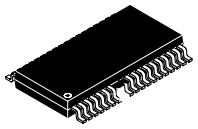


SBS-COMPLIANT GAS GAUGE IC FOR USE WITH THE bq29311

FEATURES

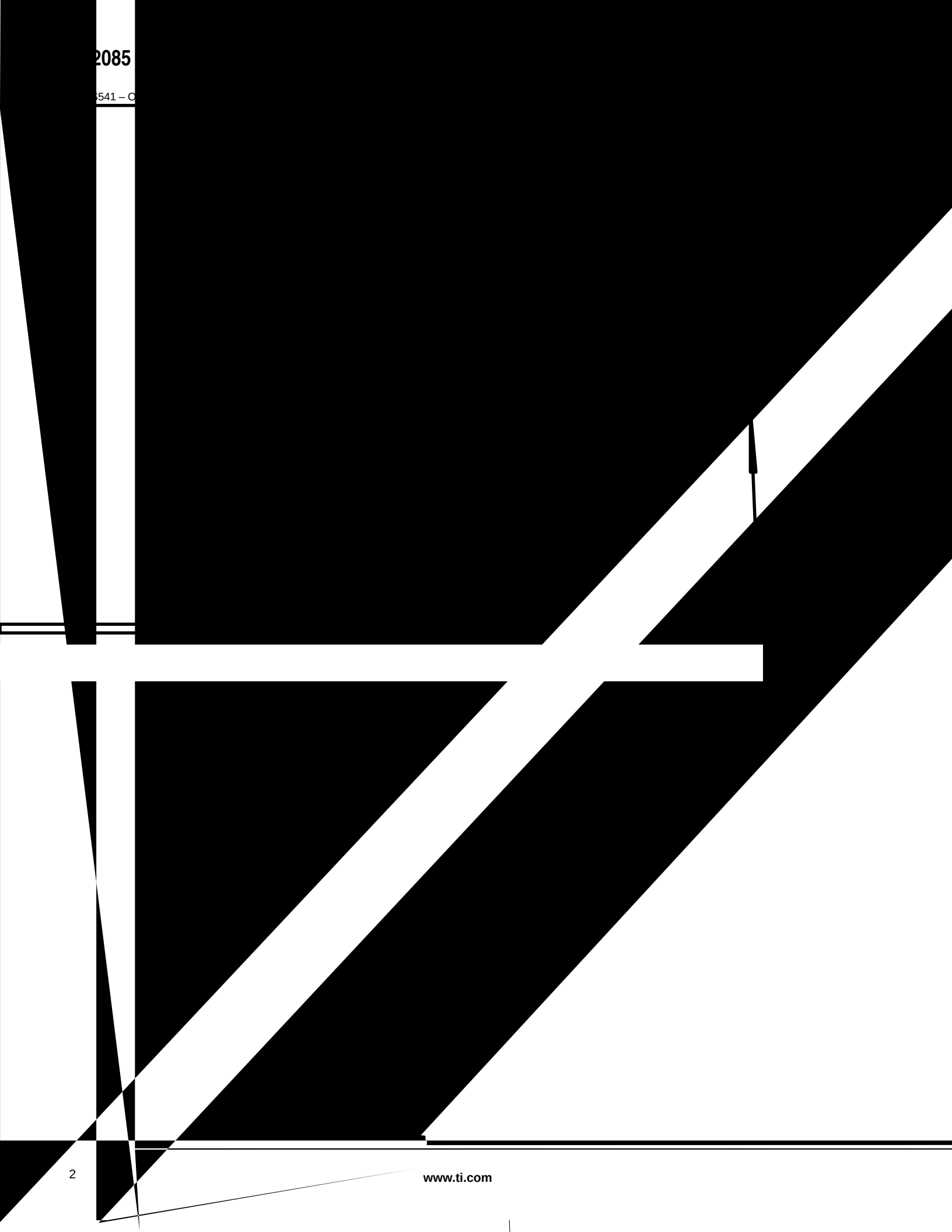
- **Provides Accurate Measurement of Available Charge in Li-Ion and Li-Polymer Batteries**
- **Supports the Smart Battery Specification (SBS) V1.1**
- **Integrated Time Base Removes Need for External Crystal**
- **Works With the TI bq29311 Analog Front End (AFE) Protection IC to Provide Complete Pack 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)**

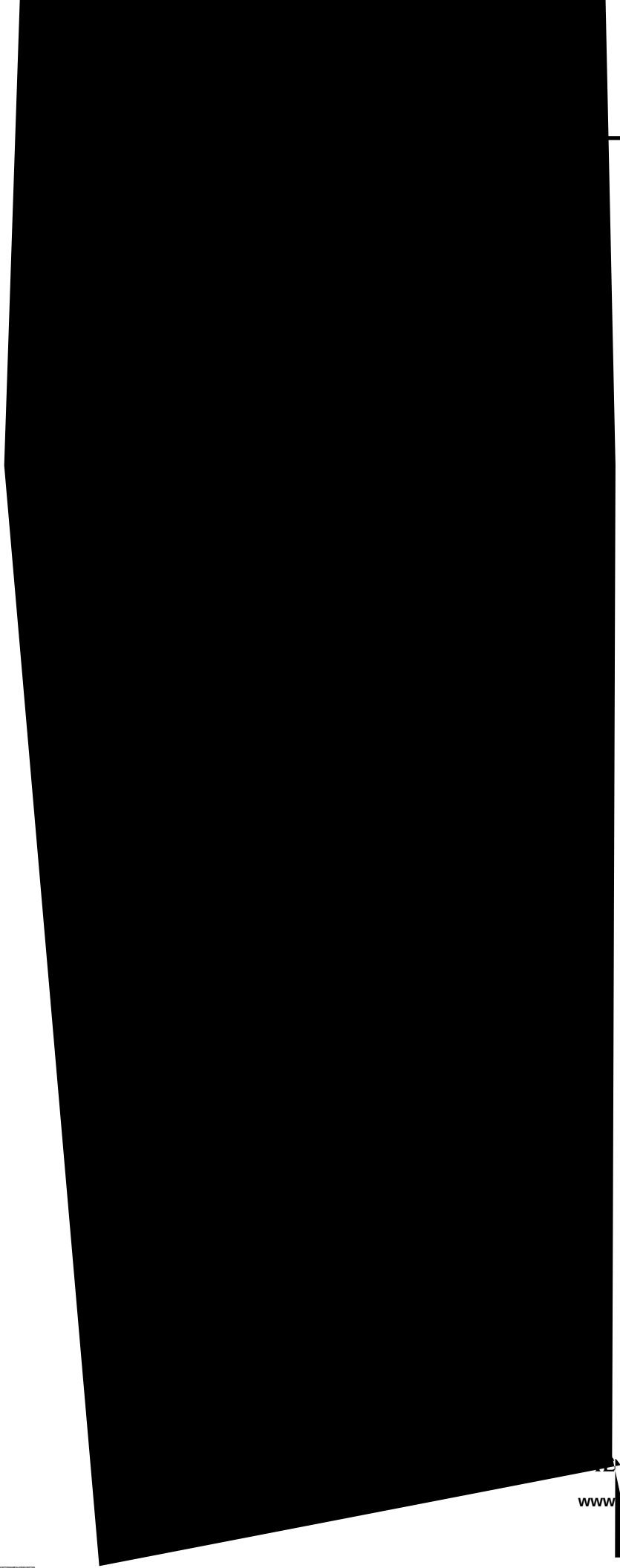
APPLICATIONS

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

DESCRIPTION

The bq2085 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 bq2085 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. istr for





SMBus TIMING SPECIFICATIONS

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_{SMB}	SMBus operating frequency	Slave mode, SMBC 50% duty cycle	10		100	kHz
F_{MAS}	SMBus master clock frequency	Master mode, no clock low slave extend		51.2		kHz
T_{BUF}	Bus free time between start and stop		4.7			µs
$T_{HD:STA}$	Hold time after (repeated) start		4.0			µs
$T_{SU:STA}$	Repeated start setup time		4.7			µs
$T_{SU:STO}$	Stop setup time		4.0			µs
$T_{HD:DAT}$	Data hold time	Receive mode	0			µs
		Transmit mode	300			
$T_{SU:DAT}$	Data setup time		250			µs
$T_{TIMEOUT}$	Error signal/detect	See Note 5	25		35	ms
T_{LOW}	Clock low period		4.7			µs
T_{HIGH}	Clock high period	See Note 6	4.0		50	µs
$T_{LOW:SEXT}$	Cumulative clock low slave extend time	See Note 7			25	ms
$T_{LOW:MEXT}$	Cumulative clock low master extend time	See Note 8			10	ms
T_F	Clock/data fall time	See Note 9			300	ns
T_R	Clock/data rise time	See Note 10			1000	ns

NOTES: 5. The bq2085 times out when any clock low exceeds $T_{TIMEOUT}$

Measurements

The bq2085 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 bq2085 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 bq2085 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 2.6 nVh. The bq2085 updates Remaining Capacity() with the charge or discharge accumulated in this internal counter once every second.

Offset Calibration

The bq2085 provides an autocalibration feature to cancel the voltage offset error across SR_1 and SR_2 for maximum charge measurement accuracy. The bq2085 performs autocalibration when the SMBus lines stay low for a minimum of 20 s. The bq2085 is capable of automatic offset calibration down to 1µV.

Digital Filter

The bq2085 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 bq2085 monitors the individual series cell voltages through the bq29311. The bq2085 configures the bq29311 to present the selected cell to the VCELL pin of the bq29311 which should be connected to VIN of the bq2085. The internal ADC of the bq2085 then measures the voltage and scales it appropriately. The bq2085 then reports the Voltage( ) and the individual cell voltages in VCELL1, VCELL2, VCELL3, and VCELL4 located in 0x3c–0x3f.

Current

The bq2085 uses the SR1 and SR2 inputs to measure and calculate the battery charge and discharge current as represented in the data register Current().

