

## 1 Channel Compact High Side Switch ICs

# 0.76A Current Limit High Side Switch ICs

### BD22641G-M

#### General Description

BD22641G-M is a low on-resistance N-channel MOSFET high-side power switch, optimized for Universal Serial Bus (USB) applications. BD22641G-M is 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:	120mΩ(Typ)
■ Over-Current Threshold:	0.76A(Typ)
■ Standby Current:	0.01μA (Typ)
■ Operating Temperature Range:	-40°C to +105°C

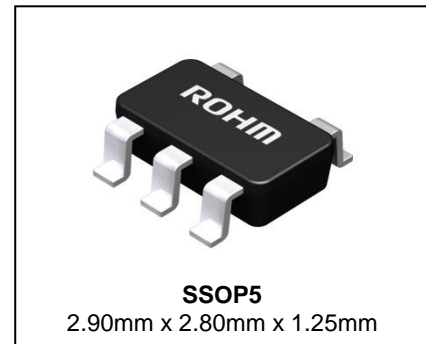
#### Features

- AEC-Q100 Qualified<sup>(Note1)</sup>
- Over Current Threshold: 0.76A
- Built-in Low ON-Resistance (Typ 120mΩ)
- N-Channel MOSFET
- Reverse Current Protection when Power Switch Off
- Thermal Shutdown
- Under-Voltage Lockout
- Open-Drain Error Flag Output
- Output Discharge Function
- Soft Start Circuit
- Control Input Logic : Active-High

(Note1: Grade2)

#### Package

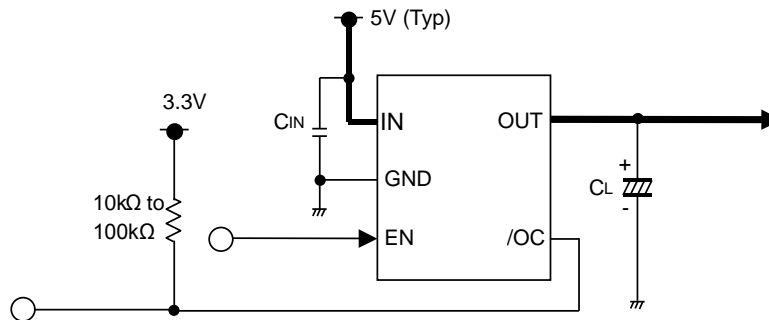
W(Typ) x D(Typ) x H(Max)



#### Applications

Car accessory, Industrial applications

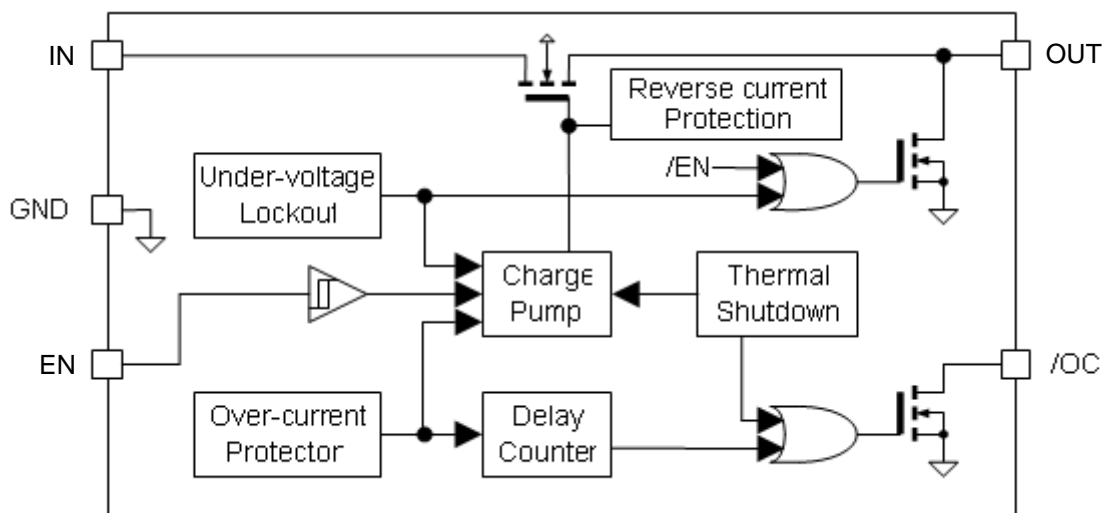
#### Typical Application Circuit



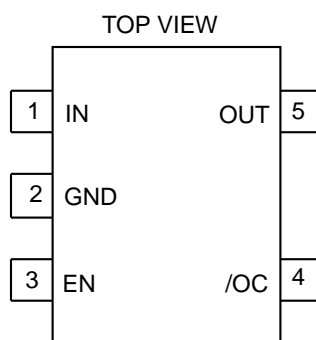
#### Lineup

Over-Current Threshold			Control Input Logic	Package		Orderable Part Number
Min	Typ	Max				
0.57A	0.76A	0.96A	High	SSOP5	Reel of 3000	BD22641G-MTR

## Block Diagram



## Pin Configurations



## Pin Description

Pin No.	Symbol	I/O	Function
1	IN	-	Switch input and supply voltage for the IC.
2	GND	-	Ground.
3	EN	I	Enable input. EN: High level input turns on the switch.
4	/OC	O	Over-current detection pin. Low level output during over-current or over-temperature condition. Open-drain fault flag output.
5	OUT	O	Switch output.

## Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
IN Supply Voltage	$V_{IN}$	-0.3 to +6.0	V
EN Input Voltage	$V_{EN}$	-0.3 to +6.0	V
/OC Voltage	$V_{/OC}$	-0.3 to +6.0	V
/OC Sink Current	$I_{/OC}$	5	mA
OUT Voltage	$V_{OUT}$	-0.3 to +6.0	V
Storage Temperature	$T_{stg}$	-55 to +150	°C

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

Thermal Resistance<sup>(Note1)</sup>

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s <sup>(Note3)</sup>	2s2p <sup>(Note4)</sup>	
SSOP5				
Junction to Ambient	θ <sub>JA</sub>	376.5	185.4	°C/W
Junction to Top Characterization Parameter <sup>(Note2)</sup>	Ψ <sub>JT</sub>	40	30	°C/W

(Note1)Based on JESD51-2A(Still-Air)

(Note2)The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note3)Using a PCB board based on JESD51-3.

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

Top	
Copper Pattern	Thickness
Footprints and Traces	70μm

(Note4)Using a PCB board based on JESD51-7.

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

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70μm	74.2mm <sup>2</sup> (Square)	35μm	74.2mm <sup>2</sup> (Square)	70μm

Recommended Operating Conditions (T<sub>j</sub>= -40°C to +105°C)

Parameter	Symbol	Rating			Unit
		Min	Typ	Max	
IN Operating Voltage	$V_{IN}$	2.7	5.0	5.5	V
Continuous Current	$I_{OMAX}$	-	-	500	mA

**Electrical Characteristics**(V<sub>IN</sub> = 5V, T<sub>j</sub> = -40 to +105°C, unless otherwise specified.)**DC Characteristics**

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Operating Current	I <sub>DD</sub>	-	110	200	μA	V <sub>EN</sub> = 5V V <sub>OUT</sub> = open
Standby Current	I <sub>STB</sub>	-	0.01	5	μA	V <sub>EN</sub> = 0V V <sub>OUT</sub> = open
EN Input Voltage	V <sub>ENH</sub>	2.0	-	-	V	High Input, V <sub>IN</sub> = 3.3 to 5V
	V <sub>ENL</sub>	-	-	0.8	V	Low Input, V <sub>IN</sub> = 5V
	V <sub>ENL</sub>	-	-	0.6	V	Low Input, V <sub>IN</sub> = 3.3V
EN Input Leakage	I <sub>EN</sub>	-1	+0.01	+1	μA	V <sub>EN</sub> = 0V or 5V
ON-Resistance	R <sub>ON</sub>	-	120	165	mΩ	V <sub>IN</sub> = 5V, I <sub>OUT</sub> = 500mA T <sub>j</sub> = 25°C
		-	120	250		V <sub>IN</sub> = 5V, I <sub>OUT</sub> = 500mA T <sub>j</sub> = -40°C to +105°C
		-	140	190		V <sub>IN</sub> = 3.3V, I <sub>OUT</sub> = 500mA T <sub>j</sub> = 25°C
		-	140	270		V <sub>IN</sub> = 3.3V, I <sub>OUT</sub> = 500mA T <sub>j</sub> = -40°C to +105°C
Reverse Leak Current	I <sub>REV</sub>	-	-	1.0	μA	V <sub>OUT</sub> = 5.0V, V <sub>IN</sub> = 0V
Over-Current Threshold	I <sub>TH</sub>	570	765	960	mA	V <sub>IN</sub> = 5V
		550	740	930		V <sub>IN</sub> = 3.3V
Short Circuit Output Current	I <sub>SC</sub>	320	500	680	mA	V <sub>IN</sub> = 3.3 to 5V, V <sub>OUT</sub> = 0V, RMS
Output Discharge Resistance	R <sub>DISC</sub>	15	60	165	Ω	I <sub>DISC</sub> = 1mA
/OC Output Low Voltage	V <sub>OC</sub>	-	-	0.4	V	I <sub>OC</sub> = 0.5mA
UVLO Threshold	V <sub>TUVH</sub>	2.1	2.3	2.5	V	V <sub>IN</sub> Increasing
	V <sub>TUVL</sub>	2.0	2.2	2.4	V	V <sub>IN</sub> Decreasing

**AC Characteristics**

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Output Rise Time	t <sub>ON1</sub>	-	1	6	ms	R <sub>L</sub> = 20Ω
Output Turn ON Time	t <sub>ON2</sub>	-	1.5	10	ms	
Output Fall Time	t <sub>OFF1</sub>	-	1	20	μs	
Output Turn OFF Time	t <sub>OFF2</sub>	-	3	40	μs	
/OC Delay Time	t <sub>OC</sub>	9	15	21	ms	

