



**THE DATASHEET OF  
BQ20Z90DBT-V150**



## SBS 1.1-COMPLIANT GAS GAUGE ENABLED WITH IMPEDANCE TRACK™ TECHNOLOGY FOR USE WITH THE bq29330

### FEATURES

- 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
- Automatically adjusts for battery aging, battery self discharge and temperature inefficiencies
- Supports the Smart Battery Specification SBS V1.1
- Works With the TI bq29330 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 50% Fewer 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
- 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
- 30-Pin TSSOP (DBT)

### APPLICATIONS

- Notebook PCs
- Medical and Test Equipment
- Portable Instrumentation

### DESCRIPTION

The bq20z90 SBS-compliant gas gauge IC, incorporating patented Impedance Track™ technology, is designed for battery-pack or in-system installation. The bq20z90 measures and maintains an accurate record of available charge in Li-ion or Li-polymer batteries using its integrated high-performance analog peripherals. The bq20z90 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 bq29330 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 <sub>A</sub> | PACKAGE                   |                                |
|----------------|---------------------------|--------------------------------|
|                | 30-PIN TSSOP (DBT) Tube   | 30-PIN TSSOP (DBT) Tape & Reel |
| -40°C to 85°C  | bq20z90DBT <sup>(1)</sup> | bq20z90DBTR <sup>(2)</sup>     |

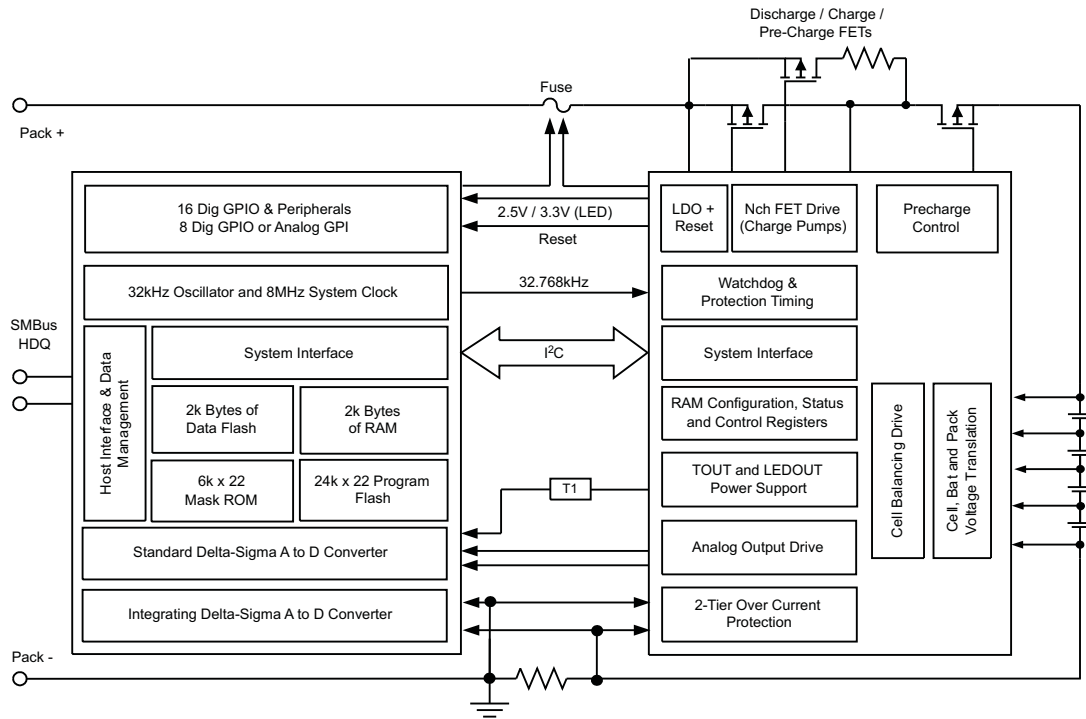
- (1) A single tube quantity is 50 units.  
 (2) A single reel quantity is 2000 units



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### SYSTEM PARTITIONING DIAGRAM



**TSSOP (DBT)  
(TOP VIEW)**

|        |    |    |        |
|--------|----|----|--------|
| NC     | 1  | 30 | VCELL- |
| XALERT | 2  | 29 | VCELL+ |
| SDATA  | 3  | 28 | NC     |
| SCLK   | 4  | 27 | RBI    |
| CLKOUT | 5  | 26 | VCC    |
| TS1    | 6  | 25 | VSS    |
| TS2    | 7  | 24 | MRST   |
| PRES   | 8  | 23 | SRN    |
| PFIN   | 9  | 22 | SRP    |
| SAFE   | 10 | 21 | *VSS   |
| SMBD   | 11 | 20 | LED5   |
| NC     | 12 | 19 | LED4   |
| SMBC   | 13 | 18 | LED3   |
| DISP   | 14 | 17 | LED2   |
| NC     | 15 | 16 | LED1   |

NC - No internal connection

**TERMINAL FUNCTIONS**

| TERMINAL |                          | I/O <sup>(1)</sup> | DESCRIPTION   |
|----------|--------------------------|--------------------|---|
| NO.      | NAME                     |                    |   |
| 1        | NC                       | –                  | Not used— leave floating  |
| 2        | XALERT                   | I                  | Input from bq29330 XALERT output.   |
| 3        | SDATA                    | I/O                | Data transfer to and from bq29330   |
| 4        | SCLK                     | I/O                | Communication clock to the bq29330  |
| 5        | CLKOUT                   | O                  | 32.768-kHz output for the bq29330. This pin should be directly connected to the AFE.  |
| 6        | TS1                      | I                  | 1 <sup>st</sup> Thermistor voltage input connection to monitor temperature  |
| 7        | TS2                      | I                  | 2 <sup>nd</sup> Thermistor voltage input connection to monitor temperature  |
| 8        | PRES                     | I                  | Active low input to sense system insertion and typically requires additional ESD protection   |
| 9        | PFIN                     | I                  | Active low input to detect secondary protector output status and allows the bq20z90 to report the status of the 2 <sup>nd</sup> level protection output |
| 10       | SAFE                     | O                  | Active high output to enforce additional level of safety protection; e.g., fuse blow.   |
| 11       | SMBD                     | I/OD               | SMBus data open-drain bidirectional pin used to transfer address and data to and from the bq20z90   |
| 12       | NC                       | –                  | Not used— leave floating  |
| 13       | SMBC                     | I/OD               | SMBus clock open-drain bidirectional pin used to clock the data transfer to and from the bq20z90  |
| 14       | $\overline{\text{DISP}}$ | I                  | Display control for the LEDs. This pin is typically connected to bq29330 REG via a 100-k $\Omega$ resistor and a push-button switch to VSS.             |
| 15       | NC                       | –                  | Not used— leave floating  |
| 16       | LED1                     | O                  | LED1 display segment that drives an external LED depending on the firmware configuration  |
| 17       | LED2                     | O                  | LED2 display segment that drives an external LED depending on the firmware configuration  |
| 18       | LED3                     | O                  | LED3 display segment that drives an external LED depending on the firmware configuration  |
| 19       | LED4                     | O                  | LED4 display segment that drives an external LED depending on the firmware configuration  |
| 20       | LED5                     | O                  | LED5 display segment that drives an external LED depending on the firmware configuration  |
| 21       | VSS                      | –                  | Connected I/O pin to VSS  |
| 22       | SRP                      | IA                 | Connections to the top of a small-value sense resistor to monitor the battery charge- and discharge-current flow  |
| 23       | SRN                      | IA                 | Connections to the bottom of a small-value sense resistor to monitor the battery charge- and discharge-current flow                                     |
| 24       | $\overline{\text{MRST}}$ | I                  | Master reset input that forces the device into reset when held low. Must be held high for normal operation  |
| 25       | VSS                      | P                  | Negative Supply Voltage   |
| 26       | VCC                      | P                  | Positive Supply Voltage   |
| 27       | RBI                      | P                  | Backup power to the bq20z90 data registers during periods of low operating voltage. RBI accepts a storage capacitor or a battery input.                 |
| 28       | NC                       | –                  | Not used— leave floating  |
| 29       | VCELL+                   | I                  | Input from bq29330 used to read a scaled value of individual cell voltages  |
| 30       | VCELL-                   | I                  | Input from bq29330 used to read a scaled value of individual cell voltages  |

(1) I = Input, IA = Analog input, I/O = Input/output, I/OD = Input/Open-drain output, O = Output, OA = Analog output, P = Power

## ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                                  |                                       | RANGE                      |
|----------------------------------|---------------------------------------|----------------------------|
| $V_{CC}$ relative to $V_{SS}$    | Supply voltage range                  | –0.3 V to 2.75 V           |
| $V_{(IOD)}$ relative to $V_{SS}$ | Open-drain I/O pins                   | –0.3 V to 6 V              |
| $V_I$ relative to $V_{SS}$       | Input voltage range to all other pins | –0.3 V to $V_{CC} + 0.3$ V |
| $T_A$                            | Operating free-air temperature range  | –40°C to 85°C              |
| $T_{stg}$                        | Storage temperature range             | –65°C to 150°C             |

