bq500100
用于无线充电的 **20V** 高侧电流传感器

1 特性

- 宽共模范围：0V 至 20V
- 偏移电压：±150μV（最大值）
  - 支持 10mV 满量程分流压降
- 精度：±2% 增益误差（最大过热误差）
- 固定增益：50V/V
- 低静态电流：100μA（最大值）
- 小型封装：SC70

2 应用

- 用于 15W 或 5W 系统的无线电源发射器，符合 WPC (Qi) 1.2 规范
- 专用无线充电器和发送器
- 以无线方式供电的工业和医疗应用
- 更多相关信息，请访问 www.ti.com/wirelesspower

3 说明

bq500100 是一款用于无线充电的电压输出和分流监控器，有助于进行外来物体检测 (FOD)。该器件可感测分流电阻在 0V 至 20V 共模电压范围内的压降，与电源电压无关。该器件 具有 50V/V 的固定电压增益，其最大增益误差为 2%，偏移电压为 150μV（最大值）。

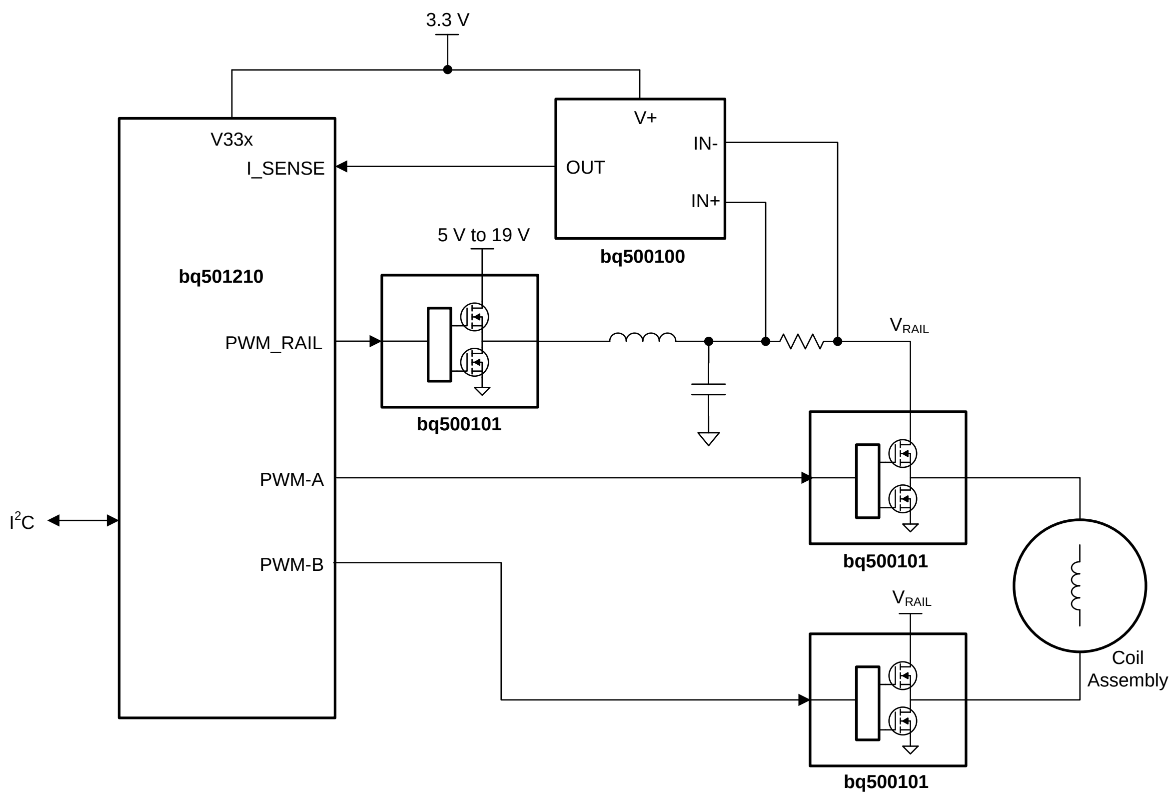
该器件可由一个电压为 2.7V 至 6V 的单电源供电，最大电源电流为 100μA。该器件采用 SC70 封装，其额定工作温度范围为 –40°C 至 +105°C。

器件信息(1)

