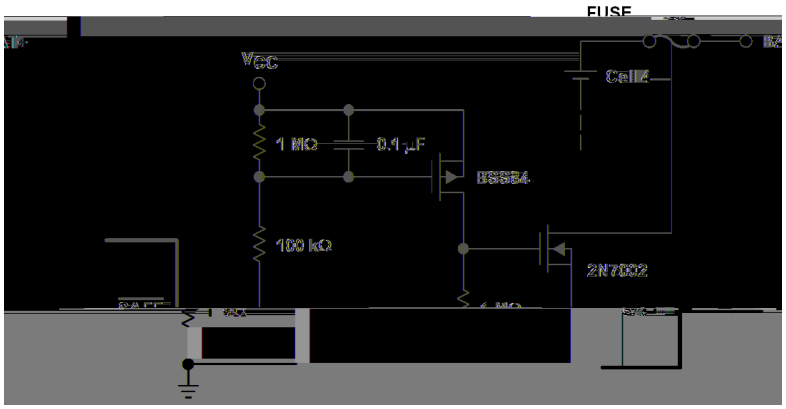


Figure 2. Example $\overline{\text{SAFE}}$ Circuit Implementation

Low-Power Modes

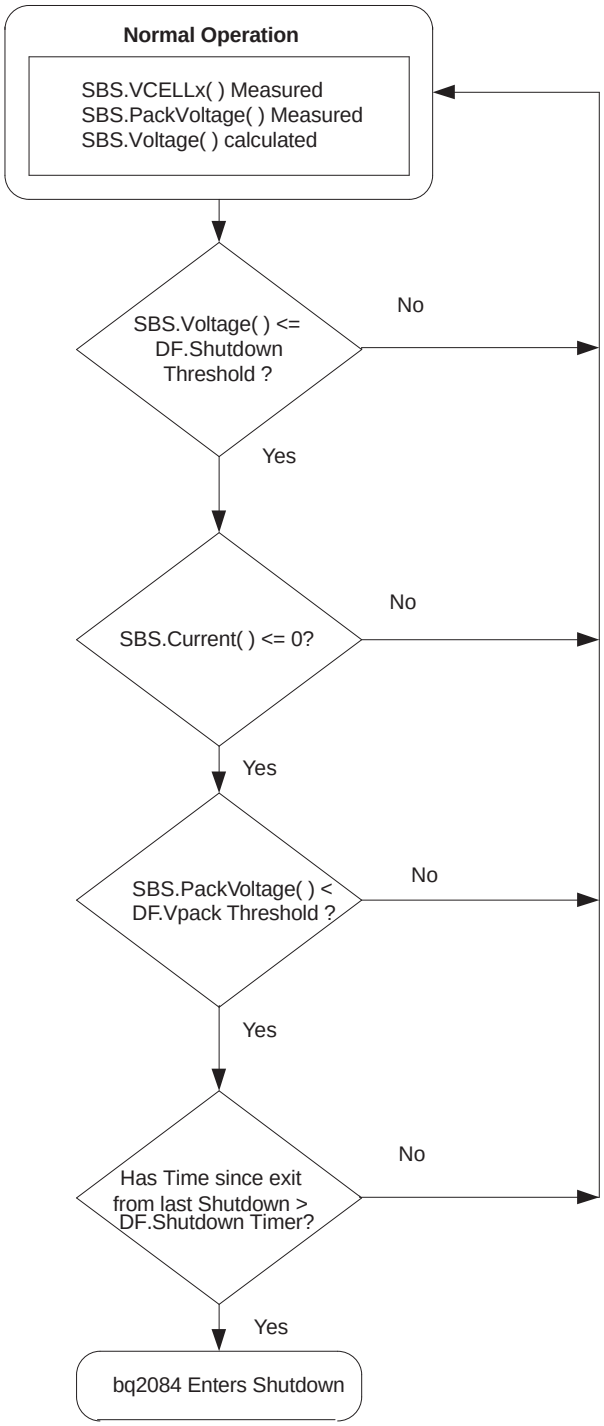
The bq2084-V143 enters sleep mode when the charge and discharge current is less than the threshold programmed in *Sleep Current Threshold* DF 0xfc, the SMBus lines are low for at least 2s, and bit 12 of *Misc. Configuration* DF 0x2a is set to zero. Additionally, PRES must be pulled high if the NR bit in Misc Config is set to 0. The bq2084-V143 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-V143 wakes up at a period set by *Sleep Current Multiplier* DF 0xfd multiplied by *Sleep Time* to measure current. The bq2084-V143 comes out of sleep when either of the SMBus lines go high or when the current is measured

Shutdown Mode

Vpack is programmed in units of 0.935 mV/count and has tolerance of ±6%. For example, to set 12 V as Vpack Threshold, the program value should be 12000/0.935 = 12834.

When the DSG FET is turned on, the pack voltage is close to the battery voltage even with no charger attached. Therefore, to enter shutdown, the Vpack threshold should be set higher than the shutdown threshold plus the tolerance.

The bq2084-V143 can also be instructed to enter Shutdown mode via the *ManufacturerAccess()* command. When the command is sent to the bq2084-V143, the bq29312 is instructed to enter shutdown ccess()enter



DEFAULTS:

Non-Removable Pack

DF.ShutdownVoltage = 2.8 V x Number of Series cells; DF.ShutdownTimer = 2 s

NOTE: VpackThreshold must be greater than Shutdown voltage + 6%.

Removable Pack

DF.ShutdownVoltage = 2.8 V x Number of Series cells; DF.ShutdownTimer = 20 s

NOTE: VpackThreshold must be greater than Shutdown voltage + 6%.

