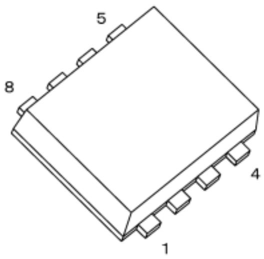
Toshiba Bi-CMOS Linear Integrated Circuits Silicon Monolithic

TPD7110F

Ideal Diode Controller

1. Description

TPD7110F is an ideal diode controller that can form an ideal diode when used in combination with N-channel MOSFETs. It incorporates a charge pump circuit, a reverse current blocking circuit from the load side, protection circuits against undervoltage and overvoltage of the power supply, and a protection circuit for reverse polarity connection. Additionally, when used together with back-to-back connected MOSFETs, it enables ON/OFF control as a load switch.



SON8-P-0303-0.65

Weight : 0.017g (typ.)

2. Applications

Power lines for automotive body control modules,
BMS (Battery Management System), HUD (Head-Up Display), etc.

3. Features

- Operating voltage range : 3 to 32 V
- Reverse current blocking from the load side
- Undervoltage/Overvoltage Protection for Power Supply
- Reverse polarity protection up to -32 V
- Current consumption during output ON : 100 μA (typ.)
- Current consumption during output OFF : 2 μA (typ.)
- AEC-Q100 Qualified
- Small package : PS-8
- Operating temperature range : T_j = -40 to 125 °C

The product(s) is/are compatible with RoHS regulations (EU directive 2011 / 65 / EU) as indicated, if any, on the packaging label ("[[G]]/RoHS COMPATIBLE", "[[G]]/RoHS [[Chemical symbol(s) of controlled substance(s)]]", "RoHS COMPATIBLE" or "RoHS COMPATIBLE, [[Chemical symbol(s) of controlled substance(s)]]>MCV").

Start of commercial production
2025-10

4. Block Diagram

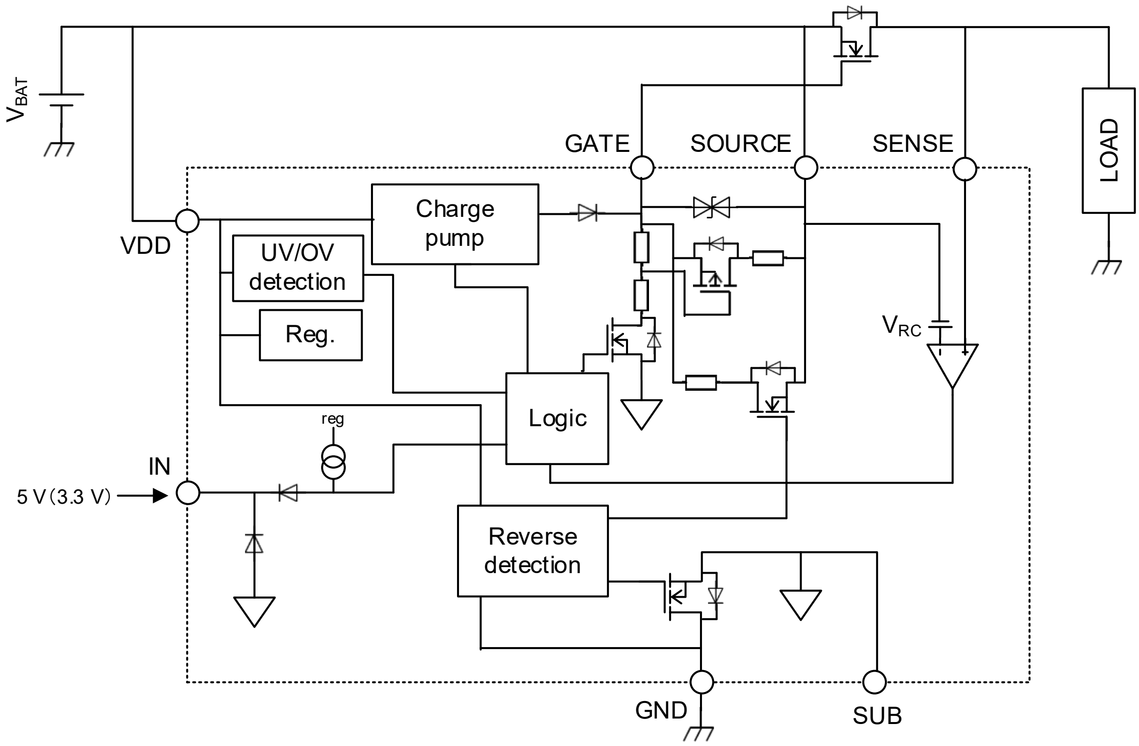


Fig. 4.1 Block Diagram

Note : The block diagram is simplified and intended for illustration only.
The surrounding connections are for reference only.

5. Pin Assignments Top view

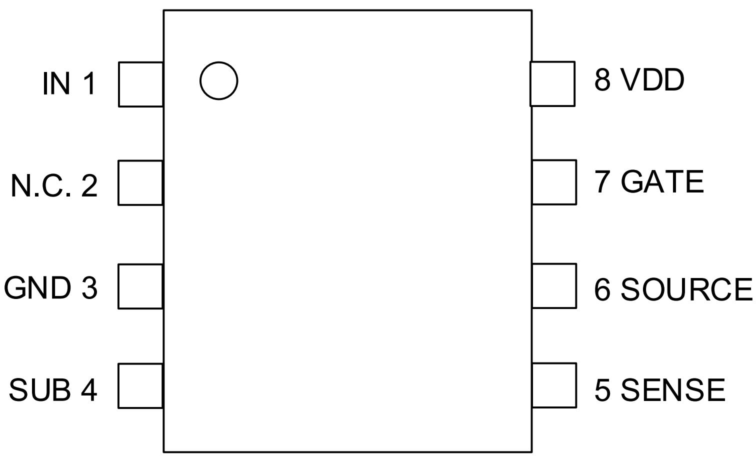


Fig. 5.1 Pin Assignments (top view)

6. Pin Description

Table 6.1 Pin Description

No.	Name	I/O	Pin Description
1	IN	INPUT	Input pin
2	N.C.	-	No connection pin
3	GND	-	GND pin
4	SUB	-	Leave the pin open to enable the reverse polarity protection
5	SENSE	INPUT	Reverse current sense pin
6	SOURCE	INPUT	Source connection pin for external N-channel MOSFETs
7	GATE	OUTPUT	Gate drive pin for external N-channel MOSFETs
8	VDD	-	Power supply pin

7. Operation Description

This device controls the ON/OFF state of N-channel MOSFETs (hereafter referred to as "MOSFETs") used in circuits such as ideal diodes or back-to-back load switch configurations. When the MOSFETs are ON, if reverse current is detected from the load side, the MOSFETs are turned off to block the reverse current. Additionally, the MOSFETs are turned off when the power supply voltage decreases, becomes excessively high, or when the power supply is connected in reverse.

7.1. Normal Operation

When the IN pin is in the HIGH state (i.e., at or above the high level input voltage, V_{IH}), the charge pump operates and generates a high level output voltage between the GATE and SOURCE pins to turn on the MOSFETs. Depending on the power supply voltage (V_{DD}), either $V_{GS(1)}$ or $V_{GS(3)}$ is output as the high level output voltage.

When the IN pin is in the LOW state (i.e., at or below the low level input voltage, V_{IL}), the charge pump is disabled and the OFF driver is activated, and the voltage between the GATE and SOURCE pins becomes a low level (V_{GSL}), thereby turning off the MOSFETs. The supply current during the OFF state operation is reduced because the charge pump is disabled.

The rise time of the output voltage when the power supply voltage is 12 V is defined by t_{ON1} and t_{ON2}, and the fall time is defined by t_{OFF1}.

