SBS-COMPLIANT GAS GAUGE IC FOR USE WITH THE bq29311

FEATURES

- **Provides Accurate Measurement of Available Charge in Li-Ion and Li-Polymer Batteries**
- **Supports the Smart Battery Specification (SBS) V1.1**
- **Works With the TI bq29311 Analog Front End (AFE) Protection IC to Provide Complete Pack Electronics for 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**
- **Measures Charge Flow Using a High Resolution 16-Bit Integrating Converter**
  - **Better Than 3-nVh of Resolution**
  - **Self-Calibrating**
  - **Offset Error Less Than 1-μV**
- **Uses 16-Bit Delta Sigma Converter for Accurate Voltage and Temperature Measurements**
- **Programmable Cell Modeling for Maximum Battery Fuel Gauge Accuracy**
- **Drives 3-, 4-, or 5-Segment LED Display for Remaining Capacity Indication**
- **38-Pin TSSOP (DBT)**

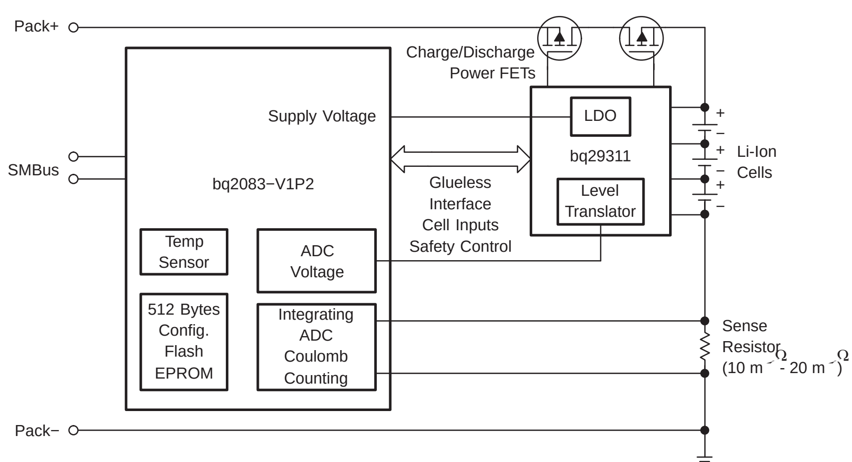
APPLICATIONS

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

DESCRIPTION

The bq2083−V1P2 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 bq2083−V1P2 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 bq29311 analog front-end (AFE) protection IC to maximize functionality and safety and minimize component count and cost in smart battery circuits. Using information from the bq2083−V1P2, the host controller can manage remaining battery power to extend the system run time as much as possible.

BLOCK DIAGRAM



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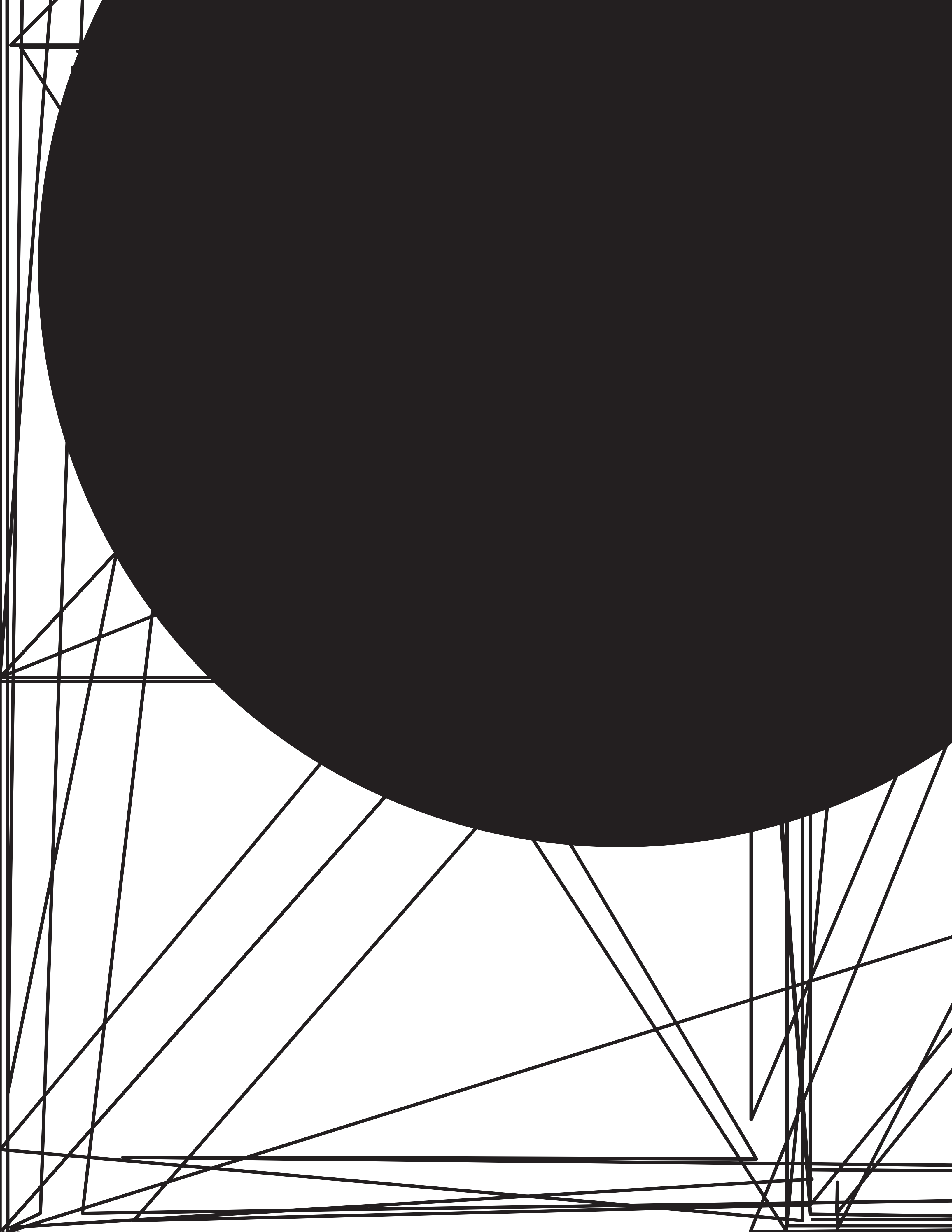


ABSOLUTE MAXIMUM RATINGS

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 6 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
ESDS Rating	HBM	1.5 kV
	CDM	1.5 kV
	MM	50 V
Operating free-air temperature range, T_A		−20°C to 85°C
Storage temperature range, T_{stg}		−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) VSS refers to the common node of $V_{(SSA)}$, $V_{(SSD)}$, and $V_{(SSP)}$.

