

System-Side Impedance Track™ Fuel Gauge with Dynamic Voltage Correlation

Check for Samples: [bq27620-G1](#)

1 INTRODUCTION

1.1 FEATURES

- Battery Fuel Gauge for 1-Series Li-Ion applications based on Patented Impedance Track™ Technology with Dynamic Voltage Correlation (IT-DVC)
- Resides on System Main Board
- No Sense Resistor Required
- Powered directly from battery with integrated LDO
- Supports embedded or removable Battery Packs
- System Side Fuel-Gauge Provides:
 - Accurate Battery Fuel Gauging; models the Battery Discharge Curve for Accurate Time-to-Empty Predictions
 - Automatically Adjusts for Battery Aging, Battery Self-Discharge, and Temperature/Rate Inefficiencies
 - Internal Temperature Sensor for Battery Temperature Reporting
 - Battery Low Interrupt Warning
 - Battery Insertion Indicator
 - Configurable Level of State of Charge (SOC) Interrupts
 - State of Health Indicator
 - 32 Bytes of Non-Volatile Scratch-Pad FLASH
- 400-kHz I²C™ Interface for Connection to System Microcontroller Port
- In a 15-Pin NanoFree™ (CSP) Packaging

1.2 APPLICATIONS

- Smartphones
- Digital Still and Video Cameras
- Handheld Terminals
- MP3 or Multimedia Players

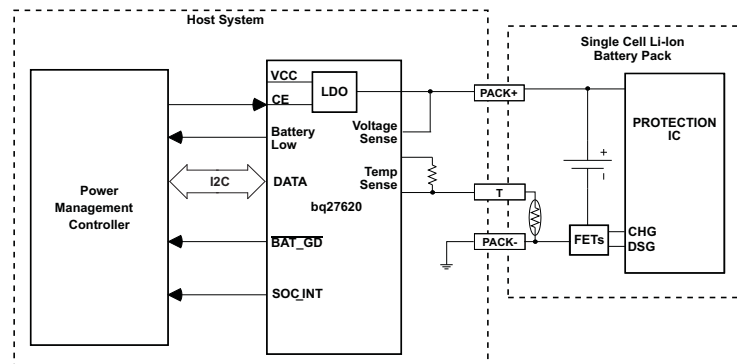
1.3 DESCRIPTION

The Texas Instruments bq27620-G1 system-side is an easy configure microcontroller peripheral that provides fuel gauging for single-cell Li-Ion battery packs. The device requires minimal user configuration and system microcontroller firmware development.

The bq27620-G1 uses the patented Impedance Track™ algorithm with Dynamic Voltage Correlation for fuel gauging. This patented process eliminates the need for a **sense resistor** when calculating remaining battery capacity (mAh), state-of-charge (%), run-time to empty (min), battery voltage (mV), temperature (°C) and state of health (%).

Battery fuel gauging with the bq27620-G1 requires connections only to PACK+ (P+), PACK– (P–), and Thermistor (T) connections to a removable battery pack or embedded battery circuit. The CSP option is a 15-ball package in the nominal dimensions of 2610 × 1956 μm with 0,5 mm lead pitch. It is ideal for space constrained applications.

TYPICAL APPLICATION



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Impedance Track, NanoFree are trademarks of Texas Instruments.
I²C is a trademark of NXP B.V. Corp Netherlands.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2012, Texas Instruments Incorporated



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

| | | | |
|---|--------------------------|--|---------------------------|
| 1 INTRODUCTION | 1 | 4.2 DATA FLASH INTERFACE | 19 |
| 1.1 FEATURES | 1 | 4.3 MANUFACTURER INFORMATION BLOCK | 20 |
| 1.2 APPLICATIONS | 1 | 4.4 ACCESS MODES | 21 |
| 1.3 DESCRIPTION | 1 | 4.5 SEALING/UNSEALING DATA FLASH | 21 |
| 2 DEVICE INFORMATION | 3 | 4.6 DATA FLASH SUMMARY | 22 |
| 2.1 AVAILABLE OPTIONS | 3 | 5 FUNCTIONAL DESCRIPTION | 26 |
| 2.2 THERMAL INFORMATION | 3 | 5.1 FUEL GAUGING | 26 |
| 2.3 PIN ASSIGNMENT AND PACKAGE DIMENSIONS | 4 | 5.2 IMPEDANCE TRACK™ VARIABLES | 27 |
| 3 ELECTRICAL SPECIFICATIONS | 5 | 5.3 DETAILED PIN DESCRIPTION | 29 |
| 3.1 ABSOLUTE MAXIMUM RATINGS | 5 | 5.4 TEMPERATURE MEASUREMENT | 34 |
| 3.2 RECOMMENDED OPERATING CONDITIONS | 5 | 5.5 OVERTEMPERATURE INDICATION | 34 |
| 3.3 SUPPLY CURRENT | 5 | 5.6 CHARGING AND CHARGE-TERMINATION INDICATION | 34 |
| 3.4 DIGITAL INPUT AND OUTPUT DC CHARACTERISTICS | 6 | 5.7 POWER MODES | 35 |
| 3.5 POWER-ON RESET | 6 | 6 APPLICATION-SPECIFIC INFORMATION | 36 |
| 3.6 2.5V LDO REGULATOR | 6 | 6.1 BATTERY PROFILE STORAGE AND SELECTION | 36 |
| 3.7 INTERNAL CLOCK OSCILLATORS | 6 | 7 COMMUNICATIONS | 37 |
| 3.8 ADC (TEMPERATURE AND CELL MEASUREMENT) CHARACTERISTICS | 7 | 7.1 I ² C INTERFACE | 37 |
| 3.9 DATA FLASH MEMORY CHARACTERISTICS | 8 | 7.2 I ² C Time Out | 37 |
| 3.10 I ² C-COMPATIBLE INTERFACE COMMUNICATION TIMING CHARACTERISTICS | 8 | 7.3 I ² C Command Waiting Time | 38 |
| 4 GENERAL DESCRIPTION | 9 | 7.4 I ² C Clock Stretching | 38 |
| 4.1 DATA COMMANDS | 10 | 8 REFERENCE SCHEMATICS | 39 |
| | | 8.1 SCHEMATIC | 39 |

2 DEVICE INFORMATION

2.1 AVAILABLE OPTIONS

| PART NUMBER | FIRMWARE VERSION ⁽¹⁾ | PACKAGE ⁽¹⁾ | T _A | COMMUNICATION FORMAT | TAPE and REEL QUANTITY |
|----------------|---------------------------------|------------------------|----------------|----------------------|------------------------|
| bq27620YZFR-G1 | 1.06 (0x106) | CSP-15 | –40°C to 85°C | I ² C | 3000 |
| bq27620YZFT-G1 | | | | | 250 |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

2.2 THERMAL INFORMATION

| THERMAL METRIC ⁽¹⁾ | | bq27620-G1 YZF(15 PINS) | UNITS |
|-------------------------------|--|----------------------------|-------|
| | | | |
| θ_{JA} | Junction-to-ambient thermal resistance | 70 | °C/W |
| θ_{JCTop} | Junction-to-case (top) thermal resistance | 17 | |
| θ_{JB} | Junction-to-board thermal resistance | 20 | |
| ψ_{JT} | Junction-to-top characterization parameter | 1 | |
| ψ_{JB} | Junction-to-board characterization parameter | 18 | |
| θ_{JCbott} | Junction-to-case (bottom) thermal resistance | n/a | |

(1) For more information about traditional and new thermal metrics, see the IC Package Thermal Metrics application report, [SPRA953](http://www.ti.com/lit/zip/SPRA953)

2.3 PIN ASSIGNMENT AND PACKAGE DIMENSIONS

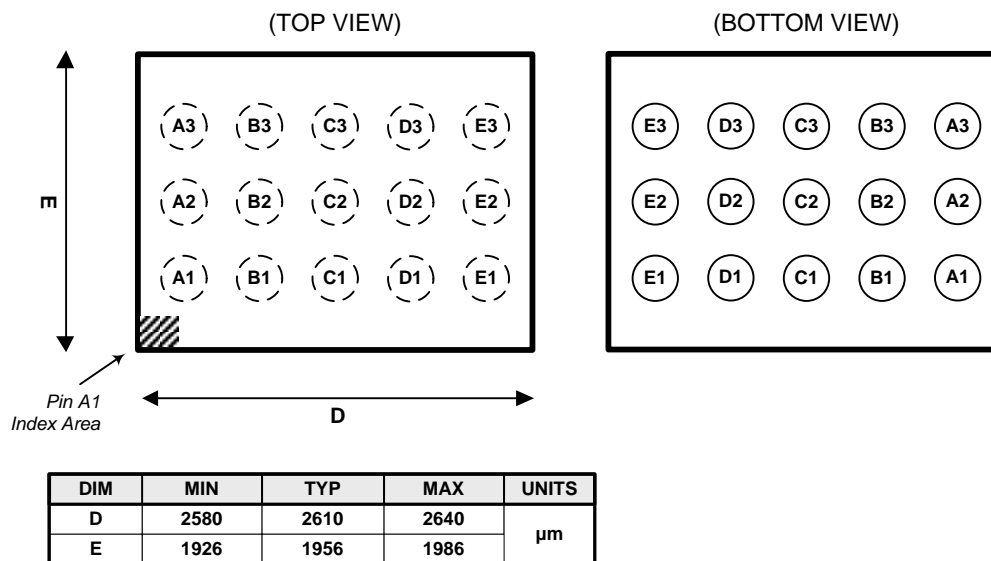


Table 2-1. PIN FUNCTIONS

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|-----------------|----------------|---------------------|--|
| NAME | NO. | | |
| V _{SS} | A1, B1, C1, C2 | P | Device ground |
| V _{CC} | D1 | P | Regulator output and bq27620-G1 processor power. Decouple with 1μF ceramic capacitor to V _{SS} . |
| REGIN | E1 | P | Regulator input. Decouple with 0.1μF ceramic capacitor to V _{SS} . |
| SOC_INT | A2 | O | SOC state interrupts output. Generates a pulse under the conditions specified by Table 5-7. Open drain output. (RA3) |
| BAT_GD | B2 | O | Battery-good indicator. Active-low by default, though polarity can be configured through the [BATG_POL] bit of Operation Configuration . Push-pull output. (RC1) |
| CE | D2 | I | Chip Enable. Internal LDO is disconnected from REGIN when driven low. |
| BAT | E2 | I | Cell-voltage measurement input. ADC input. Recommend 4.8V maximum for conversion accuracy. (RC3) |
| SCL | A3 | I | Slave I ² C serial communications clock input line for communication with system (Master). Use with 10kΩ pull-up resistor (typical). (RA2) |
| SDA | B3 | I/O | Slave I ² C serial communications data line for communication with system (Master). Open-drain I/O. Use with 10kΩ pull-up resistor (typical). (RA1) |
| BAT_LOW | C3 | O | Battery Low output indicator. Active high by default, though polarity can be configured through the [BATL_POL] bit of Operation Configuration . Push-pull output. (RC0) |
| TS | D3 | IA | Pack thermistor voltage sense (use 103AT-type thermistor). ADC input. (RC2) |
| BI/TOUT | E3 | I/O | Battery-insertion detection input. Power pin for pack thermistor network. Thermistor-multiplexer control pin. Use with pull-up resistor >1MΩ (1.8 MΩ typical). (RA0) |

(1) I/O = Digital input/output, IA = Analog input, P = Power connection

3 ELECTRICAL SPECIFICATIONS

3.1 ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| PARAMETER | | VALUE | UNIT |
|--------------------|---|-------------------------------|------|
| V _{REGIN} | Regulator input range | –0.3 to 5.5 | V |
| | | –0.3 to 6.0 ⁽²⁾ | V |
| V _{CC} | Supply voltage range | –0.3 to 2.75 | V |
| V _{IOD} | Open-drain I/O pins (SDA, SCL, SOC_INT) | –0.3 to 5.5 | V |
| V _{BAT} | BAT input pin | –0.3 to 5.5 | V |
| | | –0.3 to 6.0 ⁽²⁾ | V |
| V _I | Input voltage range to all other pins (BI/TOUT , TS , BAT_GD) | –0.3 to V _{CC} + 0.3 | V |
| ESD | Human-body model (HBM), BAT pin | 1.5 | kV |
| | Human-body model (HBM), all other pins | 2 | |
| T _A | Operating free-air temperature range | –40 to 85 | °C |
| T _F | Functional temperature range | –40 to 100 | °C |
| T _{stg} | Storage temperature range | –65 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.
- (2) Condition not to exceed 100 hours at 25 °C lifetime.

3.2 RECOMMENDED OPERATING CONDITIONS

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

| PARAMETER | | TEST CONDITIONS | | | UNIT |
|--------------------|--|--|------|-----|------|
| V _{REGIN} | Supply voltage | No operating restrictions | 2.8 | 4.5 | V |
| | | No FLASH writes | 2.45 | 2.8 | |
| C _{REGIN} | External input capacitor for internal LDO between REGIN and V _{SS} | Nominal capacitor values specified. Recommend a 5% ceramic X5R type capacitor located close to the device. | 0.1 | | μF |
| C _{LDO25} | External output capacitor for internal LDO between V _{CC} and V _{SS} | | 0.47 | 1 | μF |
| t _{PUCD} | Power-up communication delay | | 250 | | ms |

3.3 SUPPLY CURRENT

T_A = 25°C and V_{REGIN} = V_{BAT} = 3.6V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------|---|---|-----|-----|-----|------|
| I _{CC} | Normal operating-mode current ⁽¹⁾ | Fuel gauge in NORMAL mode. I _{LOAD} > Sleep Current | | 118 | | μA |
| I _{SLP} | Low-power storage-mode current ⁽¹⁾ | Fuel gauge in SLEEP mode. I _{LOAD} < Sleep Current | | 23 | | μA |
| I _{HIB} | Hibernate operating-mode current ⁽¹⁾ | Fuel gauge in HIBERNATE mode. I _{LOAD} < Hibernate Current | | 8 | | μA |

- (1) Specified by design. Not production tested.

3.4 DIGITAL INPUT AND OUTPUT DC CHARACTERISTICS

$T_A = -40^{\circ}\text{C}$ to 85°C , typical values at $T_A = 25^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------|--|---|--------------------------|-----|-----------------------|---------------|
| V_{OL} | Output voltage, low (SCL, SDA, SOC_INT, BAT_LOW, BAT_GD) | $I_{\text{OL}} = 3\text{ mA}$ | | | 0.4 | V |
| $V_{\text{OH(PP)}}$ | Output voltage, high (BAT_LOW, BAT_GD) | $I_{\text{OH}} = -1\text{ mA}$ | $V_{\text{CC}} - 0.5$ | | | V |
| $V_{\text{OH(OD)}}$ | Output voltage, high (SDA, SCL, SOC_INT) | External pullup resistor connected to V_{CC} | $V_{\text{CC}} - 0.5$ | | | |
| V_{IL} | Input voltage, low (SDA, SCL pins) | | -0.3 | | 0.6 | V |
| | Input voltage, low (BI/TOUT pin) | BAT INSERT CHECK MODE active | -0.3 | | 0.6 | |
| V_{IH} | Input voltage, high (SDA, SCL pins) | | 1.2 | | | V |
| | Input voltage, high (BI/TOUT pin) | BAT INSERT CHECK MODE active | 1.2 | | $V_{\text{CC}} + 0.3$ | |
| $V_{\text{IL(CE)}}$ | Input voltage, low (CE pin) | $V_{\text{REGIN}} = 2.8\text{ to }4.5\text{ V}$ | | | 0.8 | V |
| $V_{\text{IH(CE)}}$ | Input voltage, high (CE pin) | | $V_{\text{REGIN}} - 0.5$ | | | |
| I_{Ikg} | Input leakage current (I/O pins) (1) | | | | 0.3 | μA |

(1) Specified by design. Not production tested.

