

# BQ27Z561 Impedance Track™ バッテリー残量計ソリューション

## 1 シリーズ・セル・リチウムイオン・バッテリー・パック用

### 1 特長

- 最小 1mΩ の電流センス抵抗をサポート
- SHA-256 認証レスポンドによるバッテリー・パックのセキュリティ強化
- 2つの独立した ADC
  - 電流と電圧の同時サンプリングに対応
  - 入力オフセット誤差 1μV 未満 (標準値) の高精度クーロン・カウンタ
- 低電圧 (2V) での動作
- パック側での残量測定をサポート
- 広範な電流範囲のアプリケーションに対応 (1mA から 5A 以上まで)
- アクティブ HIGH または LOW の割り込みピン
- 低消費電力モード (一般的なバッテリー・パックの動作範囲の条件)
  - 標準スリープ・モード: 11μA 未満
  - 標準ディープ・スリープ・モード: 9μA 未満
  - 標準オフ・モード: 1.9μA 未満
- 内部および外部の温度検出機能
- 400kHz の I<sup>2</sup>C バス通信インターフェイスによる高速なプログラミングとデータ・アクセス
- HDQ One-Wire によるホストとの通信
- 小型の 12 ピン DSBGA パッケージ (YPH)

### 2 アプリケーション

- スマートフォン
- デジタル・スチル・カメラおよびデジタル・ビデオ・カメラ
- タブレット・コンピュータ
- ポータブルおよびウェアラブル健康管理機器、携帯用オーディオ・デバイス

### 3 概要

テキサス・インスツルメンツの BQ27Z561 Impedance Track™ 残量計ソリューションは高度に統合された、正確な 1 シリーズ・セルの残量計で、フラッシュによりプログラム可能なカスタム RISC (Reduced Instruction-Set CPU) と、リチウムイオンおよびリチウムポリマー・バッテリー・パック用の SHA-256 認証機能が搭載されています。1 シリーズ・セル機能には、容量を増やすための並列セルも含まれています。

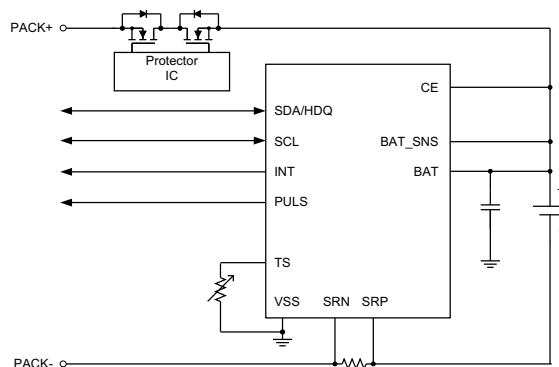
BQ27Z561 残量計は I<sup>2</sup>C 互換および HDQ One-Wire インターフェイスを使用して通信を行い、正確な残量測定アプリケーションに役立つ、いくつかの重要な機能を搭載しています。温度検出機能 (内部および外部のオプション) が内蔵されており、システムとバッテリーの温度を測定できます。内蔵の SHA-256 機能は、システムとパックとの間でセキュアな識別を行うため役立ちます。割り込み機能により、BQ27Z561 は SOC (充電状態)、電圧、または温度の異常が発生したときシステムに簡単に通知できます。低電圧で動作するため、システムはバッテリーが著しく放電した状況でもバッテリーの監視を継続できます。アクティビティの少ない状況では、デバイスを低消費電力のクーロン・カウント (CC) モードに設定できます。このモードでは、デバイスの動作電流が大幅に減少しながら、クーロン・カウントを続行できます。

#### 製品情報<sup>(1)</sup>

型番	パッケージ	本体サイズ (公称)
BQ27Z561	DSBGA (12)	1.67mm × 2.05mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。

#### 概略回路図



## 目次

<b>1</b>	特長 .....	1	6.18	I <sup>2</sup> C Timing — 400 kHz .....	7
<b>2</b>	アプリケーション .....	1	6.19	HDQ Timing .....	8
<b>3</b>	概要 .....	1	6.20	Typical Characteristics .....	10
<b>4</b>	改訂履歴 .....	2	<b>7</b>	<b>Detailed Description</b> .....	10
<b>5</b>	<b>Pin Configuration and Functions</b> .....	3	7.1	Overview .....	10
<b>6</b>	<b>Specifications</b> .....	4	7.2	Functional Block Diagram .....	11
6.1	Absolute Maximum Ratings .....	4	7.3	Feature Description .....	11
6.2	ESD Ratings .....	4	7.4	Device Functional Modes .....	13
6.3	Recommended Operating Conditions .....	4	<b>8</b>	<b>Applications and Implementation</b> .....	14
6.4	Thermal Information .....	4	8.1	Application Information .....	15
6.5	Supply Current .....	5	8.2	Typical Applications .....	15
6.6	Internal 1.8-V LDO (REG18) .....	5	<b>9</b>	<b>Power Supply Requirements</b> .....	17
6.7	I/O (CE, PULS, INT) .....	5	<b>10</b>	<b>Layout</b> .....	17
6.8	Internal Temperature Sensor .....	5	10.1	Layout Guidelines .....	17
6.9	NTC Thermistor Measurement Support .....	5	10.2	Layout Example .....	18
6.10	Coulomb Counter (CC) .....	5	<b>11</b>	<b>デバイスおよびドキュメントのサポート</b> .....	19
6.11	Analog Digital Converter (ADC) .....	6	11.1	ドキュメントのサポート .....	19
6.12	Internal Oscillator Specifications .....	6	11.2	ドキュメントの更新通知を受け取る方法 .....	19
6.13	Voltage Reference1 (REF1) .....	6	11.3	コミュニティ・リソース .....	19
6.14	Voltage Reference2 (REF2) .....	7	11.4	商標 .....	19
6.15	Flash Memory .....	7	11.5	静電気放電に関する注意事項 .....	19
6.16	I <sup>2</sup> C I/O .....	7	11.6	Glossary .....	19
6.17	I <sup>2</sup> C Timing — 100 kHz .....	7	<b>12</b>	<b>メカニカル、パッケージ、および注文情報</b> .....	19

