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1 Channel High Side Switch ICs

# 1.0A Current Limit High Side Switch ICs

**BD2041AFJ BD2051AFJ**

●General Description

Single channel high side switch IC for USB port is a high side switch having over current protection used in power supply line of universal serial bus (USB). N-channel power MOSFET of low on resistance and low supply current are realized in this IC. And, over current detection circuit, thermal shutdown circuit, under voltage lockout and soft start circuit are built in.

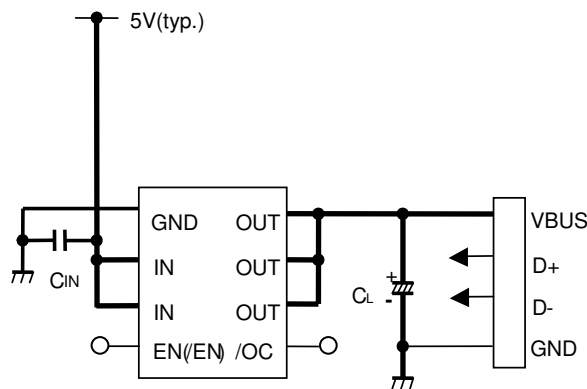
●Features

- Built-in low on resistance Nch MOS FET Switch.( Typ = 80mΩ)
- Continuous current load 0.5A
- Control input logic
  - Active-Low : BD2041AFJ
  - Active-High: BD2051AFJ
- Soft start circuit
- Over current detection
- Thermal shutdown
- Under voltage lockout
- Open drain error flag output
- Reverse-current protection when power switch off

●Applications

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

●Typical Application Circuit



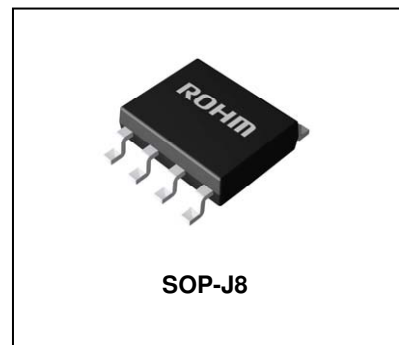
●Key Specifications

- Input voltage range: 2.7V to 5.5V
- Continuous current load: 0.5A(Typ.)
- ON resistance : 80mΩ(Typ.)
- Over current threshold: 0.7A min., 1.6A max.
- Standby current: 0.01μA (Typ.)
- Operating temperature range: -40°C to +85°C

●Package

SOP-J8

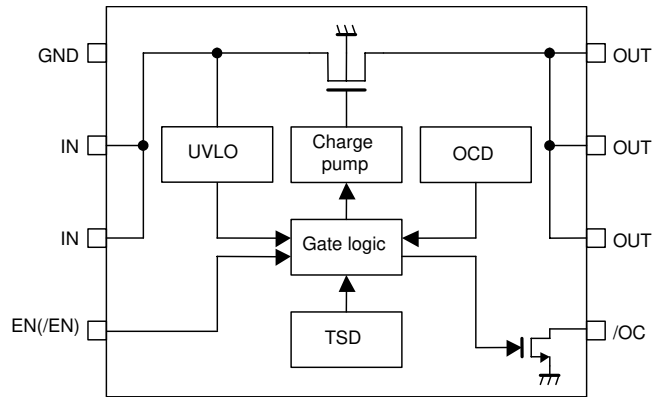
W(Typ.) D(Typ.) H(Max.)  
4.90mm x 6.00mm x 1.65mm



●Lineup

Over current detection			Control input logic	Package		Orderable Part Number
Min.	Typ.	Max.				
0.7A	1.0A	1.6A	Low	SOP-J8	Reel of 2500	BD2041AFJ-E2
0.7A	1.0A	1.6A	High	SOP-J8	Reel of 2500	BD2051AFJ-E2

●Block Diagram



●Pin Configurations



●Pin Description

Pin No.	Symbol	I / O	Pin function
1	GND	I	Ground.
2, 3	IN	I	Power supply input. Input terminal to the power switch and power supply input terminal of the internal circuit. At use, connect each pin outside.
4	EN (/EN)	I	Enable input. Power switch on at Low level. (BD2041AFJ) Power switch on at High level. (BD2051AFJ) High level input > 2.0V, Low level input < 0.8V.
5	/OC	O	Error flag output. Low at over current, thermal shutdown. Open drain output.
6, 7, 8	OUT	O	Power switch output. At use, connect each pin outside.

### ● Absolute Maximum Ratings

Parameter	Symbol	Limits	Unit
Supply voltage	V <sub>IN</sub>	-0.3 to 6.0	V
Enable voltage	V <sub>EN</sub> , V <sub>/EN</sub>	-0.3 to 6.0	V
/OC voltage	V <sub>/OC</sub>	-0.3 to 6.0	V
/OC current	I <sub>S/OC</sub>	10	mA
OUT voltage	V <sub>OUT</sub>	-0.3 to 6.0	V
Storage temperature	T <sub>STG</sub>	-55 to 150	°C
Power dissipation	PD	560 <sup>*1</sup>	mW

\*1 In the case of exceeding Ta = 25°C, 4.48mW should be reduced per 1°C.

### ● Recommended Operating Ratings

Parameter	Symbol	Limits	Unit
Operating voltage	V <sub>IN</sub>	2.7 to 5.5	V
Operating temperature	T <sub>OPR</sub>	-40 to 85	°C
Continuous output current	I <sub>LO</sub>	0 to 500	mA

### ● Electrical Characteristics

©BD2041AFJ (Unless otherwise specified, V<sub>IN</sub> = 5.0V, Ta = 25°C)

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Operating Current	I <sub>DD</sub>	-	90	120	μA	V <sub>EN</sub> = 0V, OUT = OPEN
Standby Current	I <sub>STB</sub>	-	0.01	1	μA	V <sub>EN</sub> = 5V, OUT = OPEN
/EN input voltage	V <sub>/EN</sub>	2.0	-	-	V	High input
	V <sub>/EN</sub>	-	-	0.8	V	Low input
		-	-	0.4	V	Low input 2.7V ≤ V <sub>IN</sub> ≤ 4.5V
/EN input current	I <sub>/EN</sub>	-1.0	.01	1.0	μA	V <sub>EN</sub> = 0V or V <sub>/EN</sub> = 5V
/OC output LOW voltage	V <sub>/OC</sub>	-	-	0.5	V	I <sub>/OC</sub> = 5mA
/OC output leak current	I <sub>L/OC</sub>	-	0.01	1	μA	V <sub>/OC</sub> = 5V
ON resistance	R <sub>ON</sub>	-	80	100	mΩ	I <sub>OUT</sub> = 500mA
Over-current Threshold	I <sub>TH</sub>	0.7	1.0	1.6	A	
Output current at short	I <sub>SC</sub>	0.7	1.0	1.3	A	V <sub>IN</sub> = 5V, V <sub>OUT</sub> = 0V, C <sub>L</sub> = 100μF (RMS)
Output rise time	T <sub>ON1</sub>	-	1.2	10	ms	R <sub>L</sub> = 10Ω, C <sub>L</sub> = OPEN
Output turn on time	T <sub>ON2</sub>	-	1.5	20	ms	
Output fall time	T <sub>OFF1</sub>	-	1	20	μs	
Output turn off time	T <sub>OFF2</sub>	-	3	40	μs	
UVLO threshold	V <sub>TUVH</sub>	2.1	2.3	2.5	V	Increasing V <sub>IN</sub>
	V <sub>TUVL</sub>	2.0	2.2	2.4	V	Decreasing V <sub>IN</sub>

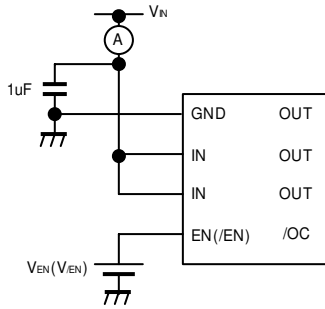


## ●Electrical Characteristics-Continued

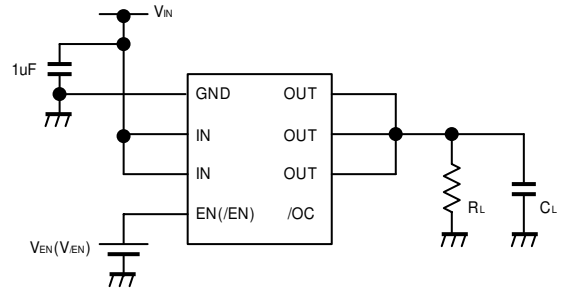
©BD2051AFJ (Unless otherwise specified,  $V_{IN} = 5.0V$ ,  $T_a = 25^{\circ}C$ )

Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
Operating Current	$I_{DD}$	-	90	120	$\mu A$	$V_{EN} = 5V$ , $OUT = OPEN$
Standby Current	$I_{STB}$	-	0.01	1	$\mu A$	$V_{EN} = 0V$ , $OUT = OPEN$
EN input voltage	$V_{EN}$	2.0	-	-	V	High input
	$V_{EN}$	-	-	0.8	V	Low input
		-	-	0.4	V	Low input $2.7V \leq V_{IN} \leq 4.5V$
EN input current	$I_{EN}$	-1.0	0.01	1.0	$\mu A$	$V_{EN} = 0V$ or $V_{EN} = 5V$
/OC output LOW voltage	$V_{OC}$	-	-	0.5	V	$I_{OC} = 5mA$
/OC output leak current	$I_{L/OC}$	-	0.01	1	$\mu A$	$V_{OC} = 5V$
ON resistance	$R_{ON}$	-	80	100	$m\Omega$	$I_{OUT} = 500mA$
Output current at short	$I_{SC}$	0.7	1.0	1.3	A	$V_{IN} = 5V$ , $V_{OUT} = 0V$ , $C_L = 100\mu F$ (RMS)
Output rise time	$T_{ON1}$	-	1.2	10	ms	$R_L = 10\Omega$ , $C_L = OPEN$
Output turn on time	$T_{ON2}$	-	1.5	20	ms	
Output fall time	$T_{OFF1}$	-	1	20	$\mu s$	
Output turn off time	$T_{OFF2}$	-	3	40	$\mu s$	
Over-current Threshold	$I_{TH}$	0.7	1.0	1.6	A	
UVLO threshold	$V_{TUVH}$	2.1	2.3	2.5	V	Increasing $V_{IN}$
	$V_{TUVL}$	2.0	2.2	2.4	V	Decreasing $V_{IN}$

