μPD166019T1F

Single P-Channel High-Side Intelligent Power Device

R07DS0730EJ0100
Rev.1.00
Apr 25, 2012

Description

The μPD166019 device is a P-channel high-side switch with diagnostic feedback and embedded protection functions. Due to the adoption of P-channel output switch this device dose not contains charge pump circuit and switching time is controllable by external resistance to IN pin.

Features

- Low noise by no built-in charge pump
- Low on-state resistance: 13.5 mΩ
- Short circuit protection
  - Shutdown by short-circuit detection
- Over temperature protection
  - Shutdown with auto-restart on cooling
- Loss of GND protection
- Small multi-chip package: JEDEC 5-pin TO-252
- Built-in Diagnostic function
  - Defined fault signal in case of thermal shutdown and/or short circuit shutdown via IN pin.

Ordering Information

Part No.	Lead Plating	Packing	Package
μPD166019T1F-E1-AY *1	Sn	Tape 2500 p/reel	5-pin TO-252 (MP-3ZK)

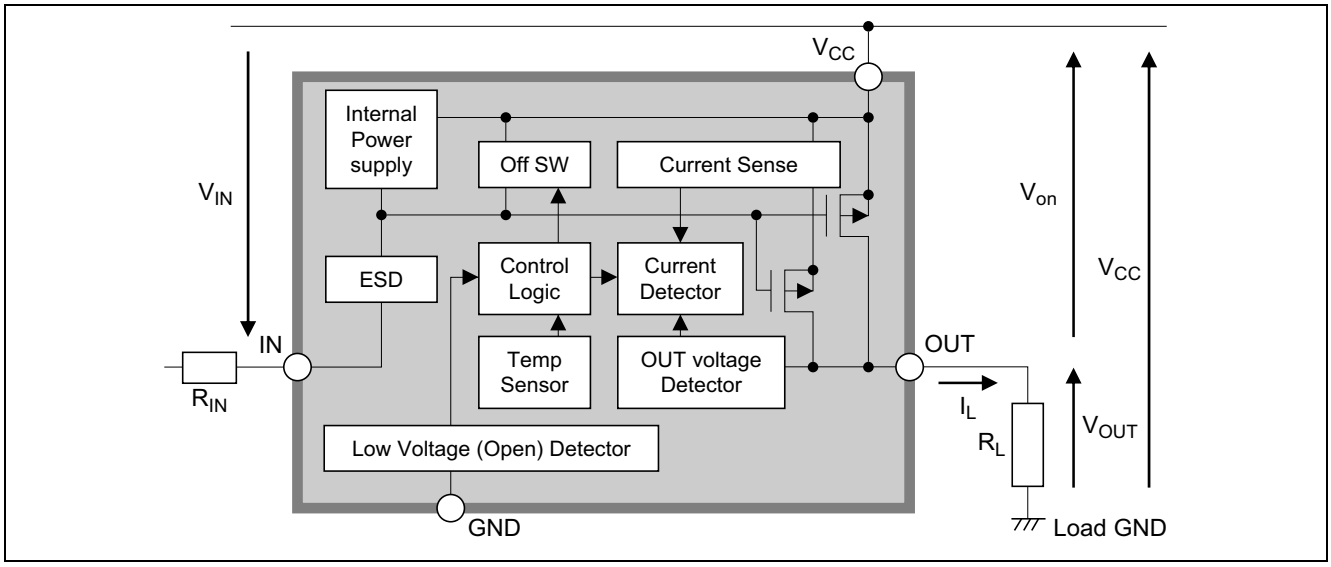
Note: *1 Pb-free (This product does not contain Pb in the external electrode.)

Application

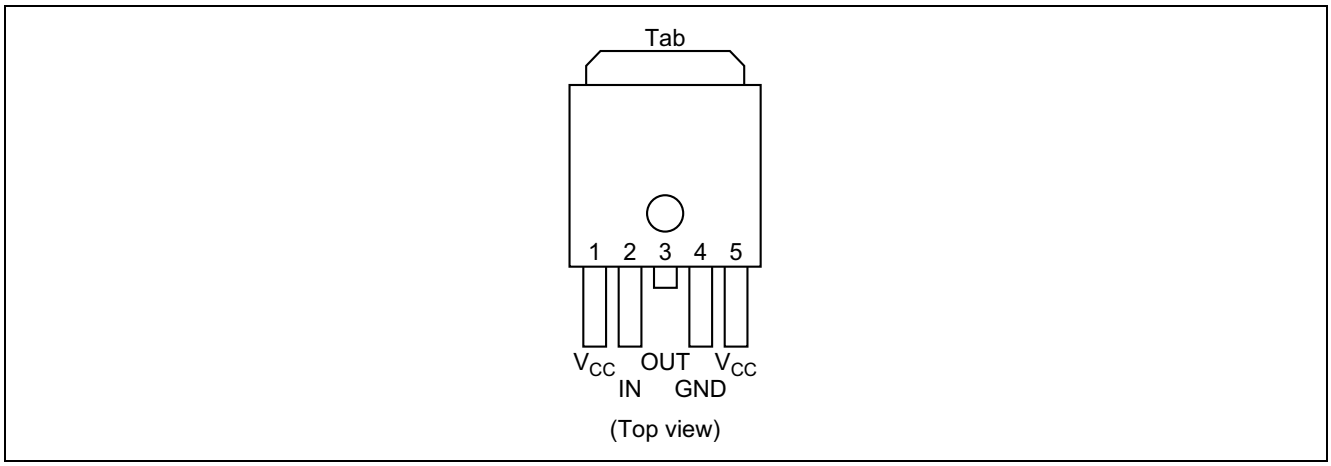
- Light bulb (to 65 W) switching
- Switching of all types of 14 V DC grounded load, such as inductor, resistor and capacitor
- Replacement of fuse and relay

Note: The information contained in this document is the one that was obtained when the document was issued, and may be subject to change.

Block Diagram



Pin Arrangement



Pin Function

Pin No.	Pin Name	Function
1	V_{CC}	Supply voltage: pin1 and 5 must be externally connected
2	IN	Input: activate the power switch by direct drive of output MOSFET
3/Tab	OUT	Output to load: Tab and pin 3 are internally connected
4	GND	Ground pin [Note]
5	V_{CC}	Supply voltage: pin1 and 5 must be externally connected

Note: In case of necessity to eliminate the destruction by the soldering bridge to V_{CC}: Pin#5, insert a resistor R_{GND} (recommended 1 kΩ max) between GND pin and system ground. In this condition, current flaws out to IN pin. R_{IN} is recommended 2 kΩ min.

GND to IN current = (R_{GND} × 1 mA – 0.6 V) / R_{IN}

Absolute Maximum Ratings

(Ta = 25°C, unless otherwise specified)

Item	Symbol	Rating	Unit	Test Conditions
V_{CC} voltage	V_{CC1}	28	V	
V_{CC} voltage for full short circuit protection	V_{CC2}	18	V	
V_{CC} voltage (Load Dump)	V_{CC3}	40	V	R_1 = 1 Ω, R_L = 1.5 Ω, t_d = 400 ms, IN = low or high
Load current (short circuit current)	$I_{L(SC)}$	Self limited	A	
Power Dissipation	P_D	59	W	Tc = 25°C
Avalanche current	I_{AS}	34	A	L = 100 μH
Channel temperature	T_{ch}	–40 to +150	°C	
Storage temperature	T_{stg}	–55 to +150	°C	
Electric discharge capability (Human Body Model)	V_{ESD}	±2.0	kV	AEC-Q100-022 std R = 1.5 kΩ, C = 100 pF
Input voltage	V_{IN}	0 to 28	V	IN pin, $V_{IN} \leq V_{CC}$, V_{CC} reference, 1 min
Input current	I_{IN}	–1.0	mA	IN pin

Recommended Operating Conditions

Item	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions
Power supply voltage	V_{CC}	7	—	16	V	T_{ch} = –40 to 150°C

Thermal Characteristics

Item	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions
Thermal resistance	$R_{th(ch-a)}$	—	45	55	°C/W	Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm^2 of 70 μm copper area

