

μPD166021T1F

MOS INTEGRATED CIRCUIT

R07DS0442EJ0100

Rev.1.00

Sep 07, 2011

1. Overview

1.1 Description

The μPD166021T1F is a single N-channel high-side switch with charge pump, diagnostic feedback with load current sense and embedded protection functions.

1.2 Features

- Built-in charge pump
- Low on-state resistance
- Short circuit protection
 - Shutdown by over current detection and over load detection
- Over temperature protection
 - Shutdown by over temperature detection and keep off-state
- Built-in diagnostic function
 - Proportional load current sensing
 - Defined fault signal in case of abnormal load condition
- Under voltage lock out
- Reverse battery protection by self turn on of N-ch MOSFET
- Small multi-chip package: JEDEC 5-pin TO-252 (MSL: 3, profile acc. J-STD-20C)
- AEC Qualified

1.3 Applications

- Light bulb (to 65 W) switching
- Switching of all types of 14 V DC grounded loads, such as LED, inductor, resistor and capacitor
- Replacement for fuse and relay

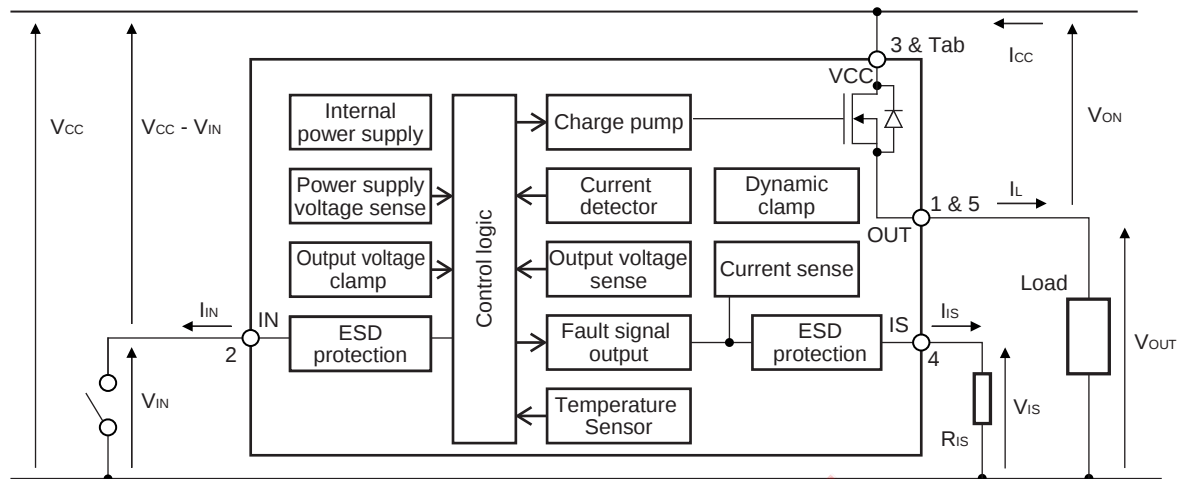
2. Ordering Information

Part No.	Lead plating	Packing	Package
μ PD166021T1F-E1-AY *1	Sn	Tape 2500 p/reel	5-pin TO-252 (MP-3ZK)

Note: *1. Pb-free (This product does not contain Pb in the external electrode.)

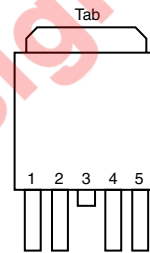
3. Specification

3.1 Block Diagram



3.2 Pin Configuration

Pin No.	Terminal Name
1	OUT
2	IN
3/Tab	VCC
4	IS
5	OUT



Pin Function

Terminal Name	Pin function	Recommended connections
OUT	Output to load	Pin 1 and Pin 5 must be externally shorted
IN	Activates the output, if it shorted to ground	If reverse battery protection feature is used, refer to 3.6.3 Power Dissipation Under Reverse Battery Condition .
VCC	Supply Voltage; tab and pin 3 are internally shorted	Connected to battery voltage with small 100 nF capacitor in parallel
IS	Sense output, diagnostic feedback	If current sense and diagnostic feature are not used, connected to GND via resistor

3.3 Absolute Maximum Ratings

$T_A = 25^\circ\text{C}$, unless otherwise specified

Parameter	Symbol	Rating	Unit	Test Conditions	
V_{CC} Voltage	V_{CC1}	28	V		
V_{CC} voltage under Load Dump condition	V_{CC2}	42	V	$R_I = 1\ \Omega$, $R_L = 1.5\ \Omega$, $R_{IS} = 1\ \text{k}\Omega$, $t_d = 400\ \text{ms}$	
V_{CC} Voltage at reverse battery condition	$-V_{CC}$	-16	V	$R_L = 2.2\ \Omega$, 1 min.	
Load Current (Short circuit current)	$I_{L(SC)}$	Self limited	A		
Power dissipation (DC)	P_D	1.2	W	$T_A = 85^\circ\text{C}$, Device on 50 mm x 50 mm x 1.5 mm epoxy PCB FR4 with 6 cm ² of 70 μm copper area	
Voltage of IN pin	V_{IN}	$V_{CC} - 28$	V	DC	
		$V_{CC} + 14$		At reverse battery condition, $t < 1\ \text{min.}$	
Voltage of IS pin	V_{IS}	$V_{CC} - 28$	V	DC	
		$V_{CC} + 14$		At reverse battery condition, $t < 1\ \text{min.}$	
Inductive load switch-off energy dissipation single pulse	E_{AS1}	50	mJ	$V_{CC} = 12\ \text{V}$, $I_L = 10\ \text{A}$, $T_{ch, start} \leq 150^\circ\text{C}$ refer to 3.6.8 Inductive Load Switch Off Energy Dissipation for a Single Pulse	
Maximum allowable energy dissipation at shutdown operation	E_{AS2}	105	mJ	$V_{CC} = 18\ \text{V}$, $T_{ch, star} \leq 150^\circ\text{C}$, $L_{supply} = 5\ \mu\text{H}$, $L_{short} = 15\ \mu\text{H}$ refer to 3.6.9 Maximum Allowable Switch off Energy (Single Pulse)	
Channel Temperature	T_{ch}	-40 to +150	$^\circ\text{C}$		
Dynamic temperature increase while switching	ΔT_{ch}	60	$^\circ\text{C}$		
Storage Temperature	T_{stg}	-55 to +150	$^\circ\text{C}$		
ESD susceptibility	V_{ESD}	2000	V	HBM	AEC-Q100-002 std. $R = 1.5\ \text{k}\Omega$, $C = 100\ \text{pF}$
		400	V	MM	AEC-Q100-003 std. $R = 0\ \Omega$, $C = 200\ \text{pF}$

3.4 Thermal Characteristics

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions
Thermal characteristics	$R_{th(ch-a)}$		45		$^\circ\text{C/W}$	Device on 50 mm x 50 mm x 1.5 mm epoxy PCB FR4 with 6 cm ² of 70 μm copper area
	$R_{th(ch-c)}$			3.17	$^\circ\text{C/W}$	

3.5 Electrical Characteristics

Operation Function

$T_{ch} = 25^{\circ}\text{C}$, $V_{CC} = 12\text{ V}$, unless otherwise specified

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions
Required current capability of Input switch	I_{IH}		1.0	2.2	mA	$T_{ch} = -40\text{ to }150^{\circ}\text{C}$
Input current for turn-off	I_{IL}			50	μA	
Standby Current	$I_{CC(off)}$		2.5	5.0	μA	$R_L = 2.2\ \Omega$, $I_{in} = 0\text{ A}$, $T_{ch} = 25^{\circ}\text{C}$
			2.5	15.0	μA	$R_L = 2.2\ \Omega$, $I_{in} = 0\text{ A}$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$
On State Resistance	R_{on}		8	10	m Ω	$I_L = 7.5\text{ A}$, $T_{ch} = 25^{\circ}\text{C}$
			14	18		$I_L = 7.5\text{ A}$, $T_{ch} = 150^{\circ}\text{C}$
Output voltage drop limitation at small load current	$V_{on(NL)}$		30	65	mV	$T_{ch} = -40\text{ to }150^{\circ}\text{C}$
Turn On Time	t_{on}		120	360	μs	$R_L = 2.2\ \Omega$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$, refer to 3.6.6 Measurement Condition
Turn Off Time	t_{off}		250	500	μs	
Slew rate on *1	$dv/dton$		0.2	0.8	V/ μs	25 to 50% V_{OUT} , $R_L = 2.2\ \Omega$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$, refer to 3.6.6 Measurement Condition
Slew rate off *1	$-dv/dtoff$		0.2	0.6	V/ μs	50 to 25% V_{OUT} , $R_L = 2.2\ \Omega$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$, refer to 3.6.6 Measurement Condition

Note: *1. Not tested, specified by design

Protection Function

$T_{ch} = 25^{\circ}\text{C}$, $V_{CC} = 12\text{ V}$, unless otherwise specified

