BQ27426 系统侧 Impedance Track™ 电量监测计

1 特性

- 单节锂离子电池电量监测计
  - 驻留在系统主板上
  - 支持嵌入式或可拆除电池
  - 由具有集成 LDO 的电池直接供电
  - 支持低值外部感应电阻器 (10mΩ)
- 负载低于 10mA 时的超低 9μA 工作电流，负载阈值由*睡眠电流*设置。
- 基于获得专利的 Impedance Track™ 技术的电池电量监测
  - 为 4.2V、4.35V 和 4.4V 电池提供三种可选的预编程配置文件
  - 借助平滑滤波器报告剩余电量和荷电状态 (SOC)
  - 针对电池老化、自放电、温度和速率变化自动调节
  - 估计电池健康状况（老化）
- 微控制器外设接口支持：
  - 400kHz I^{2}C 串行接口
  - 可配置 SOC 中断或
    电池低电量数字输出警告
  - 内部温度传感器或主机报告的温度或外部热敏电阻

2 应用

- 智能手机、功能型手机和平板电脑
- 可穿戴设备
- 楼宇自动化
- 便携式医疗/工业手持终端
- 便携式音频设备
- 游戏

3 说明

德州仪器 (TI) BQ27426 电池电量监测计是一款单节电池电量监测计，只需进行少量的用户配置和系统微控制器固件开发工作即可快速启动系统。

通过预编程三种化学配置文件，最大限度减少用户配置，并帮助客户管理项目中不同电池化学成分的库存。BQ27426 电池电量监测计在休眠模式下具有超低功耗，有助于延长电池运行时间。可配置中断有助于节省系统功耗，释放主机使其停止继续轮询。外部热敏电阻为精确温度感测提供支持。

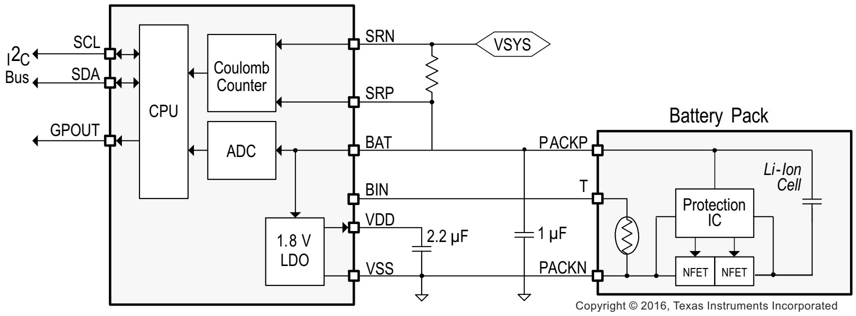
BQ27426 电池电量监测计使用已获专利的 Impedance Track™ 算法来进行电量监测，并提供诸如剩余电量 (mAh)、充电状态 (%) 和电池电压 (mV) 等信息。

使用 BQ27426 电量监测计进行电池电量监测时，只需连接至可拆卸电池包或嵌入式电池电路的 PACK+ (P+) 和 PACK- (P-)。微型、9 球、1.62mm × 1.58mm、0.5mm 间距 NanoFree™ 芯片级封装 (DSBGA) 非常适合空间受限的应用。

器件信息

器件型号	封装	封装尺寸（标称值）
BQ27426	YZF (9)(1)	1.62mm x 1.58mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



简化原理图

Table of Contents

4 Revision History

注：以前版本的页码可能与当前版本的页码不同

Changes from Revision F (July 2019) to Revision G (April 2023)	**Page**
• 阐明了睡眠模式电流	1
• Clarified SLEEP mode current	6
• Added detailed descriptions of power modes	12

Changes from Revision E (May 2019) to Revision F (July 2019)	**Page**
• Added 节 7.3.1.2	11
• Changed 图 8-2	15

Changes from Revision D (May 2016) to Revision E (May 2019)	**Page**
• Added the low-side current sense resistor	15
• Updated Typical Applications	15

5 Pin Configuration and Functions

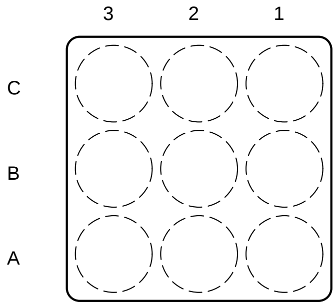


图 5-1. Top View

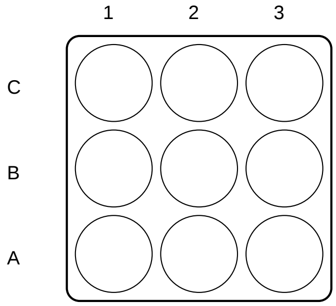


图 5-2. Bottom View

表 5-1. 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 (1 µF) 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 10-kΩ thermistor; the system board should use a 1.8-MΩ pullup resistor to V_{DD} to ensure the BIN pin is high when a battery is removed. If the battery is embedded in the system, it is recommended to leave ***[BI_PU_EN]*** = 1 and use a 10-kΩ 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. A 10-kΩ pulldown resistor should be placed between BIN and V_{SS}, even if this pin is unused. **NOTE:** The BIN pin must not be shorted directly to V_{CC} or V_{SS} and any pullup resistor on the BIN pin must be connected only to V_{DD} and not an external voltage rail. If an external thermistor is used for temperature input, the thermistor should be connected between this pin and V_{SS}.

表 5-1. Pin Functions (continued)

PIN		TYPE(1)	DESCRIPTION
NAME	NUMBER		
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 10-kΩ pullup resistor is recommended. If the device is in SHUTDOWN mode, toggling GPOUT causes 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	Slave I^{2}C serial bus for communication with system (Master). Open-drain pins. Use with external 10-kΩ pullup resistors (typical) for each pin. If the external pullup resistors will be disconnected from these pins during normal operation, use an external 1-MΩ pulldown resistors to V_{SS} at each pin to avoid floating inputs.
SDA	A2	DIO	
SRN	C2	AI	Coulomb counter differential inputs expecting an external 10 mΩ, 1% sense resistor in the high-side current path. Kelvin sense connect SRP to the positive battery terminal (PACKP) side of the external sense resistor. Kelvin sense connect SRN to the other side of the external sense resistor, the positive connection to the system (VSYS). No calibration is required. The fuel gauge is precalibrated for a standard 10 mΩ, 1% sense resistor. Low-side current sensing can be enabled. For more information, see *Typical Applications*.
SRP	C1	AI	
V_{DD}	B3	PO	1.8-V regulator output. Decouple with 2.2-µF ceramic capacitor to V_{SS}. This pin is not intended to provide power for other devices in the system.
V_{SS}	B2	PI	Ground pin

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

6 Specifications

6.1 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_{SR}	SRP and SRN pins input voltage range	– 0.3	V_{BAT} + 0.3	V
	Differential voltage across SRP and SRN. ABS(SRP – SRN)		2	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.

6.2 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 JESD22-C101(2)	±250	

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

6.3 Recommended Operating Conditions

T_A = 30°C and V_{REGIN} = V_{BAT} = 3.6 V (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.