部件号	封装	封装尺寸（标称值）
bq500100	SC70 (6)	2.00mm × 1.25mm

(1) 要了解所有可用封装，请参见数据表末尾的可订购产品附录。

典型无线充电应用



English Data Sheet: SBOS765

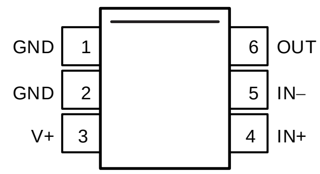
目录

4 修订历史记录

日期	修订版本	注释
2016 年 1 月	*	首次发布。

5 Pin Configuration and Functions

DCK Package
6-Pin SC70
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	SC70		
GND	1, 2	Analog	Ground for the power-supply voltage rail
IN–	5	Analog input	Connect to load side of shunt resistor
IN+	4	Analog input	Connect to supply side of shunt resistor
OUT	6	Analog output	Output voltage
V+	3	Analog	Power supply, 2.7 V to 6 V

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply voltage			7	V
Analog inputs, V_{IN+}, $V_{IN–}$ (2)	Differential (V_{IN+}) – ($V_{IN–}$)	–26	26	V
	Common-mode (3)	GND – 0.3	26	
Output (3)		GND – 0.3	(V+) + 0.3	V
Input current Into all pins (3)			5	mA
Temperature	Operating, T_A	–40	125	°C
	Junction, T_J		150	
	Storage, T_{stg}	–65	150	

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) V_{IN+} and $V_{IN–}$ are the voltages at the IN+ and IN– pins, respectively.
(3) Input voltage at any pin can exceed the voltage shown if the current at that pin is limited to 5 mA.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±1000	
		Machine model (MM)	±200	

(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

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

		MIN	NOM	MAX	UNIT
V_{CM}	Common-mode input voltage		12		V
V_S	Operating supply voltage (applied to V+)		3.3		V
T_A	Operating free-air temperature	–40		105	°C

6.4 Thermal Information

THERMAL METRIC (1)		bq500100 DCK (SC70) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	227.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	79.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	72.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	3.6	°C/W
ψ_{JB}	Junction-to-board characterization parameter	70.4	°C/W
$R_{\theta JC(bot)}$	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.

6.5 Electrical Characteristics

at T_A = 25°C, V+ = 5 V, V_{IN+} = 12 V, and V_{SENSE} = V_{IN+} – $V_{IN–}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT						
V_{CM}	Common-mode input range	T_A = –40°C to +105°C	0		20	V
CMR	Common-mode rejection	V_{IN+} = 0 V to 20 V, T_A = –40°C to +105°C	100	120		dB
V_{OS}	Offset voltage, RTI (1)			±5	±150	μV
dV_{OS}/dT	Offset voltage, RTI vs temperature	T_A = –40°C to +105°C		0.1	0.5	μV/°C
PSR	Power-supply rejection	V+ = 2.7 V to 6 V, V_{IN+} = 18 V		±0.1		μV/V
I_B	Input bias current			28		μA
I_{OS}	Input offset current			±0.02		μA
OUTPUT						
G	Gain		49	50	51	V/V
	Maximum capacitive load	No sustained oscillation		1		nF
VOLTAGE OUTPUT (2)						
	Swing to V+ power-supply rail	R_L = 10 kΩ to GND, T_A = –40°C to +105°C		(V+) – 0.05	(V+) – 0.2	V
	Swing to GND	R_L = 10 kΩ to GND, T_A = –40°C to +105°C		(V_{GND}) + 0.005	(V_{GND}) + 0.05	V
FREQUENCY RESPONSE						
GBW	Bandwidth	C_{LOAD} = 10 pF		80		kHz
SR	Slew rate			0.4		V/μs
NOISE, RTI (1)						
	Voltage noise density			25		$nV/\sqrt{Hz}$
POWER SUPPLY						
V_S	Operating voltage range (applied to V+)	T_A = –40°C to +105°C	2.7		6	V
I_Q	Quiescent current	V_{SENSE} = 0 mV		65	100	μA
		T_A = –40°C to +105°C			115	
TEMPERATURE RANGE						
	Specified range		–40		105	°C
	Operating range		–40		125	°C

(1) RTI = Referred-to-input.
(2) See typical characteristic curve, *Output Voltage Swing vs Output Current* (Figure 1).

6.6 Typical Characteristics

performance measured at T_A = 25°C, V+ = 5 V, and V_{IN+} = 12 V (unless otherwise noted)

