

bq34210-Q1 車載用、1シリーズ・セル、システム側CEDV残量ゲージ 稀にしか放電されないバッテリー用

1 特長

- 車載用認定済み: AEC-Q100、グレード3
- 1シリーズ・セル・バッテリーの残量ゲージで、Li-Ion、LiFePO4、NiMH (3セル)のバッテリーに対応
 - システム基板上に配置
 - 内蔵LDOにより、バッテリーから直接電力を供給
 - 低い値の外付けセンス抵抗(10mΩ)をサポート
- ホストからの学習負荷イネーブル(LEN)
- NORMAL (50μA)とSLEEP (9μA)の両方のモードで非常に低い消費電力
- バッテリー交換をサポート
- 減多に放電されないアプリケーションについて、バッテリーの正確なサービス終了(EOS)を判定
- 1シリーズ・セル・バッテリー用のCEDV残量ゲージ
 - 充電状態(SOC)
 - 残り時間(TTE)
 - 健全性状態(SOH)
- ハイスайдおよびローサイドの電流センシング・オプション
- 内部的な温度センサまたは外付けのサーミスタ
- マイクロコントローラの周辺機器インターフェイス
 - 400kHzの I²C™シリアル・インターフェイス
 - SOC、バッテリーのレベル、温度フォルト、充電/放電状態について割り込み(ALERT)を設定可能

2 アプリケーション

- eCallシステム
- テレマティクスバックアップ・システム
- 無停電電源装置(UPS)のバックアップ・システム
- 緊急用バッテリー電源モジュール

3 概要

bq34210-Q1は、1シリーズ・セル用のシステム側CEDV残量ゲージであり、eCallシステムや、電源障害時に使用する無停電電源装置(UPS)など、バッテリーが寿命のほとんどの時間において充電用電源に接続されており、稀にしか放電されず、常時待機状態であるようなアプリケーションにおいて、1シリーズ・セル・バッテリーの残量測定と、サービス終了(EOS)判定を行います。bq34210-Q1残量ゲージは、Li-Ion、LiFePO4、NiMHなど、さまざまな種類のバッテリーに対応しています。

残量ゲージ機能は、電圧、電流、温度のデータと、補償済み放電終了(CEDV)テクノロジーを組み合わせ使用し、充電状態(SOC)および健全性状態(SOH)データを提供します。このデバイスのEOS判定機能は、バッテリーの能力が劣化し、使用可能なサービス期間の終了が近づいたときにアラートを発します。

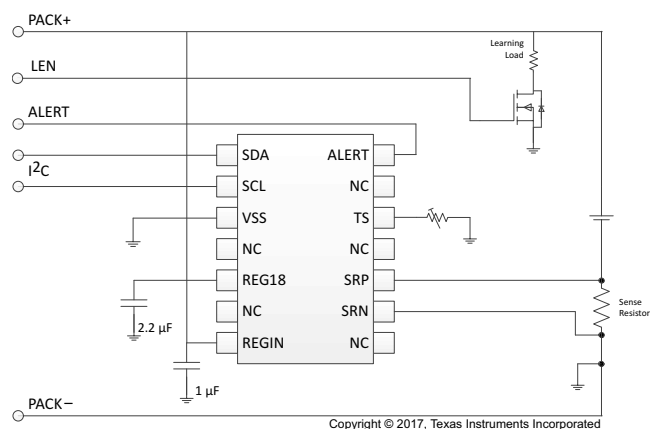
bq34210-Q1残量ゲージは、取り外し式バッテリー・パック、または埋め込み式バッテリー管理システムのPACK+ (P+)およびPACK- (P-)を接続するだけで、バッテリーの残量を測定できます。

製品情報⁽¹⁾

型番	パッケージ	本体サイズ(公称)
bq34210-Q1	PW (14)	5.00mm×4.40mm ×1.00mm

(1) 提供されているすべてのパッケージについては、巻末の注文情報を参照してください。

概略回路図



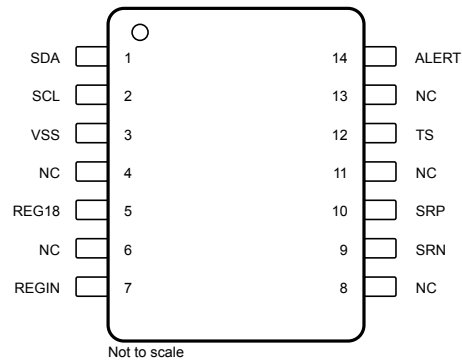
目次

1	特長	1	7	Detailed Description	8
2	アプリケーション	1	7.1	Overview	8
3	概要	1	7.2	Functional Block Diagram	8
4	改訂履歴	2	7.3	Feature Description	8
5	Pin Configuration and Functions	3	7.4	Device Functional Modes	11
6	Specifications	3	8	Application and Implementation	12
6.1	Absolute Maximum Ratings	3	8.1	Application Information	12
6.2	ESD Ratings	4	8.2	Typical Applications	12
6.3	Recommended Operating Conditions	4	9	Power Supply Recommendation	14
6.4	Thermal Information	4	9.1	Power Supply Decoupling	14
6.5	Supply Current	4	10	Layout	15
6.6	Digital Input and Output DC Characteristics	4	10.1	Layout Guidelines	15
6.7	LDO Regulator, Wake-up, and Auto-Shutdown DC Characteristics	5	10.2	Layout Example	15
6.8	LDO Regulator, Wake-up, and Auto-Shutdown AC Characteristics	5	11	デバイスおよびドキュメントのサポート	17
6.9	ADC (Temperature and Cell Measurement) Characteristics	5	11.1	デバイス・サポート	17
6.10	Integrating ADC (Coulomb Counter) Characteristics	5	11.2	ドキュメントのサポート	17
6.11	I ² C-Compatible Interface Communication Timing	6	11.3	コミュニティ・リソース	17
6.12	SHUTDOWN and WAKE-UP Timing	7	11.4	商標	17
6.13	Typical Characteristics	7	11.5	静電気放電に関する注意事項	17
			11.6	Glossary	17
			12	メカニカル、パッケージ、および注文情報	17

4 改訂履歴

日付	改訂内容	注
2017年8月	*	初版

5 Pin Configuration and Functions



Pin Functions

NUMBER	NAME	TYPE	DESCRIPTION
1	SDA	IO ⁽¹⁾	Open drain slave I ² C serial communication data line. Use with a 10-kΩ pullup resistor (typical).
2	SCL	IO	Slave I ² C serial communication clock input. Use with a 10-kΩ pullup resistor (typical).
3	VSS	P	Device ground
5	REG18	P	Capacitor required for the 1.8-V integrated LDO. Decouple with 2.2-μF ceramic capacitor to VSS.
7	REGIN	P	Battery voltage input and integrated LDO input. Decouple with 1-μF ceramic capacitor to VSS.
9	SRN	AI	Analog input pin connected to the internal coulomb-counter peripheral for integrating a small voltage between SRP and SRN where the voltage at SRN will be lower than SRP during a charging event
10	SRP	AI	Analog input pin connected to the internal coulomb-counter peripheral for integrating a small voltage between SRP and SRN where the voltage at SRP will be higher than SRN during a charging event
12	TS	AI	Pack thermistor voltage sense (use 103AT-type thermistor). Disable TS with a 10-kΩ resistor to VSS. Do not leave floating.
14	ALERT	IO	Open drain ALERT output, requires a pullup resistor (typical 10 kΩ). Used as an input to exit SHUTDOWN mode
4, 6, 8, 11, 13	NC	NC	No internal connection

(1) IO = Digital input-output, AI = Analog input, P = Power connection, NC = No internal connection