3.5 POWER-ON RESET

$T_A = -40^{\circ}\text{C}$ to 85°C , typical values at $T_A = 25^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------|---|------|------|------|------|
| $V_{\text{IT+}}$ | Positive-going battery voltage input at V_{CC} | 2.05 | 2.15 | 2.20 | V |
| V_{HYS} | Power-on reset hysteresis | 45 | 115 | 185 | mV |

3.6 2.5V LDO REGULATOR

$T_A = -40^{\circ}\text{C}$ to 85°C , $C_{\text{LDO25}} = 1\mu\text{F}$, $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITION | MIN | NOM | MAX | UNIT |
|--------------------|--------------------------|---|-----|-----|-----|------|
| V _{REG25} | Regulator output voltage | 2.8V ≤ V _{REGIN} ≤ 4.5V, I _{OUT} ≤ 16mA | 2.3 | 2.5 | 2.6 | V |
| | | 2.45V ≤ V _{REGIN} < 2.8V (low battery), I _{OUT} ≤ 3mA | 2.3 | | | V |

3.7 INTERNAL CLOCK OSCILLATORS

$T_A = -40^{\circ}\text{C}$ to 85°C , $2.4\text{ V} < V_{\text{CC}} < 2.6\text{ V}$; typical values at $T_A = 25^{\circ}\text{C}$ and $V_{\text{CC}} = 2.5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-------------------|---------------------------|-----|--------|-----|------|
| f_{OSC} | High Frequency Oscillator | | 2.097 | | MHz |
| f_{LOSC} | Low Frequency Oscillator | | 32.768 | | kHz |

3.8 ADC (TEMPERATURE AND CELL MEASUREMENT) CHARACTERISTICS

$T_A = -40^{\circ}\text{C}$ to 85°C , $2.4\text{ V} < V_{CC} < 2.6\text{ V}$; typical values at $T_A = 25^{\circ}\text{C}$ and $V_{CC} = 2.5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------------|---|---------------------------------------|-----|-----|------------------------|
| V_{A1} | Input voltage range (TS) | $V_{SS} - 0.125$ | | 2 | V |
| V_{A2} | Input voltage range (BAT) | $V_{SS} - 0.125$ | | 5 | V |
| $V_{IN(ADC)}$ | Input voltage range | 0.05 | | 1 | V |
| G_{TEMP} | Internal temperature sensor voltage gain | | -2 | | mV/ $^{\circ}\text{C}$ |
| t_{ADC_CONV} | Conversion time | | | 125 | ms |
| | Resolution | 14 | | 15 | bits |
| $V_{OS(ADC)}$ | Input offset | | 1 | | mV |
| Z_{ADC1} | Effective input resistance (TS) ⁽¹⁾ | 8 | | | M Ω |
| Z_{ADC2} | Effective input resistance (BAT) ⁽¹⁾ | bq27620-G1 not measuring cell voltage | | 8 | M Ω |
| | | bq27620-G1 measuring cell voltage | | 100 | k Ω |
| $I_{lkg(ADC)}$ | Input leakage current ⁽¹⁾ | | | 0.3 | μA |

(1) Specified by design. Not tested in production.

3.9 DATA FLASH MEMORY CHARACTERISTICS

$T_A = -40^{\circ}\text{C}$ to 85°C , $2.4\text{ V} < V_{CC} < 2.6\text{ V}$; typical values at $T_A = 25^{\circ}\text{C}$ and $V_{CC} = 2.5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------|--|--------|-----|-----|--------|
| t_{DR} | Data retention ⁽¹⁾ | 10 | | | Years |
| | Flash-programming write cycles ⁽¹⁾ | 20,000 | | | Cycles |
| $t_{WORDPROG}$ | Word programming time ⁽¹⁾ | | | 2 | ms |
| I_{CCPROG} | Flash-write supply current ⁽¹⁾ | | 5 | 10 | mA |
| $t_{DFERASE}$ | Data flash master erase time ⁽¹⁾ | 200 | | | ms |
| $t_{IFERASE}$ | Instruction flash master erase time ⁽¹⁾ | 200 | | | ms |
| $t_{PGERASE}$ | Flash page erase time ⁽¹⁾ | 20 | | | ms |

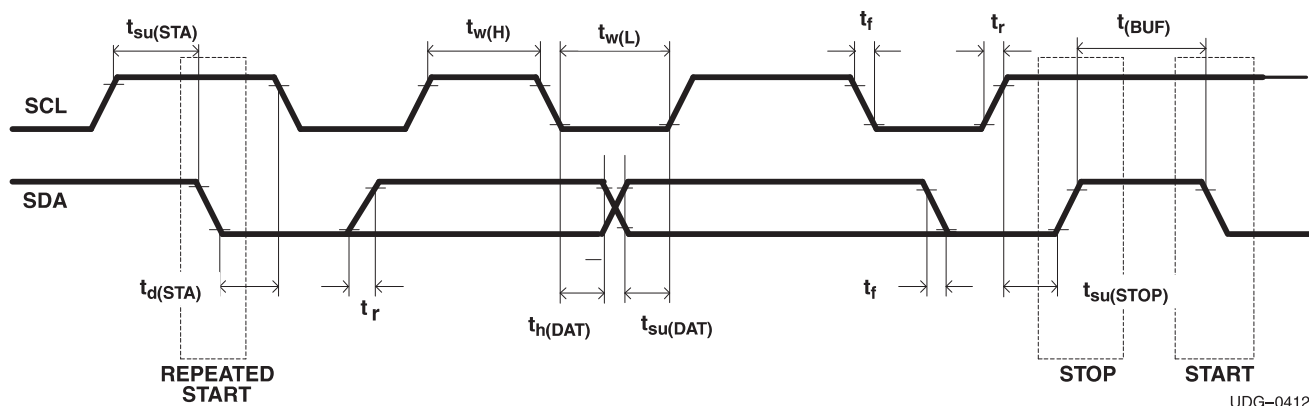
(1) Specified by design. Not production tested

3.10 I²C-COMPATIBLE INTERFACE COMMUNICATION TIMING CHARACTERISTICS

$T_A = -40^{\circ}\text{C}$ to 85°C , $2.4\text{ V} < V_{CC} < 2.6\text{ V}$; typical values at $T_A = 25^{\circ}\text{C}$ and $V_{CC} = 2.5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------|--------------------------------------|-----|-----|-----|---------------|
| t_r | SCL/SDA rise time | | | 300 | ns |
| t_f | SCL/SDA fall time | | | 300 | ns |
| $t_{w(H)}$ | SCL pulse duration (high) | 600 | | | ns |
| $t_{w(L)}$ | SCL pulse duration (low) | 1.3 | | | μs |
| $t_{su(STA)}$ | Setup for repeated start | 600 | | | ns |
| $t_{d(STA)}$ | Start to first falling edge of SCL | 600 | | | ns |
| $t_{su(DAT)}$ | Data setup time | 100 | | | ns |
| $t_{h(DAT)}$ | Data hold time | 0 | | | ns |
| $t_{su(STOP)}$ | Setup time for stop | 600 | | | ns |
| $t_{(BUF)}$ | Bus free time between stop and start | 66 | | | μs |
| f_{SCL} | Clock frequency ⁽¹⁾ | | | 400 | kHz |

(1) If the clock frequency (f_{SCL}) is $> 100\text{ kHz}$, use 1-byte write commands for proper operation. All other transactions types are supported at 400 kHz. (Refer to [Section 7.1](#) and [Section 7.3](#))



UDG-04122

Figure 3-1. I²C-Compatible Interface Timing Diagrams

4 GENERAL DESCRIPTION

The bq27620-G1 accurately predicts the battery capacity and other operational characteristics of a single Li-based rechargeable cell. It can be interrogated by a system processor to provide cell information, such as time-to-empty (TTE), time-to-full (TTF) and state-of-charge (SOC) as well as SOC interrupt signal to the host.

Information is accessed through a series of commands, called *Standard Commands*. Further capabilities are provided by the additional *Extended Commands* set. Both sets of commands, indicated by the general format *Command*(), are used to read and write information contained within the device control and status registers, as well as its data flash locations. Commands are sent from system to gauge using the bq27620-G1's I²C serial communications engine, and can be executed during application development, system manufacture, or end-equipment operation.

Cell information is stored in the device in non-volatile flash memory. Many of these data flash locations are accessible during application development. They cannot, generally, be accessed directly during end-equipment operation. Access to these locations is achieved by either use of the bq27620-G1's companion evaluation software, through individual commands, or through a sequence of data-flash-access commands. To access a desired data flash location, the correct data flash subclass and offset must be known.

The bq27620-G1 provides a 32-byte user-programmable data flash **Manufacturer Info Block**. This data space is accessed through a data flash interface. For specifics on accessing the data flash, [MANUFACTURER INFORMATION BLOCKS](#).

The key to the bq27620-G1's high-accuracy gas gauging prediction is Texas Instrument's proprietary Impedance Track™ algorithm with Dynamic Voltage Correlation (IT-DVC). This algorithm uses cell measurements, characteristics, and properties to create state-of-charge predictions that can achieve less than 5% error across a wide variety of operating conditions and over the lifetime of the battery.

The device utilizes a comprehensive battery model to estimate the average current in real time, eliminating the need of a sense resistor. When a cell is attached to the device, cell impedance is computed, open-circuit voltage (OCV), and cell voltage under loading conditions.

The device external temperature sensing is optimized with the use of a high accuracy negative temperature coefficient (NTC) thermistor with $R_{25} = 10.0k\Omega \pm 1\%$. $B_{25/85} = 3435K \pm 1\%$ (such as Semitec NTC 103AT). The bq27620-G1 can also be configured to use its internal temperature sensor. When an external thermistor is used, a 18.2k pull up resistor between BT/TOUT and TS pins is also required. The bq27620-G1 uses temperature to monitor the battery-pack environment, which is used for fuel gauging and cell protection functionality.

To minimize power consumption, the device has different power modes: NORMAL, SLEEP, HIBERNATE, and BAT INSERT CHECK. The bq27620-G1 passes automatically between these modes, depending upon the occurrence of specific events, though a system processor can initiate some of these modes directly. More details can be found in [POWER MODES](#).

NOTE

FORMATTING CONVENTIONS IN THIS DOCUMENT:

Commands: *italics* with parentheses and no breaking spaces, e.g., *RemainingCapacity*()

Data flash: *italics*, **bold**, and *breaking spaces*, e.g., **Design Capacity**

Register bits and flags: brackets and *italics*, e.g., [TDA]

Data flash bits: brackets, *italics* and **bold**, e.g., [LED1]

Modes and states: ALL CAPITALS, e.g., UNSEALED mode.

4.1 DATA COMMANDS

4.1.1 STANDARD DATA COMMANDS

The bq27620-G1 uses a series of 2-byte standard commands to enable system reading and writing of battery information. Each standard command has an associated command-code pair, as indicated in [Table 4-1](#). Because each command consists of two bytes of data, two consecutive I²C transmissions must be executed both to initiate the command function, and to read or write the corresponding two bytes of data. Additional options for transferring data, such as spooling, are described in Section of **Communication**. Read/Write permissions depend on the active access mode, SEALED or UNSEALED (for details on the SEALED and UNSEALED states, see [Section 4.4](#), Access Modes.)

Table 4-1. Standard Commands

| NAME | | COMMAND CODE | UNITS | SEALED ACCESS |
|-----------------------------------|-------|--------------|---------|---------------|
| <i>Control()</i> | CNTL | 0x00 / 0x01 | N/A | R/W |
| <i>AtRate()</i> | | 0x02 / 0x03 | mA | R/W |
| <i>AtRateTimeToEmpty()</i> | | 0x04 / 0x05 | Minutes | R |
| <i>Temperature()</i> | TEMP | 0x06 / 0x07 | 0.1 K | R/W |
| <i>Voltage()</i> | VOLT | 0x08 / 0x09 | mV | R |
| <i>Flags()</i> | FLAGS | 0x0a / 0x0b | N/A | R |
| <i>NominalAvailableCapacity()</i> | | 0x0c / 0x0d | mAh | R |
| <i>FullAvailableCapacity()</i> | | 0x0e / 0x0f | mAh | R |
| <i>RemainingCapacity()</i> | RM | 0x10 / 0x11 | mAh | R |
| <i>FullChargeCapacity()</i> | FCC | 0x12 / 0x13 | mAh | R |
| <i>EffectiveCurrent()</i> | | 0x14 / 0x15 | mA | R |
| <i>TimeToEmpty()</i> | | 0x16 / 0x17 | Minutes | R |
| <i>TimeToFull()</i> | | 0x18 / 0x19 | Minutes | R |
| <i>StandbyCurrent()</i> | | 0x1a / 0x1b | mA | R |
| <i>StandbyTimeToEmpty()</i> | | 0x1c / 0x1d | Minutes | R |
| <i>MaxLoadCurrent()</i> | | 0x1e / 0x1f | mA | R |
| <i>MaxLoadTimeToEmpty()</i> | | 0x20 / 0x21 | Minutes | R |
| <i>AvailableEnergy()</i> | | 0x22 / 0x23 | mWh | R |
| <i>AveragePower()</i> | | 0x24 / 0x25 | mW | R |
| <i>TTEatConstantPower()</i> | | 0x26 / 0x27 | Minutes | R |
| <i>StateOfHealth()</i> | SOH | 0x28 / 0x29 | % / num | R |
| <i>CycleCount()</i> | | 0x2A / 0x2B | num | R |
| <i>StateOfCharge()</i> | SOC | 0x2c / 0x2d | % | R |
| <i>InternalTemperature()</i> | | 0x36 / 0x37 | 0.1 K | R |
| <i>OperationConfiguration()</i> | | 0x3A / 0x3B | N/A | R |
| <i>ApplicationStatus()</i> | | 0x6A / 0x6B | N/A | R |

4.1.1.1 *Control()*: 0x00/0x01

Issuing a *Control()* command requires a subsequent 2-byte subcommand. These additional bytes specify the particular control function desired. The *Control()* command allows the system to control specific features of the bq27620-G1 during normal operation and additional features when the device is in different access modes, as described in [Table 4-2](#).

Table 4-2. *Control()* Subcommands

| CNTL FUNCTION | CNTL DATA | SEALED ACCESS | DESCRIPTION |
|-----------------|-----------|---------------|---|
| CONTROL_STATUS | 0x0000 | Yes | Reports the status of DF checksum, hibernate, IT, etc. |
| DEVICE_TYPE | 0x0001 | Yes | Reports the device type in hex digits. (type = 0x0620) |
| FW_VERSION | 0x0002 | Yes | Reports the firmware version on the device type |
| HW_VERSION | 0x0003 | Yes | Reports the hardware version of the device type |
| PREV_MACWRITE | 0x0007 | Yes | Returns previous MAC subcommand code |
| CHEM_ID | 0x0008 | Yes | Reports the chemical identifier of the Impedance Track™ configuration |
| OCV_CMD | 0x000c | Yes | Request the gauge to take a OCV measurement |
| BAT_INSERT | 0x000d | Yes | Forces the BAT_DET bit set when the [BIE] bit is 0 |
| BAT_REMOVE | 0x000e | Yes | Forces the BAT_DET bit clear when the [BIE] bit is 0 |
| SET_HIBERNATE | 0x0011 | Yes | Forces CONTROL_STATUS [HIBERNATE] to 1 |
| CLEAR_HIBERNATE | 0x0012 | Yes | Forces CONTROL_STATUS [HIBERNATE] to 0 |
| DF_VERSION | 0x001F | Yes | Returns the Data Flash Version code |
| SEALED | 0x0020 | No | Places the bq27620-G1 in SEALED access mode |
| OPTIMIZ | 0x0030 | No | Sets the OPTIMIZ bit and enables the optimization cycle |
| RESET | 0x0041 | No | Forces a full reset of the bq27620-G1 |

4.1.1.1.1 **CONTROL_STATUS: 0x0000**

Instructs the fuel gauge to return status information to control addresses 0x00/0x01. The status word includes the following information.

Table 4-3. CONTROL_STATUS Bit Definitions

| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|-----------|----------|-----------|--------|-------|------|---------|------------|---------|
| High byte | - | FAS | SS | RSVD | - | - | OCVCMDCOMP | OCVFAIL |
| Low byte | INITCOMP | HIBERNATE | RLearn | SLEEP | LDMD | RUP_DIS | VOK | OPTMIZ |

FAS = Status bit indicating the bq27620-G1 is in FULL ACCESS SEALED state. Active when set.