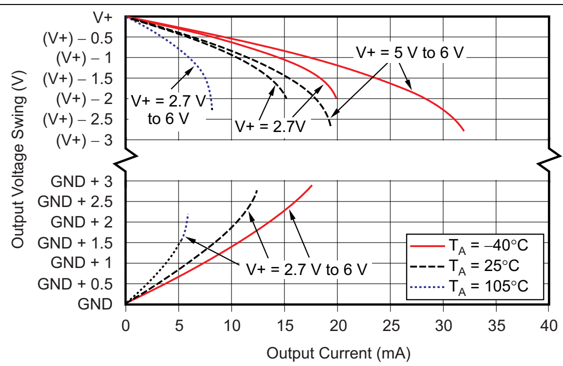


Figure 1. Output Voltage Swing vs Output Current

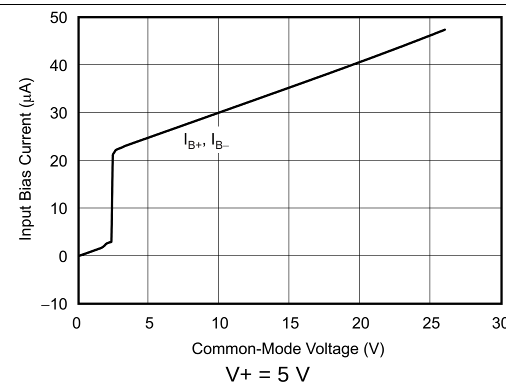


Figure 2. Input Bias Current vs Common-Mode Voltage

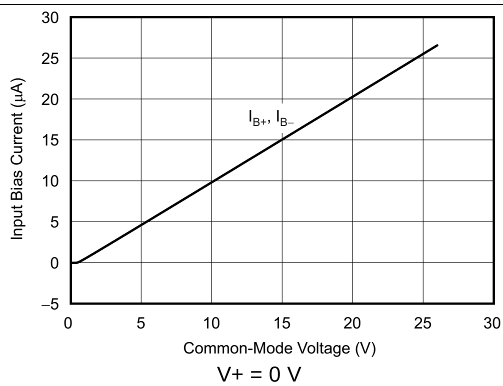


Figure 3. Input Bias Current vs Common-Mode Voltage (Shutdown)

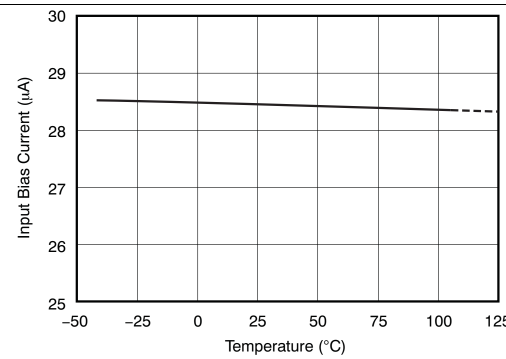


Figure 4. Input Bias Current vs Temperature

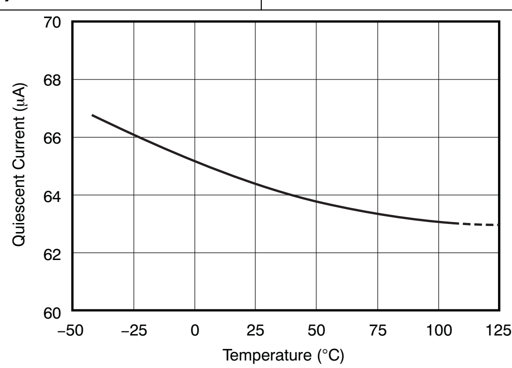


Figure 5. Quiescent Current vs Temperature

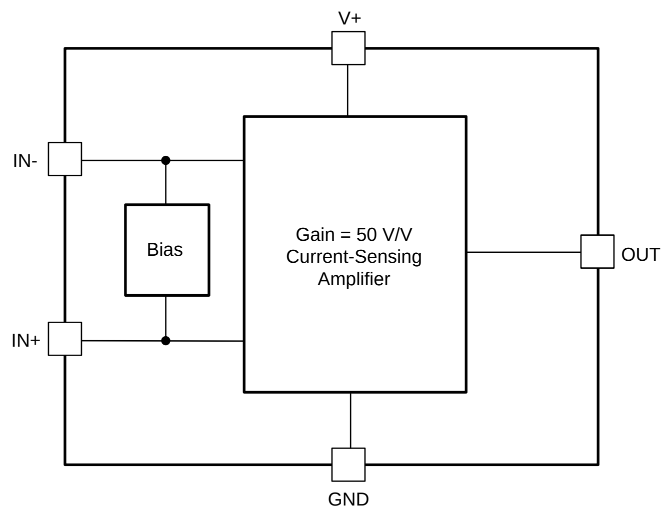
7 Detailed Description

7.1 Overview

The bq500100 is specially-designed to facilitate foreign object detection (FOD) in wireless charging applications by monitoring the coil supply current. The current-sensing amplifier is able to accurately measure voltages developed across a current-sensing resistor on common-mode voltages that far exceed the supply voltage powering the device. Current can be measured on input voltage rails as high as 20 V when the device is powered off a lower supply voltage.