Temperature

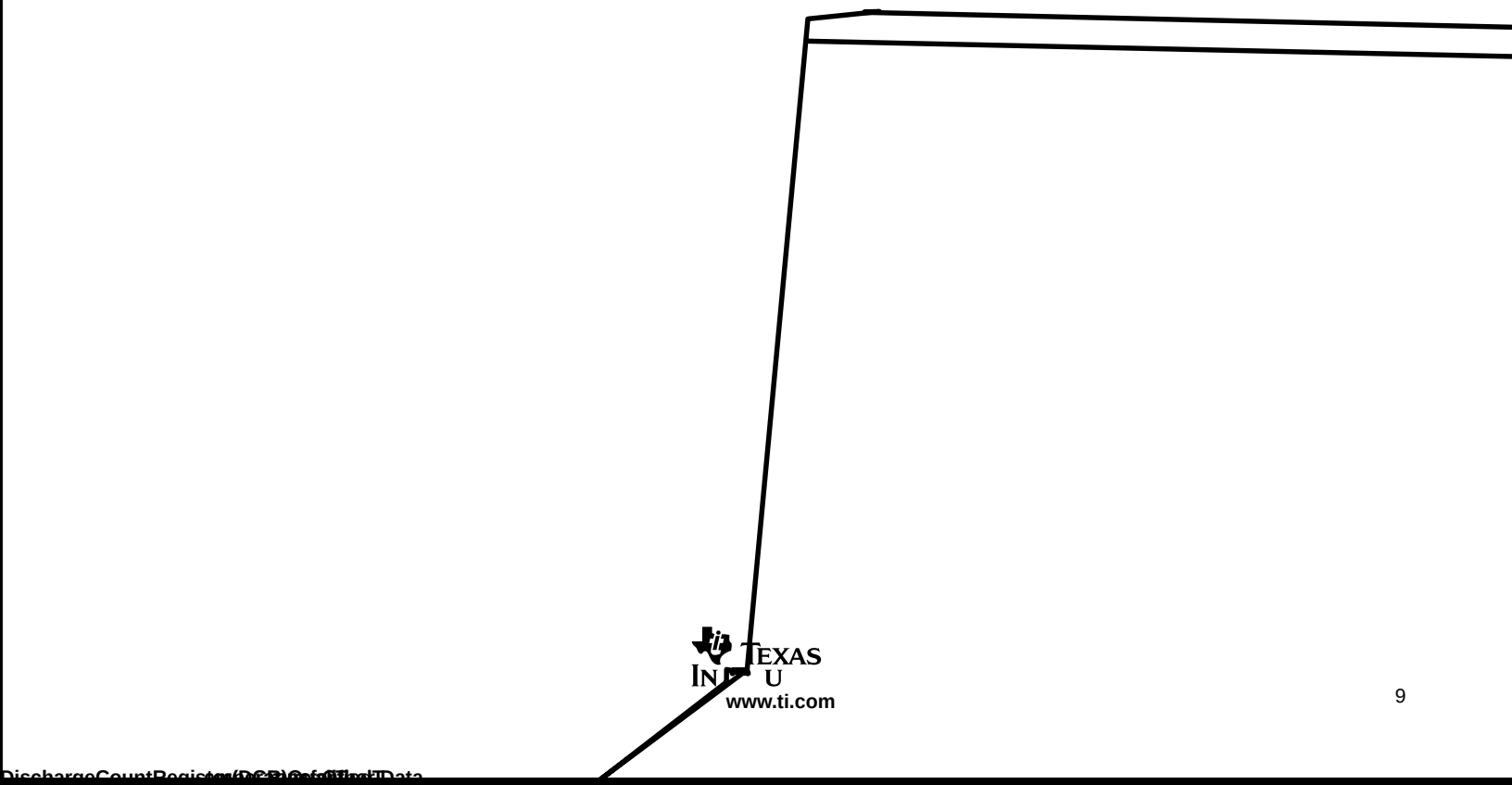
The TS input of the bq2085 in conjunction with an NTC thermistor measures the battery temperature as shown in the schematic. The bq2085 reports temperature in Temperature( ).

The bq2085 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. Configuration	42 (0x2a)	Bit 7 = 1	Bit 7 = 0
TS Const1	164/5 (0xa4/5)	0 (a3)	37251 (0x9183)
TS Const2	166/7 (0xa6/7)	0 (a2)	20848 (0x5170)
TS Const3	168/9 (0xa8/9)	–11136 (a1)	57999 (0xe28f)
TS Const4	170/1 (0xaa/b)	5754 (a0)	4012 (0x0fac)
TS Const5	172/3 (0xac/d)	13348 (3424)	5190 (0x1446)



RemainingCapacity( ) (RM)

RM represents the remaining capacity in the battery. The bq2085 computes RM in units of either mAh or 10 mWh depending on the selected mode. See Battery Mode( ) (0x03) for units configuration.

RM counts up during charge to a maximum value of FCC and down during discharge and self-discharge to a minimum of 0. In addition to charge and self-discharge compensation, the bq2085 calibrates RM at three low-battery-voltage thresholds, EDV2, EDV1, and EDV0 and three programmable midrange thresholds VOC25, VOC50, and VOC75. This provides a voltage-based calibration to the RM counter.

DesignCapacity( ) (DC)

DC is the user-specified battery full capacity. It is calculated from *Pack Capacity* DF 0x31-0x32 and is represented in units of mAh or 10 mWh. It also represents the full-battery reference for the absolute display mode.

FullChargeCapacity( ) (FCC)

FCC is the last measured discharge capacity of the battery. It is represented in units of either mAh or 10 mWh, depending on the selected mode. On initialization, the bq2085 sets FCC to the value stored in *Last Measured Discharge* DF 0x35-0x36. During subsequent discharges, the bq2085 updates FCC with the last measured discharge capacity of the battery. The last measured discharge of the battery is based on the value in the DCR register after a qualified discharge occurs. Once updated, the bq2085 writes the new FCC value to data flash in mAh to *Last Measured Discharge*. FCC represents the full battery reference for the relative display mode and relative state of charge calculations.

Discharge Count Register (DCR)

The DCR register counts up during discharge, independent of RM. DCR counts discharge activity, battery load estimation, and self-discharge increment. The bq2085 initializes DCR, at the beginning of a discharge, to FCC – RM when RM is within the programmed value in *Near Full* DF 0x2f. The DCR initial value of FCC – RM is reduced by FCC/128 if SC = 0 (bit 5 in *Gauge Configuration*) and is not reduced if SC = 1. DCR stops counting when the battery voltage reaches the EDV2 threshold on discharge.

Capacity learning (*FCC *Update) and Qualified Discharge

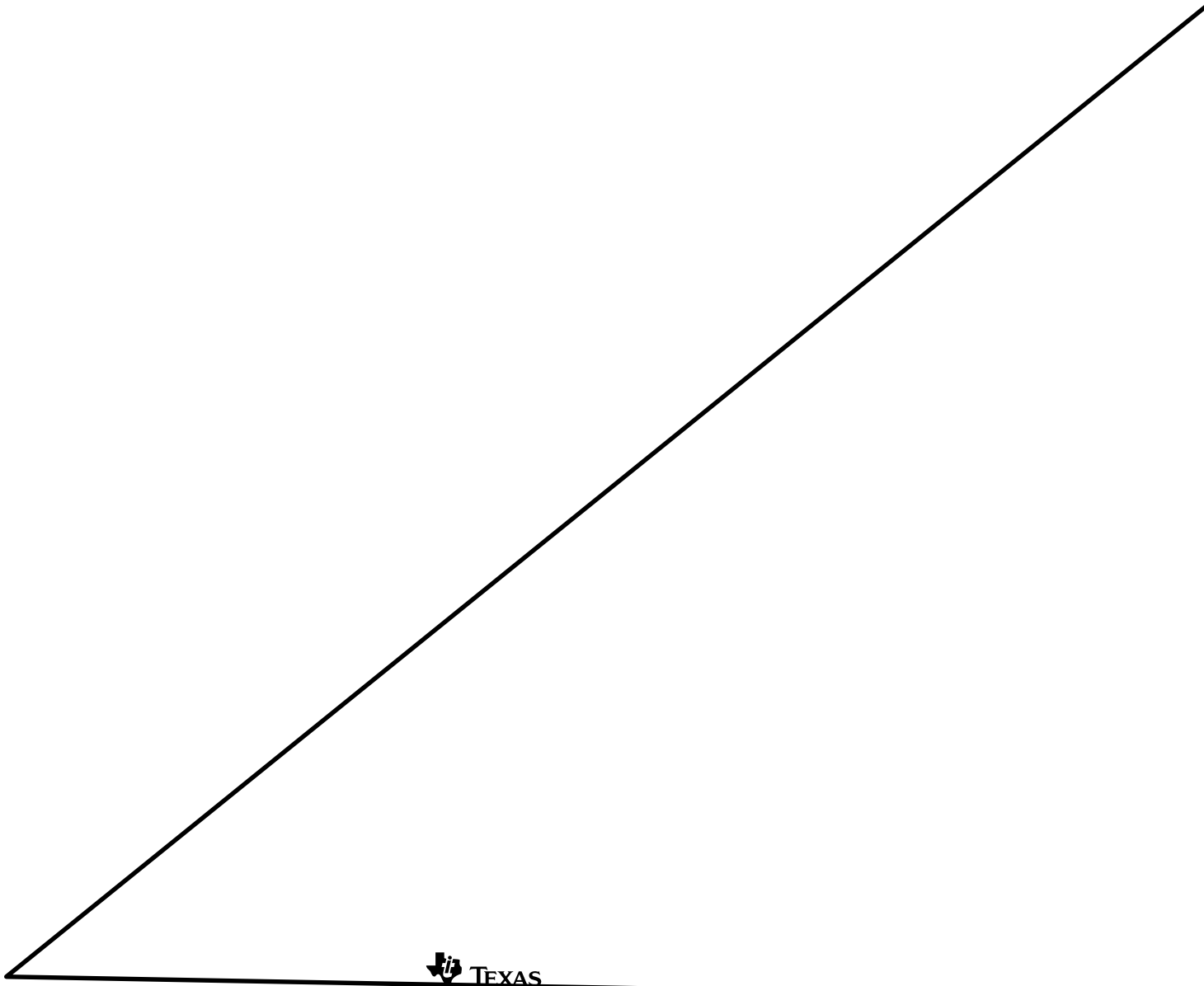
The bq2085 updates FCC with an amount based on the value in DCR if a qualified discharge occurs. The new value for FCC equals the DCR value plus the programmable nearly full and low battery levels, according to the following equation:

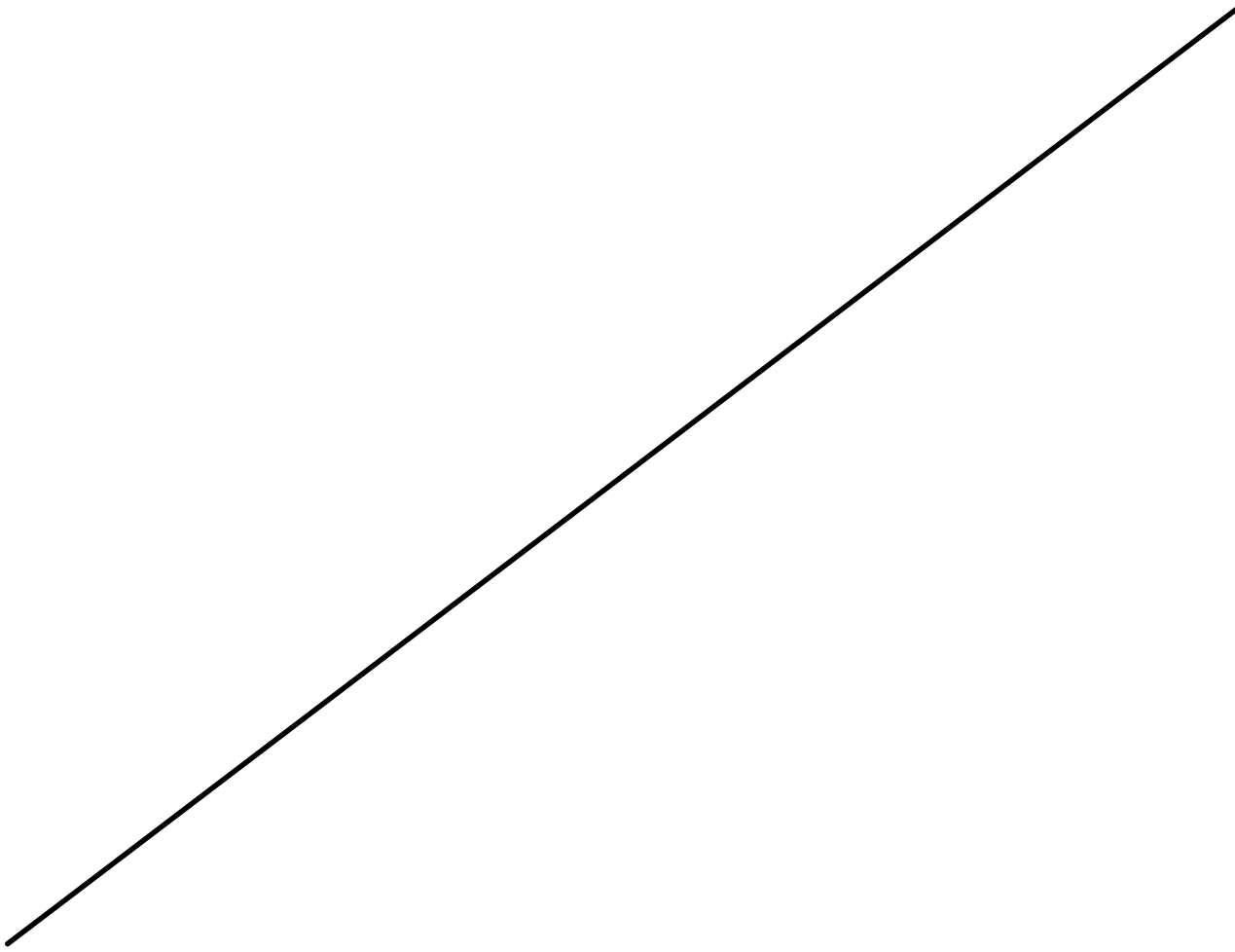
$$\text{FCC (new)} = \text{DCR (final)} = \text{DCR (initial)} + \text{Measured Discharge to EDV2} + (\text{FCC} \times \textit{Battery Low\%}) \quad (1)$$