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 2.4$  V to 2.6 V,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER   |  | TEST CONDITIONS      | MIN            | TYP                | MAX            | UNIT             |
|-------------|--|----------------------|----------------|--------------------|----------------|------------------|
| $V_{CC}$    | Supply voltage   |                      | 2.4            | 2.5                | 2.6            | V                |
| $I_{CC}$    | Operating mode current   | No flash programming |                | 400 <sup>(1)</sup> |                | $\mu\text{A}$    |
|             |  | bq20z90 + bq29330    |                | 475                |                |                  |
| $I_{(SLP)}$ | Low-power storage mode current                                 | Sleep mode           |                | 8 <sup>(1)</sup>   |                | $\mu\text{A}$    |
|             |  | bq20z90 + bq29330    |                | 51                 |                |                  |
| $V_{OL}$    | Output voltage low SMBC, SMBD, SDATA, SCLK, SAFE               | $I_{OL} = 0.5$ mA    |                |                    | 0.4            | V                |
|             | LED1 – LED5  | $I_{OL} = 10$ mA     |                |                    | 0.4            | V                |
| $V_{OH}$    | Output high voltage, SMBC, SMBD, SDATA, SCLK, SAFE             | $I_{OH} = -1$ mA     | $V_{CC} - 0.5$ |                    |                | V                |
| $V_{IL}$    | Input voltage low SMBC, SMBD, SDATA, SCLK, XALERT, PRES, PFIN  |                      | –0.3           |                    | 0.8            | V                |
|             |  | DISP                 |                | –0.3               |                | 0.8              |
| $V_{IH}$    | Input voltage high SMBC, SMBD, SDATA, SCLK, XALERT, PRES, PFIN |                      | 2              |                    | 6              | V                |
|             |  | DISP                 |                | 2                  | $V_{CC} + 0.3$ |                  |
| $C_{IN}$    | Input capacitance  |                      |                | 5                  |                | pF               |
| $V_{(AI1)}$ | Input voltage range VCELL+, VCELL-, TS1, TS2                   |                      | –0.2           |                    | $0.8XV_{CC}$   | V                |
| $V_{(AI2)}$ | Input voltage range SR1, SR2                                   |                      | –0.20          |                    | 0.20           | V                |
| $Z_{(AI2)}$ | Input impedance VCELL+, VCELL-, TS1, TS2                       | 0 V–1 V              |                | 8                  |                | $\text{M}\Omega$ |
| $Z_{(AI1)}$ | Input impedance SR1, SR2                                       | 0 V–1 V              |                | 2.5                |                | $\text{M}\Omega$ |

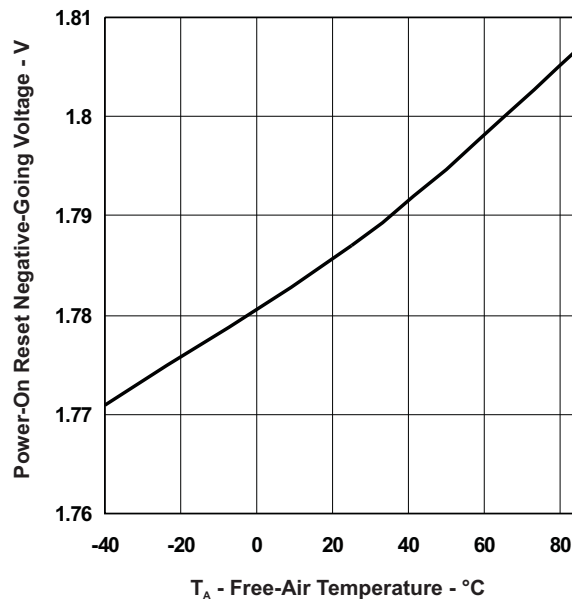
(1) This value does not include the bq29330

## POWER-ON RESET

$V_{CC} = 2.4V$  to  $2.6V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$  (unless otherwise noted)

| PARAMETER                              | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|-----------------|-----|-----|-----|------|
| $V_{IT-}$ Negative-going voltage input |                 | 1.7 | 1.8 | 1.9 | V    |
| $V_{HYS}$ Power-on reset hysteresis    |                 | 50  | 125 | 200 | mV   |

POWER ON RESET BEHAVIOR  
VS  
FREE-AIR TEMPERATURE



## INTEGRATING ADC (Coulomb Counter) CHARACTERISTICS

$V_{CC} = 2.4V$  to  $2.6V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$  (unless otherwise noted)

| PARAMETER   | TEST CONDITIONS                    | MIN  | TYP    | MAX    | UNIT    |
|---|------------------------------------|------|--------|--------|---------|
| $V_{(SR)}$ Input voltage range, $V_{(SRN)}$ and $V_{(SRP)}$ | $V_{(SR)} = V_{(SRN)} - V_{(SRP)}$ | -0.2 |        | 0.2    | V       |
| $V_{(SROS)}$ Input offset                                   |                                    |      | 10     |        | $\mu V$ |
| INL Integral nonlinearity error                             |                                    |      | 0.007% | 0.034% |         |

## OSCILLATOR

$V_{CC} = 2.4V$  to  $2.6V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$  (unless otherwise noted)

| PARAMETER                                      | TEST CONDITIONS                    | MIN   | TYP    | MAX   | UNIT |
|--|------------------------------------|-------|--------|-------|------|
| <b>HIGH FREQUENCY OSCILLATOR</b>               |                                    |       |        |       |      |
| $f_{(OSC)}$ Operating Frequency                |                                    |       |        | 4.194 | MHz  |
| $f_{(EIO)}$ Frequency Error <sup>(1)(2)</sup>  |                                    | -3%   | 0.25%  | 3%    |      |
|  | $T_A = 20^\circ C$ to $70^\circ C$ | -2%   | 0.25%  | 2%    |      |
| $t_{(SXO)}$ Start-up Time <sup>(3)</sup>       |                                    |       | 2.5    | 5     | ms   |
| <b>LOW FREQUENCY OSCILLATOR</b>                |                                    |       |        |       |      |
| $f_{(LOSC)}$ Operating Frequency               |                                    |       | 32.768 |       | KHz  |
| $f_{(LEIO)}$ Frequency Error <sup>(2)(4)</sup> |                                    | -2.5% | 0.25%  | 2.5%  |      |
|  | $T_A = 20^\circ C$ to $70^\circ C$ | -1.5% | 0.25%  | 1.5%  |      |

(1) The frequency error is measured from 4.194 MHz.

(2) The frequency drift is included and measured from the trimmed frequency at  $V_{CC} = 2.5V$ ,  $T_A = 25^\circ C$ .

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

(4) The frequency error is measured from 32.768 kHz.

**OSCILLATOR (continued)**
 $V_{CC} = 2.4\text{ V to }2.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                 | TEST CONDITIONS | MIN | TYP | MAX | UNIT          |
|---|-----------------|-----|-----|-----|---------------|
| $t_{(LSXO)}$ Start-up time <sup>(5)</sup> |                 |     |     | 500 | $\mu\text{s}$ |

(5) The start-up time is defined as the time it takes for the oscillator output frequency to be  $\pm 3\%$ .

**DATA FLASH MEMORY CHARACTERISTICS**
 $V_{CC} = 2.4\text{ V to }2.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  | TEST CONDITIONS    | MIN    | TYP | MAX | UNIT   |
|--|--------------------|--------|-----|-----|--------|
| $t_{DR}$ Data retention                    | See <sup>(1)</sup> | 10     |     |     | Years  |
| Flash programming write-cycles             | See <sup>(1)</sup> | 20,000 |     |     | Cycles |
| $t_{(WORDPROG)}$ Word programming time     | See <sup>(1)</sup> |        |     | 2   | ms     |
| $I_{(DDdPROG)}$ Flash-write supply current | See <sup>(1)</sup> |        | 5   | 10  | mA     |

(1) Assured by design. Not production tested

**REGISTER BACKUP**
 $V_{CC} = 2.4\text{ V to }2.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER   | TEST CONDITIONS   | MIN | TYP | MAX  | UNIT |
|---|---|-----|-----|------|------|
| $I_{(RB)}$ RB data-retention input current          | $V_{(RB)} > V_{(RBMIN)}$ , $V_{CC} < V_{IT-}$   |     |     | 1500 | nA   |
|   | $V_{(RB)} > V_{(RBMIN)}$ , $V_{CC} < V_{IT-}$ , $T_A = 0^\circ\text{C to }50^\circ\text{C}$ |     | 40  | 160  |      |
| $V_{(RB)}$ RB data-retention voltage <sup>(1)</sup> |   | 1.7 |     |      | V    |

(1) Specified by design. Not production tested.

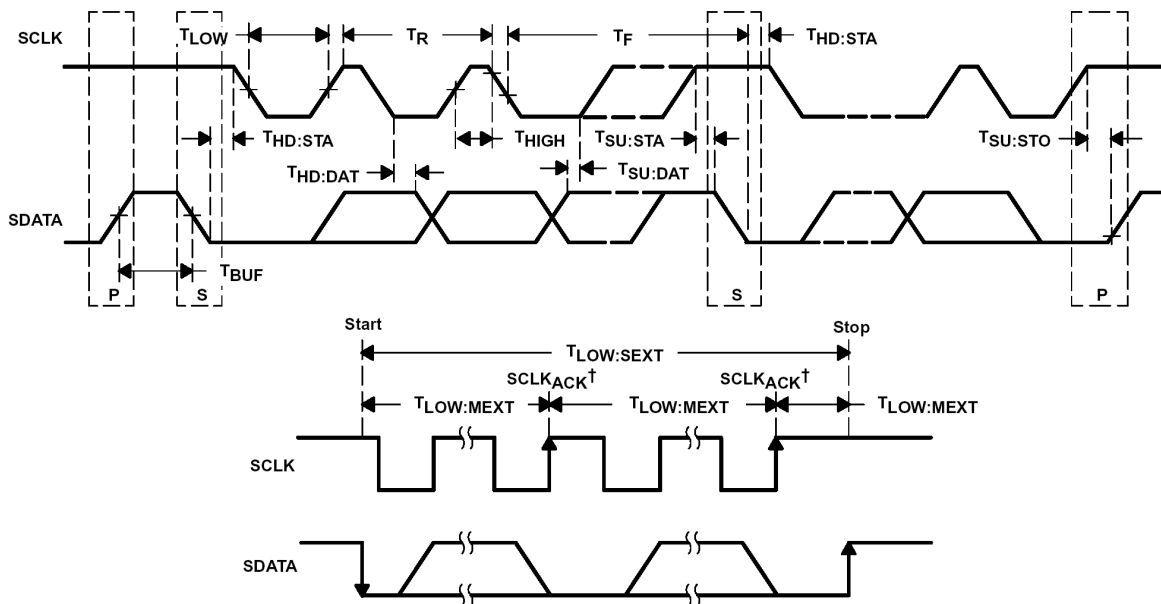
## SMBus TIMING SPECIFICATIONS

$V_{CC} = 2.4\text{ V to }2.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (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 |      |      | $\mu\text{s}$ |
| $t_{HD:STA}$   | 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   |      |      |               |
|                |   | 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 |      |      | $\mu\text{s}$ |
| $t_{HIGH}$     | 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                    | $(V_{ILMAX} - 0.15\text{ V})$ to $(V_{IHMIN} + 0.15\text{ V})$ |     |      | 300  | ns            |
| $t_R$          | Clock/data rise time                    | $0.9\text{ VCC to } (V_{ILMAX} - 0.15\text{ V})$               |     |      | 1000 |               |

- (1) The bq20z90 times out when any clock low exceeds  $t_{TIMEOUT}$ .
- (2)  $t_{HIGH:MAX}$  is minimum bus idle time. SMBC = 1 for  $t > 50\ \mu\text{s}$  causes reset of any transaction involving the bq20z90 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



<sup>†</sup>  $SCLK_{ACK}$  is the acknowledge-related clock pulse generated by the master.