6.4 Thermal Information

THERMAL METRIC(1)		BQ27426	UNIT
		YZF (DSBGA)	
		9 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	64.1	°C/W
$R_{\theta JCtop}$	Junction-to-case (top) thermal resistance	59.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	52.7	°C/W
ψ_{JT}	Junction-to-top characterization parameter	0.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	28.3	°C/W
$R_{\theta JCbot}$	Junction-to-case (bottom) thermal resistance	2.4	°C/W

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

6.5 Supply Current

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC} (1)	NORMAL mode current	I_{LOAD} > ***Sleep Current*** (2) (10mA typical)		50		µA
I_{SLP} (1)	SLEEP mode current (data measurement every 20-sec)	I_{LOAD} < ***Sleep Current*** (2) (10mA typical)		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.

6.6 Digital Input and Output DC Characteristics

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

6.7 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} = 3.6 V (unless otherwise noted)

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.

6.8 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} = 3.6 V (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

6.8 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} = 3.6 V (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.

6.9 ADC (Temperature and Cell Measurement) Characteristics

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

6.10 Integrating ADC (Coulomb Counter) Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{SR}	Input voltage range from BAT to SRP/SRN 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.

6.11 I^2C-Compatible Interface Communication Timing Characteristics

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

			MIN	NOM	MAX	UNIT
Standard Mode (100 kHz)						
$t_{d(STA)}$	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 (400 kHz)						
$t_{d(STA)}$	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

6.11 I^{2}C-Compatible Interface Communication Timing Characteristics (continued)

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

			MIN	NOM	MAX	UNIT
$t_{su(DAT)}$	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 > 100 kHz, use 1-byte write commands for proper operation. All other transactions types are supported at 400 kHz. (See 节 7.3.1.1 and 节 7.3.1.3.)

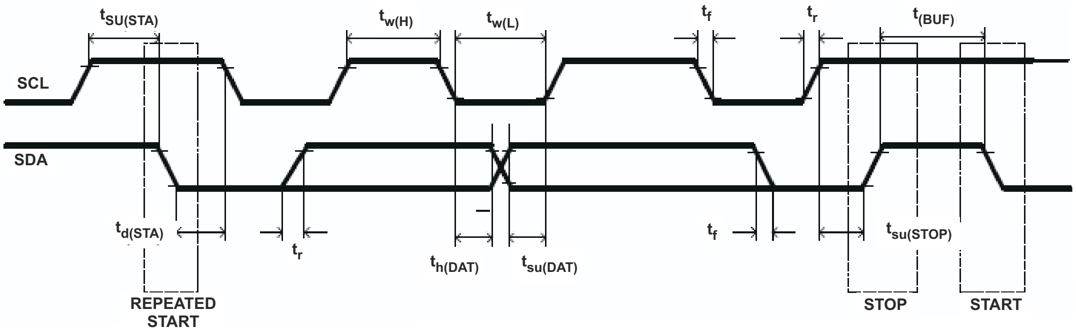
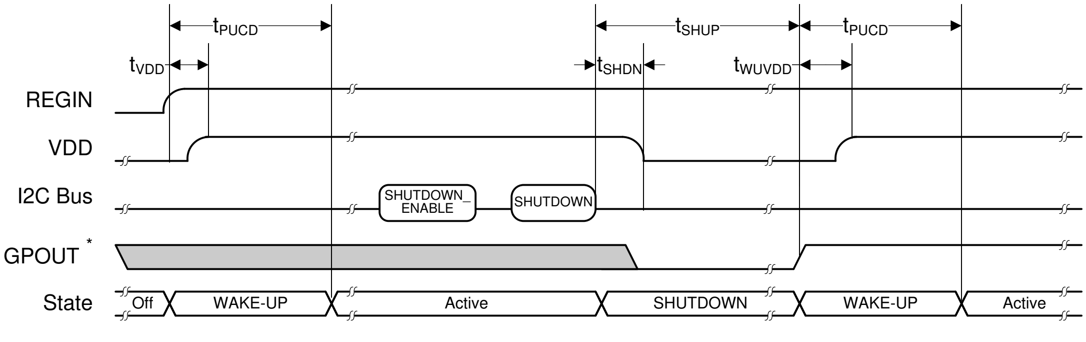


图 6-1. I^{2}C-Compatible Interface Timing Diagrams

6.12 SHUTDOWN and WAKE-UP Timing



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

图 6-2. SHUTDOWN and WAKE-UP Timing Diagram

6.13 Typical Characteristics

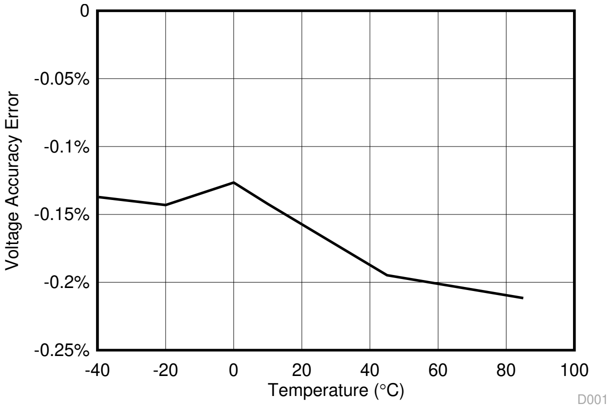


图 6-3. Voltage Accuracy Error

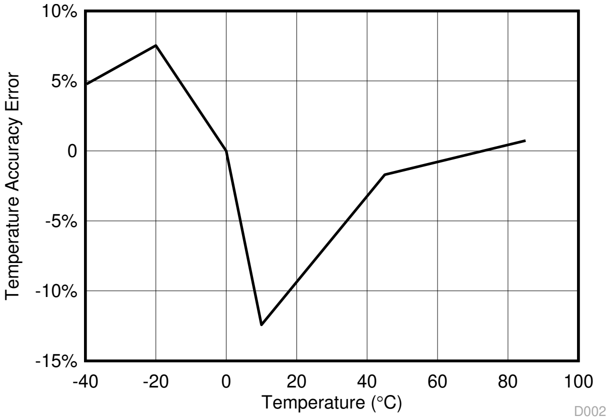


图 6-4. Internal Temperature Accuracy Error

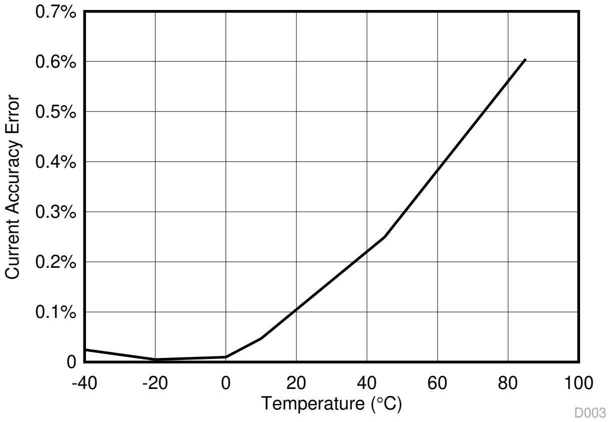


图 6-5. Current Accuracy Error

7 Detailed Description

7.1 Overview

The BQ27426 fuel gauge accurately predicts the battery capacity and other operational characteristics of a single Li-based rechargeable cell. It can be interrogated by a system processor to provide cell information, such as state-of-charge (SOC).