Figure 3. Shutdown Flow Chart in Normal Operation

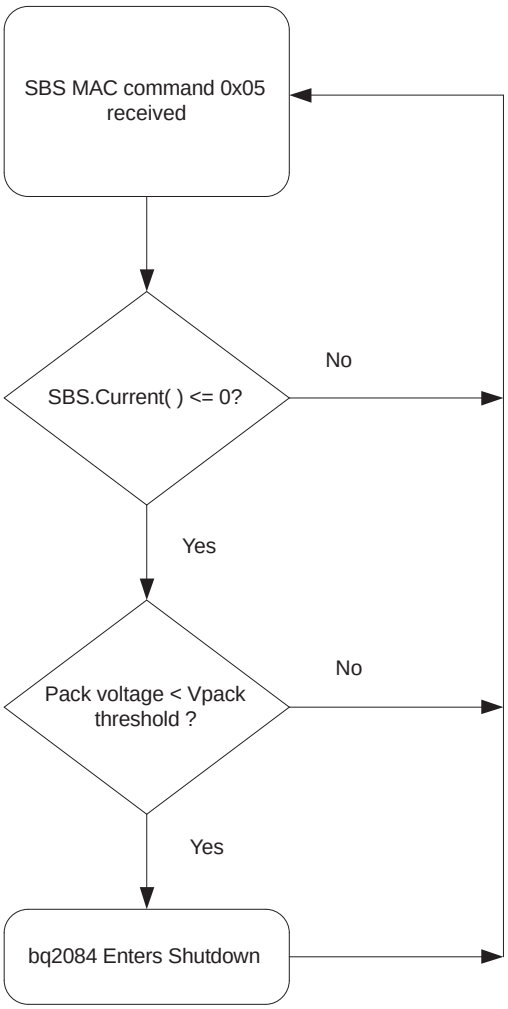


Figure 4. Shutdown Flow Chart in SBS MAC

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 soo.3 92.8 Tm /F(so97.26 C/F4 -10 Tf (Io97.26 C/F4 -10 Tf (13(so97.26 C/F4 -10 Tf (Io97.26 C/F4 e 92.

COMMUNICATION

SMBus

The SMBus interface is a command-based protocol. A processor acting as the bus master initiates communication to the bq2084-V143 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-V143 device address of 0001011

SMBus Protocol

SMBus Packet Error Checking

PEC Protocol

Gas Gauge

Figure 5. SMBus Communication Protocol Without PEC

Figure 6. SMBus Communication Protocol With PEC

PEC Calculation

The basis of the PEC calculation is an 8-bit cyclic redundancy check (CRC-8) based on the polynomial C(X) = X8 + X2 + X1 + 1. The PEC calculation includes all bytes in the transmission, including address, command, and data. The PEC calculation does not include ACKNOWLEDGE, NOT ACKNOWLEDGE, start, stop, and repeated start bits.

For example, the host requests RemainingCapacity() from the bq2084-V143. This includes the host following the read word protocol. The bq2084-V143 calculates the PEC based on the following 5 bytes of data, assuming the remaining capacity of the battery is 1001 mAh.

- Battery Address with R/W = 0: 0x16
- Command Code for RemainingCapacity(): 0x0f
- Battery Address with R/W = 1: 0x173ytes

PEC Enable in Master Mode

SMBus On- and Off-State

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-V143 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-V143 to instruct the bq29312 to enter ship mode
0x062b	Seal	Instructs the bq2084-V143 to restrict access to those functions listed in Table 3. The bq2084-V143 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-V143 functions that are not defined by the SBD.

SMBus protocol: Read or write word

Input/Output: Word

RemainingTimeAlarm() (0x02)

Description: Sets or gets the *Remaining Time Alarm* value. Whenever the *AverageTimeToEmpty()* falls below the remaining time value, the bq2084-V143 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-V143 initially sets the remaining time value to the *Remaining Time Alarm* value programmed in DF 0x00-0x01. 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-V143 *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 defined request condition is the battery requesting a conditioning cycle (*RELEARN_FLAG*).

Purpose: The *CAPACITY_MODE* bit allows power management systems to best match their electrical characteristics with those reported by the battery. For example, a switching power supply represents a constant power load, whereas a linear supply is better represented by a constant current model. The *CHARGER_MOD*E bit allows a SMBus host or smart battery charger to override the smart battery desired charging parameters by disabling the bq2084-V143 broadcasts. The *RELEARN_FLAG* bit allows the bq2084-V143 to request a conditioning cycle.

SMBus protocol: Read or write word

Input/Output: Unsigned integer—bit mapped—see Table 14.

Units: Not applicable

Range: 0-1

Granularity: Not applicable

Accuracy: Not applicable

The

PRIMARY_BATTERY bit is not used by the bq2084-V143. The bq2084-V143 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	Read only bit flag	0 - always zero
Reserved	2-6		0 - always zero
RELEARN_FLAG	7	Read only bit flag	0—Battery OK1—Relearn cycle requested
CHARGE_CONTROLLER_ENABLED	8	R/W bit flag	Not used
PRIMARY_BATTERY	9	R/W bit flag	Not used
Reserved	10-12		0 - always zero
ALARM_MODE	13	R/W bit flag	0—Enable alarm broadcast (default)1—Disable alarm broadcast
CHARGER_MODE	14	R/W bit flag	0—Enable charging broadcast (default)1—Disable charging broadcast
CAPACITY_MODE	15	R/W bit flag	0—Report in mA or mAh (default)1—Report in 10 mW or 10 mWh

ALARM_MODE bit is set to disable the bq2084-V143s ability to master the SMBus and send *AlarmWarning()* messages to the SMBus host and the smart battery charger. When set, the bq2084-V143 does *not* master the SMBus, and *AlarmWarning()* messages are not sent to the SMBus host and the smart battery charger for a period of no more than 60s and no less than 59s. When cleared (default), the smart battery sends the *AlarmWarning()* messages to the SMBus host and the smart battery charger any time an alarm condition is detected.

- The ALARM broadcast does not occur more often than once every 10 s. Whenever the BATTERY_MODE command is received, the bq2084-V143 resets the bit and starts or restarts a 60-s (nominal) timer. After the timer expires, the bq2084-V143 automatically enables alarm broadcasts to ensure that the accidental deactivation of broadcasts does not persist. An SMBus host that does not want the bq2084-V143 to be a master on the SMBus must therefore continually set this bit at least once per 59 s to keep the bq2084-V143 from broadcasting alarms.
- The *ALARM_MODE* bit defaults to a cleared state when the bq2084-V143 enters SLEEP mode.
- The condition of the *ALARM-MODE* bit does *not* affect the operation or state of the *CHARGER_MODE* bit, which is used to prevent broadcasts of *ChargingCurrent()* and *ChargingVoltage()* to the smart battery charger. *CHARGER_MODE* bit enables or disables the bq2084-V143's transmission of *ChargingCurrent()* and *ChargingVoltage()* messages to the smart battery charger. When set, the bq2084-V143 does *not* transmit *ChargingCurrent()* and *ChargingVoltage()* values to the smart battery charger. When cleared, the bq2084-V143 transmits the *ChargingCurrent()* and *ChargingVoltage()* values to the smart battery charger. The *CHARGER_MODE* bit defaults to a cleared state when the bq2084-V143 enters SLEEP mode.