SS = Status bit indicating the bq27620-G1 is in SEALED state. Active when set.

OCVCMDCOMP = Status bit indicating the bq27620-G1 has executed the OCV command. This bit can only be set with battery's presence. True when set.

OCVFAIL = Status bit indicating bq27620-G1 OCV reading is failed due to the current. This bit can only be set with battery's presence. True when set.

INITCOMP = Initialization completion bit indicating the initialization completed. This bit can only be set with battery's presence. True when set.

HIBERNATE = Status bit indicating a request for entry into HIBERNATE from SLEEP mode. True when set. Default is 0.

RLearn = Indicates that resistance has been learned. True when set.

LDMD = Status bit indicating the bq27620-G1 Impedance Track™ algorithm is using constant-power mode. True when set. Default is 0 (constant-current mode).

RUP_DIS = Status bit indicating the bq27620-G1 Ra table updates are disabled. Updates disabled when set.

VOK = Status bit indicating that a relaxed OCV measurement has occurred, always clears at the onset of charge or discharge currents. True when set.

OPTMIZ = Status bit indicating the bq27620-G1 is in an optimization mode; when set the gauge is in its optimization mode of operation for determining Qmax. True when set.

4.1.1.1.2 **DEVICE_TYPE: 0x0001**

Instructs the fuel gauge to return the device type to addresses 0x00/0x01.

4.1.1.1.3 **FW_VERSION: 0x0002**

Instructs the fuel gauge to return the firmware version to addresses 0x00/0x01. Refer to *Available Options* for the expected data value.

4.1.1.1.4 **HW_VERSION: 0x0003**

Instructs the fuel gauge to return the hardware version to addresses 0x00/0x01.

4.1.1.1.5 **PREV_MACWRITE: 0x0007**

Instructs the fuel gauge to return the previous subcommand written to addresses 0x00/0x01. **Note:** This subcommand is only supported for previous subcommand codes 0x0000 through 0x0014. For subcommand codes greater than 0x0009, a value of 0x0007 is returned.

4.1.1.1.6 **CHEM_ID: 0x0008**

Instructs the fuel gauge to return the chemical identifier for the Impedance Track™ configuration to addresses 0x00/0x01.

4.1.1.1.7 **OCV_CMD: 0x000C**

This command is to request the gauge to take a OCV reading. This command can only be issued after the *[INITCOMP]* has been set, indicating the initialization has been completed. The OCV measurement take place at the beginning of the next repeated 1s firmware synchronization clock. During the same time period, the SOC_INT will pulse. The host should use this signal to reduce the load current below the C/20 in 8ms for a valid OCV reading. The OCV command *[OCVFAIL]* bit will be set if the OCV_CMD is issued when *[CHG_INH]* is set.

4.1.1.1.8 BAT_INSERT: 0X000D

This command is to force the BAT_DET bit to be set when the battery insertion detection is disabled. When the BIE is set to 0, the battery insertion detection is disabled. The gauge relies on the host to inform the battery insertion with this command to set the BAT_DET bit.

4.1.1.1.9 BAT_REMOVE: 0X000E

This command is to force the BAT_DET bit to be clear when the battery insertion detection is disabled. When the BIE is set to 0, the battery insertion detection is disabled. The gauge relies on the host to inform it of the battery removal with this command to clear the BAT_DET bit.

4.1.1.1.10 SET_HIBERNATE: 0x0011

Instructs the fuel gauge to force the CONTROL_STATUS [HIBERNATE] bit to 1. This will allow the gauge to enter the HIBERNATE power mode after the transition to SLEEP power state is detected. The [HIBERNATE] bit is automatically cleared upon exiting from HIBERNATE mode.

4.1.1.1.11 CLEAR_HIBERNATE: 0x0012

Instructs the fuel gauge to force the CONTROL_STATUS [HIBERNATE] bit to 0. This prevents the gauge from entering the HIBERNATE power mode after the transition to the SLEEP power state is detected. It can also be used to force the gauge out of HIBERNATE mode.

4.1.1.1.12 DF_VERSION: 0x001F

Instructs the fuel gauge to return the 16-bit data flash revision code to addresses 0x00/0x01. The code is stored in **Data Flash Version** and provides a simple method for the customer to control data flash revisions. The default DF_VERSION is 0x0000.

4.1.1.1.13 SEALED: 0x0020

Instructs the fuel gauge to transition from the UNSEALED state to the SEALED state. The fuel gauge must always be set to the SEALED state for use in end equipment.

4.1.1.1.14 OPTIMIZ: 0x0030

This MAC command should be issued at the end of full charge cycle before the full discharge cycle begins. This command will set bit 0 (OPTMIZ) of the Control/Status register. When the bit is set and the gauge detects discharge it will stop using estimated current for Q measurement. Instead it will use DataFlash IT.LearnCurrent and accumulate charge using that current until discharge termination is detected from the current estimation engine. At that point the current used by the gauge defaults to zero mA. This command is only available when the fuel gauge is UNSEALED.

4.1.1.1.15 RESET: 0x0041

This command instructs the fuel gauge to perform a full reset. This command is only available when the fuel gauge is UNSEALED.

4.1.1.2 AtRateTimeToEmpty(): 0x04/0x05

This read-word function returns an unsigned integer value of the predicted remaining operating time if the battery is discharged at the AtRate() value in minutes with a range of 0 to 65,534. A value of 65,535 indicates AtRate() = 0. The fuel gauge updates AtRateTimeToEmpty() within 1 s after the system sets the AtRate() value. The fuel gauge automatically updates AtRateTimeToEmpty() based on the AtRate() value every 1 s. Both the AtRate() and AtRateTimeToEmpty() commands must only be used in NORMAL mode.

4.1.1.3 *Temperature()*: 0x06/0x07

This read/write-word function returns an unsigned integer value of the temperature in units of 0.1 K measured by the fuel gauge. If *[WRTEMP]* bit = 1, a write command sets the temperature to be used for gauging calculations while a read command returns to temperature previously written. If *[WRTEMP]* bit = 0 and *[TEMPS]* bit = 0, a read command will return the internal temperature sensor value.

4.1.1.4 *Voltage()*: 0x08/0x09

This read-word function returns an unsigned integer value of the measured cell-pack voltage in mV with a range of 0 to 6000 mV.

4.1.1.5 *Flags()*: 0x0a/0x0b

This read-word function returns the contents of the fuel-gauge status register, depicting the current operating status.

Table 4-4. Flags Bit Definitions

| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|-----------|------|------|-------|--------|----------|------|---------|------|
| High byte | OTC | OTD | – | CALEN | CHG_INH | XCHG | FC | CHG |
| Low byte | – | – | OCVGD | NEEDID | BATTDDET | SOC1 | SYSDOWN | DSG |

OTC = Overtemperature in charge condition is detected. True when set. SOC_INT will toggle once if set.

OTD = Overtemperature in discharge condition is detected. True when set. SOC_INT will toggle once if set.

CALEN = Status bit indicating the calibration function is enabled. True when set.

CHG_INH = Charge inhibit: unable to begin charging (temperature outside the range [*Charge Inhibit Temp Low, Charge Inhibit Temp High*]). True when set.

XCHG = Charge suspend alert (temperature outside the range [*Suspend Temperature Low, Suspend Temperature High*]). True when set.

FC = Full-charged condition reached. Set when charge termination condition is met. (RMFCC=1; Set FC_Set % = -1% when RMFCC = 0). True when set

CHG = (Fast) charging allowed. True when set.

OCVGD = Good OCV measurement taken. True when set.

NEEDID = Waiting to identify inserted battery. True when set.

BATTDDET = Battery detected. True when set.

SOC1 = State-of-charge threshold 1 (**SOC1 Set**) reached. The flag is enabled when BL_INT bit in **Operation Configuration B** is set. True when set.

SysDown = SystemDown bit indicating the system shut down. SOC_INT will toggle once if set.

DSG = Discharging detected. True when set.

4.1.1.6 *NominalAvailableCapacity()*: 0x0c/0x0d

This read-only command pair returns the uncompensated (less than C/20 load) battery capacity remaining. Units are mAh.

4.1.1.7 *FullAvailableCapacity()*: 0x0e/0x0f

This read-only command pair returns the uncompensated (less than C/20 load) capacity of the battery when fully charged. Units are mAh. *FullAvailableCapacity()* is updated at regular intervals, as specified by the IT algorithm.

4.1.1.8 *RemainingCapacity()*: 0x10/0x11

This read-only command pair returns the remaining battery capacity which is compensated for the present conditions of load, temperature and battery age. *RemainingCapacity()* is typically lower than the uncompensated *NominalAvailableCapacity()*. Units are mAh.

4.1.1.9 *FullChargeCapacity()*: 0x12/13

This read-only command pair returns the capacity of the battery when fully charged with compensation for the present conditions of temperature and battery age. *FullChargeCapacity()* is updated at regular intervals, as specified by the IT algorithm typically lower than the uncompensated *FullAvailableCapacity()* and . Units are mAh.

4.1.1.10 **EffectiveCurrent()**: 0x14/0x15

This read-only command pair returns a signed integer value that is taken from the Effective current Calculation being used by DVC algorithm. Units are mA.

4.1.1.11 **TimeToEmpty()**: 0x16/0x17

This read-only function returns an unsigned integer value of the predicted remaining battery life at the present rate of discharge, in minutes. A value of 65,535 indicates battery is not being discharged.

4.1.1.12 **TimeToFull()**: 0x18/0x19

This read-only function returns an unsigned integer value of predicted remaining time until the battery reaches full charge, in minutes, based upon *EffectiveCurrent()*. The computation accounts for the taper current time extension from the linear TTF computation based on a fixed *EffectiveCurrent()* rate of charge accumulation. A value of 65,535 indicates the battery is not being charged.

4.1.1.13 **StandbyCurrent()**: 0x1a/0x1b

This read-only function returns a signed integer value of the measured standby current from the Effective Current Calculation. The *StandbyCurrent()* is an adaptive measurement. Initially it reports the standby current programmed in **Initial Standby**, and after spending several seconds in standby, reports the measured standby current.

The register value is updated every 1 second when the effective current is above the **Deadband** and is less than or equal to $2 \times \text{Initial Standby}$. The first and last values that meet this criteria are not averaged in, since they may not be stable values. To approximate a 1 minute time constant, each new *StandbyCurrent()* value is computed by taking approximate 93% weight of the last standby current and approximate 7% of the effective current calculation.

4.1.1.14 **StandbyTimeToEmpty()**: 0x1c/0x1d

This read-only function returns an unsigned integer value of the predicted remaining battery life at the standby rate of discharge, in minutes. The computation uses *Nominal Available Capacity* (NAC), the uncompensated remaining capacity, for this computation. A value of 65,535 indicates battery is not being discharged.

4.1.1.15 **MaxLoadCurrent()**: 0x1e/0x1f

This read-only function returns a signed integer value, in units of mA, of the maximum load conditions. The *MaxLoadCurrent()* is an adaptive measurement which is initially reported as the maximum load current programmed in *Initial Max Load Current*. If the effective current calculation is ever greater than *Initial Max Load Current*, then *MaxLoadCurrent()* updates to the new current calculation. *MaxLoadCurrent()* is reduced to the average of the previous value and *Initial Max Load Current* whenever the battery is charged to full after a previous discharge to an SOC less than 50%. This prevents the reported value from maintaining an unusually high value.

4.1.1.16 **MaxLoadTimeToEmpty()**: 0x20/0x21

This read-only function returns an unsigned integer value of the predicted remaining battery life at the maximum load current discharge rate, in minutes. A value of 65,535 indicates that the battery is not being discharged.

4.1.1.17 **AvailableEnergy()**: 0x22/0x23

This read-only function returns an unsigned integer value of the predicted charge or energy remaining in the battery. The value is reported in units of mWh.

4.1.1.18 **AveragePower()**: 0x24/0x25

This read-only function returns an signed integer value of the average power during battery charging and discharging. It is negative during discharge and positive during charge. A value of 0 indicates that the battery is not being discharged. The value is reported in units of mW.

4.1.1.19 **TimeToEmptyAtConstantPower()**: 0x26/0x27

This read-only function returns an unsigned integer value of the predicted remaining operating time if the battery is discharged at the *AveragePower()* value in minutes. A value of 65,535 indicates *AveragePower()* = 0. The fuel gauge automatically updates *TimeToEmptyatContantPower()* based on the *AveragePower()* value every 1 s.

4.1.1.20 **StateofHealth()**: 0x28/0x29

0x28 SOH percentage: this read-only function returns an unsigned integer value, expressed as a percentage of the ratio of predicted *FCC(25°C, SOH LoadI)* over the *DesignCapacity()*. The *FCC(25°C, SOH LoadI)* is the calculated full charge capacity at 25°C and the *SOH LoadI* which is specified in the data flash. The range of the returned SOH percentage is 0x00 to 0x64, indicating 0 to 100% correspondingly.

0x29 SOH Status: this read-only function returns an unsigned integer value, indicating the status of the SOH percentage. The meanings of the returned value are:

- 0x00: SOH not valid (initialization)
- 0x01: SOH initial value for unidentified pack
- 0x02: SOH final value, pack identified

4.1.1.21 **CycleCount()**: 0x2a/0x2b

This read-only function returns an unsigned integer value of the number of cycles that the active cell has experienced with a range of 0 to 65535. One cycle occurs when accumulated discharge \geq **CC Threshold**. The gauge maintains a separate cycle counter for both cell profiles and will reset to zero if the insertion of a new pack has been detected.

4.1.1.22 **StateOfCharge()**: 0x2c/0x2d

This read-only function returns an unsigned integer value of the predicted remaining battery capacity expressed as a percentage of *FullChargeCapacity()*, with a range of 0 to 100%.

4.1.1.23 **InternalTemperature()**: 0x36/0x37

This read-only function returns an unsigned integer value of the internal temperature sensor in units of 0.1 K measured by the fuel gauge. This function can be useful as an additional system-level temperature monitor if the main *Temperature()* function is configured for external or host reported temperature.

4.1.1.24 **OperationConfiguration()**: 0x3a/0x3b

This read-only function returns the contents of the data flash **Operation Configuration** register and is most useful for system level debug to quickly determine device configuration.

4.1.1.25 **ApplicationStatus()**: 0x6a/0x6b

This read-only function returns the contents of the data flash Host Cfg register.

4.1.2 EXTENDED DATA COMMANDS

Extended commands offer additional functionality beyond the standard set of commands. They are used in the same manner; however, unlike standard commands, extended commands are not limited to 2-byte words. The number of commands bytes for a given extended command ranges in size from single to multiple bytes, as specified in [Table 4-5](#).

Table 4-5. Extended Data Commands

| NAME | COMMAND CODE | UNITS | SEALED ACCESS ⁽¹⁾ (2) | UNSEALED ACCESS ⁽¹⁾ (2) |
|--|--------------|-------|----------------------------------|------------------------------------|
| Reserved | 0x34...0x3b | N/A | R | R |
| <i>DesignCapacity()</i> | 0x3c / 0x3d | mAh | R | R |
| <i>DataFlashClass()</i> ⁽²⁾ | 0x3e | N/A | N/A | R/W |
| <i>DataFlashBlock()</i> ⁽²⁾ | 0x3f | N/A | R/W | R/W |
| <i>BlockData()</i> | 0x40...0x5f | N/A | R | R/W |
| <i>BlockDataChecksum()</i> | 0x60 | N/A | R/W | R/W |
| <i>BlockDataControl()</i> | 0x61 | N/A | N/A | R/W |
| <i>ApplicationStatus()</i> | 0x6a | N/A | R | R |
| Reserved | 0x6b...0x7f | N/A | R | R |

(1) SEALED and UNSEALED states are entered via commands to **Control()** 0x00/0x01.

(2) In sealed mode, data flash CANNOT be accessed through commands 0x3e and 0x3f.

4.1.2.1 *DesignCapacity()*: 0x3c/0x3d

SEALED and UNSEALED Access: This command returns the value is stored in **Design Capacity** and is expressed in mAh. This is intended to be the theoretical or nominal capacity of a new pack, but has no bearing on the operation of the fuel gauge functionality.