Low drift characteristics enables high-precision measurements with maximum input offset voltages as low as 200 µV with a maximum temperature contribution of 0.5 µV/°C over the full temperature range of –40°C to +105°C.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 High Input Common-Mode Range

The bq500100 can support input common-mode voltages up to 20 V. Because of the internal topology, the common-mode range is not restricted by the supply voltage as long as the input supply stays within the operational range of 2.7 V to 6 V. The ability to operate with supply voltages lower than the input voltage common-mode signal makes the device well-suited for monitoring the current in wireless charging applications where the common-mode voltage varies to obtain a desired amount of power transfer.

When the dc common-mode voltage varies, the effect on the output voltage is very small as a result of the high common-mode rejection. The dc common-mode rejection for the bq500100 is expressed in decibels and is typically as high as 120 dB. In wireless charging applications, the current-sensed rail commonly varies in voltage to adjust for the amount of power transferred by the coil.

7.3.2 High Current-Sense Accuracy Over a Wide Dynamic Range

The offset voltage, gain error, and shunt resistor are the three primary contributors that determine the current measurement accuracy over a specified current range. The offset voltage dominates the error when operating at low current values and the gain error dominates when operating at high current values. The low offset voltage allows use of smaller shunt resistors values. Both the low offset and gain error allow the bq500100 to accurately measure current over a wide dynamic range and still maintain a high level of accuracy.

7.4 Device Functional Modes

7.4.1 Normal Operation

The bq500100 is in normal operation when the following conditions are met:

- V+ is between 2.7 V and 6.0 V
- The common-mode input voltage is less than 20 V
- The differential input signal times gain is less than the supply voltage minus the output voltage swing to V+
- The differential input signal times gain is greater than the swing to GND
- Current flows into the shunt resistor from IN+ to IN– connection points (unidirectional)

When in the normal operating region, the device operates as expected and produces an output voltage that is the gained-up representation of the difference voltage from IN+ to IN–.

7.4.1.1 Device Power-Up

The topology of the bq500100 allows voltages to be present on the inputs before power is applied; therefore, there is no sequencing requirement in regards to the input voltages and the power supply rail for V+. There is a small delay of approximately 50 µs from when power is applied to when the output voltage of the bq500100 settles to the correct voltage level.

7.4.1.2 Input Differential Overload

If the differential input voltage (V_{IN+} – $V_{IN–}$) multiplied by gain exceeds the voltage swing specification, the device drives the output as close as possible to the positive supply and does not provide accurate measurement of the differential input voltage. If this behavior occurs during normal circuit operation, then reduce the value of the shunt resistor to avoid this mode of operation. If a differential overload occurs in a fault event, then the output of the bq500100 returns to the expected value approximately 250 µs after the fault condition is removed.

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 bq500100 is tailored to monitor current in wireless charging applications. This section focuses on the current-sense requirements for wireless charging. A typical application schematic and design procedure are provided in this section as reference.

8.2 Typical Application

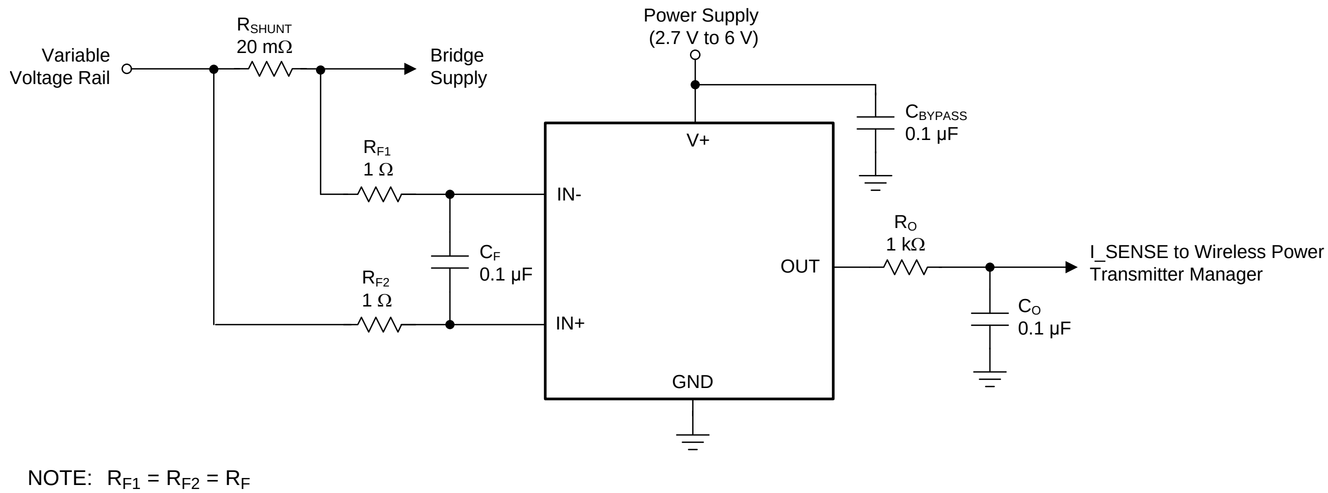


Figure 6. Typical Application for Wireless Charging

8.2.1 Design Requirements

The design requirements for a typical wireless charging application is shown in Table 1. These requirements use the schematic shown in Figure 6.

