S-5471 Series

ENERGY HARVESTING VOLTAGE MONITORING IC WITH ULTRA-LOW CURRENT CONSUMPTION

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Rev.1.1_01

The S-5471 Series, developed by using CMOS technology, is a voltage monitoring IC with an ultra-low current consumption.
Since the feed-through current in the IC is extremely low, the error can be reduced when the voltage of a power supply with high impedance is detected. In addition, since the detection voltage is extremely low, a tiny amount of power generated by energy harvesting can also be detected.
Due to its ultra-low current consumption and low-voltage operation, the S-5471 Series is suitable for battery-operated small mobile devices.

■ Features

- Ultra-low current consumption: $I_{DD} \leq$ 10 nA typ.
- Detection voltage: V_{DET} = 0.75 V typ.
- Wide operation voltage range: V_{DD} = 0.7 V to 5.5 V
- Operation temperature range: Ta = −40°C to +85°C
- Lead-free (Sn 100%), halogen-free

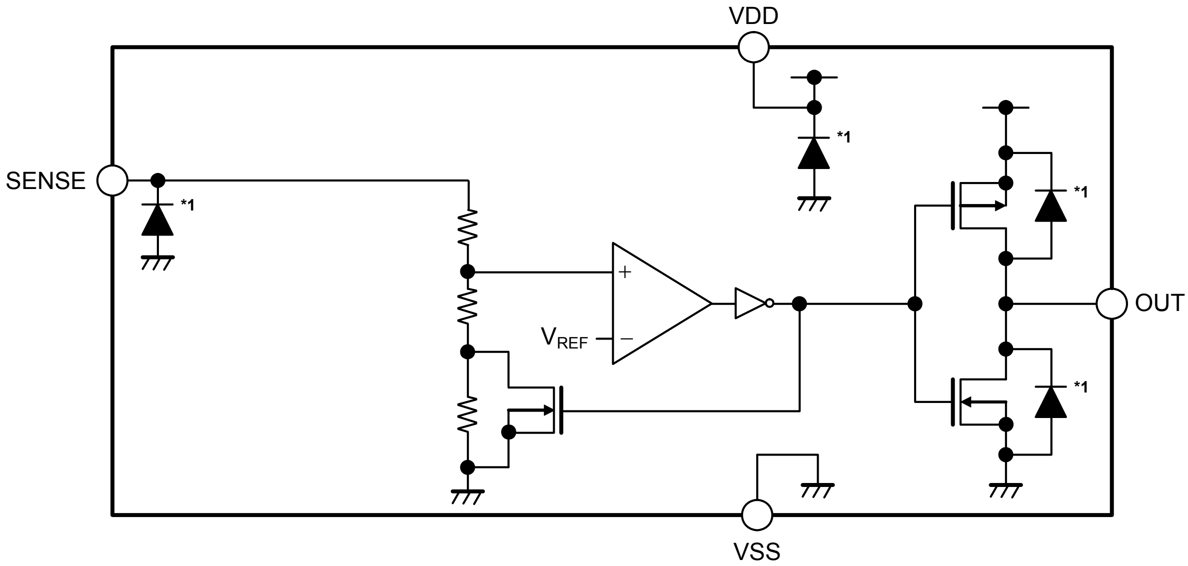
■ Applications

- Miniaturization and power consumption reduction for various sensors of portable and wireless devices
- Energy harvesting

■ Package

- SOT-23-5

■ Block Diagram



***1.** Parasitic diode

Figure 1

■ Product Name Structure

Refer to "**1. Product name**" regarding the contents of the product name, "**2. Package**" regarding the package drawings.

1. Product name

S-5471 A 21 I - M5T1 U

- **U**: Environmental code
  - U: Lead-free (Sn 100%), halogen-free
- **M5T1**: Package abbreviation and IC packing specifications*1
  - M5T1: SOT-23-5, Tape
- **I**: Operation temperature
  - I: Ta = −40°C to +85°C
- **A**: Output form and output logic
  - A: CMOS output, active "H"

***1.** Refer to the tape drawing.

2. Package

Table 1 Package Drawing Codes

Package Name	Dimension	Tape	Reel
SOT-23-5	MP005-A-P-SD	MP005-A-C-SD	MP005-A-R-SD

■ Pin Configuration

1. SOT-23-5

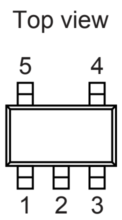


Figure 2

Table 2

Pin No.	Symbol	Description
1	VDD	Power supply pin
2	VSS	GND pin
3	TEST*1	Test pin
4	SENSE	Detection voltage input pin
5	OUT	Output pin

