

RAJ2810024H12HPD

Intelligent Power Device for automotive application

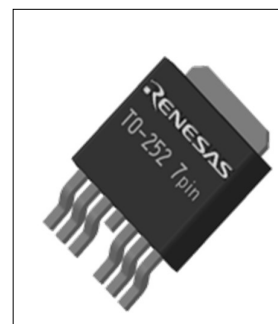
1. Overview

RAJ2810024H12HPD is a 2.3mΩ single channel Intelligent Power Device (IPD) available in a TO252-7 package. This device is a 4.5V to 28V N-channel High-Side Switch (HSS) with a charge pump, diagnostic feedback and integrated protection function. It is designed for use in automotive 12V systems.

The RAJ2810024H12HPD helps reduce power losses in the vehicle thanks to its 0.5uA standby current, which makes it suitable for use in power distribution switches, heaters, and glow plugs.

1.1 Features

- Improved current sense accuracy with offset cancelation (+9.5%/-11% @30A)
- Keep on-resistance during cranking condition (max 4mΩ@3.2V/24ms/25°C)
- Low standby current (0.5uA max @25°C)
- Short circuit protection
 - Shutdown by over current detection
 - Shutdown by absolute channel over temperature detection
- Built-in diagnostic function
 - Proportional load current sensing
 - Defined fault signal in case of abnormal load condition
- Reverse battery protection by self-turn ON
- Loss of ground protection
- Von clamp operation at inductive load switch-off
- AEC-Q100 Grade 1 qualified
- Built-in charge pump
- 3.3V compatible logic interface



1.2 Product summary

Table 1 Product summary

Parameter	Symbol	Values
Operating Voltage	Vcc	4.5V to 28V
On-state resistance at 25°C	Ron	Typ. 2.3 mΩ, Max. 3.0 mΩ
Inductive load switch-off energy dissipation single pulse	EAS	170mJ
Inductive load switch-off energy dissipation repetitive pulse	EAR	50mJ
Over current detection current1	IL1(SC)	Min. 70A, Typ. 106A
Over current detection current2	IL2(SC)	Min. 95A, Typ. 125A
Current sense ratio with offset cancel at IL=30A	KILIS	Min. 57000 Typ. 64000, Max. 70000

2. Ordering Information

Table 2 Ordering Information

Part No.	Lead plating	Packing	Package
RAJ2810024H12HPD	Pure Matte Sn	Tape 2500pcs/reel	TO252-7

All information contained in these materials, including products and product specifications, represents information on the product at the time of publication and is subject to change by Renesas Electronics Corp. without notice. Please review the latest information published by Renesas Electronics Corp. through various means, including the Renesas Electronics Corp. website (<http://www.renesas.com>).

3. Specification

3.1 Block Diagram

3.1.1 Nch High-side Single Channel Device Block Diagram

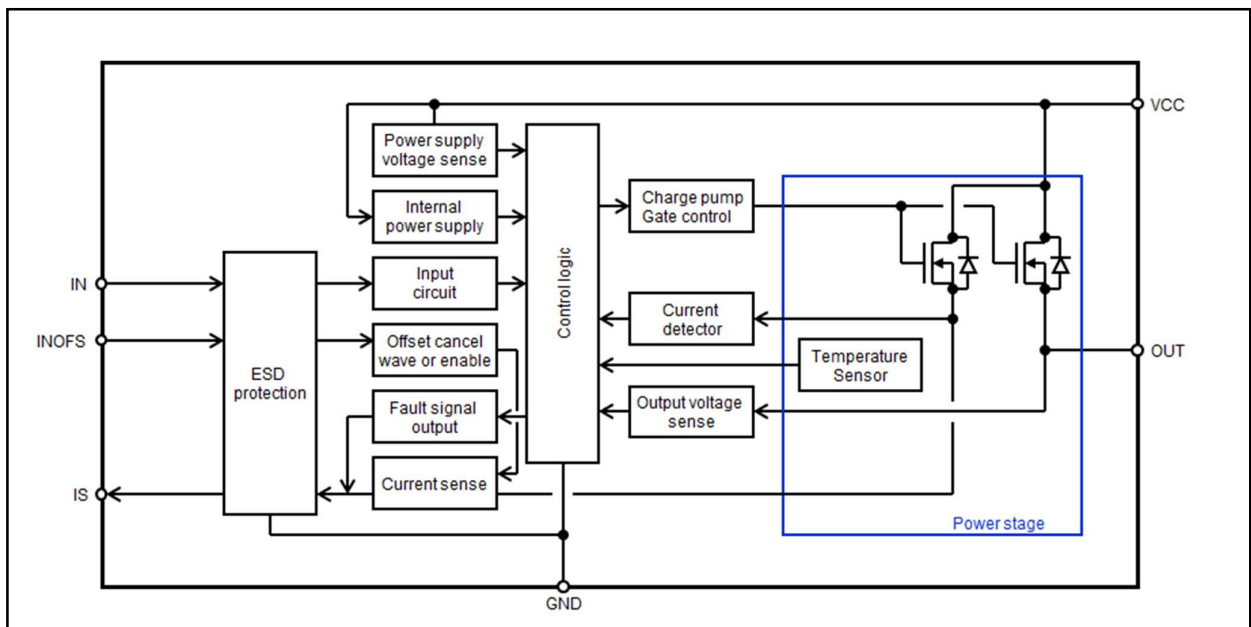


Figure 1 **Block Diagram of RAJ2810024H12HPD**

3.1.2 Voltage and Current Definition

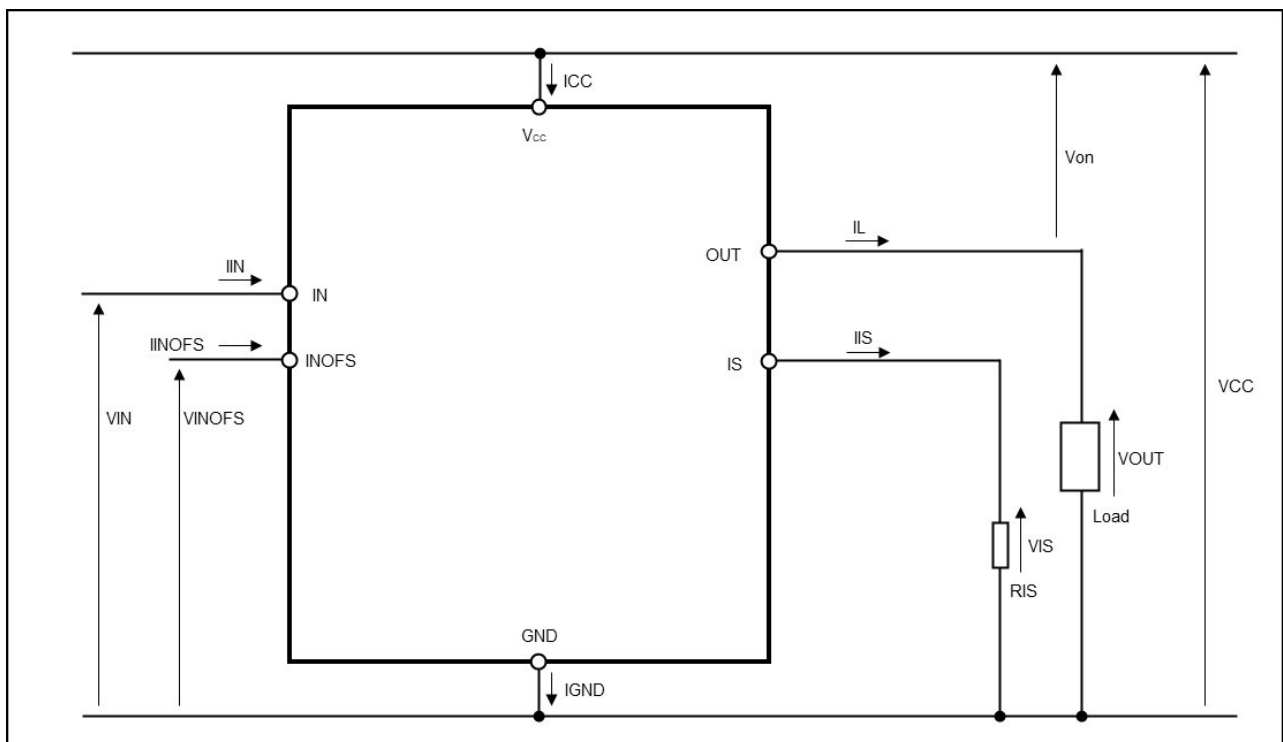


Figure 2 Voltage and Current Definition

3.2 Pin Configuration

Table 3 TO252-7 Pin Configuration

Pin No.	Terminal Name
1	OUT
2	GND
3	IN
4, Tab	VCC
5	IS
6	INOFS
7	OUT

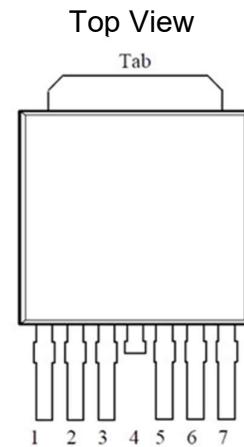


Figure 3 Pin Configuration

Table 4 Pin function

Terminal Name	Pin function	Recommended connection	
		Sense current improved accuracy function enabled	Sense current improved accuracy function disabled
GND	Ground connection	Connected to GND through a 47Ω resistor	
IN	Input signal for channel activation Active high	Connected to MCU's output port through a 2k-50kΩ serial resistor	
IS	Current sense and Diagnosis output signal	Connected to GND through a 1k-6kΩ resistor with LPF. Refer to chapter 6.	Connected to GND through a 1k-6kΩ resistor.
		Connect the resistor even if this pin is not used.	
OUT	Protected high-side power output	Connected to load with 50-100nF capacitor in parallel.	
VCC	Positive power supply for logic supply as well as output power supply	Connected to battery voltage with 22nF capacitor in parallel. Refer to chapter 6.	
INOFS	Input signal for sense current improved accuracy Active high	Connected to MCU's output port through a 2k-50kΩ serial resistor to use sense current improved accuracy function.	This pin should be open.

3.3 Absolute Maximum Ratings

Stress values that exceed those listed here may cause permanent damage to the device. Exposure to absolute maximum rating condition for extended periods may affect device reliability. Integrated protection functions are designed to prevent IC destruction under fault condition described in the data sheet. Fault conditions are considered as out of normal operation.

Table 5 Absolute Maximum Ratings

Ta=25°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
VCC Voltage	VCC	-	-	28	V	
VCC Voltage at reverse battery condition	-VCC	-	-	16	V	At nominal load current, t<2min, RIN=2kΩ, RIS=1kΩ, RGND=47Ω
VCC voltage under Load Dump condition	Vload dump	-	-	35	V	RI=1Ω, RL=Nominal load, RIS=1kΩ, RIN=2kΩ, RGND=47Ω, td=400ms
Load Current	IL	-	-	Self-limited	A	
Total power dissipation for whole device (DC)	PD	-	-	1.85	W	Ta=85°C Device on 50mmx50mmx1.5mm epoxy PCB FR4 with 6 cm2 of 70 um copper area
Voltage at IN/INOFS pin	VIN	-2	-	16	V	DC RIN=2kΩ
	VINOFS	-16	-	-		At reverse battery condition, t<2min, RIN=2kΩ
IN/INOFS pin current	IIN IINOFS	-	-	10	mA	DC
Voltage at IS pin	VIS	-2	-	VCC	V	DC RIS=1kΩ
		-16	-	-	V	At reverse battery condition, t<2min, RL= Nominal load, RIS=1kΩ
Channel Temperature	Tch	-40	-	150	°C	
Storage Temperature	Tstg	-55	-	150	°C	
Inductive load switch-off energy dissipation single pulse	EAS	-	-	170	mJ	VCC=13.5V, T _{ch, start} ¹⁾ <150°C, RL=Nominal load, Refer to 3.7.12
Inductive load switch-off energy dissipation repetitive pulse	EAR	-	-	50	mJ	VCC=13.5V, T _{ch, start} ¹⁾ =85°C, RL=Nominal load, Refer to 3.7.12

Remark) All voltages refer to ground pin of the device.