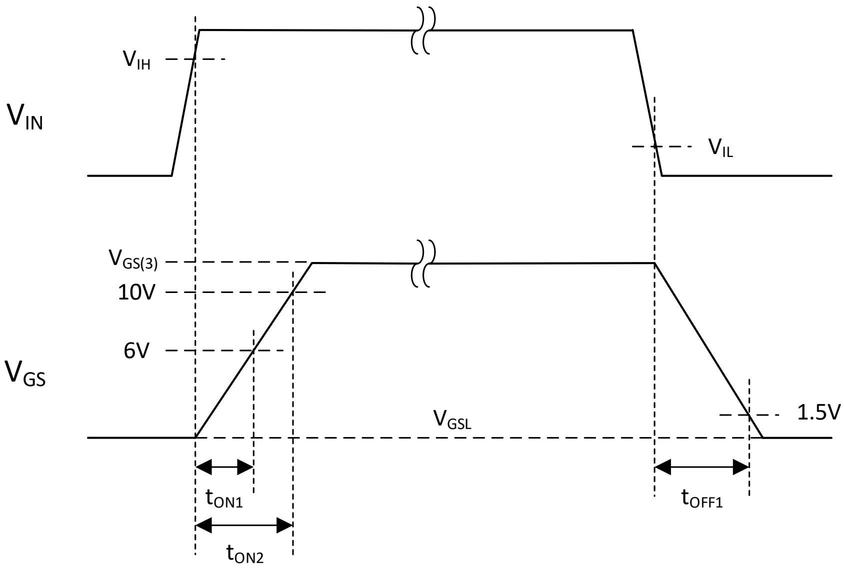


Fig. 7.1 Input threshold voltages and output voltage (V_{DD} = 12 V)

7.2. Reverse Current Blocking

This device blocks reverse current flowing from the load side back to the power supply, which can occur in redundant power systems.
The MOSFET drain voltage is applied to the SENSE pin, and the MOSFET source voltage is applied to the SOURCE pin, where they are compared by an internal comparator circuit. When the IN pin is at a high level and the MOSFET is turned on (i.e., the GATE–SOURCE voltage is at a high level), the device turns the MOSFET off if the SENSE pin voltage exceeds the SOURCE pin voltage by V_{RC} or more due to reverse current.

Afterward, when the reverse current decreases and the voltage difference between the SENSE and SOURCE pins falls to V_{RCr} or below, the device restores a high GATE–SOURCE voltage and resumes normal ON operation of the MOSFET, provided that the IN pin is in the HIGH state.

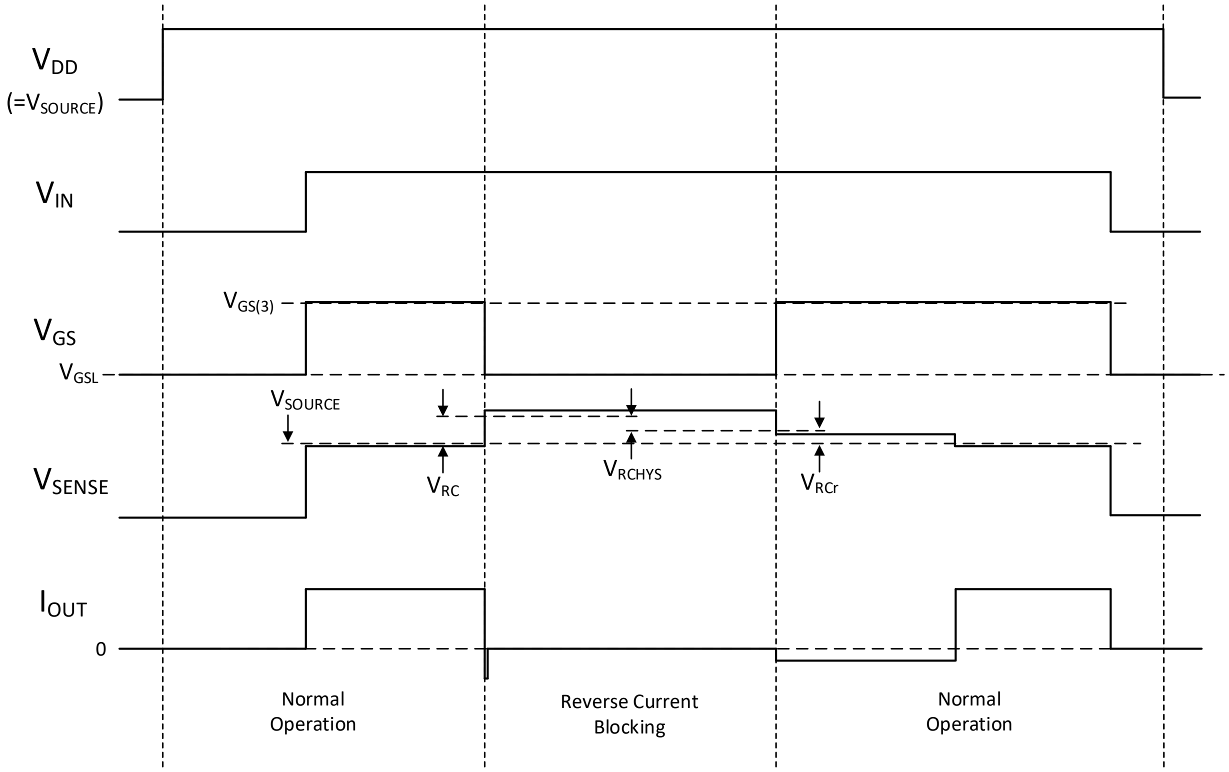


Fig. 7.2 Normal Operation and Reverse Current Blocking

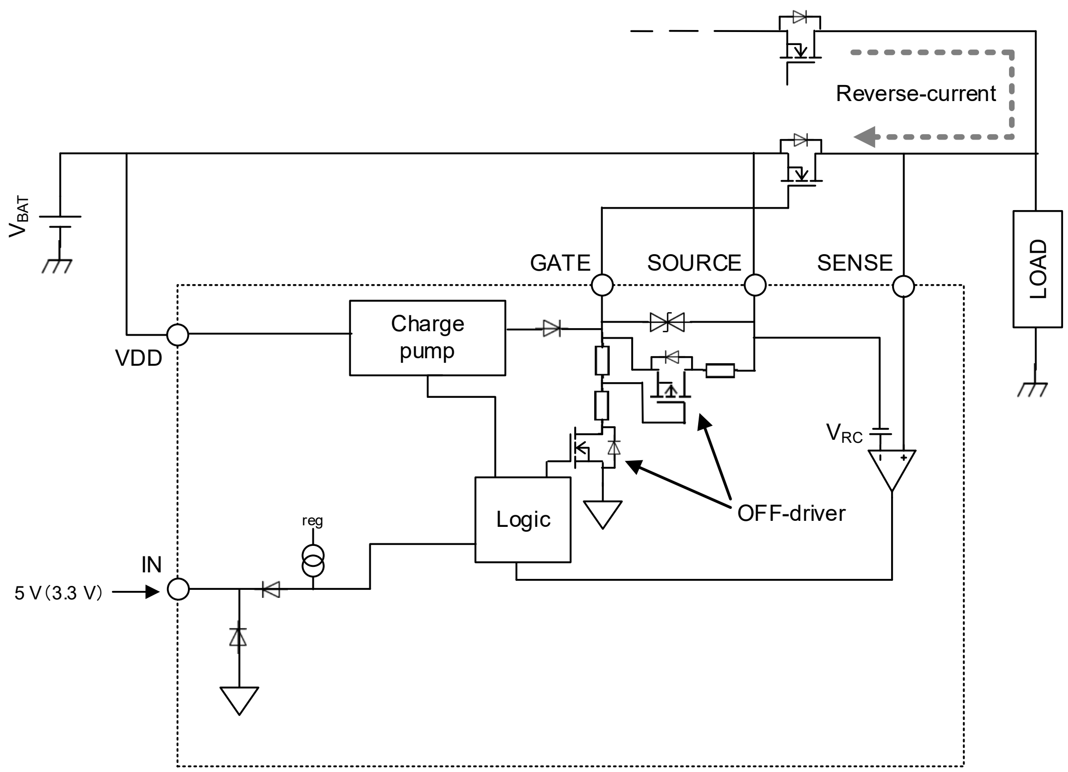


Fig. 7.3 Normal ON/OFF and Reverse Current Detection circuitry

7.3. Undervoltage Protection

This device disables operation when the power supply is in an undervoltage condition.

When the supply voltage falls to V_{UVL} or below, the GATE–SOURCE voltage is forced to a low level regardless of the IN pin state, thereby turning off the MOSFET. While the MOSFET remains OFF due to undervoltage protection, the device restores a high GATE–SOURCE voltage and resumes normal ON operation once the supply voltage rises to V_{UVH} or above, provided that the IN pin is in the HIGH state.

7.4. Overvoltage Protection

This device disables operation when the power supply is in an overvoltage condition.

When the supply voltage exceeds V_{OVH}, the GATE–SOURCE voltage is forced to a low level regardless of the IN pin state, thereby turning off the MOSFET. While the MOSFET remains OFF due to overvoltage protection, the device restores a high GATE–SOURCE voltage and resumes normal ON operation once the supply voltage decreases to V_{OVL} or below, provided that the IN pin is in the HIGH state.

To protect the downstream load against overvoltage using this function, connect the MOSFETs in a back-to-back configuration, as shown in Figure 7.5.

