S-19680 Series

AUTOMOTIVE, 105°C OPERATION, HIGH SIDE SWITCH WITH CURRENT MONITOR

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Rev.1.3_00

The S-19680 Series, developed by using CMOS technology, is a high side switch with the current monitor function.
When the Pch output transistor is turned on, voltage is supplied to the load connected to the OUT pin. Monitoring the current which flows from the VIN pin to the OUT pin by using two external resistors, the S-19680 Series limits the current so that it does not exceed the set value. Depending on the monitored current value, the S-19680 Series detects the short-circuit status or the open status of the load connected to the OUT pin, and outputs an alarm signal.
In addition, the S-19680 Series has the ON / OFF circuit to control the Pch output transistor's status, ON and OFF, and the thermal shutdown circuit to limit overheating. The hysteresis type or latch type can be selected for the thermal shutdown circuit.

ABLIC Inc. offers FIT rate calculated based on actual customer usage conditions in order to support customer functional safety design.
For more information regarding our FIT rate calculation, contact our sales representatives.

Caution **This product can be used in vehicle equipment and in-vehicle equipment. Before using the product for these purposes, it is imperative to contact our sales representatives.**

■ Features

- Power supply voltage: V_{DD} = 2.7 V to 10.0 V
- Current consumption during operation: I_{SS1} = 12 µA typ., I_{SS1} = 24 µA max. (T_j = –40°C to +105°C)
- ON resistance: R_{ON} = 1.1 Ω typ., R_{ON} = 3.7 Ω max. (T_j = –40°C to +105°C)
- Limit current: 40 mA to 100 mA, selectable in 10 mA step
- Load short-circuit detection current: I_{LIM} × 0.3 to I_{LIM} × 1.0 (I_{SHORT} ≥ 30 mA), selectable in 0.1 step
- Load open detection current: 2.5 mA to 30 mA, selectable in 2.5 mA step
- Built-in thermal shutdown circuit: Detection temperature 165°C typ.
  Selectable in hysteresis type or latch type
- Built-in ON / OFF circuit: Ensures long battery life.
- Operation temperature range: Ta = –40°C to +105°C
- Lead-free (Sn 100%), halogen-free
- AEC-Q100 qualified *1

***1.** Contact our sales representatives for details.

■ Applications

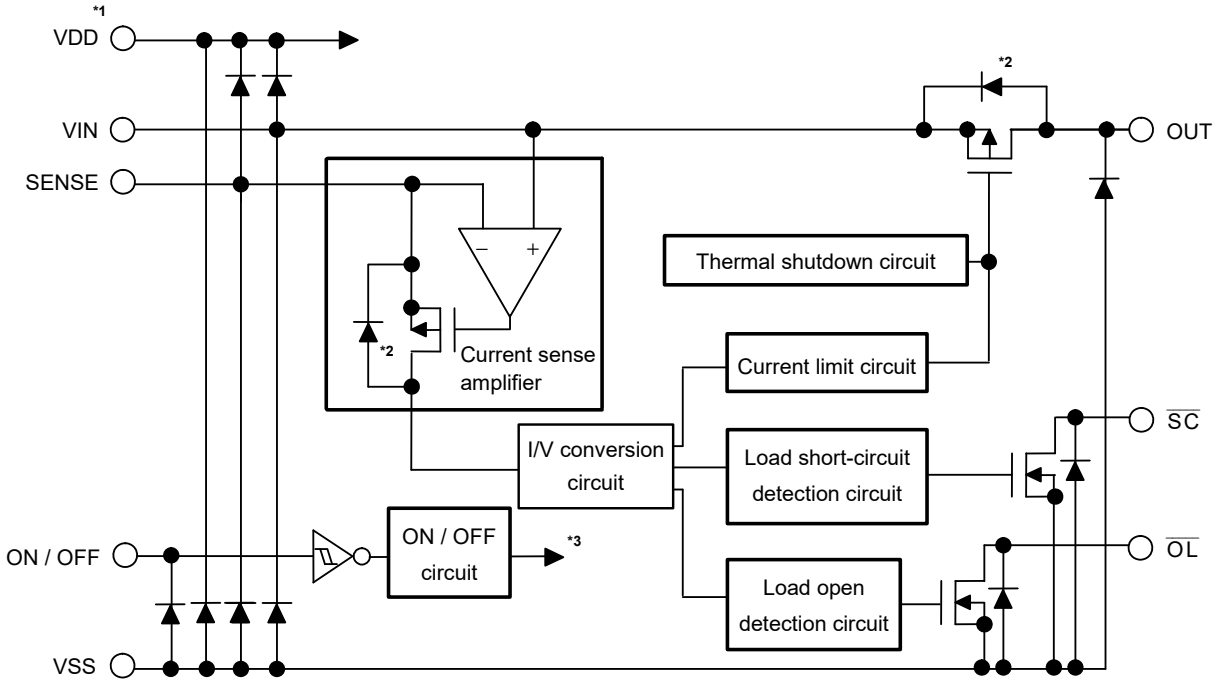
- Remote LNA phantom power such as GPS antenna
- ADAS locator
- e-call
- Car navigation system
- Car audio system

■ Package

- TMSOP-8

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■ Block Diagram



***1.** The VDD pin supplies power to the internal circuit.
***2.** Parasitic diode
***3.** The ON / OFF circuit controls the internal circuit, the Pch output transistor and the Nch output transistor.

Figure 1

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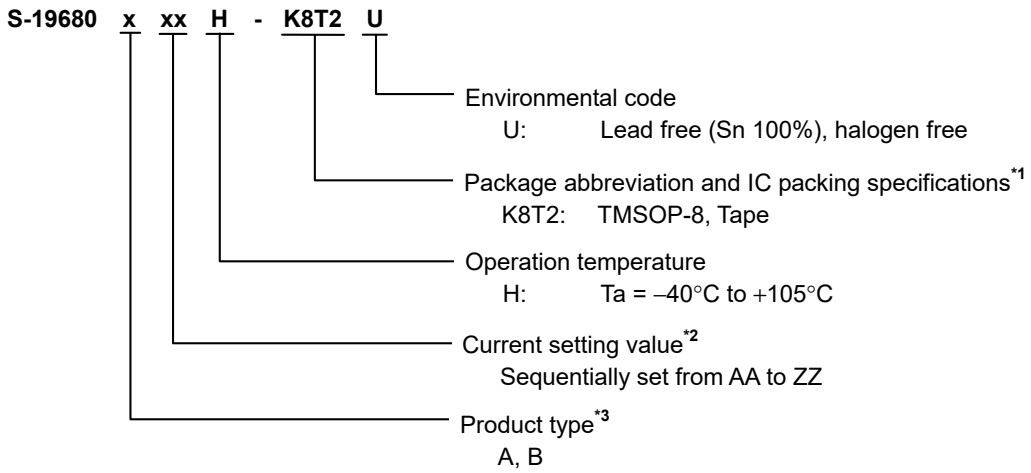
■ AEC-Q100 Qualified

This IC supports AEC-Q100 for operation temperature grade 2.
Contact our sales representatives for details of AEC-Q100 reliability specification.

■ Product Name Structure

Users can select the product type and current setting value (limit current, load short-circuit detection current, load open detection current) for the S-19680 Series. Refer to "**1. Product name**" regarding the contents of product name, "**2. Function list of product types**" regarding the product types, "**3. Package**" regarding the package drawings and "**4. Product name list**" for details of product names.

1. Product name



***1.** Refer to the tape drawing.
***2.** Refer to **"4. Product name list".**
***3.** Refer to "**2. Function list of product types".**

2. Function list of product types

Table 1

Product Type	ON / OFF Logic	Thermal Shutdown Circuit
A	Active "H"	Hysteresis type
B	Active "H"	Latch type

3. Package

Table 2 Package Drawing Codes

Package Name	Dimension	Tape	Reel
TMSOP-8	FM008-A-P-SD	FM008-A-C-SD	FM008-A-R-SD

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4. Product name list

4. 1 S-19680 Series A type

Table 3

Product Name	Limit Current (I_{LIM})	Load Short-circuit Detection Current (I_{SHORT})	Load Open Detection Current (I_{OPEN})
S-19680AAAH-K8T2U	40 mA	40 mA	2.5 mA
S-19680AABH-K8T2U	100 mA	50 mA	10 mA

Remark Please contact our sales representatives for products other than the above.

4. 2 S-19680 Series B type

Table 4

Product Name	Limit Current (I_{LIM})	Load Short-circuit Detection Current (I_{SHORT})	Load Open Detection Current (I_{OPEN})
S-19680BAAH-K8T2U	50 mA	40 mA	5.0 mA
S-19680BABH-K8T2U	50 mA	35 mA	7.5 mA
S-19680BACH-K8T2U	100 mA	50 mA	10 mA
S-19680BADH-K8T2U	100 mA	50 mA	5.0 mA
S-19680BAEH-K8T2U	60 mA	54 mA	15 mA
S-19680BAFH-K8T2U	70 mA	70 mA	5.0 mA

Remark Please contact our sales representatives for products other than the above.

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■ Pin Configuration

1. TMSOP-8

Top view

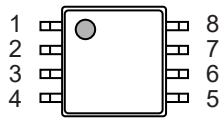


Figure 2

Table 5

Pin No.	Symbol	Description
1	VIN	Voltage input pin
2	SENSE	Current sense input pin
3	VDD	IC power supply pin
4	ON / OFF	ON / OFF pin
5	$\overline{OL}$	Load open detection signal output pin
6	$\overline{SC}$	Load short-circuit detection signal output pin
7	VSS	GND pin
8	OUT	Voltage output pin

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■ Absolute Maximum Ratings

Table 6

(Ta = +25°C unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
Input voltage	V_{DD}	V_{SS} – 0.3 to V_{SS} + 12	V
	V_{IN}	V_{SS} – 0.3 to V_{DD} + 0.3 ≤ V_{SS} + 12	V
	V_{SENSE}	V_{SS} – 0.3 to V_{DD} + 0.3 ≤ V_{SS} + 12	V
	$V_{ON / OFF}$	V_{SS} – 0.3 to V_{DD} + 0.3 ≤ V_{SS} + 12	V
	$V_{IN} - V_{SENSE}$	–3.0 to +3.0	V
Output voltage	V_{OUT}	V_{SS} – 0.3 to V_{IN} + 0.3 ≤ V_{SS} + 12	V
	$V_{\overline{OL}}$	V_{SS} – 0.3 to V_{SS} + 12	V
	$V_{\overline{SC}}$	V_{SS} – 0.3 to V_{SS} + 12	V
Output current	I_{OUT}	120	mA
	$I_{\overline{OL}}$	6	mA
	$I_{\overline{SC}}$	6	mA
Junction temperature	T_j	–40 to +150	°C
Operation ambient temperature	T_{opr}	–40 to +105	°C
Storage temperature	T_{stg}	–40 to +150	°C

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

■ Thermal Resistance Value

Table 7

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Junction-to-ambient thermal resistance[1]	θ_{JA}	TMSOP-8	Board A	–	160	–	°C/W
			Board B	–	133	–	°C/W
			Board C	–	–	–	°C/W
			Board D	–	–	–	°C/W
			Board E	–	–	–	°C/W

***1.** Test environment: compliance with JEDEC STANDARD JESD51-2A

Remark Refer to "■ **Power Dissipation**" and "**Test Board**" for details.

