Datasheet

High Side Switch ICs 1ch Small Package

BD2232G BD2233G

●General Description

BD2232G and BD2233G are low on-resistance N-channel MOSFET high-side power switches, optimized for Universal Serial Bus (USB) applications. BD2232G and BD2233G are equipped with the function of over-current detection, thermal shutdown, under-voltage lockout and soft-start.

●Features

- Output Discharge Function
- Over-Current Detection
- Thermal Shutdown
- Open-Drain Fault Flag Output
- Under-Voltage Lockout
- Soft-Start Circuit
- Control Input Logic
    - Active-High: BD2232G
    - Active-Low: BD2233G

●Applications

USB hub in consumer appliances, PC, PC peripheral equipment, and so forth

●Key Specifications

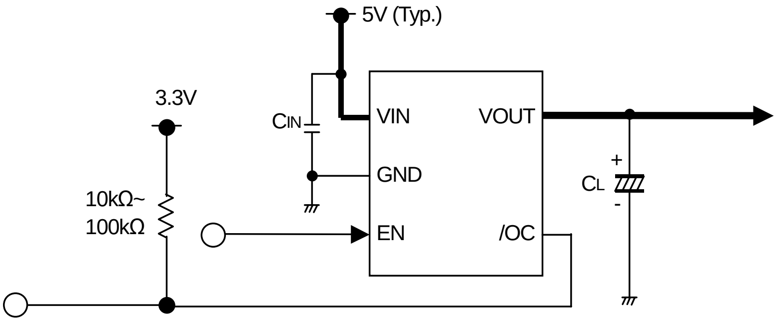
Input voltage range:	2.7V to 5.5V
ON resistance :	100mΩ(Typ.)
Over current threshold:	1.15A min., 1.4A max.
Standby current:	0.01µA (Typ.)
Operating temperature range:	-40℃ to +85℃

●Package

	W(Typ.) D(Typ.) H (Max.)
SSOP5	2.90mm x 2.80mm x 1.25mm

SSOP5

●Typical Application Circuit

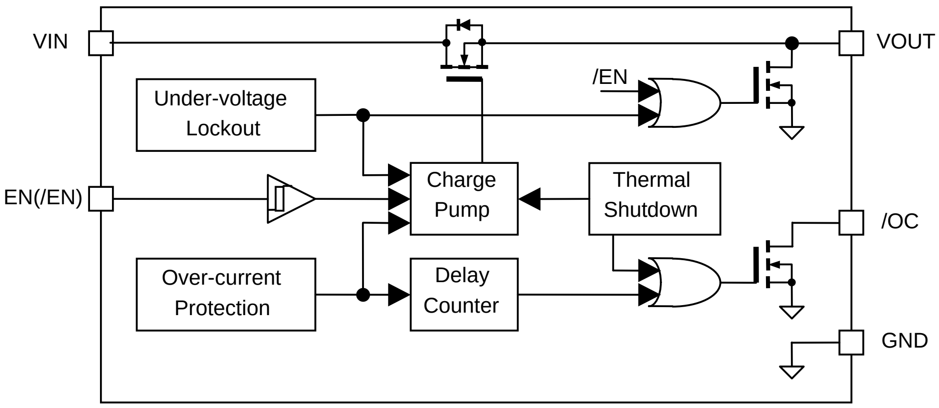


●Lineup

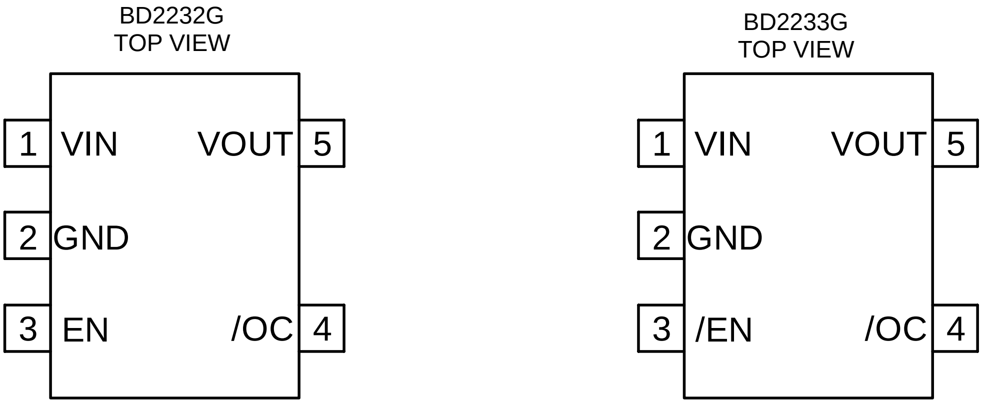
Over current detection			Control input logic	Package		Orderable Part Number
Min.	Typ.	Max.				
1150mA	1275mA	1400mA	High	SSOP5	Reel of 3000	BD2232G – TR
1150mA	1275mA	1400mA	Low	SSOP5	Reel of 3000	BD2233G – TR

○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. EN: High level input turns on the switch. (BD2232G) /EN: Low level input turns on the switch. (BD2233G)
4	/OC	O	Over-current detection terminal. Low level output during over-current or over-temperature condition. Open-drain fault flag output.
5	VOUT	O	Switch output.

●Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Ratings	Unit
VIN supply voltage	V_{IN}	-0.3 to 6.0	V
EN(/EN) input voltage	$V_{EN(/EN)}$	-0.3 to 6.0	V
/OC voltage	$V_{/OC}$	-0.3 to 6.0	V
/OC sink current	$I_{/OC}$	5	mA
VOUT voltage	V_{OUT}	-0.3 to V_{IN} + 0.3	V
Storage temperature	T_{STG}	-55 to 150	℃
Power dissipation	Pd	675 *1	mW

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

●Recommended Operating Range

Parameter	Symbol	Ratings			Unit
		Min.	Typ.	Max.	
VIN operating voltage	V_{IN}	2.7	5.0	5.5	V
Operating temperature	T_{OPR}	-40	-	85	℃

●Electrical Characteristics (V_{IN}= 5V, Ta= 25℃, unless otherwise specified.)

DC Characteristics

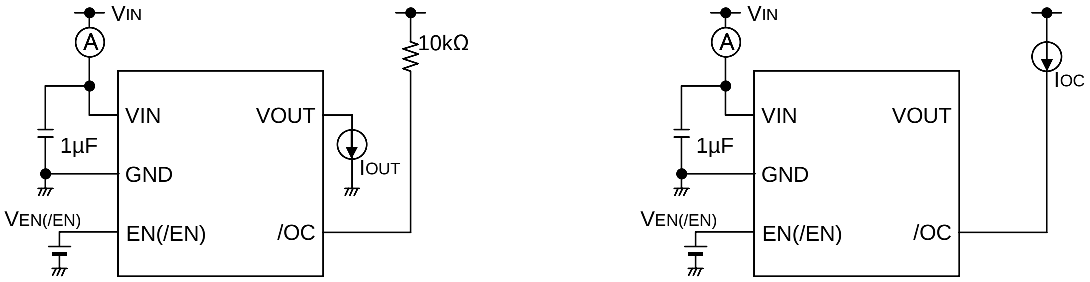
Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
Operating current	I_{DD}	-	110	160	µA	V_{EN} = 5V (BD2232G) $V_{/EN}$ = 0V (BD2233G) V_{OUT} = open
Standby current	I_{STB}	-	0.01	5	µA	V_{EN} = 0V (BD2232G) $V_{/EN}$ = 5V (BD2233G) V_{OUT} = open
EN(/EN) input voltage	$V_{ENH(/ENH)}$	2.0	-	-	V	High input
	$V_{ENL(/ENL)}$	-	-	0.8	V	Low input
EN(/EN) input leakage	$I_{EN(/EN)}$	-1	0.01	1	µA	$V_{EN(/EN)}$ = 0V or 5V
On-resistance	R_{ON}	-	100	145	mΩ	I_{OUT}= 500mA
Over-current threshold	I_{TH}	1150	1275	1400	mA	
Short circuit output current	I_{SC}	500	-	-	mA	V_{OUT}= 0V, RMS
Output discharge resistance	R_{DISC}	30	60	120	Ω	I_{DISC}= 1mA
/OC output low voltage	$V_{/OC}$	-	-	0.4	V	$I_{/OC}$= 0.5mA
UVLO threshold	V_{TUVH}	2.1	2.3	2.5	V	V_{IN} increasing
	V_{TUVL}	2.0	2.2	2.4	V	V_{IN} decreasing

