FEATURES

Battery

- **Instant Accuracy – No Learning Cycle Required**
- **Supports the Smart Battery Specification SBS V1.1**
- **Works With the TI bq29312A Analog Front-End (AFE) Protection IC to Provide Complete Pack Electronics Solution**
- **Full Array of Programmable Voltage, Current, and Temperature Protection Features**
- **Integrated Time Base Removes Need for External Crystal with Optional Crystal Input**
- **Electronics for 7.2-V, 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 Field Programmable FLASH Memory Eliminates the Need for External Configuration Memory**
- **Measures Charge Flow Using a High-Resolution, 16-Bit Integrating Delta-Sigma Converter**
  - **Better Than 0.65 nVh of Resolution**
  - **Self-Calibrating**
  - **Offset Error Less Than 1 µV**
- **Uses 16-Bit Delta-Sigma Converter for Accurate Voltage and Temperature Measurements**
- **Extensive Data Reporting Options For Improved System Interaction**
- **Optional Pulse Charging Feature for Improved Charge Times**
- **Drives 3-, 4- or 5-Segment LED Display for Remaining Capacity Indication**
- **Supports SHA-1 Authentication**
- **Lifetime Data Logging**

APPLICATIONS

Portable Instrumentation

DESCRIPTION

The bq20z80 SBS-compliant gas gauge IC, incorporating patented Impedance Track™ technology, is designed for battery-pack or in-system installation. The bq20z80 measures and maintains an accurate record of available charge in Li-ion or Li-polymer batteries using its integrated high-performance analog peripherals. The bq20z80 monitors capacity change, battery impedance, open-circuit voltage, 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 bq29312A analog front-end (AFE) protection IC to maximize functionality and safety, and minimize component count and cost in smart battery circuits.

The Impedance Track 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.

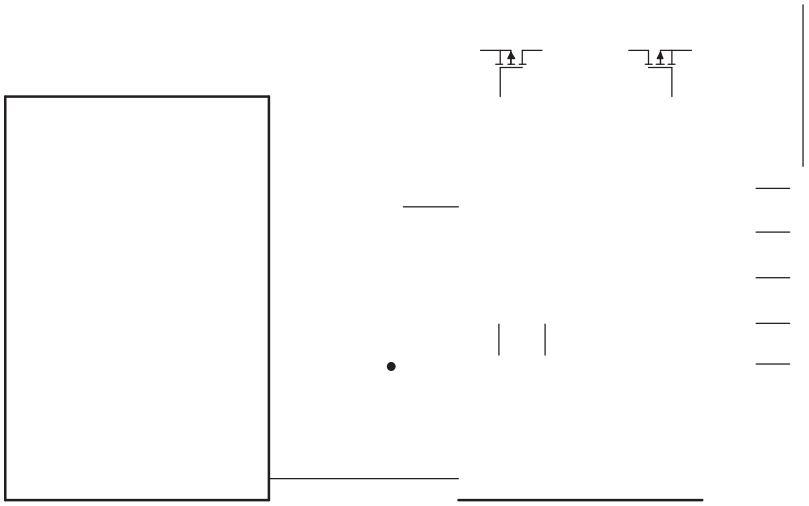
AVAILABLE OPTIONS

T_A	PACKAGE(1)	
	38-PIN TSSOP (DBT) Tube	38-PIN TSSOP (DBT) Tape and Reel
–40°C to 85°C	bq20z80ADBT(2)	bq20z80ADBTR(3)
–40°C to 85°C	bq20z80DBT(2)	bq20z80DBTR(3)

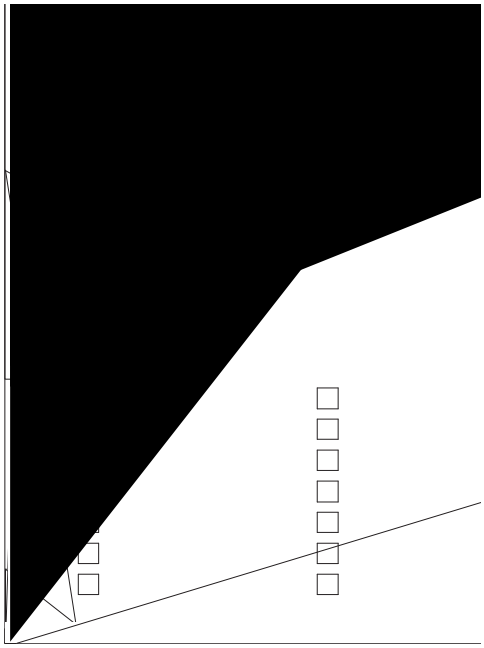
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
(2) A single tube quantity is 50 units.
(3) A single reel quantity is 2000 units