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■ Electrical Characteristics

Table 8

(V_{DD} = 5.0 V, T_j = –40°C to +105°C unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test circuit
Power supply voltage	V_{DD}	–40°C ≤ T_j ≤ +150°C		2.7	–	10.0	V	–
Current consumption during operation	I_{SS1}	$V_{ON / OFF}$ = V_{DD}, I_{OUT} = 0 mA		–	12	24	µA	1
Current consumption during power-off	I_{SS2}	$V_{ON / OFF}$ = 0 V, I_{OUT} = 0 mA		–	–	1.0	µA	1
ON resistance*1	R_{ON}	V_{IN} = V_{DD} – 0.51 V $V_{ON / OFF}$ = V_{DD}, I_{OUT} = 100 mA		–	1.1	3.7	Ω	2
Leakage current	I_{LEAK}	$V_{ON / OFF}$ = 0 V, V_{OUT} = 0 V		–	–	1.0	µA	3
Limit current*2, *5	I_{LIM}	R_{SHUNT} = 5.1 Ω R_{SENSE} = 5.1 kΩ V_{OUT} < V_{DD} × 0.8	50 mA ≤ $I_{LIM(S)}$ ≤ 100 mA	$I_{LIM(S)}$ × 0.8	$I_{LIM(S)}$	$I_{LIM(S)}$ × 1.2	mA	4
			40 mA ≤ $I_{LIM(S)}$ < 50 mA	$I_{LIM(S)}$ – 10	$I_{LIM(S)}$	$I_{LIM(S)}$ + 10	mA	4
Load short-circuit detection current*3, *5	I_{SHORT}	R_{SHUNT} = 5.1 Ω R_{SENSE} = 5.1 kΩ	50 mA ≤ $I_{SHORT(S)}$ ≤ 100 mA	$I_{SHORT(S)}$ × 0.8	$I_{SHORT(S)}$	$I_{SHORT(S)}$ × 1.2	mA	5
			30 mA ≤ $I_{SHORT(S)}$ < 50 mA	$I_{SHORT(S)}$ – 10	$I_{SHORT(S)}$	$I_{SHORT(S)}$ + 10	mA	5
Load open detection current*4, *5	I_{OPEN}	R_{SHUNT} = 5.1 Ω R_{SENSE} = 5.1 kΩ	10 mA < $I_{OPEN(S)}$ ≤ 30 mA	$I_{OPEN(S)}$ – 10	$I_{OPEN(S)}$	$I_{OPEN(S)}$ + 10	mA	5
			2.5 mA ≤ $I_{OPEN(S)}$ ≤ 10 mA	$I_{OPEN(S)}$ × 0.3	$I_{OPEN(S)}$	$I_{OPEN(S)}$ × 1.7	mA	5
$\overline{SC}$ pin output voltage	$V_{\overline{SC}}$	$I_{\overline{SC}}$ = 1 mA		–	–	0.4	V	6
$\overline{SC}$ pin leakage current	$I_{\overline{SC}_LEAK}$	$V_{\overline{SC}}$ = 10 V		–	–	1	µA	7
$\overline{OL}$ pin output voltage	$V_{\overline{OL}}$	$I_{\overline{OL}}$ = 1 mA		–	–	0.4	V	6
$\overline{OL}$ pin leakage current	$I_{\overline{OL}_LEAK}$	$V_{\overline{OL}}$ = 10 V		–	–	1	µA	7
ON / OFF pin input voltage "H"	V_{SH}	–		2.1	–	–	V	8
ON / OFF pin input voltage "L"	V_{SL}	–		–	–	0.6	V	8
ON / OFF pin input current "H"	I_{SH}	$V_{ON / OFF}$ = V_{DD}		–0.1	–	0.1	µA	8
ON / OFF pin input current "L"	I_{SL}	$V_{ON / OFF}$ = 0 V		–0.1	–	0.1	µA	8
Thermal shutdown detection temperature	T_{SD}	Junction temperature		–	165	–	°C	–
Thermal shutdown release temperature	T_{SR}	Junction temperature		–	135	–	°C	–

***1.** $R_{ON} = \frac{(V_{IN} - V_{OUT})}{I_{OUT}}$

***2.** I_{LIM}: Actual limit current
$I_{LIM(S)}$: Set limit current
Attention should be paid to the power dissipation when the output current is large.

***3.** I_{SHORT}: Actual load short-circuit detection current
$I_{SHORT(S)}$: Set load short-circuit detection current

***4.** I_{OPEN}: Actual load open detection current
$I_{OPEN(S)}$: Set load open detection current

***5.** Only the variation of the IC is considered. The variation of the external shunt resistor (R_{SHUNT}) and the sense resistor (R_{SENSE}) are not included.

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■ Test Circuits

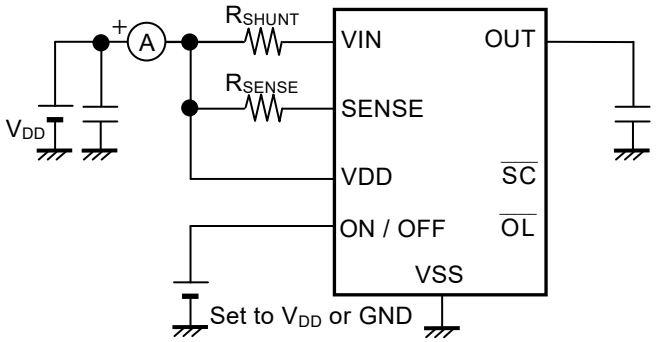


Figure 3 Test Circuit 1

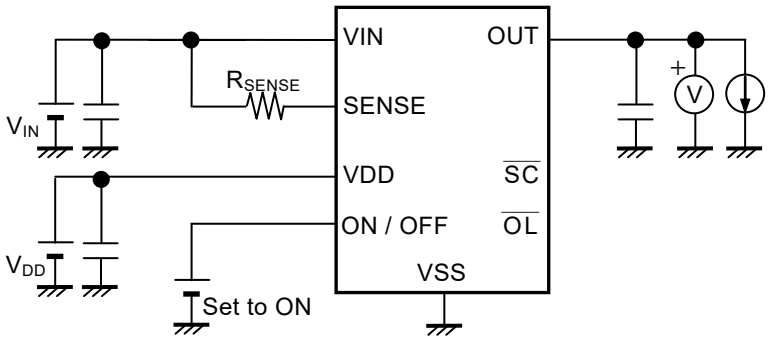


Figure 4 Test Circuit 2

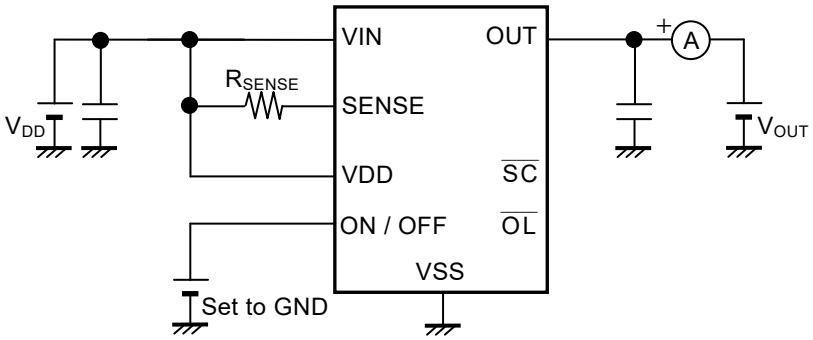


Figure 5 Test Circuit 3

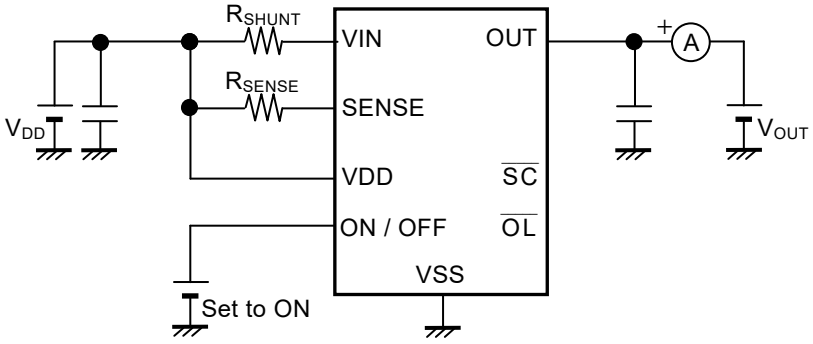


Figure 6 Test Circuit 4

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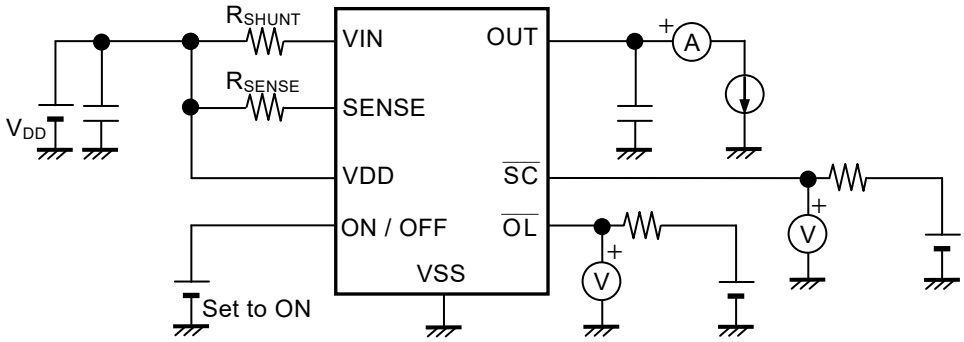