AC Characteristics

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
Output rise time	T_{ON1}	-	1	6	ms	R_L= 100Ω
Output turn-on time	T_{ON2}	-	1.5	10	ms	R_L= 100Ω
Output fall time	T_{OFF1}	-	1	20	µs	R_L= 100Ω
Output turn-off time	T_{OFF2}	-	3	40	µs	R_L= 100Ω
/OC delay time	$T_{/OC}$	10	15	20	ms	

●Measurement Circuit

A. Operating current B. EN,/EN Input voltage, Output rise/fall time



C. On-resistance, Over-current detection D. /OC Output low voltage

Figure 1. Measurement circuit

●Timing Diagram

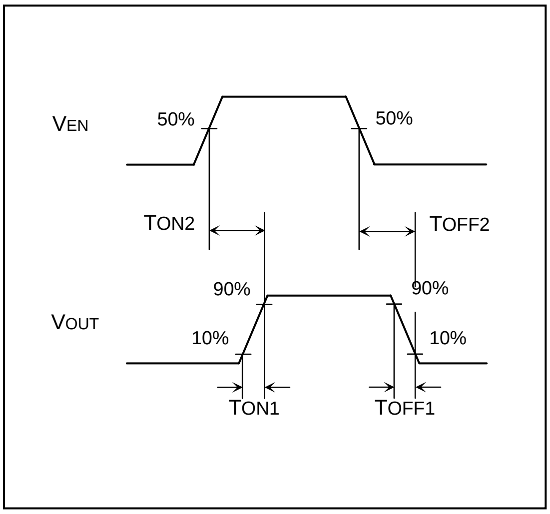


Figure 2. Output rise/fall time
(BD2232G)

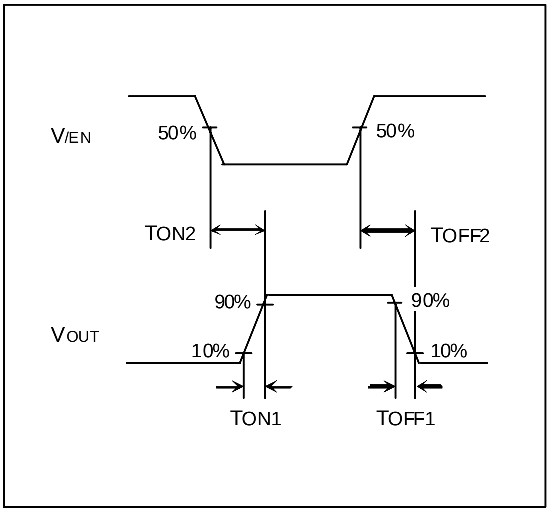


Figure 3. Output rise/fall time
(BD2233G)