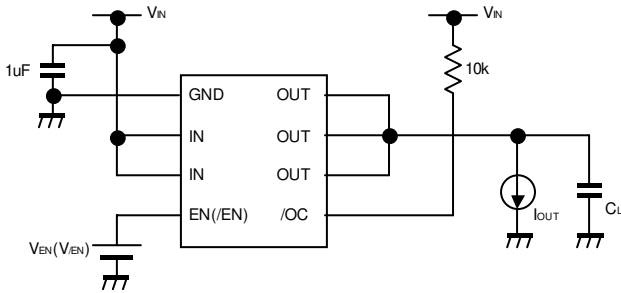
● Measurement Circuit



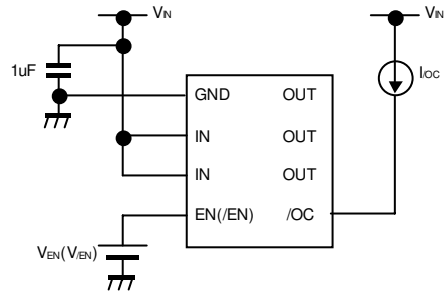
A. Operating current



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

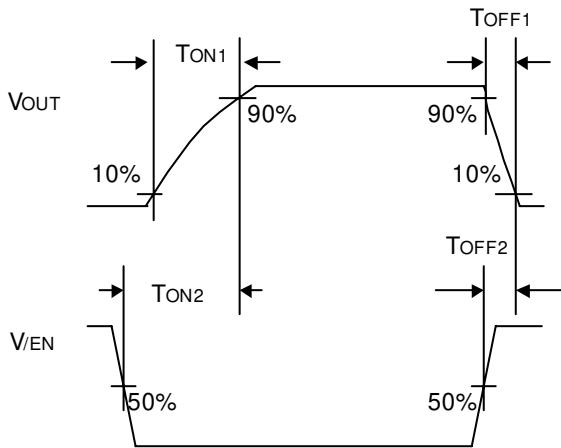


Figure 2. Timing diagram  
BD2041AFJ

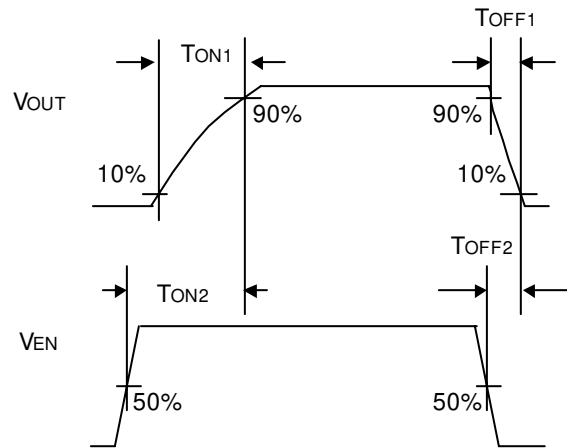


Figure 3. Timing diagram  
BD2051AFJ

● Typical Performance Curves

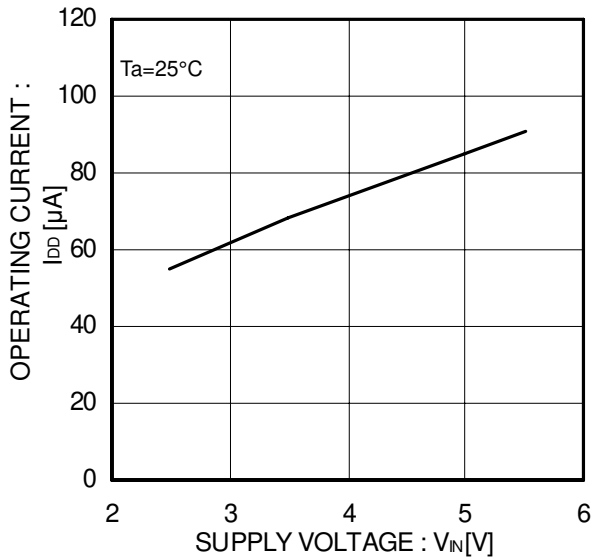


Figure 4. Operating current EN,/EN Enable

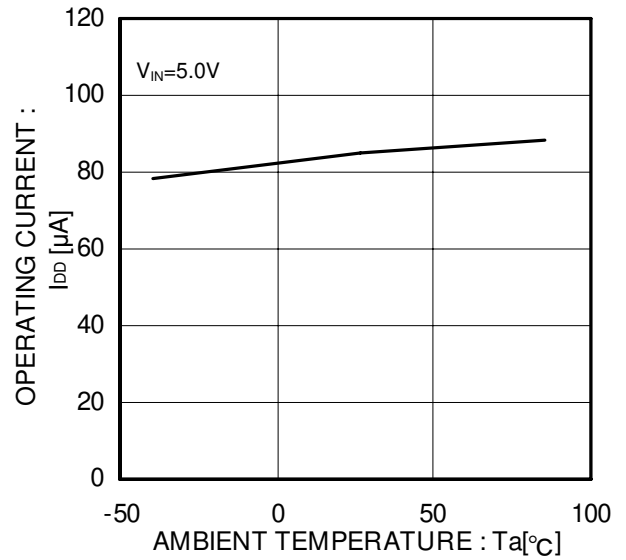


Figure 5. Operating current EN,/EN Enable

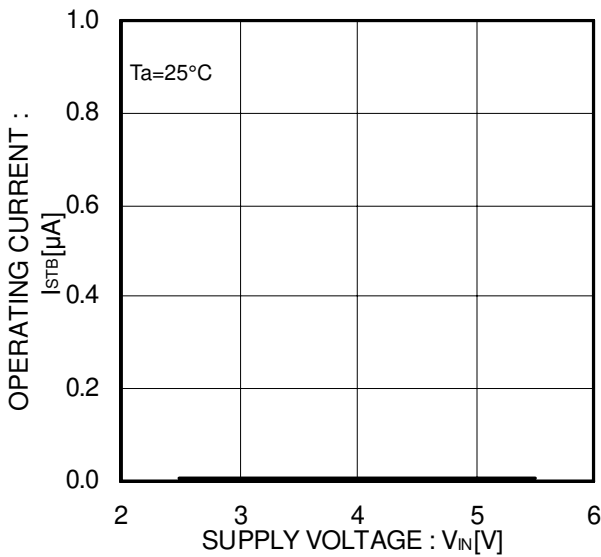


Figure 6. Operating current EN,/EN Disable

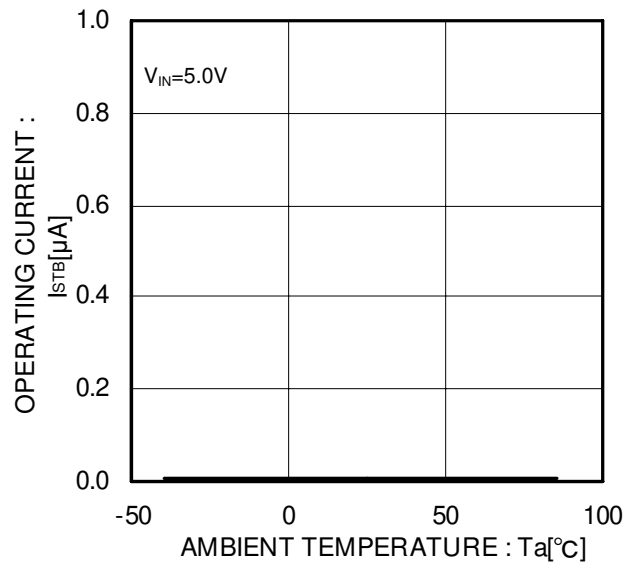


Figure 7. Operating current EN,/EN Disable

● Typical Performance Curves – Continued

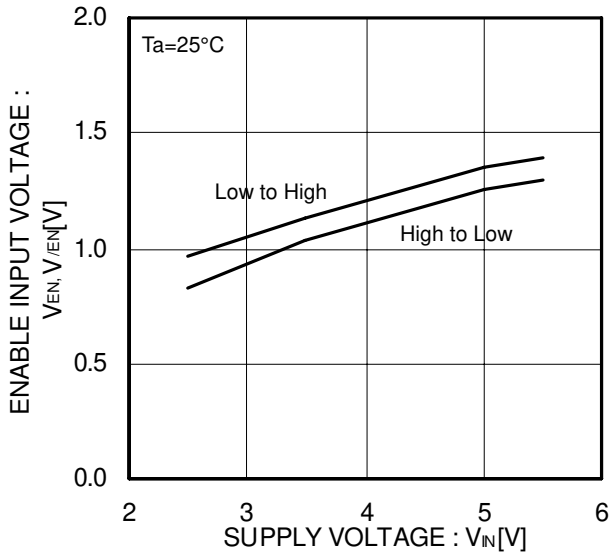


Figure 8. EN,/EN input voltage

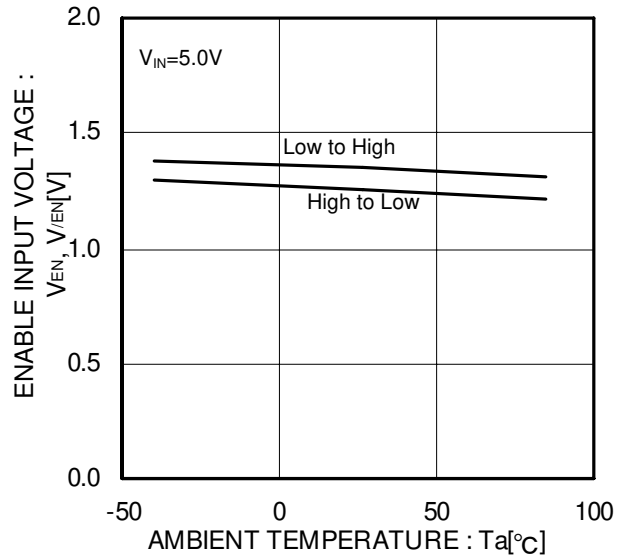


Figure 9. EN,/EN input voltage

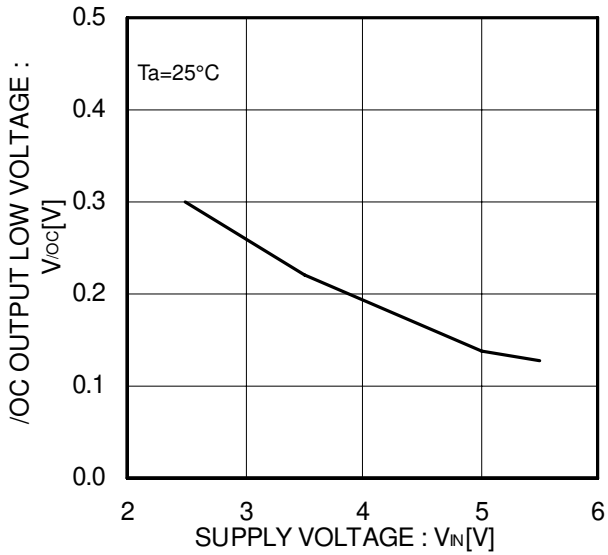


Figure 10. /OC output LOW voltage

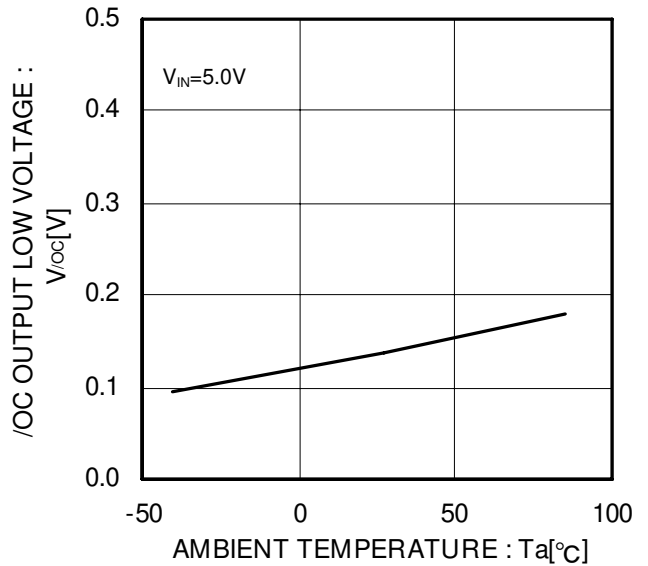


Figure 11. /OC output LOW voltage



● Typical Performance Curves – Continued

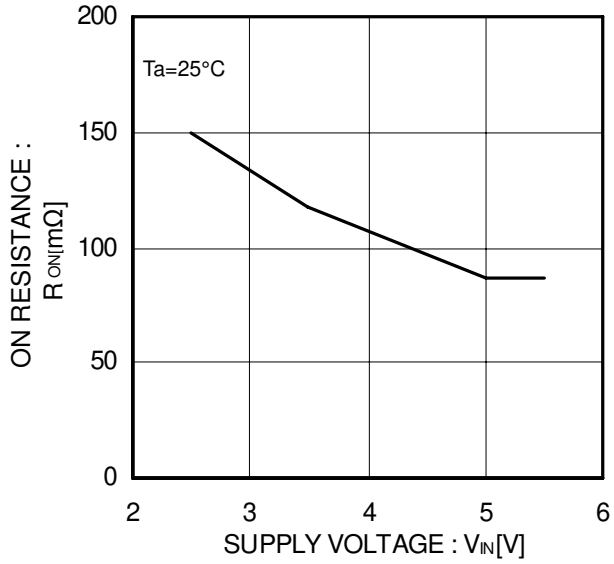


Figure 12. ON resistance

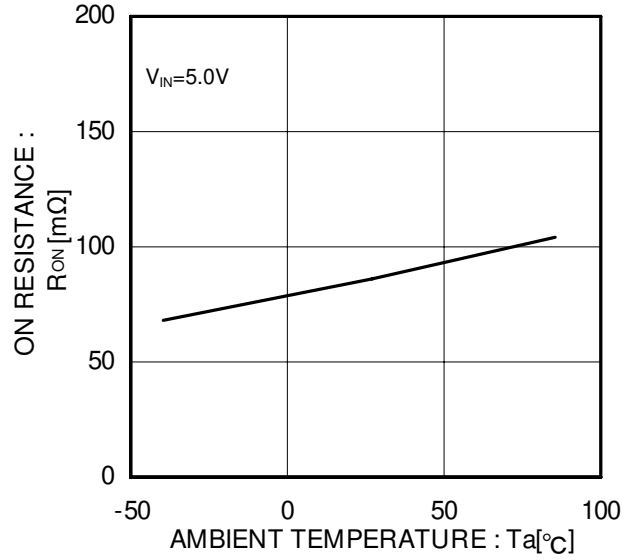


Figure 13. ON resistance

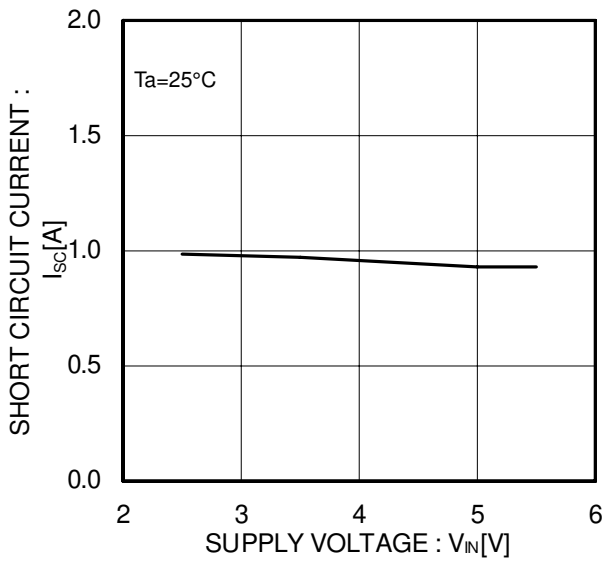


Figure 14. Output current at shortcircuit (BD2041AFJ/51AFJ)

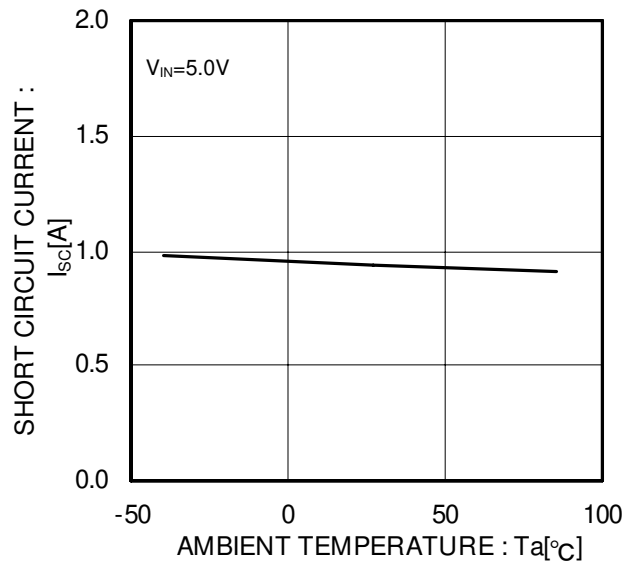


Figure 15. Output current at shortcircuit (BD2041AFJ/51AFJ)

