

# BQ27Z558 Impedance Track™ Battery Gas Gauge Solution for 1-Series Cell Li-Ion Battery Packs, with 1.2-V IO Support

## 1 Features

- Supports high-side and low-side current sense resistors down to 1 mΩ
- Supports pack-side gauging including enhanced state of health (SOH) algorithm
- Fast QMax update option based on predicted OCV
- SHA-256 authentication responder for increased battery pack security
- Sophisticated charge algorithms
  - JEITA
  - Enhanced charging
  - RSOC() charging compensation option
- Two independent ADCs
  - Support for simultaneous current and voltage sampling
  - High-accuracy coulomb counter with input offset error < 1 μV (typical)
- Low-voltage (2-V) operation
- Wide-range current applications (1 mA to > 5 A)
- Active high or low pulse or level interrupt pin
- Supports battery trip point (BTP)
- Reduced power modes (typical battery pack operating range conditions)
  - Typical SLEEP mode: < 11 μA
  - Typical DEEP SLEEP mode: < 9 μA
  - Typical HIBERNATE mode: < 3 μA
  - Typical OFF mode: < 1.9 μA
- Internal and external temperature sense functions
- Diagnostic lifetime data monitor and black box recorder
- 400-kHz I²C bus communications interface, including a 1.2-V logic level for high-speed programming and data access
- HDQ one-wire for communication with host
- Compact 12-pin DSBGA package (YPH)

## 2 Applications

- [Smartphones](#)
- [Digital still cameras](#) and [video cameras](#)
- [Tablet computing](#)
- [Portable and wearable health devices](#)
- [Portable audio devices](#)

## 3 Description

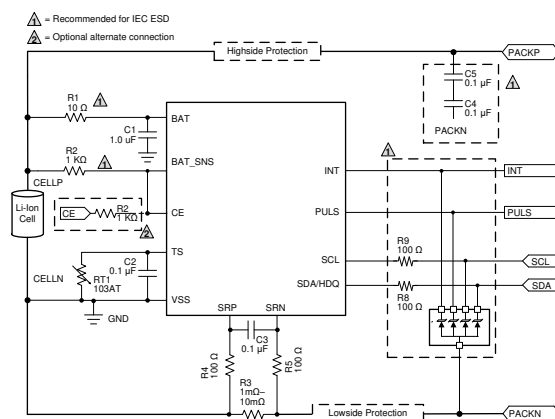
The Texas Instruments BQ27Z558 Impedance Track™ gas gauge solution is a highly integrated, accurate 1-series cell gas gauge with a flash programmable custom reduced instruction-set CPU (RISC) and SHA-256 authentication for Li-ion and Li-polymer battery packs. The 1-series cell capability includes parallel cells for increased capacity.

The BQ27Z558 gas gauge communicates through I²C-compatible and HDQ one-wire interfaces and includes several key features that can help facilitate accurate gas gauging applications. Integrated temperature sense functions (internal and external options) enable system and battery temperature measurements.

### Device Information

| PART NUMBER <sup>(1)</sup> | PACKAGE    | PACKAGE SIZE (NOM) |
|----------------------------|------------|--------------------|
| BQ27Z558                   | DSBGA (12) | 1.67 mm × 2.05 mm  |

- (1) For all available packages, see the orderable addendum at the end of the data sheet.



**Simplified Schematic**



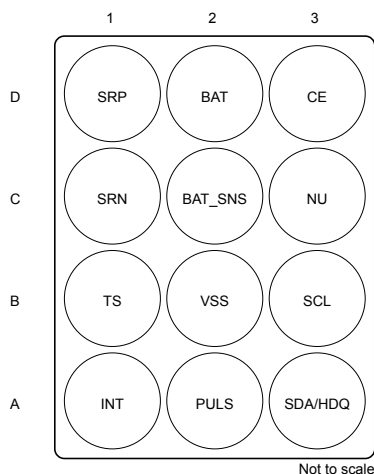
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## 4 Description (continued)

The integrated SHA-256 functionality helps enable secure identification between systems and packs. The interrupt and BTP functions facilitate the BQ27Z558 device to inform the system when a specific state-of-charge (SOC), voltage, or temperature condition occurs. The low-voltage operation enables the system to continue monitoring the battery even in deeply discharged conditions. During low-activity situations, the device can be set to the low power coulomb counting (CC) mode, which enables the device to continue its coulomb counting while reducing operating current significantly.

## 5 Pin Configuration and Functions



**Figure 5-1. Pin Diagram**

**Table 5-1. Pin Functions**

| PIN     |     | TYPE <sup>(1)</sup> | DESCRIPTION  |
|---------|-----|---------------------|--|
| NAME    | NO. |                     |  |
| BAT     | D2  | P                   | Battery voltage measurement input. Kelvin battery sense connection to BAT_SNS. Connect a capacitor (1 µF) between BAT and VSS. Place the capacitor close to the gauge. |
| CE      | D3  | I                   | Active-high chip enable  |
| BAT_SNS | C2  | AI                  | Battery sense  |
| INT     | A1  | O                   | Interrupt for voltage, temperature, and state of charge (programmable active high or low)  |
| PULS    | A2  | O                   | Programmable pulse width with active-high or -low option   |
| TS      | B1  | AI                  | Temperature input for ADC  |
| NU      | C3  | NC                  | Makes no external connection   |
| SCL     | B3  | I/O                 | Serial clock for I <sup>2</sup> C interface that requires an external pullup when used. It can be left floating if unused.   |
| SDA/HDQ | A3  | I/O                 | Serial data for I <sup>2</sup> C interface and one-wire interface for HDQ (selectable) that requires an external pullup when used. It can be left floating if unused.  |
| SRP     | D1  | I                   | Analog input pin connected to the internal coulomb counter peripheral for integrating a small voltage between SRP (positive side) and SRN                              |
| SRN     | C1  | I                   | Analog input pin connected to the internal coulomb counter peripheral for integrating a small voltage between SRP (positive side) and SRN                              |
| VSS     | B2  | P                   | Device ground  |

(1) P = Power Connection, O = Digital Output, AI = Analog Input, I = Digital Input, I/O = Digital Input/Output, NU = Not Used

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

|                                       |                   | MIN  | MAX             | UNIT |
|---------------------------------------|-------------------|------|-----------------|------|
| Input Voltage                         | BAT               | −0.3 | 6               | V    |
|                                       | INT, PULS, CE     | −0.3 | 6               | V    |
|                                       | SRP, SRN, BAT_SNS | −0.3 | $V_{BAT} + 0.3$ | V    |
|                                       | TS                | −0.3 | 2.1             | V    |
|                                       | SCL, SDA/HDQ      | −0.3 | 6               | V    |
| Operating ambient temperature, $T_A$  |                   | −40  | 85              | °C   |
| Operating junction temperature, $T_J$ |                   | −40  | 125             | °C   |
| Storage temperature, $T_{stg}$        |                   | −65  | 150             | °C   |

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

### 6.2 ESD Ratings

|                                     |   | VALUE | UNIT |
|-------------------------------------|---|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM) on all pins, per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>     | ±1500 | V    |
|                                     | Charged-device model (CDM) on all pins, per ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup> | ±500  |      |

- (1) JEDEC document JEP155 states that 500-V HBM enables safe manufacturing with a standard ESD control process.

- (2) JEDEC document JEP157 states that 250-V CDM enables safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

|                             |                                    |                           | MIN | NOM | MAX       | UNIT |
|-----------------------------|------------------------------------|---------------------------|-----|-----|-----------|------|
| $V_{BAT}$                   | Supply voltage                     | No operating restrictions | 2.0 |     | 5.5       | V    |
| $C_{BAT}$                   | External capacitor from BAT to VSS |                           | 1   |     |           | μF   |
| $V_{TS}$                    | Temperature sense                  |                           | 0   |     | 1.8       | V    |
| $V_{PULS}, V_{INT}, V_{CE}$ | Input and output pins              |                           | 0   |     | $V_{BAT}$ | V    |
| $V_{SCL}, V_{SDA/HDQ}$      | Communication pins                 |                           | 0   |     | 1.8       | V    |

## 6.4 Thermal Information

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

| THERMAL METRIC <sup>(1)</sup> |  | BQ27Z558    | UNIT |
|-------------------------------|--|-------------|------|
|                               |  | DSBGA (YPH) |      |
|                               |  | (12 PINS)   |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 64.1        | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 59.8        |      |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 52.7        |      |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.3         |      |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 28.3        |      |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 2.4         |      |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics Application Report](#).