ELECTRICAL CHARACTERISTICS

V_{DD} = 3.0 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	V_{DDA} and V_{DDD}	3.0	3.3	3.6	V
I_{DD0}	[illegible]					

POR BEHAVIOR
vs
FREE-AIR TEMPERATURE

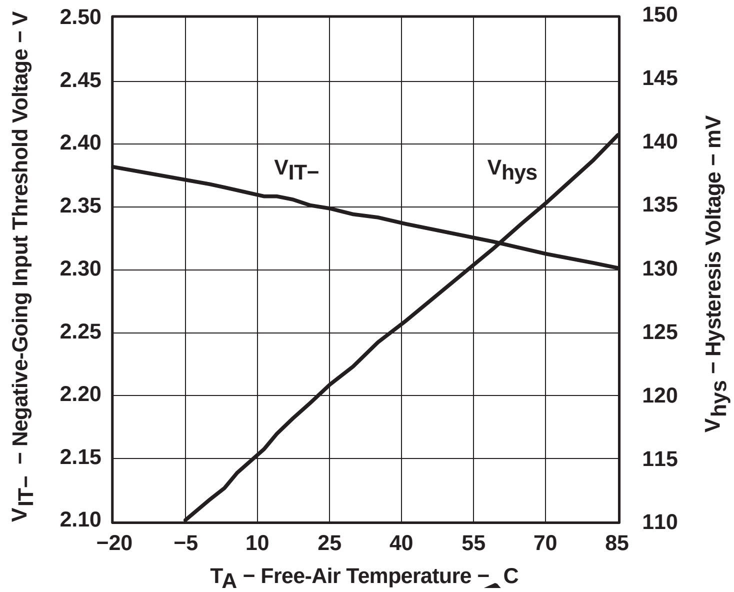


Figure 1

INTEGRATING ADC CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(SR)}$	Input voltage range, $V_{(SR2)}$ and $V_{(SR1)}$	$V_{SR} = V_{(SR2)} - V_{(SR1)}$	–0.3		1.0	V
$V_{(SROS)}$	Input offset			1		μV
INL	Integral nonlinearity error			0.003%	0.009%	

PLL SWITCHING CHARACTERISTICS

V_{DD} = 3.0 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 (see Note 1)	±0.5% frequency error		2	5	ms

(1) The frequency error is measured from 32.768 Hz.

External Oscillator

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(exo)}$	Frequency error (see Note 1)		−0.025%		0.025%	
		V_{DD} = 3.3 V	−1%		1%	
$f_{(sxo)}$	Start-up time (see Note 2)				275	μs

(1) The frequency error is measured from 32.768 Hz.
(2) The start-up time is defined as the time it takes for the oscillator output frequency to be ±1%.

[redacted]ING SPECIFICATIONS

[redacted]6 V, T_A = −20°C to 85°C (unless otherwise noted)

[redacted]	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
[redacted]	SMBus operating frequency	Slave mode, SMBC 50% duty cycle	10		100	kHz
[redacted]	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			

[redacted]

t [redacted]ING DIAGRA[redacted]PS

[redacted]

FUNCTIONAL DESCRIPTION

General Operation

The bq2083−V1P2 determines battery capacity by monitoring the amount of charge input or removed from a rechargeable battery. In addition to measuring charge and discharge, the bq2083−V1P2 measures battery voltage, temperature, and current, estimates battery self-discharge, and monitors the battery for low-voltage thresholds. The bq2083−V1P2 measures charge and discharge activity by monitoring the voltage across a small-value series sense resistor between the battery's negative terminal and the negative terminal of the battery pack. The available battery charge is determined by monitoring this voltage and correcting the measurement for environmental and operating conditions.

The bq2083−V1P2 interfaces with the bq29311 to perform battery protection, cell balancing and voltage translation functions.

The bq2083−V1P2 can accept any NTC thermistor (default is Semitec 103AT) for temperature measurement or can be configured to use its internal temperature sensor. The bq2083−V1P2 uses temperature to monitor the battery pack and to compensate the self-discharge estimate.

Measurements

The bq2083−V1P2 uses an integrating sigma-delta analog-to-digital converter (ADC) for current measurement and a second sigma delta ADC for battery voltage and temperature measurement. Voltage, current, and temperature measurements are made every second.

Charge and Discharge Counting

The integrating ADC measures the charge and discharge flow of the battery by monitoring a small-value sense resistor between the SR1 and SR2 pins as shown in the schematic. The integrating ADC measures bipolar signals from −0.3 to 1.0 V. The bq2083−V1P2 detects charge activity when $V_{SR} = V_{(SR1)}–V_{(SR2)}$ is positive and discharge activity when $V_{SR} = V_{(SR1)}–V_{(SR2)}$ is negative. The bq2083−V1P2 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 2.6 nVh. The bq2083−V1P2 updates Remaining Capacity() with the charge or discharge accumulated in this internal counter once every second.

Offset Calibration

The bq2083−V1P2 provides an autocalibration feature to cancel the voltage offset error across SR_1 and SR_2 for maximum charge measurement accuracy. The bq2083−V1P2 performs autocalibration when the SMBus lines stay low for a minimum of 20 s. The bq2083−V1P2 is capable of automatic offset calibration down to 1 μV.

Digital Filter

The bq2083−V1P2 does not measure charge or discharge counts below the digital filter threshold. The digital filter threshold is programmed in the *Digital Filter* DF 0x2b 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 bq2083−V1P2 monitors the individual series cell voltages through the bq29311. The bq2083−V1P2 configures the bq29311 to present the selected cell to the VCELL pin of the bq29311 which should be connected to VIN of the bq2083−V1P2. The internal ADC of the bq2083−V1P2 then measures the voltage and scales it appropriately. The bq2083−V1P2 then reports the Voltage( ) and the individual cell voltages in VCELL1, VCELL2, VCELL3, and VCELL4 located in 0x3c−0x3f.

Current

The bq2083−V1P2 uses the SR1 and SR2 inputs to measure and calculate the battery charge and discharge current as represented in the data register Current().

Temperature

The TS input of the bq2083−V1P2 in conjunction with an NTC thermistor measures the battery temperature as shown in the schematic. The bq2083−V1P2 reports temperature in Temperature( ).

The bq2083−V1P2 can also be configured to use its internal temperature sensor by setting the IT bit in *Misc Configuration* DF 0x2a. Data flash locations DF 0xa4 through DF 0xad also have to be changed to prescribed values if the internal temperature sensor option is selected.