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V _{REGIN}	REGIN pin input voltage range	−0.3	6	V
V _{SR}	SRP and SRN pins input voltage range	−0.3	V _{REGIN} + 0.3	V
	Differential voltage across SRP and SRN. ABS(SRP – SRN)	−0.3	2	V
V _{REG18}	REG18 LDO output for capacitor only (not a supply pin)	−0.3	2	V
V _{IOD}	Open-drain IO pins (SDA, SCL)	−0.3	6	V
V _{ALERT}	Open Drain Output / Control Input (ALERT)	−0.3	6	V
V _{AI}	TS	−0.3	REG18 + 0.3	V
T _A	Operating free-air temperature range	−40	85	°C
Storage temperature, T _{stg}		−65	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

bq34210-Q1

JAJSK0 – AUGUST 2017

www.ti.com

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

$T_A = 30^\circ\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

			MIN	NOM	MAX	UNIT
C_{REGIN} ⁽¹⁾	External input capacitor for internal LDO between REGIN and VSS	Nominal capacitor values specified. Recommend a 5% ceramic X5R-type capacitor located close to the device.	1			μF
C_{REG18} ⁽¹⁾	External output capacitor for internal LDO between REG18 and VSS		2.2			μF
V_{PU} ⁽¹⁾	External pullup voltage for open-drain pins (SDA, SCL, ALERT)		1.62		5.5	V

(1) Specified by design. Not production tested.

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		bq34210-Q1	UNIT
		PW (TSSOP)	
		14 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	111.0	°C/W
R _{θJCTop}	Junction-to-case (top) thermal resistance	37.9	°C/W
R _{θJB}	Junction-to-board thermal resistance	54.8	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	3.0	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	54.2	°C/W
R _{θJCbot}	Junction-to-case (bottom) thermal resistance	n/a	°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

$T_A = 30^\circ\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

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

(1) Specified by design. Not production tested.

(2) Wake Comparator disabled.

6.6 Digital Input and Output DC Characteristics

$T_A = -40^\circ\text{C}$ to 85°C , typical values at $T_A = 30^\circ\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{\text{IH(OD)}}$	Input voltage, high ⁽²⁾	External pullup resistor to V_{PU}		$V_{\text{PU}} \times 0.7$	V
V_{IL}	Input voltage, low ⁽²⁾			0.6	V
V_{OL}	Output voltage, low ⁽²⁾			0.6	V
I_{OH}	Output source current, high ⁽²⁾			0.5	mA
$I_{\text{OL(OD)}}$	Output sink current, low ⁽²⁾			−3	mA

(1) Specified by design. Not production tested.

(2) SCL, SDA, ALERT

Digital Input and Output DC Characteristics (continued)

 $T_A = -40^{\circ}\text{C}$ to 85°C , typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$C_{\text{IN}}^{(1)}$ Input capacitance ⁽²⁾⁽³⁾				5	pF
I_{Ikg} Input Leakage Current ⁽²⁾⁽³⁾				1	μA

(3) TS

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

 $T_A = -40^{\circ}\text{C}$ to 85°C , typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{REGIN} Battery and regulator input		2.45		4.5	V
V_{REG18} Regulator output voltage			1.85		V
$UVLO_{\text{IT+}}$ V_{REGIN} undervoltage lock-out LDO wake-up rising threshold			2		V
$UVLO_{\text{IT-}}$ V_{REGIN} undervoltage lock-out LDO auto-shutdown falling threshold			1.95		V
$V_{\text{WU+}}^{(1)}$ ALERT (input) LDO Wake-up rising edge threshold ⁽²⁾	LDO Wake-up from SHUTDOWN mode	1.2			V
t_{ALERT} Minimum ALERT high time after $V_{\text{WU+}}$ to initiate Wake up			1		ms

(1) Specified by design. Not production tested.

(2) If the device is commanded to SHUTDOWN via I²C with $V_{\text{REGIN}} > UVLO_{\text{IT+}}$, a wake-up rising edge trigger is required on ALERT.

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

 $T_A = -40^{\circ}\text{C}$ to 85°C , typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{\text{SHDN}}^{(1)}$ SHUTDOWN entry time	Time delay from SHUTDOWN command to LDO output disable.			250	ms
$t_{\text{SHUP}}^{(1)}$ SHUTDOWN ALERT low time	Minimum low time of ALERT (input) in SHUTDOWN before WAKEUP	10			μs
$t_{\text{REG18}}^{(1)}$ Initial REG18 output delay			13		ms
$t_{\text{WUREG18}}^{(1)}$ Wake-up REG18 output delay	Time delay from rising edge of ALERT (input) to nominal REG18 output.		8		ms
t_{PUCD} Power-up communication delay ⁽²⁾	Time delay from rising edge of REGIN to NORMAL mode (includes firmware initialization time).		250		ms

(1) Specified by design. Not production tested.

(2) t_{PUCD} indicates when communication can begin. Measurements are not valid for up to 1 second after any reset.

6.9 ADC (Temperature and Cell Measurement) Characteristics

 $T_A = -40^{\circ}\text{C}$ to 85°C ; typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

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

6.10 Integrating ADC (Coulomb Counter) Characteristics

 $T_A = -40^{\circ}\text{C}$ to 85°C ; typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{SRCM} Input voltage range of SRN, SRP pins		VSS		$V_{\text{REGIN}} + 100\text{ mV}$	V

Integrating ADC (Coulomb Counter) Characteristics (continued)

$T_A = -40^{\circ}\text{C}$ to 85°C ; typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{SRDM}	Input differential voltage range of $V_{\text{SRP}}-V_{\text{SRN}}$		± 80		mV
$t_{\text{SR CONV}}$	Conversion time		1		s
	Effective Resolution		16		bits

6.11 I²C-Compatible Interface Communication Timing

$T_A = -40^{\circ}\text{C}$ to 85°C ; typical values at $T_A = 30^{\circ}\text{C}$ and $V_{\text{REGIN}} = 3.6\text{ V}$ (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Standard Mode (100 kHz)					
$t_{\text{d(STA)}}$	Start to first falling edge of SCL	4			μs
$t_{\text{w(L)}}$	SCL pulse duration (low)	4.7			μs
$t_{\text{w(H)}}$	SCL pulse duration (high)	4			μs
$t_{\text{su(STA)}}$	Setup for repeated start	4.7			μs
$t_{\text{su(DAT)}}$	Data setup time	Host drives SDA	250		ns
$t_{\text{h(DAT)}}$	Data hold time	Host drives SDA	0		ns
$t_{\text{su(STOP)}}$	Setup time for stop	4			μs
$t_{\text{(BUF)}}$	Bus free time between stop and start	Includes Command Waiting Time	66		μs
t_{f}	SCL or SDA fall time ⁽¹⁾⁽²⁾			300	ns
t_{r}	SCL or SDA rise time ⁽¹⁾⁽²⁾			300	ns
f_{SCL}	Clock frequency ⁽³⁾			100	kHz
Fast Mode (400 kHz)					
$t_{\text{d(STA)}}$	Start to first falling edge of SCL	600			ns
$t_{\text{w(L)}}$	SCL pulse duration (low)	1300			ns
$t_{\text{w(H)}}$	SCL pulse duration (high)	600			ns
$t_{\text{su(STA)}}$	Setup for repeated start	600			ns
$t_{\text{su(DAT)}}$	Data setup time	Host drives SDA	100		ns
$t_{\text{h(DAT)}}$	Data hold time	Host drives SDA	0		ns
$t_{\text{su(STOP)}}$	Setup time for stop	600			ns
$t_{\text{(BUF)}}$	Bus free time between stop and start	Includes Command Waiting Time	66		μs
t_{f}	SCL or SDA fall time ⁽¹⁾⁽²⁾			300	ns
t_{r}	SCL or SDA rise time ⁽¹⁾⁽²⁾			300	ns
f_{SCL}	Clock frequency ⁽³⁾			400	kHz

(1) Specified by design. Not production tested.