1) T_{ch, start} means T_{ch} at the start of the test.

3.4 ESD

Table 6 ESD

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition		
ESD susceptibility	VESD	-2000	-	2000	V	HBM	AEC-Q100-002 std. R=1.5kΩ, C=100pF	All pin
		-4000	-	4000			IEC61000-4-2 std. R=330Ω, C=150pF, 100nF at VCC and OUT	VCC, OUT

3.5 Thermal Characteristics

Table 7 Thermal Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Thermal characteristics	Rth(ch-a)	-	35	-	°C/W	According to JEDEC JESD51-2, -5, -7 on FR4 2s2p board
	Rth(ch-c)	-	0.65	-	°C/W	

3.6 Electrical Characteristics

Table 8 Operation function
 $T_{ch} = -40$ to 150°C , $V_{CC} = 7$ to 18V , unless otherwise specified

 Typ: $T_{ch} = 25^{\circ}\text{C}$, $V_{CC} = 13.5\text{V}$ unless otherwise specified

Parameter	Symbol	Min	Typ	Max	Unit	Test Condition
Operating Voltage	V_{CC}	4.5	-	28	V	$V_{IN} = 4.5\text{V}$, $R_L = \text{Nominal load}$, Refer to 3.7.12
Operating current	I_{GND}	-	3.4	6.8	mA	$V_{IN} = 4.5\text{V}$
Output Leakage current	$I_L (\text{off})$	-	-	0.2	μA	$T_{ch} = 25^{\circ}\text{C}$
		-	-	5		$T_{ch} = -40$ to 125°C
Standby current	$I_{CC} (\text{off})$	-	-	0.5	μA	$T_{ch} = 25^{\circ}\text{C}$
		-	-	1.5		$T_{ch} = -40$ to 85°C
On-state resistance	R_{on}	-	2.3	3.0	m Ω	$T_{ch} = 25^{\circ}\text{C}$
		-	-	4.8		$T_{ch} = 150^{\circ}\text{C}$
Low level IN/INOFS pin voltage	V_{IL} V_{ILOFS}	-	-	0.8	V	
High level IN/INOFS pin voltage	V_{IH} V_{IHOFS}	2.5	-	-	V	
Low level IN/INOFS pin current	I_{IL} I_{ILOFS}	2	-	30	μA	$V_{IN} = 0.8\text{V}$ $V_{INOFS} = 0.8\text{V}$
High level IN/INOFS pin current	I_{IH} I_{IHOFS}	2	-	30	μA	$V_{IN} = 2.5\text{V}$ $V_{INOFS} = 2.5\text{V}$
Clamping IN/INOFS pin voltage ¹⁾	V_{ZIN} V_{ZINOFS}	5	6	-	V	
Operating current at cranking	$I_{GND} (\text{cr})$	-	0.5	-	mA	$V_{CC} = 3.2\text{V}$, $R_{GND} = 47\Omega$, $R_L = \text{Nominal load}$, Pulse duration = 24ms, Refer to 3.7.12
Cranking mode voltage	$V_{CC} (\text{cr})$	-	-	4.5	V	
On-state resistance at cranking	$R_{on} (\text{cr})$	-	-	4.0	m Ω	$V_{CC} = 3.2\text{V}$, $R_{GND} = 47\Omega$, $T_{ch} = 25^{\circ}\text{C}$, $R_L = \text{Nominal load}$, Pulse duration = 24ms, Refer to 3.7.3 and 3.7.12
Operating Voltage range for cranking	$V_{CC} (U_v, \text{cr})$	3.2	-	-	V	$R_{GND} = 47\Omega$, $T_{ch} = 25^{\circ}\text{C}$, Pulse duration = 24ms, $R_L = \text{Nominal load}$, Refer to 3.7.12
Operation start voltage	$V_{CC} (\text{start})$	-	-	4.5	V	
Turn on time	t_{on}	-	260	550	μs	$V_{CC} = 13.5\text{V}$, $R_L = \text{Nominal load}$, Refer to 3.7.12 $T_{ch} = 25^{\circ}\text{C}$ to 150°C
Turn on delay time	$t_{d(on)}$	-	75	150	μs	
Turn off time	t_{off}	-	190	420	μs	
Turn off delay time	$t_{d(off)}$	-	135	290	μs	
Slew rate on	dV/dt_{on}	-	0.10	0.4	V/ μs	
Slew rate off	$-dV/dt_{off}$	-	0.28	0.83	V/ μs	
Turn on time	t_{on}	-	250	550	μs	$V_{CC} = 13.5\text{V}$, $R_L = \text{Nominal load}$, Refer to 3.7.12 $T_{ch} = -40^{\circ}\text{C}$
Turn on delay time	$t_{d(on)}$	-	80	160	μs	
Turn off time	t_{off}	-	220	550	μs	
Turn off delay time	$t_{d(off)}$	-	165	430	μs	
Slew rate on	dV/dt_{on}	-	0.12	0.4	V/ μs	
Slew rate off	$-dV/dt_{off}$	-	0.29	0.83	V/ μs	
Turn on energy loss ¹⁾	E_{on}	-	15	-	mJ	$V_{CC} = 13.5\text{V}$, $T_{ch} = 25^{\circ}\text{C}$, $R_L = \text{Nominal load}$, Refer to 3.7.12
Turn off energy loss ¹⁾	E_{off}	-	5	-	mJ	
Driving capability ¹⁾	$D_r(\text{capa})$	153	-	-	m Ω	$V_{CC} = 16.0\text{V}$, $T_{ch} = 25^{\circ}\text{C}$

Remark) All voltages refer to ground pin of the device.

1) not subjected production test, guaranteed by design

Table 9 Protection functionT_{ch}= -40 to 150°C, V_{CC}=7 to 18V, unless otherwise specifiedTyp: T_{ch}=25°C, V_{CC}=13.5V unless otherwise specified

Parameter	Symbol	Min	Typ	Max	Unit	Test Condition	
Over current detection current1	IL1(SC)	70	106	-	A	VCC=13.5V, Von=5V, T _{ch} =25°C	
Over current detection Current2	IL2(SC)	95	125	-	A	VCC=13.5V, Von<Von(kilis), T _{ch} =25°C	
Sense current output trigger threshold	Von(kilis)	-	0.5	-	V	VCC=13.5V, T _{ch} =25°C	
Von check in over current state	Von (OC)	-	0.4	-	V	VCC=13.5V, T _{ch} =25°C	
Turn on check delay in over current state	tdOC (OC)	0.8	1.4	2.1	ms	VCC=13.5V, T _{ch} =25°C, Over Current state	
Von check at cranking in over current state	VonCR (OC)	-	0.2	-	V	VCC=3.2V, T _{ch} =25°C	
Absolute thermal shutdown temperature	aTth	150	-	-	°C		
Von clamp voltage at inductive load switch-off	V _{on,clamp}	35	43	47	V	VCC=13.5V, IL=40mA, T _{ch} =25°C	
Output current while GND disconnection	IL(GND)	-	-	1	mA	IIN=0A, IGND=0A, IIS=0A, IINOFs=0A	
On-state resistance at reverse battery condition	Ron(rev)	-	2.3	3.0	mΩ	T _{ch} =25°C	VCC=-13.5V, IL=Nominal current, Refer to 3.7.12
		-	-	4.8		T _{ch} =150°C	
GND current at reverse battery condition	IGND (rev)	-	-2	-	mA	VCC =-16V, T _{ch} =25 °C	

Remark) All voltages refer to ground pin of the device.

Protection functionality is kept V_{CC}=6V min.

Table 10 Diagnosis function $T_{ch}=-40$ to 150°C , $V_{CC}=7$ to 18V , $V_{IN}=4.5\text{V}$, unless otherwise specified
 Typ: $T_{ch}=25^{\circ}\text{C}$, $V_{CC}=13.5\text{V}$ unless otherwise specified

Parameter	Symbol	Min	Typ	Max	Unit	Test Condition
Current sense ratio	KILIS	56000	64000	70500	-	$I_L=4\text{A}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func)
		57000	64000	70000	-	$I_L=10\text{A}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func) ¹⁾
		57000	64000	70000	-	$I_L=15\text{A}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func) ¹⁾
		57000	64000	70000	-	$I_L=30\text{A}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func)
		28000	64000	105000	-	$I_L=4\text{A}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func)
		42000	64000	86000	-	$I_L=10\text{A}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func) ¹⁾
		48000	64000	80000	-	$I_L=15\text{A}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func) ¹⁾
		53000	64000	75000	-	$I_L=30\text{A}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func)
Current sense drift depends on temperature	dKILIS	-6	-	4	%	$V_{CC}=13.5\text{V}$, $T_{ch, start}=25^{\circ}\text{C}$, $I_L=30\text{A}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func), Refer to 3.7.12
		-10	-	10	%	$V_{CC}=13.5\text{V}$, $T_{ch, start}=25^{\circ}\text{C}$, $I_L=30\text{A}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func), Refer to 3.7.12
Offset current of sense current	lis,offset	-	-	2.5	μA	$I_L=0\text{A}$, $T_{ch}=25^{\circ}\text{C}$, $V_{INOFs}=4.5\text{V}$ (use improved accuracy func)
		-	-	20	μA	$I_L=0\text{A}$, $T_{ch}=25^{\circ}\text{C}$, $V_{INOFs}=0\text{V}$ (no use improved accuracy func)
Sense voltage under fault condition	Vis,fault	4.5	5.6	7.0	V	$R_{IS}=1\text{k}\Omega$
Sense current settling time after input signal positive slope	tsis(on)	-	460	700	μs	$V_{CC}=13.5\text{V}$, $V_{IN}=0\text{V}$ to 4.5V , $I_L/I_{IS}=KILIS$, $R_L=\text{Nominal load}$, No LPF ²⁾ , Refer to 3.7.12
Sense current settling time after input signal negative slope ¹⁾	tsis(off)	-	5	10	μs	$V_{IN}=4.5\text{V}$ to 0V , No LPF ²⁾
Fault signal delay after over current detection1 ¹⁾	tdsc(fault)1	-	5	15	μs	$V_{IN}=0\text{V}$ to 4.5V , $I_L=I_{L1}(\text{SC})$ No LPF ²⁾
Fault signal delay after over current detection2 ¹⁾	tdsc(fault)2	-	30	55	μs	$V_{IN}=0\text{V}$ to 4.5V , $I_L=I_{L2}(\text{SC})$ No LPF ²⁾
Fault signal delay after absolute thermal shutdown ¹⁾	tdot(fault)	-	8	18	μs	Refer to Figure 12, No LPF ²⁾
Fault signal off delay after input negative slope ¹⁾	tdoff(fault)	-	5	10	μs	$V_{IN}=4.5\text{V}$ to 0V , No LPF ²⁾

Remark) All voltages refer to ground pin of the device.

1) Not subjected production test, guaranteed by design

2) Refer to chapter 6 Application example in principle

Diagnosis functionality is kept $V_{CC}=6\text{V}$ min.

3.7 Feature Description

3.7.1 Driving Circuit

The high-side output is turned on if the input pin is over V_{IH} . The high-side output is turned off, if the input pin is open or the input pin is below V_{IL} . Threshold is designed between V_{IH} min and V_{IL} max with hysteresis. IN terminal is pulled down with a constant current source.