Measurement Circuit

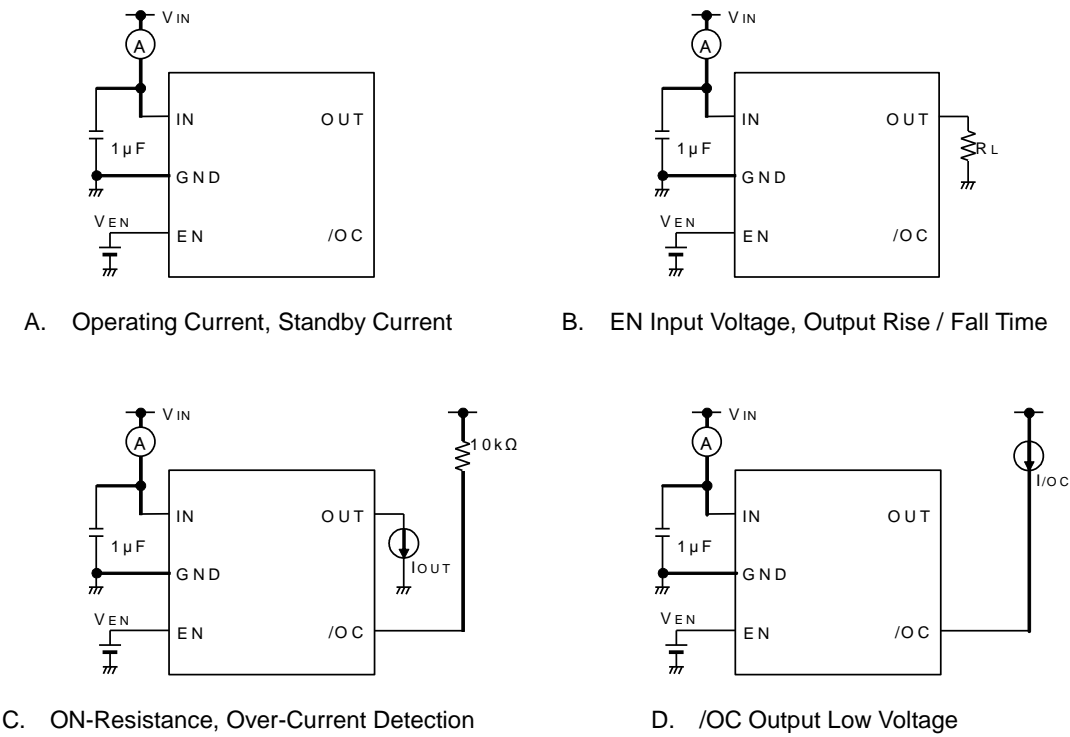


Figure 1. Measurement Circuit

Timing Diagram

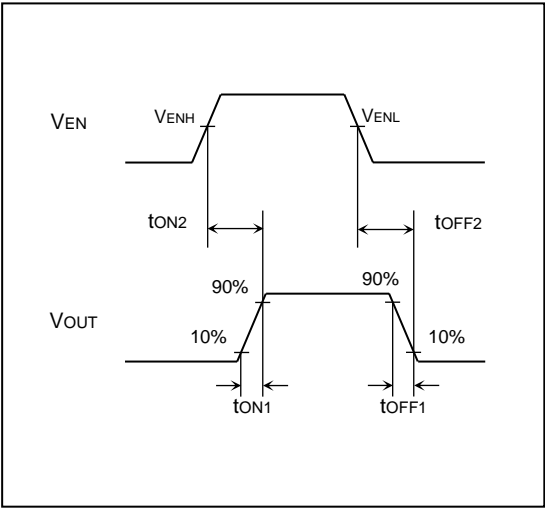


Figure 2. Output Rise / Fall Time

## Typical Performance Curves

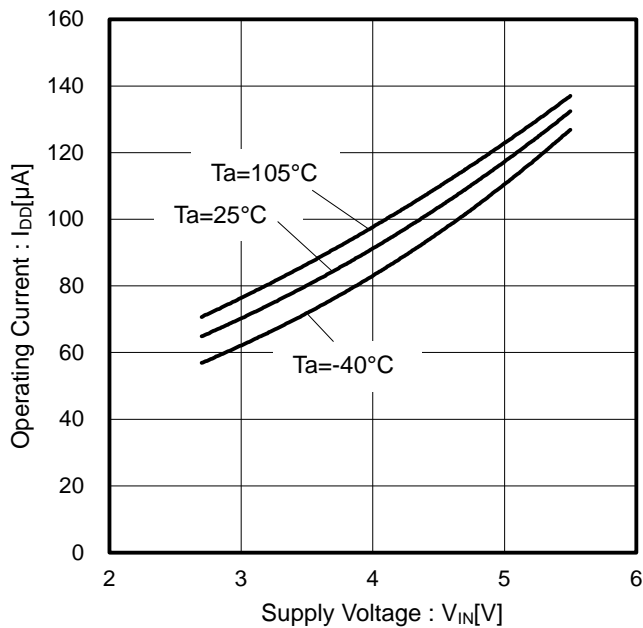


Figure 3. Operating Current vs Supply Voltage (EN Enable)

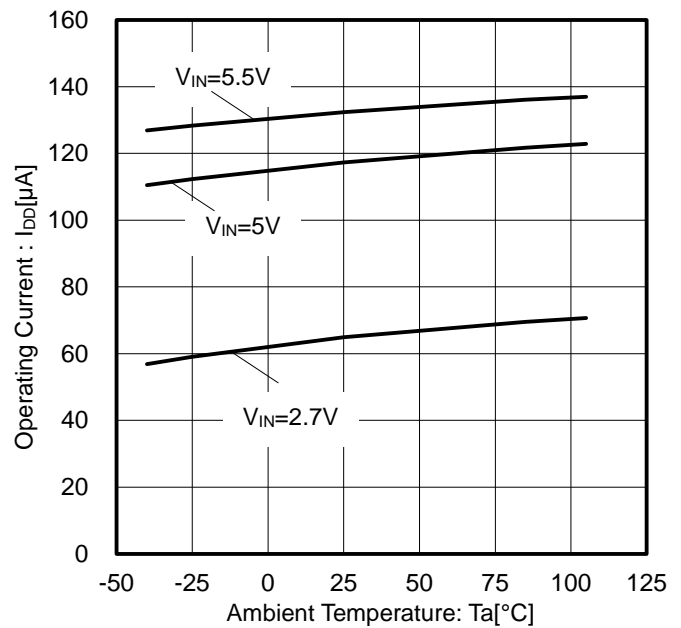


Figure 4. Operating Current vs Ambient Temperature (EN Enable)

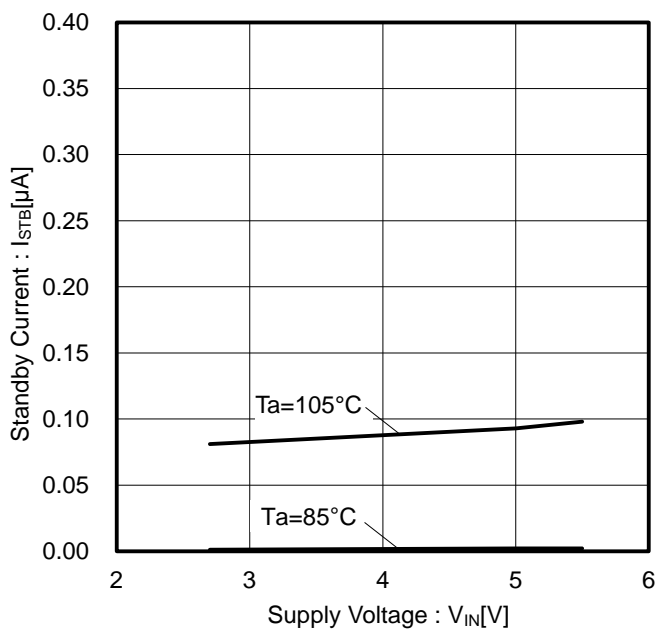


Figure 5. Standby Current vs Supply Voltage (EN Disable)

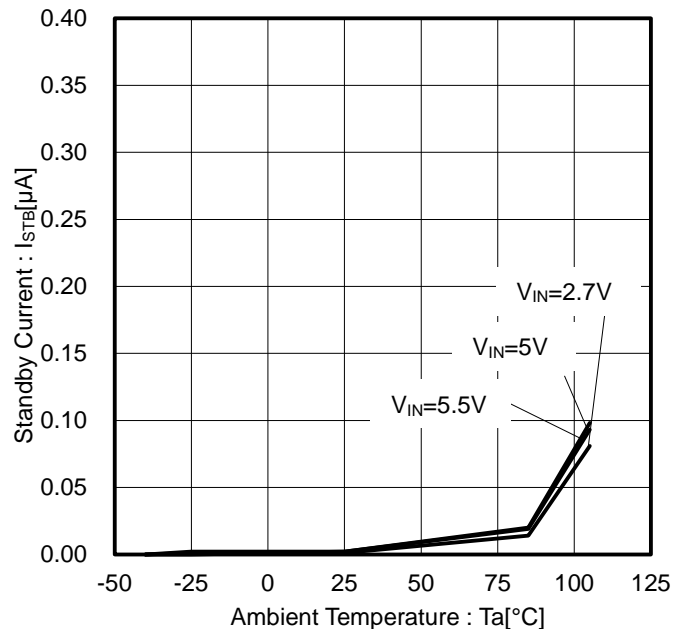


Figure 6. Standby Current vs Ambient Temperature (EN Disable)

