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

Check for Samples: bq20z75

FEATURES

- **Next Generation Patented Impedance Track™ Technology accurately Measures Available Charge in Li-Ion and Li-Polymer Batteries**
  - **Better than 1% Error Over Lifetime of the Battery**
  - **Instant Accuracy – No Learning Cycle Required**
- **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 Ultra-Low Power Modes**
- **Full Array of Programmable Protection Features**
  - **Voltage, Current and Temperature**
- **Supports SHA-1 Authentication**
- **small 38-Pin TSSOP (DBT) Package**

APPLICATIONS

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

DESCRIPTION

The bq20z75 SBS-compliant gas gauge and protection IC is a single IC solution designed for battery-pack or in-system installation. The bq20z75 measures and maintains an accurate record of available charge in Li-ion or Li-polymer batteries using its integrated high-performance analog peripherals, monitors capacity change, battery impedance, open-circuit voltage, and other critical parameters of the battery pack as well and 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 bq20z75 maximizes functionality, safety and minimize 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.

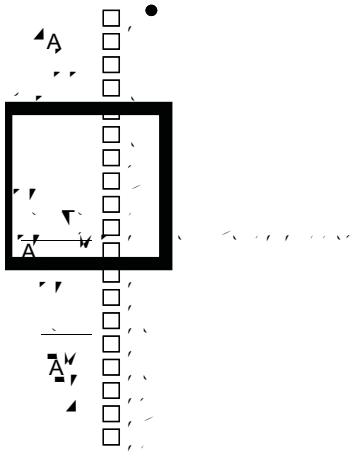
Table 1. AVAILABLE OPTIONS

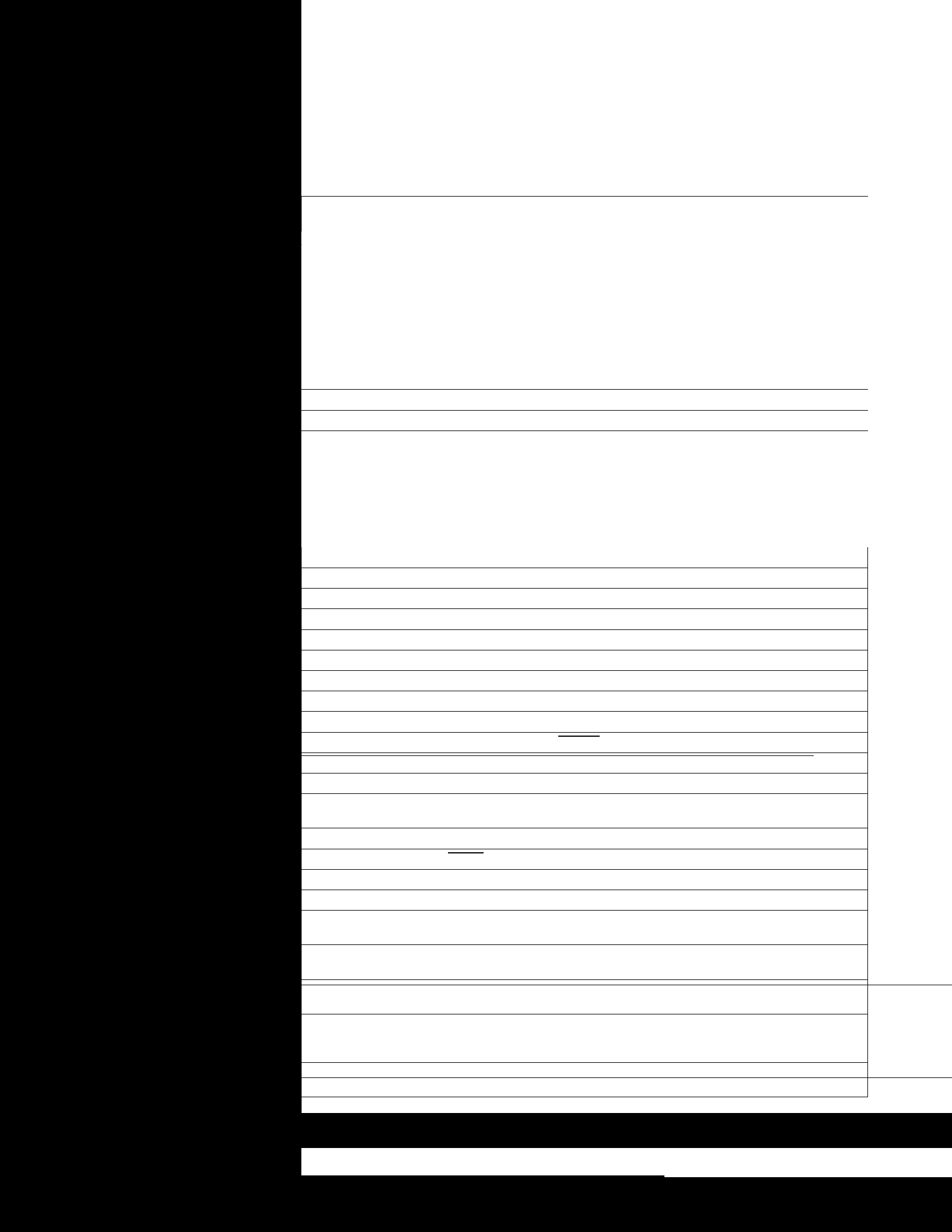
T_A	PACKAGE	
	38-PIN TSSOP (DBT) Tube(1)	**38-PIN TSSOP (DBT) Tape and Reel(2)**
–40°C to 85°C	bq20z75DBT	bq20z75DBTR
	bq20z75DBT-v160	bq20z75DBTR-v160

