ROHM SEMICONDUCTOR

Datasheet

Current Sensor

Current Sense Amplifier

BD14211G-LA

General Description

This product is a rank product for the industrial equipment market. This is the best product for use in these applications.
BD14211G-LA is a current sense amplifier.
This device operates from a single 2.7 V to 5.5 V power supply.
It has wide common mode voltage range from -0.2 V to +26 V, outputs analog voltage. The gain is 50 V/V.
The matched gain resistor minimizes gain error and offset voltage.
In additionally, the low input bias current is 1 μA that reduces the offset on the path to shunt resistor.

Key Specifications

- VDD Voltage Range: 2.7 V to 5.5 V
- Quiescent Current: 170 μA (Typ)
- Common Mode Voltage Range: -0.2 V to +26 V
- Gain: 50 V/V (Typ)
- Gain Accuracy: ±1.0 % (Max)
- Operating Temperature Range: -40 °C to +125 °C

Package

Package	W (Typ) x D (Typ) x H (Max)
SSOP6	2.9 mm x 2.8 mm x 1.25 mm

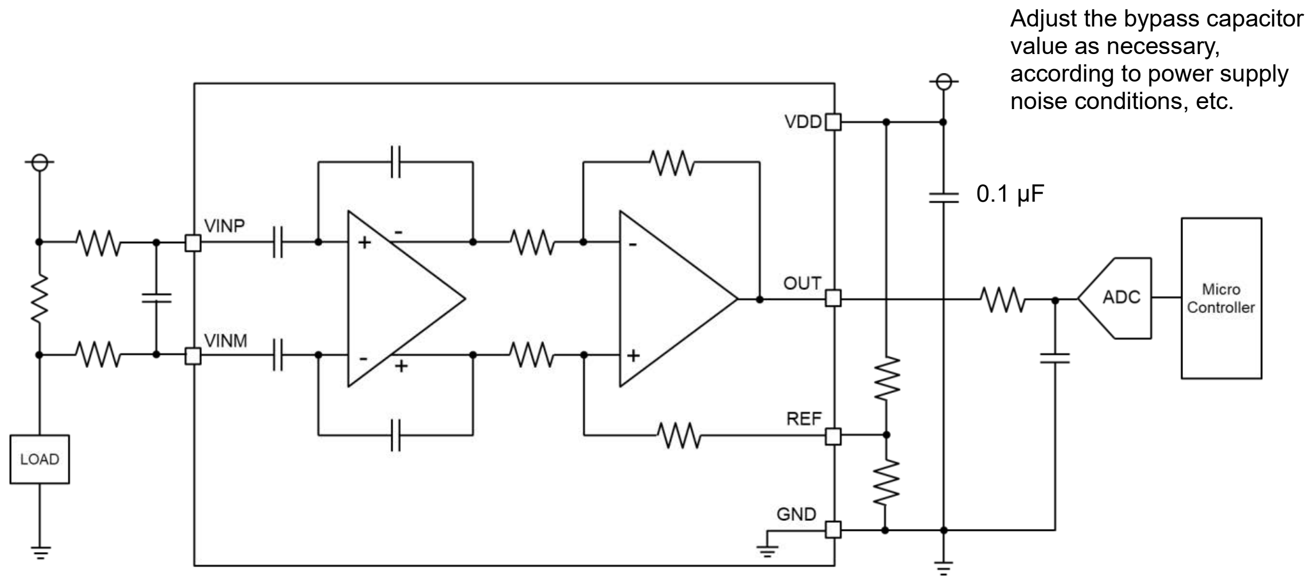
Features

- Wide Common Mode Voltage Range
- High Accuracy
- Low Offset Voltage
- Low Input Bias Current

