bq27530-G1 Battery Management Unit Impedance Track™ Fuel Gauge with MaxLife™ Technology for Use with the bq2416x Charger Controller

1 Features

- Battery Fuel Gauge and Charger Controller for 1-Cell Li-Ion Applications
- Resides on System Main Board
- Battery Fuel Gauge Based on Patented Impedance Track™ Technology
  - Models the Battery Discharge Curve for Accurate Time-to-Empty Predictions
  - Automatically Adjusts for Battery Aging, Battery Self-Discharge, and Temperature/Rate Inefficiencies
  - Low-Value Sense Resistor (5 mΩ to 20 mΩ)
- Battery Charger Controller with Customizable Charge Profiles
  - Configurable Charge Voltage and Current based on Temperature
  - Optional State-Of-Health (SOH) and Multi-Level Based Charge Profiles
- Host Free Autonomous Battery Management System
  - Reduced Software Overhead Allows for Easy Portability Across Platforms and Shorter OEM Design Cycles
  - Higher Safety and Security
- Run Time Improvements
  - Longer Battery Runtime Leveraging Impedance Track Technology
  - Tighter Accuracy Controls for Charger Termination
  - Improved Recharged Thresholds
- Intelligent Charging—Customized and Adaptive Charging Profiles
  - Charger Control Based on SOH
  - Temperature Level Charging (TLC)
- Battery Charger Controller for bq2416x Single Cell Switchmode Battery Charger
  - Stand-Alone Charging Solution
- 400-kHz I^{2}C™ Interface for Connection to System Microcontroller Port
- In a 15-Pin NanoFree™ Packaging

2 Applications

- Smartphones, Feature Phones, and Tablets
- Digital Still and Video Cameras
- Handheld Terminals
- MP3 or Multimedia Players

3 Description

The Texas Instruments bq27530-G1 system-side Li-Ion Battery Management Unit is a microcontroller peripheral that provides Impedance Track™ fuel gauging and charging control for single-cell Li-Ion battery packs. The device requires little system microcontroller firmware development. Together with bq2416x Single-Cell Switchmode Charger, the bq27530-G1 manages an embedded battery (non-removable) or a removable battery pack.

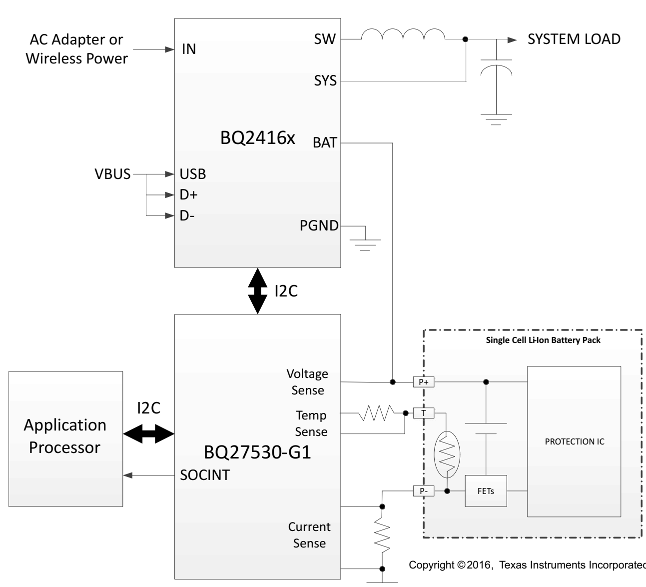
The bq27530-G1 uses the patented Impedance Track™ algorithm for fuel gauging, and provides information such as remaining battery capacity (mAh), state-of-charge (%), runtime-to-empty (min), battery voltage (mV), temperature (°C), and state-of-health (%).

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
bq27530-G1	DSBGA (15)	2.61 mm × 1.96 mm

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

Simplified Schematic



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4 Revision History

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

Changes from Revision B (January 2016) to Revision C — **Page**

- Changed Table 4, *Key Data Flash Parameters for Configuration* ... 20

Changes from Revision A (May 2015) to Revision B — **Page**

- Changed *ESD Ratings* ... 4

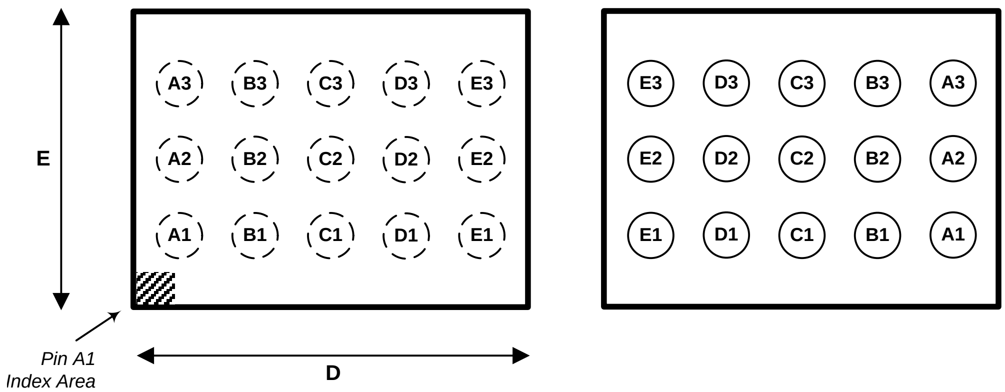
Changes from Original (December 2012) to Revision A — **Page**

- Changed the data sheet title From: Battery Management Unit Impedance Track™ Fuel Gauge for Use With the bq2416x Charger Controller To: Battery Management Unit Impedance Track™ Fuel Gauge with MaxLife Technology for Use With the bq2416x Charger Controller ... 1
- Added the *ESD Ratings* table, *Detailed Description* section, *Feature Description* section, *Device Functional Modes* section, *Programming* section, *Application and Implementation* section. *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, *Mechanical*, *Packaging*, and *Orderable Information* section . 1

5 Pin Configuration and Functions

YZF Package
15-Pin DSBGA

(TOP VIEW) (BOTTOM VIEW)



DIM	MIN	TYP	MAX	UNITS
D	2580	2610	2640	µm
E	1926	1956	1986	

Pin Functions

PIN		TYPE[(1)]	DESCRIPTION
NAME	NO.		
SRP	A1	IA	Analog input pin connected to the internal coulomb counter where SRP is nearest the PACK– connection. Connect to 5-mΩ to 20-mΩ sense resistor.
SRN	B1	IA	Analog input pin connected to the internal coulomb counter where SRN is nearest the Vss connection. Connect to 5-mΩ to 20-mΩ sense resistor.
V_{SS}	C1, C2	P	Device ground
V_{CC}	D1	P	Regulator output and bq27530-G1 power. Decouple with 1µF ceramic capacitor to Vss.
REGIN	E1	P	Regulator input. Decouple with 0.1-µF ceramic capacitor to Vss.
SOC_INT	A2	I/O	SOC state interrupts output. Open drain output.
BSCL	B2	O	Battery Charger clock output line for chipset communication. Push-pull output. **Note:** CE has an internal ESD protection diode connected to REGIN. Recommend maintaining $V_{CE} \leq V_{REGIN}$ under all conditions.
CE	D2	I	Chip Enable. Internal LDO is disconnected from REGIN when driven low.
BAT	E2	I	Cell-voltage measurement input. ADC input. Recommend 4.8V maximum for conversion accuracy.
SCL	A3	I	Slave I^2C serial communications clock input line for communication with system (Master). Open-drain I/O. Use with 10kΩ pull-up resistor (typical).
SDA	B3	I/O	Slave I^2C serial communications data line for communication with system (Master). Open-drain I/O. Use with 10kΩ pull-up resistor (typical).
BSDA	C3	I/O	Battery Charger data line for chipset communication. Push-pull output.
TS	D3	IA	Pack thermistor voltage sense (use 103AT-type thermistor). ADC input.
BI/TOUT	E3	I/O	Battery-insertion detection input. Power pin for pack thermistor network. Thermistor-multiplexer control pin. Use with pull-up resistor >1MΩ (1.8 MΩ typical).

(1) I/O = Digital input/output, IA = 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_{REGIN}	Regulator input range	–0.3 to 5.5	5.5	V
		–0.3	6 [2]	V
V_{CE}	CE input pin	–0.3	V_{REGIN} + 0.3	V
V_{CC}	Supply voltage range	–0.3	2.75	V
V_{IOD}	Open-drain I/O pins (SDA, SCL, SOC_INT)	–0.3	5.5	V
V_{BAT}	BAT input pin	–0.3	5.5	V
		–0.3	6 [2]	V
V_I	Input voltage range to all other pins (BI/TOUT, TS, SRP, SRN, BSDA, BSCL)	–0.3	V_{CC} + 0.3	V
T_A	Operating free-air temperature range	–40	85	°C
T_{stg}	Storage temperature range	–65	150	°C

(1) Stresses beyond those listed as *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated as recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Condition not to exceed 100 hours at 25°C lifetime.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001, BAT pin[1]	±1500	V
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001, All other pins[1]	±2000	
		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 Thermal Information

THERMAL METRIC[1]		bq27530-G1	UNIT
		YZF (DSBGA)	
		15 PINS	
$R_{θJA}$	Junction-to-ambient thermal resistance	70	°C/W
$R_{θJC(top)}$	Junction-to-case (top) thermal resistance	17	°C/W
$R_{θJB}$	Junction-to-board thermal resistance	20	°C/W
$ψ_{JT}$	Junction-to-top characterization parameter	1	°C/W
$ψ_{JB}$	Junction-to-board characterization parameter	18	°C/W
$R_{θJC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	°C/W

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

6.4 Recommended Operating Conditions

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

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
V_{REGIN}	Supply voltage	No operating restrictions	2.8		4.5	V
		No flash writes	2.45		2.8	
C_{REGIN}	External input capacitor for internal LDO between REGIN and V_{SS}	Nominal capacitor values specified. Recommend a 5% ceramic X5R type capacitor located close to the device.		0.1		μF
C_{LDO25}	External output capacitor for internal LDO between V_{CC} and V_{SS}		0.47	1		μF

Recommended Operating Conditions (continued)

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

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
t_{PUCD}	Power-up communication delay			250		ms

6.5 Supply Current

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC} (1)	Normal operating-mode current	Fuel gauge in NORMAL mode I_{LOAD} > ***Sleep current***		118		μA
I_{SLP+} (1)	Sleep+ operating mode current	Fuel gauge in SLEEP+ mode I_{LOAD} < ***Sleep current***		62		μA
I_{SLP} (1)	Low-power storage-mode current	Fuel gauge in SLEEP mode I_{LOAD} < ***Sleep current***		23		μA
I_{HIB} (1)	Hibernate operating-mode current	Fuel gauge in HIBERNATE mode I_{LOAD} < ***Hibernate current***		8		μA

(1) Specified by design. Not production tested.