Figure 7 Test Circuit 5

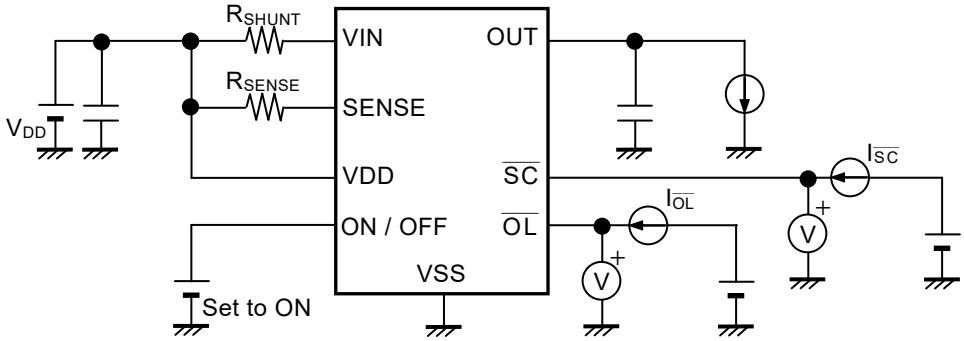


Figure 8 Test Circuit 6

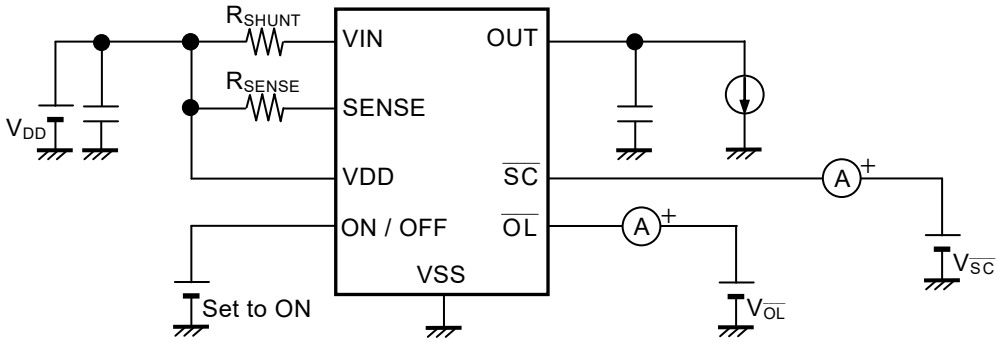


Figure 9 Test Circuit 7

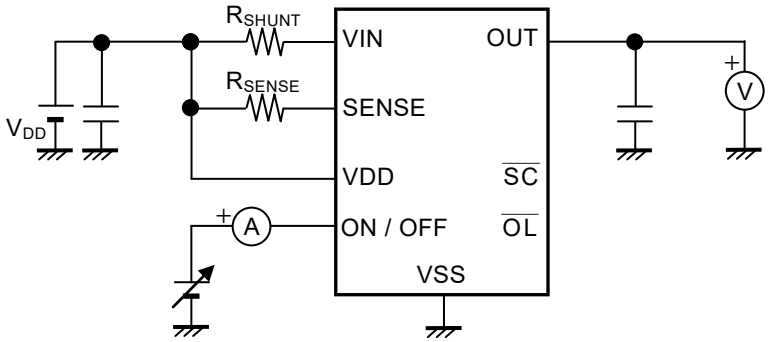
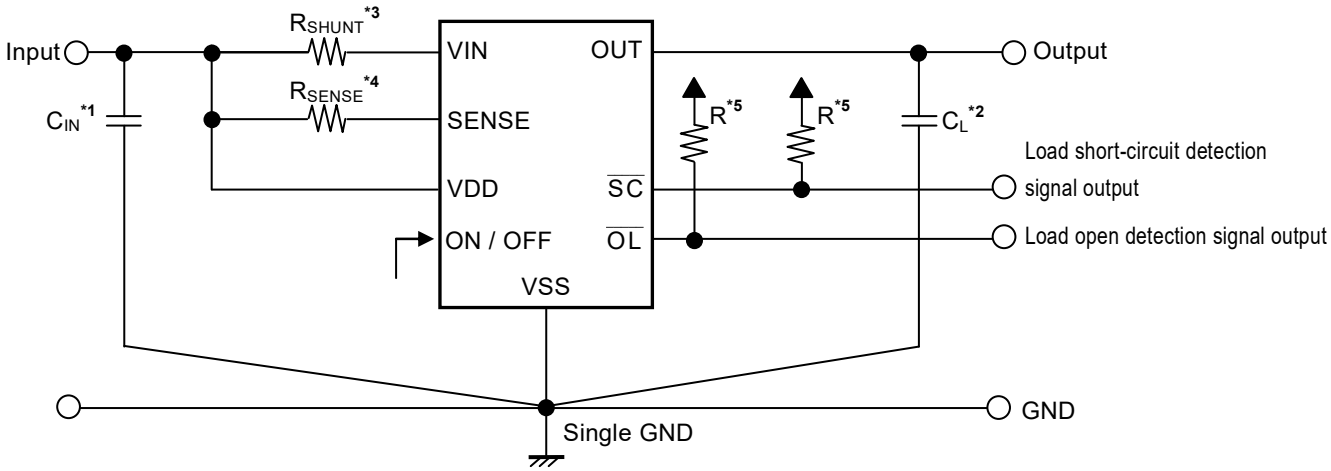


Figure 10 Test Circuit 8

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■ Standard Circuit



***1.** C_{IN} is a capacitor for stabilizing the input.
***2.** C_L is a capacitor for stabilizing the output.
***3.** R_{SHUNT} is a shunt resistor for current monitor.
***4.** R_{SENSE} is a sense resistor for current monitor.
***5.** R is the external pull-up resistor for the $\overline{SC}$ pin or the $\overline{OL}$ pin.

Figure 11

Caution The above connection diagram and constants will not guarantee successful operation. Perform thorough evaluation using the actual application to set the constants.

■ Condition of Application

Input capacitor (C_{IN}):	A ceramic capacitor with 0.1 µF or more is recommended.
Output capacitor (C_L):	A ceramic capacitor with 0.1 µF or more is recommended.
Shunt resistor (R_{SHUNT}):	5.1 Ω
Sense resistor (R_{SENSE}):	5.1 kΩ
External pull-up resistor (R):	A resistor with 100 kΩ is recommended.

■ Selection of Input Capacitor (C_{IN}) and Output Capacitor (C_L)

In the S-19680 Series, it is recommended to connect C_{IN} between the VDD pin and the VSS pin for stable operation. In addition, in order to supply stable power to the load connected to the OUT pin, it is recommended to connect C_L between the OUT pin and the VSS pin. The recommended capacitance for both C_{IN} and C_L is 0.1 µF or more.

Caution Perform thorough evaluation including the temperature characteristics with an actual application to select C_{IN} and C_L.

■ Selection of Shunt Resistor (R_{SHUNT}) and Sense Resistor (R_{SENSE})

In the S-19680 Series, R_{SHUNT} and R_{SENSE} are required for the current monitor function. A resistor with 5.1 Ω can be used for R_{SHUNT} and 5.1 kΩ for R_{SENSE}.
Select R_{SHUNT} and R_{SENSE} carefully since the accuracy of the limit current (I_{LIM}), the load short-circuit detection current (I_{SHORT}) and the load open detection current (I_{OPEN}) are affected by R_{SHUNT} and R_{SENSE} characteristics. In addition, a load current flows in R_{SHUNT}, so the heat generation must also be considered.

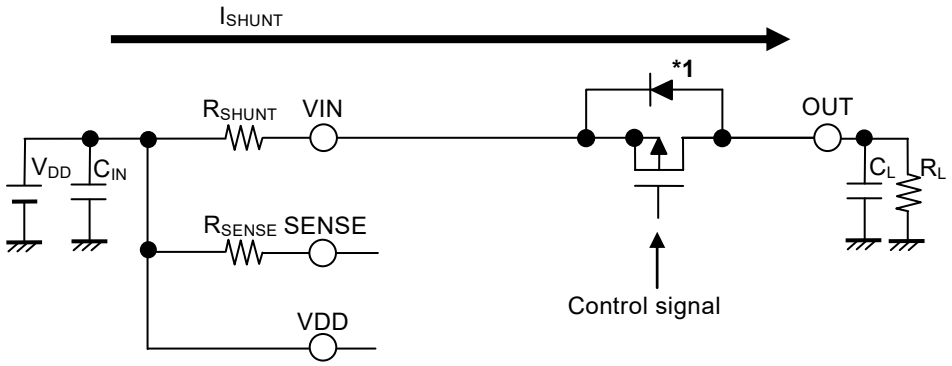
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■ Operation

1. Basic operation

Figure 12 shows the block diagram of the S-19680 Series to describe the basic operation.
Connect an external power supply to the VDD pin and a load to the OUT pin. Also, connect the external shunt resistor (R_{SHUNT}) between the VDD pin and the VIN pin and the external sense resistor (R_{SENSE}) between the VDD pin and the SENSE pin. Due to the IC internal control signal, the Pch output transistor is turned on or off, and the switch operation is performed between the VIN pin and the OUT pin.
When the Pch output transistor is turned on, the VIN pin and the OUT pin are connected. Since the output current which flows from the OUT pin to the load (I_{OUT}) is supplied from VDD via R_{SHUNT} and the Pch output transistor, the current which flows in R_{SHUNT} (I_{SHUNT}) will be $I_{SHUNT} = I_{OUT}$.
Since a voltage drop (V_{SHUNT}) occurs by flowing I_{SHUNT} in R_{SHUNT} and the Pch output transistor with ON resistance (R_{ON}), the voltage supplied to the load (V_{OUT}) is calculated by using formula (1).

(1) $V_{OUT} = V_{DD} - I_{SHUNT} \times (R_{SHUNT} + R_{ON})$



***1.** Parasitic diode

Figure 12

2. Current monitor operation

Figure 13 shows the block diagram of the current monitor operation in the S-19680 Series.
By using R_{SHUNT} and R_{SENSE}, the S-19680 Series monitors the current which flows from the VIN pin to the OUT pin. A resistor with 5.1 Ω can be used for R_{SHUNT} and 5.1 kΩ for R_{SENSE}.
The current depending on the load (I_{SHUNT}) flows in R_{SHUNT}. The current sense amplifier operates so that the SENSE pin voltage becomes the same voltage as the VIN pin voltage. V_{SHUNT} generated in R_{SHUNT} is calculated by using formula (2).

(2) $V_{SHUNT} = I_{SHUNT} \times R_{SHUNT}$

Similarly, the same voltage as V_{SHUNT} is generated in R_{SENSE}, so the current which flows in R_{SENSE} (I_{SENSE}) is calculated by using formula (3).

(3) $I_{SENSE} = I_{SHUNT} \times \dfrac{R_{SHUNT}}{R_{SENSE}}$

The current limit circuit, the load short-circuit detection circuit and the load open detection circuit monitors I_{SHUNT} depending on I_{SENSE} value.

2. 1 Current limit circuit

By the current limit circuit, the S-19680 Series limits the current so that I_{SHUNT} does not exceed the set value.
The current limit circuit monitors I_{SHUNT} depending on I_{SENSE} value. When I_{SHUNT} reaches the limit current (I_{LIM}), the circuit controls the Pch output transistor and limits the current so that I_{SHUNT} does not exceed I_{LIM}.

Caution Be aware that I_{SHUNT} which is larger than I_{LIM} flows during the period from when I_{SHUNT} reaches I_{LIM} to when the current limit circuit responds.