(1) A single tube quantity is 50 units.
(2) A single reel quantity is 2000 units

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damagemende0 T3 (d3Td smmends)s 73183–8es





TERMINAL FUNCTIONS (continued)

TERMINAL		I/O[1]	DESCRIPTION
NO.	NAME		
37	BAT	O	Battery stack voltage sense input
38	CHG	O	High side N-channel charge FET gate drive

Absolute Maximum Ratings

Over Operating Free-Air Temperature (unless otherwise noted) [1]

	DESCRIPTION	PIN	UNIT
V_{MAX}	Supply voltage range	note Tf (2008)Tn85.7 26.86 0 T=85.7 17.51 0 Td1, (73 Td86.2 0 Td (73)Tj ET 7Td (i	

Recommended Operating Conditions

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

PARAMETER		PIN	MIN	NOM	MAX	UNIT
V_{SUP}	Supply voltage	VCC, VBAT	4.5		25	V
$V_{STARTUP}$	Minimum startup voltage	VCC, BAT, PACK	5.5			V
V_{IN}	Input Voltage Range	VC(n)–VC(n+1); n = 1,2,3,4	0		5	V
		VC1, VC2, VC3, VC4	0		V_{SUP}	V
		VC5	0		0.5	V
		ASRN, ASRP	–0.5		0.5	V
		PACK, PMS	0		25	V
V_{GPOD}	Output Voltage Range	GPOD	0		25	V
A_{GPOD}	Drain Current(1)	GPOD			1	mA
C_{REG25}	2.5V LDO Capacitor	REG25	1			µF
C_{REG33}	3.3V LDO Capacitor	REG33	2.2			µF
C_{VCELL+}	Cell Voltage Output Capacitor	VCELL+	0.1			µF
C_{PACK}	PACK input block resistor(2)	PACK	1			kΩ

(1) Use external resistor to limit current to GPOD to 1mA in high voltage application.
(2) External resistor to limit inrush current PACK pin required.

Electrical Characteristics

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} = 14V, C_{REG25} = 1µF, C_{REG33} = 2.2µF; typical values at T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY CURRENT						
I_{NORMAL}	Firmware running			550		µA
I_{SLEEP}	Sleep Mode	CHG FET on; DSG FET on		124		µA
		CHG FET off; DSG FET on		90		µA
		CHG FET off; DSG FET off		52		µA
$I_{SHUTDOWN}$	Shutdown Mode			0.1	1	µA
SHUTDOWN WAKE; T_A = 25°C (unless otherwise noted)						
I_{PACK}	Shutdown exit at $V_{STARTUP}$ threshold				1	µA
SRx WAKE FROM SLEEP; T_A = 25°C (unless otherwise noted)						
V_{WAKE}	Positive or negative wake threshold with 1.00 mV, 2.25 mV, 4.5 mV and 9 mV programmable options		1.25		10	mV
V_{WAKE_ACR}	Accuracy of V_{WAKE}	V_{WAKE} = 1.0mV; IWAKE=0, RSNS1=0, RSNS0=1;	–0.7		0.7	mV
		V_{WAKE} = 2.25mV; IWAKE =1, RSNS1=0, RSNS0=1; IWAKE =0, RSNS1=1, RSNS0=0;	–0.8		0.8	
		V_{WAKE} = 4.5mV; IWAKE =1, RSNS1=1, RSNS0=1; IWAKE =0, RSNS1=1, RSNS0=0;	–1.0		1.0	
		V_{WAKE} = 9mV; IWAKE =1, RSNS1=1, RSNS0=1;	–1.4		1.4	
V_{WAKE_TCO}	Temperature drift of V_{WAKE} accuracy			0.5		%/°C
t_{WAKE}	Time from application of current and wake of bq20z75			1	10	ms
POWER-ON RESET						
V_{IT-}	Negative-going voltage input	Voltage at REG25 pin	1.70	1.80	1.90	V