6.6 Digital Input and Output DC Characteristics

T_A = –40°C to 85°C, typical values at T_A = 25°C and V_{REGIN} = 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OL}	Output voltage, low (SCL, SDA, SOC_INT, BSDA, BSCL)	I_{OL} = 3 mA			0.4	V
$V_{OH(PP)}$	Output voltage, high (BSDA, BSCL)	I_{OH} = –1 mA	V_{CC} – 0.5			V
$V_{OH(OD)}$	Output voltage, high (SDA, SCL, SOC_INT)	External pullup resistor connected to V_{CC}	V_{CC} – 0.5			
V_{IL}	Input voltage, low (SDA, SCL)		–0.3		0.6	V
	Input voltage, low (BI/TOUT)	BAT INSERT CHECK MODE active	–0.3		0.6	
V_{IH}	Input voltage, high (SDA, SCL)		1.2			V
	Input voltage, high (BI/TOUT)	BAT INSERT CHECK MODE active	1.2		V_{CC} + 0.3	
$V_{IL(CE)}$	Input voltage, low (CE)	V_{REGIN} = 2.8 to 4.5V			0.8	V
$V_{IH(CE)}$	Input voltage, high (CE)		2.65			
I_{lkg} (1)	Input leakage current (I/O pins)				0.3	μA

(1) Specified by design. Not production tested.

6.7 Power-on Reset

T_A = –40°C to 85°C, typical values at T_A = 25°C and V_{REGIN} = 3.6 V (unless otherwise noted)

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

6.8 2.5-V LDO Regulator

T_A = –40°C to 85°C, C_{LDO25} = 1 μF, V_{REGIN} = 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IREG25}	Regulator output voltage V_{CC}	2.8 V ≤ V_{REGIN} ≤ 4.5 V, I_{OUT} ≤ 16 mA (1)	2.3	2.5	2.6	V
		2.45 V ≤ V_{REGIN} < 2.8 V (low battery), I_{OUT} ≤ 3mA	2.3			V

(1) LDO output current, I_{OUT}, is the total load current. LDO regulator should be used to power internal fuel gauge only.

6.9 Internal Clock Oscillators

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{OSC}	High frequency oscillator			8.389		MHz
f_{LOSC}	Low frequency oscillator			32.768		kHz

6.10 ADC (Temperature and Cell Measurement) Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{ADC1}	Input voltage range (TS)		V_{SS} – 0.125		2	V
V_{ADC2}	Input voltage range (BAT)		V_{SS} – 0.125		5	V
$V_{IN(ADC)}$	Input voltage range		0.05		1	V
G_{TEMP}	Internal temperature sensor voltage gain			–2		mV/°C
t_{ADC_CONV}	Conversion time				125	ms
	Resolution		14		15	bits
$V_{OS(ADC)}$	Input offset			1		mV
Z_{ADC1} (1)	Effective input resistance (TS)		8			MΩ
Z_{ADC2} (1)	Effective input resistance (BAT)	bq27530-G1 not measuring cell voltage	8			MΩ
		bq27530-G1 measuring cell voltage		100		kΩ
$I_{lkg(ADC)}$ (1)	Input leakage current				0.3	µA

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

6.11 Integrating ADC (Coulomb Counter) Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{SR}	Input voltage range, $V_{(SRP)}$ and $V_{(SRN)}$	$V_{SR} = V_{(SRP)} – V_{(SRN)}$	–0.125		0.125	V
t_{SR_CONV}	Conversion time	Single conversion		1		s
	Resolution		14		15	bits
$V_{OS(SR)}$	Input offset			10		µV
INL	Integral nonlinearity error			±0.007%	±0.034%	FSR
$Z_{IN(SR)}$ (1)	Effective input resistance		2.5			MΩ
$I_{lkg(SR)}$ (1)	Input leakage current				0.3	µA

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

6.12 Data Flash Memory Characteristics

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

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

(1) Specified by design. Not production tested

Data Flash Memory Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{PGERASE}$ (1)	Flash page erase time		20			ms

6.13 I²C-Compatible Interface Communication Timing Characteristics

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

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

(1) If the clock frequency (f_{SCL}) is > 100 kHz, use 1-byte write commands for proper operation. All other transactions types are supported at 400 kHz. (Refer to *I²C Interface* and *I²C Command Waiting Time*.)

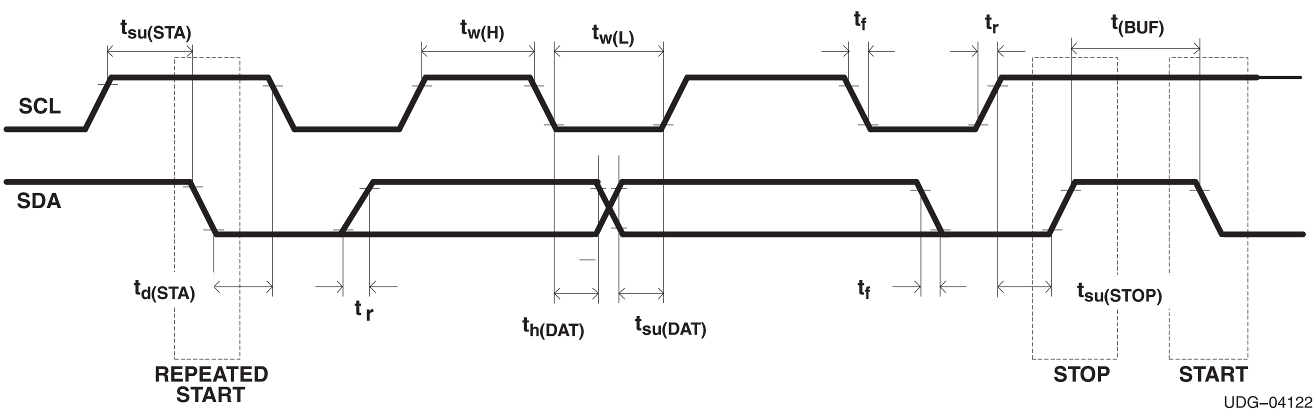


Figure 1. I²C-compatible Interface Timing Diagrams

6.14 Typical Characteristics

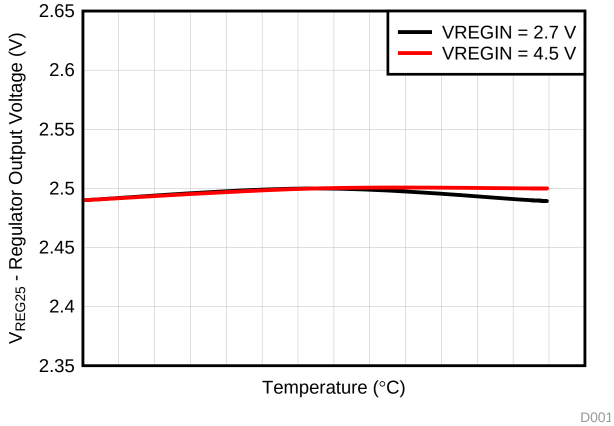


Figure 2. Regulator Output Voltage vs. Temperature

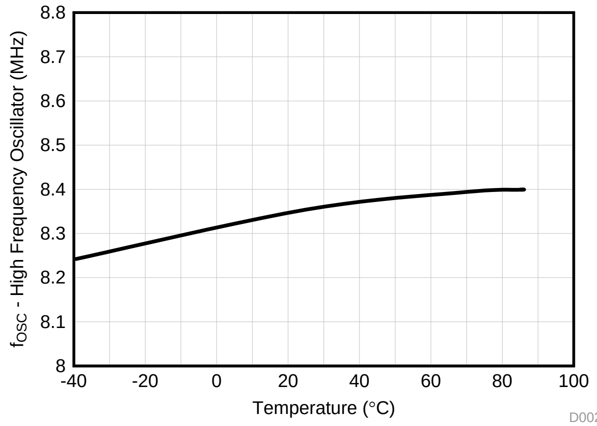


Figure 3. High-Frequency Oscillator Frequency vs. Temperature

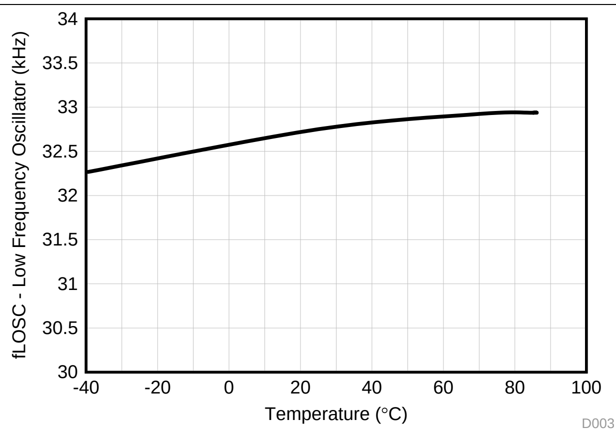


Figure 4. Low-Frequency Oscillator Frequency vs. Temperature

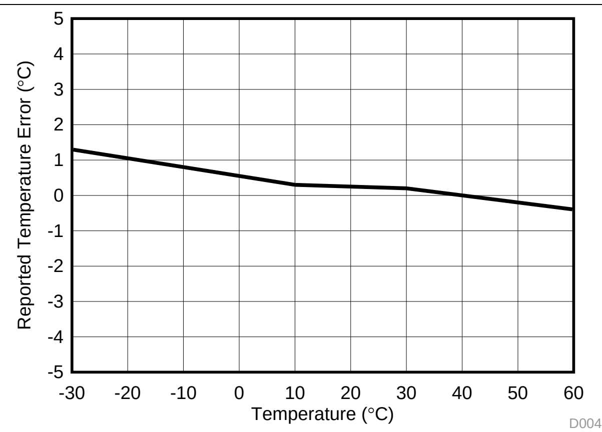


Figure 5. Reported Internal Temperature Measurement vs. Temperature

7 Detailed Description

7.1 Overview

Battery fuel gauging with the bq27530-G1 requires only PACK+ (P+), PACK– (P–), and Thermistor (T) connections to a removable battery pack or embedded battery circuit. The CSP option is a 15-ball package in the dimensions of 2.61 mm × 1.96 mm with 0.5 mm lead pitch. It is ideal for space constrained applications.

The bq27530-G1 accurately predicts the battery capacity and other operational characteristics of a single Li-based rechargeable cell. It can be interrogated by a system processor to provide cell information, such as time-to-empty (TTE), and state-of-charge (SOC) as well as SOC interrupt signal to the host.

The bq27530-G1 can control a bq2416x Charger IC without the intervention from an application system processor. Using the bq27530-G1 and bq2416x chipset, batteries can be charged with the typical constant-current, constant voltage (CCCV) profile or charged using a Multi-Level Charging (MLC) algorithm.

The fuel gauge can also be configured to suggest charge voltage and current values to the system so that the host can control a charger that is not part of the bq2416x charger family.