Applications

- Industrial Equipment
- Telecom Equipment
- Over Current Detection

Typical Application Circuit, Block Diagram

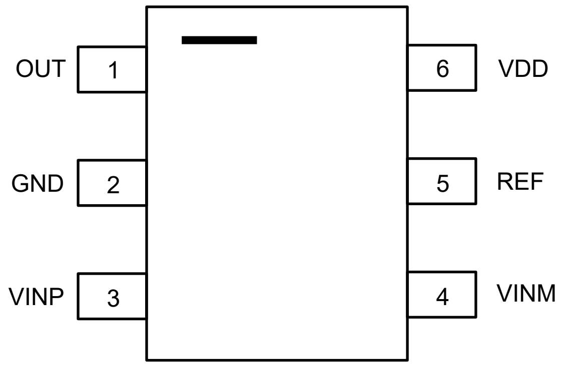


〇Product structure : Silicon integrated circuit 〇This product has no designed protection against radioactive rays.

Contents

Pin Configuration

(Top View)



Pin Descriptions

Pin No.	Pin Name	Function
1	OUT	Current detection output
2	GND	Ground
3	VINP	Voltage input of supply side of shunt resistor
4	VINM	Voltage input of load side of shunt resistor
5	REF	Reference voltage
6	VDD	Power supply(Note 1)

(Note 1) Dispose a bypass capacitor between VDD and GND.

Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Power Supply Voltage	V_{DD}	7.0	V
Common Mode Voltage	V_{CM}	-0.2 to +26	V
REF Pin Voltage	V_{REF}	-0.3 to V_{DD} + 0.3	V
Storage Temperature Range	Tstg	-40 to +150	°C
Maximum Junction Temperature	Tjmax	150	°C

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

Thermal Resistance *(Note 2)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s *(Note 4)*	2s2p *(Note 5)*	
SSOP6				
Junction to Ambient	θ_{JA}	376.5	185.4	°C/W
Junction to Top Characterization Parameter *(Note 3)*	Ψ_{JT}	40	30	°C/W

(Note 2) Based on JESD51-2A (Still-Air).
(Note 3) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 4) Using a PCB board based on JESD51-3.
(Note 5) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 µm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 µm	74.2 mm x 74.2 mm	35 µm	74.2 mm x 74.2 mm	70 µm

Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Power Supply Voltage	V_{DD}	2.7	-	5.5	V	
Common Mode Voltage	V_{CM}	-0.2	-	+26	V	VINP, VINM
Operating Temperature	Topr	-40	+25	+125	°C	

Electrical Characteristics

(Unless otherwise specified V_{DD} = 5 V, V_{CM} = 12 V, V_{REF} = V_{DD} / 2, V_{SENSE} = (V_{VINP} – V_{VINM}), Ta = 25 °C)

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Power Supply						
Quiescent Current	I_{DD}	-	170	280	µA	V_{SENSE} = 0 mV
Current Sense Amplifier						
Offset Voltage	V_{OS}	-	-	±0.6	mV	RTI(Note 6), V_{SENSE} = 0 mV
Gain	G_{AIN}	-	50	-	V/V	
Gain Accuracy	G_{ERR}	-	-	±1.0	%	V_{OUT} = 0.5 V to V_{DD} - 0.5 V Ta = -40 °C to +125 °C
Nonlinearity Error	Lin	-	±0.01	-	%	V_{OUT} = 0.5 V to V_{DD} - 0.5 V
Input Bias Current	I_{VINM}	-	1.0	-	µA	V_{SENSE} = 0 mV Ta = -40 °C to +125 °C
High-level Output Voltage	V_{OUT_H}	V_{DD} - 0.02	-	-	V	OUT, R_L = 10 kΩ pulldown
Low-level Output Voltage	V_{OUT_L}	-	-	GND + 0.05	V	OUT, R_L = 10 kΩ pullup

(Note 6) RTI = Referred To Input

Typical Performance Curves

(Unless otherwise specified V_{DD} = 5 V, V_{CM} = 12 V, V_{REF} = V_{DD} / 2, V_{SENSE} = (V_{VINP} – V_{VINM}), Ta = 25 °C)