备注

The following formatting conventions are used in this document:

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

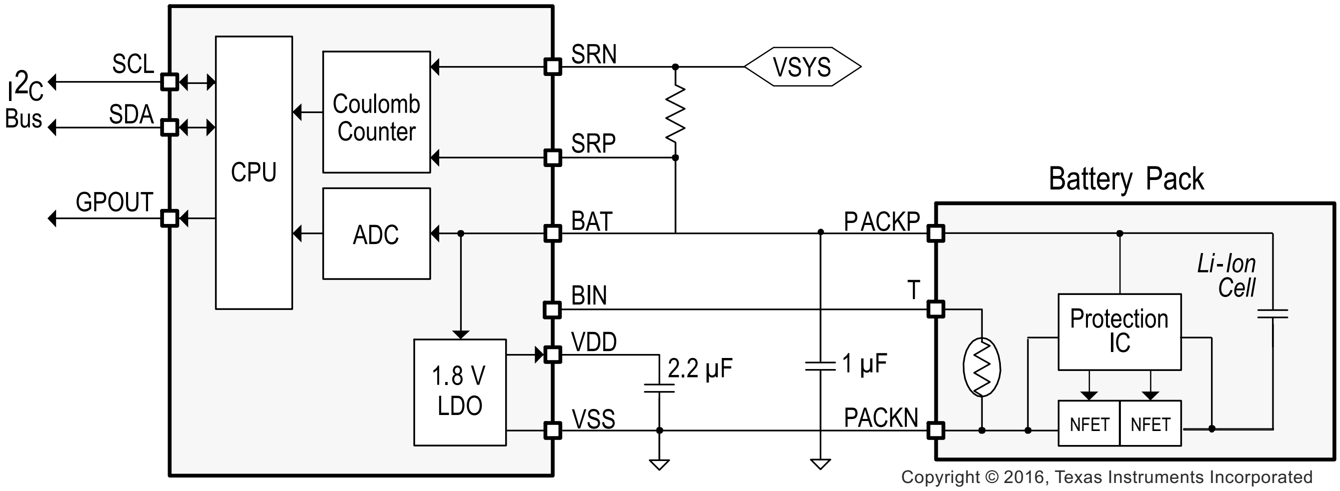
Data flash: *italics*, **bold**, and breaking spaces, for example, ***Design Capacity***.

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

7.2 Functional Block Diagram



Copyright © 2016, Texas Instruments Incorporated

7.3 Feature Description

Information is accessed through a series of commands, called *Standard Commands*. Further capabilities are provided by the additional *Extended Commands* set. Both sets of commands, indicated by the general format *Command)*, are used to read and write information contained within the control and status registers, as well as its data locations. Commands are sent from system to gauge using the I^{2}C serial communications engine, and can be executed during application development, system manufacture, or end-equipment operation.

The key to the high-accuracy gas gauging prediction is Texas Instruments proprietary Impedance Track™ algorithm. This algorithm uses cell measurements, characteristics, and properties to create state-of-charge predictions that can 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 a small-value sense resistor. When a cell is attached to the fuel gauge, cell impedance is computed 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 can provide temperature data for the fuel gauge.

For more details, see the *BQ27426 Technical Reference Manual*.

7.3.1 Communications

7.3.1.1 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, therefore, 0xAA or 0xAB for write or read, respectively.

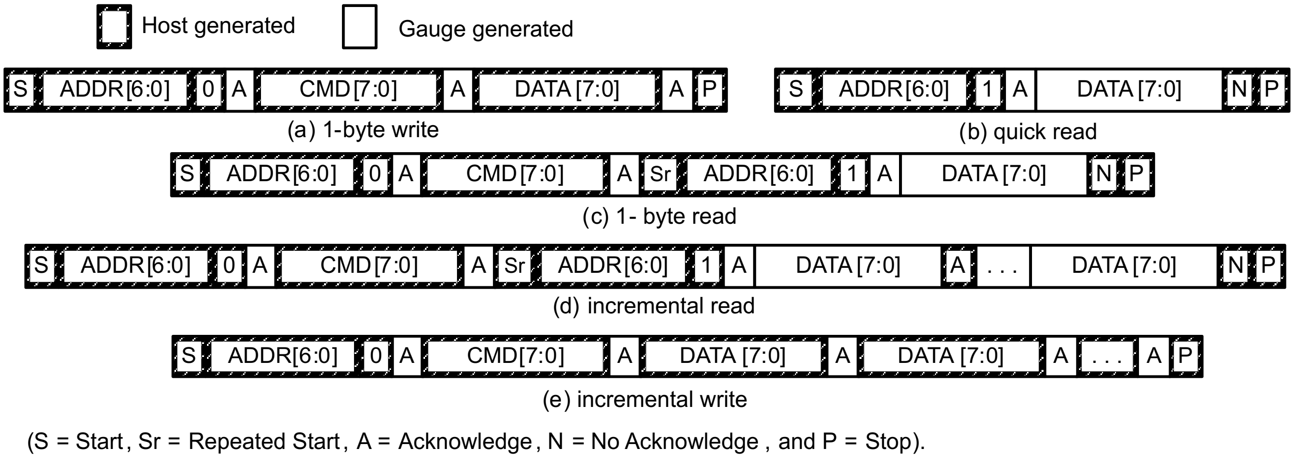


图 7-1. I²C Interface

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 master. “Quick writes” function in the same manner and are a convenient means of sending multiple bytes to consecutive command locations (such as two-byte commands that require two bytes of data).

The following command sequences are not supported:

图 7-2. Attempt To Write a Read-only Address (NACK After Data Sent By Master)

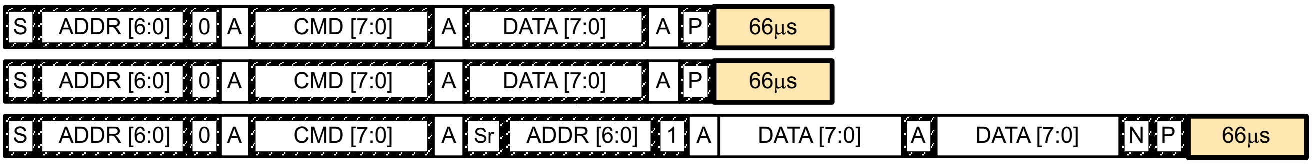
图 7-3. Attempt To Read an Address Above 0x6B (NACK Command)

7.3.1.2 I²C Time Out

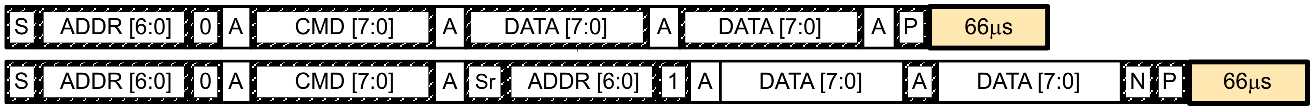
The I²C engine releases SDA and SCL if the I²C bus is held low for two seconds. If the fuel gauge is holding the lines, releasing them frees them for the master to drive the lines. If an external condition is holding either of the lines low, the I²C engine enters the low-power SLEEP mode.