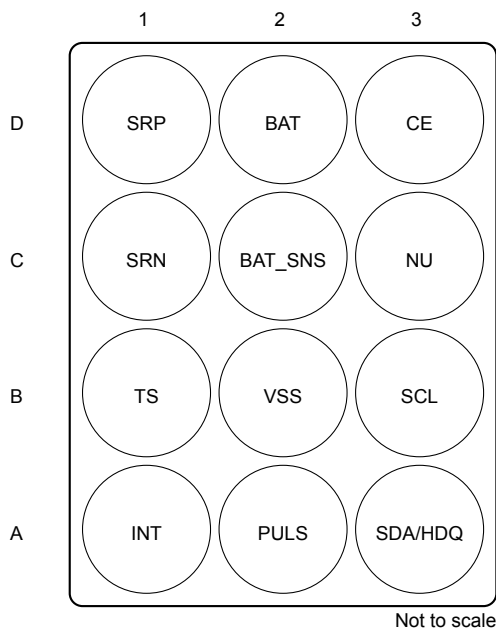
## 4 改訂履歴

Revision A (June 2018) から Revision B に変更

Page

• 「製品情報」の本体サイズを変更 .....	1
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## 5 Pin Configuration and Functions



### Pin Functions

NUMBER	NAME	I/O	DESCRIPTION
D2	BAT	P <sup>(1)</sup>	Battery voltage measurement input. Kelvin battery sense connection to BAT_SNS. Connect a capacitor (1 $\mu$ F) between BAT and VSS. Place the capacitor close to the gauge.
D3	CE	I	Active high chip enable
C2	BAT_SNS	AI	Battery sense
A1	INT	O	Interrupt for voltage, temperature, and state of charge (programmable active high or low)
A2	PULS	O	Programmable pulse width with active high or low option
B1	TS	AI	Temperature input for ADC
C3	NU	NU	Makes no external connection
B3	SCL	I/O	Serial clock for I <sup>2</sup> C interface; requires external pull up when used. It can be left floating if unused.
A3	SDA/HDQ	I/O	Serial data for I <sup>2</sup> C interface and one-wire interface for HDQ (selectable); requires external pull up when used. It can be left floating if unused.
D1	SRP	I	Analog input pin connected to the internal coulomb counter peripheral for integrating a small voltage between SRP (positive side) and SRN
C1	SRN	I	Analog input pin connected to the internal coulomb counter peripheral for integrating a small voltage between SRP (positive side) and SRN.
B2	VSS	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) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 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 JEDEC specification JESD22-C101 <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	$V_{BAT}$	V

### 6.4 Thermal Information

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

THERMAL METRIC <sup>(1)</sup>		BQ27Z561	UNIT
		DSBGA (YPH)	
		(12 PINS)	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	64.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	59.8	
$R_{\theta JB}$	Junction-to-board thermal resistance	52.7	
$\Psi_{JT}$	Junction-to-top characterization parameter	0.3	
$\Psi_{JB}$	Junction-to-board characterization parameter	28.3	
$R_{\theta JC(bot)}$	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 ([SPRA953](#)).

## 6.5 Supply Current

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
$I_{\text{NORMAL}}$	Standard operating Conditions		60		$\mu\text{A}$
$I_{\text{SLEEP}}$	Sense resistor current below SLEEP mode threshold		11		$\mu\text{A}$
$I_{\text{DEEPSLEEP}}$	Sense resistor current below DEEP SLEEP mode threshold		9		$\mu\text{A}$
$I_{\text{OFF}}$	$\text{CE} = V_{\text{IL}}$		0.5		$\mu\text{A}$

## 6.6 Internal 1.8-V LDO (REG18)

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
$V_{\text{REG18}}$	Regulator output voltage	1.6	1.8	2.0	V
$V_{\text{PORth}}$	POR threshold	Rising Threshold		1.7	V
$V_{\text{PORhy}}$	POR hysteresis		0.1		V

## 6.7 I/O (CE, PULS, INT)

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	$V_{\text{REG18}} = 1.8\text{ V}$			V
$V_{\text{IL}}$	Low-level input voltage low	$V_{\text{REG18}} = 1.8\text{ V}$		0.50	V
$V_{\text{OL}}$	Output voltage low for INT/PULS	$V_{\text{REG18}} = 1.8\text{ V}$ , $I_{\text{OL}} = 1\text{ mA}$		0.4	V
$C_1$	Input capacitance		5		pF
$I_{\text{Ikg}}$	Input leakage current			1	$\mu\text{A}$

## 6.8 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	

## 6.9 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/ $^{\circ}\text{C}$

## 6.10 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	
$V_{\text{(CC\_IN)}}$	Input voltage range	-0.1		0.1	V	
$t_{\text{(CC\_CONV)}}$	Conversion time		1000		ms	
	Effective Resolution		1 LSB		$\mu\text{V}$	
	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

## Coulomb Counter (CC) (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
Gain Error drift	15-bit + sign, Over input voltage range		4.3	9.8	LSB/ $^\circ\text{C}$
Effective input resistance		7			$\text{M}\Omega$

## 6.11 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			$\text{M}\Omega$
$t_{(\text{ADC\_CONV})}$ Conversion time			11.7		ms
Effective resolution		14	15		bits

(1) Factory calibration.