●**Typical Performance Curves**

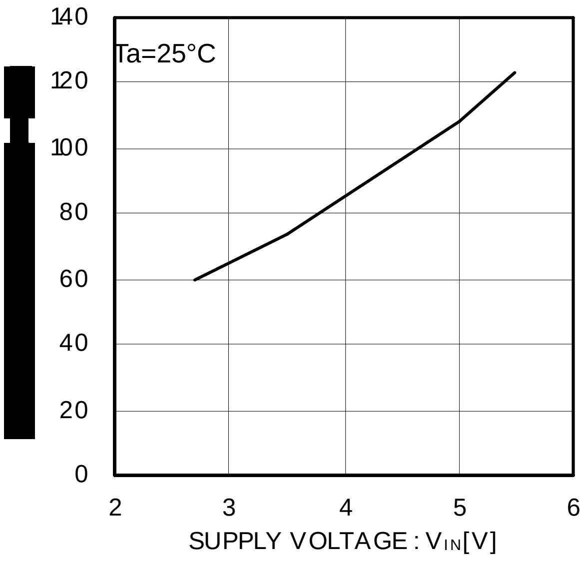


Figure 4. Operating current
EN,/EN enable

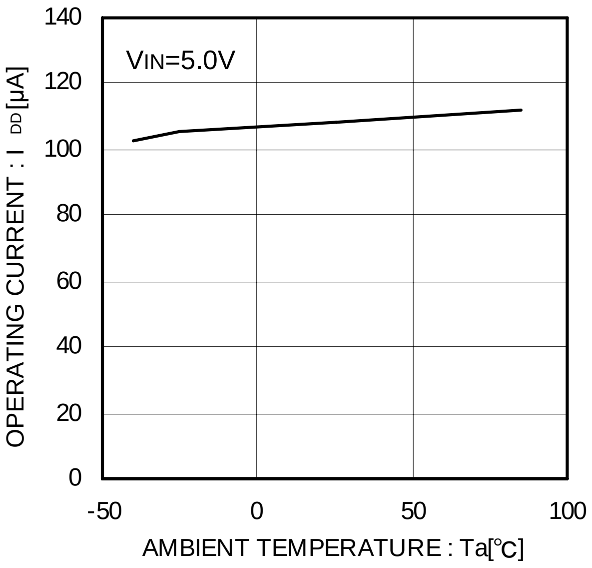


Figure 5. Operating current
EN,/EN enable

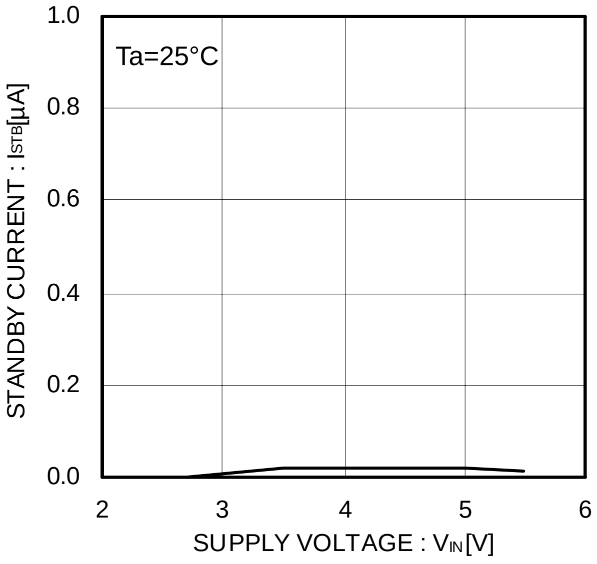


Figure 6. Standby current
EN,/EN disable

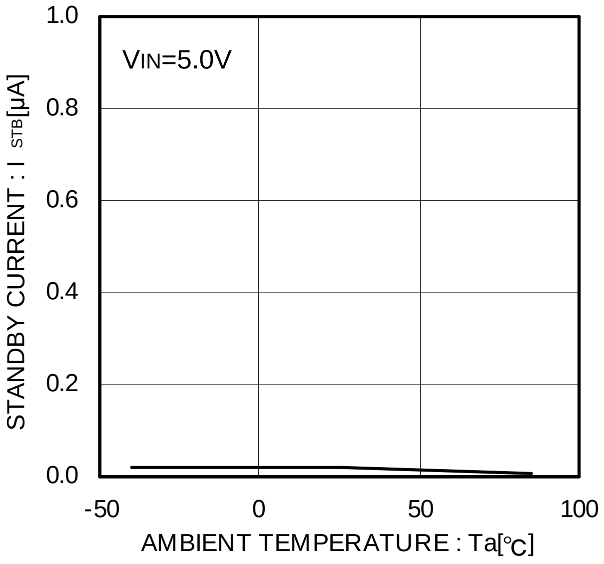


Figure 7. Standby current
EN,/EN disable

●Typical Performance Curves - continued

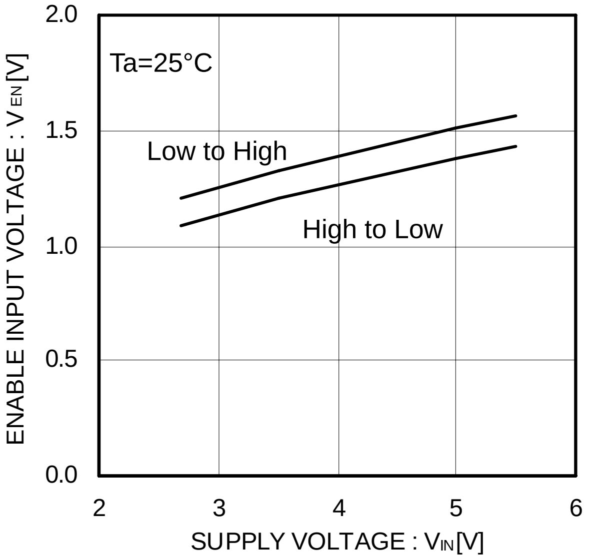


Figure 8. EN,/EN input voltage

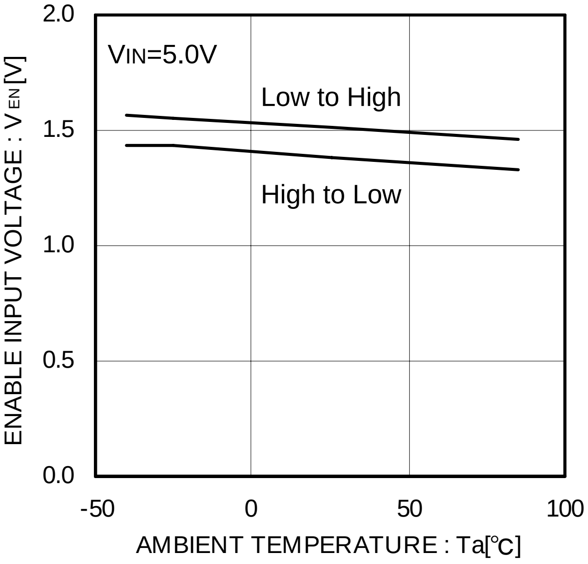


Figure 9. EN,/EN input voltage

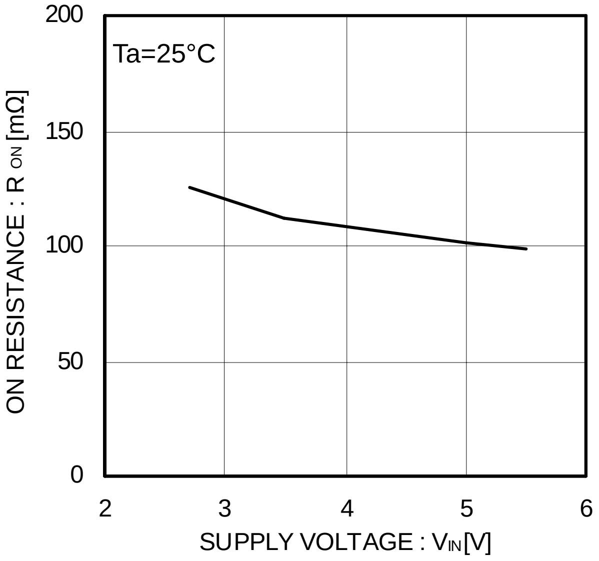


Figure 10. On-resistance

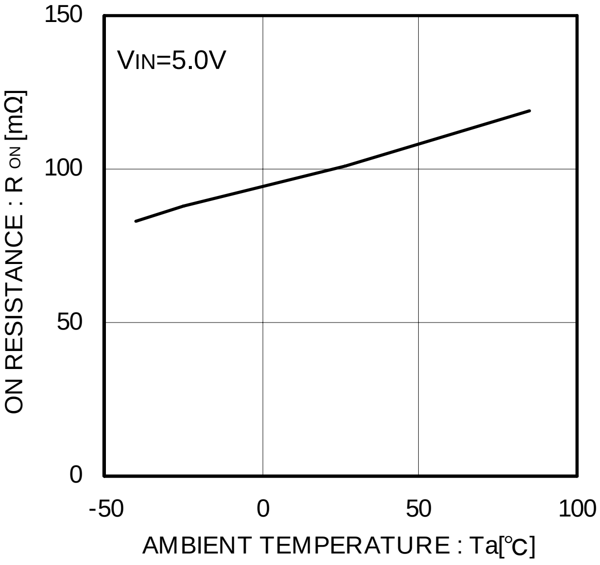


Figure 11. On-resistance

●**Typical Performance Curves - continued**