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

SYSTEM DIAGRAM



TSSOP (DBT)
(TOP VIEW)



ABSOLUTE MAXIMUM RATINGS

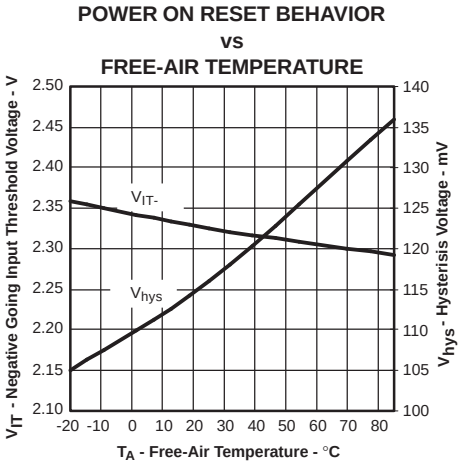
[redacted]

ELECTRICAL CHA[redacted]

POWER-ON RESET

V_{DD} = 3 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IT–}$	Negative-going voltage input		2.1	2.3	2.5	V
V_{HYS}	Power-on reset hysteresis		50	150	200	mV



INTEGRATING ADC (Coulomb Counter) CHARACTERISTICS

V_{DD} = 3 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(SR)}$	Input voltage range, $V_{(SR2)}$ and $V_{(SR1)}$	$V_{(SR)}$ = V(SR2) – V(SR1)	–0.25		0.25	V
$V_{(SROS)}$	Input offset			1		V
INL	Integral nonlinearity error			0.004%	0.019%	

PLL SWITCHING CHARACTERISTICS

V_{DD} = 3 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{(SP)}$	Start-up time (1)	0.5% frequency error		2	5	ms

(1) The frequency error is measured from the trimmed frequency of the internal system clock which is 128 oscillator frequency, nominally 4.194 MHz.

OSCILLATOR

V_{DD} = 3 V to 3.6 V, T_A = –40°C to 85°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(exo)}$	Frequency error from 32.768 kHz	ROSC = 100 kΩ	–2%	0.25%	2%	
		ROSC = 100 kΩ, V_{DD} = 3.3 V	–1%	0.25%	1%	
		XCK1 = 12-pF XTAL	–0.25%		0.25%	
$f_{(sxo)}$	Start-up time (1)	ROSC = 100 kΩ			250	s
		XCK1 = 12-pF XTAL			200	ms

(1) The start-up time is defined as the time it takes for the oscillator output frequency to be within 1% of the specified frequency.

