[illegible]

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)**

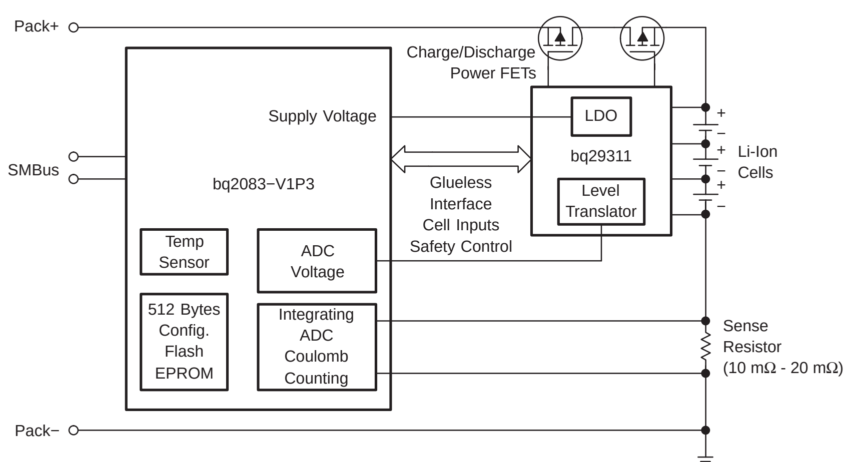
APPLICATIONS

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

DESCRIPTION

The bq2083−V1P3 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−V1P3 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−V1P3, the host controller can manage remaining battery power to extend the system run time as much as possible.

BLOCK DIAGRAM



DESCRIPTION (CONTINUED)

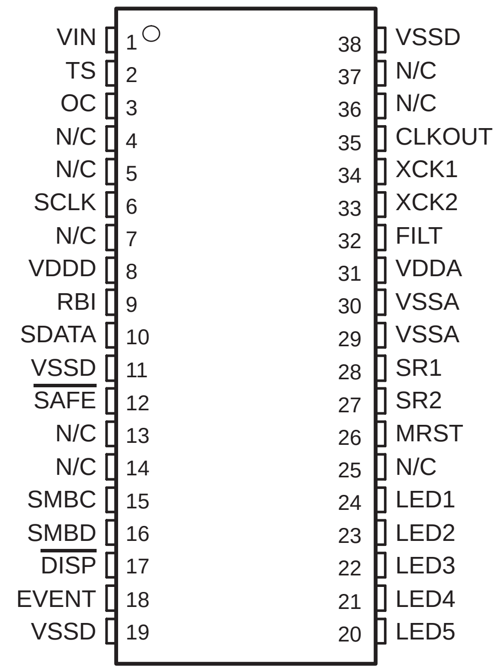
The bq2083−V1P3 uses an integrating converter with continuous sampling for the measurement of battery charge and discharge currents. Optimized for coulomb counting in portable applications, the self-calibrating integrating converter has a resolution better than 3-nVh and an offset measurement error of less than 1-µV (typical). For voltage and temperature reporting, the bq2083−V1P3 uses a 16-bit A-to-D converter. In conjunction with the bq29311, the onboard ADC also monitors individual cell voltages in a battery pack and allows the bq2083−V1P3 to generate the control signals necessary to implement the cell balancing and the required safety protection for Li-ion and Li-polymer battery chemistries.

The bq2083−V1P3 supports the Smart Battery Data (SBData) commands and charge-control functions. It communicates data using the System Management Bus (SMBus) 2-wire protocol. The data available include the battery's remaining capacity, temperature, voltage, current, and remaining run-time predictions. The bq2083−V1P3 provides LED drivers and a push-button input to depict remaining battery capacity from full to empty in 20%, 25%, or 33% increments with a 3-, 4-, or 5-segment display.

The bq2083−V1P3 contains 512 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 bq2083−V1P3 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 bq29311 AFE protection IC provides power to the bq2083−V1P3 from a 3 or 4 series Li-ion cell stack, eliminating the need for an external regulator circuit.

TSSOP PACKAGE
(TOP VIEW)



NC − No internal connection

AVAILABLE OPTIONS

T_A	PACKAGE 38-PIN TSSOP (DBT)
−20°C to 85°C	bq2083DBT−V1P3(1)

(1) The bq2083−V1P3 is available taped and reeled. Insert an R suffix to the device type (e.g., bq2083DBTR−V1P3) to order tape and reel version.

150

145

140

V_{IT-} V_{hys}

135

130

125

120

115

110

T_A − Free-Air Temperature − °

ts()ST PS

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

$$\text{Temp} = ((A3 \times AD \times 2^{-16} + A2) \times AD \times 2^{-16} + A1) \times AD \times 2^{-16} + A0)$$

General

The operational overview in Figure 3 illustrates the gas gauge operation of the bq2083−V1P3. Table 3 describes the bq2083−V1P3 registers.

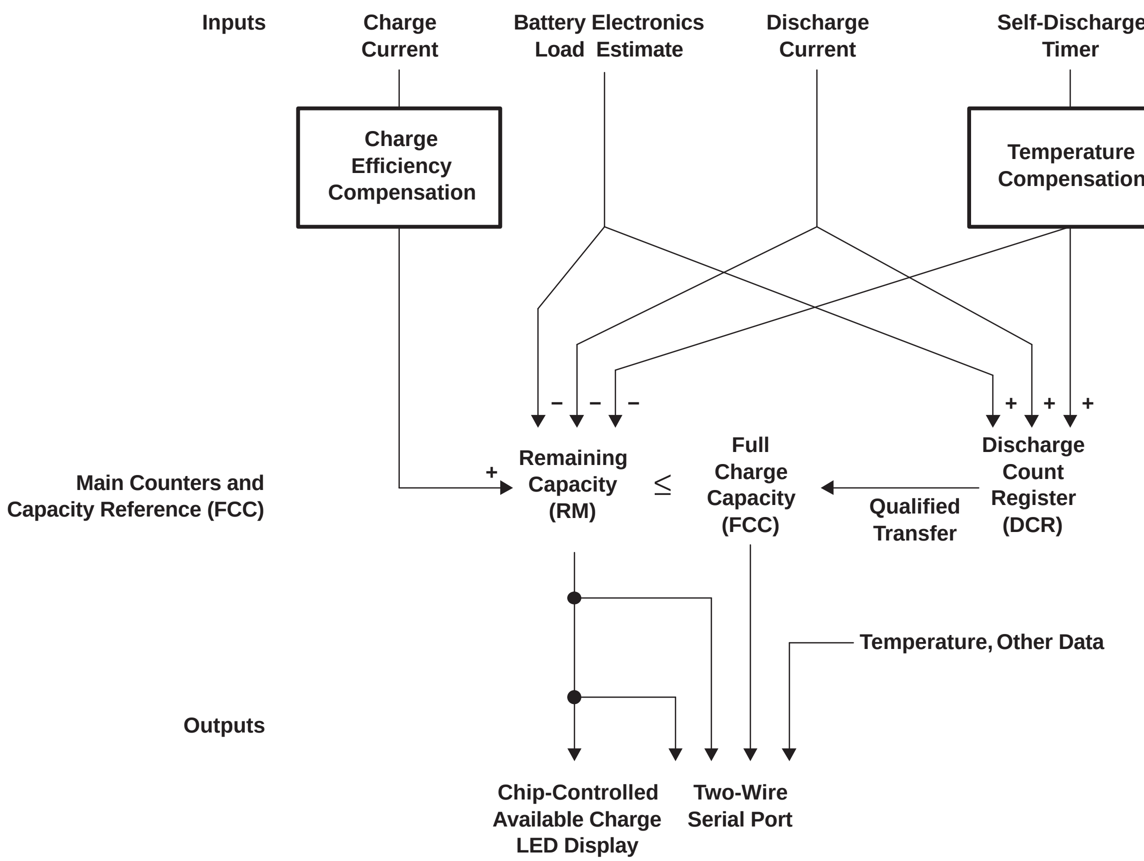


Figure 3. bq2083−V1P3 Operational Overview

The bq2083−V1P3 accumulates a measure of charge and discharge currents and estimates self-discharge of the battery. The bq2083−V1P3 compensates the charge current measurement for temperature and state-of-charge of the battery. The bq2083−V1P3 also adjusts the self-discharge estimation based on temperature.