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} = 14V, C_{REG25} = 1µF, C_{REG33} = 2.2µF; typical values at T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{VCELL+OUT}$	Drive Current to VCELL+ capacitor	VC(n) – VC(n+1) = 0V; VCELL+ = 0V; T_A = –40°C to 100°C	12	18		mA
$V_{VCELL+O}$	CELL offset error	CELL output (VC2 = VC1 = 18V) – CELL output (VC2 = VC1 = 0V)	–18	–1	18	mV
I_{VCnL}	VC(n) pin leakage current	VC1, VC2, VC3, VC4, VC5 = 3V	–1	0.01	1	mA
CELL BALANCING						
R_{BAL}	internal cell balancing FET resistance	$R_{DS(on)}$ for internal FET switch at V_{DS} = 2V; T_A = 25°C	200	400	600	Ω
HARDWARE SHORT CIRCUIT AND OVERLOAD PROTECTION; T_A = 25°C (unless otherwise noted)						
$V_{(OL)}$	OL detection threshold voltage accuracy	V_{OL} = 25mV (min)	15	25	35	mV
		V_{OL} = 100mV; RSNS = 0, 1	90	100	110	
		V_{OL} = 205mV (max)	185	205	225	
$V_{(SCC)}$	SCC detection threshold voltage accuracy	V_{SCC} = 50mV (min)	30	50	70	mV
		V_{SCC} = 200mV; RSNS = 0, 1	180	200	220	
		V_{SCC} = 475mV (max)	428	475	523	
$V_{(SCD)}$	SCD detection threshold voltage accuracy	V_{SCD} = –50mV (min)	–30	–50	–70	mV
		V_{SCD} = –200mV; RSNS = 0, 1	–180	–200	–220	
		V_{SCD} = –475mV (max)	–428	–475	–523	
t_{da}	Delay time accuracy			±15.25		ms
t_{pd}	Protection circuit propagation delay			50		ms
FET DRIVE CIRCUIT; T_A = 25°C (unless otherwise noted)						
V_{DSGON}	DSG pin output on voltage	$V_{DSGON} = V_{DSG} – V_{PACK}$; V_{GS} = 10MΩ;DSG and CHG on; T_A = –40°C to 100°C	8	12	16	V
V_{CHGON}	CHG pin output on voltage	$V_{CHGON} = V_{CHG} – V_{BAT}$; V_{GS} = 10MΩ;DSG and CHG on; T_A = –40°C to 100°C	8	12	16	V
V_{DSGOFF}	DSG pin output off voltage	$V_{DSGOFF} = V_{DSG} – V_{PACK}$			0.2	V
V_{CHGOFF}	CHG pin output off voltage	$V_{CHGOFF} = V_{CHG} – V_{BAT}$			0.2	V
t_R	Rise time	C_L=4700pF; V_{PACK} ≤ DSG ≤V_{PACK} + 4V		400	1000	ms
		C_L=4700pF; V_{BAT} ≤ CHG ≤V_{BAT} + 4V		400	1000	
t_F	Fall time	C_L=4700pF; V_{PACK} + V_{DSGON} ≤ DSG ≤V_{PACK} + 1V		40	200	ms
		C_L=4700pF; V_{BAT} + V_{CHGON} ≤ CHG ≤V_{BAT} + 1V		40	200	
V_{ZVCHG}	ZVCHG clamp voltage	BAT = 4.5V	3.3	3.5	3.7	V
LOGIC; T_A = –40°C to 100°C (unless otherwise noted)						
R_{PULLUP}	Internal pullup resistance	$\overline{ALERT}$	60	100	200	kΩ
		$\overline{RESET}$	1	3	6	
V_{OL}	Logic low output voltage level	$\overline{ALERT}$			0.2	V
		$\overline{RESET}$; V_{BAT} = 7V; V_{REG25} = 1.5V; $I_{\overline{RESET}}$ = 200mA			0.4	
		GPOD; I_{GPOD} = 50mA			0.6	
LOGIC SMBC, SMBD, $\overline{PFIN}$, $\overline{PRES}$, SAFE, ALERT						
V_{IH}	High-level input voltage		2.0			V
V_{IL}	Low-level input voltage				0.8	V

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} = 14V, C_{REG25} = 1µF, C_{REG33} = 2.2µF; typical values at T_A = 25°C (unless otherwise noted)