## 6.12 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)					
$f_{\text{HFO}}$ Operating frequency			16.78		MHz
$f_{\text{HFO}}$ HFO frequency drift	$T_A = -20^\circ\text{C}$ to $70^\circ\text{C}$	-2.5%		2.5%	
	$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	-3.5		3.5	
$t_{\text{HFOSTART}}$ HFO Start-up time	$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ , oscillator frequency within +/- 3% of nominal frequency or a power-on reset			4	ms
Low Frequency Oscillator (LFO)					
$f_{\text{LFO}}$ Operating frequency			65.536		kHz
$f_{\text{LFO(ERR)}}$ Frequency error	$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$	-2.5%		+2.5%	

## 6.13 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/ $^\circ\text{C}$

(1) Used for CC and LDO

## 6.14 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
$V_{REF2}$	Internal Reference Voltage <sup>(1)</sup>	1.2	1.21	1.22	V
$V_{REF2\_DRIFT}$	Internal Reference Voltage Drift	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		20	PPM/ $^{\circ}\text{C}$

(1) Used for ADC

## 6.15 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
$t_{(ROWPROG)}$	Row programming time			40	$\mu\text{s}$
$t_{(MASSERASE)}$	Mass-erase time	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		40	ms
$t_{(PAGEERASE)}$	Page-erase time	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		40	ms
$I_{FLASHREAD}$	Flash Read Current	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		1	mA
$I_{FLASHWRITE}$	Flash Write Current	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		5	mA
$I_{FLASHERASE}$	Flash Erase Current	$T_A = -40^{\circ}\text{C}$ to $85^{\circ}\text{C}$		15	mA

## 6.16 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
$V_{IH}$	High-level input voltage	SCL, SDA/HDQ, $V_{REG18} = 1.8\text{ V}$		1.26	V
$V_{IL}$	Low-level input voltage low	$V_{REG18} = 1.8\text{ V}$		0.54	V
$V_{OL}$	Low-level output voltage	$I_{OL} = 1\text{ mA}$ , $V_{REG18} = 1.8\text{ V}$		0.36	V
$C_i$	Input capacitance			10	pF
$I_{lkg}$	Input leakage current		1		$\mu\text{A}$

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

PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
$f_{SCL}$	Clock Operating Frequency	SCL duty cycle = 50%		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	10% to 90%		1000	ns
$t_f$	Clock Fall Time	90% to 10%		300	ns
$t_{SU:STO}$	Setup time STOP Condition	4.0			$\mu\text{s}$
$t_{BUF}$	Bus free time STOP to START	4.7			$\mu\text{s}$

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

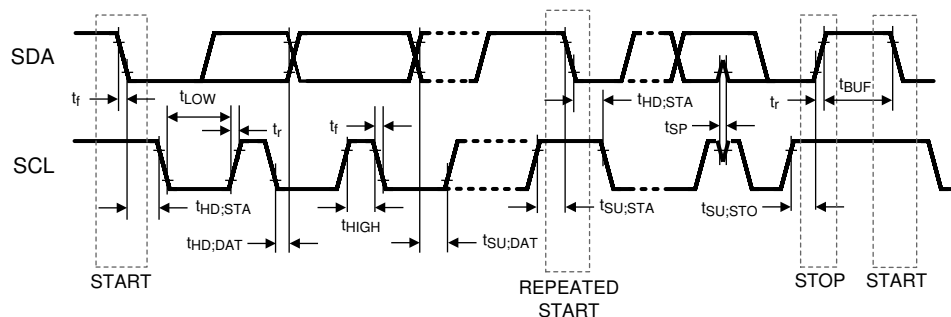
PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
$f_{SCL}$	Clock Operating Frequency	SCL duty cycle = 50%		400	kHz
$t_{HD:STA}$	START Condition Hold Time	0.6			$\mu\text{s}$

**I<sup>2</sup>C Timing — 400 kHz (continued)**

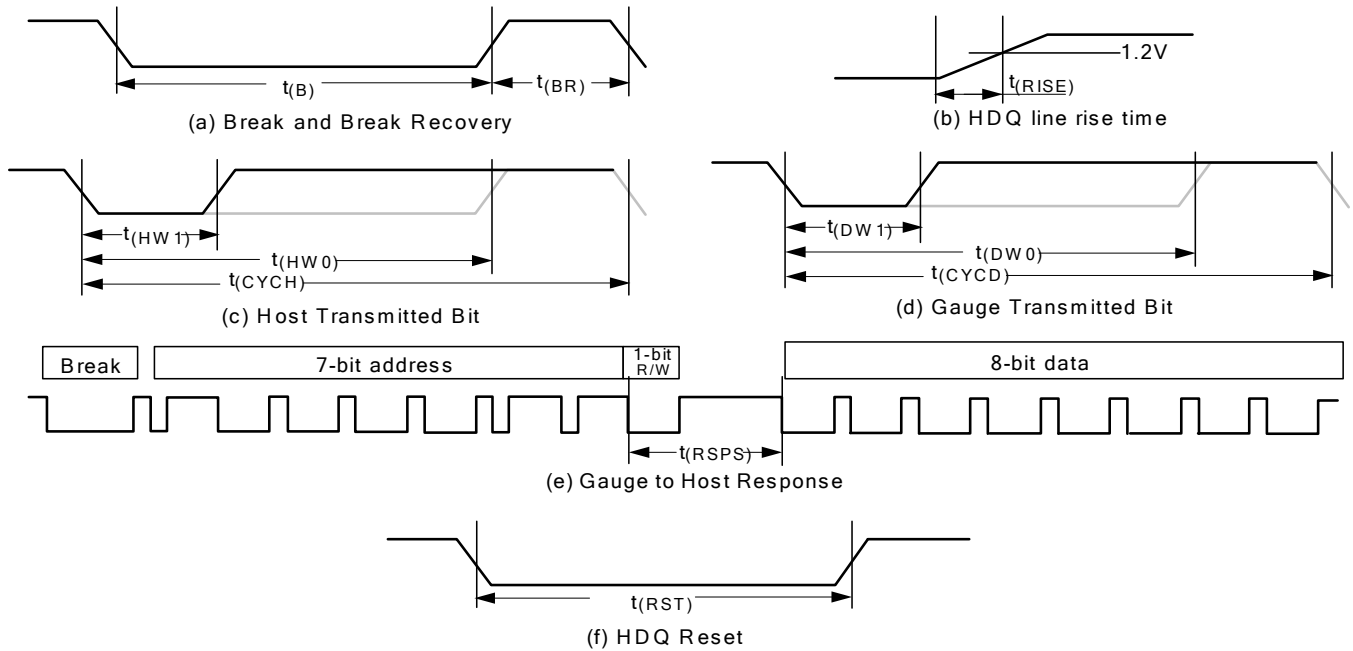
PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
$t_{LOW}$	Low period of the SCL Clock		1.3		$\mu$ s
$t_{HIGH}$	High period of the SCL Clock		600		ns
$t_{SU:STA}$	Setup repeated START		600		ns
$t_{HD:DAT}$	Data hold time (SDA input)		0		ns
$t_{SU:DAT}$	Data setup time (SDA input)		100		ns
$t_r$	Clock Rise Time	10% to 90%		300	ns
$t_f$	Clock Fall Time	90% to 10%		300	ns
$t_{SU:STO}$	Setup time STOP Condition		0.6		$\mu$ s
$t_{BUF}$	Bus free time STOP to START		1.3		$\mu$ s

