SBS 1.1-COMPLIANT GAS GAUGE AND PROTECTION ENABLED WITH IMPEDANCE TRACK™

Check for Samples: bq20z65-R1

FEATURES

- **Next Generation Patented Impedance Track™ Technology Accurately Measures Available Charge in Li-Ion and Li-Polymer Batteries**
  - **Better Than 1% Error Over the Lifetime of the Battery**
- **Supports the Smart Battery Specification SBS V1.1**
- **Flexible Configuration for 2 to 4 Series Li-Ion and Li-Polymer Cells**
- **Powerful 8-Bit RISC CPU With Ultralow Power Modes**
- **Full Array of Programmable Protection Features**
  - **Voltage, Current, and Temperature**
- **Satisfies JEITA Guidelines**
- **Added Flexibility to Handle More Complex Charging Profiles**
- **Lifetime Data Logging**
- **Drives 3, 4, and 5 Segment LED Display for Battery-Pack Conditions**
- **Supports SHA-1 Authentication**
- **Complete Battery Protection and Gas Gauge Solution in One Package**
- **Available in a 44-Pin TSSOP (DBT) package**

APPLICATIONS

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

DESCRIPTION

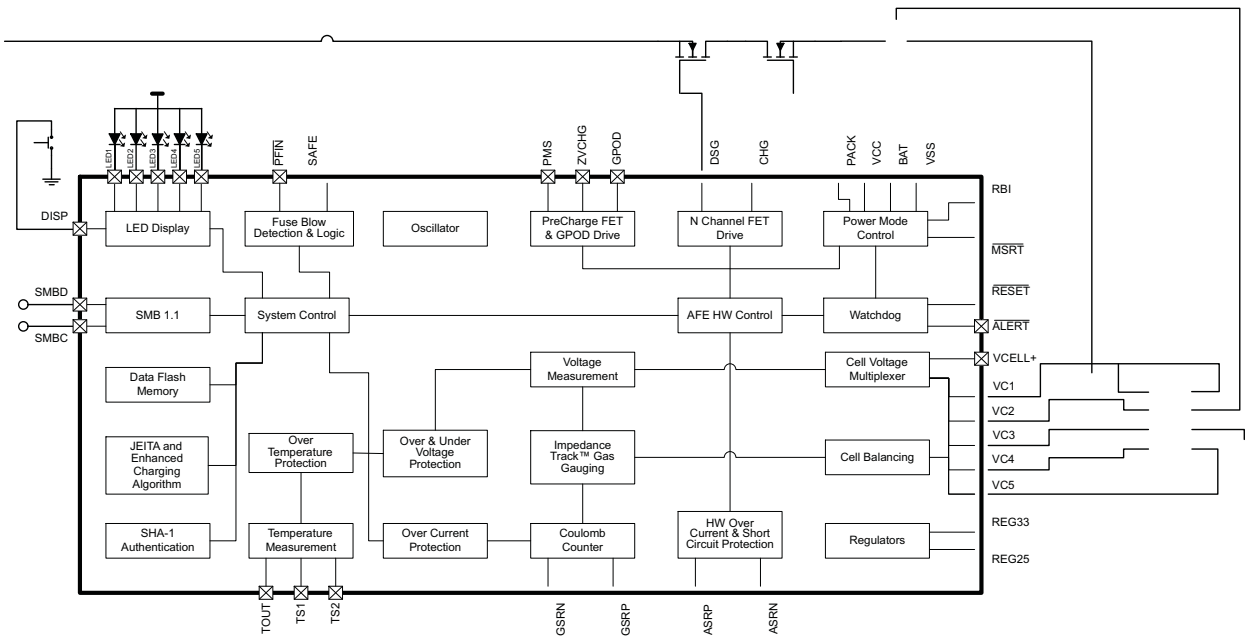
The bq20z65-R1 SBS-compliant gas gauge and protection IC, incorporating patented Impedance Track™ technology, is a single IC solution designed for battery-pack or in-system installation. The bq20z65-R1 measures and maintains an accurate record of available charge in Li-ion or Li-polymer batteries using its integrated high-performance analog peripherals. The bq20z65-R1 monitors capacity change, battery impedance, open-circuit voltage, and other critical parameters of the battery pack which reports the information to the system host controller over a serial-communication bus. Together with the integrated analog front-end (AFE) short-circuit and overload protection, the bq20z65-R1 maximizes functionality and safety while minimizing external component count, cost, and size in smart battery circuits.

The implemented Impedance Track™ gas gauging technology continuously analyzes the battery impedance, resulting in superior gas-gauging accuracy. This enables remaining capacity to be calculated with discharge rate, temperature, and cell aging all accounted for during each stage of every cycle with high accuracy.