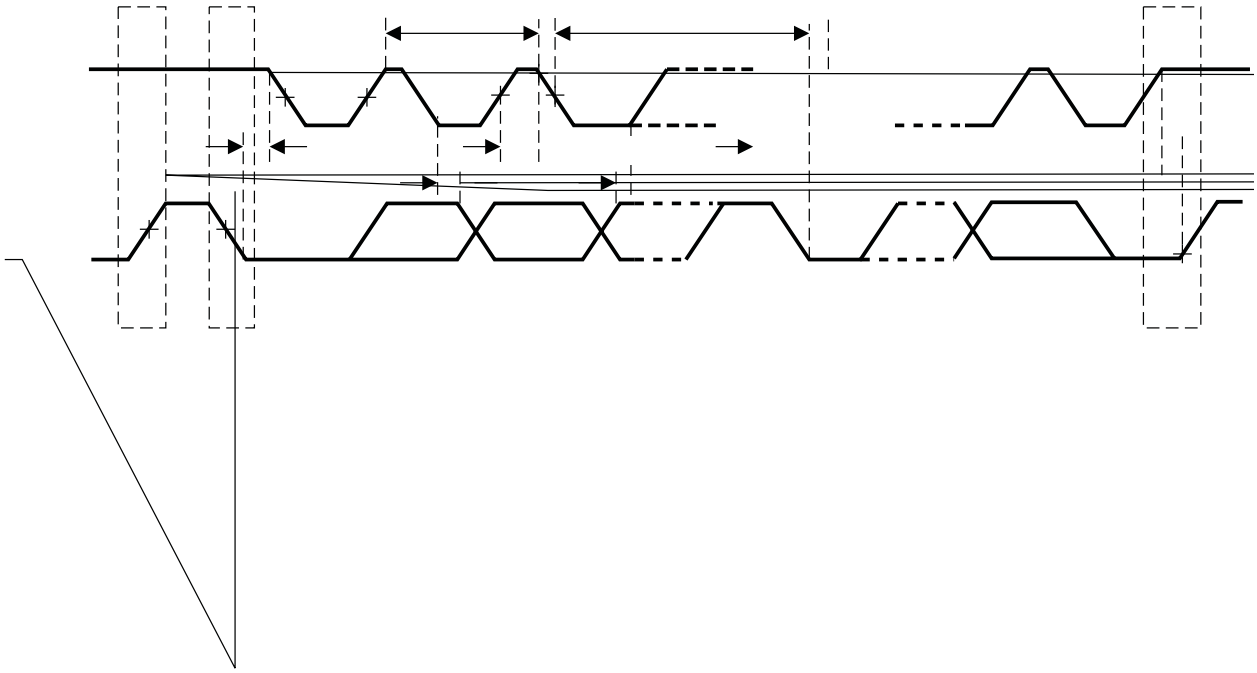
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Frequencyerror	$f_{(EIO)}$ Frequency error (12) (13)		–3%	0.25%	3%	
		T_A = 20°C to 70°C	–2%	0.25%	2%	
	$t_{(SXO)}$ Start-up time (14)			2.5	5	ms
LOW FREQUENCY OSCILLATOR						
	$f_{(LOSC)}$ Operating frequency			32.768		kHz

Start-up			
Start-up			

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
$t_{(TIMEOUT)}$ Error signal/detect (see Figure 1	j 25.0144.3.3 r41.1 0.31O25d (90.8 0.3 r1 285.2 666.8 S((see)Tj /F3 6 rg33 4 693.2 (1				25.0144.3.3 r41.1 0.31O25



FEATURE SET

Primary (1st Level) Safety Features

The bq20z75 supports a wide range of battery and system protection features that can easily be configured. The primary safety features include:

- Cell over/under voltage protection
- Charge and Discharge over current
- Short Circuit
- Charge and Discharge Over temperature
- AFE Watchdog

Secondary (2nd Level) Safety Features

The secondary safety features of the bq20z75 can be used to indicate more serious faults via the SAFE (pin 7). 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 overcurrent in Charge and Discharge
- Safety overtemperature in Charge and Discharge
- Charge FET and 0 Volt Charge FET fault
- Discharge FET fault
- AFE communication fault

Charge Control Features

The bq20z75 charge control features include:

- 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
- Support fast 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 bq20z75 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.

Authentication

The bq20z75 supports authentication by the host using SHA-1.

Power Modes

The bq20z75 supports 3 different power modes to reduce power consumption:

- In Normal Mode, the bq20z75 performs measurements, calculations, protection decisions and data updates in 1 second intervals. Between these intervals, the bq20z75 is in a reduced power stage.

• 0 0 rg 7 Tf 10inc (Copyrigh 54 246.2 .S8 0 Td 0 Ths.7 35.rzn 0 Td 91.36 0 ink(s):y)Tj 34.6 Td Submit

- In Sleep Mode, the bq20z75 performs measurements, calculations, protection decisions and data update in adjustable time intervals. Between these intervals, the bq20z75 is in a reduced power stage. The bq20z75 has a wake function that enables exit from Sleep mode, when current flow or failure is detected.
- In Shutdown Mode the bq20z75 is completely disabled.

CONFIGURATION

Oscillator Function

The bq20z75 fully integrates the system oscillators. Therefore the bq20z75 requires no external components for this feature.

System Present Operation

The bq20z75 checks the $\overline{\text{PRES}}$ pin periodically (1 s). Connect the $\overline{\text{PRES}}$ pin to TOUT with a 100kΩ resistor. If $\overline{\text{PRES}}$ input is pulled to ground by external system host, the bq20z75 detects this as system present.

BATTERY PARAMETER MEASUREMENTS

The bq20z75 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 SRP and SRN pins. The integrating ADC measures bipolar signals from –0.25 V to 0.25 V. The bq20z75 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 bq20z75 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 0.65 nVh.