**6.19 HDQ Timing**

PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
$t_B$	Break Time		190		$\mu$ s
$t_{BR}$	Break Recovery Time		40		$\mu$ s
$t_{HW1}$	Host Write 1 Time	Host drives HDQ		50	$\mu$ s
$t_{HW0}$	Host Write 0 Time	Host drives HDQ		145	$\mu$ s
$t_{CYCH}$	Cycle Time, Host to device	Device drives HDQ			$\mu$ s
$t_{CYCD}$	Cycle Time, device to Host	Device drives HDQ	205	250	$\mu$ s
$t_{DW1}$	Device Write 1 Time	Device drives HDQ		50	$\mu$ s
$t_{DW0}$	Device Write 0 Time	Device drives HDQ		145	$\mu$ s
$t_{RSPS}$	Device Response Time	Device drives HDQ		950	$\mu$ s
$t_{TRND}$	Host Turn Around Time	Host drives HDQ after device drives HDQ	250		$\mu$ s
$t_{RISE}$	HDQ Line Rising Time to Logic 1			1.8	$\mu$ s
$t_{RST}$	HDQ Reset	Host drives HDQ low before device reset	2.2		s


**Figure 1. I<sup>2</sup>C Timing**

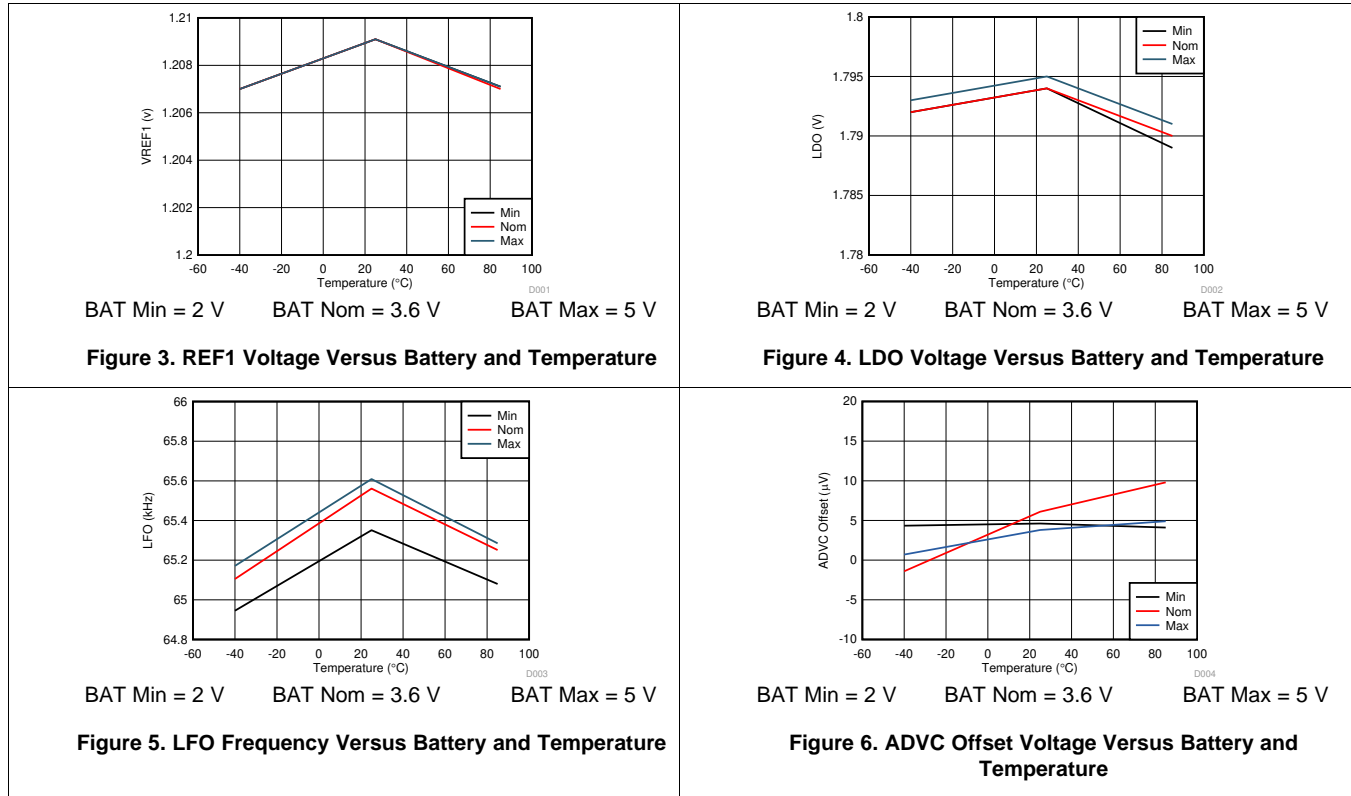




- a. HDQ Breaking
- b. Rise time of HDQ line
- c. HDQ Host to fuel gauge communication
- d. Fuel gauge to Host communication
- e. Fuel gauge to Host response format
- f. HDQ Host to fuel gauge