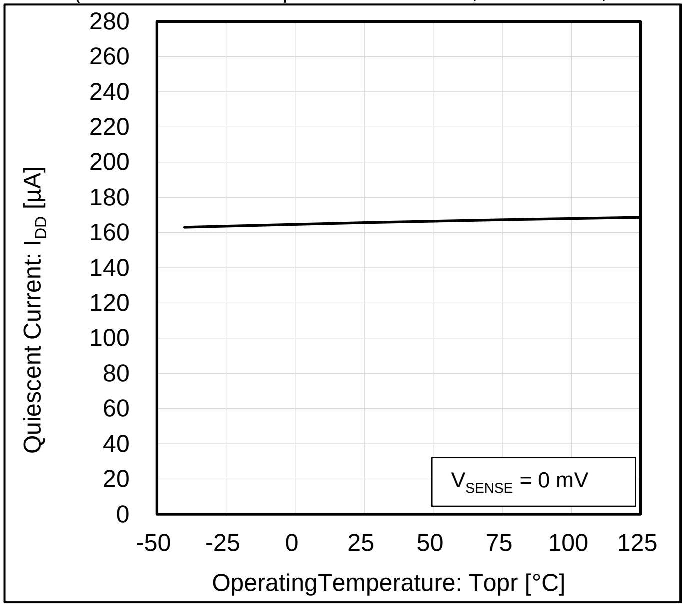


Figure 1. Quiescent Current vs Operating Temperature

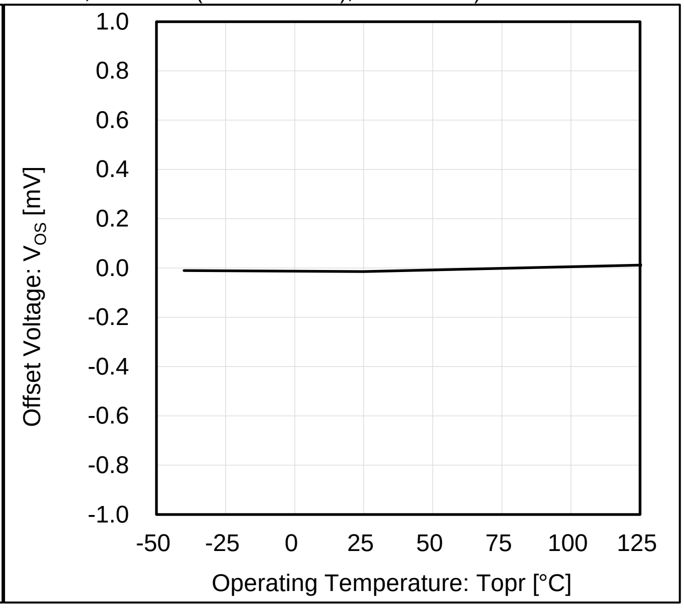


Figure 2. Offset Voltage vs Operating Temperature

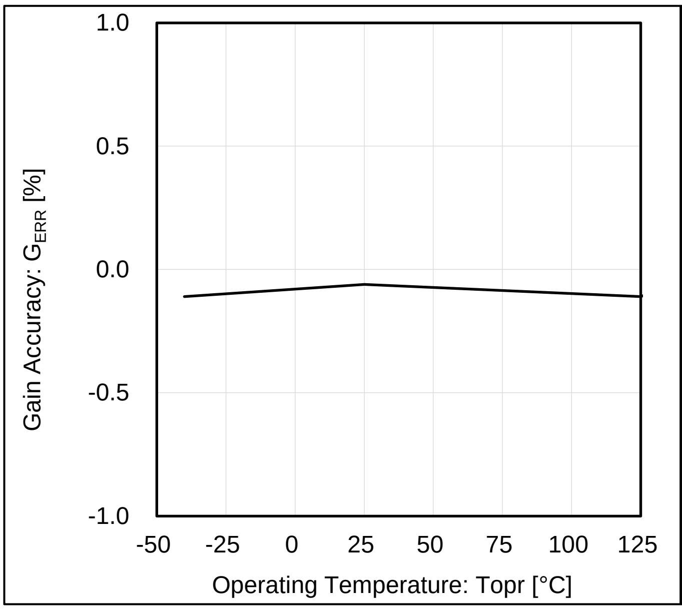


Figure 3. Gain Accuracy vs Operating Temperature