Battery Low % = (value stored in DF 0x2e) ÷ 2.56

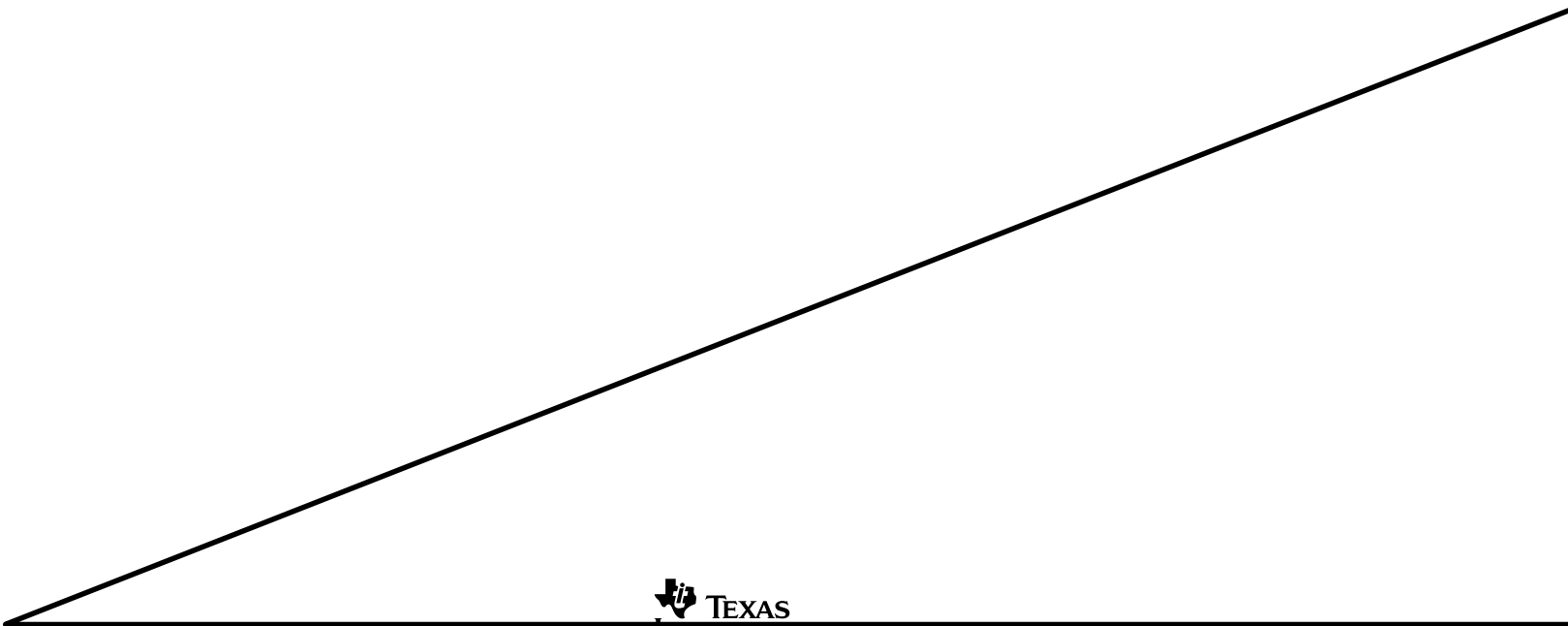
A qualified discharge occurs if the battery discharges from RM ≥ FCC – *Near Full* to the EDV2 voltage threshold with the following conditions:

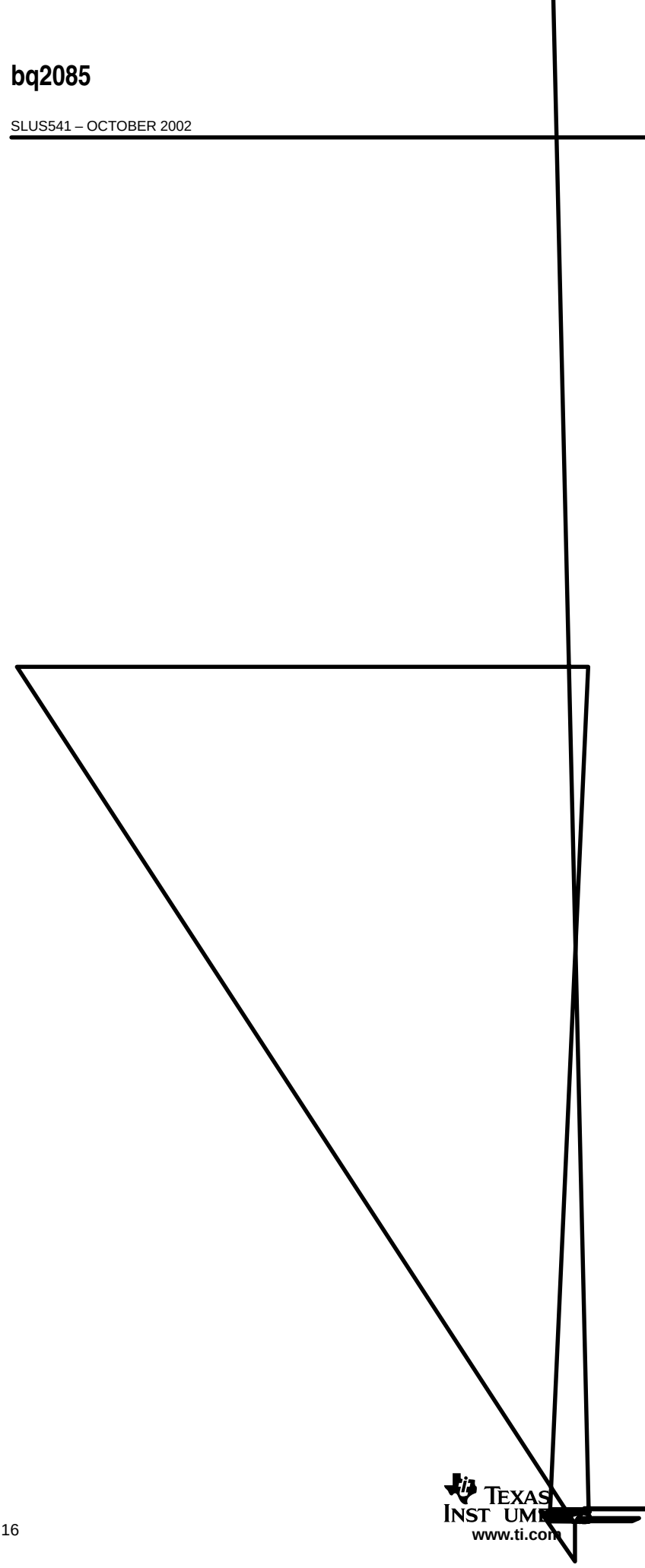
- No valid charge activity occurs during the discharge period. A valid charge is defined as a charge of 10 mAh into the battery.
- No more than 256 mAh of self-discharge or battery load estimation occurs during the discharge period.
- The temperature does not drop below the low temperature thresholds programmed in *Learning Low Temp* DF 0x9b during the discharge period.
- The battery voltage reaches the EDV2 threshold during the discharge period and the voltage is greater than or equal to the EDV2 threshold minus 256 mV when the bq2085 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.

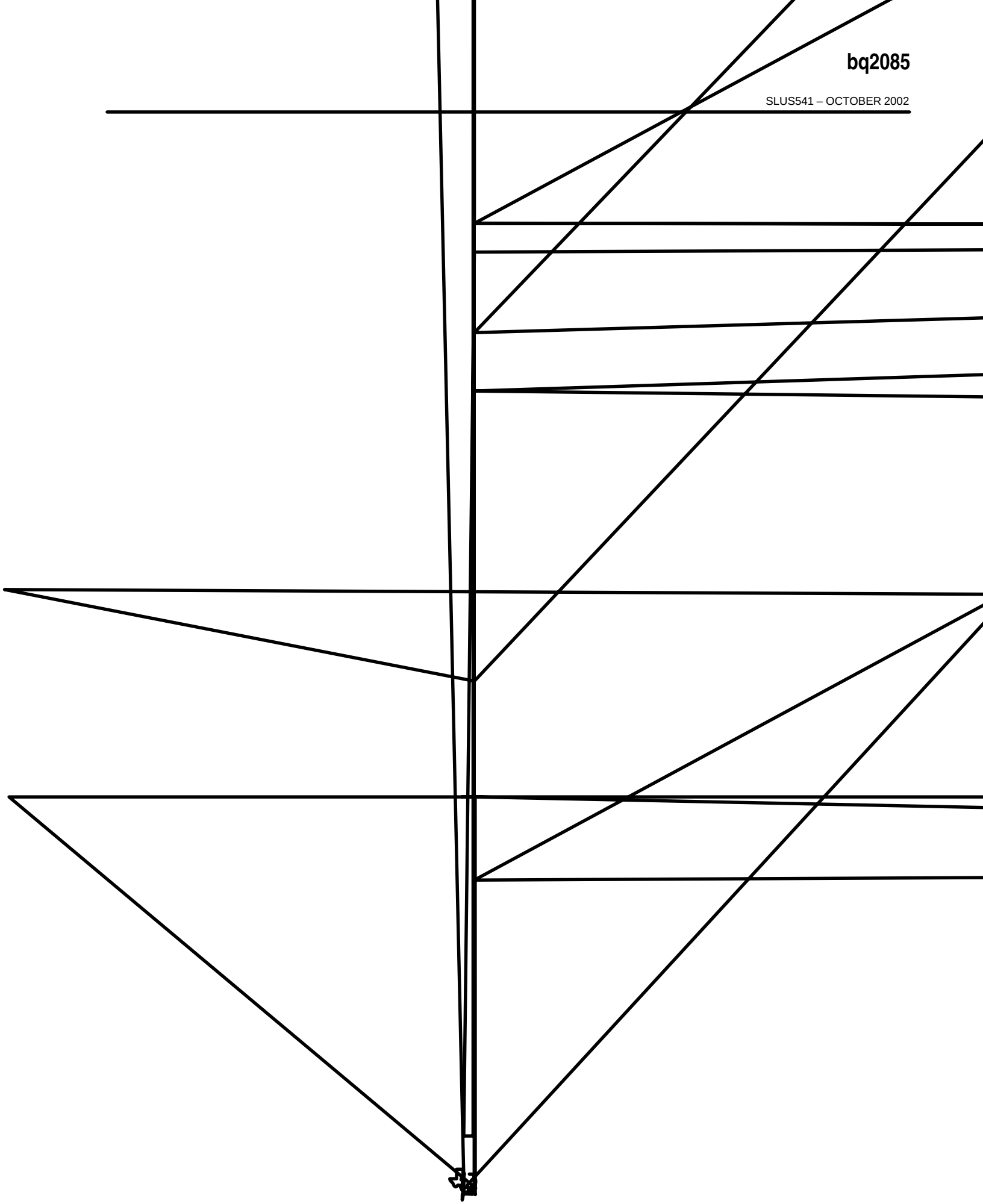




32Y%







Battery State (Table 6)