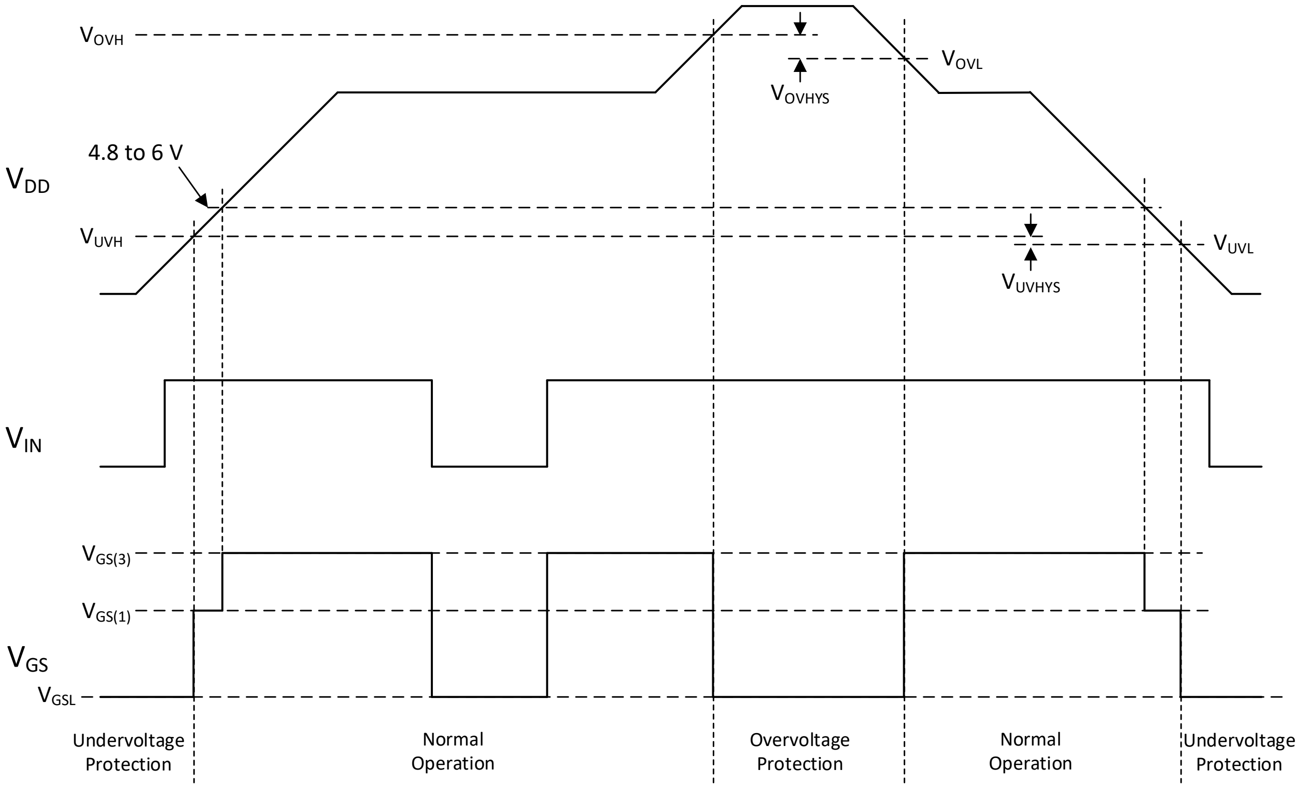


Fig. 7.4 Undervoltage and Overvoltage Protection

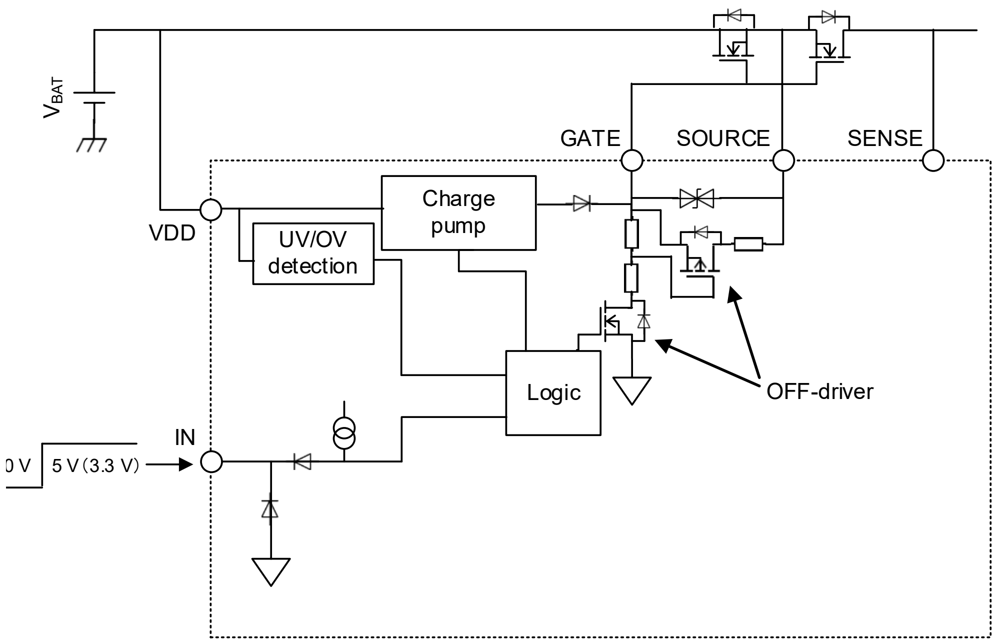


Fig. 7.5 Undervoltage and Overvoltage Protection circuitry

7.5. Reverse Polarity Protection

This device protects the system by turning off the MOSFET when a reverse polarity condition is applied to the power supply input.
The reverse polarity detection circuit monitors the voltages at the VDD and GND terminals. When a reverse polarity is detected, the reverse polarity protection off-driver is activated, setting the voltage between the GATE and SOURCE terminals to a low level (V_{GSL}), thereby turning off the MOSFET.
Additionally, the GND switch is turned off to disconnect the internal GND wiring of the IC from the external GND, preventing reverse current from flowing into the IC through the GND terminal.

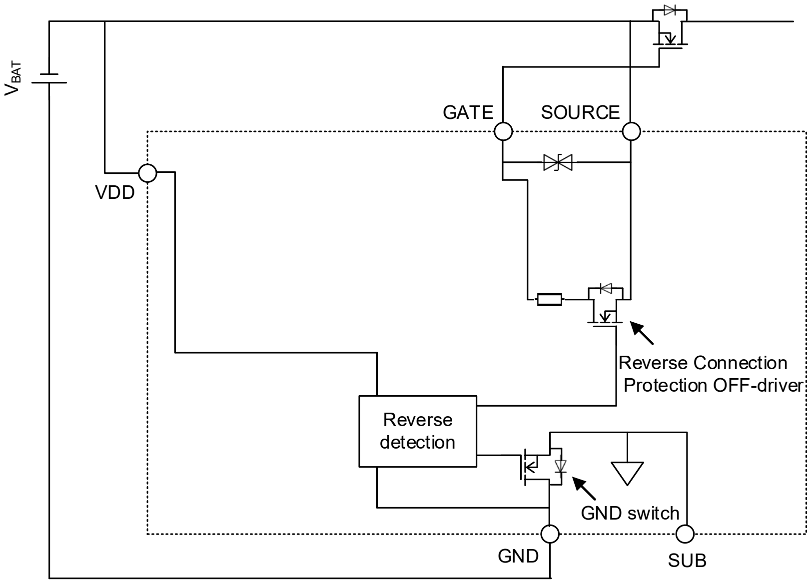


Fig.7.6 Reverse Polarity Protection circuitry

7.6. Truth Table

Table 7.1 Truth Table

Operating Mode	V_{DD}	IN	V_{GS} (Note 1)	MOSFET
Normal Operation	$V_{UVL} < V_{DD} < V_{OVH}$	L	L	OFF
		H	H	ON
Reverse current blocking ($V_{SENSE} - V_{SOURCE} \geq V_{RC}$)		H	L	OFF
Undervoltage Protection	$V_{GND} \leq V_{DD} \leq V_{UVL}$	-	L	OFF
Overvoltage Protection	$V_{DD} \geq V_{OVH}$	-	L	OFF
Reverse polarity Protection	$V_{GND} > V_{DD}$	-	L	OFF