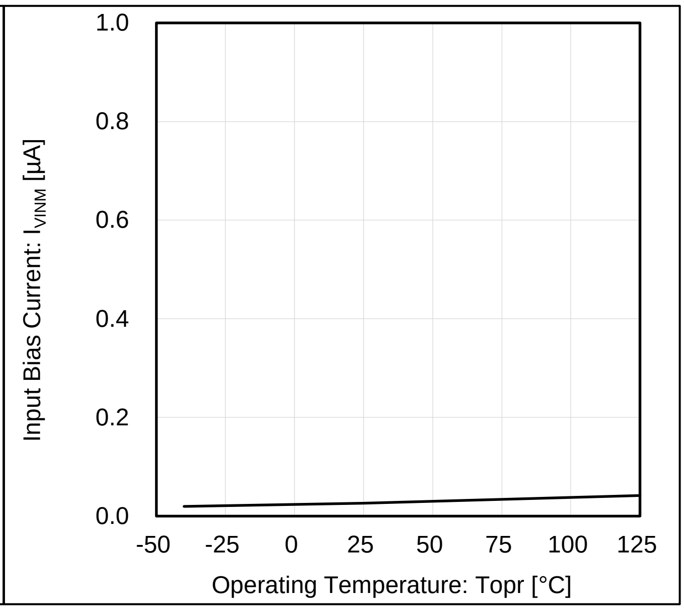


Figure 4. Input Bias Current vs Operating Temperature

Typical Performance Curves - continued

(Unless otherwise specified V_{DD} = 5 V, V_{CM} = 12 V, V_{REF} = V_{DD} / 2, V_{SENSE} = (V_{VINP} – V_{VINM}), Ta = 25 °C)