***1.** Connect to GND.

■ Absolute Maximum Ratings

Table 3

(Ta = +25°C unless otherwise specified)

Item	Symbol	Absolute Maximum Rating	Unit
Power supply voltage	V_{DD}	V_{SS} − 0.3 to V_{SS} + 7.0	V
Input voltage	V_{SENSE}	V_{SS} − 0.3 to V_{SS} + 7.0	V
Output voltage	V_{OUT}	V_{SS} − 0.3 to V_{DD} + 0.3	V
Output pin current	I_{SOURCE}	20	mA
	I_{SINK}	20	mA
Operation ambient temperature	T_{opr}	−40 to +85	°C
Storage temperature	T_{stg}	−55 to +125	°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 4

Item	Symbol	Condition		Min.	Typ.	Max.	Unit
Junction-to-ambient thermal resistance*1	θ_{JA}	SOT-23-5	Board A	−	192	−	°C/W
			Board B	−	160	−	°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.

■ Electrical Characteristics

Table 5

(Ta = +25°C, V_{DD} = 3.0 V unless otherwise specified)

Item	Symbol	Condition		Min.	Typ.	Max.	Unit	Test Circuit
Power supply voltage	V_{DD}	Ta = −40°C to +85°C		0.7	−	5.5	V	−
Current consumption	I_{DD}	V_{SENSE} = V_{SS}		−	1	150	nA	1
		V_{SENSE} = 1.0 V		−	3	150	nA	1
Detection voltage	V_{DET}	−		0.69	0.75	0.81	V	2
Release voltage	V_{REL}	−		V_{DET} − 0.07	V_{DET} − 0.05	V_{DET} − 0.03	V	2
Detection voltage temperature coefficient	V_{TC}	Ta = −40°C to +85°C		−	−0.24	−	%/°C	−
Input current	I_{SENSE}	V_{SENSE} = 1.0 V		−	1.45	100	nA	3
Source current	I_{SOURCE}	V_{OUT} = V_{DD} − 0.3 V	V_{DD} = 0.7 V	0.01	0.3	−	mA	4
			V_{DD} = 3.0 V	4.0	5.3	−	mA	4
Sink current	I_{SINK}	V_{OUT} = 0.3 V	V_{DD} = 0.7 V	0.01	0.6	−	mA	5
			V_{DD} = 3.0 V	8.0	10.2	−	mA	5
Output response time	t_{OD}	−		−	−	15	ms	−