Table 3. bq2083−V1P3 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, 10mW
AtRateTimeToFull	0x05	read	minutes
AtRateTimeToEmpty	0x06	read	minutes
AtRateOK	0x07	read	Boolean
Temperature	0x08	read	0.1°K
Voltage	0x09	read	mV
Current	0x0a	read	mA
AverageCurrent	0x0b	read	mA
MaxError	0x0c	read	percent
RelativeStateOfCharge	0x0d	read	percent
AbsoluteStateOfCharge	0x0e	read	percent
RemainingCapacity	0x0f	read	mAh, 10 mWh
FullChargeCapacity	0x10	read	mAh, 10 mWh
RunTimeToEmpty	0x11	read	minutes
AverageTimeToEmpty	0x12	read	minutes
AverageTimeToFull	0x13	read	minutes
ChargingCurrent	0x14	read	mA
ChargingVoltage	0x15	read	mV
Battery Status	0x16	read	NA
CycleCount	0x17	read	cycles
DesignCapacity	0x18	read	mAh, 10 mWh
DesignVoltage	0x19	read	mV
SpecificationInfo	0x1a	read	NA
ManufactureDate	0x1b	read	NA
SerialNumber	0x1c	read	integer
Reserved	0x1d-0x1f	0	0
ManufacturerName	0x20	read	string
DeviceName	0x21	read	string
DeviceChemistry	0x22	read	string
ManufacturerData	0x23	read	string
Pack status	0x2f (LSB)	read	NA
Pack configuration	0x2f (MSB)	read	NA
VCELL4	0x3c	read	mV
VCELL3	0x3d	read	mV
VCELL2	0x3e	read	mV
VCELL1	0x3f	read	mV

Self-Discharge

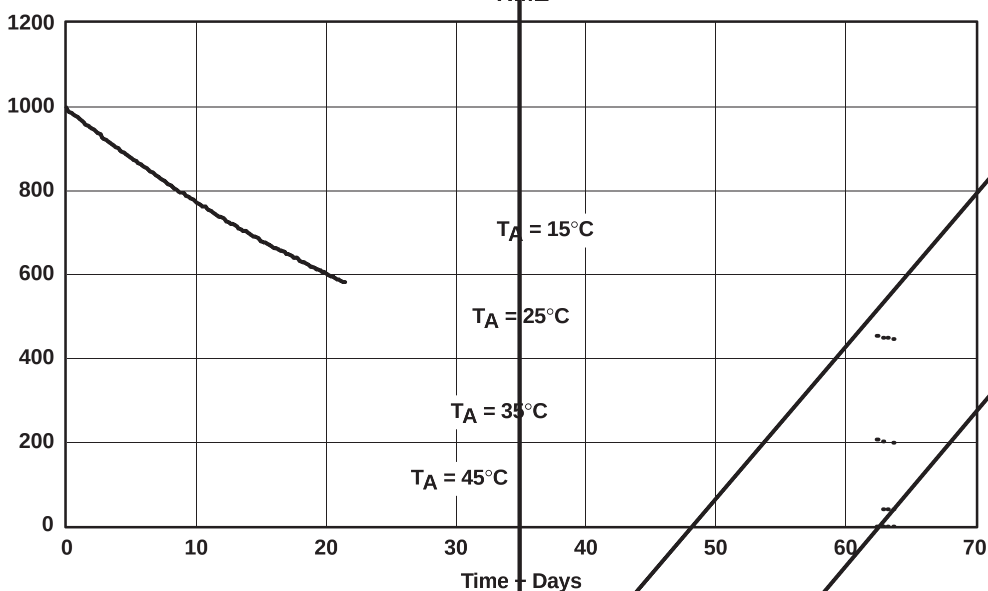
The bq2083−V1P3 estimates the self-discharge of the battery to maintain an accurate measure of the battery capacity during periods of inactivity. The bq2083−V1P3 makes self-discharge adjustments to RM( ) every 1/4 seconds when awake and periodically when in sleep mode. The period is determined by *Sleep 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

CAPACITY vs TIME



Midrange Capacity Corrections

The bq2083−V1P3 applies midrange capacity corrections when the VCOR bit is set in *Gauge Configuration* DF 0x29. The bq2083−V1P3 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−V1P3 makes midrange corrections as shown in Table 5. For a correction to occur, the bq2083−V1P3 must detect the need for correction twice during subsequent 20-s intervals. With the VCOR bit set, the bq2083−V1P3 makes midrange corrections whenever conditions permit. If the OTVC bit in *Gauge Configuration* DF 0x29 is set and VCOR = 0, the bq2083−V1P3 makes a single attempt of mid-range correction immediately after device reset and does not require a second validation.

Table 5. Midrange Corrections

CONDITION		RESULT
Voltage( )	≥ VOC75 and RelativeStateOfCharge( ) ≤ 63%	RelativeStateOfCharge()→75%
	< VOC75 and RelativeStateOfCharge( ) ≥ 87%	RelativeStateOfCharge()→75%
	≥VOC50 and RelativeStateOfCharge( ) ≤ 38%	RelativeStateOfCharge()→50%
	<VOC50 and RelativeStateOfCharge( ) ≥ 62%	RelativeStateOfCharge()→50%
	≥ VOC25 and RelativeStateOfCharge( ) ≤ 13%	RelativeStateOfCharge()→25%
	< VOC25 and RelativeStateOfCharge( ) ≥ 37%	RelativeStateOfCharge()→25%

Charge Control

Charging Voltage and Current Broadcasts

The bq2083−V1P3 supports SBS charge control by broadcasting the ChargingCurrent( ) and ChargingVoltage( ) to the Smart Charger address. The bq2083−V1P3 broadcasts the requests every 50 seconds. The bq2083−V1P3

Charge Suspension

The bq2083−V1P3 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−V1P3 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−V1P3 sets the ChargingCurrent( ) to zero and sets the TERMINATE_CHARGE_ALARM bit in Battery Status( ). The overcurrent condition and TERMINATE_CHARGE_ALARM are cleared when the measured current drops below *Overcurrent Margin*.
- Overvoltage: An overvoltage condition exists when the bq2083−V1P3 measures the battery voltage to be more than *Over Voltage Margin* plus ChargingVoltage( ), or when a cell voltage has exceeded the overvoltage limit programmed in *Cell Over Voltage*. *Over Voltage Margin* is programmed in DF 0x5a−0x5b and *Cell Over Voltage* in DF 0x60. On detecting an overvoltage condition, the bq2083−V1P3 sets the ChargingCurrent( ) to zero and sets the TERMINATE_CHARGE_ALARM bit in BatteryStatus( ). The bq2083−V1P3 clears the TERMINATE_CHARGE_ALARM bit when it detects that the battery is no longer being charged (DISCHARGING bit set in BatteryStatus( )). The bq2083−V1P3 continues to broadcast zero charging current until the overvoltage condition is cleared. The overvoltage condition is cleared when the measured battery voltage drops below the ChargingVoltage( ) plus the *Over Voltage Margin* and all cell voltages are less than the *Cell Over Voltage* Reset threshold in DF 0xcf, 0xd0.
- Overtemperature: An overtemperature condition exists when Temperature( ) is greater than or equal to the *Max Temperature* value programmed in DF 0x53, 0x54. On detecting an overtemperature condition, the bq2083−V1P3 sets the ChargingCurrent( ) to zero and sets the OVER_TEMP_ALARM and TERMINATE_CHARGE_ ALARM bit in BatteryStatus( ) and the CVOV bit in pack status. The overtemperature condition is cleared when Temperature( ) is equal to or below (*Max Temperature − Temperature Hysteresis* DF 0x55, 0x56) or 43°C.
- Overcharge: An overcharge condition exists if the battery is charged more than the *Maximum Overcharge* value after RM = FCC. *Maximum Overcharge* is programmed in DF 0x4e-0x4f. On detecting an overcharge condition, the bq2083−V1P3 sets the ChargingCurrent( ) to zero and sets the OVER_CHARGED_ALARM and TERMINATE_CHARGE_ ALARM bits in BatteryStatus( ). The bq2083−V1P3 clears the TERMINATE_CHARGE_ ALARM when it detects that the battery is no longer being charged and clears the OVER_CHARGED_ALARM when 2mAh of discharge are measured. The FULLY_CHARGED bit remains set and the bq2083−V1P3 continues to broadcast zero charging current until RelativeStateOfCharge( ) is less than *Fully Charged Clear*% programmed in DF 0x47. The counter used to track overcharge capacity is reset with 2 mAh of discharge.
- Undertemperature: An undertemperature condition exists if Temperature( ) < 0°C. On detecting an under temperature condition, the bq2083−V1P3 sets ChargingCurrent( ) to zero. The bq2083−V1P3 sets ChargingCurrent( ) to the appropriate precharge rate or fast-charge rate when Temperature( ) ≥ 0°C.