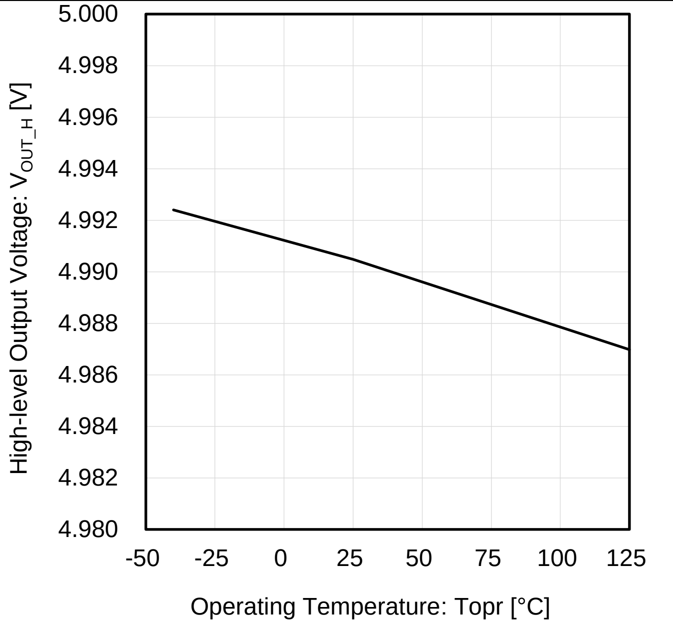


Figure 5. High-level Output Voltage vs Operating Temperature

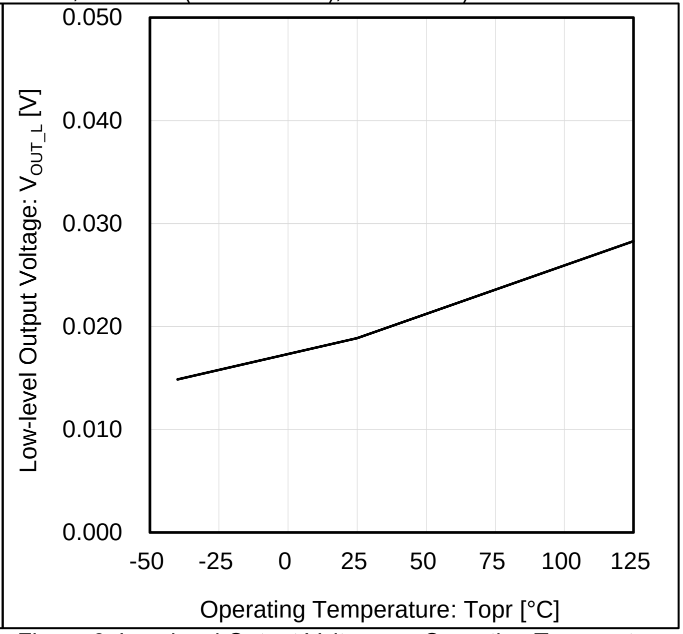


Figure 6. Low-level Output Voltage vs Operating Temperature

Timing Chart

1. Control Sequence

1.1 Power supply start-up sequence

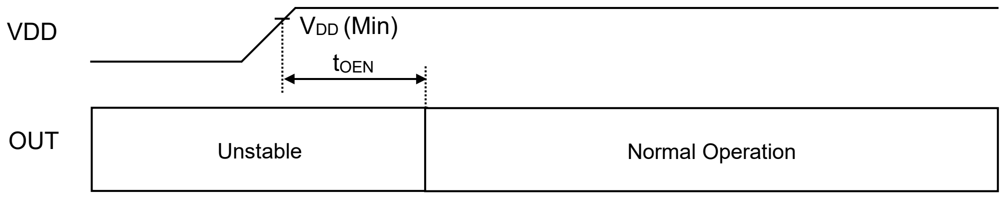


Figure 7. Timing Chart at Power ON

Stable time of OUT (t_{OEN}) should be 1 ms or more.

1.2 Power supply off sequence

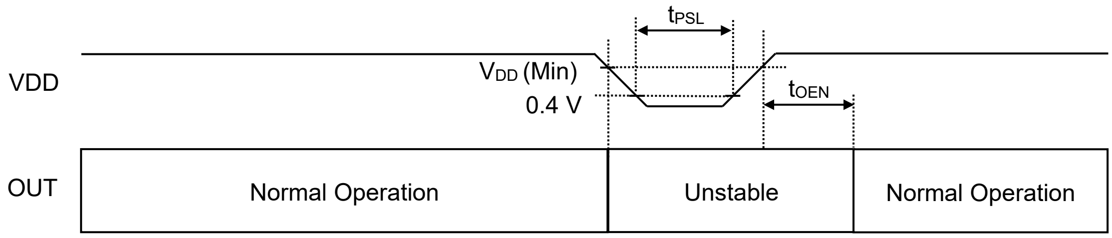


Figure 8. Timing Chart at Power OFF

Power off time (t_{PSL}) should be 1 ms or more.
If V_{DD} is under the recommended operating condition, LSI is unstable state. In that case, set Power OFF and ON again. When the power is ON again, the period of V_{DD} < 0.4 V should be t_{PSL} or more.

Application Example

This IC has the structure specialized for Current Sense Amplifier and has the following features. Common mode voltage range is maximum 26 V with V_{DD} of maximum 5.5 V, therefore it is possible to detect the current flowing in a power supply line exceeding V_{DD} voltage. And its input bias current is very low.