## Typical Performance Curves

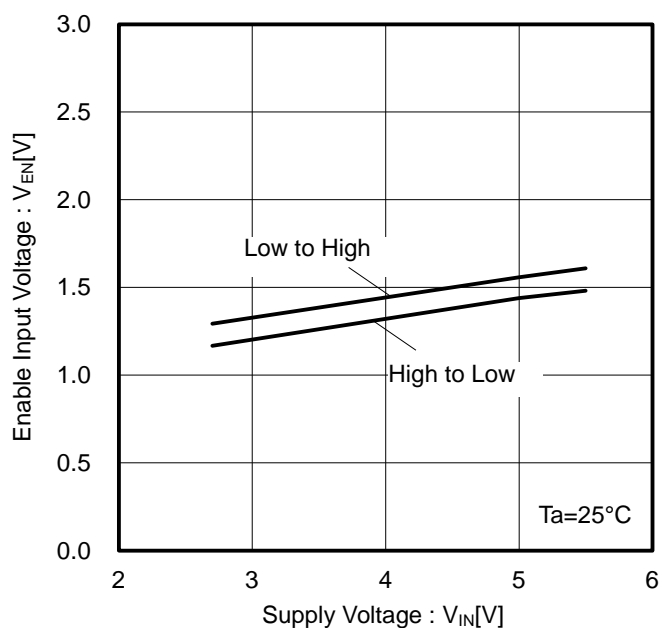


Figure 7. EN Input Voltage vs Supply Voltage  
( $V_{ENH}$ ,  $V_{ENL}$ )

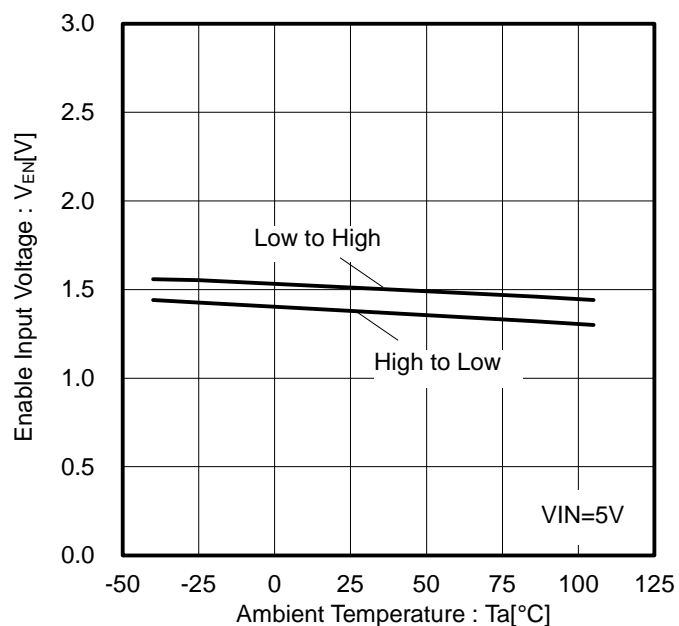


Figure 8. EN Input Voltage vs Ambient Temperature  
( $V_{ENH}$ ,  $V_{ENL}$ )