≥

CV UV+14 Overload Overdischarged Offset Not15

Table 11. Stand-Alone bq29311 Protection Control

MODE	CONDITION	CLEAR (see Note 16)
Over Load	*AFE Over Curr Dsg* (DF 0xb2) is breached for *Over Curr Delay* (DF 0xb4)	AverageCurrent() = 0 mA
Over Current	*AFE Over Curr Chg* (DF 0x0b3) is breached for *Over Curr Delay* (DF 0xb4)	AverageCurrent() = 0 mA
Short Circuit, Discharge	*AFE Short Circ Thresh* (DF 0xb6) is breached for *AFE Short Circuit Delay* (DF 0xb7, lower nibble)	AverageCurrent() = 0 mA

Low-Power Modes

The bq2085 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 bq2085 wakes up periodically to monitor voltage and temperature and to apply self-discharge adjustment. The sleep period is set in *Sleep Timer* DF 0xe7. The bq2085 wakes up at a period set by *Sleep Current Time* DF 0xe6 to measure current. The bq2085 comes out of sleep when the SMBus lines go high or if the current is greater than *Sleep Current Threshold*. A rising edge on SMBC or SMBD restores the bq2085 to the full operating mode.

Reset Conditions

On power-up the entire IC is reset and data is loaded from Data Flash to configure the SBS Data and the system. On a partial reset (loss of VCC but RBI holds RAM valid) then a limited number of locations are taken.

These actions are the following:

- The AFE registers are rewritten.
- PackStatus() VDQ flag is cleared (the proposed change is not to clear VDQ).
- PackStatus() EDV2 flag is cleared.
- BatteryStatus() DISCHARGING flag is cleared.
- The charger and alarm broadcast period is set to 10 seconds between broadcasts.

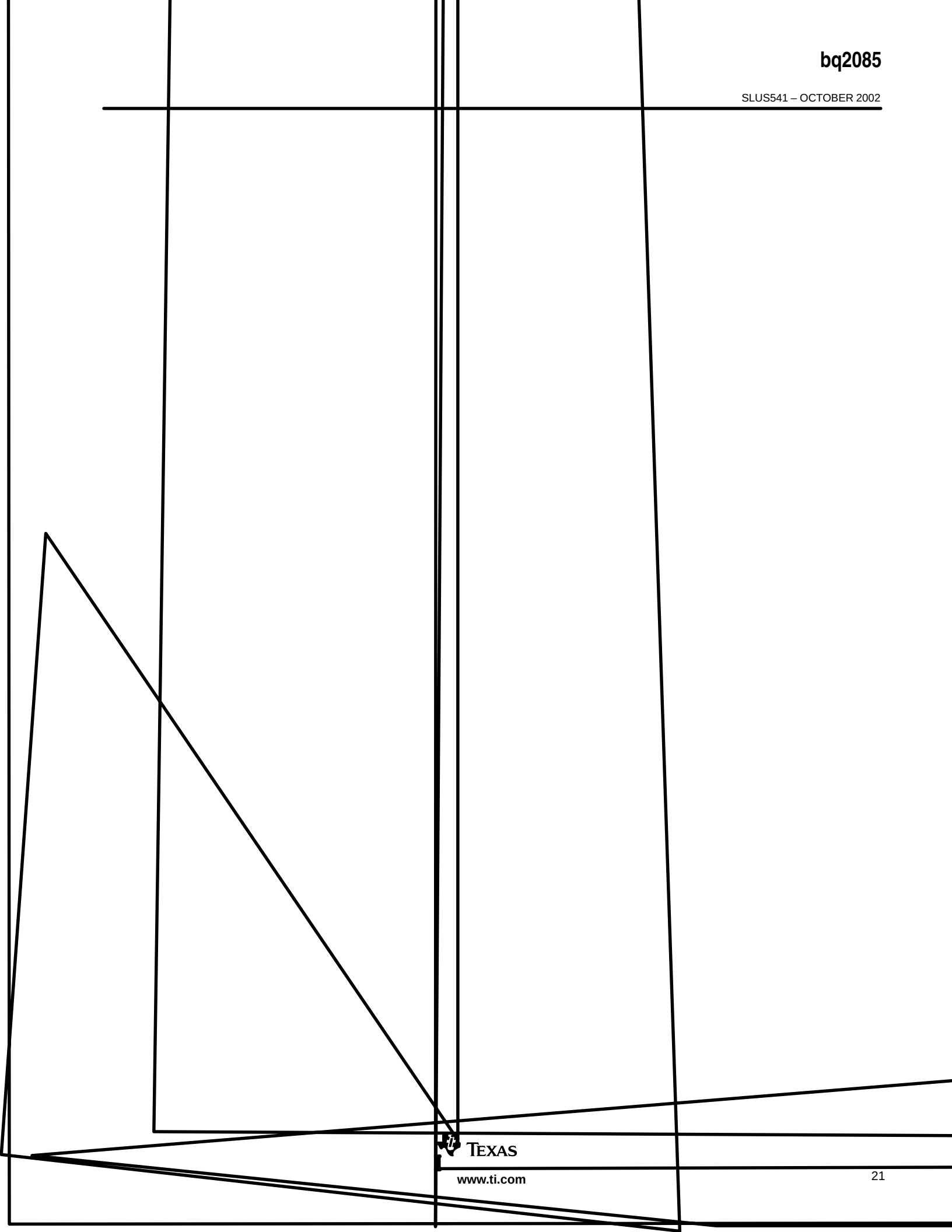
COMMUNICATION

The bq2085 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 bq2085 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 bq2085. 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 bq2085 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 bq2085 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 thef4 device aTD tr471nication



PEC Protocol (Continued)

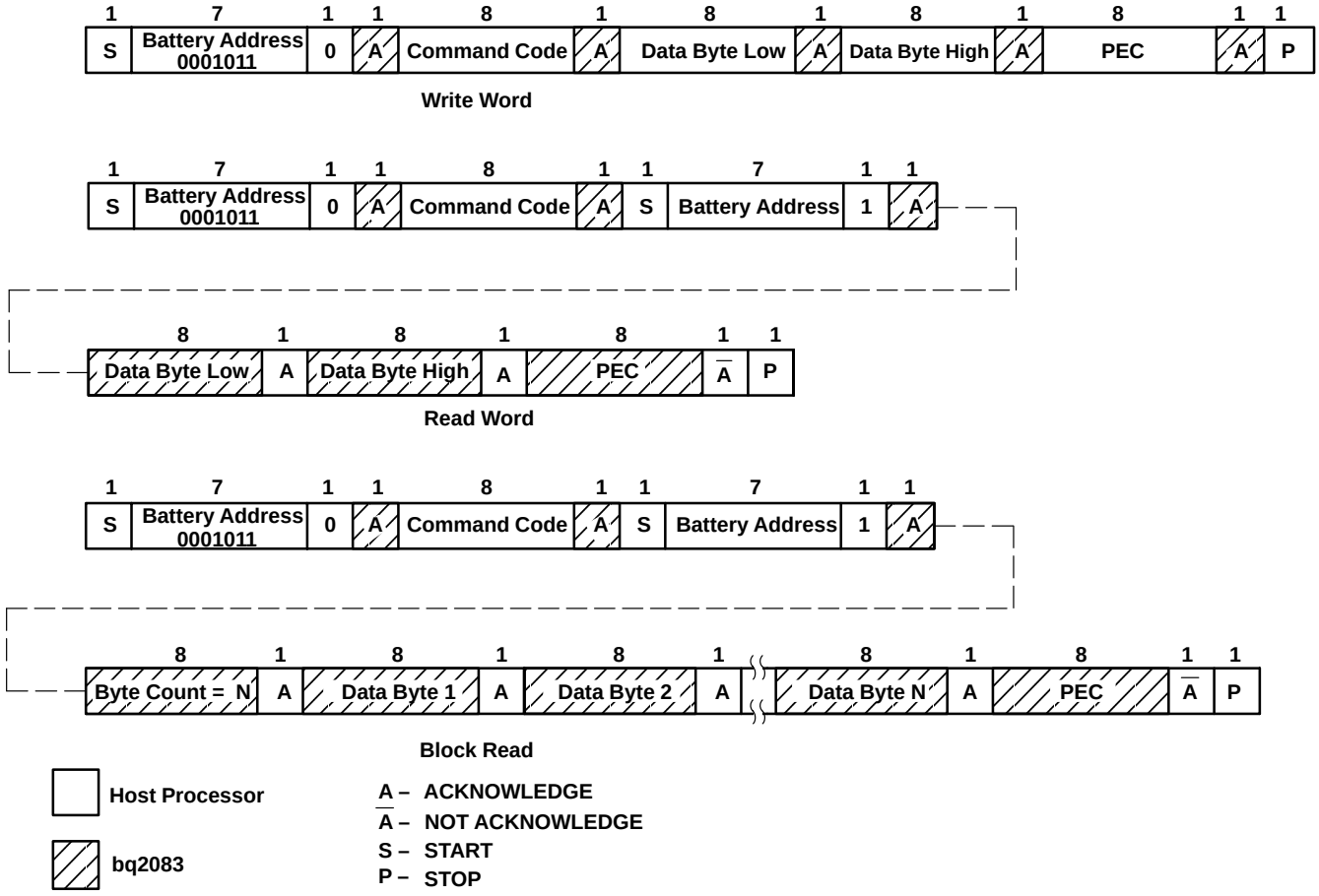


Figure 7. SMBus Communication Protocol With PEC

PEC Calculation

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

For example, the host requests RemainingCapacity( ) from the bq2085. This includes the host following the read word protocol. The bq2085 calculates the PEC based on the following 5 bytes of data, assuming the remaining capacity of the battery is 1001 mAh.

- Battery Address with R/$\overline{W}$ = 0: 0x16
- Command Code for RemainingCapacity( ): 0x0f
- Battery Address with R/$\overline{W}$ = 1: 0x17
- RemainingCapacity( ): 0x03e9

For 0x160f17e903, the bq2085 transmits a PEC of 0xe8 to the host.

PEC Enable in Master Mode

PEC for master mode broadcasts to the charger, host, or both can be enabled/disabled with the combination of the bits hpe and cpe in *Pack Configuration* DF 0x28.

PRIMARY_BATTERY_SUPPORT bit is not used by the bq2085.

RELEARN_FLAG bit set indicates that the bq2085 is requesting a capacity relearn cycle for the battery. The bq2085 sets the RELEARN_FLAG on a full reset and if it detects 20 cycle counts without an FCC update. The bq2085 clears this flag after a learning cycle has been completed.

CHARGE_CONTROLLER_ENABLED bit is not used by the bq2085. The bq2085 forces this bit to zero.

PRIMARY_BATTERY bit is not used by the bq2085. The bq2085 forces this bit to zero.