Table 1. AVAILABLE OPTIONS

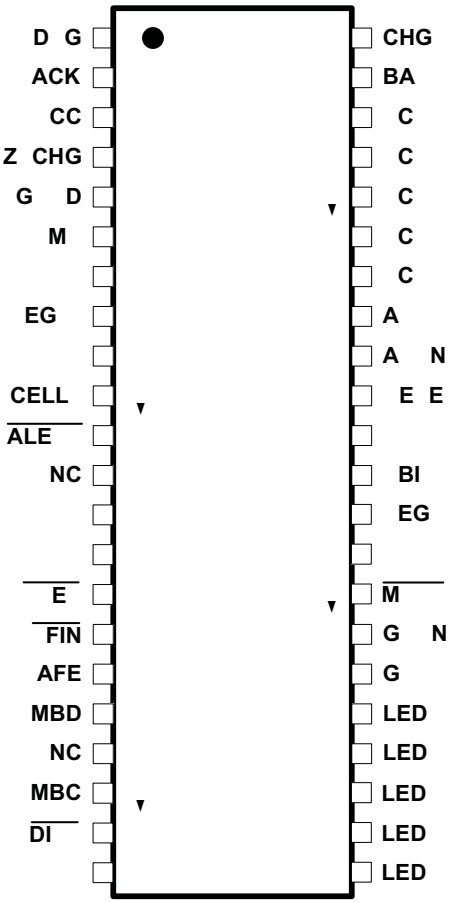
T_A	PACKAGE(1)	
	44-PIN TSSOP (DBT) Tube	44-PIN TSSOP (DBT) Tape and Reel
–40°C to 85°C	bq20z65-R1DBT(2)	bq20z65-R1DBTR(3)

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
(2) A single tube quantity is 40 units.
(3) A single reel quantity is 2000 units


LED1
LED2
LED3
LED4
LED5
PFIN
SAFE
PMS
ZVCHG
GPOD
DSG
CHG
PACK
VCC
BAT
VSS
DISP
LED Display
Fuse Blow Detection & Logic
Oscillator
PreCharge FET & GPOD Drive
N Channel FET Drive
Power Mode Control
RBI
MSRT
SMBD
SMBC
SMB 1.1
System Control
AFE HW Control
Watchdog
RESET
ALERT
Voltage Measurement
Cell Voltage Multiplexer
VCELL+
VC1
VC2
VC3
VC4
VC5
Data Flash Memory
JEITA and Enhanced Charging Algorithm
Over Temperature Protection
Over & Under Voltage Protection
Impedance Track™ Gas Gauging
Cell Balancing
SHA-1 Authentication
Temperature Measurement
Over Current Protection
Coulomb Counter
HW Over Current & Short Circuit Protection
Regulators
REG33
REG25
TOUT
TS1
TS2
GSRN
GSRP
ASRP
ASRN

PACKAGE PINOUT DIAGRAM

bq20z65-R1
DBT PACKAGE
(TOP VIEW)



TERMINAL FUNCTIONS

TERMINAL		I/O(1)	DESCRIPTION
NO.	NAME		
1	DSG	O	High side N-chan discharge FET gate drive
2	PACK	IA, P	Battery pack input voltage sense input. It also serves as device wake up when device is in shutdown mode.
3	VCC	P	Positive device supply input. Connect to the center connection of the CHG FET and DSG FET to ensure device supply either from battery stack or battery pack input
4	ZVCHG	O	P-chan pre-charge FET gate drive
5	GPOD	OD	High voltage general purpose open drain output. Can be configured to be used in pre-charge condition
6	PMS	I	Pre-charge mode setting input. Connect to PACK to enable 0v pre-charge using charge FET connected at CHG pin. Connect to VSS to disable 0V pre-charge using charge FET connected at CHG pin.
7	VSS	P	Negative supply voltage input. Connect all VSS pins together for operation of device
8	REG33	P	3.3V regulator output. Connect at least a 2.2µF capacitor to REG33 and VSS
9	TOUT	P	Thermistor bias supply output
10	VCELL+	-	Internal cell voltage multiplexer and amplifier output. Connect a 0.1µF capacitor to VCELL+ and VSS
11	$\overline{\text{ALERT}}$	OD	Alert output. In case of short circuit condition, overload condition and watchdog time out this pin will be triggered.
12	NC	-	Not used - leave floating
13	TS1	IA	1st Thermistor voltage input connection to monitor temperature
14	TS2	IA	2nd Thermistor voltage input connection to monitor temperature
15	$\overline{\text{PRES}}$	I	Active low input to sense system insertion. Typically requires additional ESD protection.
16	$\overline{\text{PFIN}}$	I	Active low input to detect secondary protector status, and to allow the bq20z65-R1 to report the status of the 2nd level protection input.
17	SAFE	OD	Active high output to enforce additional level of safety protection; e.g., fuse blow.
18	SMBD	I/OD	SMBus data open-drain bidirectional pin used to transfer address and data to and from the bq20z65-R1
19	NC	-	Not used - leave floating
20	SMBC	I/OD	SMBus clock open-drain bidirectional pin used to clock the data transfer to and from the bq20z65-R1
21	$\overline{\text{DISP}}$	I	Display control for the LEDs. This pin is typically connected to VCC via a 100kΩ resistor and a push button switch connected to VSS.
22	VSS	P	Negative supply voltage input. Connect all VSS pins together for operation of device
23	LED1	I	LED1 display segment that drives an external LED depending on the firmware configuration
24	LED2	I	LED2 display segment that drives an external LED depending on the firmware configuration
25	LED3	I	LED3 display segment that drives an external LED depending on the firmware configuration
26	LED4	I	LED4 display segment that drives an external LED depending on the firmware configuration
27	LED5	I	LED5 display segment that drives an external LED depending on the firmware configuration
28	GSRP	IA	Coulomb counter differential input. Connect to one side of the sense resistor
29	GSRN	IA	Coulomb counter differential input. Connect to one side of the sense resistor
30	$\overline{\text{MRST}}$	I	Master reset input that forces the device into reset when held low. Must be held high for normal operation. Connect to $\overline{\text{RESET}}$ for correct operation of device
31	VSS	P	Negative supply voltage input. Connect all VSS pins together for operation of device
32	REG25	P	2.5V regulator output. Connect at least a 1mF capacitor to REG25 and VSS
33	RBI	P	RAM / Register backup input. Connect a capacitor to this pin and VSS to protect loss of RAM / Register data in case of short circuit condition.
34	VSS	P	Negative supply voltage input. Connect all VSS pins together for operation of device
35	$\overline{\text{RESET}}$	O	Reset output. Connect to $\overline{\quad}$