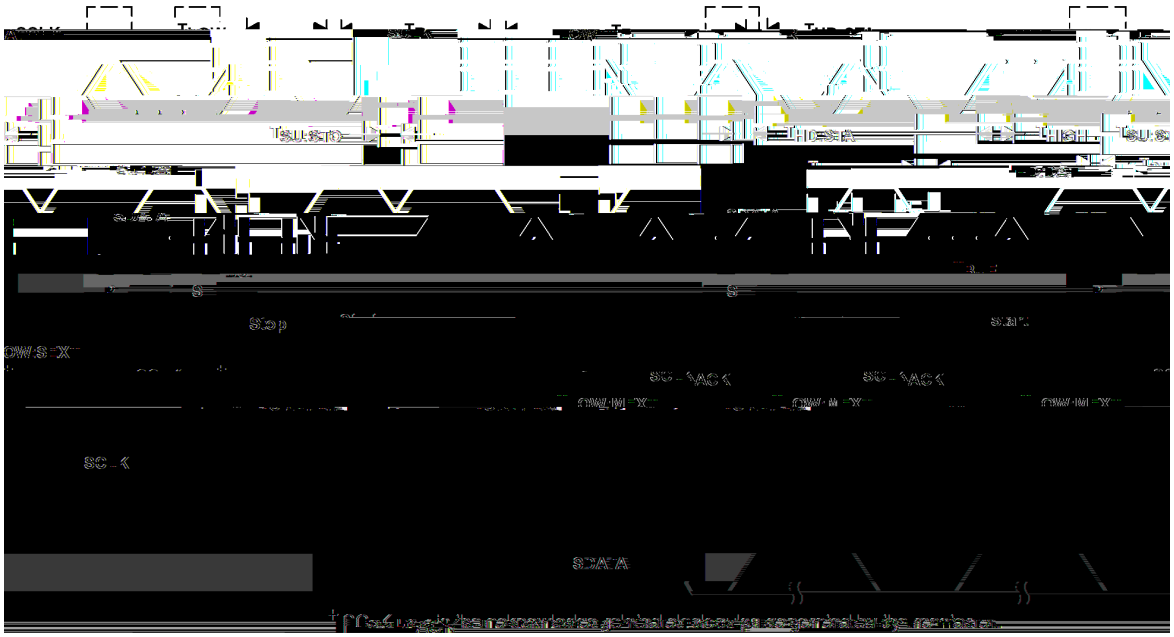
SMBus TIMING SPECIFICATIONS

V_{DD} = 3 V to 3.6 V, T_A = –40°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		
t_{BUF}	Bus free time between start and stop		4.7			s
$t_{HD:STA}$	Hold time after (repeated) start		4			
$t_{SU:STA}$	Repeated start setup time		4.7			
$t_{SU:STO}$	Stop setup time		4			
$t_{HD:DAT}$	Data hold time	Receive mode	0			ns
		Transmit mode	300			
$t_{SU:DAT}$	Data setup time		250			
$t_{TIMEOUT}$	Error signal/detect	See (1)	25		35	ms
t_{LOW}	Clock low period		4.7			s
t_{HIGH}	Clock high period	See (2)	4		50	
$t_{LOW:SEXT}$	Cumulative clock low slave extend time	See (3)			25	ms
$t_{LOW:MEXT}$	Cumulative clock low master extend time	See (4)			10	
t_F	Clock/data fall time	(V_{ILMAX} – 0.15 V) to (V_{IHMIN} + 0.15 V)			300	ns
t_R	Clock/data rise time	0.9 VDD to (VILMAX – 0.15 V)			1000	

(1) The bq20z80 times out when any clock low exceeds $t_{TIMEOUT}$.
(2) $t_{HIGH:MAX}$. is minimum bus idle time. SMBC = 1 for t > 50 s causes reset of any transaction involving the bq20z80 that is in progress.
(3) $t_{LOW:SEXT}$ is the cumulative time a slave device is allowed to extend the clock cycles in one message from initial start to the stop.
(4) $t_{LOW:MEXT}$ is the cumulative time a master device is allowed to extend the clock cycles in one message from initial start to the stop.

SMBus TIMING DIAGRAM



FEATURE SET

NOTE

The bq20z80-V102 is designed to work with the bq29312A AFE. The bq20z80 features are only available with the bq29312A.

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Primary (1st Level) Safety Features

The bq20z80 supports a wide range of battery and system protection features that care easily configured. The primary safety features includes:

- Battery cell over/undervoltage protection
- Battery pack over/undervoltage protection
- 2 independent charge overcurrent protection
- 3 independent discharge overcurrent protection
- Short circuit protection
- Overtemperature protection
- Host watchdog

Secondary (2nd Level) Safety Features

The secondary safety features of the bq20z80 can be used to indicate more serious faults via the SAFE (pin 7) and $\overline{\text{SAFE}}$ (pin 12) pins. These pins can be used to blow a in-line fuse to permanently disable the battery pack from charging or discharging. The secondary safety features includes:

-

Charge Control Features

FEATURE SET (continued)

Gas Gauging

The bq20z80 uses the Impedance Track™ Technology to measure and calculate the available charge in battery cells. The achievable accuracy is better than the coulomb counting method 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.

LED Display

The bq20z80 can drive 3-, 4-, or 5- segment LED display for remaining capacity indication.