Electrical Characteristics

(V_{CC} = 12 V, T_{ch} = 25°C, unless otherwise specified)

Item	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions	
Low level input current	I_{IL}	—	—	20	μA	V_{IN} = 12 V, T_{ch} = –40 to 150°C	
Input voltage for turn-on	V_{INon}	4.5	—	—	V	V_{ON} = 0.16 V, I_L = 7.5 A, V_{CC} reference	
Input voltage for turn-off	V_{INoff}	—	—	1.5	V	$I_L \leq$ 1 mA, V_{CC} reference	
Standby Current	I_{GNDoff}	—	—	1.0	μA	T_{ch} = 25°C	V_{IN} = 0 V
		—	—	1.0	μA	T_{ch} = –40 to 150°C	
Output leakage current	I_{OUToff}	—	—	1.0	μA	T_{ch} = 25°C	V_{IN} = 0 V
		—	—	15	μA	T_{ch} = –40 to 150°C	
Circuit current	I_{GNDon}	—	—	1.0	mA	T_{ch} = 25°C	V_{IN} = 12 V
		—	—	1.5	mA	T_{ch} = –40 to 150°C	
On state resistance	R_{ON}	—	10.5	13.5	mΩ	T_{ch} = 25°C	V_{IN} = 12 V, I_L = 7.5 A
		—	17.5	23.0	mΩ	T_{ch} = 150°C	
On state resistance	R_{ON2}	—	13.5	21.0	mΩ	T_{ch} = 25°C	V_{IN} = 4.5 V, I_L = 7.5 A
		—	23.0	35.0	mΩ	T_{ch} = 150°C	
Turn on delay time	t_{don}	—	2.2	10	μs	R_L = 2.2 Ω, R_{IN} = 0 Ω, T_{ch} = –40 to 150°C	
Turn off delay time	t_{doff}	—	11.3	50	μs		
Rise time	t_r	—	4	20	μs		
Fall time	t_f	—	5	20	μs		

Protection Function

(V_{CC} = 12 V, T_{ch} = 25°C, unless otherwise specified)

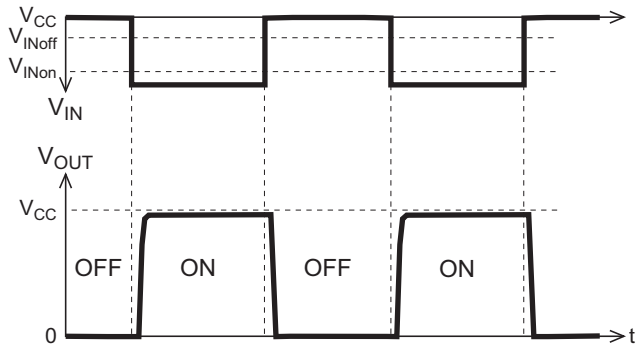
Item	Symbol	MIN.	TYP.	MAX.	Unit	Test Conditions	
Short circuit detection current	$I_{L7,3(SC)}$ *1	—	96	135	A	T_{ch} = –40°C	V_{CC} = 7 V, $V_{on} \leq$ 3 V
		33	67	—		T_{ch} = –25C	
		19	50	—		T_{ch} = 150°C	
	$I_{L9,3(SC)}$ *1	—	105	145		T_{ch} = –40°C	V_{CC} = 9 V, $V_{on} \leq$ 3 V
		42	96	—		T_{ch} = –25C	
		30	73	—		T_{ch} = 150°C	
	$I_{L12,3(SC)}$ *1	—	143	190		T_{ch} = –40°C	V_{CC} = 12 V, $V_{on} \leq$ 3 V
		56	130	—		T_{ch} = –25C	
		42	105	—		T_{ch} = 150°C	
	$I_{L16,3(SC)}$	—	144	190		T_{ch} = –40°C	V_{CC} = 16 V, $V_{on} \leq$ 3 V
		75	131	—		T_{ch} = –25C	
		60	107	—		T_{ch} = 150°C	
Thermal shutdown temperature	T_{th}	150	175	200	°C		
Thermal hysteresis	ΔT_{th}	—	14	—	°C	Resume temp: over 130°C	
Under voltage shutdown	$V_{CIN(UV)}$	3.7	4.8	5.7	V		
Under voltage restart	$V_{CIN(ST)}$	—	5.0	6.0	V		
Output current in fault condition	I_{OL}	180	300	—		V_{IN} = 7 V, V_{CC} = 7 V, T_{ch} = –40 to 150°C	

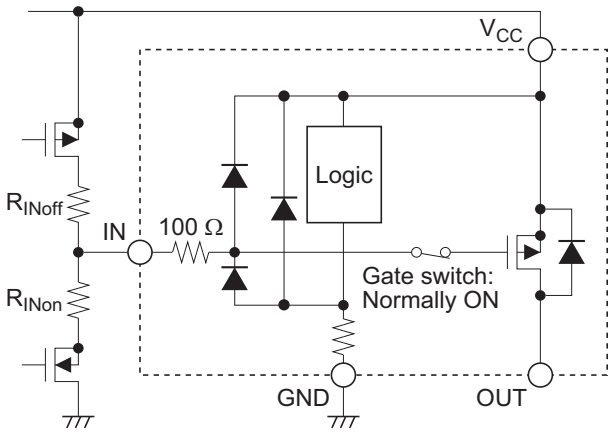
Note: *1 Not subject to production test, specified by design.

Function Description

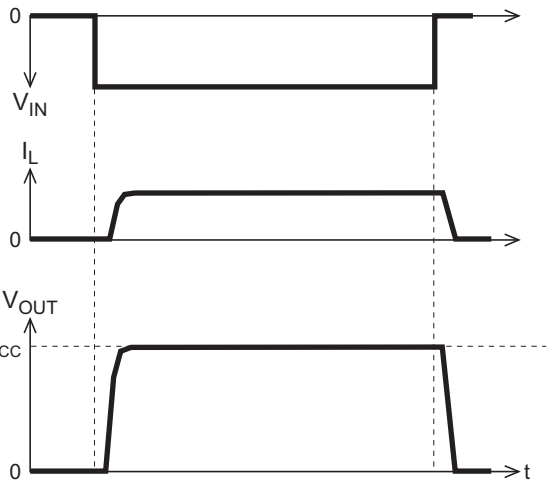
Driver Circuit (On-Off Control)

The high-side output, Pch MOSFET is turned on, if the IN input voltage is higher than V_{INon}. The high-side output, Pch MOSFET is turned off, if the IN input voltage is below V_{INoff}. Switching characteristics is adjustable by external resistor to IN pin.