CAPACITY_MODE bit indicates if capacity information is reported in mA/mAh or 10 mW/10 mWh. When set, the bq2084-V143 reports capacity information in 10 mW/10 mWh as appropriate. When cleared, the bq2084-V143 reports capacity information in mA/mAh as appropriate. The CAPACITY_MODE bit defaults to a cleared state when the bq2084-V143 enters SLEEP mode.

The following functions are changed to accept or return values in mA/mAh or 10 mW/10 mWh depending on the *CAPACITY_MODE* bit:

- *RemainingCapacityAlarm()*
- *AtRate()*
- *RemainingCapacity()*
- *FullChargeCapacity()*
- *DesignCapacity()*

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-V143 updates the non-AtRate related register values

AtRate() (0x04)

	relof 1 56.6 84.2 T4.09 Tm /F4 -10 Tf (the)Tj	

AtRateTimeToFull() (0x05)

AtRateTimeToEmpty() (0x06)

AtRateOK() (0x07)

Temperature() (0x08)

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

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-V143 sets *MaxError()* to 100% on a full reset. The bq2084-V143 sets *MaxError()* to 2% on completion of a learning cycle, unless the bq2084-V143 limits the learning cycle to the +512/-256 mAh maximum adjustment values. If the learning cycle is limited, the bq2084-V143 sets MaxError() to 8% unless *MaxError()* was already below 8%. In this case, *MaxError()* does not change. The bq2084-V143 increments *MaxError( )*

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 that *AbsoluteStateOfCharge()* can return values greater than 100%.

Purpose: The *AbsoluteStateOfCharge()* function is used to estimate the amount of charge remaining in the battery relative to the nominal or *DesignCapacity()*.

SMBus protocol: Read word

Output: Unsigned integer—percent of remaining capacity.

Units: %

Range: 0-100+%

Granularity: 1%

Accuracy: -0, +MaxError()

RemainingCapacity() (0x0f)

Description: Returns the predicted charge or energy remaining in the battery. The *RemainingCapacity()* value is expressed in either charge or energy, depending on the setting of the *BatteryMode() CAPACITY_MODE* bit.

Purpose: The *RemainingCapacity()* function returns the battery's remaining capacity. This information is a numeric indication of remaining charge or energy given by the *AbsoluteStateOfCharge()* or *RelativeStateOfCharge()* functions and may be in a better form for use by power management systems.

SMBus protocol: Read word

Output: Unsigned integer—remaining charge in units of mAh or 10 mWh.

	BATTERY MODES	
	CAPACITY_MODE BIT = 0	CAPACITY_MODE BIT = 1
Units	mAh	10 mWh
Range	0-65,535 mAh	0-65,535 10 mWh
Granularity	mAh	10 mWh
Accuracy	-0, +MaxError() *	FullCharageCapacity()

FullChargeCapacity() (0x10)

Description: Returns the predicted pack capacity when it is fully charged. The *FullChargeCapacity()* value is expressed in either current (mAh at a C/5 discharge rate) or power (10 mWh at a P/5 discharge rate) depending on the setting of the *BatteryMode()CAPACITY_MODE* bit.

6 431.2

Purpose: The *FullChargeCapacity()* [illegible] of the battery. This information, along with information about the original capacity of the battery, indicates battery wear.

SMBus protocol: Read word

Output: Unsigned integer—estimated full-charge capacity in units of mAh or 10 mWh.

	BATTERY MODES	
	CAPACITY_MODE BIT = 0	CAPACITY_MODE BIT = 1
Units	mAh	10 mWh
Range	0-65,535 mAh	0-65,535 10 mWh
Granularity	mAh	10 mWh
Accuracy	-0, +MaxError() × FullCharageCapacity()	

RunTimeToEmpty() (0x11)

Description: Returns the predicted remaining battery life at the present rate of discharge (minutes). The*RunTimeToEmpty()* value is calculated based on either current or power depending on the setting of the *BatteryMode() CAPACITY_MODE* bit.

Purpose: The of

AverageTimeToEmpty() (0x12)

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)

Description: Returns the desired charging rate in mA.

Purpose: The *ChargingCurrent()* function sets the maximum charge current of the battery. *TheChargingCurrent()* value should be used in combination with the *ChargingVoltage()* value to set the charger's operating point. Together, these functions permit the bq2084-V143 to dynamically control the charging profile (current/voltage) of the battery. The bq2084-V143 can effectively turn off a charger by returning a value of 0 for this function. The charger may be operated as a constant-voltage source above its maximum regulated current range by returning a *ChargingCurrent()* value of 65,535.

SMBus protocol: Read word

Output: Unsigned integer—maximum charger output current in mA.

Units: mA

Range: 0 to 65,535 mA

Granularity: 1 mA

Accuracy: Not applicable

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

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-V143 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-V143 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 by the power management system to get alarm and status bits, as well as error codes from the bq2084-V143. This is basically the same information broadcast to both the SMBus host and the smart battery charger by the *AlarmWarning()* function except that thethethethet4.2 Tm /F4 7.9rtteg

SMBus protocol: Read word**Output:**UnsignedInteger-statusregisterwithalarmcondi 274sbit-mappedasfollows:

ALARM BITS0x8000OVER_CHARGED_ALARM	
0x4000	TERMINATE_CHARGE_ALARM
0x2000	Reserved
0x1000	OVER_TEMP_ALARM0x0800TERMINATE_DISCHARGE_ALARM
0x0400	Reserved
0x0200	REMAINING_CAPACITY_ALARM
0x0100	REMAINING_TIME_ALARM
STATUS BITS0x0080Ini 2alized0x0040DISCHARGING	
0x0020	FULLY_CHARGED
0x0010	FULLY_DISCHARGED
ERROR CODES0x0007UnknownError0x0006BadSize	
0x0005	Overflow/Underflow
0x0004	AccessDenied0x0003UnsupportedCommand0x0002ReservedCommand
0x0001	Busy
0x0000	OK

theOVER_CHARGED_ALARMthe1 0 0 1 56.6 671f (the1 0 0 1 185.7 671f (the)T4 -10 Tf (bit)Tj 1 0 0 1 201.464671f (the)T4

ALARM BITS

DF 0x51-0x52. This bit
is cleared when the bq2084-V143 detects that the battery is no longer being charged and there are 2 mAh ofcontinuousd

TERMINATE_CHARGE_ALARM bit is set when the bq2084-V143 detects a primary charge termination. This bit is cleared when the bq2084-V143 detects that the battery is no longer being charged.