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions	
On-state resistance at reverse battery condition *1	R _{on(rev)}		9.5	13	mΩ	T _{ch} = 25°C	V _{CC} = −12 V, I _L = −7.5 A, R _{IS} = 1 kΩ
			16	22	mΩ	T _{ch} = 150°C	
Short circuit detection current	I _{L6,3(SC)} *1		50	120	A	T _{ch} = −40°C	V _{CC} − V _{IN} = 6 V, V _{on} = 3 V
			50			T _{ch} = 25°C	
		20	45			T _{ch} = 150°C	
	I _{L6,6(SC)} *1		35	110		T _{ch} = −40°C	V _{CC} − V _{IN} = 6 V, V _{on} = 6 V
			35			T _{ch} = 25°C	
		10	35			T _{ch} = 150°C	
	I _{L12,3(SC)}		110	180		T _{ch} = −40°C	V _{CC} − V _{IN} = 12 V, V _{on} = 3 V
		76	105			T _{ch} = 25°C	
		50	95			T _{ch} = 150°C	
	I _{L12,6(SC)} *1		90	160		T _{ch} = −40°C	V _{CC} − V _{IN} = 12 V, V _{on} = 6 V
			85			T _{ch} = 25°C	
		40	80			T _{ch} = 150°C	
	I _{L12,12(SC)} *1		55	120		T _{ch} = −40°C	V _{CC} − V _{IN} = 12 V, V _{on} = 12 V
			50			T _{ch} = 25°C	
		10	45			T _{ch} = 150°C	
	I _{L18,3(SC)} *1		130	200		T _{ch} = −40°C	V _{CC} − V _{IN} = 18 V, V _{on} = 3 V
			125			T _{ch} = 25°C	
		60	110			T _{ch} = 150°C	
	I _{L18,6(SC)} *1		110	170		T _{ch} = −40°C	V _{CC} − V _{IN} = 18 V, V _{on} = 6 V
			110			T _{ch} = 25°C	
		50	110			T _{ch} = 150°C	
	I _{L18,12(SC)} *1		75	120		T _{ch} = −40°C	V _{CC} − V _{IN} = 18 V, V _{on} = 12 V
			70			T _{ch} = 25°C	
		30	65			T _{ch} = 150°C	
	I _{L18,18(SC)} *1		50	90		T _{ch} = −40°C	V _{CC} − V _{IN} = 18 V, V _{on} = 18 V
			50			T _{ch} = 25°C	
		5	45			T _{ch} = 150°C	
Turn-on check delay after input current positive slope *1	t _{d(OC)}	0.9	2.1	3.8	ms	T _{ch} = −40 to 150°C	
Remaining Turn-on check delay after turn-on time *1	t _{d(OC)} −t _{on}	0.65	1.6		ms	R _L = 2.2 Ω, T _{ch} = −40 to 150°C	
Over load detection voltage	V _{on(OvL)}	0.65	1	1.45	V	T _{ch} = −40 to 150°C	
Under voltage shutdown	V _{CIN(Uv)}			5.5	V	T _{ch} = −40°C	
		3.2	4.0	5.35	V	T _{ch} = 25°C	
		2.7			V	T _{ch} = 150°C	
Under voltage restart of charge pump	V _{CIN(CPr)}			6.3	V	T _{ch} = −40°C	
		3.6	4.5	6.2	V	T _{ch} = 25°C	
		3.2			V	T _{ch} = 150°C	
Output clamp voltage (inductive load switch off)	V _{on(CL)}	30	34	40	V	I _L = 40 mA, T _{ch} = −40 to 150°C	
Thermal shutdown temperature *1	T _{th}	150	175		°C		

Note: *1. Not tested, specified by design

Diagnosis Function

$T_{ch} = 25^{\circ}\text{C}$, $V_{CC} = 12\text{ V}$, unless otherwise specified

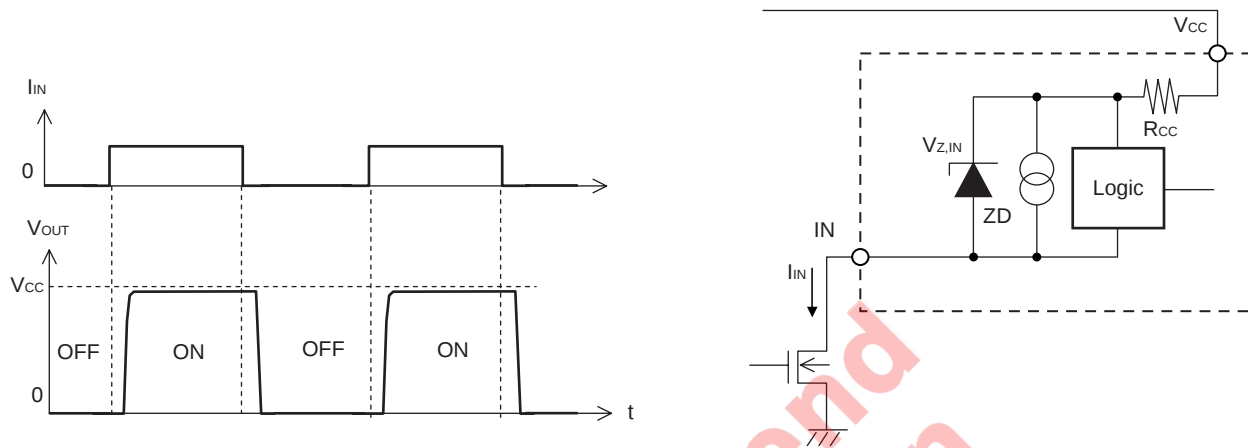
Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions
Current sense ratio	K_{ILIS}					$K_{ILIS} = I_L/I_{IS}$, $I_{IS} < I_{IS,lim}$
		8300	9200	11000		$T_{ch} = -40^{\circ}\text{C}$
		8300	9200	10600		$T_{ch} = 25^{\circ}\text{C}$
		8400	9300	10200		$T_{ch} = 150^{\circ}\text{C}$
		7500	9200	11400		$T_{ch} = -40^{\circ}\text{C}$
		8000	9300	10800		$T_{ch} = 25^{\circ}\text{C}$
		8300	9300	10400		$T_{ch} = 150^{\circ}\text{C}$
		7100	10200	13400		$T_{ch} = -40^{\circ}\text{C}$
		7700	10000	12500		$T_{ch} = 25^{\circ}\text{C}$
		8000	9800	12000		$T_{ch} = 150^{\circ}\text{C}$
		5000	12000	21000		$T_{ch} = -40^{\circ}\text{C}$
		5500	11500	17000		$T_{ch} = 25^{\circ}\text{C}$
		6000	11500	16000		$T_{ch} = 150^{\circ}\text{C}$
Sense current offset current	$I_{IS,offset}$		0.1	1	μA	$V_{IN} = 0\text{ V}$, $I_L = 0\text{ A}$
Sense current under fault condition	$I_{IS,fault}$	3.5	6.0	12.0	mA	Under fault conditions $8\text{ V} < V_{CC} - V_{IS} < 12\text{ V}$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$
Sense current saturation current	$I_{IS,lim}$	3.5	7.0	12.0	mA	$V_{IS} < V_{OUT} - 6\text{ V}$, $T_{ch} = -40\text{ to }150^{\circ}\text{C}$
Fault Sense Signal delay after short circuit detection *1	$t_{sdelay(fault)}$		2	6	μs	$T_{ch} = -40\text{ to }150^{\circ}\text{C}$
Sense current leakage current	$I_{IS(LL)}$		0.1	0.5	μA	$I_{IN} = 0\text{ A}$
Current sense settling time to $I_{IS}(\text{static})$ after input current positive slope *1	$t_{son(IS)}$			700	μs	$T_{ch} = -40\text{ to }150^{\circ}\text{C}$, $I_{IN} = 0\text{ A}$ $\square$ I_{IH} , $R_L = 2.2\ \Omega$
Current sense settling time during on condition *1	$T_{sic(IS)}$		50	100	μs	$T_{ch} = -40\text{ to }150^{\circ}\text{C}$, $I_L = 10\text{ A}$ $\square$ 20 A

Note: *1. Not tested, specified by design

3.6 Feature Description

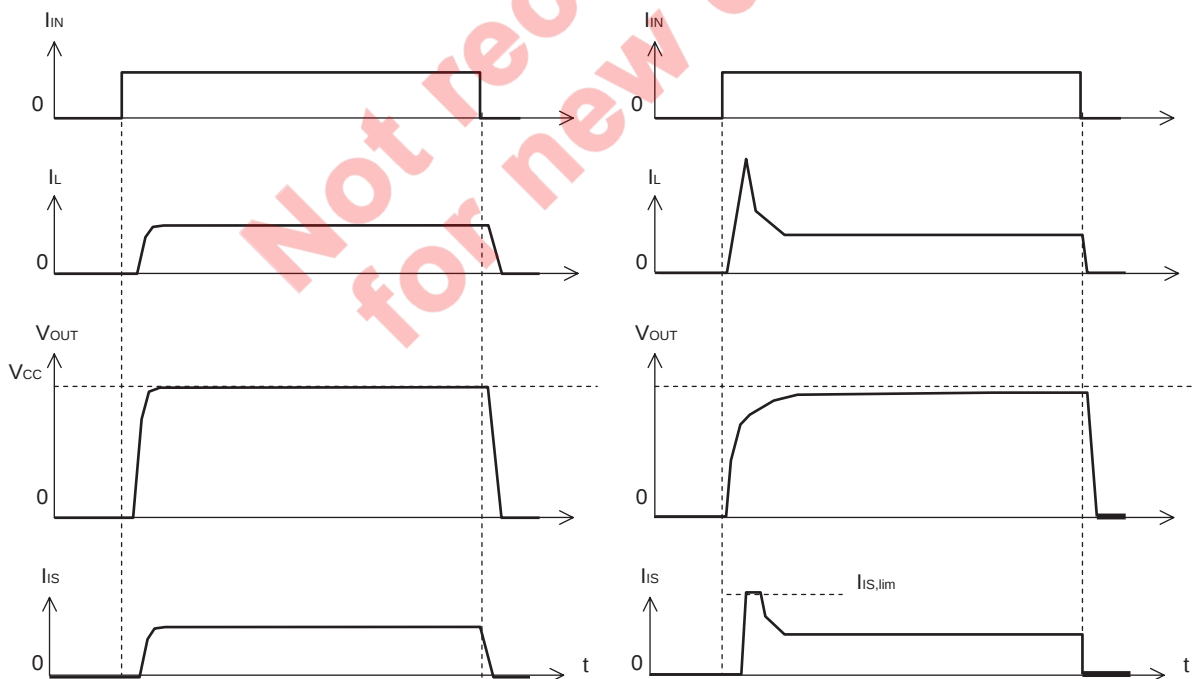
3.6.1 Driving Circuit

The high-side output is turned on, if the input pin is shorted to ground. The input current is below I_{IH} . The high-side output is turned off, if the input pin is open or the input current is below I_{IL} . R_{CC} is 100 Ω TYP. ESD protection diode: 46 V TYP.