NOTE

FORMATTING CONVENTIONS IN THIS DOCUMENT:

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

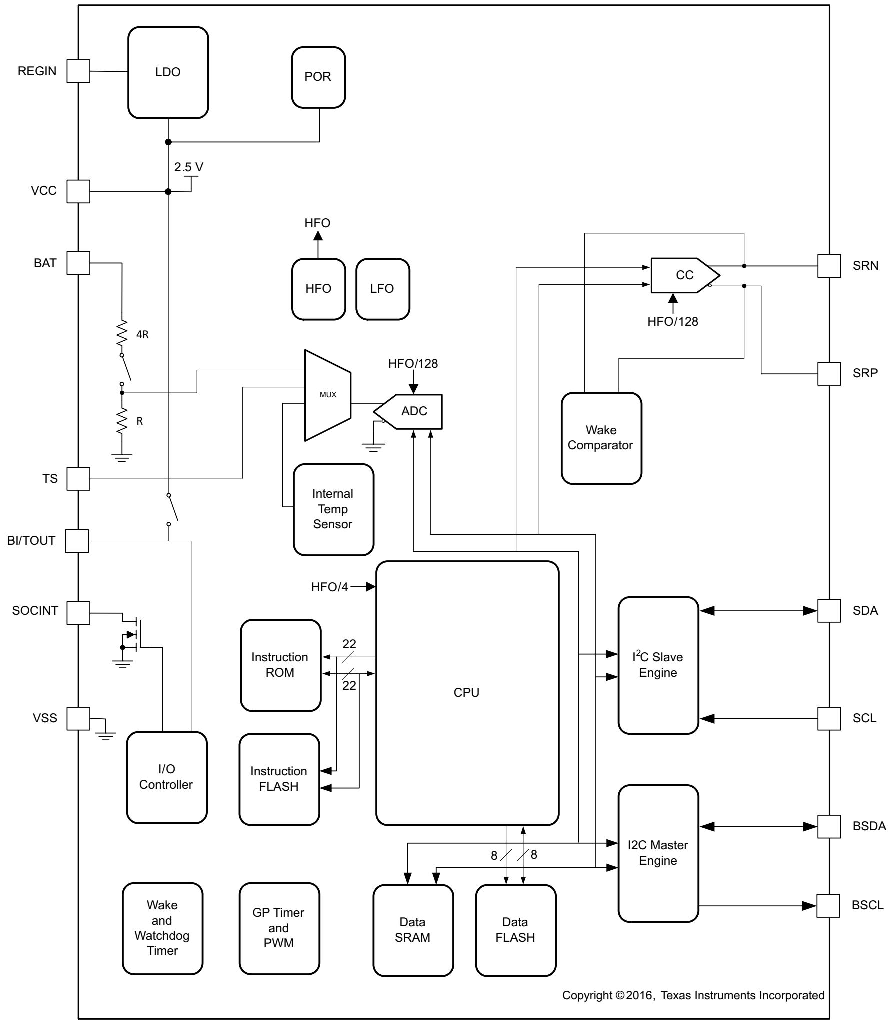
Data flash: *italics*, **bold**, and *breaking spaces*, e.g., ***Design Capacity***

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

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

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

7.2 Functional Block Diagram



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 flash locations. Commands are sent from system to gauge using the I^2C serial communications engine, and can be executed during application development, pack manufacture, or end-equipment operation.

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

The key to the high-accuracy gas gauging prediction is the TI proprietary Impedance Track™ algorithm. This algorithm uses cell measurements, characteristics, and properties to create SOC predictions that can achieve less than 1% error 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 series sense resistor (5 to 20 mΩ, typical) located between the system V_{SS} and the battery PACK– terminal. 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 external temperature sensing is optimized with the use of a high-accuracy negative temperature coefficient (NTC) thermistor with R25 = 10.0 kΩ ±1%, B25/85 = 3435 K ± 1% (such as Semitec NTC 103AT). The fuel gauge can also be configured to use its internal temperature sensor. When an external thermistor is used, a 18.2-kΩ pullup resistor between the BI/TOUT and TS pins is also required. The fuel gauge uses temperature to monitor the battery-pack environment, which is used for fuel gauging and cell protection functionality.

To minimize power consumption, the fuel gauge has different power modes: NORMAL, SLEEP, SLEEP+, HIBERNATE, and BAT INSERT CHECK. 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.

7.3.1 Functional Description

The fuel gauge measures the cell voltage, temperature, and current to determine battery SOC. The fuel gauge monitors the charging and discharging of the battery by sensing the voltage across a small-value resistor (5 mΩ to 20 mΩ, typical) between the SRP and SRN pins and in series with the cell. By integrating charge passing through the battery, the battery SOC is adjusted during battery charge or discharge.

The total battery capacity is found by comparing states of charge before and after applying the load with the amount of charge passed. When an application load is applied, the impedance of the cell is measured by comparing the OCV obtained from a predefined function for present SOC with the measured voltage under load. Measurements of OCV and charge integration determine chemical SOC and chemical capacity (Qmax). The initial Qmax values are taken from a cell manufacturers' data sheet multiplied by the number of parallel cells. It is also used for the value in ***Design Capacity***. The fuel gauge acquires and updates the battery-impedance profile during normal battery usage. It uses this profile, along with SOC and the Qmax value, to determine *FullChargeCapacity()* and *StateOfCharge()*, specifically for the present load and temperature. *FullChargeCapacity()* is reported as capacity available from a fully-charged battery under the present load and temperature until *Voltage()* reaches the ***Terminate Voltage***. *NominalAvailableCapacity()* and *FullAvailableCapacity()* are the uncompensated (no or light load) versions of *RemainingCapacity()* and *FullChargeCapacity()*, respectively.

The fuel gauge has two flags accessed by the *Flags()* function that warn when the battery SOC has fallen to critical levels. When *RemainingCapacity()* falls below the first capacity threshold as specified in ***SOC1 Set Threshold***, the *[SOC1] (State of Charge Initial)* flag is set. The flag is cleared once *RemainingCapacity()* rises above ***SOC1 Clear Threshold***.

When the voltage is discharged to ***Terminate Voltage***, the SOC will be set to 0.

7.4 Device Functional Modes

7.4.1 Power Modes

The fuel gauge has different power modes:

- BAT INSERT CHECK: The BAT INSERT CHECK mode is a powered-up, but low-power halted, state where the fuel gauge resides when no battery is inserted into the system.
- NORMAL: In NORMAL mode, the fuel gauge is fully powered and can execute any allowable task.
- SLEEP: In SLEEP mode, the fuel gauge turns off the high-frequency oscillator and exists in a reduced- power state, periodically taking measurements and performing calculations.
- SLEEP+: In SLEEP+ mode, both low-frequency and high-frequency oscillators are active. Although the SLEEP+ mode has higher current consumption than the SLEEP mode, it is also a reduced power mode.
- HIBERNATE: In HIBERNATE mode, the fuel gauge is in a low power state, but can be woken up by communication or certain I/O activity.

The relationship between these modes is shown in Figure 6.

7.4.1.1 BAT INSERT CHECK Mode

This mode is a halted-CPU state that occurs when an adapter, or other power source, is present to power the fuel gauge (and system), yet no battery has been detected. When battery insertion is detected, a series of initialization activities begin, which include: OCV measurement, setting the *Flags() [BAT_DET]* bit, and selecting the appropriate battery profiles.

Some commands, issued by a system processor, can be processed while the fuel gauge is halted in this mode. The gauge wakes up to process the command, then returns to the halted state awaiting battery insertion.

7.4.1.2 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, 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.

7.4.1.3 SLEEP Mode

SLEEP mode is entered automatically if the feature is enabled (***Op Config [SLEEP]*** = 1) and *AverageCurrent()* is below the programmable level ***Sleep Current*** . Once entry into SLEEP mode has been qualified, but prior to entering it, the fuel gauge performs a coulomb counter autocalibration to minimize offset.

During SLEEP mode, the fuel gauge periodically takes data measurements and updates its data set. However, a majority of its time is spent in an idle condition.

The fuel gauge exits SLEEP mode if any entry condition is broken, specifically when:

- *AverageCurrent()* rises above ***Sleep Current*** , or
- A current in excess of I_{WAKE} through R_{SENSE} is detected.

In the event that a battery is removed from the system while a charger is present (and powering the gauge), Impedance Track updates are not necessary. Hence, the fuel gauge enters a state that checks for battery insertion and does not continue executing the Impedance Track algorithm.

Device Functional Modes (continued)

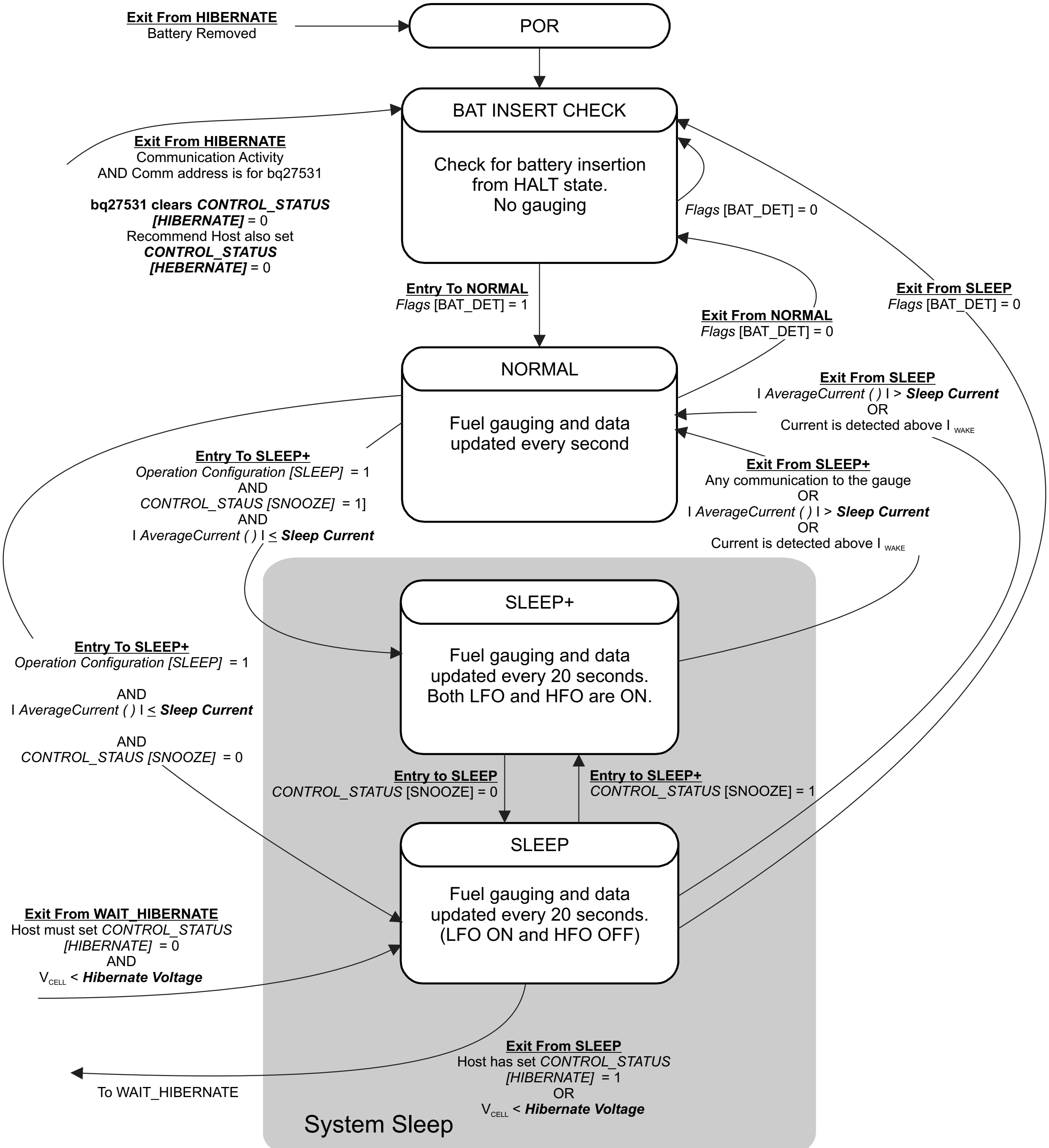


Figure 6. Power Mode Diagram—System Sleep

Device Functional Modes (continued)

