

# 1ch Small Package High Side Switch ICs for USB Devices and Memory Cards

**BD2220G-LB BD2221G-LB**

## General Description

This product guarantees long time support in Industrial market.

BD2220G and BD2221G are low on-resistance N-channel MOSFET high-side power switches, optimized for Universal Serial Bus (USB) applications. BD2220G and BD2221G are equipped with the function of over-current detection, thermal shutdown, under-voltage lockout and soft-start.

## Key Specifications

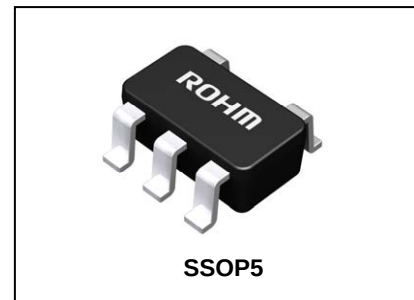
|                                |                      |
|--------------------------------|----------------------|
| ■ Input voltage range:         | 2.7V to 5.5V         |
| ■ ON resistance:               | 160mΩ(Typ.)          |
| ■ Over current threshold:      | 0.5A min., 1.0A max. |
| ■ Standby current:             | 0.01μA (Typ.)        |
| ■ Operating temperature range: | -40°C to +85°C       |

**Package**  
SSOP5

W(Typ.) D (Typ.) H (Max.)  
2.90mm x 2.80mm x 1.25mm

## Features

- Long time support a product for Industrial applications.
- Low On-Resistance (Typ. 160mΩ) N-channel MOSFET Built-in
- Over-Current Detection (Output off-latch operation)
- Thermal Shutdown
- Open-Drain Fault Flag Output
- Under-Voltage Lockout
- Soft-Start Circuit
- Control Input Logic
  - Active-High : BD2220G
  - Active-Low : BD2221G
- Reverse Current Protection when Power Switch Off

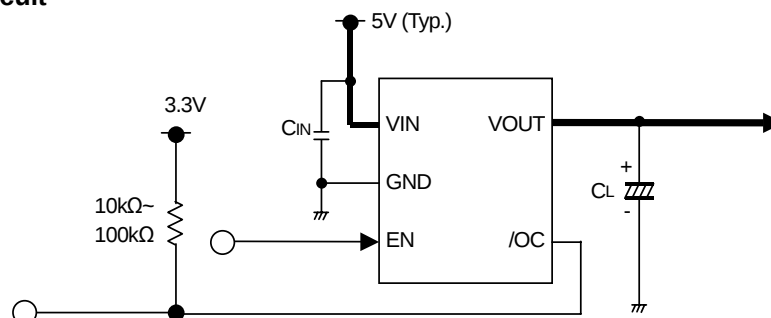


SSOP5

## Applications

Industrial Equipment,  
USB hub in consumer appliances, Car accessory, PC,  
PC peripheral equipment, and so forth

## Typical Application Circuit

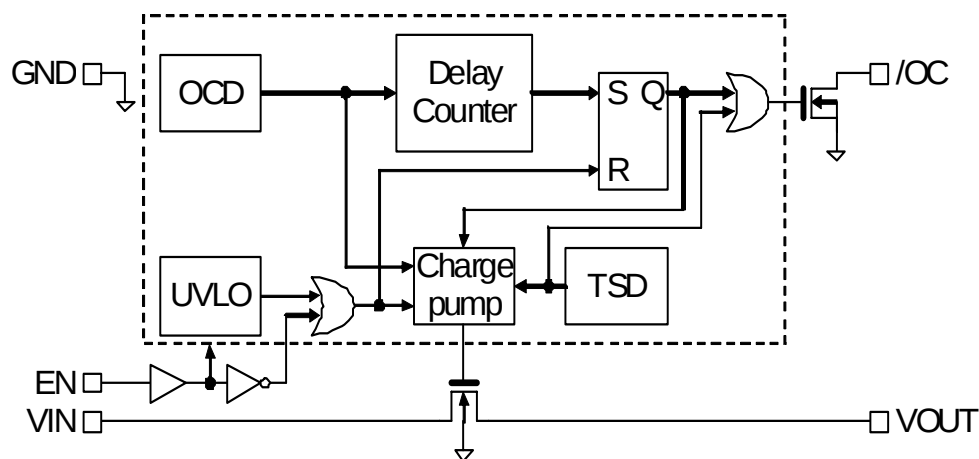


## Lineup

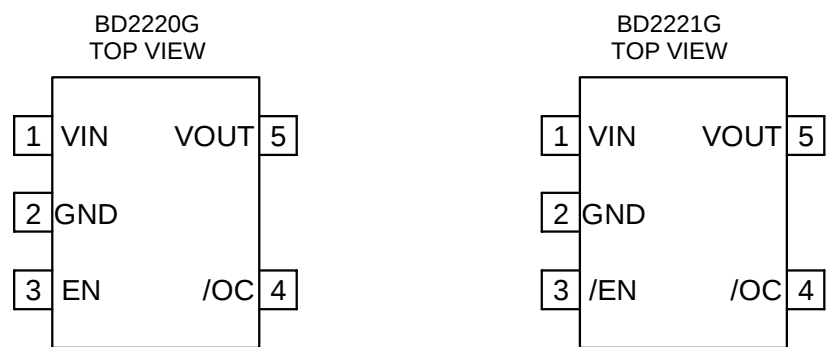
| Over current detection |      |      | Control input logic | Package |              | Orderable Part Number |
|------------------------|------|------|---------------------|---------|--------------|-----------------------|
| Min.                   | Typ. | Max. |                     |         |              |                       |
| 0.5A                   | -    | 1.0A | High                | SSOP5   | Reel of 3000 | BD2220G – LBTR        |
| 0.5A                   | -    | 1.0A | Low                 | SSOP5   | Reel of 3000 | BD2221G – LBTR        |

○Product structure : Silicon monolithic integrated circuit ○This product has no designed protection against radioactive rays

Block Diagram



Pin Configurations



Pin Description

| Pin No. | Symbol  | I/O | Function                                                                                                                                    |
|---------|---------|-----|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | VIN     | -   | Switch input and the supply voltage for the IC.                                                                                             |
| 2       | GND     | -   | Ground.                                                                                                                                     |
| 3       | EN, /EN | I   | Enable input.<br>EN: High level input turns on the switch. (BD2220G)<br>/EN: Low level input turns on the switch. (BD2221G)                 |
| 4       | /OC     | O   | Over-current notification terminal.<br>Low level output during over-current or over-temperature condition.<br>Open-drain fault flag output. |
| 5       | VOUT    | O   | Switch output.                                                                                                                              |

**Absolute Maximum Ratings** (Ta=25°C)

| Parameter             | Symbol   | Ratings           | Unit |
|-----------------------|----------|-------------------|------|
| VIN supply voltage    | VIN      | -0.3 to 6.0       | V    |
| EN(/EN) input voltage | VEN(/EN) | -0.3 to 6.0       | V    |
| /OC voltage           | V/OC     | -0.3 to 6.0       | V    |
| /OC sink current      | I/OC     | 5                 | mA   |
| VOU voltage           | VOUT     | -0.3 to 6.0       | V    |
| Storage temperature   | TSTG     | -55 to 150        | °C   |
| Power dissipation     | Pd       | 675 <sup>*1</sup> | mW   |

\*1 Mounted on 70mm x 70mm x 1.6mm glass epoxy board. Reduce 5.4mW per 1°C above 25°C.

**Recommended Operation Range**

| Parameter             | Symbol | Ratings |      |      | Unit |
|-----------------------|--------|---------|------|------|------|
|                       |        | Min.    | Typ. | Max. |      |
| VIN operating voltage | VIN    | 2.7     | 5.0  | 5.5  | V    |
| Operating temperature | TOPR   | -40     | -    | 85   | °C   |

**Electrical Characteristics** (VIN= 5V, Ta= 25°C, unless otherwise specified.)DC Characteristics

| Parameter                    | Symbol   | Limits |      |      | Unit | Conditions                                               |
|------------------------------|----------|--------|------|------|------|----------------------------------------------------------|
|                              |          | Min.   | Typ. | Max. |      |                                                          |
| Operating current            | IDD      | -      | 110  | 160  | μA   | VEN = 5V (BD2220G)<br>V/EN = 0V (BD2221G)<br>VOUT = open |
| Standby current              | ISTB     | -      | 0.01 | 5    | μA   | VEN = 0V (BD2220G)<br>V/EN = 5V (BD2221G)<br>VOUT = open |
| EN(/EN) input voltage        | VEN(/EN) | 2.0    | -    | -    | V    | High input                                               |
|                              | VEN(/EN) | -      | -    | 0.8  | V    | Low input                                                |
| EN(/EN) input leakage        | IEN(/EN) | -1.0   | 0.01 | 1.0  | μA   | VEN(/EN) = 0V or 5V                                      |
| On-resistance                | RON      | -      | 160  | 210  | mΩ   | IOUT = 50mA                                              |
| Switch leak current          | ILSW     | -      | -    | 1.0  | μA   | VEN(/EN) = 0V, VOUT = 0V                                 |
| Reverse leak current         | IREV     | -      | -    | 1.0  | μA   | VOUT = 5.5V, VIN = 0V                                    |
| Over-current threshold       | ITH      | 0.5    | -    | 1.0  | A    |                                                          |
| Short circuit output current | ISC      | 0.35   | -    | -    | A    | VOUT = 0V, RMS                                           |
| /OC output low voltage       | V/OC     | -      | -    | 0.4  | V    | I/OC = 0.5mA                                             |
| UVLO threshold               | VTUVH    | 2.1    | 2.3  | 2.5  | V    | VIN increasing                                           |
|                              | VTUVL    | 2.0    | 2.2  | 2.4  | V    | VIN decreasing                                           |