This IC amplifies the voltage difference across the shunt resistor between VINP and VINM and outputs a voltage with the REF pin as reference voltage.
If the current flows from VINP to VINM, OUT pin voltage is higher than REF pin voltage. If the current flows from VINM to VINP, OUT pin voltage is lower than REF pin voltage. When the voltages of VINP and VINM are equal, OUT pin voltage is equal to REF pin voltage.

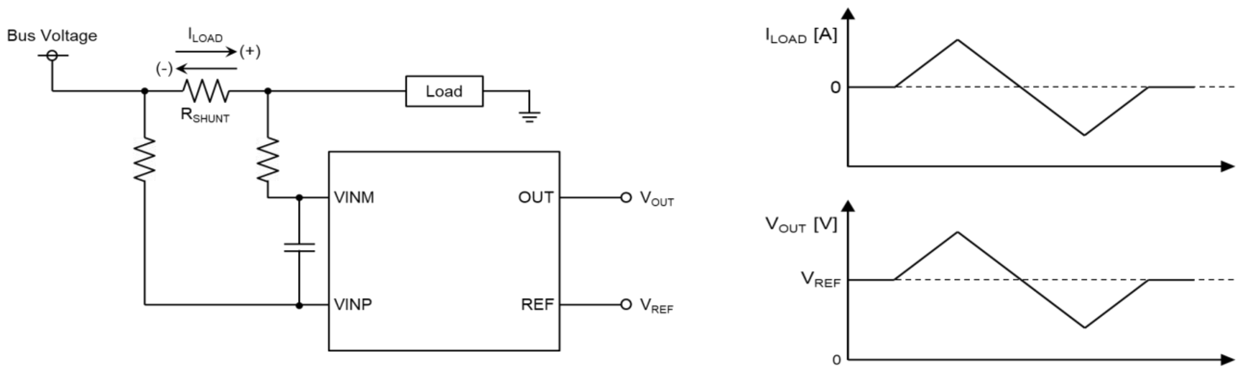


Figure 9. Basic Explanation

V_{OUT} is calculated by the below formula.

$$V_{OUT} = (R_{SHUNT} \times I_{LOAD} \times G_{AIN}) + V_{REF}$$

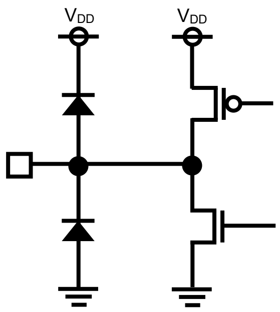
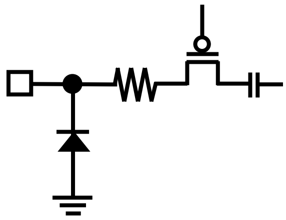
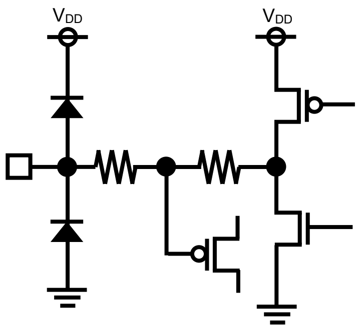
Where,
R_{SHUNT} is the Shunt resistance
I_{LOAD} is the Load current
G_{AIN} is the Gain of Current Sense Amplifier
V_{REF} is the REF pin voltage

Also, V_{OUT} needs to be GND < V_{OUT} < V_{DD}.
V_{OUT} is clipped to Low-level Output Voltage (V_{OUT_L}) when it's under GND.
V_{OUT} is clipped to High-level Output Voltage (V_{OUT_H}) when it's over V_{DD}.

To accurately sense the current through the shunt resistor, a 4-terminal Kelvin connection must be used to avoid errors in the impedance of the current path.
For stability, dispose and connect a bypass capacitor for removing power source noise close to IC.