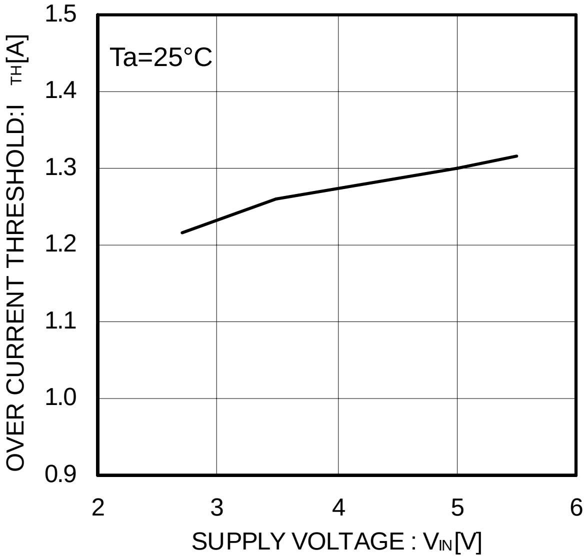


Figure 12. Over-current threshold

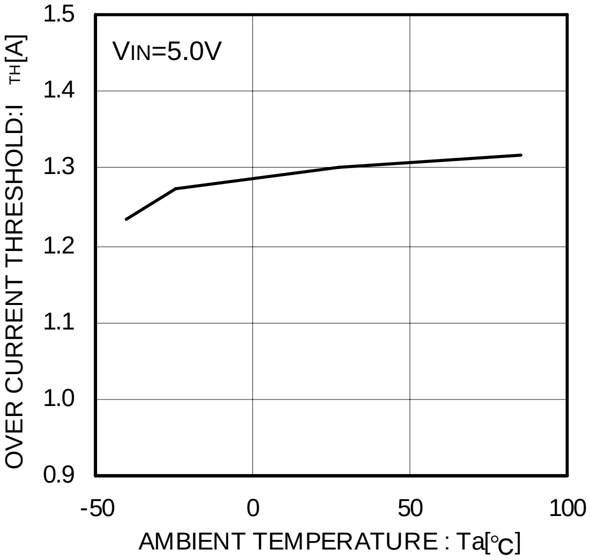


Figure 13. Over-current threshold

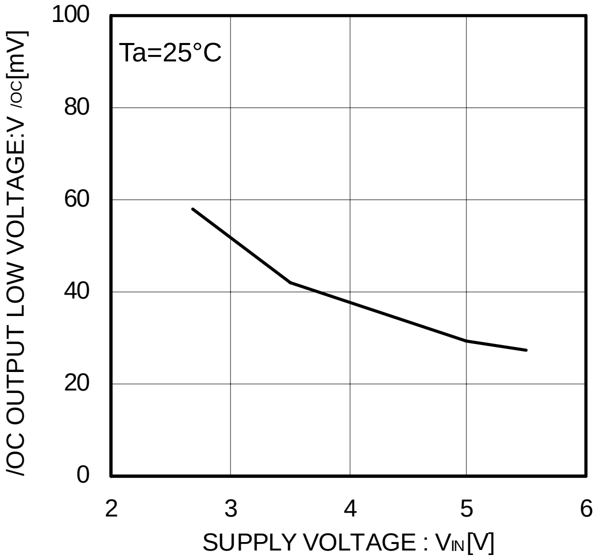


Figure 14. /OC output low voltage

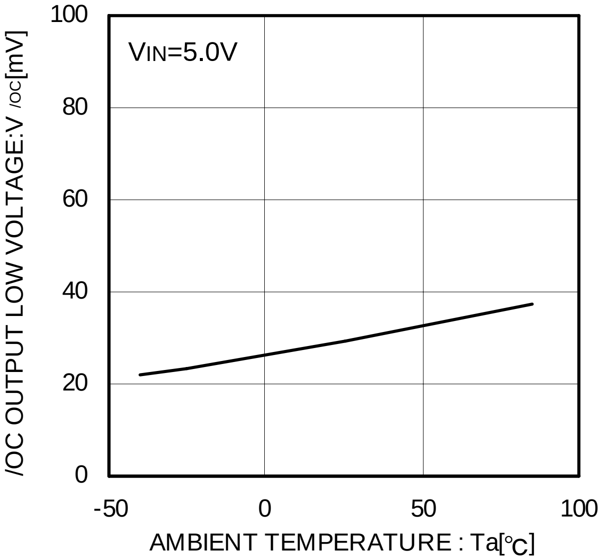


Figure 15. /OC output low voltage

●**Typical Performance Curves - continued**

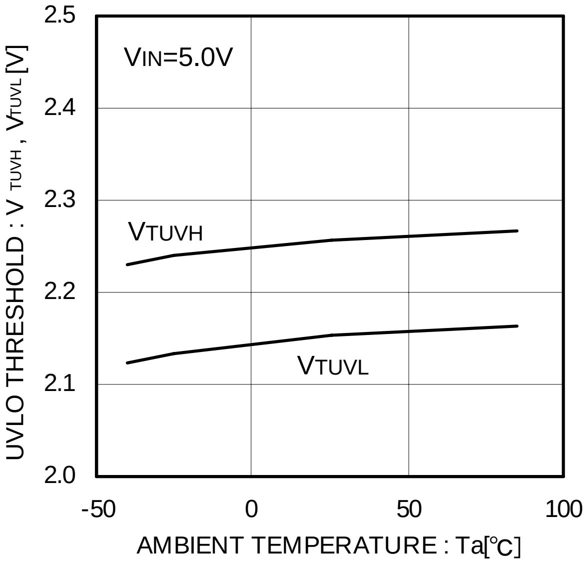


Figure 16. UVLO threshold

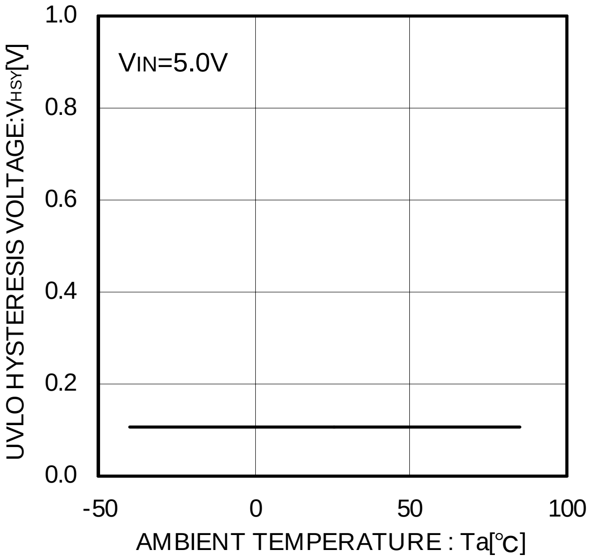


Figure 17. UVLO hysteresis voltage

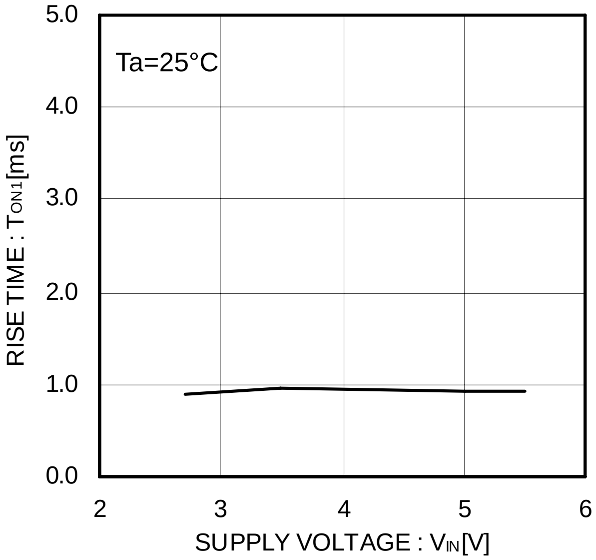


Figure 18. Output rise time

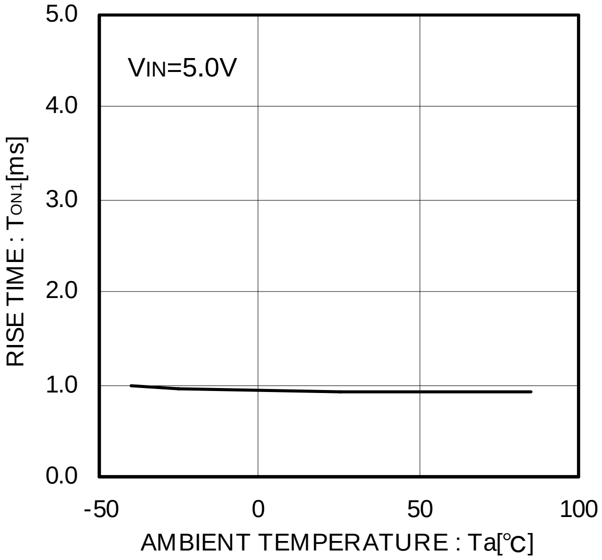


Figure 19. Output rise time

●Typical Performance Curves - continued

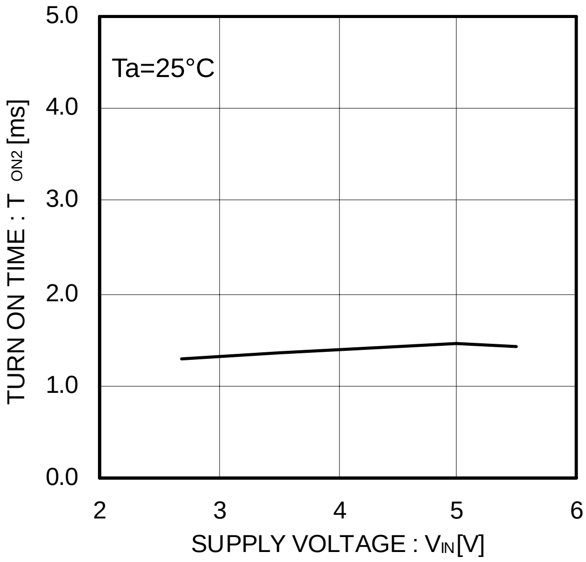


Figure 20. Output turn-on time

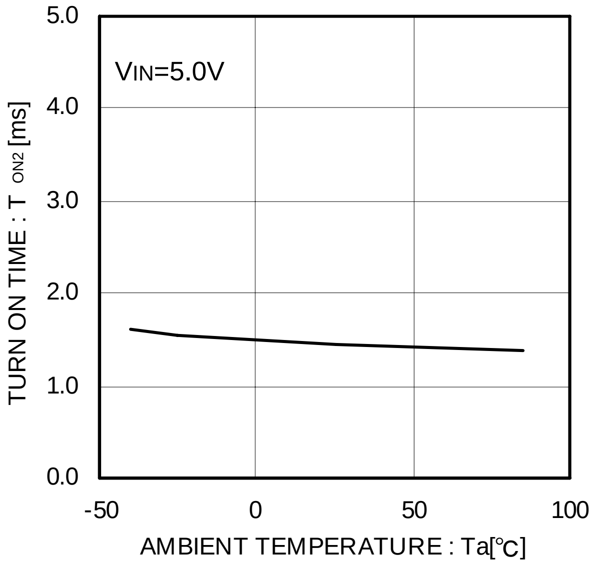