■ Test Circuits

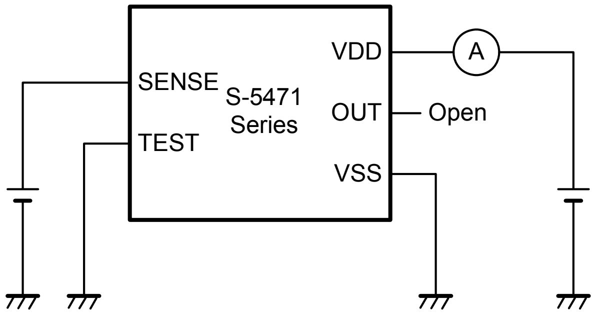


Figure 3 Test Circuit 1

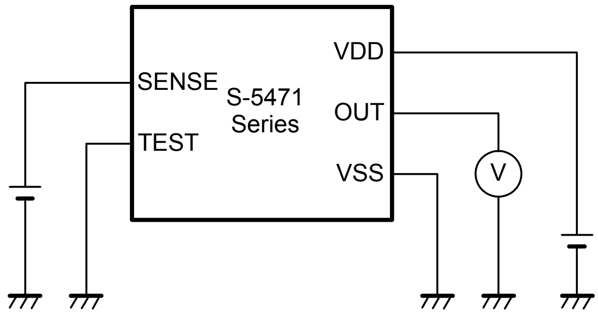


Figure 4 Test Circuit 2

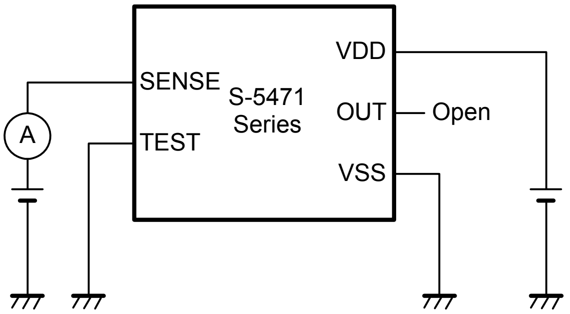


Figure 5 Test Circuit 3

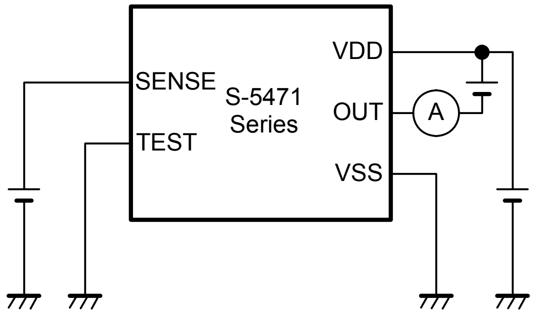


Figure 6 Test Circuit 4

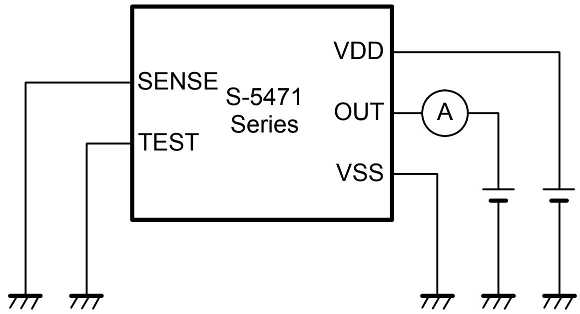


Figure 7 Test Circuit 5

■ Standard Circuit

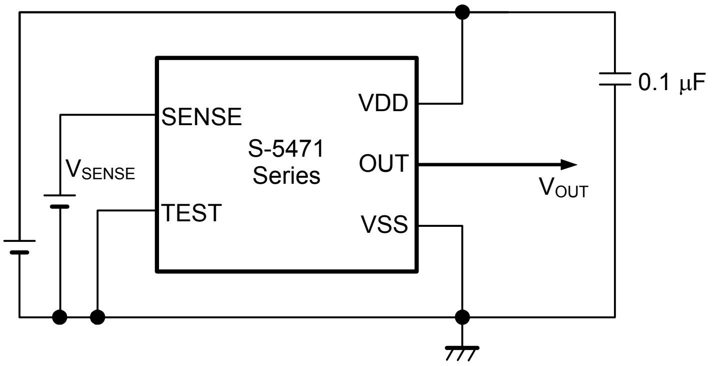


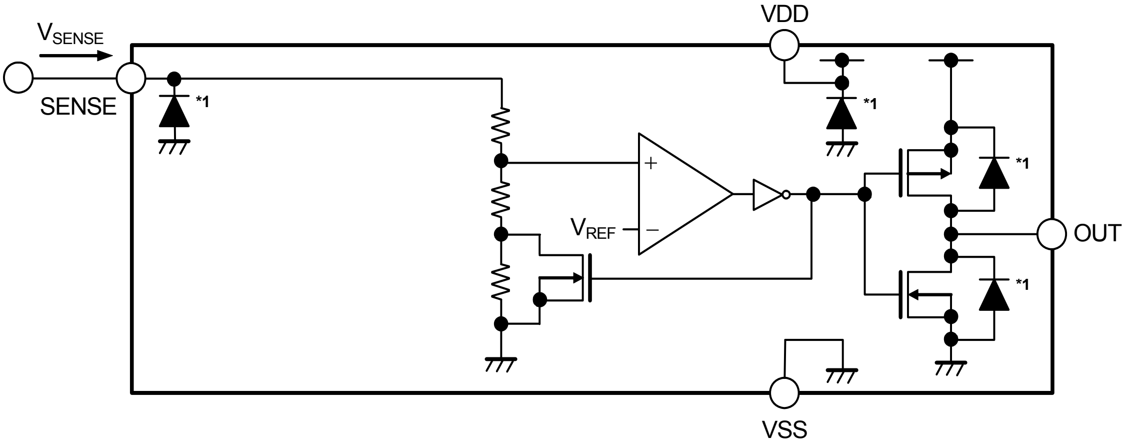
Figure 8

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

■ Operation

1. Basic operation

Figure 9 shows an explanatory diagram for the operation at voltage detection.