Table 1. Design Parameters

PARAMETER	DESIGN REQUIREMENT
Supply voltage range for V+	3.3 V ± 3% provided by a dc-dc converter
Common-mode voltage range	9 V to 19 V provided by a dc-dc converter
Power loss in the shunt resistor	20 mW or less at 1 A
Current-monitoring accuracy (gain error + offset error)	Better than 2.3% at 1 A, V_{CM} = 12 V, T_A = 25°C
I_SENSE peak-to-peak ripple	Less than 15 mV

8.2.2 Detailed Design Procedure

The first step in designing a solution is to make sure that the supply voltage and common-mode voltage are within the specified operational range of the device. For the supply and common-mode voltage requirements specified in Table 1, the bq500100 reliably operates and is an ideal fit for this application.

The next step is to select the desired value for the shunt resistor. In this application example, the maximum power dissipation in the shunt resistor is specified to be 20 mW or less with a 1-A current-sense signal. The maximum power dissipation requirement limits the maximum value of the shunt resistor to 20 mW / (1 A)^2, or 20 mΩ. To meet this application requirement and still maximize the current-sense accuracy, the maximum allowable resistance of 20 mΩ is selected.

Additional input filtering (see Figure 6) is required to mitigate the affects of differential noise and switching ripple because the device is sensing the voltage rail of the dc-dc supply. When adding series resistance to the input, keeping the resistance as small as possible is recommended because any added resistance adds to the gain error of the device. For the bq500100, the amount of additional gain error resulting from the filter resistance R_S can be calculated using Equation 1:

$$\text{Gain Error (\%)} = 100 - \left(100 \times \frac{20{,}000}{(17 \times R_F) + 20{,}000}\right) \quad (1)$$

Applying Equation 1 for the case where R_F is equal to 1 Ω results in an additional gain error of 0.085%. Applying this result to the total gain error is calculated to be approximately 2.085%.

The total offset voltage can be calculated by adding the effects of drift, change in supply voltage, and change in the common-mode input voltage to the specified offset voltage. In this example, no additional errors need to be added to the common-mode voltage and temperature because the conditions specified in Table 1 match the V_{OS} conditions specified in the *Electrical Characteristics* table. The only additional error that needs to be added to the offset voltage is the effect of changes to the supply voltage. This document specifies a supply voltage of 5 V; however, this application calls for a supply voltage of 3.3 V. The change in offset voltage resulting from the difference in supply voltage can be calculated by using the PSR specification in this document; see the *Electrical Characteristics* table. The PSRR of the device is typically ±0.1 µV/V; therefore, the change in offset voltage can be calculated by taking the difference in supply voltage and multiplying by this value. In this case, the supply voltage difference is 1.7 V (5 V – 3.3 V), so the change in offset voltage is 0.17 µV. Therefore the total offset voltage error is 150.17 µV. Because the offset voltage error is a fixed value, the percentage influence on the accuracy is a function of the load current and can be calculated by applying Equation 2.

$$\text{Total Offset Error (\%)} = \frac{\text{Total Offset Error (V)}}{I_{SHUNT}(A) \times R_{SHUNT}(\Omega)} \times 100\% \quad (2)$$

Applying Equation 2 with an offset value of 150.15 µV, an R_{SHUNT} value of 20 mΩ, and a shunt current of 1 A results in a percentage error of 0.751%.

Now that the total gain error and offset error of the device are known, the accuracy of the current-shunt monitor can be calculated with Equation 3:

$$\text{Total Error (\%)} = \sqrt{\text{Total Gain Error (\%)}^2 + \text{Total Offset Error (\%)}^2} \quad (3)$$

Applying Equation 3 with a total gain error of 2.085% and a total offset error of 0.751% results in a total accuracy of 2.22% at 1 A, which is within the design target of 2.3%. Using a resistor tolerance of 0.5% to minimize errors introduced by R_{SHUNT} is recommended.

Additional output filtering consisting of R_O and C_O (see Figure 6) is required to further reduce the ripple at the bq500100 current-sense output. For best performance, keeping the ripple on the current monitor output below 15 mV is recommended. The values provided in Figure 6 are sufficient for most use cases.

8.2.3 Application Curve

An example output response of the wireless charging application is shown in Figure 7.