Figure 21. Output turn-on time

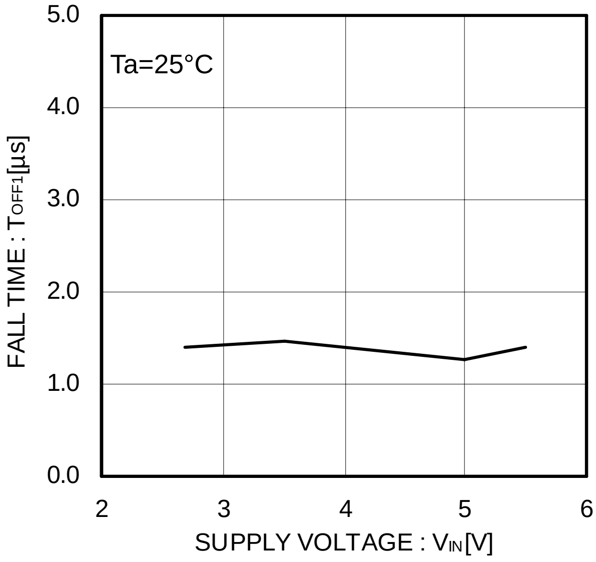


Figure 22. Output fall time

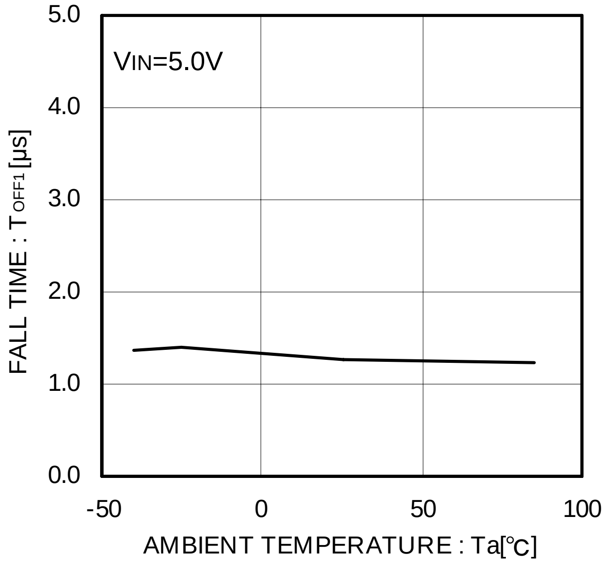


Figure 23. Output fall time

●**Typical Performance Curves - continued**

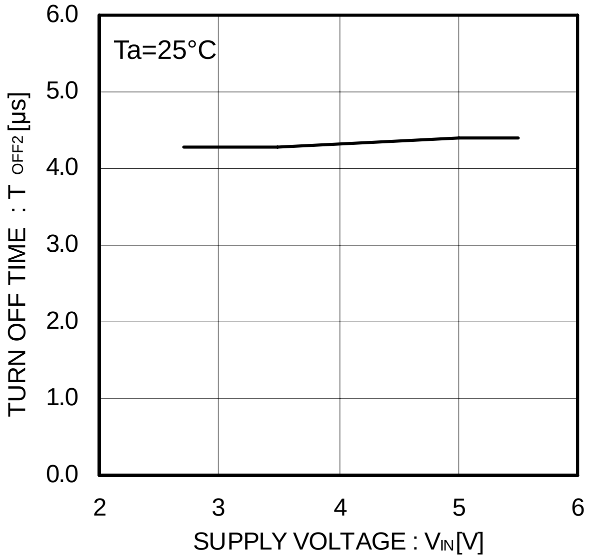


Figure 24. Output turn-off time

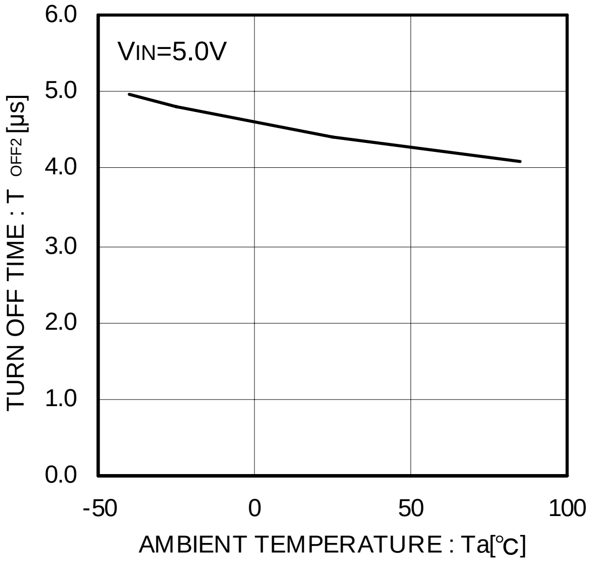


Figure 25. Output turn-off time

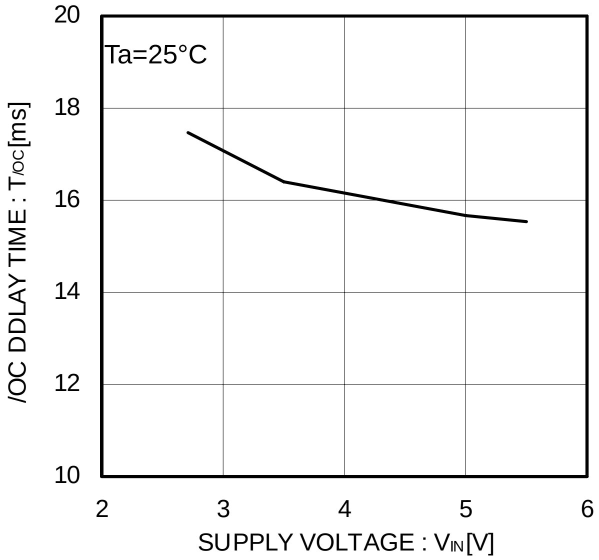


Figure 26. /OC delay time

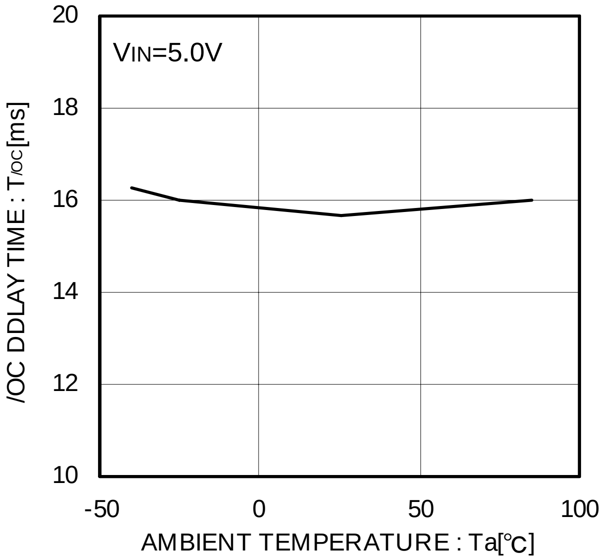


Figure 27. /OC delay time

●**Typical Performance Curves - continued**

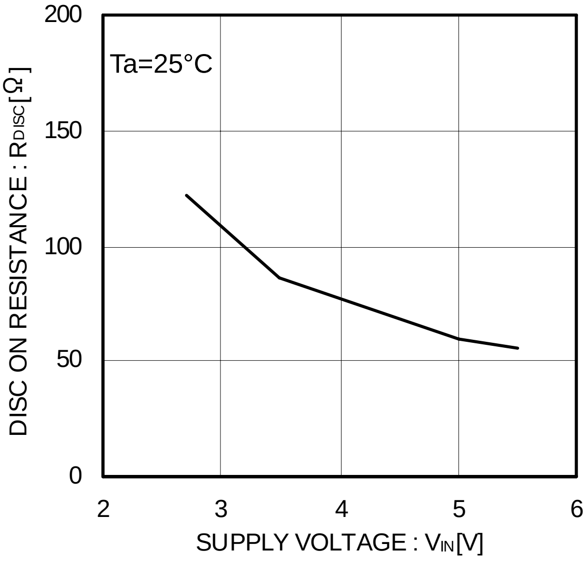


Figure 28. Discharge on resistance

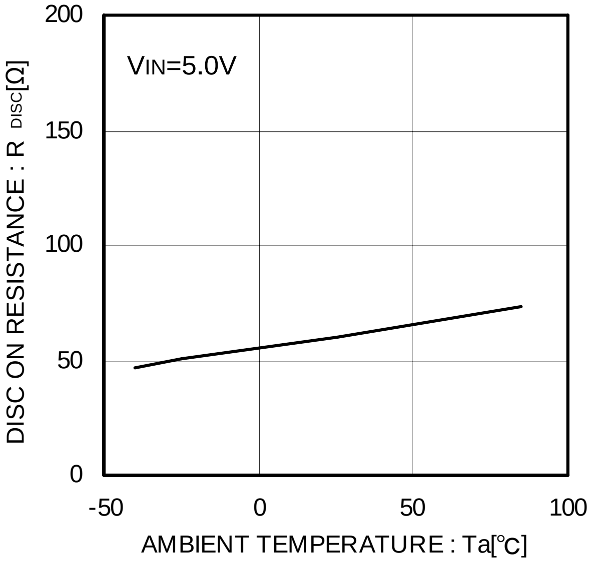


Figure 29. Discharge on resistance

●Typical Wave Forms

(BD2232G)