***1.** Parasitic diode

Figure 9 Explanatory Diagram for Operation at Voltage Detection

(1) If V_{SENSE} is lower than V_{DET}, "L" is output from the OUT pin.
(2) If V_{SENSE} increases and becomes equal to or higher than V_{DET}, "H" is output from the OUT pin (point A in **Figure 10**). Even if V_{SENSE} decreases and falls below V_{DET}, as long as V_{SENSE} is higher than V_{REL}, "H" is output from the OUT pin.
(3) If V_{SENSE} then decreases further and becomes equal to or lower than V_{REL}, "L" is output from the OUT pin (point B in **Figure 10**).

Remark V_{SENSE}: Voltage input to the SENSE pin
V_{DET}: Detection voltage (refer to "**3. 1 Detection voltage (V_{DET})**")
V_{REL}: Release voltage (refer to "**3. 2 Release voltage (V_{REL})**")

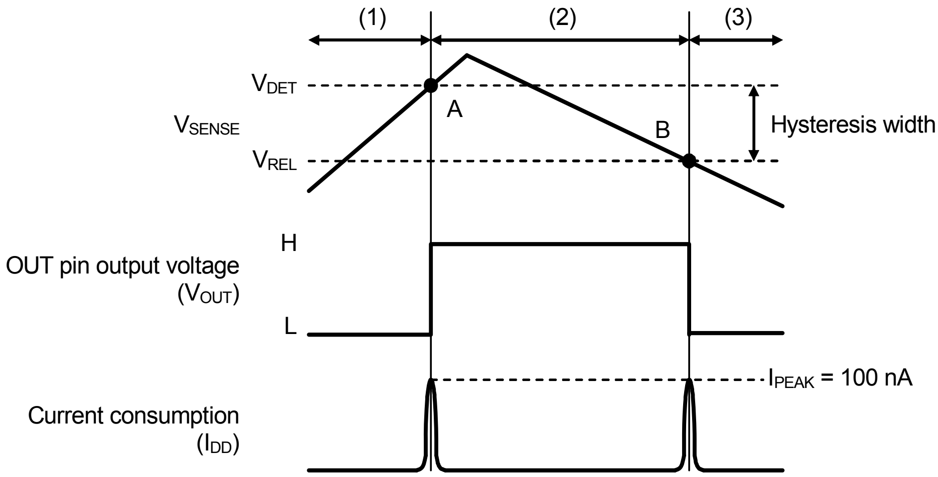
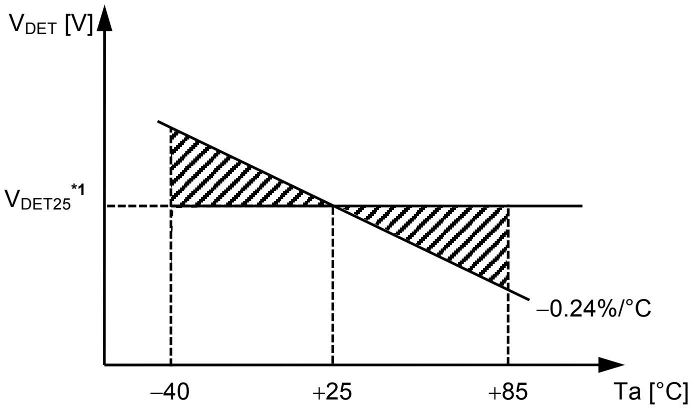


Figure 10 Operation at Voltage Detection

Caution **Feed-through current (I_{PEAK} = 100 nA) flows around the time when the OUT pin voltage switches, as shown in Figure 10. Therefore, if the V_{SENSE} is fixed around this time, the current consumption will increase.**

2. Temperature characteristics of detection voltage

The shaded area in **Figure 11** shows the temperature characteristics of the detection voltage in the operation temperature range.



***1.** V_{DET25}: Detection voltage value at Ta = +25°C

Figure 11 Temperature Characteristics of Detection Voltage

3. Explanation of terms

3. 1 Detection voltage (V_{DET})

The detection voltage (V_{DET}) is a voltage at which the output voltage (V_{OUT}) turns to "H".