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2. 2 Load short-circuit detection circuit

By the load short-circuit detection circuit, the S-19680 Series detects the short-circuit status of the load connected to the OUT pin, and outputs an alarm signal. The output form of the $\overline{SC}$ pin which outputs the alarm signal is Nch open-drain output, the output logic is active "L".

The load short-circuit detection circuit monitors I_{SHUNT} depending on I_{SENSE} value. When the condition of $I_{SHUNT} \geq$ load short-circuit detection current (I_{SHORT}) is satisfied, the status changes to the load short-circuit detection status and the Nch output transistor is turned on. When the condition of $I_{SHUNT} < I_{SHORT}$ is satisfied, the status changes to the load short-circuit release status and the Nch output transistor is turned off.

Caution 1. As a result of the power supply startup and the power supply fluctuation, an inrush current may flow from the VIN pin to the OUT pin. Even in the load short-circuit release status, when the condition of $I_{SHUNT} \geq I_{SHORT}$ is satisfied temporarily due to the inrush current, the status changes to the load short-circuit detection status. Therefore, caution should be exercised.

2. As a result of the power supply fluctuation, the VIN pin voltage may drop lower than the OUT pin voltage. At this time, no current flows from the VIN pin to the OUT pin. For this reason, even in the load short-circuit detection status, the condition of $I_{SHUNT} < I_{SHORT}$ is satisfied temporarily and the status changes to the load short-circuit release status. Therefore, caution should be exercised.

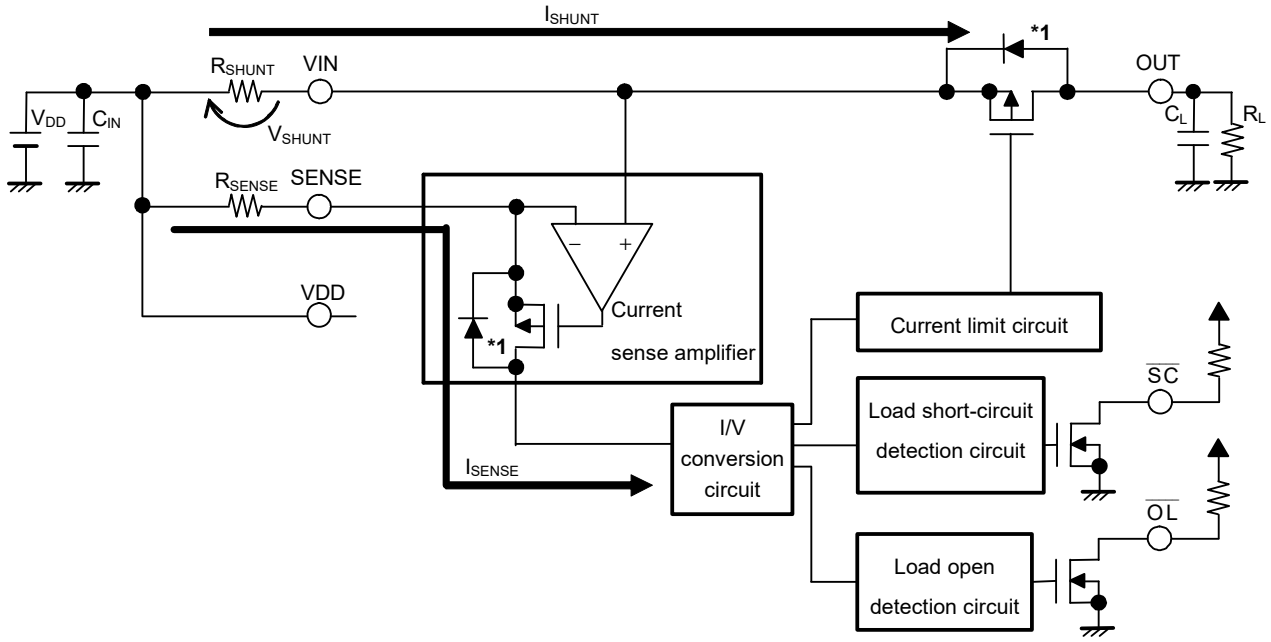
2. 3 Load open detection circuit

By the load open detection circuit, the S-19680 Series detects the open status of the load connected to the OUT pin, and outputs an alarm signal. The output form of the $\overline{OL}$ pin which outputs the alarm signal is Nch open-drain output, the output logic is active "L".

The load open detection circuit monitors I_{SHUNT} depending on I_{SENSE} value. When the condition of $I_{SHUNT} \leq$ load open detection current (I_{OPEN}) is satisfied, the status changes to the load open detection status and the Nch output transistor is turned on. When the condition of $I_{SHUNT} > I_{OPEN}$ is satisfied, the status changes to the load open release status and the Nch output transistor is turned off.

Caution 1. As a result of the power supply startup and the power supply fluctuation, an inrush current may flow from the VIN pin to the OUT pin. Even in the load open detection status, when the condition of $I_{SHUNT} > I_{OPEN}$ is satisfied temporarily due to the inrush current, the status changes to the load open release status. Therefore, caution should be exercised.

2. As a result of the power supply fluctuation, the VIN pin voltage may drop lower than the OUT pin voltage. At this time, no current flows from the VIN pin to the OUT pin. For this reason, even in the load open release status, the condition of $I_{SHUNT} \leq I_{OPEN}$ is satisfied temporarily and the status changes to the load open detection status. Therefore, caution should be exercised.



***1.** Parasitic diode

Figure 13

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2. 4 Truth-value table of load status

According to the $\overline{SC}$ pin output and the $\overline{OL}$ pin output, the S-19680 Series can confirm the status of the load connected to the OUT pin. Refer to **Table 9** for details. Since the output form of the $\overline{SC}$ pin or the $\overline{OL}$ pin is Nch open-drain output, "H" is output by the external pull-up resistor.

Table 9

$\overline{SC}$ Pin Output	$\overline{OL}$ Pin Output	Load Status
"L"	"H"	Load short-circuit status
"H"	"L"	Load open status
"H"	"H"	Load normal status

2. 5 Effects caused from shunt resistor (R_{SHUNT}) and sense resistor (R_{SENSE}) characteristics

R_{SHUNT} and R_{SENSE} variations and temperature characteristics affect the accuracy of I_{LIM}, I_{SHORT} and I_{OPEN}. The values shown in "■ **Electrical Characteristics**" are only considered the variation of the IC. In practice, R_{SHUNT} and R_{SENSE} variations also need to be considered, so caution should be exercised.

The following example is for I_{LIM}. The same results are obtained similarly in both I_{SHORT} and I_{OPEN}.
When R_{SHUNT} and R_{SENSE} variations are considered, I_{LIM} maximum value can be expressed by using formula (1), and the minimum value by using formula (2).

(1) $$I_{LIMmax}' = I_{LIMmax} \times \frac{(R_{SENSEmax} / R_{SENSE})}{(R_{SHUNTmin} / R_{SHUNT})}$$

(2) $$I_{LIMmin}' = I_{LIMmin} \times \frac{(R_{SENSEmin} / R_{SENSE})}{(R_{SHUNTmax} / R_{SHUNT})}$$

In case of R_{SHUNT} = 5.1 Ω ± 1% and R_{SENSE} = 5.1 kΩ ± 1%, I_{LIM} values are calculated by using formula (3) and formula (4), and the values have approximately ±2% variation compared to the values shown in "■ **Electrical Characteristics**".

(3) $$I_{LIMmax}' = \frac{I_{LIMmax} \times 1.01}{0.99} = I_{LIMmax} \times 1.02$$

(4) $$I_{LIMmin}' = \frac{I_{LIMmin} \times 0.99}{1.01} = I_{LIMmin} \times 0.98$$

Remark $R_{SHUNTmax}$, $R_{SHUNTmin}$: R_{SHUNT} variation maximum value and minimum value
$R_{SENSEmax}$, $R_{SENSEmin}$: R_{SENSE} variation maximum value and minimum value
I_{LIMmax}, I_{LIMmin}: I_{LIM} maximum value and minimum value which are considered only the IC variation.
I_{LIMmax}', I_{LIMmin}': I_{LIM} maximum value and minimum value which are considered variations of R_{SHUNT} and R_{SENSE}.

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3. ON / OFF pin

This pin starts and stops the switch operation and the current monitor operation. When the ON / OFF pin is set to OFF, the internal circuit stops operating and the Pch output transistor and the Nch output transistor (the $\overline{SC}$ pin and the $\overline{OL}$ pin) are turned off, reducing current consumption significantly.

The internal equivalent circuit related to the ON / OFF pin is configured as shown in **Figure 14**, the ON / OFF pin is neither pulled down nor pulled up. For this reason, do not use it in the floating status. When not using the ON / OFF pin, connect it to the VDD pin. The current consumption increases when a voltage of 0.6 V to V_{DD} – 0.3 V is applied to the ON / OFF pin, so caution should be exercised.

Table 10

Product Type	ON / OFF Pin	Internal Circuit	OUT Pin Voltage	$\overline{SC}$ Pin Voltage*3	$\overline{OL}$ Pin Voltage*3	Current Consumption
A / B	"H": ON	Operate	Power Supply Voltage*1	"H": Load normal status "L": Load short-circuit status	"H": Load normal status "L": Load open status	I_{SS1}
	"L": OFF	Stop	V_{SS}*2	"H"	"H"	I_{SS2}

***1.** Power supply voltage is output by turning the Pch output transistor on.
A voltage drop occurs by flowing I_{SHUNT} in R_{SHUNT} and the Pch output transistor with ON resistance (R_{ON}).

***2.** The OUT pin is neither pulled up nor pulled down internally. The OUT pin voltage changes to V_{SS} level by the load connected to the OUT pin.

***3.** Since the output form of the $\overline{SC}$ pin or the $\overline{OL}$ pin is Nch open-drain output, it changes to "H" by an external pull-up resistor.

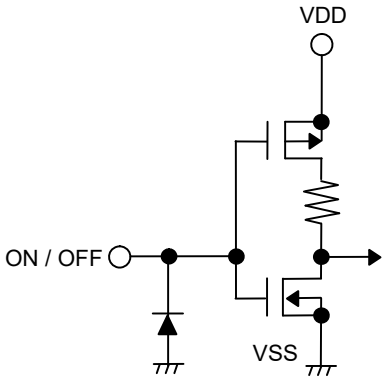


Figure 14

4. Low power supply voltage detection circuit

The S-19680 Series has a built-in low power supply voltage detection circuit. When power supply voltage drops lower than the detection voltage, the internal circuit stops operating and the Pch output transistor and Nch output transistor (the $\overline{SC}$ pin and the $\overline{OL}$ pin) are turned off. In the latch type thermal shutdown circuit, the detection status latch is released.

When power supply voltage rises higher than the release voltage, the internal circuit starts operating. The detection voltage is 2.15 V typ. and the release voltage is 2.2 V typ.