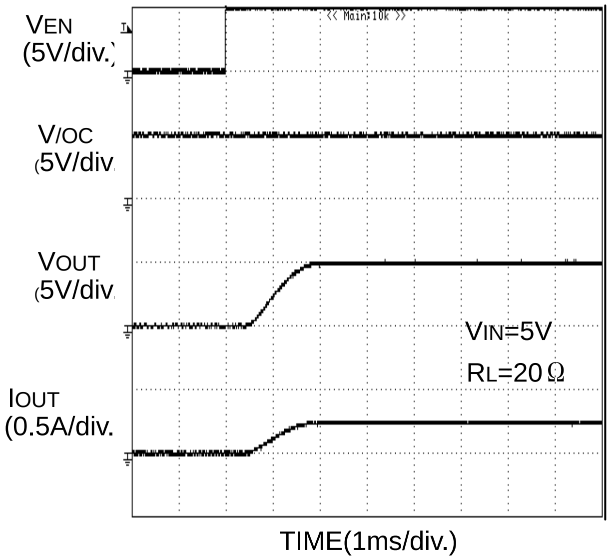


Figure 30. Output rise characteristic

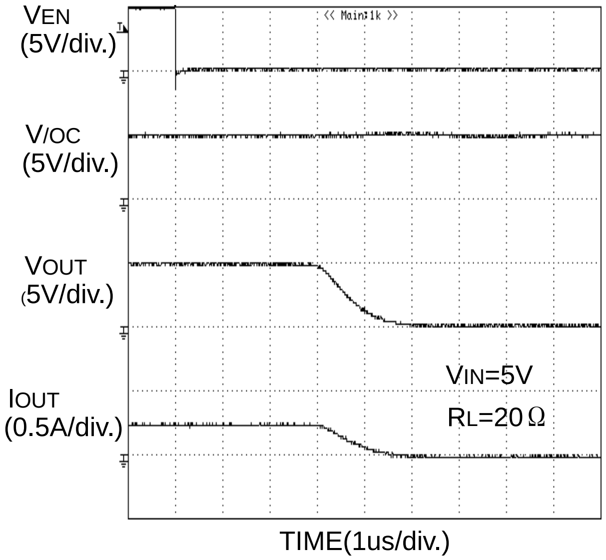


Figure 31. Output fall characteristic

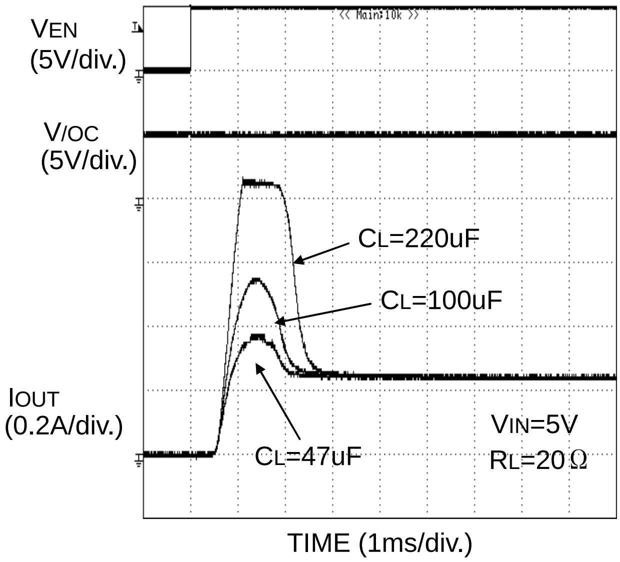


Figure 32. Inrush current response

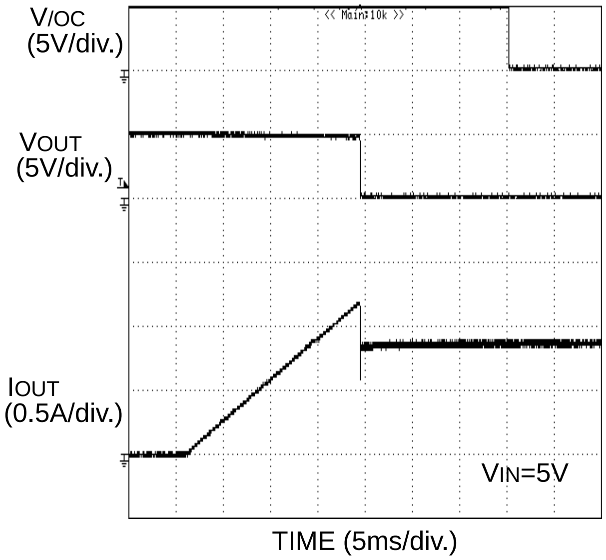


Figure 33. Over-current response
ramped load

●**Typical Wave Forms - continued**

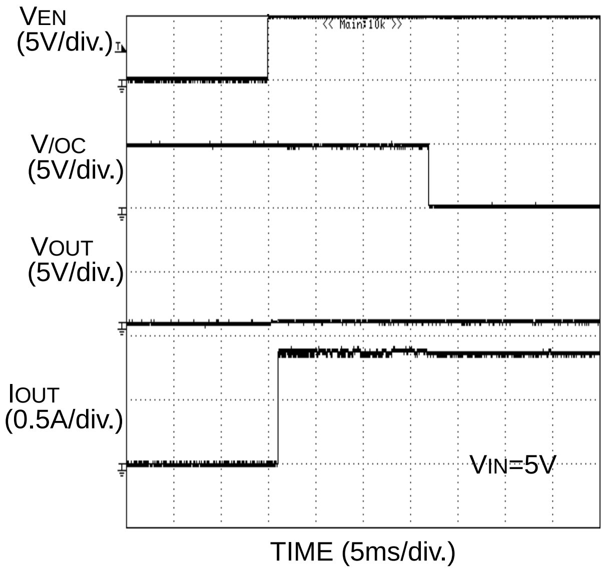


Figure 34. Over-current response
enable to shortcircuit

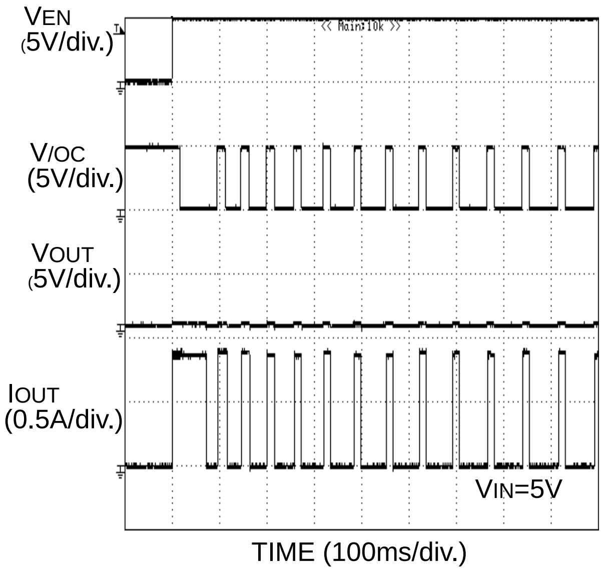


Figure 35. Over-current response
enable to shortcircuit

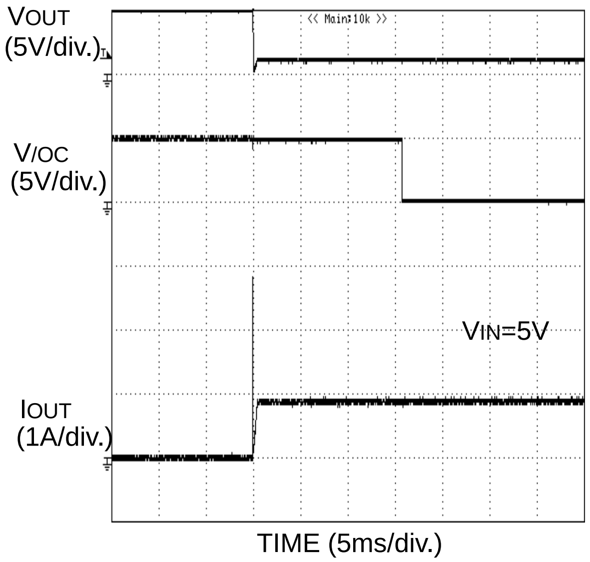


Figure 36. Over-current response
1Ω load to enabled device

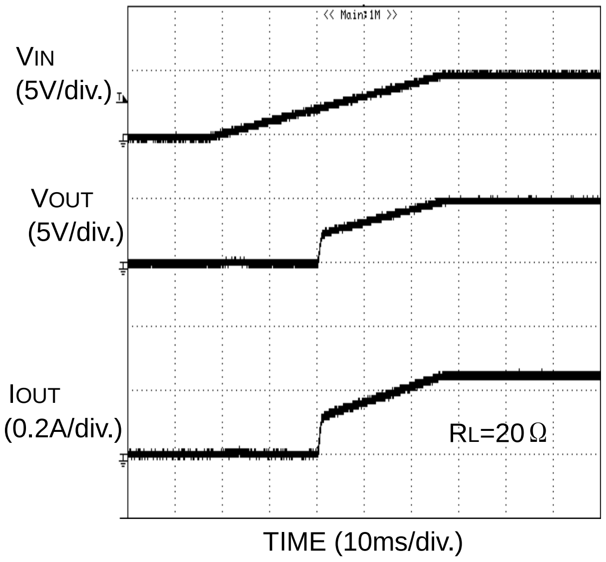


Figure 37. UVLO response
increasing VIN

●Typical Wave Forms - continued

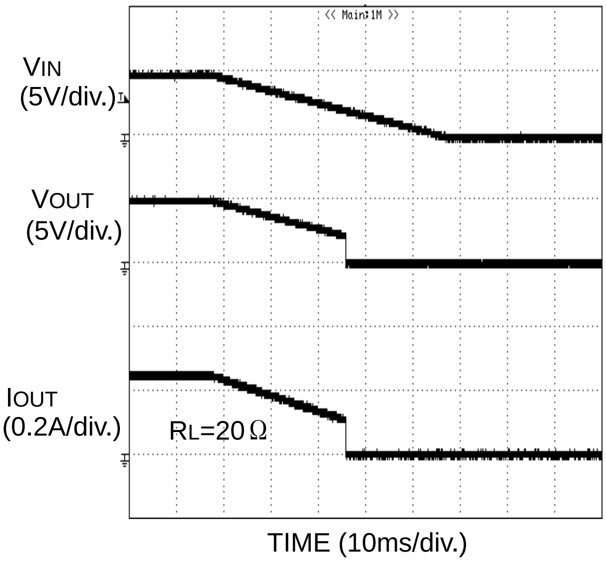
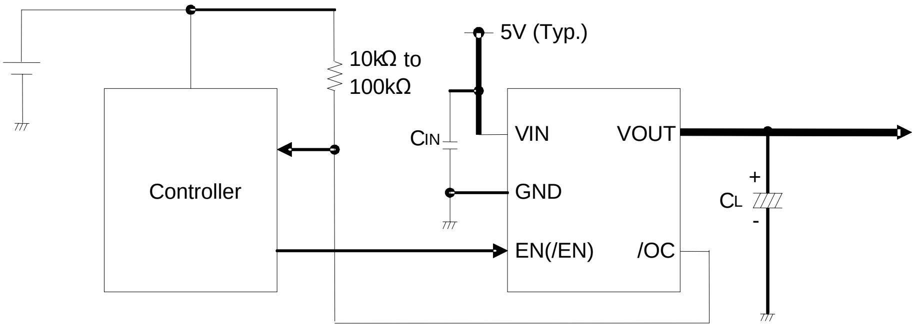


Figure 38. UVLO response decreasing VIN

●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. In order to decrease voltage fluctuations from power source line to IC, connect a low ESR capacitor in parallel with C_{IN}. 10μF to 100μF or higher is effective.

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

Set up value which satisfies the application as C_L.

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, VIN terminal and VOUT terminal are connected by a 100mΩ(Typ.) switch. At on state, the switch is bidirectional, therefore, when the potential of VOUT terminal is higher than that of VIN terminal, current flows from VOUT terminal to VIN terminal.

2. Thermal Shutdown Circuit (TSD)

If over-current would continue, the temperature of the IC would increase drastically. If the junction temperature is beyond 135℃(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 115℃(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.