7.3.1.3 I²C Command Waiting Time

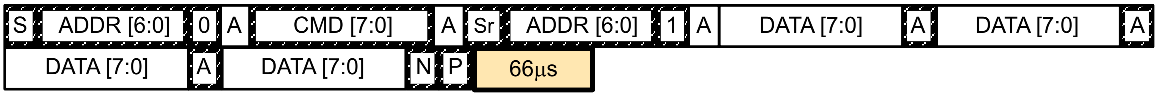
To ensure proper operation at 400 kHz, a $t_{(BUF)} \geqslant 66$ μs bus-free waiting time must be inserted between all packets addressed to the fuel gauge. In addition, if the SCL clock frequency (f_{SCL}) is > 100 kHz, use individual 1-byte write commands for proper data flow control. The following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



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



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



Waiting time inserted after incremental read

图 7-4. I^{2}C Command Waiting Time

7.3.1.4 I^{2}C Clock Stretching

A clock stretch can occur during all modes of fuel gauge operation. In SLEEP mode, a short ≤ 100-μs clock stretch occurs on all I^{2}C traffic as the device must wake-up to process the packet. In the other modes (INITIALIZATION, NORMAL), a ≤ 4-ms clock stretching period may occur within packets addressed for the fuel gauge as the I^{2}C interface performs normal data flow control.

7.4 Device Functional Modes

The fuel gauge has different operating modes: POR, INITIALIZATION, NORMAL, CONFIG UPDATE, and SLEEP. Upon powering up from OFF or SHUTDOWN, a power-on reset (POR) occurs and the fuel gauge begins INITIALIZATION. In NORMAL mode, the fuel gauge is fully powered and can execute any allowable task. Configuration data in RAM can be updated by the host using the CONFIG UPDATE mode. In SLEEP mode, the fuel gauge turns off the high-frequency oscillator clock to enter a reduced-power state, periodically taking measurements and performing calculations.

The fuel gauge passes automatically between these modes, depending upon the occurrence of specific events, though a system processor can initiate some of these modes directly. For more details, see the *BQ27426 Technical Reference Manual*.

7.4.1 SHUTDOWN Mode

In SHUTDOWN mode, the LDO output is disabled so internal power and all RAM-based volatile data are lost. The host can command the gauge to immediately enter SHUTDOWN mode by first unsealing the gauge and then enabling the mode with a *SHUTDOWN_ENABLE* subcommand (SHUTDOWN_ENABLE: 0x001B) followed by the *SHUTDOWN* subcommand (SHUTDOWN: 0x001C). To exit SHUTDOWN mode, the GPOUT pin must be raised from logic low to logic high for at least 200 μs.

7.4.2 POR and INITIALIZATION Modes

Upon a POR, the fuel gauge copies ROM-based configuration defaults to RAM and begins INITIALIZATION mode where essential data is initialized. The occurrence of a POR or a *Control() RESET* subcommand will set the *Flags() [ITPOR]* status bit to indicate that RAM has returned to ROM default data. When battery insertion is detected, a series of initialization activities begin including an OCV measurement. In addition, *CONTROL_STATUS [QMAX_UP]* and *[RES_UP]* bits are cleared to allow unfiltered learning of Qmax and impedance. Completion of INITIALIZATION mode is indicated by the *CONTROL_STATUS [INITCOMP]* bit.

7.4.3 CONFIG UPDATE Mode

If the application requires different configuration data for the fuel gauge, the system processor can update RAM-based data memory parameters using the *Control() SET_CFGUPDATE* subcommand to enter the CONFIG UPDATE mode. Operation in this mode is indicated by the *Flags() [CFGUPMODE]* status bit. In this mode, fuel gauging is suspended while the host uses the extended data commands to modify the configuration data blocks. To resume fuel gauging, the host must send a *Control() SOFT_RESET* subcommand to exit the CONFIG UPDATE mode which clears both *Flags() [ITPOR]* and *[CFGUPMODE]* bits. After a timeout of approximately 240 seconds (4 minutes), the gauge will automatically exit the CONFIG UPDATE mode if it has not received a *SOFT_RESET* subcommand from the host.

7.4.4 NORMAL Mode

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

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

7.4.5 SLEEP Mode

SLEEP mode is an ultra low power operating mode. It is entered automatically if the feature is enabled (***OpConfig [SLEEP]*** = 1) and *AverageCurrent()* is below the programmable level ***Sleep Current*** (default = 10 mA). Once entry into SLEEP mode has been qualified, but prior to entering it, the fuel gauge may perform an ADC autocalibration to minimize the offset.

During SLEEP mode, the fuel gauge remains in a very-low-power state and automatically takes data measurements every 20 seconds.

After taking the measurements on the 20-second interval, the fuel gauge will exit SLEEP mode when *AverageCurrent()* rises above ***Sleep Current*** (default = 10 mA). Alternatively, an early data measurement before the 20-second internal is possible if the instantaneous current detected by an internal hardware comparator is above an approximate threshold of ±30 mA.