OVER_TEMP_ALARM bit is set when the bq2084-V143 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 appropriate.

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-V143 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-V143 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-V143 has detected a valid load of data flash at full or partial reset. It is cleared when the bq2084-V143 detects an improper data flash load.

DISCHARGING bit is set when the bq2084-V143 determines that the battery is not being charged. This bit is cleared when the bq2084-V143 detects that the battery is being charged.

FULLY_CHARGED bit is set when the bq2084-V143 detects a primary charge termination or an Overcharge condition. It is cleared when RelativeStateOfCharge() is less than the programmed *Fully Charged Clear %* in DF 0x4a.

FULLY_DISCHARGED bit is set when *Voltage()* or *VCELL* is less than the EDV2 threshold and *Current()* < *Overload Current* or when *RelativeStateOfCharge()* < *Battery Low %*. This bit is cleared when *RelativeStateOfCharge()* is greater than or equal to 20%.

ERROR CODES

ERROR CODES	DESCRIPTION
OK	The bq2084-V143 processed the function code without detecting any errors.
Busy	The bq2084-V143 is unable to process the function code at this time.
Reserved	The bq2084-V143 detected an attempt to read or write to a function code reserved by this version of the specification. The bq2084-V143 detected an attempt to access an unsupported optional manufacturer function code.
Unsupported	The bq2084-V143 does not d275.71 452.2 Tm /F4 561.6 Tm /F4 -8 Tf (d275.7178t)Tj 1 0 0 1 23 1 0 Tm / 1 484.7759 548.4 Tm // 1 48

CycleCount()(0x17)

Output: Unsigned integer—count of total charge removed from the battery over its life.

Units: cycle

Range: 0 to 65,534 cycles; 65,535 indicates battery has experienced 65,535 or more cycles.

Granularity: 1 cycle

Accuracy: batteryba (ct Tfharge)Tj 1 0 054 .8 93 101.2 T 0 1 214.1more**(0x18)**

DesignCapacity() (0x18)

DesignVoltage() (0x19)

SpecificationInfo() (0x a)

MreDatSerialNumber1 147.38 155.8 Tm 0 28-334 1 2760 Tz -10 TL 0 0 1c147.38 155.8 T/F6 -468 1 2760 T			

ManufactureDate() (0x1b)

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-V143 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-V143

The ManufacturerData() (0x23)

Pack Status and Pack Configuration (0x2f)

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-V143.

0 The bq2084-V143 is in the unsealed state.

1 The bq2084-V143 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-V143 *PF Flag* has been set. It is cleared only when the *PF Flag* has been cleared.