4.1.2.2 *DataFlashClass()*: 0x3e

UNSEALED Access: This command sets the data flash class to be accessed. The class to be accessed must be entered in hexadecimal.

SEALED Access: This command is not available in SEALED mode.

4.1.2.3 *DataFlashBlock()*: 0x3f

UNSEALED Access: This command sets the data flash block to be accessed. When 0x00 is written to *BlockDataControl()*, *DataFlashBlock()* holds the block number of the data flash to be read or written. Example: writing a 0x00 to *DataFlashBlock()* specifies access to the first 32-byte block, a 0x01 specifies access to the second 32-byte block, and so on.

SEALED Access: This command directs which data flash block is accessed by the *BlockData()* command. Writing a 0x01 or 0x02 instructs the *BlockData()* command to transfer the **Manufacturer Info Block**. All other *DataFlashBlock()* values are reserved.

4.1.2.4 *BlockData()*: 0x40...0x5f

UNSEALED Access: This data block is the remainder of the 32 byte data block when accessing data flash.

SEALED Access: This data block is the remainder of the 32 byte data block when accessing **Manufacturer Block Info**.

4.1.2.5 *BlockDataChecksum()*: 0x60

UNSEALED Access: This byte contains the checksum on the 32 bytes of block data read or written to data flash. The least-significant byte of the sum of the data bytes written must be complemented ($[255 - x]$, for x the least-significant byte) before being written to 0x60.

SEALED Access: This byte contains the checksum for the 32 bytes of block data written to **the Manufacturer Info Block**. The least-significant byte of the sum of the data bytes written must be complemented ($[255 - x]$, for x the least-significant byte) before being written to 0x60.

4.1.2.6 *BlockDataControl()*: 0x61

UNSEALED Access: This command is used to control data flash access mode. Writing 0x00 to this command enables *BlockData()* to access general data flash. Writing a 0x01 to this command enables SEALED mode operation of *DataFlashBlock()*.

SEALED Access: This command is not available in SEALED mode.

4.1.2.7 *ApplicationStatus()*: 0x6a

This byte function allows the system to read the bq27620-G1 Host Cfg data flash location. See [Table 6-1](#) for specific bit definitions.

4.1.2.8 Reserved — 0x6b–0x7f

4.2 DATA FLASH INTERFACE

4.2.1 ACCESSING THE DATA FLASH

The bq27620-G1 data flash is a non-volatile memory that contains bq27620-G1 initialization, default, cell status, calibration, configuration, and user information. The data flash can be accessed in several different ways, depending on what mode the bq27620-G1 is operating in and what data is being accessed.

Commonly accessed data flash memory locations, frequently read by a system, are conveniently accessed through specific instructions, already described in [Section 4.1, DATA COMMANDS](#). These commands are available when the bq27620-G1 is either in UNSEALED or SEALED modes.

Most data flash locations, however, are only accessible in UNSEALED mode by use of the bq27620-G1 evaluation software or by data flash block transfers. These locations should be optimized and/or fixed during the development and manufacture processes. They become part of a golden image file and can then be written to multiple battery packs. Once established, the values generally remain unchanged during end-equipment operation.

To access data flash locations individually, the block containing the desired data flash location(s) must be transferred to the command register locations, where they can be read to the system or changed directly. This is accomplished by sending the set-up command *BlockDataControl*() (0x61) with data 0x00. Up to 32 bytes of data can be read directly from the *BlockData*() (0x40...0x5f), externally altered, then rewritten to the *BlockData*() command space. Alternatively, specific locations can be read, altered, and rewritten if their corresponding offsets are used to index into the *BlockData*() command space. Finally, the data residing in the command space is transferred to data flash, once the correct checksum for the whole block is written to *BlockDataChecksum*() (0x60).

Occasionally, a data flash CLASS will be larger than the 32-byte block size. In this case, the *DataFlashBlock*() command is used to designate which 32-byte block the desired locations reside in. The correct command address is then given by $0x40 + \text{offset} \bmod 32$. For example, to access **Terminate Voltage** in the *Gas Gauging* class, *DataFlashClass*() is issued 80 (0x50) to set the class. Because the offset is 44, it must reside in the second 32-byte block. Hence, *DataFlashBlock*() is issued 0x01 to set the block offset, and the offset used to index into the *BlockData*() memory area is $0x40 + 44 \bmod 32 = 0x40 + 12 = 0x40 + 0x0C = 0x4C$.

Reading and writing subclass data are block operations up to 32 bytes in length. If during a write the data length exceeds the maximum block size, then the data is ignored.

None of the data written to memory are bounded by the bq27620-G1 – the values are not rejected by the fuel gauge. Writing an incorrect value may result in hardware failure due to firmware program interpretation of the invalid data. The written data is persistent, so a power-on reset does resolve the fault.

4.3 MANUFACTURER INFORMATION BLOCK

The bq27620-G1 contains 32 bytes of user programmable data flash storage called the **Manufacturer Info Block**. The method for accessing these memory locations is slightly different, depending on whether the device is in UNSEALED or SEALED modes.

When in UNSEALED mode and when 0x00 has been written to *BlockDataControl()*, accessing the manufacturer information blocks is identical to accessing general data flash locations. First, a *DataFlashClass()* command is used to set the subclass, then a *DataFlashBlock()* command sets the offset for the first data flash address within the subclass. The *BlockData()* command codes contain the referenced data flash data. When writing the data flash, a checksum is expected to be received by *BlockDataChecksum()*. Only when the checksum is received and verified is the data actually written to data flash.

When in SEALED mode or when 0x01 *BlockDataControl()* does not contain 0x00, data flash is no longer available in the manner used in UNSEALED mode. Rather than issuing subclass information, a designated Manufacturer Information Block is selected with the *DataFlashBlock()* command. Issuing a 0x01 or 0x02 with this command causes the corresponding information block to be transferred to the command space 0x40...0x5f for editing or reading by the system. Upon successful writing of checksum information to *BlockDataChecksum()*, the modified block is returned to data flash. **Note: The Manufacturer Info Block** is read-only when in SEALED mode.

4.4 ACCESS MODES

The bq27620-G1 provides three security modes (FULL ACCESS, UNSEALED, and SEALED) that control data flash access permissions, according to [Table 4-6](#). *Data Flash* refers to those data flash locations, specified in [Section 4.6](#), that are accessible to the user.

Table 4-6. Data Flash Access

| Security Mode | Data Flash | Manufacture Info Block |
|---------------|------------|------------------------|
| FULL ACCESS | R/W | R/W |
| UNSEALED | R/W | R/W |
| SEALED | None | R |

Although FULL ACCESS and UNSEALED modes appear identical, only FULL ACCESS allows the bq27620-G1 to write access-mode transition keys.

4.5 SEALING/UNSEALING DATA FLASH

The bq27620-G1 implements a key-access scheme to transition between SEALED, UNSEALED, and FULL-ACCESS modes. Each transition requires that a unique set of two keys be sent to the bq27620-G1 via the *Control()* control command. The keys must be sent consecutively, with no other data being written to the *Control()* register in between. Note that to avoid conflict, the keys must be different from the codes presented in the *CNTL DATA* column of [Table 4-2](#) subcommands.

When in SEALED mode, the CONTROL_STATUS [SS] bit is set, but when the UNSEAL keys are correctly received by the bq27620-G1, the [SS] bit is cleared. When the full-access keys are correctly received, then the CONTROL_STATUS [FAS] bit is cleared.

Both the sets of keys for each level are 2 bytes each in length and are stored in data flash. The UNSEAL key (stored at **Unseal Key 0** and **Unseal Key 1**) and the FULL-ACCESS key (stored at **Full-Access Key 0** and **Full-Access Key 1**) can only be updated when in FULL-ACCESS mode. The order of the keys is **Key 1** followed by **Key 0**. The order of the bytes entered through the *Control()* command is the reverse of what is read from the part. For example, if the **Key 1** and **Key 0** of the **Unseal Keys** returns 0x1234 and 0x5678, then the *Control()* should supply 0x3412 and 0x7856 to unseal the part.

4.6 DATA FLASH SUMMARY

The following table summarizes the data flash locations available to the user, including their default, minimum, and maximum values.

Table 4-7. Data Flash Summary

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units (EVSW Units)* |
|---------------|-------------|--------------------|--------|----------------------------|-----------|-----------|-----------|---------------|---------------------|
| Configuration | 2 | Safety | 0 | OT Chg | I2 | 0 | 1200 | 550 | 0.1°C |
| Configuration | 2 | Safety | 2 | OT Chg Time | U1 | 0 | 60 | 2 | s |
| Configuration | 2 | Safety | 3 | OT Chg Recovery | I2 | 0 | 1200 | 500 | 0.1°C |
| Configuration | 2 | Safety | 5 | OT Dsg | I2 | 0 | 1200 | 600 | 0.1°C |
| Configuration | 2 | Safety | 7 | OT Dsg Time | U1 | 0 | 60 | 2 | s |
| Configuration | 2 | Safety | 8 | OT Dsg Recovery | I2 | 0 | 1200 | 550 | 0.1°C |
| Configuration | 32 | Charge Inhibit Cfg | 0 | Chg Inhibit Temp Low | I2 | -400 | 1200 | 0 | 0.1°C |
| Configuration | 32 | Charge Inhibit Cfg | 2 | Chg Inhibit Temp High | I2 | -400 | 1200 | 450 | 0.1°C |
| Configuration | 32 | Charge Inhibit Cfg | 4 | Temp Hys | I2 | 0 | 100 | 50 | 0.1°C |
| Configuration | 34 | Charge | 0 | Charging Voltage | I2 | 0 | 4600 | 4200 | mV |
| Configuration | 34 | Charge | 2 | Delta Temp | I2 | 0 | 500 | 50 | 0.1°C |
| Configuration | 34 | Charge | 4 | Suspend Low Temp | I2 | -400 | 1200 | -50 | 0.1°C |
| Configuration | 34 | Charge | 6 | Suspend High Temp | I2 | -400 | 1200 | 550 | 0.1°C |
| Configuration | 36 | Charge Termination | 0 | Taper Current | I2 | 0 | 1000 | 100 | mA |
| Configuration | 36 | Charge Termination | 2 | Min Taper Capacity | I2 | 0 | 1000 | 25 | mAh |
| Configuration | 36 | Charge Termination | 4 | Taper Voltage | I2 | 0 | 1000 | 100 | mV |
| Configuration | 36 | Charge Termination | 6 | Current Taper Window | U1 | 0 | 60 | 40 | s |
| Configuration | 36 | Charge Termination | 9 | FC Set % | I1 | -1 | 100 | -1 | % |
| Configuration | 36 | Charge Termination | 10 | FC Clear % | I1 | -1 | 100 | 98 | % |
| Configuration | 36 | Charge Termination | 11 | DODatEOC Delta T | I2 | 0 | 1000 | 50 | 0.1°C |
| Configuration | 48 | Data | 0 | Initial Standby | I1 | -256 | 0 | -10 | mA |
| Configuration | 48 | Data | 1 | Initial MaxLoad | I2 | -32767 | 0 | -750 | mA |
| Configuration | 48 | Data | 3 | CC Threshold | I2 | 100 | 32767 | 1050 | mAh |
| Configuration | 48 | Data | 6 | Design Capacity | I2 | 0 | 32767 | 1140 | mA |
| Configuration | 48 | Data | 10 | Design Voltage | I2 | 0 | 32767 | 3600 | MilliVolt |
| Configuration | 48 | Data | 12 | SOH Loadl | I2 | -32767 | 0 | -400 | mA |
| Configuration | 48 | Data | 14 | Default Temp | I2 | 0 | 3050 | 2982 | °K |
| Configuration | 48 | Data | 16 | Data Flash Version | H2 | 0x0000 | 0xffff | 0x0000 | |
| Configuration | 48 | Data | 18 | Device Name | S8 | x | x | bq27620 | - |
| Configuration | 49 | Discharge | 0 | SOC1 Set Threshold | U1 | 0 | 255 | 150 | mA |
| Configuration | 49 | Discharge | 1 | SOC1 Clear Threshold | U1 | 0 | 255 | 175 | mA |
| Configuration | 49 | Discharge | 5 | SysDown Set Volt Threshold | I2 | 0 | 4200 | 3150 | mV |
| Configuration | 49 | Discharge | 7 | SysDown Set Volt Time | U1 | 0 | 60 | 2 | s |
| Configuration | 49 | Discharge | 8 | SysDown Clear Volt | I2 | 0000 | 4200 | 3400 | mV |
| Configuration | 49 | Discharge | 15 | Def Cell 0 DOD at EOC | I2 | 0 | 16384 | 0 | |
| Configuration | 49 | Discharge | 17 | Def Avg I Last Run | I2 | -32768 | 32767 | -50 | mA |
| Configuration | 49 | Discharge | 19 | Def Avg P Last Run | I2 | -32768 | 32767 | -50 | mWatt |
| Configuration | 64 | Registers | 0 | Op Config | H2 | 0x0000 | 0xffff | 0x0853 | |
| Configuration | 64 | Registers | 2 | SOC Delta | U1 | 0 | 25 | 1 | % |
| Configuration | 64 | Registers | 3 | i2c Timeout | U1 | 0 | 7 | 4 | % |
| Configuration | 64 | Registers | 4 | DF Wr Ind Wait | U2 | 0 | 65535 | 0 | % |
| Configuration | 64 | Registers | 6 | OpConfig B | H1 | 0x00 | 0xff | 0x4b | |
| Configuration | 64 | Registers | 7 | OpConfig C | H1 | 0x00 | 0xff | 0x28 | |
| Configuration | 64 | Registers | 8 | Clk Ctl Reg | H1 | 0x00 | 0x0f | 0x09 | Hex |
| Configuration | 68 | Power | 0 | Flash Update OK Voltage | I2 | 0 | 4200 | 2800 | mV |
| Configuration | 68 | Power | 4 | Sleep Current | I2 | 0 | 100 | 10 | mA |
| Configuration | 68 | Power | 6 | Sleep Time | U1 | 0 | 100 | 20 | s |