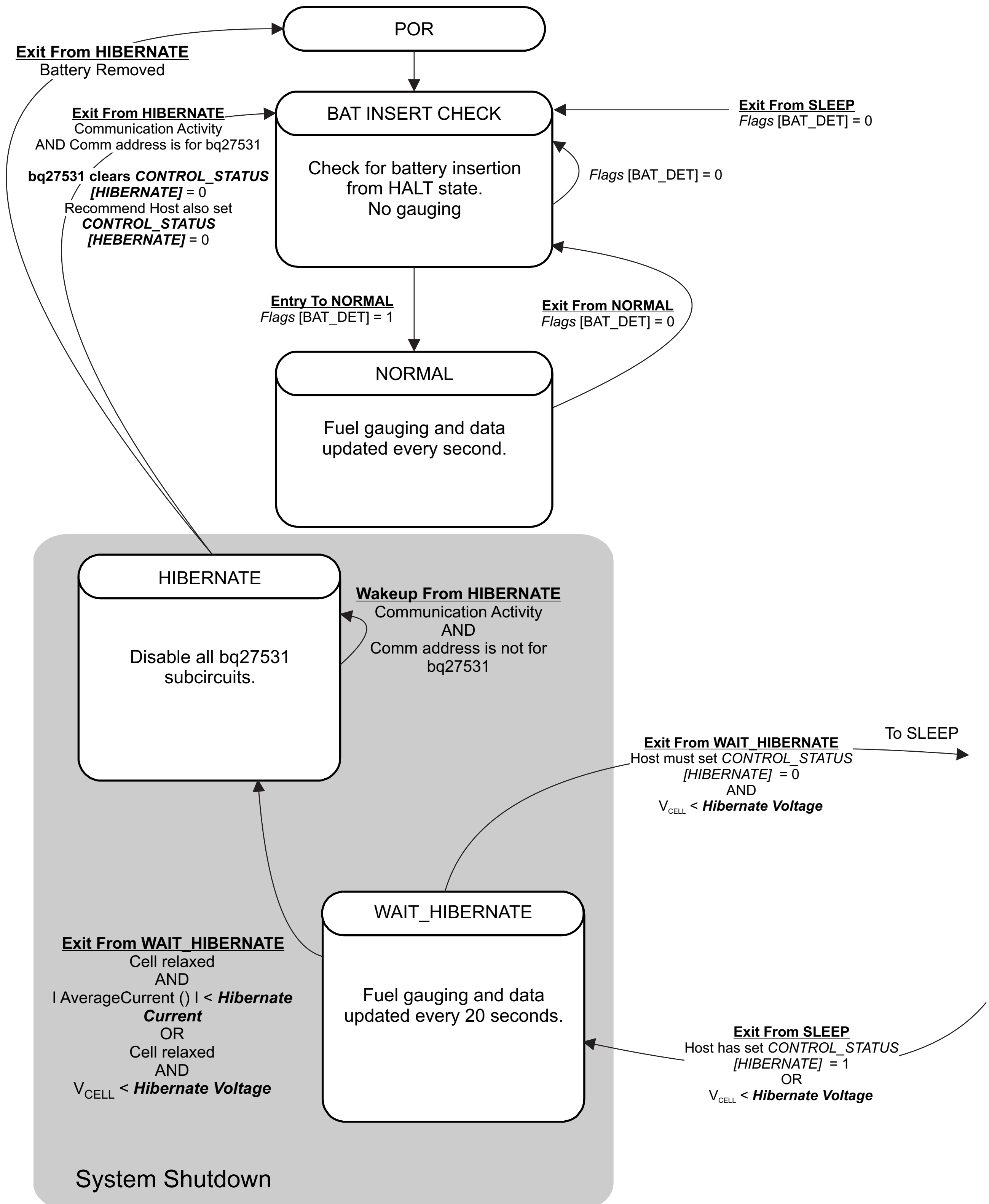


Figure 7. Power Mode Diagram—System Shutdown

Device Functional Modes (continued)

7.4.2 SLEEP+ Mode

Compared to the SLEEP mode, SLEEP+ mode has the high-frequency oscillator in operation. The communication delay could be eliminated. The SLEEP+ mode is entered automatically if the feature is enabled *(CONTROL_STATUS [SNOOZE] = 1)* and *AverageCurrent()* is below the programmable level ***Sleep Current***.

During SLEEP+ mode, the fuel gauge periodically takes data measurements and updates its data set. However, a majority of its time is spent in an idle condition.

The fuel gauge exits SLEEP+ mode if any entry condition is broken, specifically when:

- Any communication activity with the gauge, or
- *AverageCurrent()* rises above ***Sleep Current***, or
- A current in excess of I_{WAKE} through R_{SENSE} is detected.

7.4.3 HIBERNATE Mode

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

Before the fuel gauge can enter HIBERNATE mode, the system must set the *CONTROL_STATUS [HIBERNATE]* bit. The gauge waits to enter HIBERNATE mode until it has taken a valid OCV measurement and the magnitude of the average cell current has fallen below ***Hibernate Current***. The gauge can also enter HIBERNATE mode if the cell voltage falls below ***Hibernate Voltage*** and a valid OCV measurement has been taken. The gauge remains in HIBERNATE mode until the system issues a direct I^2C command to the gauge or a POR occurs. Any I^2C communication that is not directed to the gauge does not wake the gauge.

It is the responsibility of the system to wake the fuel gauge after it has gone into HIBERNATE mode. After waking, the gauge can proceed with the initialization of the battery information (OCV, profile selection, and so forth).

7.5 Programming

7.5.1 Standard Data Commands

The bq27530-G1 uses a series of 2-byte standard commands to enable system reading and writing of battery information. Each standard command has an associated command-code pair, as indicated in Table 1. Because each command consists of two bytes of data, two consecutive I^2C transmissions must be executed both to initiate the command function, and to read or write the corresponding two bytes of data.

Table 1. Standard Commands

NAME	COMMAND CODE	UNITS	SEALED ACCESS	UNSEALED ACCESS
Control()	0x00/0x01	N/A	R/W	R/W
AtRate()	0x02/0x03	mA	R/W	R/W
AtRateTimeToEmpty()	0x04/0x05	Minutes	R	R/W
Temperature()	0x06/0x07	0.1 K	R/W	R/W
Voltage()	0x08/0x09	mV	R	R/W
Flags()	0x0a/0x0b	N/A	R	R/W
NominalAvailableCapacity()	0x0c/0x0d	mAh	R	R/W
FullAvailableCapacity()	0x0e/0x0f	mAh	R	R/W
RemainingCapacity()	0x10/0x11	mAh	R	R/W
FullChargeCapacity()	0x12/0x13	mAh	R	R/W
AverageCurrent()	0x14/0x15	mA	R	R/W
TimeToEmpty()	0x16/0x17	Minutes	R	R/W
RemainingCapacityUnfiltered()	0x18/0x19	mAh	R	R/W
StandbyCurrent()	0x1a/0x1b	mA	R	R/W

Programming (continued)

Table 1. Standard Commands (continued)

NAME	COMMAND CODE	UNITS	SEALED ACCESS	UNSEALED ACCESS
RemainingCapacityFiltered()	0x1c/0x1d	mAh	R	R/W
ProgChargingCurrent()	0x1e/0x1f	mA	R (1)	R (1)
ProgChargingVoltage()	0x20/0x21	mV	R (1)	R (1)
FullChargeCapacityUnfiltered()	0x22/0x23	mAh	R	R/W
AveragePower()	0x24/0x25	mW	R	R/W
FullChargeCapacityFiltered()	0x26/0x27	mAh	R	R/W
StateOfHealth()	0x28/0x29	%/num	R	R/W
CycleCount()	0x2a/0x2b	Counters	R	R/W
StateOfCharge()	0x2c/0x2d	%	R	R/W
TrueSOC()	0x2e/0x2f	%	R	R/W
InstantaneousCurrentReading()	0x30/0x31	mA	R	R/W
InternalTemperature()	0x32/0x33	0.1 K	R	R/W
ChargingLevel()	0x34/0x35	HEX	R	R
LevelTaperCurrent()	0x6e/0x6f	mA	R	R
CalcChargingCurrent()	0x70/0x71	mA	R	R
CalcChargingVoltage()	0x72/0x73	V	R	R

(1) Only writeable when ***Charger Options [BYPASS]*** is set.

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

Issuing a *Control()* command requires a subsequent 2-byte subcommand. These additional bytes specify the particular control function desired. The *Control()* command allows the system to control specific features of the bq27530-G1 during normal operation and additional features when the device is in different access modes, as described in Table 2.