Voltage

The bq20z75 updates the individual series cell voltages at one second intervals. The internal ADC of the bq20z75 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 bq20z75 uses the GSRP and GSRN inputs to measure and calculate the battery charge and discharge current using a 5 mΩ to 20 mΩ typ. sense resistor.

Auto Calibration

The bq20z75 provides an auto-calibration feature to cancel the voltage offset error across GSRN and GSRP for maximum charge measurement accuracy. The bq20z75 performs auto-calibration when the SMBus lines stay low continuously for a minimum of 5 s.

Temperature

The bq20z75 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 bq20z75 can be configured to use internal or external temperature sensors.

COMMUNICATIONS

The bq20z75 uses SMBus v1.1 with Master Mode and package error checking (PEC) options per the SBS specification.

SMBus On and Off State

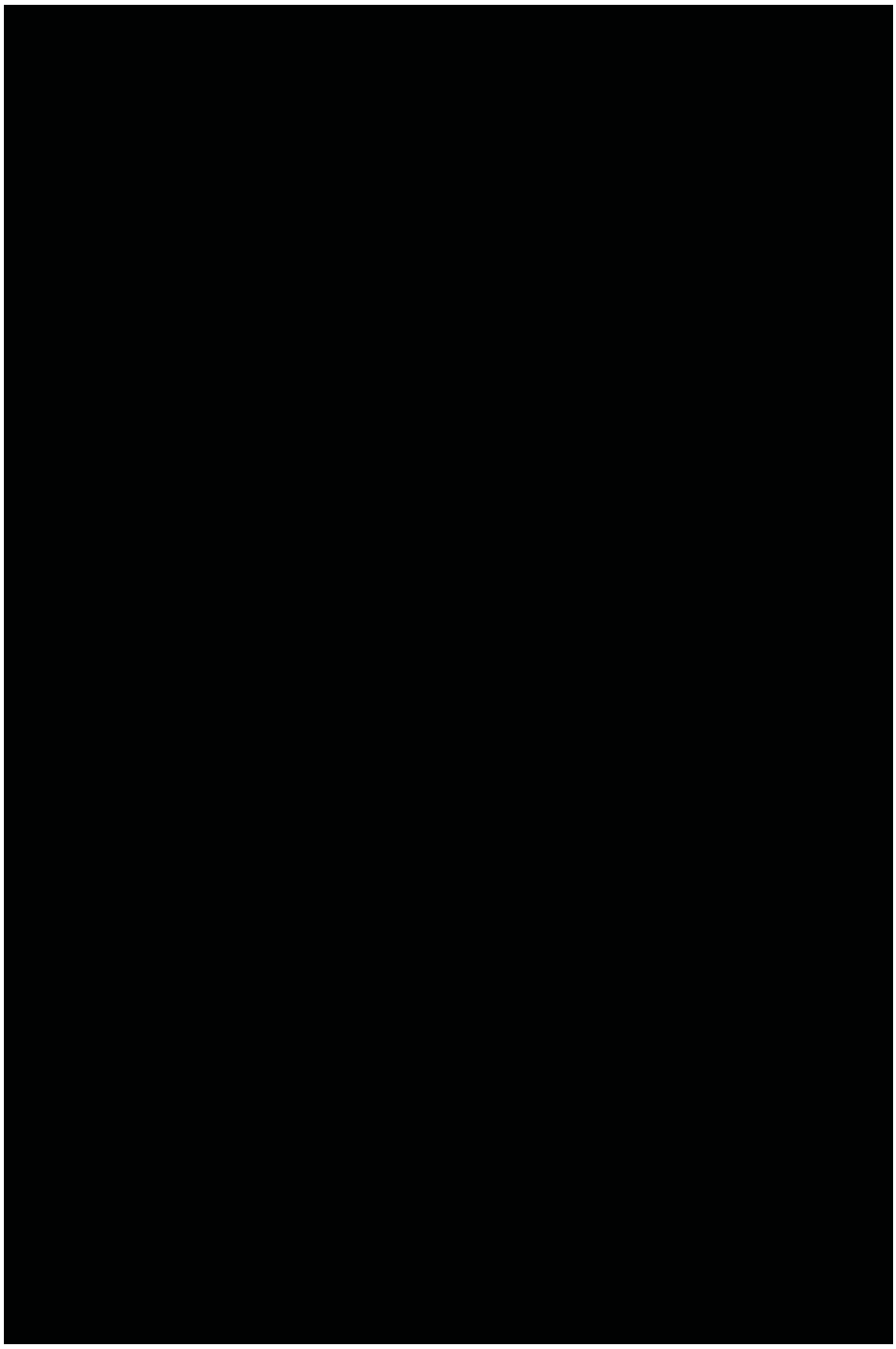
The bq20z75 detects an SMBus off state when SMBC and SMBD are logic-low for ≥ 2 seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