(1)

RECOMMENDED OPERATING CONDITIONS (continued)

Over operating free-air temperature range (unless otherwise d 0 Td (otherwise)Tj 41.21 0 T21 0 T41.77 0 Td (ot51.e)Tj 00755.6 Td Tz 0 0 0

ELECTRICAL CHARACTERISTICS (continued)

Over operating free-air temperature range (unless otherwise noted), T_A = –40°C to 85°C, $V_{(REG25)}$ = 2.41 V to 2.59 V, $V_{(BAT)}$ = 14 V, $C_{(REG25)}$ = 1 µF, $C_{(REG33)}$ = 2.2 µF; typical values at T_A = 25°C (unless otherwise noted)

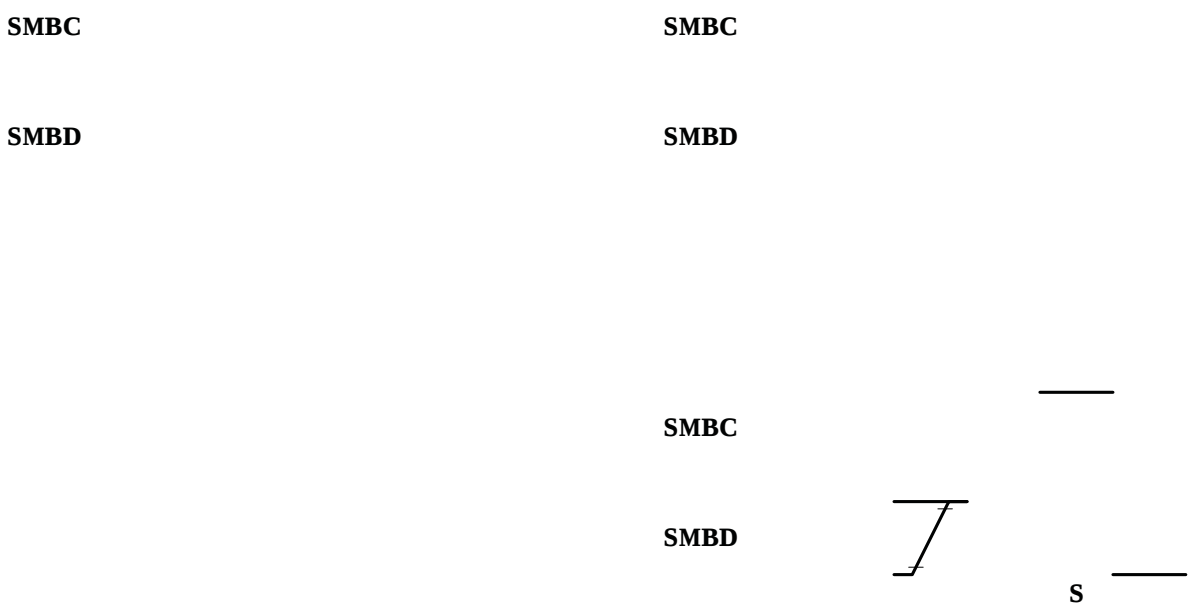
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(TOUT)}$	Output voltage	$I_{(TOUT)}$ = 0 mA; T_A = 25°C		$V_{(REG25)}$		V
$R_{DS(on)}$	TOUT pass element resistance	$I_{(TOUT)}$ = 1 mA; $R_{DS(on)}$ = ($V_{(REG25)}$ - $V_{(TOUT)}$)/ 1 mA; T_A = –40°C to 100°C		50	100	Ω
LED OUTPUTS						
V_{OL}	Output low voltage	LED1, LED2, LED3, LED4, LED5			0.4	V
VCELL+ HIGH VOLTAGE INPUT						

measureoftheaverage

SMBus TIMING CHARACTERISTICS (continued)