Table 4-7. Data Flash Summary (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units (EVSU Units)* |
|-------------------|-------------|--------------------|--------|----------------------------|-----------|-----------|-----------|---------------|---------------------|
| Configuration | 68 | Power | 7 | Hibernate I | U2 | 0 | 700 | 8 | mA |
| Configuration | 68 | Power | 9 | Hibernate V | U2 | 2400 | 3000 | 2550 | mV |
| System Data | 57 | Manufacturer Info | 0-31 | Block [0-31] | H1 | 0x00 | 0xff | [Table] | - |
| Gas Gauging | 80 | IT Cfg | 0 | Load Select | U1 | 0 | 255 | 1 | |
| Gas Gauging | 80 | IT Cfg | 1 | Load Mode | U1 | 0 | 255 | 0 | |
| Gas Gauging | 80 | IT Cfg | 21 | Max Res Factor | U1 | 0 | 255 | 15 | |
| Gas Gauging | 80 | IT Cfg | 22 | Min Res Factor | U1 | 0 | 255 | 5 | |
| Gas Gauging | 80 | IT Cfg | 24 | Ra Filter | U2 | 0 | 1000 | 800 | |
| Gas Gauging | 80 | IT Cfg | 44 | Terminate Voltage | I2 | -32768 | 32767 | 3200 | mV |
| Gas Gauging | 80 | IT Cfg | 46 | Term V Delta | I2 | 0 | 4200 | 200 | mV |
| Gas Gauging | 80 | IT Cfg | 49 | ResRelax Time | U2 | 0 | 65534 | 500 | s |
| Gas Gauging | 80 | IT Cfg | 53 | User Rate-mA | I2 | -2000 | -100 | 0 | mA |
| Gas Gauging | 80 | IT Cfg | 55 | User Rate-mW | I2 | -7200 | -350 | 0 | cW |
| Gas Gauging | 80 | IT Cfg | 57 | Reserve Cap-mAh | I2 | 0 | 9000 | 0 | mA |
| Gas Gauging | 80 | IT Cfg | 59 | Reserve Cap-mWh | I2 | 0 | 14000 | 0 | 10mW |
| Gas Gauging | 80 | IT Cfg | 64 | Min Delta Voltage | I2 | -32000 | 32000 | 0 | |
| Gas Gauging | 80 | IT Cfg | 68 | Ra Max Delta | U2 | 0 | 65535 | 44 | mΩ |
| Gas Gauging | 80 | IT Cfg | 70 | DeltaV Max dV | U2 | 0 | 65535 | 10 | mV |
| Gas Gauging | 80 | IT Cfg | 72 | Max Res Scale | U2 | 0 | 32767 | 5000 | Num |
| Gas Gauging | 80 | IT Cfg | 74 | Min Res Scale | U2 | 0 | 32767 | 200 | Num |
| Gas Gauging | 80 | IT Cfg | 76 | Fast Scale Start SOC | U1 | 0 | 100 | 10 | % |
| Gas Gauging | 80 | IT Cfg | 83 | LC Dection Sensitivity | U1 | 0 | 100 | 80 | % |
| Gas Gauging | 81 | Current Thresholds | 6 | Dsg Relax Time | U2 | 0 | 8191 | 60 | s |
| Gas Gauging | 81 | Current Thresholds | 8 | Chg Relax Time | U1 | 0 | 255 | 60 | s |
| Gas Gauging | 81 | Current Thresholds | 9 | Quit Relax Time | U1 | 0 | 63 | 1 | s |
| Gas Gauging | 81 | Current Thresholds | 10 | Transient Factor Charge | U1 | 0 | 255 | 128 | |
| Gas Gauging | 81 | Current Thresholds | 11 | Transient Factor Discharge | U1 | 0 | 255 | 128 | |
| Gas Gauging | 81 | Current Thresholds | 12 | Max IR Correct | U2 | 0 | 1000 | 400 | mV |
| Gas Gauging | 82 | State | 0 | Host Cfg | H1 | 0x01 | 0xff | 0x00 | |
| Gas Gauging | 82 | State | 1 | Qmax Cell 0 | I2 | 0 | 32767 | 16384 | rate |
| Gas Gauging | 82 | State | 3 | Cycle Count0 | U2 | 0 | 65535 | 0 | |
| Gas Gauging | 82 | State | 5 | Qmax Cell 1 | I2 | 0 | 32767 | 16384 | rate |
| Gas Gauging | 82 | State | 7 | Cycle Count 1 | U2 | 0 | 65535 | 0 | |
| Gas Gauging | 82 | State | 9 | Chg DoD0 C 0 | U2 | 0 | 65535 | 0 | |
| Gas Gauging | 82 | State | 11 | Chg DoD0 C 1 | U2 | 0 | 65535 | 0 | |
| Gas Gauging | 82 | State | 15 | DoDatEOC | U2 | 0 | 65535 | 0 | |
| Gas Gauging | 82 | State | 25 | T Rise | U2 | 0 | 65535 | 20 | Num |
| Gas Gauging | 82 | State | 27 | T Time Constant | U2 | 0 | 65535 | 1000 | Num |
| OCV Table | 83 | OCVa Table | 0 | Chem ID | H2 | 0x0000 | 0xffff | 0x1124 | hex |
| Default Ra Tables | 85 | Def Ra | 0 | Cell0 R_a flag | H1 | 0x00 | 0x00 | 0x55 | - |
| Default Ra Tables | 85 | Def Ra | 1 | Cell0 R_a 0 | I2 | 1 | 32767 | 424 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 3 | Cell0 R_a 1 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 5 | Cell0 R_a 2 | I2 | 1 | 32767 | 538 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 7 | Cell0 R_a 3 | I2 | 1 | 32767 | 535 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 9 | Cell0 R_a 4 | I2 | 1 | 32767 | 461 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 11 | Cell0 R_a 5 | I2 | 1 | 32767 | 460 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 13 | Cell0 R_a 6 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |

Table 4-7. Data Flash Summary (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units (EVSW Units)* |
|-------------------|-------------|----------|--------|-----------------|-----------|-----------|-----------|---------------|---------------------|
| Default Ra Tables | 85 | Def Ra | 15 | Cell0 R_a 7 | I2 | 1 | 32767 | 578 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 17 | Cell0 R_a 8 | I2 | 1 | 32767 | 563 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 19 | Cell0 R_a 9 | I2 | 1 | 32767 | 544 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 21 | Cell0 R_a 10 | I2 | 1 | 32767 | 574 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 23 | Cell0 R_a 11 | I2 | 1 | 32767 | 726 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 25 | Cell0 R_a 12 | I2 | 1 | 32767 | 956 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 27 | Cell0 R_a 13 | I2 | 1 | 32767 | 1222 | 2 ⁻¹⁰ Ω |
| Default Ra Tables | 85 | Def Ra | 29 | Cell0 R_a 14 | I2 | 1 | 32767 | 8099 | 2 ⁻¹⁰ Ω |
| | | | | | | | | | |
| Ra Table | 88 | R_a0 | 0 | Cell0 R_a flag | H1 | 0x00 | 0x255 | 0x55 | - |
| Ra Table | 88 | R_a0 | 1 | Cell0 R_a 0 | I2 | 1 | 32767 | 424 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 3 | Cell0 R_a 1 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 5 | Cell0 R_a 2 | I2 | 1 | 32767 | 538 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 7 | Cell0 R_a 3 | I2 | 1 | 32767 | 535 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 9 | Cell0 R_a 4 | I2 | 1 | 32767 | 461 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 11 | Cell0 R_a 5 | I2 | 1 | 32767 | 460 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 13 | Cell0 R_a 6 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 15 | Cell0 R_a 7 | I2 | 1 | 32767 | 578 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 17 | Cell0 R_a 8 | I2 | 1 | 32767 | 563 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 19 | Cell0 R_a 9 | I2 | 1 | 32767 | 544 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 21 | Cell0 R_a 10 | I2 | 1 | 32767 | 574 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 23 | Cell0 R_a 11 | I2 | 1 | 32767 | 726 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 25 | Cell0 R_a 12 | I2 | 1 | 32767 | 956 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 27 | Cell0 R_a 13 | I2 | 1 | 32767 | 1222 | 2 ⁻¹⁰ Ω |
| Ra Table | 88 | R_a0 | 29 | Cell0 R_a 14 | I2 | 1 | 32767 | 8099 | 2 ⁻¹⁰ Ω |
| | | | | | | | | | |
| Ra Table | 89 | R_a1 | 0 | Cell1 R_a flag | H1 | 0x00 | 0x255 | 0x55 | - |
| Ra Table | 89 | R_a1 | 1 | Cell1 R_a 0 | I2 | 1 | 32767 | 424 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 3 | Cell1 R_a 1 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 5 | Cell1 R_a 2 | I2 | 1 | 32767 | 538 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 7 | Cell1 R_a 3 | I2 | 1 | 32767 | 535 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 9 | Cell1 R_a 4 | I2 | 1 | 32767 | 461 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 11 | Cell1 R_a 5 | I2 | 1 | 32767 | 460 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 13 | Cell1 R_a 6 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 15 | Cell1 R_a 7 | I2 | 1 | 32767 | 578 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 17 | Cell1 R_a 8 | I2 | 1 | 32767 | 563 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 19 | Cell1 R_a 9 | I2 | 1 | 32767 | 544 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 21 | Cell1 R_a 10 | I2 | 1 | 32767 | 574 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 23 | Cell1 R_a 11 | I2 | 1 | 32767 | 726 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 25 | Cell1 R_a 12 | I2 | 1 | 32767 | 956 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 27 | Cell1 R_a 13 | I2 | 1 | 32767 | 1222 | 2 ⁻¹⁰ Ω |
| Ra Table | 89 | R_a1 | 29 | Cell1 R_a 14 | I2 | 1 | 32767 | 8099 | 2 ⁻¹⁰ Ω |
| | | | | | | | | | |
| Ra Table | 90 | R_a0x | 0 | xCell0 R_a flag | H1 | 0x00 | 0x255 | 0x55 | - |
| Ra Table | 90 | R_a0x | 1 | xCell0 R_a 0 | I2 | 1 | 32767 | 424 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 3 | xCell0 R_a 1 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |

Table 4-7. Data Flash Summary (continued)

| Class | Subclass ID | Subclass | Offset | Name | Data Type | Min Value | Max Value | Default Value | Units (EVSW Units)* |
|-------------|-------------|----------|--------|--------------------|-----------|-----------------|------------|---------------|---------------------|
| Ra Table | 90 | R_a0x | 5 | xCell0 R_a 2 | I2 | 1 | 32767 | 538 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 7 | xCell0 R_a 3 | I2 | 1 | 32767 | 535 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 9 | xCell0 R_a 4 | I2 | 1 | 32767 | 461 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 11 | xCell0 R_a 5 | I2 | 1 | 32767 | 460 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 13 | xCell0 R_a 6 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 15 | xCell0 R_a 7 | I2 | 1 | 32767 | 578 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 17 | xCell0 R_a 8 | I2 | 1 | 32767 | 563 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 19 | xCell0 R_a 9 | I2 | 1 | 32767 | 544 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 21 | xCell0 R_a 10 | I2 | 1 | 32767 | 574 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 23 | xCell0 R_a 11 | I2 | 1 | 32767 | 726 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 25 | xCell0 R_a 12 | I2 | 1 | 32767 | 956 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 27 | xCell0 R_a 13 | I2 | 1 | 32767 | 1222 | 2 ⁻¹⁰ Ω |
| Ra Table | 90 | R_a0x | 29 | xCell0 R_a 14 | I2 | 1 | 32767 | 8099 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 0 | xCell1 R_a flag | H1 | 0x00 | 0x255 | 0x55 | - |
| Ra Table | 91 | R_a1x | 1 | xCell1 R_a 0 | I2 | 1 | 32767 | 424 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 3 | xCell1 R_a 1 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 5 | xCell1 R_a 2 | I2 | 1 | 32767 | 538 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 7 | xCell1 R_a 3 | I2 | 1 | 32767 | 535 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 9 | xCell1 R_a 4 | I2 | 1 | 32767 | 461 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 11 | xCell1 R_a 5 | I2 | 1 | 32767 | 460 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 13 | xCell1 R_a 6 | I2 | 1 | 32767 | 509 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 15 | xCell1 R_a 7 | I2 | 1 | 32767 | 578 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 17 | xCell1 R_a 8 | I2 | 1 | 32767 | 563 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 19 | xCell1 R_a 9 | I2 | 1 | 32767 | 544 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 21 | xCell1 R_a 10 | I2 | 1 | 32767 | 574 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 23 | xCell1 R_a 11 | I2 | 1 | 32767 | 726 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 25 | xCell1 R_a 12 | I2 | 1 | 32767 | 956 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 27 | xCell1 R_a 13 | I2 | 1 | 32767 | 1222 | 2 ⁻¹⁰ Ω |
| Ra Table | 91 | R_a1x | 29 | xCell1 R_a 14 | I2 | 1 | 32767 | 8099 | 2 ⁻¹⁰ Ω |
| Calibration | 104 | Data | 2 | Int Temp Offset | I1 | -128 | 127 | 0 | |
| Calibration | 104 | Data | 3 | Ext Temp Offset | I1 | -128 | 127 | 0 | |
| Calibration | 104 | Data | 4 | Pack V Offset | I1 | -128 | 127 | 0 | |
| Security | 112 | Codes | 0 | Sealed to Unsealed | H4 | 0x00000000 0 | 0xffffffff | 0x00000000 | - |
| Security | 112 | Codes | 4 | Unsealed to Full | H4 | 0x00000000 0 | 0xffffffff | 0x00000000 | - |
| Security | 112 | Codes | 8 | FactRestore Key | H4 | 0x00000000 0 | 0xffffffff | 0x00000000 | - |

5 FUNCTIONAL DESCRIPTION

5.1 FUEL GAUGING

The bq27620-G1 measures cell voltage and temperature to determine battery SOC. Current is not directly measured but is estimated by the Impedance Track™ with Dynamic Voltage Correlation (DVC) algorithm. When an application load is applied, the impedance of the cell is measured by comparing the OCV obtained from a predefined function for present SOC with the measured voltage under load. Measurements of OCV and battery impedance determine chemical state of charge. The bq27620-G1 acquires and updates the battery-impedance profile during normal battery usage to determine *FullChargeCapacity*() and *StateOfCharge*(), specifically for the present load and temperature. *FullChargeCapacity*() is reported as capacity available from a fully charged battery under the present load and temperature until *Voltage*() reaches the **Terminate Voltage**. *NominalAvailableCapacity*() and *FullAvailableCapacity*() are the uncompensated (no or light load) versions of *RemainingCapacity*() and *FullChargeCapacity*() respectively.

The bq27620-G1 has two flags accessed by the *Flags*() function that warns when the battery's SOC has fallen to critical levels. When *RemainingCapacity*() falls below the first capacity threshold, specified in **SOC1 Set Threshold**, the *[SOC1]* (*State of Charge Initial*) flag is set. The flag is cleared once *RemainingCapacity*() rises above SOC1 Set Threshold. All units are in mAh.

When *Voltage*() falls below the system shut down threshold voltage, **SysDown Set Volt Threshold**, the *[SYSDOWN]* flag is set, serving as a final warning to shut down the system. The SOC_INT also signals. When *Voltage*() rises above **SysDown Clear Voltage** and the *[SYSDOWN]* flag has already been set, the *[SYSDOWN]* flag is cleared. The SOC_INT also signals such change. All units are in mV.

5.2 IMPEDANCE TRACK™ VARIABLES

The bq27620-G1 has several data flash variables that permit the user to customize the Impedance Track™ algorithm for optimized performance. These variables are dependent upon the power characteristics of the application as well as the cell itself.

5.2.1 Load Mode

Load Mode is used to select either the constant-current or constant-power model for the Impedance Track™ algorithm as used in **Load Select** (see **Load Select**). When **Load Mode** is 0, the *Constant Current Model* is used (default). When 1, the *Constant Power Model* is used. The [LDMD] bit of CONTROL_STATUS reflects the status of **Load Mode**.

5.2.2 Load Select

Load Select defines the type of power or current model to be used to compute load-compensated capacity in the Impedance Track™ algorithm. If **Load Mode** = 0 (*Constant-Current*) then the options presented in Table 5-1 are available.

Table 5-1. Constant-Current Model Used When Load Mode = 0

| LoadSelect Value | Current Model Used |
|------------------|---|
| 0 | Average discharge current from previous cycle: There is an internal register that records the average discharge current through each entire discharge cycle. The previous average is stored in this register. |
| 1(default) | Present average discharge current: This is the average discharge current from the beginning of this discharge cycle until present time. |
| 2 | Average current: based on EffectiveCurrent() |
| 3 | Current: based off of a low-pass-filtered version of EffectiveCurrent() ($\tau = 14$ s) |
| 4 | Design capacity / 5: C Rate based off of Design Capacity /5 or a C/5 rate in mA. |
| 5 | AtRate (mA): Use whatever current is in AtRate() |
| 6 | User_Rate-mA: Use the value in User_Rate-mA . This mode provides a completely user-configurable method. |

If **Load Mode** = 1 (*Constant Power*) then the following options shown in Table 5-2 are available

Table 5-2. Constant-Power Model Used When Load Mode = 1

| LoadSelect Value | Power Model Used |
|------------------|---|
| 0 | Average discharge power from previous cycle: There is an internal register that records the average discharge power through each entire discharge cycle. The previous average is stored in this register. |
| 1(default) | Present average discharge power: This is the average discharge power from the beginning of this discharge cycle until present time. |
| 2 | Average current x voltage: based off the EffectiveCurrent() and Voltage() . |
| 3 | Current x voltage: based off of a low-pass-filtered version of EffectiveCurrent() ($\tau = 14$ s) and Voltage() |
| 4 | Design energy / 5: C Rate based off of Design Energy /5 or a C/5 rate in mA. |
| 5 | AtRate (10 mW): Use whatever value is in AtRate() . |
| 6 | User_Rate-10mW: Use the value in User_Rate-10mW . This mode provides a completely user-configurable method. |

5.2.3 Reserve Cap-mAh

Reserve Cap-mAh determines how much actual remaining capacity exists after reaching 0 **RemainingCapacity()**, before **Terminate Voltage** is reached. A no-load rate of compensation is applied to this reserve.