● Typical Performance Curves – Continued

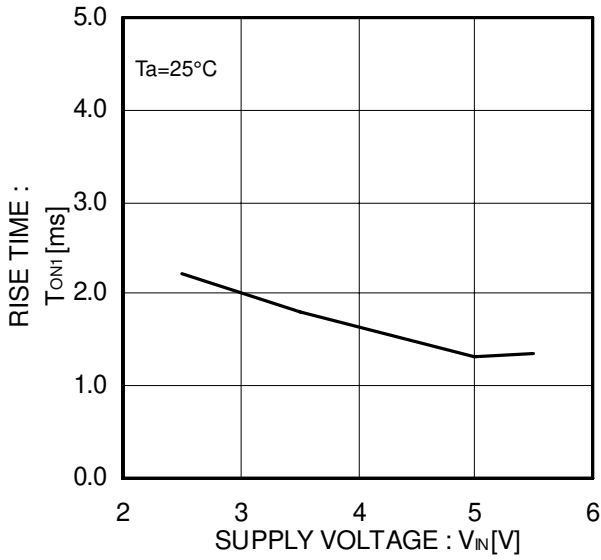


Figure 16. Output rise time

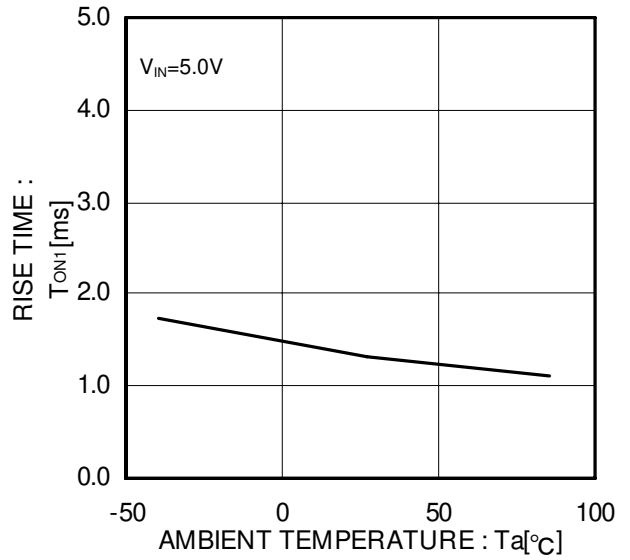


Figure 17. Output rise time

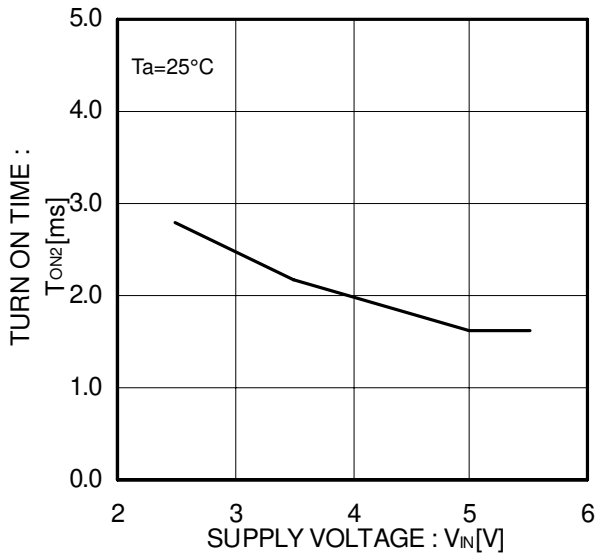


Figure 18. Output turn on time

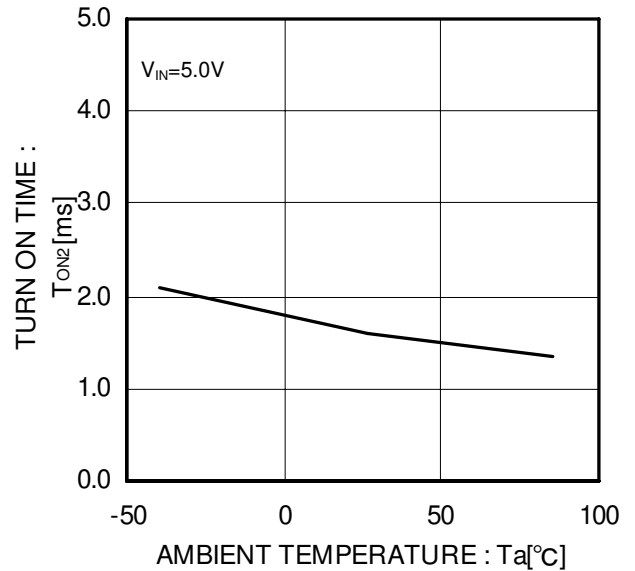


Figure 19. Output turn on time

● Typical Performance Curves – Continued

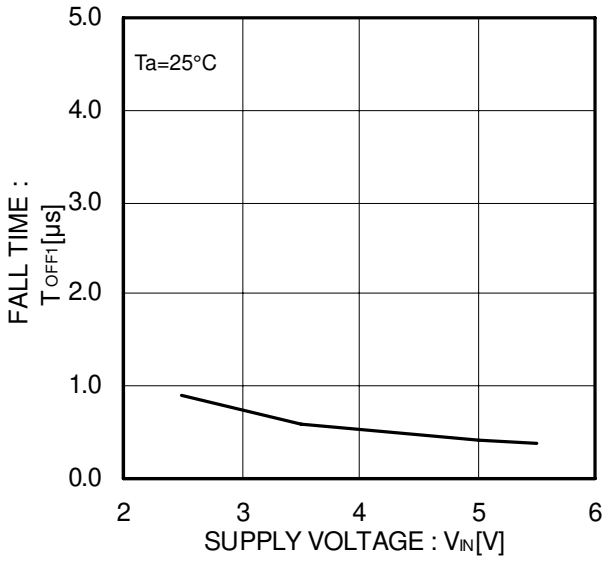


Figure 20. Output fall time

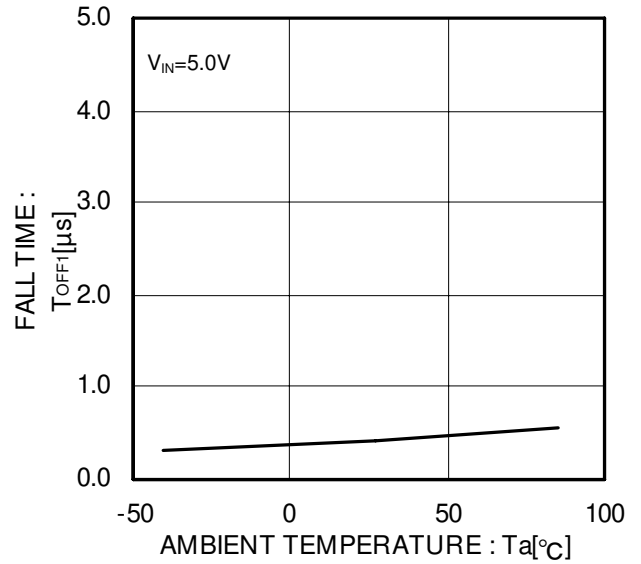


Figure 21. Output fall time

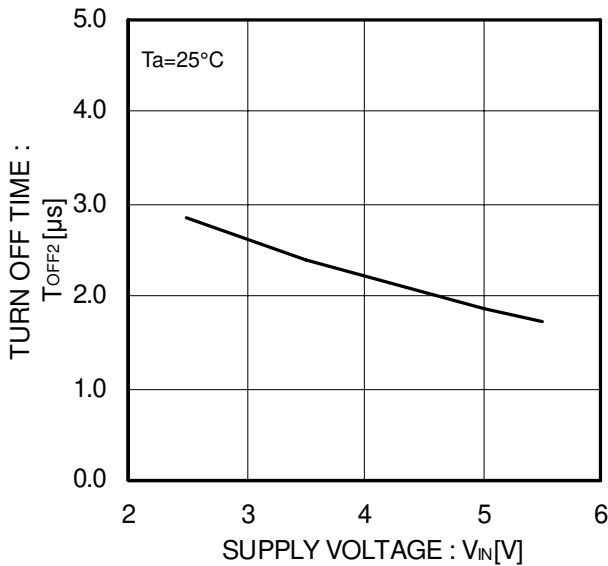


Figure 22. Output turn off time

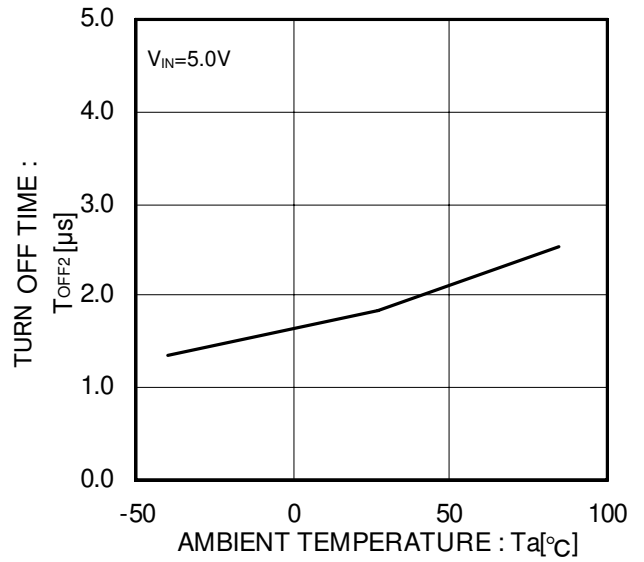