T_A = –40°C to 85°C Typical Values at T_A = 25°C and V_{REG25} = 2.5 V (Unless Otherwise Noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(MAS)}$	SMBus master clock frequency	Master mode, No clock low slave extend		51.2		kHz
$t_{(BUF)}$	Bus free time between start and stop (see Figure 1)		4.7			µs
$t_{(HD:STA)}$	Hold time after (repeated) start (see Figure 1)		4			µs
$t_{(SU:STA)}$	Repeated start setup time (see Figure 1)		4.7			µs
$t_{(SU:STO)}$	Stop setup time (see Figure 1)		4			µs
$t_{(HD:DAT)}$	Data hold time (see Figure 1)	Receive mode	0			ns
		Transmit mode	300			
$t_{(SU:DAT)}$	Data setup time (see Figure 1)		250			ns
$t_{(TIMEOUT)}$	Error signal/detect (see Figure 1)	See (1)	25		35	µs
$t_{(LOW)}$	Clock low period (see Figure 1)		4.7			µs
$t_{(HIGH)}$	Clock high period (see Figure 1)	See (2)	4		50	µs
50						



A. SCLKACK is the acknowledge-related clock pulse generated by the master.

Figure 1. SMBus Timing Diagram

FEATURE SET

Primary (1st Level) Safety Features

The bq20z65-R1 supports a wide range of battery and system protection features that can easily be configured. The primary safety features include:

- Cell over/undervoltage protection
- Charge and discharge overcurrent
- Short Circuit protection
- Charge and discharge overtemperature with independent alarms and thresholds for each thermistor
- AFE Watchdog

Secondary (2nd Level) Safety Features

The secondary safety features of the bq20z65-R1 can be used to indicate more serious faults via the SAFE pin. This pin can be used to blow an in-line fuse to permanently disable the battery pack from charging or discharging. The secondary safety protection features include:

- Safety overvoltage
- Safety undervoltage
- 2nd level protection IC input
- Safety overcurrent in charge and discharge
- Safety over-temperature in charge and discharge with independent alarms and thresholds for each thermistor
- Charge FET and zero-volt charge FET fault
- Discharge FET fault
- Cell imbalance detection (active and at rest)
- Open thermistor detection
- Fuse blow detection
- AFE communication fault

Charge Control Features

The bq20z65-R1 charge control features include:

- Supports JEITA temperature ranges. Reports charging voltage and charging current according to the active temperature range.
- Handles more complex charging profiles. Allows for splitting the standard temperature range into 2 sub-ranges and allows for varying the charging current according to the cell voltage.
- Reports the appropriate charging current needed for constant current charging and the appropriate charging voltage needed for constant voltage charging to a smart charger using SMBus broadcasts.
- Determines the chemical state of charge of each battery cell using Impedance Track™ and can reduce the charge difference of the battery cells in fully charged state of the battery pack gradually using cell balancing algorithm during charging. This prevents fully charged cells from overcharging and causing excessive degradation and also increases the usable pack energy by preventing premature charge termination
- Supports pre-charging/zero-volt charging
- Supports charge inhibit and charge suspend if battery pack temperature is out of temperature range
- Reports charging fault and also indicate charge status via charge and discharge alarms.

Gas Gauging

The bq20z65-R1 uses the Impedance Track™ Technology to measure and calculate the available charge in battery cells. The achievable accuracy is better than 1% error over the lifetime of the battery and there is no full charge discharge learning cycle required.

See *Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm* application note (SLUA364) for further details.

CONFIGURATION

Oscillator Function

The bq20z65-R1 fully integrates the system oscillators therefore, no external components are required for this feature.

System Present Operation

The bq20z65-R1 periodically verifies the $\overline{\text{PRES}}$ pin and detects that the battery is present in the system via a low state on a $\overline{\text{PRES}}$ input. When this occurs, the bq20z65-R1 enters normal operating mode. When the pack is removed from the system and the $\overline{\text{PRES}}$ input is high, the bq20z65-R1 enters the battery-removed state, disabling the charge, discharge, and ZVCHG FETs. The $\overline{\text{PRES}}$ input is ignored and can be left floating when non-removal mode is set in the data flash.

BATTERY PARAMETER MEASUREMENTS

The bq20z65-R1 uses an integrating delta-sigma analog-to-digital converter (ADC) for current measurement, and a second delta-sigma ADC for individual cell and battery voltage, and temperature measurement.