LifeTime Data Logging Features

The bq20z80 offers a lifetime data logging array, where all important measurements are stored for warranty and analysis purposes. The data monitored includes:

- Lifetime maximum temperature
- Lifetime minimum temperature
- Lifetime maximum battery cell voltage
- Lifetime minimum battery cell voltage
- Lifetime maximum battery pack voltage
- Lifetime minimum battery pack voltage
- Lifetime maximum charge current
- Lifetime maximum discharge current
- Lifetime maximum charge power
- Lifetime maximum discharge power
- Lifetime maximum average discharge current
- Lifetime maximum average discharge power
- Lifetime average temperature

Authentication

The bq20z80 supports authentication by the host using SHA-1.

Power Modes

The bq20z80 supports 3 different power modes to reduce power consumption:

- In Normal Mode, the bq20z80 performs measurements, calculations, protection decision, data update in 1 second intervals. Between these intervals, the bq20z80 is in a reduced power stage.
- In Sleep Mode, the bq20z80 performs measurements, calculations, protection decision, data update in adjustable time intervals. Between these intervals, the bq20z80 is in a reduced power stage.
- In Shutdown Mode the bq20z80 is completely disabled.

CONFIGURATION

Oscillator Function

The oscillator of the bq20z80 can be set up for internal or external operation. On power up, the bq20z80 automatically attempts to start the internal oscillator. If a 100-kΩ resistor is not connected to ROSC (pin 33), then it attempts to start the oscillator using an external 32.768-kHz crystal.

NOTE

Install either the 100-kΩ ROSC resistor *or* the 12-pF, 32.768-kHz crystal. Do not install both.

FEATURE SET (continued)

The performance of the internal oscillator depends on the tolerance of the 100-kΩ resistor between RSOC (pin 33) and VSSA (pin 34). Choose a resistor with a tolerance of ±0.1%, and 50-ppm or better temperature drift. Place this resistor as close as possible to the bq20z80. If a 12-pF crystal is used, place it as close as possible to the XCK1 (pin 34) and XCK2 (pin 33) pins. If not properly implemented, the PCB layout in this area can degrade oscillator performance.

System Present Operation

The bq20z80 pulls the PU pin high periodically (1 s). Connect this pin to the $\overline{\text{PRES}}$ pin of the bq20z80 via a resistor of approximately 5 kΩ. The bq20z80 measures the $\overline{\text{PRES}}$ input during the PU-active period to determine its state. If $\overline{\text{PRES}}$ input is pulled to ground by external system, the bq20z80 detects this as system present.

BATTERY PARAMETER MEASUREMENTS

The bq20z80 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 bq20z80 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 bq20z80 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 0.65 nVh.

Voltage

The bq20z80 updates the individual series cell voltages through the bq29312A at one second intervals. The bq20z80 configures the bq29312A to con-10 Tf (to)Tj 15j 15 390.2 Tm /F2 -Tj .2 Tm /F2 -10 Tf 0 Tf 5v78.19 390.2 Tm /F2 -10

