BQ27427 System-Side Impedance Track™ Fuel Gauge With Integrated Sense Resistor

1 Features

- Single-cell Li-ion battery fuel gauge
  - Resides on system board
  - Supports embedded or removable batteries
  - Powers directly from the battery with integrated LDO
  - Integrates low-value sense resistor: 7mΩ
- Ultra low power consumption
  - NORMAL mode: 50μA
  - SLEEP mode: 9μA
- Battery fuel gauging based on patented Impedance Track™ technology
  - Provides three selectable preprogrammed profiles for 4.2V, 4.35V, and 4.4V cells
  - Reports remaining capacity and state-of-charge (SOC) with smoothing filter
  - Adjusts automatically for battery aging, self-discharge, temperature, and rate changes
  - Estimates battery state-of-health (aging)
- Microcontroller peripheral interface supports:
  - I^2C serial interface: 400kHz
  - Configurable SoC interrupt or battery low digital output warning
  - Internal temperature sensor or host reported temperature or external thermistor

2 Applications

- Smartphones, feature phones, and tablets
- Wearables
- Building automation
- Portable medical and industrial handsets
- Portable audio
- Gaming

3 Description

The Texas Instruments BQ27427 battery fuel gauge is a single-cell gauge that requires minimal user-configuration and system microcontroller firmware development, leading to quick system bring-up.

Three chemistry profiles are preprogrammed to enable minimal user-configuration and to help manage user inventory across projects with different battery chemistries. The BQ27427 battery fuel gauge has very low sleep power consumption, leading to longer battery run time. Configurable interrupts help to save system power and free the host from continuous polling. An external thermistor supports accurate temperature sensing.

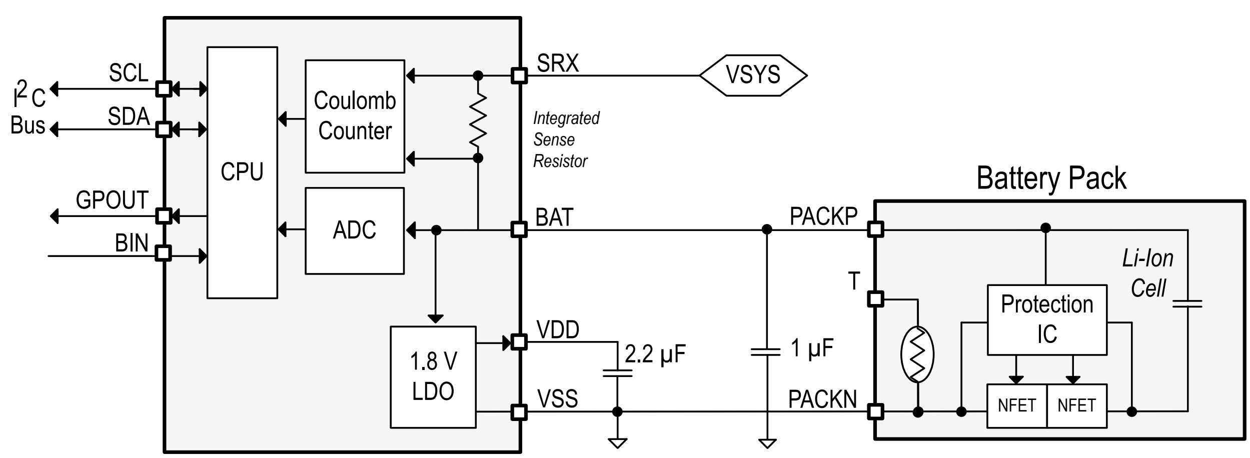
The BQ27427 battery fuel gauge uses the patented Impedance Track™ algorithm for fuel gauging, and provides information such as remaining battery capacity (mAh), state-of-charge (%), and battery voltage (mV).

Battery fuel gauging with the BQ27427 fuel gauge requires connections only to PACK+ (P+) and PACK– (P–) for a removable battery pack or embedded battery circuit. The tiny, 9-ball, 1.62mm × 1.58mm, 0.5mm pitch NanoFree™ chip scale package (DSBGA) is appropriate for space-constrained applications.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
BQ27427	DSBGA (YZF, 9)	1.62mm × 1.58mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Schematic

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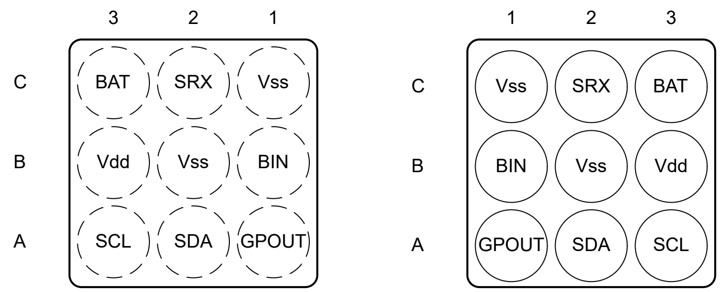


Figure 4-1. Top and Bottom View

Table 4-1. Pin Functions

PIN		TYPE[(1)]	DESCRIPTION
NAME	**NUMBER**		
BAT	C3	PI, AI	LDO regulator input and battery voltage measurement input. Kelvin sense connect to positive battery terminal (PACKP). Connect a capacitor (1µF) between BAT and V_{SS}. Place the capacitor close to the gauge.
BIN	B1	DI	Battery insertion detection input. If ***OpConfig [BI_PU_EN]*** = 1 (default), a logic low on the pin is detected as battery insertion. For a removable pack, the BIN pin can be connected to V_{SS} through a pulldown resistor on the pack, typically the 10kΩ thermistor; the system board should use a 1.8MΩ pullup resistor to V_{DD} to verify the BIN pin is high when a battery is removed. If the battery is embedded in the system, leave ***[BI_PU_EN]*** = 1 and use a 10kΩ pulldown resistor from BIN to V_{SS}. If ***[BI_PU_EN]*** = 0, then the host must inform the gauge of battery insertion and removal with the *BAT_INSERT* and *BAT_REMOVE* subcommands. Place a 10kΩ pulldown resistor between BIN and V_{SS}, even if this pin is unused. **NOTE:** Do not short the BIN pin directly to V_{CC} or V_{SS} and verify that any pullup resistor on the BIN pin only connects to V_{DD} and not an external voltage rail. If an external thermistor is used for temperature input, verify that the thermistor connected between this pin and V_{SS}.
GPOUT	A1	DO	This open-drain output can be configured to indicate BAT_LOW when the ***OpConfig [BATLOWEN]*** bit is set. By default ***[BATLOWEN]*** is cleared and this pin performs an interrupt function (SOC_INT) by pulsing for specific events, such as a change in state-of-charge. Signal polarity for these functions is controlled by the ***[GPIOPOL]*** configuration bit. This pin should not be left floating, even if unused; therefore, a 10kΩ pullup resistor is recommended. If the device is in SHUTDOWN mode, toggling GPOUT will make the gauge exit SHUTDOWN. Connect GPOUT to a GPIO of the host MCU so that in case of any inadvertent shutdown condition, the gauge can be commanded to come out of SHUTDOWN.
SCL	A3	DIO	Peripheral I^2C serial bus for communication with system (primary). Open-drain pins. Use with external 10kΩ pullup resistors (typical) for each pin. If the external pullup resistors are disconnected from these pins during normal operation, use external 1MΩ pulldown resistors to V_{SS} at each pin to avoid floating inputs.
SDA	A2	DIO	
SRX	C2	AI	Integrated high-side sense resistor and coulomb counter input, connected between battery pack and system power rail VSYS.
V_{DD}	B3	PO	1.8V regulator output. Decouple with 2.2µF ceramic capacitor to V_{SS}. This pin is not intended to provide power for other devices in the system.
V_{SS}	B2, C1	PI	Ground pin