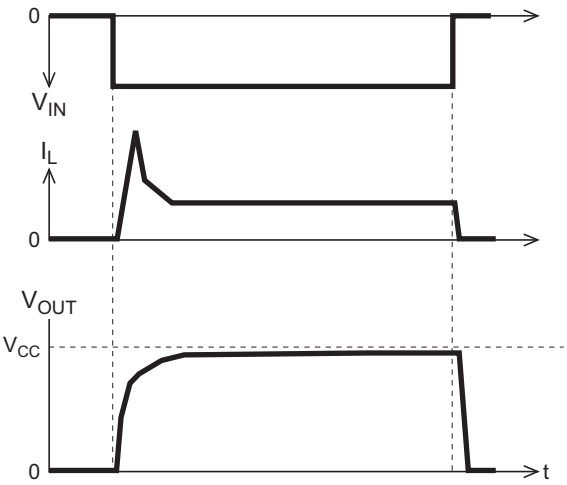




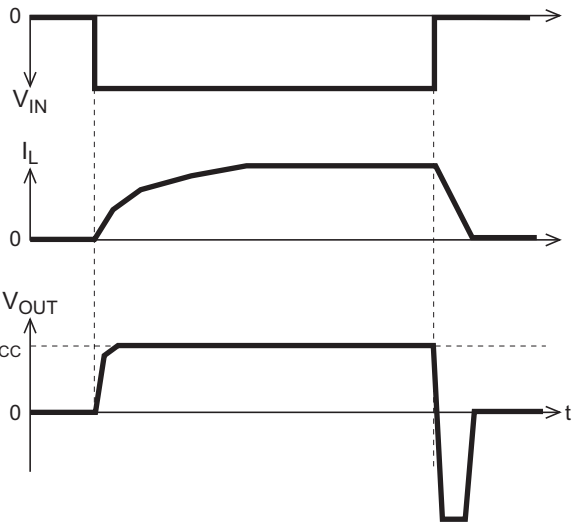
Switching a resistive load



Switching lamps



Switching an inductive load

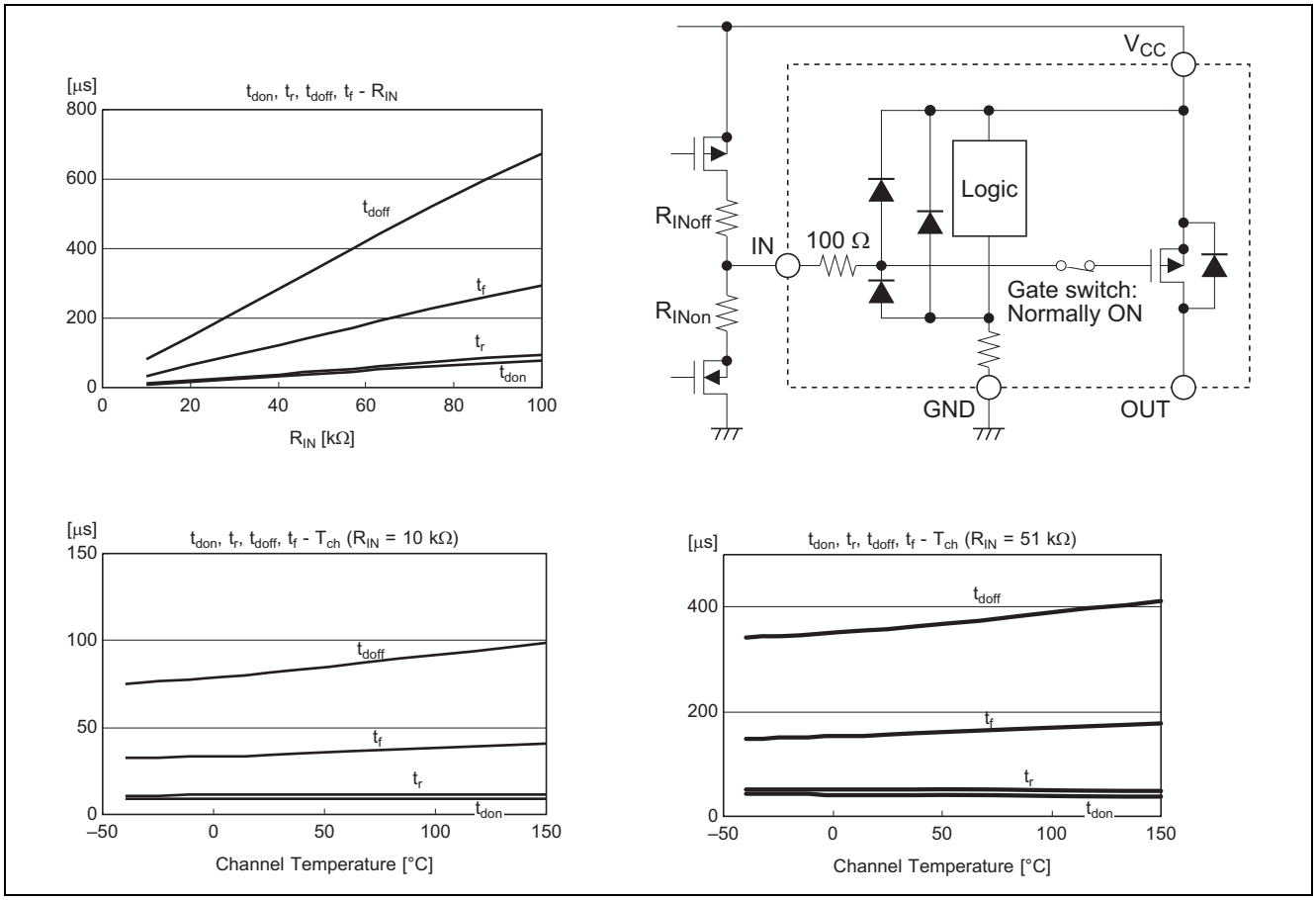


Avalanche Operation at Inductive Load Switch Off

The output MOS, Pch MOSFET is in avalanche when the inductive load is switched off. When the over-voltage is applied to V_{CC}, the output MOS, Pch MOSFET also works in avalanche operation.

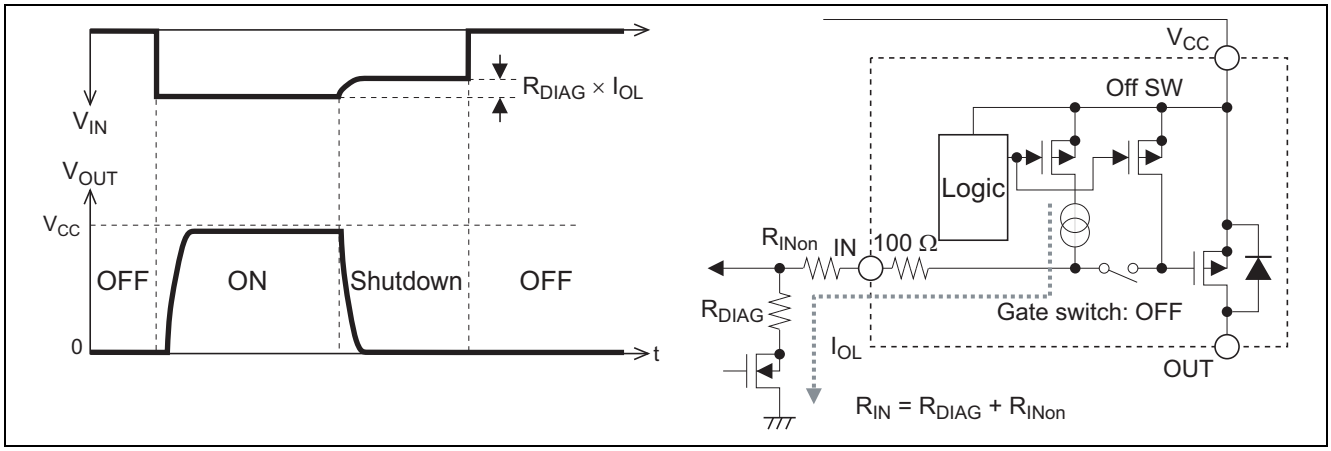
Adjustable Switching Characteristics by External Resistor

Switching characteristics is adjustable by the value of input resistance as following.