5.2.4 Reserve Cap-mWh

Reserve Cap-mWh determines how much actual remaining capacity exists after reaching 0 **AvailableEnergy()**, before **Terminate Voltage** is reached. A no-load rate of compensation is applied to this reserve capacity.

5.2.5 Dsg Current Threshold Rate

This register is used as a threshold by many functions in the bq27620-G1 to determine if actual discharge current is flowing into or out of the cell. The default for this register is in [Section 4.6](#), which should be sufficient for most applications. This threshold should be set low enough to be below any normal application load current but high enough to prevent noise or drift from affecting the measurement.

5.2.6 Chg Current Threshold Rate

This register is used as a threshold by many functions in the bq27620-G1 to determine if actual charge current is flowing into or out of the cell. The default for this register is in [Section 4.6](#), which should be sufficient for most applications. This threshold should be set low enough to be below any normal charge current but high enough to prevent noise or drift from affecting the measurement.

5.2.7 Quit Current, DSG Relax Time, CHG Relax Time, and Quit Relax Time

The **Quit Current** is used as part of the Impedance Track™ algorithm to determine when the bq27620-G1 enters relaxation mode from a current-flowing mode in either the charge direction or the discharge direction. The value of **Quit Current** is set to a default value in [Section 4.6](#) and should be above the standby current of the system.

Either of the following criteria must be met to enter relaxation mode:

- $|EffectiveCurrent()| < |Quit Current|$ for **Dsg Relax Time**
- $|EffectiveCurrent()| < |Quit Current|$ for **Chg Relax Time**

After about 5 minutes in relaxation mode, the bq27620-G1 attempts to take accurate OCV readings. An additional requirement of $dV/dt < 1 \mu V/s$ is required for the bq27620-G1 to perform optimization cycle. These updates are used in the Impedance Track™ algorithms. It is critical that the battery voltage be relaxed during OCV readings to and that the current is not be higher than C/20 when attempting to go into relaxation mode.

Quit Relax Time specifies the minimum time required for *EffectiveCurrent()* to remain above the **QuitCurrent** threshold before exiting relaxation mode.

5.2.8 Delta Voltage

The bq27620-G1 stores the maximum difference of *Voltage()* during short load spikes and normal load, so the Impedance Track™ algorithm can calculate remaining capacity for pulsed loads. It is not recommended to change this value.

5.2.9 Default Ra and Ra Tables

These tables contain encoded data and, with the exception of the **Default Ra Tables**, are automatically updated during device operation. Arbitrations happen on pack insert and based on a Ra measurement. No user changes should be made except for reading/writing the values from a pre-learned pack (part of the process for creating golden image files).

5.3 DETAILED PIN DESCRIPTION

5.3.1 The Operation Configuration Register

Some bq27620-G1 pins are configured via the **Operation Configuration** data flash register, as indicated in [Table 5-3](#). This register is programmed/read via the methods described in [Section 4.2.1](#), Accessing the Data Flash. The register is located at subclass = 64, offset = 0.

Table 5-3. Operation Configuration Bit Definition

| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|------------------|----------|----------|----------|-------|--------|---------|---------|-------|
| High Byte | RESCAP | BATG_OVR | INT_BREM | PFC1 | PFC2 | – | – | – |
| Default = | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 0x08 | | | | | | | | |
| Low Byte | INT_FOCV | IDSELEN | LDODEOC | RMFCC | SOCPOL | BATGPOL | BATLPOL | TEMPS |
| Default = | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0x73 | | | | | | | | |

RESCAP = No-load rate of compensation is applied to the reserve capacity calculation. True when set.

BATG_OVR = BAT_GD override bit. If the gauge enters Hibernate only due to the cell voltage, the BAT_GD pin will not negate. True when set.

INT_BREM = Battery removal interrupt bit. The SOC_INT pulses 1ms when the battery removal interrupt is enabled. True when set.

PFC1/PFC2 = Pin function code (PFC) mode selection: PFC 0, 1, or 2 selected by 0/0, 0/1, or 1/0, respectively.

INT_FOCV = Indication of the measurement of the OCV during the initialization. The SOC_INT will pulse during the first measurement if this bit is set. True when set.

IDSELEN = Enables cell profile selection feature. True when set.

LDODEOC = Learned DoD at EOC is the recording of DoD at EOC when set. If cleared the bq27620 records the the V_charger voltage and uses it to dynamically compute DoD at EOC based on the current temperature. True when set.

RMFCC = RM is updated with the value from FCC, on valid charge termination. True when set.

SOCPOL = SOC interrupt polarity is active-low. True when cleared.

BATGPOL = BAT_GD pin is active-low. True when cleared.

BATLPOL = BAT_LOW pin is active-high. True when set.

TEMPS = Selects external thermistor for *Temperature()* measurements. True when set.

Some bq27620-G1 pins are configured via the **Operation Configuration B** data flash register, as indicated in [Table 5-4](#). This register is programmed/read via the methods described in Section 4.2.1: Accessing the Data Flash. The register is located at subclass = 64, offset = 9.

Table 5-4. Operation Configuration B Bit Definition

| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|----------|--------|------|--------|--------|------|-----------|-----------|-----------|
| Byte | WRTEMP | BIE | BL_INT | GNDSEL | FCE | DFWrIndBL | RFACTSTEP | INDFACRES |
| Default= | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 0x4B | | | | | | | | |

WRTEMP = Enables the temperature write. The temperature could be written by the host. True when set.

BIE = Battery insertion detection enable. When the battery insertion detection is disabled, the gauge relies on the host command to set the BAT_DET bit. True when set.

BL_INT = Battery low interrupt enable. True when set.

GNDSEL = The ADC ground select control. The Vss (Pin D1) is selected as ground reference when the bit is clear. Pin A1 is selected when the bit is set.

FCE = The Fast Convergence Enabled.

DFWrIndBL = DataFlash Write Indication. SOC_INT is used for indication if the bit is clear. BAT_LOW is used for indication if the bit is set.

RFACTSTEP = Enables Ra Step up/down to Min/Max Res Factor before disabling Ra updates.

INDFACRES = Although the default is '1', the function associated with this bit has been removed from firmware.

Table 5-5. Operation Configuration C Bit Definition

| | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|-----------|-----------|-----------|-----------|-----------|------|------|------------|------------|
| Byte | BATGSPUEN | BATGWPUEN | BATLSPUEN | BATLWPUEN | VCCE | – | DeltaVOpt1 | DeltaVOpt0 |
| Default = | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 0x28 | | | | | | | | |

BATGSPUEN = BAT_GD pin strong pull-up enable.

BATGWPUEN = BAT_GD pin weak pull-up enable.

BATLSPUEN = BAT_LOW pin strong pull-up enable.

BATLWPUEN = BAT_LOW pin weak pull-up enable.

VCCE = Voltage Consistency Check Enable.

DeltaVOpt[1:0] = Configures options for determination of **Delta Voltage** which is defined as the maximum difference in *Voltage()* during normal load and short load spikes. **Delta Voltage** is used as a compensation factor for calculating for *RemainingCapacity()* under pulsed loads.

0/0 = Standard DeltaV. Average variance from steady state voltage used to determine end of discharge voltage. (Default)

0/1 = No Averaging. The last instantaneous change in *Voltage()* from steady state is used to determine the end of discharge voltage.

1/0 = Use the value in **Min Delta Voltage**.

1/1 = Not used.

5.3.2 Pin Function Code Descriptions

This fuel gauge has several pin-function configurations available for the end application. Each configuration is assigned a pin function code, or PFC, specified by **Op Config [PFC_CFG1, PFC_CFG0]**. (see [Table 5-6](#) below.) If the fuel gauge is configured to measure external temperature via **Op Config [TEMPS]**, a voltage bias of approximately 125 mSec will be applied periodically to the external thermistor network in order to make a temperature measurement.

Table 5-6. Pin Function Code Summary

| PFC | PFC_CFG [1:0] | External Thermistor Bias Rate ([TEMPS]=1 only) | | | BAT_GD pin Usage for PFC | Pin Function Description |
|-----|---------------|--|---------|------------|---|---|
| | | Dis-charge | Charge | Sleep | | |
| 0 | 0/0 | 1 / sec | 1 / sec | 1 / 20 sec | N/A | A dedicated external thermistor is used for the fuel gauge to monitor battery temperature in all conditions. The BAT_GD pin is not used to interface with a charger IC. |
| 1 | 0/1 | | | | Temperature-based Charge Inhibit. | A dedicated external thermistor is used for the fuel gauge to monitor battery temperature in all conditions. If battery charging temperature falls outside of the preset range defined in data flash, a charger can be disabled via the BAT_GD pin until cell temperature recovers. See <i>Charge Inhibit and Suspend</i> , for additional details. |
| 2 | 1/0 | | None | | N/A | A shared external thermistor is supported between the fuel gauge and a charger IC; however, the BAT_GD pin is not used to interface with the charger IC. The fuel gauge will bias the thermistor for battery temperature measurement and BAT INSERT CHECK mode (If OpConfig B [BIE] = 1) under discharge and relaxation conditions only so the charger IC can separately bias the thermistor during charge mode. |
| 3 | 1/1 | | 1 / sec | | Follows <i>Flags() [FC]</i> flags bit. | Used to disable a battery charger IC when fuel gauge has determined the battery is fully charged. The BAT_GD pin reflects the logical status of the <i>Flags() [FC]</i> bit and is typically connected directly to the charger's Charge Enable/Disable (CE/CD) pin or via a network to drive the charger's Temperature Sense (TS) pin. |

5.3.3 BAT_LOW Pin

The BAT_LOW pin provides a system processor with an electrical indicator of battery status. The signaling on the BAT_LOW pin follows the status of the [SOC1] bit in the *Flags()* register. Note that the polarity of the BAT_LOW pin can be inverted via the [BATL_POL] bit of **Operation Configuration**.

5.3.4 Power Path Control With the BAT_GD Pin

The bq27620-G1 must operate in conjunction with other electronics in a system appliance, such as chargers or other ICs and application circuits that draw appreciable power. After a battery is inserted into the system, there should be no charging current or a discharging current higher than C/20, so that an accurate OCV can be read. The OCV is used for helping determine which battery profile to use, as it constitutes part of the battery impedance measurement

When a battery is inserted into a system, the Impedance Track™ algorithm requires that no charging of the battery takes place and that any discharge is limited to less than C/20—these conditions are sufficient for the fuel gauge to take an accurate OCV reading. To disable these functions, the BAT_GD pin is merely negated from the default setting. Once an OCV reading has been made, the BAT_GD pin is asserted, thereby enabling battery charging and regular discharge of the battery. The **Operation Configuration [BATG_POL]** bit can be used to set the polarity of the battery good signal, should the default configuration need to be changed.

Figure 5-1 details how the BAT_GD pin functions in the context of battery insertion and removal, as well as NORMAL vs. SLEEP modes.

In PFC 1, the BAT_GD pin is also used to disable battery charging when the bq27620-G1 reads battery temperatures outside the range defined by [**Charge Inhibit Temp Low, Charge Inhibit Temp High**]. The BAT_GD line is asserted once temperature falls within the range [**Charge Inhibit Temp Low + Temp Hys, Charge Inhibit Temp High – Temp Hys**].

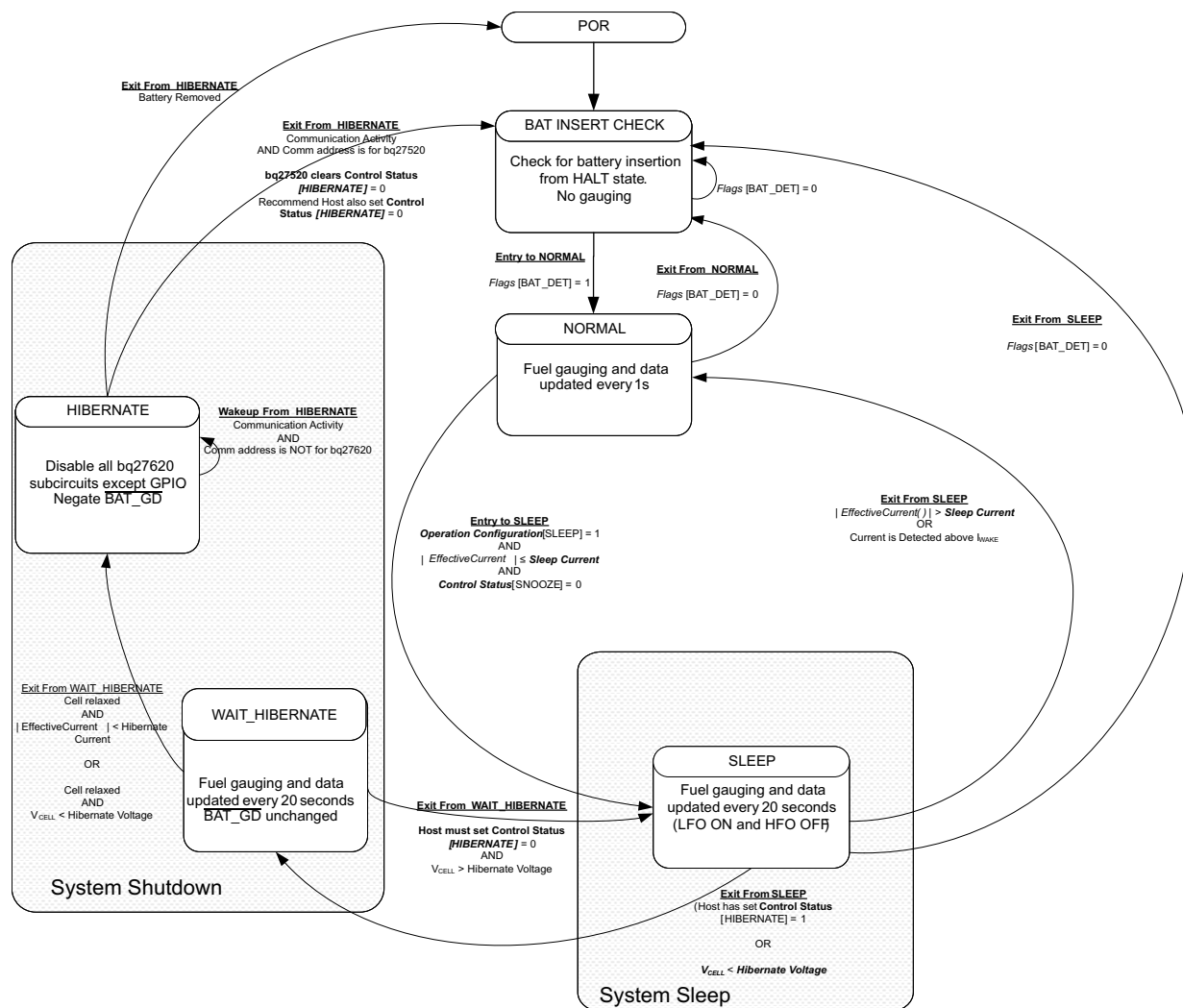


Figure 5-1. Power Mode Diagram

5.3.5 Battery Detection Using the BI/TOUT Pin

During power-up or hibernate activities, or any other activity where the bq27620-G1 needs to determine whether a battery is connected or not, the fuel gauge applies a test for battery presence. First, the BI/TOUT pin is put into high-Z status. The weak 1.8MΩ pull-up resistor will keep the pin high while no battery is present. When a battery is inserted (or is already inserted) into the system device, the BI/TOUT pin will be pulled low. This state is detected by the fuel gauge, which polls this pin every second when the gauge has power. A *battery-disconnected* status is assumed when the bq27620-G1 reads a thermistor voltage that is near 2.5V.

5.3.6 SOC_INT pin

The SOC_INT pin generates a pulse of different pulse widths under various conditions as indicated by the table below. After initialization only one SOC_INT pulse will be generated within any given one second time slot and therefore, may indicate multiple event conditions.