(2) Bus capacitance and pull-up resistance impact rise and fall times. View the rise and fall times to assist with debugging.

(3) If the clock frequency (f_{SCL}) is $> 100\text{ kHz}$, use 1-byte write commands for proper operation. All other transactions types are supported at 400 kHz. (See [I²C Interface](#) and [I²C Command Waiting Time](#).)

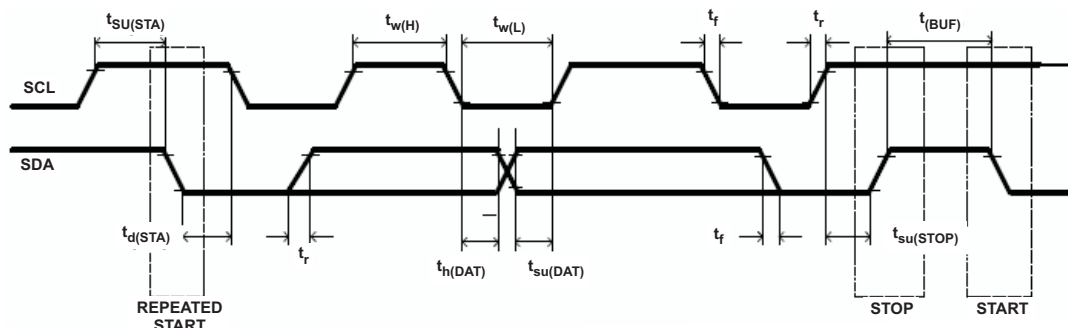
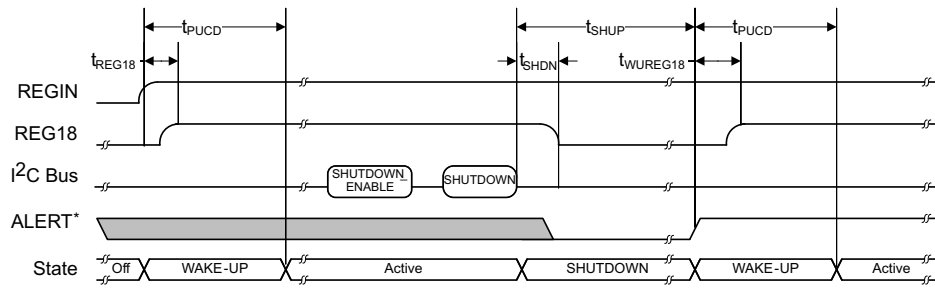


Figure 1. I²C-Compatible Interface Timing Diagrams

6.12 SHUTDOWN and WAKE-UP Timing



* ALERT is configured as an input for wake-up signaling

Figure 2. SHUTDOWN and WAKE-UP Timing Diagram

6.13 Typical Characteristics

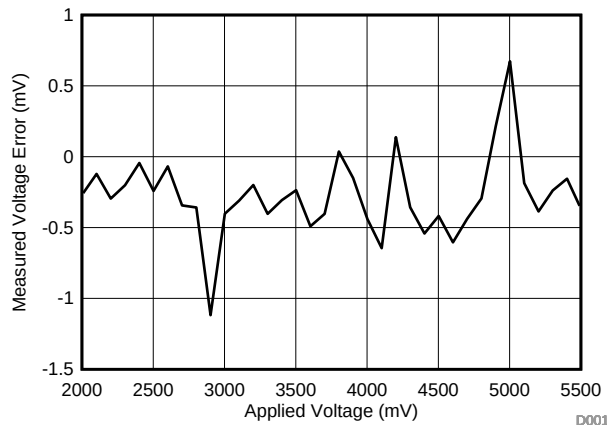


Figure 3. Impact of Applied (REGIN) Voltage on Voltage Measurement

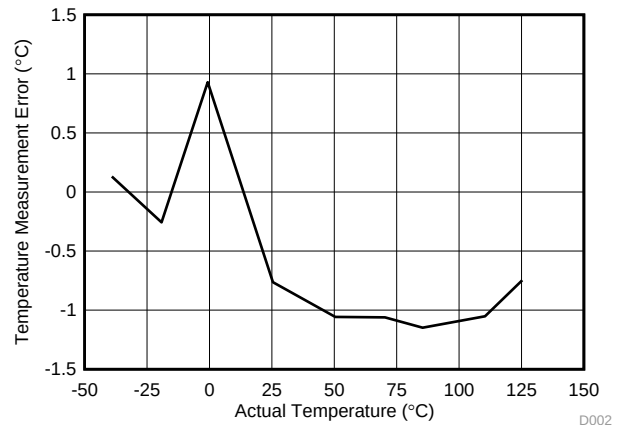


Figure 4. Internal Temperature Measurement Error

7 Detailed Description

7.1 Overview

The bq34210-Q1 incorporates fuel gauging and an End-of-Service (EOS) Determination function for use in 1-series cell packs with support for multiple battery chemistries, including Lithium-Ion (Li-Ion), Lithium Iron Phosphate (LiFePO₄), and Nickel Metal Hydride (NiMH). The gas gauging function uses Compensated End-of-Discharge Voltage (CEDV) technology to accurately predict the battery capacity and other operational characteristics of the battery, and can be interrogated by a host processor to provide cell information, such as remaining capacity, full charge capacity, and average current.

See the *bq34210-Q1 Technical Reference Manual* (TRM, [SLUUBE8](#)) for further details.

NOTE

The following formatting conventions are used in this document:

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

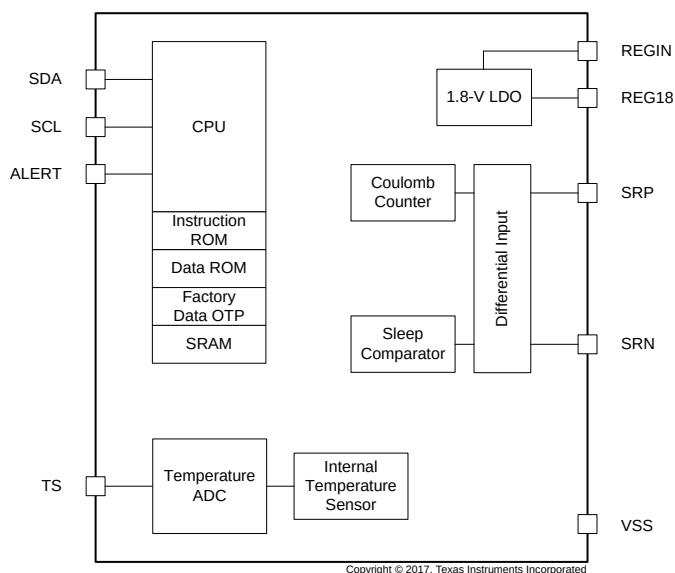
Data Flash: *italics*, **bold**, and breaking spaces, for example, ***Design Capacity***.

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

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

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

7.2 Functional Block Diagram



7.3 Feature Description

Information is accessed through a series of commands called *Standard Commands*. The *Extended Commands* set provides additional capabilities. Both sets of commands, indicated by the general format *Command()*, are used to read and write information in the control and status registers, as well as its data locations. Commands are sent from the system to the gauge via the I²C serial communications engine, and can be executed during application development, system manufacture, or end-equipment operation.