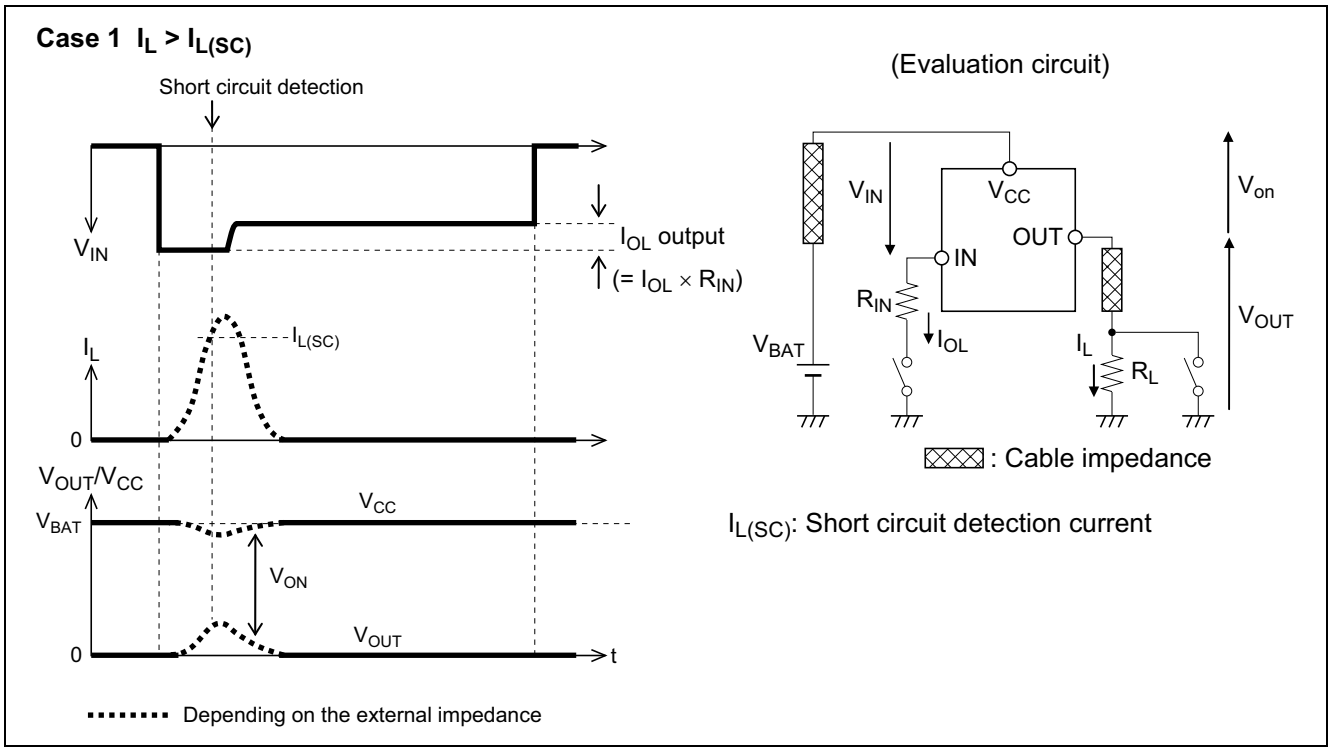
Diagnosis Output via IN Pin

The I_{OL} current starts flawing via IN pin, if the shut down occurred by the protection of short circuit or over temperature. In this condition, internal gate switch is turned-off and the I_{OL} current switch is turned-on. This diagnosis signals is detectable by external circuit, resistor and comparator.

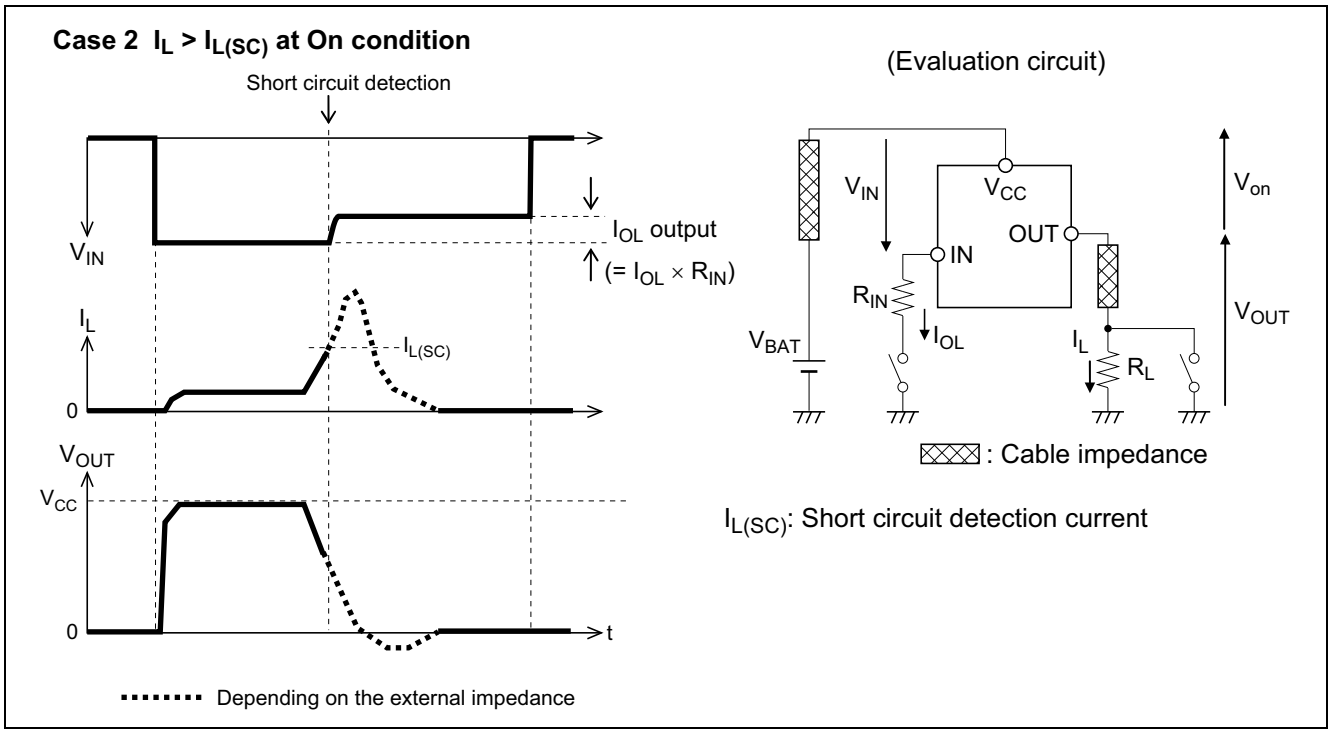


Short Circuit Protection

Case 1: Turn on in an overloaded condition, which includes a short circuit condition. The device shut down automatically when $I_L > I_{L(SC)}$ condition is detected. Then the V_{IN} value is increased by the output of I_{OL} current. Shutdown is latched until the next reset via IN input.

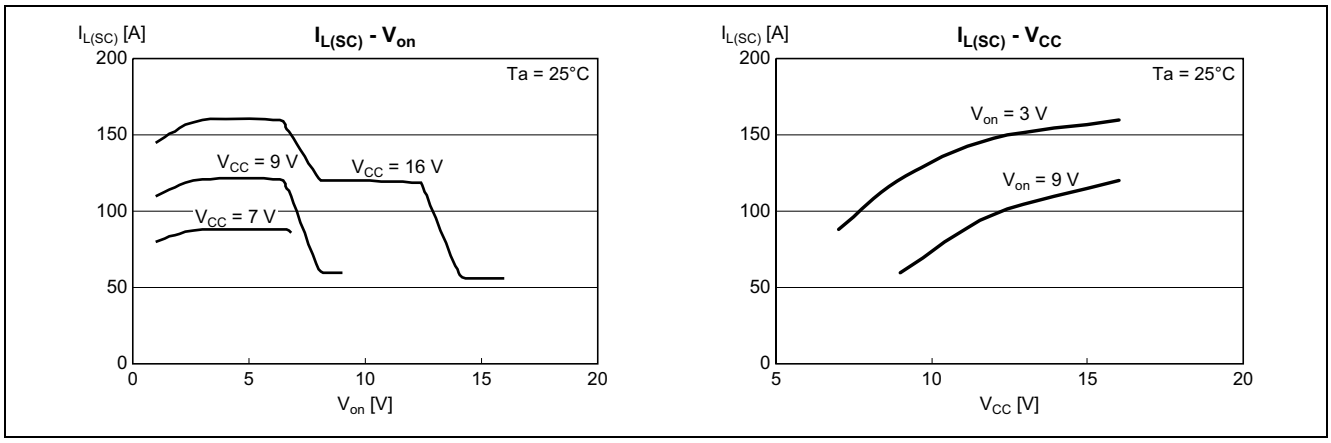


Case 2: Short circuit during On-condition. The device shut down automatically when $I_L > I_{L(SC)}$ condition is detected. Then the V_{IN} value is increased by the output of I_{OL} current. Shutdown is latched until the next reset via IN input.