## 6.5 Supply Current

Unless otherwise noted, characteristics noted under conditions of T<sub>A</sub> = –40°C to 85°C

| PARAMETER              | TEST CONDITIONS  | MIN | TYP | MAX | UNIT |
|------------------------|--|-----|-----|-----|------|
| I <sub>NORMAL</sub>    | Standard operating conditions  |     | 60  |     | μA   |
| I <sub>SLEEP</sub>     | Sense resistor current below SLEEP mode threshold                              |     | 11  |     | μA   |
| I <sub>DEEPSLEEP</sub> | Sense resistor current below DEEP SLEEP mode threshold                         |     | 9   |     | μA   |
| I <sub>HIBERNATE</sub> | CE = V <sub>IH</sub> , OFF state with ability to wake from valid communication |     | 3   |     | μA   |
| I <sub>OFF</sub>       | CE = V <sub>IL</sub>   |     | 0.5 |     | μA   |

## 6.6 Internal 1.8-V LDO (REG18)

Unless otherwise noted, characteristics noted under conditions of T<sub>A</sub> = –40°C to 85°C

| PARAMETER          | TEST CONDITIONS          | MIN              | TYP  | MAX | UNIT |
|--------------------|--------------------------|------------------|------|-----|------|
| V <sub>REG18</sub> | Regulator output voltage | 1.6              | 1.8  | 2.0 | V    |
| V <sub>PORth</sub> | POR threshold            | Rising threshold | 1.45 | 1.7 | V    |
| V <sub>PORhy</sub> | POR hysteresis           |                  | 0.1  |     | V    |

## 6.7 I/O (PULS, INT)

Unless otherwise noted, characteristics noted under conditions of T<sub>A</sub> = –40°C to 85°C

| PARAMETER        | TEST CONDITIONS             | MIN  | TYP  | MAX  | UNIT |
|------------------|-----------------------------|--|------|------|------|
| V <sub>IH</sub>  | High-level input voltage    | V <sub>REG18</sub> = 1.8 V                         | 1.15 |      | V    |
| V <sub>IL</sub>  | Low-level input voltage low | V <sub>REG18</sub> = 1.8 V                         |      | 0.50 | V    |
| V <sub>OL</sub>  | Output voltage low          | V <sub>REG18</sub> = 1.8 V, I <sub>OL</sub> = 1 mA |      | 0.4  | V    |
| C <sub>I</sub>   | Input capacitance           |  | 5    |      | pF   |
| I <sub>Ikg</sub> | Input leakage current       |  |      | 1    | μA   |

## 6.8 Chip Enable (CE)

Unless otherwise noted, characteristics noted under conditions of T<sub>A</sub> = –40°C to 85°C

| PARAMETER       | TEST CONDITIONS                                 | MIN                        | TYP                     | MAX                     | UNIT |
|-----------------|---|----------------------------|-------------------------|-------------------------|------|
| V <sub>IH</sub> | High-level input voltage (assured by design)    | V <sub>REG18</sub> = 1.8 V | 0.75 × V <sub>BAT</sub> |                         | V    |
| V <sub>IL</sub> | Low-level input voltage low (assured by design) | V <sub>REG18</sub> = 1.8 V |                         | 0.25 × V <sub>BAT</sub> | V    |

## 6.9 Internal Temperature Sensor

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER   | TEST CONDITIONS  | MIN  | TYP  | MAX  | UNIT                   |
|---|--|------|------|------|------------------------|
| $V_{(\text{TEMP})}$ Internal temperature sensor voltage drift | $V_{\text{TEMP}}$  | 1.65 | 1.73 | 1.8  | mV/ $^{\circ}\text{C}$ |
|   | $V_{\text{TEMP}} - V_{\text{TEMPN}}$ (assured by design) | 0.17 | 0.18 | 0.19 |                        |

## 6.10 NTC Thermistor Measurement Support

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER   | TEST CONDITIONS | MIN  | TYP  | MAX  | UNIT                    |
|---|-----------------|------|------|------|-------------------------|
| $R_{\text{NTRC(PU)}}$ Internal pullup resistance          |                 | 14.4 | 18   | 21.6 | k $\Omega$              |
| $R_{\text{NTC(DRIFT)}}$ Resistance drift over temperature |                 | -250 | -120 | 0    | PPM/ $^{\circ}\text{C}$ |

## 6.11 Coulomb Counter (CC)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER  | TEST CONDITIONS                           | MIN   | TYP  | MAX   | UNIT                    |
|--|---|-------|------|-------|-------------------------|
| $V_{(\text{CC\_IN})}$ Differential input voltage range |   | -0.1  |      | 0.1   | V                       |
| $t_{(\text{CC\_CONV})}$ Conversion time                | Single conversion                         |       | 1000 |       | ms                      |
| Effective resolution                                   | 1 LSB                                     |       | 3.8  |       | $\mu\text{V}$           |
| Integral nonlinearity                                  | 16-bit, best fit over input voltage range | -22.3 | 5.2  | +22.3 | LSB                     |
| Differential nonlinearity                              | 16-bit, no missing codes                  |       | 1.5  |       | LSB                     |
| Offset error   | 16-bit post calibration                   | -2.6  | 1.3  | +2.6  | LSB                     |
| Offset error drift                                     | 15-bit + sign, post calibration           |       | 0.04 | 0.07  | LSB/ $^{\circ}\text{C}$ |
| Gain error   | 15-bit + sign, over input voltage range   | -492  | 131  | +492  | LSB                     |
| Gain error drift                                       | 15-bit + sign, over input voltage range   |       | 4.3  | 9.8   | LSB/ $^{\circ}\text{C}$ |
| Effective input resistance                             |   | 7     |      |       | M $\Omega$              |

## 6.12 Analog Digital Converter (ADC)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER                                      | TEST CONDITIONS  | MIN  | TYP  | MAX  | UNIT                    |
|--|--|------|------|------|-------------------------|
| $V_{\text{ADC\_TS\_GPIO}}$ Input voltage range | $V_{\text{FS}} = V_{\text{REF2}}$  | -0.2 |      | 1.0  | V                       |
|  | $V_{\text{FS}} = V_{\text{REG18}} \times 2$                                | -0.2 |      | 1.44 | V                       |
| $V_{\text{BAT\_MODE}}$ Battery input voltage   |  | -0.2 |      | 5.5  | V                       |
| Integral nonlinearity                          | 16-bit, best fit, $-0.1\text{ V}$ to $0.8 \times V_{\text{REF2}}$          | -8.4 |      | +8.4 | LSB                     |
| Differential nonlinearity                      | 16-bit, no missing codes   |      | 1.5  |      | LSB                     |
| Offset error                                   | 16-bit post calibration <sup>(1)</sup> , $V_{\text{FS}} = V_{\text{REF2}}$ | -4.2 | 1.8  | +4.2 | LSB                     |
| Offset error drift                             | 16-bit post calibration <sup>(1)</sup> , $V_{\text{FS}} = V_{\text{REF2}}$ |      | 0.02 | 0.1  | LSB/ $^{\circ}\text{C}$ |
| Gain Error                                     | 16-bit, $-0.1$ to $0.8 \times V_{\text{FS}}$                               | -492 | 131  | +492 | LSB                     |
| Gain error drift                               | 16-bit, $-0.1$ to $0.8 \times V_{\text{FS}}$                               |      | 2    | 4.5  | LSB/ $^{\circ}\text{C}$ |
| Effective input resistance                     |  | 8    |      |      | M $\Omega$              |
| $t_{(\text{ADC\_CONV})}$ Conversion time       |  |      | 11.7 |      | ms                      |
| Effective resolution                           |  | 14   | 15   |      | bits                    |

(1) Factory calibration

## 6.13 Internal Oscillator Specifications

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER                       | TEST CONDITIONS     | MIN   | TYP   | MAX   | UNIT |
|---------------------------------|---------------------|---|-------|-------|------|
| High Frequency Oscillator (HFO) |                     |   |       |       |      |
| f <sub>HFO</sub>                | Operating frequency | 16.78   |       |       | MHz  |
| f <sub>HFO</sub>                | HFO frequency drift | TA = −20°C to 70°C  | −2.5% | 2.5%  |      |
|                                 |                     | TA = −40°C to 85°C  | −3.5  | 3.5   |      |
| t <sub>HFOSTART</sub>           | HFO start-up time   | TA = −40°C to 85°C, oscillator frequency within +/- 3% of nominal frequency or a power-on reset |       |       | 4ms  |
| Low Frequency Oscillator (LFO)  |                     |   |       |       |      |
| f <sub>LFO</sub>                | Operating frequency | 65.536  |       |       | kHz  |
| f <sub>LFO(ERR)</sub>           | Frequency error     | TA = −40°C to 85°C  | −2.5% | +2.5% |      |

## 6.14 Voltage Reference1 (REF1)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER                | TEST CONDITIONS                           | MIN   | TYP  | MAX   | UNIT          |
|--------------------------|---|---|------|-------|---------------|
| $V_{\text{REF1}}$        | Internal reference voltage <sup>(1)</sup> | 1.195   | 1.21 | 1.227 | V             |
| $V_{\text{REF1\_DRIFT}}$ | Internal reference voltage drift          | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |      |       | -80 +80 PPM/C |

(1) Used for CC and LDO

## 6.15 Voltage Reference2 (REF2)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER                | TEST CONDITIONS                           | MIN   | TYP  | MAX  | UNIT          |
|--------------------------|---|---|------|------|---------------|
| $V_{\text{REF2}}$        | Internal reference voltage <sup>(1)</sup> | 1.2   | 1.21 | 1.22 | V             |
| $V_{\text{REF2\_DRIFT}}$ | Internal reference voltage drift          | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |      |      | -20 20 PPM/°C |