Feature Description (continued)

The integrated End-of-Service (EOS) Determination function is specifically intended for applications where the battery is rarely discharged, such as in eCall systems, uninterruptible power supplies (UPS), enterprise server backup systems, and telecommunications backup modules. In such systems, the battery may remain in a fully (or near-fully) charged state for much of its lifetime, with it rarely or never undergoing a significant discharge. If the health of the battery in such a system is not monitored regularly, then it may degrade beyond the level required for a system backup/discharge event, and thus fail precisely at the time when it is needed most.

The EOS Determination function monitors the health of the battery through the use of infrequent learning phases, which involve a controlled discharge of ~1% capacity, and provides an alert to the system when the battery is approaching the end of its usable service. By coordinating battery charging with the learning phases, the battery capacity available to the system can be maintained above a preselected level, which helps to avoid compromising the battery's ability to support a system discharge event.

NOTE

The following sections offer a brief overview of the content available in the *bq34210-Q1 Technical Reference Manual* (TRM, [SLUUBE8](#)), and should be used only as references to the respective sections in the TRM for full details.

7.3.1 Device Configuration

The device must select the correct CEDV profile, interrupt functions (enables, levels), and more during its initial configuration setup. The bq34210-Q1 includes two CEDV profiles (XYZ and ABC), which are stored in ROM. If neither of these profiles matches the battery used, a new configuration must be stored in RAM using Texas Instruments tools (see [Getting Started](#) for more details). Changing batteries also requires a new initialization of the configuration settings. This enables the device to be reconfigured for different battery chemistries or capacities through the host. If another battery is chosen, the parameters must be generated using TI's web-based tool, Gauge Parameter Calculator for CEDV Gauges ([GAUGEPARCAL](#)). The [TRM](#) provides further details.

7.3.2 ALERT Interrupt and SHUTDOWN Wake-up

The interrupt function of the ALERT pin enables the bq34210-Q1 to communicate with the main system.

Even if the host is not using the ALERT functionality, it is recommended that ALERT be connected to a GPIO of the host so that in cases where the device is in SHUTDOWN, toggling ALERT can wake up the gauge from the SHUTDOWN state.

7.3.3 Voltage Measurement and Calibration

Voltage measurements and calibration are done automatically. The Battery Management Studio [bqStudio](#) tool aids in setting up this function to match system requirements.

7.3.4 Temperature Measurement

The device can be configured to use an external thermistor (103AT type) to measure temperature or use its internal temperature sensor.

7.3.5 Charging and Termination

The bq34210-Q1 monitors charging and detects termination. The termination works for Li-Ion, LiFePO₄, and NiMH systems.

7.3.6 Accumulated Charge Measurement

The device measures the accumulated charge and reports the duration over which that charge was accumulated. The *AccumulatedCharge()* and *AccumulatedChargeTime()* registers can be used to send an alert to the host when a certain threshold is achieved.

Feature Description (continued)

7.3.7 Gas Gauging

The bq34210-Q1 device features the Compensated End-of-Discharge Voltage (CEDV) gauging algorithm. This algorithm uses the accumulated measured quantities for charge and discharge in addition to estimating self-discharge of the battery. Registers including Remaining Capacity, Design Capacity, Full Charge Capacity, and Discharge Count Register (DCR) are used in this algorithm.

7.3.8 Battery Condition Warnings

Battery status indications are stored in registers and are used by the device to take action and provide warnings. Examples of indicator parameters are state-of-charge low detection, overtemperature-in-charge, and battery voltage high/low.

7.3.9 Configuration Update

CONFIG UPDATE mode is used when updating the configuration data of the fuel gauge. Gauging is disabled during this mode. This is required when a new battery is inserted.

7.3.10 End-Of-Service Determination

The bq34210-Q1 device incorporates the End-of-Service (EOS) Determination function to calculate the end of useful service of the battery and to provide alerts based on this detection. Learning phases are used to gather information about the present state of the battery through its cell resistance.

7.3.11 Battery Level Threshold

The Battery Level Threshold (BLT) feature indicates when the SOC of a battery pack has depleted to a certain value stored in a register. The thresholds can be set for the charge and discharge conditions.

7.3.12 Communications

7.3.12.1 I²C Interface

The slave-only 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.

7.3.12.2 I²C Time Out

The I²C engine releases SDA and SCL if the I²C bus is held low for 2 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.

7.3.12.3 I²C Command Waiting Time

To ensure proper operation at 400 kHz, a $t_{(BUF)} \geq 66 \mu s$ 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.

7.3.12.4 I²C Clock Stretching

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

7.3.13 Additional Data Memory Parameter Descriptions

The calibration method requires a correction due to offset errors, using a number of samples to get a statistical average for the golden image.

7.4 Device Functional Modes

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

- INITIALIZATION
- NORMAL
- SLEEP
- SHUTDOWN

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. The *bq34210-Q1 Technical Reference Manual* ([SLUUBE8](#)) provides more details.

7.4.1 INITIALIZATION Mode

The bq34210-Q1 enters INITIALIZATION mode at power up. This mode prepares the device to enter NORMAL mode through its internal power-on reset sequence. When the reset sequence is complete, the device automatically moves to NORMAL mode.

7.4.2 NORMAL Mode

The bq34210 NORMAL mode is entered from INITIALIZATION mode when the power-on reset is complete. When the charge and discharge currents are above the programmable level, the device will remain in NORMAL mode. If the measured currents are below the programmable level, SLEEP mode is entered. Once the currents increase above the threshold, the device will reenter NORMAL mode. The device will enter SHUTDOWN mode through a command sequence.

7.4.3 SLEEP Mode

SLEEP mode is entered from NORMAL mode if enabled and the current is below a programmable level. Once the current increases above that level, NORMAL mode is reentered.

7.4.4 SHUTDOWN Mode

The lowest power mode is SHUTDOWN mode. In this mode, the device is completely off. It is entered through an I²C command. Exiting from SHUTDOWN mode can be done by battery removal and replacement or through the ALERT pin. Pulling ALERT low for t_{SHUP} and then above $V_{IH(OD)}$ enables the bq34210 device to go through its standard power-up sequence (into INITIALIZATION mode).

8 Application and Implementation

NOTE

Information in the following application section 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 bq34210-Q1 fuel gauge is a microcontroller peripheral that provides system-side fuel gauging for 1-series cell batteries of a variety of chemistries. 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 [Design Requirements](#).

8.1.1 Getting Started

To help configure and evaluate a bq34210-Q1 solution, Texas Instruments provides many supporting tools on the [TI.com](http://ti.com) website, including the following:

- Battery Management Studio ([bqStudio](#))
- Gauge Parameter Calculator for CEDV Gauges ([GAUGEPARCAL](#))
- [bqProduction](#) to assist with the manufacturing process

These tools work with a TI EVM and with a self-designed solution. The *bq34210-Q1 Technical Reference Manual* ([SLUUBE8](#)) provides details on programming the gauge.