## FEATURE SET

### Primary (1st Level) Safety Features

The bq20z90 supports a wide range of battery and system protection features that can easily be configured. The primary safety features include:

- Battery cell over/under voltage protection
- Battery pack over/under voltage protection
- 2 independent charge overcurrent protection
- 3 independent discharge overcurrent protection
- Short circuit protection
- Over temperature protection
- AFE Watchdog
- Host Watchdog

### Secondary (2nd Level) Safety Features

The secondary safety features of the bq20z90 can be used to indicate more serious faults via the SAFE (pin 10) 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 features include:

- Safety over voltage
- Battery cell imbalance
- 2nd level protection IC input
- Safety over current
- Safety over temperature
- Open thermistor
- Charge FET and Zero-Volt Charge FET fault
- Discharge FET fault
- Fuse blow failure detection
- AFE Communication error
- AFE Verification error
- Internal flash data error

### Charge Control Features

The bq20z90 charge control features include:

- Report 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.
- Determine the chemical state of charge of each battery cell using Impedance Track™. Using cell balancing algorithm, gradually decrease the differences in the cells' state of charge in a fully charged state. This prevents high cells from overcharging, causing excessive degradation and also increases the usable pack energy by preventing early charge termination.
- Support Pre-charging/Zero-volt charging
- Support Fast charging
- Support Pulse charging
- Support Charge Inhibit and Charge Suspend modes
- Report charging faults and also indicate charging status via charge and discharge alarms.

### Gas Gauging

The bq20z90 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.

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## FEATURE SET (continued)

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

### LED Display

The bq20z90 can drive a 3-, 4-, or 5- segment LED display for remaining capacity indication. The LED drive current can be adjusted to 3mA, 4mA and 5mA digitally.

### LifeTime Data Logging Features

The bq20z90 offers a lifetime data logging array, where all important measurements are stored for warranty and analysis purposes. The data monitored include:

- 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 bq20z90 supports authentication by the host using SHA-1.

### Power Modes

The bq20z90 supports 3 different power modes to reduce power consumption:

- In Normal Mode, the bq20z90 performs measurements, calculations, protection decisions, and data updates in 1 second intervals. Between these intervals, the bq20z90 is in a reduced power stage.
- In Sleep Mode, the bq20z90 performs measurements, calculations, protection decisions, and data updates in adjustable time intervals. Between these intervals, the bq20z90 is in a reduced power stage.
- In Shutdown Mode the bq20z90 is completely disabled.

## CONFIGURATION

### Oscillator Function

The bq20z90 fully integrates the system and processor oscillators and, therefore, requires no pins or components for this feature.

### System Present Operation

The bq20z90 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, bq20z90 enters normal operating mode. When the pack is removed from the system and the  $\overline{\text{PRES}}$  input is high, the bq20z90 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.

## FEATURE SET (continued)

### BATTERY PARAMETER MEASUREMENTS

The bq20z90 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 bq20z90 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 bq20z90 continuously integrates the signal over time, using an internal counter. The fundamental rate of the counter is 0.65 nVh.

#### Voltage

The bq20z90 updates the individual series cell voltages through the bq29330 at one second intervals. The bq20z90 configures the bq29330 to connect the selected cell, cell offset, or bq29330 VREF to the CELL pin of the bq29330, which is required to be connected to VIN of the bq20z90. The internal ADC of the bq20z90 measures the voltage, scales it, and calibrates itself appropriately. This data is also used to calculate the impedance of the cell for the Impedance Track™ gas-gauging.

#### Current

The bq20z90 uses the SRP and SRN inputs to measure and calculate the battery charge and discharge current using a 5 mΩ to 20 mΩ typ. sense resistor.

#### Wake Function

The bq20z90 can exit sleep mode, if enabled, by the presence of a programmable level of current signal across SRP and SRN.

#### Auto Calibration

The bq20z90 provides an auto-calibration feature to cancel the voltage offset error across SRP and SRN for maximum charge measurement accuracy. The bq20z90 performs auto-calibration when the SMBus lines stay low continuously for a minimum of a programmable amount of time.

#### Temperature

The bq20z90 TS1 and TS2 inputs, in conjunction with two identical NTC thermistors (default are Semitec 103AT), measure the battery environmental temperature. The bq20z90 can also be configured to use its internal temperature sensor.

### COMMUNICATIONS

The bq20z90 uses SMBus v1.1 with Master Mode and package error checking (PEC) options per the SBS specification.

#### SMBus On and Off State

The bq20z90 detects an SMBus off state when SMBC and SMBD are logic-low for  $\geq 2$  seconds. Clearing this state requires either SMBC or SMBD to transition high. Within 1 ms, the communication bus is available.

**Table 1. 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     | 300           | mAh or 10mWh |
| 0x02    | R/W  | RemainingTimeAlarm     | unsigned int | 2             | 0         | 65535     | 10            | min          |

**FEATURE SET (continued)**
**Table 1. SBS COMMANDS (continued)**

| SBS Cmd | Mode | Name                  | Format       | Size in Bytes | Min Value | Max Value | Default Value | Unit         |
|---------|------|-----------------------|--------------|---------------|-----------|-----------|---------------|--------------|
| 0x03    | R/W  | BatteryMode           | hex          | 2             | 0x0000    | 0xe383    | —             |              |
| 0x04    | R/W  | AtRate                | signed int   | 2             | -32768    | 32767     | —             | mA or 10mW   |
| 0x05    | R    | AtRateTimeToFull      | unsigned int | 2             | 0         | 65534     | —             | min          |
| 0x06    | R    | AtRateTimeToEmpty     | unsigned int | 2             | 0         | 65534     | —             | 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         | 65535     | —             | 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         | 65534     | —             | min          |
| 0x12    | R    | AverageTimeToEmpty    | unsigned int | 2             | 0         | 65534     | —             | min          |
| 0x13    | R    | AverageTimeToFull     | unsigned int | 2             | 0         | 65534     | —             | min          |
| 0x14    | R    | ChargingCurrent       | unsigned int | 2             | 0         | 65534     | —             | mA           |
| 0x15    | R    | ChargingVoltage       | unsigned int | 2             | 0         | 65534     | —             | mV           |
| 0x16    | R    | BatteryStatus         | unsigned int | 2             | 0x0000    | 0xdbff    | —             |              |
| 0x17    | R/W  | CycleCount            | unsigned int | 2             | 0         | 65535     | —             |              |
| 0x18    | R/W  | DesignCapacity        | unsigned int | 2             | 0         | 65535     | 4400          | mAh or 10mWh |
| 0x19    | R/W  | DesignVoltage         | unsigned int | 2             | 0         | 65535     | 14400         | mV           |
| 0x1a    | R/W  | SpecificationInfo     | hex          | 2             | 0x0000    | 0xffff    | 0x0031        |              |
| 0x1b    | R/W  | ManufactureDate       | unsigned int | 2             | —         | —         | 01-Jan-1980   | ASCII        |
| 0x1c    | R/W  | SerialNumber          | hex          | 2             | 0x0000    | 0xffff    | 0x0001        |              |
| 0x20    | R/W  | ManufacturerName      | String       | 11+1          | —         | —         | Texas Inst.   | ASCII        |
| 0x21    | R/W  | DeviceName            | String       | 7+1           | —         | —         | bq20z90       | ASCII        |
| 0x22    | R/W  | DeviceChemistry       | String       | 4+1           | —         | —         | LION          | ASCII        |
| 0x23    | R/W  | 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           |

**Table 2. EXTENDED SBS COMMANDS**

| SBS Cmd | Mode | Name          | Format       | Size in Bytes | Min Value | Max Value | Default Value | Unit  |
|---------|------|---------------|--------------|---------------|-----------|-----------|---------------|-------|
| 0x45    | R    | AFEDData      | String       | 11+1          | —         | —         | —             | ASCII |
| 0x46    | R/W  | FETControl    | hex          | 1             | 0x00      | 0x1e      | —             |       |
| 0x4f    | R    | StateOfHealth | unsigned int | 1             | 0         | 100       | —             | %     |
| 0x50    | R    | SafetyAlert   | hex          | 2             | 0x0000    | 0xffff    | —             |       |

**Table 2. EXTENDED SBS COMMANDS (continued)**

| SBS Cmd | Mode | Name                   | Format       | Size in Bytes | Min Value  | Max Value  | Default Value | Unit  |
|---------|------|------------------------|--------------|---------------|------------|------------|---------------|-------|
| 0x51    | R    | SafetyStatus           | hex          | 2             | 0x0000     | 0xffff     | —             |       |
| 0x52    | R    | PFAAlert               | hex          | 2             | 0x0000     | 0x9fff     | —             |       |
| 0x53    | R    | PFStatus               | hex          | 2             | 0x0000     | 0x9fff     | —             |       |
| 0x54    | R    | OperationStatus        | hex          | 2             | 0x0000     | 0xf7f7     | —             |       |
| 0x55    | R    | ChargingStatus         | hex          | 2             | 0x0000     | 0xffff     | —             |       |
| 0x57    | R    | ResetData              | hex          | 2             | 0x0000     | 0xffff     | —             |       |
| 0x58    | R    | WDRResetData           | unsigned int | 2             | 0          | 65535      | —             |       |
| 0x5a    | R    | PackVoltage            | unsigned int | 2             | 0          | 65535      | ---           | mV    |
| 0x5d    | R    | AverageVoltage         | unsigned int | 2             | 0          | 65535      | —             | mV    |
| 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 | —             |       |
| 0x70    | R/W  | ManufacturerInfo       | String       | 8+1           | —          | —          | —             | ASCII |
| 0x71    | R/W  | SenseResistor          | unsigned int | 2             | 0          | 65535      | —             | μΩ    |
| 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            | —          | —          | —             |       |

**NOTE:**

All reserved bits in data flash should be set to zero.