Charge and Discharge Counting

The integrating delta-sigma ADC measures the charge/discharge flow of the battery by measuring the voltage drop across a small-value sense resistor between the SR1 and SR2 pins. The integrating ADC measures bipolar signals from -0.25 V to 0.25 V. The bq20z65-R1 detects charge activity when $V_{SR} = V_{(SRP)}-V_{(SRN)}$is positive and discharge activity when $V_{SR} = V_{(SRP)} - V_{(SRN)}$ is negative. The bq20z65-R1 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 0.65nVh.

Voltage

The bq20z65-R1 updates the individual series cell voltages at one second intervals. The internal ADC of the bq20z65-R1 measures the voltage, scales and calibrates it appropriately. This data is also used to calculate the impedance of the cell for the Impedance Track™ gas-gauging.

Current

The bq20z65-R1 uses the SRP and SRN inputs to measure and calculate the battery charge and discharge current using a 5mΩ to 20mΩ typ. sense resistor.

Wake Function

The bq20z65-R1 can exit sleep mode, if enabled, by the presence of a programmable level of current signal across SRP and SRN.

Auto Calibration

The bq20z65-R1 provides an auto-calibration feature to cancel the voltage offset error across SRN and SRP for maximum charge measurement accuracy. The bq20z65-R1 performs auto-calibration when the SMBus lines stay low continuously for a minimum of a programmable amount of time.

Temperature

The bq20z65-R1 has an internal temperature sensor and 2 external temperature sensor inputs, TS1 and TS2, used in conjunction with two identical NTC thermistors (default are Semitec 103AT) to sense the battery environmental temperature. The bq20z65-R1 can be configured to use the internal temperature sensor or up to 2 external temperature sensors.

COMMUNICATIONS

The bq20z65-R1 uses SMBus v1.1 with Master Mode and package error checking (PEC) options per the SBS specification.

SMBus On and Off State

The bq20z65-R1 detects an SMBus off state when SMBC and SMBD are logic-low for ≥ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

SBS Commands

Table 3. SBS COMMANDS (continued)

SBS CMD	MODE	NAME	FORMAT	SIZE IN BYTES	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
0x19	R/W	DesignVoltage	Integer	2	7000	18,000	14,400	mV
0x1a	R/W	SpecificationInfo	Hex	2	0x0000	0xffff	0x0031	—
0x1b	R/W	ManufactureDate	Unsigned integer	2	0	65,535	0	—
0x1c	R/W	SerialNumber	Hex	2	0x0000	0xffff	0x0000	—
0x20	R/W	ManufacturerName	String	20+1	—	—	Texas Instruments	—
0x21	R/W	DeviceName	String	20+1	—	—	bq20z65-R1	—
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	—
0x23	R	ManufacturerData	String	14+1	—	—	—	—
0x2f	R/W	Authenticate	String	20+1	—	—	—	—
0x3c	R	CellVoltage4	Unsigned integer	2	0	65,535	—	mV
0x3d	R	CellVoltage3	Unsigned integer	2	0	65,535	—	mV
0x3e	R	CellVoltage2	Unsigned integer	2	0	65,535	—	mV
0x3f	R	CellVoltage1	Unsigned integer	2	0	65,535	—	mV