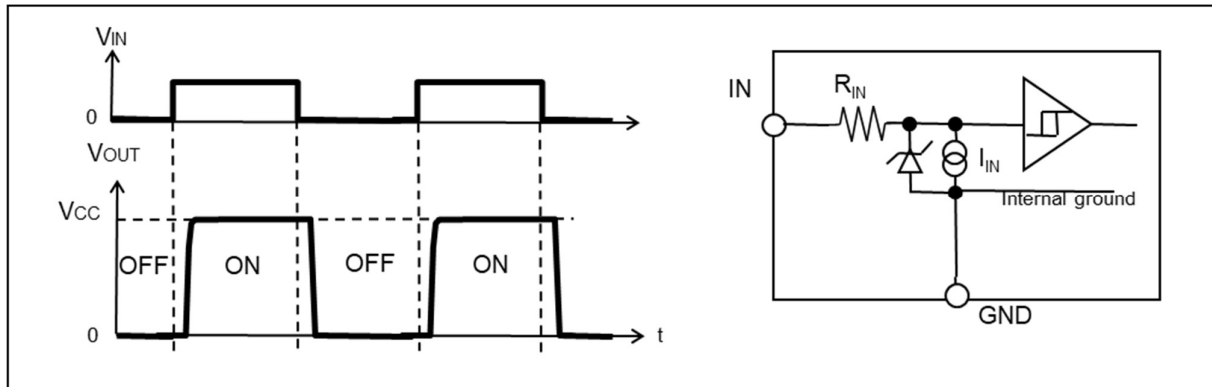


Figure 4 Driving Circuit

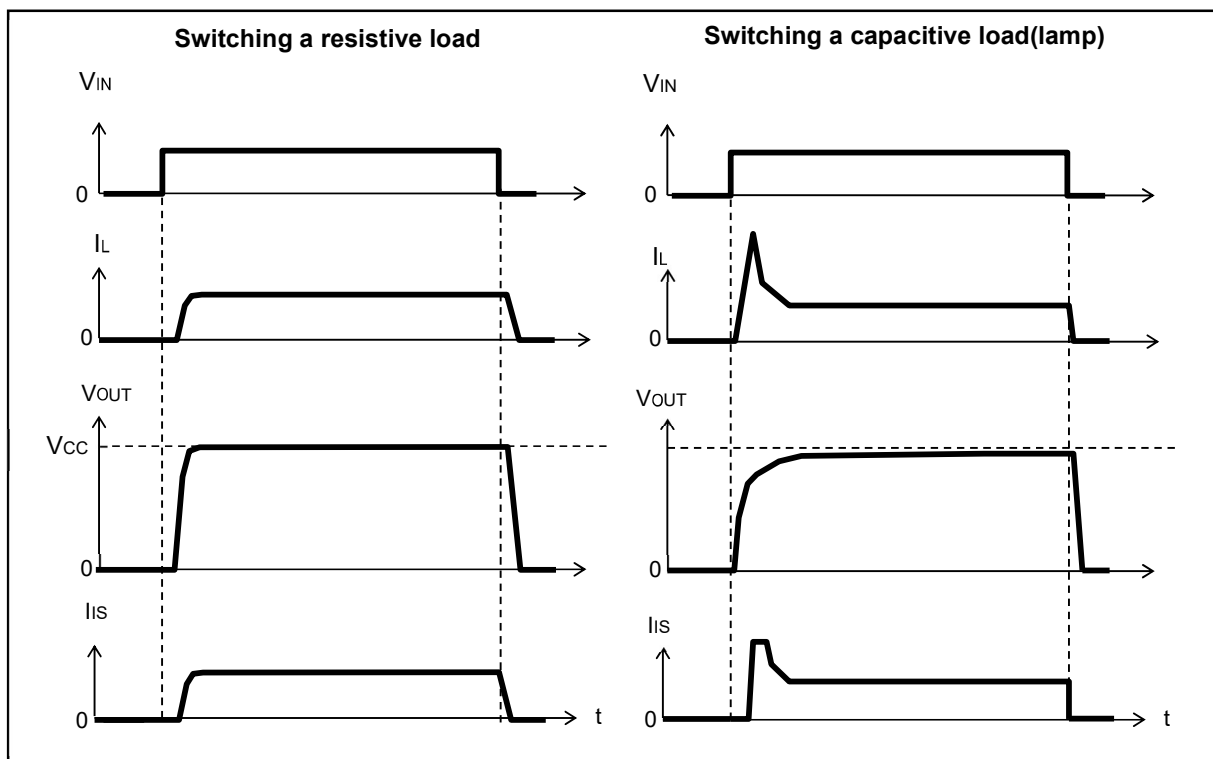


Figure 5-a Switching waveform

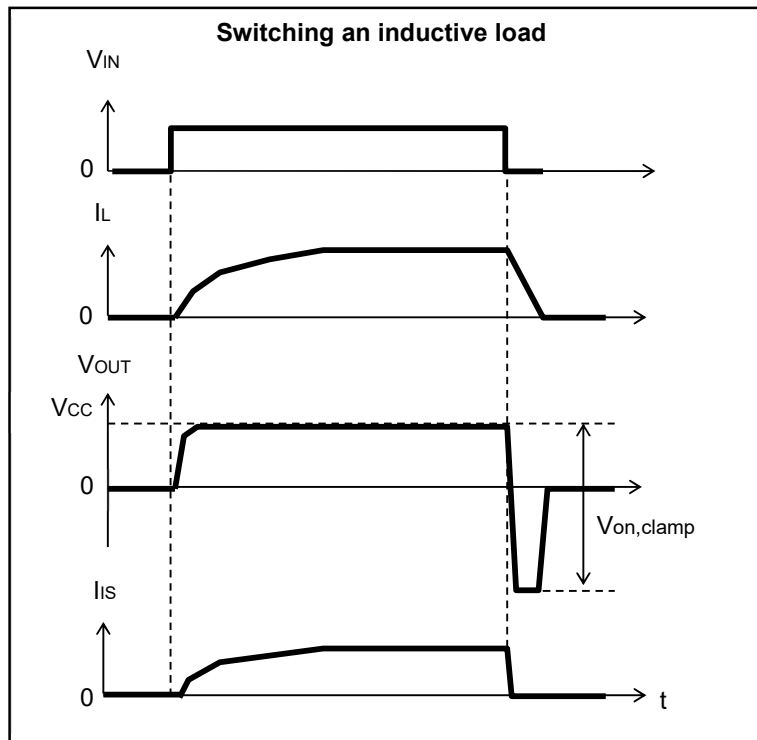


Figure 5-b Switching waveform

When the inductive load is switched off, the voltage of OUT falls below 0V. The internal MOSFET goes into breakdown state and keeps the voltage $V_{on,clamp}$.

3.7.3 Device behavior at low voltage condition

If the voltage supply (V_{CC}) goes down under $V_{CC(CR)}$, the device outputs shut down in case of $V_{on} > V_{onCR(OC)}$. If voltage supply (V_{CC}) increases over $V_{CC(start)}$, the device outputs turn back on automatically. The IS output is cleared during off-state.

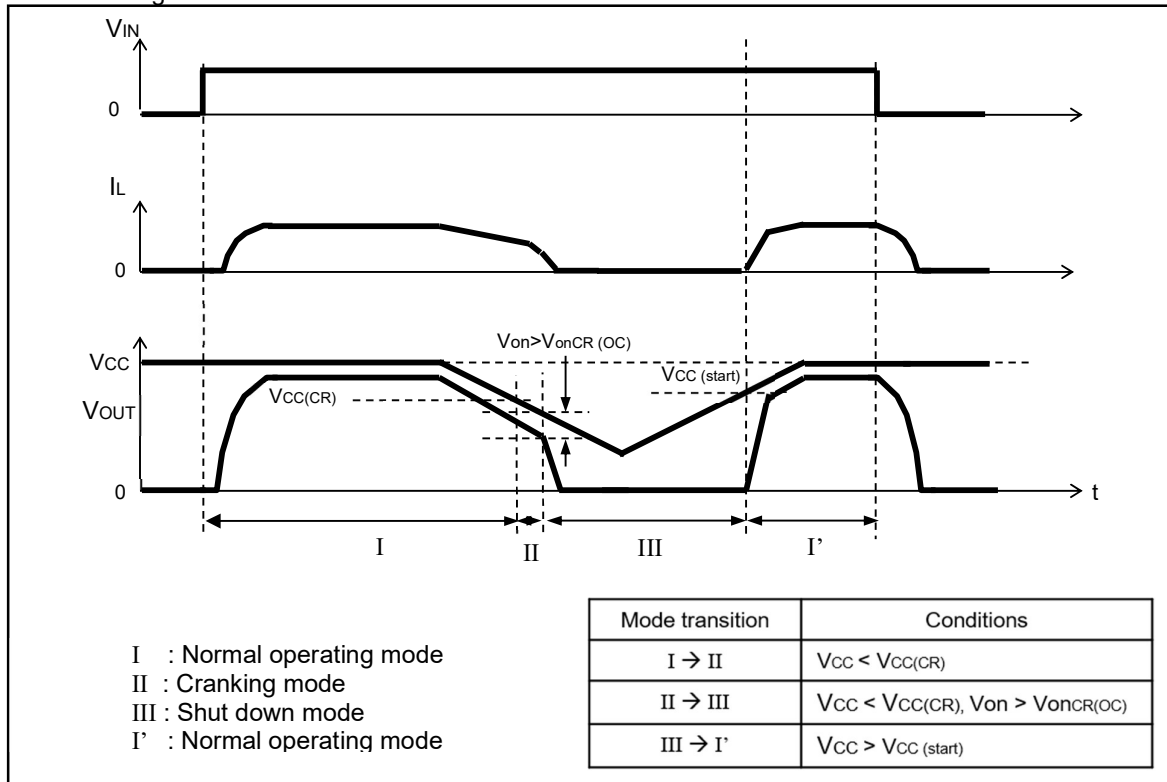


Figure 7 Device behavior at low voltage condition

Table 11 Function and protection availability by mode

○: Enable, ×: Disable,

Function/Protection	Modes of Figure 7			Note
	I, I'	II	III	
Turn on	○	×	×	
Turn off	○	○	×	
Keep on-state	○	○ (*1)	×	(*1) Ron is defined as Ron (Cr).
KILIS function	○	×	×	In case of $V_{on} < V_{on(kilis)}$
Over current detection current1 : IL1(SC)	○ (*2)	×	×	(*2) Disabled when $V_{CC} < 6V(max)$, Refer to 3.7.6
Over current detection current2 : IL2(SC)	○ (*3)	×	×	(*3) Disabled when $V_{CC} < 6V(max)$, Refer to 3.7.6
Von check in over current state: Von (OC), Turn on check delay in over current state: tdoc (OC)	○	×	×	$V_{on} > V_{on(OC)}$ after tdoc(OC), Refer to 3.7.6
Von check at cranking in over current state : VonCR (OC)	×	○	×	$V_{on} > V_{onCR(OC)}$ at cranking mode, Refer to 3.7.6
Absolute thermal shutdown temperature : aTth	○	○	×	$T_{ch} > aTth$, Refer to 3.7.6

3.7.4 Definition of on-state resistance at cranking

On-state resistance at Cranking (Figure 7, mode II) is defined $R_{on}(CR)$ as shown in Figure 8. $R_{on}(CR)$ is adapted in the condition of $V_{CC} > 3.2V$ and within 24ms.

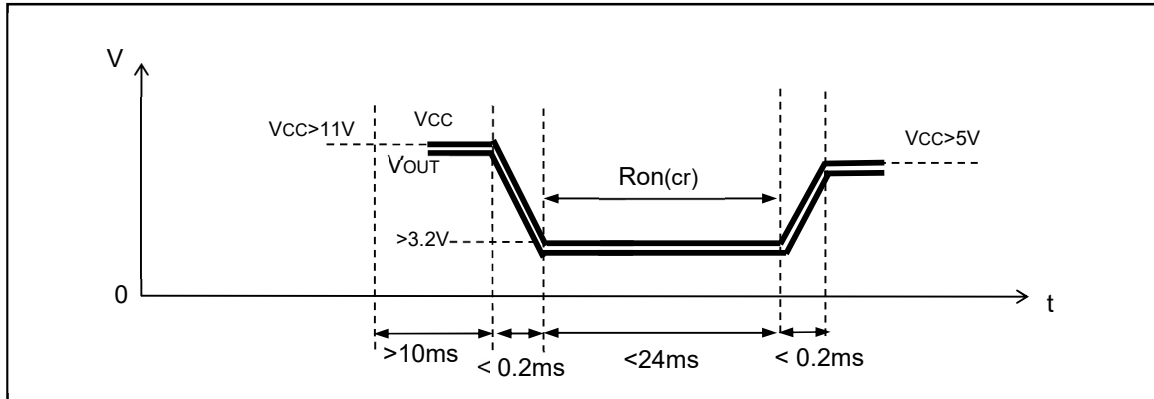


Figure 8 Definition of on-state resistance at cranking

3.7.5 Loss of Ground protection

In case of complete loss of the device ground connection with or without load, the device securely changes to off if V_{IN} was initially greater than V_{IH} state or keeps the off state if V_{IN} was initially lower than V_{IL} state. In case of loss of ground, there is a potential that the current flow from IN terminal to MCU. Therefore, insert a protective resistor between MCU and IN terminal.