0 bq2084-V143 *PF Flag* = 0x00

1 bq2084-V143 *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

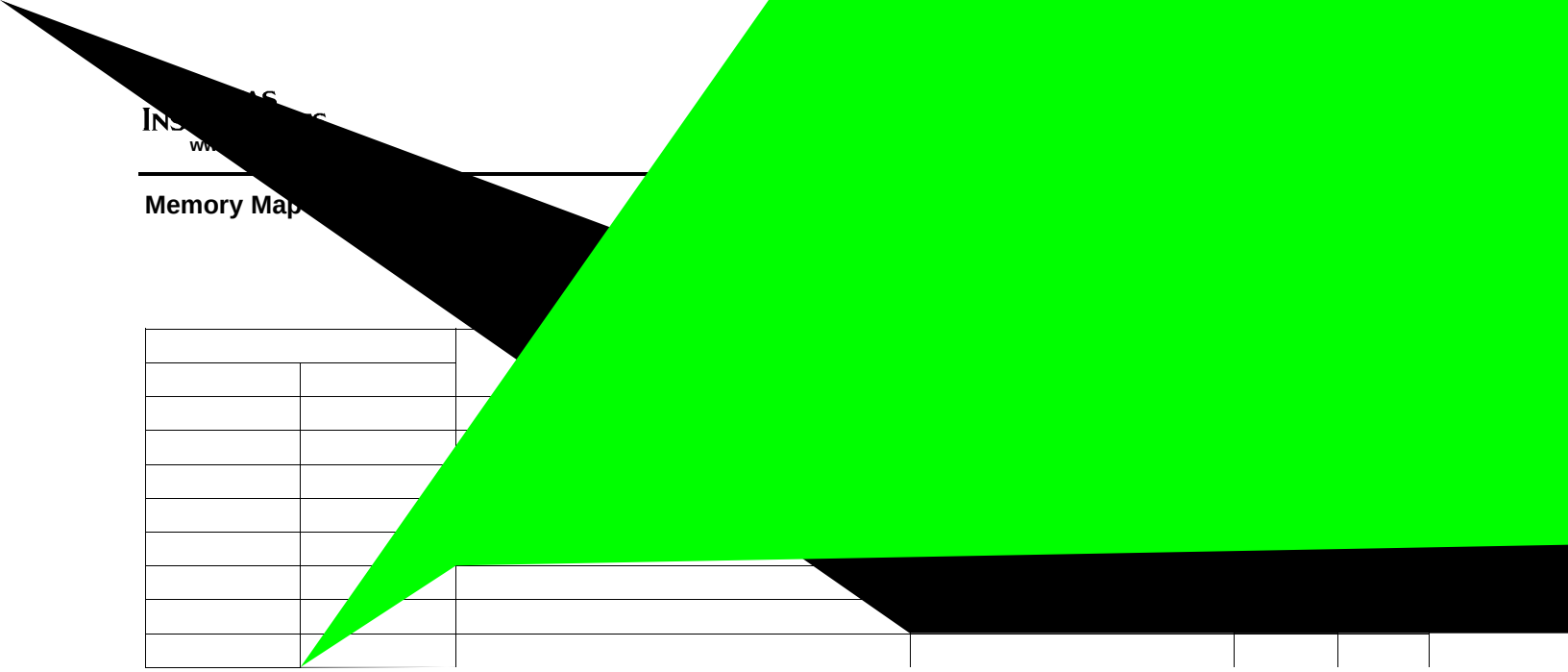
CVUV

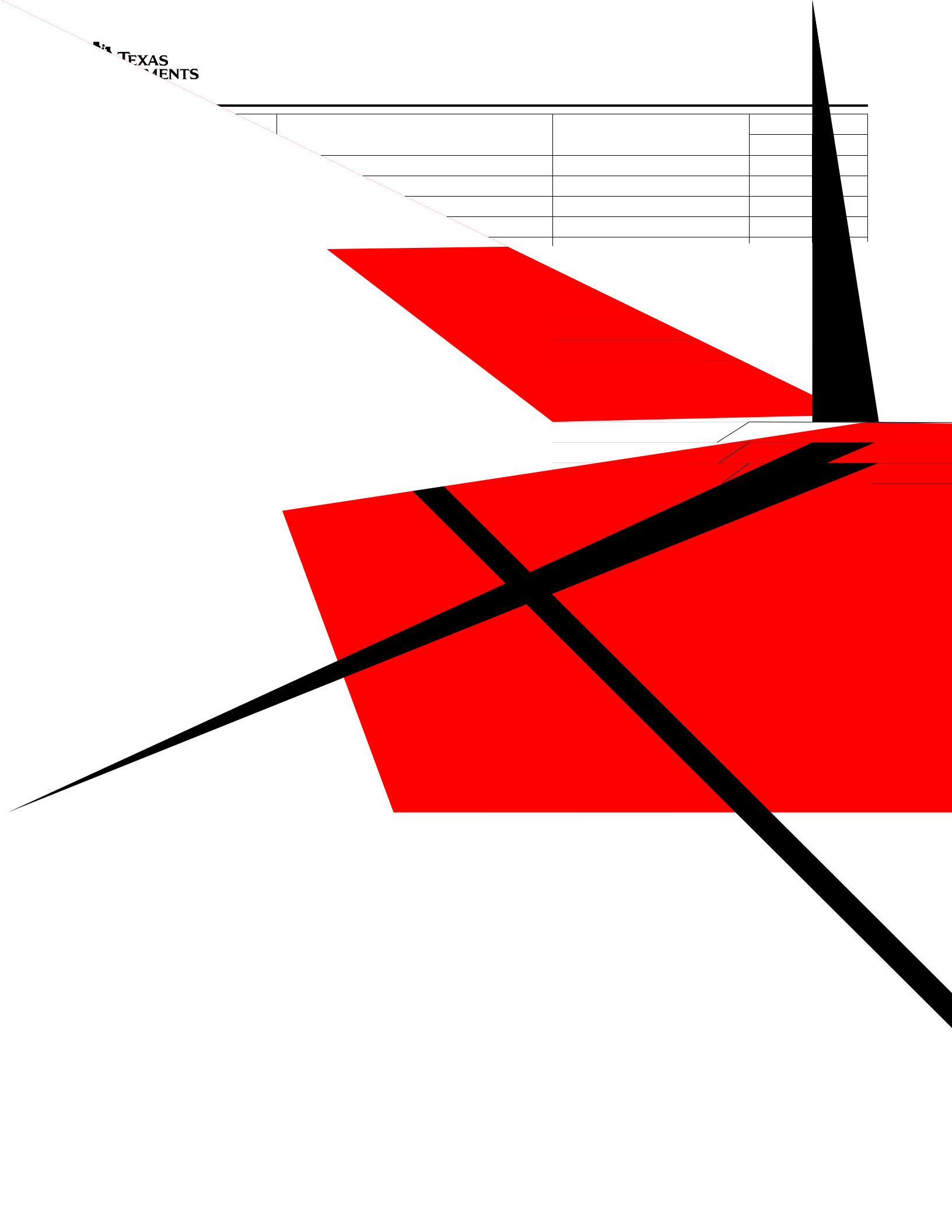
The CVUV bit indicates that a protection limit has been exceeded including overload or overdischarge conditions. The bit is not latched and merely reflects the 9condary