Selection of shunt resistor
Shunt resistor R_{SHUNT} should be selected considering the accuracy of measuring current and the maximum power dissipation according to an application.
If the value of shunt resistor is high, it minimizes the influence of offset and increases the accuracy of measuring current.
If the value of shunt resistor is low, it reduces the power dissipation of V_{DD}.

I/O Equivalence Circuits

Pin Name	Equivalence Circuit Diagram	Pin Name	Equivalence Circuit Diagram
OUT		VINP VINM	
REF			

Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes - continued

10. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

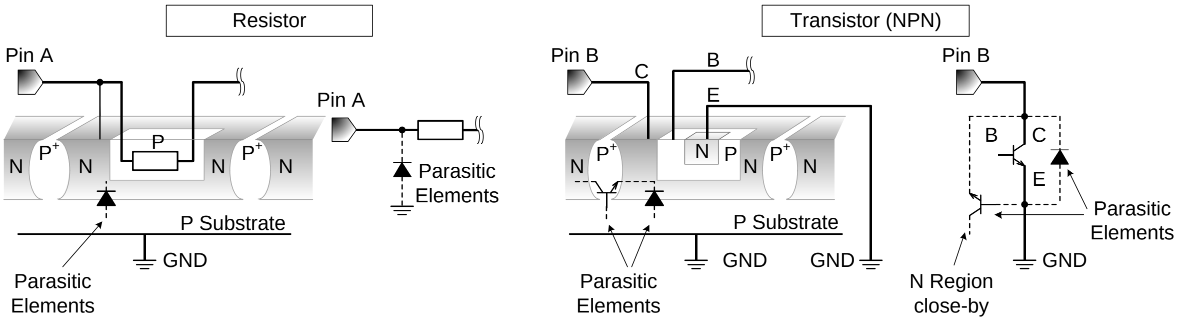


Figure 10. Example of Monolithic IC Structure

11. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