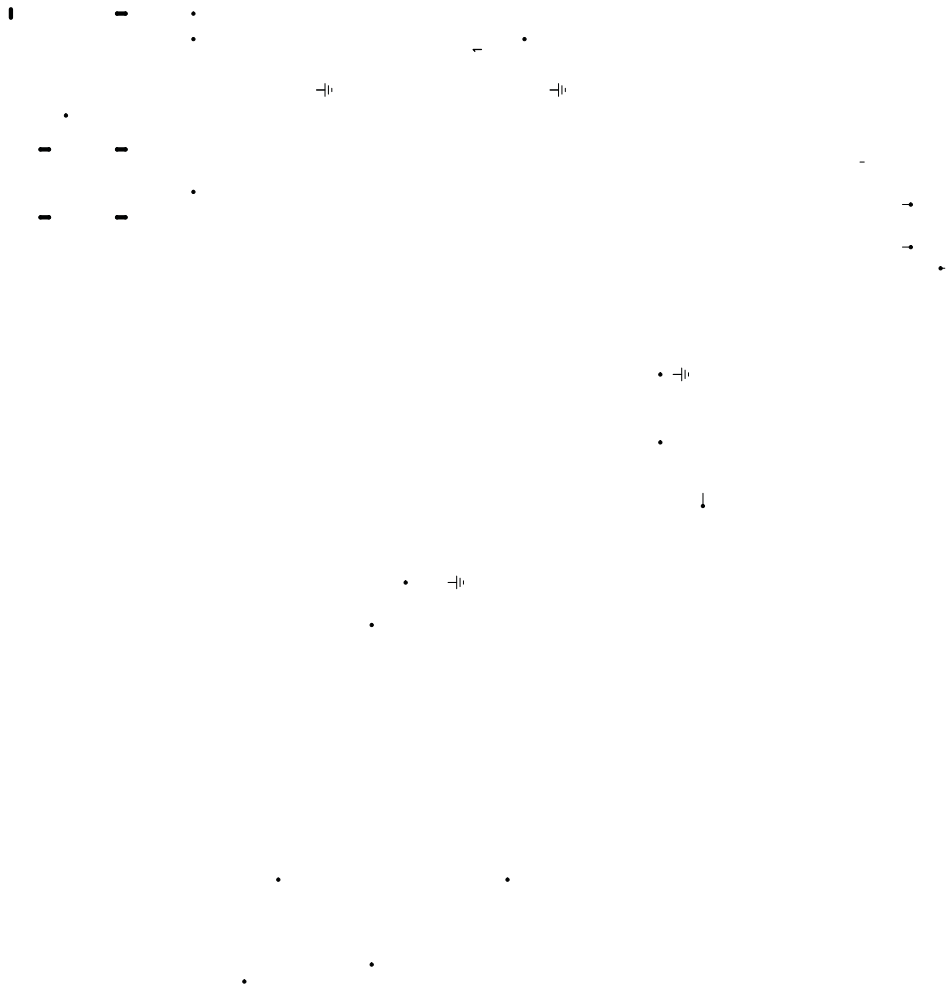
Table 4. EXTENDED SBS COMMANDS

SBS CMD	MODE	NAME	FORMAT	SIZE IN BYTES	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
0x45	R	AFEData	String	11+1	—	—	—	—
0x46	R/W	FETControl	Hex	2	0x00	0xff	—	—
0x4f	R	StateOfHealth	Hex	2	0x0000	0xffff	—	%
0x51	R	SafetyStatus	Hex	2	0x0000	0xffff	—	—
0x52	R	PFAlert	Hex	2	0x0000	0xffff	—	—
0x53	R	PFStatus	Hex	2	0x0000	0xffff	—	—
0x54	R	OperationStatus	Hex	2	0x0000	0xffff	—	—
0x55	R	ChargingStatus	Hex	2	0x0000	0xffff	—	—
0x57	R	ResetData	Hex	2	0x0000	0xffff	—	—
0x58	R	WDResetData	Unsigned integer	2	0	65,535	—	—
0x5a	R	PackVoltage	Unsigned integer	2	0	65,535	—	mV
0x5d	R	AverageVoltage	Unsigned integer	2	0	65,535	—	mV
0x5e	R	TS1Temperature	Integer	2	-400	1200	—	0.1°C
0x5f	R	TS2Temperature	Integer	2	-400	1200	—	0.1°C
0x60	R/W	UnSealKey	Hex	4	0x00000000	0xffffffff	—	—
0x61	R/W	FullAccessKey	Hex	4	0x00000000	0xffffffff	—	—
0x62	R/W	PFKey	Hex	4	0x00000000	0xffffffff	—	—
0x63	R/W	AuthenKey3	Hex	4	0x00000000	0xffffffff	—	—
0x64	R/W	AuthenKey2	Hex	4	0x00000000	0xffffffff	—	—
0x65	R/W	AuthenKey1	Hex	4	0x00000000	0xffffffff	—	—
0x66	R/W	AuthenKey0	Hex	4	0x00000000	0xffffffff	—	—
0x68	R	SafetyAlert2	Hex	2	0x0000	0x000f	—	—
0x69	R	SafetyStatus2	Hex	2	0x0000	0x000f	—	—

Table 4. EXTENDED SBS COMMANDS (continued)

SBS CMD	MODE	NAME	FORMAT	SIZE IN BYTES	MIN VALUE	MAX VALUE	DEFAULT VALUE	UNIT
0x6a	R	PFAlert2	Hex	2	0x0000	0x000f	—	—
0x6b	R	PFStatus2	Hex	2	0x0000	0x000f	—	—
0x6c	R	ManufBlock1	String	20	—	—	—	—
0x6d	R	ManufBlock2	String	20	—	—	—	—
0x6e	R	ManufBlock3	String	20	—	—	—	—
0x6f	R	ManufBlock4	String	20	—	—	—	—
0x70	R/W	ManufacturerInfo	String	31+1	—	—	—	—
0x71	R/W	SenseResistor	Unsigned integer	2	0	65,535	—	µΩ
0x72	R	TempRange	Hex	2	—	—	—	—
0x73	R	LifetimeData1	String	32+1	—	—	—	—
0x74	R	LifetimeData2	String	8+1	—	—	—	—
0x77	R/W	DataFlashSubClassID	Hex	2	0x0000	0xffff	—	—
0x78	R/W	DataFlashSubClassPage1	Hex	32	—	—	—	—
0x79	R/W	DataFlashSubClassPage2	Hex	32	—	—	—	—
0x7a	R/W	DataFlashSubClassPage3	Hex	32	—	—	—	—
0x7b	R/W	DataFlashSubClassPage4	Hex	32	—	—	—	—
0x7c	R/W	DataFlashSubClassPage5	Hex	32	—	—	—	—
0x7d	R/W	DataFlashSubClassPage6	Hex	32	—	—	—	—
0x7e	R/W	DataFlashSubClassPage7	Hex	32	—	—	—	—
0x7f	R/W	DataFlashSubClassPage8	Hex	32	—	—	—	—