Current

Auto Calibration

Temperature

COMMUNICATIONS

SMBus On and Off State

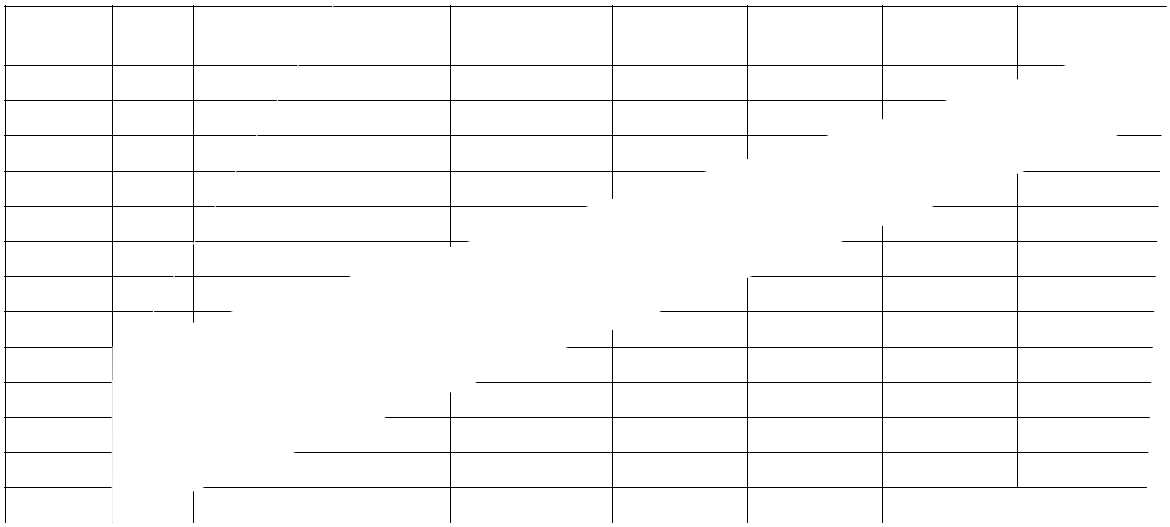


Table 3. CHANGE DETAILS (continued)

CHANGE	bq0z80-V110	bq20z80-V102	COMMENTS
Proper FET operation in presence of partial resets	Clear sleep mode flag (and all Sbscc_control flags) with partial and full resets to correct condition where charge FET can remain off.	CHG_off flag set while in SLEEP but a partial reset would incorrectly clear this flag	
Prevent false detection of PF	Force full reset for attempted shutdown (prevent PF_SHUT from causing a PF condition if shutdown does not occur)	Shutdown does cause a PF	
Allow shutdown to work correctly when the part is in sleep	Fix shutdown when in sleep	A race condition was occurring between sleep and shutdown that was not allowing the device to shutdown when in sleep mode.	
Change default charger present voltage from 12000 to 3000 mv	Change default charger present voltage from 12000 to 3000 mv	bq29312 will not reliably shutdown until pack+ voltage is below 3000 mv. Prevents failed shutdown attempts	
Meet SBS specification	Change default DF:Rem Cap Alarm for		

bq20z80-V101 to bq20z80-V102 Changes

Table 4. CHANGE DETAILS (continued)