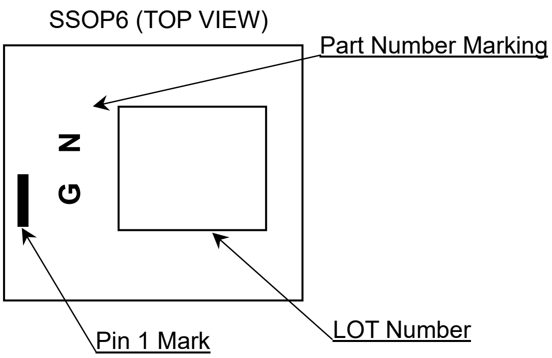
Ordering Information

B	D	1	4	2	1	1	G	-	LATR

Package
G: SSOP6

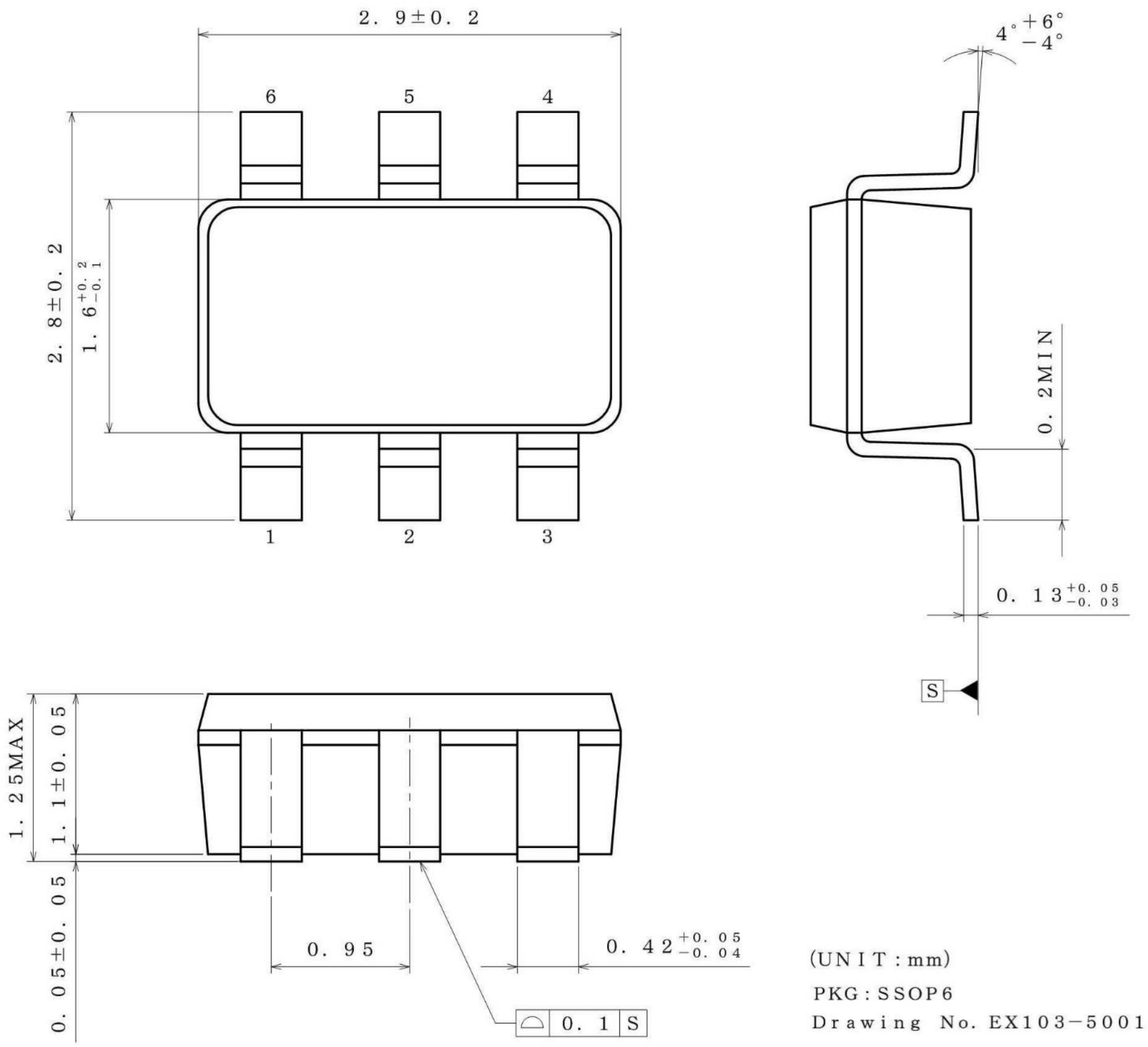
Product Class
LA: for Industrial Applications
Packaging and Forming Specification
TR: Embossed Tape and Reel

Marking Diagram



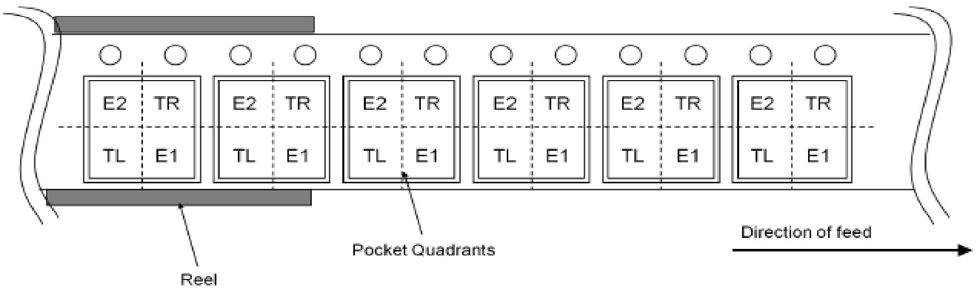
Physical Dimension and Packing Information

Package Name	SSOP6



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



Revision History

Date	Revision	Changes
21.Sep.2023	001	New Release

Notice

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(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

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This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

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