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 bq2085's ability to master the SMBus and send AlarmWarning( ) messages to the SMBus host and the smart battery charger. When set, the bq2085 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 bq2085 resets the bit and starts or restarts a 60-seconds (nominal) timer. After the timer expires, the bq2085 automatically enables alarm broadcasts to ensure that the accidental deactivation of broadcasts does not persist. An SMBus host that does not want the bq2085 to be a master on the SMBus must therefore continually set this bit at least once per 59 seconds to keep the bq2085 from broadcasting alarms.
- The ALARM_MODE bit defaults to a cleared state when the bq2085 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 bq2085's transmission of ChargingCurrent( ) and ChargingVoltage( ) messages to the smart battery charger. When set, the bq2085 does *not* transmit ChargingCurrent( ) and ChargingVoltage( ) values to the smart battery charger. When cleared, the bq2085 transmits the ChargingCurrent( ) and ChargingVoltage( ) values to the smart battery charger. The CHARGER_MODE bit defaults to a cleared state when the bq2085 enters SLEEP mode.

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 bq2085 updates AtRateOK( ) within 5 ms after the SMBus host sets the AtRate( ) value. The bq2085 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 bq2085.

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}

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)

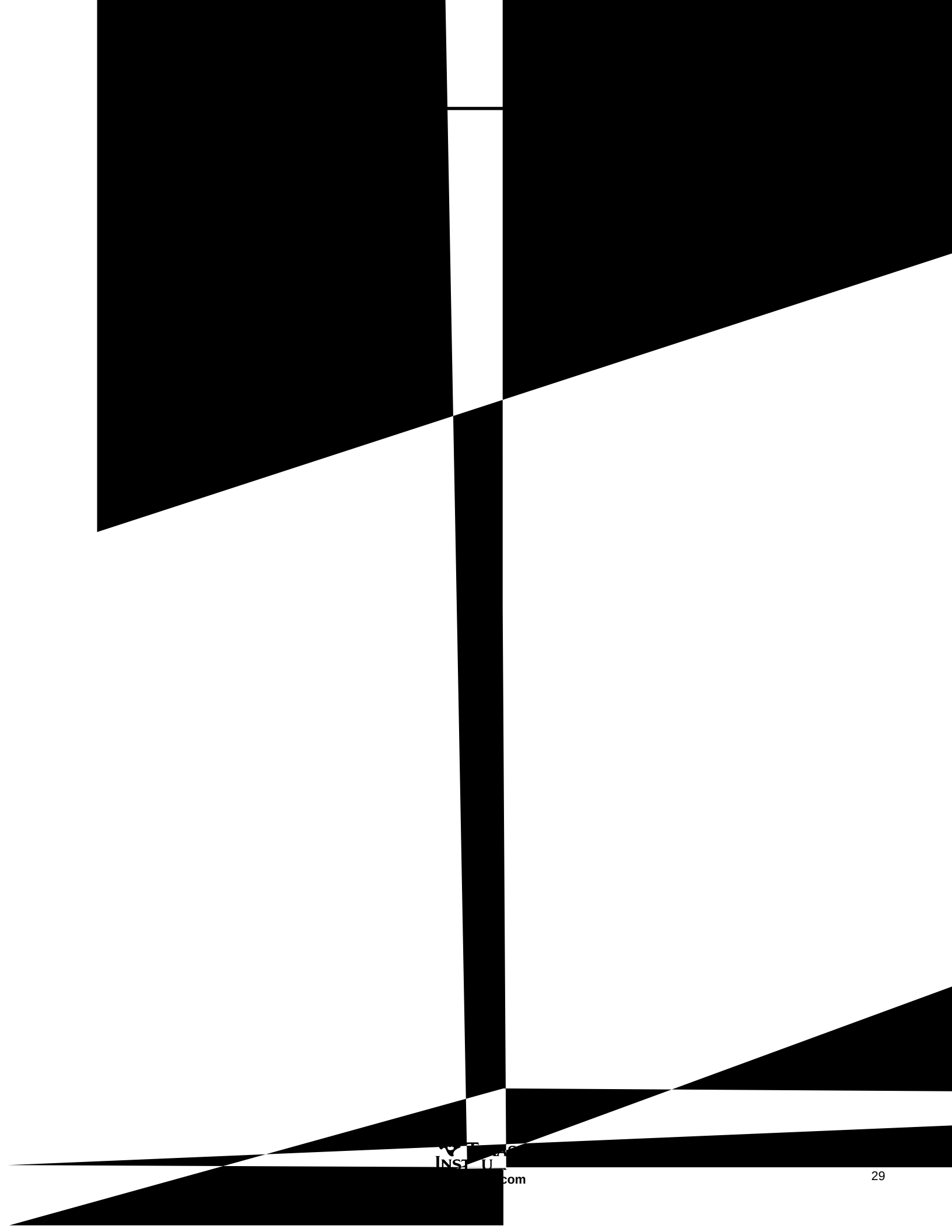
Current( ) (0x0a)

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.



Output: Unsigned integer-percent of remaining capacity.

Units: %

Range: 0–100%

Granularity: 1%

Accuracy: -0, +MaxError( )

AbsoluteStateOfCharge( )(0x0e)

Description:

CAPACITY_MODE	CAPACITY_MODE	
mAh	mWh	10

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 bq2085 to dynamically control the charging profile (current/voltage) of the battery. The bq2085 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 bq2085 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

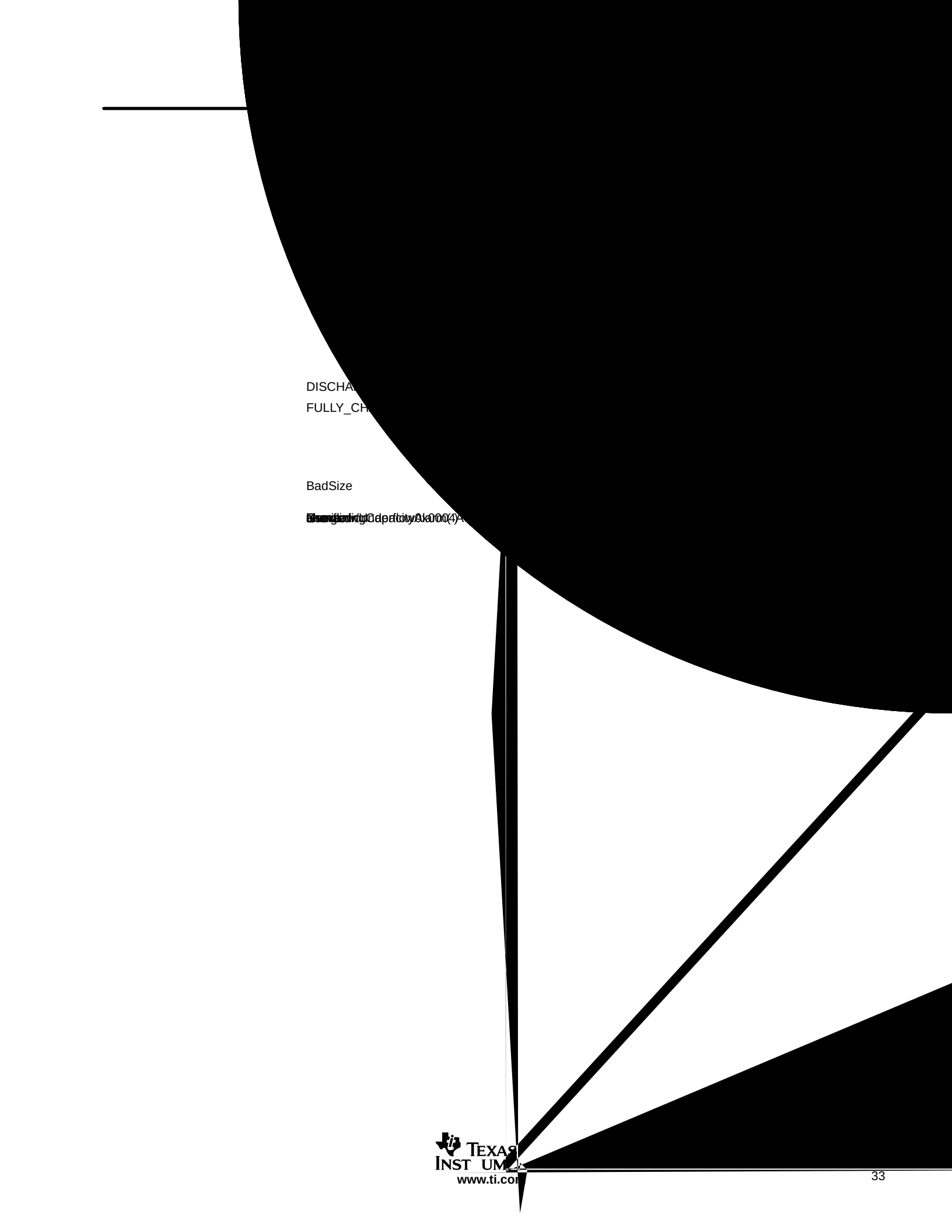
Invalid Data Indication: 65,535 indicates the charger should operate as a current source outside its maximum regulated voltage range.

BatteryStatus( ) (0x16)

Description: Returns the bq2085 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 bq2085. 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


DISCHA
FULLY_CH
BadSize

CycleCount( )(0x17)Description: Returns the number of cycles the battery has experienced. The mAh value of each count isde

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 bq2085 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 bq2085 VScale (voltage scaling) and IPScale (current scaling) should always be set to zero. The bq2085 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

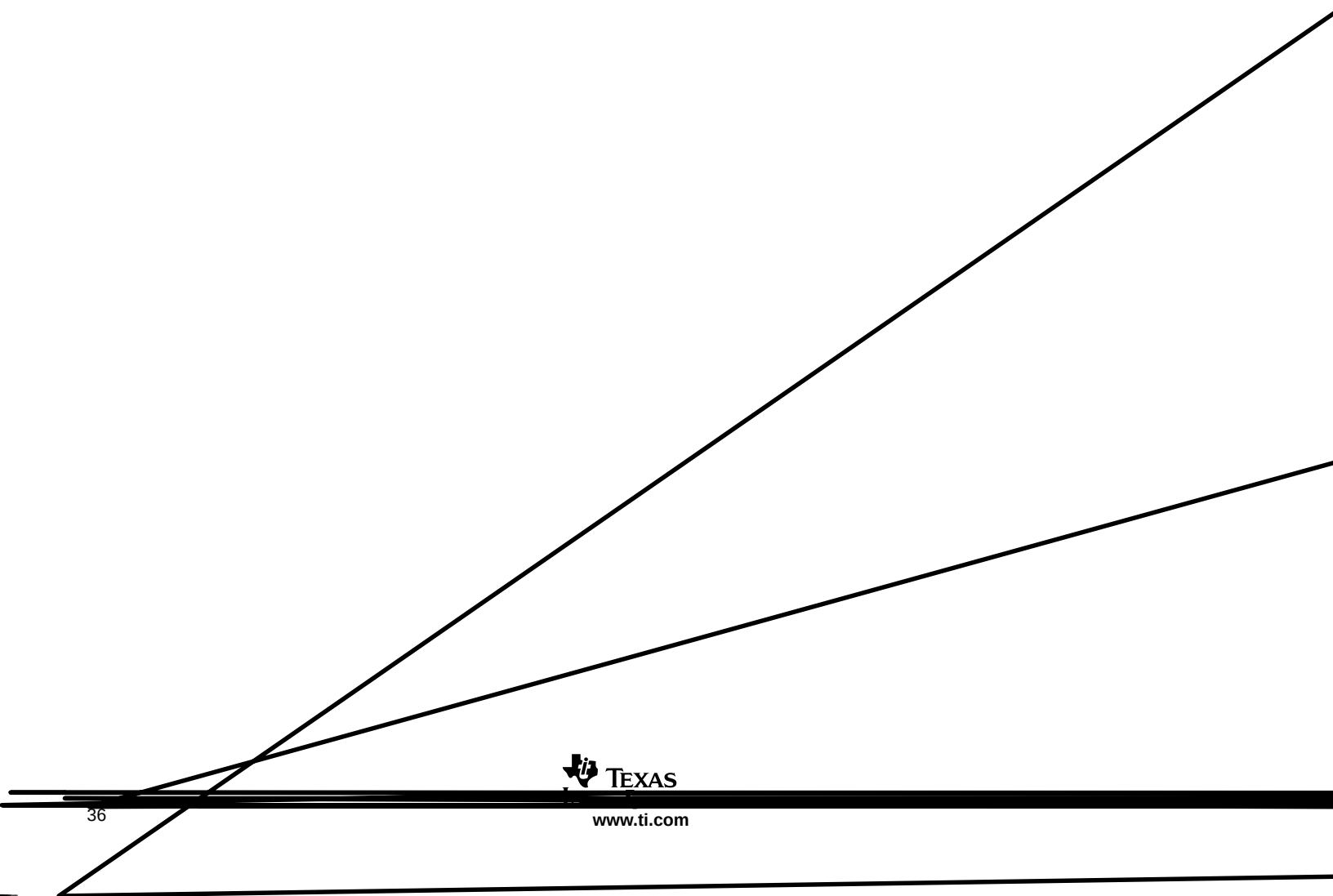
Output: Unsigned integer—packed specification number and scaling information:

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 bq2085 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( ).