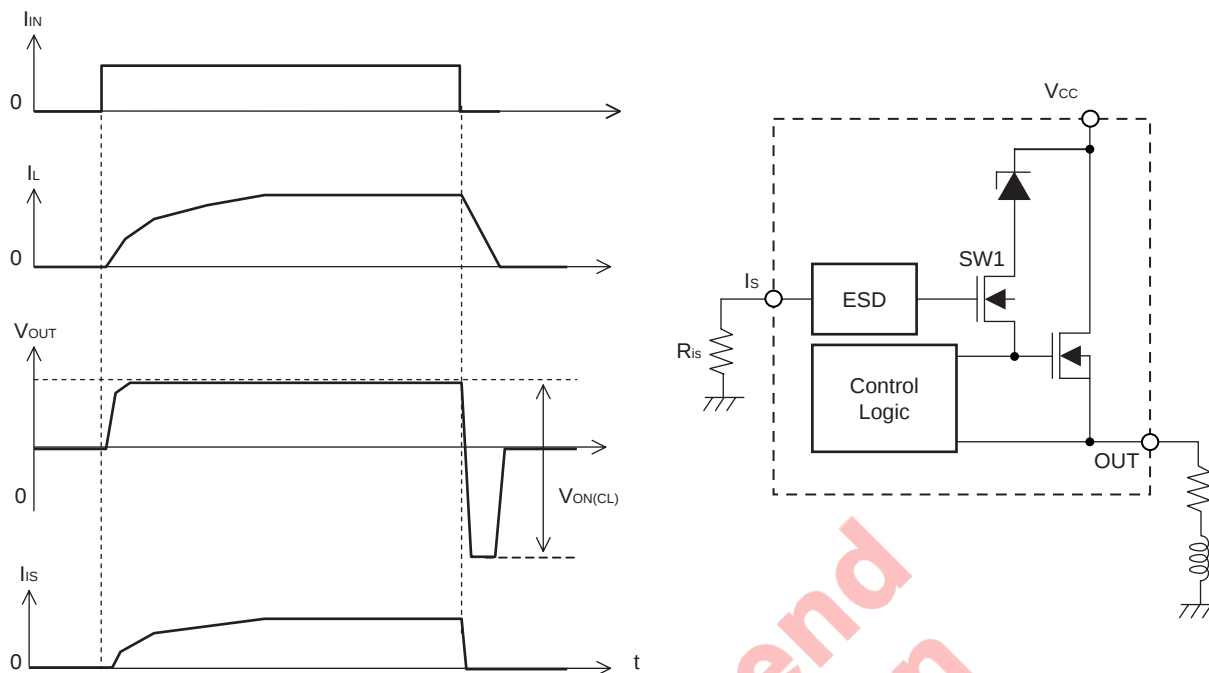


Switching a resistive load

Switching lamps



Switching an inductive load

**Dynamic clamp operation at inductive load switch off**

The dynamic clamp circuit works only when the inductive load is switched off. When the inductive load is switched off, the voltage of OUT falls below 0 V. The gate voltage of SW1 is then nearly equal to GND because the IS terminal is connected to GND via an external resistor. Next, the voltage at the source of SW1 (= gate of output MOS) falls below the GND voltage. SW1 is turned on, and the clamp diode is connected to the gate of the output MOS, activating the dynamic clamp circuit.

When the over-voltage is applied to V_{CC} , the gate voltage and source voltage of SW1 are both nearly equal to GND. SW1 is not turned on, the clamp diode is not connected to the gate of the output MOS, and the dynamic clamp circuit is not activated.

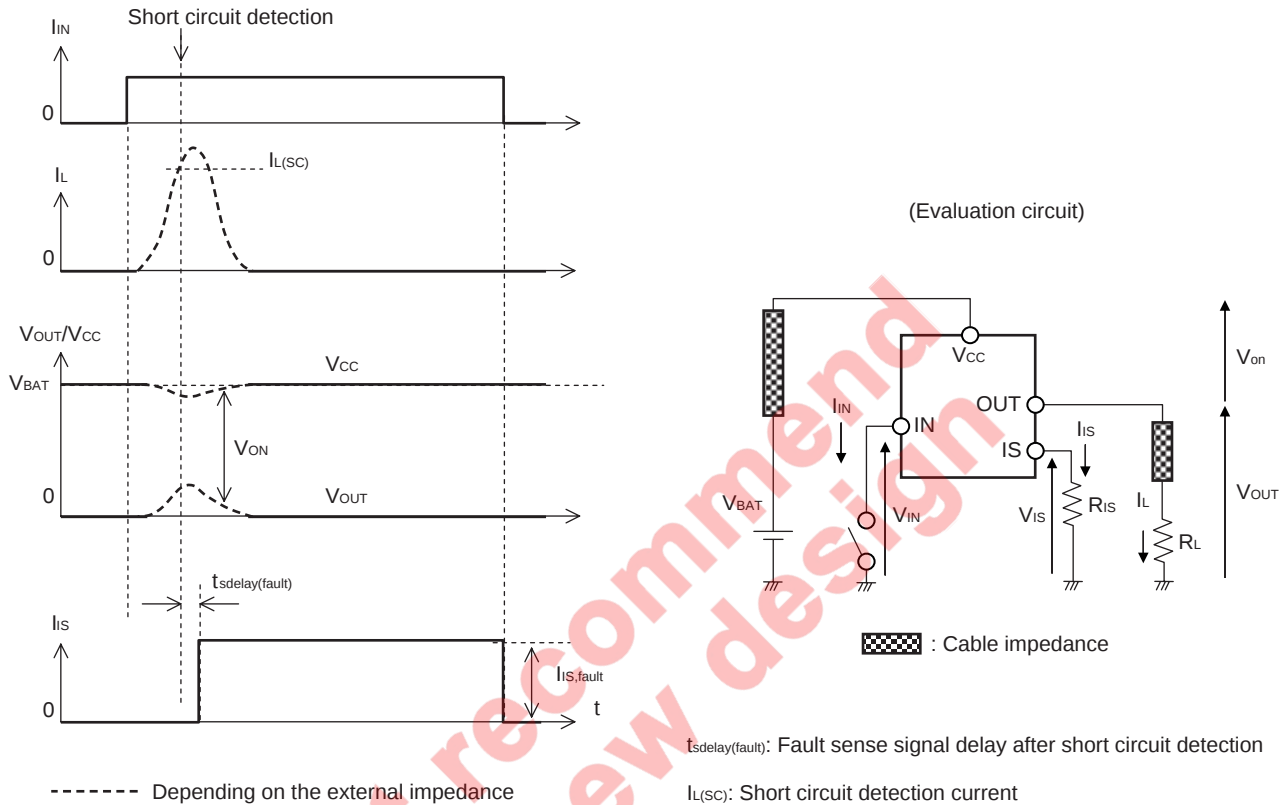
3.6.2 Short Circuit Protection

Case 1: I_{IN} pin is shorted to ground in an overload condition, which includes a short circuit condition.

The device shuts down automatically when either or both of following conditions (a, b) is detected. The sense current is fixed at $I_{IS, fault}$. Shutdown is latched until the next reset via input.