Table 2. *Control( )* Subcommands

CNTL FUNCTION	CNTL DATA	SEALED ACCESS	DESCRIPTION
CONTROL_STATUS	0x0000	Yes	Reports the status of hibernate, IT, and so on
DEVICE_TYPE	0x0001	Yes	Reports the device type (for example: bq27530)
FW_VERSION	0x0002	Yes	Reports the firmware version on the device type
HW_VERSION	0x0003	Yes	Reports the hardware version of the device type
PREV_MACWRITE	0x0007	Yes	Returns previous MAC subcommand code
CHEM_ID	0x0008	Yes	Reports the chemical identifier of the Impedance Track™ configuration
BOARD_OFFSET	0x0009	No	Forces the device to measure and store the board offset
CC_OFFSET	0x000a	No	Forces the device to measure the internal CC offset
CC_OFFSET_SAVE	0x000b	No	Forces the device to store the internal CC offset
OCV_CMD	0x000c	Yes	Request the gauge to take a OCV measurement
BAT_INSERT	0x000d	Yes	Forces the BAT_DET bit set when the *[BIE]* bit is 0
BAT_REMOVE	0x000e	Yes	Forces the BAT_DET bit clear when the *[BIE]* bit is 0
SET_HIBERNATE	0x0011	Yes	Forces CONTROL_STATUS *[HIBERNATE]* to 1
CLEAR_HIBERNATE	0x0012	Yes	Forces CONTROL_STATUS *[HIBERNATE]* to 0
SET_SLEEP+	0x0013	Yes	Forces CONTROL_STATUS *[SNOOZE]* to 1
CLEAR_SLEEP+	0x0014	Yes	Forces CONTROL_STATUS *[SNOOZE]* to 0
DIV_CUR_ENABLE	0x0017	Yes	Makes the programmed charge current to be half of what is calculated by the gauge charging algorithm.
CHG_ENABLE	0x001A	Yes	Enable charger. Charge will continue as dictated by gauge charging algorithm.

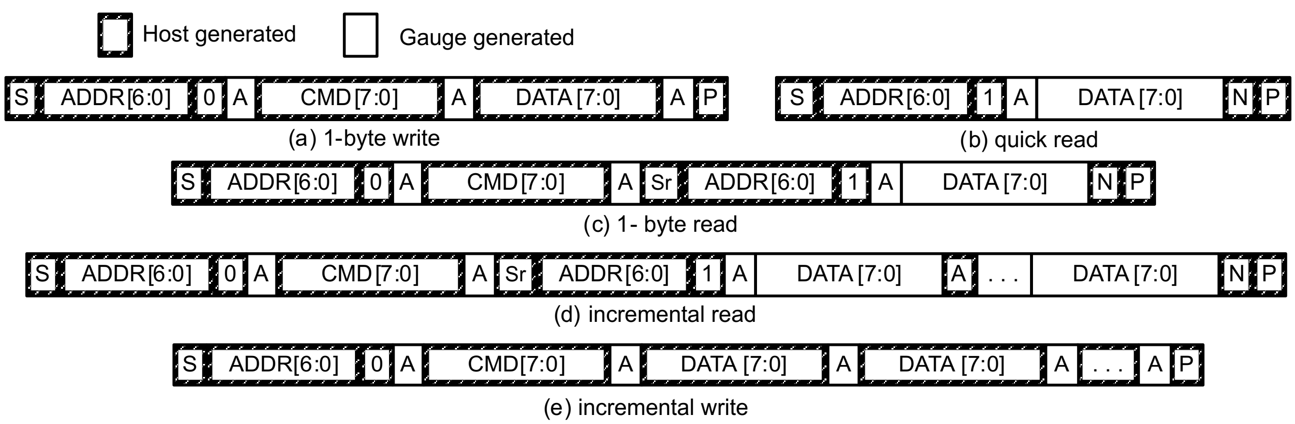
Table 2. *Control( )* Subcommands (continued)

CNTL FUNCTION	CNTL DATA	SEALED ACCESS	DESCRIPTION
CHG_DISABLE	0x001B	Yes	Disable charger (Set $\overline{CE}$ bit of bq2416x)
GG_CHGRCTL_ENABLE	0x001C	Yes	Enables the gas gauge to control the charger while continuosly resetting the charger watchdog
GG_CHGRCTL_DISABLE	0x001D	Yes	The gas gauge stops resetting the charger watchdog
DIV_CUR_DISABLE	0x001E	Yes	Makes the programmed charge current to be same as what is calculated by the gauge charging algorithm.
DF_VERSION	0x001F	Yes	Returns the Data Flash Version
SEALED	0x0020	No	Places device in SEALED access mode
IT_ENABLE	0x0021	No	Enables the Impedance Track™ algorithm
RESET	0x0041	No	Forces a full reset of the bq27530-G1

7.5.3 Communications

7.5.3.1 I²C Interface

The bq27530-G1 supports the standard I²C read, incremental read, quick read, one-byte write, and incremental write functions. The 7-bit device address (ADDR) is the most significant 7 bits of the hex address and is fixed as 1010101. The first 8 bits of the I²C protocol are, therefore, 0xAA or 0xAB for write or read, respectively.



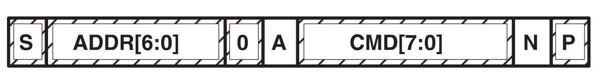
(S = Start , Sr = Repeated Start , A = Acknowledge , N = No Acknowledge , and P = Stop).

The quick read returns data at the address indicated by the address pointer. The address pointer, a register internal to the I²C communication engine, increments whenever data is acknowledged by the bq27530-G1 or the I²C master. "Quick writes" function in the same manner and are a convenient means of sending multiple bytes to consecutive command locations (such as two-byte commands that require two bytes of data).

The following command sequences are not supported:

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

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



7.5.3.2 I²C Time Out

The I²C engine releases both SDA and SCL if the I²C bus is held low for 2 seconds. If the bq27530-G1 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.

7.5.3.3 I²C Command Waiting Time

To ensure proper operation at 400 kHz, a $t_{(BUF)}$ ≥ 66 µs bus-free waiting time must be inserted between all packets addressed to the bq27530-G1. In addition, if the SCL clock frequency (f_{SCL}) is > 100 kHz, use individual 1-byte write commands for proper data flow control. Figure 8 shows the standard waiting time required between issuing the control subcommand the reading the status result. A DF_CHECKSUM subcommand requires 100 ms minimum prior to reading the result. An OCV_CMD subcommand requires 1.2 seconds prior to reading the 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.

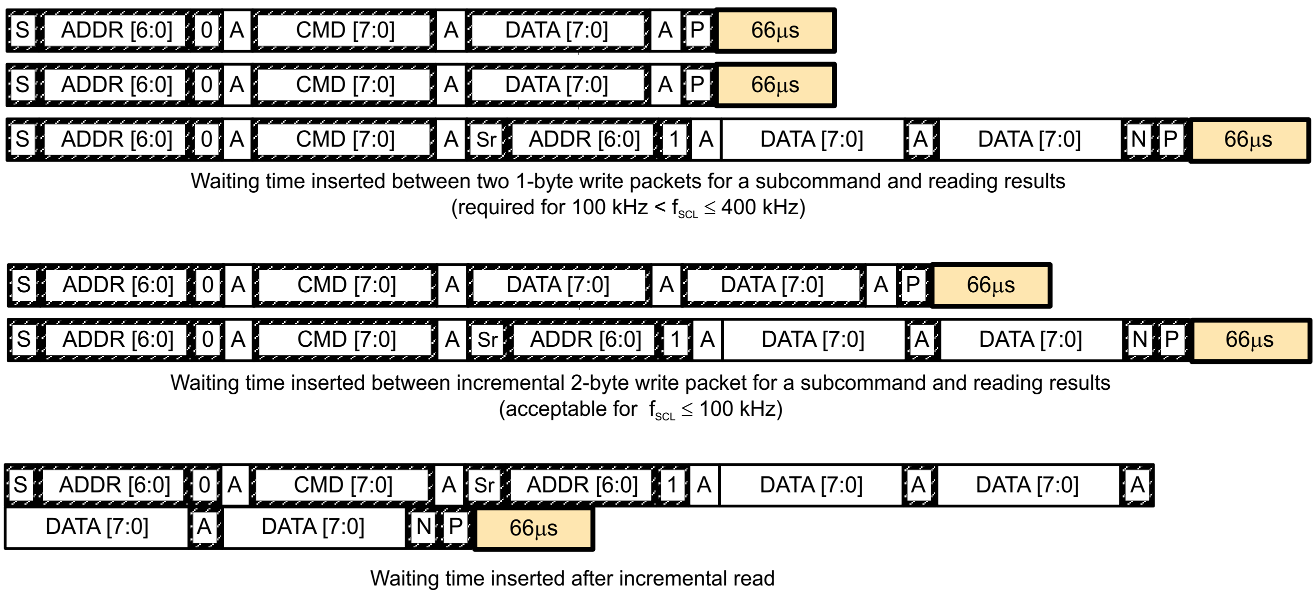


Figure 8. Standard Waiting Time

7.5.3.4 I²C Clock Stretching

A clock stretch can occur during all modes of fuel gauge operation. In SLEEP and HIBERNATE modes, a short clock stretch occurs on all I²C traffic as the device must wake-up to process the packet. In the other modes (BAT INSERT CHECK, NORMAL, SLEEP+) clock stretching only occurs for packets addressed for the fuel gauge. The majority of clock stretch periods are small as the I²C interface performs normal data flow control. However, less frequent yet more significant clock stretch periods may occur as blocks of Data Flash are updated. Table 3 summarizes the approximate clock stretch duration for various fuel gauge operating conditions.

Table 3. Approximate Clock Stretch Duration

GAUGING MODE	OPERATING CONDITION/COMMENT	APPROXIMATE DURATION
SLEEP HIBERNATE	Clock stretch occurs at the beginning of all traffic as the device wakes up.	≤ 4 ms
BAT INSERT CHECK NORMAL SLEEP+	Clock stretch occurs within the packet for flow control (after a start bit, ACK or first data bit).	≤ 4 ms
	Normal Ra table Data Flash updates.	24 ms
	Data Flash block writes.	72 ms
	Restored Data Flash block write after loss of power.	116 ms
	End of discharge Ra table Data Flash update.	144 ms

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

8.1 Application Information

The fuel gauge can control a bq2416x Charger IC without the intervention from an application system processor. Using the bq27530-G1 and bq2416x chipset, batteries can be charged with the typical constant-current, constant-voltage (CCCV) profile or charged using a Multi-Level Charging (MLC) algorithm.