Gas Gauge Operation

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

LABEL	LOCATION Dec (Hex)	INTERNAL TEMP SENSOR SETTING Dec (Hex)	EXTERNAL TEMP SENSOR SETTING Dec (Hex)
Misc. Config	42 (0x2a)	Bit 7 = 1	Bit 7 = 0
TS Const1 A3	164/5 (0xa4/5)	0 (0x0000)	−28285 (0x9183)
TS Const2 A2	166/7 (0xa6/7)	0 (0x0000)	20848 (0x5170)
TS Const3 A1	168/9 (0xa8/9)	−11136 (0xd480)	−7537 (0xe28f)
TS Const4 A0	170/1 (0xaa/b)	5734 (0x1666)	4012 (0x0fac)
Min Temp AD	172/3 (0xac/d)	0 (0x0000)	0 (0x000)
Max Temp	174/5 (0xae/f)	5734 (0x1666)	4012 (0x0fac)

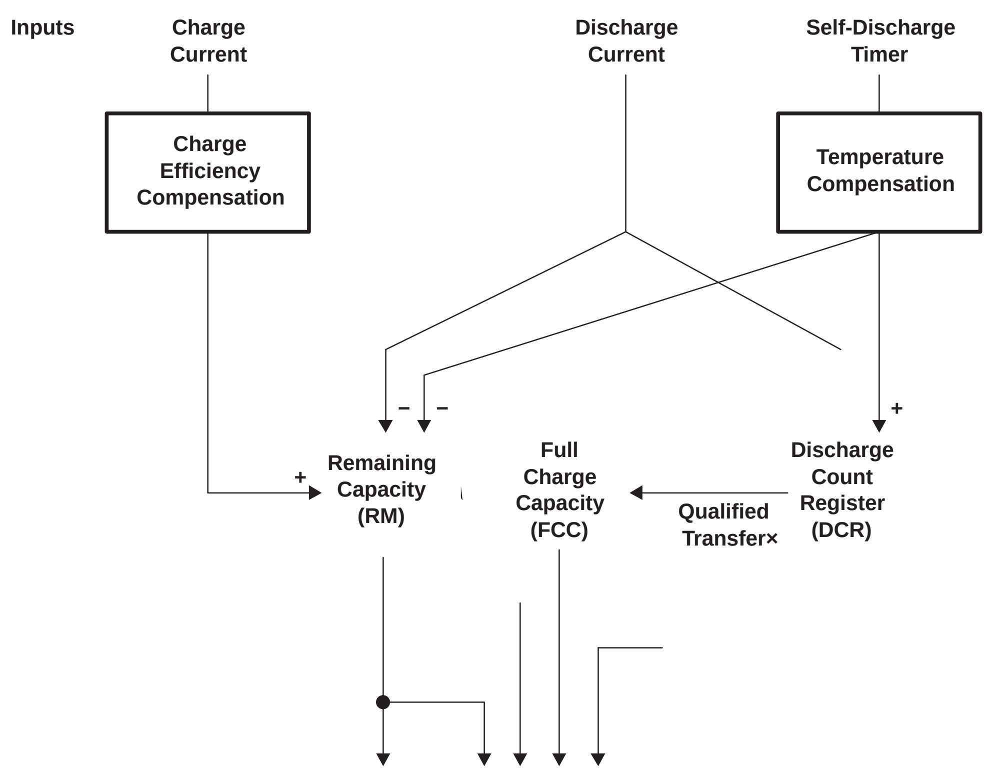
If AD < Min Temp AD then Temp = Max Temp

else

Temp = ((A3 AD 2^−16 +A2) AD 2^−16 + A1) AD 2^−16 + A0)

General

The operational overview in Figure 3 illustrates the gas gauge operation of the bq2083−V1P2. Table 3 describes the bq2083−V1P2 registers.



- 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 thresholds programmed in *Learning Low Temp* DF 0x9b when EDV2 is detected.
- The battery voltage reaches the EDV2 threshold during the discharge period and the voltage is greater than or equal to the EDV2 threshold minus 384 mV when the bq2083−V1P2 detected 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%* *FCC.

The bq2083−V1P2 sets VDQ=1 in pack status when qualified discharge begins. The bq2083−V1P2 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 bq2083−V1P2 saves the new FCC value to the data flash within 4 seconds of being updated.

End-of-Discharge Thresholds and Capacity Correction

The bq2083−V1P2 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 bq2083−V1P2 for overall voltage or single-cell EDV thresholds. If programmed for single cell EDV determination, the bq2083−V1P2 determines EDV on the basis of the lowest single-cell voltage. Fixed EDV thresholds may be programmed in *EMF/EDV0* DF 0x84-0x85, *EDV C0 Factor/EDV1* DF 0x86-0x87, and *EDV R Factor/EDV2* DF 0x88-0x89. If the CEDV bit in *Gauge Configuration* DF 0x29 is set, automatic EDV compensation is enabled and the bq2083−V1P2 computes the EDV0, EDV1, and EDV2 thresholds based on the values in DF 0x84-0x8d and the battery's current discharge rate and temperature. The bq2083−V1P2 disables EDV detection if Current( ) exceeds the *Overload Current* threshold programmed in DF 0x58 − DF 0x59. The bq2083−V1P2 resumes EDV threshold detection after Current( ) drops below the *Overload Current* threshold. Any EDV threshold detected is reset after charge is applied and VDQ is cleared after 10mAh of charge.

Table 2. State of Charge Based on Low Battery Voltage

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

The bq2083−V1P2 uses the EDV thresholds to apply voltage-based corrections to the RM register according to Table 1. The bq2083−V1P2 performs EDV-based RM adjustments with Current( ) ≥ C/32. No EDVs are set if current < C/32. The bq2083−V1P2 adjusts RM as it detects each threshold. If the voltage threshold is reached before the corresponding capacity on discharge, the bq2083−V1P2 reduces RM to the appropriate amount as shown in Table 2. This reduction occurs only if current ≥ C/32 when the EDV threshold is detected. If RM reaches the capacity level before the voltage threshold is reached on discharge, the bq2083−V1P2 prevents RM from decreasing further until the battery voltage reaches the corresponding threshold only on a full learning cycle discharge. RM is not held at the associated EDV percentage on a nonlearning discharge cycle (VDQ=0) or if current < C/32.

If *Battery Low* % is set to zero, EDV1 and EDV0 corrections are disabled.

Table 3. bq2083−V1P2 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	[redacted]	[redacted]	[redacted]
AtRate	[redacted]	[redacted]	[redacted]
AtRateTimeToFull	[redacted]	[redacted]	[redacted]
AtRateTimeToEmpty	[redacted]	[redacted]	[redacted]
AtRateOK	[redacted]	[redacted]	[redacted]
Temperature	[redacted]	[redacted]	[redacted]
Voltage	[redacted]	[redacted]	[redacted]
Current	[redacted]	[redacted]	[redacted]
AverageCurrent	0x0b	read	mA