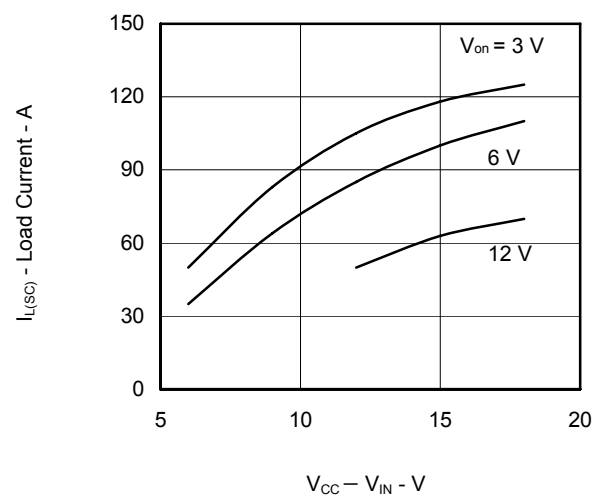
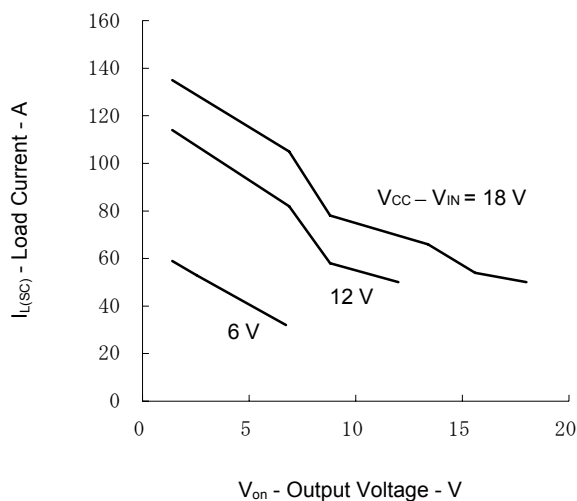
- (a) $I_L > I_{L(SC)}$
- (b) $V_{on} > V_{on(OVL)}$ after $t_{d(OC)}$

Case 1-(a) $I_L > I_{L(SC)}$

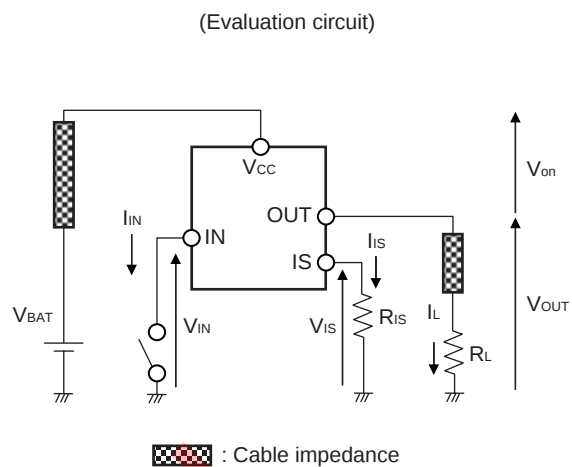
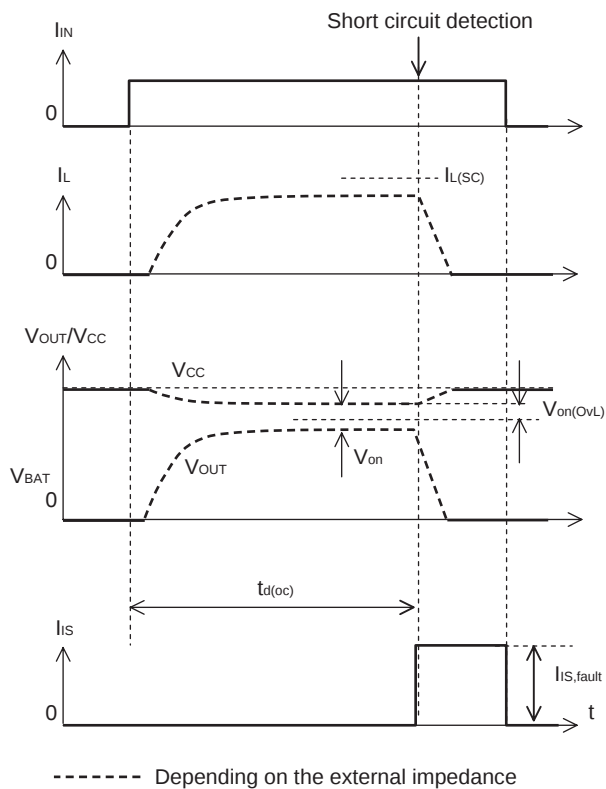


Typical Short circuit detection current characteristics

The short circuit detection current changes according to V_{CC} voltage and V_{on} voltage for the purpose of to be strength of the robustness under short circuit condition.



Case 1-(b) $V_{on} > V_{on(OvL)}$ after $t_{d(OC)}$



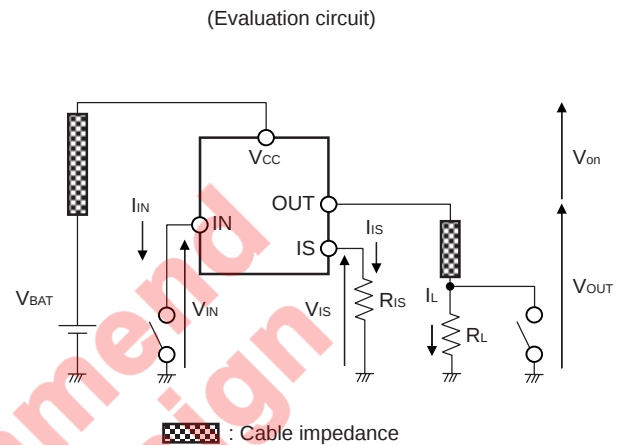
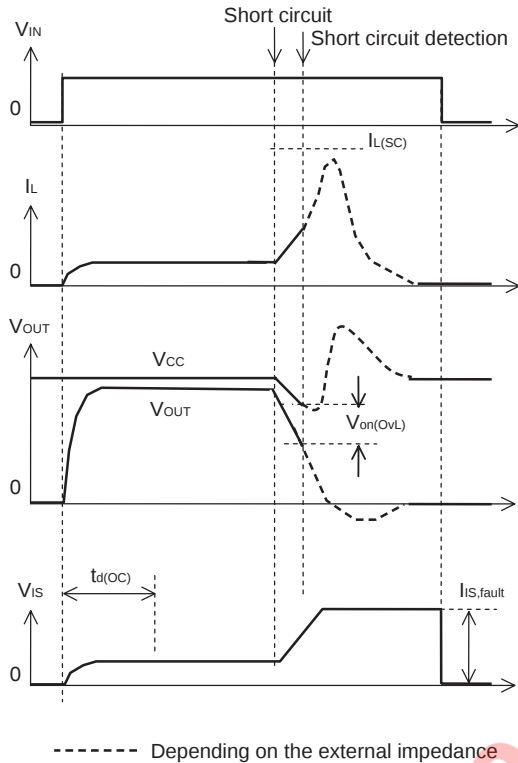
$t_{d(oc)}$: Turn-on check delay after input current positive slope

Case 2: Short circuit during on-condition

The device shuts down automatically when following conditions (a) is detected. The sense current is fixed at $I_{IS, fault}$. Shutdown is latched until the next reset via input. In the case of $V_{on(NL)}$ works such open load condition at on-state, $t_{d(OC)}$ is expired.

(a) $V_{on} > V_{on(OvL)}$ after $t_{d(OC)}$

Case 2-(a) $V_{on} > V_{on(OvL)}$ after $t_{d(OC)}$

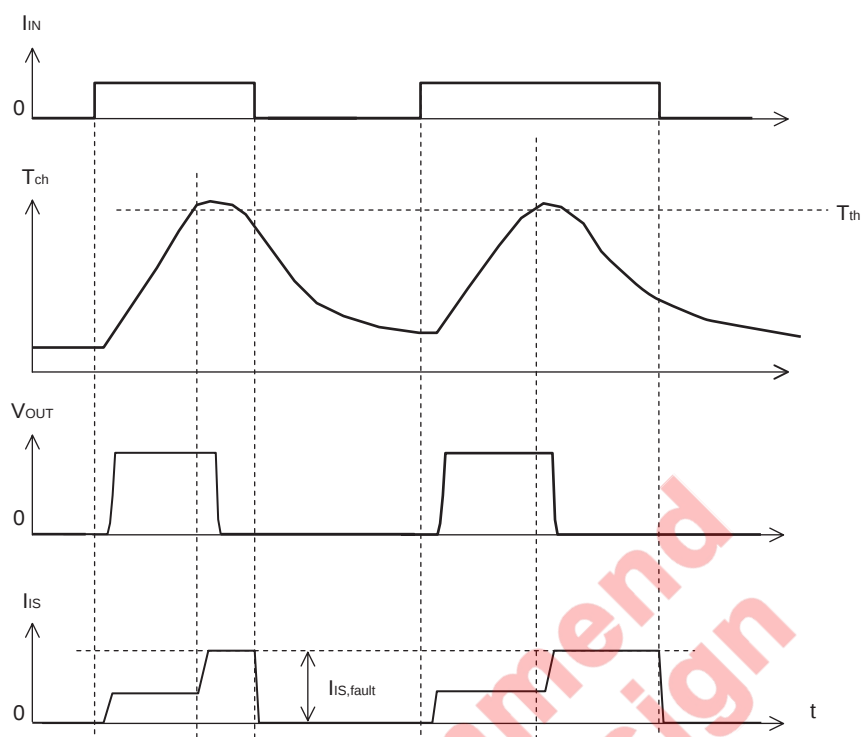


$t_{d(OC)}$: Turn-on check delay after input current positive slope

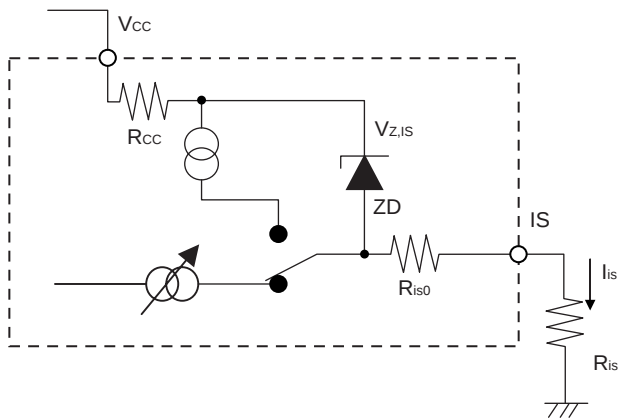
$I_{L(SC)}$: Short circuit detection current

Over-temperature protection

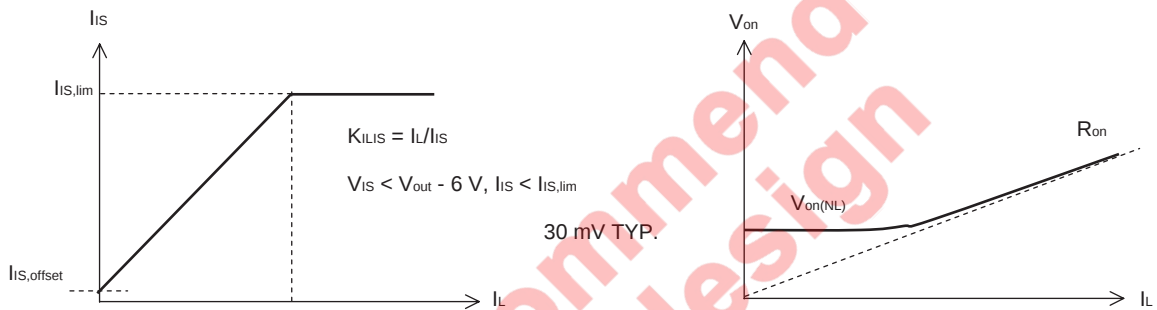
The output is switched off if over-temperature is detected. Shutdown is latched until the next reset via input.