Figure 2. HDQ Timing

## 6.20 Typical Characteristics

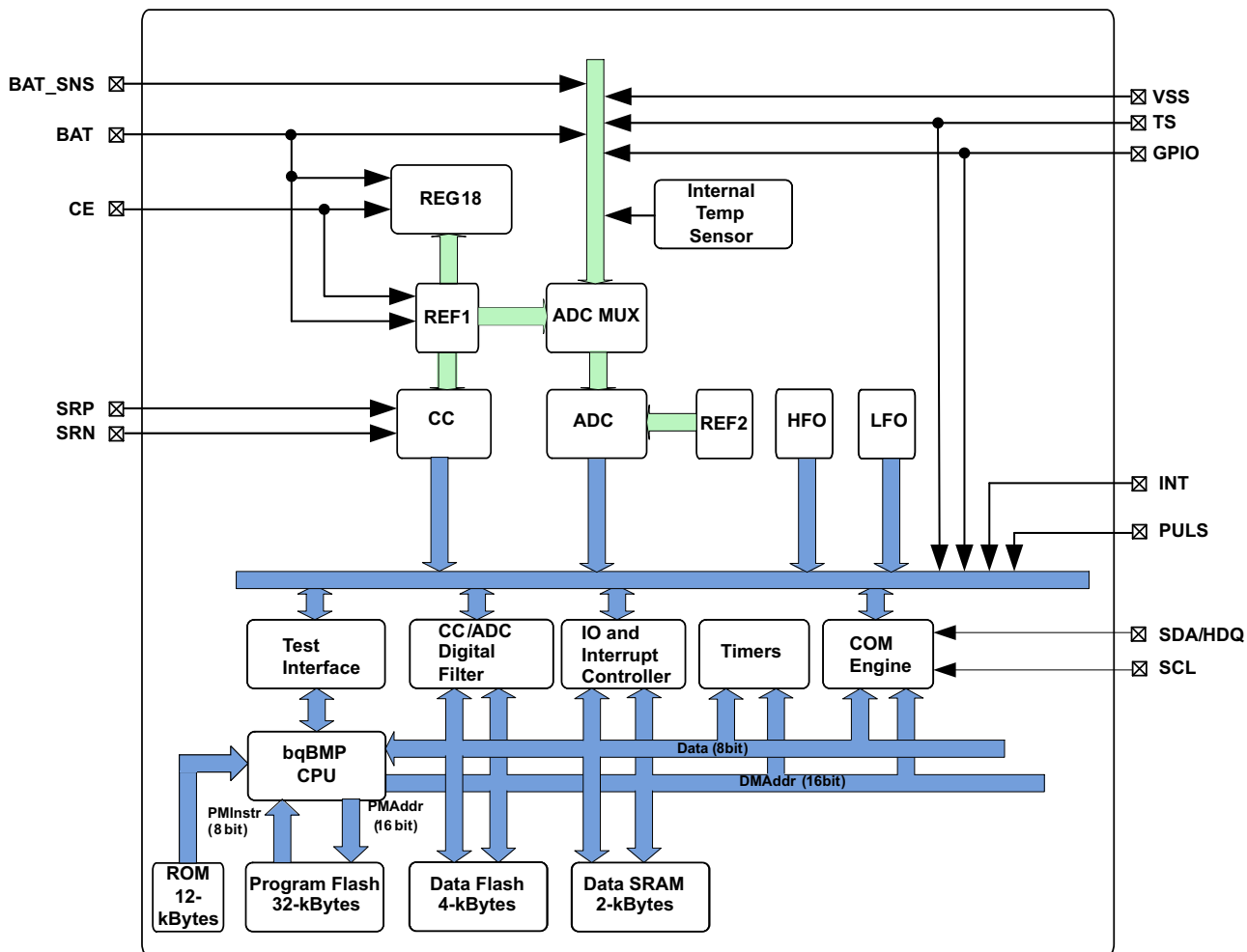


## 7 Detailed Description

### 7.1 Overview

The BQ27Z561 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 BQ27Z561 device interfaces with a host system via 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 BQ27Z561 device.

## 7.2 Functional Block Diagram



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## 7.3 Feature Description

### 7.3.1 BQ27Z561 Processor

The BQ27Z561 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 BQ27Z561 processor supports variable instruction lengths of 8, 16, or 24 bits.

### 7.3.2 Battery Parameter Measurements

The BQ27Z561 device measures cell voltage and current simultaneously, and also measures temperature to calculate the information related to remaining capacity, full charge capacity, state-of-health, and 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 terminals with a resolution of 3.74  $\mu$ V.

## Feature Description (continued)

### 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 external pins BAT, BAT\_SNS, TS, the internal temperature sensor, internal reference voltages, internal 1.8-V regulator, and 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)

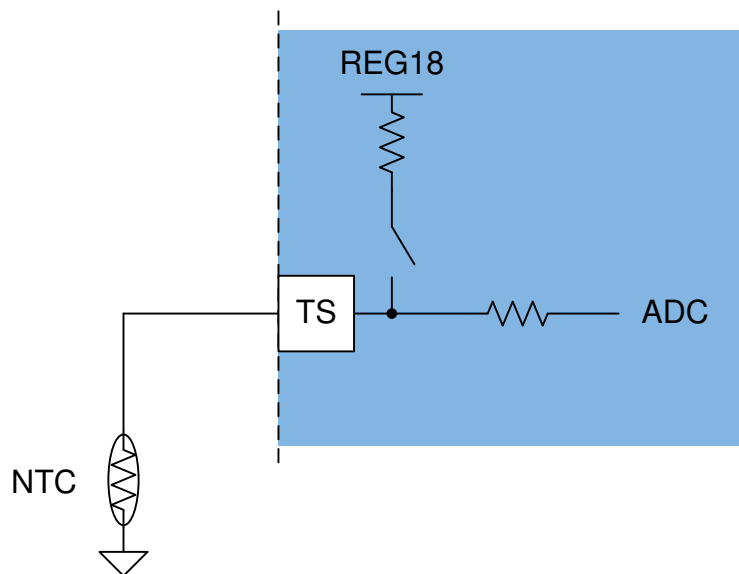
The second ADC is a 16-bit delta-sigma converter designed for general-purpose measurements. The ADC automatically scales the input voltage range during sampling based on channel selection. The converter resolution is a function of its full-scale range and number of bits, yielding a 38- $\mu$ V resolution.

### 7.3.2.5 Internal Temperature Sensor

An internal temperature sensor is available on the BQ27Z561 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 $\Omega$  (Typ.) linearization pull-up 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 analog measurement is then taken via the ADC through its input multiplexer. If a different thermistor type is required, then changes to configurations may be required.