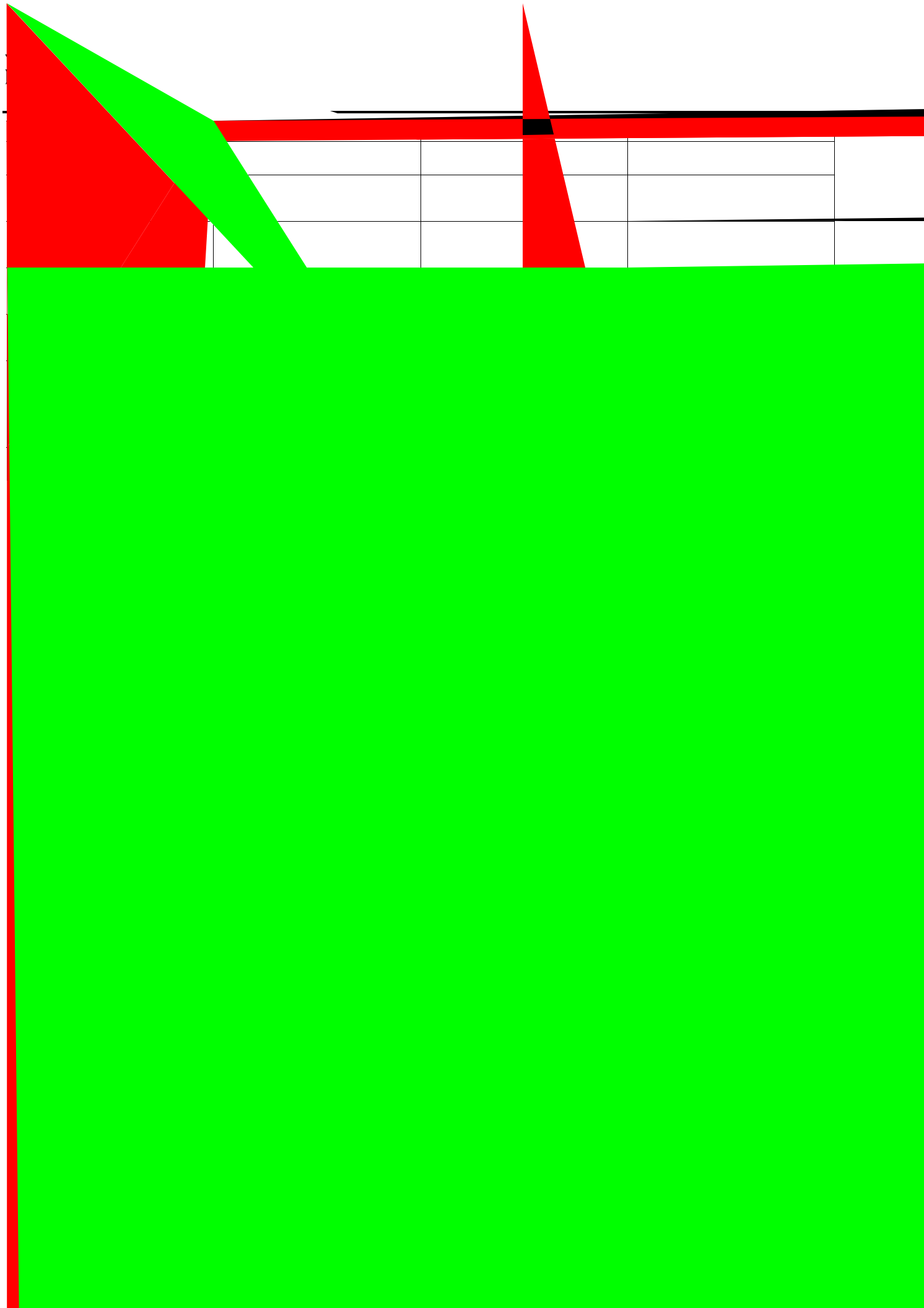
CHANGE	bq0z80-V102	bq20z80-V101	COMMENTS
Implement disable of resistance update based on accumulative scale. If the product of 15 consecutive (default value) resistance scale factors is less than 0.5 or more than 1.5, then resistance update is disabled until the next valid soc measurement. Sets bit 2 of Operation Status to indicate resistance update disabled.	Prevent invalid soc values from causing incorrect resistance updates	Incorrect resistance updates that could result from invalid soc values	More reliable resistance updates under all system conditions
Implement disable of resistance update based on estimated capacity error. Sets bit 2 of Operation Status to indicate resistance update disabled.	Prevent invalid soc values from causing incorrect resistance updates	Incorrect resistance updates that could result from invalid soc values	More reliable resistance updates under all system conditions
Disable Qmax increment if due to Grid 14 and exit of discharge	Prevent unnecessary Qmax increments	Qmax increments can occur due to Grid 14 and exit of discharge	Improved Qmax data reliability under all system conditions.
Drive all unused pins low	Provides better ESD immunity	Not all unused pins driven low	Improved ESD immunity
Initial charge capacity calculation when dod0 is measured in the overdischarged state is corrected	Overdischarged state does not affect the accuracy of FCC calculations	An incorrect initial charge capacity affects FCC that is calculated during discharge or a Qmax update. If FCC is not changed by a Qmax update, then reported RemainingCapacity could be negative after 5 hours of relaxation	More reliable *SBS:FullChargeCapacity( )* *SBS:RemainingCapacity( )* calculation under all system conditions
Correct calculation of FCC and RemCap when dod0 is taken when the battery is overdischarged or overcharged. This allows RemCap to go negative, or greater than FCC (though is only reported from 0 - FCC).	Overcharged/Overdischarged does not affect the accuracy of FCC and RemCap calculations	The RemainingCapacity will increment (or decrement) during charging (discharging) even when the battery is in an overdischarged (overcharged) state.	More reliable *SBS:FullChargeCapacity( )* *SBS:RemainingCapacity( )* calculation under all system conditions
Change cell imbalance *DF:Battery Rest Time* from 1 byte to 2 bytes and set the default value to 1800 seconds	New feature providing improved customization	Feature not available	Improved customization for Cell Imbalance detection
Use upper and lower limit for resistance accumulative scale. Set default values to 300% and 30%.			More reliable resistance updates under all system conditions
Add *DF:CF MaxError limit* for setting *SBS.BatteryMode( ) [CONDITION FLAG]*. Set default value to 100%.	New feature providing improved customization	Feature not available	Improved customization
Use *SBS.AtRate( )*, UserRate and C/5 rate for relaxed capacity calculation, respectively, if set by Load Select; otherwise, use previous rate.			More reliable *SBS:FullChargeCapacity( )* *SBS:RemainingCapacity( )* calculation under all system conditions
Correct Host Watchdog from being reset by broadcasts	Host Watchdog functionality not affected by alarm or charger broadcasts	Host Watchdog reset by alarm or charger broadcasts	Reliable Host Watchdog functionality under all system conditions