8.2 Typical Applications

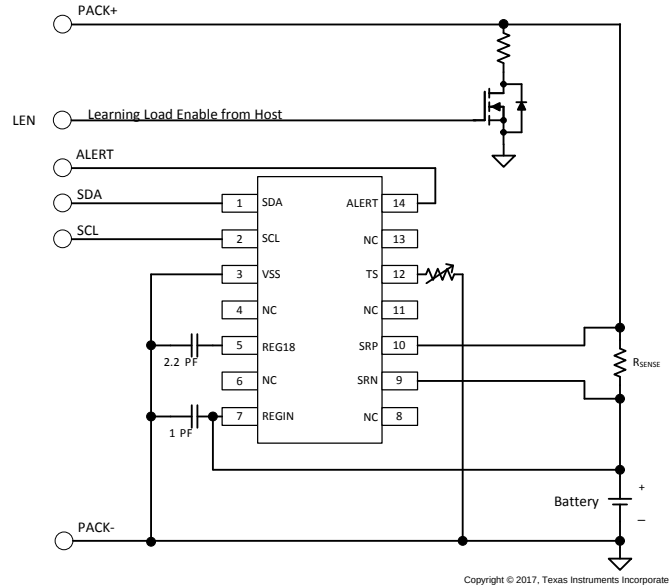


Figure 5. Typical Application

8.2.1 Design Requirements

This design, for example, is for an automotive eCall solution. Calculate the required battery capacity by taking into account the required talk and standby time while in battery backup. Assume 10 minutes for a call followed by a 60-minute idle time (while pinging still occurs), and finally an additional 10-minute call. Understand the typical aging characteristics of the battery to know when the remaining capacity still fulfills the required capacity calculated previously. If the calculations show the requirement for a 1-Ah battery, a reasonable capacity battery to use would be 20% larger, or 1.2 mAh.

Typical Applications (continued)

8.2.2 Detailed Design Procedure

8.2.2.1 REGIN Voltage Sense Input

A ceramic capacitor at the input to the REGIN pin is used to bypass AC voltage ripple to ground, greatly reducing its influence on battery voltage measurements.

8.2.2.2 Integrated LDO Capacitor

The fuel gauge has an integrated LDO with an output on the REG18 pin of approximately 1.8 V. A capacitor of at least a 2.2-μF value should be connected between the REG18 pin and VSS. The capacitor must be placed close to the fuel gauge and have short traces to both the REG18 pin and VSS. 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. The power rating must be consistent with the maximum current and sense resistor value. The bq34210-Q1 device supports sense resistors from 5 mΩ to 20 mΩ.

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. For more details, see the *Temperature Measurement* section of the bq34210-Q1 TRM ([SLUUBE8](#)).

8.2.4 Learning Load Enable (LEN) from Host

The learning load helps to determine the status of the battery (EOS). The host must control the load during the learning phase and put the bq34210-Q1 gauge into the learning phase. The resistance is set by selecting the learning current. With 220 mA and the charge voltage of 4.2 V, use Ohm's law to calculate the resistance (19.09 Ω).

8.2.5 I²C

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 VSS to avoid floating inputs to the I²C engine.

The value of the SCL and SDA pullup resistors should take into consideration the pullup voltage and the bus capacitance along with the communication speed. Many communication errors are a result of improper sizing of the resistors. Rounding of the clock and data signals indicated improper RC configurations. The maximum pullup resistance (R_{PUmax}) can be estimated by this equation:

$$R_{PUmax} = t_r / (0.4873 \times C_{BUS})$$

Where t_r is the rise time and C_{BUS} is the total bus capacitance.

Assuming a bus capacitance of 10 pF, [Table 1](#) shows some recommended values.

Table 1. Recommended Values for SCL and SDA Pullup Resistors

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

8.2.6 Temperature Sense

The TS pin is used to measure the system temperature.

If the battery pack thermistor is not connected to the TS pin, the TS pin should be pulled down to VSS with a 10-k Ω resistor. The TS pin must not be shorted directly to any other pin.

8.2.7 Application Curves

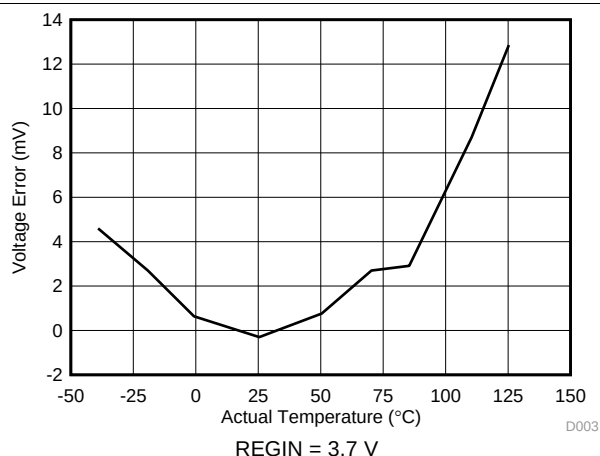


Figure 6. Voltage Error vs Actual Temperature

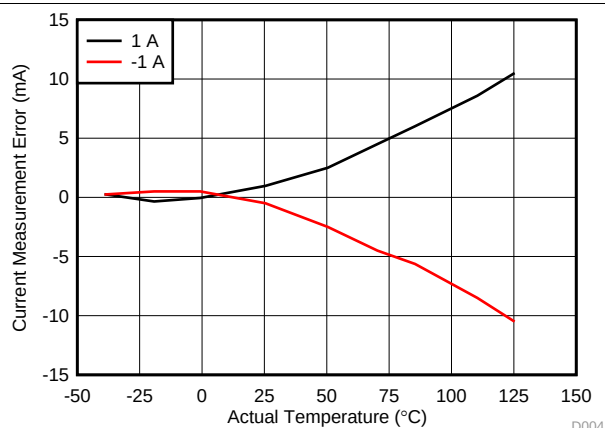


Figure 7. Current Measurement Error vs Actual Temperature

9 Power Supply Recommendation

9.1 Power Supply Decoupling

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

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

A capacitor of value of at least 1 μ F should be connected between REGIN and VSS. Place the capacitor close to the fuel gauge and have short traces to the REGIN pin and VSS.

The fuel gauge has an integrated LDO with an output on the REG18 pin of approximately 1.8 V. A capacitor of value at least 2.2 μ F should be connected between the REG18 pin and VSS. Place the capacitor close to the fuel gauge and have short traces to both the REG18 pin and VSS. 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 REG18 pin and VSS. The capacitor should be placed close to the fuel gauge and have short traces to both the REG18 pin and VSS as shown in [bq34210-Q1 Capacitor Layout](#). This regulator must not be used to provide power for other devices in the system.
- If the connection between the battery pack and the gauge REGIN pin has the potential to pick up noise, it is required to have a capacitor of at least 1.0 μF connect between the REGIN pin and VSS. Place the capacitor close to the fuel gauge and have short traces to both the REGIN pin and VSS.
- The SRP and SRN pins should be Kelvin connected to the R_{SENSE} terminals.
- For the low-side sense resistor:
 - Connect SRP to the battery pack side of R_{SENSE} and SRN to the system side of the R_{SENSE} , as shown in [bq34210-Q1 Sense Resistor Layout](#).
 - Kelvin connect the REGIN pin to the battery PACK+ terminal.