3.7.6 Over Current protection

The N-ch MOSFET switches off automatically when condition (a), (b), (c), (d) or (e) is detected. In case of (a), (b), (c), (d), the IS pin outputs $V_{is,fault}$. The MOSFET maintains off state until the IN pin turns low level (V_{IL}).

- (a) $I_L > I_{L1}(SC)$
- (b) $I_L > I_{L2}(SC)$
- (c) $V_{on} > V_{on}(OC)$ after $t_{doc}(OC)$
- (d) $T_{ch} > aT_{th}$
- (e) $V_{on} > V_{onCR}(OC)$ at cranking mode

3.7.7 Diagnostic signal

Table 12 Truth table

	Input (IN)	Input (INOFS)	Output (OUT)	Diagnostic output (IS)
Normal Operation	H	H	V_{CC}	$IIS = IL/KILIS^{7)}$
		L		$IIS = IL/KILIS^{8)}$
	L	H	$L^{2)}$	$L^{3)}$
		L		
Shutdown by over current detection ¹⁾	H	H	$L^{2)}$	$Vis, fault^{4)}$
		L		
	L	H	$L^{2)}$	$L^{3)}$
		L		
Shutdown by over absolute channel temperature detection	H	H	$L^{2)}$	$Vis, fault^{5)}$
		L		
	L	H	$L^{2)}$	$L^{3)}$
		L		
Short circuit to V_{CC}	H	H	V_{CC}	$<IIS$
		L		
	L	H	$V_{OUT}^{6)}$	$L^{3)}$
		L		

- 1) Over Current detection is included IL1(SC), IL2(SC), Von (OC)after tdOC (OC) or VonCR (OC).
- 2) In case of OUT terminal is connected to GND via load.
- 3) In case of IS terminal is connected to GND via resistor.
- 4) IS terminal keeps Vis,fault as long as input signal activate after the over current detection.
- 5) IS terminal keeps Vis,fault as long as input signal activate after over absolute channel temperature detection.
- 6) VOUT depends on the ratio of V_{CC} -OUT-GND resistive component.
- 7) The current sense ratio (KILIS) is the value when the improved accuracy function is used.
- 8) The current sense ratio (KILIS) is the value when the improved accuracy function is not used.

3.7.8 Current sense output

The device outputs analog feedback current proportional to output current from IS pin. In the case of much higher current than nominal load current, current sense output is saturated at Vis,fault.

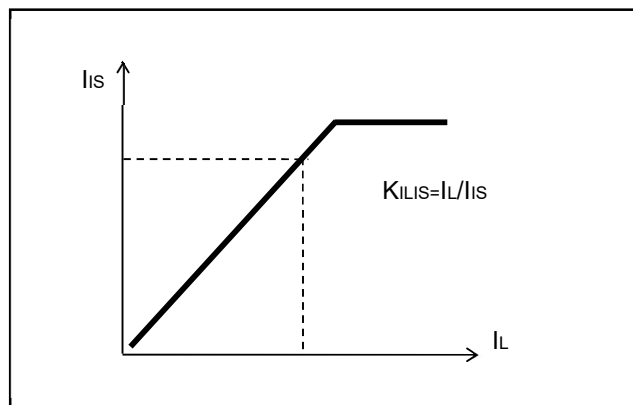


Figure 9 Current sense output

3.7.9 Timings

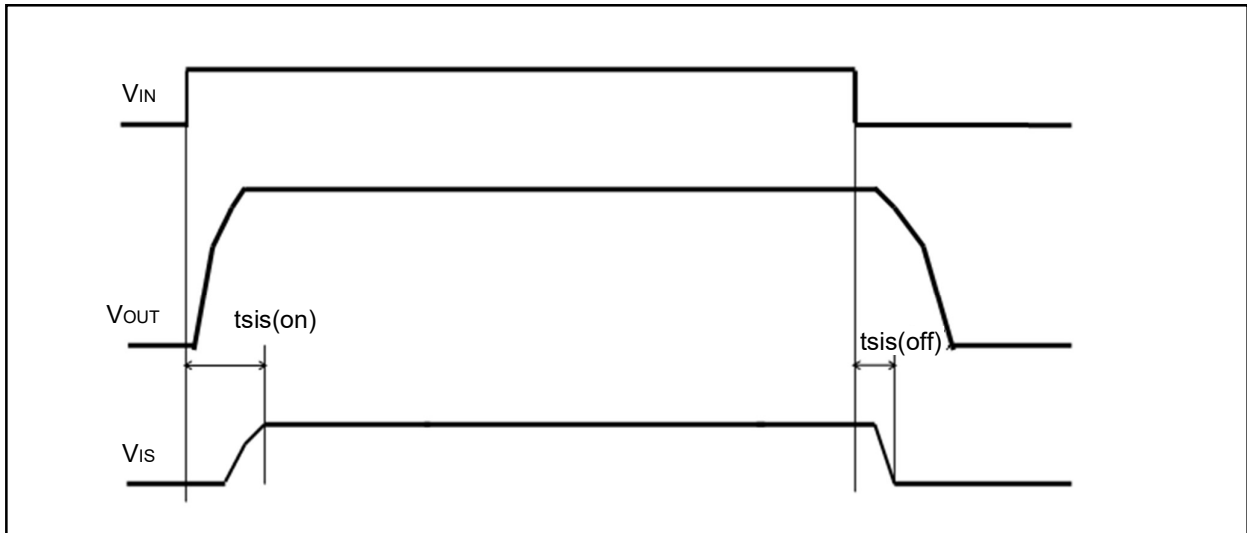


Figure 10 Sense voltage setting time

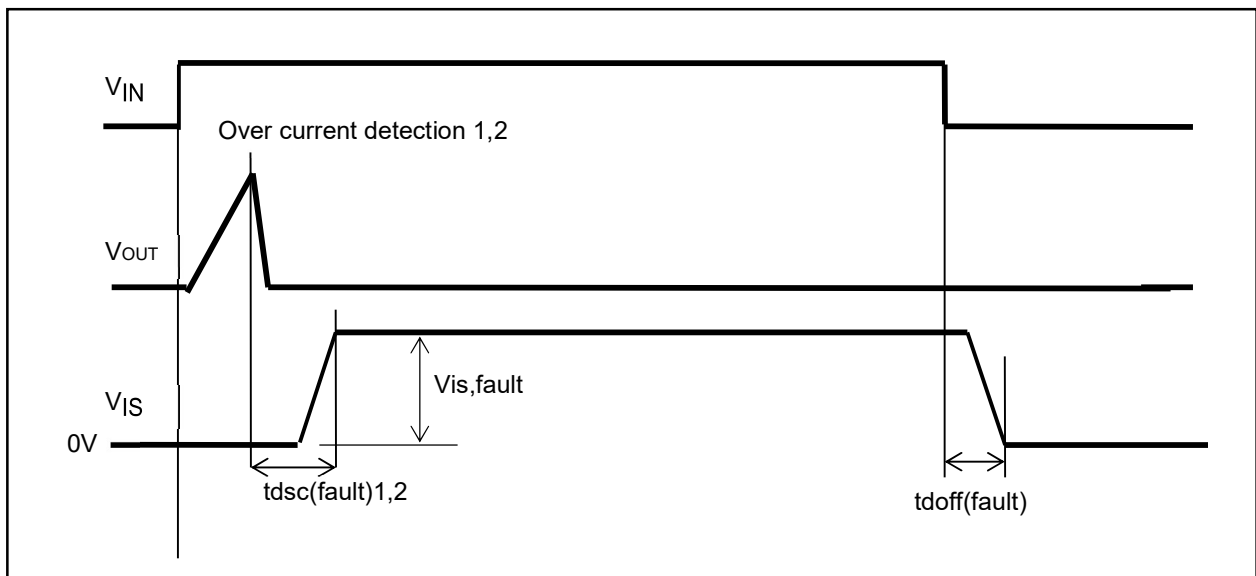


Figure 11 Fault signal delay time at over current detection and input negative slope

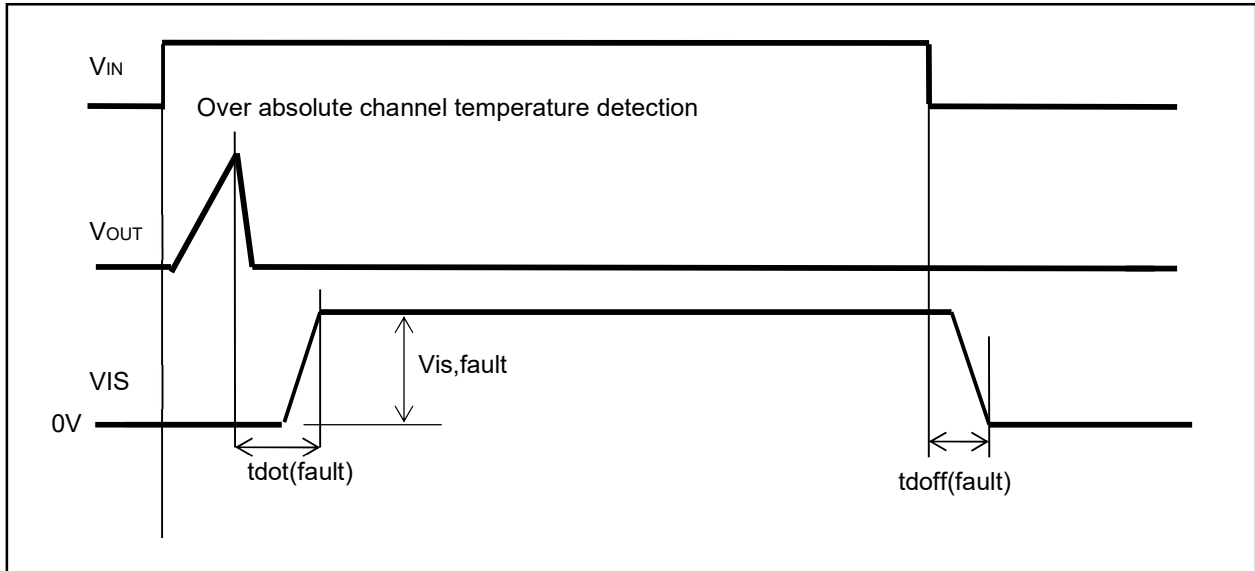


Figure 12 Fault signal delay time at over absolute channel temperature detection and input negative slope