Note 1 : Voltage between the GATE and SOURCE terminals

7.7. State Transition Diagram

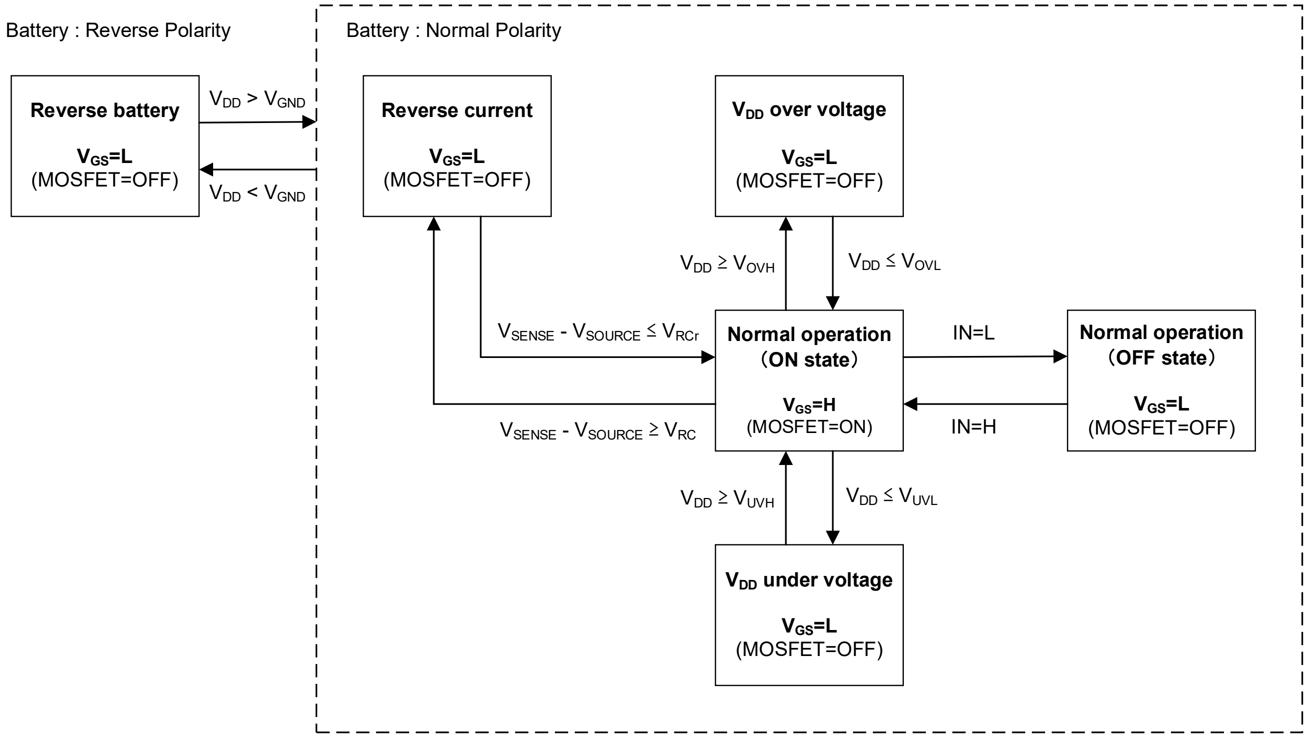


Fig. 7.7 State Transition Diagram

8. Absolute Maximum Ratings

Table 8.1 Absolute Maximum Ratings (Note)

(Unless otherwise specified, Ta = 25 °C)

Item	Symbol	Rating	Unit	Conditions
Power supply voltage	$V_{DD(1)}$	-0.3 to 60	V	DC
Power supply voltage under reverse connection	$V_{DD(2)}$	-32	V	SUB pin : Open
Input voltage (1)	V_{IN}	-0.3 to 6	V	IN pin
Input voltage (2)	V_{SENSE}	-0.3 to 60	V	SENSE pin
Input voltage (3)	V_{SOURCE}	-0.3 to 60	V	SOURCE pin
Output voltage	V_{GATE}	-0.3 to 60	V	GATE pin
Output source current	$I_{GS(-)}$	Internal capacity	μA	-
Output sink current	$I_{GS(+)}$	200	mA	-
Allowable power dissipation	P_D	0.99	W	JEDEC 4-layer board
Operating temperature	T_{opr}	-40 to 125	°C	-
Junction temperature	T_j	150	°C	-
Storage temperature	T_{stg}	-55 to 150	°C	-

Note : Absolute maximum ratings are specifications that must never be exceeded, even momentarily. Exceeding these ratings may result in destruction, degradation, or damage to the IC, and may also cause harm to other components.
Ensure that your design does not exceed the absolute maximum ratings under any operating conditions.
Please use the device within the operating ranges specified in the documentation.

8.1. Thermal Resistance

Table 8.2 Thermal Resistance

Item	Symbol	Rating	Unit
Thermal resistance (junction-to-ambient)	$R_{th\ (j\text{–}a)}$	126	°C / W

Board Conditions : JEDEC 4-layer board

9. Operating Range

Table 9.1 Operating supply voltage

Item	Symbol	Condition	Min	Typ.	Max	Unit
Operating supply voltage	$V_{DD(opr)}$	T_j = -40 to 125 °C	3	-	32	V

10. Electrical Characteristics

Table 10.1 Electrical Characteristics

(Unless otherwise specified, T_j = -40 to 125 °C, V_{DD} = 3 to 32 V)

Item	Symbol	Test Conditions	Min	Typ.	Max	Unit
Supply current	$I_{DD(ON1)}$	Refer to test circuit 1 V_{DD} = 12 V, V_{IN} = 5 V T_j = 25 °C	-	100	150	μA
	$I_{DD(ON2)}$	Refer to test circuit 1 V_{DD} = 32 V, V_{IN} = 5 V T_j = -40 °C to 125 °C	-	-	280	μA
	$I_{DD(OFF1)}$	Refer to test circuit 1 V_{DD} = 12 V, V_{IN} = 0 V T_j = 25 °C		2	3	μA
	$I_{DD(OFF2)}$	Refer to test circuit 1 V_{DD} = 32 V, V_{IN} = 0 V T_j = -40 °C to 125 °C		-	10	μA
High level input voltage	V_{IH}	-	2.4	-	-	V
Low level input voltage	V_{IL}	-	-	-	0.6	V
Input voltage hysteresis	V_{IHYS}	-	-	0.5	-	V
High level input current	I_{IH}	V_{IN} = 5 V	-	0.3	1.0	μA
Low level input current	I_{IL}	V_{IN} = 0 V	-2.0	-0.3	-	μA
High level output voltage(1)	$V_{GS(1)}$	Refer to test circuit 2 V_{DD} = 3 V to 4.8 V, V_{IN} = 5 V	6.0	7.0	8.0	V
High level output voltage(2)	$V_{GS(2)}$	Refer to test circuit 2 V_{DD} = 4.8 V to 6 V, V_{IN} = 5 V	6.0	-	13.5	V
High level output voltage(3)	$V_{GS(3)}$	Refer to test circuit 2 V_{DD} = 6 V to 32 V, V_{IN} = 5 V	10.0	12.0	13.5	V
Low level output voltage	V_{GSL}	Refer to test circuit 2 V_{IN} = 0 V	-	-	0.5	V
Output clamp voltage	V_{CL}	-	15.5	18.0	19.5	V
Overvoltage detection voltage	V_{OVH}	-	33	36	39	V
Overvoltage release voltage	V_{OVL}	-	32	-	-	V
Overvoltage detection hysteresis	V_{OVHYS}	-	-	1	-	V
Undervoltage detection voltage	V_{UVL}	-	2.4	-	2.9	V
Undervoltage release voltage	V_{UVH}	-	-	-	3.0	V
Undervoltage detection hysteresis	V_{UVHYS}	-	-	0.1	-	V
Output resistance	R_{SINK}	Refer to test circuit 3	-	30	40	Ω
Reverse current blocking threshold voltage	V_{RC}	Refer to test circuit 4 T_j = 25 °C	20	30	40	mV
Reverse current blocking release voltage	V_{RCr}	Refer to test circuit 4 T_j = 25 °C	-	-	23	mV
Reverse current blocking voltage hysteresis	V_{RCHYS}	Refer to test circuit 4 T_j = 25 °C	-	22	-	mV

Output voltage under reverse polarity	V_{GSREV}	Refer to test circuit 5 V_{DD} = -3 V to -32 V, T_j = 25 °C	-	-	0.5	V
Supply current under reverse polarity	I_{REV}	Refer to test circuit 5 V_{DD} = -3 V to -32 V, T_j = 25 °C	-	-	100	μA
Switching time	t_{ON1}	Refer to test circuit 6 T_j = 25 °C	-	1.6	2.8	ms
	t_{ON2}		-	3.2	5.8	ms
	t_{OFF1}		-	3.9	5.0	μs