AC Characteristics

| Parameter            | Symbol | Limits |      |      | Unit | Conditions |
|----------------------|--------|--------|------|------|------|------------|
|                      |        | Min.   | Typ. | Max. |      |            |
| Output rise time     | TON1   | -      | 1    | 6    | ms   | RL = 20Ω   |
| Output turn-on time  | TON2   | -      | 1.5  | 10   | ms   | RL = 20Ω   |
| Output fall time     | TOFF1  | -      | 1    | 20   | μs   | RL = 20Ω   |
| Output turn-off time | TOFF2  | -      | 3    | 40   | μs   | RL = 20Ω   |
| /OC delay time       | T/OC   | 10     | 15   | 20   | ms   |            |

Measurement Circuit

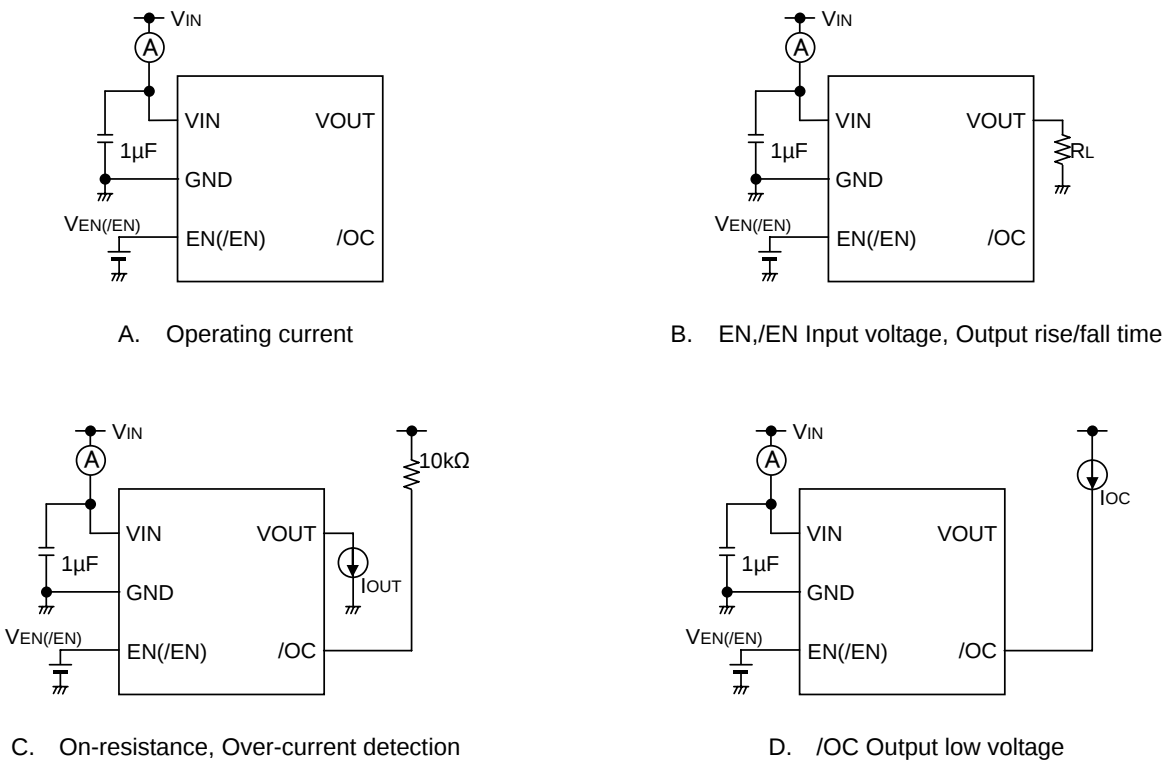


Figure 1. Measurement circuit

Timing Diagram

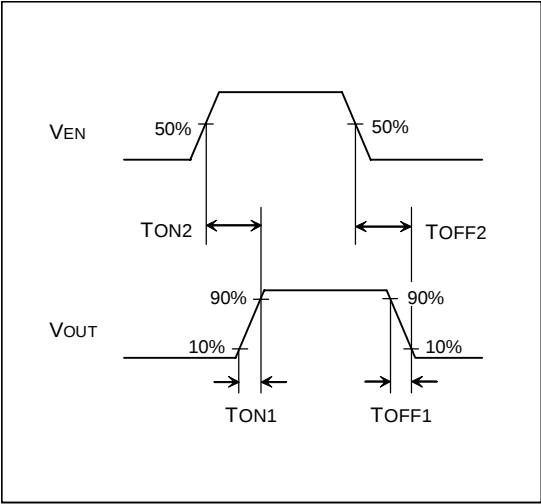


Figure 2. Output rise/fall time (BD2220G)

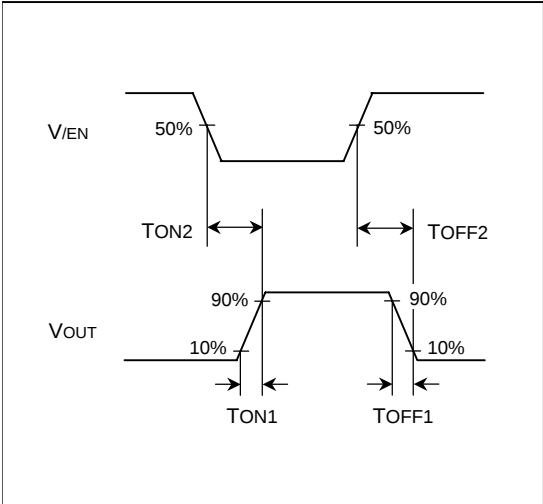


Figure 3. Output rise/fall time (BD2221G)