3.7.10 Measurement condition

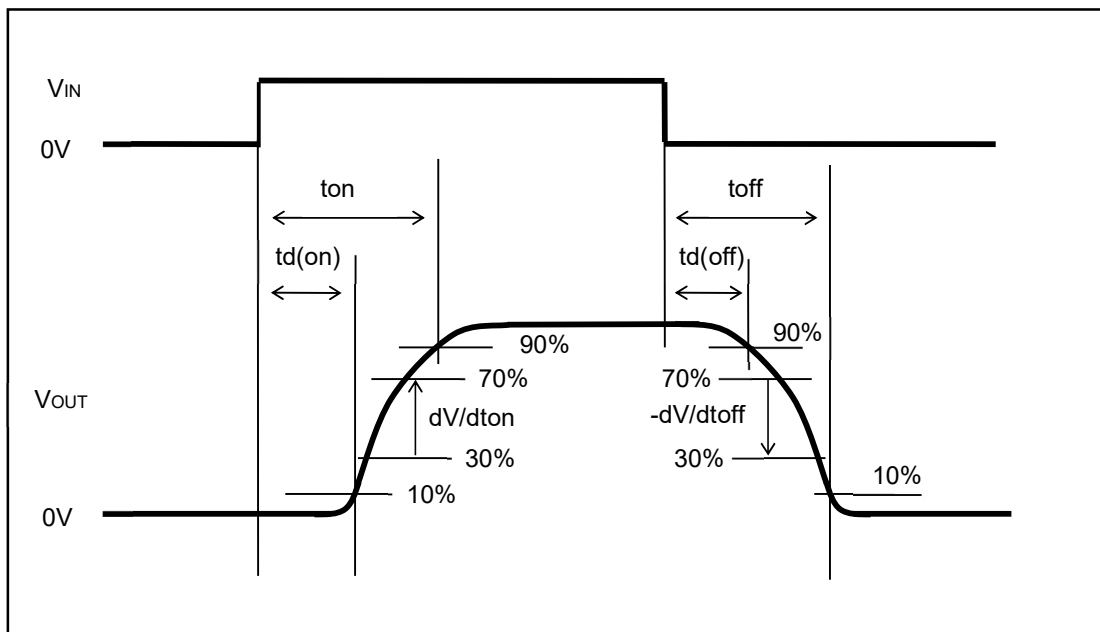


Figure 13 Switching waveform of OUT terminal

3.7.11 Measurement condition for Turn on check in over current state

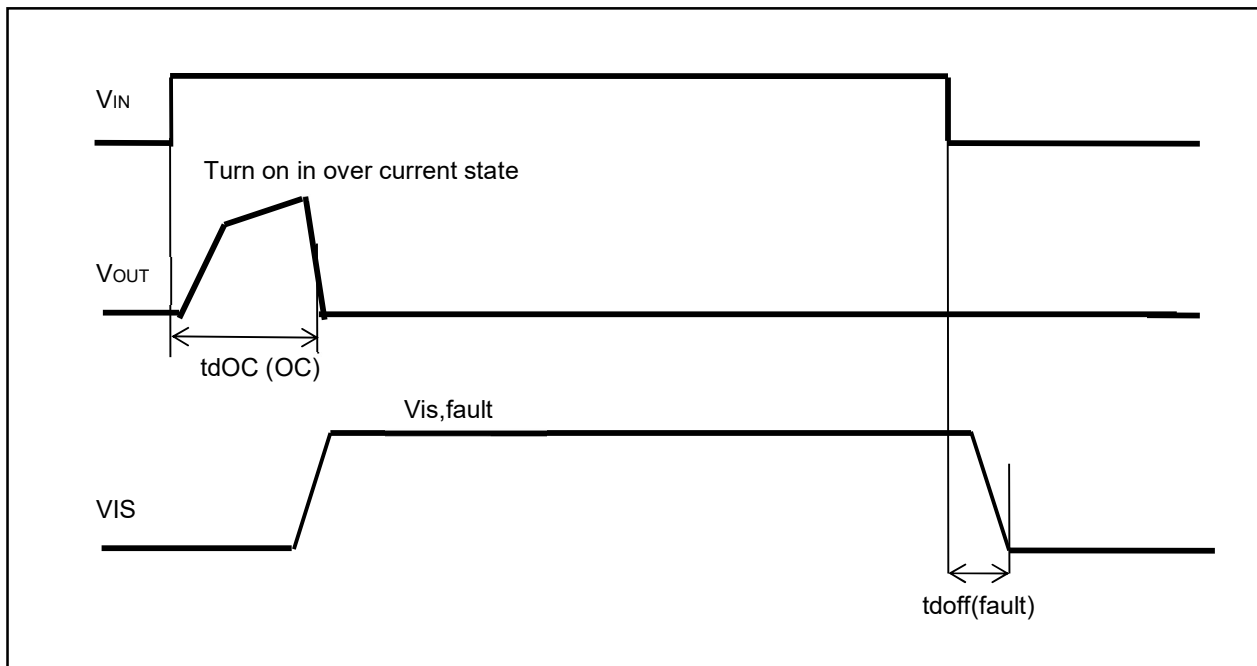


Figure 14 Measurement condition for Turn on check in over current state

3.7.12 Nominal load and nominal current

Table 13 Nominal load and nominal current

Parameter	Values	Condition
Nominal load	0.45 Ω	$T_{ch} \leq 150^{\circ}\text{C}$ ($V_{CC}=13.5\text{V}$)
Nominal current	30 A	$T_{ch} = 25^{\circ}\text{C}$
Nominal current 2	19.6A	$T_a=85^{\circ}\text{C}$, $T_{ch} \leq 150^{\circ}\text{C}$

3.7.13 Driving Capability

Driving Capability is specified as load impedance. Over current detection characteristics is designed above Driving Capability characteristics. If the estimated load impedance which comes from peak inrush current is lower than Driving Capability characteristics, then the device does not detect inrush current as over current and does not shutdown the output. If estimated load impedance which comes from peak inrush current is higher than Driving Capability characteristics and reach the IL1(SC) or IL2(SC) thresholds level, then the device detects inrush current as over current and shutdown the output.

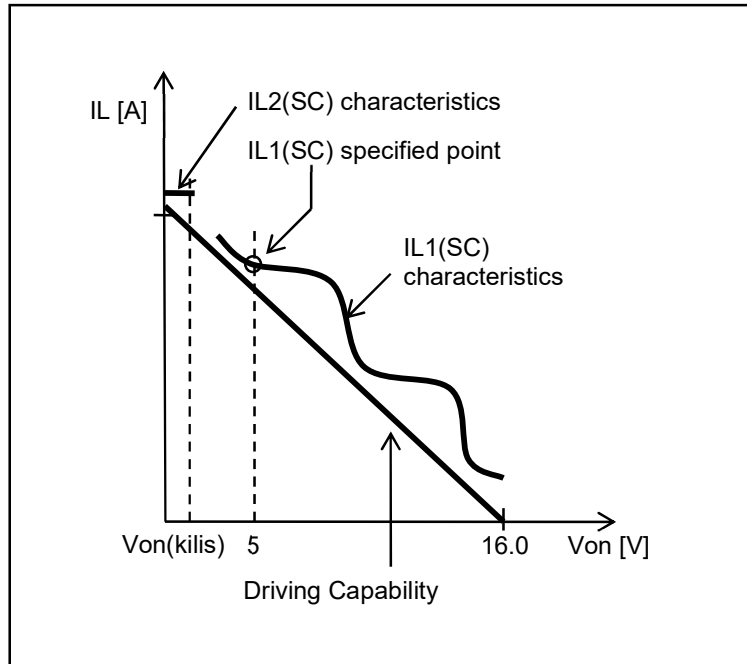


Figure 15 Driving capability

3.7.14 Cross current protection in case of H-bridge high side usage

In case of using High side driver in H-bridge circuit, the High side driver protects itself and the low side driver from high power dissipation by cross current when low side driver switches on.

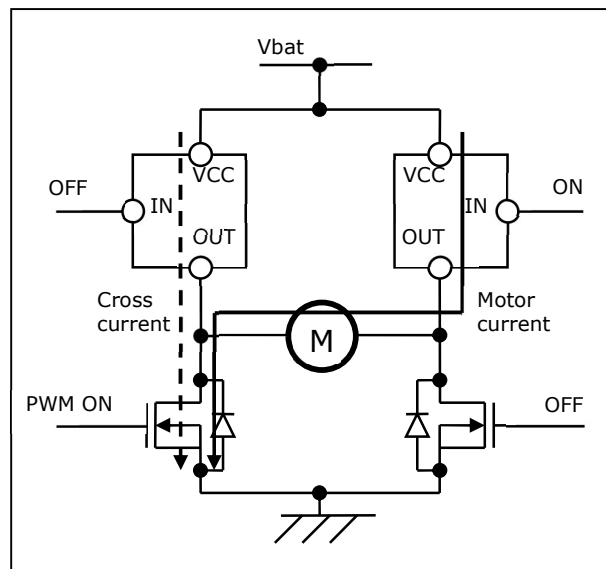


Figure 16 Cross current protection in case of H-bridge high side usage

3.7.15 Reverse Battery Protection by turning on the output

In case a reverse battery is applied to the device, the N-ch MOSFET will turn on only if reverse current flow into the GND pin. The reverse current through the N-ch MOSFET must be limited by the connected load. $I_{GND(rev)}$ is limited internally approx. 2mA even without external R_{GND} . Reverse current flow from IN, INOFS and IS should be limited by external components such as recommendation value in Pin function, refer to 3.2 Pin configuration.