The coil driver current is shown in green and has both ac and dc components. The I_SENSE signal is shown in red and is filtered to generate a signal representative of the dc current for foreign object detection.

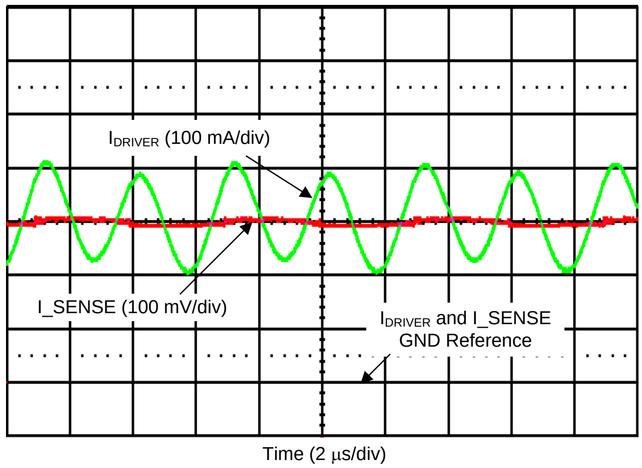


Figure 7. Current-Sense Output in a Wireless Charging Application

9 Power Supply Recommendations

The input circuitry of the bq500100 can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power-supply voltage can be as high as 20 V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Also, the bq500100 can withstand the full input signal range up to the 20-V range in the input pins, regardless of whether the device has power applied or not.

10 Layout

10.1 Layout Guidelines

- Make connections to the shunt resistor with a Kelvin or 4-wire connection. This connection technique ensures that only the current-sensing resistor impedance is detected between the input pins. Poor routing of the current-sensing resistor commonly results in additional resistance present between the input pins. Given the very low ohmic value of the current resistor, any additional high-current carrying impedance can cause significant measurement errors.
- Place the power-supply bypass capacitor as closely as possible to the supply and ground pins. The recommended value of this bypass capacitor is 0.1 µF. Additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.
- Place the input filter capacitor, C_F, as close as possible to the input pins of the device. Place the input filter resistors as close as possible to each other to minimize the enclosed loop area between the device and the shunt resistor.
- The output of the current-sense circuit must be located as close as possible to the wireless power transmitter manager device. If the distance to the wireless power transmitter is greater than 1 cm, the output filter capacitor (C_O) shown in Figure 8 must be placed next to the I_SENSE pin of the wireless power transmitter manger. Placing the capacitor at the I_SENSE pin of the wireless power transmitter manger provides the best filtering of the current-sense signal.