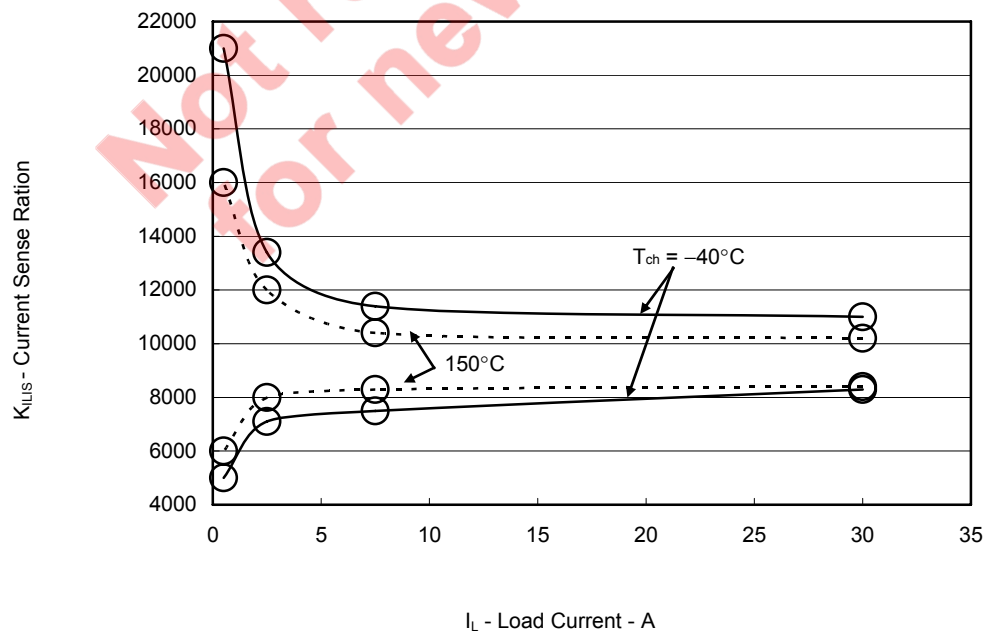
3.6.5 Current Sense Output



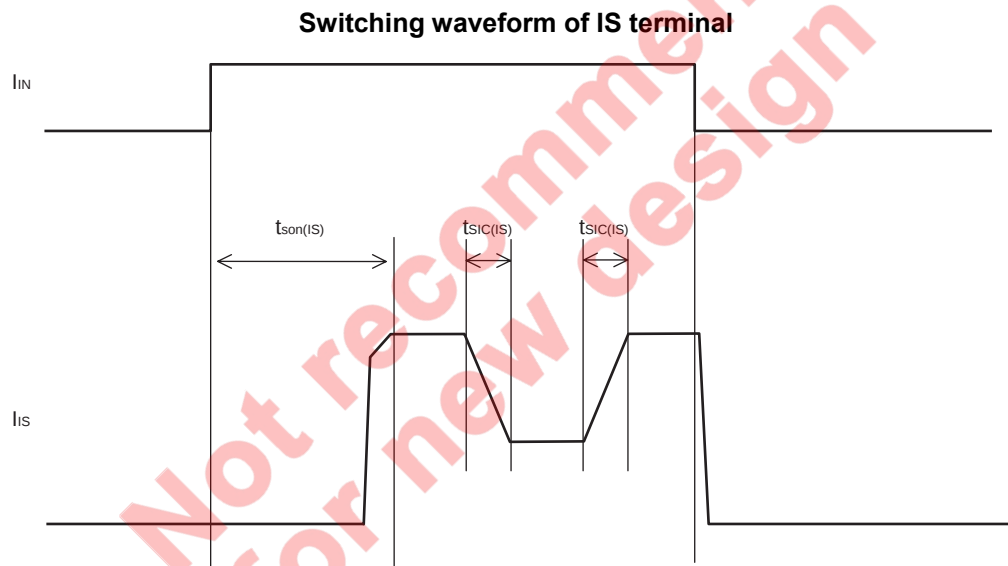
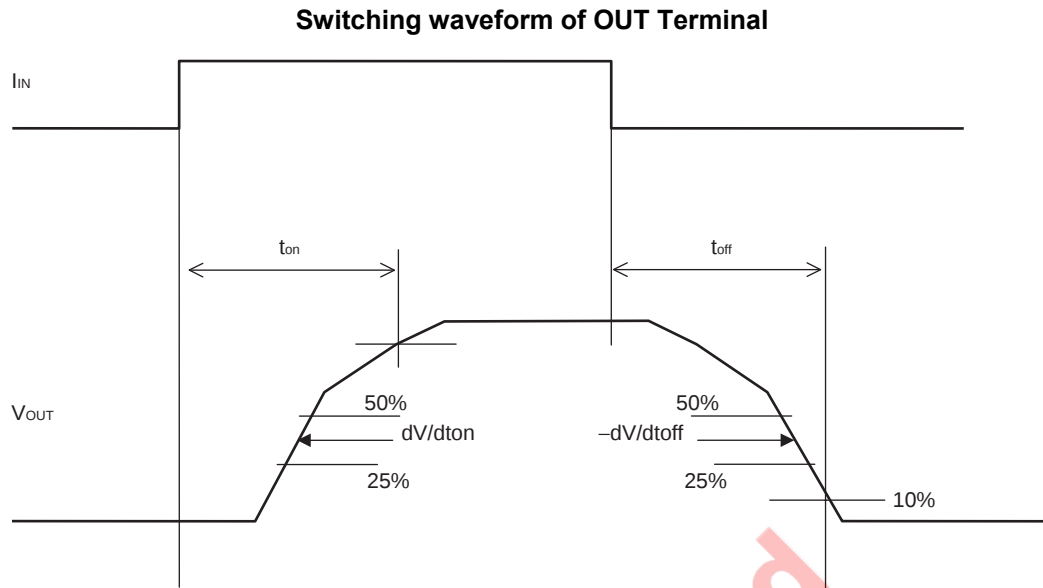
R_{cc} and R_{is0} are 100 Ω (TYP.). $V_{Z,IS}$ = 46 V (TYP.), R_{is} = 1 k Ω nominal.



Current sense ratio



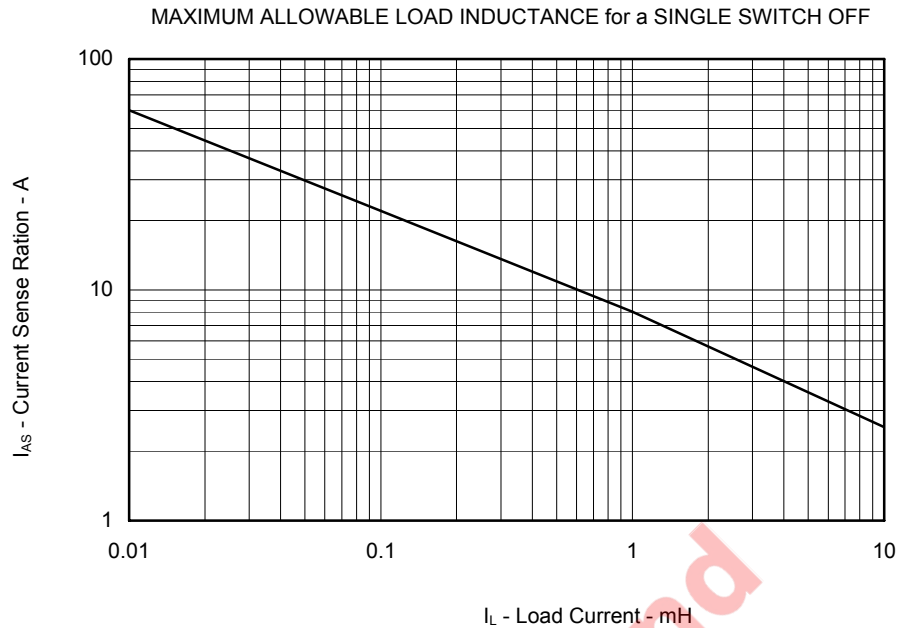
3.6.6 Measurement Condition



3.6.7 Truth Table

Input Current	State	Output	Sense Current
L	—	OFF	$I_{IS(LL)}$
H	Normal Operation	ON	I_L/K_{IIS}
	Over-temperature or Short circuit	OFF	$I_{IS,fault}$
	Open Load	ON	$I_{IS,offset}$