11. Test circuits

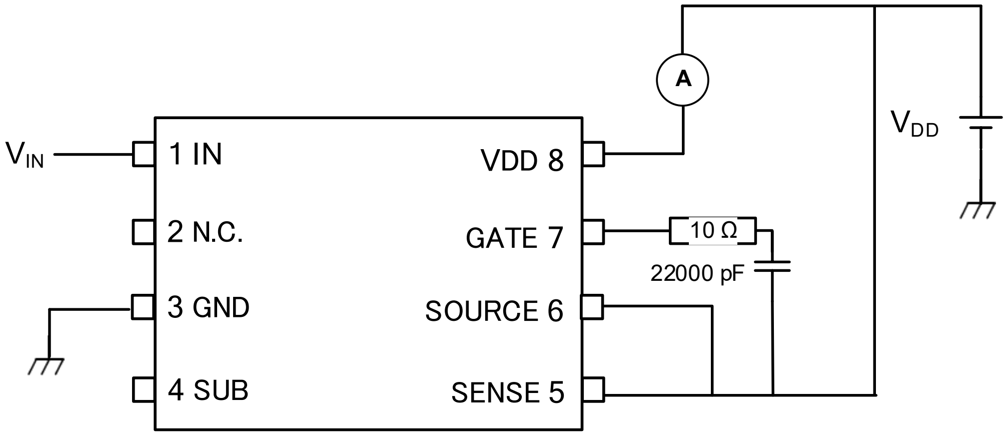


Fig. 11.1 Test circuit 1

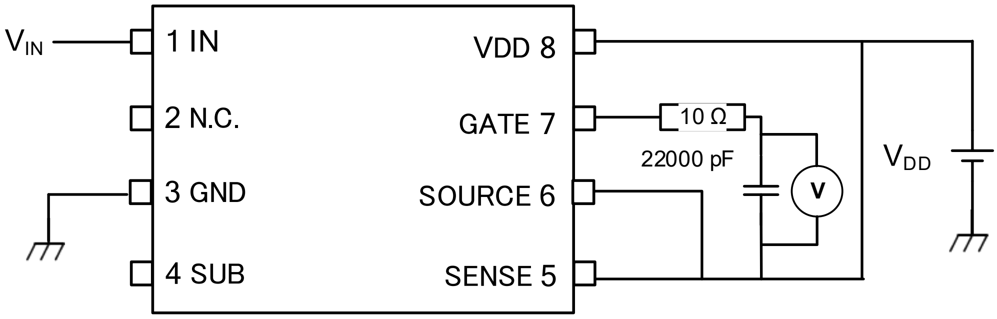


Fig. 11.2 Test circuit 2

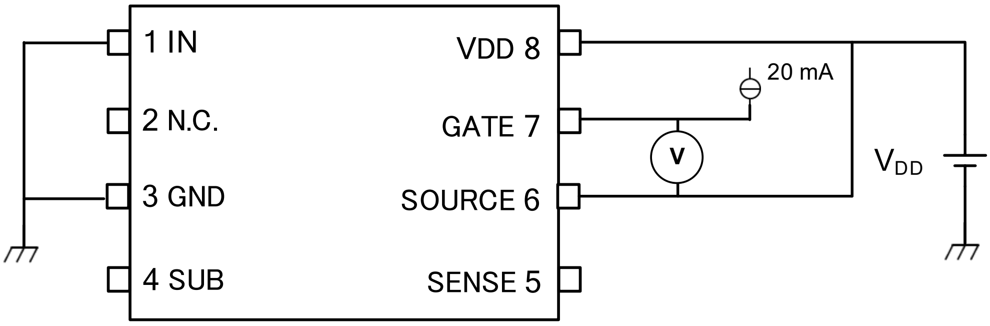


Fig. 11.3 Test circuit 3

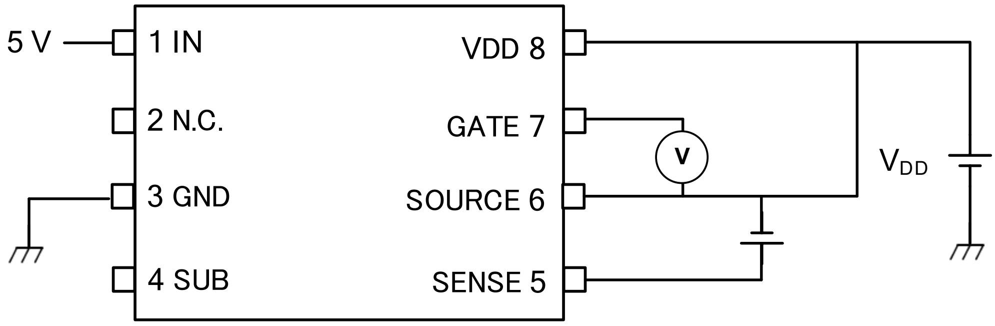


Fig. 11.4 Test circuit 4

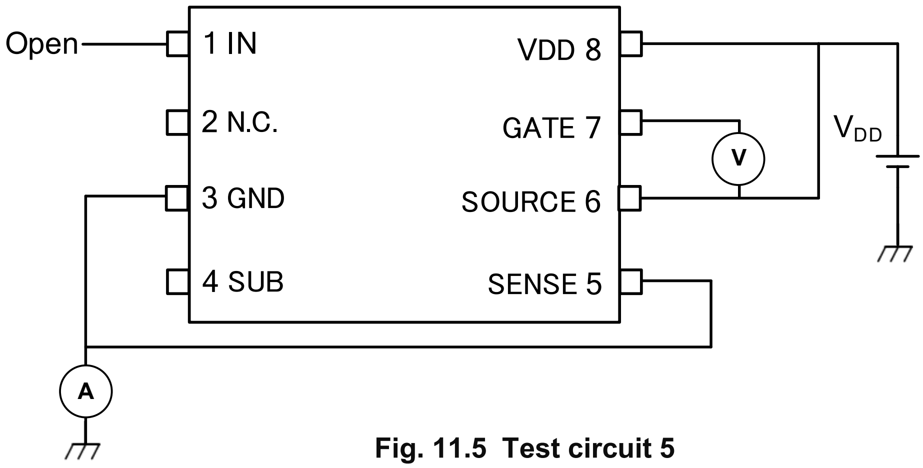


Fig. 11.5 Test circuit 5

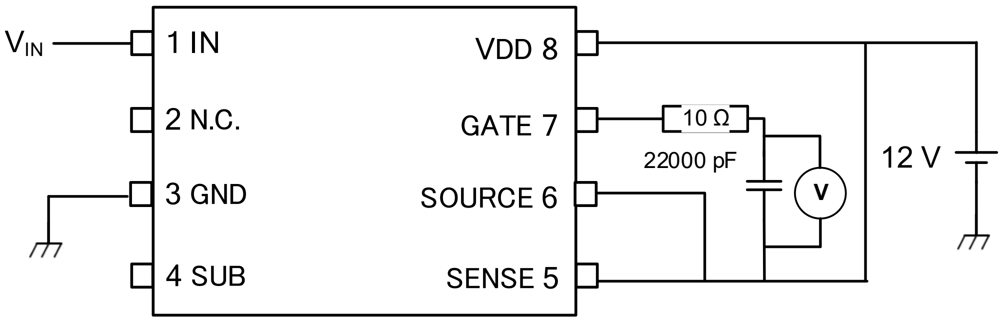


Fig. 11.6 Test circuit 6

12. Characteristic curves

The above characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

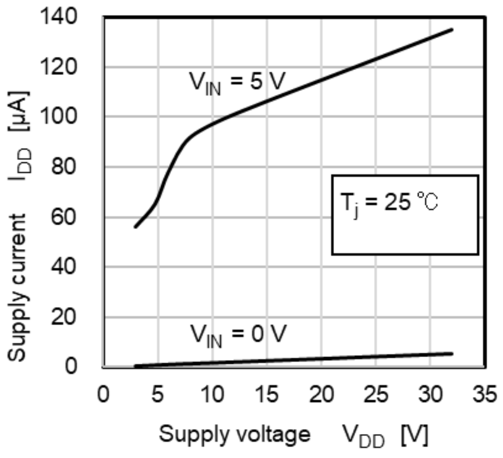


Fig. 12.1 I_{DD} - V_{DD}

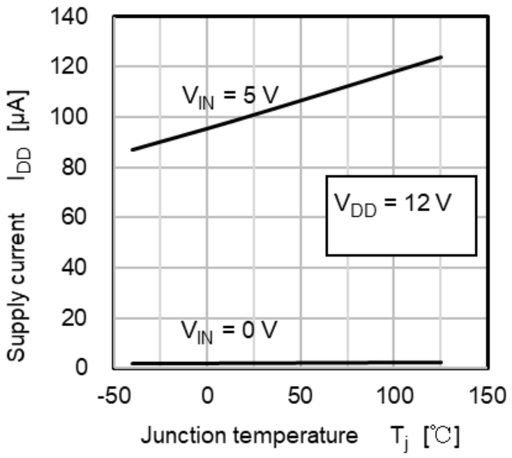


Fig. 12.2 I_{DD} - T_j

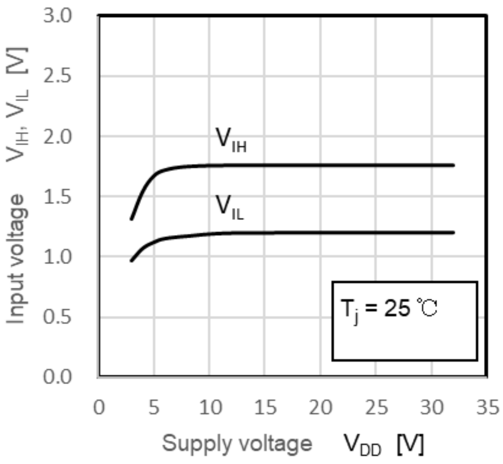


Fig. 12.3 V_{IH},V_{IL} - V_{DD}

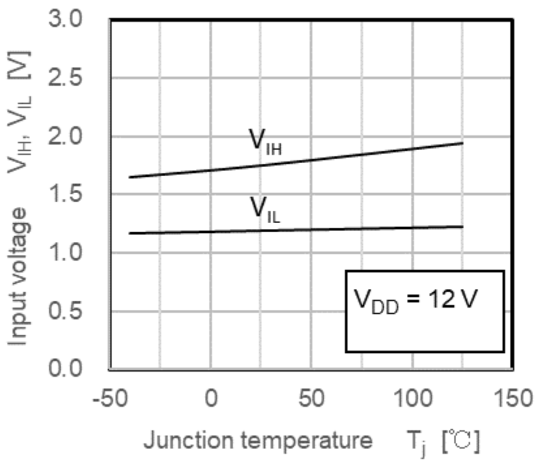


Fig. 12.4 V_{IH},V_{IL} - T_j