Primary Charge Termination

The bq2083−V1P3 terminates charge if it detects a charge-termination condition based on current taper. A charge-termination condition includes the following:

For current taper, ChargingVoltage( ) must be set to the pack voltage desired during the constant-voltage phase of charging. The bq2083−V1P3 detects a current taper termination when the pack voltage is greater than or equal to ChargingVoltage( ) minus *Current Taper Qual Voltage* in DF 0x4a and the charging current is below a threshold determined by *Current Taper Threshold* in DF 0x48−0x49 and above 22.5 mA for two consecutive 40-second intervals.

Once the bq2083−V1P3 detects a Primary Charge Termination, the bq2083−V1P3 sets the TERMINATE_CHARGE_ALARM and FULLY_CHARGED bits in BatteryStatus( ), and sets the ChargingCurrent( ) to the maintenance charge rate as programmed in *Maintenance Charging Current* DF 0x3f, 0x40. On termination, the bq2083−V1P3 also sets RM to a programmed percentage of FCC, provided that RelativeStateOfCharge( ) is below the desired percentage of FCC and the CSYNC bit in *Gauge Configuration* DF 0x29 is set. The programmed percentage of FCC, *Fast Charge Termination %*, is set in DF 0x46. The bq2083−V1P3 clears the FULLY_CHARGED bit when RelativeStateOfCharge( ) is less than the programmed *Fully Charged Clear %*. The bq2083−V1P3 broadcasts the fast-charge rate when the FULLY_CHARGED bit is cleared and voltage and temperature permit. The bq2083−V1P3 clears the TERMINATE_CHARGE_ALARM 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*		

The DMODE bit in *Pack Configuration* DF 0x28 programs the bq2083−V1P3 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 $\overline{DISP}$ 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 $\overline{DISP}$ 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 $\overline{DISP}$ input must be pulled up to V_{CC}.

If the EDV0 bit is set, the bq2083−V1P3 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−V1P3 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

Li-Ion Protector Control

The bq2083−V1P3 provides protection for Li-Ion batteries, as shown in Table 10. The bq2083−V1P3 uses the bq29311 to measure and report individual series cell voltages. The bq2083−V1P3 determines if a voltage protection condition has been breached and turns off the respective control FET via I^{2}C™ communication to the bq29311. It is recomm437n P Pro l 9063 Tw [960059(viaat tection for Li-Ion , as sho9 367.68be validatespby two success0 0 l serieTw tspby)

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

The bq2083−V1P3 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−V1P3 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−V1P3 increments an internal counter.

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

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

An example circuit using the $\overline{\text{SAFE}}$ output to blow a fuse is shown in Figure 5.

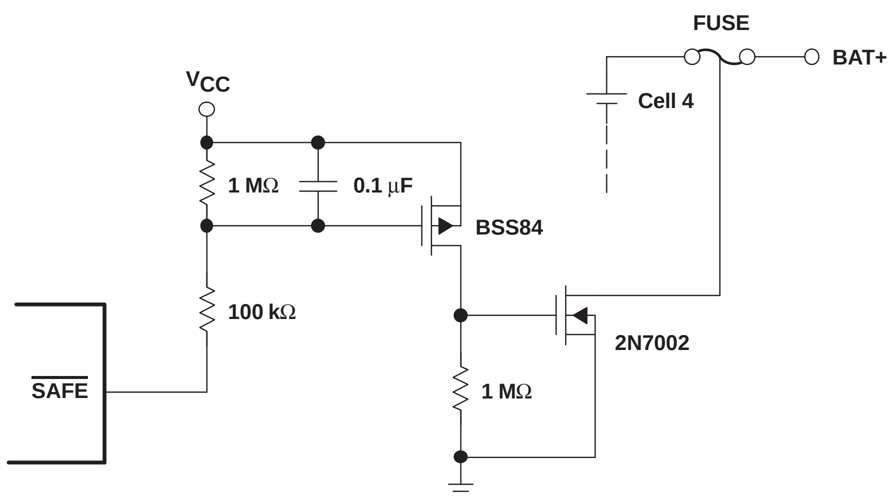


Figure 5. Example $\overline{\text{SAFE}}$ Circuit Implementation

Low-Power Modes

The bq2083−V1P3 enters sleep mode when the charge and discharge current is less than the threshold programmed in *Sleep Current Threshold* DF 0xe5, the SMBus lines are low for at least 2 s, and bit 4 of *Misc. Configuration* DF 0x2a is set to zero. The bq2083−V1P3 wakes up periodically to monitor voltage and temperature and to apply self-discharge adjustment. The sleep period is set in *Sleep Timer*

Device Reset

The following procedure resets the bq2083−V1P3:

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−V1P3 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−V1P3 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−V1P3. In this way a system can efficiently monitor and manage the battery.

SMBus

The SMBus interface is a command-based protocol. A processor acting as the bus master initiates communication to the bq2083−V1P3 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 bq2083−V1P3 device address of 0001011 (bits 7-1) plus a R/W bit (bit 0) followed by an SMBus command code. The R/W bit (LSB) and the command code instruct the bq2083−V1P3 to either store the forthcoming data to a register specified by the SMBus command code or output the data from the specified register. The processor completes the access with a stop condition. A stop condition consists of a low-to-high transition of the SMBD line while the SMBC is high. With SMBus, the most-significant bit (MSB) of a data byte is transmitted first.

In some instances, the bq2083−V1P3 acts as the bus master. This occurs when the bq2083−V1P3 broadcasts charging requirements and alarm conditions to device addresses 0x12 (SBS Smart Charger) and 0x10 (SBS Host Controller).

SMBus Protocol

The bq2083−V1P3 supports the following SMBus protocols:

- Read word
- Write word
- Block read

A processor acting as the bus master uses the three protocols to communicate with the bq2083−V1P3. The bq2083−V1P3 acting as the bus master uses the write word protocol.

The SMBD and SMBC pins are open drain and require external pullup resistors. A 1-MΩ pulldown resistor in the battery pack on SMBC and SMBD is required to assure the detection of the SMBus offstate, the performance of automatic offset calibration, and the initiation of the low-power sleep mode when the battery pack is removed.

SMBus Packet Error Checking

The bq2083−V1P3 supports packet error checking as a mechanism to confirm proper communication between it and another SMBus device. Packet error checking requires that both the transmitter and receiver calculate a packet error code (PEC) for each communication message. The device that supplies the last byte in the communication message appends the PEC to the message. The receiver compares the transmitted PEC to its PEC result to determine if there is a communication error.

PEC Protocol

The bq2083−V1P3 can receive or transmit data with or without PEC. Figure 6 shows the communication protocol for the read word, write word, and read block messages without PEC. Figure 7 includes PEC.

In the read word protocol, the bq2083−V1P3 receives the PEC after the last byte of data from the host. If the host does not support PEC, the last byte of data is followed by a stop condition. After receipt of the PEC, the bq2083−V1P3 compares the value to its calculation. If the PEC is correct, the bq2083−V1P3 responds with an ACKNOWLEDGE. If it is not correct, the bq2083−V1P3 responds with a NOT ACKNOWLEDGE and sets an error code.

In the write word and block read, the host generates an ACKNOWLEDGE after the last byte of data sent by the bq2083−V1P3. The bq2083−V1P3 then sends the PEC and the host acting as a master-receiver generates a NOT ACKNOWLEDGE and a stop condition.