Typical Performance Curves

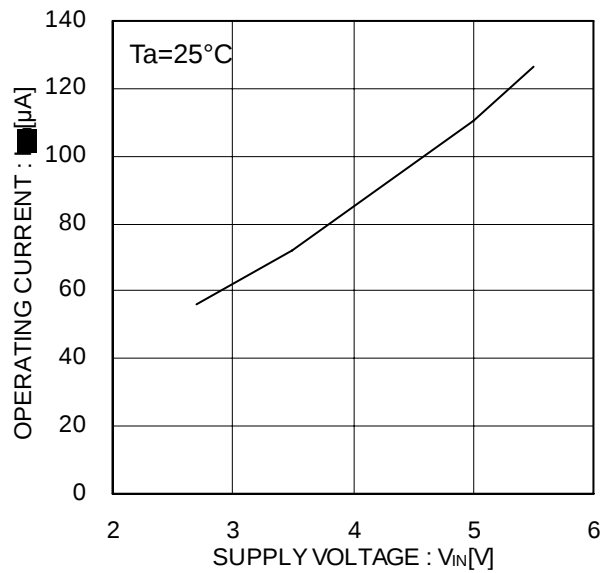


Figure 4. Operating current  
EN,/EN enable

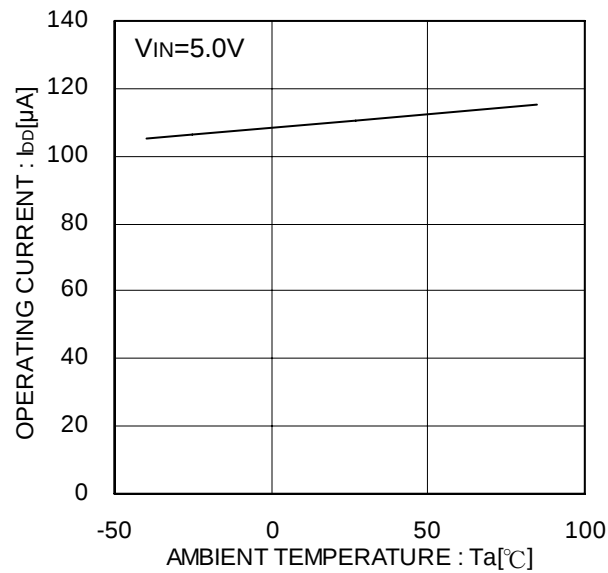


Figure 5. Operating current  
EN,/EN enable

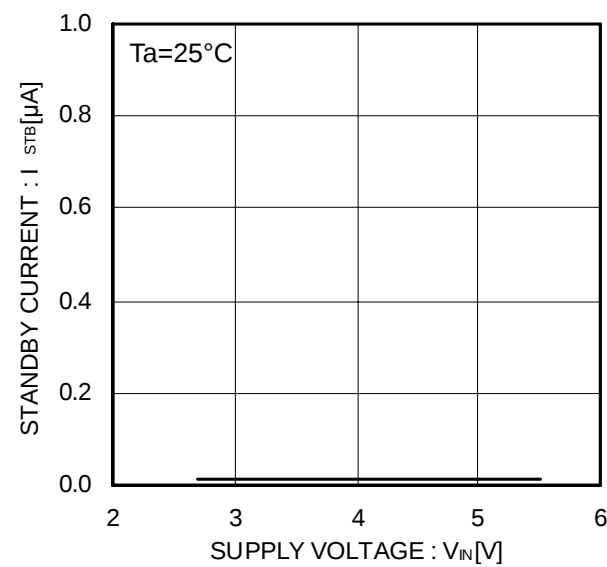


Figure 6. Standby current  
EN,/EN disable

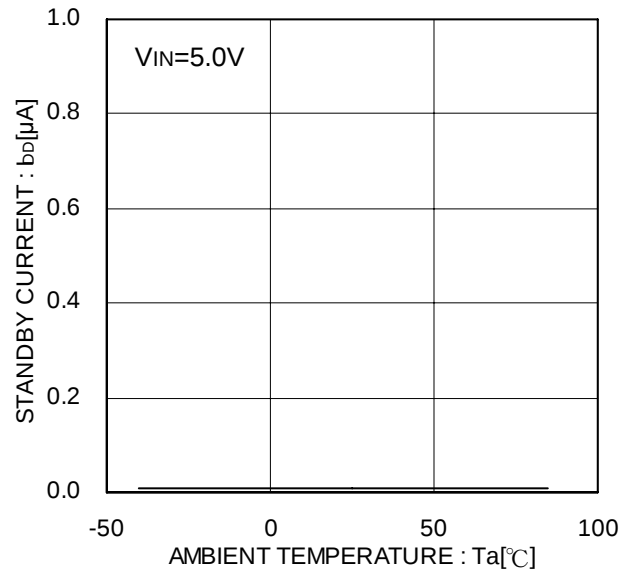


Figure 7. Standby current  
EN,/EN disable

Typical Performance Curves - continued

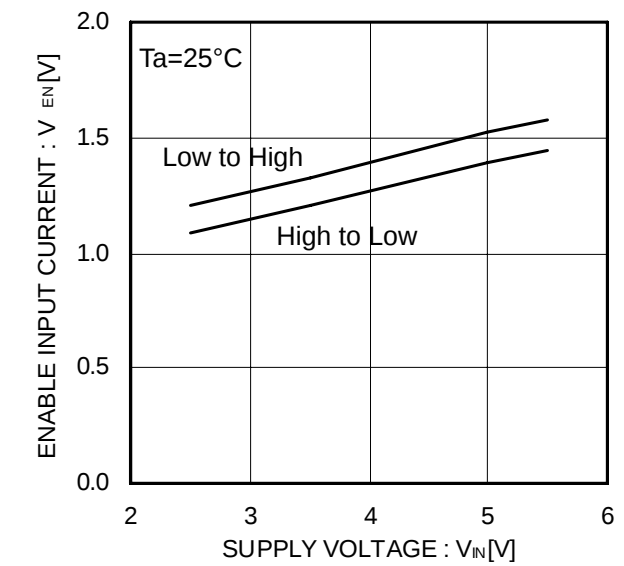


Figure 8. EN, /EN input voltage

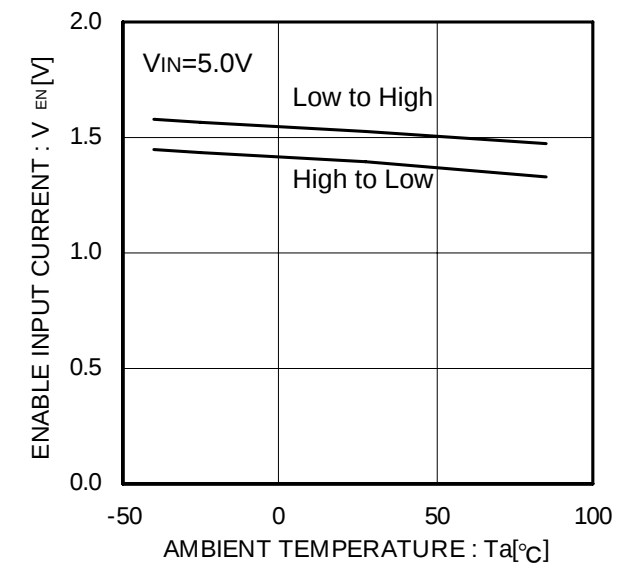


Figure 9. EN, /EN input voltage

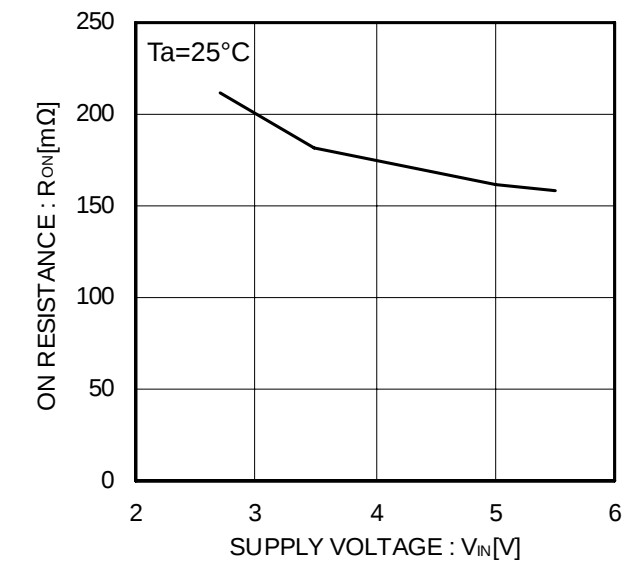


Figure 10. On-resistance

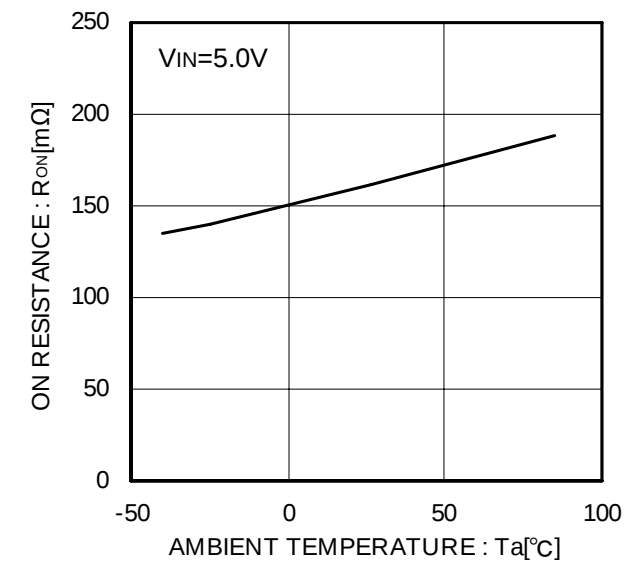


Figure 11. On-resistance

Typical Performance Curves - continued

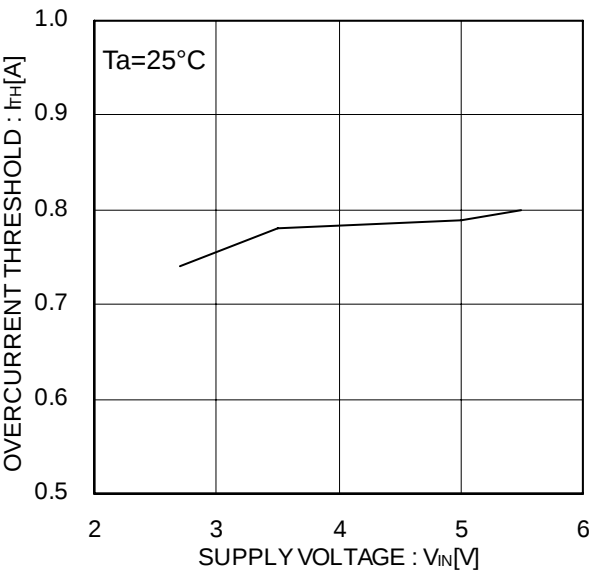


Figure 12. Over-current threshold