**Figure 7. External Thermistor Biasing**

### 7.3.3 Power Supply Control

The BQ27Z561 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 non-current carrying path and used at the Kelvin reference for BAT.

## Feature Description (continued)

### 7.3.4 Bus Communication Interface

The BQ27Z561 device has an I<sup>2</sup>C bus communication interface. Alternatively, the BQ27Z561 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 BQ27Z561 device includes a low frequency oscillator (LFO) running at 65.536 kHz.

### 7.3.6 High Frequency Oscillator

The BQ27Z561 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 BQ27Z561 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 BQ27Z561 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 (SLUA450)* 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 sub-ranges 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
- Selects the chemical state-of-charge of each battery cell using the Impedance Track method
- Reports charging faults and indicates charge status via 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 four 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 every 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

## Device Functional Modes (continued)

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.
- OFF mode: The device is completely disabled by pulling CE low. CE disables the internal voltage rail. All non-volatile 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

### 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/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 BQ27Z561 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 via the external NTC on the TS pin. These two measurements are individually enabled and configured.

## 8 Applications and Implementation

### 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. Customers should validate and test their design implementation to confirm system functionality.

## 8.1 Application Information

The BQ27Z561 gas gauge can be used with a 1-series li-ion/Li Polymer battery pack. To implement and design a comprehensive set of parameters for a specific battery pack, the user needs 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 *BQ27Z561 Technical Reference Manual (SLUUB07)*. Using the bqStudio tool, these default values can be changed to cater to specific application requirements during development once the system parameters, such as enable/disable of certain features for operation, cell configuration, chemistry that best matches the cell used, and more are known. The final flash image, which is extracted once configuration and testing are complete, will be used for mass production and is referred to as the "golden image."

## 8.2 Typical Applications

The following is an example BQ27Z561 application schematic for a single-cell battery pack.

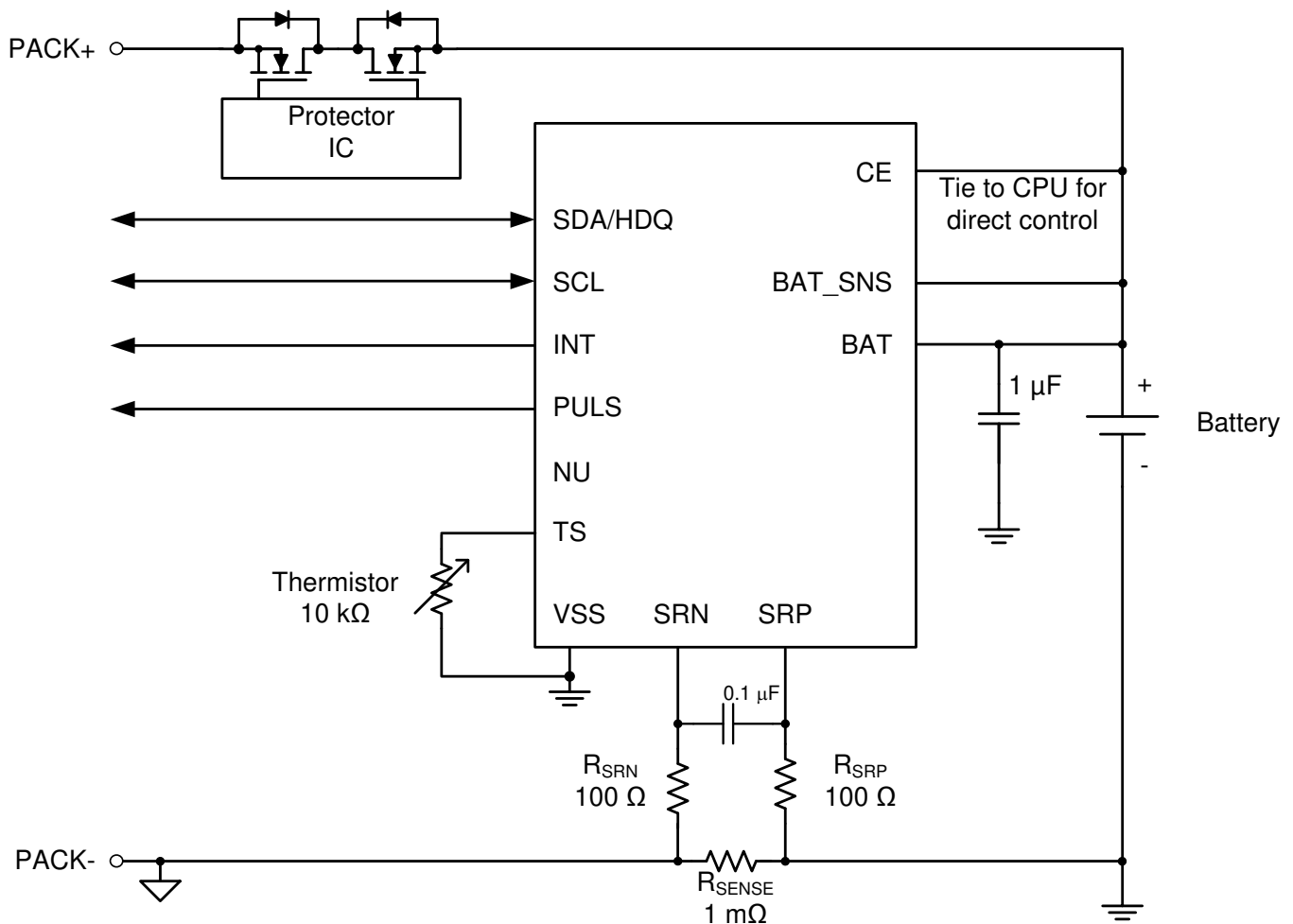


Figure 8. BQ27Z561 1-Series Cell Typical Implementation

### 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

## Typical Applications (continued)

Design Parameter	Example
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 *BQ27Z561 Technical Reference Manual (SLUUB07)*.