(1) IO = Digital input-output, AI = Analog input, P = Power connection

5 Specifications

5.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
V_{BAT}	BAT pin input voltage range	–0.3	6	V
V_{SRX}	SRX pin input voltage range	V_{BAT} – 0.3	V_{BAT} + 0.3	V
V_{DD}	V_{DD} pin supply voltage range (LDO output)	–0.3	2	V
V_{IOD}	Open-drain IO pins (SDA, SCL)	–0.3	6	V
V_{IOPP}	Push-pull IO pins (BIN)	–0.3	V_{DD} + 0.3	V
T_A	Operating free-air temperature range	–40	85	°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.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[1]	±1500	V
		Charged-device model (CDM), per JEDEC specification ANSI/ESDA/JEDEC JS-002[2]	±250	

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

T_A = 30°C and V_{REGIN} = V_{BAT} = 3.6V (unless otherwise noted)

			MIN	NOM	MAX	UNIT
C_{BAT} [1]	External input capacitor for internal LDO between BAT and V_{SS}	Nominal capacitor values specified. Recommend a 5% ceramic X5R-type capacitor located close to the device.		0.1		µF
C_{LDO18} [1]	External output capacitor for internal LDO between V_{DD} and V_{SS}			2.2		µF
V_{PU} [1]	External pullup voltage for open-drain pins (SDA, SCL, GPOUT)		1.62		3.6	V

(1) Specified by design. Not production tested.

5.4 Thermal Information

THERMAL METRIC[1]		BQ27427 YZF (DSBGA) 9 PINS	UNIT
$R_{θJA}$	Junction-to-ambient thermal resistance	107.8	°C/W
$R_{θJCtop}$	Junction-to-case (top) thermal resistance	0.7	°C/W
$R_{θJB}$	Junction-to-board thermal resistance	60.4	°C/W
$Ψ_{JT}$	Junction-to-top characterization parameter	3.5	°C/W
$Ψ_{JB}$	Junction-to-board characterization parameter	60.4	°C/W
$R_{θJCbot}$	Junction-to-case (bottom) thermal resistance	NA	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics Application Report*, SPRA953.

5.5 Supply Current

T_A = 30°C and V_{REGIN} = V_{BAT} = 3.6V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC} (1)	NORMAL mode current	I_{LOAD} > ***Sleep Current*** (2)		50		µA
I_{SLP} (1)	SLEEP mode current	I_{LOAD} < ***Sleep Current*** (2)		9		µA
I_{SD} (1)	SHUTDOWN mode current	Fuel gauge in host commanded SHUTDOWN mode. (LDO regulator output disabled)		0.6		µA

(1) Specified by design. Not production tested.
(2) Wake Comparator Disabled.

5.6 Digital Input and Output DC Characteristics

T_A = –40°C to 85°C, typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IH(OD)}$	Input voltage, high(2)	External pullup resistor to V_{PU}	V_{PU} × 0.7			V
$V_{IH(PP)}$	Input voltage, high (3)		1.4			V
V_{IL}	Input voltage, low(2) (3)				0.6	V
V_{OL}	Output voltage, low(2)				0.6	V
I_{OH}	Output source current, high(2)				0.5	mA
$I_{OL(OD)}$	Output sink current, low(2)				–3	mA
C_{IN} (1)	Input capacitance(2) (3)				5	pF
I_{lkg}	Input Leakage Current (SCL, SDA, BIN, GPOUT)				1	µA

(1) Specified by design. Not production tested.
(2) Open Drain pins: (SCL, SDA, GPOUT)
(3) Push-Pull pin: (BIN)

5.7 LDO Regulator, Wake-up, and Auto-Shutdown DC Characteristics

T_A = –40°C to 85°C, typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted) (1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{BAT}	BAT pin regulator input		2.45		4.5	V
V_{DD}	Regulator output voltage			1.85		V
$UVLO_{IT+}$	V_{BAT} undervoltage lock-out LDO wake-up rising threshold			2		V
$UVLO_{IT-}$	V_{BAT} undervoltage lock-out LDO auto-shutdown falling threshold			1.95		V
V_{WU+} (1)	GPOUT (input) LDO Wake-up rising edge threshold(2)	LDO Wake-up from SHUTDOWN mode	1.2			V

(1) Specified by design. Not production tested.
(2) If the device is commanded to SHUTDOWN via I^2C with V_{BAT} > $UVLO_{IT+}$, a wake-up rising edge trigger is required on GPOUT.

5.8 LDO Regulator, Wake-up, and Auto-Shutdown AC Characteristics

T_A = –40°C to 85°C, typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{SHDN} (1)	SHUTDOWN entry time	Time delay from SHUTDOWN command to LDO output disable.			250	ms
t_{SHUP} (1)	SHUTDOWN GPOUT low time	Minimum low time of GPOUT (input) in SHUTDOWN before WAKEUP	10			µs
t_{VDD} (1)	Initial V_{DD} output delay			13		ms

5.8 LDO Regulator, Wake-up, and Auto-Shutdown AC Characteristics (continued)

T_A = –40°C to 85°C, typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{WUVDD} (1)	Wake-up V_{DD} output delay	Time delay from rising edge of GPOUT (input) to nominal V_{DD} output		8		ms
t_{PUCD}	Power-up communication delay	Time delay from rising edge of REGIN to the Active state. Includes firmware initialization time		250		ms

(1) Specified by design. Not production tested.

5.9 ADC (Temperature and Cell Measurement) Characteristics

T_A = –40°C to 85°C; typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted) (1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{IN(BAT)}$	BAT pin voltage measurement range	Voltage divider enabled	2.45		4.5	V
t_{ADC_CONV}	Conversion time			125		ms
	Effective resolution			15		bits

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

5.10 Integrating ADC (Coulomb Counter) Characteristics

T_A = –40°C to 85°C; typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted) (1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{SR}	Input voltage range from BAT to SRX pins			BAT ± 25		mV
t_{SR_CONV}	Conversion time	Single conversion		1		s
	Effective Resolution	Single conversion		16		bits

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

5.11 Integrated Sense Resistor Characteristics, –40°C to 85°C

T_A = –40°C to 85°C; typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted) (1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SRX_{RES} (2)	Resistance of Integrated Sense Resistor from SRX to V_{SS}	T_A = 30°C		7		mΩ
I_{SRX} (1)	Recommended sense resistor input current.	Long term RMS, average device utilization			2000	mA
		Peak RMS current, 10% device utilization, –40°C to 70°C(3)			3500	
		Peak RMS current, 10% device utilization, –40°C to 85°C(3)			2500	mA
		Peak pulsed current, 250ms max, 1% device utilization, –40°C to 70°C(3)			4500	
		Peak pulsed current, 250ms max, 1% device utilization, –40°C to 85°C(3)			3500	mA

(1) Specified by design; not tested in production.
(2) Firmware compensation applied for temperature coefficient of resistor.
(3) Device utilization is the long-term usage profile at a specific condition compared to the average condition.