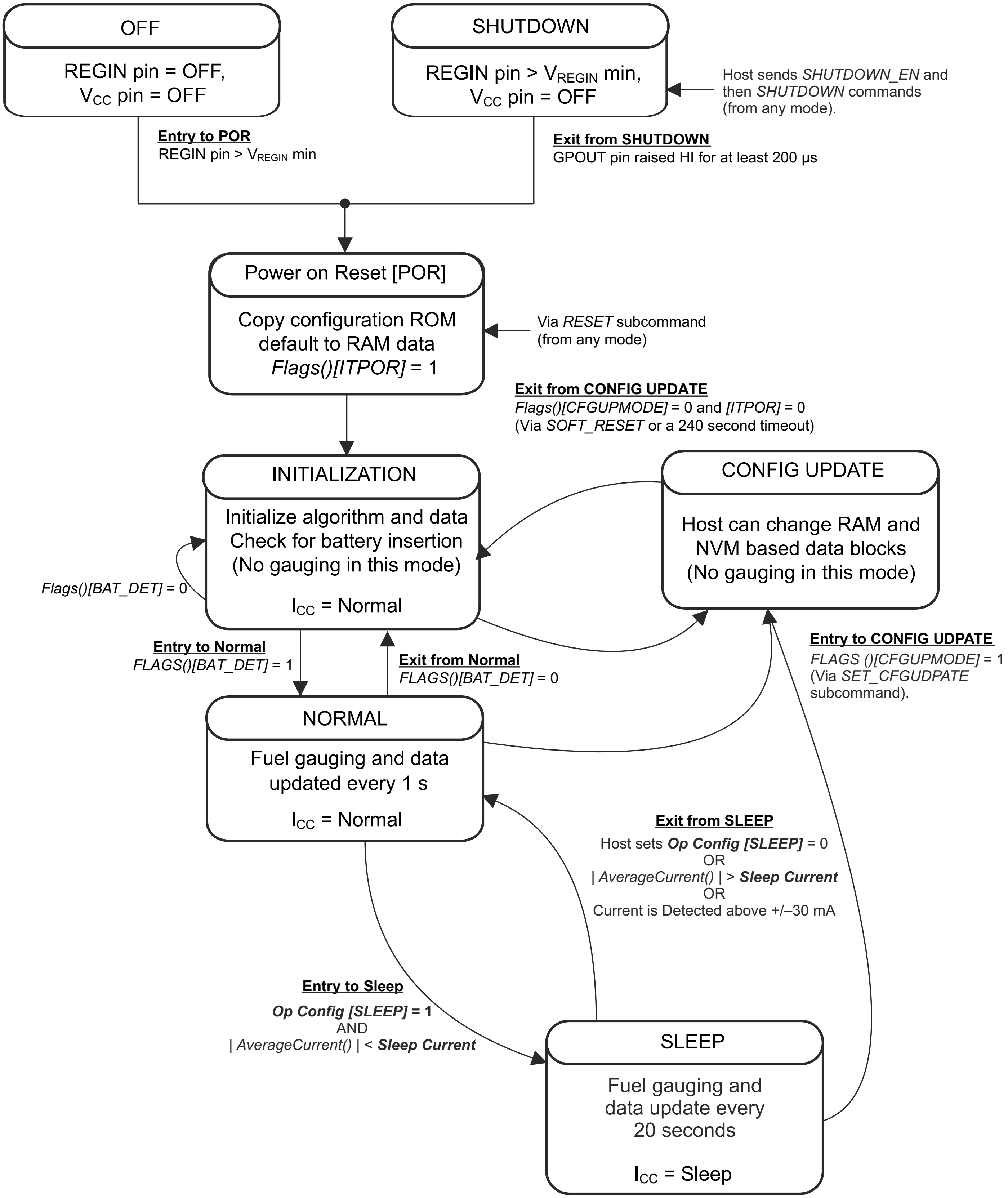


图 7-5. Power Mode Diagram

8 Application and Implementation

备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

8.1 Application Information

The BQ27426 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 optimal performance in the end application, special considerations must be taken to ensure minimization of measurement error through proper printed circuit board (PCB) board layout. Such requirements are detailed in *节 8.2.1*.

8.2 Typical Applications

The BQ27426 device can be used with a high-side current sense resistor (as shown in 图 8-1) or a low-side current sense resistor (as shown in 图 8-2).

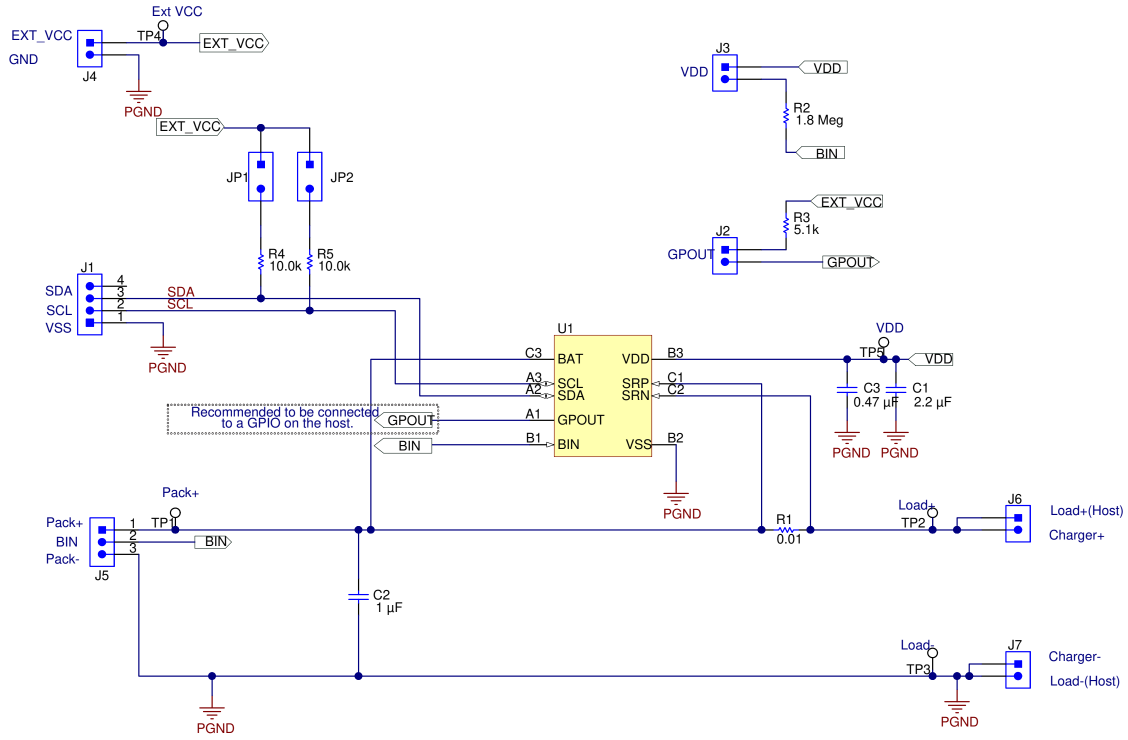


图 8-1. Typical Application with High-Side Current Sense Resistor

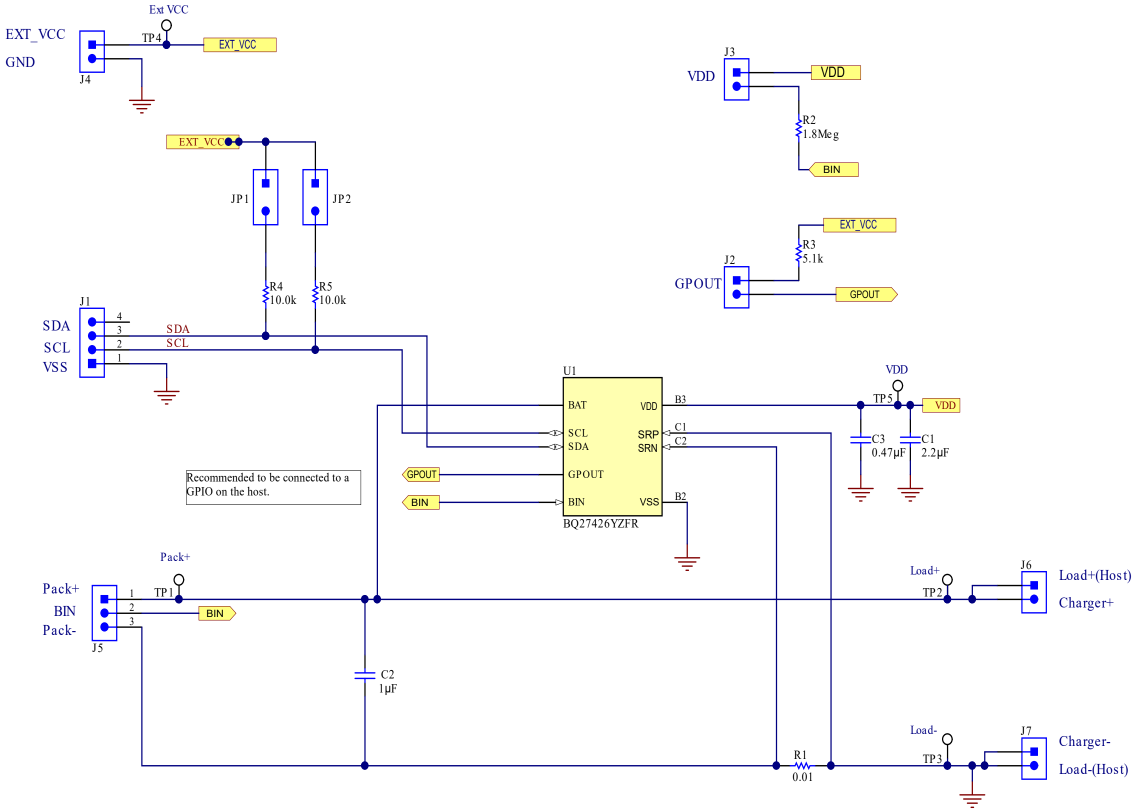


图 8-2. Typical Application with Low-Side Current Sense Resistor

8.2.1 Design Requirements

As shipped from the Texas Instruments factory, the BQ27426 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 *BQ27426 Technical Reference Manual* shows the default and typically expected values appropriate for most applications.