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 (I_{SC}) and outputs fault flag (/OC) when current flowing in each switch 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 shortcircuit status or so, the switch gets in current limit status immediately.

3-2. When the output shortcircuits while the switch is on
When the output shortcircuits or high-current load is connected while the switch is on, very large current will flow 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(Typ.). If the VIN drops below 2.2V(Typ.) while the switch turns on, then UVLO shuts off the power switch. UVLO has hysteresis of 100mV(Typ).
   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 N-MOS open drain output. At detection of over-current or thermal shutdown, output is low-level.
   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.

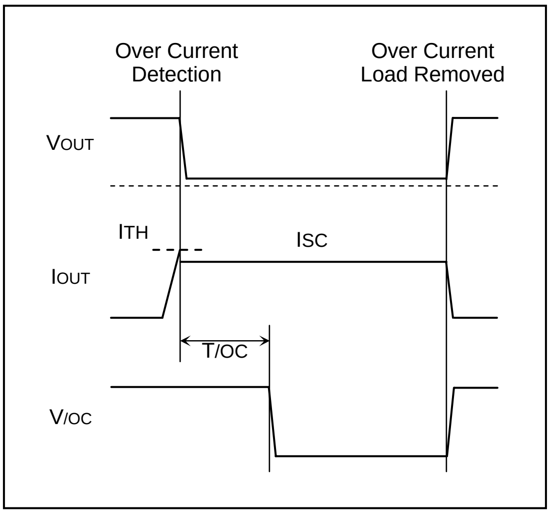


Figure 39. Over-current detection

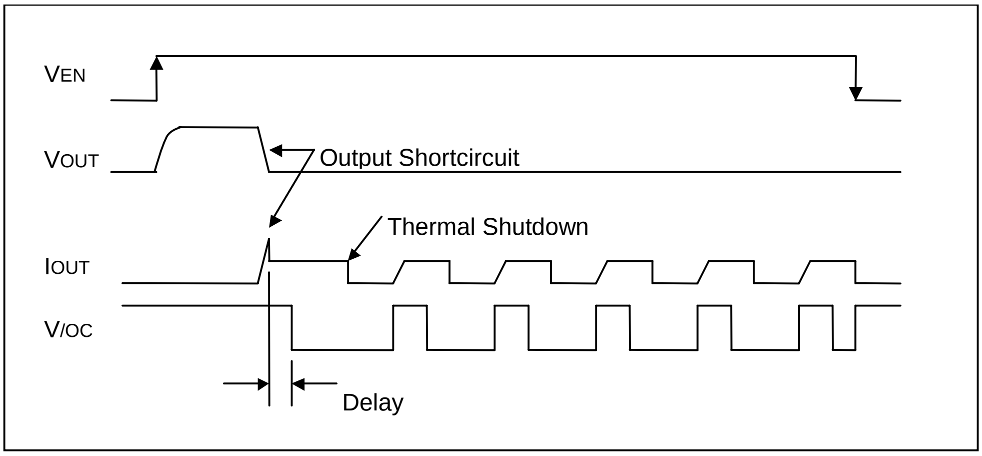


Figure 40. Over-current detection, Thermal shutdown timing (BD2232G)

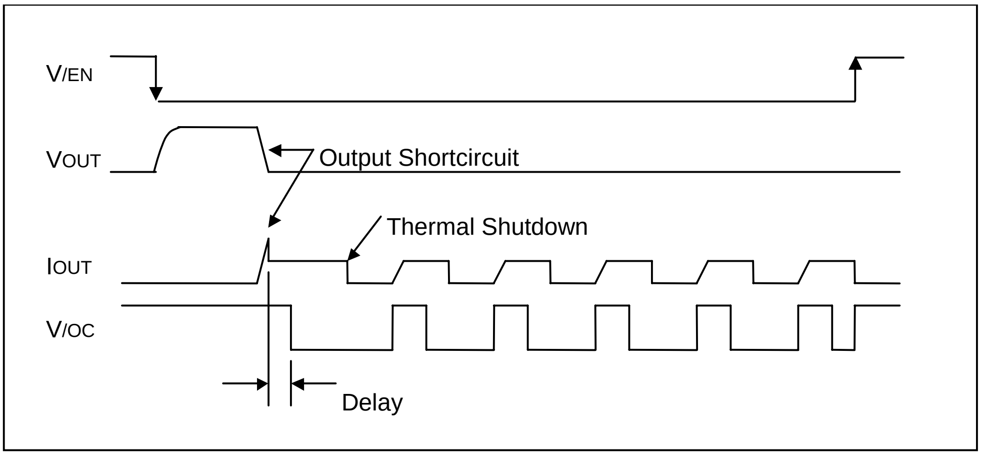
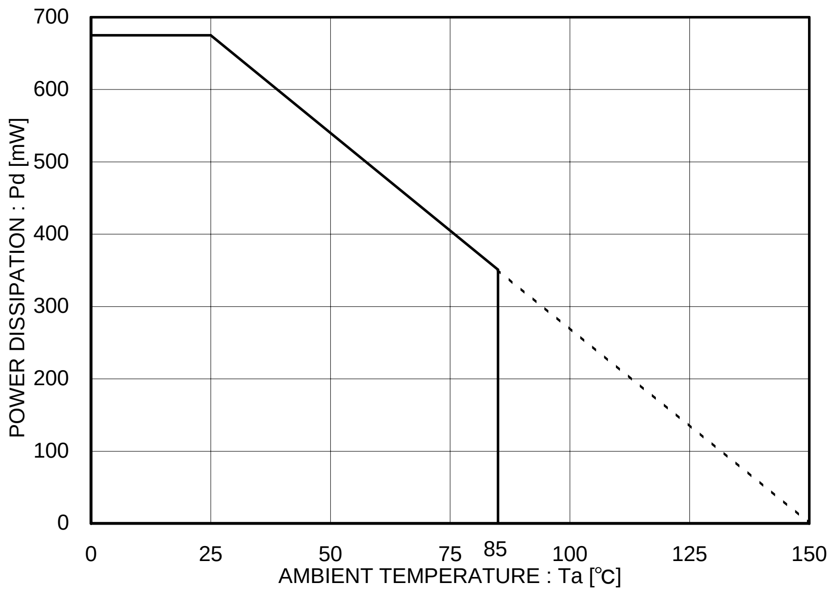


Figure 41. Over-current detection, Thermal shutdown timing (BD2233G)

●Power Dissipation

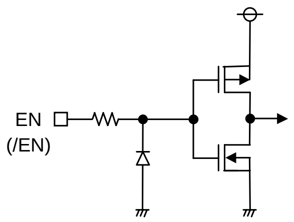
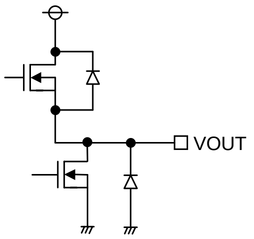
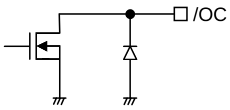
(SSOP5 package)



* 70mm x 70mm x 1.6mm Glass Epoxy Board

Figure 42. Power Dissipation Curve (Pd-Ta Curve)

●I/O Equivalence Circuit

Symbol	Pin No.	Equivalence Circuit
EN (/EN)	3	
VOUT	5	
/OC	4	

●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 > 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.