Table 4. CHANGE DETAILS (continued)

CHANGE	bq0z80-V102	bq20z80-V101	COMMENTS
The voltage table chemistry ID can be read by writing 0x0008 to ManufacturerAccess and then reading from ManufacturerAccess. The default chemistry ID is 0x0100	New feature providing more information	Feature not available	Improved information access
SBS.BatteryMode( ) is initialized on high transition of the SMBus lines to *DF:Init BatteryMode*, instead of always clearing *SBS.BatteryMode( )* defined bits on high transition of the SMBus lines.	Customization allows for preserving *SBS.BatteryMode( )* settings through SMBus line transitions	Feature not available	Improved customization
Broadcast timers are set correctly on high transition of SMBus lines. The timers are set to 10 seconds on high transition of SMBus lines.	Broadcast timer accurate regardless of CC offset calibration or entry to sleep	Broadcast timer accuracy required a CC offset calibration and entry to sleep.	Improved broadcast timing accuracy to meet Smart Battery Data spec

bq20z80 to bq20z80-V101 Changes

CHANGE	bq20z80	bq20z80-V101	COMMENTS
Added authentication (optional SBS command 0x2f)	Command 0x2f has no function and is not acknowledged.	Command 0x2f is the *SBS.Authenticate( )* command to the bq20z80 to begin the SHA1 authentication.	Additional feature to enable host to authenticate the battery
Added Cell Balancing	Cell balancing not available	Added State of Charge cell balancing algorithm	Additional feature to enable longer lifetime of battery
Added charge fault FET Enable register	When charge faults occur, FET action is taken.	When charge faults occur, FET action is taken if enabled in *DF:FET Enable* register.	Adds flexibility to system interaction
Added pulse compensation for end of discharge	Applications with pulsed current loads and minimum voltage requirements can have less RemainingCapacity than reported.	The voltage pulses caused by pulsed current loads are measured and used to better estimate RemainingCapacity.	Added additional feature to improve capacity prediction
Added *SBS.BatteryStatus( ) [TDA, FD]* voltage thresholds	*SBS.BatteryStatus( ) [TDA, FD]* are only set on SBS.RSOC, detection of charge termination or faults	*SBS.BatteryStatus( ) [TDA, FD]* are now set and cleared based on *SBS.Voltage( )*	Adds flexibility to system interaction
Added option for LEDs in series with current source	LED display is only in parallel.	LED display is available in series (with current source) or parallel.	Adds capability for higher brightness LEDs
Configured pin 7 as active high fuse	Pin 7 is not connected.	Pin 7 is now an	



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)

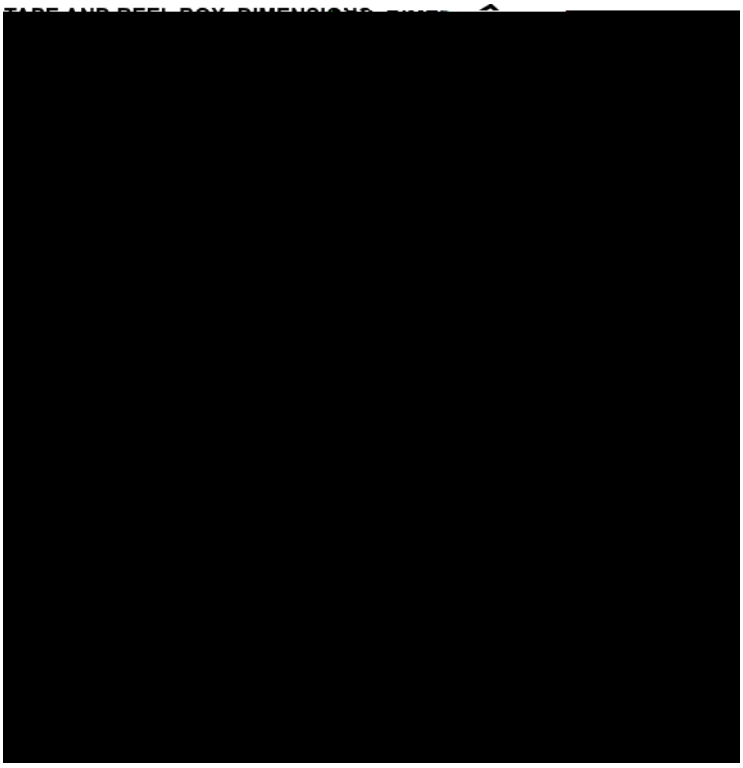
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