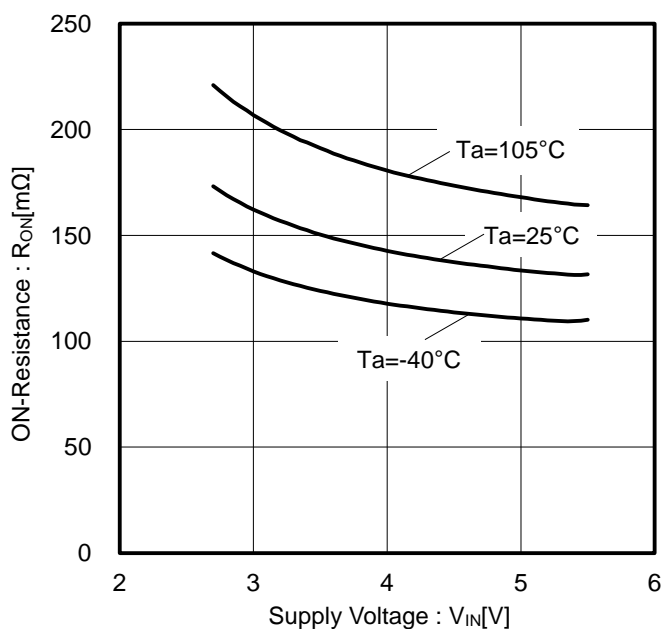


Figure 9 ON-Resistance vs Supply Voltage

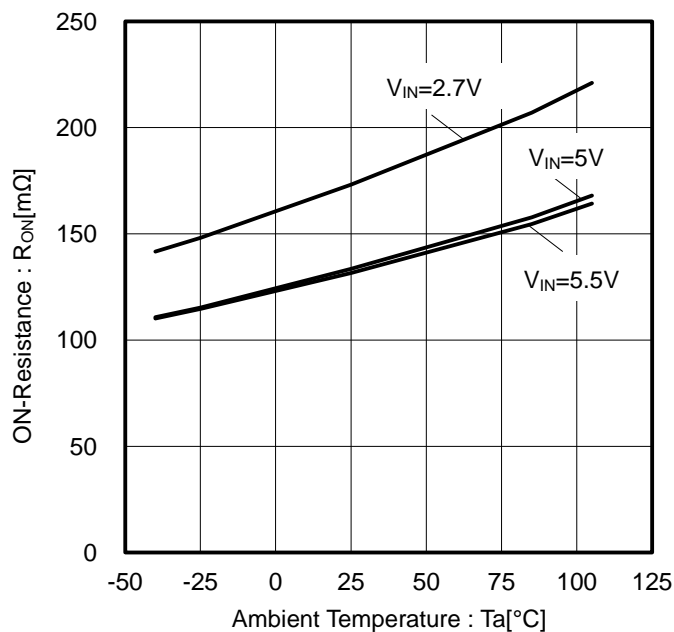


Figure 10. ON-Resistance vs Ambient Temperature

## Typical Performance Curves - continued

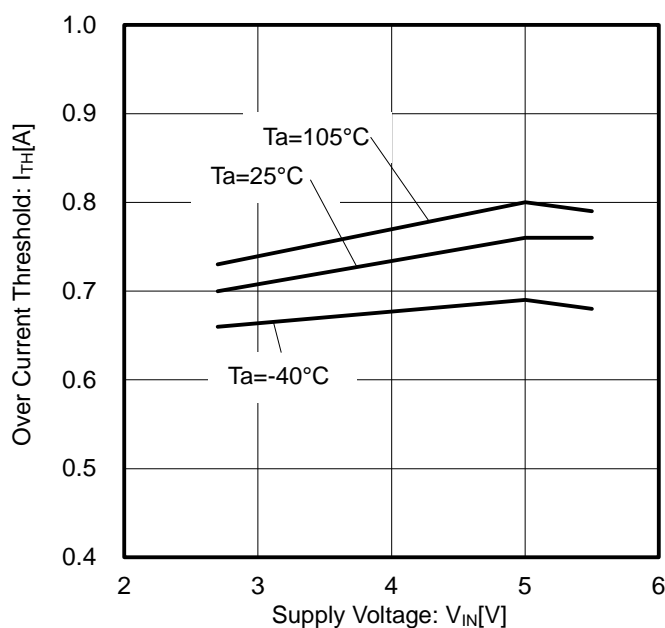


Figure 11. Over-Current Threshold vs Supply Voltage

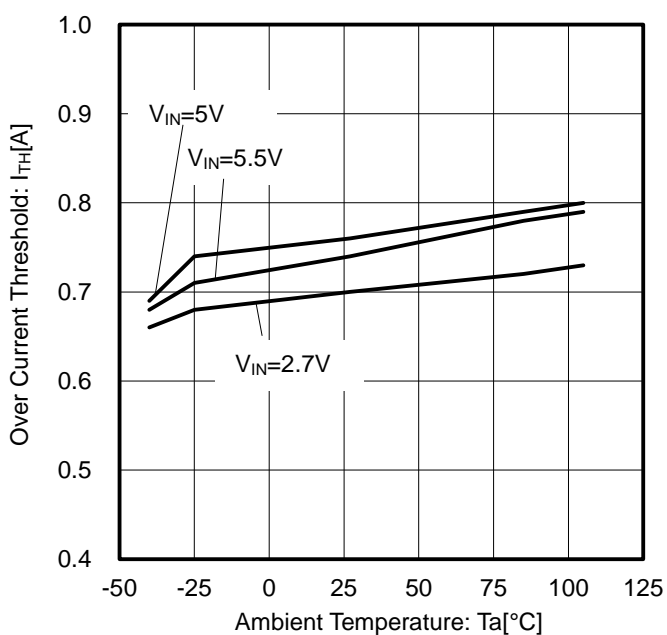


Figure 12. Over-Current Threshold vs Ambient Temperature

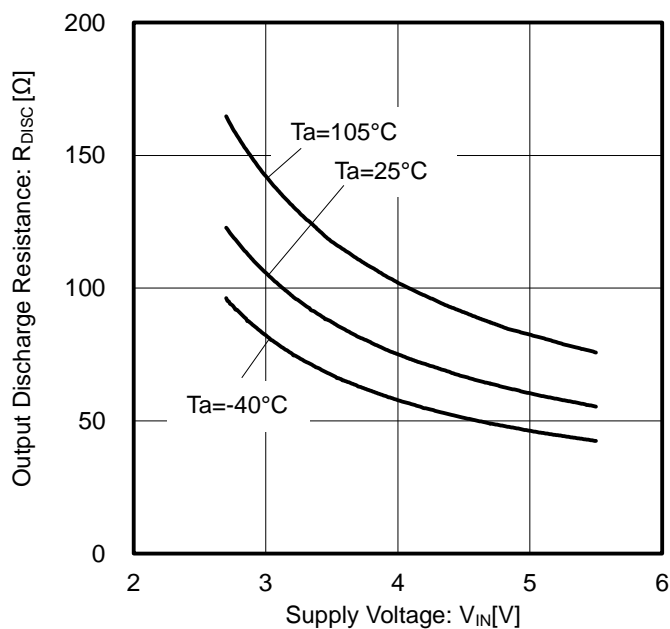


Figure 13. Output Discharge Resistance vs Supply Voltage

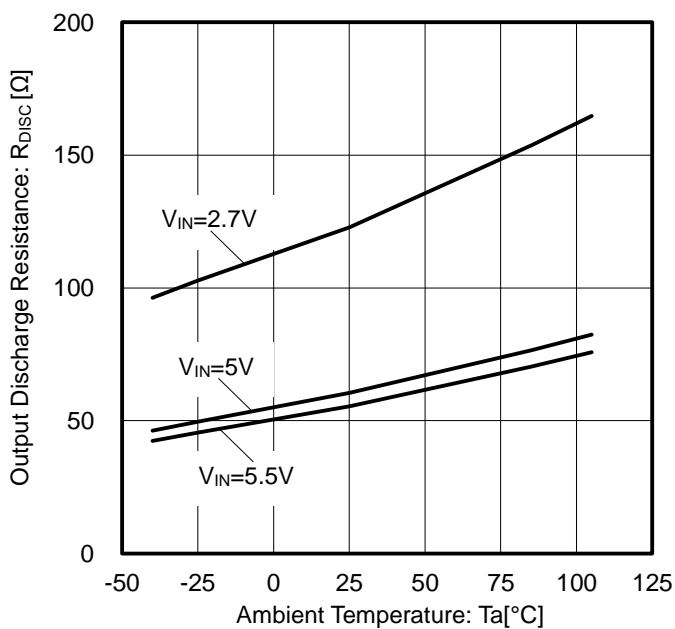


Figure 14. Output Discharge Resistance vs Ambient Temperature



## Typical Performance Curves - continued

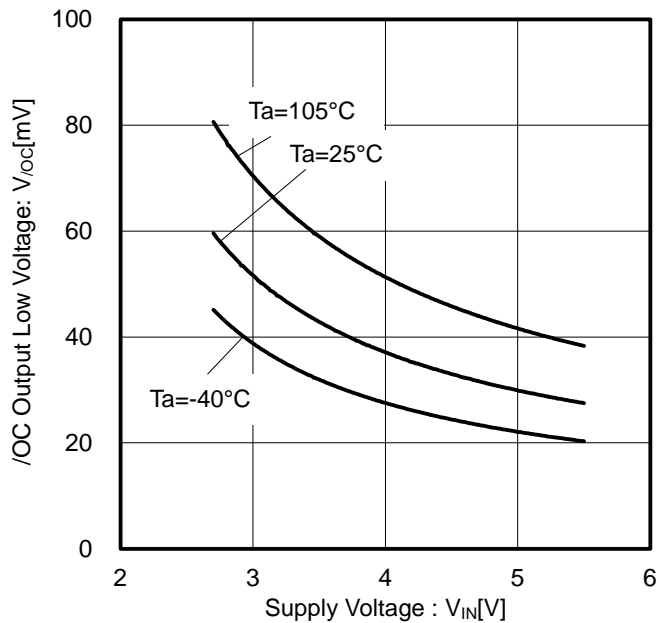


Figure 15. /OC Output Low Voltage vs Supply Voltage

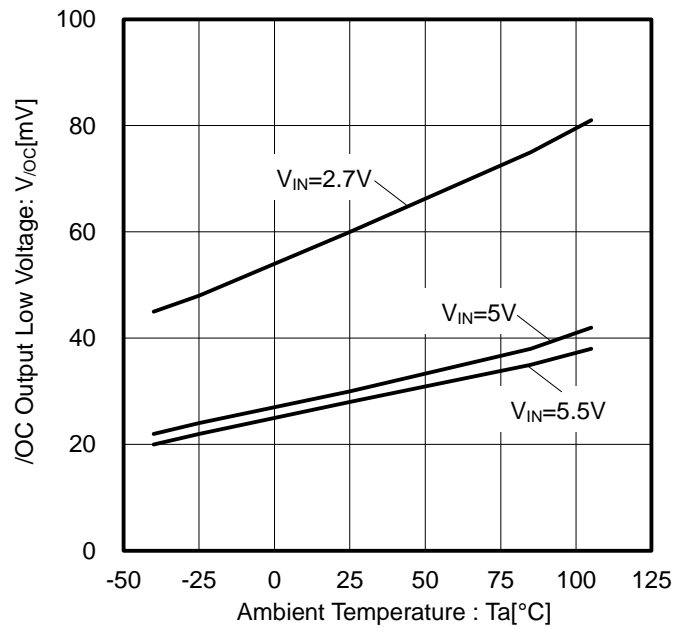


Figure 16. /OC Output Low Voltage vs Ambient Temperature