Typical Short Circuit Detection Current Characteristics

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

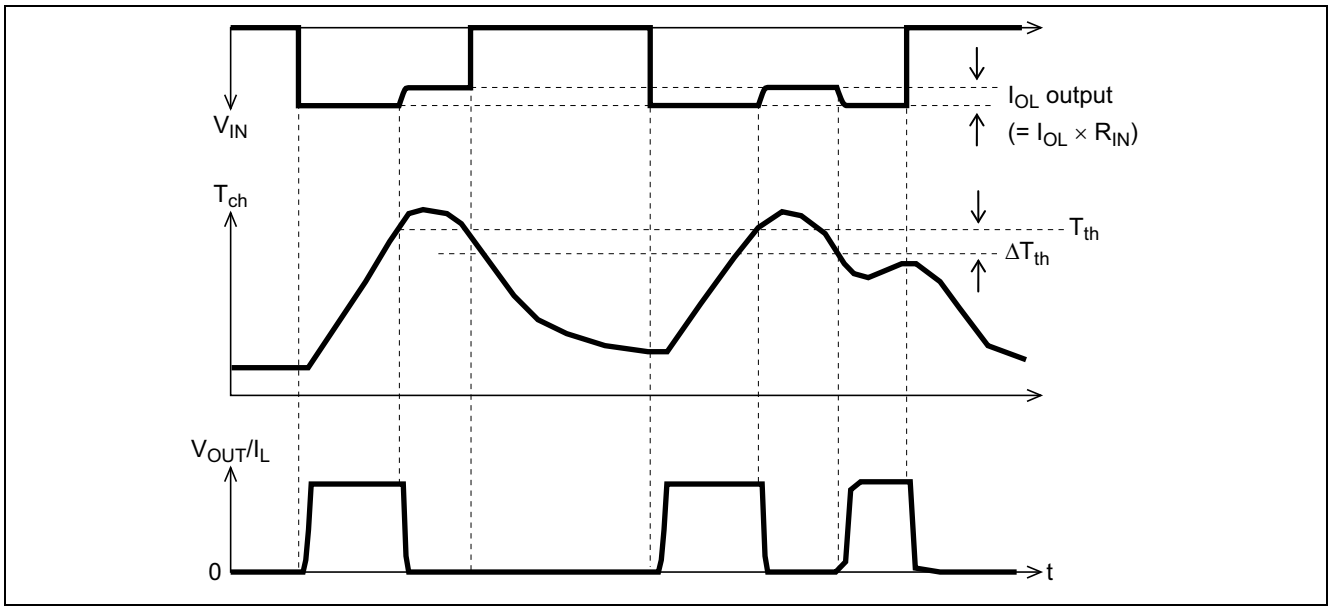


Driving Capability

The μPD166019 can drive above 215 mΩ, equivalent with 65 W bulb as load resistibility include load itself, wire harness, contact resistance of connector, wiring resistibility of PCB at V_{CC} = 9 to 16 V, T_{ch} = 25°C condition.

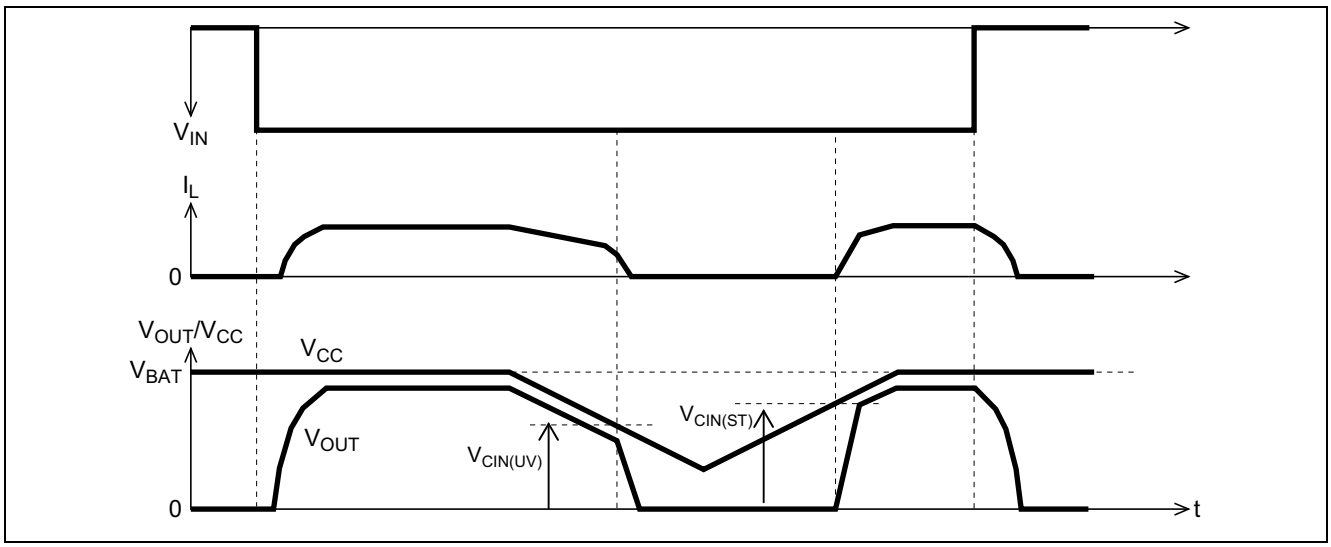
Over-Temperature Protection

The output is switched off if over-temperature is detected. The device switches on again after it cools down.



Device Behavior at Low Voltage Condition

If the supply voltage, V_{CC} goes down under $V_{CIN(UV)}$, The device shuts down the output. If the supply voltage, V_{CC} increase over $V_{CIN(ST)}$, the device turns on the output automatically. The device keeps off-state if supply voltage, V_{CC} does not increase over $V_{CIN(ST)}$ after under voltage shutdown.



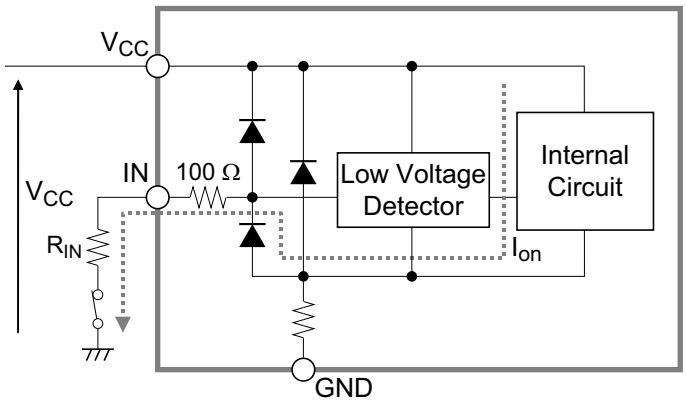
Loss of Ground Protection

In case of complete loss of the device ground connection, but connected load ground, the device securely changes to off-state by low voltage detector. In loss of ground condition voltage of internal circuit is as below. Thus RIN should be bigger than 40 kΩ to activate this function.

Internal circuit voltage = $V_{CC} - I_{on} \times (R_{IN} + 100\ \Omega) - Vf$

Low voltage detection voltage: $V_{CIN(UV)}$

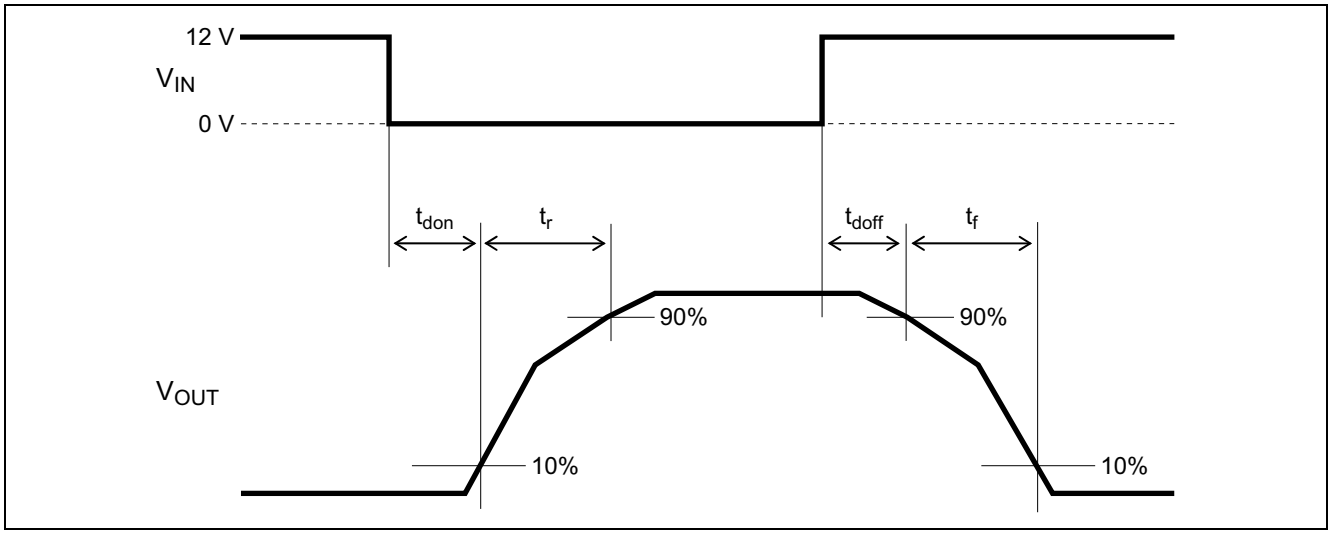
Even though there is possibility to keep on state if R_{IN} is lower than 40 kΩ, output MOSFET is secured in full on state by circuit design.