(1) Used for ADC

## 6.16 Flash Memory

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER                      | TEST CONDITIONS      | MIN   | TYP | MAX | UNIT          |
|--------------------------------|----------------------|---|-----|-----|---------------|
| Data retention                 |                      | 10  | 100 |     | Years         |
| Flash programming write cycles | Data Flash           | 20000   |     |     | Cycles        |
|                                | Instruction Flash    | 1000  |     |     | Cycles        |
| $t_{\text{(ROWPROG)}}$         | Row programming time |   |     | 40  | $\mu\text{s}$ |
| $t_{\text{(MASSERASE)}}$       | Mass-erase time      | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |     |     | 40 ms         |
| $t_{\text{(PAGEERASE)}}$       | Page-erase time      | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |     |     | 40 ms         |
| $I_{\text{FLASHREAD}}$         | Flash read current   | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |     |     | 1 mA          |
| $I_{\text{FLASHWRTIE}}$        | Flash write current  | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |     |     | 5 mA          |
| $I_{\text{FLASHERASE}}$        | Flash erase current  | $T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ |     |     | 15 mA         |

## 6.17 I<sup>2</sup>C I/O

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER       | TEST CONDITIONS             | MIN                            | TYP | MAX  | UNIT  |
|-----------------|-----------------------------|--------------------------------|-----|------|-------|
| $V_{\text{IH}}$ | High-level input voltage    | SCL, SDA/HDQ<br>0.78           |     |      | V     |
| $V_{\text{IL}}$ | Low-level input voltage low |                                |     | 0.43 | V     |
| $V_{\text{OL}}$ | Low-level output voltage    | $I_{\text{OL}} = 3 \text{ mA}$ |     |      | 0.4 V |

## 6.17 I<sup>2</sup>C I/O (continued)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER | TEST CONDITIONS       | MIN | TYP | MAX | UNIT          |
|-----------|-----------------------|-----|-----|-----|---------------|
| $C_I$     | Input capacitance     |     |     | 10  | pF            |
| $I_{Ikg}$ | Input leakage current |     | 1   |     | $\mu\text{A}$ |

## 6.18 I<sup>2</sup>C Timing — 100 kHz

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . Device supports 100 kHz when SCL and SDA pins are pulled up to  $V_{PULL-UP} = 1.2\text{ V}, 1.8\text{ V}, 2.5\text{ V},$  or  $3.3\text{ V}$

| PARAMETER    | TEST CONDITIONS              | MIN                         | NOM | MAX  | UNIT          |
|--------------|------------------------------|-----------------------------|-----|------|---------------|
| $f_{SCL}$    | Clock operating frequency    |                             |     | 100  | kHz           |
| $t_{HD:STA}$ | Start condition hold time    | 4.0                         |     |      | $\mu\text{s}$ |
| $t_{LOW}$    | Low period of the SCL Clock  | 4.7                         |     |      | $\mu\text{s}$ |
| $t_{HIGH}$   | High period of the SCL Clock | 4.0                         |     |      | $\mu\text{s}$ |
| $t_{SU:STA}$ | Setup repeated START         | 4.7                         |     |      | $\mu\text{s}$ |
| $t_{HD:DAT}$ | Data hold time (SDA input)   | 0                           |     |      | ns            |
| $t_{SU:DAT}$ | Data setup time (SDA input)  | 250                         |     |      | ns            |
| $t_r$        | Clock rise time              | 30% to 70% of $V_{PULL-UP}$ |     | 1000 | ns            |
| $t_f$        | Clock fall time              | 70% to 30% of $V_{PULL-UP}$ |     | 300  | ns            |
| $t_{SU:STO}$ | Setup time STOP condition    | 4.0                         |     |      | $\mu\text{s}$ |
| $t_{BUF}$    | Bus free time STOP to START  | 4.7                         |     |      | $\mu\text{s}$ |

## 6.19 I<sup>2</sup>C Timing — 400 kHz

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . Device supports 400 kHz when SCL and SDA pins are pulled up to  $V_{PULL-UP} = 1.2\text{ V}, 1.8\text{ V}, 2.5\text{ V},$  or  $3.3\text{ V}$

| PARAMETER    | TEST CONDITIONS              | MIN                         | NOM                                      | MAX | UNIT          |
|--------------|------------------------------|-----------------------------|--|-----|---------------|
| $f_{SCL}$    | Clock operating frequency    |                             |  | 400 | kHz           |
| $t_{HD:STA}$ | START condition hold time    | 0.6                         |  |     | $\mu\text{s}$ |
| $t_{LOW}$    | Low period of the SCL Clock  | 1.3                         |  |     | $\mu\text{s}$ |
| $t_{HIGH}$   | High period of the SCL Clock | 600                         |  |     | ns            |
| $t_{SU:STA}$ | Setup repeated START         | 600                         |  |     | ns            |
| $t_{HD:DAT}$ | Data hold time (SDA input)   | 0                           |  |     | ns            |
| $t_{SU:DAT}$ | Data setup time (SDA input)  | 100                         |  |     | ns            |
| $t_r$        | Clock rise time              | 30% to 70% of $V_{PULL-UP}$ | 20                                       | 300 | ns            |
| $t_f$        | Clock fall time              | 70% to 30% of $V_{PULL-UP}$ | $20 \times (V_{PULL-UP} / 5.5\text{ V})$ | 300 | ns            |
| $t_{SU:STO}$ | Setup time STOP condition    | 0.6                         |  |     | $\mu\text{s}$ |
| $t_{BUF}$    | Bus free time STOP to START  | 1.3                         |  |     | $\mu\text{s}$ |

## 6.20 HDQ Timing

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

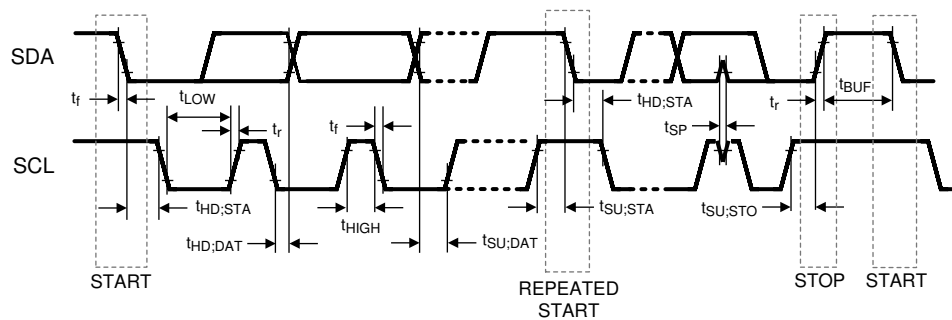
| PARAMETER | TEST CONDITIONS     | MIN | NOM | MAX | UNIT          |
|-----------|---------------------|-----|-----|-----|---------------|
| $t_B$     | Break time          | 190 |     |     | $\mu\text{s}$ |
| $t_{BR}$  | Break recovery time | 40  |     |     | $\mu\text{s}$ |
| $t_{HW1}$ | Host write 1 time   | 0.5 |     | 50  | $\mu\text{s}$ |
| $t_{HW0}$ | Host write 0 time   | 86  |     | 145 | $\mu\text{s}$ |



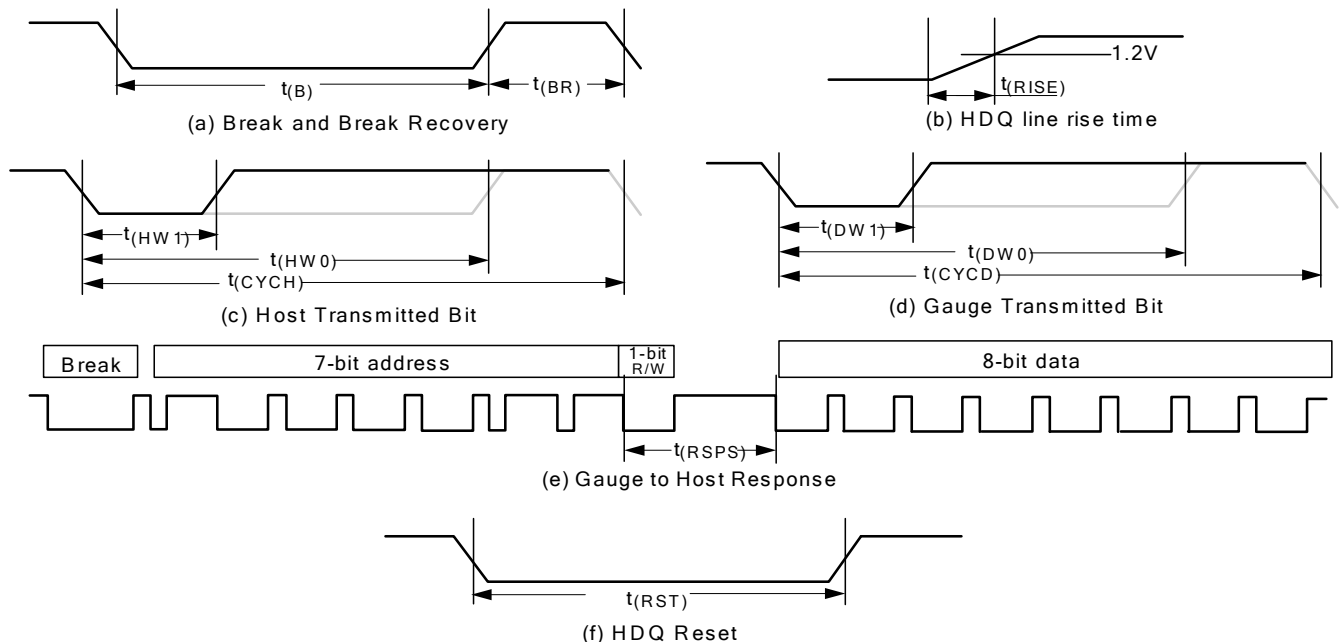
## 6.20 HDQ Timing (continued)