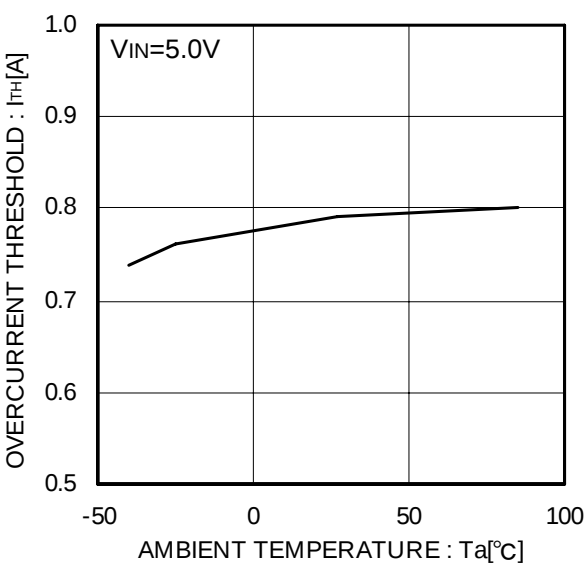


Figure 13. Over-current threshold

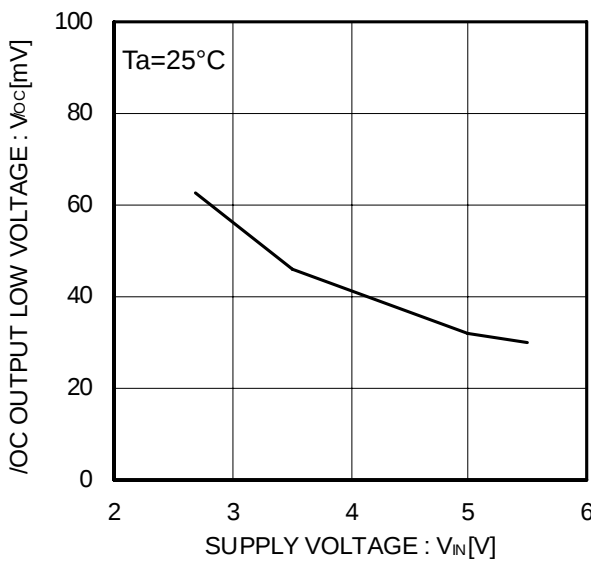


Figure 14. /OC output low voltage

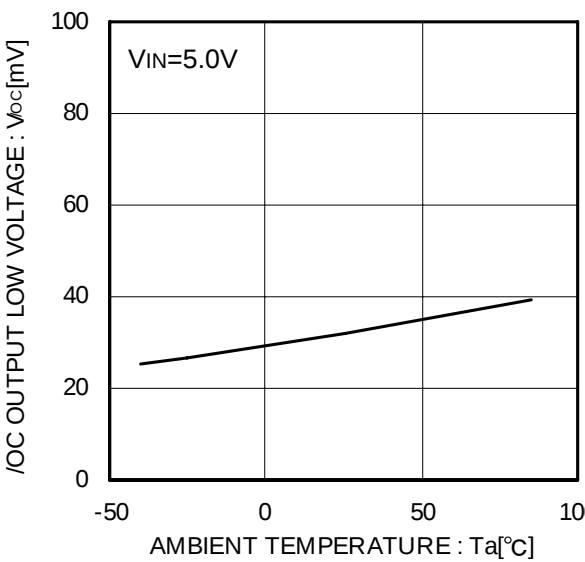


Figure 15. /OC output low voltage

Typical Performance Curves - continued

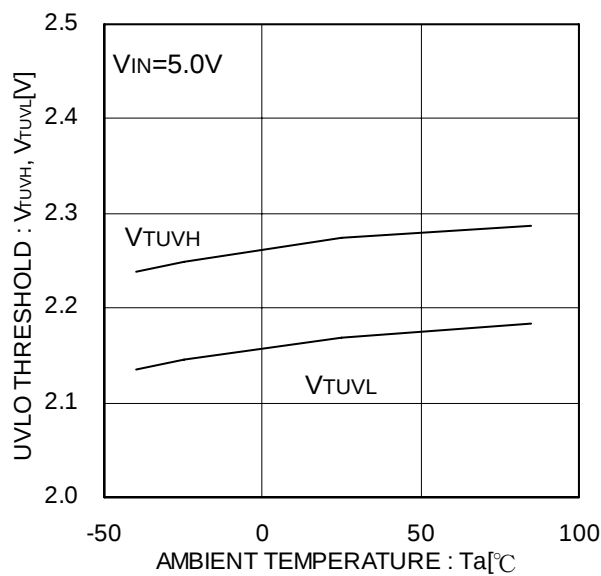


Figure 16. UVLO threshold

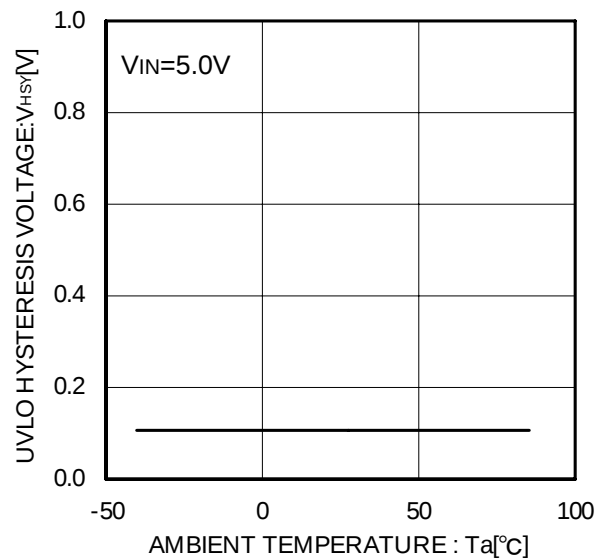


Figure 17. UVLO hysteresis voltage

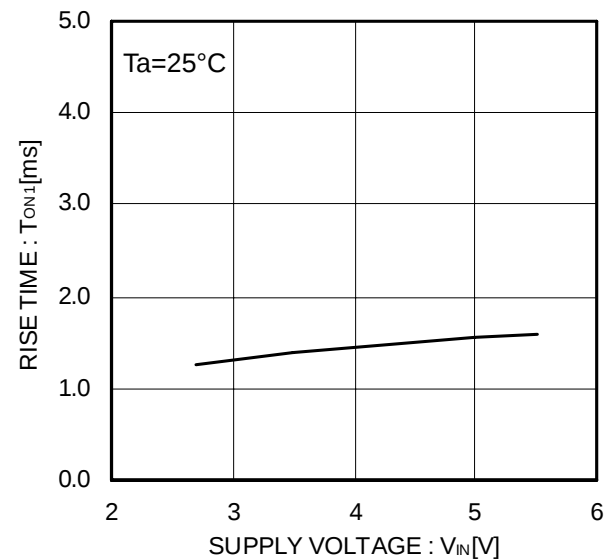


Figure 18. Output rise time

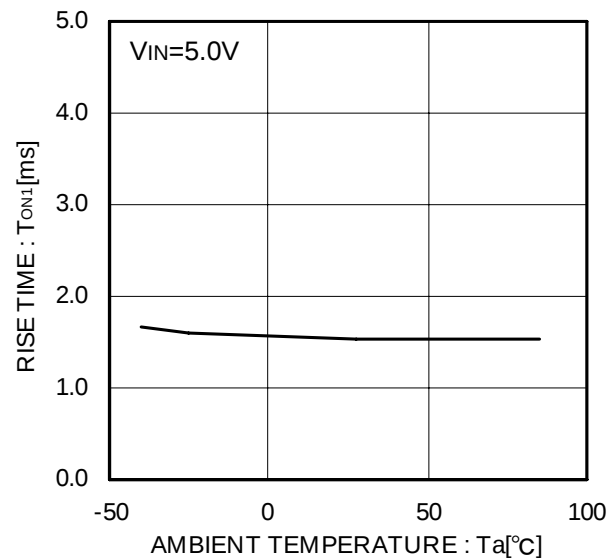


Figure 19. Output rise time

Typical Performance Curves - continued

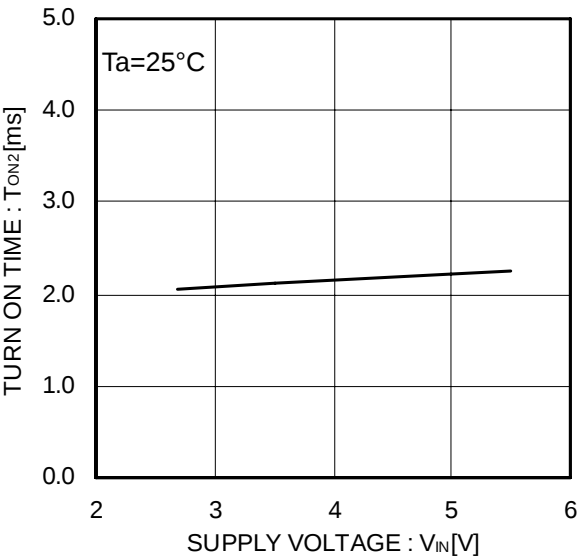


Figure 20. Output turn-on time

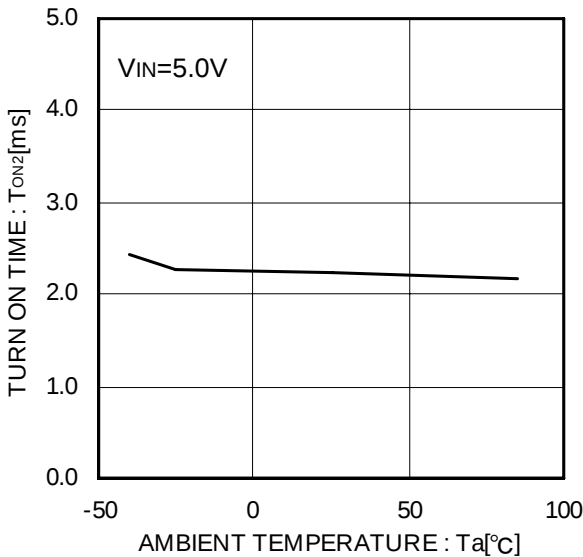


Figure 21. Output turn-on time

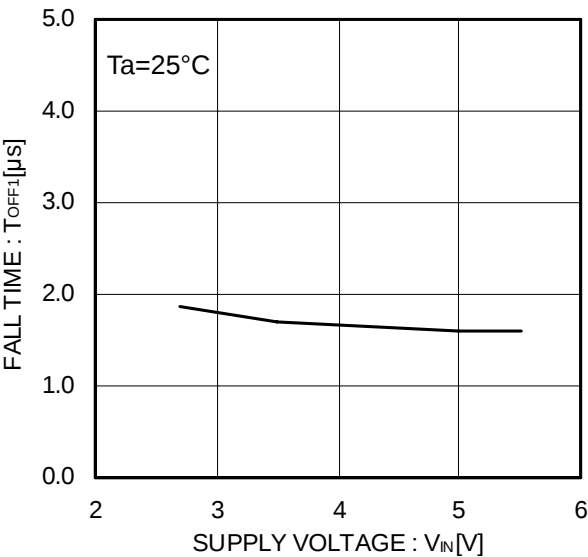


Figure 22. Output fall time

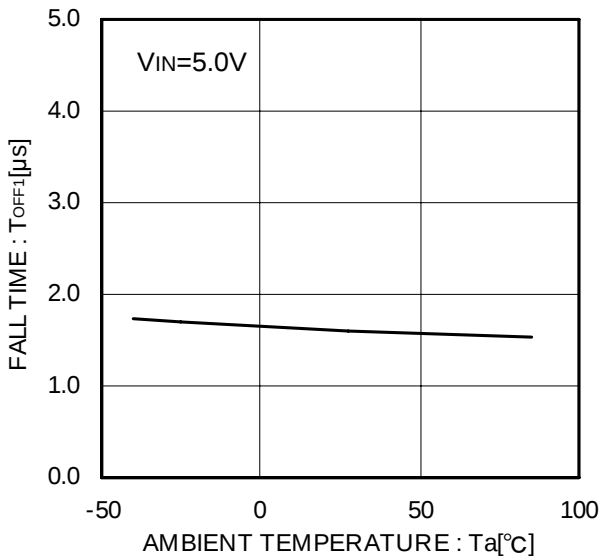