I_{on}: Circuit current, 300 μA min

Measurement Condition

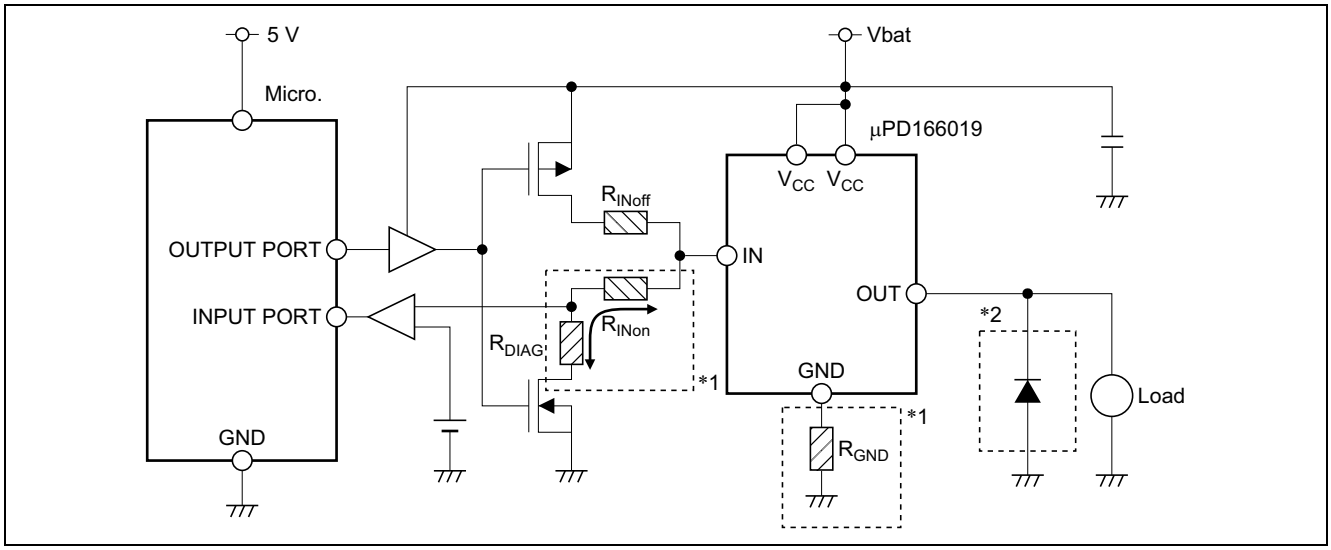
Switching waveform of OUT pin



Truth Table

Input Voltage	State	Output	Output Current in Fault Condition
$V_{IN} \leq V_{INoff}$	OFF state	OFF	—
$V_{IN} \geq V_{INon}$	Normal operation	ON	—
	Over-temperature	OFF (Shut down), restart by $T_{ch} < T_{th} - \Delta T_{th}$	I_{OL}
	Short circuit	OFF (Shut down)	I_{OL}

Application Example in Principle



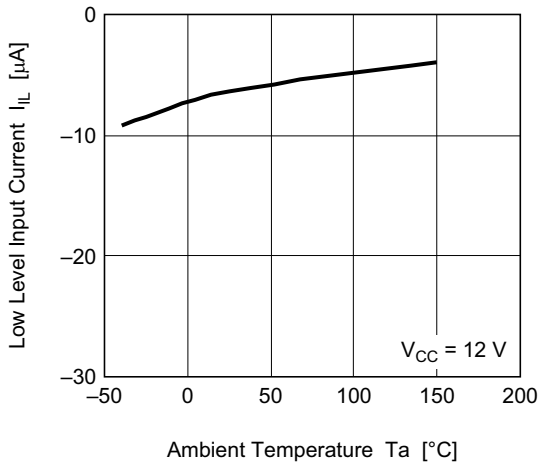
Notes: *1 In case of necessity to eliminate the destruction by the soldering bridge to Vcc: Pin#5, insert a resistor R_{GND} (recommended 1 kΩ max) between GND pin and system ground. In this condition current flows out to IN pin. R_{INon} is recommended 2 kΩ min.

GND to IN current = (R_{GND} × 1 mA – 0.6 V) / R_{INon}

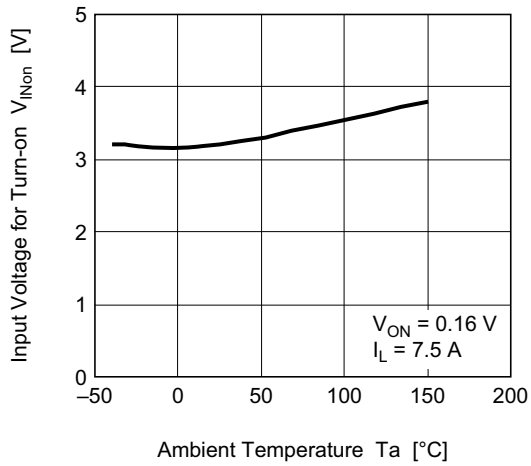
*2 If the load is inductive, it is recommended to connect a free-wheel diode between OUT pin and ground.

Typical Characteristics

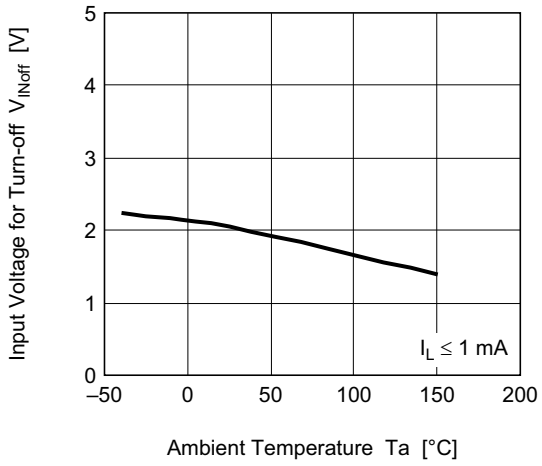
LOW LEVEL INPUT CURRENT vs.
AMBIENT TEMPERATURE



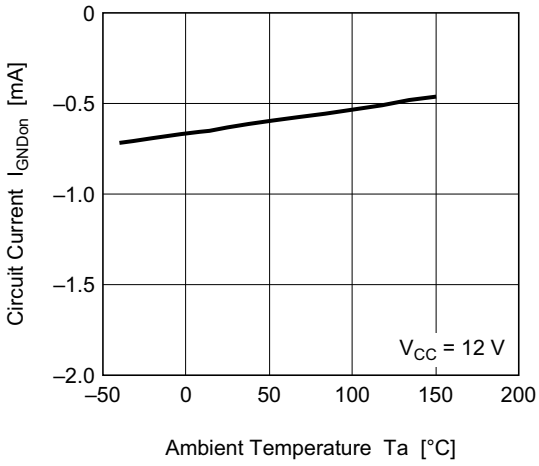
INPUT VOLTAGE FOR TURN-ON vs.
AMBIENT TEMPERATURE