8.2.2 Detailed Design Procedure

8.2.2.1 BAT Voltage Sense Input

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

8.2.2.2 Integrated LDO Capacitor

The fuel gauge has an integrated LDO with an output on the V_{DD} pin of approximately 1.8 V. A capacitor of value at least 2.2 μF should be connected between the V_{DD} pin and V_{SS}. The capacitor must be placed close to the gauge IC and have short traces to both the V_{DD} pin and V_{SS}. This regulator must not be used to provide power for other devices in the system.

8.2.2.3 Sense Resistor Selection

Any variation encountered in the resistance present between the SRP and SRN pins of the fuel gauge will affect the resulting differential voltage, and derived current, it senses. As such, it is recommended to select a sense resistor with minimal tolerance and temperature coefficient of resistance (TCR) characteristics. The standard recommendation based on best compromise between performance and price is a 1% tolerance, 50 ppm drift sense resistor with a 1-W power rating.

8.2.3 External Thermistor Support

The fuel gauge temperature sensing circuitry is designed to work with a negative temperature coefficient-type (NTC) thermistor with a characteristic 10-kΩ 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 to ensure highest accuracy temperature measurement performance.

8.2.4 Application Curves

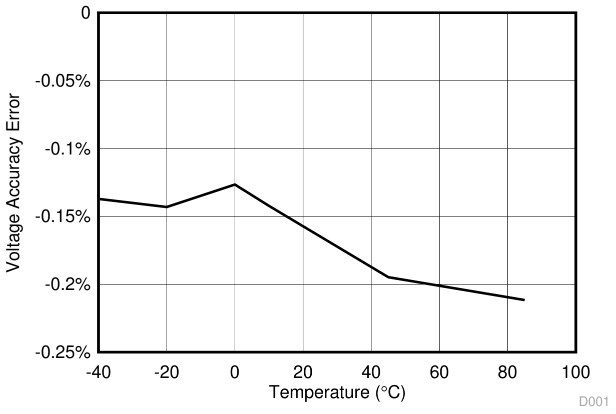


图 8-3. Voltage Accuracy Error

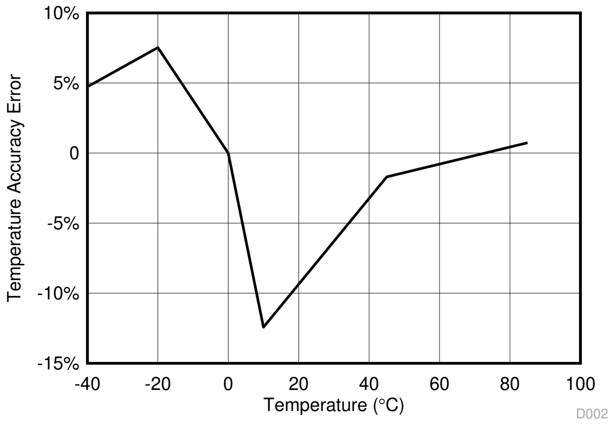


图 8-4. Internal Temperature Accuracy Error

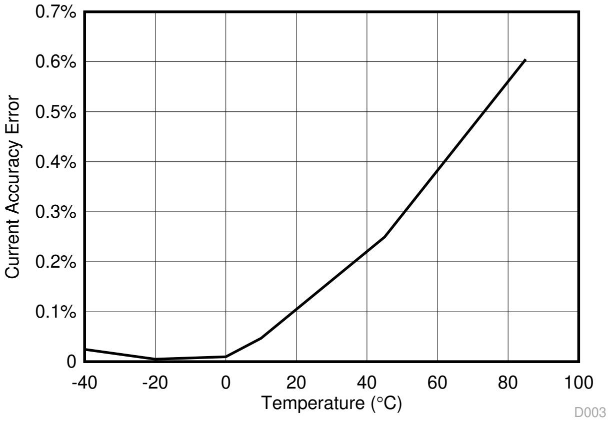


图 8-5. Current Accuracy Error

9 Power Supply Recommendation

9.1 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.

A capacitor of value of at least 1 μF should be connected between BAT and V_{SS}. The capacitor should be placed 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 1.8 V. A capacitor of value at least 2.2 μF should be connected between the V_{DD} pin and V_{SS}. The capacitor should be placed close to the gauge IC and have short traces to both the V_{DD} pin and V_{SS}. This regulator must not be used to provide power for other devices in the system.

10 Layout

10.1 Layout Guidelines

- A capacitor of a value of at least 2.2 μF is connected between the V_{DD} pin and V_{SS}. The capacitor should be placed close to the gauge IC and have short traces to both the V_{DD} pin and V_{SS}. This regulator must not be used to provide power for other devices in the system.
- It is required to have a capacitor of at least 1.0 μF connect 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. The capacitor should be placed close to the gauge IC and have short traces to both the V_{DD} pin and V_{SS}.
- If the external pullup resistors on the SCL and SDA lines will be disconnected from the host during low-power operation, it is recommended to use external 1-MΩ pulldown resistors to V_{SS} to avoid floating inputs to the I^2C engine.
- The value of the SCL and SDA pullup resistors should take into consideration the pullup voltage and the bus capacitance. Some recommended values, assuming a bus capacitance of 10 pF, can be seen in 表 10-1.

表 10-1. Recommended Values for SCL and SDA Pullup Resistors

VPU	1.8 V		3.3 V	
R_{PU}	Range	Typical	Range	Typical
	$400\ \Omega \leqslant R_{PU} \leqslant 37.6\ k\Omega$	10 kΩ	$900\ \Omega \leqslant R_{PU} \leqslant 29.2\ k\Omega$	5.1 kΩ

- If the host is not using the GPOUT functionality, then it is recommended that GPOUT be connected to a GPIO of the host so that in cases where the device is in SHUTDOWN, toggling GPOUT can wake the gauge up from the SHUTDOWN state.
- If the battery pack thermistor is not connected to the BIN pin, the BIN pin should be pulled down to V_{SS} with a 10-kΩ resistor.
- The BIN pin should not be shorted directly to V_{DD} or V_{SS}.
- The actual device ground is pin 3 (V_{SS}).
- The SRP and SRN pins should be Kelvin connected to the R_{SENSE} terminals. SRP to the battery pack side of R_{SENSE} and SRN to the system side of the R_{SENSE}.
- Kelvin connects the BAT pin to the battery PACKP terminal.