**Table 3. DATA FLASH VALUES**

| Class            | Subclass ID | Subclass | Offset | Name          | Data Type | Min Value | Max Value | Default Value | Units |
|------------------|-------------|----------|--------|---------------|-----------|-----------|-----------|---------------|-------|
| 1st Level Safety | 0           | Voltage  | 0      | COV Threshold | I2        | 3700      | 5000      | 4300          | mV    |
| 1st Level Safety | 0           | Voltage  | 2      | COV Time      | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 0           | Voltage  | 3      | COV Recovery  | I2        | 0         | 4400      | 3900          | mV    |
| 1st Level Safety | 0           | Voltage  | 5      | COV Delta     | U1        | 0         | 200       | 20            | mV    |
| 1st Level Safety | 0           | Voltage  | 6      | COV Temp. Hys | U1        | 0         | 250       | 100           | 0.1°C |
| 1st Level Safety | 0           | Voltage  | 7      | POV Threshold | I2        | 0         | 18000     | 17500         | mV    |
| 1st Level Safety | 0           | Voltage  | 9      | POV Time      | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 0           | Voltage  | 10     | POV Recovery  | I2        | 0         | 17000     | 16000         | mV    |
| 1st Level Safety | 0           | Voltage  | 12     | CUV Threshold | I2        | 0         | 3500      | 2200          | mV    |

**Table 3. DATA FLASH VALUES (continued)**

| Class            | Subclass ID | Subclass    | Offset | Name                   | Data Type | Min Value | Max Value | Default Value | Units |
|------------------|-------------|-------------|--------|------------------------|-----------|-----------|-----------|---------------|-------|
| 1st Level Safety | 0           | Voltage     | 14     | CUV Time               | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 0           | Voltage     | 15     | CUV Recovery           | I2        | 0         | 3600      | 3000          | mV    |
| 1st Level Safety | 0           | Voltage     | 17     | PUV Threshold          | I2        | 0         | 16000     | 11000         | mV    |
| 1st Level Safety | 0           | Voltage     | 19     | PUV Time               | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 0           | Voltage     | 20     | PUV Recovery           | I2        | 0         | 16000     | 12000         | mV    |
| 1st Level Safety | 1           | Current     | 0      | OC (1st Tier) Chg      | I2        | 0         | 20000     | 6000          | mA    |
| 1st Level Safety | 1           | Current     | 2      | OC (1st Tier) Chg Time | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 1           | Current     | 3      | OC Chg Recovery        | I2        | -1000     | 1000      | 200           | mA    |
| 1st Level Safety | 1           | Current     | 5      | OC (1st Tier) Dsg      | I2        | 0         | 20000     | 6000          | mA    |
| 1st Level Safety | 1           | Current     | 7      | OC (1st Tier) Dsg Time | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 1           | Current     | 8      | OC Dsg Recovery        | I2        | 0         | 1000      | 200           | mA    |
| 1st Level Safety | 1           | Current     | 10     | OC (2nd Tier) Chg      | I2        | 0         | 20000     | 8000          | mA    |
| 1st Level Safety | 1           | Current     | 12     | OC (2nd Tier) Chg Time | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 1           | Current     | 13     | OC (2nd Tier) Dsg      | I2        | 0         | 22000     | 8000          | mA    |
| 1st Level Safety | 1           | Current     | 15     | OC (2nd Tier) Dsg Time | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 1           | Current     | 16     | Current Recovery Time  | U1        | 0         | 60        | 8             | s     |
| 1st Level Safety | 1           | Current     | 17     | AFE OC Dsg             | H1        | 0x00      | 0x1f      | 0x12          |       |
| 1st Level Safety | 1           | Current     | 18     | AFE OC Dsg Time        | H1        | 0x00      | 0x0f      | 0x0f          |       |
| 1st Level Safety | 1           | Current     | 19     | AFE OC Dsg Recovery    | I2        | 10        | 1000      | 5             | mA    |
| 1st Level Safety | 1           | Current     | 21     | AFE SC Chg Cfg         | H1        | 0x00      | 0xff      | 0x77          |       |
| 1st Level Safety | 1           | Current     | 22     | AFE SC Dsg Cfg         | H1        | 0x00      | 0xff      | 0x77          |       |
| 1st Level Safety | 1           | Current     | 23     | AFE SC Recovery        | I2        | 0         | 200       | 1             | mA    |
| 1st Level Safety | 2           | Temperature | 0      | Over Temp Chg          | I2        | 0         | 1200      | 550           | 0.1°C |
| 1st Level Safety | 2           | Temperature | 2      | OT Chg Time            | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 2           | Temperature | 3      | OT Chg Recovery        | I2        | 0         | 1200      | 500           | 0.1°C |
| 1st Level Safety | 2           | Temperature | 5      | Over Temp Dsg          | I2        | 0         | 1200      | 600           | 0.1°C |
| 1st Level Safety | 2           | Temperature | 7      | OT Dsg Time            | U1        | 0         | 60        | 2             | s     |
| 1st Level Safety | 2           | Temperature | 8      | OT Dsg Recovery        | I2        | 0         | 1200      | 550           | 0.1°C |
| 1st Level Safety | 3           | Host Comm   | 0      | Host Watchdog Timeout  | U1        | 0         | 255       | 0             | s     |
| 2nd Level Safety | 16          | Voltage     | 0      | SOV Threshold          | I2        | 0         | 20000     | 18000         | mV    |

**Table 3. DATA FLASH VALUES (continued)**

| Class            | Subclass ID | Subclass           | Offset | Name                        | Data Type | Min Value | Max Value | Default Value | Units |
|------------------|-------------|--------------------|--------|-----------------------------|-----------|-----------|-----------|---------------|-------|
| 2nd Level Safety | 16          | Voltage            | 2      | SOV Time                    | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 16          | Voltage            | 3      | Cell Imbalance Current      | I1        | 0         | 200       | 5             | mA    |
| 2nd Level Safety | 16          | Voltage            | 4      | Cell Imbalance Fail Voltage | I2        | 0         | 5000      | 1000          | mV    |
| 2nd Level Safety | 16          | Voltage            | 6      | Cell Imbalance Time         | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 16          | Voltage            | 7      | Battery Rest Time           | U2        | 0         | 65535     | 1800          | s     |
| 2nd Level Safety | 16          | Voltage            | 9      | PFIN Detect Time            | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 17          | Current            | 0      | SOC Chg                     | I2        | 0         | 30000     | 10000         | mA    |
| 2nd Level Safety | 17          | Current            | 2      | SOC Chg Time                | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 17          | Current            | 3      | SOC Dsg                     | I2        | 0         | 30000     | 10000         | mA    |
| 2nd Level Safety | 17          | Current            | 5      | SOC Dsg Time                | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 18          | Temperature        | 0      | SOT Chg                     | I2        | 0         | 1200      | 650           | 0.1°C |
| 2nd Level Safety | 18          | Temperature        | 2      | SOT Chg Time                | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 18          | Temperature        | 3      | SOT Dsg                     | I2        | 0         | 1200      | 750           | 0.1°C |
| 2nd Level Safety | 18          | Temperature        | 5      | SOT Dsg Time                | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 18          | Temperature        | 6      | Open Thermistor             | I2        | -1000     | 1200      | -333          | 0.1°C |
| 2nd Level Safety | 18          | Temperature        | 8      | Open Time                   | I1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 19          | FET Verification   | 0      | FET Fail Limit              | I2        | 0         | 500       | 20            | mA    |
| 2nd Level Safety | 19          | FET Verification   | 2      | FET Fail Time               | U1        | 0         | 30        | 0             | s     |
| 2nd Level Safety | 20          | AFE Verification   | 0      | AFE Check Time              | U1        | 0         | 255       | 0             | s     |
| 2nd Level Safety | 20          | AFE Verification   | 1      | AFE Fail Limit              | U1        | 0         | 255       | 10            |       |
| 2nd Level Safety | 20          | AFE Verification   | 2      | AFE Fail Recovery Time      | U1        | 0         | 255       | 20            | s     |
| 2nd Level Safety | 20          | AFE Verification   | 3      | AFE Init Retry Limit        | U1        | 0         | 255       | 6             |       |
| 2nd Level Safety | 20          | AFE Verification   | 4      | AFE Init Limit              | U1        | 0         | 255       | 20            |       |
| 2nd Level Safety | 21          | Fuse Verification  | 0      | Fuse Fail Limit             | I2        | 0         | 20        | 2             | mA    |
| 2nd Level Safety | 21          | Fuse Verification  | 2      | Fuse Fail Time              | U1        | 0         | 30        | 0             | s     |
| Charge Control   | 32          | Charge Inhibit Cfg | 0      | Chg Inhibit Temp Low        | I2        | -400      | 1200      | 0             | 0.1°C |
| Charge Control   | 32          | Charge Inhibit Cfg | 2      | Chg Inhibit Temp High       | I2        | -400      | 1200      | 450           | 0.1°C |
| Charge Control   | 32          | Charge Inhibit Cfg | 4      | Temp Hys                    | I2        | 0         | 100       | 10            | 0.1°C |
| Charge Control   | 33          | Pre-Charge Cfg     | 0      | Pre-chg Current             | I2        | 0         | 2000      | 250           | mA    |
| Charge Control   | 33          | Pre-Charge Cfg     | 2      | Pre-chg Temp                | I2        | -400      | 1200      | 120           | 0.1°C |
| Charge Control   | 33          | Pre-Charge Cfg     | 4      | Pre-chg Voltage             | I2        | 0         | 20000     | 3000          | mV    |
| Charge Control   | 33          | Pre-Charge Cfg     | 6      | Recovery Voltage            | I2        | 0         | 20000     | 3100          | mV    |
| Charge Control   | 34          | Fast Charge Cfg    | 0      | Fast Charge Current         | I2        | 0         | 10000     | 4000          | mA    |
| Charge Control   | 34          | Fast Charge Cfg    | 2      | Charging Voltage            | I2        | 0         | 20000     | 16800         | mV    |