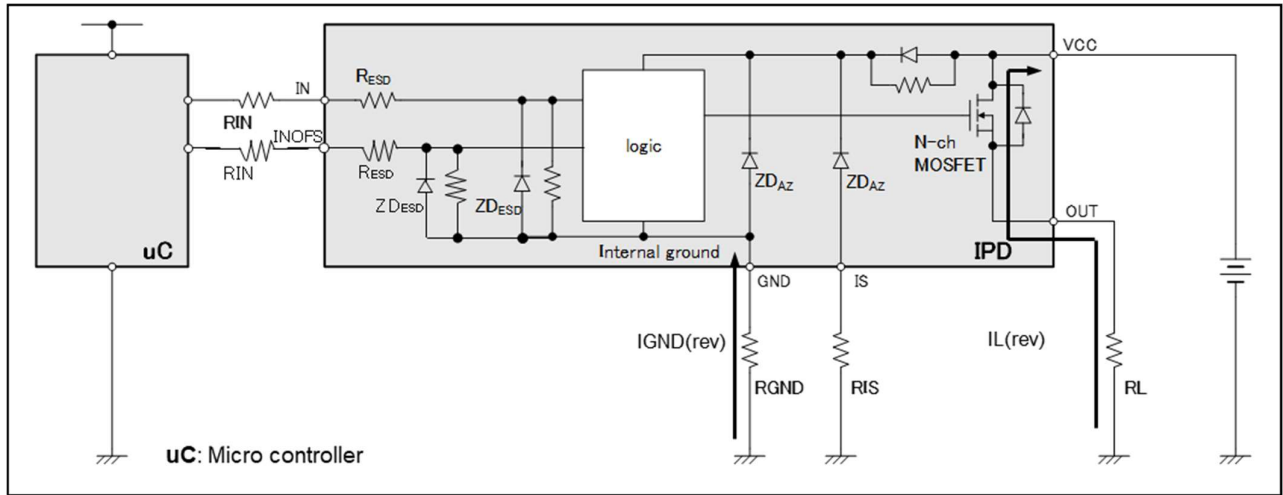


Figure 17 Reverse Battery Protection by turning on the output

3.8 Package drawing (TO252-7)

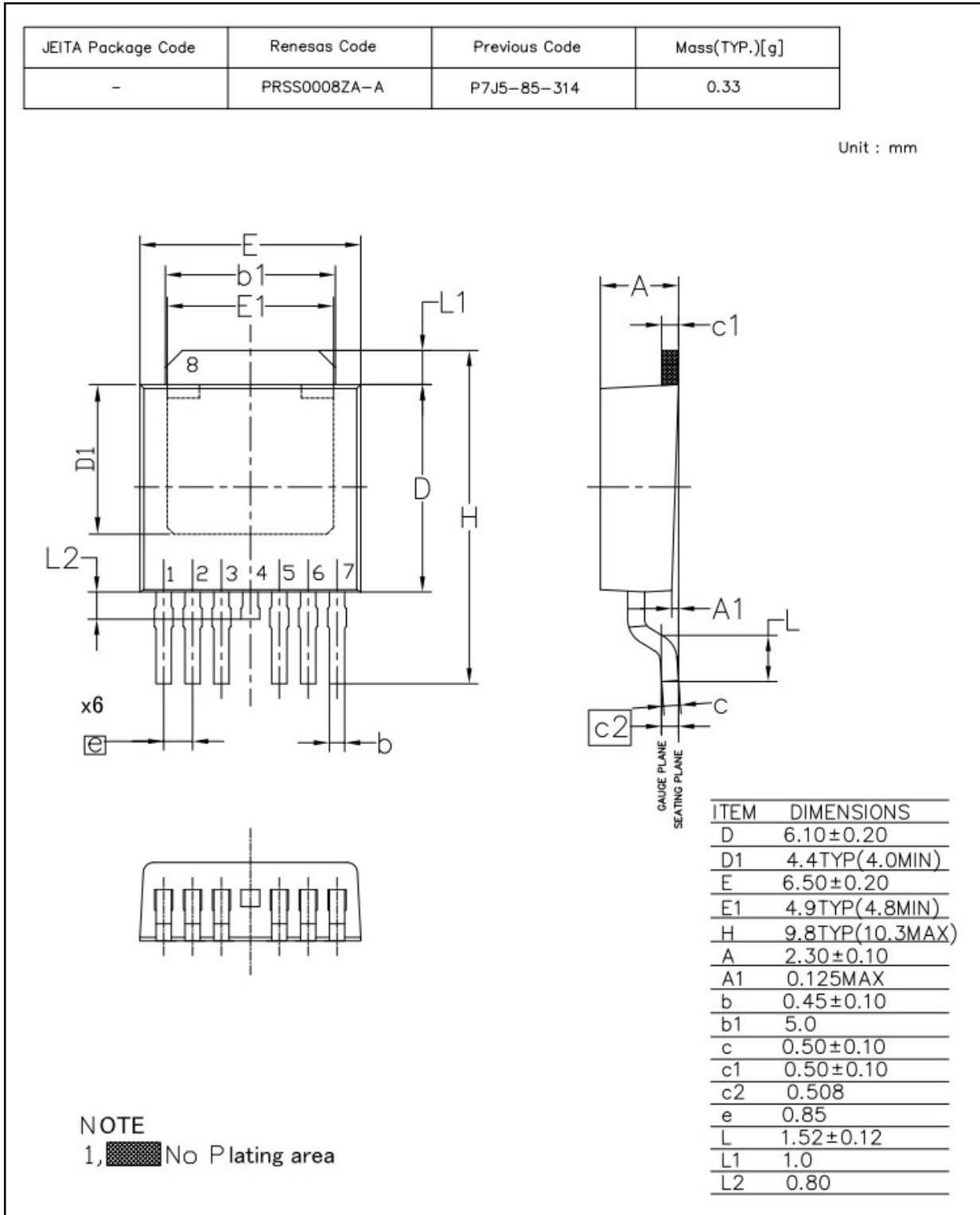


Figure 18 TO252-7 Package Outline

3.9 Taping information

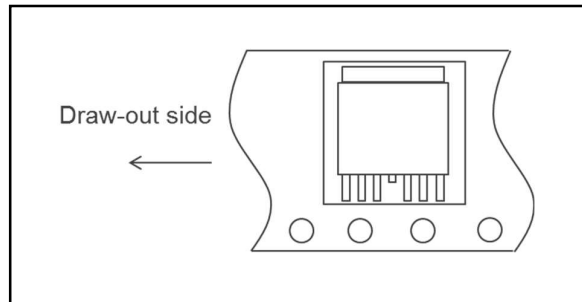


Figure 19 Taping information

3.10 Marking information

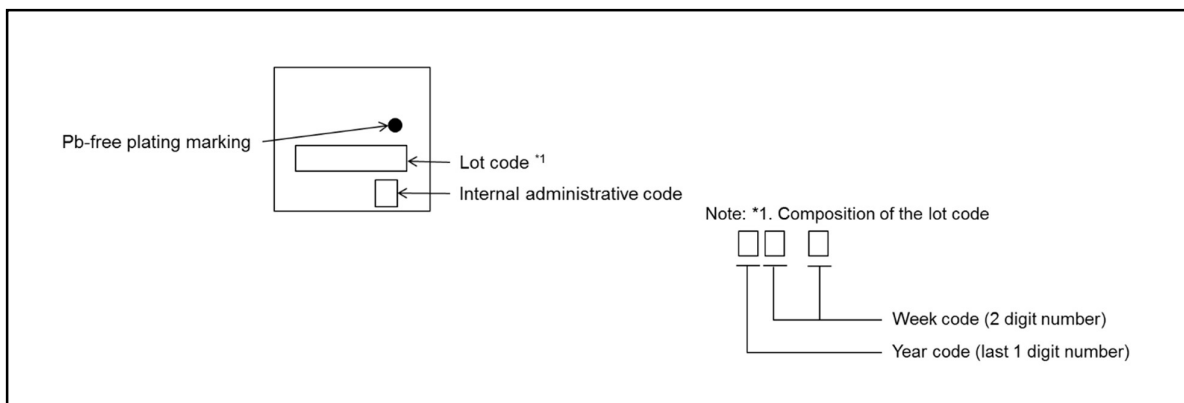


Figure 20 Marking information

4 Typical characteristics

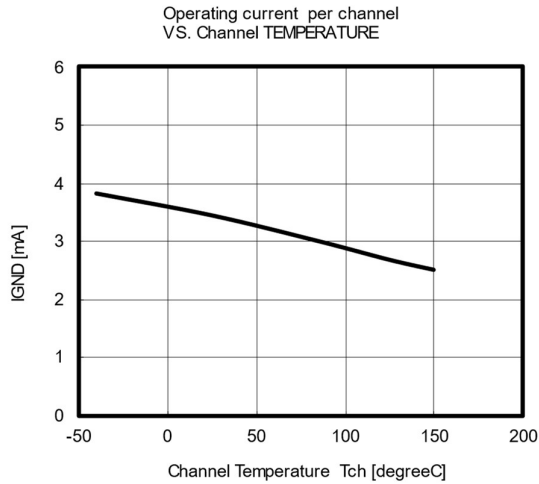


Figure 21. IGND

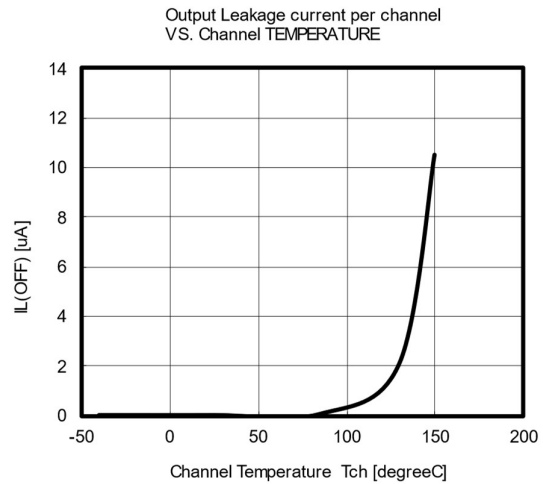


Figure 22. IL(OFF)

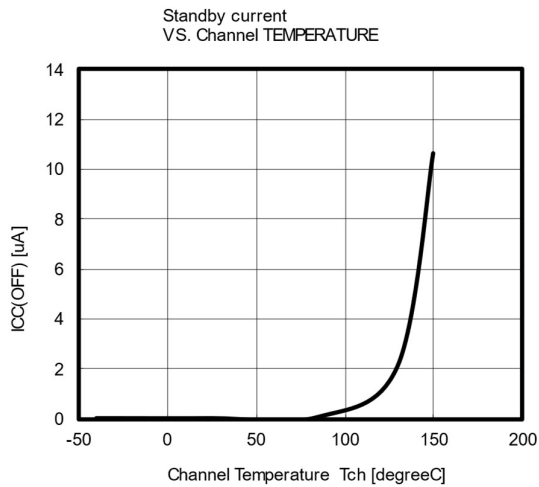


Figure 23. ICC(OFF)

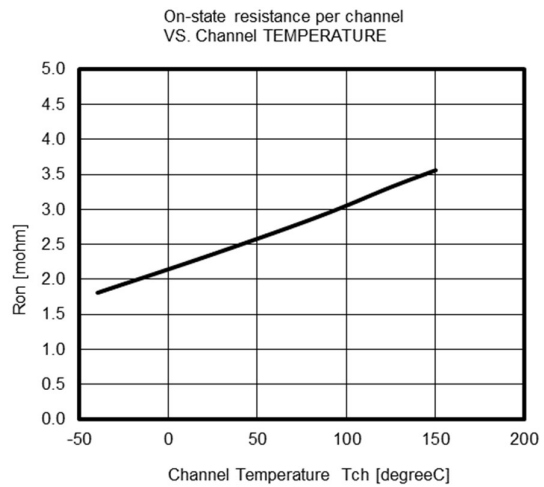


Figure 24. Ron

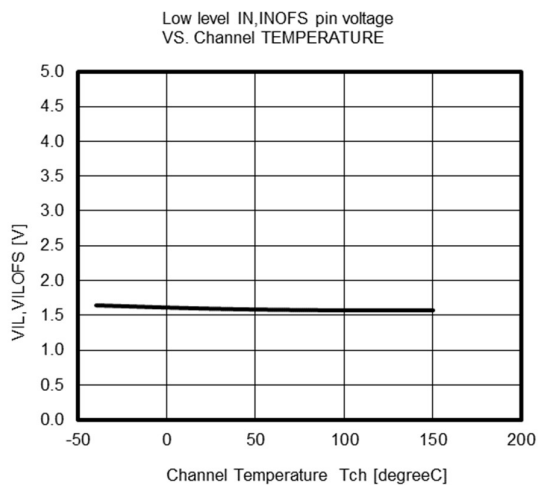


Figure 25. VIL, VILOFS

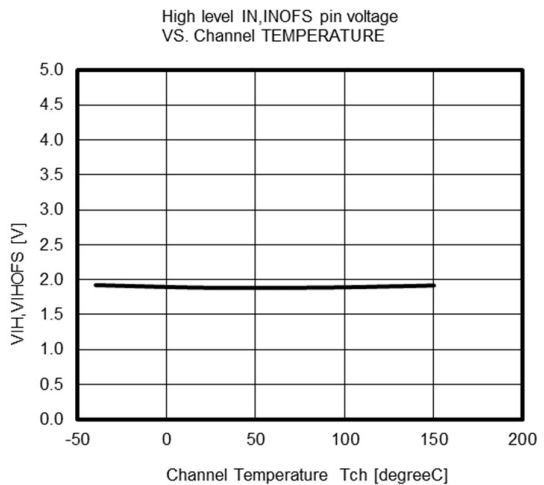


Figure 26. VIH, VIHOFs

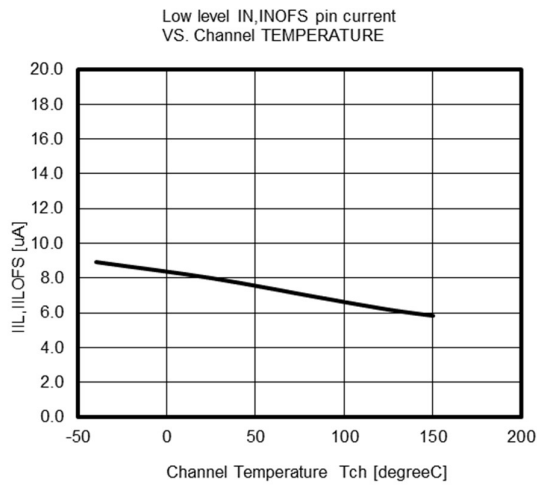


Figure 27. IIL, ILOFS

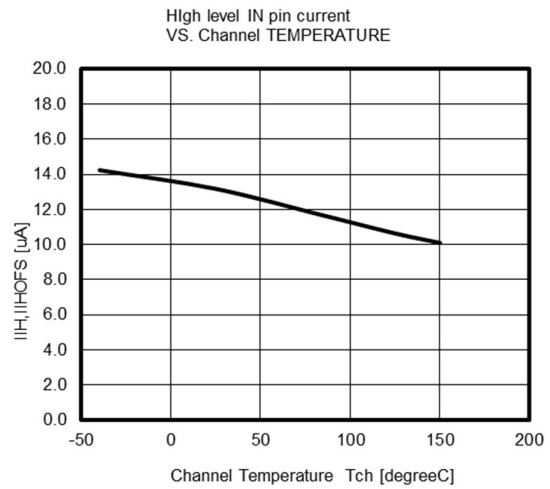


Figure 28. IIH, IHOFS

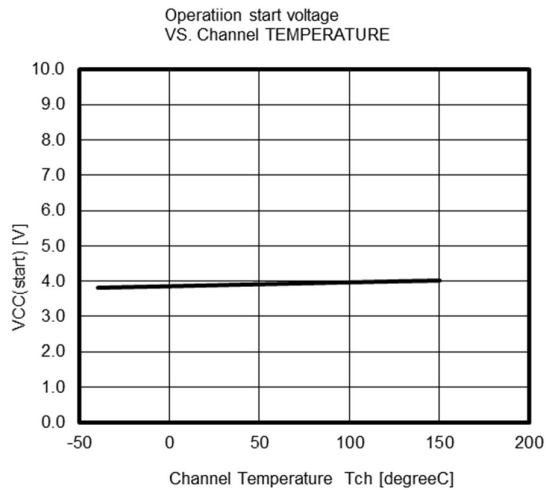


Figure 29. VCC (start)