Figure 23. Output turn off time

● Typical Performance Curves – Continued

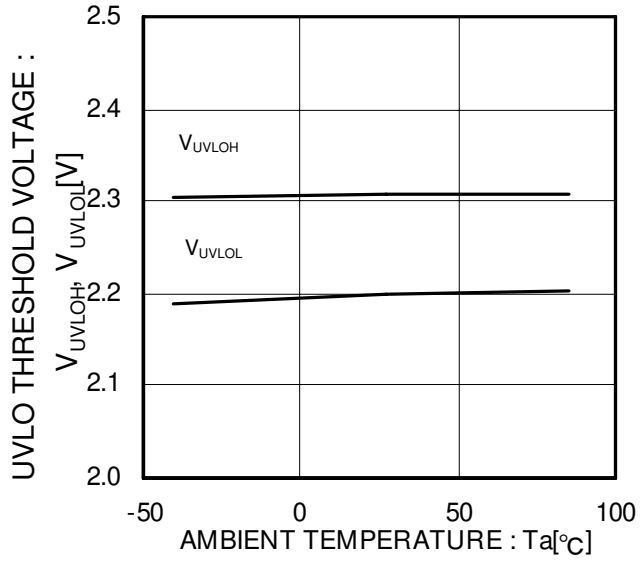


Figure 24. UVLO threshold voltage

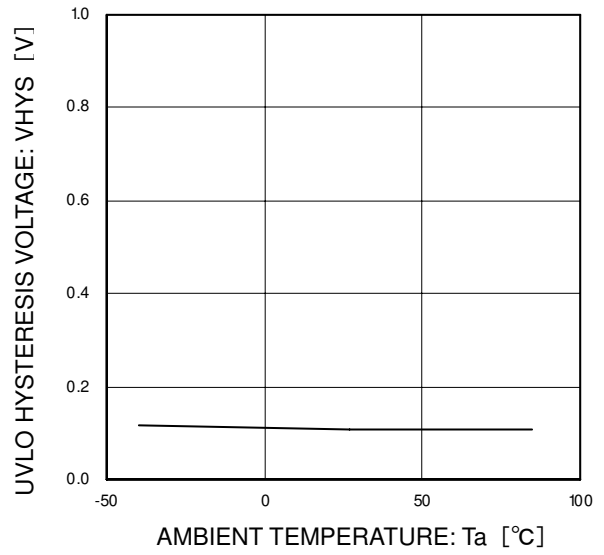


Figure 25. UVLO hysteresis voltage

● Typical Wave Forms

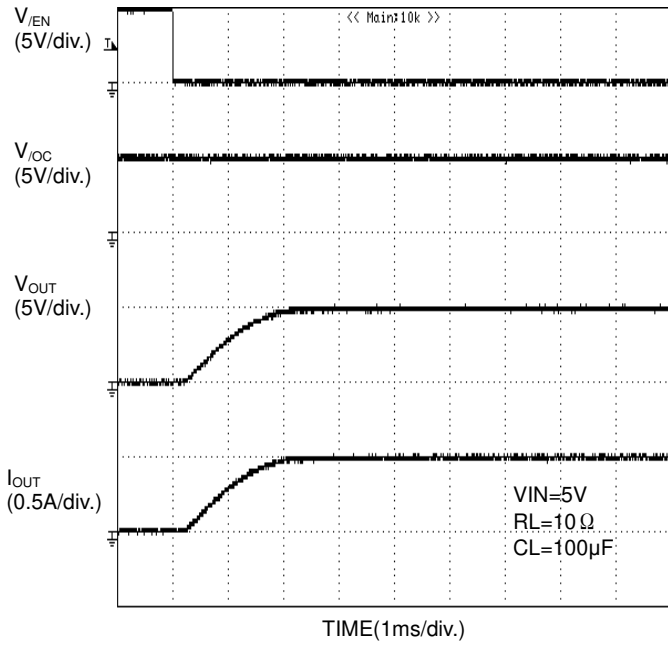


Figure 26. Output rise characteristic (BD2041AFJ)

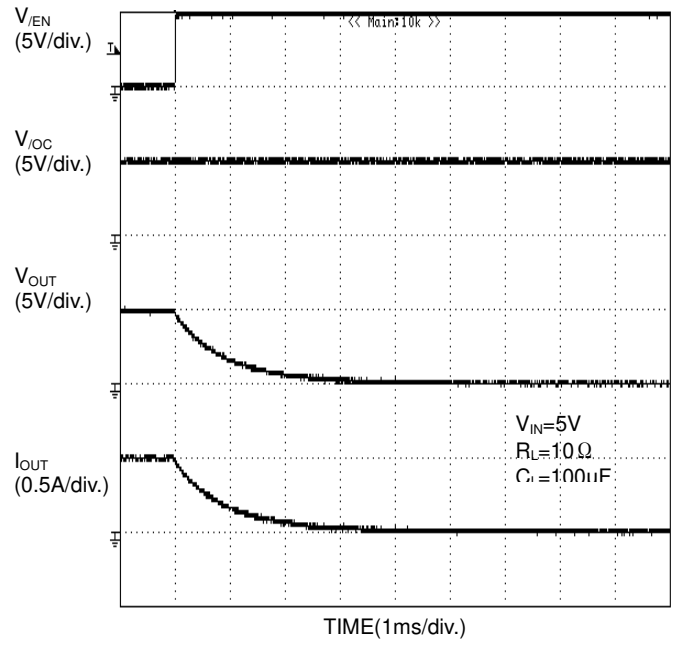


Figure 27. Output fall characteristic (BD2041AFJ)

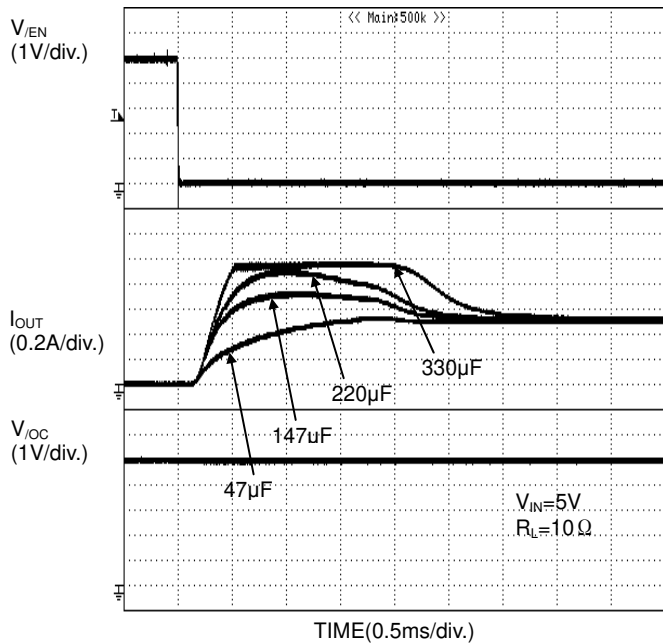


Figure 28. Inrush current (BD2041AFJ)

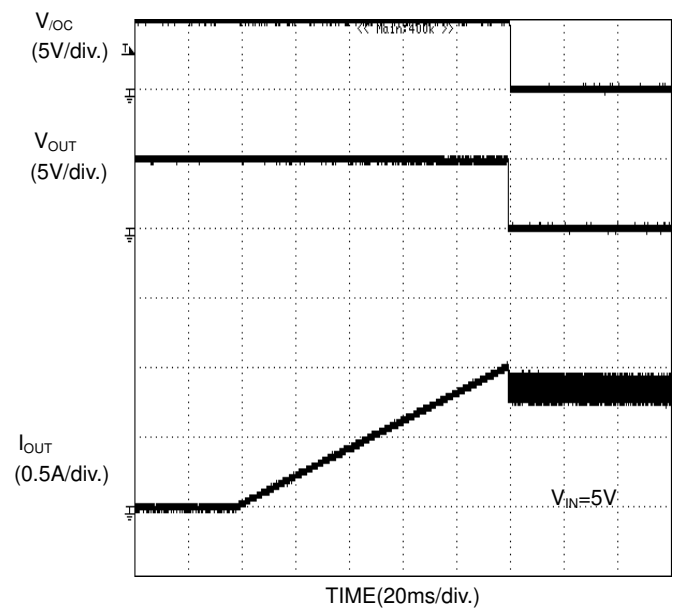


Figure 29. Over current response Ramped load (BD2041AFJ)