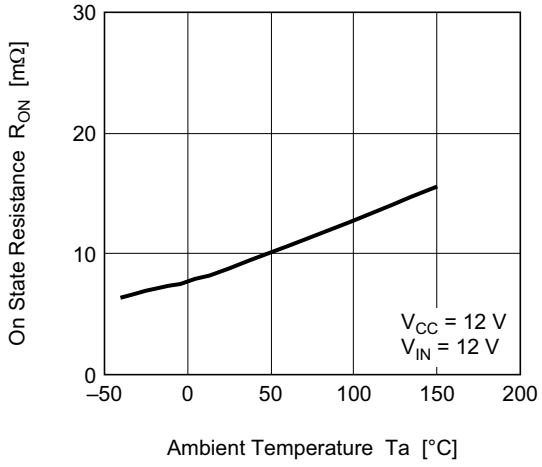
INPUT VOLTAGE FOR TURN-OFF vs.
AMBIENT TEMPERATURE



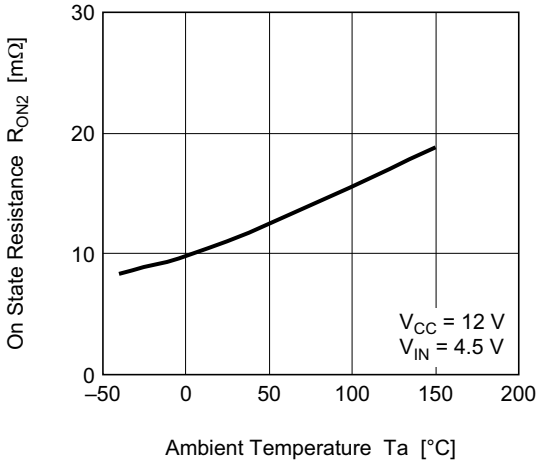
CIRCUIT CURRENT vs.
AMBIENT TEMPERATURE



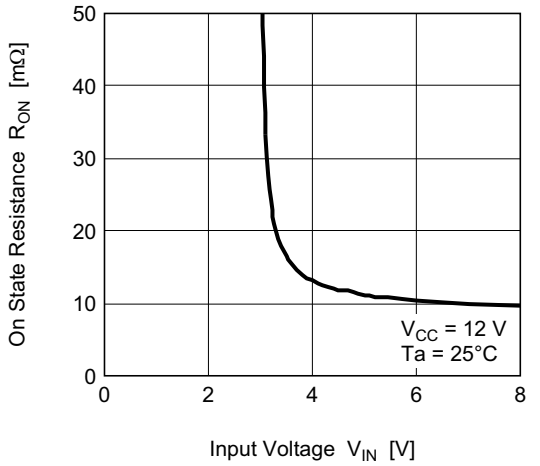
ON STATE RESISTANCE vs.
AMBIENT TEMPERATURE



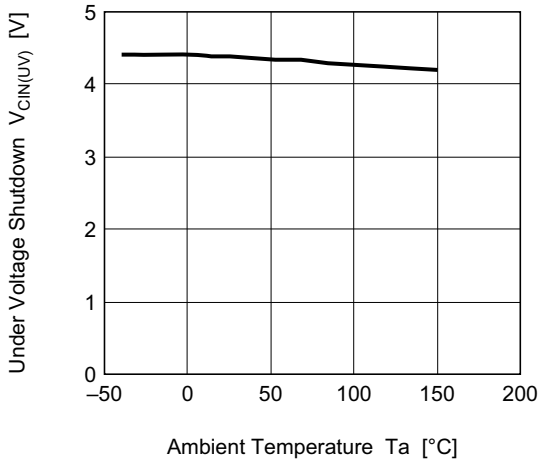
ON STATE RESISTANCE vs.
AMBIENT TEMPERATURE



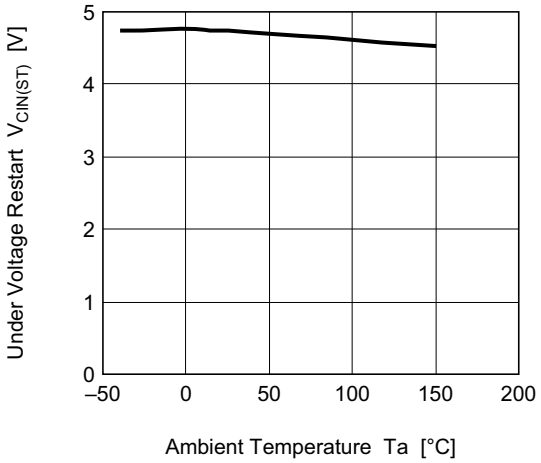
ON STATE RESISTANCE vs.
INPUT VOLTAGE



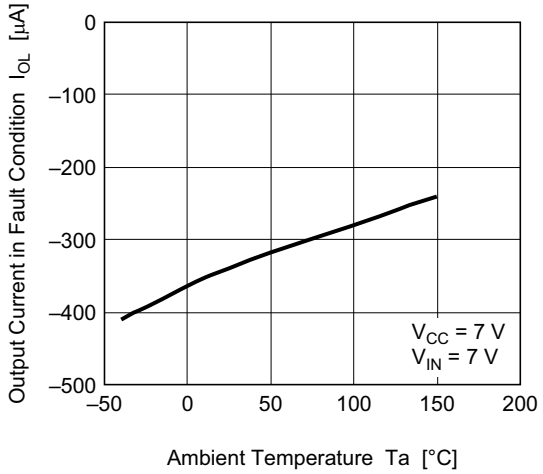
UNDER VOLTAGE SHUTDOWN vs.
AMBIENT TEMPERATURE



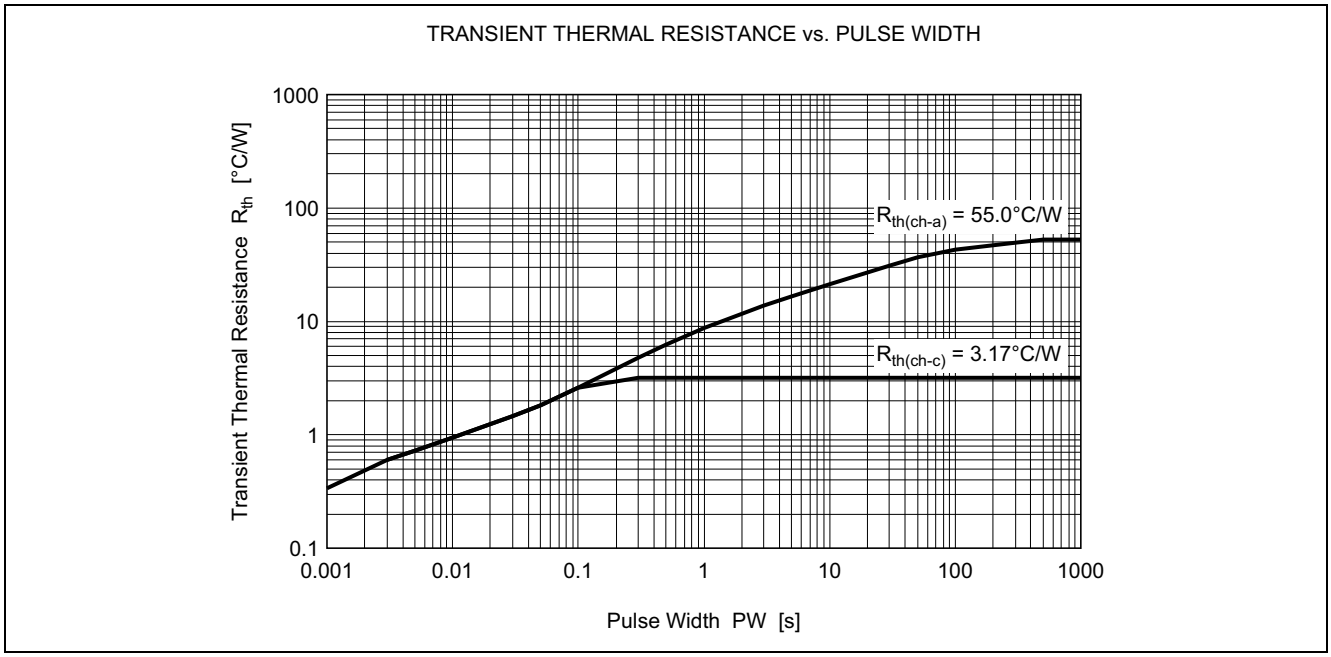
UNDER VOLTAGE RESTART vs.
AMBIENT TEMPERATURE