**Table 3. DATA FLASH VALUES (continued)**

| Class             | Subclass ID | Subclass           | Offset | Name                     | Data Type | Min Value | Max Value | Default Value | Units                         |
|-------------------|-------------|--------------------|--------|--------------------------|-----------|-----------|-----------|---------------|-------------------------------|
| Charge Control    | 34          | Fast Charge Cfg    | 4      | Delta Temp               | I2        | 0         | 500       | 50            | 0.1°C                         |
| Charge Control    | 34          | Fast Charge Cfg    | 6      | Suspend Low Temp         | I2        | -400      | 1200      | -50           | 0.1°C                         |
| Charge Control    | 34          | Fast Charge Cfg    | 8      | Suspend High Temp        | I2        | -400      | 1200      | 550           | 0.1°C                         |
| Charge Control    | 35          | Pulse Charge Cfg   | 0      | Turn ON Voltage          | I2        | 0         | 5000      | 4150          | mV                            |
| Charge Control    | 35          | Pulse Charge Cfg   | 2      | Turn OFF Voltage         | I2        | 0         | 5000      | 4250          | mV                            |
| Charge Control    | 35          | Pulse Charge Cfg   | 4      | Max ON Pulse Time        | U1        | 0         | 240       | 240           | Seconds/4                     |
| Charge Control    | 35          | Pulse Charge Cfg   | 5      | Min OFF Pulse Time       | U1        | 0         | 240       | 0             | Seconds/4                     |
| Charge Control    | 35          | Pulse Charge Cfg   | 6      | Max OFF Voltage          | I2        | 0         | 5000      | 4270          | mV                            |
| Charge Control    | 36          | Termination Cfg.   | 0      | Maintenance Current      | I2        | 0         | 1000      | 0             | mA                            |
| Charge Control    | 36          | Termination Cfg.   | 2      | Taper Current            | I2        | 0         | 1000      | 250           | mA                            |
| Charge Control    | 36          | Termination Cfg.   | 6      | Taper Voltage            | I2        | 0         | 1000      | 300           | mV                            |
| Charge Control    | 36          | Termination Cfg.   | 8      | Current Taper Window     | U1        | 0         | 60        | 40            | s                             |
| Charge Control    | 36          | Termination Cfg.   | 9      | TCA Set %                | I1        | -1        | 100       | -1            | %                             |
| Charge Control    | 36          | Termination Cfg.   | 10     | TCA Clear %              | I1        | -1        | 100       | 95            | %                             |
| Charge Control    | 36          | Termination Cfg.   | 11     | FC Set %                 | I1        | -1        | 100       | -1            | %                             |
| Charge Control    | 36          | Termination Cfg.   | 12     | FC Clear %               | I1        | -1        | 100       | 98            | %                             |
| Charge Control    | 37          | Cell Balancing Cfg | 0      | Min Cell Deviation       | U2        | 0         | 65535     | 1750          | s/mAh                         |
| Charge Control    | 38          | Charging Faults    | 0      | Over Charging Voltage    | I2        | 0         | 3000      | 500           | mV                            |
| Charge Control    | 38          | Charging Faults    | 2      | Over Charging Volt Time  | U1        | 0         | 60        | 2             | s                             |
| Charge Control    | 38          | Charging Faults    | 3      | Over Charging Current    | I2        | 0         | 2000      | 500           | mA                            |
| Charge Control    | 38          | Charging Faults    | 5      | Over Charging Curr Time  | U1        | 0         | 60        | 2             | s                             |
| Charge Control    | 38          | Charging Faults    | 6      | Over Charging Curr Recov | I2        | 0         | 2000      | 100           | mA                            |
| Charge Control    | 38          | Charging Faults    | 8      | Depleted Voltage         | I2        | 0         | 16000     | 8000          | mV                            |
| Charge Control    | 38          | Charging Faults    | 10     | Depleted Voltage Time    | U1        | 0         | 60        | 2             | s                             |
| Charge Control    | 38          | Charging Faults    | 11     | Depleted Recovery        | I2        | 0         | 16000     | 8500          | mV                            |
| Charge Control    | 38          | Charging Faults    | 13     | Over Charge Capacity     | I2        | 0         | 4000      | 300           | mAh                           |
| Charge Control    | 38          | Charging Faults    | 15     | Over Charge Recovery     | I2        | 0         | 100       | 2             | mAh                           |
| Charge Control    | 38          | Charging Faults    | 17     | FC-MTO                   | U2        | 0         | 65535     | 10800         | s                             |
| Charge Control    | 38          | Charging Faults    | 19     | PC-MTO                   | U2        | 0         | 65535     | 3600          | s                             |
| Charge Control    | 38          | Charging Faults    | 21     | Charge Fault Cfg         | H1        | 0x00      | 0x3f      | 0x00          |                               |
| SBS Configuration | 48          | Data               | 0      | Rem Cap Alarm            | I2        | 0         | 700       | 300           | mAh                           |
| SBS Configuration | 48          | Data               | 2      | Rem Energy Alarm         | I2        | 0         | 1000      | 432           | 10mW                          |
| SBS Configuration | 48          | Data               | 4      | Rem Time Alarm           | U2        | 0         | 30        | 10            | min                           |
| SBS Configuration | 48          | Data               | 6      | Init Battery Mode        | H2        | 0x0000    | 0xffff    | 0x0081        |                               |
| SBS Configuration | 48          | Data               | 8      | Design Voltage           | I2        | 7000      | 18000     | 14400         | mV                            |
| SBS Configuration | 48          | Data               | 10     | Spec Info                | H2        | 0x0000    | 0xffff    | 0x0031        |                               |
| SBS Configuration | 48          | Data               | 12     | Manuf Date               | U2        | 0         | 65535     | 0             | Day + Mo*32 + (Yr - 1980)*256 |
| SBS Configuration | 48          | Data               | 14     | Ser. Num.                | H2        | 0x0000    | 0xffff    | 0x0001        |                               |
| SBS Configuration | 48          | Data               | 16     | Cycle Count              | U2        | 0         | 65535     | 0             | Count                         |
| SBS Configuration | 48          | Data               | 18     | CC Threshold             | I2        | 100       | 32767     | 4400          | mAh                           |
| SBS Configuration | 48          | Data               | 20     | CC %                     | U1        | 0         | 100       | 90            | %                             |

**Table 3. DATA FLASH VALUES (continued)**

| Class             | Subclass ID | Subclass              | Offset | Name                      | Data Type | Min Value | Max Value | Default Value | Units |
|-------------------|-------------|-----------------------|--------|---------------------------|-----------|-----------|-----------|---------------|-------|
| SBS Configuration | 48          | Data                  | 21     | CF MaxError Limit         | U1        | 0         | 100       | 100           | %     |
| SBS Configuration | 48          | Data                  | 22     | Design Capacity           | I2        | 0         | 65535     | 4400          | mAh   |
| SBS Configuration | 48          | Data                  | 24     | Design Energy             | I2        | 0         | 65535     | 6336          | 10mW  |
| SBS Configuration | 48          | Data                  | 26     | Manuf Name                | S12       | -         | -         | Texas Inst.   | ASCII |
| SBS Configuration | 48          | Data                  | 38     | Device Name               | S8        | -         | -         | bq20z90       | ASCII |
| SBS Configuration | 48          | Data                  | 46     | Device Chemistry          | S5        | -         | -         | LION          | ASCII |
| SBS Configuration | 49          | Configuration         | 0      | TDA Set %                 | I1        | -1        | 100       | 6             | %     |
| SBS Configuration | 49          | Configuration         | 1      | TDA Clear %               | I1        | -1        | 100       | 8             | %     |
| SBS Configuration | 49          | Configuration         | 2      | FD Set %                  | I1        | -1        | 100       | 2             | %     |
| SBS Configuration | 49          | Configuration         | 3      | FD Clear %                | I1        | -1        | 100       | 5             | %     |
| SBS Configuration | 49          | Configuration         | 4      | TDA Set Volt Threshold    | I2        | 0         | 16800     | 5000          | mV    |
| SBS Configuration | 49          | Configuration         | 6      | TDA Set Volt Time         | U1        | 0         | 60        | 5             | s     |
| SBS Configuration | 49          | Configuration         | 7      | TDA Clear Volt            | I2        | 0         | 16800     | 5500          | mV    |
| SBS Configuration | 49          | Configuration         | 9      | FD Set Volt Threshold     | I2        | 0         | 16800     | 5000          | mV    |
| SBS Configuration | 49          | Configuration         | 11     | FD Volt Time              | U1        | 0         | 60        | 5             | s     |
| SBS Configuration | 49          | Configuration         | 12     | FD Clear Volt             | I2        | 0         | 16800     | 5500          | mV    |
| System Data       | 56          | Manufacturer Data     | 0      | Pack Lot Code             | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| System Data       | 56          | Manufacturer Data     | 2      | PCB Lot Code              | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| System Data       | 56          | Manufacturer Data     | 4      | Firmware Version          | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| System Data       | 56          | Manufacturer Data     | 6      | Hardware Revision         | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| System Data       | 56          | Manufacturer Data     | 8      | Cell Revision             | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| System Data       | 58          | Manufacturer Info     | 0      | Manuf. Info               | S9        | -         | -         | 12345678      |       |
| System Data       | 59          | Lifetime Data         | 0      | Lifetime Max Temp         | I2        | 0         | 1400      | 300           | 0.1°C |
| System Data       | 59          | Lifetime Data         | 2      | Lifetime Min Temp         | I2        | -600      | 1400      | 200           | 0.1°C |
| System Data       | 59          | Lifetime Data         | 4      | Lifetime Max Cell Voltage | I2        | 0         | 32767     | 3500          | mV    |
| System Data       | 59          | Lifetime Data         | 6      | Lifetime Min Cell Voltage | I2        | 0         | 32767     | 3200          | mV    |
| System Data       | 59          | Lifetime Data         | 8      | Lifetime Max Pack Voltage | I2        | 0         | 32767     | 14000         | mV    |
| System Data       | 59          | Lifetime Data         | 10     | Lifetime Min Pack Voltage | I2        | 0         | 32767     | 12800         | mV    |
| System Data       | 59          | Lifetime Data         | 12     | Lifetime Max Chg Current  | I2        | -32768    | 32767     | 1500          | mA    |
| System Data       | 59          | Lifetime Data         | 14     | Lifetime Max Dsg Current  | I2        | -32768    | 32767     | -3000         | mA    |
| System Data       | 59          | Lifetime Data         | 16     | Lifetime Max Chg Power    | I2        | -32768    | 32767     | 1500          | cWatt |
| System Data       | 59          | Lifetime Data         | 18     | Lifetime Max Dsg Power    | I2        | -32768    | 32767     | -1500         | cWatt |
| System Data       | 59          | Lifetime Data         | 22     | Life Max AvgDsg Cur       | I2        | -32768    | 32767     | -1000         | mA    |
| System Data       | 59          | Lifetime Data         | 26     | Life Max AvgDsg Pow       | I2        | -32768    | 32767     | -1500         | cW    |
| System Data       | 59          | Lifetime Data         | 28     | Lifetime Avg Temp         | I2        | -40       | 1400      | 250           | 0.1°C |
| System Data       | 60          | Lifetime Temp Samples | 0      | LT Temp Samples           | I4        | 0         | 140000000 | 0             | Count |
| Configuration     | 64          | Registers             | 0      | Operation Cfg A           | H2        | 0x0000    | 0xffff    | 0x0f29        |       |
| Configuration     | 64          | Registers             | 2      | Operation Cfg B           | H2        | 0x0000    | 0xffff    | 0x6440        |       |
| Configuration     | 64          | Registers             | 4      | Operation Cfg C           | H2        | 0x0000    | 0xffff    | 0x0000        |       |