10.2 Layout Example

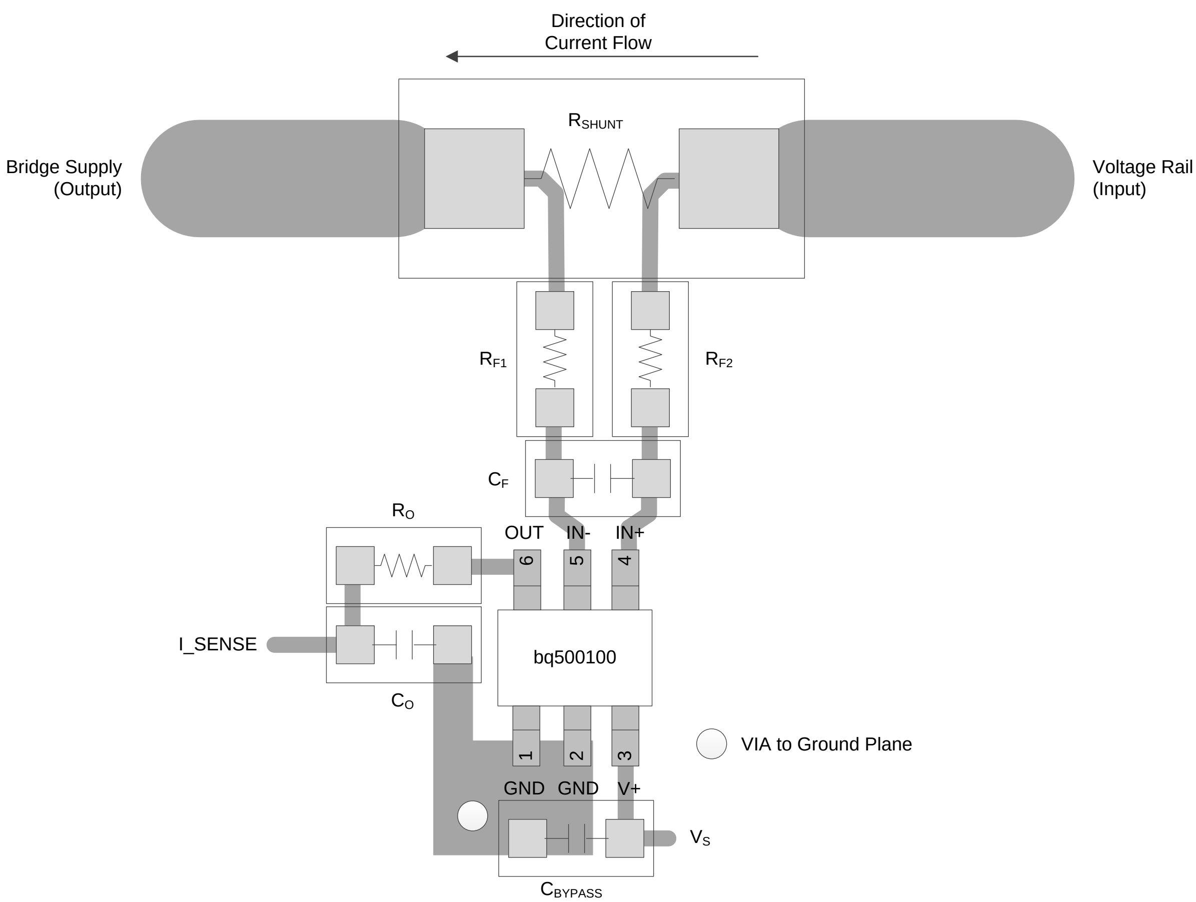


Figure 8. Recommended Layout

11 器件和文档支持

11.1 文档支持

11.1.1 相关文档

《bq501210 数据表》，SLUSCF5

《bq500101 数据表》，SLPS585

《分流监控器的瞬态稳定性》，TIDU473

11.2 社区资源

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 商标

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11.4 静电放电警告

这些装置包含有限的内置 ESD 保护。 存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏

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)
BQ500100DCKR	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU | SN	Level-2-260C-1 YEAR	-	12Y
BQ500100DCKR.B	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	See BQ500100DCKR	12Y
BQ500100DCKT	Active	Production	SC70 (DCK) | 6	250 | SMALL T&R	Yes	NIPDAU | SN	Level-2-260C-1 YEAR	-	12Y
BQ500100DCKT.B	Active	Production	SC70 (DCK) | 6	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	See BQ500100DCKT	12Y

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

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

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

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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

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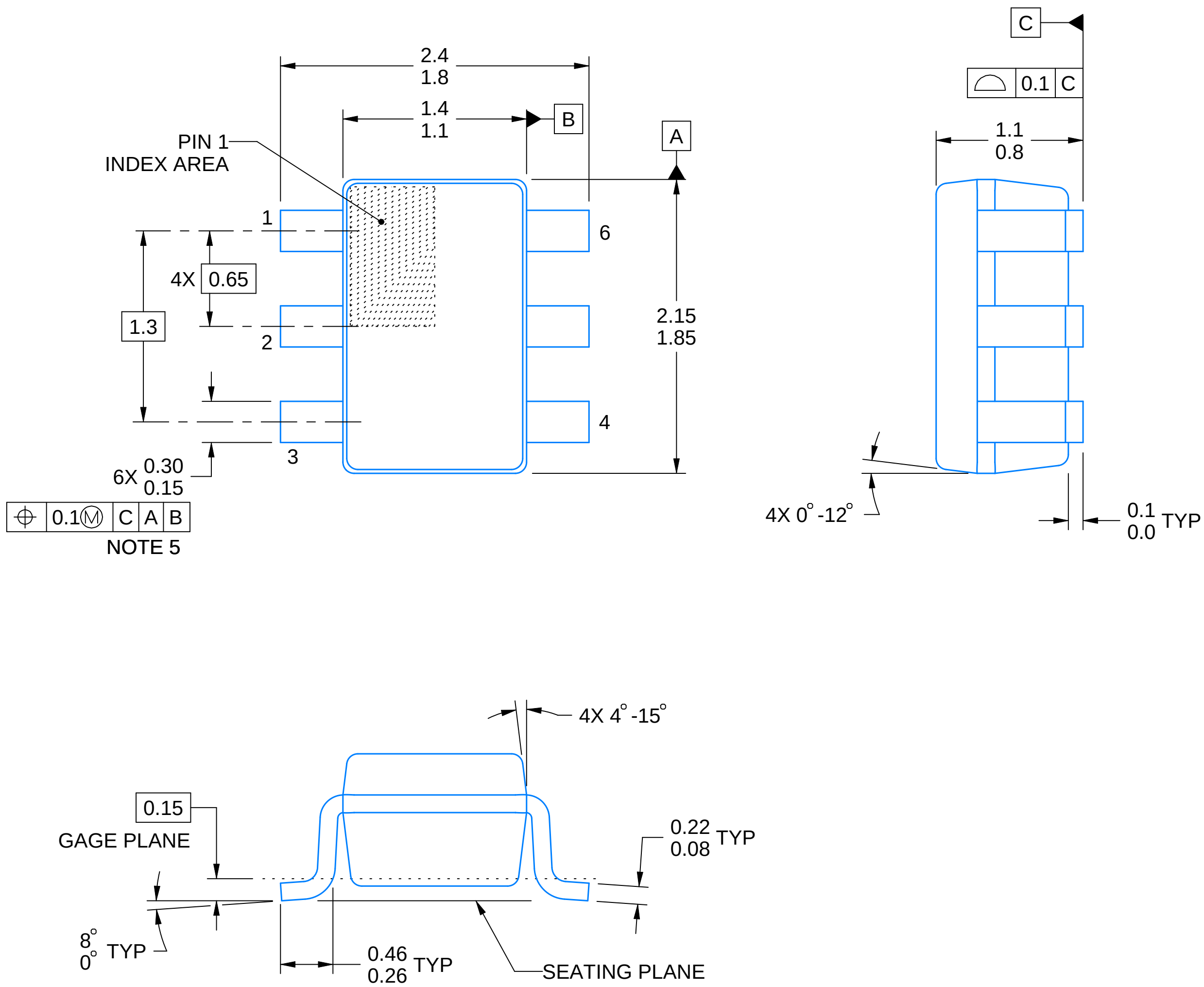