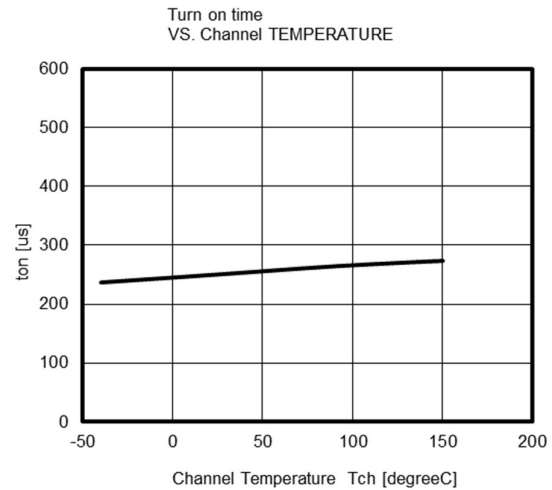


Figure 30. ton

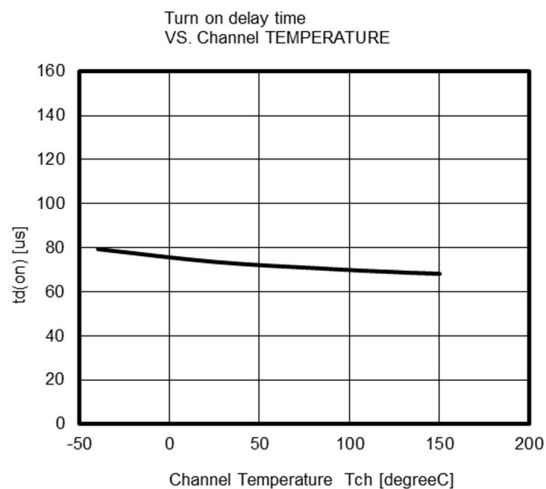


Figure 31. td(on)

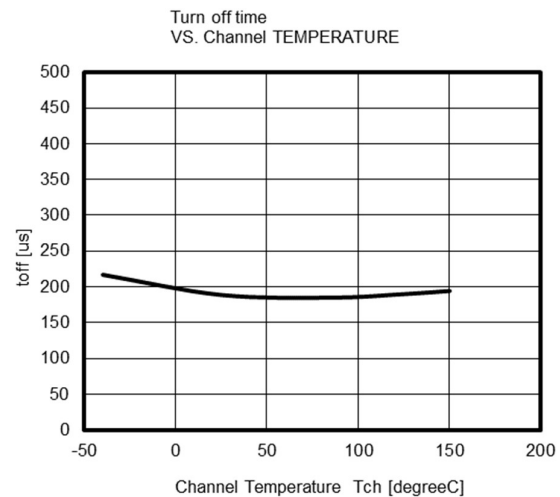


Figure 32. toff

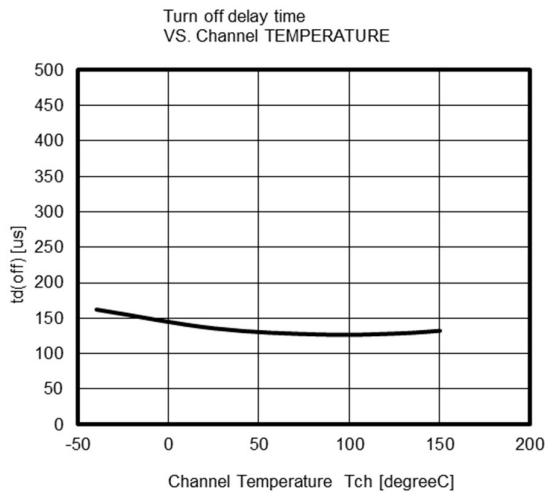


Figure 33. td(off)

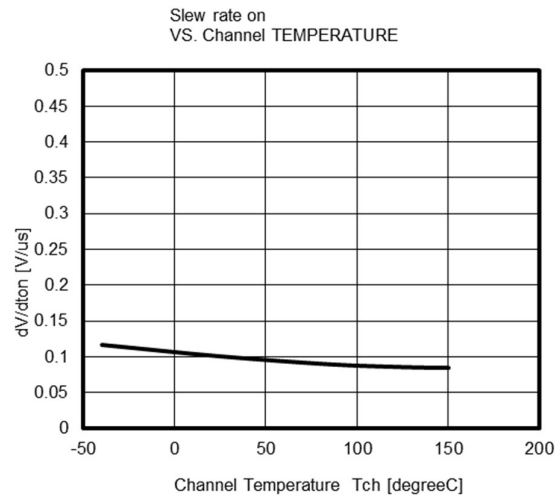


Figure 34. dV/dton

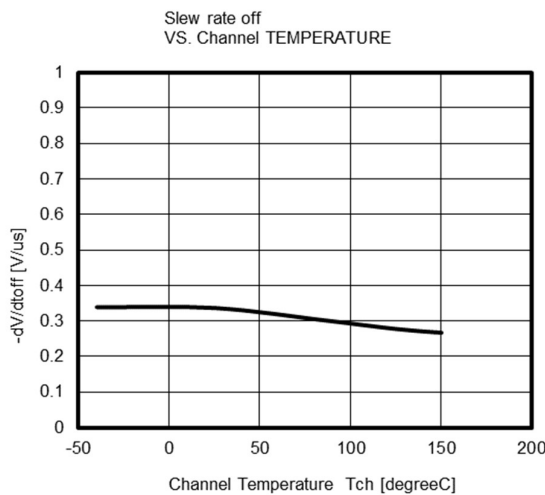


Figure 35. -dV/dtoff

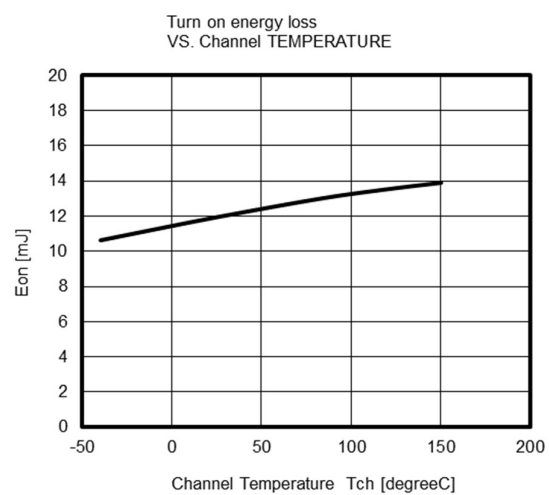


Figure 36. Eon

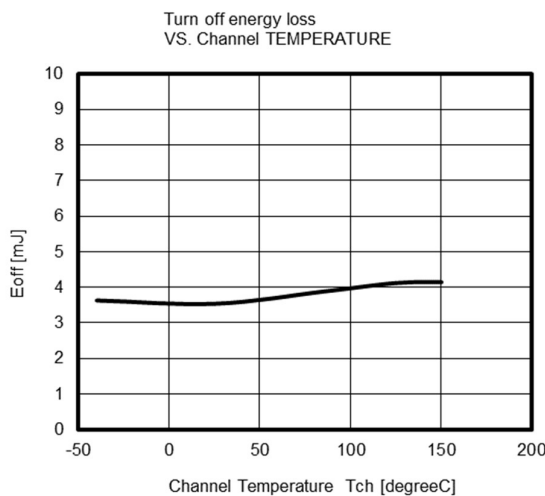


Figure 37. Eoff

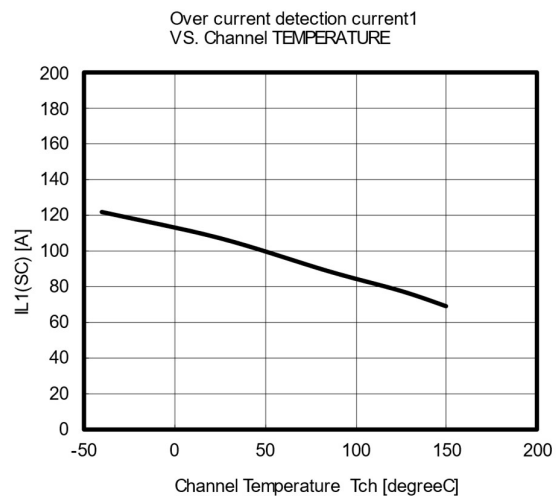


Figure 38. IL1(SC)

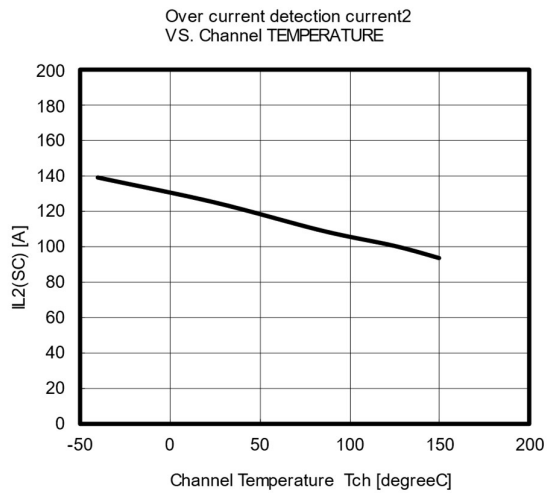


Figure 39. IL2(SC)

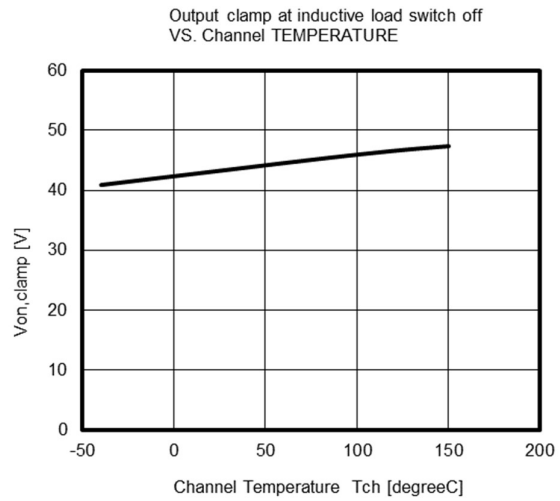


Figure 40. Von,clamp

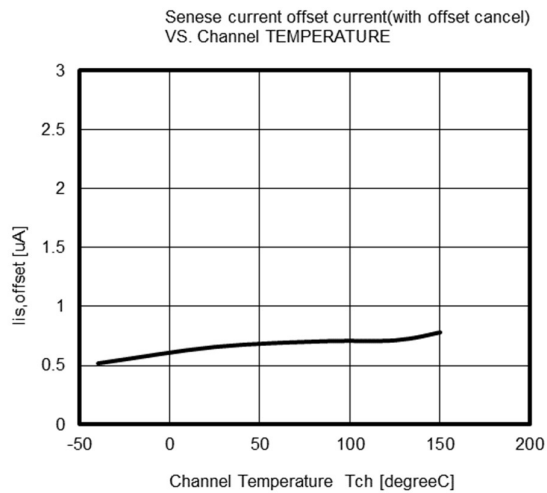


Figure 41. Iis,offset
(use improved accuracy func)