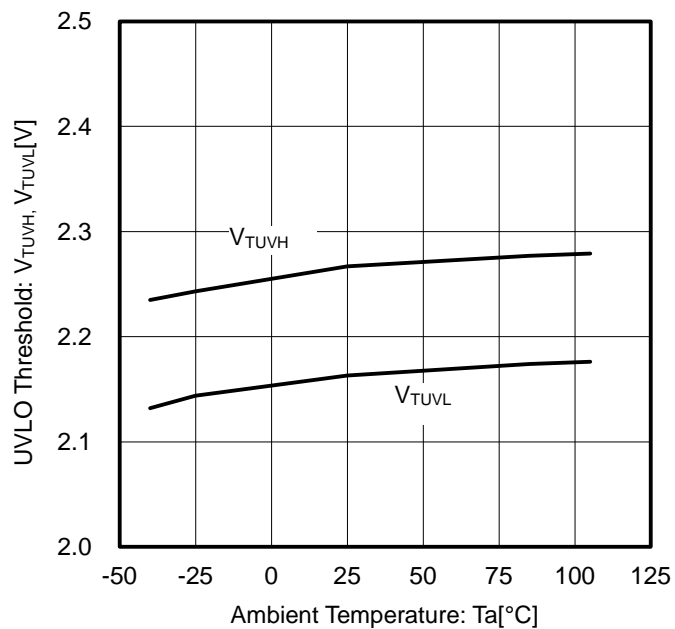


Figure 17. UVLO Threshold Voltage vs Ambient Temperature

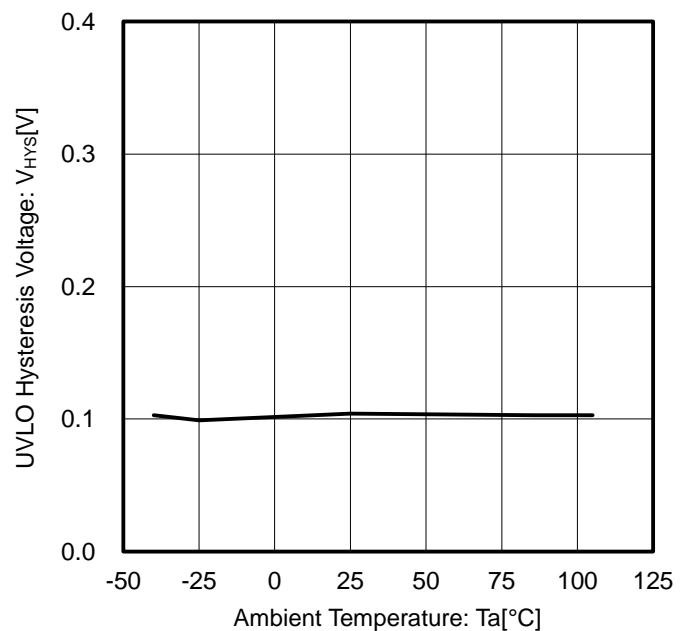


Figure 18. UVLO Hysteresis Voltage vs Ambient Temperature

## Typical Performance Curves - continued

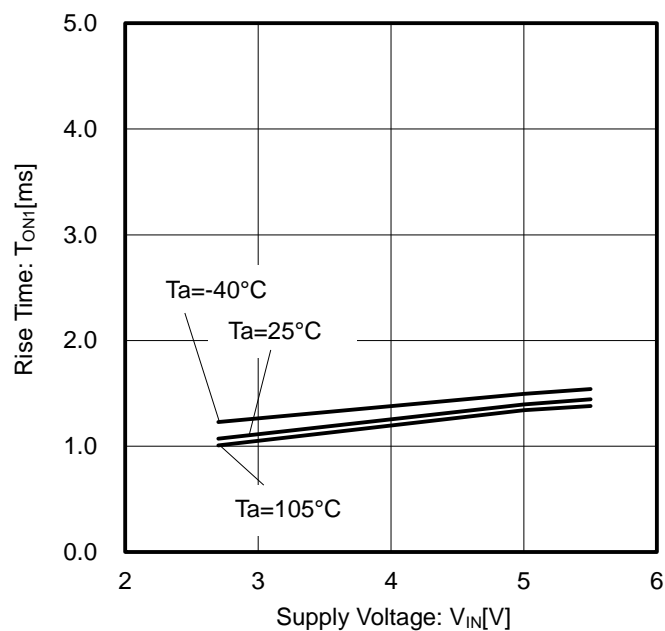


Figure 19. Output Rise Time vs Supply Voltage

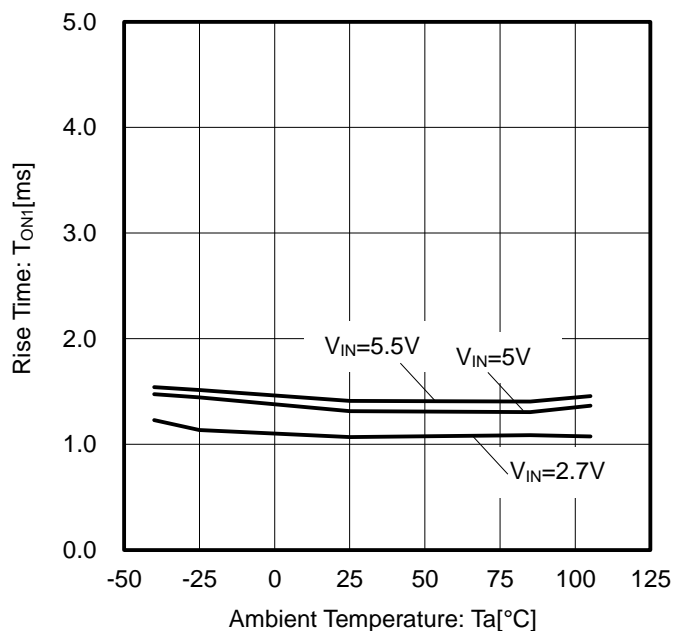


Figure 20. Output Rise Time vs Ambient Temperature

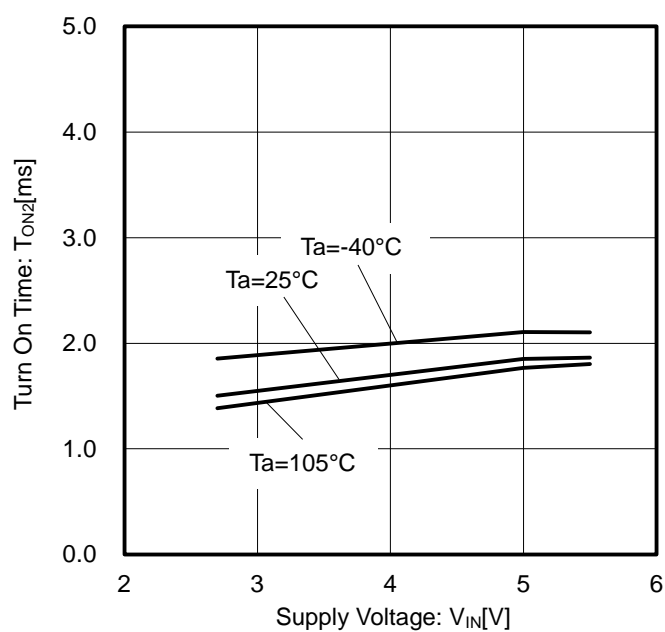


Figure 21. Output Turn-On Time vs Supply Voltage

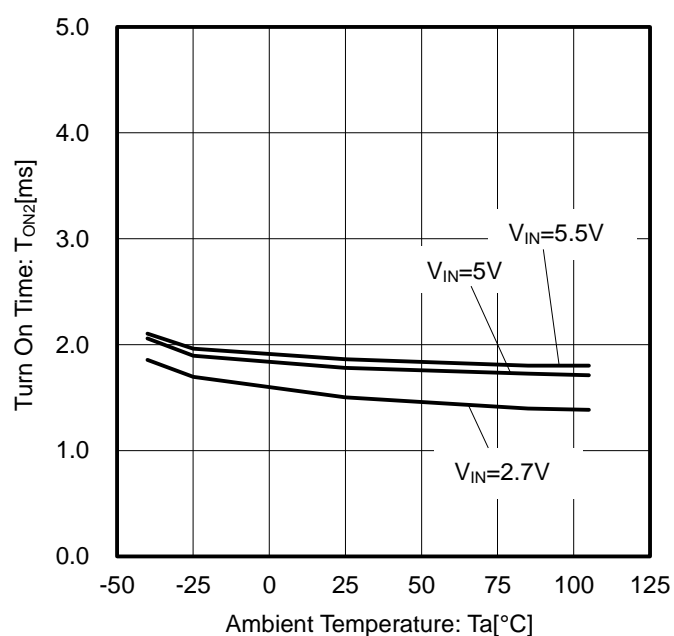


Figure 22. Output Turn-On Time vs Ambient Temperature

## Typical Performance Curves - continued

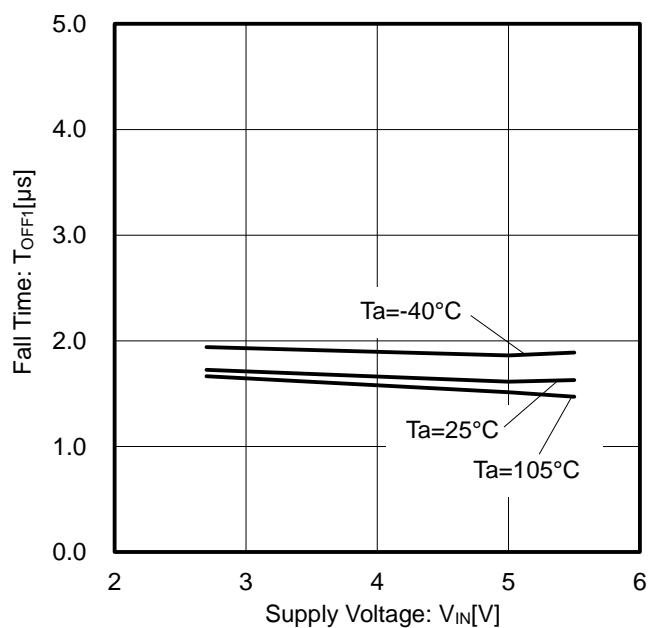


Figure 23. Output Fall Time vs Supply Voltage

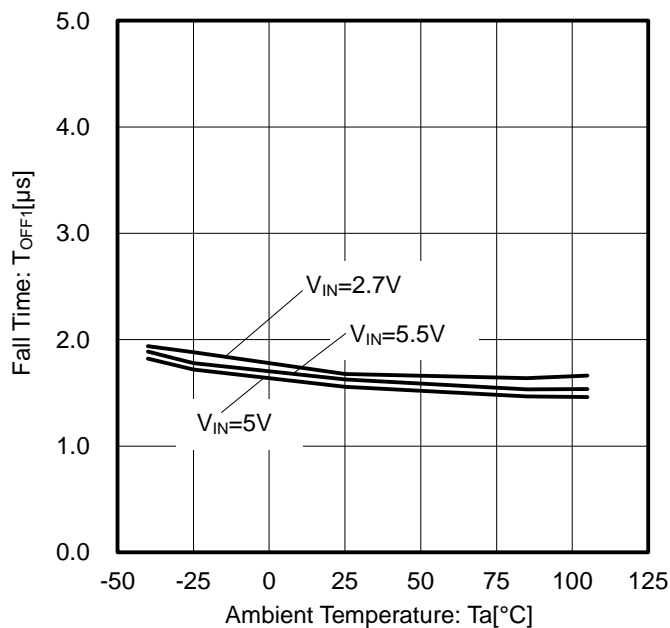


Figure 24. Output Fall Time vs Ambient Temperature

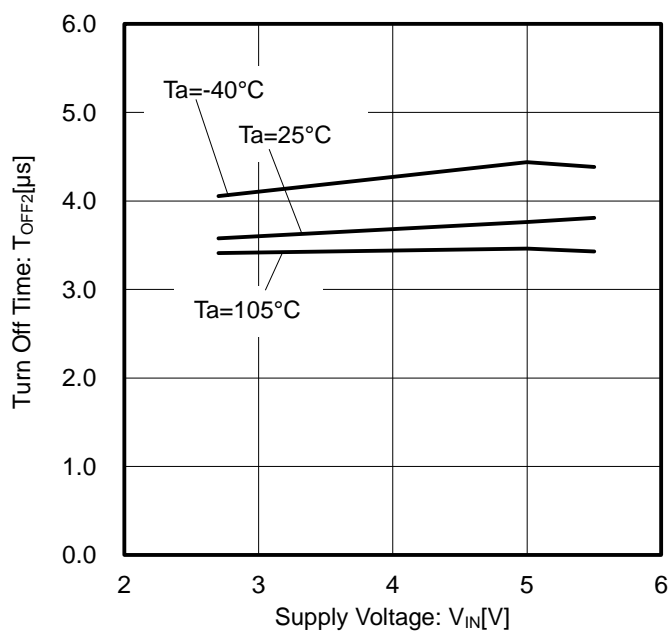