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 bq2085 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 bq2085 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 of status bits relating to bq2085 operation. The pack status register is the least significant byte of the word.

The pack configuration register reflects how the bq2085 is configured as defined by the value programmed in *Pack Configuration* in DF 0x28.

The pack status register consists of the following bits:

b7	b6	b5	b4	b3	b2	b1	b0
AFE	EDV2	SS	VDQ	0	SOV	CVOV	CVUV

AFE

The AFE bit indicates whether the bq29311 RAM integrity check has failed.

0 bq29311 integrity check passed

1 bq29311 integrity check failed

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 bq2085.

0 The bq2085 is in the unsealed state.

1 The bq2085 is in the sealed state.

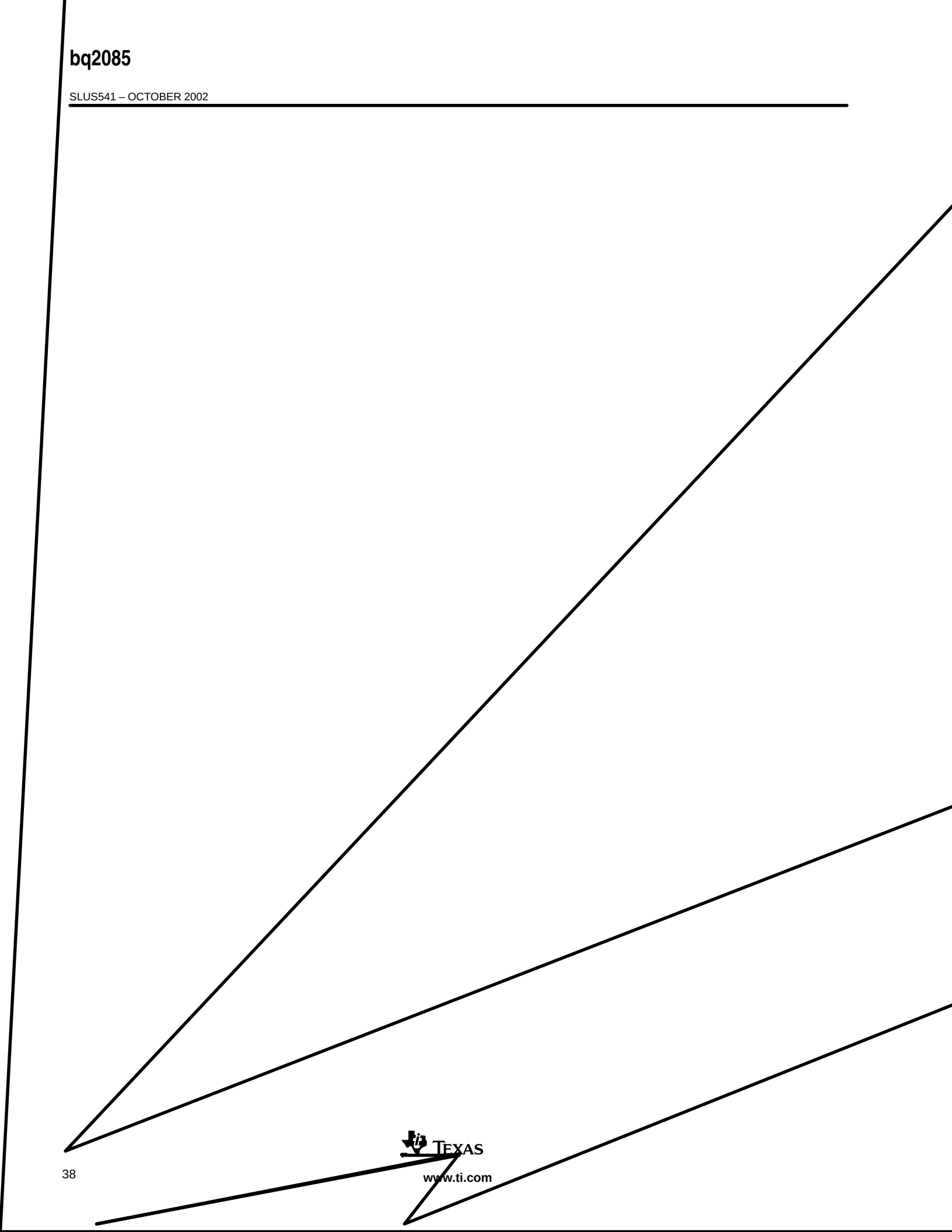


Table 13. Data Flash Memory Map

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		40
0x2a		*Misc Configuration*	VOD		01
0x2b		*Digital Filter*	9860 nV		22
0x2c		*Self-Discharge Rate*	0.2%		14
0x2d		*Electronics Load*	0 mA		00
0x2e		*Battery Low %*	7.03%		12
0x2f	0x30	*Near Full*	200 mAh	00	c8

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.

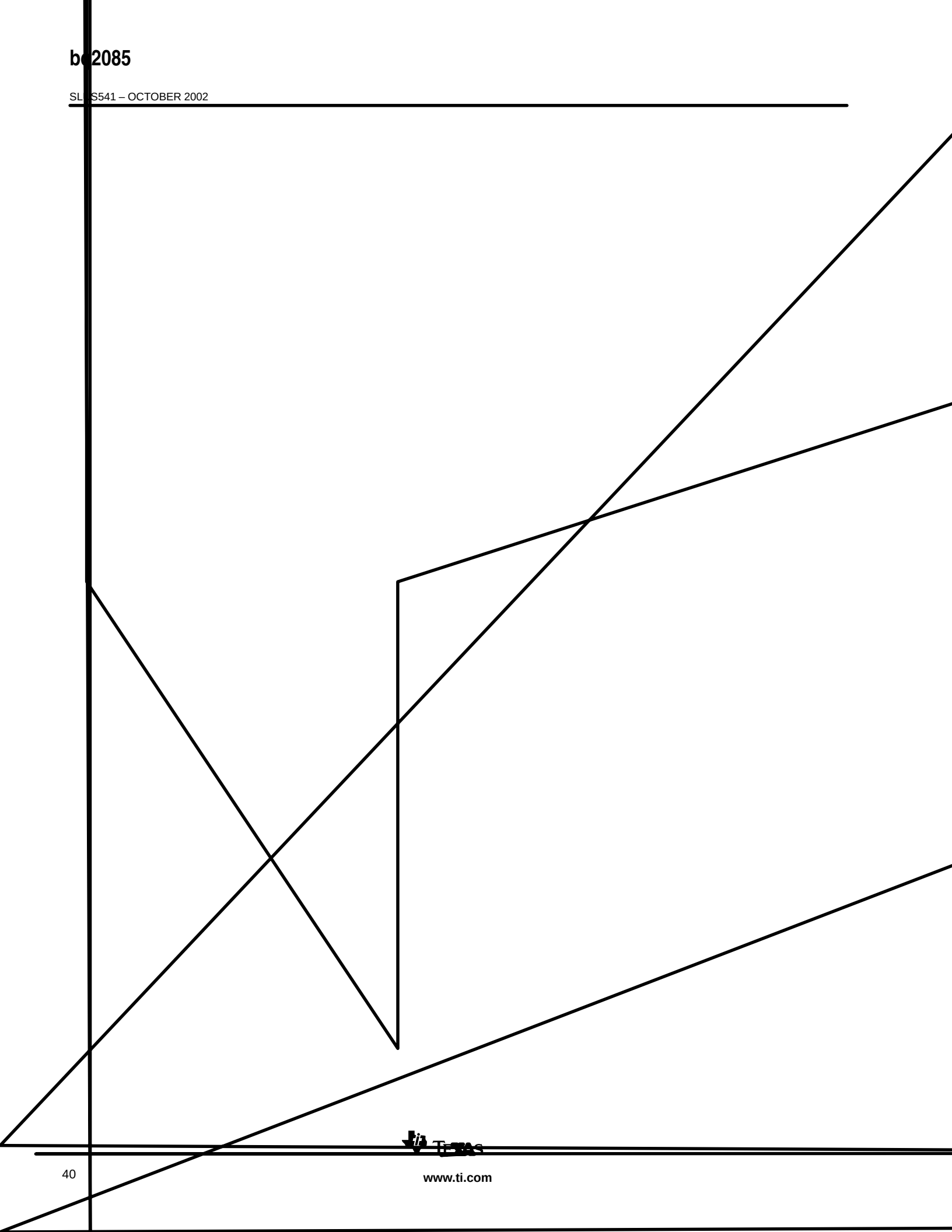


Table 13. Data Flash Memory Map (Continued)

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 μs (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	1.0	01	00
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*	100 seconds		64

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.

EDV Discharge Rate and Temperature Compensation

If EDV compensation is enabled, the bq2085 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

$$EDV0,1,2 = n (EMF \bullet FBL - | ILOAD | \bullet R0 \bullet FTZ) \quad (5)$$

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.

$$FBL = f (C0, C + C1, T) \quad (6)$$

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

$$FTZ = f (R1 , T0, T, C + C1, TC) \quad (7)$$

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.