Unless otherwise noted, characteristics noted under conditions of  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

| PARAMETER  | TEST CONDITIONS                 | MIN                                     | NOM | MAX | UNIT          |
|------------|---------------------------------|---|-----|-----|---------------|
| $t_{CYCH}$ | Cycle time, host to device      | Device drives HDQ                       |     | 190 | $\mu\text{s}$ |
| $t_{CYCD}$ | Cycle time, device to Host      | Device drives HDQ                       | 205 | 250 | $\mu\text{s}$ |
| $t_{DW1}$  | Device write 1 time             | Device drives HDQ                       |     | 32  | $\mu\text{s}$ |
| $t_{DW0}$  | Device write 0 time             | Device drives HDQ                       |     | 80  | $\mu\text{s}$ |
| $t_{RSPS}$ | Device response time            | Device drives HDQ                       |     | 190 | $\mu\text{s}$ |
| $t_{TRND}$ | Host turn around time           | Host drives HDQ after device drives HDQ |     | 250 | $\mu\text{s}$ |
| $t_{RISE}$ | HDQ line rising time to logic 1 |   |     | 1.8 | $\mu\text{s}$ |
| $t_{RST}$  | HDQ Reset                       | Host drives HDQ low before device reset |     | 2.2 | s             |



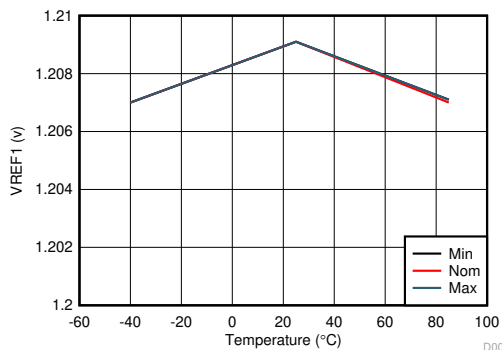
**Figure 6-1. I²C Timing**



- a. HDQ Breaking
- b. Rise time of HDQ line
- c. HDQ Host to fuel gauge communication
- d. Fuel gauge to Host communication
- e. Fuel gauge to Host response format
- f. HDQ Host to fuel gauge

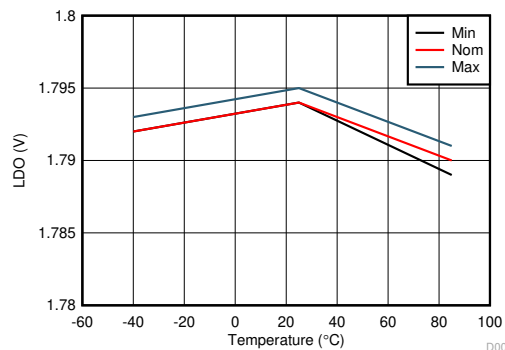
**Figure 6-2. HDQ Timing**

## 6.21 Typical Characteristics



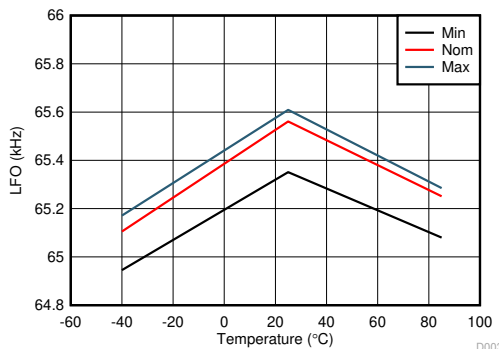
BAT Min = 2 V    BAT Nom = 3.6 V    BAT Max = 5 V

**Figure 6-3. REF1 Voltage Versus Battery and Temperature**



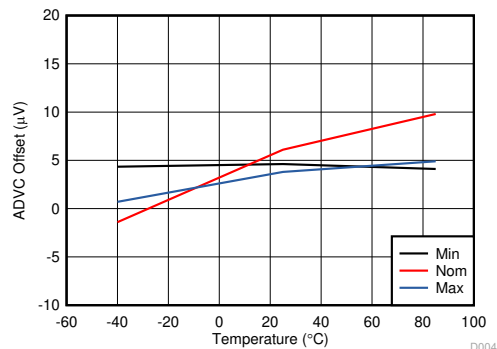
BAT Min = 2 V    BAT Nom = 3.6 V    BAT Max = 5 V

**Figure 6-4. LDO Voltage Versus Battery and Temperature**



BAT Min = 2 V    BAT Nom = 3.6 V    BAT Max = 5 V

**Figure 6-5. LFO Frequency Versus Battery and Temperature**



BAT Min = 2 V    BAT Nom = 3.6 V    BAT Max = 5 V

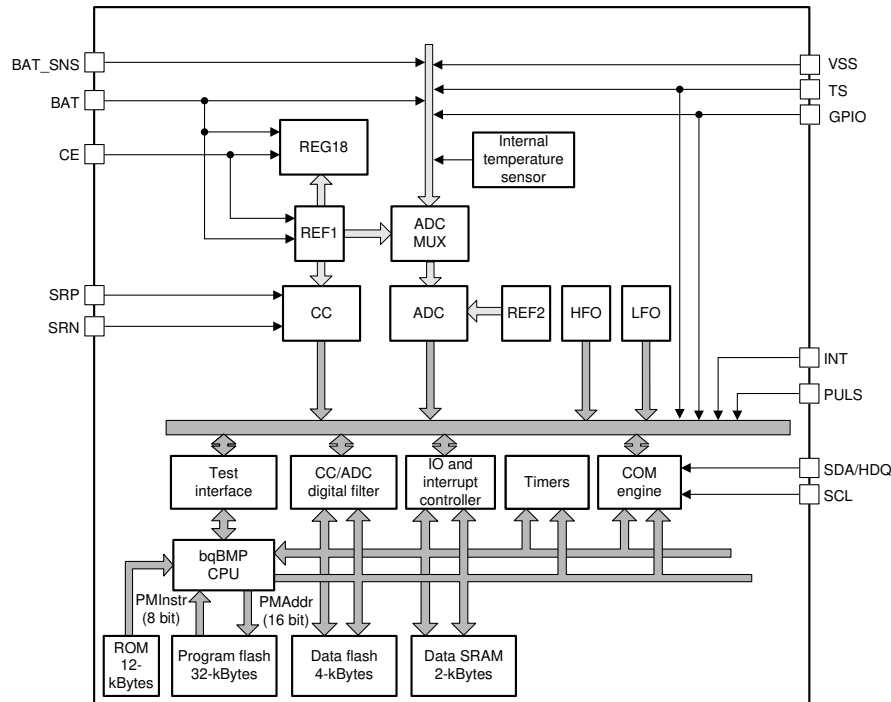
**Figure 6-6. ADCV Offset Voltage Versus Battery and Temperature**

## 7 Detailed Description

### 7.1 Overview

The BQ27Z558 gas gauge is a fully integrated battery manager that employs flash-based firmware to provide a complete solution for battery-stack architectures composed of 1-series cells. The BQ27Z558 device interfaces with a host system through an I<sup>2</sup>C or HDQ protocol. High-performance, integrated analog peripherals enable support for a sense resistor down to 1 mΩ, and simultaneous current/voltage data conversion for instant power calculations. The following sections detail all of the major component blocks included as part of the BQ27Z558 device.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 BQ27Z558 Processor

The BQ27Z558 device uses a custom TI-proprietary processor design that features a Harvard architecture and operates at frequencies up to 4.2 MHz. Using an adaptive, three-stage instruction pipeline, the BQ27Z558 processor supports variable instruction lengths of 8, 16, or 24 bits.

#### 7.3.2 Battery Parameter Measurements

The BQ27Z558 device measures cell voltage and current simultaneously, and also measures temperature to calculate the information related to the following:

- Remaining capacity
- Full charge capacity
- State-of-health
- Other gauging parameters.

##### 7.3.2.1 Coulomb Counter (CC)

The first ADC is an integrating analog-to-digital converter designed specifically for tracking charge and discharge activity, or coulomb counting, of a rechargeable battery. It features a single-channel differential input that converts the voltage difference across a sense resistor between the SRP and SRN pins with a resolution of 3.74 μV.