● Typical Wave Forms – Continued

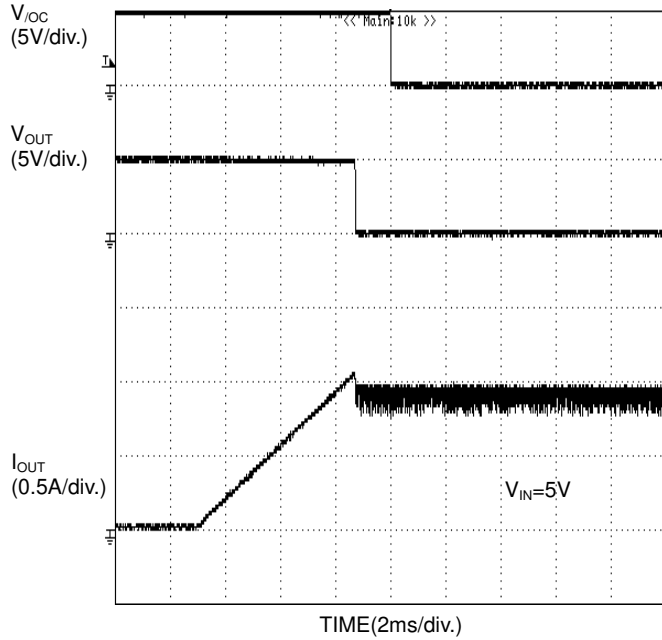


Figure 30. Over current response  
Ramped load  
(BD2041AFJ)

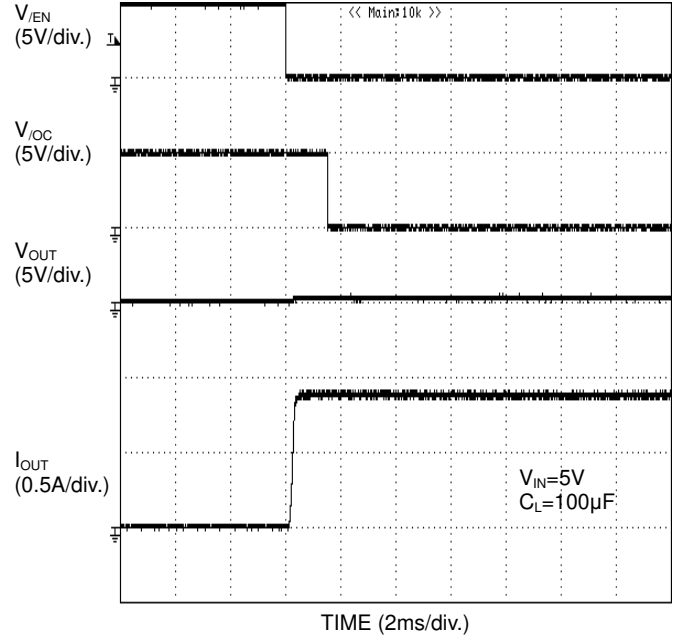


Figure 31. Over current response  
Enable to shortcircuit  
(BD2041AFJ)

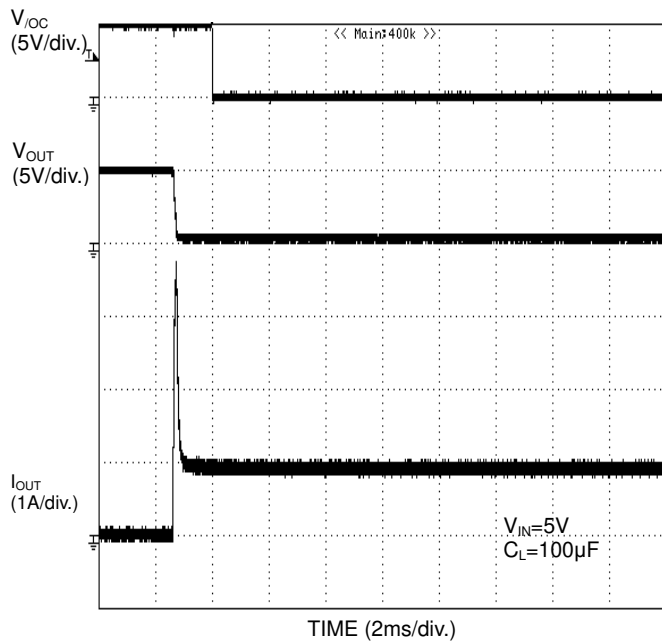


Figure 32. Over current response  
Output shortcircuit at Enable  
(BD2041AFJ)

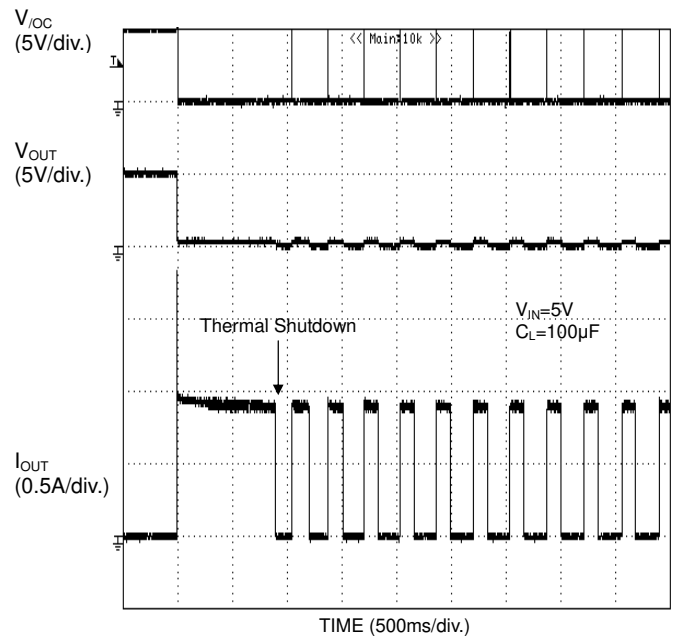


Figure 33. Over current response  
Output shortcircuit at Enable  
(BD2041AFJ)



● Typical Wave Forms – Continued

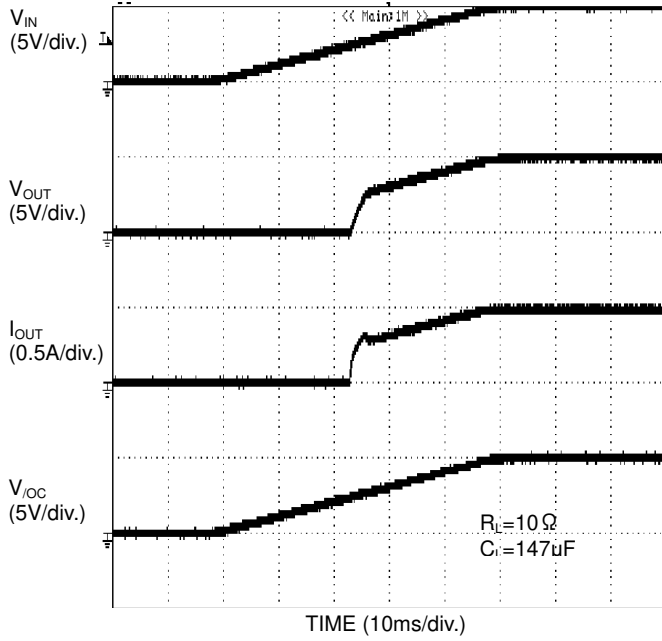


Figure 34. UVLO  
V<sub>DD</sub> increasing  
(BD2041AFJ)

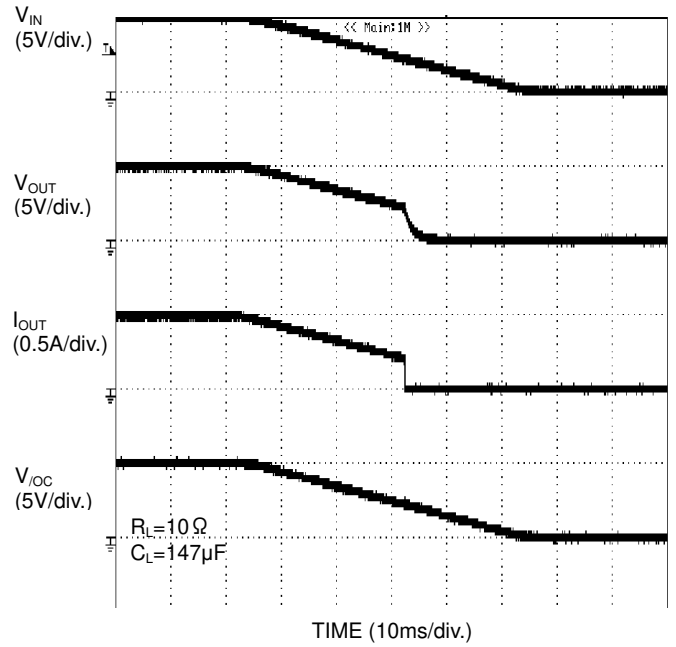
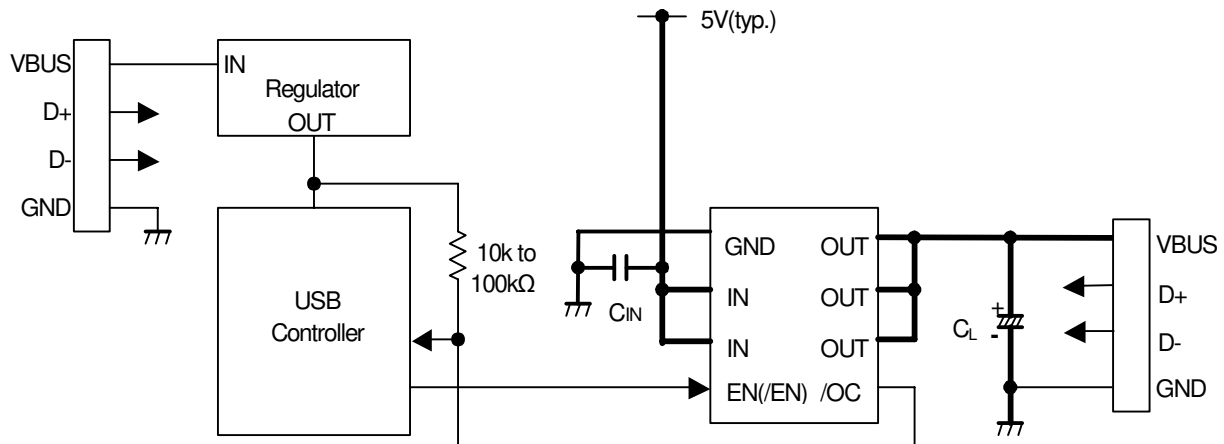


Figure 35. UVLO  
V<sub>DD</sub> decreasing  
(BD2041AFJ)

Regarding the output rise/fall and over current detection characteristics of BD2051AFJ, refer to the characteristic of BD2041AFJ.