5.12 I²C-Compatible Interface Communication Timing Characteristics

T_A = –40°C to 85°C; typical values at T_A = 30°C and V_{REGIN} = 3.6V (unless otherwise noted)

			MIN	NOM	MAX	UNIT
STANDARD MODE (100kHz)						
$t_{d(STA)}$	Start to first falling edge of SCL		4			µs
$t_{w(L)}$	SCL pulse duration (low)		4.7			µs
$t_{w(H)}$	SCL pulse duration (high)		4			µs
$t_{su(STA)}$	Setup for repeated start		4.7			µs
$t_{su(DAT)}$	Data setup time	Host drives SDA	250			ns
$t_{h(DAT)}$	Data hold time	Host drives SDA	0			ns
$t_{su(STOP)}$	Setup time for stop		4			µs
$t_{(BUF)}$	Bus free time between stop and start	Includes Command Waiting Time	66			µs
t_f	SCL or SDA fall time(1)				300	ns
t_r	SCL or SDA rise time(1)				300	ns
f_{SCL}	Clock frequency(2)				100	kHz
FAST MODE (400kHz)						
$t_{d(STA)}$	Start to first falling edge of SCL		600			ns
$t_{w(L)}$	SCL pulse duration (low)		1300			ns
$t_{w(H)}$	SCL pulse duration (high)		600			ns
$t_{su(STA)}$	Setup for repeated start		600			ns
$t_{su(DAT)}$	Data setup time	Host drives SDA	100			ns
$t_{h(DAT)}$	Data hold time	Host drives SDA	0			ns
$t_{su(STOP)}$	Setup time for stop		600			ns
$t_{(BUF)}$	Bus free time between stop and start	Includes Command Waiting Time	66			µs
t_f	SCL or SDA fall time(1)				300	ns
t_r	SCL or SDA rise time(1)				300	ns
f_{SCL}	Clock frequency(2)				400	kHz

(1) Specified by design. Not production tested.
(2) If the clock frequency (f_{SCL}) is > 100kHz, use 1-byte write commands for proper operation. All other transactions types are supported at 400kHz. (See Section 6.3.1.1 and Section 6.3.1.3.)

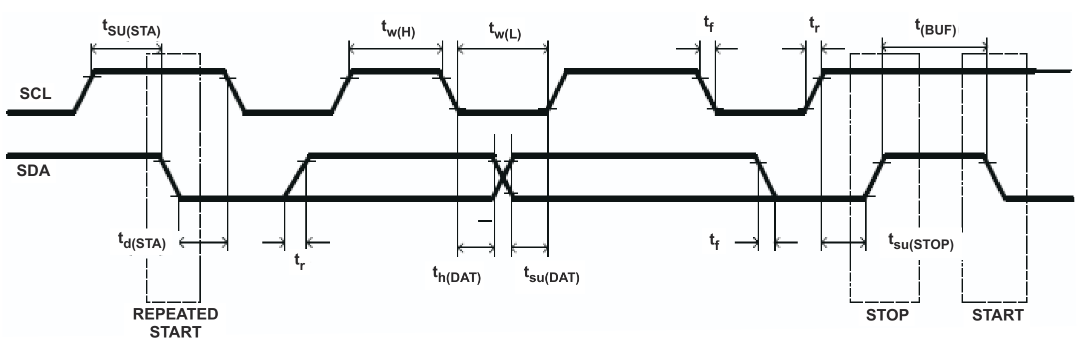
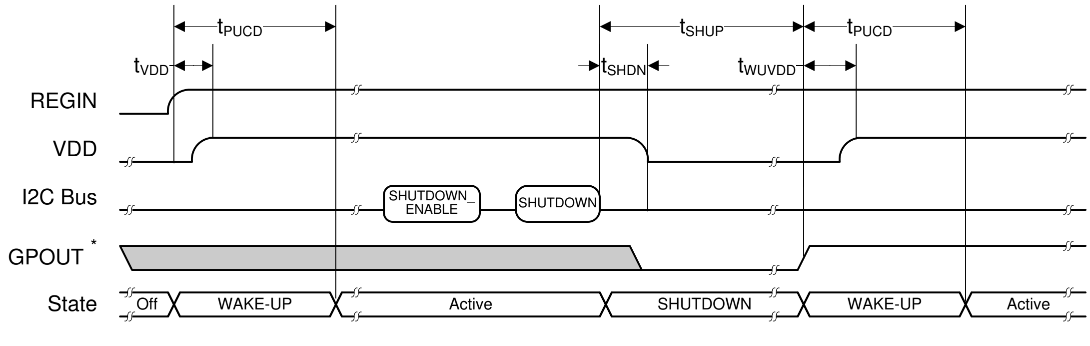


Figure 5-1. I²C-Compatible Interface Timing Diagrams

5.13 SHUTDOWN and WAKE-UP Timing



* GPOUT is configured as an input for wake-up signaling.

Figure 5-2. SHUTDOWN and WAKE-UP Timing Diagram

5.14 Typical Characteristics

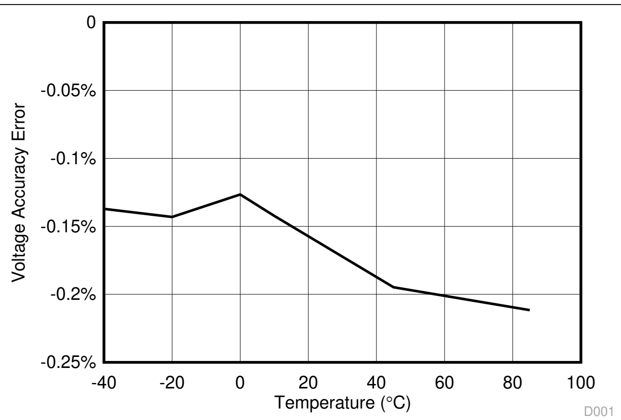


Figure 5-3. Voltage Accuracy Error

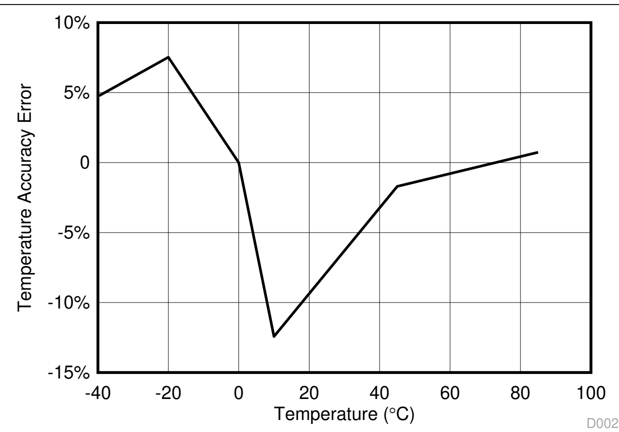


Figure 5-4. Internal Temperature Accuracy Error

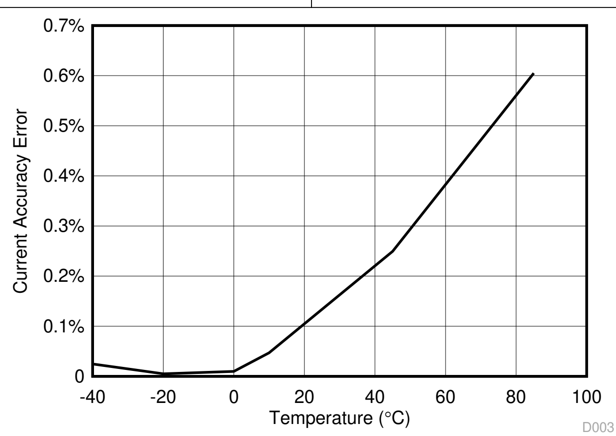


Figure 5-5. Current Accuracy Error

6 Detailed Description

6.1 Overview

The BQ27427 fuel gauge accurately predicts the battery capacity and other operational characteristics of a single Li-based rechargeable cell. Interrogate the BQ27427 fuel gauge by a system processor to provide cell information, such as state-of-charge (SOC).