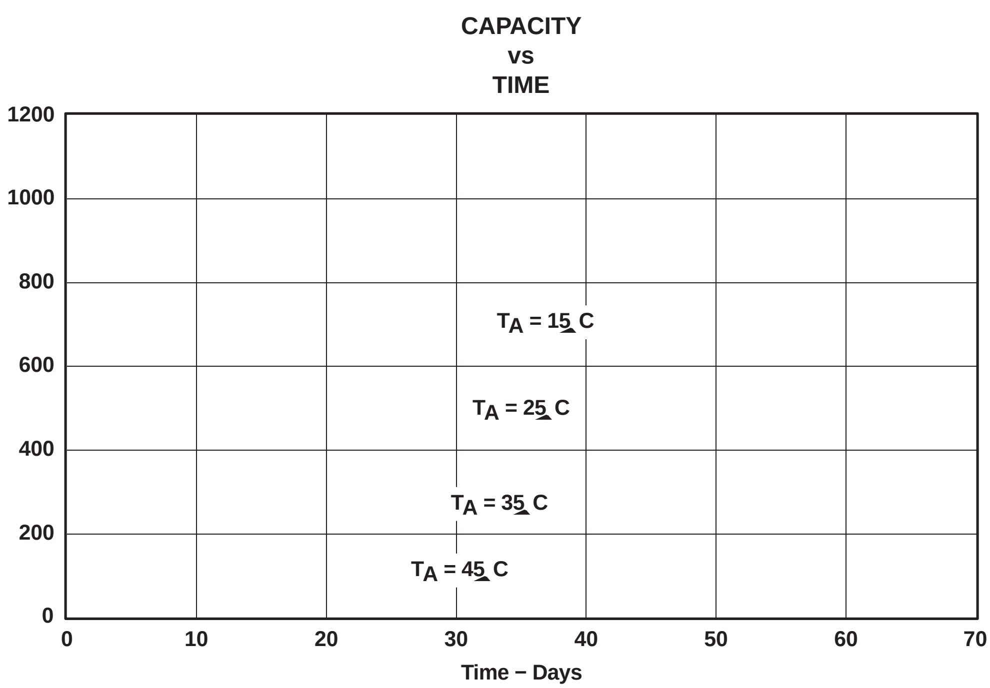
Self-Discharge

The bq2083−V1P2 estimates the self-discharge of the battery to maintain an accurate measure of the battery capacity during periods of inactivity. The bq2083−V1P2 makes self-discharge adjustments to RM( ) every 1/4 seconds when awake and periodically when in sleep mode. The period is determined by *Sleep Timer* DF 0xe7.

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. The following table 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 0x2c).

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



Midrange Capacity Corrections

The bq2083−V1P2 applies midrange capacity corrections when the VCOR bit is set in *Gauge Configuration* DF 0x29. The bq2083−V1P2 adjusts RM to the associated percentage at three different voltage levels: VOC25, VOC50, and VOC75. The VOC values represent the open circuit battery voltage at which RM corresponds to the associated for each threshold.

For the midrange corrections to occur, the temperature must be in the range of 19°C to 31°C inclusive and the Current( ) and AverageCurrent( ) must both be between −64 mA and 0. The bq2083−V1P2 makes midrange corrections as

Charge Suspension

The bq2083−V1P2 may temporarily suspend charge if it detects a charging fault. A charging fault includes the following conditions.

- Overcurrent: An overcurrent condition exists when the bq2083−V1P2 measures the charge current to be equal to or greater than *Overcurrent Margin* plus ChargingCurrent( ). *Overcurrent Margin* is programmed in DF 0x5c−0x5d. On detecting an overcurrent condition, the bq2083−V1P2 sets the ChargingCurrent( ) to zero and sets the TERMINATE_CHARGE_ALARM bit in Battery Status( ). The overcurrent condition and TERMINATE_ when it no longer detects that the battery is being charged or it no longer detects the termination condition. See Table 6 for a summary of BatteryStatus( ) alarm and status bit operation.

Table 6. Alarm and Status Bit Summary

BATTERY STATE	CONDITIONS	CC( ) CURRENT AND STATUS BITS SET	STATUS CLEAR CONDITION
Overcurrent	C( ) ≥ CC( ) + *Overcurrent Margin*	CC( ) = 0, TCA = 1	C( ) < *Overcurrent Margin*
Prolonged Overcurrent	AC( ) ≥ *Fast-Charging Current* + *Overcurrent Margin*	CVOV = 1 CC( ) = 0, TCA = 1	AC( ) < 256 mA
Overload	AC( ) ≤ −*Overload Current*	CVUV = 1	AC( ) < –256 mA
Overvoltage	V( ) ≥ CV( ) + *Over Voltage Margin* VCELL1, 2, 3, or 4 ≥ *Cell Over Voltage*	TCA = 1	DISCHARGING = 1
		CC( ) = 0, CVOV = 1	V( ) < CV( ) + *Over Voltage Margin* VCELL(all) ≤ *Cell Over Voltage Reset*
Overtemperature	T( ) ≥ *Max Temperature*	CC( ) = 0, OTA = 1, TCA = 1, CVOV = 1	T( ) ≤ *Max Temperature* − *Temperature Hysteresis* or T( ) ≤ 43°C
	[illegible]	CC( ) = 0, FC = 1	RSOC( ) < *Fully Charged Clear %*

The DMODE bit in *Pack Configuration* DF 0x28 programs the bq2083−V1P2 for the absolute or relative display mode. The LED bits program the 3-, 4-, or 5-LED option.

Activation

The display may be activated at any time by a high-to-low transition on the $\overline{\text{DISP}}$ input. This is usually accomplished with a pullup resistor and a pushbutton switch. Detection of the transition activates the display and starts a four second display timer. Reactivation of the display requires that the $\overline{\text{DISP}}$ 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 $\overline{\text{DISP}}$ input must be pulled up to V_{CC}.

If the EDV0 bit is set, the bq2083−V1P2 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 Table 8 for 4 LEDs, and Table 9 for 3 LEDs.

In either mode, the bq2083−V1P2 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 StateOfCharge( )	FIVE-LED DISPLAY OPTION				
	LED_1	LED_2	LED_3	LED_4	LED_5
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 StateOfCharge( )	FOUR-LED DISPLAY OPTION			
	LED1	LED2	LED3	LED4
EDV0 = 1	OFF	OFF	OFF	OFF
<25%	ON	OFF	OFF	OFF
≥ 25%, < 50%	ON	ON	OFF	OFF
≥ 50%, < 75%	ON	ON	ON	OFF
≥ 75%	ON	ON	ON	ON

Table 9. Display Mode for Three LEDs

CONDITION RELATIVE OR ABSOLUTE StateOfCharge( )	THREE-LED DISPLAY OPTION		
	LED1	LED2	LED3
EDV0 = 1	OFF	OFF	OFF
<34%	ON	OFF	OFF
≥ 34%, < 67%	ON	ON	OFF
≥ 67%	ON	ON	ON

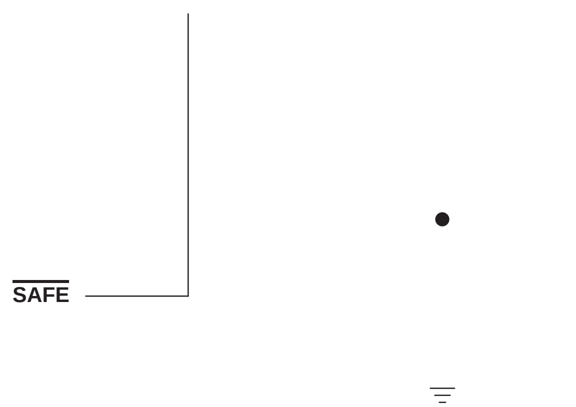
- When Miscellaneous Configuration (0x2a) bit 5 AC is set, and the AFE has failed at least AFE Fail Times (DF 0xd3, d4)

The bq2083−V1P2 checks the programming of the AFE registers at a period determined by AFE Check Time DF 0xe4. The units of the check period are seconds unless the bq2083−V1P2 is in sleep mode, in which case the period is *AFE Check Time* x *Sleep Current Time* (DF 0xe7). If the data is not correct, the bq2083−V1P2 increments an internal counter.