### 7.3.2.2 CC Digital Filter

The CC digital filter generates a 16-bit conversion value from the delta-sigma CC front end. Its FIR filter uses the HFO clock output. New conversions are available every 1 s.

### 7.3.2.3 ADC Multiplexer

The ADC multiplexer provides selectable connections to the following:

- External pins BAT, BAT\_SNS, TS
- Internal temperature sensor
- Internal reference voltages
- Internal 1.8-V regulator
- VSS ground reference input

In addition, the multiplexer can independently enable the TS input connection to the internal thermistor biasing circuitry, and enables the user to short the multiplexer inputs for test and calibration purposes.

### 7.3.2.4 Analog-to-Digital Converter (ADC)

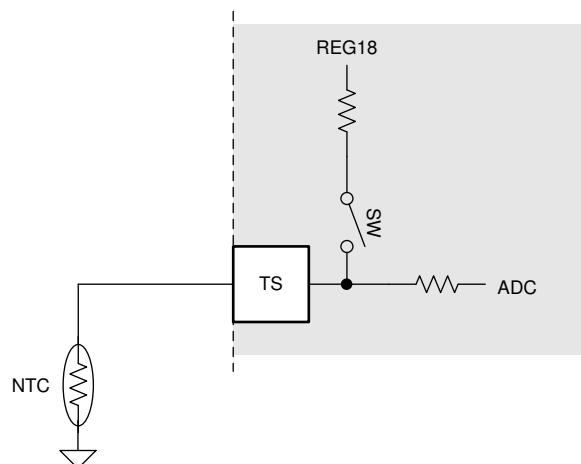
The second ADC is a 16-bit delta-sigma converter designed for general-purpose measurements. The ADC automatically scales the input voltage range during sampling based on channel selection. The converter resolution is a function of its full-scale range and number of bits, yielding a 38- $\mu$ V resolution.

### 7.3.2.5 Internal Temperature Sensor

An internal temperature sensor is available on the BQ27Z558 device to reduce the cost, power, and size of the external components necessary to measure temperature. It is available for connection to the ADC using the multiplexer, and is ideal for quickly determining pack temperature under a variety of operating conditions.

### 7.3.2.6 External Temperature Sensor Support

The TS input is enabled with an internal 18-k $\Omega$  (typical) linearization pullup resistor to support the use of a 10-k $\Omega$  (25°C) NTC external thermistor, such as the Semitec 103AT-2. The NTC thermistor should be connected between VSS and the individual TS pin. The ADC, through its input multiplexer, then takes the analog measurement. If a different thermistor type is required, then changes to configurations might be required.



**Figure 7-1. External Thermistor Biasing**

## 7.3.3 Power Supply Control

The BQ27Z558 device uses the BAT pin as its power source. BAT powers the internal voltage sources that supply references for the device. BAT\_SNS is a noncurrent carrying path and used at the Kelvin reference for BAT.

### 7.3.4 Bus Communication Interface

The BQ27Z558 device has an I<sup>2</sup>C bus communication interface. Alternatively, the BQ27Z558 can be configured to communicate through the HDQ pin (shared with SDA).

---

#### Note

Once the device is switched to the HDQ protocol, it is not reversible.

---

### 7.3.5 Low Frequency Oscillator

The BQ27Z558 device includes a low frequency oscillator (LFO) running at 65.536 kHz.

### 7.3.6 High Frequency Oscillator

The BQ27Z558 includes a high frequency oscillator (HFO) running at 16.78 MHz. It is frequency locked to the LFO output and scaled down to 8.388 MHz with a 50% duty cycle.

### 7.3.7 1.8-V Low Dropout Regulator

The BQ27Z558 device contains an integrated capacitor-less 1.8-V LDO (REG18) that provides regulated supply voltage for the device CPU and internal digital logic.

### 7.3.8 Internal Voltage References

The BQ27Z558 device provides two internal voltage references. REF1 is used by REG18, oscillators, and CC. REF2 is used by the ADC.

### 7.3.9 Gas Gauging

This device uses the Impedance Track™ technology to measure and determine the available charge in battery cells. See the [Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm Application Report](#) for further details.

### 7.3.10 Charge Control Features

This device supports charge control features, such as:

- Reports charging voltage and charging current based on the active temperature range—JEITA temperature ranges T1, T2, T3, T4, T5, and T6
- Provides more complex charging profiles, including subranges within a standard temperature range
- Reports the appropriate charging current required for constant current charging, and the appropriate charging voltage needed for constant voltage charging to a smart charger, using the bus communication interface
- Compensates the charging profile based on the value of *RelativeStateOfCharge()*
- Selects the chemical state-of-charge of each battery cell using the Impedance Track method
- Reports charging faults and indicates charge status through charge and discharge alarms

### 7.3.11 Authentication

This device supports security with the following features, which can be enabled if desired:

- Authentication by the host using the SHA-256 method
- The gas gauge requires SHA-256 authentication before the device can be unsealed or allow full access.

## 7.4 Device Functional Modes

This device supports five modes, but the current consumption varies, based on firmware control of certain functions and modes of operation:

- **NORMAL mode:** In this mode, the device performs measurements, calculations, protections, and data updates in 250-ms intervals. Between these intervals, the device is operating in a reduced power stage to minimize total average current consumption.

- **SLEEP mode:** In this mode, the device performs measurements, calculations, and data updates in adjustable time intervals. Between these intervals, the device is operating in a reduced power stage to minimize total average current consumption.
- **DEEP SLEEP mode:** In this mode, the current is reduced slightly while current and voltage are still measured periodically, with a user-defined time between reads.
- **HIBERNATE mode:** In this mode, the device is completely disabled with CE remaining high. This mode is exited upon two valid communications within a specified time window.
- **OFF mode:** The device is completely disabled by pulling CE low. CE disables the internal voltage rail. All nonvolatile memory is unprotected.

#### 7.4.1 Lifetime Logging Features

The device supports data logging of several key parameters for warranty and analysis:

- Maximum and minimum cell temperature
- Maximum current in CHARGE or DISCHARGE mode
- Maximum and minimum cell voltages
- Total run time (This data is stored with a resolution of two hours.)
- Time spent different temperature ranges (This data is stored with a resolution of two hours.)

#### 7.4.2 Configuration

The device supports accurate data measurements and data logging of several key parameters.

##### 7.4.2.1 Coulomb Counting

The device uses an integrating delta-sigma analog-to-digital converter (ADC) for current measurement. The ADC measures charge and discharge flow of the battery by measuring the voltage across a very small external sense resistor. The integrating ADC measures a bipolar signal from a range of  $-100\text{ mV}$  to  $100\text{ mV}$ , with a positive value when  $V_{(SRP)} - V_{(SRN)}$ , indicating charge current and a negative value indicating discharge current.

The current measurement is performed by measuring the voltage drop across the external sense resistor, which can be as low as  $1\text{ m}\Omega$ , and the polarity of the differential voltage determines if the cell is in the CHARGE or DISCHARGE mode.

##### 7.4.2.2 Cell Voltage Measurements

The BQ27Z558 gas gauge measures the cell voltage at 1-s intervals using the ADC. This measured value is internally scaled for the ADC and is calibrated to reduce any errors due to offsets. This data is also used for calculating the impedance of the cell for Impedance Track gas gauging.

##### 7.4.2.3 Auto Calibration

The auto-calibration feature helps to cancel any voltage offset across the SRP and SRN pins for accurate measurement of the cell voltage, charge/discharge current, and thermistor temperature. The auto-calibration is performed when there is no communication activity for a minimum of 5 s on the bus lines.

##### 7.4.2.4 Temperature Measurements

This device has an internal sensor for on-die temperature measurements, and the ability to support an external temperature measurement through the external NTC on the TS pin. These two measurements are individually enabled and configured.