The detection voltage varies slightly even among products with the same specification. The variation in detection voltage from the minimum detection voltage (V_{DET} min.) to the maximum detection voltage (V_{DET} max.) is called the detection voltage range (refer to **Figure 12**).

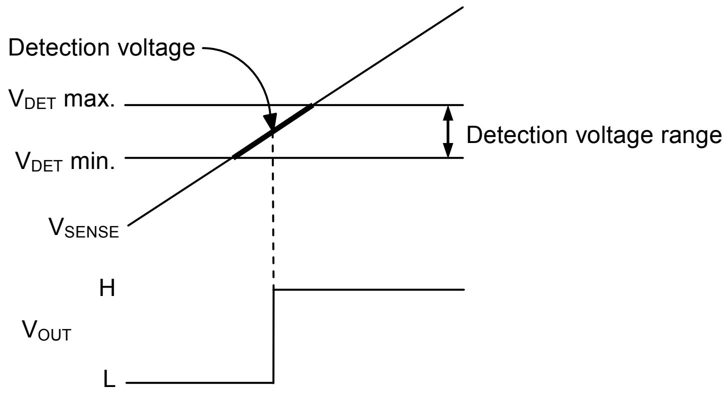


Figure 12 Detection Voltage

3. 2 Release voltage (V_{REL})

The release voltage (V_{REL}) is a voltage at which the output voltage (V_{OUT}) turns to "L".

The release voltage varies slightly even among products with the same specification. The variation in release voltage from the minimum release voltage (V_{REL} min.) to the maximum release voltage (V_{REL} max.) is called the release voltage range (refer to **Figure 13**).
The range is calculated from the actual detection voltage (V_{DET}) of a product and is in the range of $V_{DET} - 0.07 \leq V_{REL} \leq V_{DET} - 0.03$.

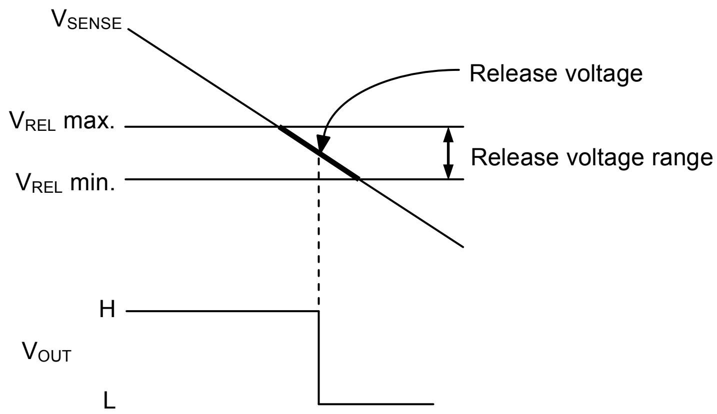


Figure 13 Release Voltage

3. 3 Hysteresis width

The hysteresis width is the voltage difference between the detection voltage and the release voltage (voltage at point A − voltage at point B in "**Figure 10 Operation at Voltage Detection**").
The hysteresis width between the detection voltage and the release voltage prevents malfunction caused by noise in the input voltage.

■ Precautions

- Use the S-5471 Series with the output pin current of 20 mA or less.
- The S-5471 Series may malfunction if the power supply voltage changes steeply.
- The output in the S-5471 Series is unstable in lower voltage than the minimum operation voltage. At the time of power-on, use the S-5471 Series after output stabilization.
- Connect a capacitor of 0.1 μF or more between the VDD pin and VSS pin for stabilization.
- Since the SENSE pin is easy to be affected by disturbance noise, perform countermeasures such as mounting external parts to the IC as close as possible.
- If the impedance of the power supply is high, the S-5471 Series may malfunction due to voltage drop caused by feed-through current. Make wire patterns very carefully so that the impedance of the power supply lowers.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.
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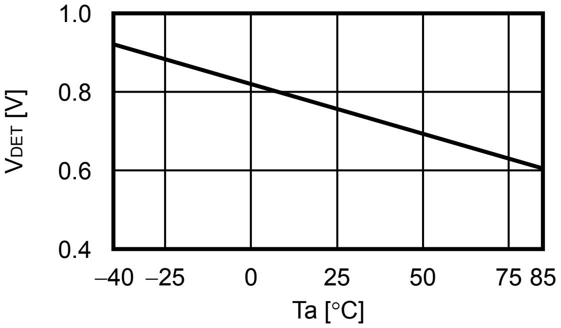
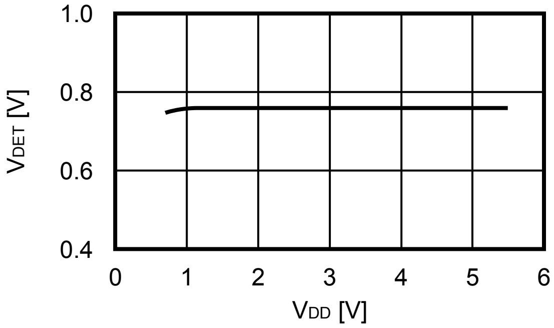
■ Characteristics (Typical Data)