The CVOV flag in PackStatus() (0x2f) is set in any of the following ways:

- Voltage() $\geq$ ChargingVoltage() + OverVoltageMargin (DF 0x5a and 0x5b)
- AverageCurrent() $\geq$ FastCurrent + OvercurrentMargin (DF 0x5c and 0x5d)
- Any cell voltage $\geq$ CellOverVoltage (DF 0x60 and 0x61)
- The BatteryStatus() Over temperature bit is set

An example circuit using the SAFE output to blow a fuse is shown in Figure 5.



Device Reset

The following procedure resets the bq2083−V1P2:

1. Write 0x653 to Address 0. (This puts the device in calibration mode.)
2. Write 0x000 to Address 5E. (This puts the device back into normal mode.)

NOTE: No other write actions should be attempted between step 1 and step 2.

COMMUNICATION

The bq2083−V1P2 includes an SMBus communication port. The SMBus interface is a 2-wire bidirectional protocol using the SMBC (clock) and SMBD (data) pins. The communication lines are isolated from VCC and may be pulled-up higher than V_{CC}. Also, the bq2083−V1P2 does not pull these lines low if V_{CC} to the part is zero.

The communication ports allow a host controller, an SMBus compatible device, or other processor to access the memory registers of the bq2083−V1P2. In this way a system can efficiently monitor and manage the battery.

In the write word and block read, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq2083−V1P2. The bq2083−V1P2 then sends the PEC and the host acting as a master-receiver generates a NOT ACKNOWLEDGE and a stop condition.

COMMAND CODES

The SMBus command codes are in ( ). Temperature( ), Voltage( ), Current( ), and AverageCurrent( ), performance specifications are at bq29311 regulated V_{CC} ($V_{(REG)}$) and a temperature of 0-70°C.

ManufacturerAccess( ) (0x00)

Description: This function provides writable command codes to control the bq2083−V1P2 during normal operation and pack manufacture. The following commands are available:

0x0001 Device Type instructs the bq2083−V1P2 to return the IC part number; i.e., 2083 (0823h) to Manufacture Access ( ) so it can be read.

0x0002 Firmware Revision instructs the bq2083−V1P2 to return the firmware revision.

0x0003 EDV Level instructs the bq2083−V1P2 to return the pending end-of-discharge voltage level so it can be read.

0x062b

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 bq2083−V1P2 RemainingTimeAlarm( ).

SMBus protocol: Read or write word

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

Units: Minutes

Table 12. Battery Mode Bits and Values

Battery Mode( ) BITS	BITS USED	FORMAT	ALLOWABLE VALUES
INTERNAL_CHARGE_CONTROLLER	0	Read only bit flag	
PRIMARY_BATTERY_SUPPORT	1	Read only bit flag	
Reserved	2–6		
RELEARN_FLAG			

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 bq2083−V1P2 updates the non-AtRate related register values within 1 s of changing the state of the CAPACITY_MODE bit. The AtRate( ) values are updated after the next AtRate value is written to the bq2083−V1P2 (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: Since 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

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 bq2083−V1P2 updates AtRateTimeToEmpty( ) within 5 ms after the SMBus host sets the AtRate( ) value. The bq2083−V1P2 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 seconds. 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 bq2083−V1P2 updates AtRateOK( ) within 5 ms after the SMBus host sets the AtRate( ) value. The bq2083−V1P2 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 bq2083−V1P2.

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

Range: 0 to +6553.5° K (real range)

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 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 Absolute or Relative StateOfCharge( ) functions and may be in a better form for use by power management systems.

SMBus protocol: Read word

Output:

host and the smart battery charger by the AlarmWarning() function except that the AlarmWarning() function setsthe error code bits all high before se

current or power depending on the setting of the BatteryMode( ) CAPACITY_MODE bit. This is important becauseuse of the wrong calculation mode

32BatteryStatus() (0x16)Description: Returns the bq2083−V1P2 status word (flags). Some of the BatteryStatus( ) flags(REMAINING_CAPACITY_ALAR

DesignCapacity( ) (0x18)

Description: Returns the theoretical or nominal capacity of a new pack. The DesignCapacity( ) 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.

Purpose: The DesignCapacity( ) function is used by the SMBus host's power management in conjunction with FullChargeCapacity( ) to determine battery wear. The power management system may present this information to the user and also adjust its power policy as a result.

SMBus protocol: Read word

Output: Unsigned integer. battery 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	Not applicable	Not applicable
Accuracy	Not applicable	Not applicable

DesignVoltage( ) (0x19)

Description: Returns the theoretical voltage of a new pack (mV). The bq2083−V1P2 sets DesignVoltage( ) to the value programmed in *Design Voltage* DF 0x04−0x05.

Purpose: The DesignVoltage( ) function can be used to give additional information about a particular smart battery expected terminal voltage.

SMBus protocol: Read word

Output: Unsigned integer. the battery's designed terminal voltage in mV

Units: mV

Range: 0 to 65,535 mV

Granularity: Not applicable

Accuracy: Not applicable

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 bq2083−V1P2 VScale (voltage scaling) and IPScale (current scaling) should always be set to zero. The bq2083−V1P2 sets SpecificationInfo( ) to the value programmed in *Specification Information* DF 0x06-0x07.

Purpose: The SpecificationInfo( ) function is used by the SMBus host's power management system to determine what information the smart battery can provide.

SMBus protocol: Read word

Output: Unsigned integer. packed specification number and scaling information:

FIELD	BITS USED	FORMAT	ALLOWABLE VALUES
SpecID_L	0...3	4-bit binary value	0–15
SpecID_H	4...7	4-bit binary value	0–15
VScale	8...11	4-bit binary value	0 (multiplies voltage by 10^ VScale)
IPScale	12...15	4-bit binary value	0 (multiplies current by 10 ^ IPScale)

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 bq2083−V1P2 sets DeviceChemistry( ) to the value programmed in *Device Chemistry Length* DF 0x22−0x26.

Purpose: The DeviceChemistry( ) function gives cell chemistry information for use by charging systems. The bq2083−V1P2 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.

Lead acid	PbAc
Lithium ion	LION
Nickel cadmium	NiCd
Nickel metal hydride	NiMH
Nickel zinc	NiZn

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 bq2083−V1P2.

0 The bq2083−V1P2 is in the unsealed state.
1 The bq2083−V1P2 is in the sealed state.

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

SOV

The SOV bit indicates that the safety output limits have been exceeded. Once set, the flag stays set until the bq2083−V1P2 is reset.

0 Safety limits not exceeded
1 Safety limits exceeded

CVOV

The CVOV bit indicates that a protection limit has been exceeded. It is set on a Prolonged Overcurrent, Overvoltage, or Overtemperature condition. 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. It is set on an overload or overdischarge condition. 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 bq2083−V1P2 accesses the internal data flash during reset and when storing historical data. The data flash stores basic configuration information for use by the bq2083−V1P2. The data flash must be programmed correctly for proper bq2083−V1P2 operation.

Memory Map

Table 13 shows the memory map for the data flash. It shows the default programming for the bq2083−V1P2. The default programming reflects example data for a 3s2p Li-Ion battery pack with a 0.02-Ω sense resistor. The data flash must be reprogrammed to meet the requirements of individual applications.