APPLICATION SCHEMATIC

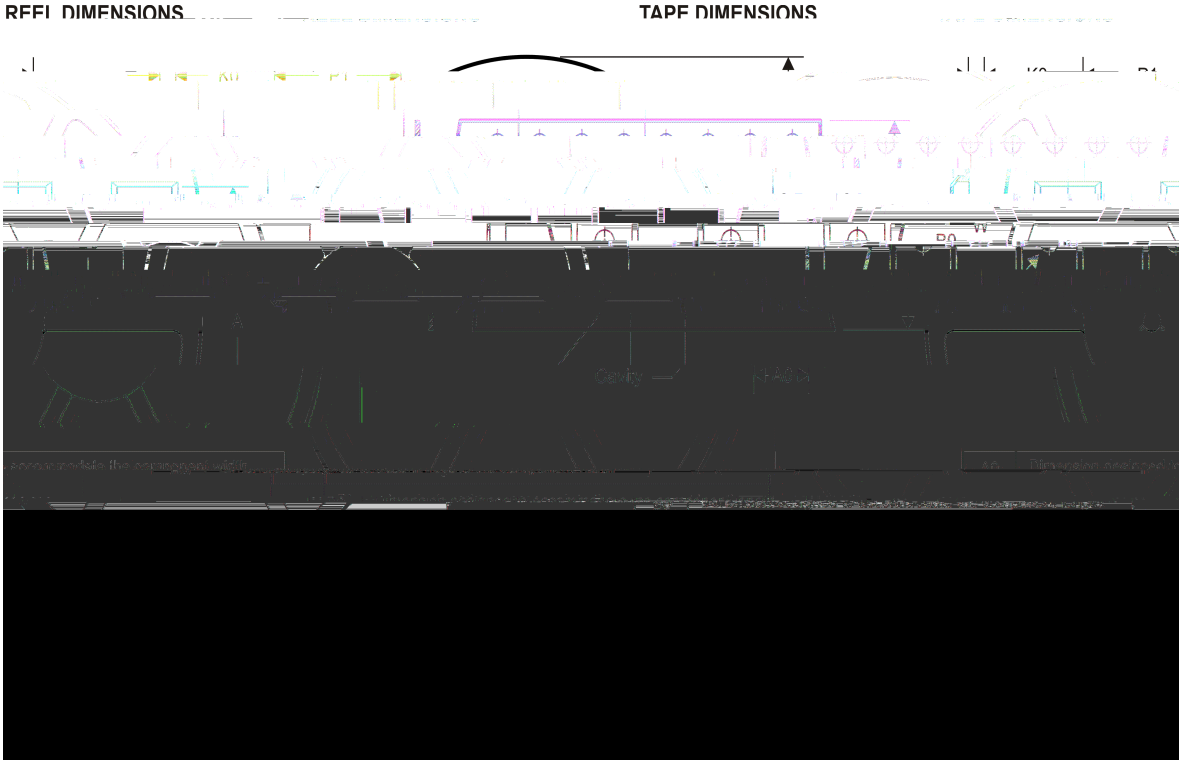


PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
BQ20Z65DBT-R1	ACTIVE	TSSOP	DBT	44	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ20Z65DBTR-R1	ACTIVE	TSSOP	DBT	44	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 that5 re f Q BT 1 8.e f Q BT 1 8278.0 (as) -278libtr)

TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ20Z65DBTR-R1	TSSOP	DBT	44	2000	330.0	24.4	6.8	11.7	1.6	12.0	24.0	Q1