Note

The following formatting conventions are used in this document:

Commands: *italics* with parentheses() and no breaking spaces, for example, *Control()*.

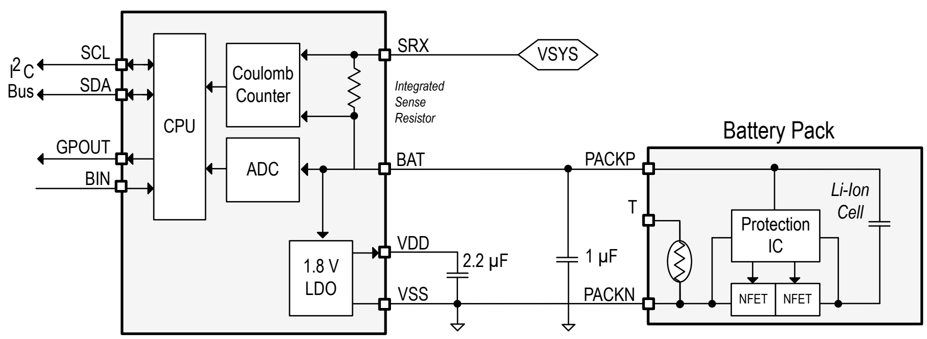
Data flash: *italics*, **bold**, and breaking spaces, for example, ***Design Capacity*** .

Register bits and flags: *italics* with brackets [ ], for example, *[TDA]*

Data flash bits: *italics*, **bold**, and brackets [ ], for example, ***[LED1]***

Modes and states: ALL CAPITALS, for example, UNSEALED mode

6.2 Functional Block Diagram



6.3 Feature Description

Access information through a series of commands, called *Standard Commands*. The additional *Extended Commands* set provide further capabilities. Both sets of commands, indicated by the general format *Command()*, are used to read and write information contained within the control and status registers, as well as data locations. The I^{2}C serial communications engine sends commands from the system to the gauge. Execute the commands during application development, system manufacture, or end-equipment operation.

The key to the high-accuracy gas gauging prediction is the Texas Instruments proprietary Impedance Track™ algorithm. The Impedance Track™ algorithm uses cell measurements, characteristics, and properties to create state-of-charge predictions that achieve high accuracy across a wide variety of operating conditions and over the lifetime of the battery.

The fuel gauge measures the charging and discharging of the battery by monitoring the voltage across an integrated small-value sense resistor. When a cell is attached to the fuel gauge, cell impedance computes based on cell current, cell open-circuit voltage (OCV), and cell voltage under loading conditions.

The fuel gauge uses an integrated temperature sensor for estimating cell temperature. Alternatively, the host processor provided temperature data for the fuel gauge.

For more details, see the *BQ27427 Technical Reference Manual*.

6.3.1 Communications

6.3.1.1 I²C Interface

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

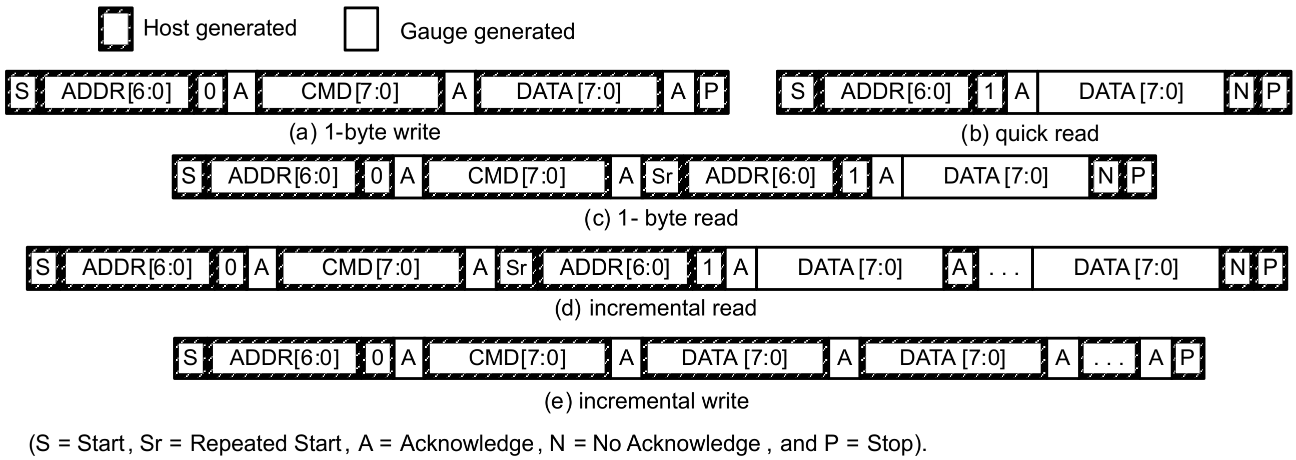


Figure 6-1. I²C Interface

The quick read returns data at the address indicated by the address pointer. The address pointer, a register internal to the I²C communication engine, increments whenever data is acknowledged by the fuel gauge or the I²C primary. The *Quick writes* functions in the same manner and are a convenient means of sending multiple bytes to consecutive command locations (such as two-byte commands that require two bytes of data).

The following command sequences are not supported:

Figure 6-2. Attempt To Write a Read-only Address (NACK After Data Sent By Primary)

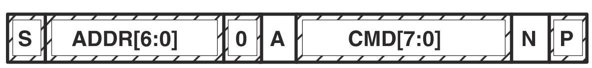


Figure 6-3. Attempt To Read an Address Above 0x6B (NACK Command)

6.3.1.2 I²C Time Out

The I²C engine releases SDA and SCL if the I²C bus is held low for two seconds. If the fuel gauge is holding the lines, releasing them frees them for the primary to drive the lines. If an external condition is holding either of the lines low, the I²C engine enters the low-power SLEEP mode.

6.3.1.3 I²C Command Waiting Time

For proper operation at 400kHz, insert a $t_{(BUF)}$ ≥ 66µs bus-free waiting time between all of the packets addressed to the fuel gauge. In addition, if the SCL clock frequency (f_{SCL}) is > 100kHz, use individual 1-byte write commands for proper data flow control. The following diagram shows the standard waiting time required between issuing the control subcommand the reading the status result. For read-write standard command, a minimum of 2 seconds is required to update the results. For read-only standard commands, there is no waiting time required, but the host must not issue any standard command more than two times per second. Otherwise, the gauge can result in a reset issue due to the expiration of the watchdog timer.