Table 13. Data Flash Memory Map (Continued)

DATA FLASH ADDRESS

Table 13. Data Flash Memory Map (Continued)

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0xac	0xad	TS Const 5		00	00
0xae	0xaf	Reserved		0f	ac
0xb0		Reserved			32
0xb1		*AFE Brnout Shutdn*	Shutdown = 6.475, Brownout = 7.975 V		00
0xb2		*AFE Over Curr Dsg*	140 mV		12
0xb3		*AFE Over Curr Chg*	70 mV		04
0xb4		*AFE Over Curr Delay*	Charge = 31 ms, Discharge = 31 ms		ff
0xb5		Reserved			00
0xb6		*AFE Short Circ Thrsh*	275 mV		07
0xb7		*AFE Short Circuit Delay*	61 , s (charge and discharge)		11
0xb8	0xb9	*AFE Vref**	9750 mV	26	16
0xba	0xbb	*Sense Resistor Gain**	0.02 Ω	3b	d0
0xbc	0xbd	*CC Delta**	0.0001298 mAh	94	08
0xbe	0xbf	*CC Delta**		b1	c0
0xc0		Reserved			fa
0xc1	0xc2	*CC Offset**	1528	05	f8
0xc3		*DSC Offset**	15		10
0xc4		*ADC Offset**	16		11
0xc5		*Temperature Offset**	0		00
0xc6		*Board Offset**	0		00
0xc7	0xc8	Reserved		00	40
0xc9	0xca	Reserved		01	00
0xcb		Reserved			05
0xcc	0xcd	Version	1.2	01	20
0xce		Reserved		00	32
0xcf	0xd0	*Cell Over Voltage Reset*	4150 mV	10	36
0xd1	0xd2	*Cell Under Voltage Reset*	3000 mV	0b	b8
0xd3	0xd4	*AFE Fail Limit*	2 counts	00	02
0xd5	0xd6	Reserved		ff	ff
0xd7	0xd8	*Cell Balance Thresh*	3900 mV	0f	3c
0xd9	0xda	*Cell Balance Window*	100 mV	00	64
0xdb		*Cell Balance Min*	40 mV		28
0xdc		*Cell Balance Interval*	20 seconds		14
0xdd	0xde	Reserved		a5	5a
0xdf	0xd0	Reserved		7a	43
0xe1	0xe2	Reserved		20	83
0xe3		Reserved			00
0xe4		*AFE Check Time*	0 seconds		00
0xe5		*Sleep Current Thresh*	2 mA		04
0xe6		*Sleep Current Time*	20 seconds		14
0xe7		*Sleep Time*			

PROGRAMMING INFORMATION

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 0xbc−0xbf 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 0xba-0xbb 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.

$$\textit{Sense Resistor Gain} = \frac{306.25}{Rs} \qquad (2)$$

Digital Filter

The desired digital filter threshold, VDF (V), is set by the value stored in *Digital Filter* DF 0x2b.

$$\textit{Digital Filter} = \frac{VDF}{290\ nV} \qquad (3)$$

Cell and Pack Characteristics

Battery Pack Capacity and Voltage

Pack capacity in mAh units is stored in *Design Capacity*, DF 0x31−0x32. In mAh mode, the bq2083−V1P2 copies *Design Capacity* to DesignCapacity( ). In mWh mode, the bq2083−V1P2 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 *Last Measured Discharge*, in mAh, is stored in DF 0x35−0x36. *Last Measured Discharge* is modified over the course of pack usage to reflect cell aging under the particular use conditions. The bq2083−V1P2 updates *Last Measured Discharge* in mAh after a capacity learning cycle. The bq2083−V1P2 uses the *Last Measured Discharge* value to calculate FullChargeCapacity( ) in units of mAh or 10 mWh.

Remaining Time and Capacity Alarms

Remaining Time Alarm in DF 0x00-0x01 and *Remaining Capacity Alarm* in 0x02-0x03 set 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.

EDV Thresholds and Near Full Percentage

The bq2083−V1P2 uses three pack-voltage thresholds to provide voltage-based warnings of low battery capacity. The bq2083−V1P2 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 0x84−0x85, DF 0x86−0x87, and DF 0x88−0x89, respectively.

For capacity correction at EDV2, *Battery Low %* DF 0x2e 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.

$$\textit{Battery Low \%} = (STATEOFCHARGE\% \times 2.56) \qquad (4)$$

The bq2083−V1P2 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* in DF 0x2f, 0x30 in mAh.

EDV Discharge Rate and Temperature Compensation

If EDV compensation is enabled, the bq2083−V1P2 calculates battery voltage to determine EDV0, EDV1, and EDV2 thresholds as a function of battery capacity, temperature, and discharge load. The general equation for EDV0, EDV1, and EDV2 calculation is:

$$EDV0,1,2 = n\,(EMF \times FBL - |ILOAD| \times R0 \times FTZ)$$

EMF is a no-load cell voltage higher than the highest cell EDV threshold computed. EMF is programmed in mV in *EMF/EDV1* DF 0x84−0x85.

ILOAD is the current discharge load magnitude.
n = the number of series cells

FBL is the factor that adjusts the EDV voltage for battery capacity and temperature to match the no-load characteristics of the battery.

$$FBL = f\,(C0,\ C + C1,\ T)$$

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 0x86−87. C1 is the desired residual battery capacity remaining at EDV0 (RM = 0). The C1 factor is stored in *EDV C1 Factor* DF 0x8f.

T is the current temperature in °K.

$R0 \times FTZ$ 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 0x88−0x89.

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 0x8c-0x8d.

T0 adjusts the variation of impedance with battery temperature. T0 is programmed in *EDV T0 Rate Factor* DF 0x8a−0x8b.

TC adjusts the variation of impedance for cold temperatures (T < 23°C). TC is programmed in *EDV TC* DF 0x8e.