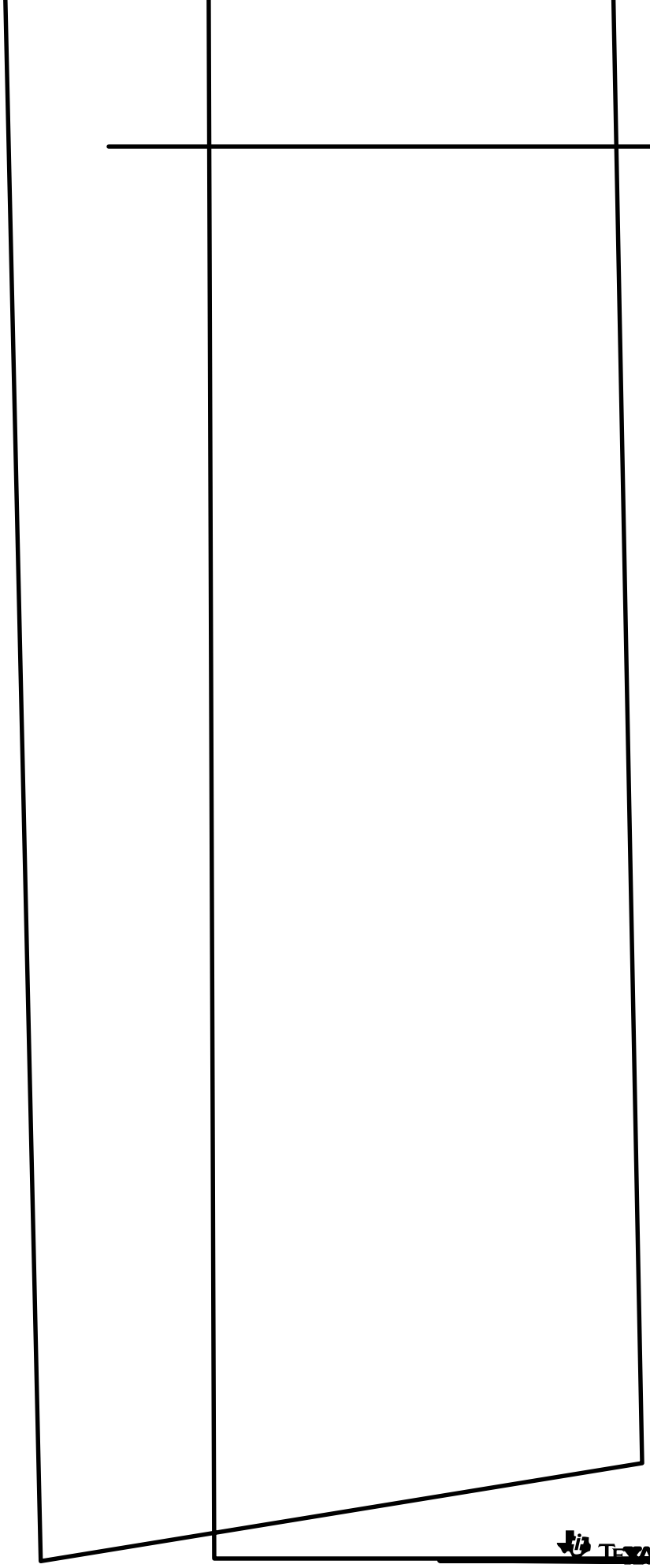
T0 adjusts the variation of impedance with battery temperature. T0 is programmed in *EDV T0 Rate Factor* DF 0x8a–0x8b.

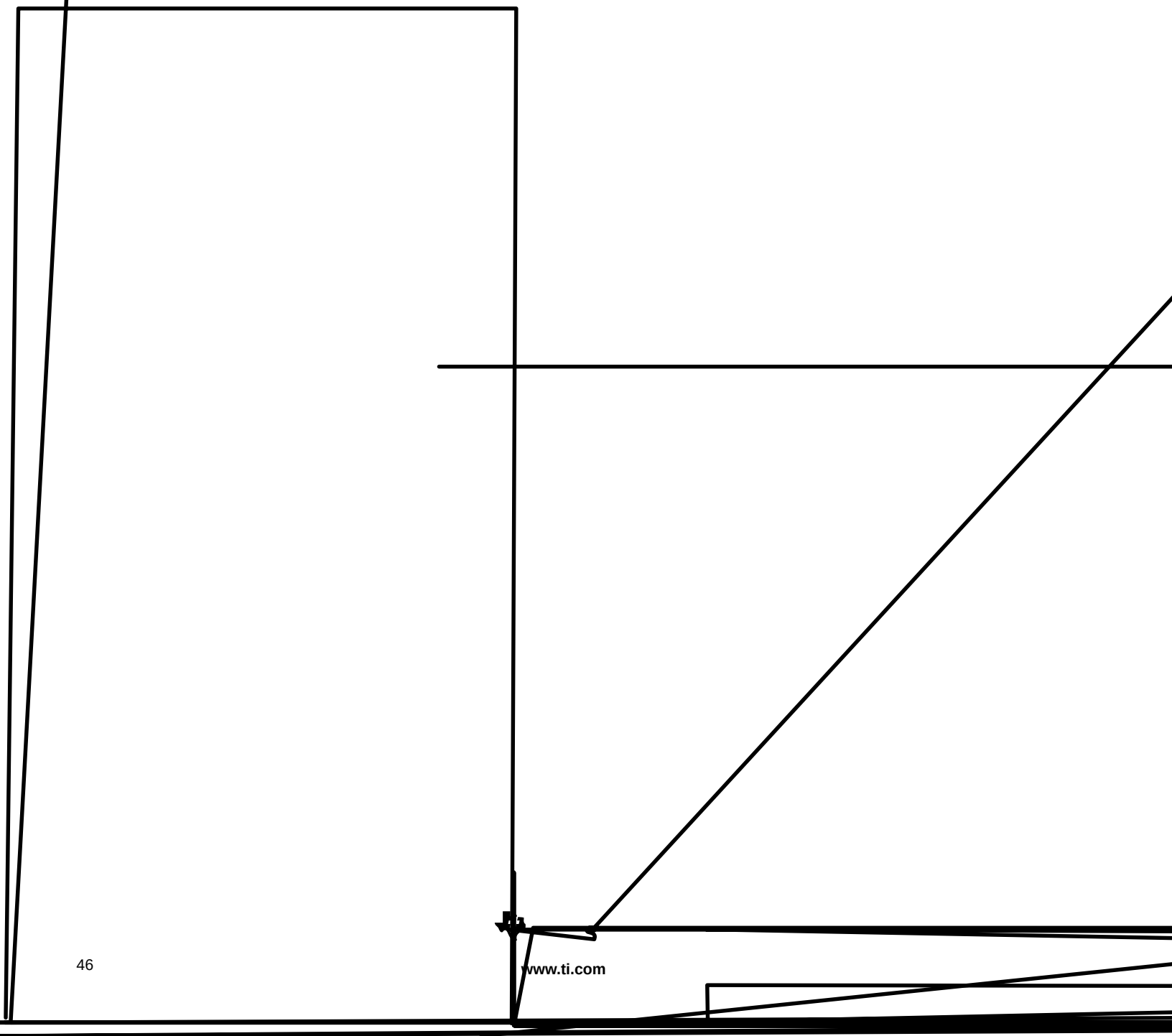
TC adjusts the variation of impedance for cold temperatures (T < 23°C). TC is programmed in *EDV TC* DF 0x8e.

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

EMF = 11550/3
T0 = 4475
C0 = 235
C1 = 0
R0 = 5350/3
R1 = 250
TC = 3

The graphs in Figures 8 and 9 show the calculated EDV0, EDV1, and EDV2 thresholds versus capacity using the typical compensation values for different temperatures and loads for a Li-Ion 3s2p 18650 pack. The compensation values vary widely for different cell types and manufacturers and must be matched exactly to the unique characteristics for optimal performance.





HPE

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

0 No PEC byte on alarm warning to host

1 PEC byte on alarm warning to host

CPE

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

0 No PEC byte on broadcasts to charger

1 PEC byte on broadcasts to charger

SM

The SM bit enables/disables master mode broadcasts by the bq2085.

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 bq2085 for the number of series cells in the battery pack.

1–1 Configures the bq2085 for four series cells

1–0 Configures the bq2085 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 bq2085, 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 bq2085 does not alter RM at the time of a valid charge termination.

1 The bq2085 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

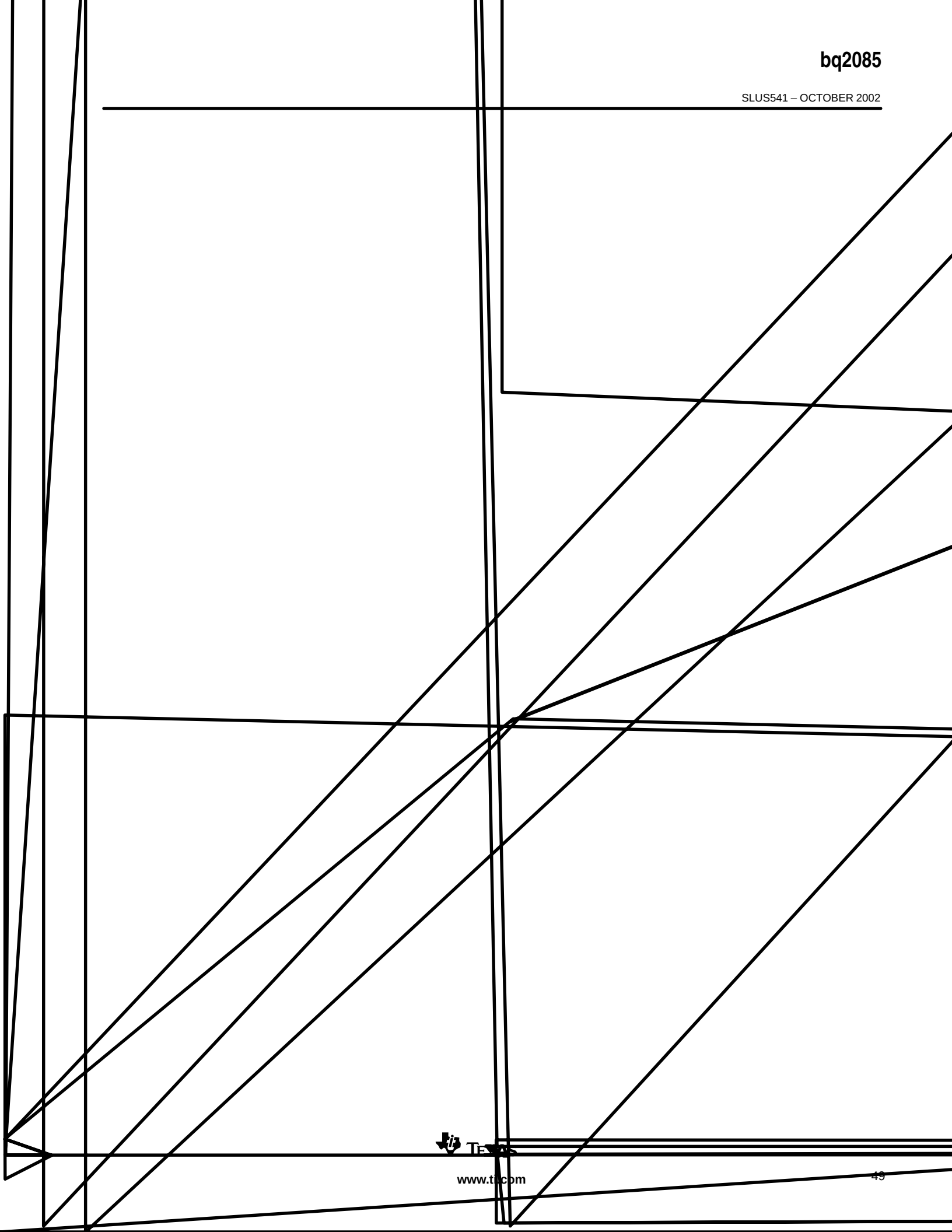
0 Learning cycle optimized for Smart Charger