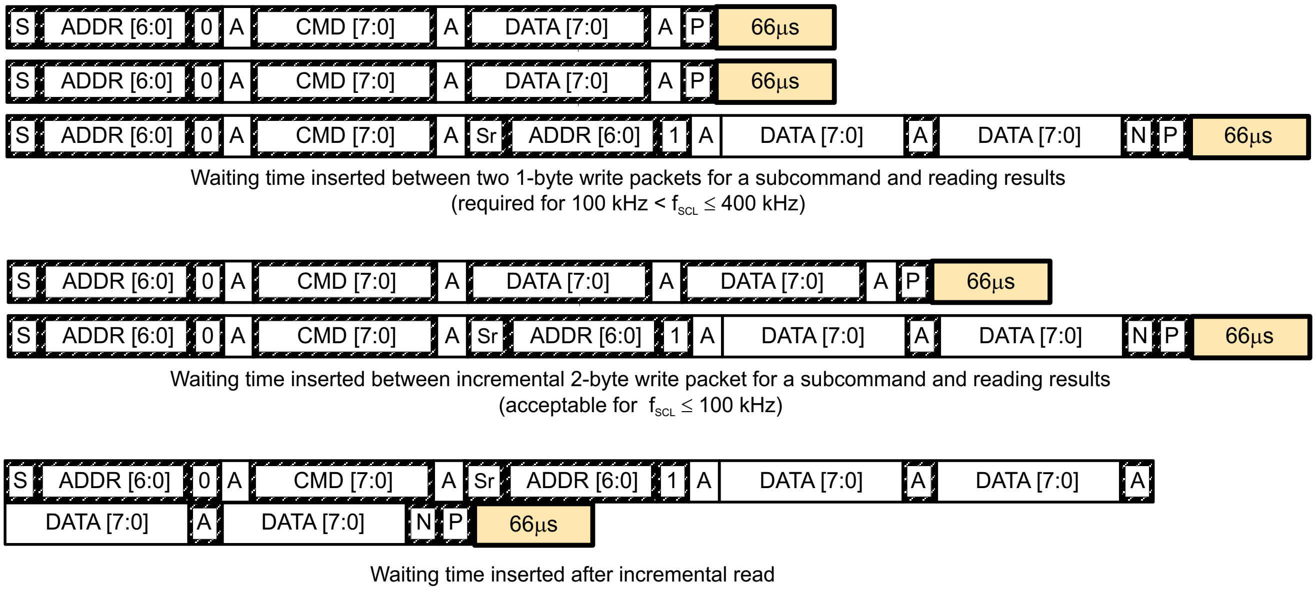


Figure 6-4. I²C Command Waiting Time

6.3.1.4 I²C Clock Stretching

A clock stretch can occur during all modes of fuel gauge operation. In SLEEP mode, a short ≤ 100µs clock stretch occurs on all I²C traffic as the device must wake-up to process the packet. In the other modes (INITIALIZATION, NORMAL), a ≤ 4ms clock stretching period can occur within packets addressed for the fuel gauge as the I²C interface performs normal data-flow control.

6.4 Device Functional Modes

To minimize power consumption, the fuel gauge has several power modes:

- INITIALIZATION
- NORMAL
- SLEEP
- SHUTDOWN

The fuel gauge passes automatically between these modes, depending upon the occurrence of specific events. A system processor initiates some of these modes directly. For more details, see the *BQ27427 Technical Reference Manual*.

7 Application 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, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

The BQ27427 fuel gauge is a microcontroller peripheral that provides system-side fuel gauging for single-cell, Li-Ion batteries. Battery fuel gauging with the fuel gauge requires connections only to PACK+ and PACK– for a removable battery pack or embedded battery circuit. To allow for prime performance in the end application, take special consideration to establish minimization of measurement error through proper printed circuit board (PCB) board layout. Such requirements are detailed in Section 7.2.1.

7.2 Typical Applications

The BQ27427 device can be used without current sense resistor (as shown in the schematic below).

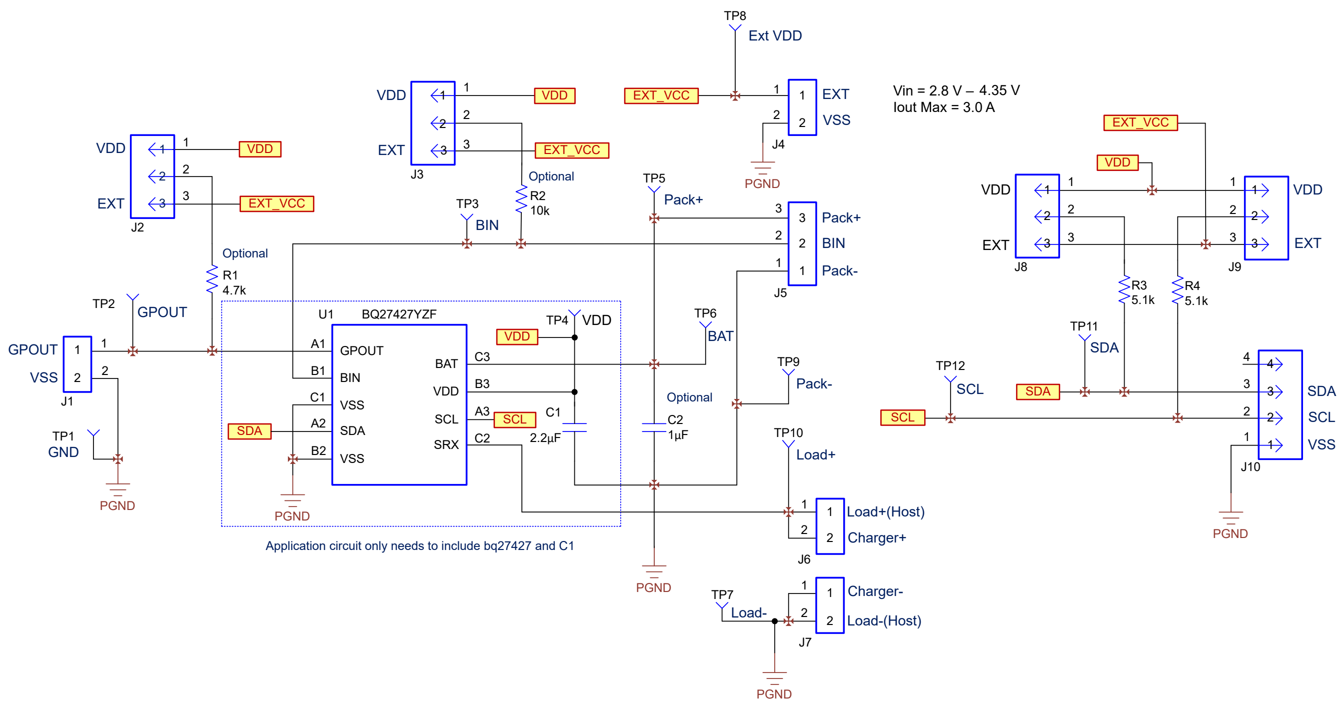


Figure 7-1. Typical Application with High-Side Current Sense Resistor

7.2.1 Design Requirements

As shipped from the Texas Instruments factory, the BQ27427 fuel gauge comes with three preprogrammed chemistry profiles and gauging parameters in ROM. Upon device reset, the contents of ROM are copied to associated volatile RAM-based data memory blocks. For proper operation, all parameters in RAM-based data memory require initialization. This can be done by updating data memory parameters in a lab/evaluation situation or by downloading the parameters from a host. The *BQ27427 Technical Reference Manual* shows the default and typically expected values appropriate for most applications.