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

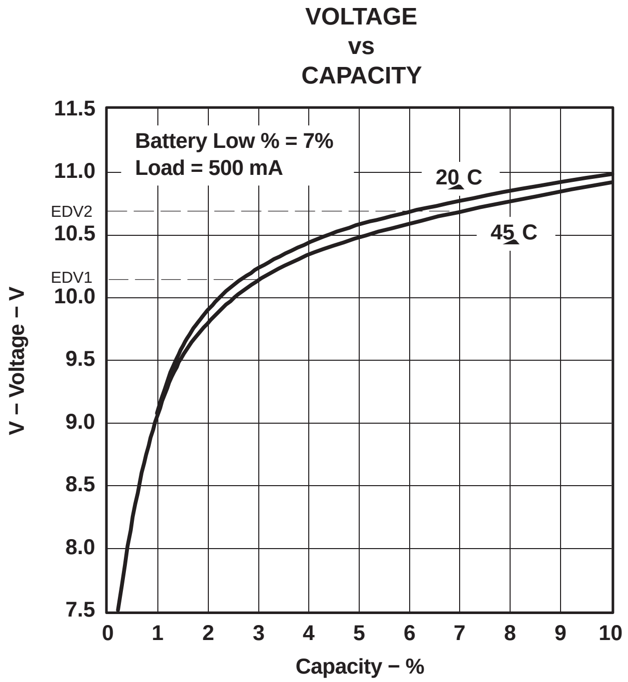


Figure 8. EDV Calculations vs Capacity for Various Temperatures

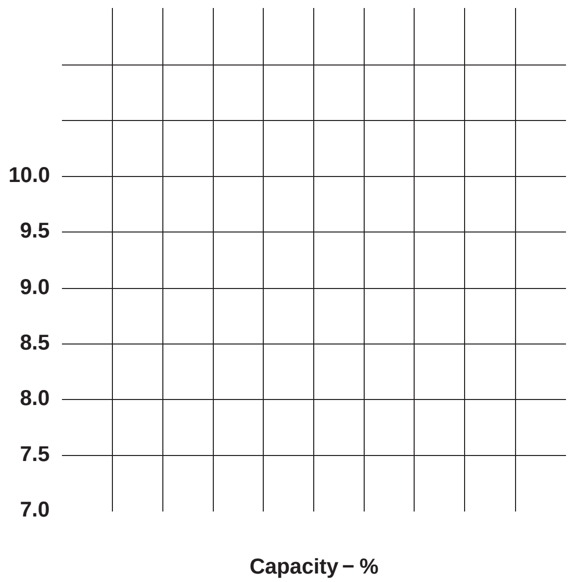


Figure 9. EDV Calculations vs Capacity for Various Loads

Change Control

Charging Voltage

The 16-bit value, *Charging Voltage* DF 0x39−0x3a programs the ChargingVoltage( ) value broadcast to a smart charger. It ialso sets the base value for determining overvoltage conditions during charging and voltage compliance during a constant-voltage charging methodology. It is stored in mV.

Over Voltage

The 16-bit value, *Over Voltage Margin* DF 0x5a−0x5b, sets the limit over ChargingVoltage( ) in mV that is to be considered as an overvoltage charge-suspension condition.

Charging Current

ChargingCurrent( ) values are either broadcast to a Level 2 smart battery charger or read from the bq2083−V1P2 by a Level 3 smart battery charger. The bq2083−V1P2 sets the value of ChargingCurrent( ), depending on the charge requirements and charge conditions of the pack.

When fast charge is allowed, the bq2083−V1P2 sets ChargingCurrent( ) to the rate programmed in *Fast-Charging Current* DF 0x3d−0x3e. *Fast-Charging Current* is stored in mA.

When fast charge terminates, the bq2083−V1P2 sets ChargingCurrent( ) to zero and then to the *Maintenance Charging Current* DF 0x3f, 0x40 when the termination condition ceases. The desired maintenance current is stored in mA.

When Voltage( ) is less than EDV0, the bq2083−V1P2 sets ChargingCurrent( ) to *Precharge Current* DF 0x41, 0x42. 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. The desired precharge rate is stored in mA.

If temperature is between 0°C and the precharge threshold PC (°C), the bq2083−V1P2 sets ChargingCurrent( ) to *PreCharge Current.* The threshold is programmed in the *Precharge Temp* DF 0x43.

$$Precharge\ Temp = \frac{PC\ (°C)}{0.1} \qquad (10)$$

The bq2083−V1P2 also sets ChargingCurrent( ) to the precharge rate if Voltage( ) is less than the value programmed in *Precharge Voltage* DF 0x3b−0x3c. *Precharge Voltage* is programmed in mV.

Charge Suspension

During charge, the bq2083−V1P2 compares the current to the ChargingCurrent( ) plus the value in *OverCurrent Margin* DF 0x5c−0x5d. If the pack is charged at a current above or equal to the ChargingCurrent( ) plus the programmed value, the bq2083−V1P2 sets ChargingCurrent( ) to zero to stop charging.

The desired *Overcurrent Margin* is programmed in mA.

The desired temperature threshold for charge suspension, MAXTEMP (°C), is programmed in *Max Temperature* DF 0x53, 0x54 and is stored as shown:

$$Max\ Temperature = \frac{MAXTEMP}{0.1} \qquad (11)$$

The bq2083−V1P2 clears the maximum temperature condition when Temperature( ) drops by the amount programmed in *Temperature Hysteresis* DF 0x55 from MAXTEMP or when the temperature is less than or equal to 43.0°C. *Temperature Hysteresis* is stored in °C.

The bq2083−V1P2 suspends fast charge when fast charge continues past full by the amount programmed in *Maximum Overcharge* DF 0x4e-0x4f. *Maximum Overcharge* is programmed in mAh.

FULLY_CHARGED Bit Clear Threshold

The bq2083−V1P2 clears the FULLY_CHARGED bit in BatteryStatus( ) when RelativeStateOfCharge( ) reaches the value, *Fully Charged Clear %* DF 0x47. *Fully Charged Clear %* is an 8-bit value and is stored in percent.

Fast Charge Termination Percentage

The bq2083−V1P2 sets RM to a percentage of FCC on charge termination if the CSYNC bit is set in the gauge configuration register. The percentage of FCC, FCT%, is stored in *Fast Charge Termination %* in DF 0x46. The value is stored as shown:

Fast Charge Termination% = (FCT% * 2.56−1)

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.

Current Taper Termination Characteristics

Two factors in the data flash set the current taper termination for Li-Ion battery packs. The two locations are *Current Taper Qual Voltage* DF 0x4a and *Current Taper Threshold* DF 0x48−0x49. Current taper termination occurs during charging when the pack voltage is above or equal to the charging voltage minus the qualification voltage, and the charging current is below the taper threshold for at least 40 seconds. *Current Taper Qual Voltage* DF 0x4a is stored in mV and *Current Taper Threshold* DF 0x48−0x49 in mA.

Cell Balancing

Four constants set the cell balancing parameters. *Cell Balance Threshold* DF 0xd9−0xda sets the minimum voltage in mV that each cell must achieve to initiate cell balancing. *Cell Balance Window* DF 0xd9−0xda sets in mV the amount that the cell balance threshold can increase. *Cell Balance Min* DF 0xdb sets in mV the cell differential that must exist to initiate cell balancing and *Cell Balance Interval* DF 0xdc sets the cell balancing time interval in seconds. Programming *Cell Balance Threshold* to 65,535 disables cell balancing.

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.

0−1 Configures the bq2083−V1P2 for three LEDs

1−0 Configures the bq2083−V1P2 for four LEDs

1−1 or 0−0 Configures the bq2083−V1P2 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

VCOR

The VCOR bit enables the midrange voltage correction algorithm. When it is set, the bq2083−V1P2 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 bq2083−V1P2 to perform a midrange voltage one time after a device reset.

0 One-time midrange correction disabled
1 One-time midrange correction enabled

Safety Control

Secondary Protection Limits for Li-Ion

The cell undervoltage (VUV) and overvoltage (VOV) limits are programmed in *Cell Under and Cell Over Voltage* DF 0x62−0x63, DF 0x60−0x61, respectively. Both values are stored in mV. *Cell Over Voltage Reset* DF 0xef and *Cell Under Voltage Reset* 0xd1−0xd2 set the reset points in mV for these safety parameters.