10.2 Layout Example

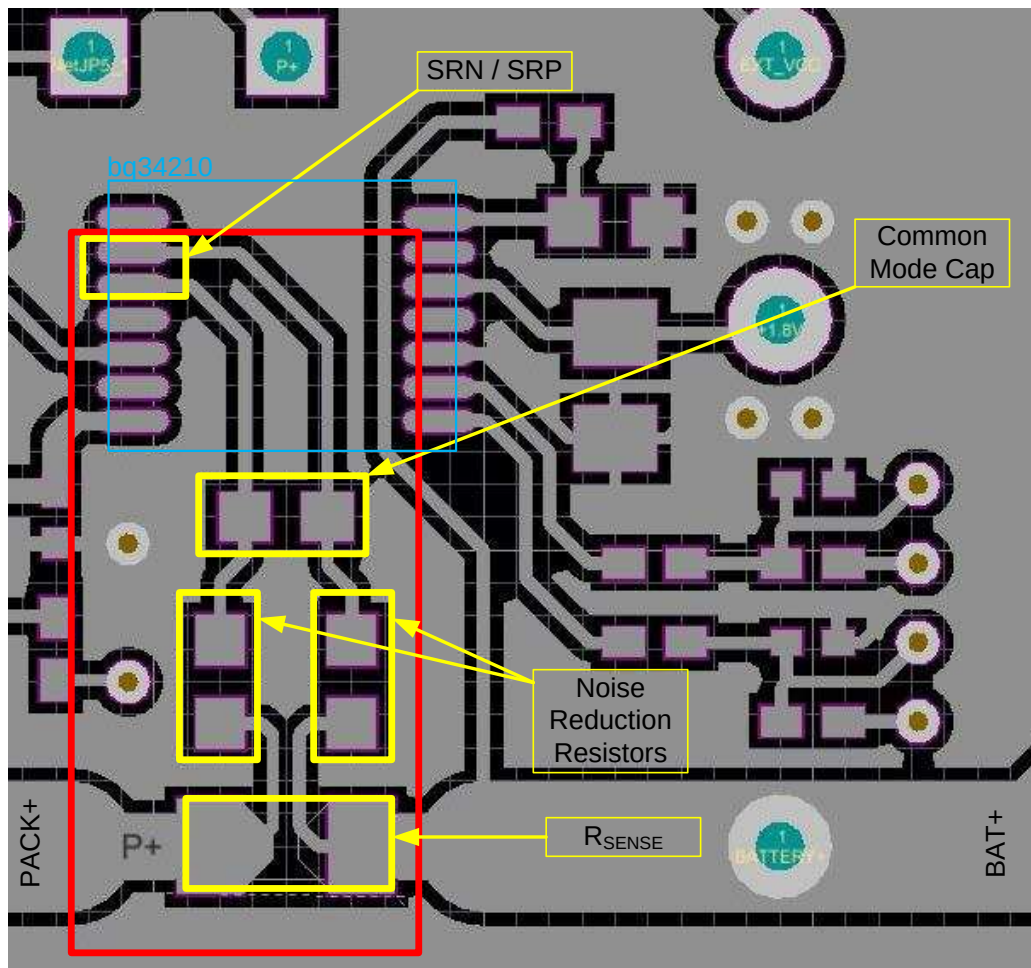


Figure 8. bq34210-Q1 Sense Resistor Layout

Layout Example (continued)

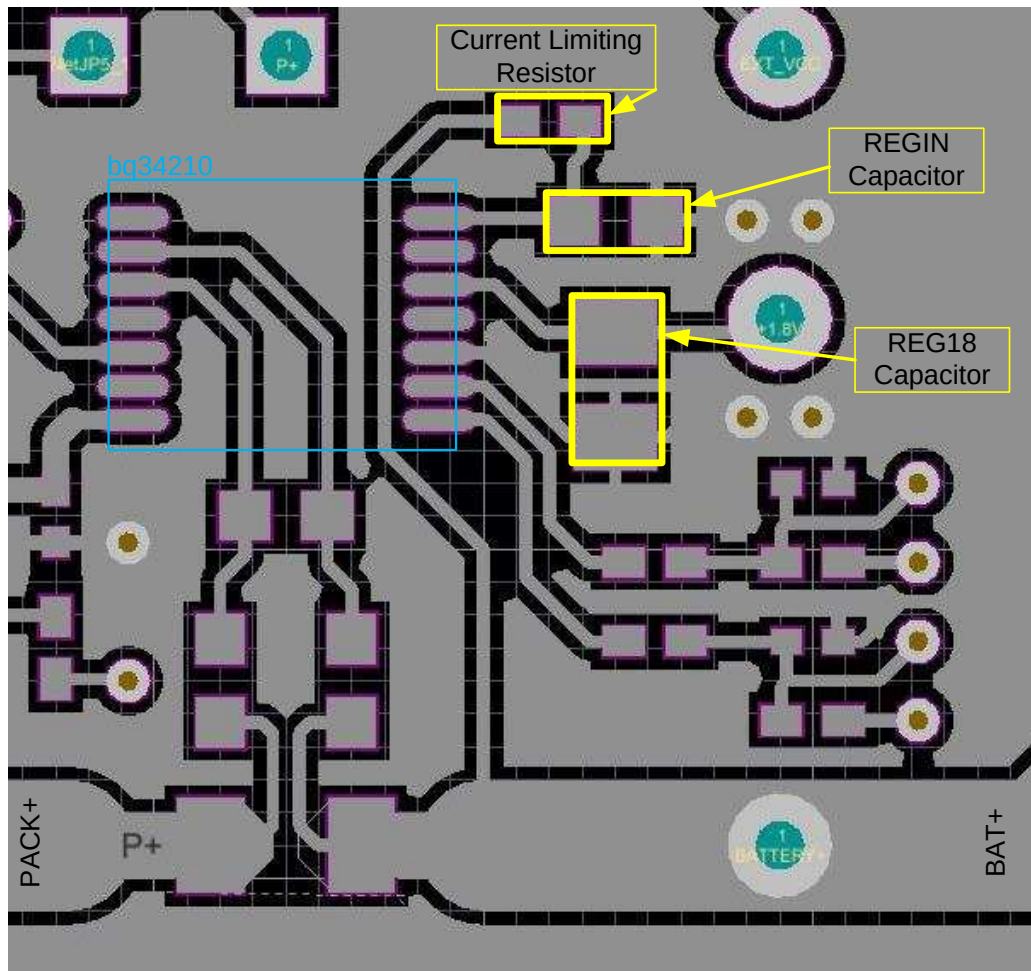


Figure 9. bq34210-Q1 Capacitor Layout

11 デバイスおよびドキュメントのサポート

11.1 デバイス・サポート

11.1.1 ツール

- Battery Management Studio (**bqStudio**)
- CEDVゲージ用のゲージ・パラメータ計算器(**GAUGEPARCAL**)
- 製造プロセスを補助する**bqProduction**

11.2 ドキュメントのサポート

11.2.1 関連資料

- 『bq34210-Q1テクニカル・リファレンス・マニュアル』(**SLUUBE8**)
- 『単一セルの残量ゲージの回路設計』(**SLUA456**)
- 『ハンドヘルドのバッテリー駆動電子機器のESDおよびRF低減』(**SLUA460**)

11.3 コミュニティ・リソース

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™ オンライン・コミュニティ TIのE2E (*Engineer-to-Engineer*) コミュニティ。エンジニア間の共同作業を促進するために開設されたものです。e2e.ti.comでは、他のエンジニアに質問し、知識を共有し、アイデアを検討して、問題解決に役立てることができます。

設計サポート TIの設計サポート 役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

11.4 商標

E2E is a trademark of Texas Instruments.

I²C is a trademark of NXP Semiconductors N.V.

All other trademarks are the property of their respective owners.

11.5 静電気放電に関する注意事項



すべての集積回路は、適切なESD保護方法を用いて、取扱いと保存を行うようにして下さい。

静電気放電はわずかな性能の低下から完全なデバイスの故障に至るまで、様々な損傷を与えます。高精度の集積回路は、損傷に対して敏感であり、極めてわずかなパラメータの変化により、デバイスに規定された仕様に適合しなくなる場合があります。

11.6 Glossary

SLYZ022 — TI Glossary.