Table 5-7. SOC_INT Pulse Condition and Width

| | Enable Condition | Pulse Width | Comment |
|------------------|--|--|--|
| SOC_Delta Point | SOC_Delta \neq 0 | 1 ms | During charge, when the SOC is greater than ($>$) the points, $100\% - n \times \text{SOC_Delta}$ and 100% ; During discharge, when the SOC reaches (\leq) the points $100\% - n \times \text{SOC_Delta}$ and 0% ; where n is an integer starting from 0 to the number generating SOC no less than 0% |
| SOC1 Set | Always | 1 ms | When RSOC reached the SOC1 Set or Clear threshold set in the Data Flash and BL_INT bit in Operation Configuration B is set. |
| SOC1 Clear | Always | 1 ms | |
| SysDown Set | Always | 1 ms | |
| SysDown Clear | Always | 1 ms | When the Battery Voltage reached the SysDown Set or Clear threshold set in the Data Flash |
| State Change | SOC_Delta \neq 0 | 1 ms | When there is a state change including charging, discharging and relaxation. This function is disabled when SOC_Delta is set to 0. |
| Battery Removal | INT_BREM bit is set in OpConfig AND BIE bit is set | 1 ms | This function is disabled when BIE is cleared. |
| OCV Command | After Initialization | About 165ms. Same as the OCV command execution time period | SOC_INT pulses for the OCV command after the initialization. |
| OCV Command | INT_FOCV bit is set in OpConfig | About 165ms. Same as the OCV command execution time period | This command is to generate the SOC_INT pulse during the initialization. |
| Data Flash Write | After Initialization AND DFWrIndWaitTime \neq 0 | Programmable pulse width flash (see comment) | SOC_INT is used to indicate the data flash update. The gauge will wait DFWrIndWaitTime times $5\mu\text{s}$ after the SOC_INT signal to start the data flash update. This function is disabled if DFWrIndWaitTime is set to 0. |
| OTC or OTD Flags | Always | 1 ms | Upon first assertion of Flags[OTC] or Flags[OTD] over temperature conditions. |

5.4 TEMPERATURE MEASUREMENT

The bq27620-G1 measures battery temperature via its TS input, in order to supply battery temperature status information to the fuel gauging algorithm and charger-control sections of the gauge. Alternatively, it can also measure internal temperature via its on-chip temperature sensor, but only if the **[TEMPS]** bit of the **Operation Configuration** register is cleared. The **[GNDSEL]** bit of Operation Configuration B register selects the ground reference of the ADC converter for temperature measurement.

Regardless of which sensor is used for measurement, a system processor can request the current battery temperature by calling the *Temperature()* function (see [Section 4.1.1, Standard Data Commands](#), for specific information).

The thermistor circuit requires the use of an external NTC 103AT-type thermistor. Additional circuit information for connecting this thermistor to the bq27620-G1 is shown in [Section 8, Reference Schematic](#).

5.5 OVERTEMPERATURE INDICATION

5.5.1 Overtemperature: Charge

If during charging, *Temperature()* reaches the threshold of **OT Chg** for a period of **OT Chg Time** and *EffectiveCurrent()* > **Chg Current Threshold**, then the **[OTC]** bit of *Flags()* is set. When *Temperature()* falls to **OT Chg Recovery**, the **[OTC]** of *Flags()* is reset.

If **OT Chg Time** = 0, then the feature is completely disabled.

5.5.2 Overtemperature: Discharge

If during discharging, *Temperature()* reaches the threshold of **OT Dsg** for a period of **OT Dsg Time**, and *EffectiveCurrent()* ≤ **-Dsg Current Threshold**, then the **[OTD]** bit of *Flags()* is set. When *Temperature()* falls to **OT Dsg Recovery**, the **[OTD]** bit of *Flags()* is reset.

If **OT Dsg Time** = 0, then feature is completely disabled.

5.6 CHARGING AND CHARGE-TERMINATION INDICATION

5.6.1 Detecting Charge Termination

For proper bq27620-G1 operation, the cell charging voltage must be specified by the user. The default value for this variable is **Charging Voltage** [Section 4.6](#).

The bq27620-G1 detects charge termination when (1) during 2 consecutive periods of **Current Taper Window**, the *EffectiveCurrent()* is < **Taper Current**, (2) during the same periods, the accumulated change in capacity > Min Taper Charge / **Current Taper Window**, and (3) *Voltage()* > **Charging Voltage – Taper Voltage**. When this occurs, the **[CHG]** bit of *Flags()* is cleared. Also, if the **[RMFCC]** bit of **Operation Configuration** is set, then *RemainingCapacity()* is set equal to *FullChargeCapacity()*.

5.6.2 Charge Inhibit and Suspend

The bq27620-G1 can indicate when battery temperature has fallen below or risen above predefined thresholds **Charge Inhibit Temp Low** or **Charge Inhibit Temp High**, respectively. In this mode, the **[CHG_INT]** bit is set and the $\overline{\text{BAT_GD}}$ pin is deserialized to indicate this condition. The **[CHG_INT]** bit is cleared and the $\overline{\text{BAT_GD}}$ pin is asserted once the battery temperature returns to the range **[Charge Inhibit Temp Low + Temp Hys, Charge Inhibit Temp High – Temp Hys]**.

When **PFC** = 1, the bq27620-G1 can indicate when battery temperature has fallen below or risen above predefined thresholds **Suspend Low Temp** or **Suspend High Temp**, respectively. In this mode, the **[XCHG]** bit is set to indicate this condition. The **[XCHG]** bit is cleared once the battery temperature returns to the range **[Charge Inhibit Temp Low + Temp Hys, Charge Inhibit Temp High – Temp Hys]**.

The charging should not start when the temperature is below the Charge Inhibit Temp Low or above the Charge Inhibit Temp High. The charging can continue if the charging starts inside the window [Charge Inhibit Temp Low, Charge Inhibit Temp High] until the temperature is either below Suspend Low Temp or above the Suspend Low Temp. Therefore, the window [Charge Inhibit Temp Low, Charge Inhibit Temp High] must be inside the window of [Suspend Low Temp, Suspend High Temp].

5.7 POWER MODES

The bq27620-G1 has different power modes: BAT INSERT CHECK, NORMAL and HIBERNATE. In NORMAL mode, the bq27620-G1 is fully powered and can execute any allowable task. In HIBERNATE mode, the fuel gauge is in a low power state, but can be woken up by communication or certain I/O activity. Finally, the BAT INSERT CHECK mode is a powered-up, but low-power halted, state, where the bq27620-G1 resides when no battery is inserted into the system.

The relationship between these modes is shown in [Figure 5-1](#).

5.7.1 BAT INSERT CHECK Mode

This mode is a halted-CPU state that occurs when an adapter, or other power source, is present to power the bq27620-G1 (and system), yet no battery has been detected. When battery insertion is detected, a series of initialization activities begin, which include: OCV measurement, setting the `BAT_GD` pin, and selecting the appropriate battery profiles.

Some commands, issued by a system processor, can be processed while the bq27620-G1 is halted in this mode. The gauge will wake up to process the command, then return to the halted state awaiting battery insertion.

5.7.2 NORMAL MODE

The fuel gauge is in NORMAL mode when not in any other power mode. During this mode, *EffectiveCurrent()*, *Voltage()* and *Temperature()* measurements are taken, and the interface data set is updated. Decisions to change states are also made. This mode is exited by activating a different power mode.

Because the gauge consumes the most power in NORMAL mode, the Impedance Track™ algorithm minimizes the time the fuel gauge remains in this mode.

5.7.3 HIBERNATE MODE

HIBERNATE mode should be used when the system equipment needs to enter a low-power state, and minimal gauge power consumption is required. This mode is ideal when a system equipment is set to its own HIBERNATE, SHUTDOWN, or OFF modes.

Before the fuel gauge can enter HIBERNATE mode, the system must set the *[HIBERNATE]* bit of the `CONTROL_STATUS` register. The gauge waits to enter HIBERNATE mode until it has taken a valid OCV measurement and the magnitude of the average cell current has fallen below **Hibernate Current**. The gauge can also enter HIBERNATE mode if the cell voltage falls below **Hibernate Voltage**. The gauge will remain in HIBERNATE mode until the system issues a direct I²C command to the gauge or a POR occurs. I²C Communication that is not directed to the gauge will not wake the gauge.

It is important that `BAT_GD` be de-asserted status (no battery charging/discharging). This prevents a charger application from inadvertently charging the battery before an OCV reading can be taken. It is the system's responsibility to wake the bq27620-G1 after it has gone into HIBERNATE mode. After waking, the gauge can proceed with the initialization of the battery information (OCV, profile selection, etc.)

6 APPLICATION-SPECIFIC INFORMATION

6.1 BATTERY PROFILE STORAGE AND SELECTION

6.1.1 Common Profile Aspects

The bq27620-G1 maintains two chemistry profiles, PACK0 and PACK1. These profiles hold dynamic battery data, and keep track of the status for up to two of the most recent batteries used. When a battery pack is removed from host equipment, the bq27620-G1 selects the battery information when the battery is re-inserted. This way, Impedance Track™ algorithm has a means of recovering battery-status information, thereby maintaining good state-of-charge (SOC) estimates.

The bq27620-G1 can manage the information on two removable battery packs. In addition, the gauge has two default battery profiles available to store battery information. The profiles are used to provide the Impedance Track™ algorithm with the default information on two possible battery types expected to be used with the end-equipment. If a new pack is inserted that replaces an older worn out pack, the gauge automatically selects from one of the default profiles and writes that data into the oldest of the PACK0 or PACK1 profile.

6.1.2 Activities Upon Pack Insertion

6.1.2.1 First OCV and Impedance Measurement

At power-up the BAT_GD pin is inactive, so that the system might not obtain power from the battery (this depends on actual implementation). In this state, the battery should be put in a condition with load current less than C/20. Next, the bq27620-G1 measures its first open-circuit voltage (OCV) via the BAT pin. The *[OCVCMDCOMP]* bit will set once the OCV measurement is completed. Depending on the load current, the *[OCVFAIL]* bit indicates whether the OCV reading is valid. From the OCV(SOC) table, the SOC of the inserted battery is found. Then the BAT_GD pin is made active, and the impedance of the inserted battery is calculated from the measured voltage and the load current: $Z(SOC) = (OCV(SOC) - V) / I$. This impedance is compared with the impedance of the dynamic profiles, **Packn**, and the default profiles, **Defn**, for the same SOC (the letter **n** depicts either a **0** or **1**). The *[INITCOMP]* bit will be set afterwards and the OCV command could be issued

6.1.3 Reading HostCfg

The **HostCfg** data flash location contains cell profile status information, and can be read using the *ApplicationStatus()* extended command (0x6a). The bit configuration of this function/location is shown in [Table 6-1](#).

Table 6-1. HostCfg Bit Definitions.

| HostCfg | bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---------|------|------|------|------|--------|------|------|---------|
| Byte | — | — | — | — | OPTCMP | — | — | LU_PROF |

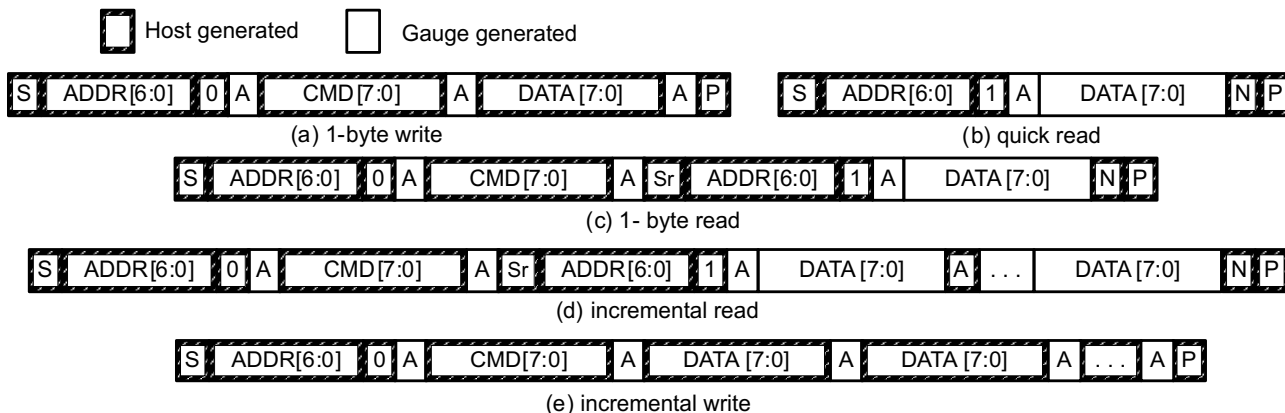
LU_PROF = Last profile used by fuel gauge. *Cell0* last used when cleared. *Cell1* last used when set. Default is 0.

OPTCMP = OPTMIZ bit is set. Default is 0.

7 COMMUNICATIONS

7.1 I²C INTERFACE

The bq27620-G1 supports the standard I²C read, incremental read, quick read, one byte write, and incremental write functions. The 7 bit device address (ADDR) is the most significant 7 bits of the hex address and is fixed as 1010101. The first 8-bits of the I²C protocol will; therefore, be 0xAA or 0xAB for write or read, respectively.

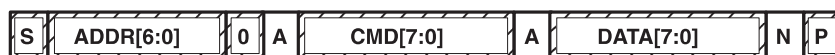


(S = Start, Sr = Repeated Start, A = Acknowledge, N = No Acknowledge, and P = Stop).

The “quick read” returns data at the address indicated by the address pointer. The address pointer, a register internal to the I²C communication engine, will increment whenever data is acknowledged by the bq27620-G1 or the I²C master. “Quick writes” function in the same manner and are a convenient means of sending multiple bytes to consecutive command locations (such as two-byte commands that require two bytes of data)

The following command sequences are not supported:

Attempt to write a read-only address (NACK after data sent by master):



Attempt to read an address above 0x6B (NACK command):

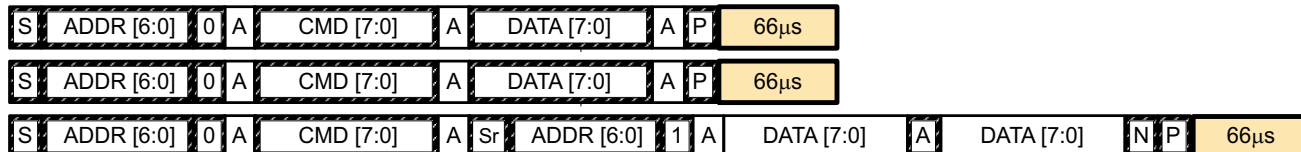


7.2 I²C Time Out

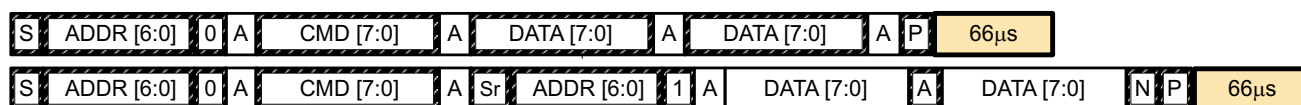
The I²C engine will release both SDA and SCL if the I²C bus is held low for 2 seconds. If the bq27620-G1 was holding the lines, releasing them will free them for the master to drive the lines. If an external condition is holding either of the lines low, the I²C engine will enter the low power sleep mode.

7.3 I²C Command Waiting Time

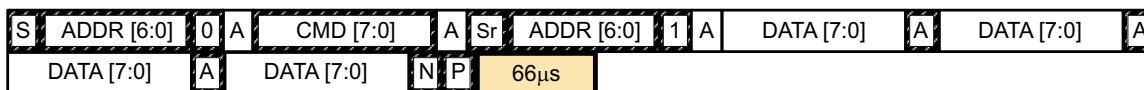
To ensure proper operation at 400 kHz, a $t_{\text{BUF}} \geq 66 \mu\text{s}$ bus free waiting time should be inserted between all packets addressed to the bq27620-G1. In addition, if the SCL clock frequency (f_{SCL}) is $> 100 \text{ kHz}$, use individual 1-byte write commands for proper data flow control. The following diagram shows the standard waiting time required between issuing the control subcommand the reading the status result. For read-write standard command, a minimum of 2 seconds is required to get the result updated. For read-only standard commands, there is no waiting time required, but the host should not issue all standard commands more than two times per second. Otherwise, the gauge could result in a reset issue due to the expiration of the watchdog timer.