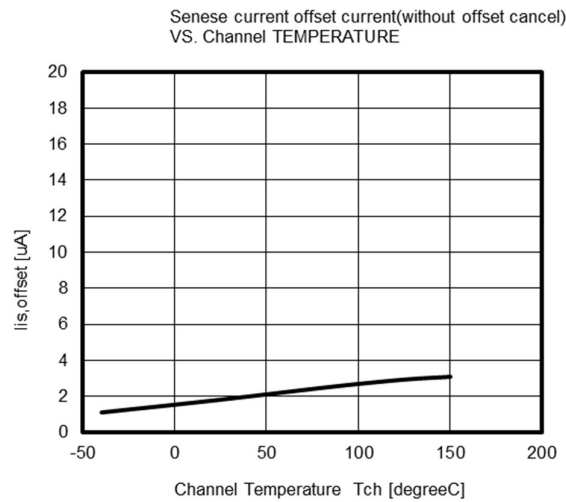


Figure 42. Iis,offset
(no use improved accuracy func)

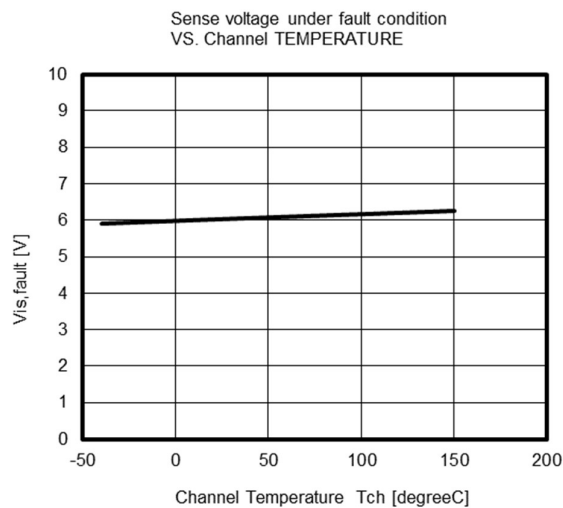


Figure 43. Vis,fault

5 Thermal characteristics

5.1 Thermal characteristics board condition(2s2p)

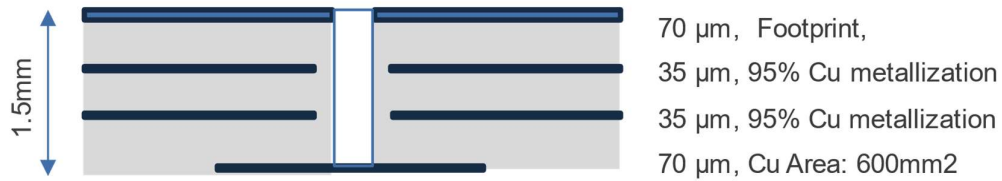


Figure 44 Cross section 2s2p board

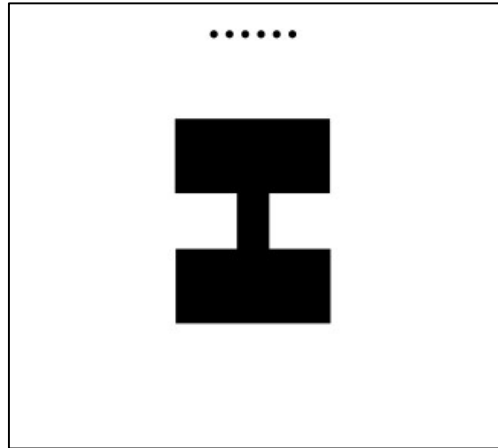


Figure 45: Botom layer pattern

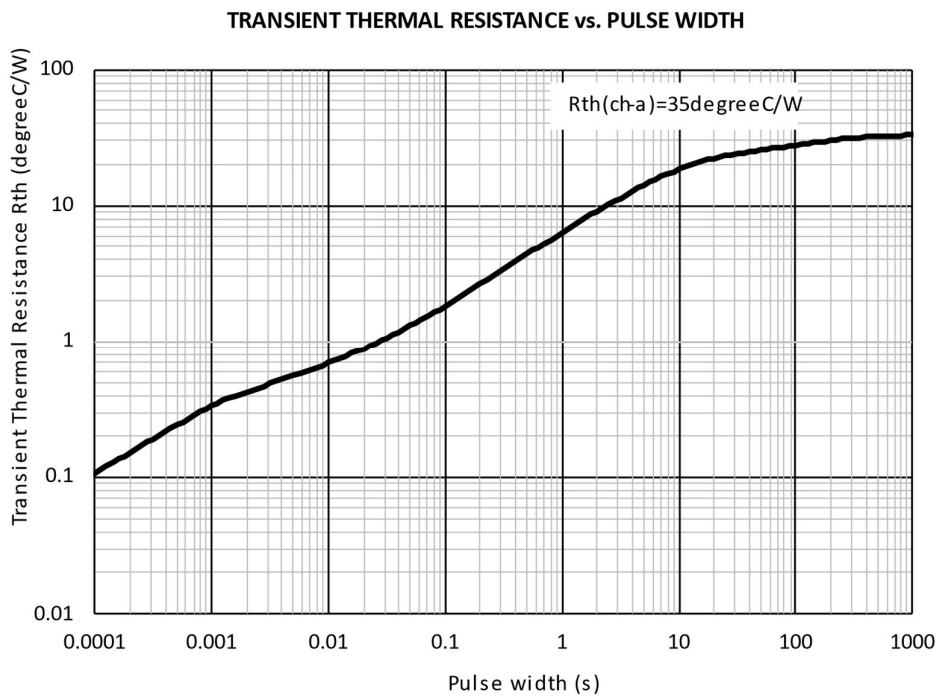


Figure 46 Thermal characteristics(2s2p)

5.2 2nd layer connected condition metallization dependency



Figure 47 Cross section of 2nd layer metallization dependency

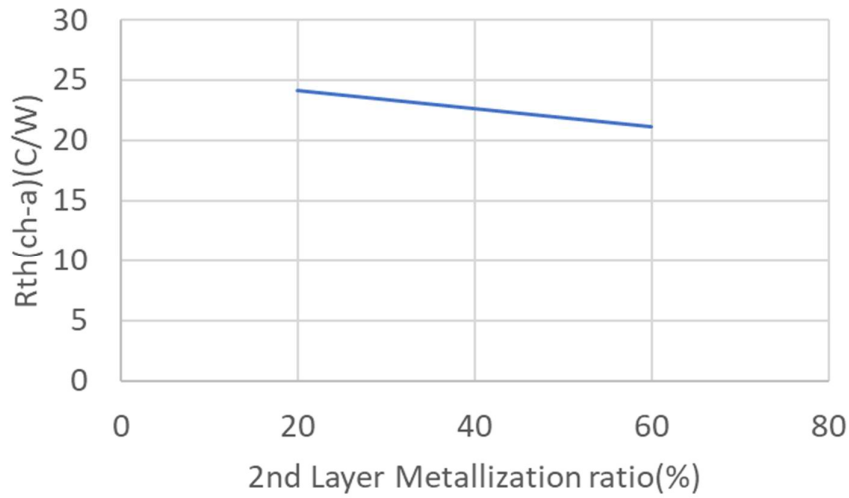


Figure 48 2nd layer metallization dependency

6 Application example in principle

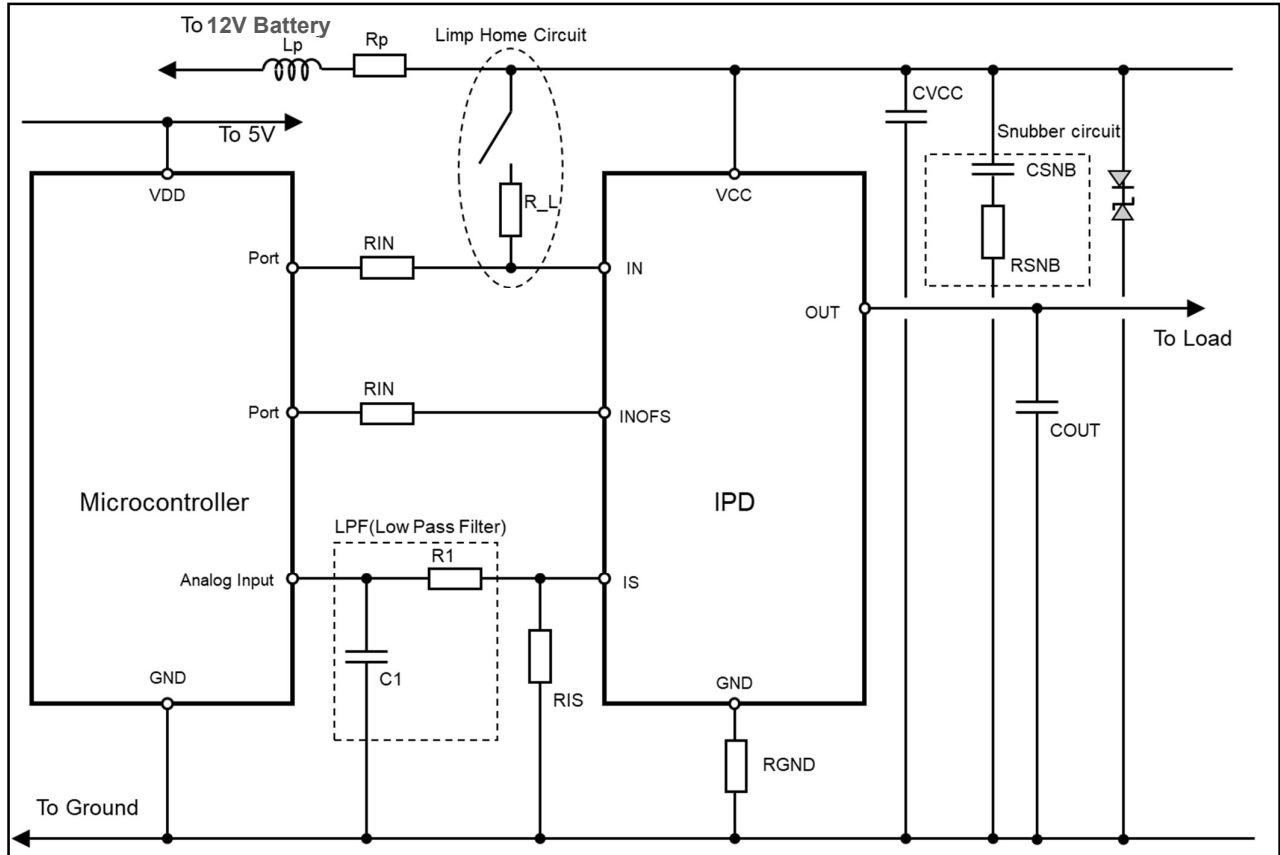


Figure 45 Application example in principle

RIN values are in range of 2k to 50kΩ depending on microcontroller while R_L value is typically 4kΩ.

RIS values are in range of 1k to 6kΩ.

Time constant parameter of LPF for KILIS improved accuracy function T(kilis) is represented as follows.

$$T(\text{kilis}) = (R1 + RIS) \times C1$$

Time constant parameter of LPF for Vis,fault function T(fault) is represented as follows.

$$T(\text{fault}) = R1 \times C1$$

R1 values are in range of over 2kΩ.

100us or more is recommended as T(kilis), considering T(fault) parameter.

If necessary to raise HBM tolerated dose, adding a resistor between OUT terminal and Ground is effective, the resistor's value is typically 100kΩ.

Additional snubber circuit is recommended if necessary, to prevent VCC drop less than minimum operating voltage threshold, by parasitic inductance (Lp) and parasitic resistance (Rp) resonance.

Recommended values are as follows:

CVCC : 22nF

RSNB¹⁾ : $RSNB = \sqrt{(Lp/CVCC)} \cdot 0.125W$ (ex. Lp:3.94uH -> RSNB=10Ω)

CSNB²⁾ : 1.0uF (ex. GCM21BR71H105MA03(Murata Manufacturing Co.Ltd.)).

1) High pulse withstands resistor.

2) High pulse withstands capacitor.

RGND is recommended if necessary for unexpected external surge protection.

47 ohm is recommended as RGND.

7 Revision History

Rev.	Date	Description	
		Page	Summary
1.0	May.13.2024		Initial release

Notice

1. 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 or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving 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, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

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

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, 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 and impractical, you are responsible for evaluating the safety of the final products or systems 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. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall 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. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/