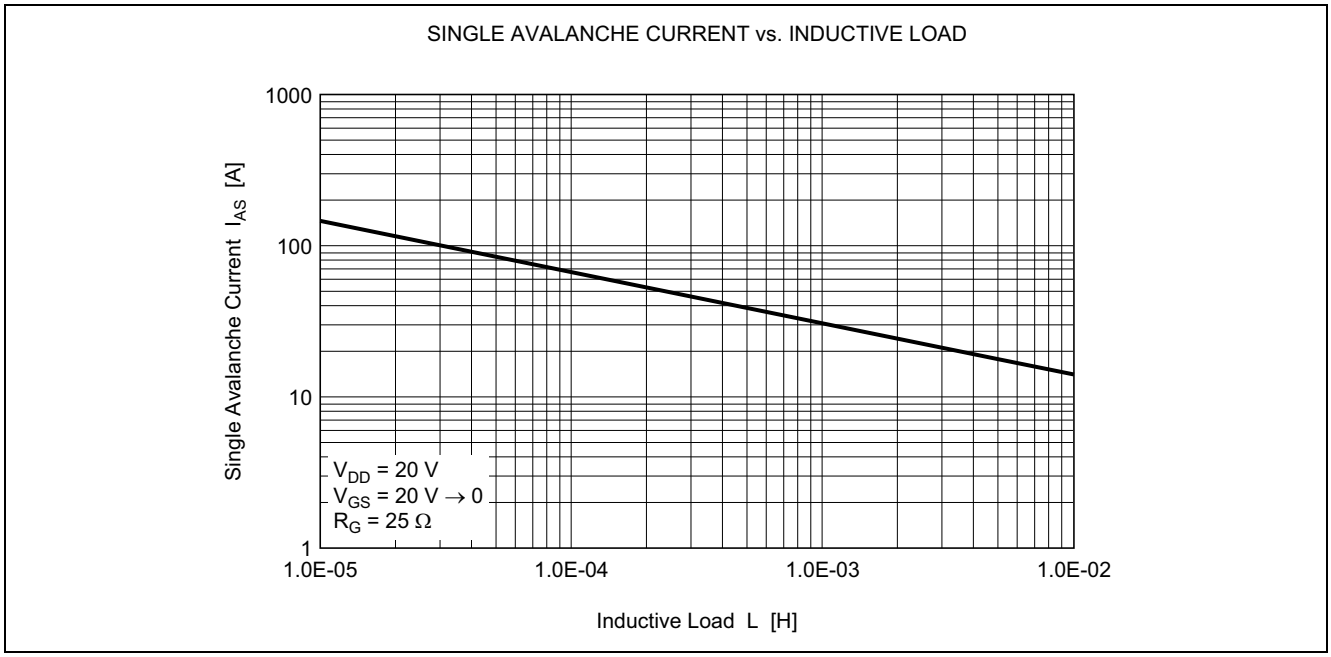
OUTPUT CURRENT IN FAULT CONDITION vs.
AMBIENT TEMPERATURE



Thermal Characteristics

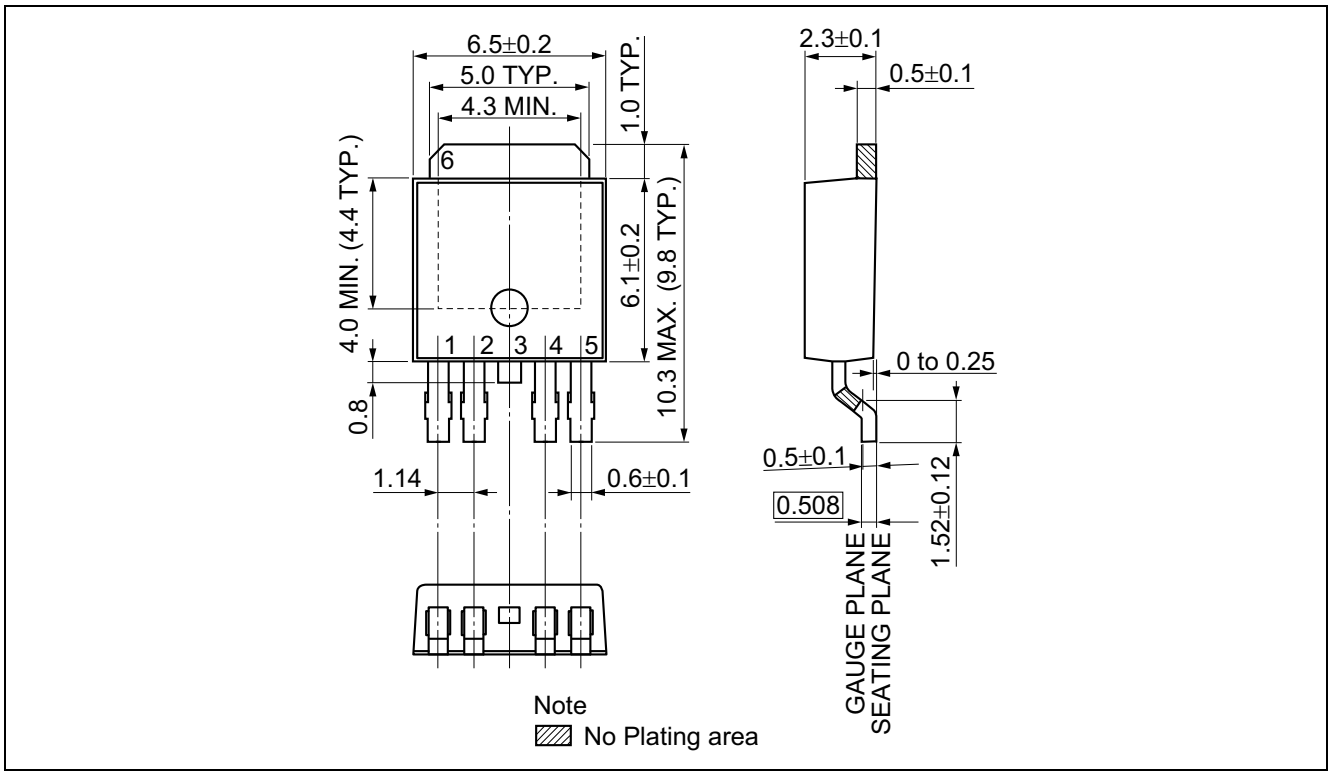


Single Avalanche Current vs. Inductive Load



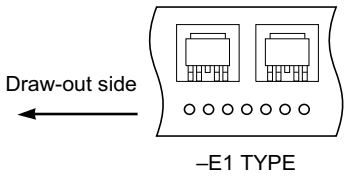
Package Dimensions (Unit: mm)

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



Taping Information

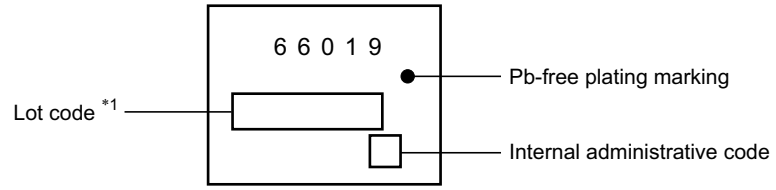
This is one type (E1) of direction of the device in the career tape.



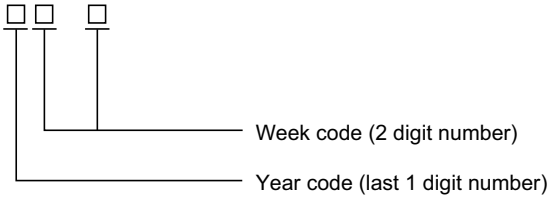
–E1 TYPE

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



Revision History	μPD166019T1F Data Sheet

Rev.	Date	Description	
		Page	Summary
1.00	Apr 25, 2012	—	First Edition Issued

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