## ● Typical Application Circuit



## ● Application Information

When excessive current flows owing to output shortcircuit or so, ringing occurs by inductance of power source line to IC, and may cause bad influences upon IC actions. In order to avoid this case, connect a bypass capacitor by IN terminal and GND terminal of IC.  $1\mu\text{F}$  or higher is recommended.

Pull up /OC output by resistance  $10\text{k}\Omega$  to  $100\text{k}\Omega$ .

Set up value which satisfies the application as  $C_L$ .

This system connection diagram doesn't guarantee operating as the application.

The external circuit constant and so on is changed and it uses, in which there are adequate margins by taking into account external parts or dispersion of IC including not only static characteristics but also transient characteristics.

## ● Functional Description

### 1. Switch operation

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

When the switch is turned on from EN/EN control input, IN terminal and OUT terminal are connected by a  $80\text{m}\Omega$  switch. In on status, the switch is bidirectional. Therefore, when the potential of OUT terminal is higher than that of IN terminal, current flows from OUT terminal to IN terminal.

Since a parasitic diode between the drain and the source of switch MOSFET is canceled, in the off status, it is possible to prevent current from flowing reversely from OUT to IN.

### 2. Thermal shutdown circuit (TSD)

If over current would continue, the temperature of the IC would increase drastically. If the junction temperature were beyond  $140^\circ\text{C}$  (typ.) in the condition of over current detection, thermal shutdown circuit operates and makes power switch turn off and outputs error flag (/OC). Then, when the junction temperature decreases lower than  $120^\circ\text{C}$  (typ.), power switch is turned on and error flag (/OC) is cancelled. Unless the fact of the increasing chips 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 error 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 soon.

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

When the output shortcircuits or large capacity is connected while the switch is on, very large current flows until the over current limit circuit reacts. When the current detection, 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  $V_{IN}$  exceeds 2.3V(Typ.). If the  $V_{IN}$  drops below 2.2V(Typ.) while the switch turns on, then UVLO shuts off the power switch. UVLO has hysteresis of a 100mV(Typ.).

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

5. Error flag (/OC) output

Error flag output is N-MOS open drain output. At detection of over current, thermal shutdown, low level is output.

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.

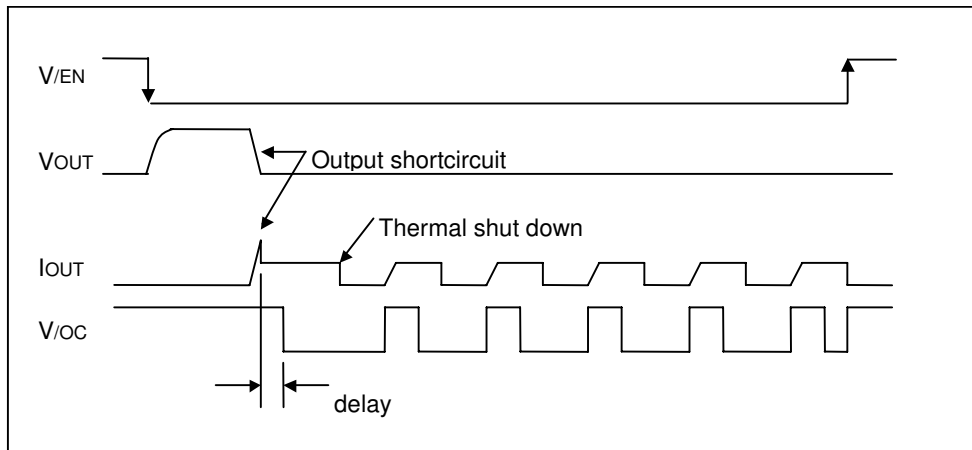


Figure 36. Over current detection, thermal shutdown timing (BD2041AFJ)

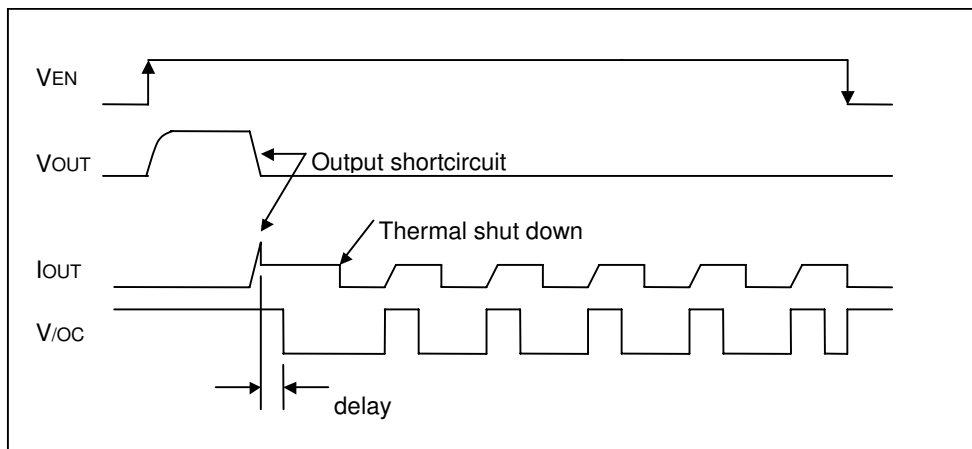


Figure 37. Over current detection, thermal shutdown timing (BD2051AFJ)

● Power Dissipation  
(SOP-J8)

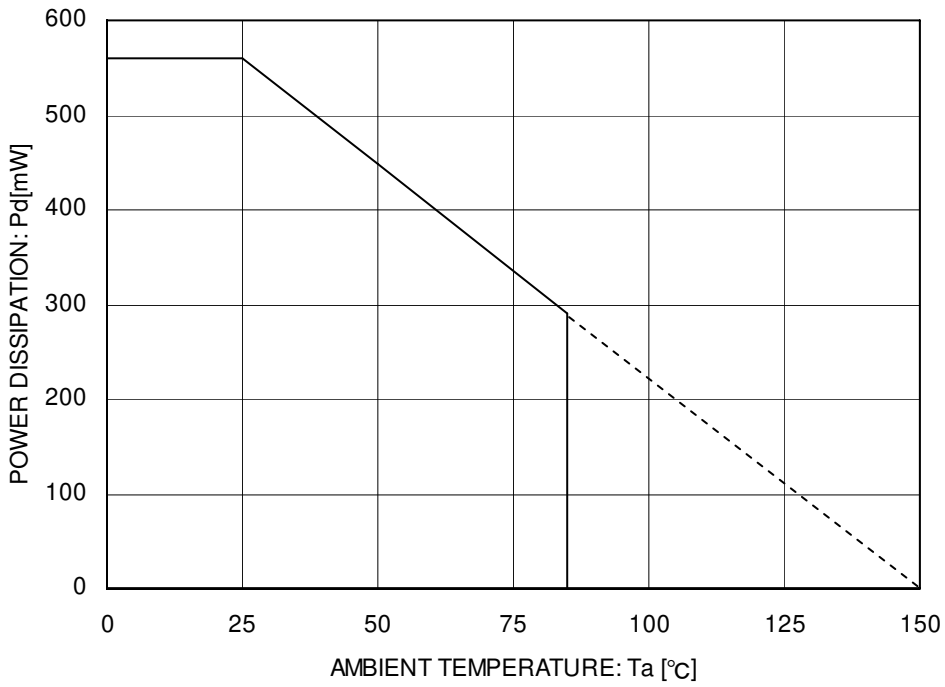


Figure 38. Power dissipation curve (Pd-Ta Curve)