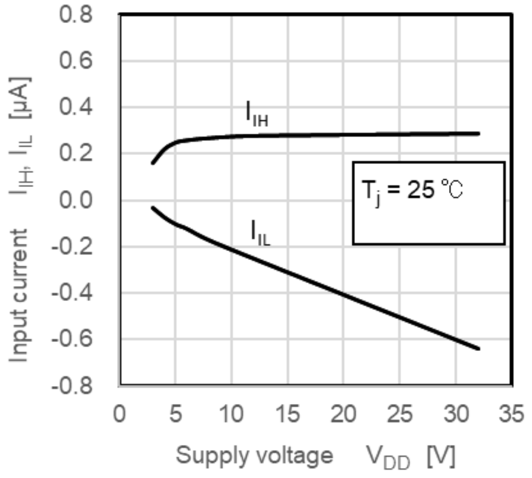


Fig. 12.5 I_{IH},I_{IL} - V_{DD}

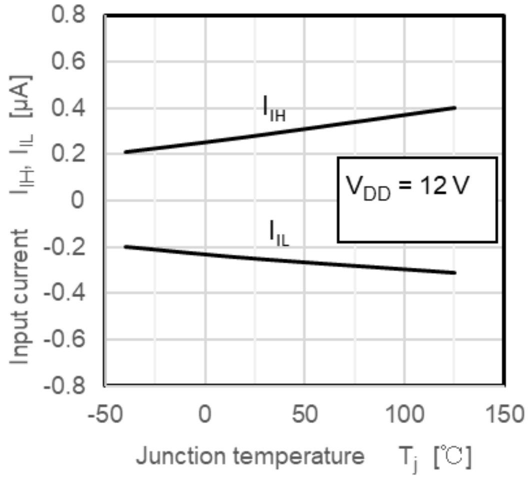


Fig. 12.6 I_{IH},I_{IL} - T_j

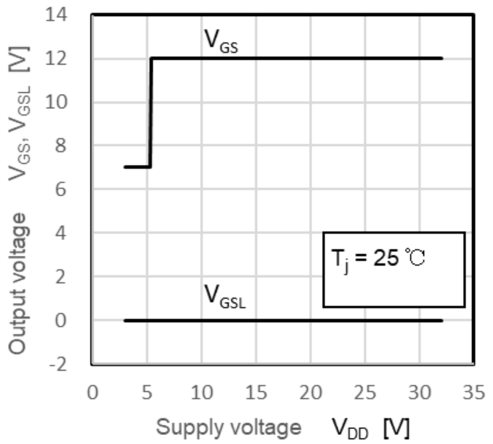


Fig. 12.7 V_{GS},V_{GSL} - V_{DD}

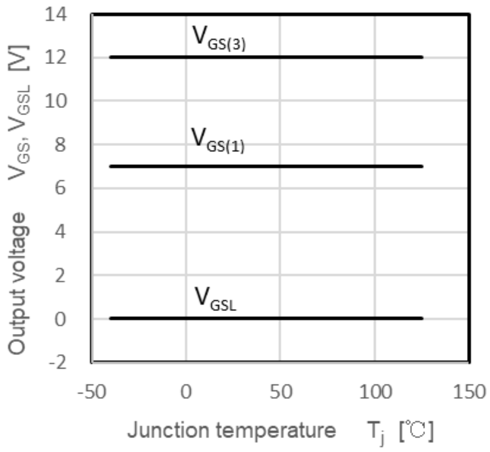


Fig. 12.8 V_{GS},V_{GSL} - T_j

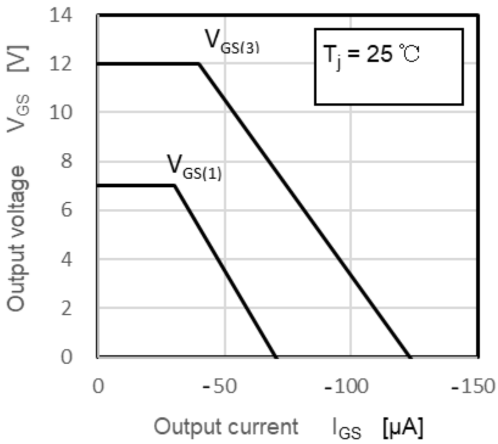


Fig. 12.9 V_{GS} - I_{GS}

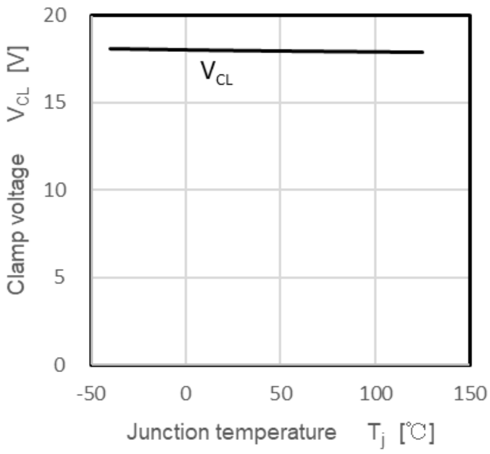


Fig. 12.10 V_{CL} - T_j

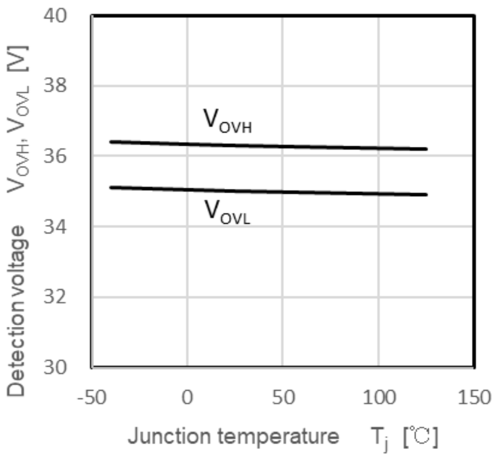


Fig. 12.11 V_{OVH},V_{OVL} - T_j

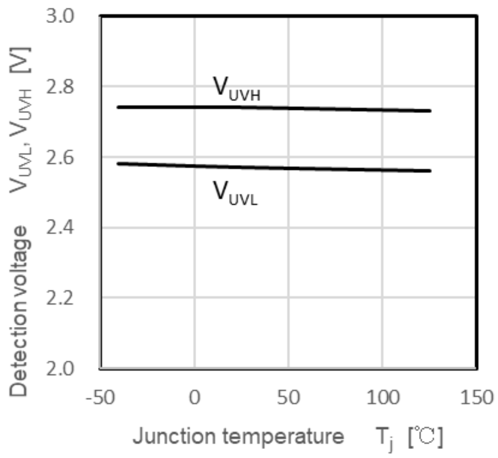


Fig. 12.12 V_{UVL},V_{UVH} - T_j

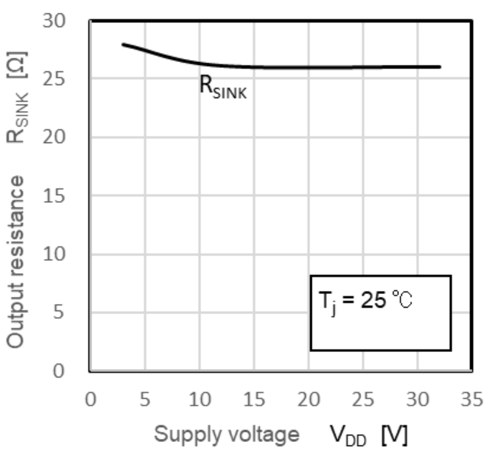


Fig. 12.13 R_{SINK} - V_{DD}

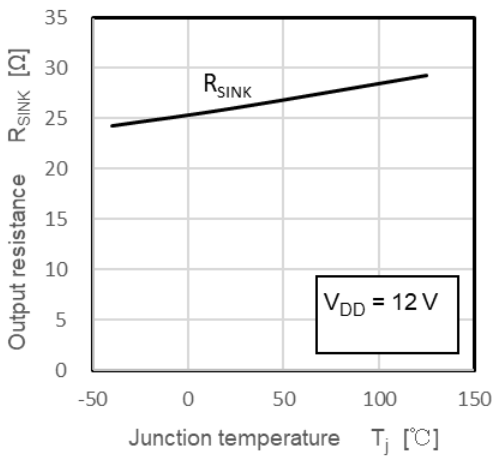


Fig. 12.14 R_{SINK} - T_j

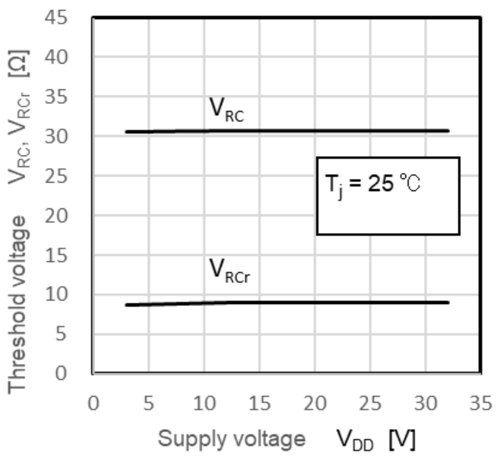


Fig. 12.15 V_{RC},V_{RCr} - V_{DD}

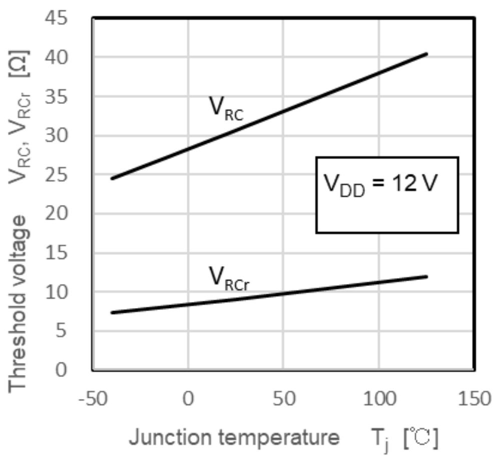