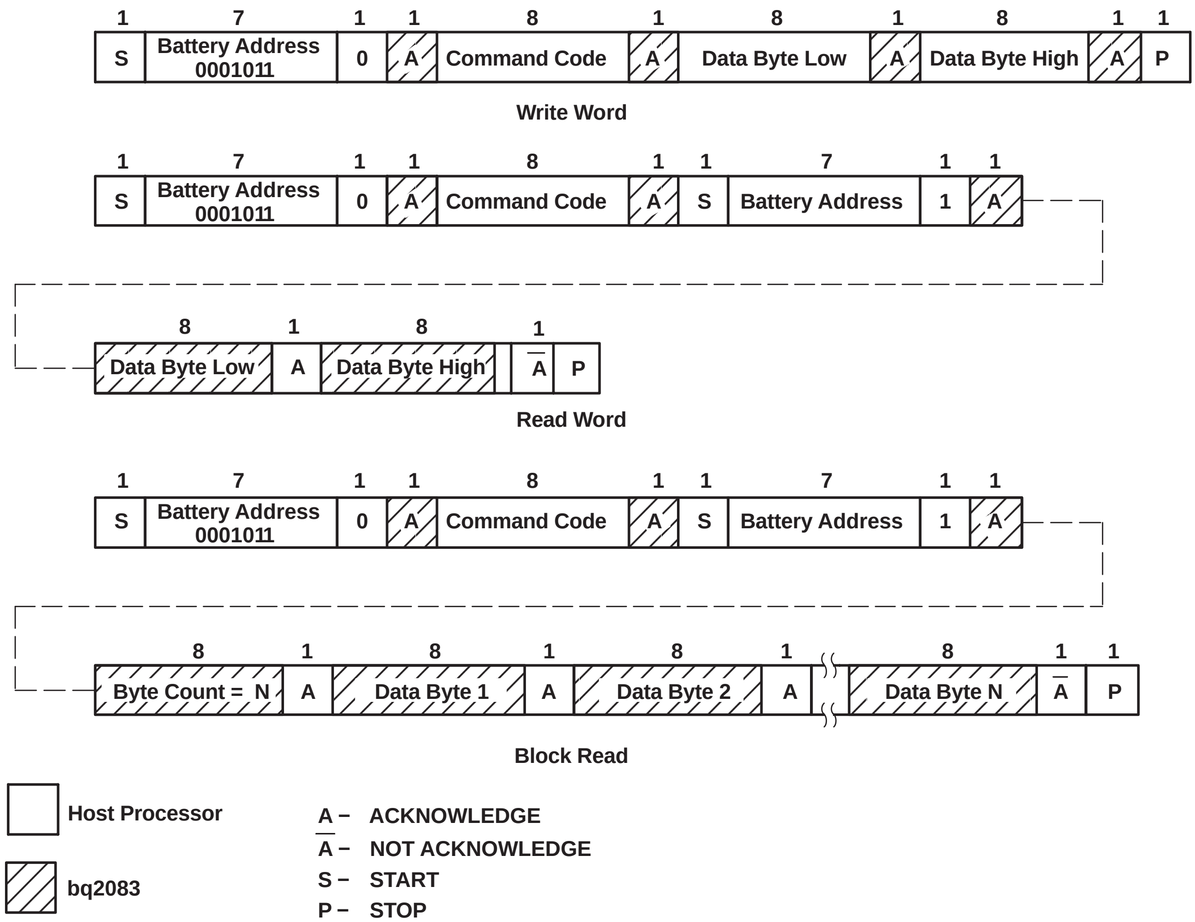
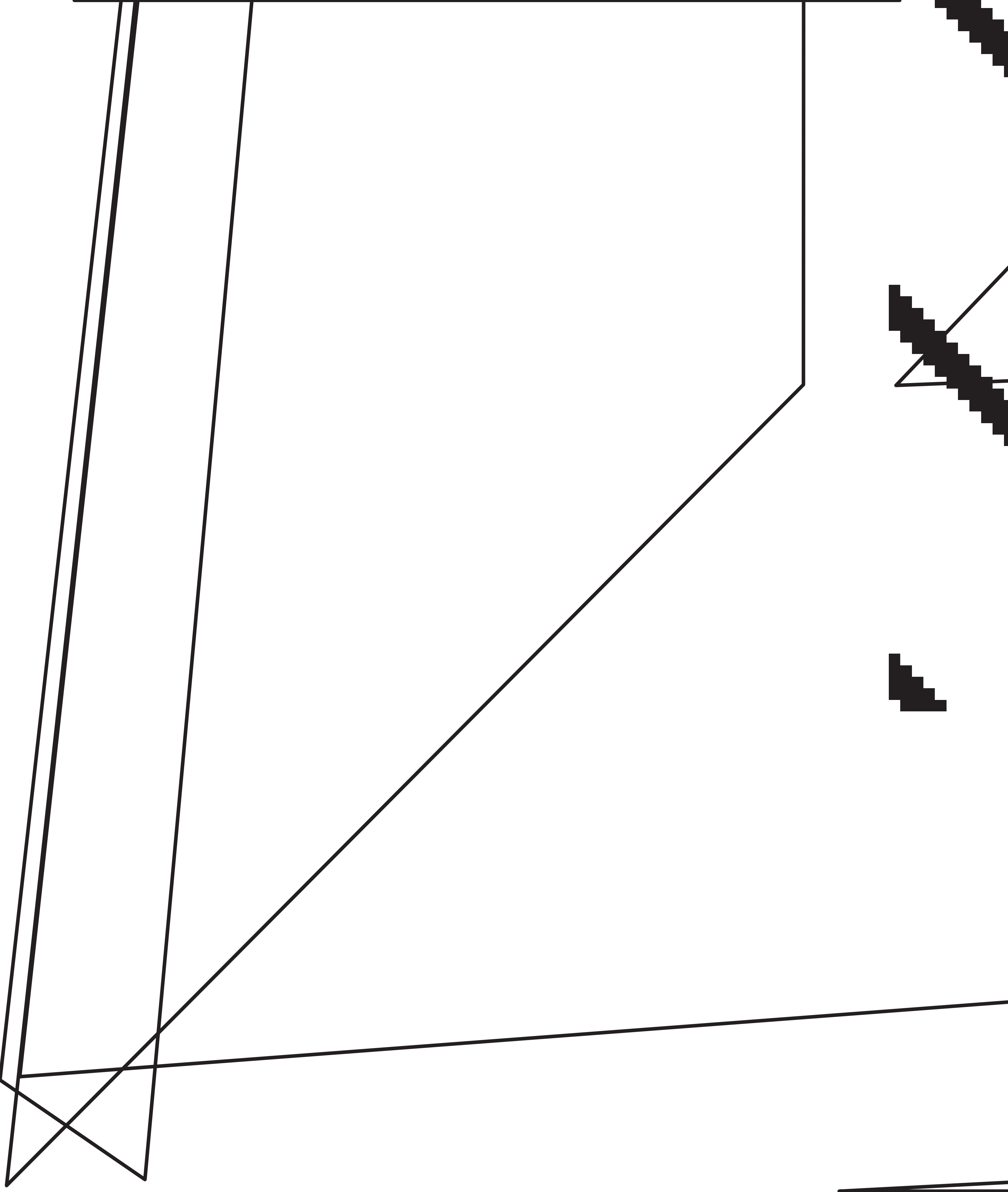


Figure 6. SMBus Communication Protocol Without PEC



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−V1P3 during normal

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−V1P3 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

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	7	Read only bit flag	0—Battery OK 1—Relearn cycle requested
CHARGE_CONTROLLER_ENABLED	8	R/W bit flag	
PRIMARY_BATTERY	9	R/W bit flag	
Reserved	10–12		
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 10mW or 10 mWh

ALARM_MODE bit is set to disable the bq2083−V1P3's ability to master the SMBus and send AlarmWarning( ) messages to the SMBus host and the smart battery charger. When set, the bq2083−V1P3 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 60 seconds and no less than 59 seconds. 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 bq2083−V1P3 resets the bit and starts or restarts a 60-seconds (nominal) timer. After the timer expires, the bq2083−V1P3 automatically enables alarm broadcasts to ensure that the accidental deactivation of broadcasts does not persist. An SMBus host that does not want the bq2083−V1P3 to be a master on the SMBus must therefore continually set this bit at least once per 59 seconds to keep the bq2083−V1P3 from broadcasting alarms.
- The ALARM_MODE bit defaults to a cleared state when the bq2083−V1P3 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 bq2083−V1P3's transmission of ChargingCurrent( ) and ChargingVoltage( ) messages to the smart battery charger. When set, the bq2083−V1P3 does *not* transmit ChargingCurrent( ) and ChargingVoltage( ) values to the smart battery charger. When cleared, the bq2083−V1P3 transmits the ChargingCurrent( ) and ChargingVoltage( ) values to the smart battery charger. The CHARGER_MODE bit defaults to a cleared state when the bq2083−V1P3 enters SLEEP mode.