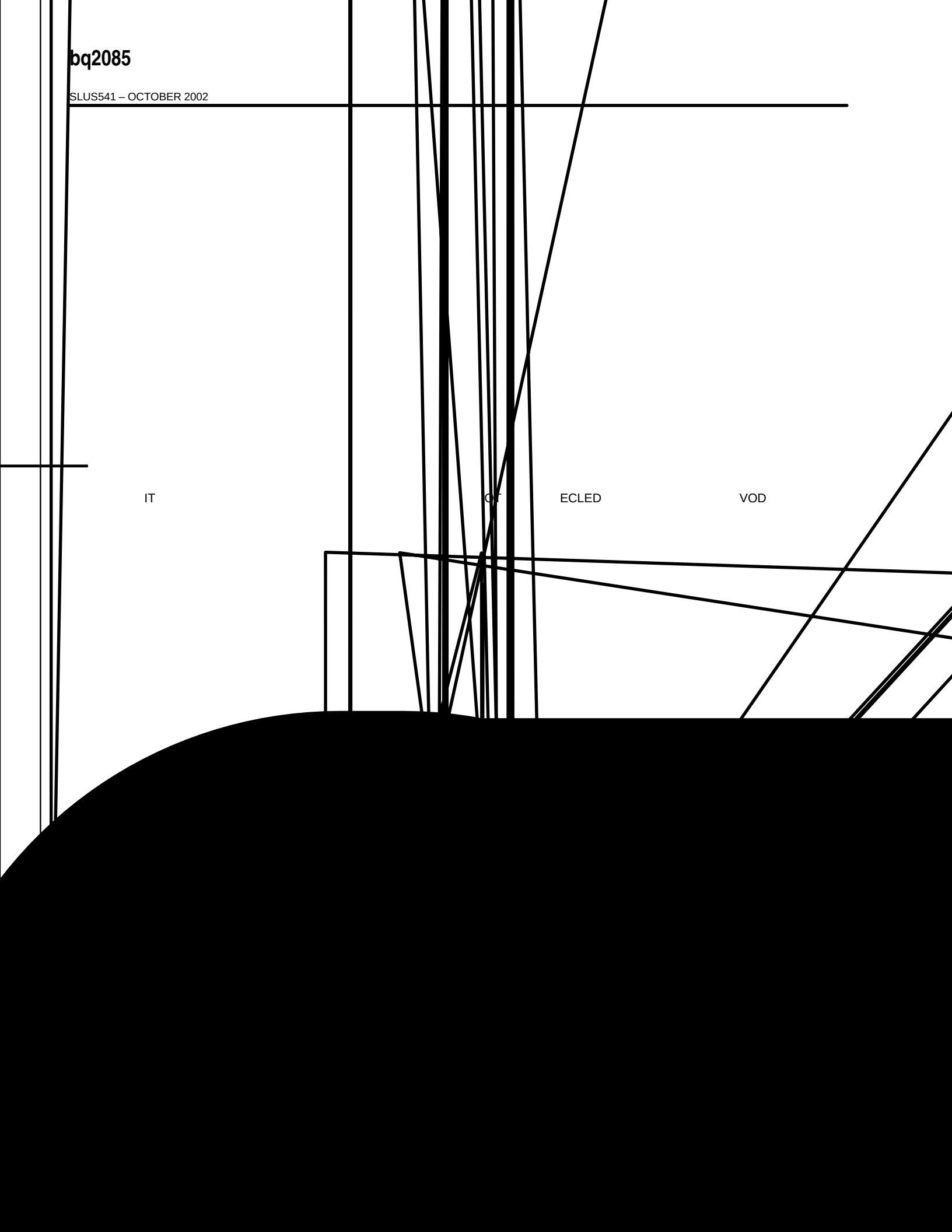
CEDV

The CEDV bit determines whether the bq2085 implements automatic EDV compensation to calculate the EDV0, EDV1, and EDV2 thresholds base on rate, temperature, and capacity. If the bit is cleared, the bq2085 uses the fixed values programmed in data flash for EDV0, EDV1, and EDV2. If the bit is set, the bq2085 calculates EDV0, EDV1, and EDV2.

0 EDV compensation disabled

1 EDV compensation enabled




IT
OT
ECLED
VOD

PHG

The PHG bit configures the bq2085 to control a precharge FET.

0 The bq2085 does not control a precharge FET.

1 The bq2085 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 SepcificationInfo( ).

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.

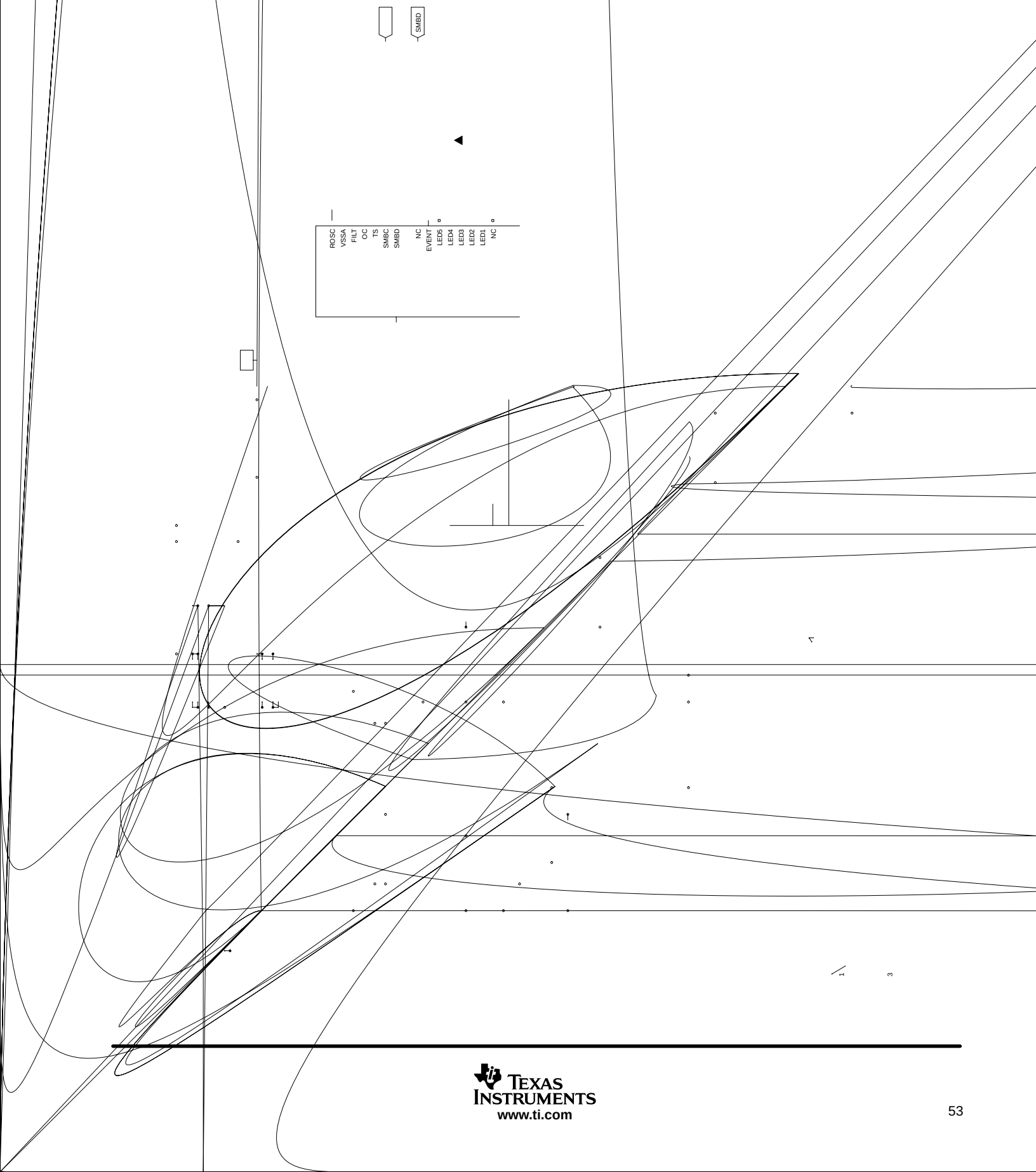
Device Chemistry Data

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



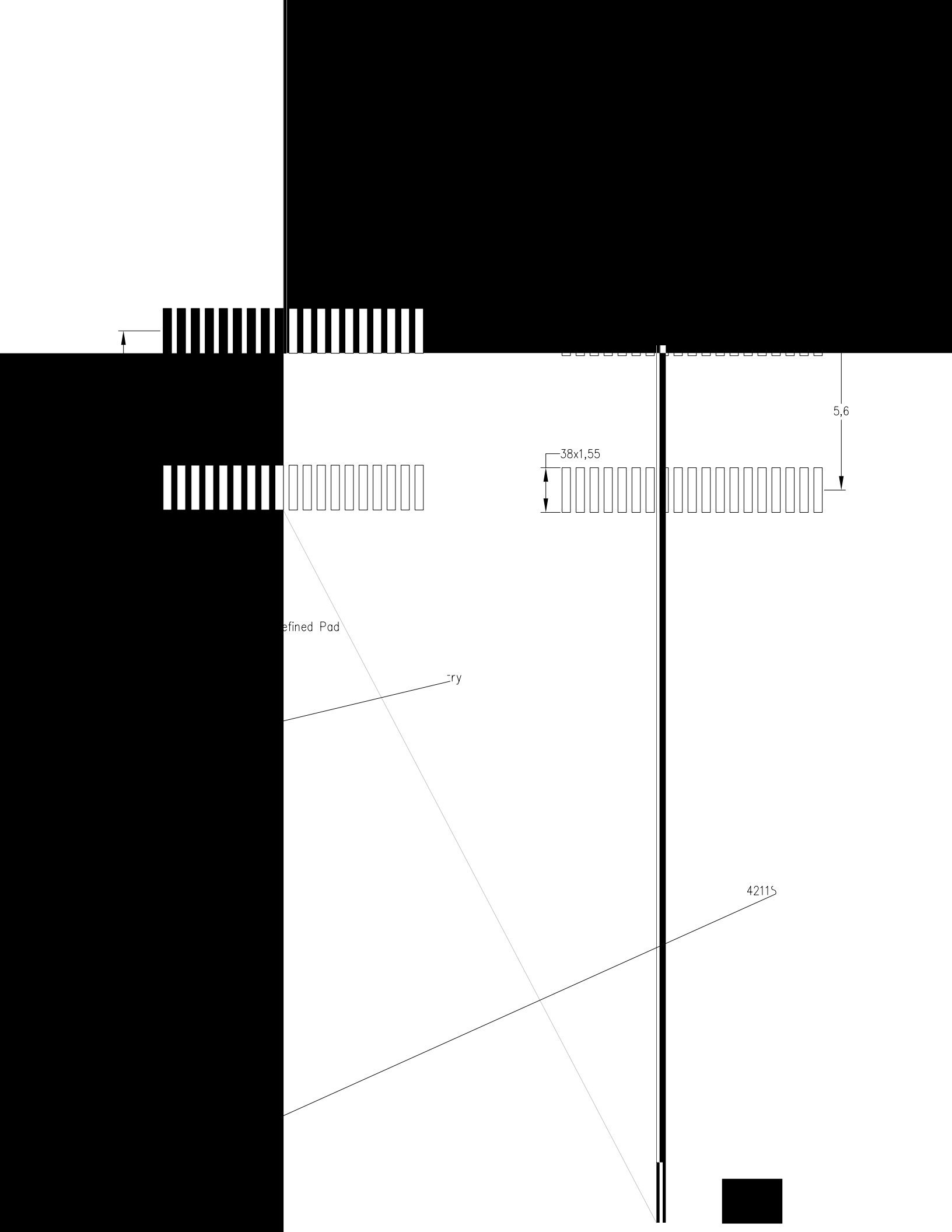
PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
BQ2085DBT	NRND	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
BQ2085DBTG4	NRND	TSSOP	DBT	38	50	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.


5,6
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