10.2 Layout Example

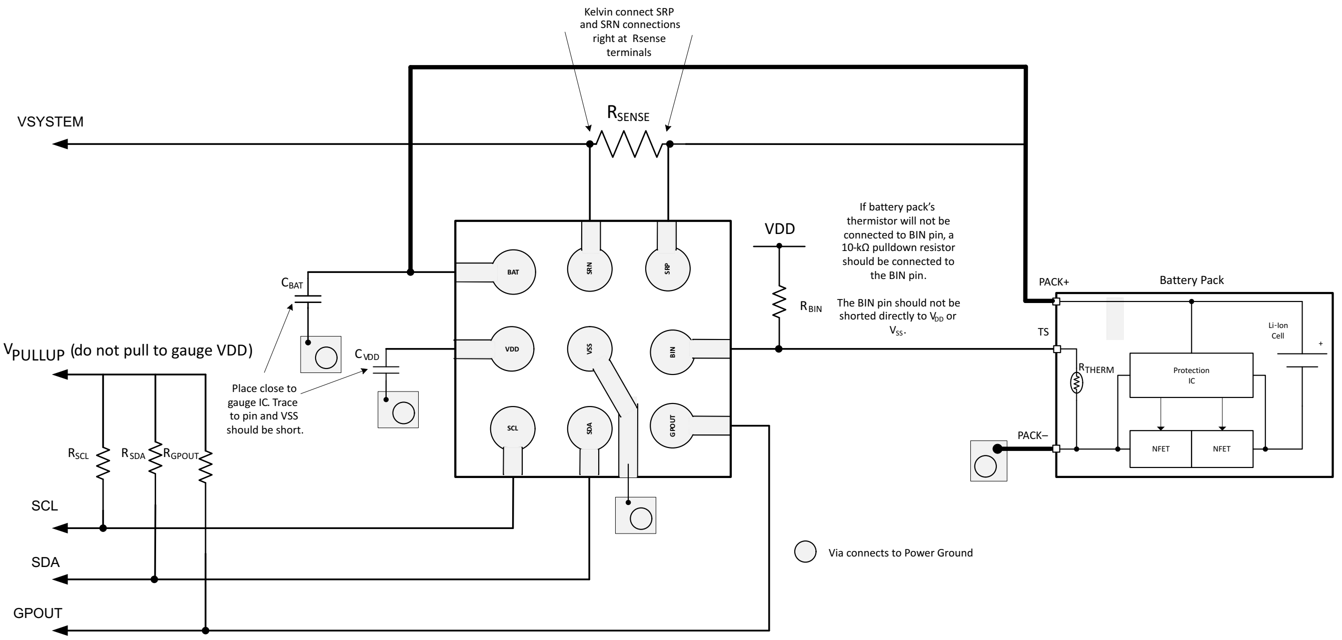


图 10-1. BQ27426 Board Layout

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 第三方产品免责声明

TI 发布的与第三方产品或服务有关的信息，不能构成与此类产品或服务或保修的适用性有关的认可，不能构成此类产品或服务单独或与任何 TI 产品或服务一起的表示或认可。

11.1.2 Related Documentation

- *BQ27426 Technical Reference Manual*
- *Single Cell Gas Gauge Circuit Design*
- *Single Cell Impedance Track Printed-Circuit Board Layout Guide*
- *ESD and RF Mitigation in Handheld Battery Electronics*

11.2 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*订阅更新*进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

11.3 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

11.4 Trademarks

Impedance Track™, NanoFree™, and TI E2E™ are trademarks of Texas Instruments.
所有商标均为其各自所有者的财产。

11.5 静电放电警告

静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

11.6 术语表

TI 术语表	本术语表列出并解释了术语、首字母缩略词和定义。

12 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)
BQ27426YZFR	Active	Production	DSBGA (YZF) | 9	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27426
BQ27426YZFR.A	Active	Production	DSBGA (YZF) | 9	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27426
BQ27426YZFT	Active	Production	DSBGA (YZF) | 9	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27426
BQ27426YZFT.A	Active	Production	DSBGA (YZF) | 9	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27426

(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.

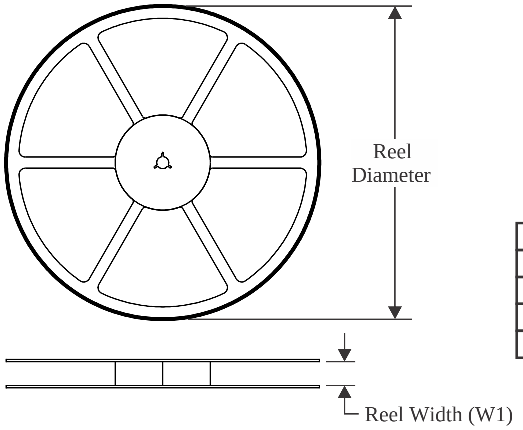
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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

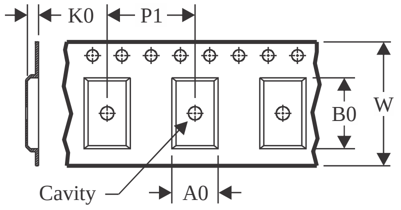
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

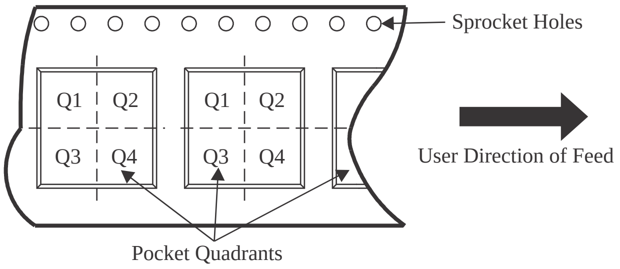


TAPE DIMENSIONS



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

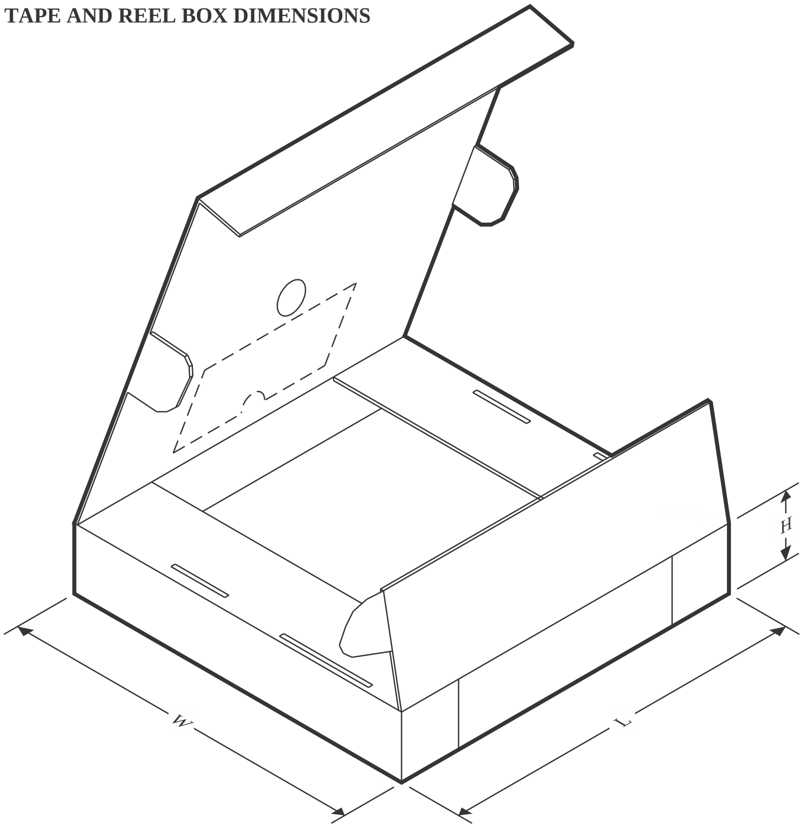
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