**Table 3. DATA FLASH VALUES (continued)**

| Class         | Subclass ID | Subclass           | Offset | Name                    | Data Type | Min Value | Max Value | Default Value | Units |
|---------------|-------------|--------------------|--------|-------------------------|-----------|-----------|-----------|---------------|-------|
| Configuration | 64          | Registers          | 6      | Permanent Fail Cfg      | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| Configuration | 64          | Registers          | 8      | Non-Removable Cfg       | H2        | 0x0000    | 0xffff    | 0x0000        |       |
| LED Support   | 67          | LED Cfg            | 0      | LED Flash Rate          | U2        | 0         | 65535     | 512           | 500us |
| LED Support   | 67          | LED Cfg            | 2      | LED Blink Rate          | U2        | 0         | 65535     | 1024          | 500us |
| LED Support   | 67          | LED Cfg            | 4      | LED Delay               | U2        | 1         | 65535     | 100           | 500us |
| LED Support   | 67          | LED Cfg            | 6      | LED Hold Time           | U1        | 0         | 255       | 4             | sec   |
| LED Support   | 67          | LED Cfg            | 7      | CHG Flash Alarm         | I1        | -1        | 101       | 10            | %     |
| LED Support   | 67          | LED Cfg            | 8      | CHG Thresh 1            | I1        | -1        | 101       | 0             | %     |
| LED Support   | 67          | LED Cfg            | 9      | CHG Thresh 2            | I1        | -1        | 101       | 20            | %     |
| LED Support   | 67          | LED Cfg            | 10     | CHG Thresh 3            | I1        | -1        | 101       | 40            | %     |
| LED Support   | 67          | LED Cfg            | 11     | CHG Thresh 4            | I1        | -1        | 101       | 60            | %     |
| LED Support   | 67          | LED Cfg            | 12     | CHG Thresh 5            | I1        | -1        | 101       | 80            | %     |
| LED Support   | 67          | LED Cfg            | 13     | DSG Flash Alarm         | I1        | -1        | 101       | 10            | %     |
| LED Support   | 67          | LED Cfg            | 14     | DSG Thresh 1            | I1        | -1        | 101       | 0             | %     |
| LED Support   | 67          | LED Cfg            | 15     | DSG Thresh 2            | I1        | -1        | 101       | 20            | %     |
| LED Support   | 67          | LED Cfg            | 16     | DSG Thresh 3            | I1        | -1        | 101       | 40            | %     |
| LED Support   | 67          | LED Cfg            | 17     | DSG Thresh 4            | I1        | -1        | 101       | 60            | %     |
| LED Support   | 67          | LED Cfg            | 18     | DSG Thresh 5            | I1        | -1        | 101       | 80            | %     |
| LED Support   | 67          | LED Cfg            | 19     | Sink Current            | U1        | 0         | 3         | 3             |       |
| Power         | 68          | Power              | 0      | Flash Update OK Voltage | I2        | 6000      | 20000     | 7500          | mV    |
| Power         | 68          | Power              | 2      | Shutdown Voltage        | I2        | 5000      | 20000     | 7000          | mV    |
| Power         | 68          | Power              | 4      | Shutdown Time           | U1        | 0         | 60        | 10            | s     |
| Power         | 68          | Power              | 5      | Charger Present         | I2        | 0         | 23000     | 3000          | mV    |
| Power         | 68          | Power              | 7      | Sleep Current           | I2        | 0         | 100       | 10            | mA    |
| Power         | 68          | Power              | 9      | Bus Low Time            | U1        | 0         | 255       | 5             | s     |
| Power         | 68          | Power              | 10     | Cal Inhibit Temp Low    | I2        | -400      | 1200      | 50            | 0.1°C |
| Power         | 68          | Power              | 12     | Cal Inhibit Temp High   | I2        | -400      | 1200      | 450           | 0.1°C |
| Power         | 68          | Power              | 14     | Sleep Voltage Time      | U1        | 0         | 100       | 5             | s     |
| Power         | 68          | Power              | 15     | Sleep Current Time      | U1        | 0         | 255       | 20            | s     |
| Power         | 68          | Power              | 16     | Wake Current Reg        | H1        | 0x00      | 0x07      | 0x00          |       |
| Gas Gauging   | 80          | IT Cfg             | 0      | Load Select             | U1        | 0         | 255       | 3             |       |
| Gas Gauging   | 80          | IT Cfg             | 1      | Load Mode               | U1        | 0         | 255       | 0             |       |
| Gas Gauging   | 80          | IT Cfg             | 45     | Term Voltage            | I2        | -32768    | 32767     | 12000         | mV    |
| Gas Gauging   | 80          | IT Cfg             | 60     | User Rate-mA            | I2        | 2000      | 9000      | 0             | mA    |
| Gas Gauging   | 80          | IT Cfg             | 62     | User Rate-mW            | I2        | 3000      | 14000     | 0             | 10mW  |
| Gas Gauging   | 80          | IT Cfg             | 64     | Reserve Cap-mAh         | I2        | 0         | 9000      | 0             | mAh   |
| Gas Gauging   | 80          | IT Cfg             | 66     | Reserve Cap-mWh         | I2        | 0         | 14000     | 0             | 10mWh |
| Gas Gauging   | 81          | Current Thresholds | 0      | Dsg Current Threshold   | I2        | 0         | 2000      | 100           | mA    |
| Gas Gauging   | 81          | Current Thresholds | 2      | Chg Current Threshold   | I2        | 0         | 2000      | 50            | mA    |
| Gas Gauging   | 81          | Current Thresholds | 4      | Quit Current            | I2        | 0         | 1000      | 10            | mA    |
| Gas Gauging   | 81          | Current Thresholds | 6      | Dsg Relax Time          | U1        | 0         | 255       | 1             | s     |
| Gas Gauging   | 81          | Current Thresholds | 7      | Chg Relax Time          | U1        | 0         | 255       | 60            | s     |
| Gas Gauging   | 82          | State              | 0      | Qmax Cell 0             | I2        | 0         | 32767     | 4400          | mAh   |
| Gas Gauging   | 82          | State              | 2      | Qmax Cell 1             | I2        | 0         | 32767     | 4400          | mAh   |
| Gas Gauging   | 82          | State              | 4      | Qmax Cell 2             | I2        | 0         | 32767     | 4400          | mAh   |
| Gas Gauging   | 82          | State              | 6      | Qmax Cell 3             | I2        | 0         | 32767     | 4400          | mAh   |
| Gas Gauging   | 82          | State              | 8      | Qmax Pack               | I2        | 0         | 32767     | 4400          | mAh   |

**Table 3. DATA FLASH VALUES (continued)**

| Class       | Subclass ID | Subclass | Offset | Name           | Data Type | Min Value | Max Value | Default Value | Units              |
|-------------|-------------|----------|--------|----------------|-----------|-----------|-----------|---------------|--------------------|
| Gas Gauging | 82          | State    | 12     | Update Status  | H1        | 0x00      | 0x03      | 0x00          |                    |
| Gas Gauging | 82          | State    | 21     | Avg I Last Run | I2        | -32768    | 32767     | -2000         | mA                 |
| Gas Gauging | 82          | State    | 23     | Avg P Last Run | I2        | -32768    | 32767     | -3022         | cWatt              |
| Gas Gauging | 82          | State    | 25     | Delta Voltage  | I2        | -32768    | 32767     | 0             | mV                 |
| Ra Table    | 88          | R_a0     | 0      | Cell0 R_a flag | H2        | 0x0000    | 0x0000    | 0xff55        |                    |
| Ra Table    | 88          | R_a0     | 2      | Cell0 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 4      | Cell0 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 6      | Cell0 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 8      | Cell0 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 10     | Cell0 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 12     | Cell0 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 14     | Cell0 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 16     | Cell0 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 18     | Cell0 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 20     | Cell0 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 22     | Cell0 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 24     | Cell0 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 26     | Cell0 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 28     | Cell0 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table    | 88          | R_a0     | 30     | Cell0 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 0      | Cell1 R_a flag | H2        | 0x0000    | 0x0000    | 0xff55        |                    |
| Ra Table    | 89          | R_a1     | 2      | Cell1 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 4      | Cell1 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 6      | Cell1 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 8      | Cell1 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 10     | Cell1 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 12     | Cell1 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 14     | Cell1 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 16     | Cell1 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 18     | Cell1 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 20     | Cell1 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 22     | Cell1 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 24     | Cell1 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 26     | Cell1 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 28     | Cell1 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table    | 89          | R_a1     | 30     | Cell1 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 0      | Cell2 R_a flag | H2        | 0x0000    | 0x0000    | 0xff55        |                    |
| Ra Table    | 90          | R_a2     | 2      | Cell2 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 4      | Cell2 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 6      | Cell2 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 8      | Cell2 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 10     | Cell2 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 12     | Cell2 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 14     | Cell2 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 16     | Cell2 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 18     | Cell2 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 20     | Cell2 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 22     | Cell2 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 24     | Cell2 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table    | 90          | R_a2     | 26     | Cell2 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |

**Table 3. DATA FLASH VALUES (continued)**

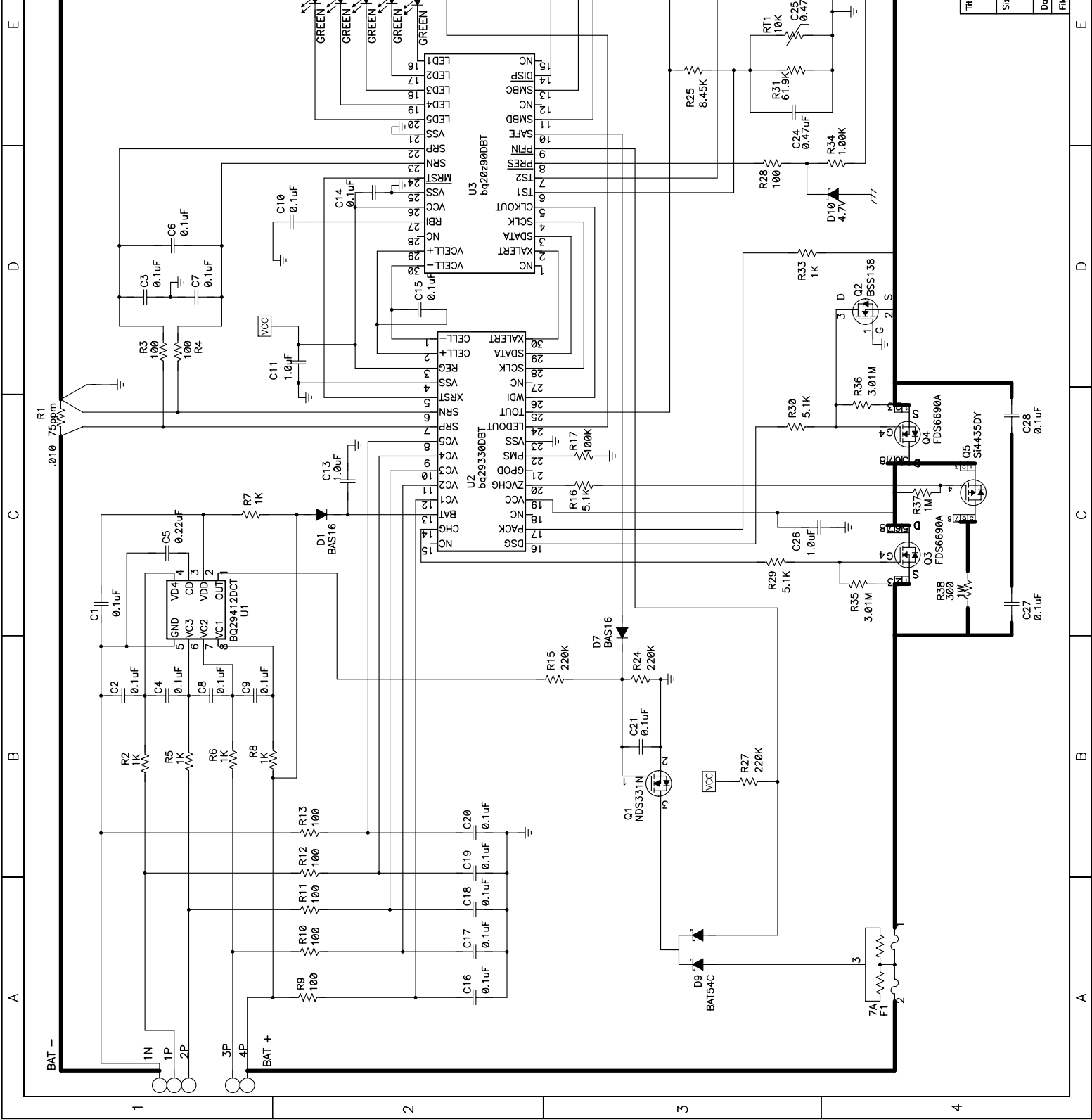
| Class    | Subclass ID | Subclass | Offset | Name            | Data Type | Min Value | Max Value | Default Value | Units              |
|----------|-------------|----------|--------|-----------------|-----------|-----------|-----------|---------------|--------------------|
| Ra Table | 90          | R_a2     | 28     | Cell2 R_a 13    | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table | 90          | R_a2     | 30     | Cell2 R_a 14    | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 0      | Cell3 R_a flag  | H2        | 0x0       | 0x0       | 0xff55        |                    |
| Ra Table | 91          | R_a3     | 2      | Cell3 R_a 0     | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 4      | Cell3 R_a 1     | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 6      | Cell3 R_a 2     | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 8      | Cell3 R_a 3     | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 10     | Cell3 R_a 4     | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 12     | Cell3 R_a 5     | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 14     | Cell3 R_a 6     | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 16     | Cell3 R_a 7     | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 18     | Cell3 R_a 8     | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 20     | Cell3 R_a 9     | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 22     | Cell3 R_a 10    | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 24     | Cell3 R_a 11    | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 26     | Cell3 R_a 12    | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 28     | Cell3 R_a 13    | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table | 91          | R_a3     | 30     | Cell3 R_a 14    | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 0      | xCell0 R_a flag | H2        | 0xffff    | 0xffff    | 0xffff        |                    |
| Ra Table | 92          | R_a0x    | 2      | xCell0 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 4      | xCell0 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 6      | xCell0 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 8      | xCell0 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 10     | xCell0 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 12     | xCell0 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 14     | xCell0 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 16     | xCell0 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 18     | xCell0 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 20     | xCell0 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 22     | xCell0 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 24     | xCell0 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 26     | xCell0 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 28     | xCell0 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table | 92          | R_a0x    | 30     | xCell0 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 0      | xCell1 R_a flag | H2        | 0xffff    | 0xffff    | 0xffff        |                    |
| Ra Table | 93          | R_a1x    | 2      | xCell1 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 4      | xCell1 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 6      | xCell1 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 8      | xCell1 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 10     | xCell1 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 12     | xCell1 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 14     | xCell1 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 16     | xCell1 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 18     | xCell1 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 20     | xCell1 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 22     | xCell1 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 24     | xCell1 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 26     | xCell1 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 28     | xCell1 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table | 93          | R_a1x    | 30     | xCell1 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |

**Table 3. DATA FLASH VALUES (continued)**

| Class     | Subclass ID | Subclass           | Offset | Name            | Data Type | Min Value | Max Value | Default Value | Units              |
|-----------|-------------|--------------------|--------|-----------------|-----------|-----------|-----------|---------------|--------------------|
| Ra Table  | 94          | R_a2x              | 0      | xCell2 R_a flag | H2        | 0xffff    | 0xffff    | 0xffff        |                    |
| Ra Table  | 94          | R_a2x              | 2      | xCell2 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 4      | xCell2 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 6      | xCell2 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 8      | xCell2 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 10     | xCell2 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 12     | xCell2 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 14     | xCell2 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 16     | xCell2 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 18     | xCell2 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 20     | xCell2 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 22     | xCell2 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 24     | xCell2 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 26     | xCell2 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 28     | xCell2 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table  | 94          | R_a2x              | 30     | xCell2 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 0      | xCell3 R_a flag | H2        | 0xffff    | 0xffff    | 0xffff        |                    |
| Ra Table  | 95          | R_a3x              | 2      | xCell3 R_a 0    | I2        | 183       | 183       | 160           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 4      | xCell3 R_a 1    | I2        | 181       | 181       | 166           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 6      | xCell3 R_a 2    | I2        | 198       | 198       | 153           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 8      | xCell3 R_a 3    | I2        | 244       | 244       | 151           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 10     | xCell3 R_a 4    | I2        | 254       | 254       | 145           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 12     | xCell3 R_a 5    | I2        | 261       | 261       | 152           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 14     | xCell3 R_a 6    | I2        | 333       | 333       | 176           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 16     | xCell3 R_a 7    | I2        | 338       | 338       | 204           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 18     | xCell3 R_a 8    | I2        | 345       | 345       | 222           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 20     | xCell3 R_a 9    | I2        | 350       | 350       | 254           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 22     | xCell3 R_a 10   | I2        | 382       | 382       | 315           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 24     | xCell3 R_a 11   | I2        | 429       | 429       | 437           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 26     | xCell3 R_a 12   | I2        | 502       | 502       | 651           | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 28     | xCell3 R_a 13   | I2        | 545       | 545       | 1001          | 2 <sup>~</sup> 10Ω |
| Ra Table  | 95          | R_a3x              | 30     | xCell3 R_a 14   | I2        | 366       | 366       | 1458          | 2 <sup>~</sup> 10Ω |
| PF Status | 96          | Device Status Data | 0      | PF Flags 1      | H2        | 0x0000    | 0x6fff    | 0x0000        |                    |
| PF Status | 96          | Device Status Data | 2      | Fuse Flag       | H2        | 0x0000    | 0xffff    | 0x0000        |                    |
| PF Status | 96          | Device Status Data | 4      | PF Voltage      | I2        | 0         | 32767     | 0             | mV                 |
| PF Status | 96          | Device Status Data | 6      | PF C4 Voltage   | I2        | 0         | 9999      | 0             | mV                 |
| PF Status | 96          | Device Status Data | 8      | PF C3 Voltage   | I2        | 0         | 9999      | 0             | mV                 |
| PF Status | 96          | Device Status Data | 10     | PF C2 Voltage   | I2        | 0         | 9999      | 0             | mV                 |
| PF Status | 96          | Device Status Data | 12     | PF C1 Voltage   | I2        | 0         | 9999      | 0             | mV                 |
| PF Status | 96          | Device Status Data | 14     | PF Current      | I2        | -32768    | 32767     | 0             | mA                 |
| PF Status | 96          | Device Status Data | 16     | PF Temperature  | I2        | -9999     | 9999      | 0             | 0.1 K              |
| PF Status | 96          | Device Status Data | 18     | PF Batt Stat    | H2        | 0x0000    | 0xffff    | 0x0000        |                    |
| PF Status | 96          | Device Status Data | 20     | PF RC-mAh       | I2        | 0         | 32767     | 0             | mAh                |