Figure 25. Output Turn-Off Time vs Supply Voltage

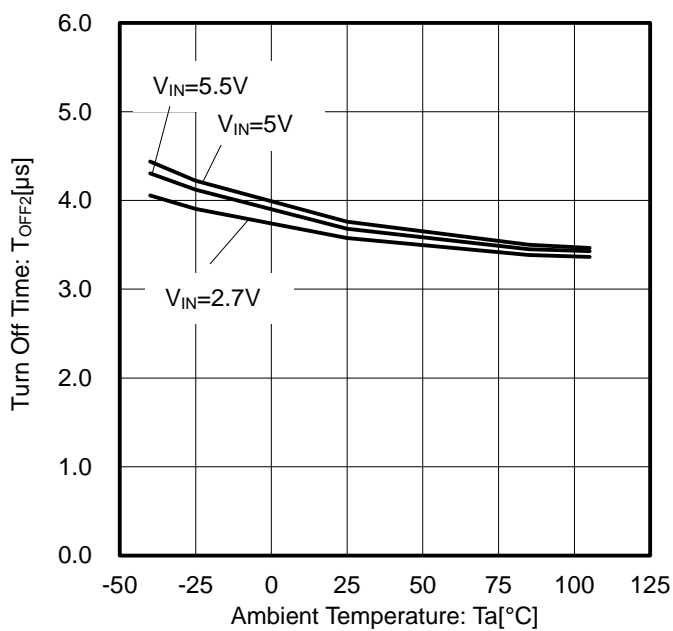


Figure 26. Output Turn-Off Time vs Ambient Temperature

Typical Performance Curves - continued

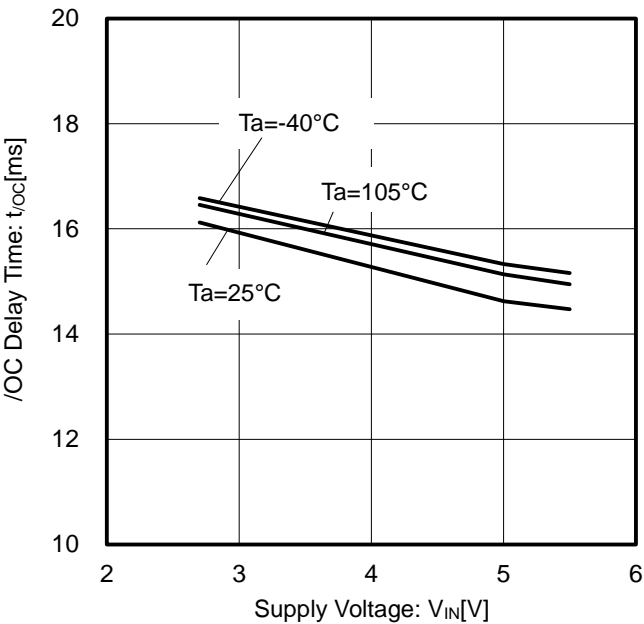


Figure 27. /OC Delay Time vs Supply Voltage

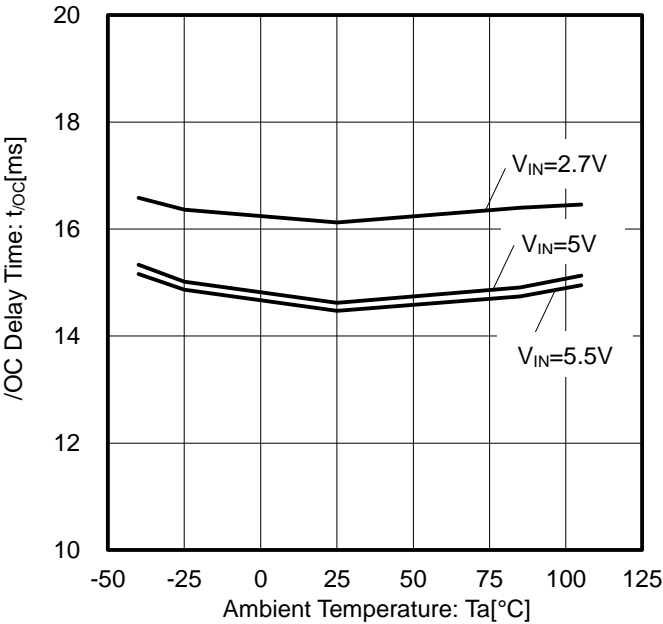


Figure 28. /OC Delay Time vs Ambient Temperature

### Typical Wave Forms

(Ta=25°C, unless otherwise specified)

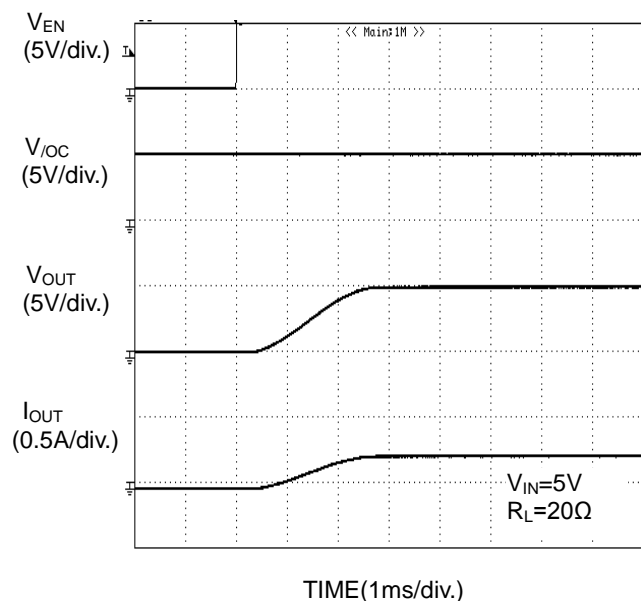


Figure 29. Output Rise Characteristic

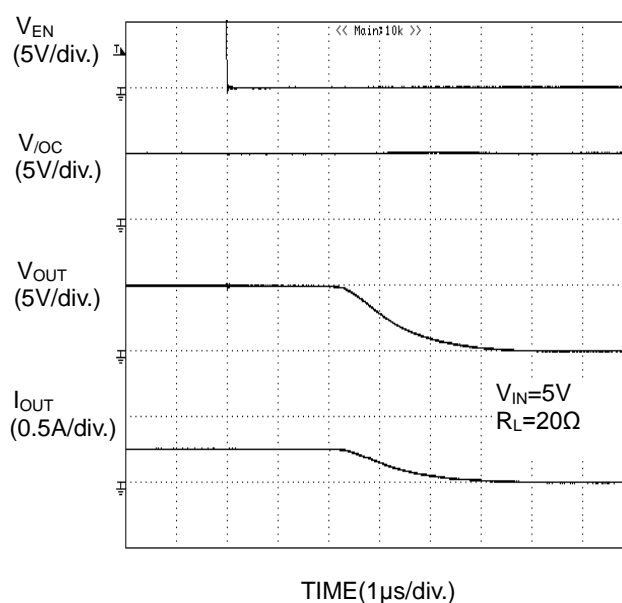


Figure 30. Output Fall Characteristic

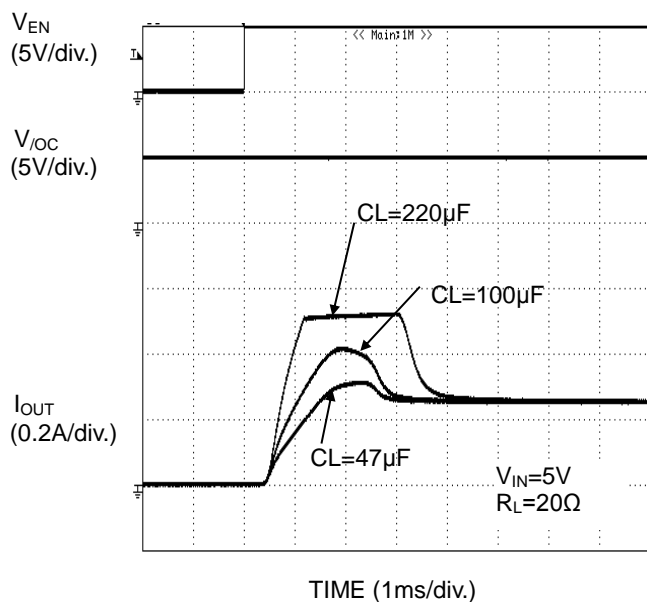


Figure 31. Inrush Current Response

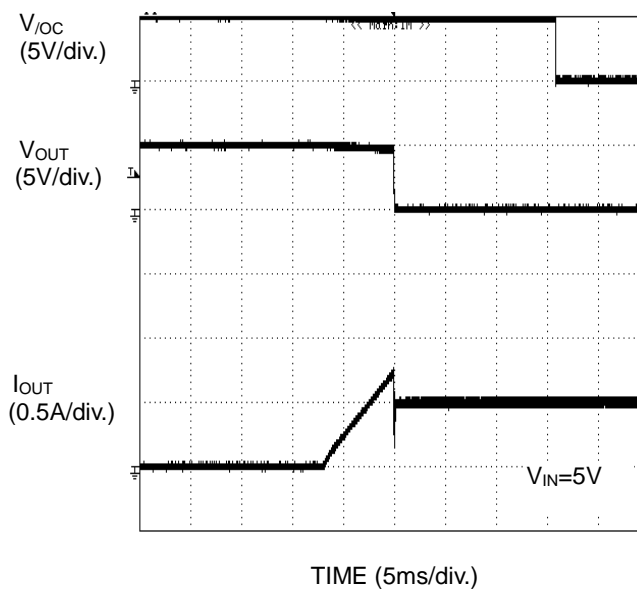
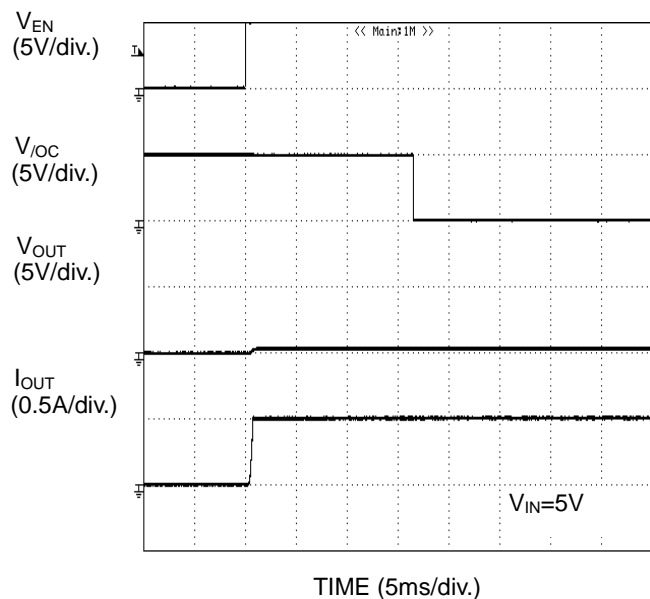
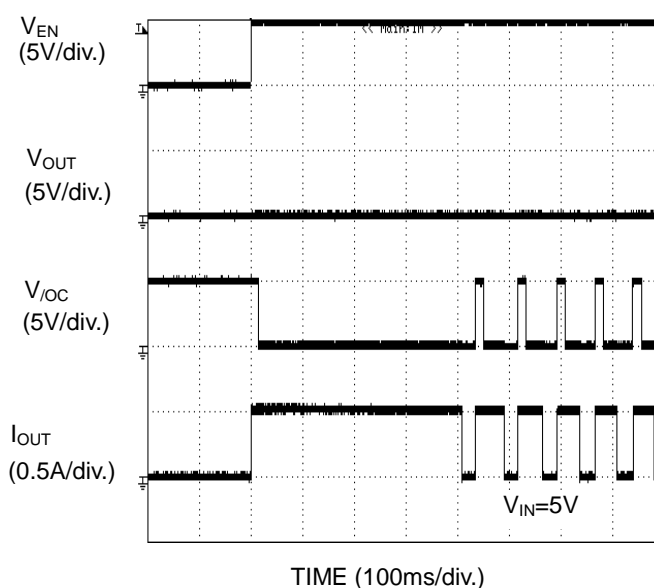
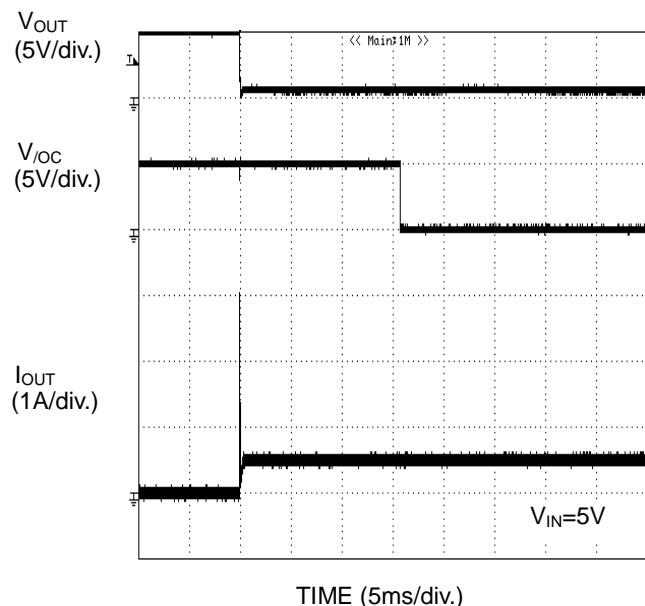
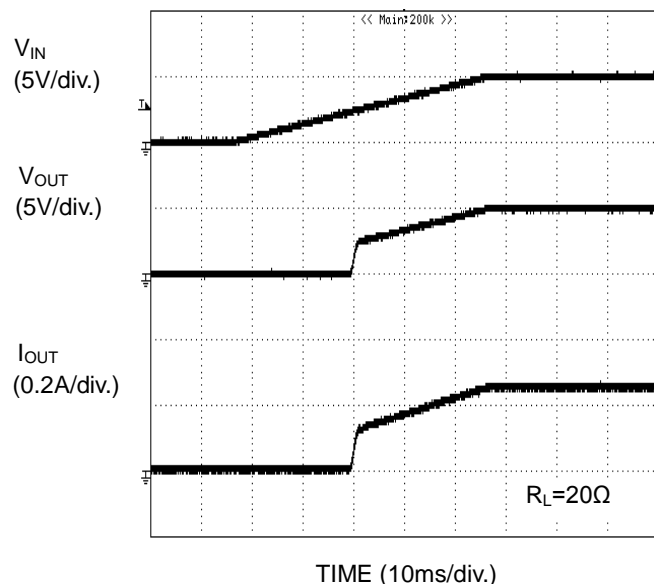