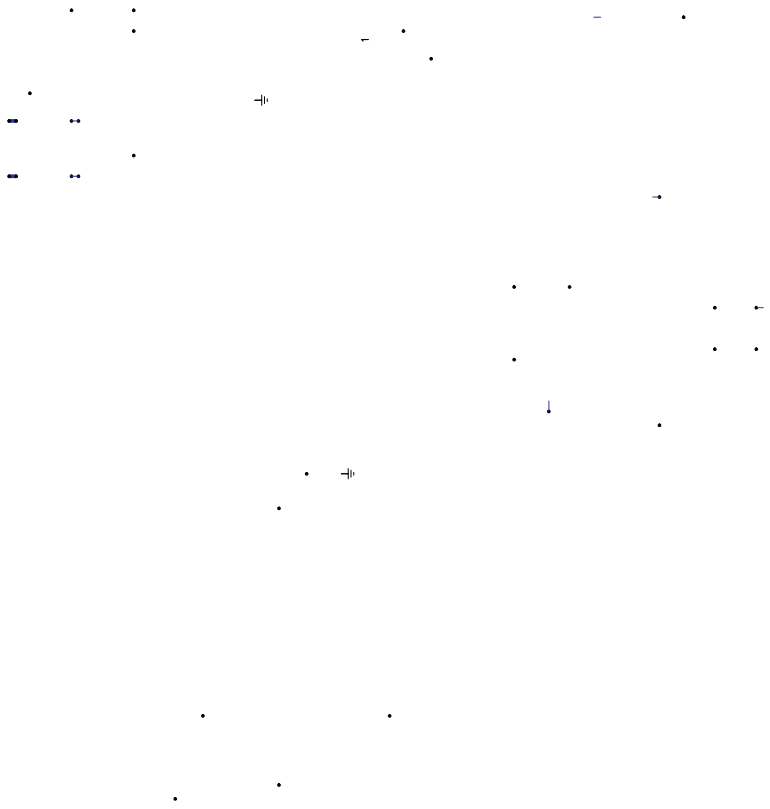
SBS and Dataflash Values

Table 2. SBS COMMANDS

SBS Cmd	Mode	Name	Format	Size in Bytes	Min Value	Max Value	Default Value	Unit
0x00	R/W	ManufacturerAccess	hex	2	0x0000	0xffff	—	
0x01	R/W	RemainingCapacityAlarm	unsigned int	2	0	65535	—	mAh or 10mWh
0x02	R/W	RemainingTimeAlarm	unsigned int	2	0	65535	—	min
0x03	R/W	BatteryMode	hex	2	0x0000	0xffff	—	
0x04	R/W	AtRate	signed int	2	–32768	32767	—	mA or 10mW
0x05	R	AtRateTimeToFull	unsigned int	2	0	65535	—	min
0x06	R	AtRateTimeToEmpty	unsigned int	2	0	65535	—	min
0x07	R	AtRateOK	unsigned int	2	0	65535	—	
0x08	R	Temperature	unsigned int	2	0	65535	—	0.1°K
0x09	R	Voltage	unsigned int	2	0	20000	—	mV
0x0a	R	Current	signed int	2	–32768	32767	—	mA
0x0b	R	AverageCurrent	signed int	2	–32768	32767	—	mA
0x0c	R	MaxError	unsigned int	1	0	100	—	%
0x0d	R	RelativeStateOfCharge	unsigned int	1	0	100	—	%
0x0e	R	AbsoluteStateOfCharge	unsigned int	1	0	100	—	%
0x0f	R/W	RemainingCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x10	R	FullChargeCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x11	R	RunTimeToEmpty	unsigned int	2	0	65535	—	min
0x12	R	AverageTimeToEmpty	unsigned int	2	0	65535	—	min
0x13	R	AverageTimeToFull	unsigned int	2	0	65535	—	min
0x14	R	ChargingCurrent	unsigned int	2	0	65535	—	mA
0x15	R	ChargingVoltage	unsigned int	2	0	65535	—	mV
0x16	R	BatteryStatus	unsigned int	2	0x0000	0xffff	—	
0x17	R/W	CycleCount	unsigned int	2	0	65535	—	
0x18	R/W	DesignCapacity	unsigned int	2	0	65535	—	mAh or 10mWh
0x19	R/W	DesignVoltage	unsigned int	2	7000	16000	14400	mV
0x1a	R/W	SpecificationInfo	unsigned int	2	0x0000	0xffff	0x0031	
0x1b	R/W	ManufactureDate	unsigned int	2	0	65535	0	
0x1c	R/W	SerialNumber	hex	2	0x0000	0xffff	-	
0x20	R/W	ManufacturerName	String	11+1	—	—	Texas Instruments	ASCII
0x21	R/W	DeviceName	String	7+1	—	—	bq20z75	ASCII
0x22	R/W	DeviceChemistry	String	4+1	—	—	LION	ASCII
0x23	R	ManufacturerData	String	14+1	—	—	—	ASCII
0x2f	R/W	Authenticate	String	20+1	—	—	—	ASCII
0x3c	R	CellVoltage4	unsigned int	2	0	65535	—	mV
0x3d	R	CellVoltage3	unsigned int	2	0	65535	—	mV
0x3e	R	CellVoltage2	unsigned int	2	0	65535	—	mV
0x3f	R	CellVoltage1	unsigned int	2	0	65535	—	mV