## 8 Applications and Implementation

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### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

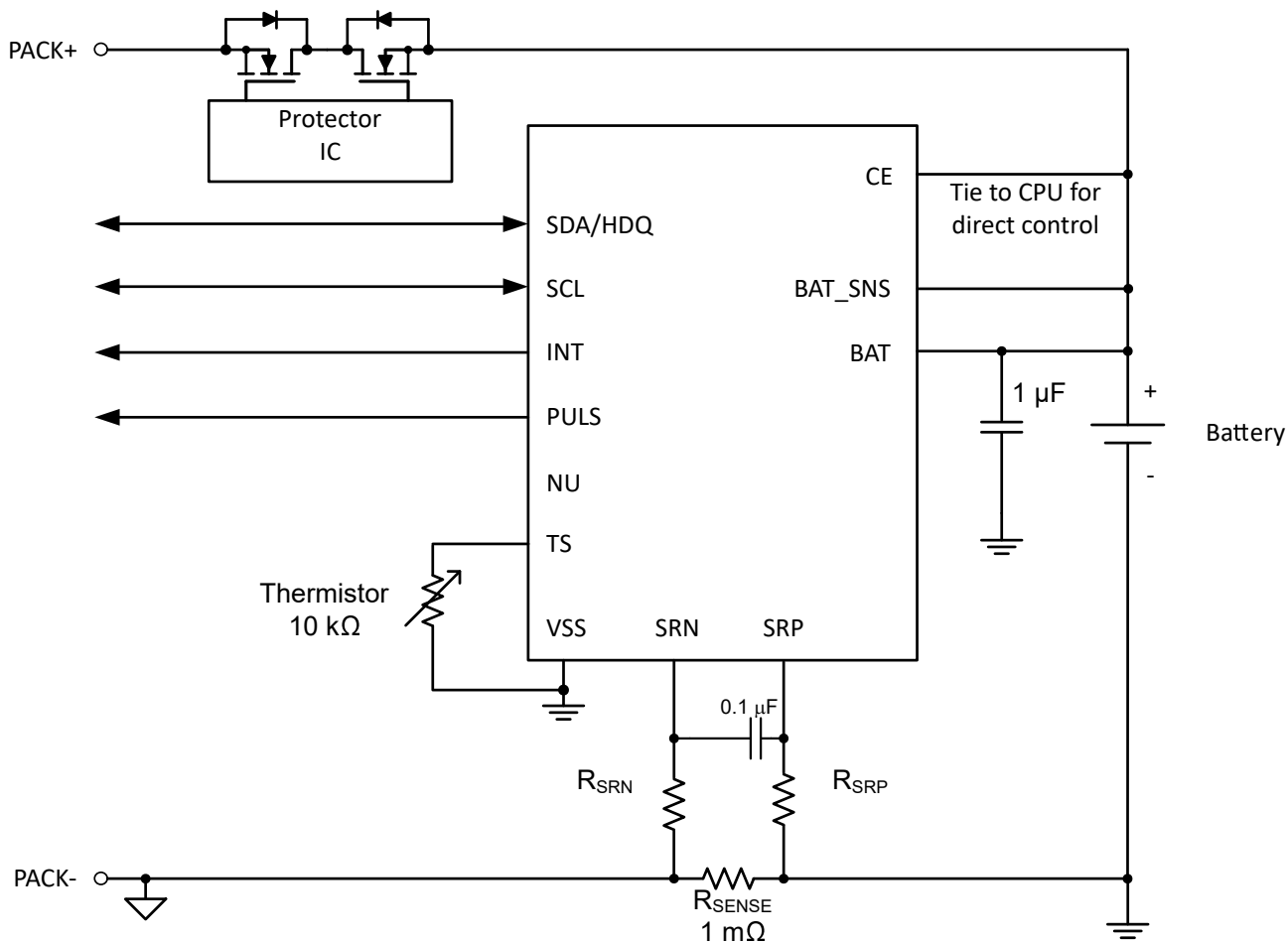
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## 8.1 Application Information

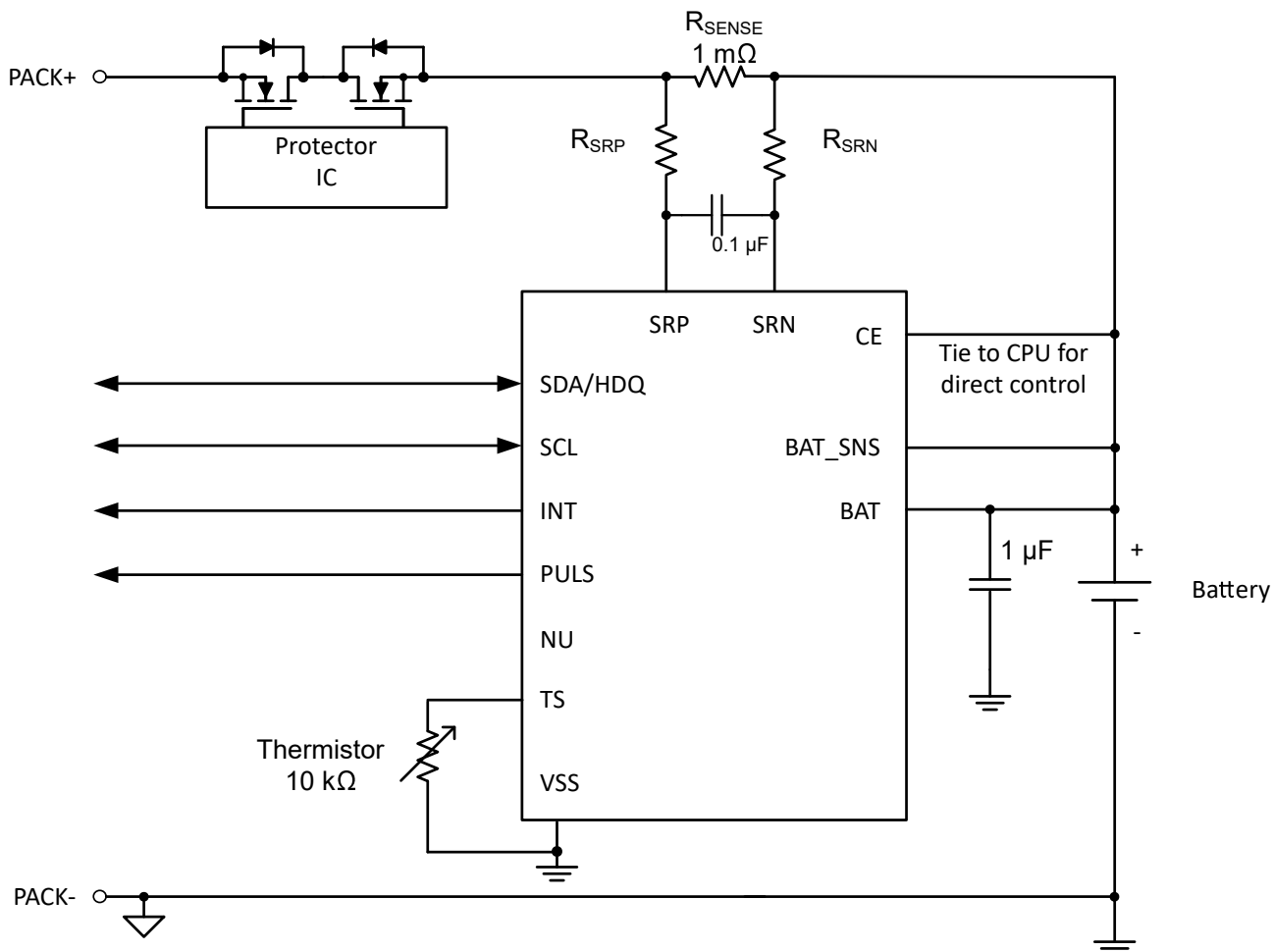
The BQ27Z558 gas gauge can be used with a 1-series Li-ion and Li-polymer battery pack. To implement and design a comprehensive set of parameters for a specific battery pack, customers need Battery Management Studio ([bqSTUDIO](#)), which is a graphical user-interface tool installed on a PC during development. The firmware installed in the product has default values, which are summarized in the [BQ27Z558 Technical Reference Manual](#). Using the bqSTUDIO tool, these default values can be changed to cater to specific application requirements during development once the system parameters, such as enabling and disabling certain features for operation, cell configuration, and chemistry that best matches the cell used, and more, are known. The final flash image, which is extracted once configuration and testing are complete, is used for mass production and is referred to as the "golden image."

## 8.2 Typical Applications

The following is an example BQ27Z558 application schematic for a single-cell battery pack.



**Figure 8-1. BQ27Z558 Typical Implementation with Low-Side Current Sensing**



**Figure 8-2. BQ27Z558 Typical Implementation with High-Side Current Sensing**

### 8.2.1 Design Requirements (Default)

| DESIGN PARAMETER   | EXAMPLE                         |
|--------------------|---------------------------------|
| Cell Configuration | 1s1p (1 series with 1 parallel) |
| Design Capacity    | 5300 mAh                        |
| Device Chemistry   | li-ion                          |
| Design Voltage     | 4000 mV                         |
| Cell Low Voltage   | 2500 mV                         |

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Changing Design Parameters

For the firmware settings needed for the design requirements, refer to the [BQ27Z558 Technical Reference Manual](#).

- To change design capacity, set the data flash value (in mAh) in the **Gas Gauging: Design: Design Capacity** register.
- To set device chemistry, go to the data flash **I<sup>2</sup>C Configuration: Data: Device Chemistry**. The bqStudio software automatically populates the correct chemistry identification. This selection is derived from using the BQCHEM feature in the tools and choosing the option that matches the device chemistry from the list.
- To set the design voltage, go to **Gas Gauging: Design: Design Voltage** register.



- To set the Cell **Low Voltage** or clear the Cell **Low Voltage**, use **Settings: Configuration: Init Voltage Low Set** or **Clear**. This is used to set the cell voltage level that will set (clear) the [VOLT\_LO] bit in the *Interrupt Status* register.
- To enable the internal temperature and the external temperature sensors: Set **Settings: Configuration: Temperature Enable**: Bit 0 (TSInt) = 1 for the internal sensor; set Bit 1 (TS1) = 1 for the external sensor.