Even if the power supply voltage is higher than the release voltage immediately after power supply startup, the Pch output transistor and Nch output transistor (the $\overline{SC}$ pin and the $\overline{OL}$ pin) are turned off until the internal IC operates stably.

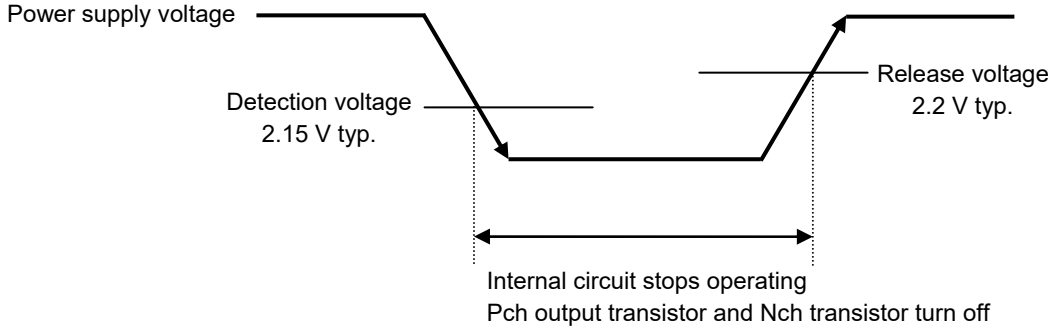


Figure 15

Downloaded from Arrow.com.

5. Thermal shutdown circuit

The S-19680 Series has a built-in thermal shutdown circuit to limit overheating.
The hysteresis type or latch type can be selected for the thermal shutdown circuit.

5. 1 Hysteresis type

When the junction temperature increases to 165°C typ., the thermal shutdown circuit becomes the detection status, and the Pch output transistor is turned off. When the junction temperature decreases to 135°C typ., the thermal shutdown circuit becomes the release status, and the Pch output transistor is turned on again.
If the thermal shutdown circuit becomes the detection status due to self-heating, the Pch output transistor is turned off and V_{OUT} decreases. For this reason, the self-heating is limited and the temperature of the IC decreases. The thermal shutdown circuit becomes the release status when the temperature of the IC decreases, and the Pch output transistor is turned on, generating the self-heating again. Repeating this procedure makes the waveform of V_{OUT} into a pulse-like form. This phenomenon continues unless decreasing either or both of the V_{DD} or I_{OUT} in order to reduce the internal power consumption, or decreasing the ambient temperature. Note that the product may suffer physical damage such as deterioration if the above phenomenon occurs continuously.

5. 2 Latch type

When the junction temperature increases to 165°C typ., the thermal shutdown circuit becomes the detection status, and the Pch output transistor is turned off. Even if the junction temperature would decrease to 135°C typ., the thermal shutdown circuit detection status is latched and the Pch output transistor remains in the status, OFF.
The thermal shutdown circuit detection status latch is released by using the ON / OFF pin to set the IC power-off status or lowering the power supply voltage to change the low power supply voltage detection circuit to the detection status.
Set the power supply voltage 0.5 V or lower in order to change the low power supply voltage detection circuit to the detection status.

Caution 1. When a steep fluctuation of the power supply occurs, the thermal shutdown circuit may become the detection status even if the junction temperature would not reach 165°C typ., so pay enough attention to the power supply voltage to ensure stable status sufficiently. Perform thorough evaluation using the actual application.

2. If the OUT pin is steeply shorted with GND, a negative voltage exceeding the absolute maximum ratings may occur in the OUT pin due to resonance phenomenon of the inductance and the capacitance including C_L on the application. When a negative voltage exceeding the absolute maximum rating occurs, the thermal shutdown circuit may become the detection status even if the junction temperature would not reach 165°C typ. If V_{OUT} does not rise when the short-circuit is eliminated after the OUT pin is steeply shorted with the GND, release the detection status latch with the method shown in "5. 2 Latch type".

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■ Precautions

- The wiring patterns for the power supply and GND should be designed so that the impedance is low.
  When mounting the input capacitor (C_{IN}) between the VDD pin and the VSS pin, and the output capacitor (C_L) between the OUT pin and the VSS pin, connect them as close as possible to the respective destination pins of the IC.
- The following use conditions are recommended to ensure stable operation of the S-19680 Series; however, perform thorough evaluation including the temperature characteristics with an actual application to select C_{IN} and C_L.

  Input capacitor (C_{IN}): A ceramic capacitor with 0.1 μF or more is recommended.
  Output capacitor (C_L): A ceramic capacitor with 0.1 μF or more is recommended.

- Wiring patterns on the application related to the VDD pin, the VIN pin and the SENSE pin should be designed so that the impedance is low.
  When mounting the shunt resistor (R_{SHUNT}) between the VDD pin and the VIN pin, and the sense resistor (R_{SENSE}) between the VDD pin and SENSE pin, connect them as close as possible to the respective destination pins of the IC. If capacitance is added to the SENSE pin, the current sense amplifier may oscillate, so caution should be exercised.
- For R_{SHUNT} or R_{SENSE}, use the resistor with the following resistance. The values shown in "**■ Electrical Characteristics**" are considered only the variation of the IC. In practice, R_{SHUNT} and R_{SENSE} variations also need to be considered, so caution should be exercised.

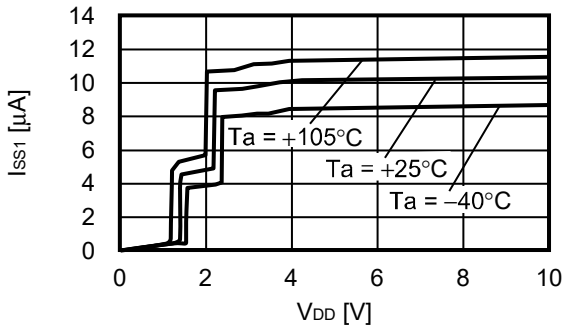
  Shunt resistor (R_{SHUNT}): 5.1 Ω
  Sense resistor (R_{SENSE}): 5.1 kΩ

- When voltage of 3 V or higher is continuously applied between the VIN pin and SENSE pin, the current sense amplifier characteristics may change, so caution should be exercised.
- If the OUT pin is steeply shorted with GND, a negative voltage exceeding the absolute maximum ratings may occur in the OUT pin due to resonance phenomenon of the inductance and the capacitance including C_L on the application. The resonance phenomenon is expected to be weakened by inserting a series resistance into the resonance path, and the negative voltage is expected to be limited by inserting a protection diode between the OUT pin and the VSS pin.
- Make sure of the conditions for the power supply voltage and the load current so that the internal loss does not exceed the power dissipation.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
- ABLIC Inc. claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

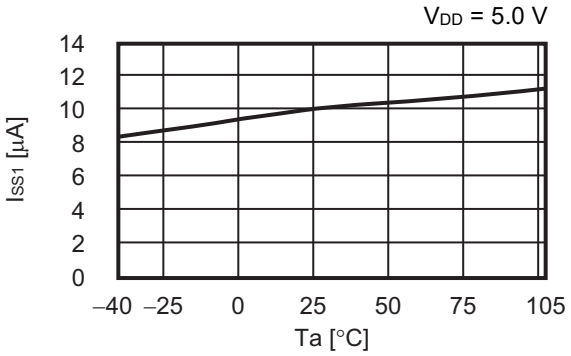
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■ Characteristics (Typical Data)

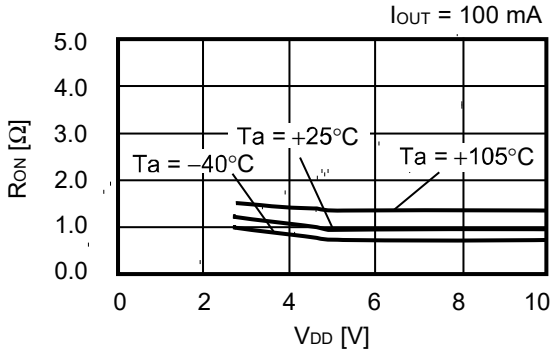
1. Current consumption during operation vs. Power supply voltage



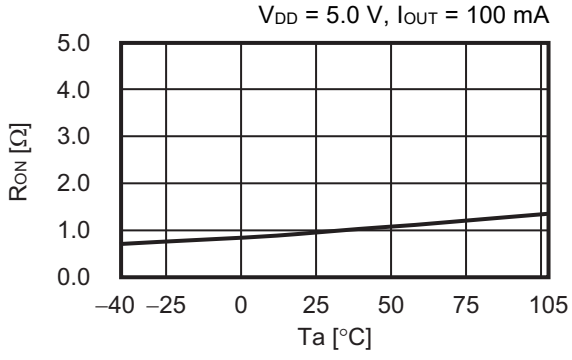
2. Current consumption during operation vs. Temperature



3. ON resistance vs. Power supply voltage



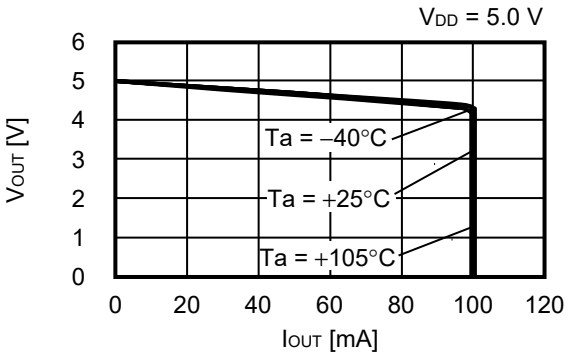
4. ON resistance vs. Temperature



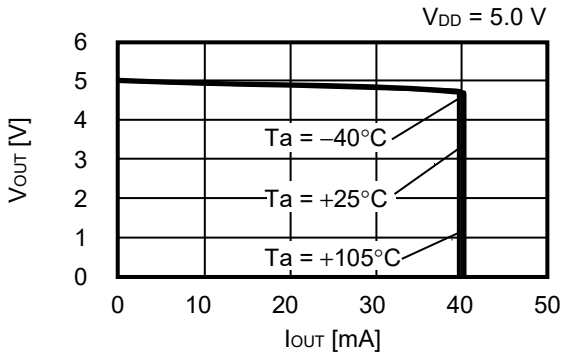
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5. Output voltage vs. Output current