Fig. 12.16 V_{RC},V_{RCr} - T_j

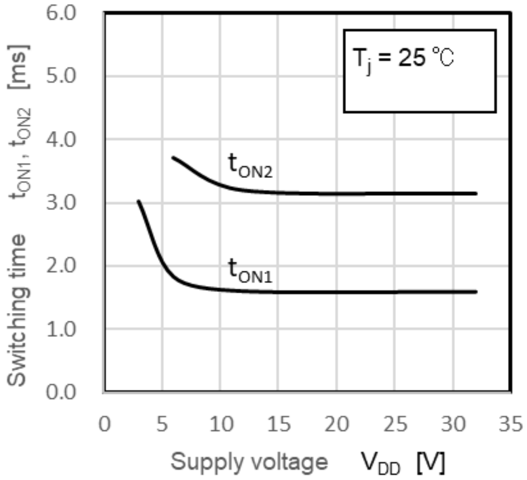


Fig. 12.17 t_{ON1},t_{ON2} - V_{DD}

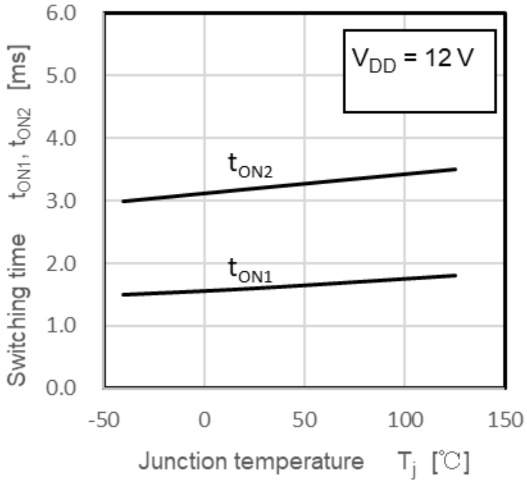


Fig. 12.18 t_{ON1},t_{ON2} - T_j

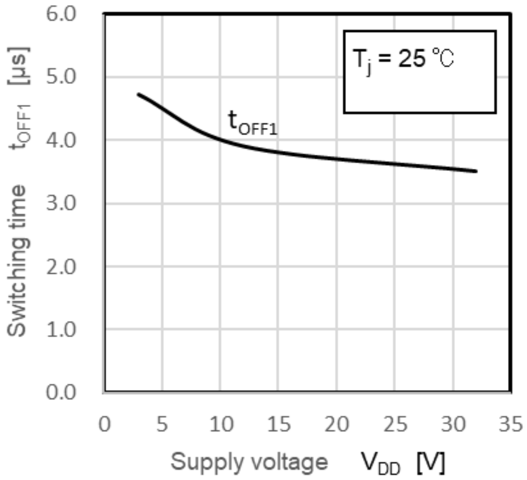


Fig. 12.19 t_{OFF1} - V_{DD}

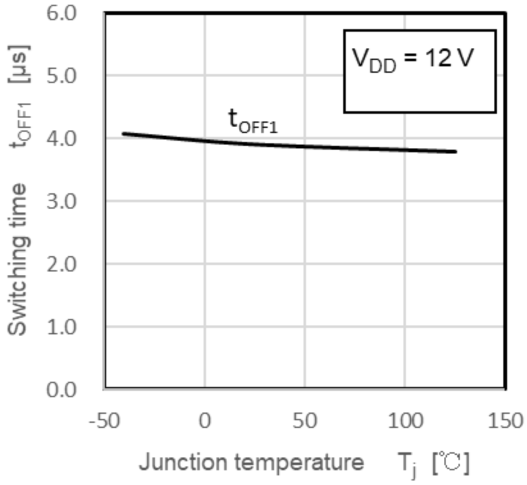


Fig. 12.20 t_{OFF1} - T_j

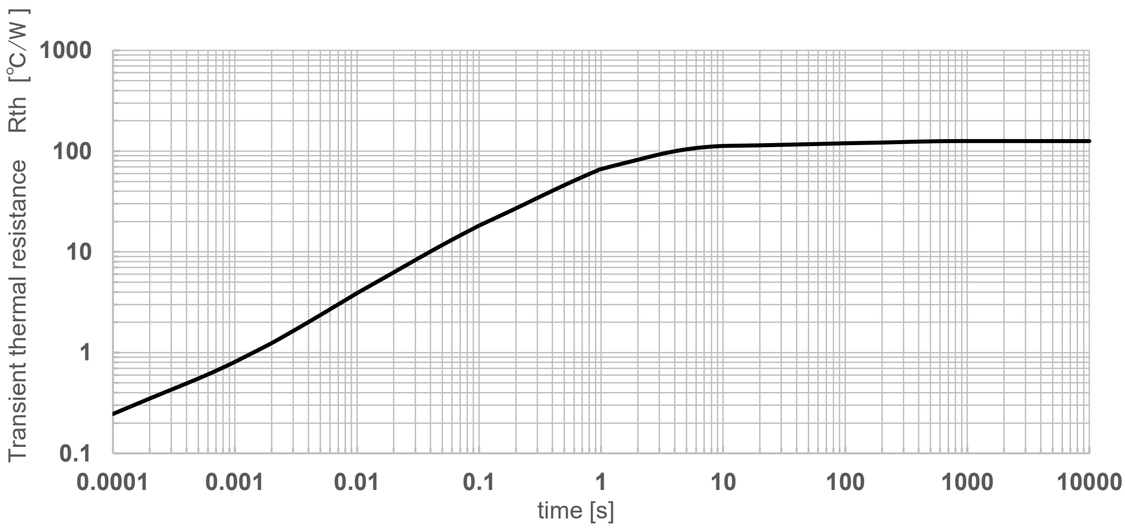


Fig. 12.21 Rth - t

13. Application circuit examples

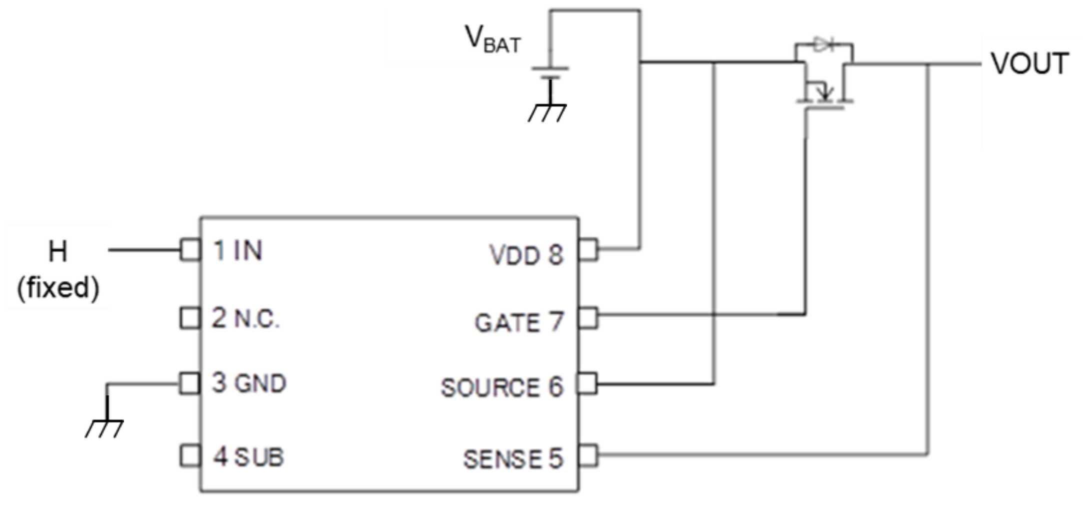


Fig. 13.1 Ideal Diode Application Circuit

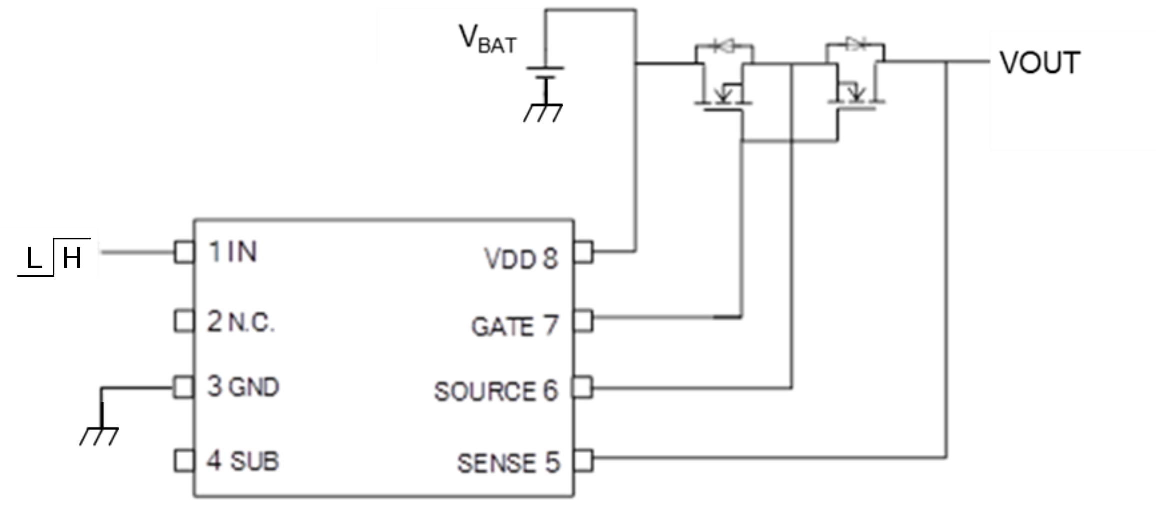
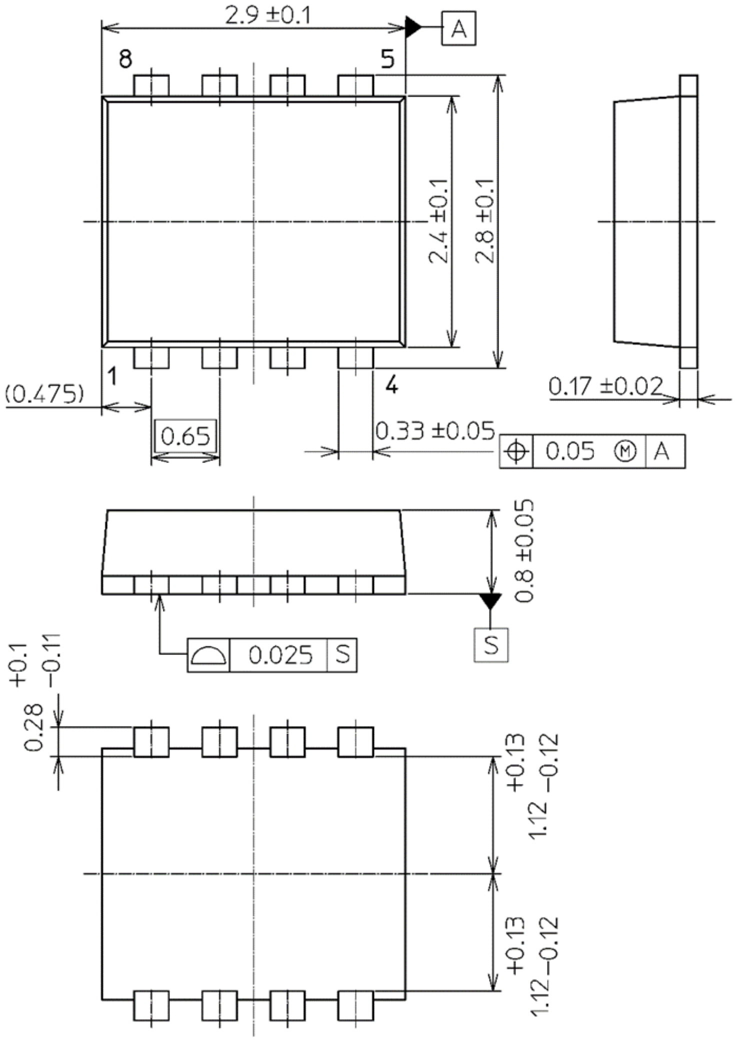


Fig. 13.2 Load Switch Application Circuit

14. Package Information

14.1. Dimensions

SON8-P-0303-0.65 Unit : mm



Weight : 0.017 g(typ.)

Fig. 14.1 Dimensions

14.2. Marking

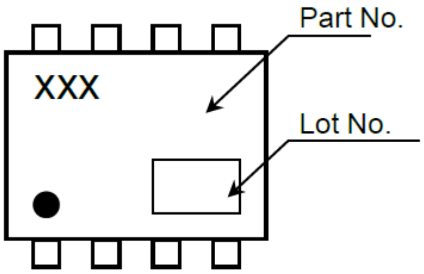