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

12 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

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)
BQ34210IPWRQ1	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	BQ34210I
BQ34210IPWRQ1.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	BQ34210I

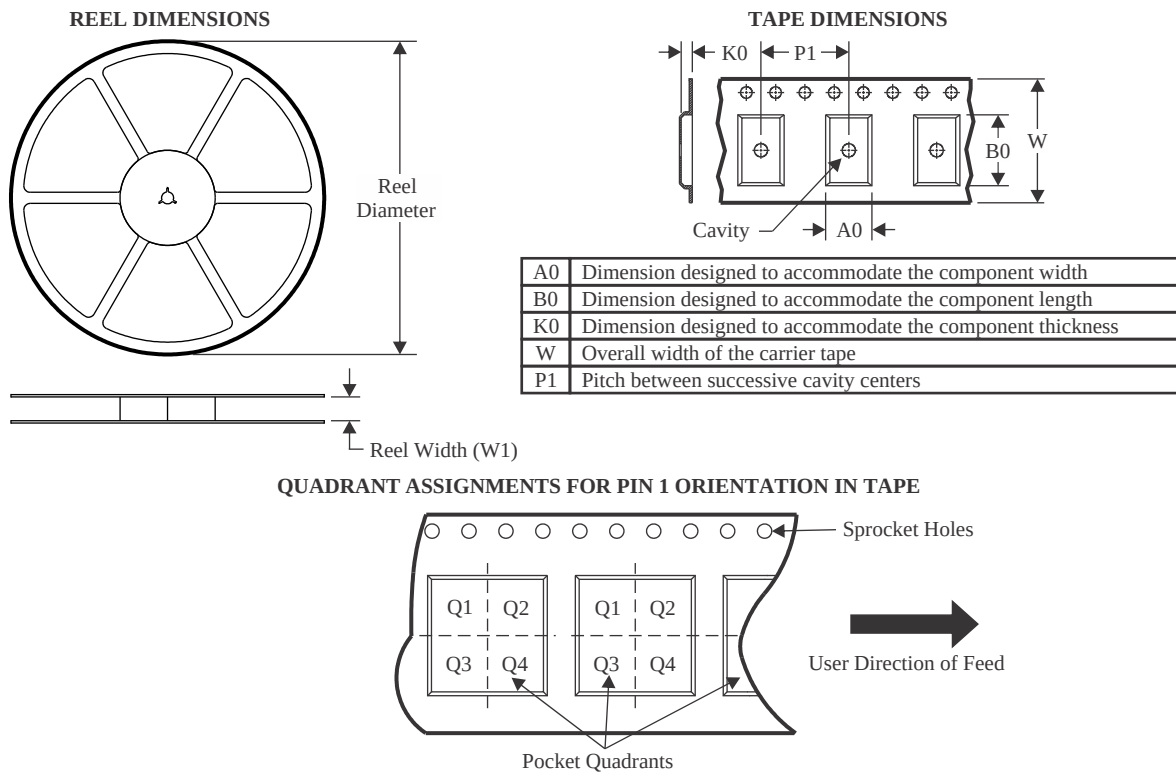
- ⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).
- ⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, 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.

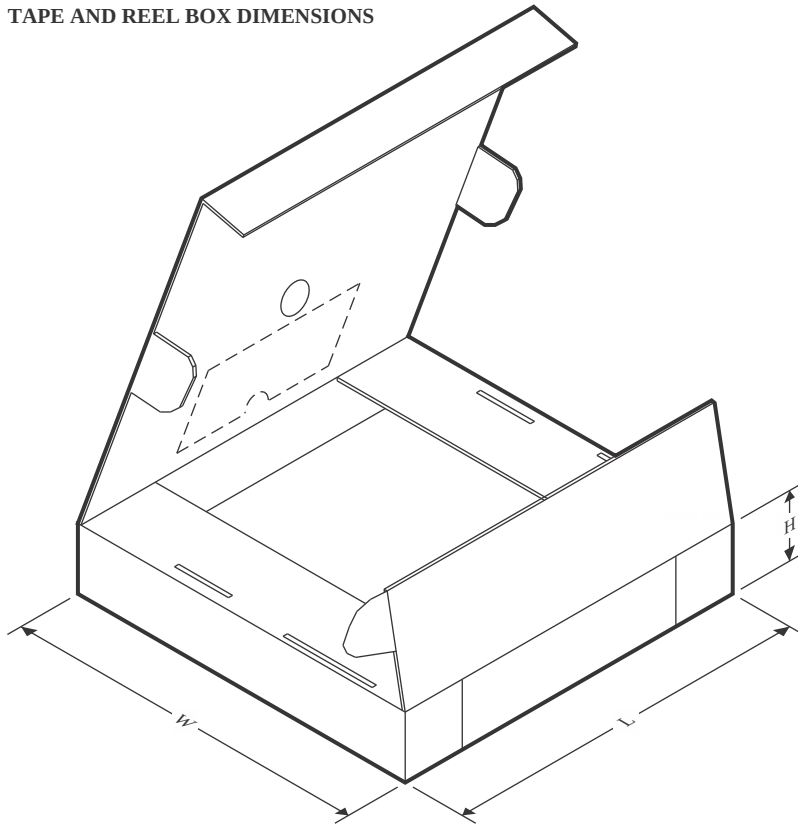
TAPE AND REEL INFORMATION



*All dimensions are nominal

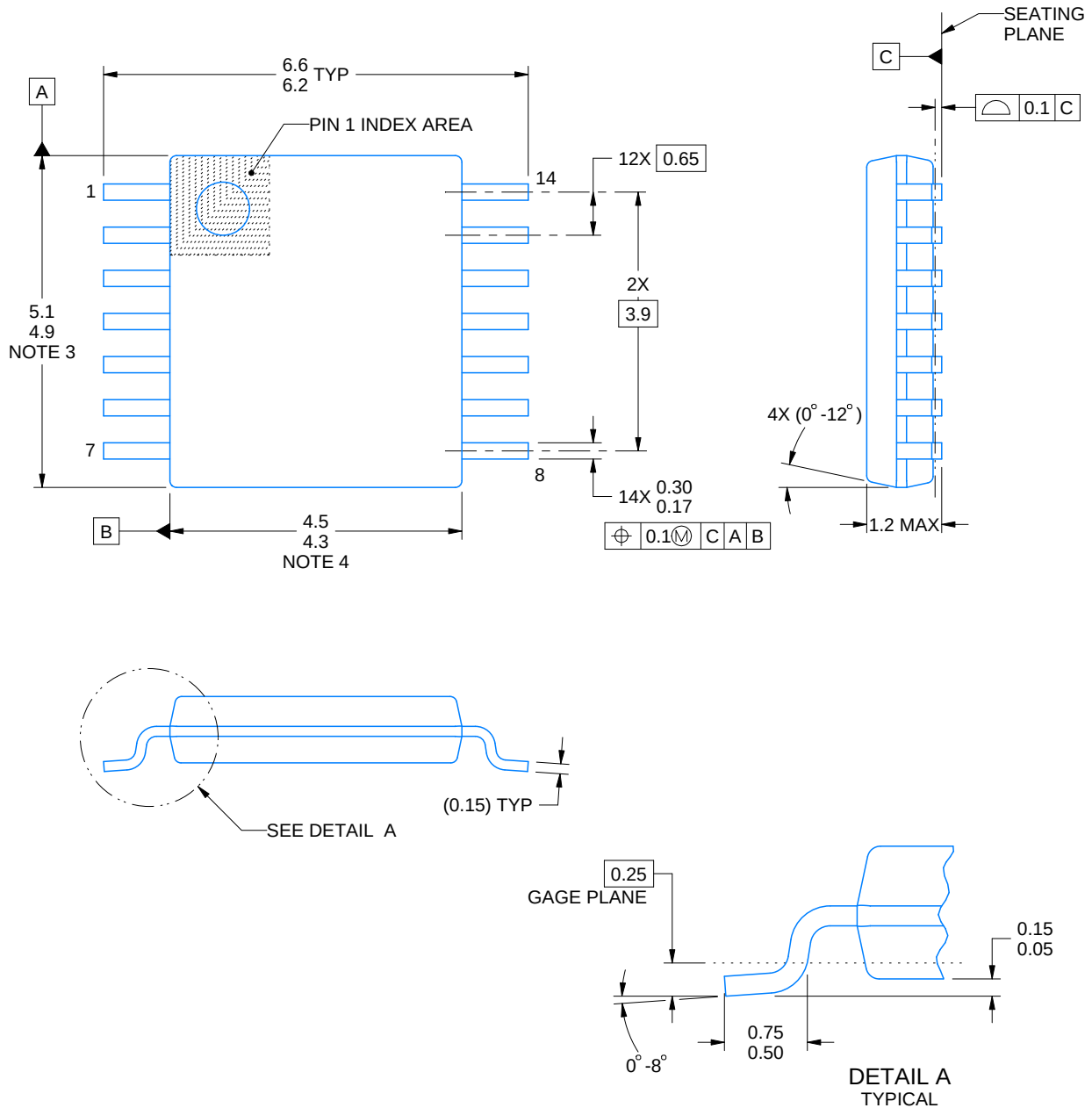
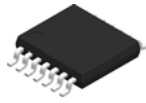
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ34210IPWRQ1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ34210IPWRQ1	TSSOP	PW	14	2000	350.0	350.0	43.0