8.2 Typical Application

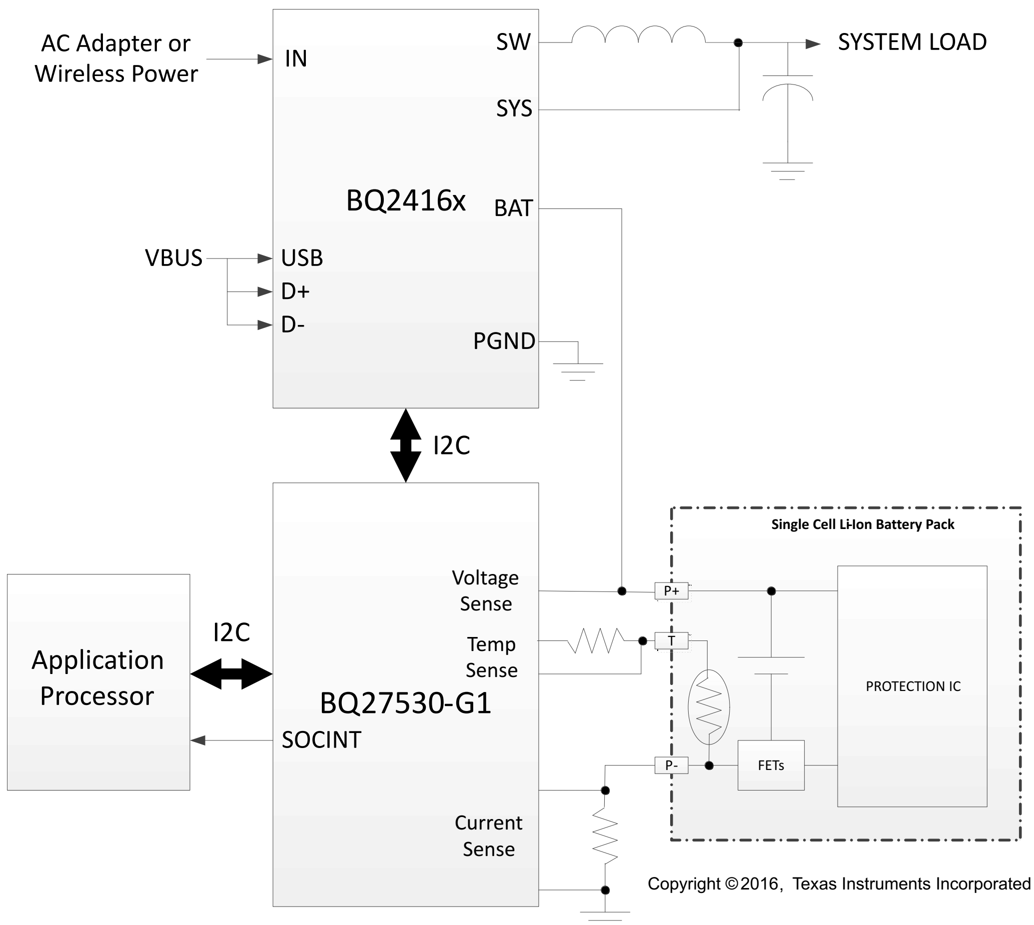


Figure 9. Typical Application

Typical Application (continued)

8.2.1 Design Requirements

Several key parameters must be updated to align with a given application's battery characteristics. For highest accuracy gauging, it is important to follow-up this initial configuration with a learning cycle to optimize resistance and maximum chemical capacity (Qmax) values prior to sealing and shipping systems to the field. Successful and accurate configuration of the fuel gauge for a target application can be used as the basis for creating a "golden" gas gauge (.fs) file that can be written to all gauges, assuming identical pack design and Li-ion cell origin (chemistry, lot, and so on). Calibration data is included as part of this golden GG file to cut down on system production time. If going this route, it is recommended to average the voltage and current measurement calibration data from a large sample size and use these in the golden file. Table 4, shows the items that should be configured to achieve reliable protection and accurate gauging with minimal initial configuration.

Table 4. Key Data Flash Parameters for Configuration

NAME	DEFAULT	UNIT	RECOMMENDED SETTING
Design Capacity	1544	mAh	Set based on the nominal pack capacity as interpreted from cell manufacturer's data sheet. If multiple parallel cells are used, should be set to N × Cell Capacity.
Reserve Capacity-mAh	0	mAh	Set to desired runtime remaining (in seconds/3600) × typical applied load between reporting 0% SOC and reaching ***Terminate Voltage***, if needed.
Cycle Count Threshold	1390	mAh	Set to 90% of configured ***Design Capacity***.
Chem ID	1189	hex	Should be configured using TI-supplied Battery Management Studio software. Default open-circuit voltage and resistance tables are also updated in conjunction with this step. Do not attempt to manually update reported Device Chemistry as this does not change all chemistry information! Always update chemistry using the appropriate software tool (that is, bqStudio).
Load Mode	0	—	Set to applicable load model, 0 for constant current or 1 for constant power.
Load Select	1	—	Set to load profile which most closely matches typical system load.
Qmax Cell 0	1544	mAh	Set to initial configured value for Design Capacity. The gauge will update this parameter automatically after the optimization cycle and for every regular Qmax update thereafter.
V at Chg Term Cell 0	4200	mV	Set to nominal cell voltage for a fully charged cell. The gauge will update this parameter automatically each time full charge termination is detected.
Terminate Voltage	3200	mV	Set to empty point reference of battery based on system needs. Typical is between 3000 mV and 3200 mV.
Ra Max Delta	44	mΩ	Set to 15% of Cell0 R_a 4 resistance after an optimization cycle is completed.
Charging Voltage	4200	mV	Set based on nominal charge voltage for the battery in normal conditions (25°C, etc). Used as the reference point for offsetting by ***Taper Voltage*** for full charge termination detection.
Taper Current	77	mA	Set to the nominal taper current of the charger + taper current tolerance to ensure that the gauge will reliably detect charge termination.
Taper Voltage	100	mV	Sets the voltage window for qualifying full charge termination. Can be set tighter to avoid or wider to ensure possibility of reporting 100% SOC in outer JEITA temperature ranges that use derated charging voltage.
Dsg Current Threshold	60	mA	Sets threshold for gauge detecting battery discharge. Should be set lower than minimal system load expected in the application and higher than ***Quit Current***.
Chg Current Threshold	75	mA	Sets the threshold for detecting battery charge. Can be set higher or lower depending on typical trickle charge current used. Also should be set higher than ***Quit Current***.
Quit Current	40	mA	Sets threshold for gauge detecting battery relaxation. Can be set higher or lower depending on typical standby current and exhibited in the end system.
Avg I Last Run	–299	mA	Current profile used in capacity simulations at onset of discharge or at all times if ***Load Select*** = 0. Should be set to nominal system load. Is automatically updated by the gauge every cycle.
Avg P Last Run	–1131	mW	Power profile used in capacity simulations at onset of discharge or at all times if ***Load Select*** = 0. Should be set to nominal system power. Is automatically updated by the gauge every cycle.
Sleep Current	10	mA	Sets the threshold at which the fuel gauge enters SLEEP mode. Take care in setting above typical standby currents else entry to SLEEP may be unintentionally blocked.

Typical Application (continued)

Table 4. Key Data Flash Parameters for Configuration (continued)

NAME	DEFAULT	UNIT	RECOMMENDED SETTING
Charge T0	0	°C	Sets the boundary between charging inhibit and charging with T0 parameters.
Charge T1	10	°C	Sets the boundary between charging with T0 and T1 parameters.
Charge T2	45	°C	Sets the boundary between charging with T1 and T2 parameters.
Charge T3	50	°C	Sets the boundary between charging with T2 and T3 parameters.
Charge T4	60	°C	Sets the boundary between charging with T3 and T4 parameters.
Charge Current T0	50	% Des Cap	Sets the charge current parameter for T0.
Charge Current T1	100	% Des Cap	Sets the charge current parameter for T1.
Charge Current T2	100	% Des Cap	Sets the charge current parameter for T2.
Charge Current T3	100	% Des Cap	Sets the charge current parameter for T3.
Charge Current T4	0	% Des Cap	Sets the charge current parameter for T4.
Charge Voltage T0	210	20 mV	Sets the charge voltage parameter for T0.
Charge Voltage T1	210	20 mV	Sets the charge voltage parameter for T1.
Charge Voltage T2	207	20 mV	Sets the charge voltage parameter for T2.
Charge Voltage T3	205	20 mV	Sets the charge voltage parameter for T3.
Charge Voltage T4	0	20 mV	Sets the charge voltage parameter for T4.
Chg Temp Hys	3	°C	Adds temperature hysteresis for boundary crossings to avoid oscillation if temperature is changing by a degree or so on a given boundary.
Chg Disabled Regulation V	4200	mV	Sets the voltage threshold for voltage regulation to system when charge is disabled. It is recommended to program to same value as Charging Voltage and maximum charge voltage that is obtained from Charge Voltage Tn parameters.
CC Gain	10	mΩ	Calibrate this parameter using TI-supplied bqStudio software and calibration procedure in the TRM. Determines conversion of coulomb counter measured sense resistor voltage to current.
CC Delta	10	mΩ	Calibrate this parameter using TI-supplied bqStudio software and calibration procedure in the TRM. Determines conversion of coulomb counter measured sense resistor voltage to passed charge.
CC Offset	–1418	Counts	Calibrate this parameter using TI-supplied bqStudio software and calibration procedure in the TRM. Determines native offset of coulomb counter hardware that should be removed from conversions.
Board Offset	0	Counts	Calibrate this parameter using TI-supplied bqStudio software and calibration procedure in the TRM. Determines native offset of the printed circuit board parasitics that should be removed from conversions.
Pack V Offset	0	mV	Calibrate this parameter using TI-supplied bqStudio software and calibration procedure in the TRM. Determines voltage offset between cell tab and ADC input node to incorporate back into or remove from measurement, depending on polarity.

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 SRP and SRN Current Sense Inputs

The filter network at the input to the coulomb counter is intended to improve differential mode rejection of voltage measured across the sense resistor. These components should be placed as close as possible to the coulomb counter inputs and the routing of the differential traces length-matched to best minimize impedance mismatch-induced measurement errors.

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, 100 ppm drift sense resistor with a 1-W power rating.

8.2.2.4 TS Temperature Sense Input

Similar to the BAT pin, a ceramic decoupling capacitor for the TS pin is used to bypass AC voltage ripple away from the high-impedance ADC input, minimizing measurement error. Another helpful advantage is that the capacitor provides additional ESD protection since the TS input to system may be accessible in systems that use removable battery packs. It should be placed as close as possible to the respective input pin for optimal filtering performance.

8.2.2.5 Thermistor Selection

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 103AT-2 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 in data flash to ensure highest accuracy temperature measurement performance.

8.2.2.6 REGIN Power Supply Input Filtering

A ceramic capacitor is placed at the input to the fuel gauge internal LDO to increase power supply rejection (PSR) and improve effective line regulation. It ensures that voltage ripple is rejected to ground instead of coupling into the internal supply rails of the fuel gauge.

8.2.2.7 V_{CC} LDO Output Filtering

A ceramic capacitor is also needed at the output of the internal LDO to provide a current reservoir for fuel gauge load peaks during high peripheral utilization. It acts to stabilize the regulator output and reduce core voltage ripple inside of the fuel gauge.