● I/O Equivalence Circuit

Symbol	Pin No	Equivalence circuit
EN(/EN)	4	
/OC	5	
OUT	6,7,8	

**●Operational Notes**

- (1) Absolute Maximum Ratings  
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given to take physical safety measures including the use of fuses, etc.
- (2) Operating conditions  
These conditions represent a range within which characteristics can be provided approximately as expected. The electrical characteristics are guaranteed under the conditions of each parameter.
- (3) Reverse connection of power supply connector  
The reverse connection of power supply connector can break down ICs. Take protective measures against the breakdown due to the reverse connection, such as mounting an external diode between the power supply and the IC's power supply terminal.
- (4) Power supply line  
Design PCB pattern to provide low impedance for the wiring between the power supply and the GND lines. In this regard, for the digital block power supply and the analog block power supply, even though these power supplies has the same level of potential, separate the power supply pattern for the digital block from that for the analog block, thus suppressing the diffraction of digital noises to the analog block power supply resulting from impedance common to the wiring patterns. For the GND line, give consideration to design the patterns in a similar manner.  
Furthermore, for all power supply terminals to ICs, mount a capacitor between the power supply and the GND terminal. At the same time, in order to use an electrolytic capacitor, thoroughly check to be sure the characteristics of the capacitor to be used present no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.
- (5) GND voltage  
Make setting of the potential of the GND terminal so that it will be maintained at the minimum in any operating state. Furthermore, check to be sure no terminals are at a potential lower than the GND voltage including an actual electric transient.
- (6) Short circuit between terminals and erroneous mounting  
In order to mount ICs on a set PCB, pay thorough attention to the direction and offset of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign matters entering between terminals or between the terminal and the power supply or the GND terminal, the ICs can break down.
- (7) Operation in strong electromagnetic field  
Be noted that using ICs in the strong electromagnetic field can malfunction them.
- (8) Inspection with set PCB  
On the inspection with the set PCB, if a capacitor is connected to a low-impedance IC terminal, the IC can suffer stress. Therefore, be sure to discharge from the set PCB by each process. Furthermore, in order to mount or dismount the set PCB to/from the jig for the inspection process, be sure to turn OFF the power supply and then mount the set PCB to the jig. After the completion of the inspection, be sure to turn OFF the power supply and then dismount it from the jig. In addition, for protection against static electricity, establish a ground for the assembly process and pay thorough attention to the transportation and the storage of the set PCB.
- (9) Input terminals  
In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input terminal. Therefore, pay thorough attention not to handle the input terminals, such as to apply to the input terminals a voltage lower than the GND respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input terminals when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input terminals a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.

## (10) Ground wiring pattern

If small-signal GND and large-current GND are provided, it will be recommended to separate the large-current GND pattern from the small-signal GND pattern and establish a single ground at the reference point of the set PCB so that resistance to the wiring pattern and voltage fluctuations due to a large current will cause no fluctuations in voltages of the small-signal GND. Pay attention not to cause fluctuations in the GND wiring pattern of external parts as well.

## (11) External capacitor

In order to use a ceramic capacitor as the external capacitor, determine the constant with consideration given to a degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.

## (12) Thermal shutdown circuit (TSD)

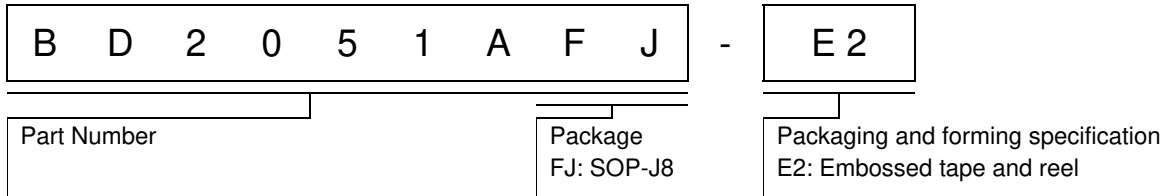
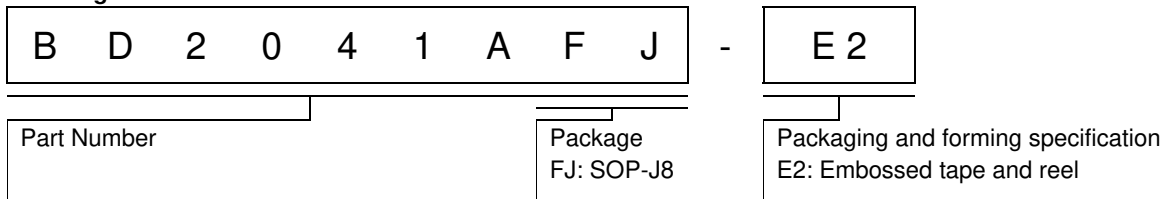
When junction temperatures become detected temperatures or higher, the thermal shutdown circuit operates and turns a switch OFF. The thermal shutdown circuit is aimed at isolating the LSI from thermal runaway as much as possible. Do not continuously use the LSI with this circuit operating or use the LSI assuming its operation.

## (13) Thermal design

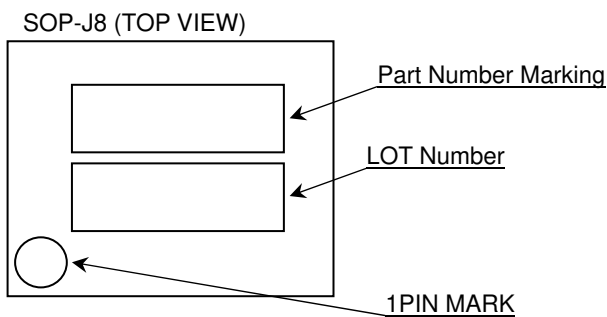
Perform thermal design in which there are adequate margins by taking into account the power dissipation (Pd) in actual states of use.



● Ordering Information

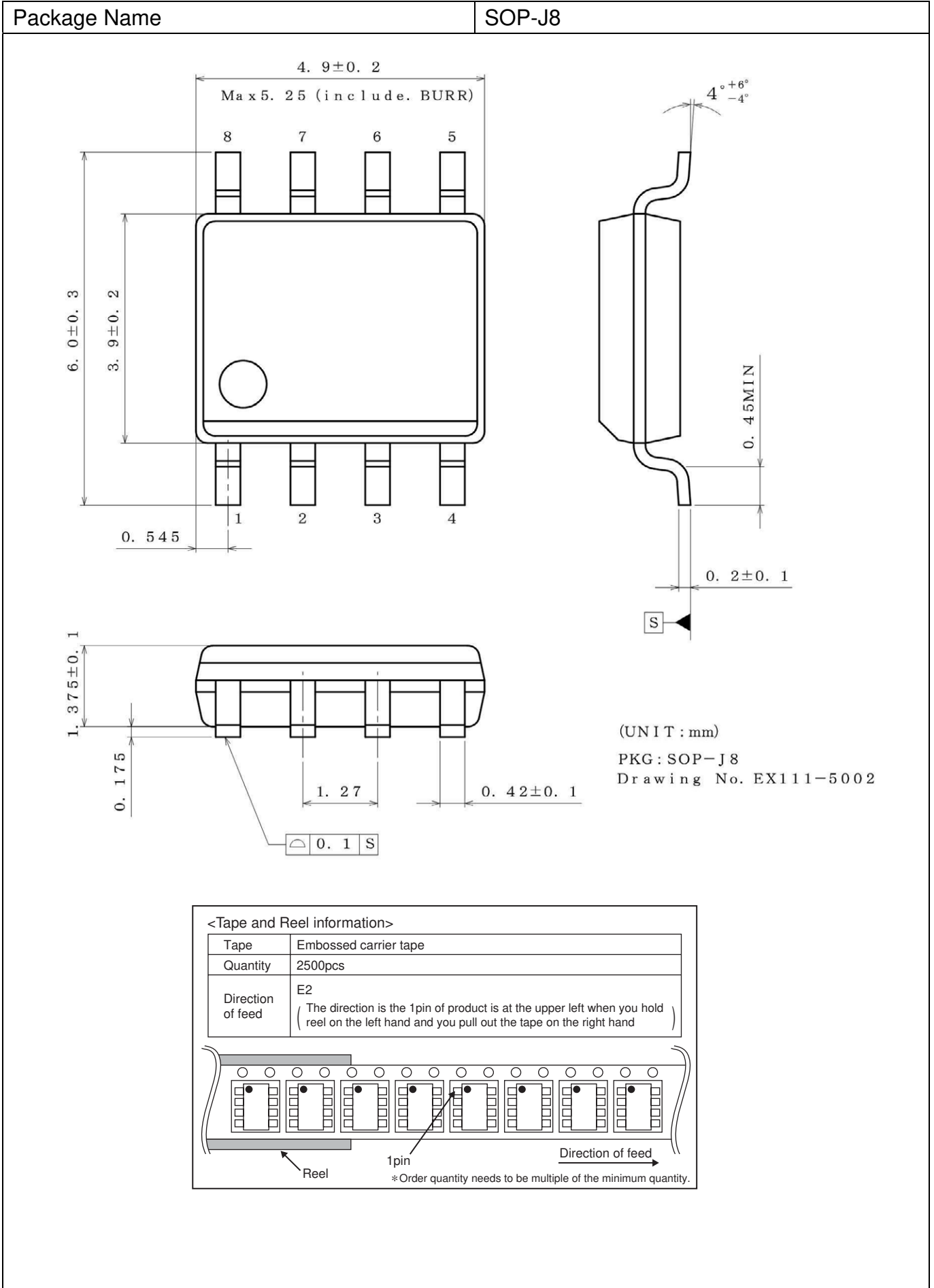


● Marking Diagram



Part Number	Part Number Marking
BD2041AFJ	D041A
BD2051AFJ	D051A

●Physical Dimension, Tape and Reel Information



## ●Revision History

Date	Revision	Changes
08.Mar.2013	001	New Release

# Notice

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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<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.
- 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 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.

● **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**

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