Figure 32. Over-Current Response

## Typical Wave Forms – continued

(Ta=25°C, unless otherwise specified)

Figure 33. Over-Current Response  
Enable to Short CircuitFigure 34. Over-Current Response  
Enable to Short CircuitFigure 35. Over-Current Response  
1Ω Load Connected to VOUTFigure 36. UVLO Response when  
Increasing  $V_{IN}$

**Typical Wave Forms – continued**

(Ta=25°C, unless otherwise specified)

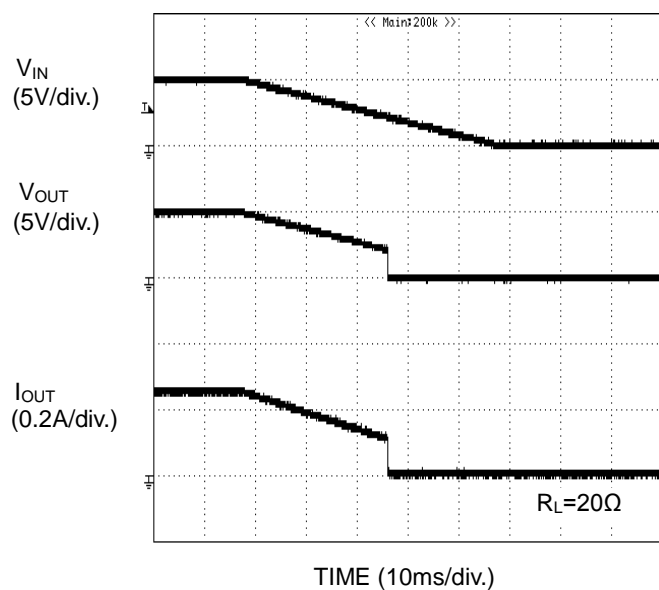
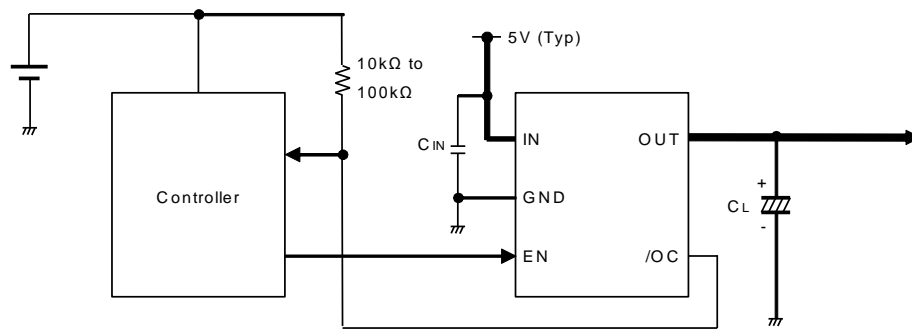


Figure 37. UVLO Response when  
Decreasing  $V_{IN}$

## Typical Application Circuit



## Application Information

When excessive current flows due to output short-circuit, ringing occurs because of the inductance between power source line and the IC. IN pin functions as both the power supply of the internal circuit of the IC and input of power switch. Therefore, ringing of power line may cause adverse effects on IC operations. In order to avoid this, it is recommended to connect a low ESR bypass capacitor (1 $\mu$ F or higher) between IN and GND pin which should be placed as close to these pins as possible. Additionally, in order to decrease voltage fluctuations from power source line to IC, connect a low ESR capacitor in parallel with C<sub>IN</sub>. 10 $\mu$ F to 100 $\mu$ F or higher is effective.

Pull up /OC output using 10k $\Omega$  to 100k $\Omega$  resistor values.

The value of C<sub>L</sub> should be chosen to satisfy the intended application.

This system connection diagram does not guarantee operation as the intended application.

When using the circuit with changes to the external circuit values, make sure to leave an adequate margin for external components taking into consideration the DC and transient characteristics as well as the design tolerance of the IC.

## Functional Description

### 1. Switch Operation

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

When the switch is turned ON from EN control input, the IN and OUT pins are connected by a 120m $\Omega$  (Typ) switch. In ON status, the switch is bidirectional. Therefore, when the potential of OUT pin is higher than that of IN pin, current flows from OUT to IN pin. On the other hand, when the switch is turned off, it is possible to prevent current from flowing reversely from OUT to IN pin since a parasitic diode between the drain and the source of switch MOSFET is not present.

### 2. Thermal Shutdown Circuit (TSD)

In the event of continuous over-current condition, the temperature of the IC would increase drastically. If the junction temperature goes beyond 165°C (Typ) due to over-current detection, thermal shutdown circuit operates and turns power switch off, and the IC outputs a fault flag (/OC). Then, when the junction temperature decreases lower than 145°C (Typ), the power switch is turned on and fault flag (/OC) is cancelled. This operation repeats, unless the cause of the increase of chip's temperature is removed or the output of power switch is turned OFF.

The thermal shutdown circuit operates when the switch is ON (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. The over-current detection circuit works when the switch is on (EN signal is active). There are three types of response against over-current:

- (1) When the switch is turned on while the output is in short circuit status, the switch goes into current limit status immediately.
- (2) When the output short-circuits or high capacity 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 operates, current limitation is carried out.
- (3) When the output current increases gradually, current limitation would not operate unless 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  $V_{IN}$  drops below 2.2V (Typ) while the switch is still ON, then UVLO shuts off the power switch. UVLO has a hysteresis of 100mV (Typ). Under-voltage lockout circuit operates when the switch is on (EN signal is active).

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

Fault flag output is an N-MOS open drain output. During detection of over-current and/or thermal shutdown, the output level will turn low.

Over-current detection has delay filter. This delay filter prevents current detection flags from being sent during instantaneous events such as inrush current at switch on or during hot plug. If fault flag output is unused, /OC pin should be connected to open or ground line.

#### 6. Output Discharge Function

When the switch is turned off by disabling control input or UVLO function, the 60Ω(Typ.) discharge circuit between OUT and GND turns on which discharges the electric charge of the capacitive load. However, if the voltage of IN declines rapidly, then the OUT pin becomes Hi-Z without UVLO function.