7.2.2 Detailed Design Procedure

7.2.2.1 BAT Voltage Sense Input

Use a ceramic capacitor at the input to the BAT pin to bypass AC voltage ripple to ground, greatly reducing the BAT voltage sense input influence on battery voltage measurements. This method proves most effective in applications with load profiles that exhibit high-frequency current pulses (for example, cell phones) but is recommended for use in all applications to reduce noise on BAT, which is a sensitive high-impedance measurement node.

7.2.2.2 Integrated LDO Capacitor

The fuel gauge has an integrated LDO with an output on the V_{DD} pin of approximately 1.8V. Connect a capacitor with a capacitance value at least 2.2µF between the V_{DD} pin and V_{SS}. Place the capacitor close to the gauge IC and establish short traces to both the V_{DD} and V_{SS} pins. Do not use this LDO to provide power for other devices in the system.

7.2.3 External Thermistor Support

The fuel gauge temperature sensing circuitry is designed to work with a negative temperature coefficient-type (NTC) thermistor with a characteristic 10kΩ resistance at room temperature (25°C). The default curve-fitting coefficients configured in the fuel gauge specifically assume a Semitec 103AT type thermistor profile and so that is the default recommendation for thermistor selection purposes. Moving to a separate thermistor resistance profile (for example, JT-2 or others) requires an update to the default thermistor coefficients which can be modified in RAM for the highest accuracy temperature measurement performance.

7.2.4 Application Curves

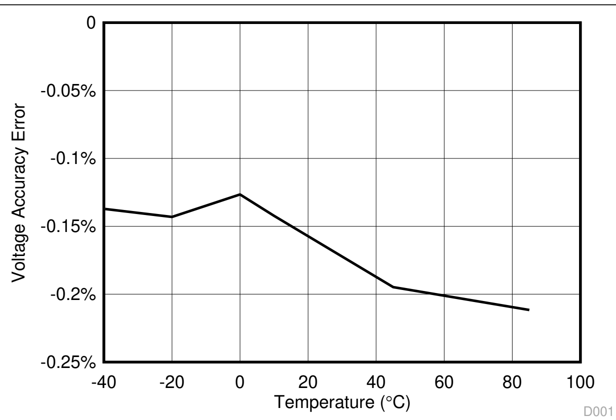


Figure 7-2. Voltage Accuracy Error

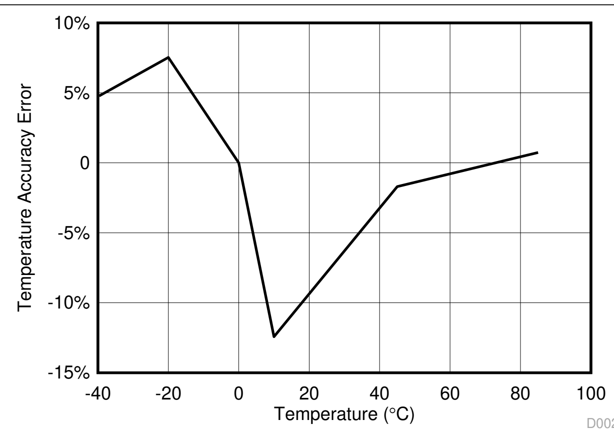


Figure 7-3. Internal Temperature Accuracy Error

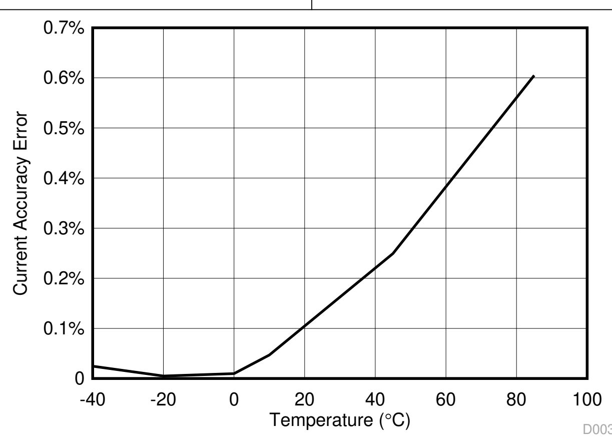


Figure 7-4. Current Accuracy Error

7.3 Power Supply Recommendation

7.3.1 Power Supply Decoupling

The battery connection on the BAT pin is used for two purposes:

- To supply power to the fuel gauge
- To provide an input for voltage measurement of the battery.

Connect a capacitor of value of at least 1 µF between BAT and V_{SS}. Place the capacitor close to the gauge IC and have short traces to both the BAT pin and V_{SS}.

The fuel gauge has an integrated LDO with an output on the V_{DD} pin of approximately 1.8V. Connect a capacitor of value at least 2.2 µF between the V_{DD} pin and V_{SS}. Place the capacitor close to the gauge IC and have short traces to both the V_{DD} pin and V_{SS}. Do not use this regulator to provide power for other devices in the system.

7.4 Layout

7.4.1 Layout Guidelines

- A capacitor of a value of at least 2.2µF is connected between the V_{DD} pin and V_{SS}. Place the capacitor close to the gauge IC and establish short traces to both the V_{DD} pin and V_{SS}. Do not use the regulator to provide power for other devices in the system.
- Confirm there is a capacitor of at least 1.0µF that connects between the BAT pin and V_{SS} if the connection between the battery pack and the gauge BAT pin has the potential to pick up noise. Place the capacitor close to the gauge IC and provide short traces to both the V_{DD} pin and V_{SS}.
- Use external 1MΩ pulldown resistors to V_{SS} to avoid floating inputs to the I^2C engine if the external pullup resistors on the SCL and SDA lines disconnect from the host during low-power operation.
- When establishing the value of the SCL and SDA pullup resistors, take into consideration the pullup voltage and the bus capacitance. Some recommended values, assuming a bus capacitance of 10pF, are in Table 7-1.

Table 7-1. Recommended Values for SCL and SDA Pullup Resistors

VPU	1.8V		3.3V	
R_{PU}	Range	Typical	Range	Typical
	400Ω ≤ R_{PU} ≤ 37.6kΩ	10kΩ	900Ω ≤ R_{PU} ≤ 29.2kΩ	5.1kΩ

- If the host is not using the GPOUT functionality, connect GPOUT to a GPIO of the host. In cases where the device is in SHUTDOWN, toggling GPOUT wakes up the gauge from the SHUTDOWN state.
- If the battery pack thermistor is not connected to the BIN pin, pull down the BIN pin to V_{SS} with a 10kΩ resistor.
- Do not directly short the BIN pin to V_{DD} or V_{SS}.
- The actual device ground is V_{SS}.
- Kelvin connects the BAT pin to the battery PACKP terminal.