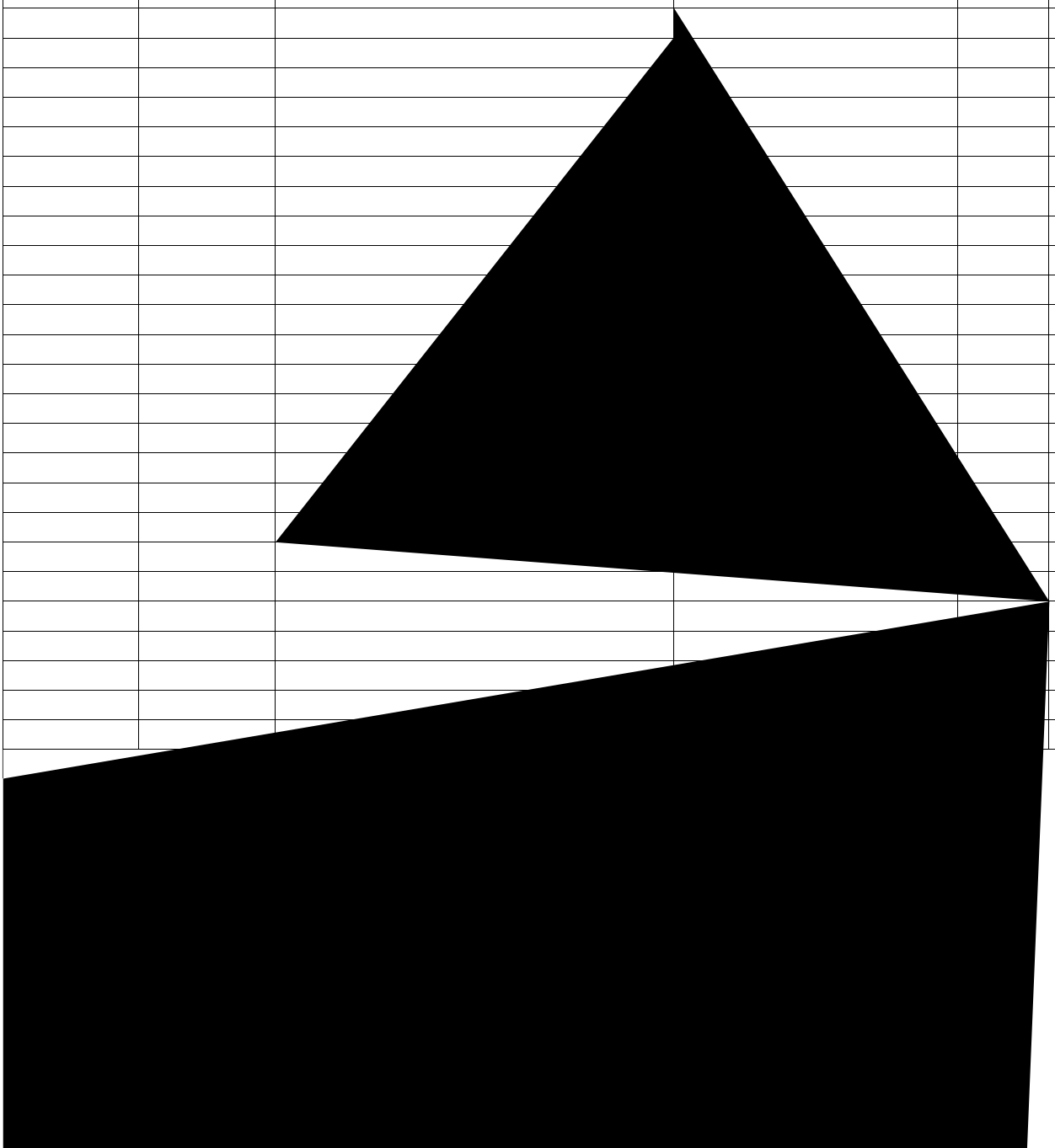
VCELL4-VCELL1 (0x3c-0x3f)

DATA FLASH

General







DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x10b	0x10c	*Pulse Max On Time*	60 s	01	e0
0x10d	0x10e	*Pulse Min Off Time*	0.125 s	00	01
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
0x130		*Fault Reset Time*	30 s		1e
0x131	0x132	*VPACK Threshold*		07	d0
0x133		*Shutdown Timer*	20 s		14
0x134		*Cell Imbalance Time*	20 s		14
0x135	0x136	Reserved			
0x137	0x138	EDV0	3000mV	0b	b8
0x139		*Misc Configuration 2*			00
0x13a	13b	Reserved		ff	ff
0x13c	13d	Reserved		ff	ff
0x13e	13f	Reserved		ff	ff
0x140		*Aux Device Name Length*	0 bytes		00
0x141	0x14f	*Aux Device Name*		00	00
0x150		*Aux Manufacturer Name Length*	0 bytes		00
0x151	0x15f	*Aux Manufacturer Name*		00	00
0x160		*AFE Recovery*	3s		03
0x161		*AFE Holdoff*	30s		1e
0x162		*Over Temperature Time*	10s		0a
0x163	0x164	Reserved		00	0a
0x165		Reserved			0a
0x168		Max 32K Reinit	3		03

ADDITIONAL PROGRAMMING INFORMATION

ADDITIONAL DATA FLASH PROGRAMMING

The following sections describe the function of each data flash location and how the data is to be stored.

Fundamental Parameters

Sense Resistor Value

The 32-bit *CC Delta* DF 0xcd-0xd0 corrects the coulomb counter for sense resistor variations. It represents the gain factor for the coulomb counter. The 16-bit *Sense Resistor Gain* in DF 0xcb-0xcc scales each integrating converter conversion to mAh. The Current() related measurement *Sense Resistor Gain* is based on the resistance of the series sense resistor. The following formula computes a nominal or starting value for *Sense Resistor Gain* from the sense resistor value (in Ω).

Sense Resistor Gain = 306.25/Rs

CELL AND PACK CHARACTERISTICS

Battery Pack Capacity and Voltage

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 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-V143 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

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-V143 for five LEDs

0-1 Configures the bq2084-V143 for three LEDs

1-0 Configures the bq2084-V143 for four LEDs

1-1 Configures the bq2084-V143 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-V143.

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-V143 for the number of series cells in the battery pack.

1-1 Configures the bq2084-V143 for four series cells

1-0 Configures the bq2084-V143 for three series cells

0-1 Configures the bq2084-V143 for two series cells

Gauge Configuration

Gauge Configuration DF 0x29 contains bit-programmable features:

b7	b6	b5	b4	b3	b2	b1	b0
FEDV0	CSYNC	SC	CEDV	EDVV	OVSEL	VCOR	OTVC

FEDV0

When this bit is set, the EDV0 voltage is fixed while the EDV1 and EDV2 are left as compensated values if CEDV is also set. When this bit is set, the compensated values of EDV1 and EDV2 are limited from going below EDV0.

0 EDV0 acted upon per CEDV bit setting

1 EDV0 fixed regardless of CEDV setting

CSYNC

In usual operation of the bq2084-V143, 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-V143 does not alter RM at the time of a valid charge termination.

1 The bq2084-V143 updates RM with a programmed percentage of FCC at a valid charger termination.

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-V143 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-V143 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the bq2084-V143 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 number of cells and then compared to the safety voltage.

VCOR

The VCOR bit enables the midrange voltage correction algorithm. When it is set, the bq2084-V143 compares the pack voltage to RM and may adjust RM according to the values programmed in VOC25, VOC50, and VOC75.

0 Continuous midrange corrections disabled

1 Continuous midrange corrections enabled

OTVC

The OTVC bit programs the bq2084-V143 to perform a midrange voltage one time after a device reset

0 One-time midrange correction disabled

1 One-time midrange correction enabled

Miscellaneous Configuration

Misc Configuration DF 0x2a (high) and 0x2b (low) contains additional bit programmable features.