4220202/B 12/2023

NOTES:

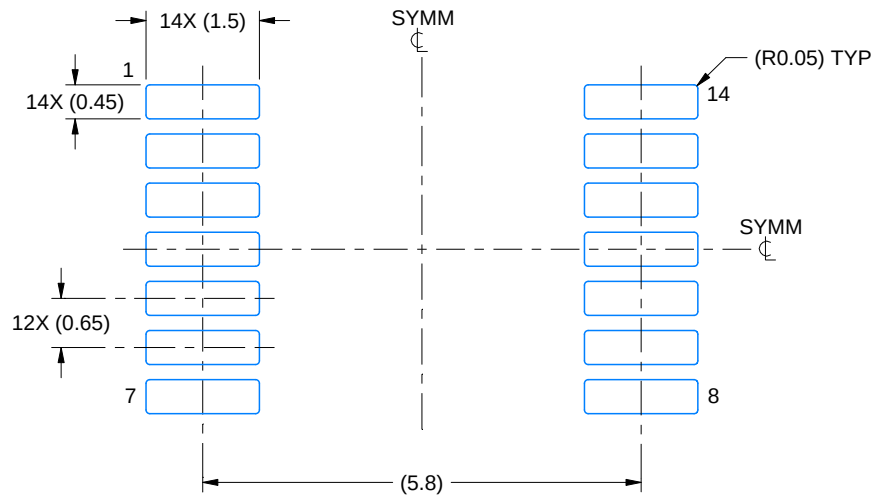
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

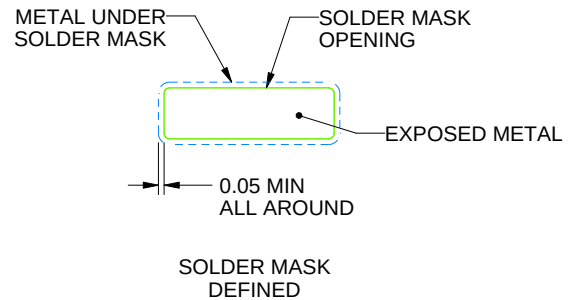
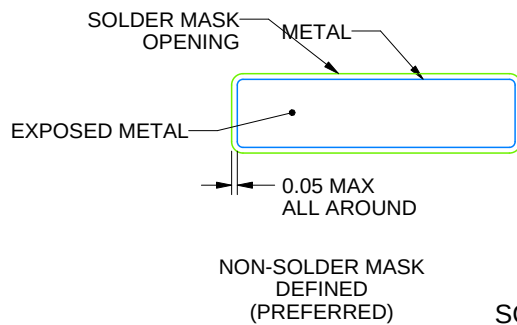
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

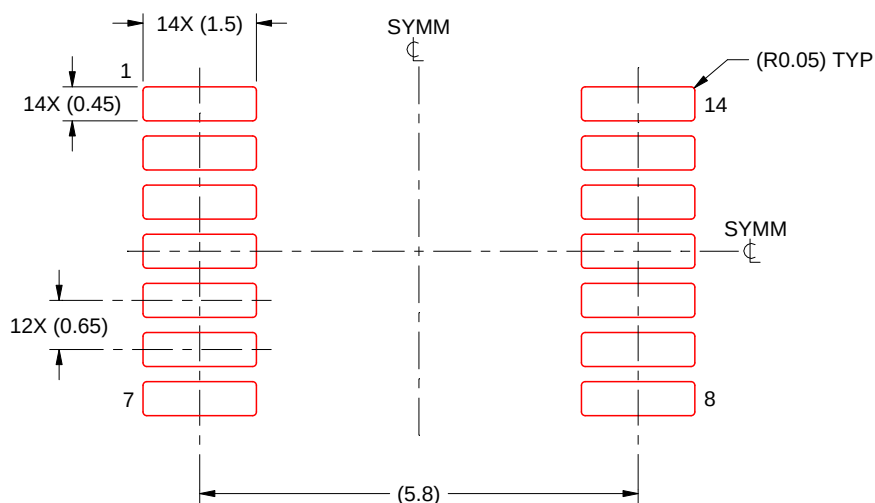
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220202/B 12/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

重要なお知らせと免責事項

TI は、技術データと信頼性データ (データシートを含みます)、設計リソース (リファレンス デザインを含みます)、アプリケーションや設計に関する各種アドバイス、Web ツール、安全性情報、その他のリソースを、欠陥が存在する可能性のある「現状のまま」提供しており、商品性および特定目的に対する適合性の黙示保証、第三者の知的財産権の非侵害保証を含むいかなる保証も、明示的または黙示的にかかわらず拒否します。

これらのリソースは、TI 製品を使用する設計の経験を積んだ開発者への提供を意図したものです。(1) お客様のアプリケーションに適した TI 製品の選定、(2) お客様のアプリケーションの設計、検証、試験、(3) お客様のアプリケーションに該当する各種規格や、その他のあらゆる安全性、セキュリティ、規制、または他の要件への確実な適合に関する責任を、お客様のみが単独で負うものとし、TI は一切の責任を拒否します。

上記の各種リソースは、予告なく変更される可能性があります。これらのリソースは、リソースで説明されている TI 製品を使用するアプリケーションの開発の目的でのみ、TI はその使用をお客様に許諾します。これらのリソースに関して、他の目的で複製することや掲載することは禁止されています。TI や第三者の知的財産権のライセンスが付与されている訳ではありません。お客様は、これらのリソースを自身で使用した結果発生するあらゆる申し立て、損害、費用、損失、責任について、TI およびその代理人を完全に補償するものとし、TI は一切の責任を拒否します。

TI の製品は、[TI の販売条件](#)、[TI の総合的な品質ガイドライン](#)、[ti.com](https://www.ti.com) または TI 製品などに関連して提供される他の適用条件に従い提供されます。TI がこれらのリソースを提供することは、適用される TI の保証または他の保証の放棄の拡大や変更を意味するものではありません。TI がカスタム、またはカスタマー仕様として明示的に指定していない限り、TI の製品は標準的なカタログに掲載される汎用機器です。

お客様がいかなる追加条項または代替条項を提案する場合も、TI はそれらに異議を唱え、拒否します。

Copyright © 2025, Texas Instruments Incorporated

最終更新日：2025 年 10 月