- 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 **FC 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 *BQ27Z561 Technical Reference Manual (SLUUB07)* 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/capacity gain, and temperature measurement for both internal and external sensors.

#### 8.2.4 Gauging Data Updates

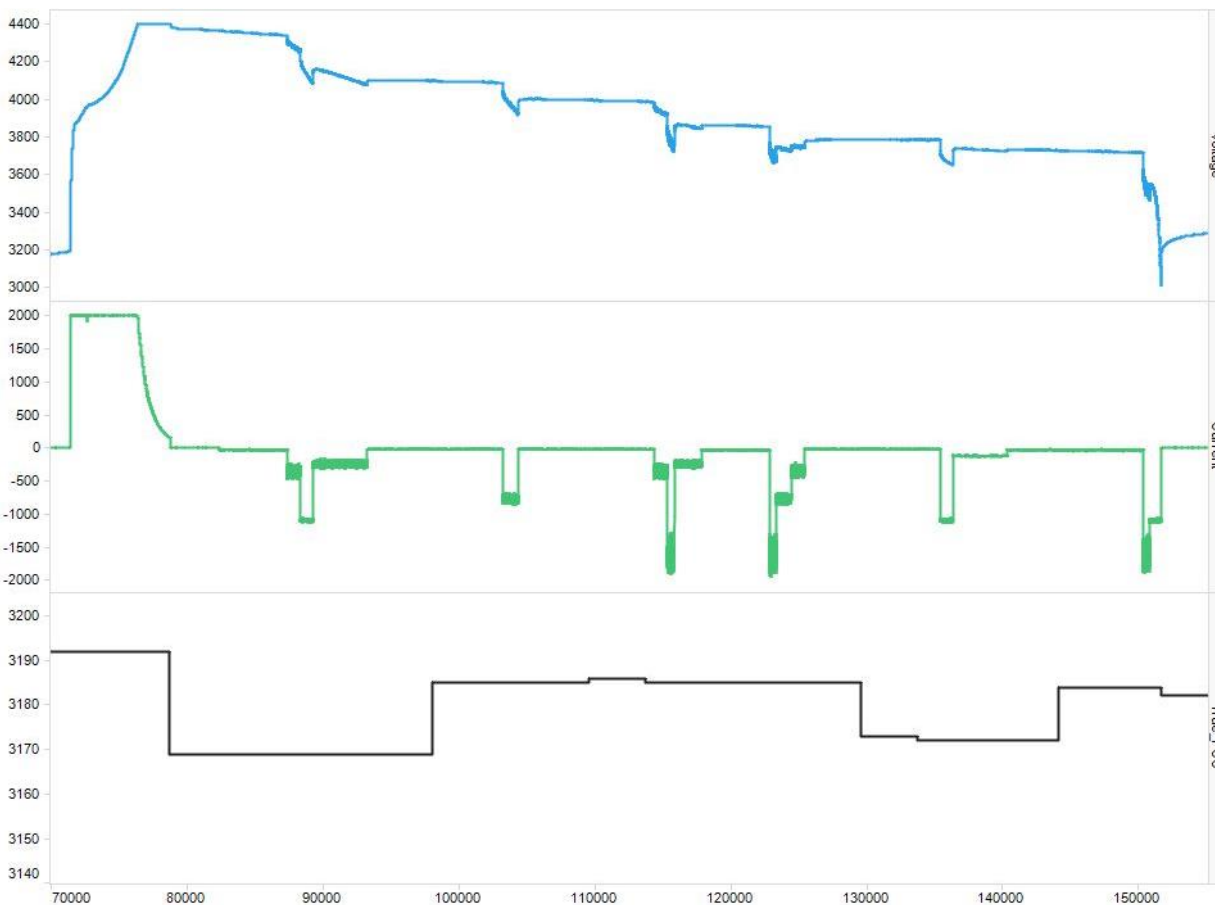
When a battery pack enabled with the BQ27Z561 gas gauge is cycled, the value of *FullChargeCapacity()* updates several times, including the onset of charge or discharge, charge termination, temperature delta, resistance updates during discharge, and relaxation. [Figure 9](#) shows actual battery voltage, 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 9. Full Charge Capacity Tracking (X-Axis Is Seconds)**

## 9 Power Supply Requirements

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.

## 10 Layout

### 10.1 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 BQ27Z561 gas gauge. Select the smallest value possible to minimize the negative voltage generated on the BQ27Z561 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-m $\Omega$  to 3-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 BQ27Z561 gas gauge uses an integrating delta-sigma ADC for current measurements. Add a 100- $\Omega$  resistor from the sense resistor to the SRP and SRN inputs of the device. Place a 0.1- $\mu$ F filter capacitor



## 11 デバイスおよびドキュメントのサポート

### 11.1 ドキュメントのサポート

#### 11.1.1 関連資料

- 『*BQ27z561 Technical Reference*』(英語) ([SLUUB07](#))
- 『*Theory and Implementation of Impedance Track Battery Fuel-Gauging Algorithm Application Report*』(英語) ([SLUA364](#))

### 11.2 ドキュメントの更新通知を受け取る方法

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### 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 メカニカル、パッケージ、および注文情報

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**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">BQ27Z561YPHR</a>	Active	Production	DSBGA (YPH)   12	3000   LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	BQ27Z561
BQ27Z561YPHR.Z	Active	Production	DSBGA (YPH)   12	3000   LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	BQ27Z561
<a href="#">BQ27Z561YPHT</a>	Active	Production	DSBGA (YPH)   12	250   SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	BQ27Z561
BQ27Z561YPHT.Z	Active	Production	DSBGA (YPH)   12	250   SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	BQ27Z561

<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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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**