Misc Configuration (high) DF 0x2a

b15	b14	b13	b12	b11	b10	b9	b8
IT	0	AFEDET	DS	OT	ECLED	1	VOD

IT

The IT bit configures the bq2084-V143 to use its internal temperature sensor. The DF constants 0xb5-0xc0 need to match the required thermistor on internal temperature sensor. See the Data Flash Settings for Internal or External Temperature Sensor Table.

0 bq2084-V143 requires an external thermistor.

1 bq2084-V143 uses its internal temperature sensor.

AFEDET

The AFEDET bit programs the bq2084-V143 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-V143 to enter sleep mode on SMBus inactivity.

0 bq2084-V143 enters sleep mode when the SMBus is low for 2 s.

1 bq2084-V143 does not enter sleep mode.

OT

The OT bit enables the bq2084-V143 to turn off the FETs when the bq2084-V143 detects an overtemperature condition.

1 bq2084-V143 turns the appropriate FET off under over temperature conditions

0 bq2084-V143 takes no FET action at all on over temperature conditions

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 (low) DF 0x2b

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

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 are off when there is a RemainingCapacityAlarm.

PFET1, PFET0

The PFETx bits define the precharge FET operation. See the bq29312 data sheet for more detail.

0,0 The bq29312 ZVCHG FET isFET

1 ManufacturerName( ) and DeviceName( ) strings are 26 and 22 characters respectively

NVCELL

When this bit is set, it forces SBS.VCELL1..4( ) to be accessible via alternative commands.

0 SBS.VCELL1..4( ) available via 0x3c-0x3f

1 SBS.VCELL1..4( ) available via 0x38-0x3b

CCDSG

When this bit is set, it forces SBS.ChargingCurrent( ) to be reported as 0 when SBS.BatteryStatus( ) DISCHARGING is also set.

0 SBS.ChargingCurrent( ) is not modified just because SBS.BatteryStatus( ) DISCHARGING is set.

1 SBS.ChargingCurrent( ) is set to 0 when SBS.BatteryStatus( ) DISCHARGING is set.

SOCL

When this bit is set, it limits both RSOC and ASOC to 99% until a valid charge termination is detected.

0 RSOC and ASOC are not limited.

1 RSOC and ASOC are limited to 99% until charge termination.

CVFC

When this bit is set, it causes SBS.ChargingVoltage( ) to be set to 0 when SBS.BatteryStatus( ) FC = 1.

0 SBS.ChargingVoltage( ) is not modified

1 SBS.ChargingVoltage( ) is set to 0 when FC = 1

DEPFET

When this bit is set, it enables the CHG FET to be turned on when in depleted mode and when the lowest cell voltage reading is greater than the precharge voltage threshold

0 No FET action taken

1 CHG FET turned on

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.

Safety OverTemperature Discharge

Safety OverTemperature Discharge DF 0x77-0x78 sets the temperature, in degrees C/10, above which, during discharging, the pack enters permanent failure, if the *XSOTD* bit in *Permanent Failure Configuration* is set.

Charge Detection Current

Charge Detection Current DF 0x113-0x114 sets the threshold in milliamperes for detecting charge current. This is a signed value and is positive. This threshold is used for detecting cross-conduction, and ensuring that charge termination is not improperly detected due to loss of charging current.

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-V143, is shut down to conserve power. All FETs are turned off by the AFE.

APPLICATION INFORMATION

Figure 7 shows a typical bq2084-V143-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-V143 operation.

APPLICATION INFORMATION (continued)