**Table 3. DATA FLASH VALUES (continued)**

| Class       | Subclass ID | Subclass           | Offset | Name             | Data Type | Min Value | Max Value | Default Value | Units            |
|-------------|-------------|--------------------|--------|------------------|-----------|-----------|-----------|---------------|------------------|
| PF Status   | 96          | Device Status Data | 22     | PF RC-10mWh      | I2        | 0         | 32767     | 0             | cWattHr          |
| PF Status   | 96          | Device Status Data | 24     | PF Chg Status    | H2        | 0x0000    | 0xffff    | 0x0000        |                  |
| PF Status   | 96          | Device Status Data | 26     | PF Safety Status | H2        | 0x0000    | 0xffff    | 0x0000        |                  |
| PF Status   | 96          | Device Status Data | 28     | PF Flags 2       | H2        | 0x0000    | 0x8000    | 0x0000        |                  |
| PF Status   | 97          | AFE Regs           | 0      | AFE Status       | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 1      | AFE Output       | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 2      | AFE State        | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 3      | AFE Function     | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 4      | AFE Cell Select  | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 5      | AFE OLV          | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 6      | AFE OLT          | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 7      | AFE SCC          | H1        | 0x00      | 0xff      | 0x00          |                  |
| PF Status   | 97          | AFE Regs           | 8      | AFE SCD          | H1        | 0x00      | 0xff      | 0x00          |                  |
| Calibration | 104         | Data               | 0      | CC Gain          | F4        | 0.1       | 4         | 0.9419        |                  |
| Calibration | 104         | Data               | 4      | CC Delta         | F4        | 29826     | 1193046   | 280932.6      |                  |
| Calibration | 104         | Data               | 8      | Ref Voltage      | I2        | 0         | 32767     | 24500         | 50 $\mu$ V       |
| Calibration | 104         | Data               | 12     | AFE Pack Gain    | I2        | 0         | 32767     | 22050         | $\mu$ V/cnt      |
| Calibration | 104         | Data               | 14     | CC Offset        | I2        | -32768    | 32767     | -1667         |                  |
| Calibration | 104         | Data               | 16     | Board Offset     | I2        | -32767    | 32767     | 0             |                  |
| Calibration | 104         | Data               | 18     | Int Temp Offset  | I1        | -128      | 127       | 0             |                  |
| Calibration | 104         | Data               | 19     | Ext1 Temp Offset | I1        | -128      | 127       | 0             |                  |
| Calibration | 104         | Data               | 20     | Ext2 Temp Offset | I1        | -128      | 127       | 0             |                  |
| Calibration | 105         | Config             | 0      | CC Current       | I2        | 0         | 32767     | 3000          | mA               |
| Calibration | 105         | Config             | 2      | Voltage Signal   | I2        | 0         | 32767     | 16800         | mV               |
| Calibration | 105         | Config             | 4      | Temp Signal      | I2        | 0         | 32767     | 2980          | 0.1 $^{\circ}$ C |
| Calibration | 105         | Config             | 6      | CC Offset Time   | U2        | 0         | 65535     | 250           | ms               |
| Calibration | 105         | Config             | 8      | ADC Offset Time  | U2        | 0         | 65535     | 32            | ms               |
| Calibration | 105         | Config             | 10     | CC Gain Time     | U2        | 0         | 65535     | 250           | ms               |
| Calibration | 105         | Config             | 12     | Voltage Time     | U2        | 0         | 65535     | 1984          | ms               |
| Calibration | 105         | Config             | 14     | Temperature Time | U2        | 0         | 65535     | 32            | s                |
| Calibration | 105         | Config             | 17     | Cal Mode Timeout | U2        | 0         | 65535     | 38400         | 1/128 s          |
| Calibration | 106         | Temp Model         | 0      | Ext Coef 1       | I2        | -32768    | 32767     | -28285        | s                |
| Calibration | 106         | Temp Model         | 2      | Ext Coef 2       | I2        | -32768    | 32767     | 20848         | s                |
| Calibration | 106         | Temp Model         | 4      | Ext Coef 3       | I2        | -32768    | 32767     | -7537         | s                |
| Calibration | 106         | Temp Model         | 6      | Ext Coef 4       | I2        | -32768    | 32767     | 4012          | s                |
| Calibration | 106         | Temp Model         | 8      | Ext Min AD       | I2        | -32768    | 32767     | 0             | s                |
| Calibration | 106         | Temp Model         | 10     | Ext Max Temp     | I2        | -32768    | 32767     | 4012          | s                |
| Calibration | 106         | Temp Model         | 12     | Int Coef 1       | I2        | -32768    | 32767     | 0             | s                |
| Calibration | 106         | Temp Model         | 14     | Int Coef 2       | I2        | -32768    | 32767     | 0             | s                |
| Calibration | 106         | Temp Model         | 16     | Int Coef 3       | I2        | -32768    | 32767     | -11136        | s                |
| Calibration | 106         | Temp Model         | 18     | Int Coef 4       | I2        | -32768    | 32767     | 5754          | s                |
| Calibration | 106         | Temp Model         | 20     | Int Min AD       | I2        | -32768    | 32767     | 0             | s                |
| Calibration | 106         | Temp Model         | 22     | Int Max Temp     | I2        | -32768    | 32767     | 5754          | s                |
| Calibration | 107         | Current            | 0      | Filter           | U1        | 0         | 255       | 239           |                  |
| Calibration | 107         | Current            | 1      | Deadband         | U1        | 0         | 255       | 3             | mA               |
| Calibration | 107         | Current            | 2      | CC Deadband      | U1        | 0         | 255       | 34            | 294 nV           |



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**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|---------|
| BQ20Z90DBT       | NRND          | TSSOP        | DBT                | 30   | 60             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 85    | 20Z90DBT                |         |

(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.

**OBSELETE:** 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.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

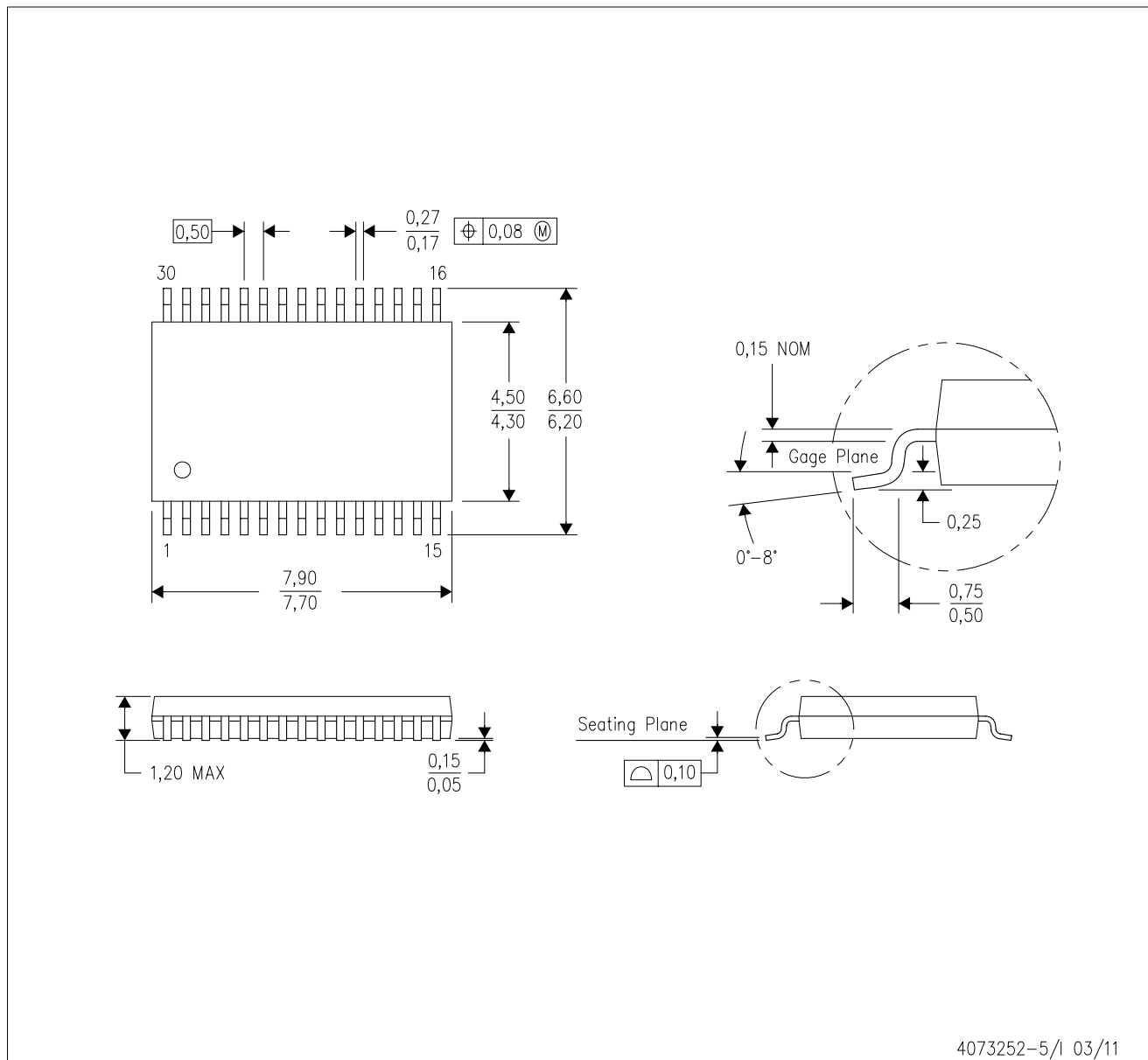
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DBT (R-PDSO-G30)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-153.

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