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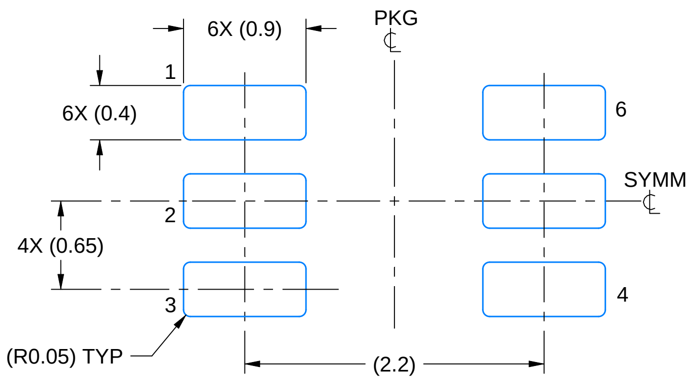
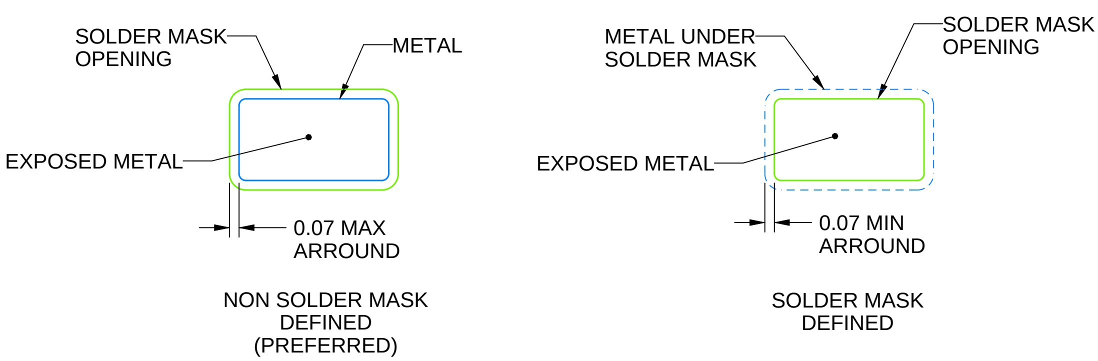
NOTES:

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Falls within JEDEC MO-203 variation AB.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



SOLDER MASK DETAILS

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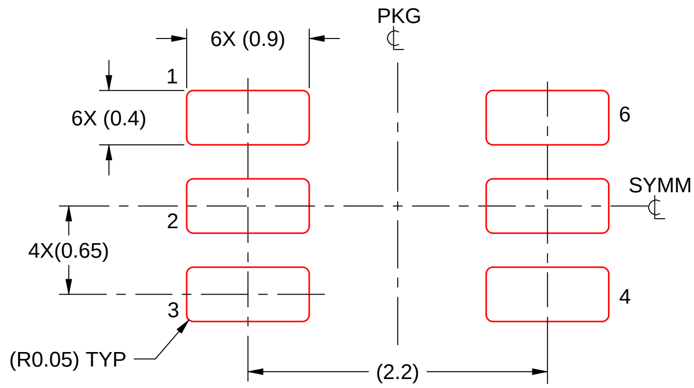
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

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NOTES: (continued)

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

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