Waiting time inserted between two 1-byte write packets for a subcommand and reading results
(required for $100 \text{ kHz} < f_{\text{SCL}} \leq 400 \text{ kHz}$)



Waiting time inserted between incremental 2-byte write packet for a subcommand and reading results
(acceptable for $f_{\text{SCL}} \leq 100 \text{ kHz}$)



Waiting time inserted after incremental read

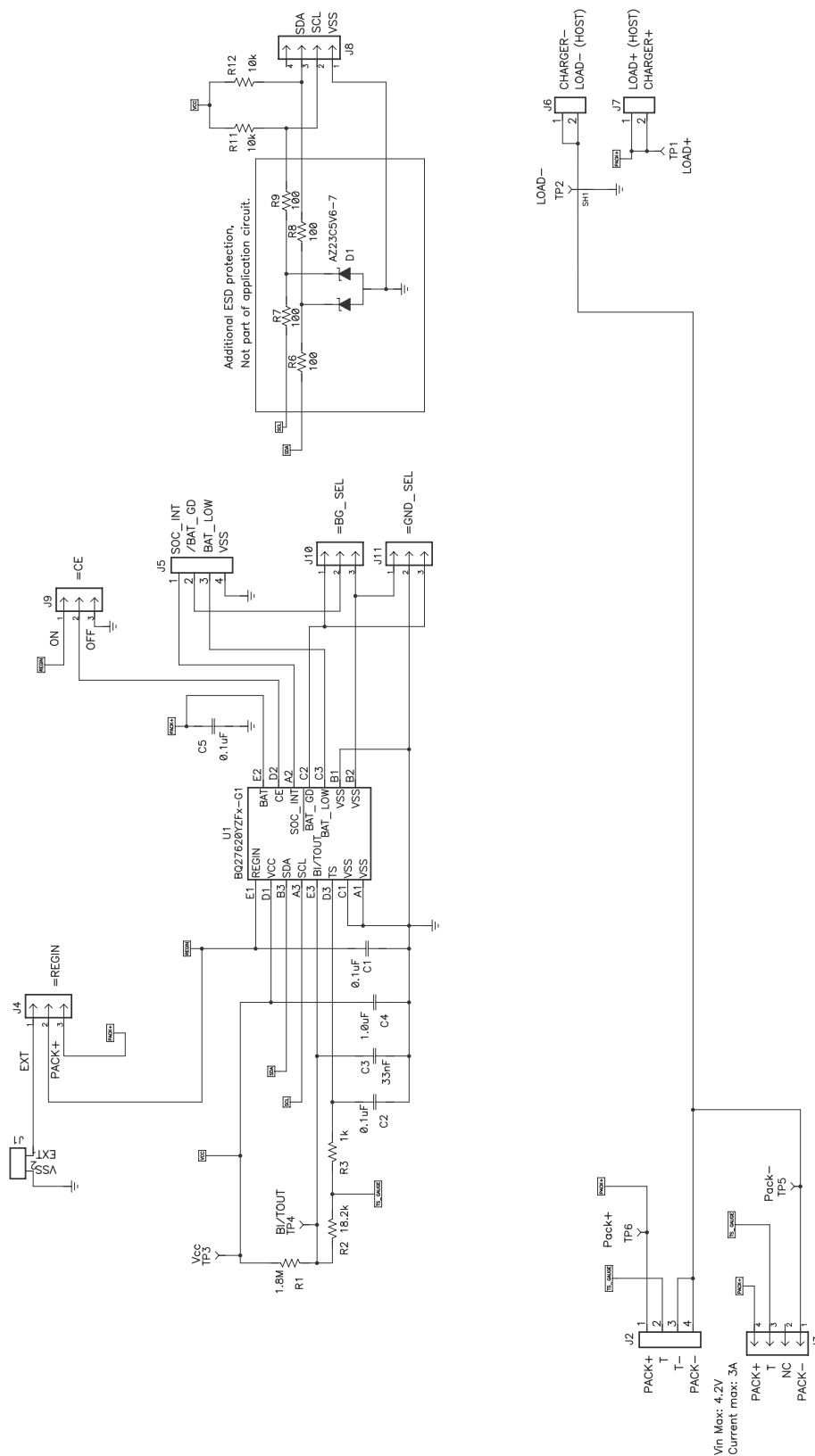
7.4 I²C Clock Stretching

A clock stretch can occur during all modes of fuel gauge operation. In SLEEP and HIBERNATE modes, a short clock stretch will occur on all I²C traffic as the device must wake-up to process the packet. In the other modes (BAT INSERT CHECK, NORMAL) clock stretching will only occur for packets addressed for the fuel gauge. The majority of clock stretch periods are small as the I²C interface performs normal data flow control. However, less frequent yet more significant clock stretch periods may occur as blocks of Data Flash are updated. The following table summarizes the approximate clock stretch duration for various fuel gauge operating conditions.

| Gauging Mode | Operating Condition / Comment | Approximate Duration |
|----------------------------|---|----------------------|
| SLEEP HIBERNATE | Clock stretch occurs at the beginning of all traffic as the device wakes up. | $\leq 4 \text{ ms}$ |
| BAT INSERT CHECK NORMAL | Clock stretch occurs within the packet for flow control. (after a start bit, ACK or first data bit) | $\leq 4 \text{ ms}$ |
| | Normal Ra table Data Flash updates. | 24 ms |
| | Data Flash block writes. | 72 ms |
| | Restored Data Flash block write after loss of power. | 116 ms |
| | End of discharge Ra table Data Flash update. | 144 ms |

8 REFERENCE SCHEMATICS

8.1 SCHEMATIC



PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| BQ27620YZFR-G1 | ACTIVE | DSBGA | YZF | 15 | 3000 | RoHS & Green | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | BQ27620G | Samples |
| BQ27620YZFT-G1 | ACTIVE | DSBGA | YZF | 15 | 250 | RoHS & Green | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | BQ27620G | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

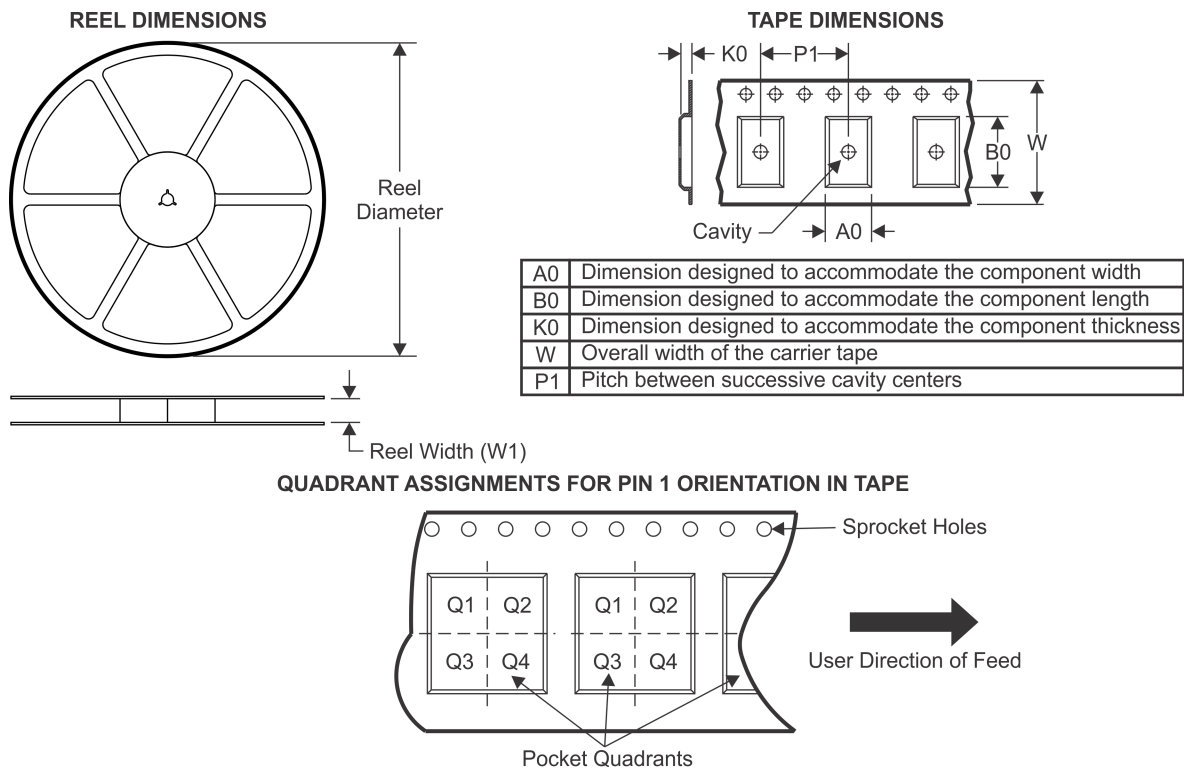
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

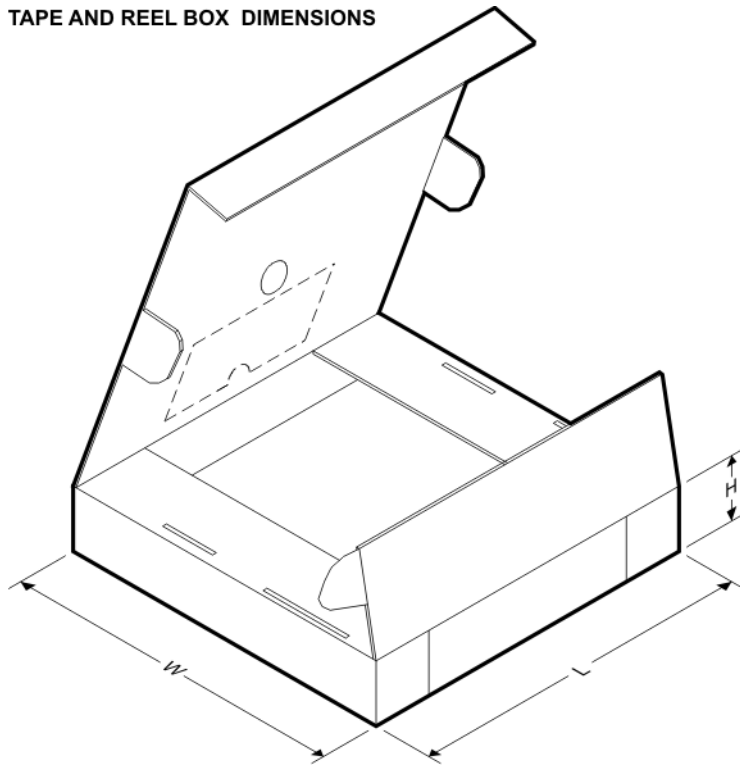
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ27620YZFR-G1 | DSBGA | YZF | 15 | 3000 | 180.0 | 8.4 | 2.1 | 2.76 | 0.81 | 4.0 | 8.0 | Q1 |
| BQ27620YZFT-G1 | DSBGA | YZF | 15 | 250 | 180.0 | 8.4 | 2.1 | 2.76 | 0.81 | 4.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

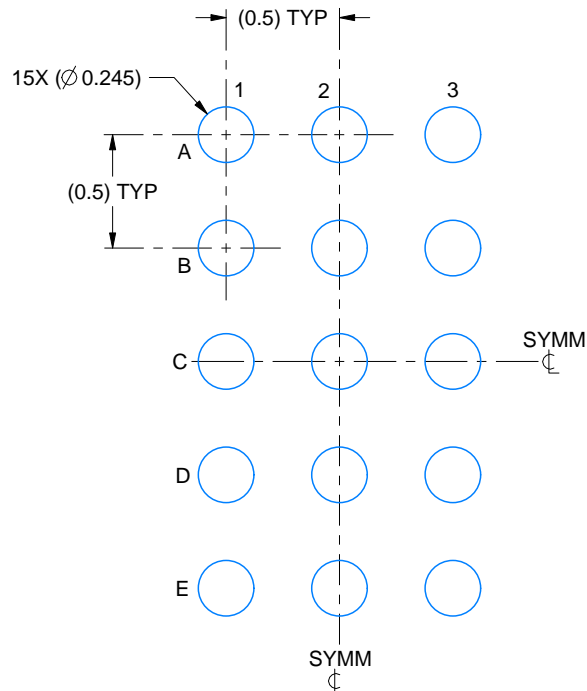
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ27620YZFR-G1 | DSBGA | YZF | 15 | 3000 | 182.0 | 182.0 | 20.0 |
| BQ27620YZFT-G1 | DSBGA | YZF | 15 | 250 | 182.0 | 182.0 | 20.0 |

EXAMPLE BOARD LAYOUT

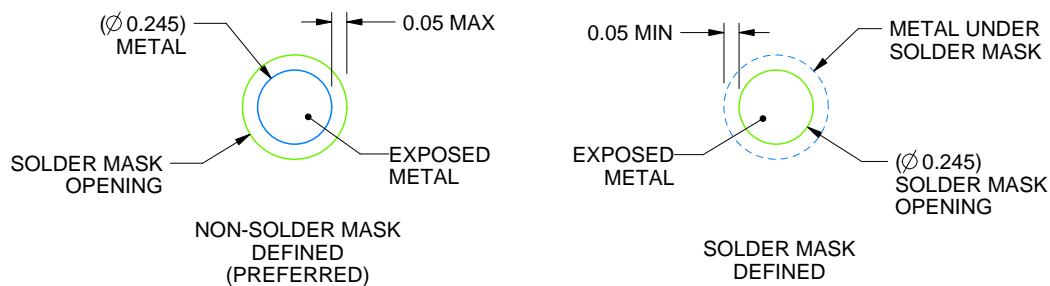
YZF0015

DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:30X



SOLDER MASK DETAILS
NOT TO SCALE

4219381/A 02/2017

NOTES: (continued)

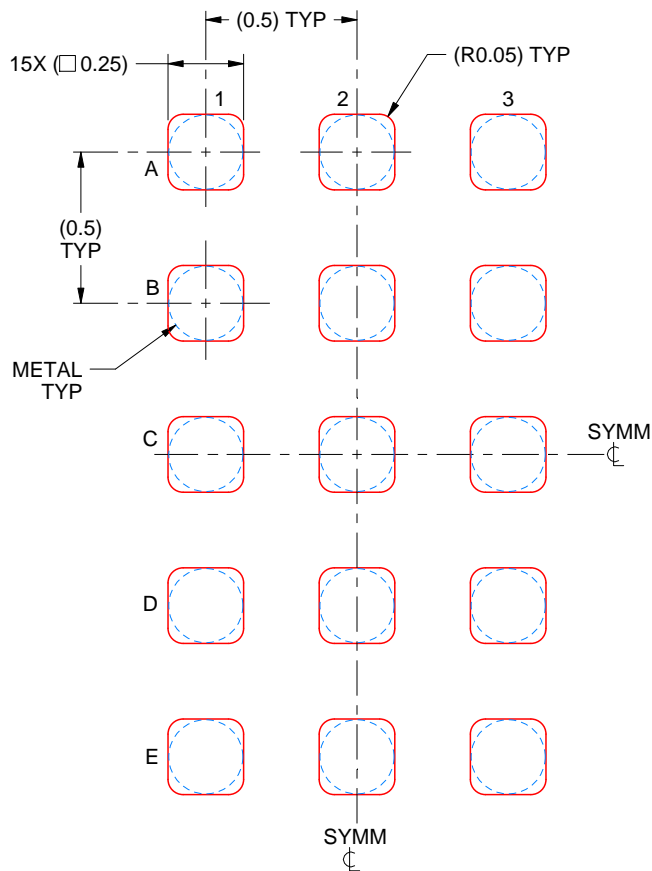
4. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YZF0015

DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:40X

4219381/A 02/2017

NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2020, Texas Instruments Incorporated