3.6.8 Inductive Load Switch Off Energy Dissipation for a Single Pulse

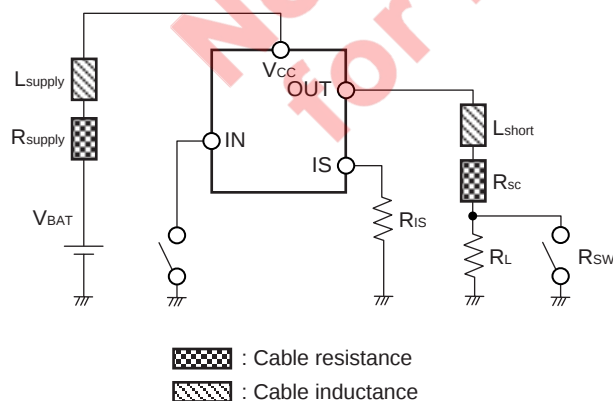


The energy dissipation for an inductive load switch-off single pulse in device (E_{AS1}) is estimated by the following formula as $R_L = 0 \Omega$.

$$E_{AS1} = \frac{1}{2} I^2 L \left(\frac{V_{on(CL)}}{V_{on(CL)} - V_{CC}} \right)$$

3.6.9 Maximum Allowable Switch off Energy (Single Pulse)

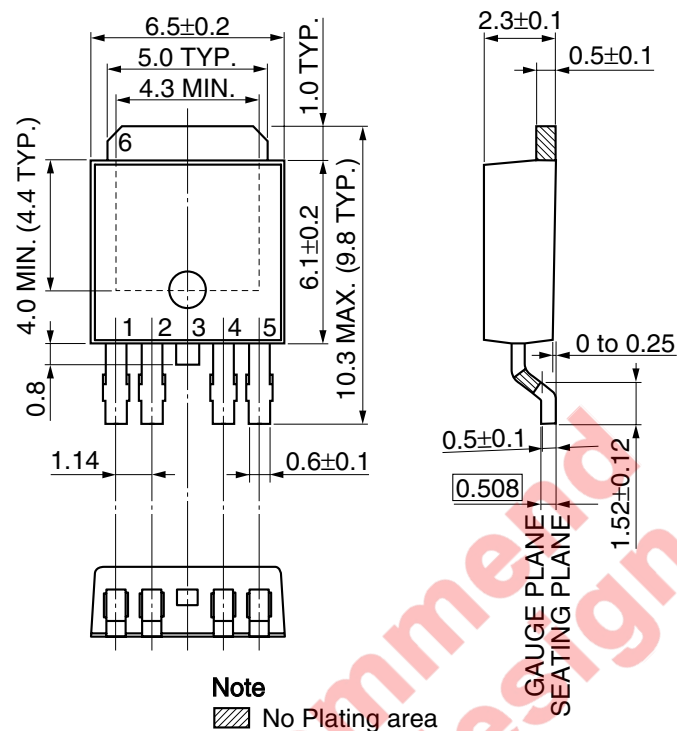
The harness connecting the power supply, the load and the device has a small inductance and resistance. When the device turns off, the energy stored in the harness inductance is dissipated by the device, the harness resistance and the internal resistance of power supply. If the current is abnormally high due to a load short, the energy stored in the harness can be large. This energy has to be taken into consideration for the safe operation. The following figure shows the condition for E_{AS2} , the maximum switch-off energy (single pulse) for abnormally high current.



$V_{BAT} = 18 \text{ V}$,
 $R_{supply} = 10 \text{ m}\Omega$, $R_{short} = R_{sc} + R_{SW(on)} = 50 \text{ m}\Omega$,
 $L_{supply} = 5 \text{ }\mu\text{H}$, $L_{short} = 15 \text{ }\mu\text{H}$,
 $T_{ch,start} \leq 150^\circ\text{C}$

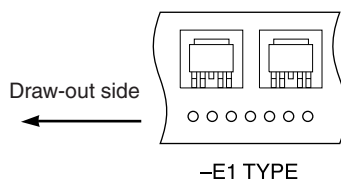
3.7 Package Drawing (unit: mm)

5-pin TO-252 (MP-3ZK)



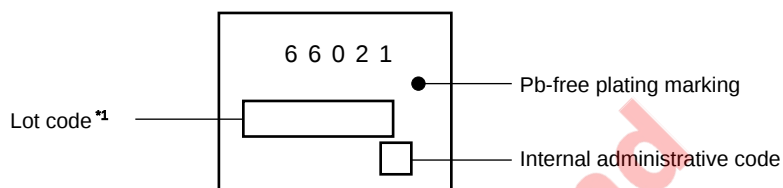
3.8 Taping Information

This is one type (E1) of direction of the device in the carrier tape.

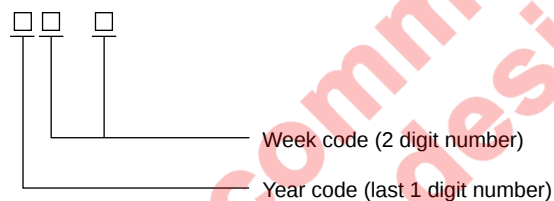


3.9 Marking Information

This figure indicates the marking items and arrangement. However, details of the letterform, the size and the position aren't indicated.

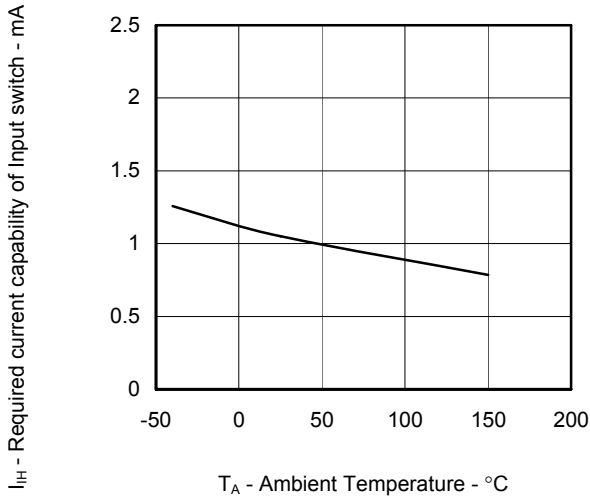


Note: *1. Composition of the lot code

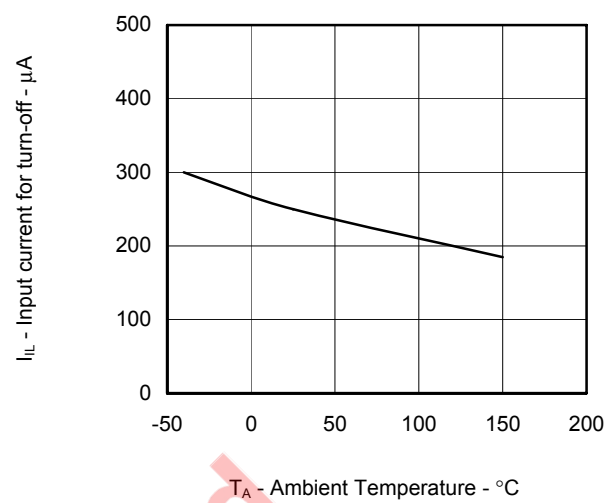


4. Typical Characteristics

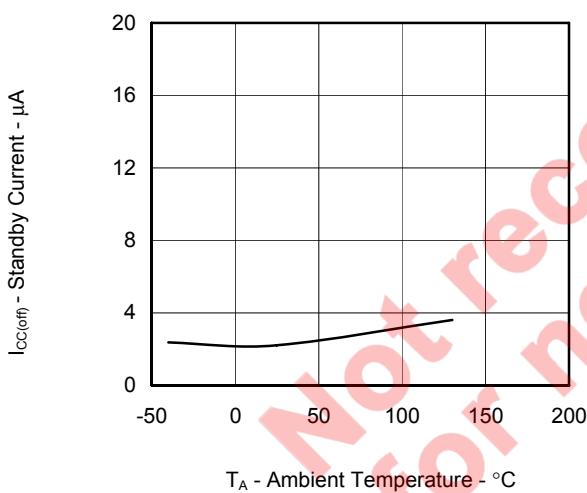
REQUIRED CURRENT CAPABILITY OF INPUT SWITCH vs. AMBIENT TEMPERATURE



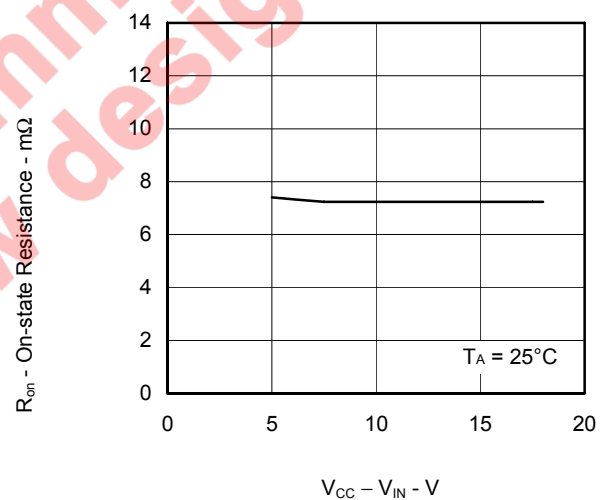
INPUT CURRENT FOR TURN OFF vs. AMBIENT TEMPERATURE