5. 1 I_{LIM} = 100 mA product

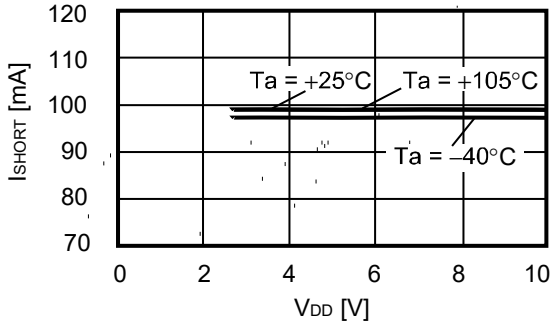


5. 2 I_{LIM} = 40 mA product

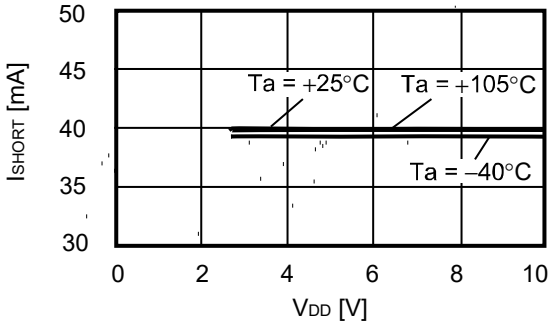


6. Load short-circuit detection current vs. Power supply voltage

6. 1 I_{SHORT} = 100 mA product

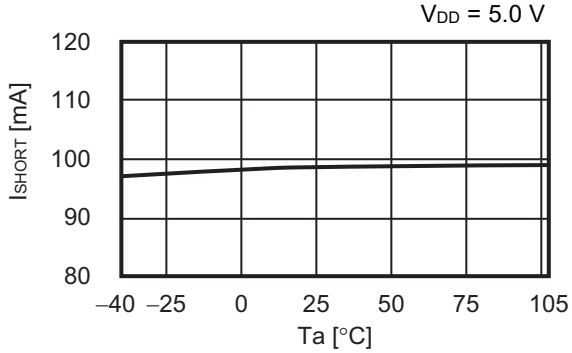


6. 2 I_{SHORT} = 40 mA product

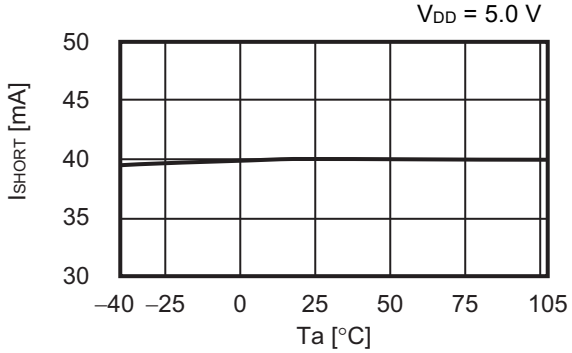


7. Load short-circuit detection current vs. Temperature

7. 1 I_{SHORT} = 100 mA product

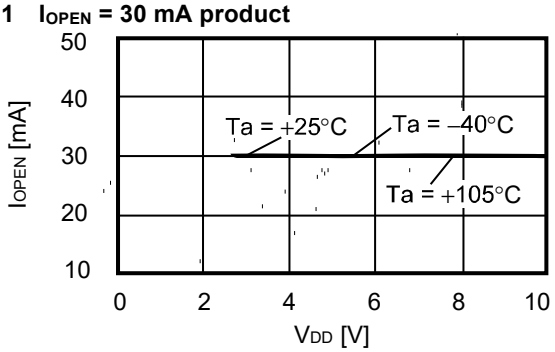


7. 2 I_{SHORT} = 40 mA product

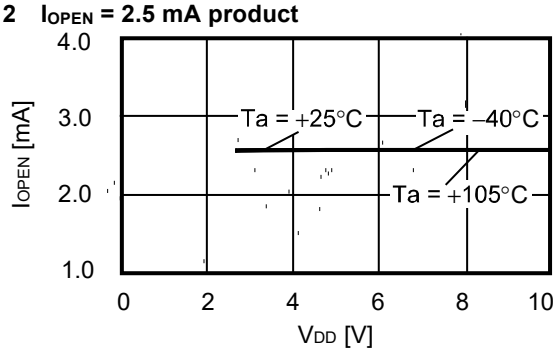


8. Load open detection current vs. Power supply voltage

8. 1 I_{OPEN} = 30 mA product



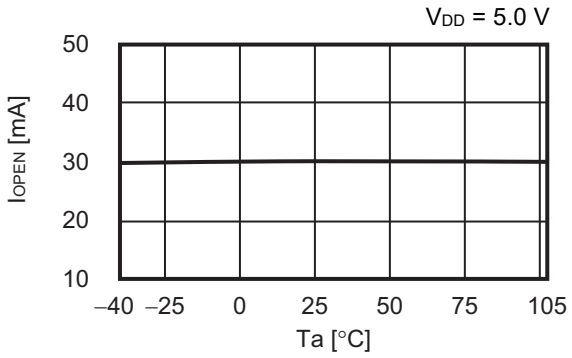
8. 2 I_{OPEN} = 2.5 mA product



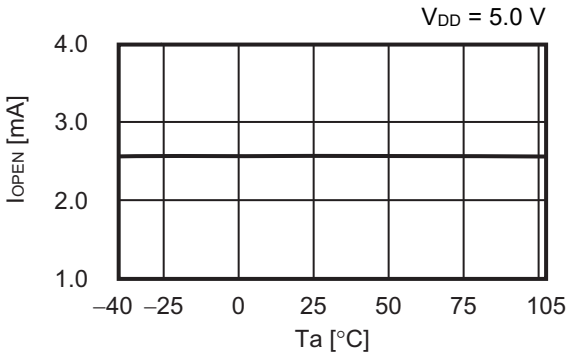
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9. Load open detection current vs. Temperature

9. 1 I_{OPEN} = 30 mA product

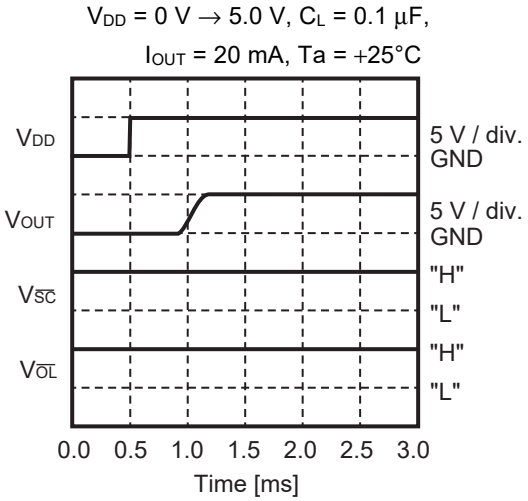


9. 2 I_{OPEN} = 2.5 mA product

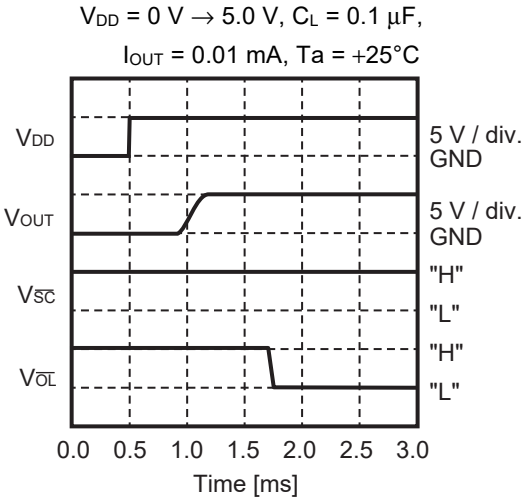


10. Power supply startup characteristics (I_{LIM} = 100 mA, I_{SHORT} = 40 mA, I_{OPEN} = 2.5 mA product)

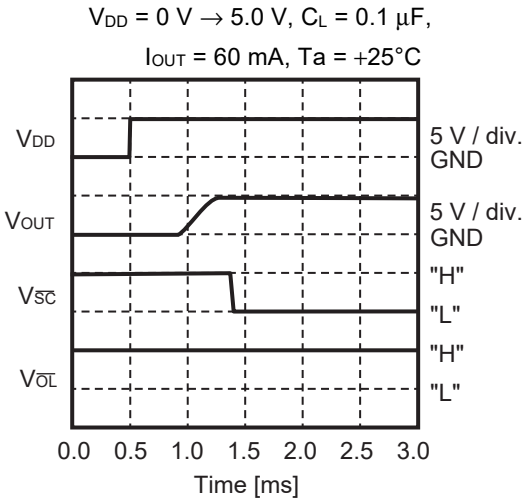
10. 1 Load normal status ($I_{OPEN} < I_{OUT} < I_{SHORT}$)



10. 2 Load open status ($I_{OUT} < I_{OPEN}$)



10. 3 Load short-circuit status ($I_{SHORT} < I_{OUT} < I_{LIM}$)

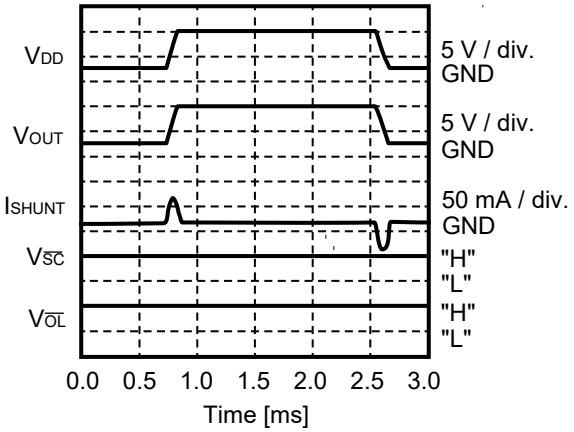


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11. Power supply fluctuation characteristics (I_{LIM} = 100 mA, I_{SHORT} = 40 mA, I_{OPEN} = 2.5 mA product)

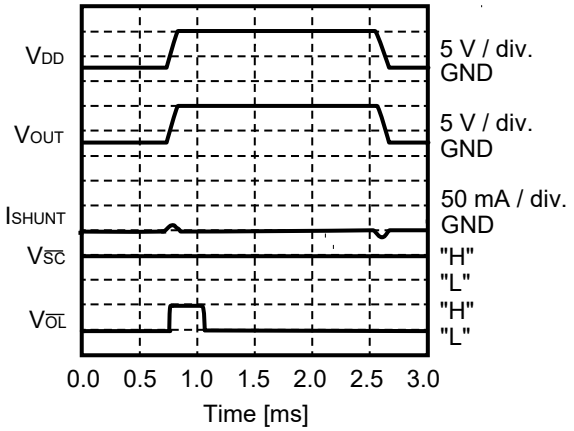
11. 1 Load normal status ($I_{OPEN} < I_{OUT} < I_{SHORT}$)

V_{DD} = 2.7 V ↔ 10.0 V (0.1 V/µs),
C_L = 0.1 µF, I_{OUT} = 20 mA, Ta = +25°C



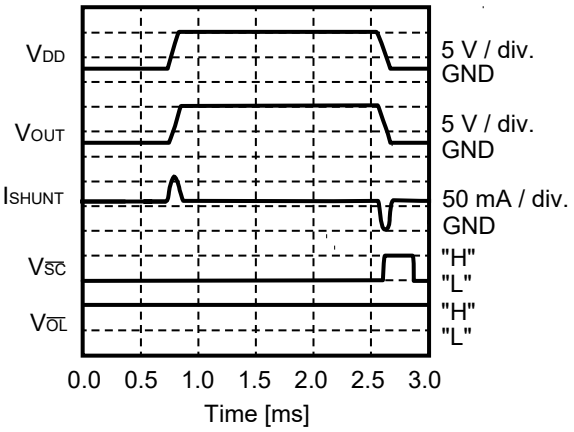
11. 2 Load open status ($I_{OUT} < I_{OPEN}$)