Figure 23. Output fall time

## Typical Performance Curves - continued

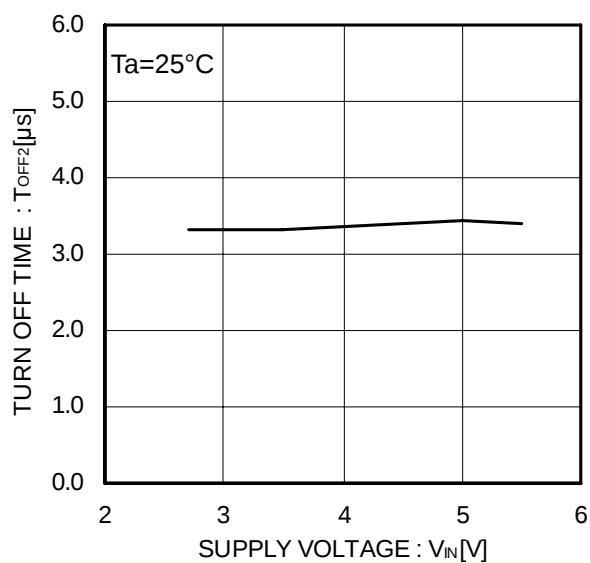


Figure 24. Output turn-off time

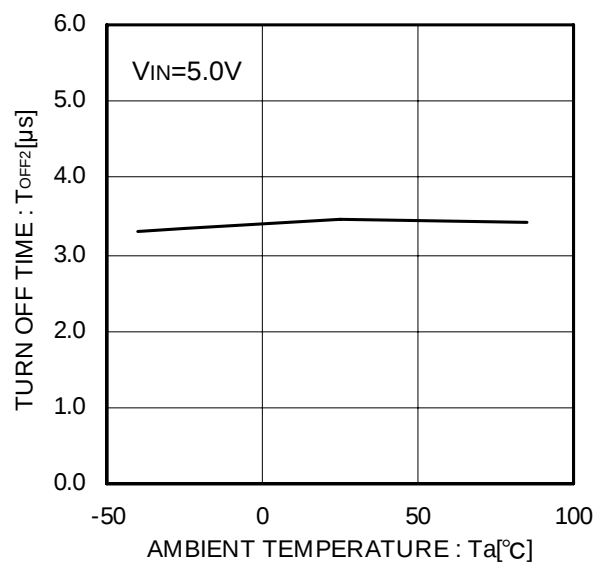


Figure 25. Output turn-off time

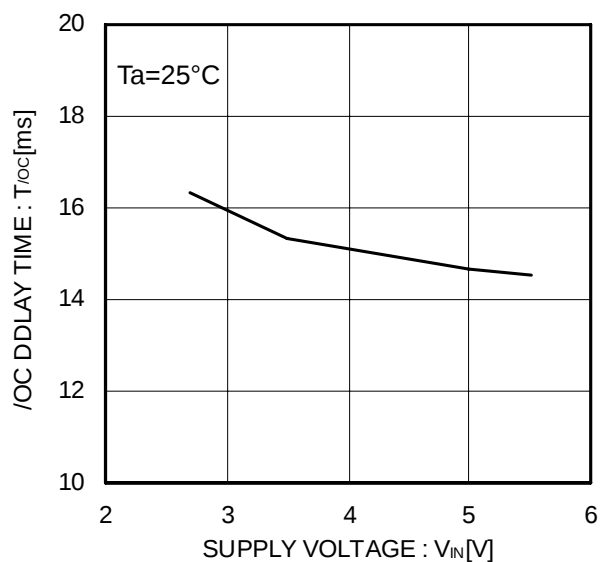


Figure 26. /OC delay time

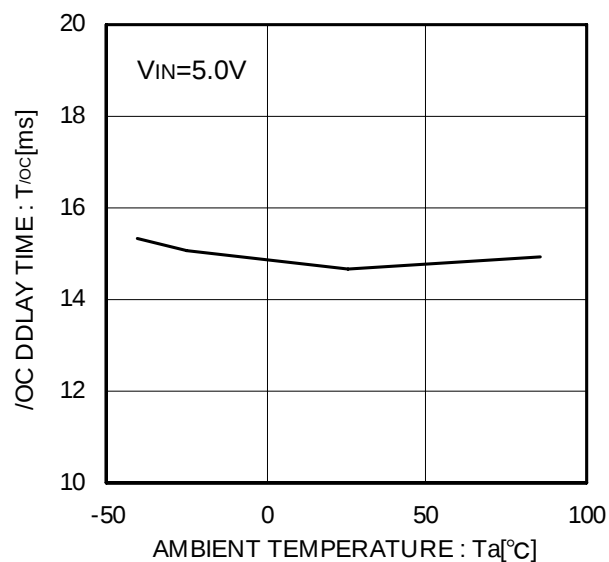


Figure 27. /OC delay time

Typical Waveforms

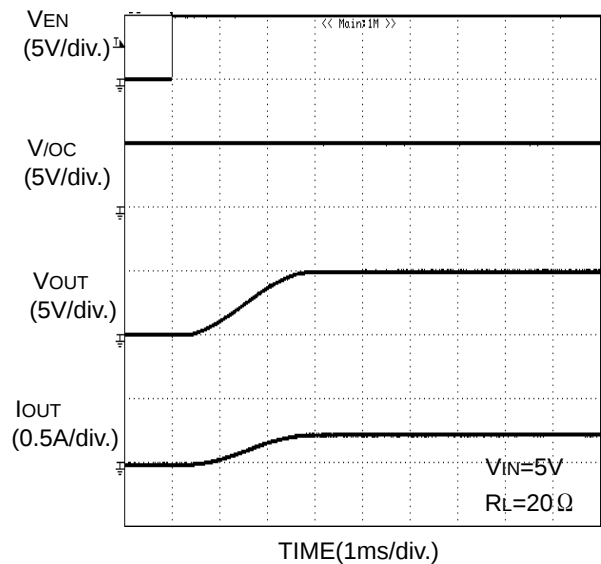


Figure 28. Output rise characteristic

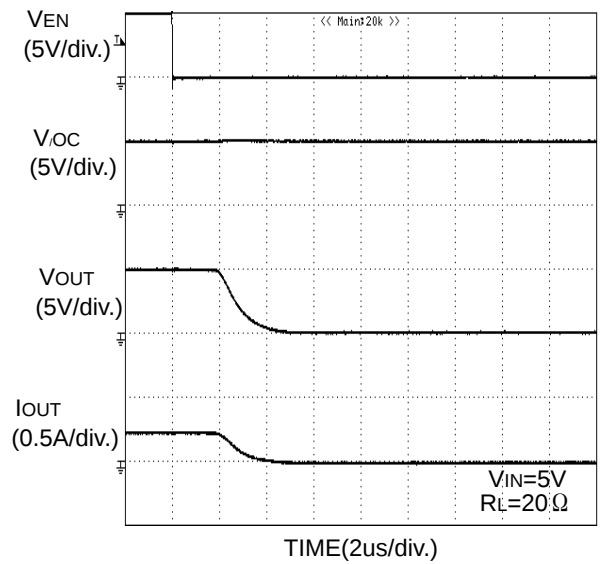


Figure 29. Output fall characteristic

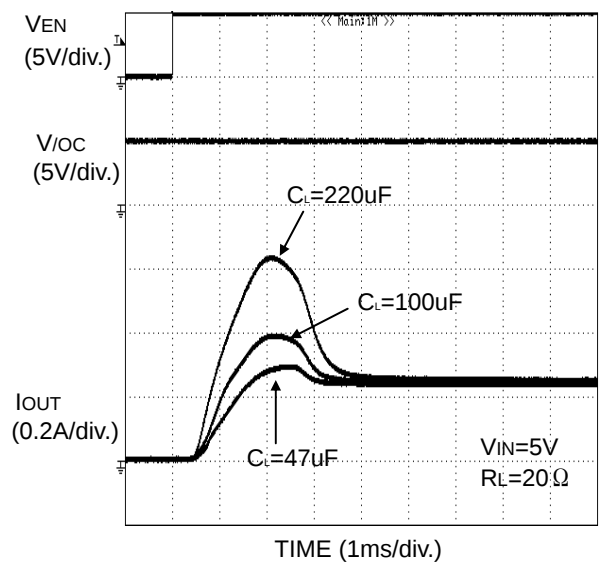


Figure 30. Inrush current response

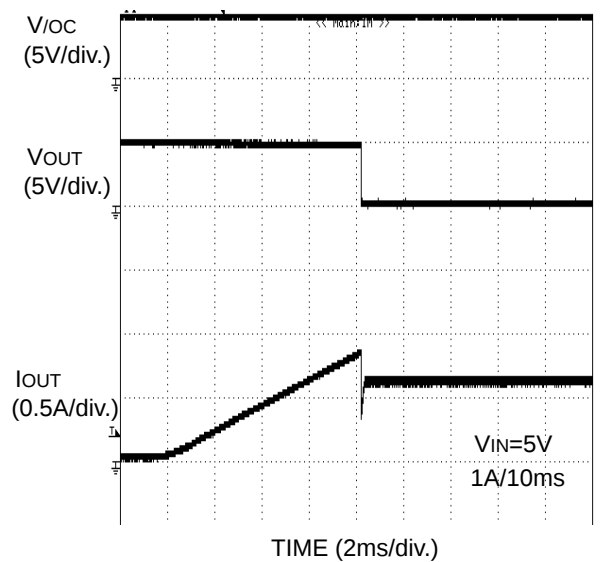


Figure 31. Over-current response  
ramped load

Typical Waveforms - continued

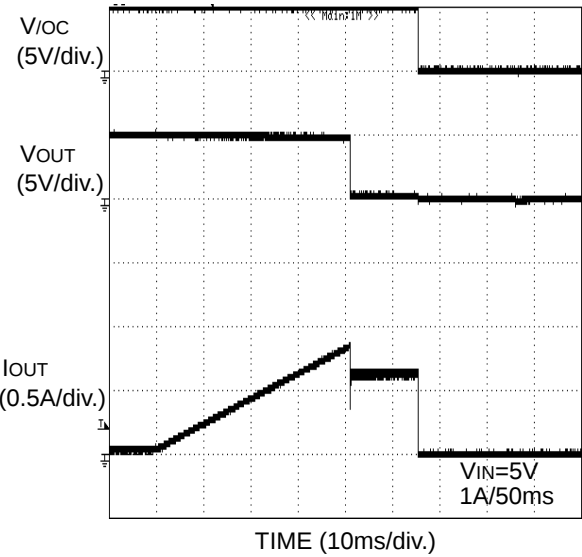


Figure 32. Over-current response  
ramped load