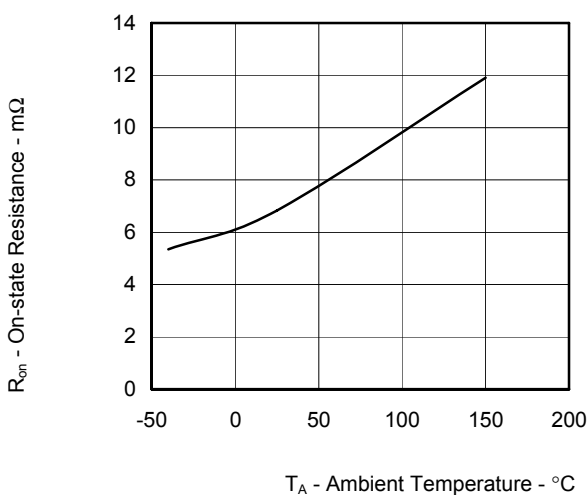
STANDBY CURRENT vs. AMBIENT TEMPERATURE



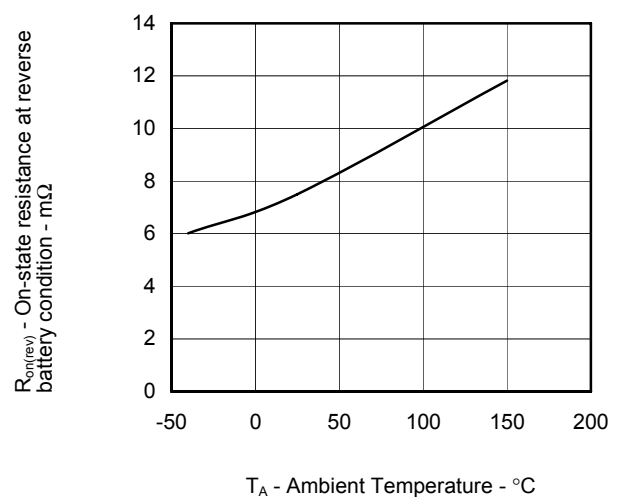
ON STATE RESISTANCE vs. $V_{CC} - V_{IN}$ voltage



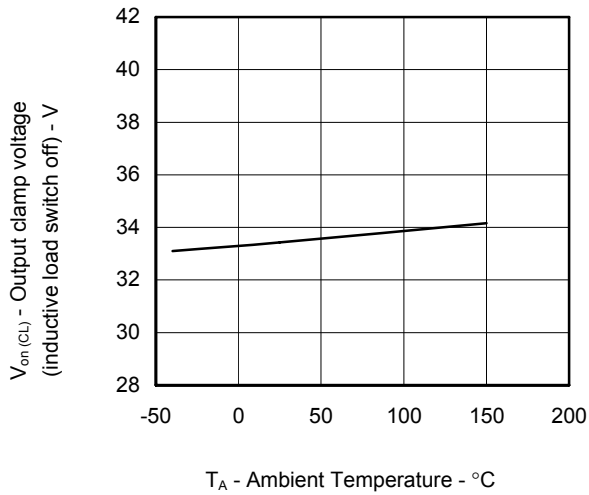
ON STATE RESISTANCE vs. AMBIENT TEMPERATURE



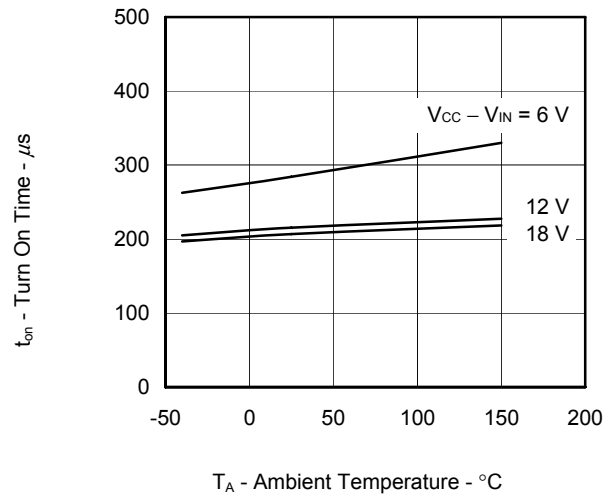
ON STATE RESISTANCE AT REVERSE BATTERY CONDITION vs. AMBIENT TEMPERATURE



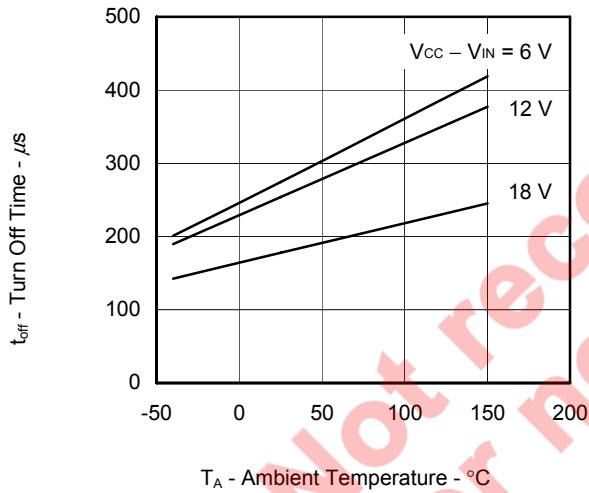
OUTPUT CLAMP VOLTAGE (INDUCTIVE LOAD SWITCH OFF) vs. AMBIENT TEMPERATURE



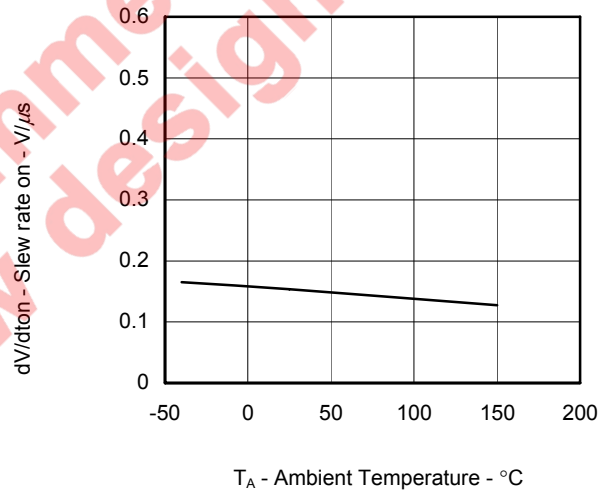
TURN ON TIME vs. AMBIENT TEMPERATURE



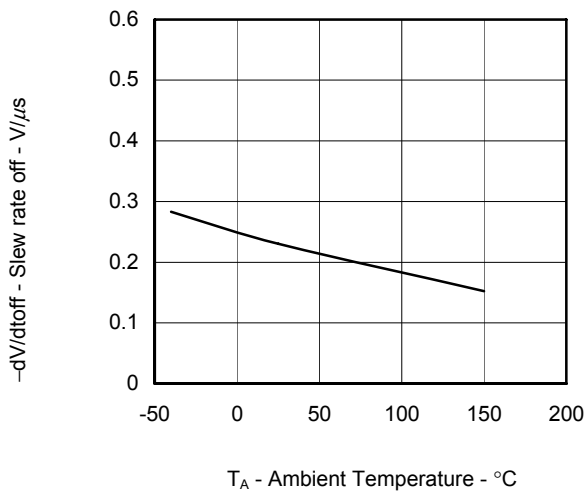
TURN OFF TIME vs. AMBIENT TEMPERATURE



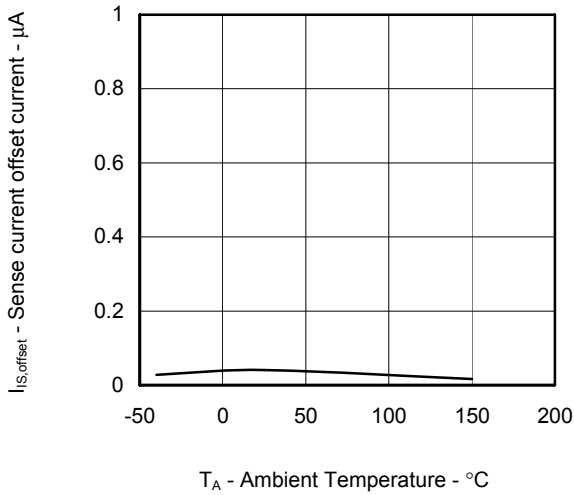
SLEW RATE ON vs. AMBIENT TEMPERATURE



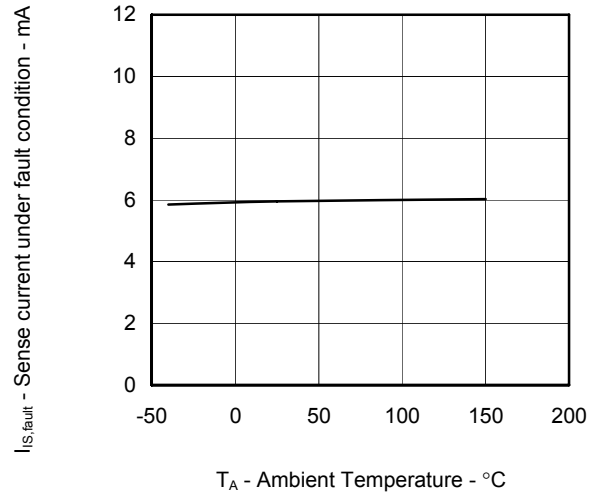
SLEW RATE OFF vs. AMBIENT TEMPERATURE



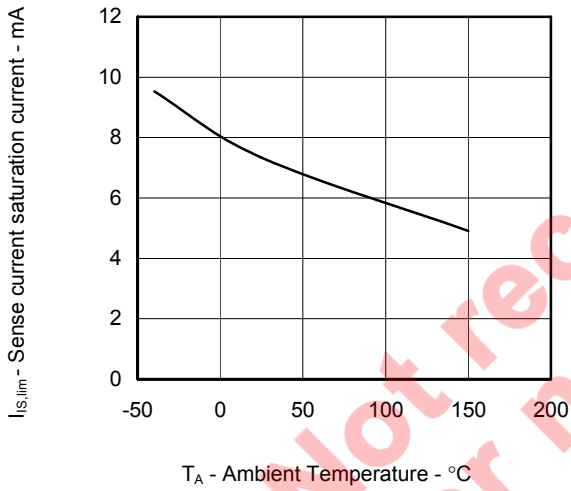
SENSE CURRENT OFFSET CURRENT
vs. AMBIENT TEMPERATURE