### 8.2.3 Calibration Process

The calibration of current, voltage, and temperature readings is accessible by writing 0xF081 or 0xF082 to *ManufacturerAccess()*. A detailed procedure is included in the [BQ27Z558 Technical Reference Manual](#) in the *Calibration* section. The description allows for calibration of cell voltage measurement offset, battery voltage, current calibration, coulomb counter offset, PCB offset, CC gain and capacity gain, and temperature measurement for both internal and external sensors.

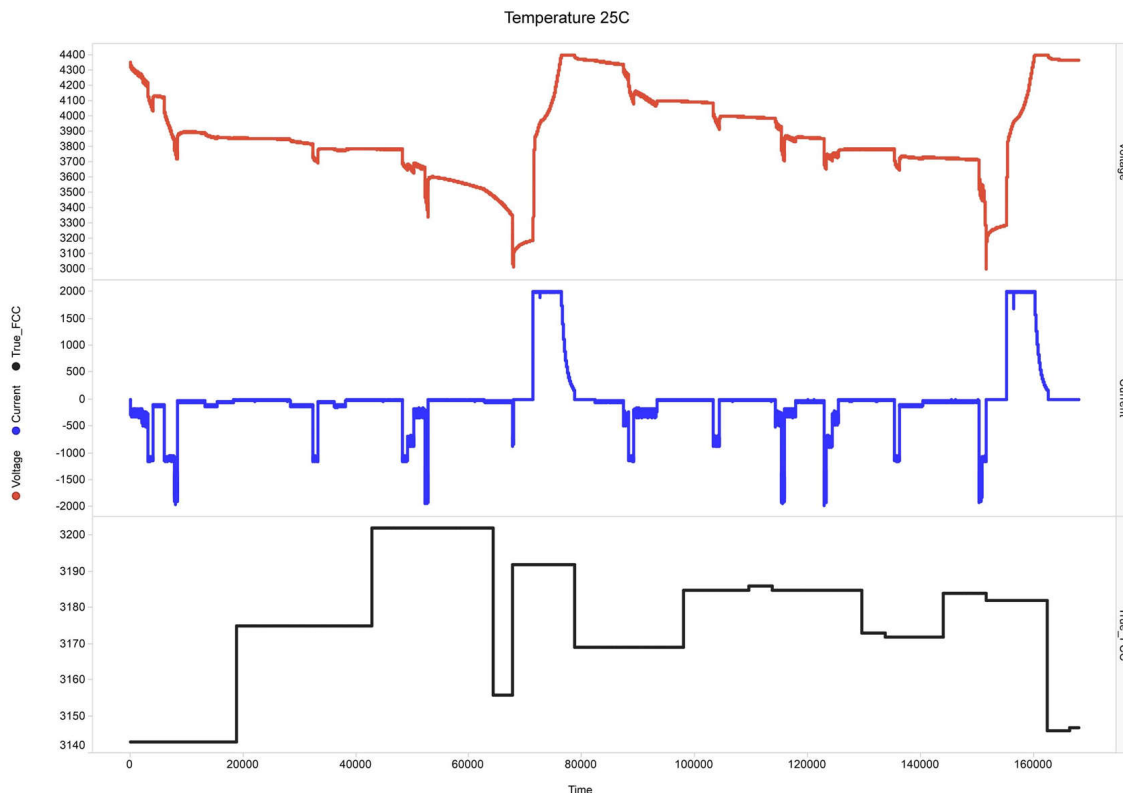
### 8.2.4 Gauging Data Updates

When a battery pack enabled with the BQ27Z558 gas gauge is cycled, the value of *FullChargeCapacity()* updates several times, including the onset of charge or discharge, charge termination, temperature delta, resistance updates during discharge, and relaxation. [Figure 8-3](#) shows actual battery voltage, load current, and *FullChargeCapacity()* when some of those updates occur during a single application cycle.

Update points from the plot include:

- Charge termination at 7900 s
- Relaxation at 9900 s
- Resistance update at 11500 s

#### 8.2.4.1 Application Curve



**Figure 8-3. Full Charge Capacity Tracking (X-Axis Is Seconds)**

## 8.3 Power Supply Recommendations

The only power supply is the BAT pin, which is connected to the positive terminal of the battery. The input voltage for the BAT pin will have a minimum of 2 V to a maximum of 5 V.

## 8.4 Layout

### 8.4.1 Layout Guidelines

- The quality of the Kelvin connections at the sense resistor is critical. The sense resistor must have a temperature coefficient no greater than 50 ppm to minimize current measurement drift with temperature. Choose the value of the sense resistor to correspond to the available overcurrent and short-circuit ranges of the BQ27Z558 gas gauge. Select the smallest value possible to minimize the negative voltage generated on the BQ27Z558 VSS node during a short circuit. This pin has an absolute minimum of  $-0.3$  V. Parallel resistors can be used as long as good Kelvin sensing is ensured. The device is designed to support a  $1\text{-m}\Omega$  to  $3\text{-m}\Omega$  sense resistor.
- BAT\_SNS should be tied directly to the positive connection of the battery. It should not share a path with the BAT pin.
- In reference to the gas gauge circuit the following features require attention for component placement and layout: differential low-pass filter and I<sup>2</sup>C communication.
- The BQ27Z558 gas gauge uses an integrating delta-sigma ADC for current measurements. Add a  $100\text{-}\Omega$  resistor from the sense resistor to the SRP and SRN inputs of the device. Place a  $0.1\text{-}\mu\text{F}$  filter capacitor across the SRP and SRN inputs. If required for a circuit,  $0.1\text{-}\mu\text{F}$  filter capacitors can be added for additional noise filtering for each sense input pin to ground. Place all filter components as close as possible to the device. Route the traces from the sense resistor in parallel to the filter circuit. Adding a ground plane around the filter network can provide additional noise immunity.
- The BQ27Z558 has an internal LDO that is internally compensated and does not require an external decoupling capacitor.
- The I<sup>2</sup>C clock and data pins have integrated high-voltage ESD protection circuits; however, adding a Zener diode and series resistor provides more robust ESD performance. The I<sup>2</sup>C clock and data lines have an internal pulldown. When the gas gauge senses that both lines are low (such as during removal of the pack), the device performs auto-offset calibration and then goes into SLEEP mode to conserve power.

## 8.4.2 Layout Example

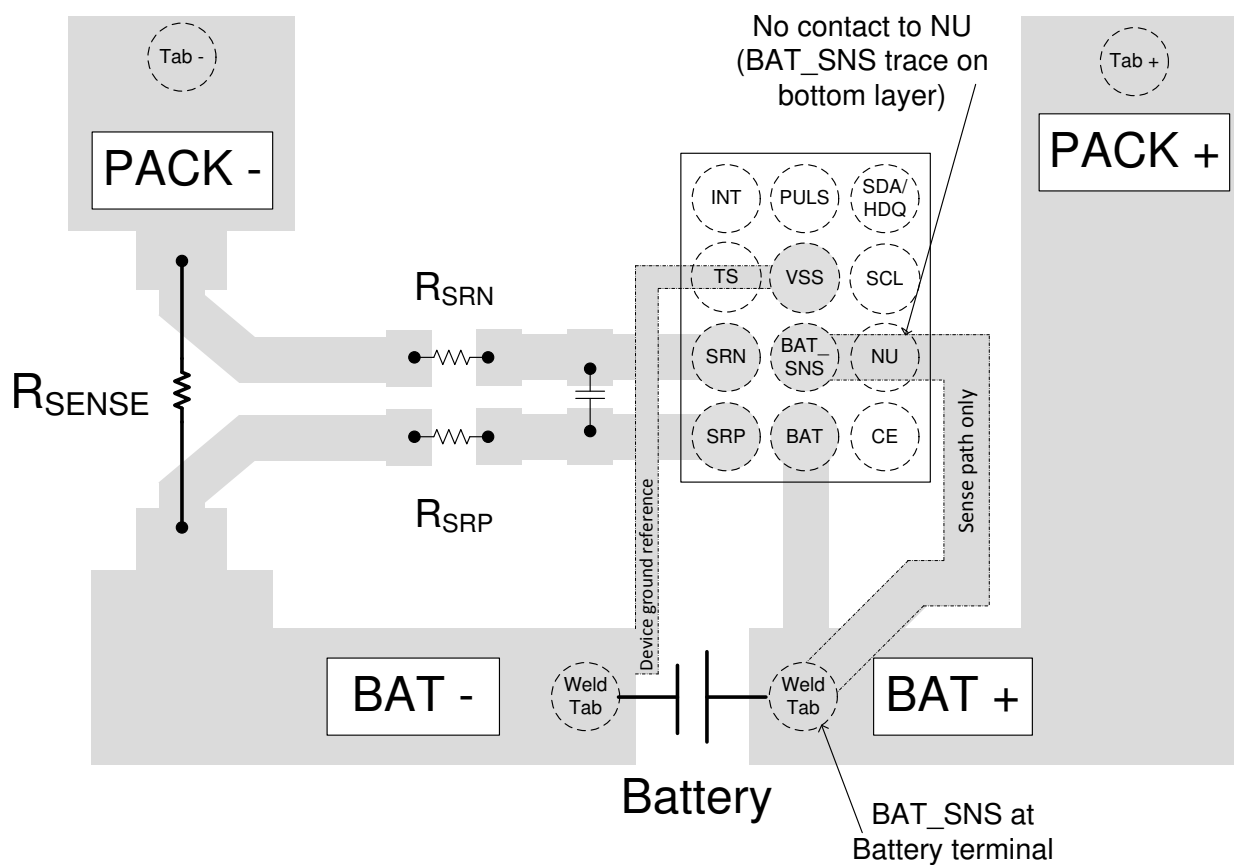


Figure 8-4. BQ27Z558 Key Trace Board Layout

## 9 Device and Documentation Support

### 9.1 Device Support

#### 9.1.1 Third-Party Products Disclaimer

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### 9.2 Documentation Support