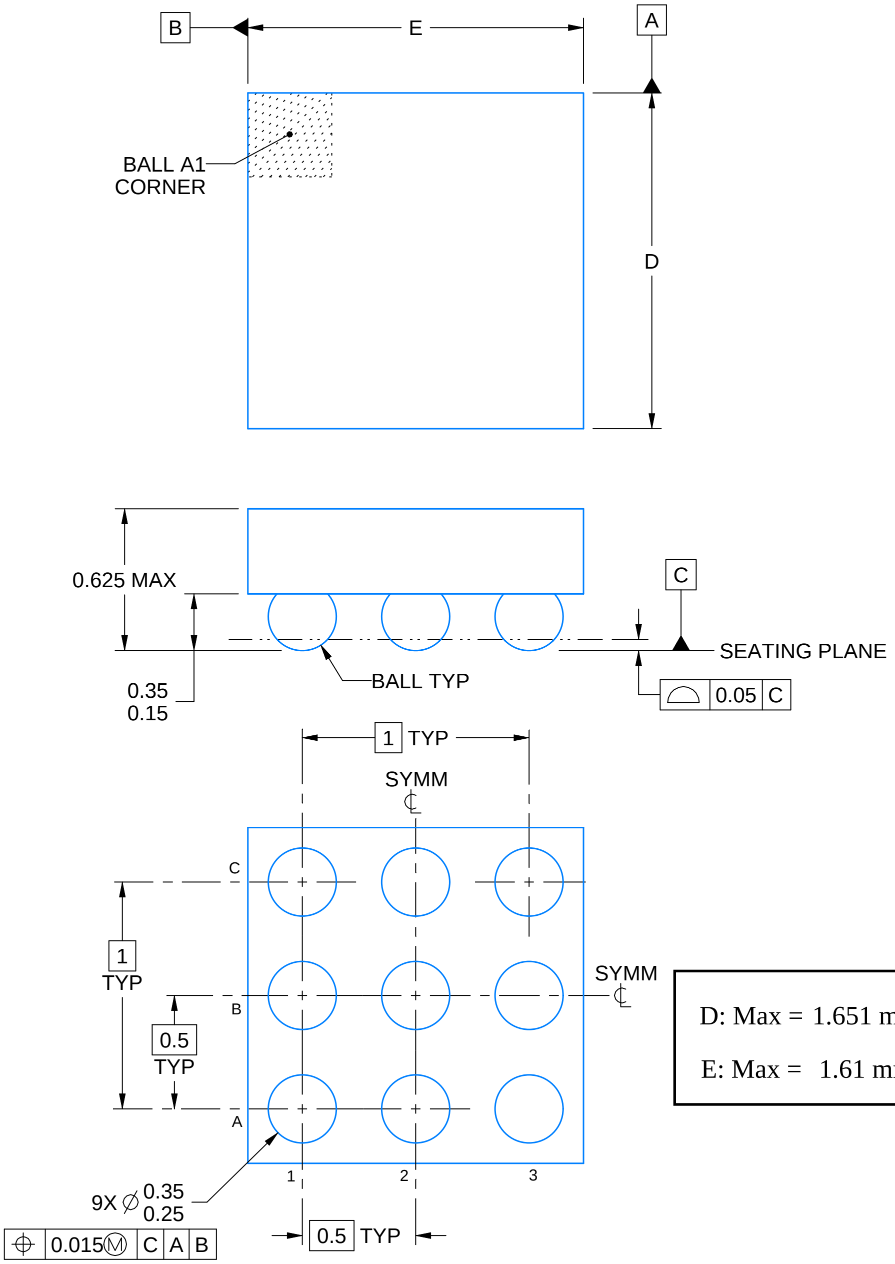
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ27426YZFR	DSBGA	YZF	9	3000	180.0	8.4	1.78	1.78	0.69	4.0	8.0	Q1
BQ27426YZFT	DSBGA	YZF	9	250	180.0	8.4	1.78	1.78	0.69	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ27426YZFR	DSBGA	YZF	9	3000	182.0	182.0	20.0
BQ27426YZFT	DSBGA	YZF	9	250	182.0	182.0	20.0

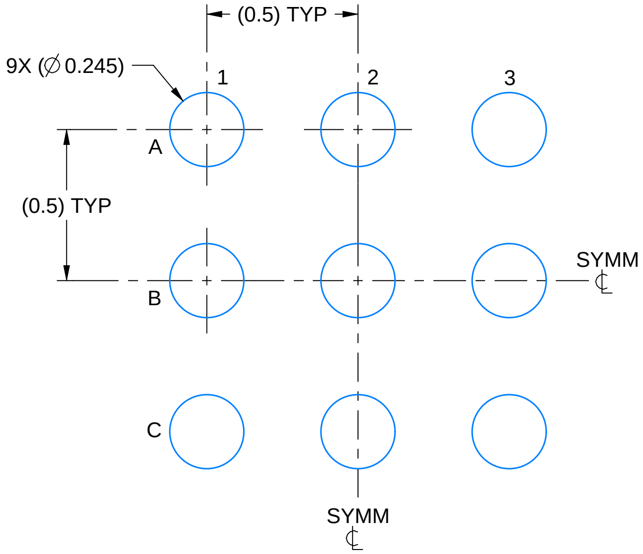


D: Max = 1.651 mm, Min = 1.59 mm

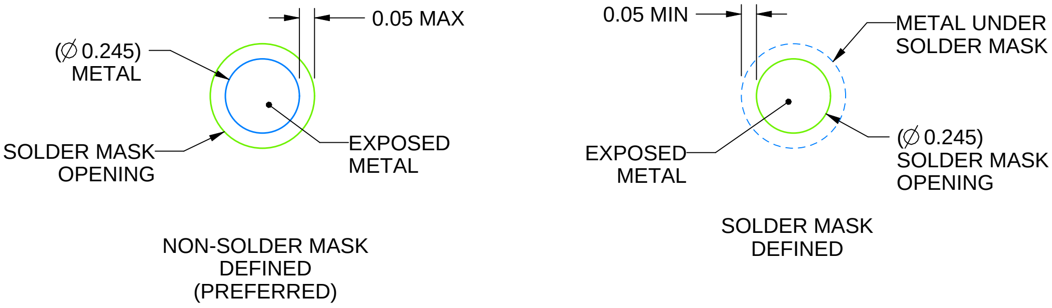
E: Max = 1.61 mm, Min = 1.55 mm

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

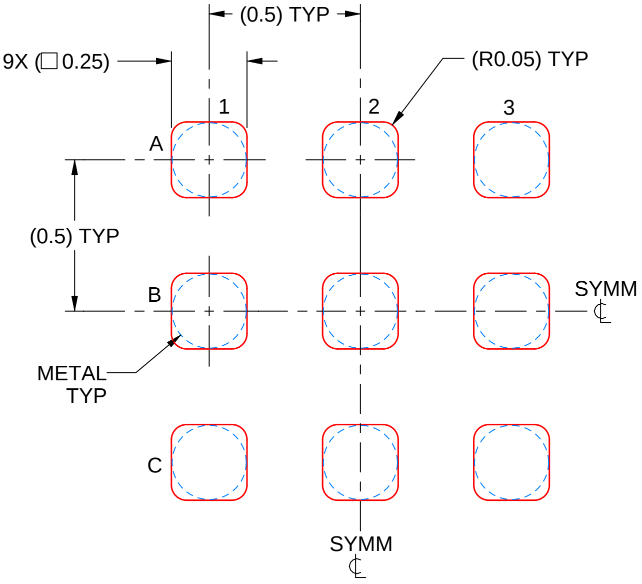


SOLDER MASK DETAILS
NOT TO SCALE

4219558/A 10/2018

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

NOTES: (continued)

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

重要通知和免责声明

邮寄地址：Texas Instruments, Post Office Box 655303, Dallas, Texas 75265