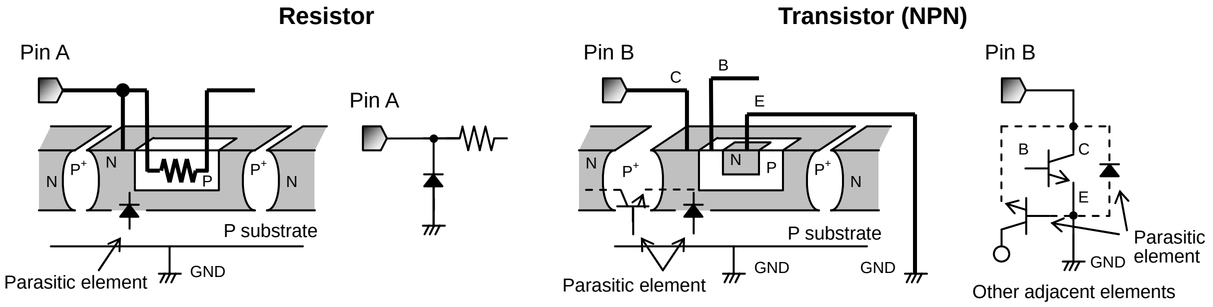


Figure 43. Example of monolithic IC structure

(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 (Pd) in actual operating conditions. Consider Pc that does not exceed Pd in actual operating conditions ($Pc \geq Pd$).

Package Power dissipation : $Pd\ (W) = (Tjmax - Ta)/\theta ja$

Power dissipation : $Pc\ (W) = (Vcc - Vo) \times Io + Vcc \times Ib$

Tjmax : Maximum junction temperature=150℃, Ta : Peripheral temperature[℃] ,
θja : Thermal resistance of package-ambience[℃/W], Pd : Package Power dissipation [W],
Pc : Power dissipation [W], Vcc : Input Voltage, Vo : Output Voltage, Io : Load, Ib : Bias Current

●Ordering Information

B D 2 2 3 2 G - T R

Part Number

Package
G: SSOP5

Packaging and forming specification
TR: Embossed tape and reel

B D 2 2 3 3 G - T R

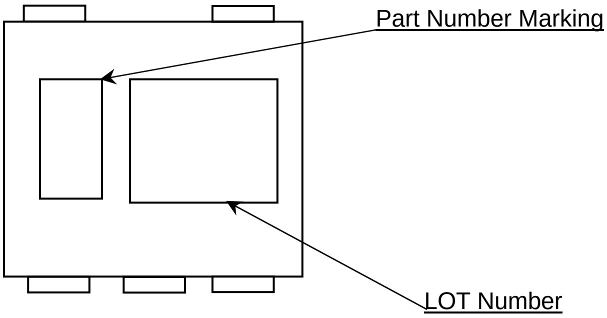
Part Number

Package
G: SSOP5

Packaging and forming specification
TR: Embossed tape and reel

●Marking Diagram

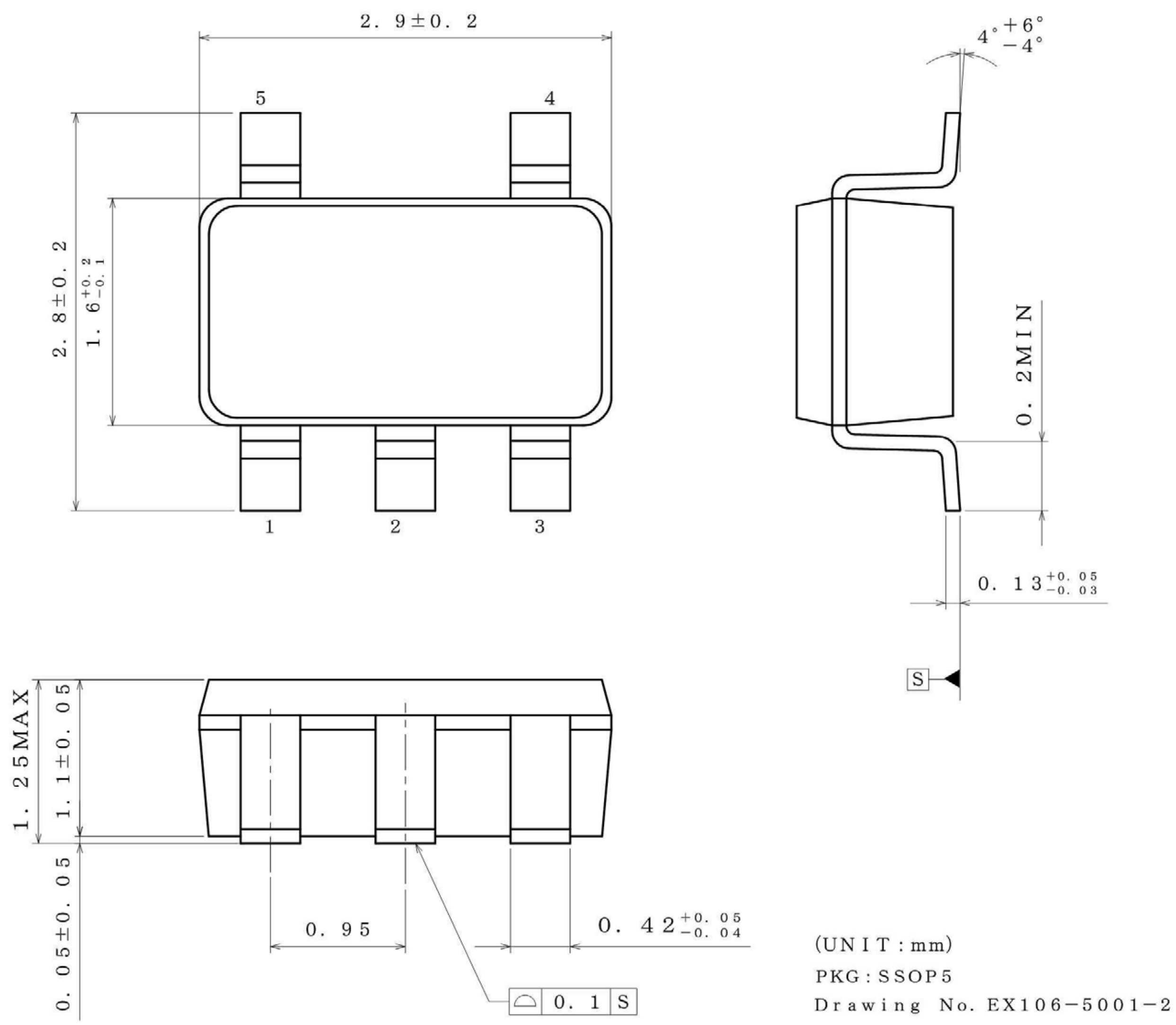
SSOP5 (TOP VIEW)



Part Number	**Part Number Marking**
BD2232G	J1
BD2233G	J7

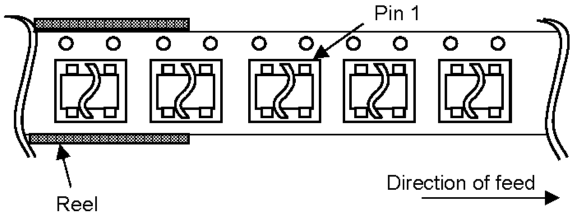
●Physical Dimension, Tape and Reel Information

Package Name	SSOP5



< 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
11.Mar.2013	001	New Release

Notice

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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 (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.

7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient 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; 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.

2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

●Precaution for Electrostatic

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 Cl2, H2S, NH3, SO2, and NO2
    [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.

●Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

●Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

●Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

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