#### 9.2.1 Related Documentation

- [BQ27Z558 Technical Reference Manual](#)
- [Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm Application Report](#)

### 9.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on **Alert me** to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 9.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 9.5 Trademarks

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### 9.6 Electrostatic Discharge Caution



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

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 9.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE          | REVISION | NOTES           |
|---------------|----------|-----------------|
| November 2023 | *        | Initial Release |

## 11 Mechanical, Packaging, and Orderable Information

The following page includes mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">BQ27Z558YPHR</a> | Active        | Production           | DSBGA (YPH)   12 | 3000   LARGE T&R      | Yes         | SAC396                               | Level-1-260C-UNLIM                | -40 to 85    | BQ27Z558            |
| BQ27Z558YPHR.A               | Active        | Production           | DSBGA (YPH)   12 | 3000   LARGE T&R      | Yes         | SAC396                               | Level-1-260C-UNLIM                | -40 to 85    | BQ27Z558            |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts 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.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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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

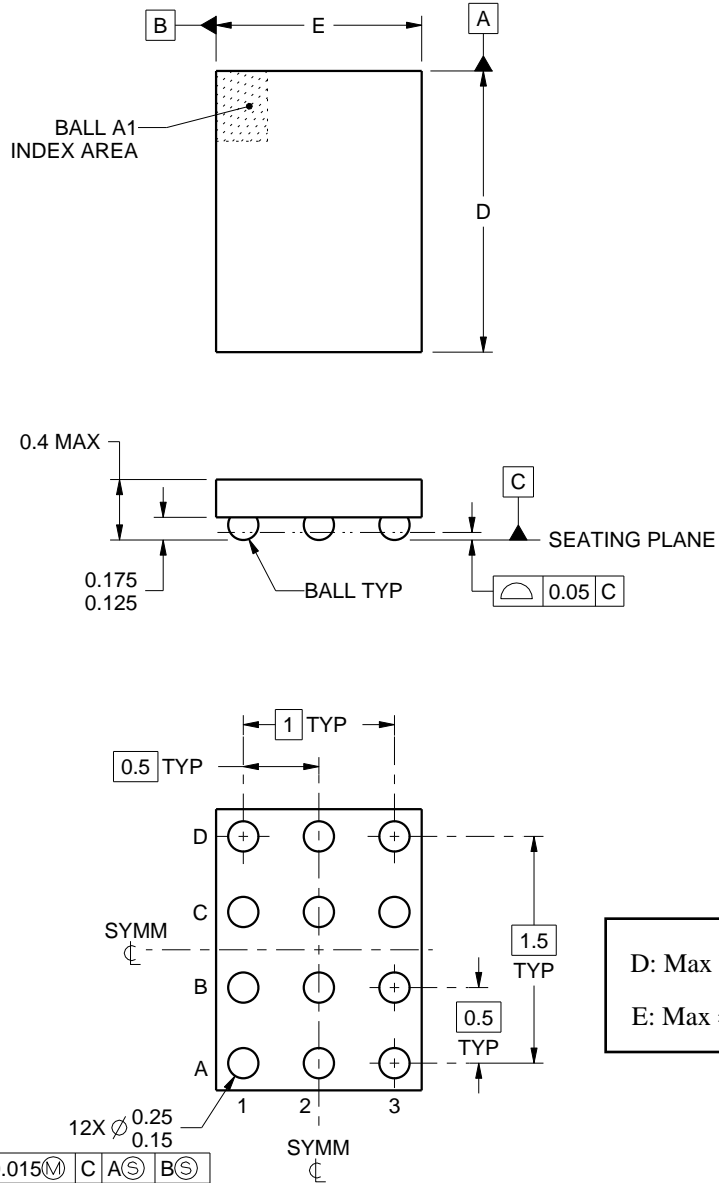
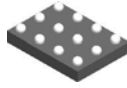
| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ27Z558YPHR | DSBGA        | YPH             | 12   | 3000 | 180.0              | 8.4                | 1.83    | 2.2     | 0.53    | 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) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ27Z558YPHR | DSBGA        | YPH             | 12   | 3000 | 182.0       | 182.0      | 20.0        |



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## NOTES:

NanoFree is a trademark of Texas Instruments.

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. NanoFree™ package configuration.

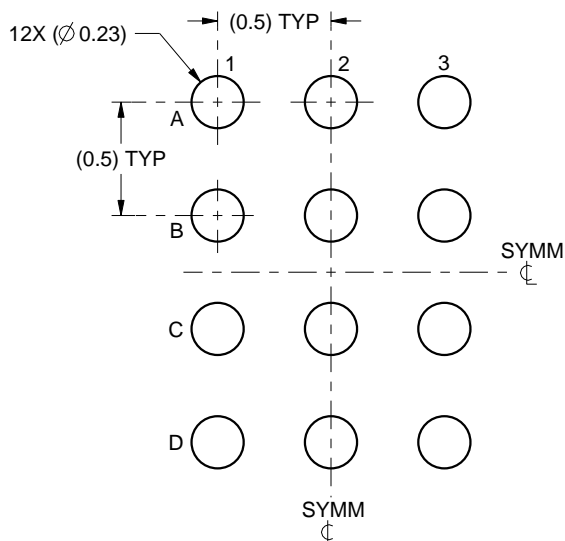


# EXAMPLE BOARD LAYOUT

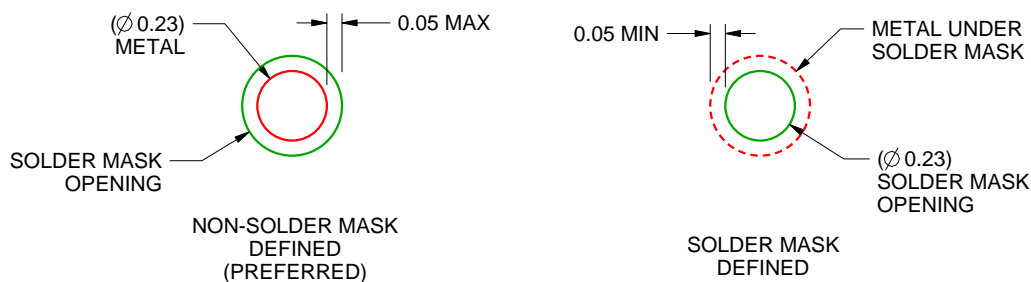
YPH0012

DSBGA - 0.4 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE  
SCALE:30X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

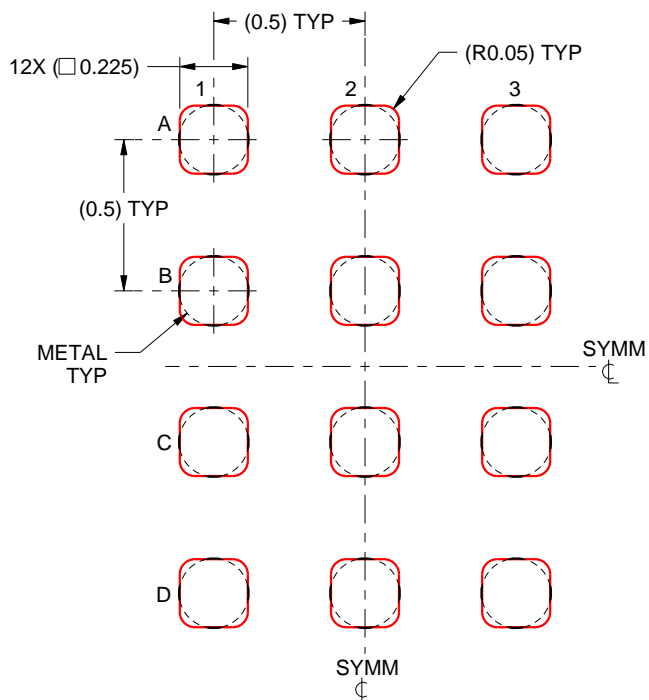
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SNVA009 ([www.ti.com/lit/snva009](http://www.ti.com/lit/snva009)).

## EXAMPLE STENCIL DESIGN

YPH0012

DSBGA - 0.4 mm max height

DIE SIZE BALL GRID ARRAY



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

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NOTES: (continued)

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

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