V_{DD} = 2.7 V ↔ 10.0 V (0.1 V/µs),
C_L = 0.1 µF, I_{OUT} = 0.01 mA, Ta= +25°C



11. 3 Load short-circuit status ($I_{SHORT} < I_{OUT} < I_{LIM}$)

V_{DD} = 2.7 V ↔ 10.0 V (0.1 V/µs),
C_L = 0.1 µF, I_{OUT} = 60 mA, Ta = +25°C

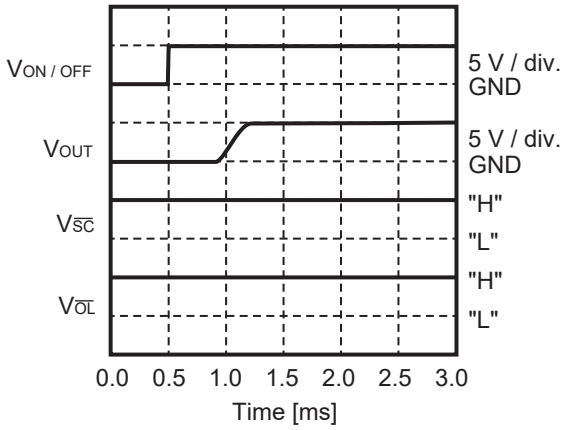


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12. Turning on (I_{LIM} = 100 mA, I_{SHORT} = 40 mA, I_{OPEN} = 2.5 mA product)

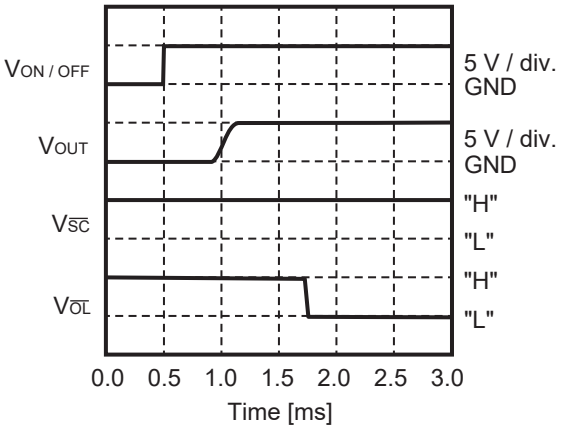
12. 1 Load normal status ($I_{OPEN} < I_{OUT} < I_{SHORT}$)

V_{DD} = 5.0 V, $V_{ON / OFF}$ = 0 V → 5.0 V,
C_{IN} = 0.1 µF, C_L = 0.1 µF, I_{OUT} = 20 mA, Ta = +25°C



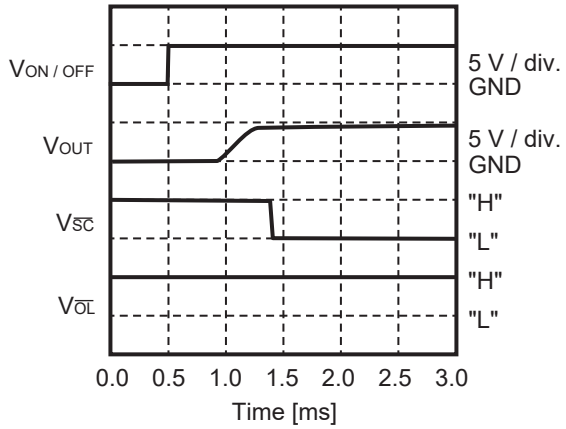
12. 2 Load open status ($I_{OUT} < I_{OPEN}$)

V_{DD} = 5.0 V, $V_{ON / OFF}$ = 0 V → 5.0 V,
C_{IN} = 0.1 µF, C_L = 0.1 µF, I_{OUT} = 0.01 mA, Ta = +25°C



12. 3 Load short-circuit status ($I_{SHORT} < I_{OUT} < I_{LIM}$)

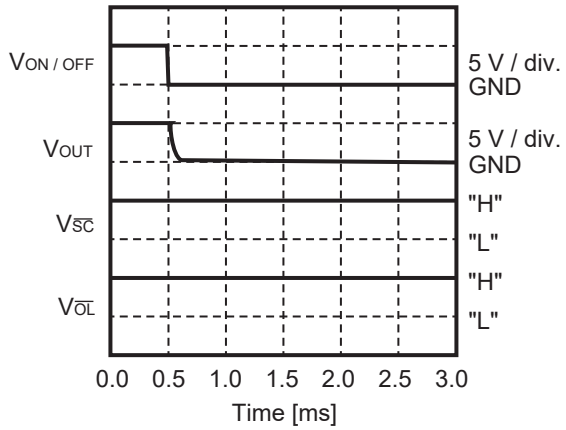
V_{DD} = 5.0 V, $V_{ON / OFF}$ = 0 V → 5.0 V,
C_{IN} = 0.1 µF, C_L = 0.1 µF, I_{OUT} = 60 mA, Ta = +25°C



13. Turning off (I_{LIM} = 100 mA, I_{SHORT} = 40 mA, I_{OPEN} = 2.5 mA product)

13. 1 Load normal status ($I_{OPEN} < I_{OUT} < I_{SHORT}$)

V_{DD} = 5.0 V, $V_{ON / OFF}$ = 5.0 V → 0 V,
C_{IN} = 0.1 µF, C_L = 0.1 µF, I_{OUT} = 20 mA, Ta = +25°C

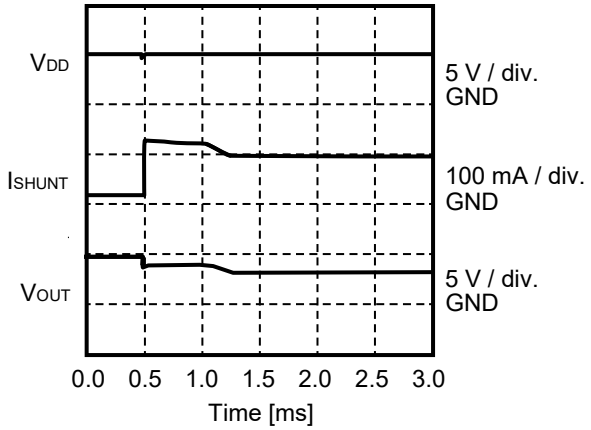


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14. Current limit response characteristics

14. 1 I_{LIM} = 100 mA product

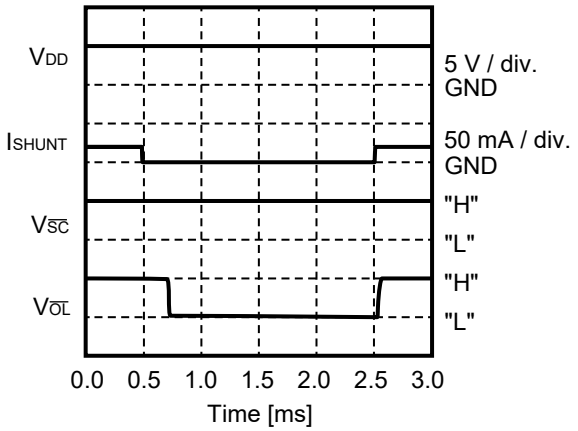
V_{DD} = 5.0 V, C_{IN} = 0.1 µF, C_L = 0.1 µF,
I_{OUT} = 20 mA → 130 mA, Ta = +25°C



15. Load fluctuation characteristics

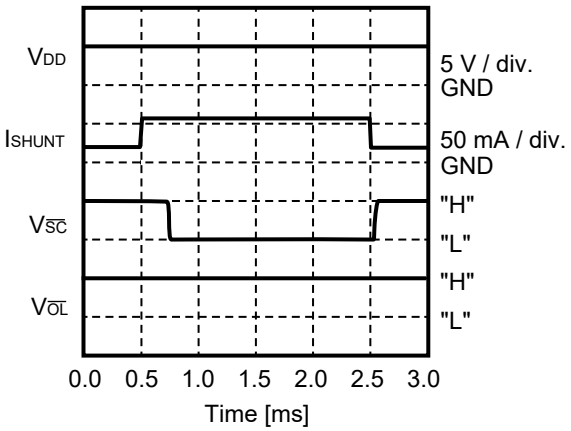
15. 1 I_{OPEN} = 2.5 mA product

V_{DD} = 5.0 V, C_{IN} = 0.1 µF, C_L = 0.1 µF,
I_{OUT} = 0 mA ↔ 20 mA, Ta = +25°C



15. 2 I_{SHORT} = 40 mA product

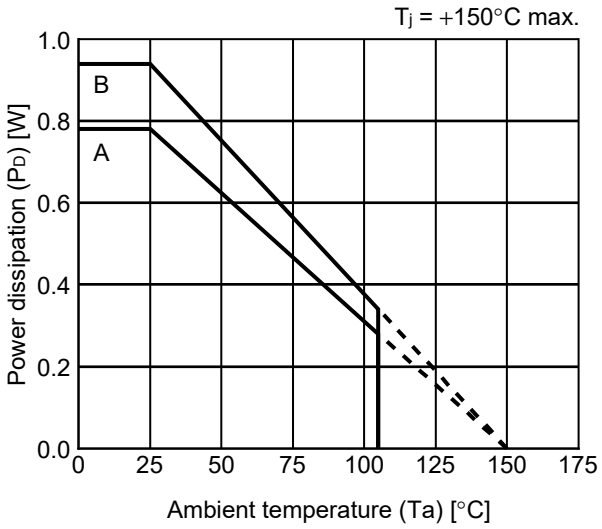
V_{DD} = 5.0 V, C_{IN} = 0.1 µF, C_L = 0.1 µF,
I_{OUT} = 20 mA ↔ 60 mA, Ta = +25°C



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■ Power Dissipation

TMSOP-8



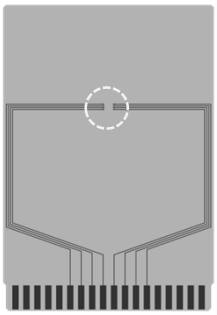
Board	Power Dissipation (P_D)
A	0.78 W
B	0.94 W
C	–
D	–
E	–

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TMSOP-8 Test Board

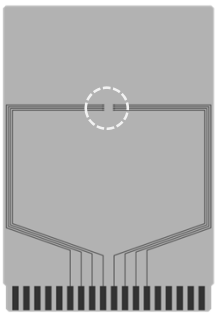
(1) Board A

IC Mount Area



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		2
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	-
	3	-
	4	74.2 x 74.2 x t0.070
Thermal via		-