7.4.2 Layout Example

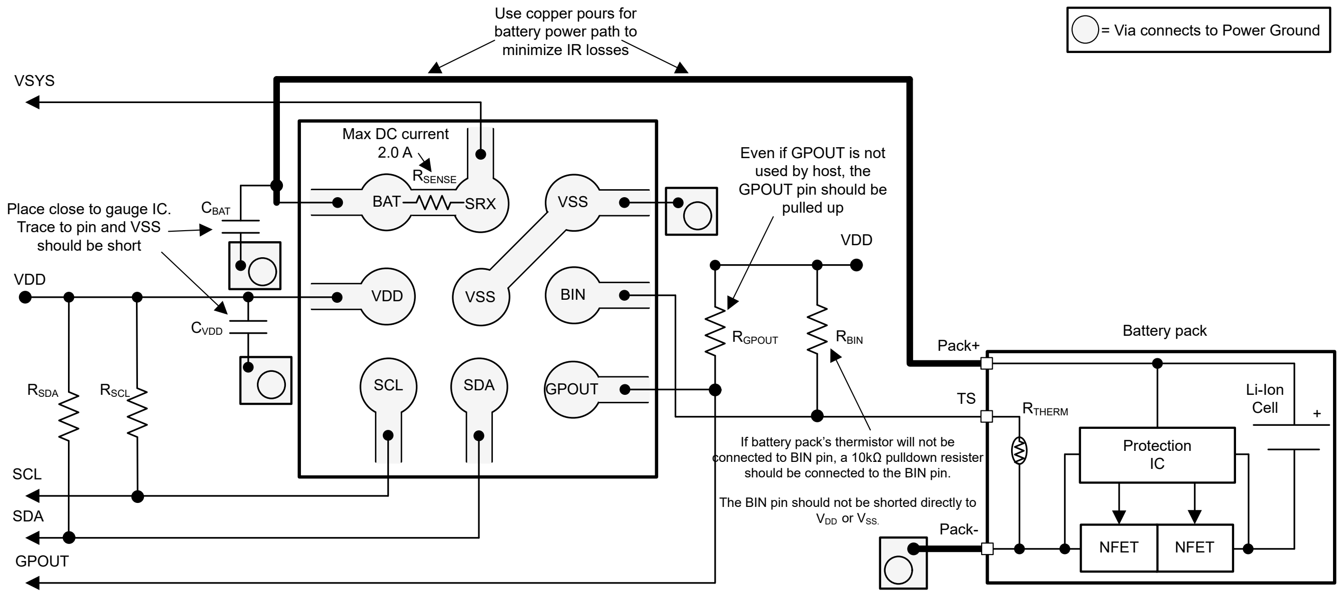


Figure 7-5. BQ27427 Board Layout

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Third-Party Products Disclaimer

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8.1.2 Related Documentation

- Texas Instruments, *BQ27427 Technical Reference Manual*
- Texas Instruments, *ESD and RF Mitigation in Handheld Battery Electronics* application note
- Texas Instruments, *Single Cell Gas Gauge Circuit Design* application note
- Texas Instruments, *Single Cell Impedance Track Printed-Circuit Board Layout Guide* application note

8.2 Trademarks

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8.3 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.

8.4 Glossary

TI Glossary — This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

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

Changes from Revision A (October 2023) to Revision B (September 2025)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Updated *Top and Bottom View* diagram with pin names	3

Changes from Revision * (December 2022) to Revision A (October 2023)	Page
• Updated Typical Applications	12
• Changed the LDO output capacitor value from 0.47µF to 2.2µF in Power Supply Decoupling	14

10 Mechanical, Packaging, and Orderable Information

The following pages include 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 (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)
BQ27427YZFR	Active	Production	DSBGA (YZF) | 9	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27427
BQ27427YZFR.A	Active	Production	DSBGA (YZF) | 9	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27427

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **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.

(5) **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.

(6) **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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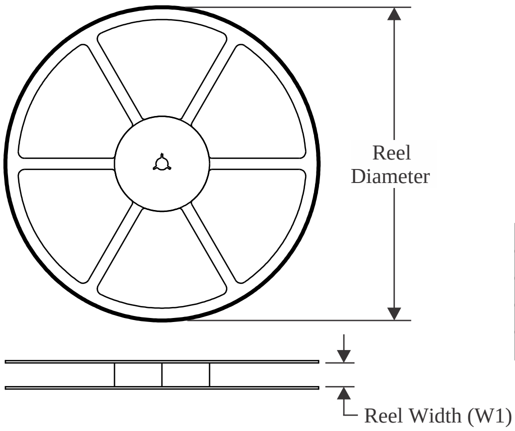
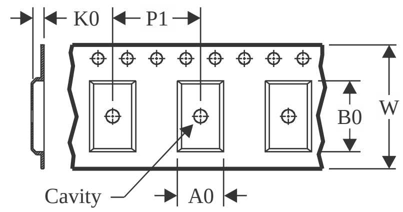
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

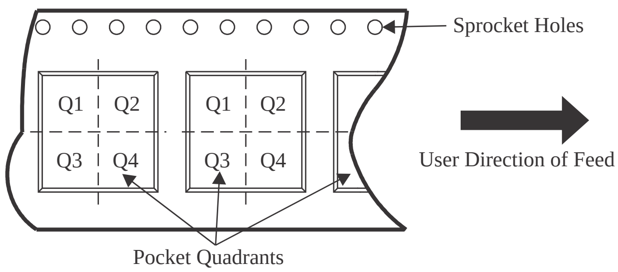


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

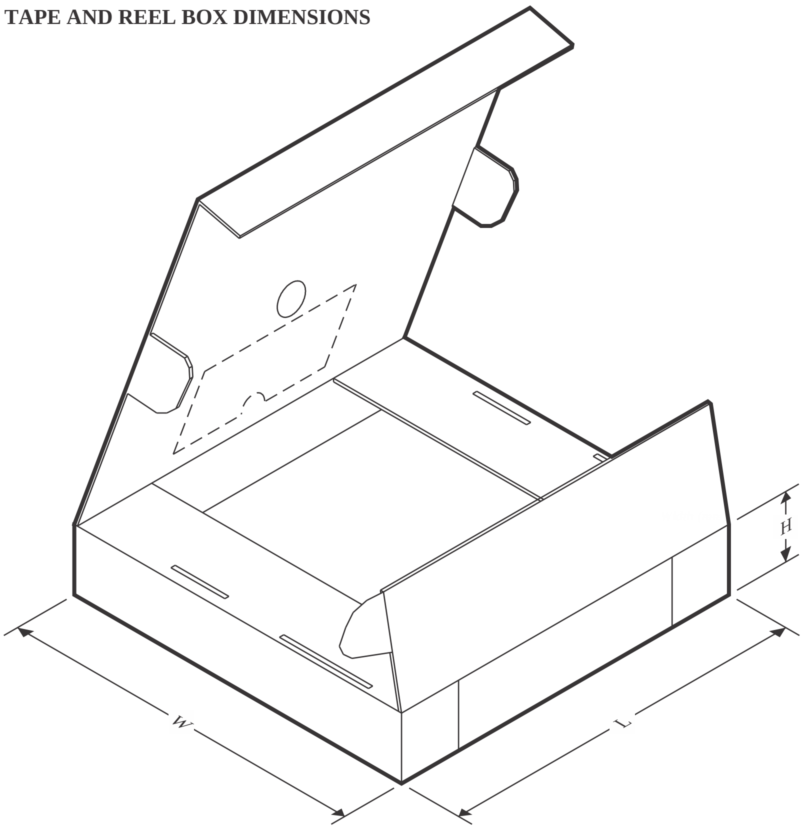
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