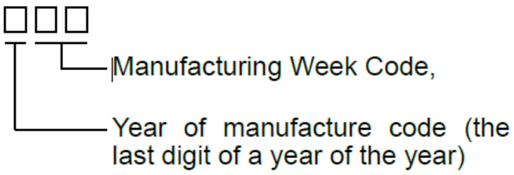


Fig. 14.2 Marking

- The mark bottom dot (●) indicates terminal 1 when viewed from the front.
- Weekly lot display
- Consists of three-digit mathematical figures, with the last one digit of the calendar year and the remaining two digits being the manufacturing week.



14.3. Land Pattern Dimensions (for reference only)

Unit : mm

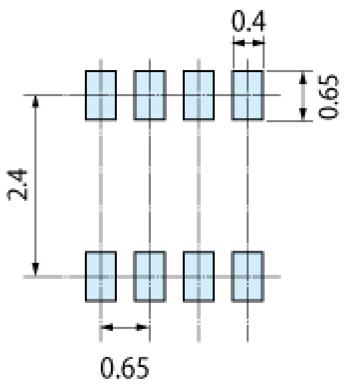


Fig. 14.3 Land Pattern Dimensions (for reference only)

15. IC Usage Considerations

15.1. Notes on handing of ICs

The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. It cannot be exceeded for any of multiple ratings. Exceeding the absolute maximum ratings may cause breakage, damage or deterioration, resulting in injury due to explosion or combustion.

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