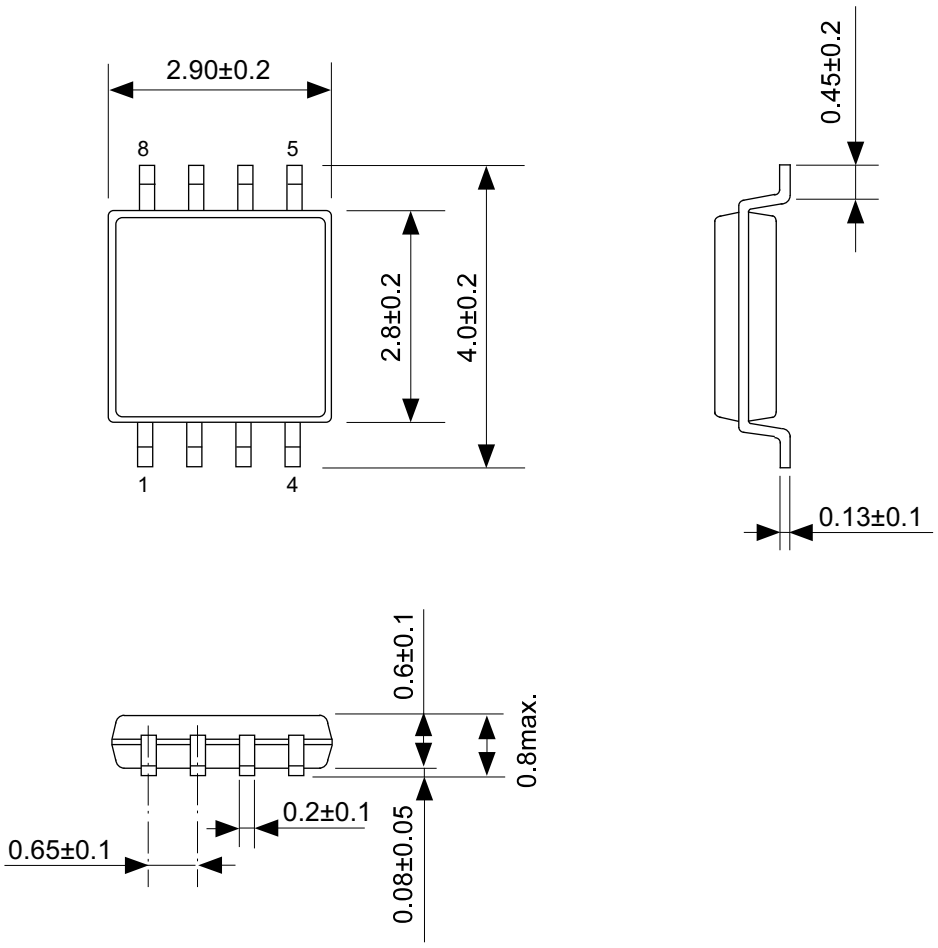
(2) Board B



Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		4
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	74.2 x 74.2 x t0.035
	3	74.2 x 74.2 x t0.035
	4	74.2 x 74.2 x t0.070
Thermal via		-

No. TMSOP8-A-Board-SD-1.0

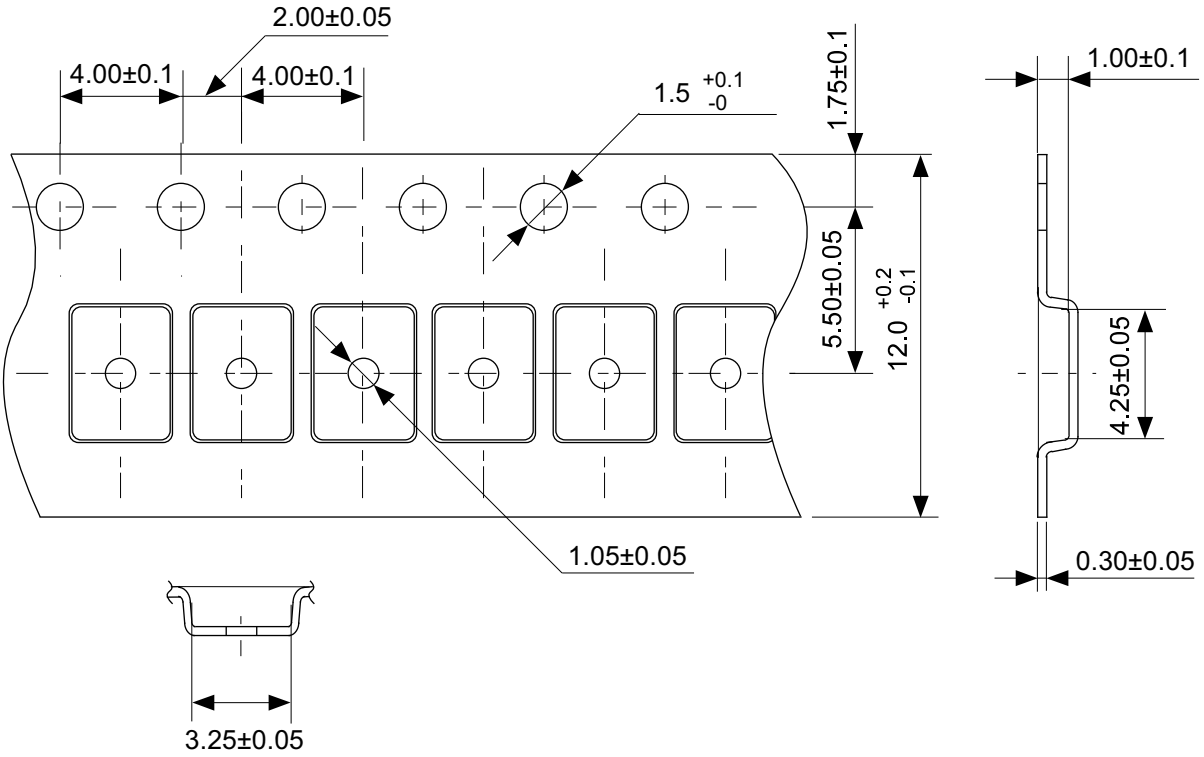
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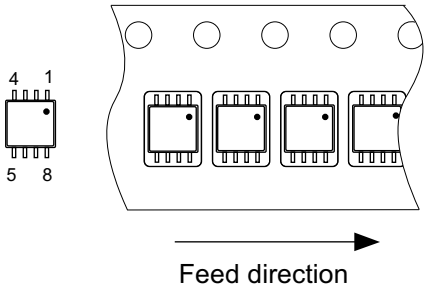


No. FM008-A-P-SD-1.2

TITLE	TMSOP8-A-PKG Dimensions
No.	FM008-A-P-SD-1.2
ANGLE	
UNIT	mm
ABLIC Inc.	

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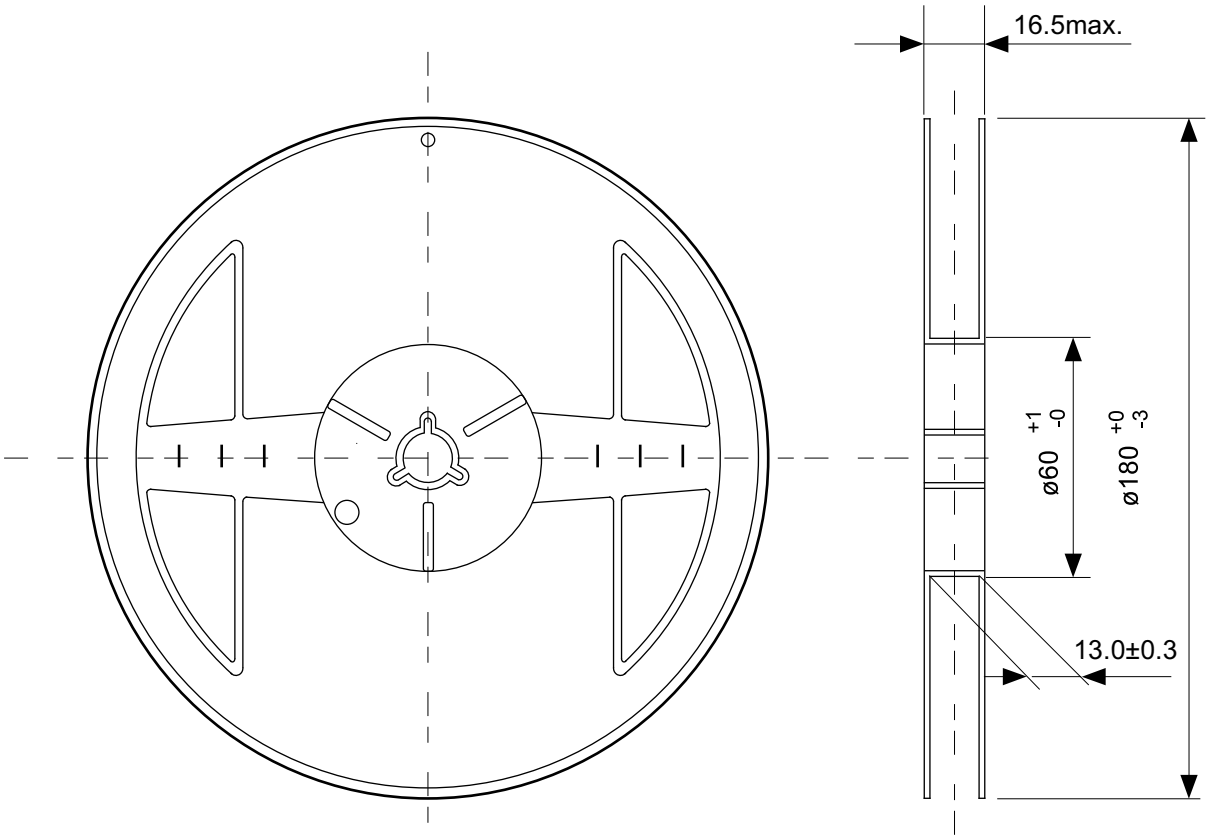




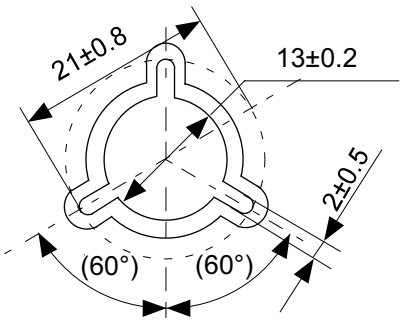
No. FM008-A-C-SD-2.0

TITLE	TMSOP8-A-Carrier Tape
No.	FM008-A-C-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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Enlarged drawing in the central part



No. FM008-A-R-SD-1.0

TITLE	TMSOP8-A-Reel		
No.	FM008-A-R-SD-1.0		
ANGLE		QTY.	4,000
UNIT	mm		
ABLIC Inc.			

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