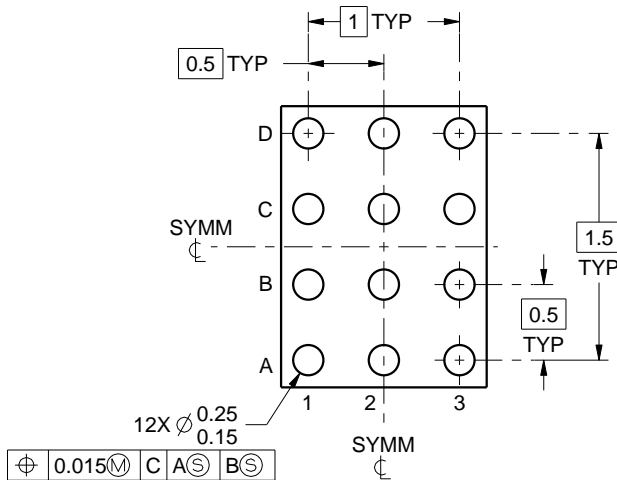
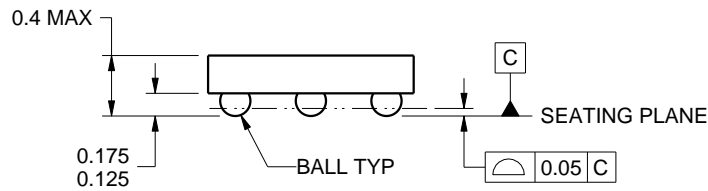
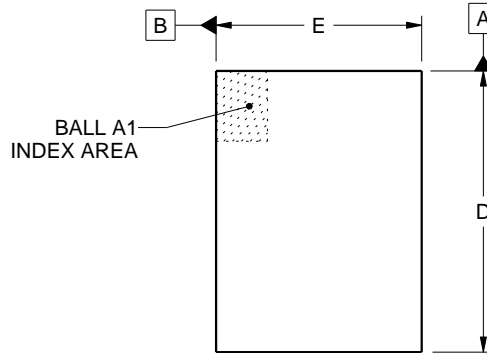
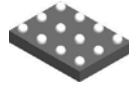

\*All dimensions are nominal

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
BQ27Z561YPHR	DSBGA	YPH	12	3000	180.0	8.4	1.83	2.2	0.53	4.0	8.0	Q1
BQ27Z561YPHT	DSBGA	YPH	12	250	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)
BQ27Z561YPHR	DSBGA	YPH	12	3000	182.0	182.0	20.0
BQ27Z561YPHT	DSBGA	YPH	12	250	182.0	182.0	20.0



D: Max = 2.08 mm, Min = 2.02 mm  
 E: Max = 1.705 mm, Min = 1.644 mm

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NOTES:

NanoFree is a trademark of Texas Instruments.

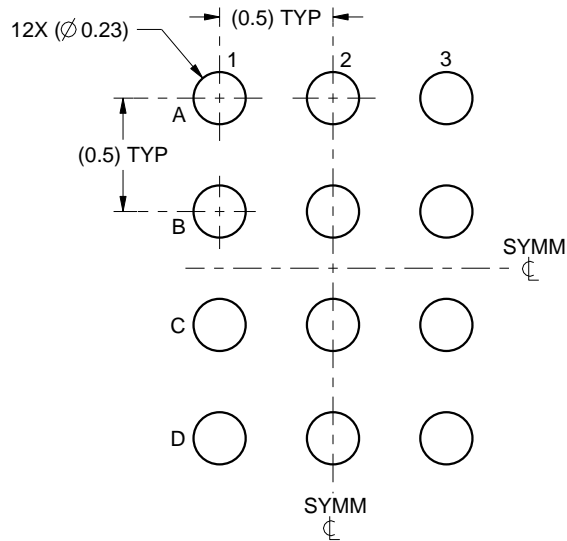
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. NanoFree™ package configuration.

# EXAMPLE BOARD LAYOUT

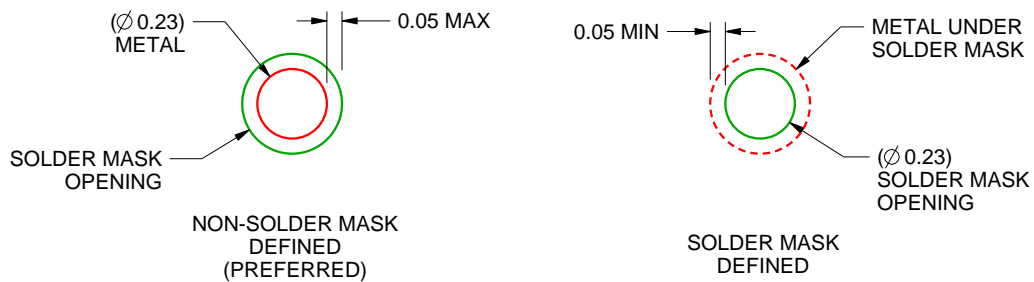
YPH0012

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)

- 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](http://www.ti.com/lit/snva009)).

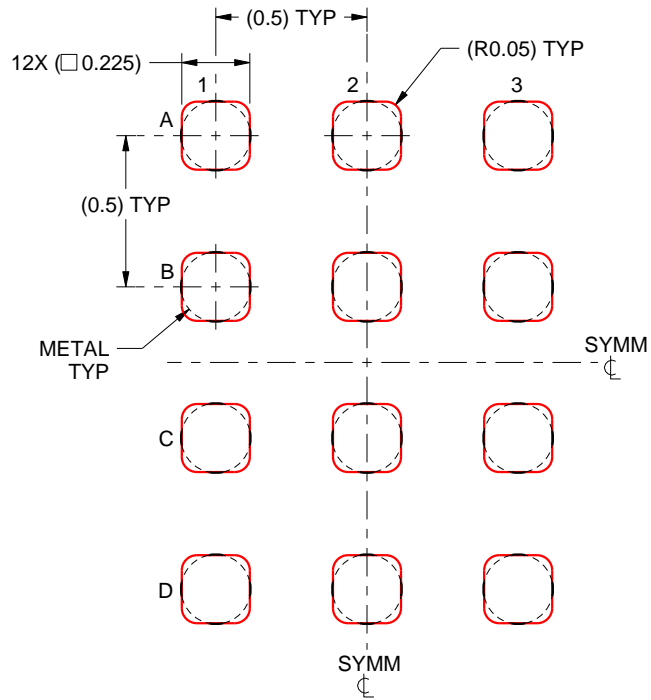


# EXAMPLE STENCIL DESIGN

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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