8.2.3 Application Curves

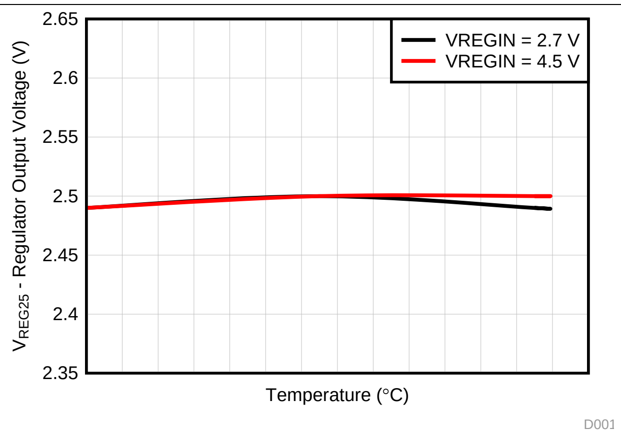


Figure 10. Regulator Output Voltage vs. Temperature

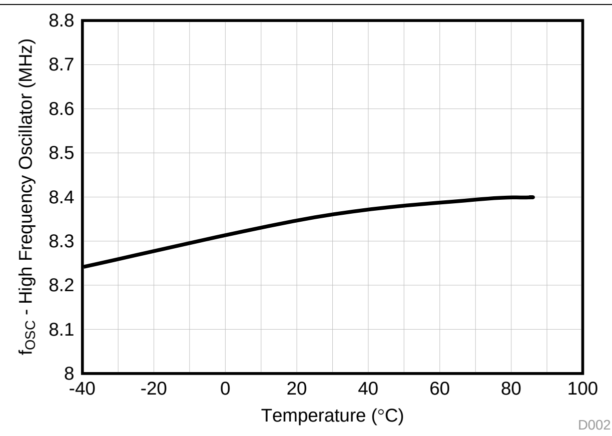


Figure 11. High-Frequency Oscillator Frequency vs. Temperature

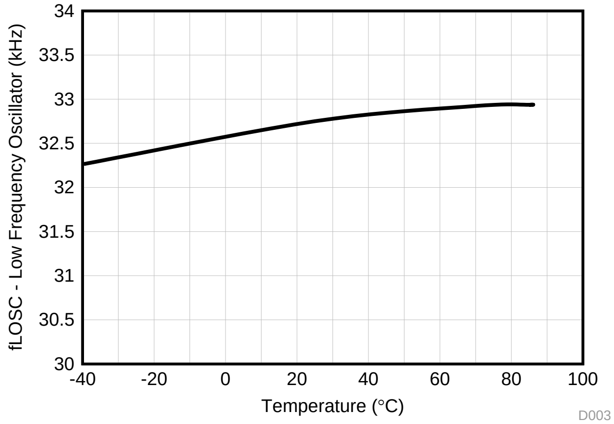


Figure 12. Low-Frequency Oscillator Frequency vs. Temperature

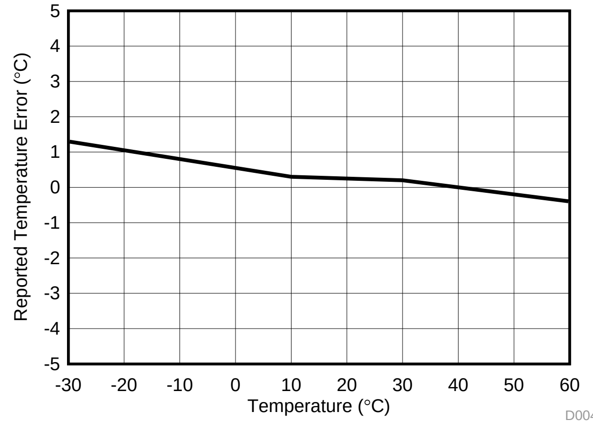


Figure 13. Reported Internal Temperature Measurement vs. Temperature

9 Power Supply Recommendations

9.1 Power Supply Decoupling

Both the REGIN input pin and the V_{CC} output pin require low equivalent series resistance (ESR) ceramic capacitors placed as closely as possible to the respective pins to optimize ripple rejection and provide a stable and dependable power rail that is resilient to line transients. A 0.1-µF capacitor at the REGIN and a 1-µF capacitor at V_{CC} will suffice for satisfactory device performance.

10 Layout

10.1 Layout Guidelines

10.1.1 Sense Resistor Connections

Kelvin connections at the sense resistor are just as critical as those for the battery terminals themselves. The differential traces should be connected at the inside of the sense resistor pads and not anywhere along the high-current trace path to prevent false increases to measured current that could result when measuring between the sum of the sense resistor and trace resistance between the tap points. In addition, the routing of these leads from the sense resistor to the input filter network and finally into the SRP and SRN pins needs to be as closely matched in length as possible else additional measurement offset could occur. It is further recommended to add copper trace or pour-based "guard rings" around the perimeter of the filter network and coulomb counter inputs to shield these sensitive pins from radiated EMI into the sense nodes. This prevents differential voltage shifts that could be interpreted as real current change to the fuel gauge. All of the filter components need to be placed as close as possible to the coulomb counter input pins.

10.1.2 Thermistor Connections

The thermistor sense input should include a ceramic bypass capacitor placed as close to the TS input pin as possible. The capacitor helps to filter measurements of any stray transients as the voltage bias circuit pulses periodically during temperature sensing windows.

10.1.3 High-Current and Low-Current Path Separation

For best possible noise performance, it is extremely important to separate the low-current and high-current loops to different areas of the board layout. The fuel gauge and all support components should be situated on one side of the boards and tap off of the high-current loop (for measurement purposes) at the sense resistor. Routing the low-current ground around instead of under high-current traces will further help to improve noise rejection.

10.2 Layout Example

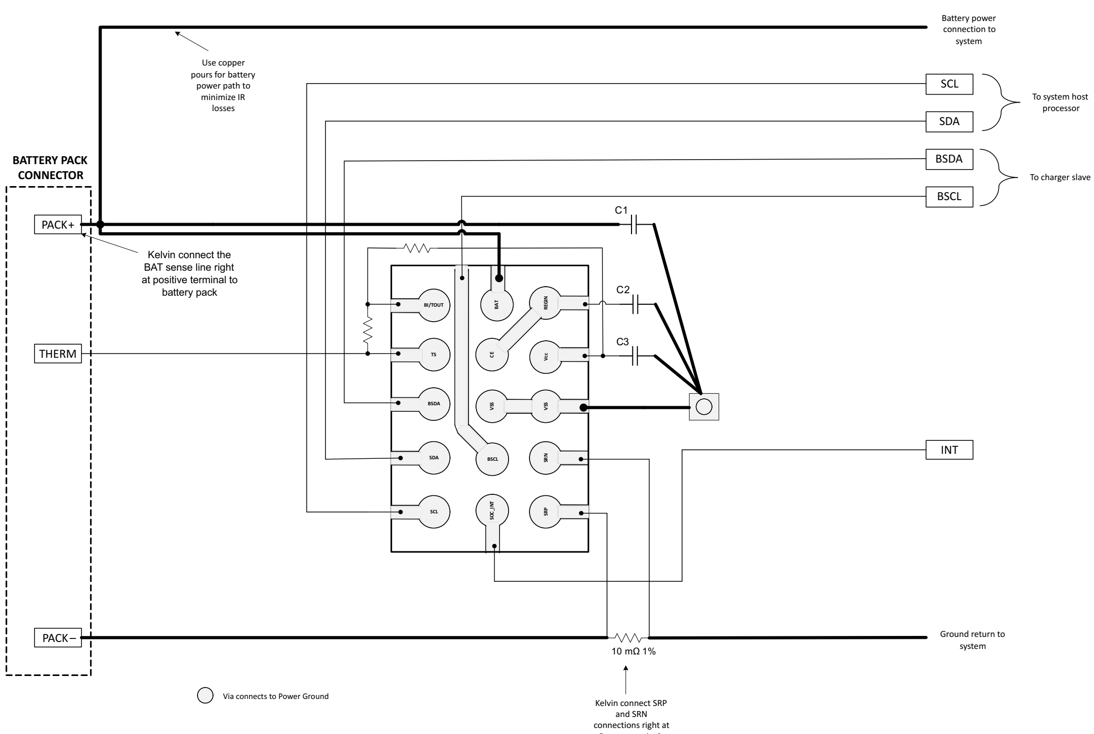


Figure 14. Layout Example

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on ***Alert me*** to register and receive a weekly digest of any product

11.2 Community Resource

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

MaxLife, Impedance Track, NanoFree, E2E are trademarks of Texas Instruments.
I^2C is a trademark of NXP B.V. Corp Netherlands.
All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution

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

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

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)
BQ27530YZFR-G1	Active	Production	DSBGA (YZF) | 15	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27530
BQ27530YZFR-G1.B	Active	Production	DSBGA (YZF) | 15	3000 | LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27530
BQ27530YZFT-G1	Active	Production	DSBGA (YZF) | 15	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27530
BQ27530YZFT-G1.B	Active	Production	DSBGA (YZF) | 15	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	BQ27530

(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.

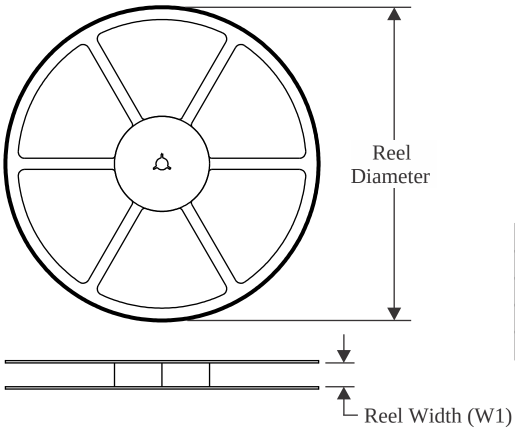
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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.

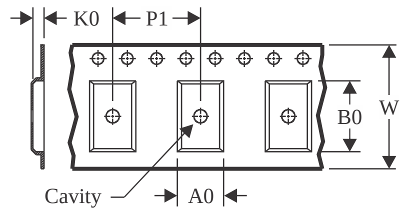
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

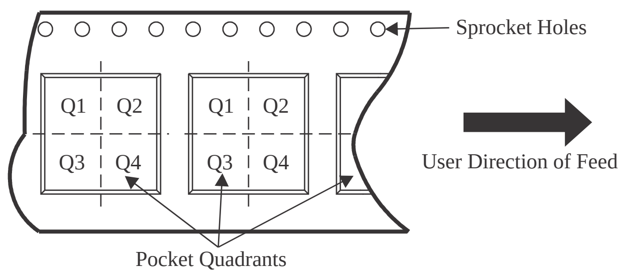


TAPE DIMENSIONS



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

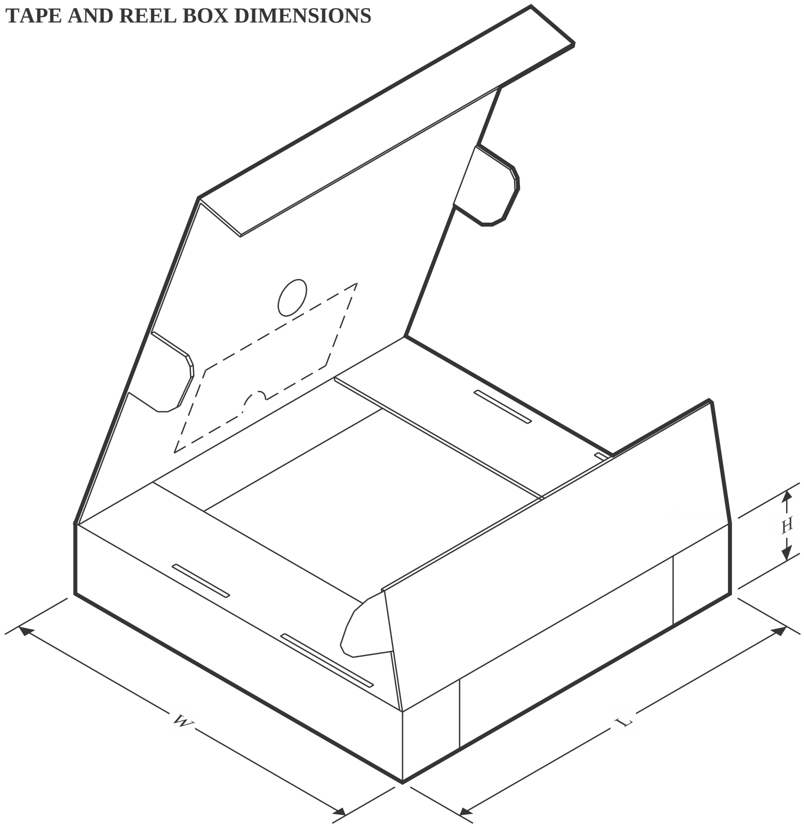
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