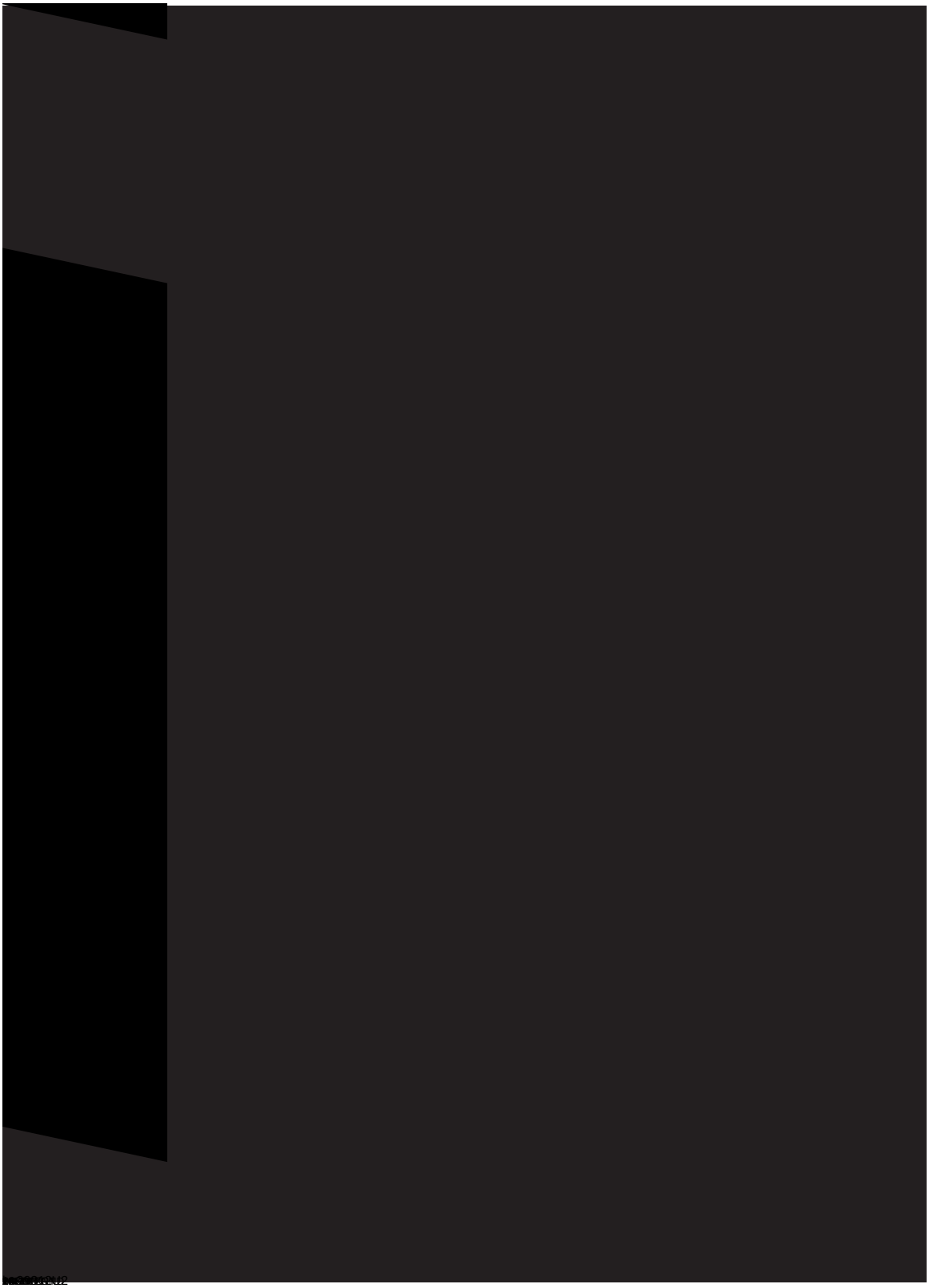


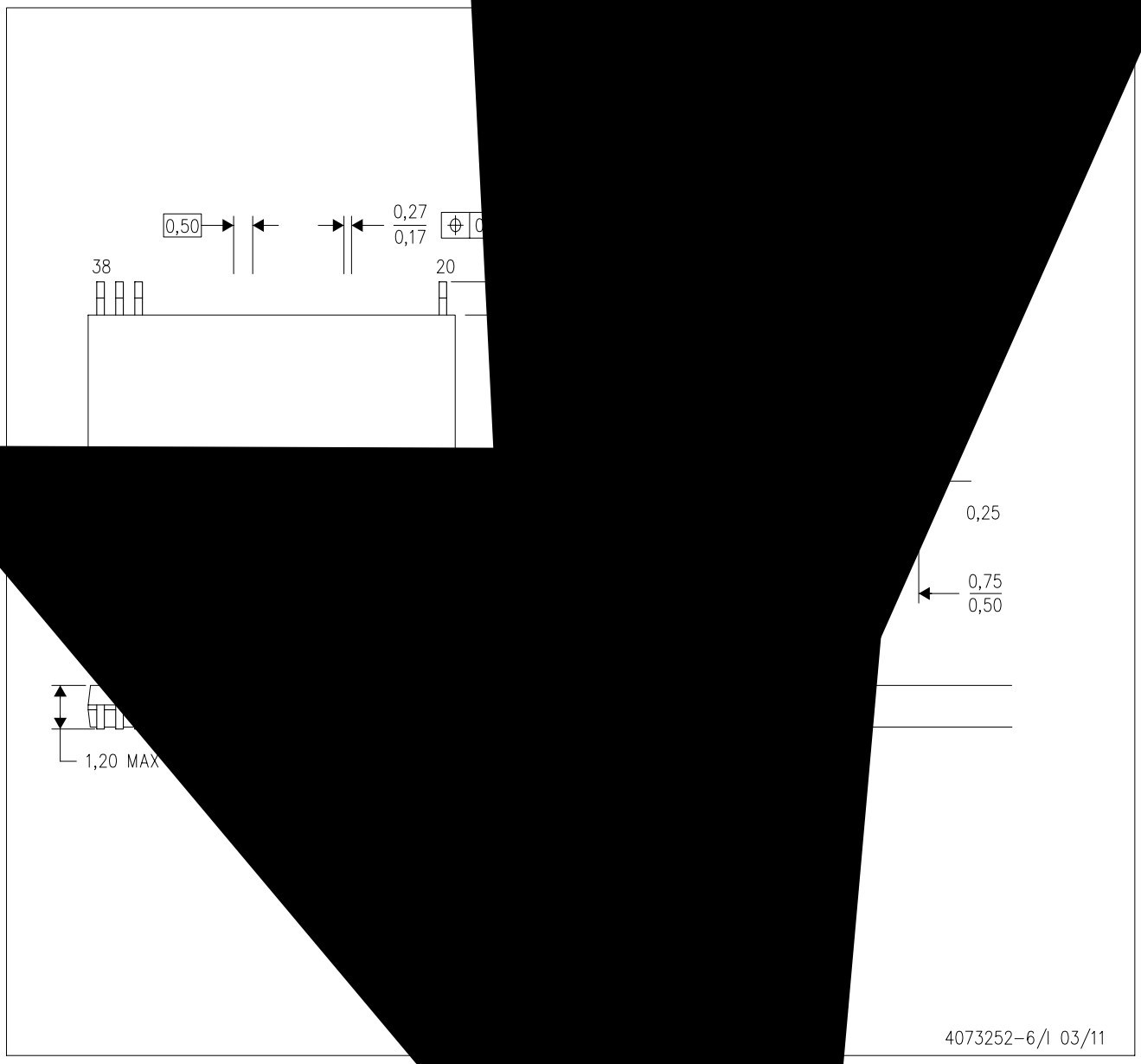
Figure 7. bq2084-V143 Based Battery Pack Schematic

PACKAGING INFORMATION

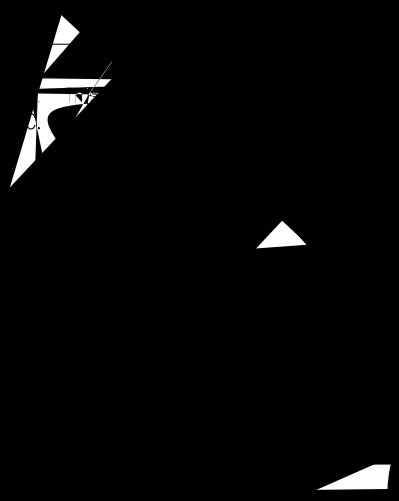
Orderable Device	Status (1)	Package Type	Package Drawing	Pins

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

DBT (R–PDSO–G38)



NOTES: A. All linear dimensions are in millimeters. –1994.
B. This drawing is subject to change with
C. Body dimensions do not include mold fla
D. Falls within JEDEC MO–153.



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