PACKAGE MATERIALS INFORMATION

www.ti.com

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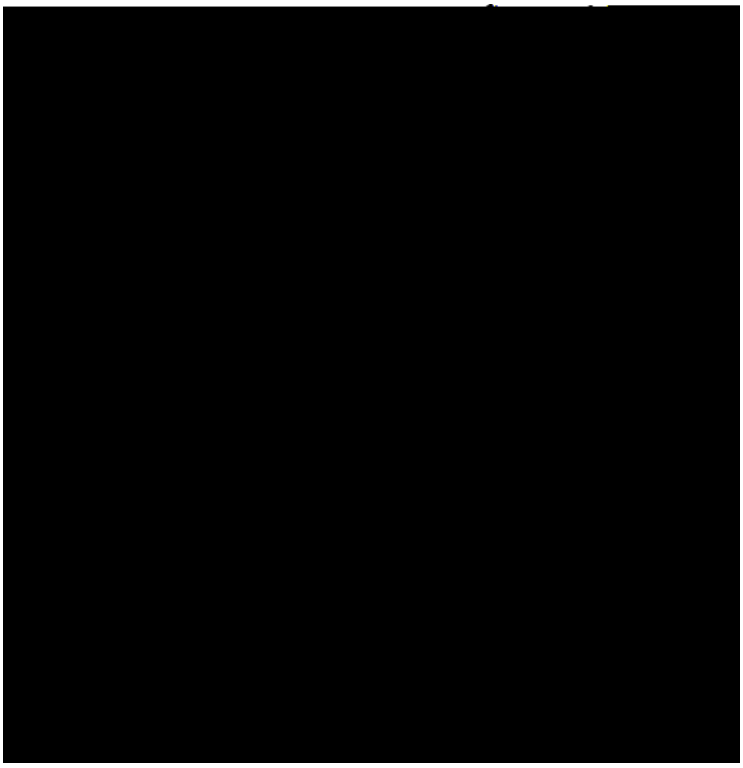
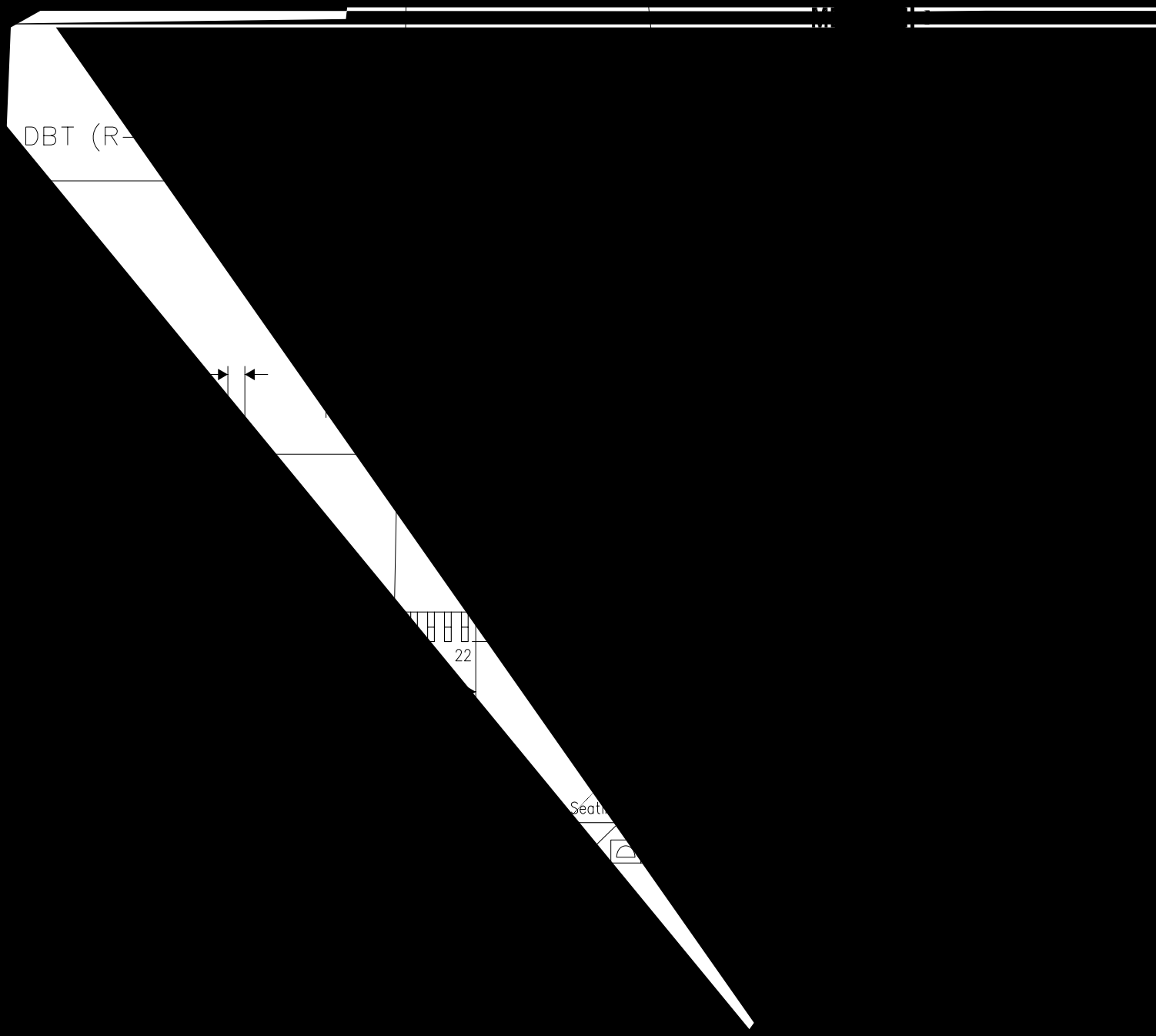


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ20Z65DBTR-R1	TSSOP	DBT	44	2000	367.0	367.0	45.0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