CAPACITY_MODE bit indicates if capacity information is reported in mA/mAh or 10mW/10 mWh. When set, the bq2083−V1P3 reports capacity information in 10 mW/10 mWh as appropriate. When cleared, the bq2083−V1P3 reports capacity information in mA/mAh as appropriate. The CAPACITY_MODE bit defaults to a cleared state when the bq2083−V1P3 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 bq2083−V1P3 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−V1P3 (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 at the AtRate value of charge.
- When the AtRate( ) value is negative, the AtRateTimeToEmpty( ) function returns the predicted operating time at the AtRate value of discharge.
- When the AtRate( ) value is negative, the AtRateOK( ) function returns a boolean value that predicts the battery's ability to supply the AtRate value of *additional* discharge energy (current or power) for 10 seconds.

The default value for AtRate( ) is zero.

SMBus protocol: Read or write word

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

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

AtRateTimeToFull( ) (0x05)

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

Purpose: The AtRateTimeToFull( ) function is part of a two-function call-set used to determine the predicted remaining charge time at the AtRate value in mA. The bq2083−V1P3 updates AtRateTimeToFull( ) within 5 ms after the SMBus host sets the AtRate value. The bq2083−V1P3 automatically updates AtRateTimeToFull( ) based on the AtRate( ) value every 1 s.

SMBus protocol: Read word

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

Units: Minutes

Granularity: 0.1°K

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

Voltage( ) (0x09)

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

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

SMBus protocol: Read word

Output: Unsigned integer—battery terminal voltage in mV.

Units: mV

Range: 0 to 20,000 mV

Granularity: 1 mV

Accuracy: ±0.25% (after calibration)

Current( ) (0x0a)

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

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

SMBus protocol: Read word

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

Units: mA

Range: −32,768 to 32,767 mA

Granularity: 1 mA

Accuracy: 0.25% or 5 mA, whichever is greater

AverageCurrent( ) (0x0b)

Description: Returns a value that approximates a one-minute rolling average of the current being supplied (or accepted) through the battery terminals (mA). The AverageCurrent( ) function returns values equivalent to Current( ) during the battery's first minute of operation.

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:

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: 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	0–65,535mAh	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.

Purpose: The FullChargeCapacity( ) function provides a means of understanding the tank size 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 RunTimeToEmpty( ) provides the power management system with information about the relative gain or loss in remaining battery life in response to a change in power policy. This information is **not** the same as the AverageTimeToEmpty( ), which is not suitable to determine the effects that result from a change in power policy.

SMBus protocol: Read word

Output: Unsigned integer—minutes of operation left.

Units: Minutes

Range: 0 to 65,534 min

Granularity: 2 min or better

Accuracy: −0, +MaxError( ) * FullChargeCapacity( ) / Current( )

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

AverageTimeToEmpty( ) (0x12)

Description: Returns a one-minute rolling average of the predicted remaining battery life (minutes). The AverageTimeToEmpty( ) value is calculated based on either current or power depending on the setting of the BatteryMode( ) CAPACITY_MODE bit.

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

SMBus protocol: Read word

Output:

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 one-minute rolling average of the predicted remaining time until the battery reaches full charge (minutes).

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. The ChargingCurrent( ) value should be used in combination with the ChargingVoltage( ) value to set the charger's operating point. Together, these functions permit the bq2083−V1P3 to dynamically control the charging profile (current/voltage) of the battery. The bq2083−V1P3 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 bq2083−V1P3 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: 1mV

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 bq2083−V1P3 status word (flags). Some of the BatteryStatus( ) flags (REMAINING_CAPACITY_ALARM 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 bq2083−V1P3. This is basically the same information broadcast to both the SMBus host and the smart battery charger by the AlarmWarning( ) function except that the AlarmWarning( ) function sets the error code bits all high before sending the data.

SMBus protocol: Read word

Output: Unsigned Integer-Status Register with Alarm Conditions Bit Mapped as follows:

ALARM BITS	
0x8000	OVER_CHARGED_ALARM
0x4000	TERMINATE_CHARGE_ALARM
0x2000	Reserved
0x1000	OVER_TEMP_ALARM
0x0800	TERMINATE_DISCHARGE_ALARM
0x0400	Reserved
0x0200	REMAINING_CAPACITY_ALARM
0x0100	REMAINING_TIME_ALARM
STATUS BITS	
0x0080	Initialized
0x0040	DISCHARGING
0x0020	FULLY_CHARGED
0x0010	FULLY_DISCHARGED
ERROR CODES	
0x0007	Unknown Error
0x0006	BadSize
0x0005	Overflow/Underflow
0x0004	AccessDenied
0x0003	UnsupportedCommand
0x0002	ReservedCommand
0x0001	Busy
0x0000	OK

Alarm Bits

OVER_CHARGED_ALARM bit is set whenever the bq2083−V1P3 detects that the battery is being charged beyond the maximum overcharge limit. This bit is cleared when the bq2083−V1P3 detects that the battery is no longer being charged and there are 2 mAh of continuous discharge (i.e., the bq2083−V1P3 detects discharge activity or no activity above the digital filter).

TERMINATE_CHARGE_ALARM bit is set when the bq2083−V1P3 detects that one or more of the battery charging parameters are out of range (e.g., its voltage, current, or temperature is too high) or when the bq2083−V1P3 detects a primary charge termination. This bit is cleared when the parameter falls back into the allowable range, the termination condition ceases, or when the bq2083−V1P3 detects that the battery is no longer being charged.

OVER_TEMP_ALARM bit is set when the bq2083−V1P3 detects that the internal battery temperature is greater than or equal to the *Max Temperature* threshold. This bit is cleared when the internal temperature falls back into the acceptable range.

TERMINATE_DISCHARGE_ALARM bit is set when any of the following are true: RM = 0, Voltage( ) ≤ *Terminate Voltage*, 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 Voltage*. The bit is cleared when all of the following are true: Voltage( ) > *Terminate Voltage*, RM( ) > 0, and the CVUV bit is cleared.

REMAINING_CAPACITY_ALARM bit is set when the bq2083−V1P3 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 bq2083−V1P3 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 bq2083−V1P3 is has detected a valid load of data flash at full or partial reset. It is cleared when the bq2083−V1P3 detects an improper data flash load.

DISCHARGING bit is set when the bq2083−V1P3 determines that the battery is not being charged. This bit is cleared when the bq2083−V1P3 detects that the battery is being charged.

FULLY_CHARGED bit is set when the bq2083−V1P3 detects a primary charge termination or an Overcharge condition. It

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−V1P3 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−V1P3 VScale (voltage scaling) and IPScale (current scaling) should always be set to zero. The bq2083−V1P3 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)

ManufactureDate( ) (0x1b)

Description: This function returns the date the cell pack was manufactured in a packed integer. The date is packed in the following fashion: (year-1980) * 512 + month * 32 + day. The bq2083−V1P3 sets ManufactureDate( ) to the value programmed in *Manufacture Date* DF 0x08−0x09.

Purpose: The ManufactureDate( ) provides the system with information that can be used to uniquely identify a particular battery pack when used in conjunction with SerialNumber( ).

SMBus protocol: Read word

Output: Unsigned integer—packed date of manufacture.