$\overline{\text{SAFE}}$ Threshold

The safety voltage threshold is programmed in *Safety Over Voltage* DF 0x68−0x69. It is stored in mV.

If Guage Configuration bit 2 (OVSEL) = 0 then Safety Over Voltage is based on pack voltage, but if OVSEL = 1, then it is based on highest cell voltage.

The safety overtemperature (SOT) in°C is programmed in *Safety Over Temperature* DF 0x6a−0x6b. It is stored as

$$SafetyOvertemperature = \frac{SOT}{0.1} \quad (12)$$

AFE CONFIGURATION

The AFE protection limits are programmed as specified in the bq29311 data sheet.

AFE Brnout/Shutdn 0xb1 sets the brownout and shutdown voltage levels

AFE Over Curr Dsg DF 0xb2 sets the overcurrent threshold on discharge.

AFE Over Curr Chg DF 0xb3 sets the overcurrent threshold on charge.

AFE Over Curr Delay DF 0xb4 sets the delay timing for over current in the charge and discharge direction.

AFE Short Circ Thresh DF 0xb6 sets the short circuit threshold.

AFE Short Circuit Delay DF 0xb7 sets the short circuit delay time.

AFE INTEGRITY CHECK

AFE Check time DF 0xe4 sets the period in seconds for the AFE integrity check.

An *AFE Fail Limit* of 65,535 is the number of AFE integrity check failures that occur before the AFC flag is set.

SLEEP MODE

The sleep current threshold, SLP (mA), is stored in *Sleep Current Thresh* DF 0xe5 as:

$$Sleep\ Current\ Thresh = \frac{SLP(mA)}{0.5} \quad (13)$$

The wake-up period for current measurement, WAT(s), is set in *Sleep Current Time* DF 0xe6 as:

$$Sleep\ Current\ Time = \frac{WAT(s)}{0.5} \quad (14)$$

Miscellaneous Configuration

Misc Configuration DF 0x2a contains additional bit programmable features.

b7	b6	b5	b4	b3	b2	b1	b0
IT	0	AC	DS	OT	ECLED	PHG	VOD

IT

The IT bit configures the bq2083−V1P2 to use its internal temperature sensor.

0 bq2083−V1P2 requires an external thermistor.

1 bq2083−V1P2 uses its internal temperature sensor.

AC

The AC bit enables the $\overline{\text{SAFE}}$ output to function based on the AFE integrity check.

0 $\overline{\text{SAFE}}$ not activated based on the AFE integrity check.

1 $\overline{\text{SAFE}}$ activated based on the AFE integrity check.

DS

The DS bit programs the bq2083−V1P2 to enter sleep mode on SMBus inactivity.

0 bq2083−V1P2 enters sleep mode when the SMBus is low for 2 s.

1 bq2083−V1P2 does not enter sleep mode.

OT

The OT bit programs the bq2083−V1P2 to turn off the discharge FET when the bq2083−V1P2 detects an overtemperature condition. Charge FET is always turned off in overtemperature conditions.

0 bq2083−V1P2 does not turn off the discharge FET on overtemperature.

1 bq2083−V1P2 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.

PHG

The PHG bit configures the bq2083−V1P2 to control a precharge FET.

0 The bq2083−V1P2 does not control a precharge FET.

1 The bq2083−V1P2 may turn on or off a precharge FET according to the programmed precharge conditions.

VOD

The VOD bit enables a 1-second time delay on the charge and discharge FET control.

0 No delay

1 1-second delay

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.

Manufacturers 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.

APPLICATION INFORMATION

The schematic shows a typical bq2083−V1P2-based battery pack application. The circuit consists of the bq29311 analog front end (AFE) IC, LED display, 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 bq2083−V1P2 operation. Table 13 shows the data flash memory map and outlines the programmable functions available in the bq2083−V1P2.

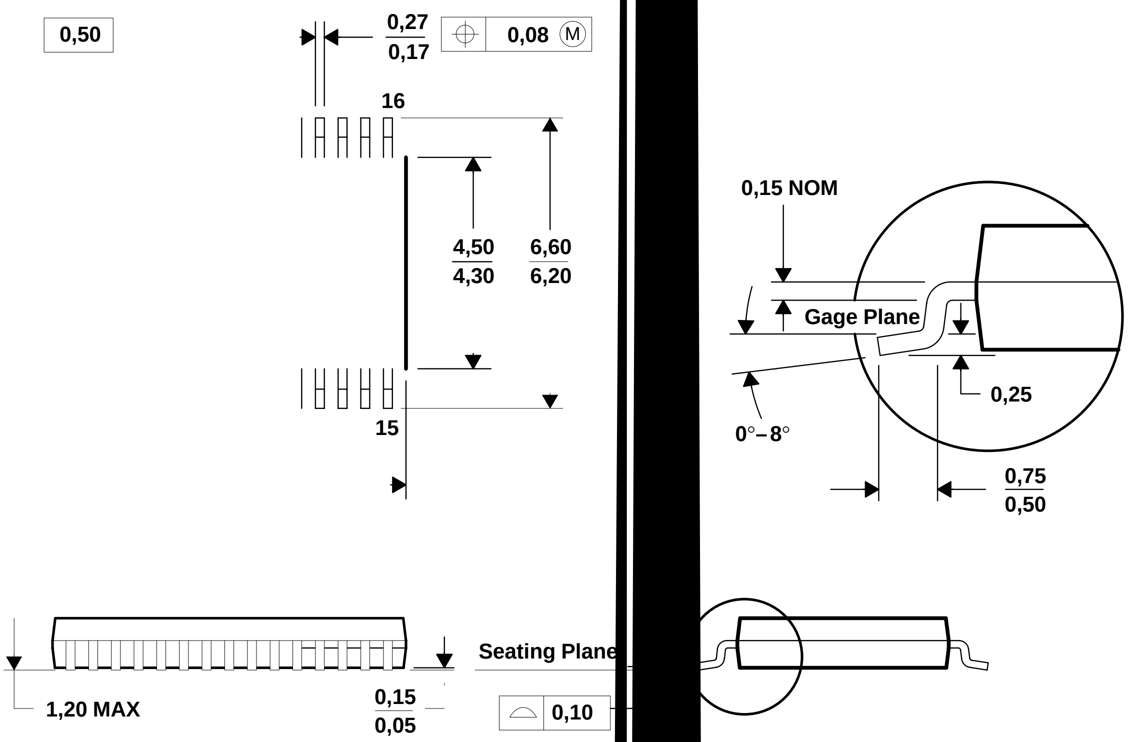
APPLICATION INFORMATION

DATA SHEET REVISION HISTORY

REV	DATE	PAGE NO.	NATURE OF CHANGE
A	11/2003	4	Removed low-power storage mode current
		14	Updated request time from 10 to 50 seconds
		23	Removed hibernate from description

DBT (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

30 PINS SHOWN



PINS ** / DIM	20	24	28	[redacted]	38	44	50
A MAX	5,10	6,60	7,90	[redacted]	9,80	11,10	12,60
A MIN	4.90	6,40	7,70	[redacted]	9,60	10,90	12,40

4073252/E 02/02

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion.
- D. Falls within JEDEC MO-153

IMPORTANT NOTICE