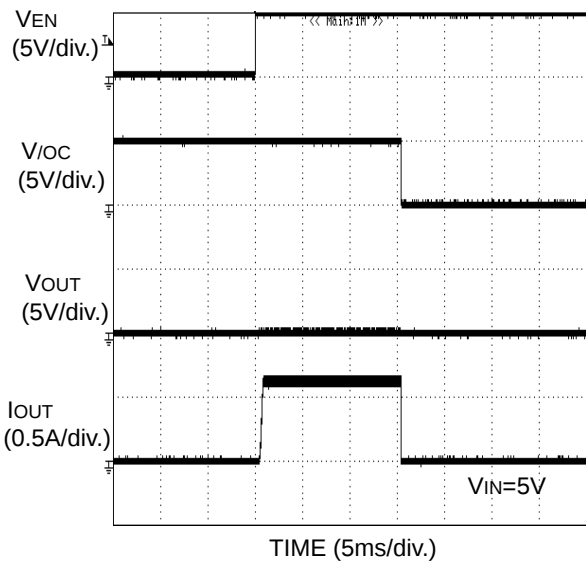


Figure 33. Over-current response  
enable to short-circuit

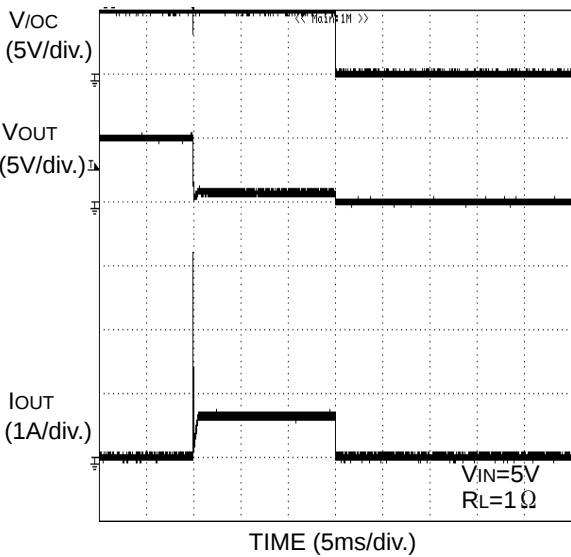


Figure 34. Over-current response  
1Ω load connected at EN

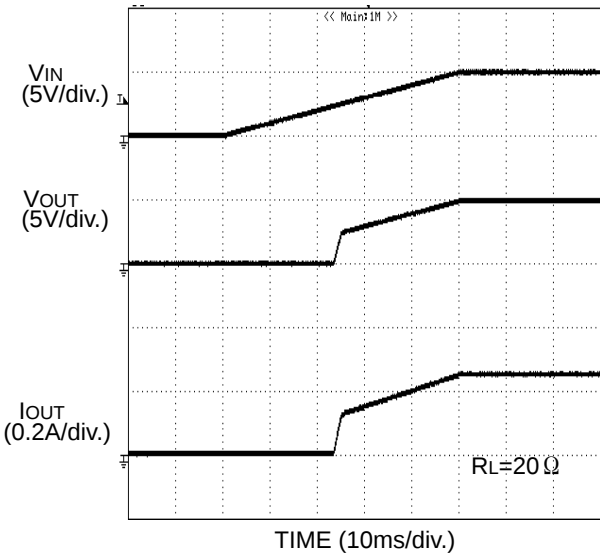


Figure 35. UVLO response  
an increasing VIN

## Typical Wave Forms - continued

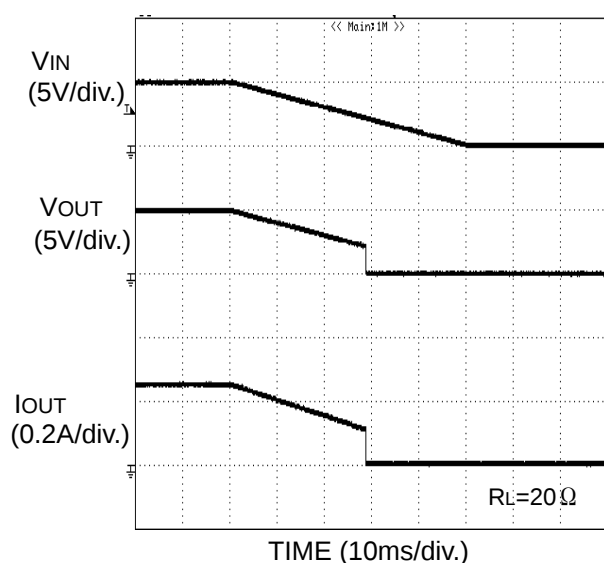
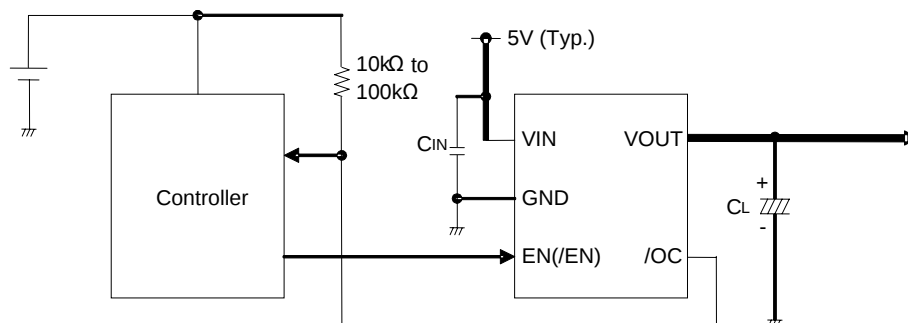


Figure 36. UVLO response in a decreasing  $V_{IN}$

## Typical Application Circuit



## Application Information

When excessive current flows due to output short-circuit or so, ringing occurs because of inductance between power source line to IC, and may cause bad influences on IC operations. In order to avoid this case, connect a bypass capacitor across IN terminal and GND terminal of IC. 1μF or higher is recommended.