Application Schematics





PACKAGING INFORMATION

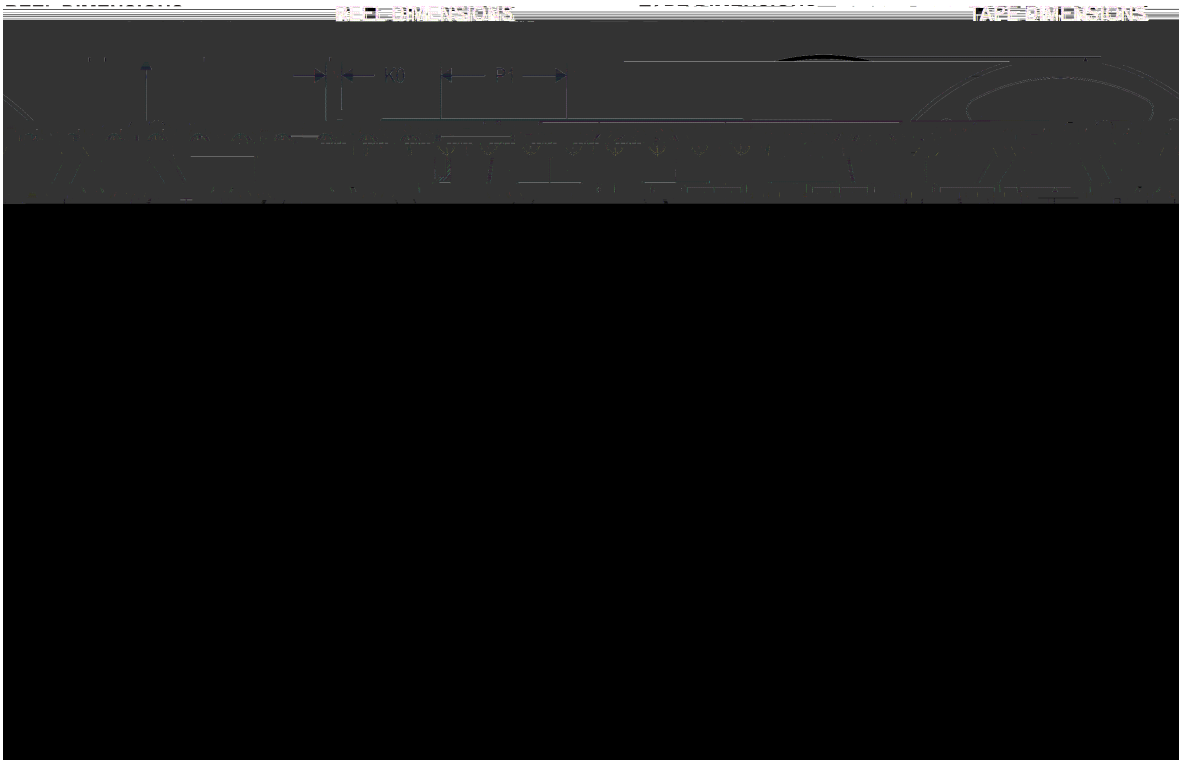
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
BQ20Z75DBT-V160	NRND	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
BQ20Z75DBT-V160G4	NRND	TSSOP	DBT	38	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
BQ20Z75DBTR-V160	NRND	TSSOP	DBT	38	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
BQ20Z75DBTR-V160G4	NRND	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)

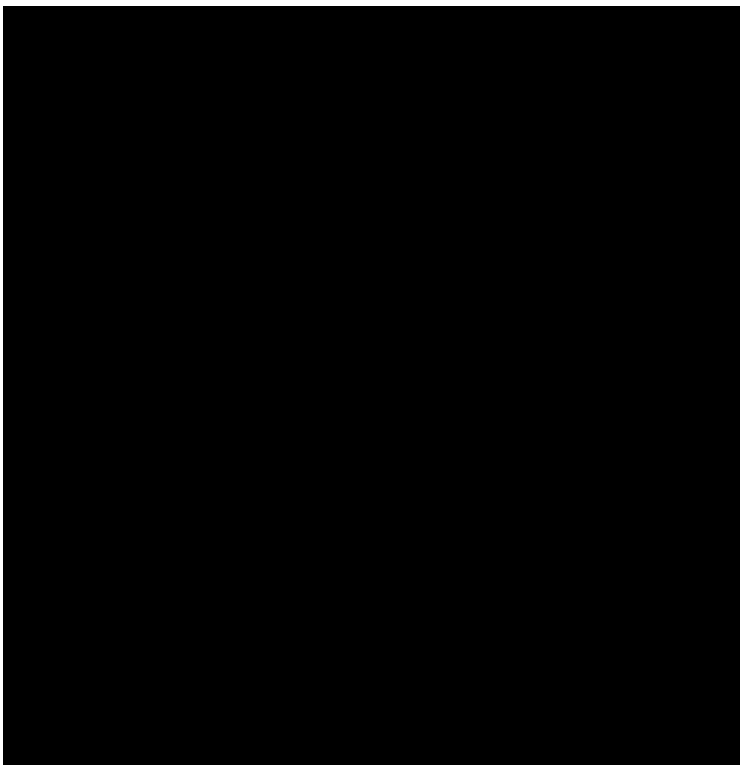
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION



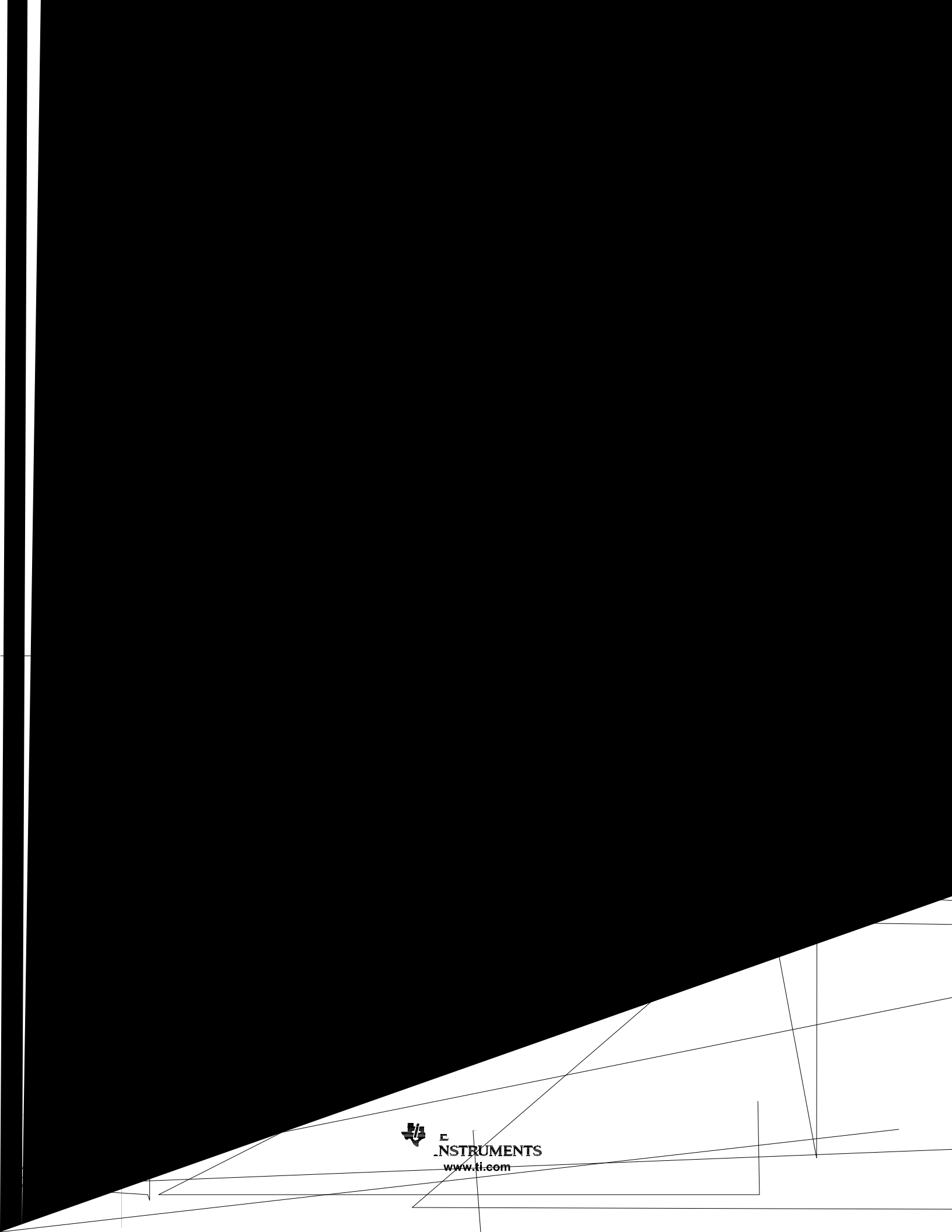
*All dimensions are nominal

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
BQ20Z75DBTR-V160	TSSOP	DBT	38	2000	330.0	16.4	6.9	10.2	1.8	12.0	16.0	Q1



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ20Z75DBTR-V160	TSSOP	DBT	38	2000	367.0	367.0	38.0


NSTRUMENTS
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