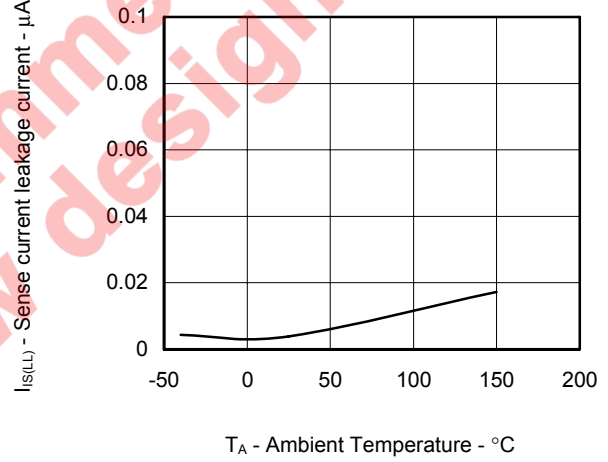
SENSE CURRENT UNDER FAULT CONDITION
vs. AMBIENT TEMPERATURE



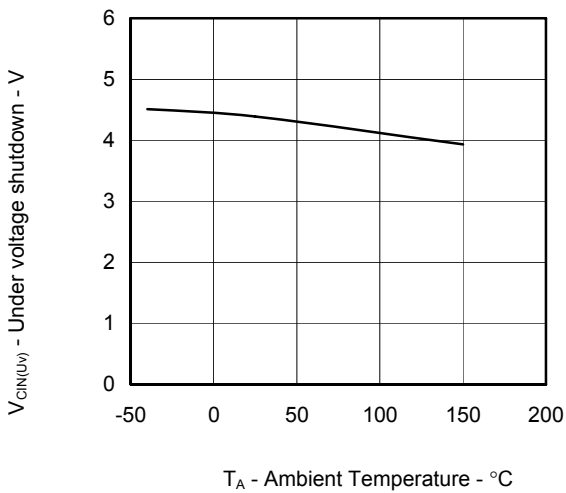
SENSE CURRENT SATURATION CURRENT
vs. AMBIENT TEMPERATURE



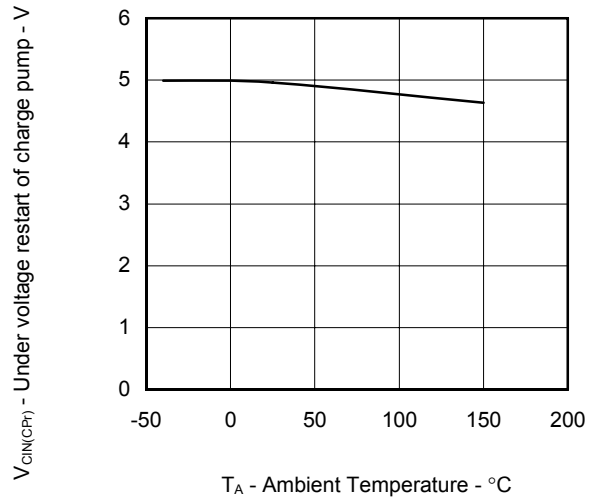
SENSE CURRENT LEAKAGE CURRENT
vs. AMBIENT TEMPERATURE



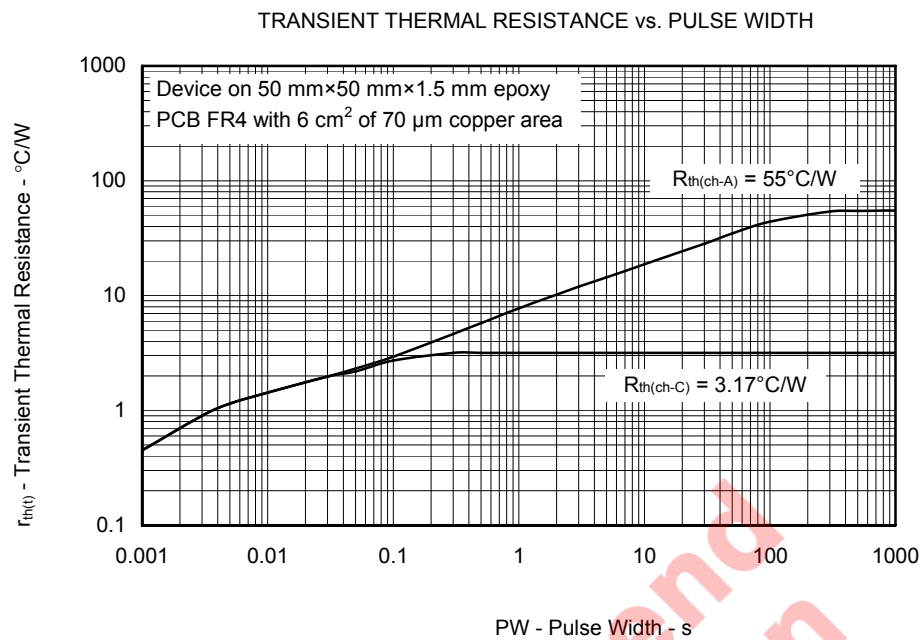
UNDER VOLTAGE SHUTDOWN
vs. AMBIENT TEMPERATURE



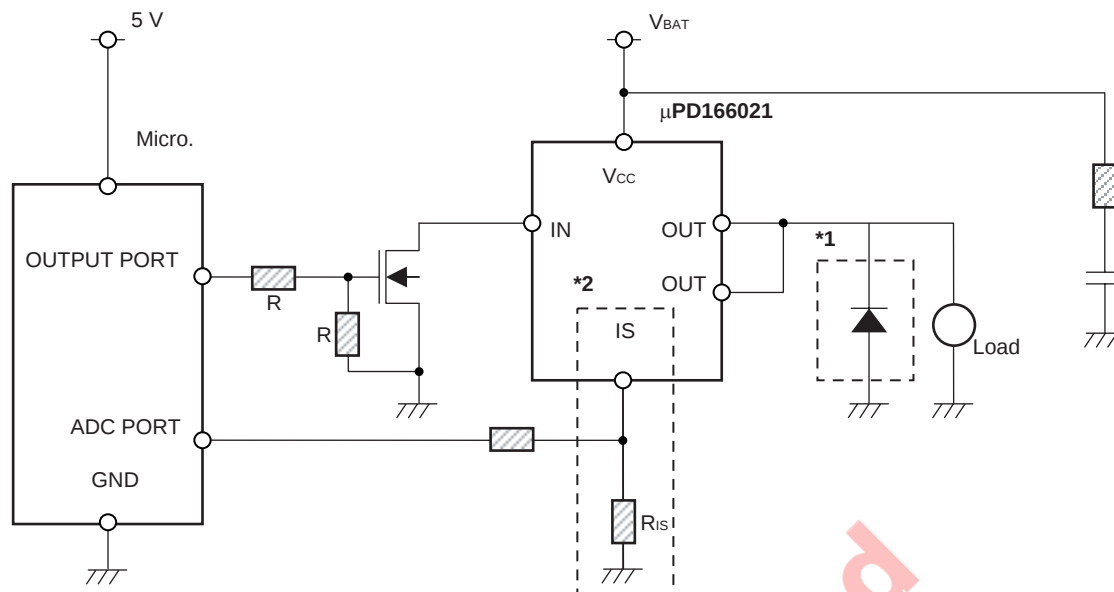
UNDER VOLTAGE RESTART OF CHARGE PUMP
vs. AMBIENT TEMPERATURE



5. Thermal Characteristics



6. Application Example in Principle



Notes: *1. If output current is over the maximum allowable current for inductive load at a single switch off, or if energy at a single switch off is over E_{AS1}/E_{AS2} , then a free wheeling diode must be connected in parallel the load.
*2. If current sense and diagnostic features are not used, IS terminal has to be connected to GND via resistor.

Revision History	μPD166021T1F Data Sheet
-------------------------	--------------------------------

Rev.	Date	Description	
		Page	Summary
1.00	Sep 07, 2011	–	First Edition Issued

Not recommend
for new design

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

"Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.

8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.

2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited

1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH

Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.

7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.

Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

Renesas Electronics Hong Kong Limited

Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.

13F, No. 363, Fu Shing North Road, Taipei, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.

1 harbourFront Avenue, #06-10, Keppel Bay Tower, Singapore 098632
Tel: +65-6213-0200, Fax: +65-6278-8001

Renesas Electronics Malaysia Sdn.Bhd.

Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics Korea Co., Ltd.

11F., Samik Laviel' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141