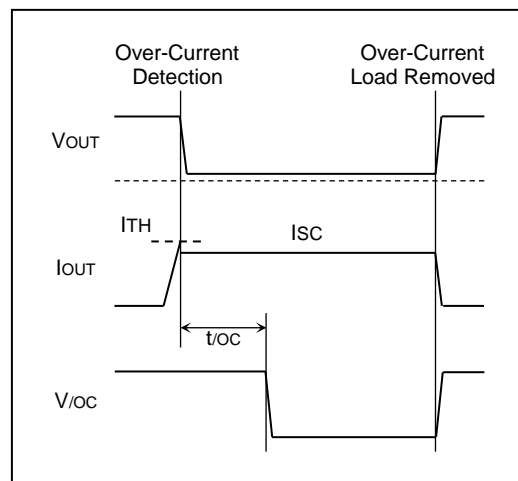


Figure 38. Over-Current Detection

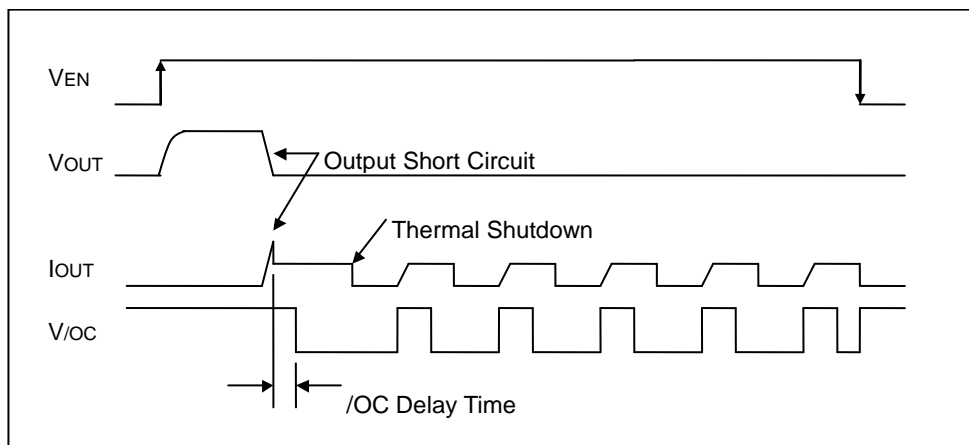


Figure 39. Over-Current Detection, Thermal Shutdown Timing

I/O Equivalent Circuit

Symbol	Pin No.	Equivalent Circuit
EN	3	
OUT	5	
/OC	4	

## Operational Notes

### 1. Reverse Connection of Power Supply

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

### 2. Power Supply Lines

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

### 3. Ground Voltage

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

### 4. Ground Wiring Pattern

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

### 5. Thermal Consideration

The amount of heat generated depends on the On-state resistance and Output current.

Should by any condition the maximum junction temperature  $T_{jmax} = 150\text{ }^{\circ}\text{C}$  rating be exceeded by the temperature increase of the chip, it may result in deterioration of the properties of the chip. The thermal impedance in this specification is based on recommended PCB and measurement condition by JEDEC standard. Verify the application and allow sufficient margins in the thermal design.

### 6. 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.

### 7. Inrush Current

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

### 8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 9. 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.

### 10. Inter-pin Short and Mounting Errors

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

### 11. Unused Input Pins

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

## Operational Notes – continued

**12. Regarding the Input Pin of the IC**

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

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

When  $GND > Pin\ B$ , the P-N junction operates as a parasitic transistor.

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

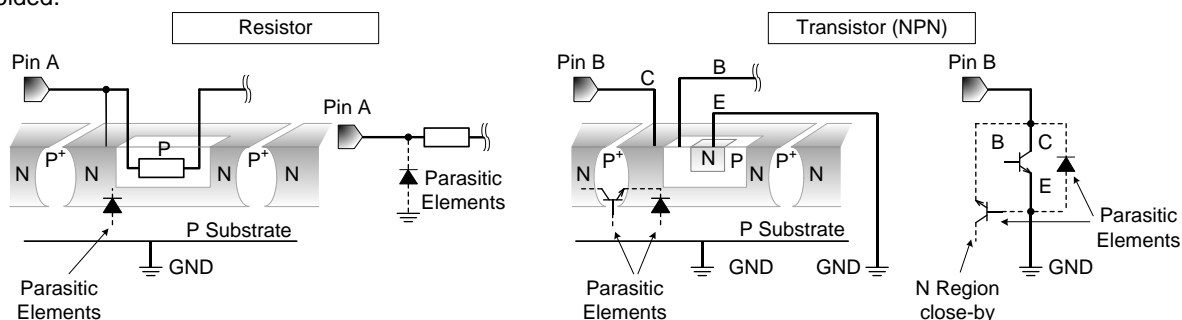


Figure 40. Example of monolithic IC structure

**13. Ceramic 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.

**14. Thermal Shutdown Circuit(TSD)**

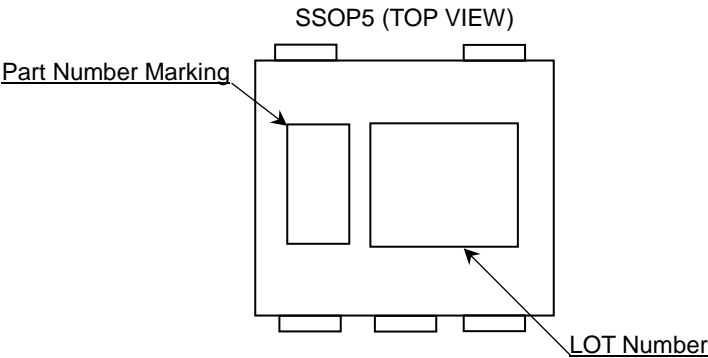
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that will turn OFF all output pins. When the  $T_j$  falls below the TSD threshold, the circuits are automatically restored to normal operation.

Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

Ordering Information

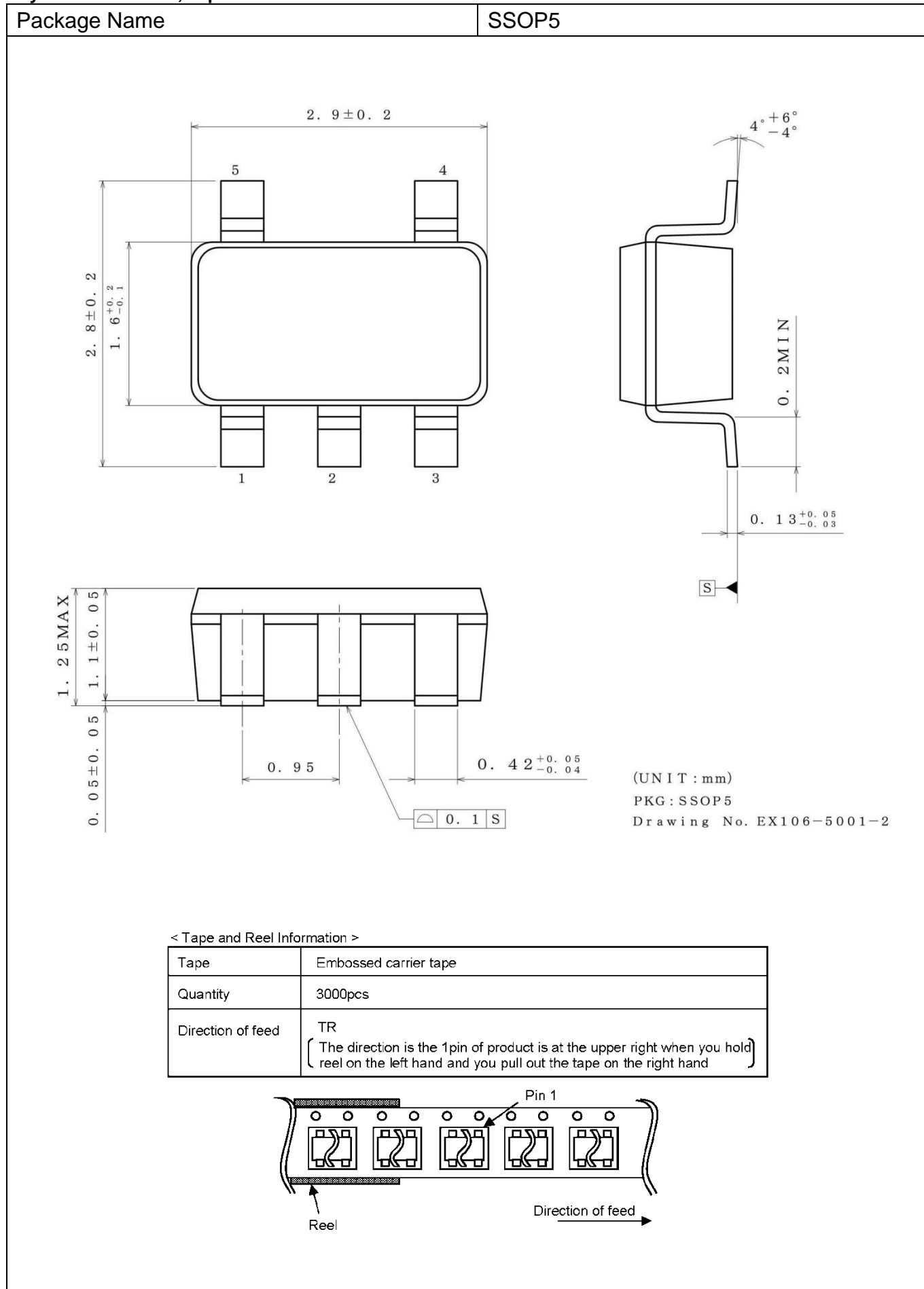
B D 2 2 6 4 1 G							-	M T R		
Part Number BD22641G								Package G: SSOP5		
								Product Rank M: for Automotive		
								Packaging and forming specification TR: Embossed tape and reel		

Marking Diagram



Part Number	Part Number Marking
BD22641G-M	XU

## Physical Dimension, Tape and Reel Information



## Revision History

Date	Revision	Changes
2.Nov.2016	001	New Release

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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>
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  - [h] Use of the Products in places subject to dew condensation
4. The Products are not subject to radiation-proof design.
5. Please verify and confirm characteristics of the final or mounted products in using the Products.
6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
8. Confirm that operation temperature is within the specified range described in the product specification.
9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification



## Precautions Regarding Application Examples and External Circuits

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

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## Precaution for Disposition

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

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