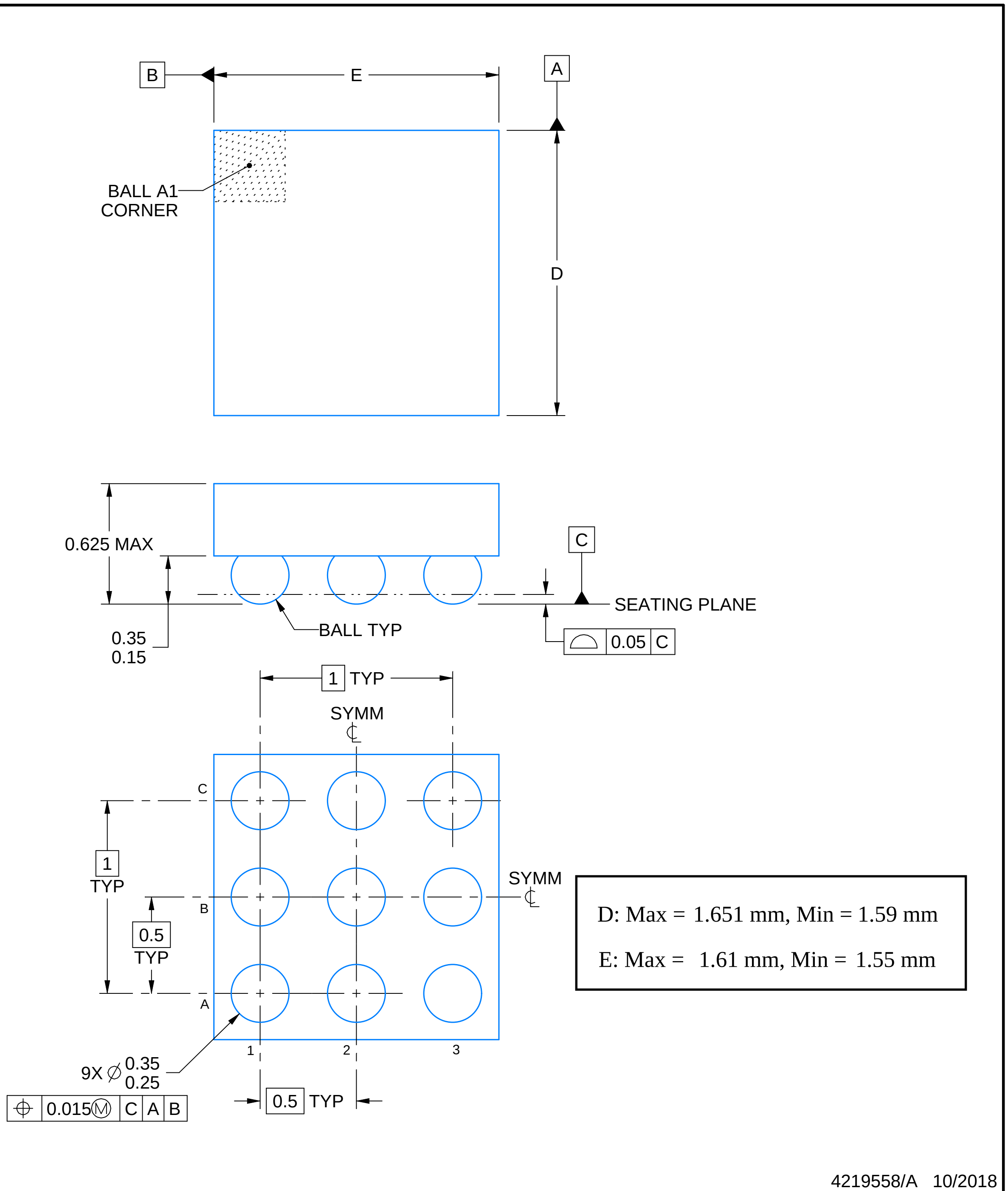
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ27427YZFR	DSBGA	YZF	9	3000	180.0	8.4	1.78	1.78	0.69	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



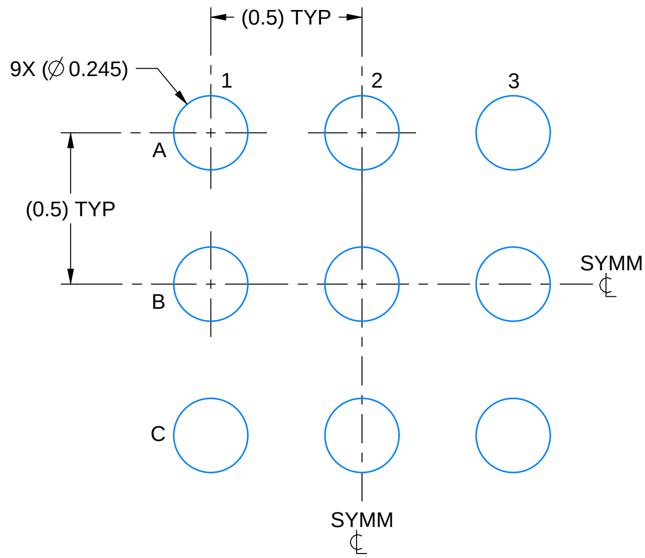
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ27427YZFR	DSBGA	YZF	9	3000	182.0	182.0	20.0

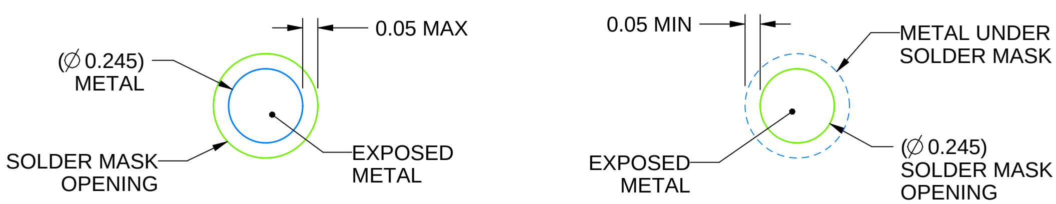


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 40X



NON-SOLDER MASK
DEFINED
(PREFERRED)

SOLDER MASK
DEFINED

SOLDER MASK DETAILS
NOT TO SCALE

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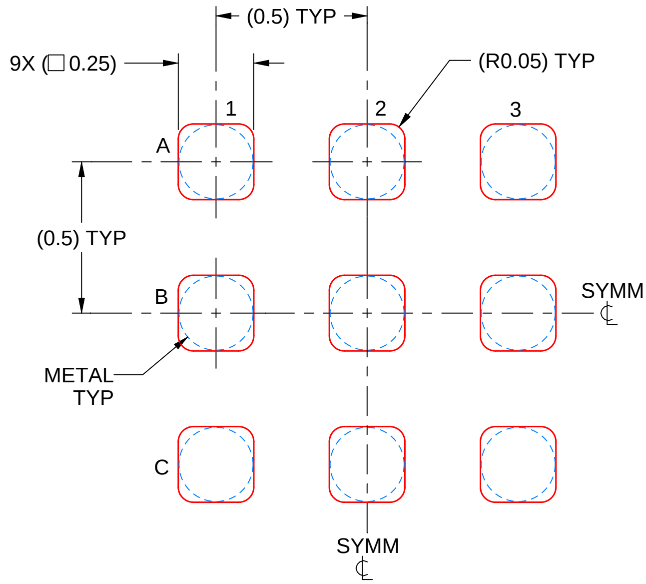
NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).



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

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NOTES: (continued)

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

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