FIELD	BITS USED	FORMAT	ALLOWABLE VALUES
Day	0...4	5-bit binary value	0–31 (corresponds to date)
Month	5...8	4-bit binary value	1–12 (corresponds to month number)
Year	9...15	7-bit binary value	0−127 (corresponds to year biased by 1980)

SerialNumber( ) (0x1c)

Description: This function is used to return a serial number. This number, when combined with the ManufacturerName( ), the DeviceName( ), and the ManufactureDate( ), uniquely identifies the battery (unsigned integer). The bq2083−V1P3 sets SerialNumber( ) to the value programmed in *Serial Number* DF 0x0a−0x0b.

Purpose: The SerialNumber( ) function can be used to identify a particular battery. This may be important in systems that are powered by multiple batteries where the system can log information about each battery that it encounters.

SMBus protocol: Read word
Output: Unsigned integer

ManufacturerName( ) (0x20)

Description: This function returns a character array containing the battery manufacturer's name. For example, MyBattCo identifies the smart battery manufacturer as MyBattCo. The bq2083−V1P3 sets ManufacturerName( ) to the value programmed in *Manufacturer Name Length* DF 0x0e−0x19.

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

SMBus protocol: Read block

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

DeviceName( ) (0x21)

Description: This function returns a character string that contains the battery name. For example, a

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−V1P3 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−V1P3 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
Rechargeable alkaline-manganese	RAM
Zinc air	ZnAr

The ManufacturerData( ) (0x23)

Description: This function allows access to the manufacturer data contained in the battery (data). The bq2083−V1P3 stores seven critical operating parameters in this data area.

Purpose: The ManufacturerData( ) function may be used to access the manufacturer’s data area. The data fields of this command reflect the programming of eight critical data flash locations and can be used to facilitate evaluation of the bq2083−V1P3 under various programming sets. The ManufacturerData( ) function returns the following information in order: *Pack Configuration, Gauge Configuration, Misc Configuration, Digital Filter, Self Discharge Rate, Pack Load Estimate, Battery Low%, and Near Full* (2 bytes) AFE Status, and the pending EDV threshold voltage (low byte and high byte).

SMBus protocol: Read block

Output: Block data—data that reflects data flash programming as assigned by the manufacturer with maximum length of 13 characters (12 + length byte).

Pack Status and Pack Configuration (0x2f)

This function returns the pack status and pack configuration registers. The pack status register contains a number

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−V1P3.

0 The bq2083−V1P3 is in the unsealed state.
1 The bq2083−V1P3 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−V1P3 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−V1P3 accesses the internal data flash during reset and when storing historical data. The data flash stores basic configuration information for use by the bq2083−V1P3. The data flash must be programmed correctly for proper bq2083−V1P3 operation.

Memory Map

Table 13 shows the memory map for the data flash. It shows the default programming for the bq2083−V1P3. 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.

Read

Reading the data flash is a two step process:

1. Using the SMBus write word protocol, use command code 0x51 and let the LSB data byte be the address of the flash location. The MSB data byte is set to 0.
2. Using the SMBus read word protocol, use command code 0x52 to retrieve the data.

Write

Using the SMBus write word protocol, use command code 0x50. Place the address of the flash location into the LS byte of the data word. Place the data to be written into the MS byte data word.

Table 13. Data Flash Memory Map

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x00	0x01	*Remaining Time Alarm*	10 minutes	00	0a
0x02	0x03	*Remaining Capacity Alarm*	360 mAh	01	68
0x04	0x05	*Design Voltage*	10800 mV	2a	30
0x06	0x07	*Specification Information*	v1.1/PEC	00	31
0x08	0x09	*Manufacture Date*	2/15/02=11343	2c	4f
0x0a	0x0b	*Serial Number*	1	00	01
0x0c	0x0d	*Cycle Count*	0	00	00
0x0e		*Manufacturer Name Length*	11		0b
0x0f		Character 1	T		54
0x10		Character 2	e		45
0x11		Character 3	x		58
0x12		Character 4	a		41
0x13		Character 5	s		53
0x14		Character 6			20
0x15		Character 7	I		49
0x16		Character 8	n		4e
0x17		Character 9	s		53
0x18		Character 10	t		54
0x19		Character 11	.		2e
0x1a		*Device Name Length*	6		06
0x1b		Character 1	b		42
0x1c		Character 2	q		51
0x1d		Character 3	2		32
0x1e		Character 4	0		30
0x1f		Character 5	8		38
0x20		Character 6	3		33
0x21		Character 7	—		00
0x22		*Device Chemistry Length*	4		04
0x23		Character 1	L		4c
0x24		Character 2	I		49
0x25		Character 3	O		4f
0x26		Character 4	N		4e
0x27		*Manufacturer Data Length*	12		09
0x28		*Pack Configuration*	DMODE, LED1, CC1		c2
0x29		*Gauge Configuration*	CSYNC		

Table 13. Data Flash Memory Map (Continued)

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x31	0x32	*Design Capacity*	3600 mAh	0e	10
0x33	0x34	Reserved	0	00	00
0x35	0x36	*Last Measured Discharge*	3600 mAh	0e	10
0x37	0x38	*Cycle Count Threshold*	2880 mAh	0b	40
0x39	0x3a	*Charging Voltage*	12600 mV	31	38
0x3b	0x3c	*Precharge Voltage*	8000 mV	1f	40
0x3d	0x3e	*Fast-Charging Current*	2500 mA	09	c4
0x3f	0x40	*Maintenance Charging Current*	0 mA	00	00
0x41	0x42	*Precharge Current*	100 mA	00	64
0x43		*Precharge Temp*	9.6°C		60
0x44		Reserved			1e
0x45		Reserved			00
0x46		*Fast Charge Termination %*	100%		ff
0x47		*Fully Charged Clear %*	95%		5f
0x48	0x49	*Current Taper Threshold*	240 mA	00	f0
0x4a	0x4b	*Current Taper Qual Voltage*	100 mV	00	64
0x4c		Reserved			28
0x4d		Reserved			40
0x4e	0x4f	*Maximum Overcharge*	300 mAh	01	2c
0x50		Reserved			02
0x51		*Charge Efficiency*	100%		ff
0x52		Reserved			64
0x53	0x54	*MaxTemperature*	54.6°C	02	22
0x55		*Temperature Hysteresis*	5°C		32
0x56	0x57	Reserved		01	ae
0x58	0x59	*Overload Current*	5000 mA	13	88
0x5a	0x5b	*Over Voltage Margin*	208 mV	00	d0
0x5c	0x5d	*Overcurrent Margin*	500 mA	01	f4
0x5e	0x5f	Reserved		01	00
0x60	0x61	*Cell Over Voltage*	4350 mV	10	fe
0x62	0x63	*Cell Under Voltage*	2300 mV	08	fc
0x64	0x65	*Terminate Voltage*	8500 mV	21	34
0x66	0x67	Reserved		00	00
0x68	0x69	*Safety Over Voltage*	20000 mV	4e	20
0x6a	0x6b	*Safety Over Temperature*	70°C	02	bc
0x6c					

Table 13. Data Flash Memory Map (Continued)

DATA FLASH ADDRESS		NAME	LI-ION EXAMPLE	DATA	
HIGH BYTE	LOW BYTE			MSB	LSB
0x72		Reserved			40
0x73	0x74	*VOC50*	11430 mV	2c	a6
0x75		Reserved			7f
0x76		Reserved			3d
0x77		Reserved			27
0x78	0x79	*VOC25*	11270 mV	2c	06
0x7a		Reserved			3f
0x7b		Reserved			24
0x7c		Reserved			0e
0x7c		Reserved			14
0x7e		Reserved			40
0x7f	0x80	Reserved		0b	e1
0x81	0x82	Reserved		0b	68
0x83		Reserved			19
0x84	0x85	*EMF/EDV0*	3000 mV	0b	b8
0x86	0x87	*EDV C0 Factor/EDV1*	3250 mV	0c	b2
0x88	0x89	*EDV R0 Factor/EDV2*	3400 mV	0d	48
0x8a	0x8b	*EDV T0 Factor*	0	00	00
0x8c	0x8d	*EDV R1 Factor*	0	00	00
0x8e		*EDV TC Factor*	0		00
0x8f		*EDV C1 Factor*	0		00
0x90		Reserved			08
0x91		Reserved			9b
0x92		Reserved			c7
0x93		Reserved			64
0x94		Reserved			14
0x95	0x96	Reserved		02	00
0x97	0x98	Reserved		01	00
0x99		Reserved			08
0x9a		Reserved			02
0x9b		*Learning Low Temp*	11.9°C		77
0x9c		Reserved			0a
0x9d	0x9e	Reserved		01	80
0x9f	0xa0	Reserved		01	00
0xa1		Reserved			08
0xa2		Reserved			18
0xa3		Reserved			14
0xa4	0xa5	TS Const 1		91	83
0xa6	0xa7	TS Const 2		51	70
0xa8	0xa9	TS Const 3		e2	8f
0xaa	0xab	TS Const 4		0f	ac

NOTE: Reserved locations must be set as shown. Locations marked with an * are typical calibration values that can be adjusted for maximum accuracy. For these locations the table shows the appropriate default or initial setting.