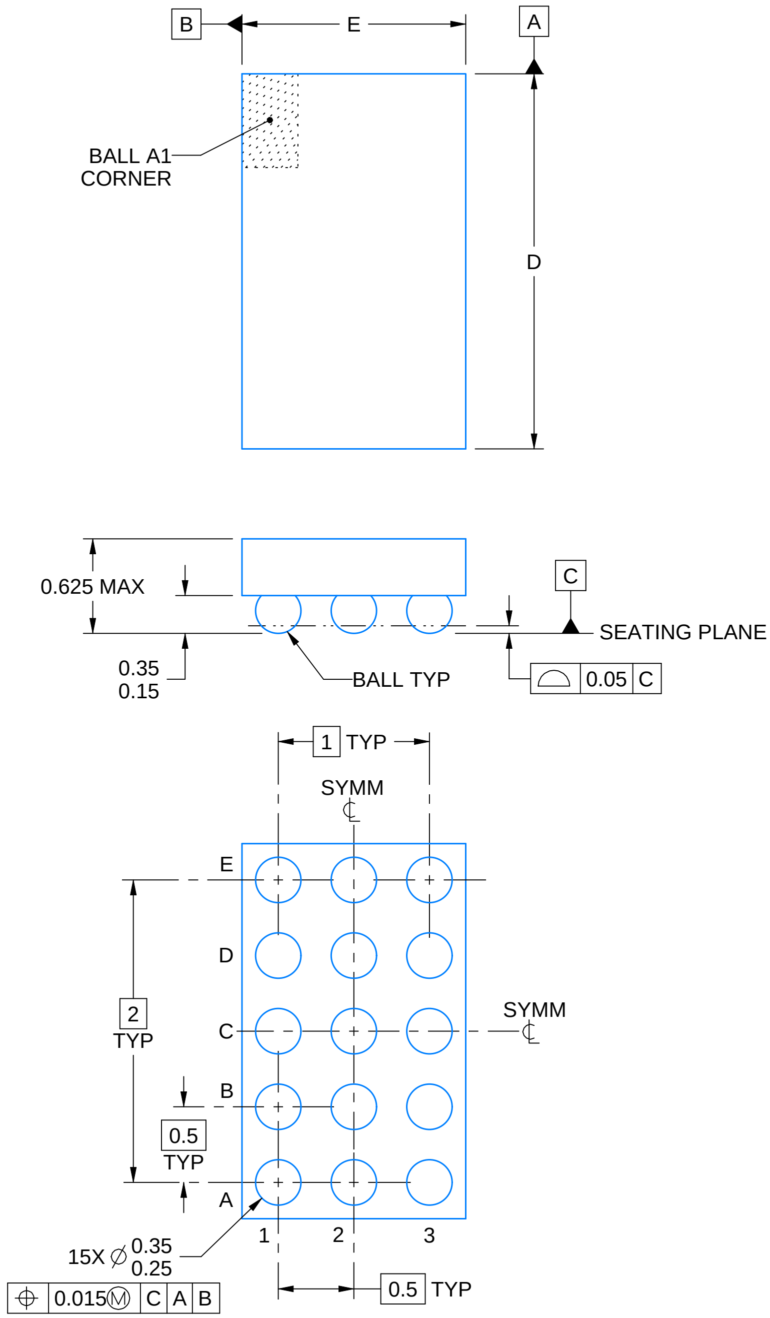
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ27530YZFR-G1	DSBGA	YZF	15	3000	180.0	8.4	2.1	2.76	0.81	4.0	8.0	Q1
BQ27530YZFT-G1	DSBGA	YZF	15	250	180.0	8.4	2.1	2.76	0.81	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ27530YZFR-G1	DSBGA	YZF	15	3000	182.0	182.0	20.0
BQ27530YZFT-G1	DSBGA	YZF	15	250	182.0	182.0	20.0



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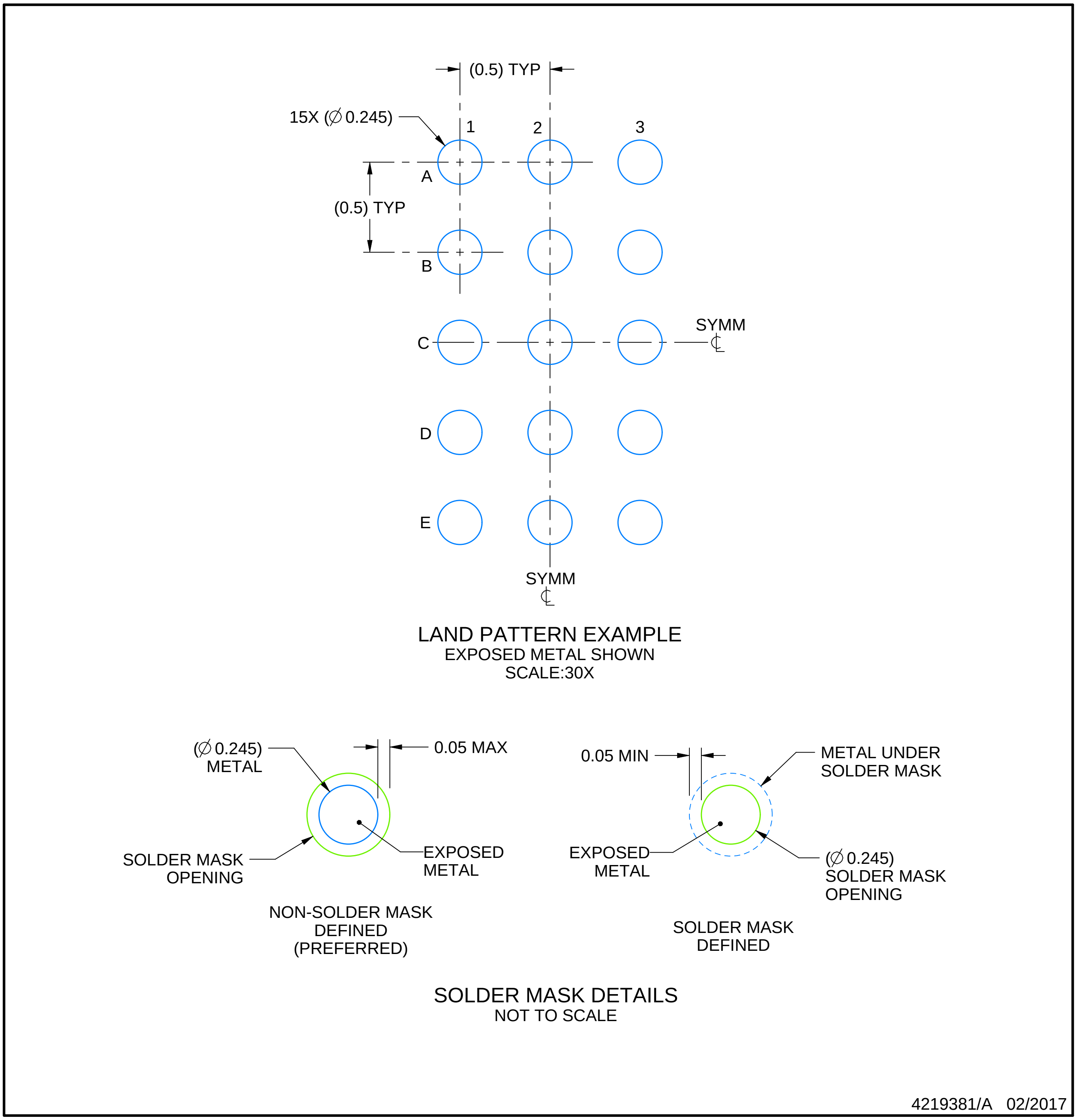
NOTES:

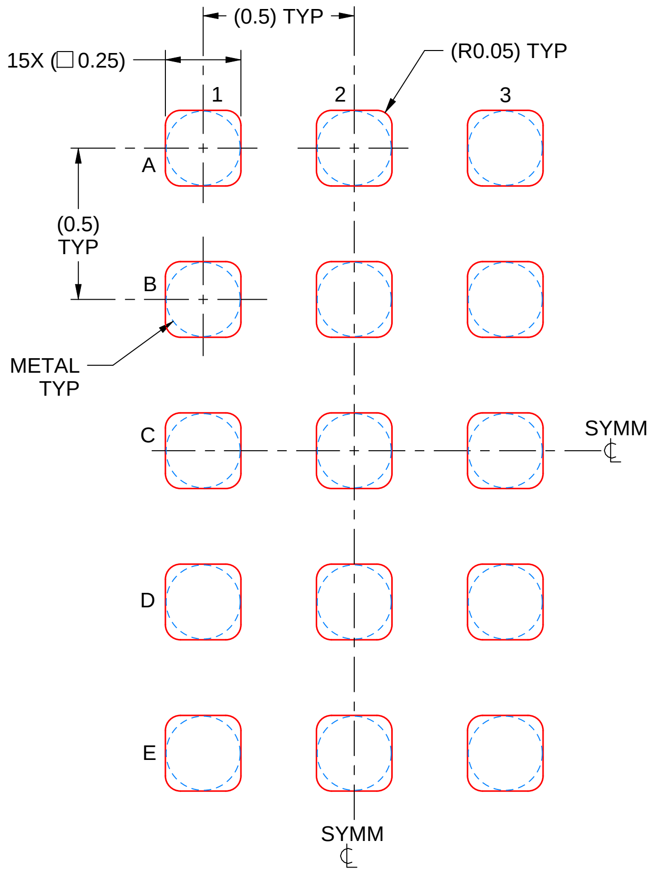
NanoFree Is a trademark of Texas Instruments.

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



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).



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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