Pull up /OC output by a resistance value of 10kΩ to 100kΩ.

Set up value which satisfies the application of either CL.

This application circuit does not guarantee its operation.

When using the circuit with changes to the external circuit constants, make sure to leave an adequate margin for external components including AC/DC characteristics as well as dispersion of the IC.

## Functional Description

### 1. Switch Operation

VIN terminal and VOUT terminal are connected to the drain and the source of switch MOSFET respectively. And the VIN terminal is used also as power source input to internal control circuit.

When the switch is turned ON from EN,/EN control input, the switch is bidirectional. VIN terminal and VOUT terminal are connected by a 160mΩ (Typical) switch. Therefore, when the potential of VOUT terminal is higher than that of VIN terminal, current flows from VOUT terminal to VIN terminal. On the other hand, when the switch is turned OFF, it is possible to prevent current from flowing reversely from VOUT to VIN since a parasitic diode between the drain and the source of switch MOSFET is not present.

### 2. Thermal Shutdown Circuit (TSD)

If over current would continue, the temperature of the IC would increase drastically. If the junction temperature were beyond 170°C (typ.) in the condition of over current detection, thermal shutdown circuit operates and makes power switch turn off and outputs fault flag (/OC). Then, when the junction temperature decreases lower than 150°C (typ.), power switch is turned on and fault flag (/OC) is cancelled. Unless the increasing of the chip's temperature is removed or the output of power switch is turned off, this operation repeats.

Note: The thermal shutdown circuit operates when the switch is on (EN,/EN signal is active).

### 3. Over Current Detection (OCD)

The Over Current Detection circuit limits current (Isc) and outputs a fault flag (/OC) when current flowing in each MOSFET exceeds a specified value. There are three types of response against over current. The over current detection circuit works when the switch is on (EN,/EN signal is active).

#### 3-1. When the switch is turned ON while the output is in shortcircuit status

When the switch is turned on while the output is in short-circuit status, the switch goes into current limit status immediately.

#### 3-2. When the output shortcircuits while the switch is on

When the output short-circuits or high-current load is connected while the switch is on, very large current flows until the over current limit circuit reacts. When the current detection and limit circuit works, current limitation is carried out.

#### 3-3. When the output current increases gradually

When the output current increases gradually, current limitation does not work until the output current exceeds the over current detection value. When it exceeds the detection value, current limitation is carried out.

### 4. Under Voltage Lockout (UVLO)

UVLO circuit prevents the switch from turning on until the VIN exceeds 2.3V(Typical). If the VIN drops below 2.2V(Typical) while the switch is still ON, then UVLO will shut off the power switch. UVLO has a hysteresis of 100mV(Typical).

Note: Under voltage lockout circuit works when the switch is on (EN,/EN signal is active).

### 5. Fault Flag (/OC) Output

Fault flag output is an NMOS open drain output. At detection of over current and/or thermal shutdown, the output level is low.

Over current detection has delay filter. This delay filter prevents instantaneous current detection such as inrush current at switch on, hot plug from being informed to outside.

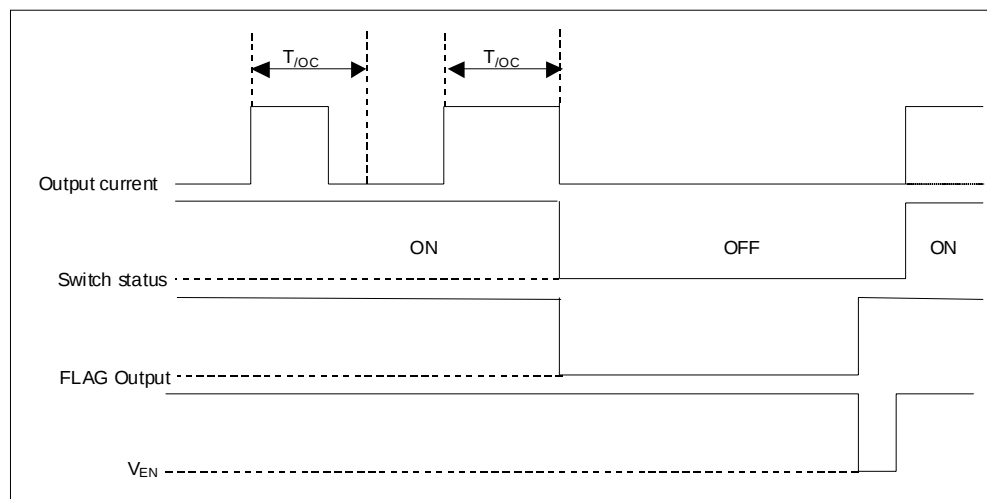


Figure 37. Over-current shutdown operation (reset at toggle of EN) (BD2220G)

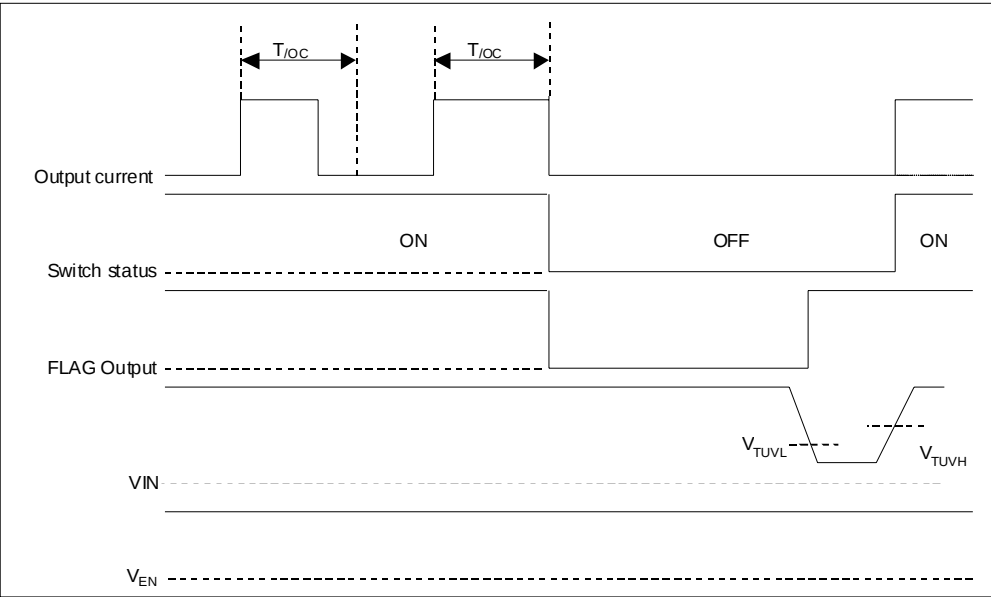


Figure 38. Over-current shutdown operation (reset at UVLO operation) (BD2220G)

Power Dissipation  
(SSOP5 package)

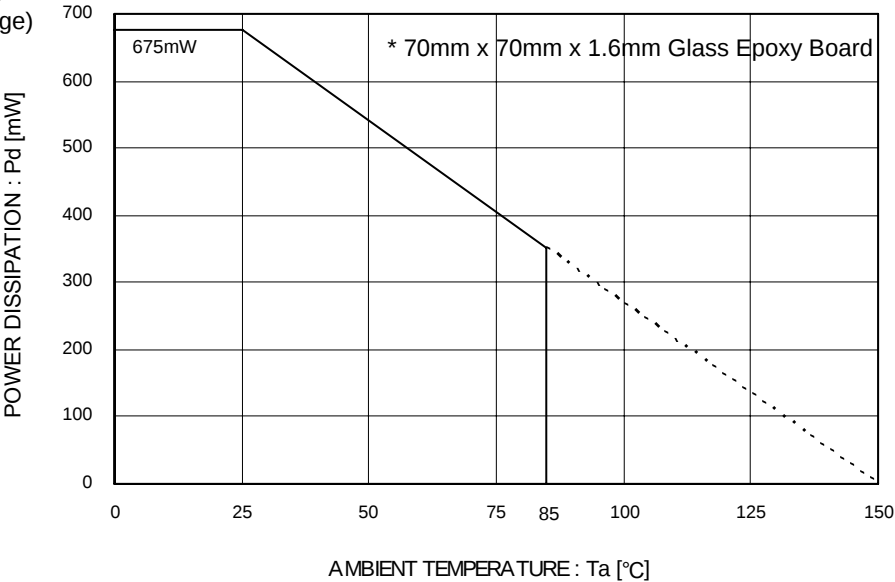


Figure 39. Power dissipation curve (Pd-Ta curve)

I/O Equivalence Circuit

| Symbol      | Pin No. | Equivalence circuit | Symbol | Pin No. | Equivalence circuit |
|-------------|---------|---------------------|--------|---------|---------------------|
| EN<br>(/EN) | 3       |                     | /OC    | 4       |                     |
| VOUT        | 5       |                     | -      | -       | -                   |

## Operational Notes

- (1) Absolute maximum ratings  
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. 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.
- (2) Recommended operating conditions  
These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.
- (3) 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 terminals
- (4) Power supply lines  
Design the PCB layout pattern to provide low impedance ground and supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. 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.
- (5) Ground voltage  
The voltage of the ground pin must be the lowest voltage of all pins of the IC at all operating conditions. Ensure that no pins are at a voltage below the ground pin at any time, even during transient condition.
- (6) Short between pins and mounting errors  
Be careful when mounting the IC on printed circuit boards. The IC may be damaged if it is mounted in a wrong orientation or if pins are shorted together. Short circuit may be caused by conductive particles caught between the pins.
- (7) Operation under strong electromagnetic field  
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.
- (8) 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.
- (9) Regarding input pins 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  $GND > \text{Pin A}$  and  $GND > \text{Pin B}$ , the P-N junction operates as a parasitic diode.