[redacted]TS

[redacted]ET 1.96 526.080 8 60.

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

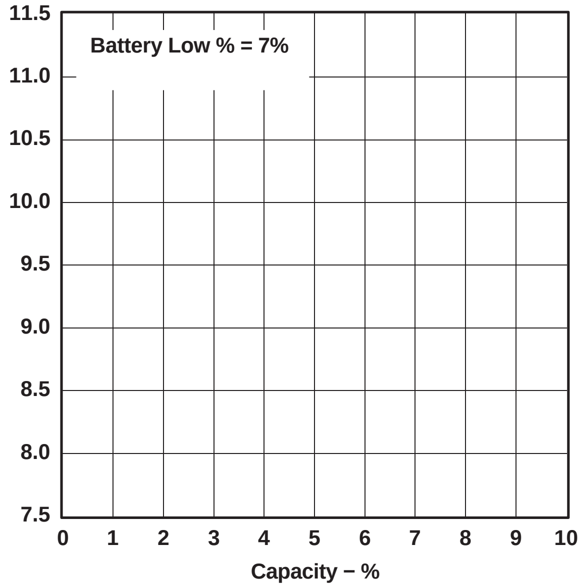
The 32-bit *CC Delta* DF 0xbc−0xbf corrects the coulomb counter for sense resistor variations. It represents the gain factor for the coulomb counter.

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.

$$\textit{Sense Resistor Gain} = \frac{306.25}{Rs}$$

Digital Filter

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


Battery Low % = 7%
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
0
1
2
3
4
5
6
7
8
9
10
Capacity − %

Change Control

Charging Voltage

The 16-bit value, *Charging Voltage*

Fast Charge Termination Percentage

The bq2083−V1P3 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

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 bq2083−V1P3.

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 bq2083−V1P3 for the number of series cells in the battery pack.

1−1 Configures the bq2083−V1P3 for four series cells

1−0 Configures the bq2083−V1P3 for three series cells

Gauge Configuration

Gauge Configuration DF 0x29 contains bit programmable features:

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

CSYNC

In usual operation of the bq2083−V1P3, 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 bq2083−V1P3 does not alter RM at the time of a valid charge termination.

1 The bq2083−V1P3 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 bq2083−V1P3 implements automatic EDV compensation to calculate the EDV0, EDV1, and EDV2 thresholds base on rate, temperature, and capacity. If the bit is cleared, the bq2083−V1P3 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the bq2083−V1P3 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 pack or highest cell voltages.

0 Safety over voltage based on pack voltage

1 Safety over voltage based on highest cell voltage multiplied by the number of cells and then compared to the safety voltage

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−V1P3 to use its internal temperature sensor.

0 bq2083−V1P3 requires an external thermistor.

1 bq2083−V1P3 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−V1P3 to enter sleep mode on SMBus inactivity.

0 bq2083−V1P3 enters sleep mode when the SMBus is low for 2 s.

1 bq2083−V1P3 does not enter sleep mode.

OT

The OT bit programs the bq2083−V1P3 to turn off the discharge FET when the bq2083−V1P3 detects an overtemperature condition. Charge FET is always turned off in overtemperature conditions.

0 bq2083−V1P3 does not turn off the discharge FET on overtemperature.

1 bq2083−V1P3 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−V1P3 to control a precharge FET.

0 The bq2083−V1P3 does not control a precharge FET.

1 The bq2083−V1P3 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( ).

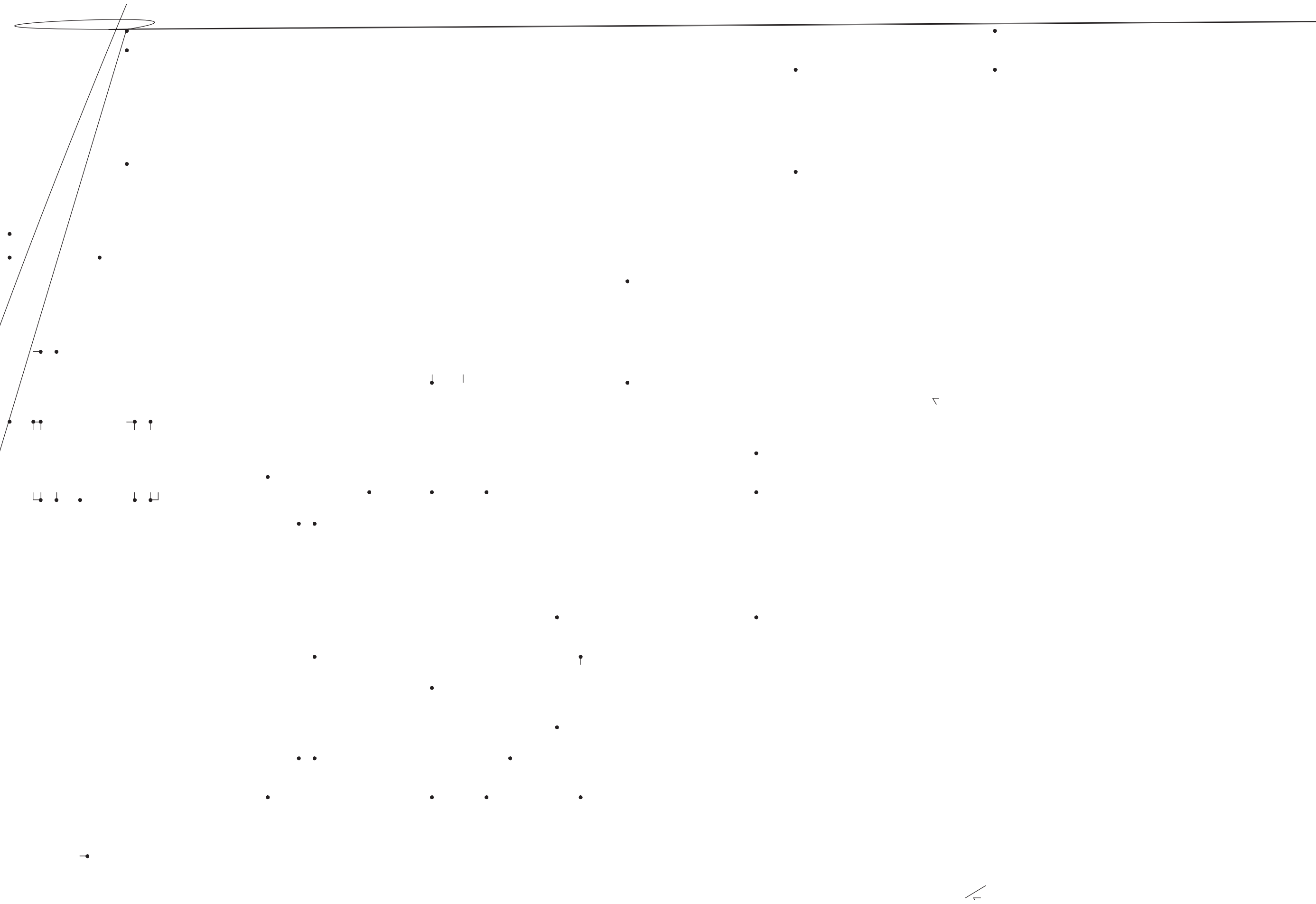
Serial Number

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 ASCIIhe charge

APPLICATION INFORMATION



PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
BQ2083DBT-V1P3	ACTIVE	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2083DBT-V1P3G4	ACTIVE	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2083DBTR-V1P3	ACTIVE	TSSOP	DBT	38	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2083DBTR-V1P3G4	ACTIVE	TSSOP	DBT	38	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