TAPE AND REEL INFORMATION

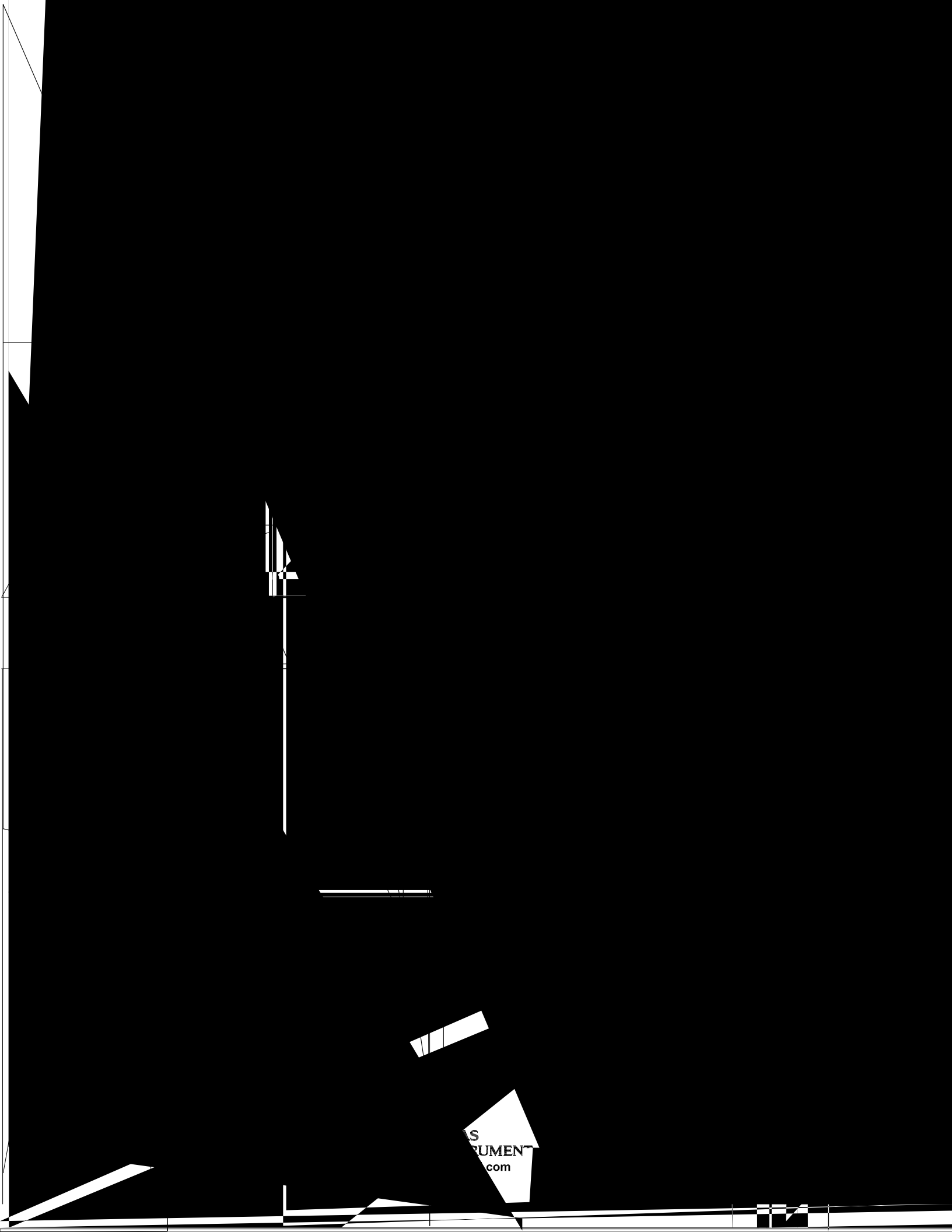
*All dimensions are nominal

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
BQ20Z80ADBTR-V110	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	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