When  $GND > \text{Pin B}$ , 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.

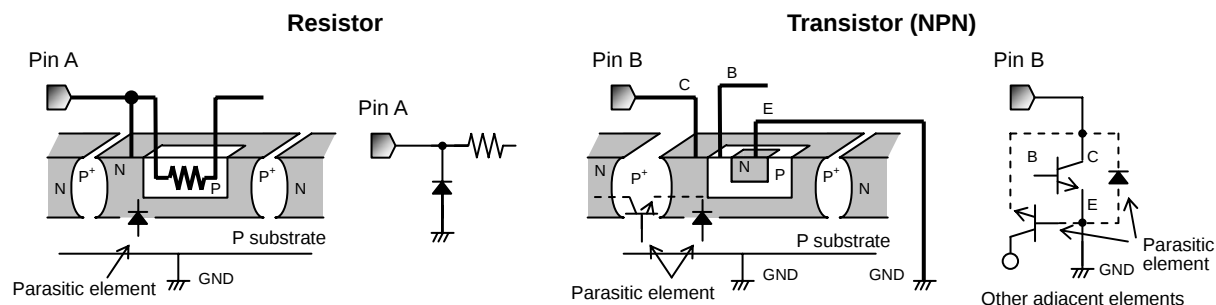


Figure 40. Example of monolithic IC structure

## (10) GND wiring pattern

When using both small-signal and large-current GND 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 GND traces of external components do not cause variations on the GND voltage. The power supply and ground lines must be as short and thick as possible to reduce line impedance.

## (11) External capacitor

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

## (12) Thermal shutdown circuit (TSD)

The IC incorporates a built-in thermal shutdown circuit, which is designed to turn off the IC when the internal temperature of the IC reaches a specified value. Do not continue to operate the IC after this function is activated. Do not use the IC in conditions where this function will always be activated.

## (13) Thermal consideration

Use a thermal design that allows for a sufficient margin by taking into account the permissible power dissipation ( $P_d$ ) in actual operating conditions. Consider  $P_c$  that does not exceed  $P_d$  in actual operating conditions ( $P_c \geq P_d$ ).

Package Power dissipation :  $P_d (W) = (T_{jmax} - T_a) / \theta_{ja}$

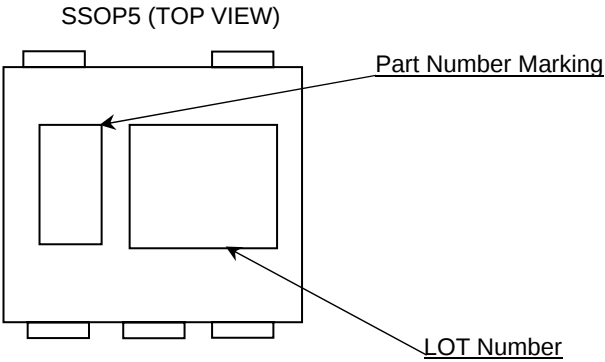
Power dissipation :  $P_c (W) = (V_{cc} - V_o) \times I_o + V_{cc} \times I_b$

$\left( \begin{array}{l} T_{jmax} : \text{Maximum junction temperature} = 150^\circ\text{C}, T_a : \text{Peripheral temperature} [^\circ\text{C}], \\ \theta_{ja} : \text{Thermal resistance of package-ambience} [^\circ\text{C/W}], P_d : \text{Package Power dissipation [W]}, \\ P_c : \text{Power dissipation [W]}, V_{cc} : \text{Input Voltage}, V_o : \text{Output Voltage}, I_o : \text{Load}, I_b : \text{Bias Current} \end{array} \right)$

Ordering Information

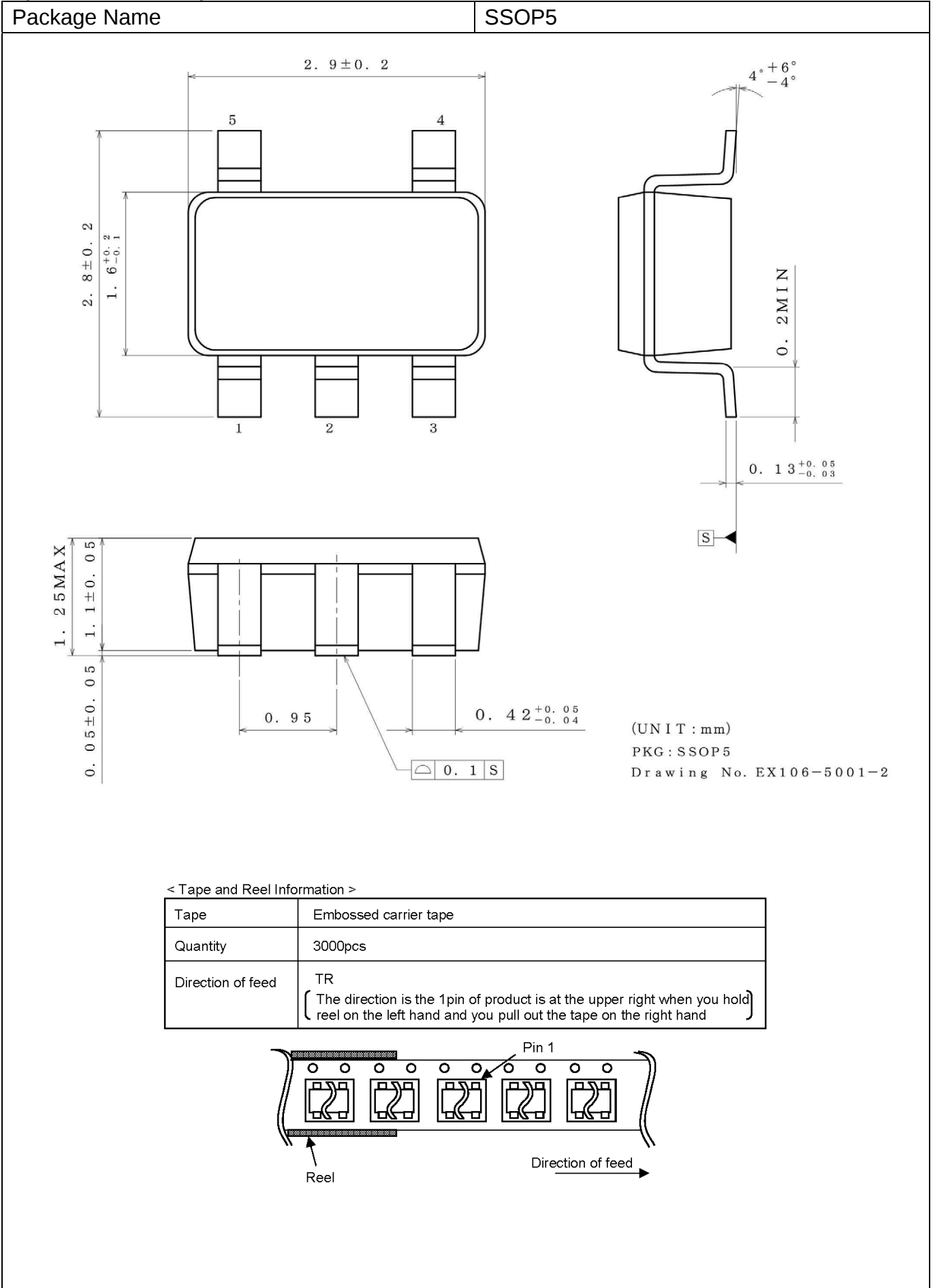
|               |  |  |  |  |  |                      |                                                                                                                      |  |  |
|---------------|--|--|--|--|--|----------------------|----------------------------------------------------------------------------------------------------------------------|--|--|
| B D 2 2 2 x G |  |  |  |  |  | -                    | L B T R                                                                                                              |  |  |
| Part Number   |  |  |  |  |  | Package<br>G : SSOP5 | Product class<br>LB for Industrial applications<br>Packaging and forming specification<br>TR: Embossed tape and reel |  |  |

Marking Diagram



| Part Number | Part Number Marking |
|-------------|---------------------|
| BD2220G     | DX                  |
| BD2221G     | DY                  |

## Physical Dimension Tape and Reel Information



**Revision History**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                              |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13.Mar.2013 | 001      | New Release                                                                                                                                                                                                                                                                          |
| 21.Feb.2014 | 002      | Delete sentence "and log life cycle" in General Description and Futures (page 1).<br>Change "Industrial Applications" to "Industrial Equipment" in Applications (page 1).<br>Applied new style ("title", "Ordering Information" and "Physical Dimension Tape and Reel Information"). |

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(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

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  - [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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 (even if you use no-clean type fluxes, cleaning residue of flux is recommended); 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.
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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; if flow soldering method is preferred, 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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## Precaution for Electrostatic

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## 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<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [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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## Precaution for Disposition

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