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

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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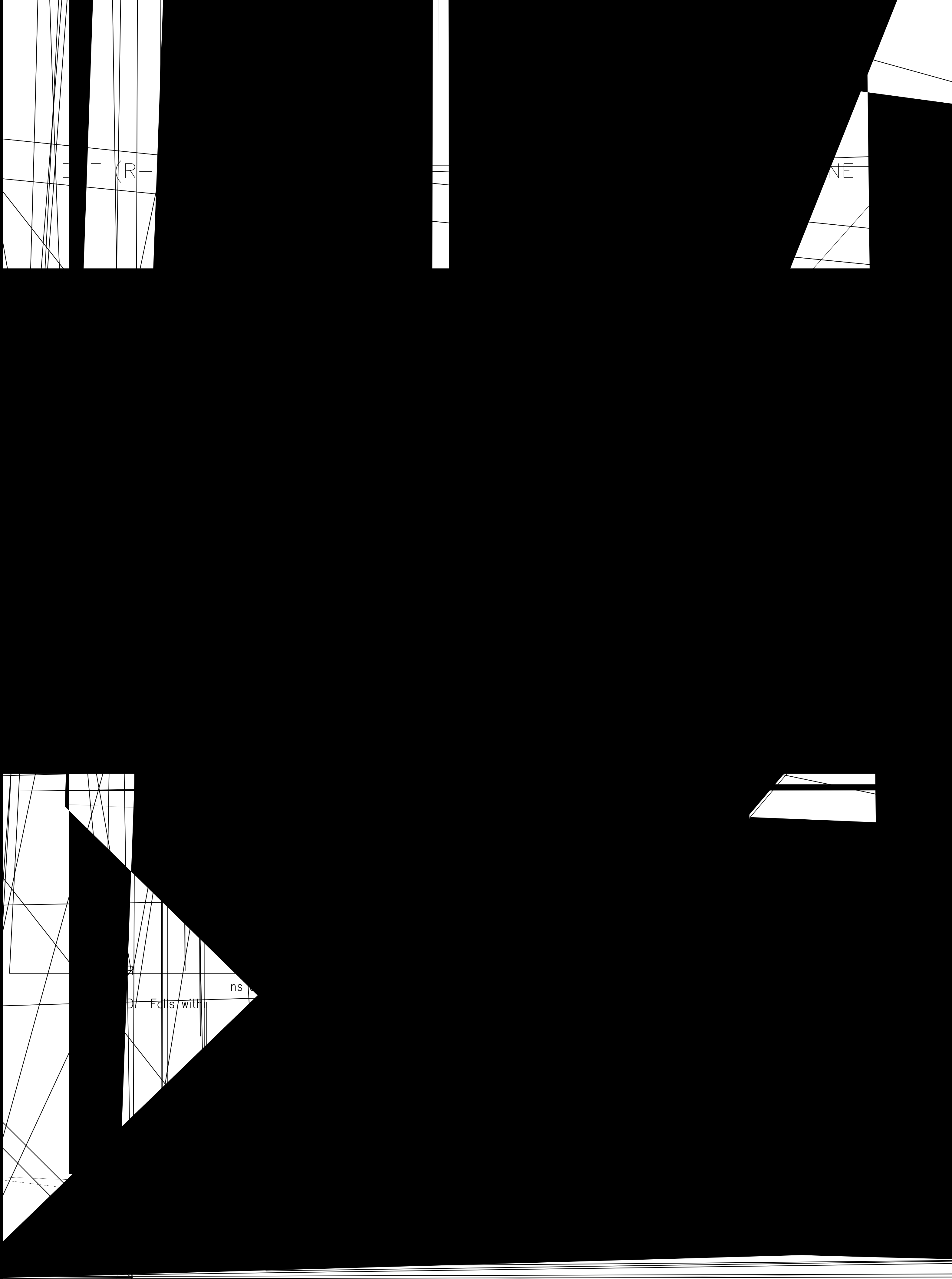
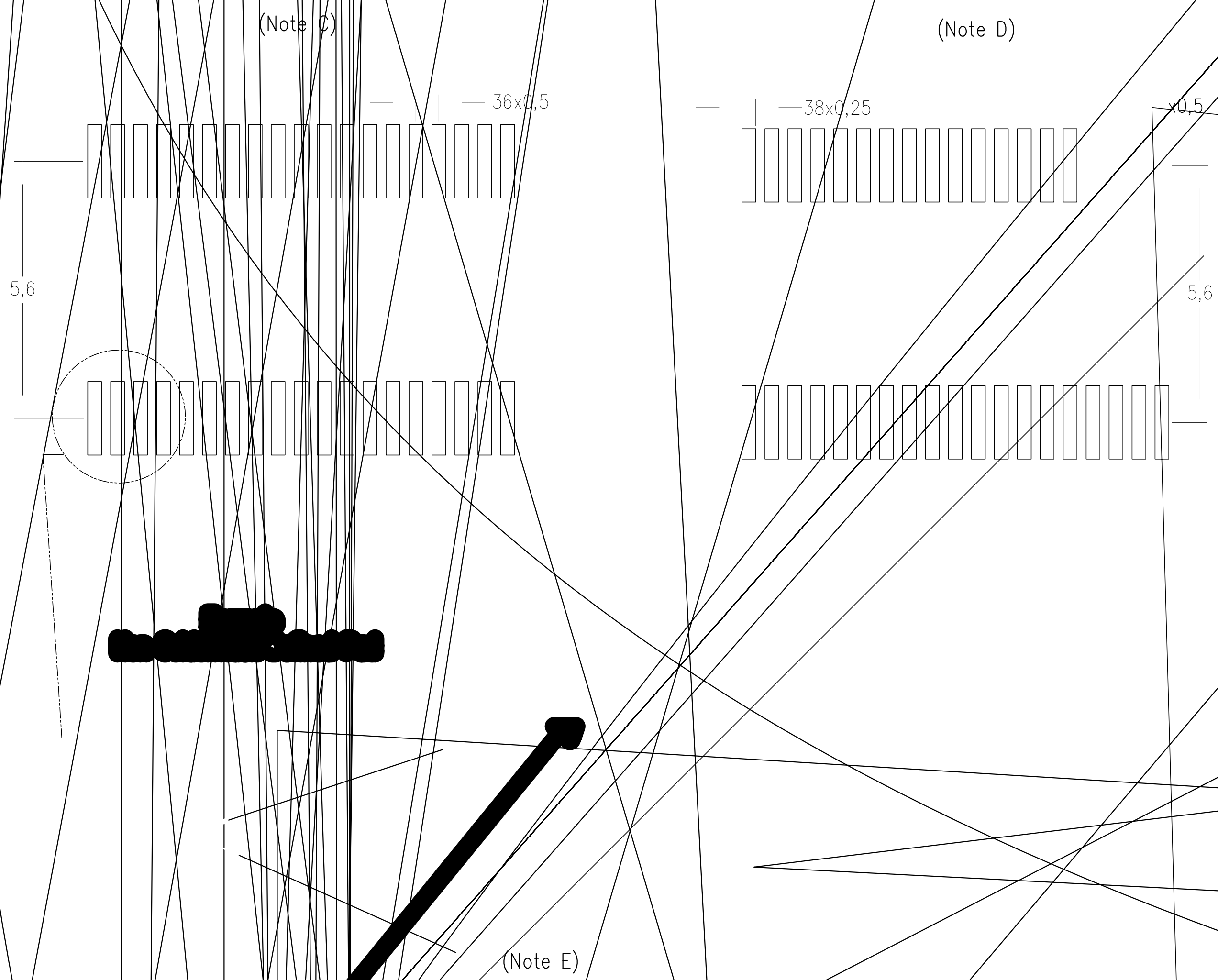


D T (R- [redacted] NE
[redacted]
ns [redacted]
Di Falls with [redacted]

LAND PATTERN DATA

PLASTIC SMALL OUTLINE



NOTES: dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Publication IPC 7351 is

D. res with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site

E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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