1. Detection voltage vs. Temperature

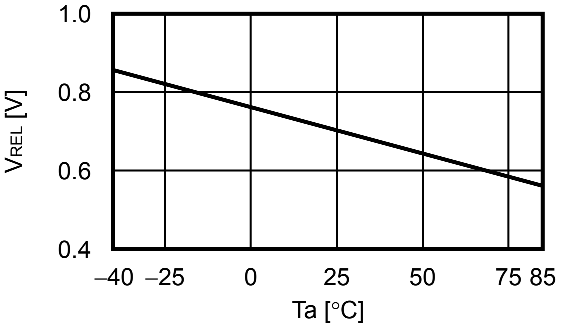


2. Detection voltage vs. Power supply voltage

Ta = +25°C

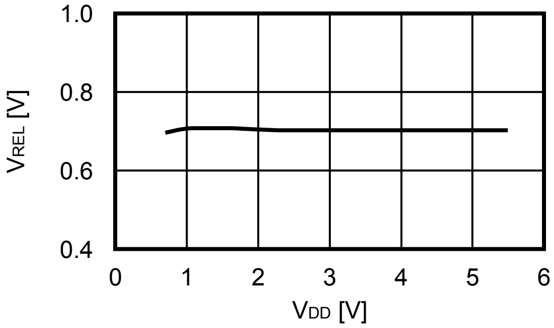


3. Release voltage vs. Temperature

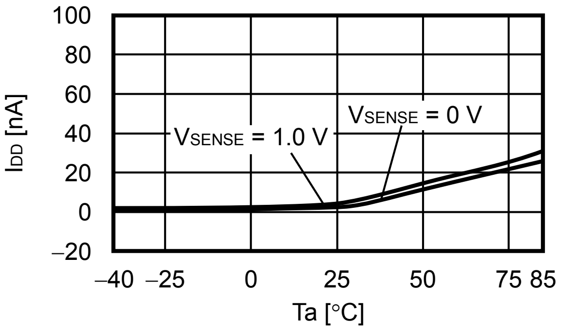


4. Release voltage vs. Power supply voltage

Ta = +25°C

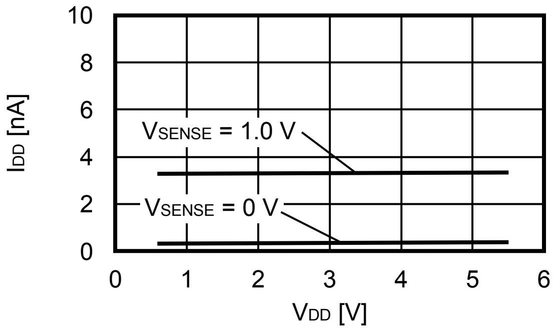


5. Current consumption vs. Temperature



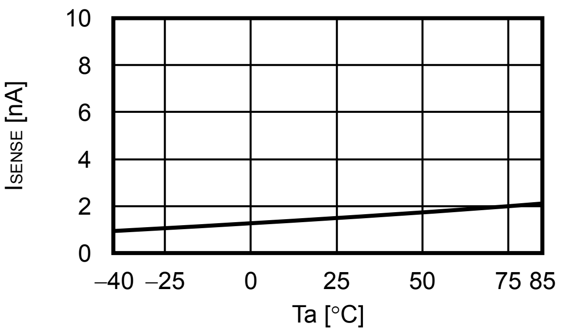
6. Current consumption vs. Power supply voltage

Ta = +25°C



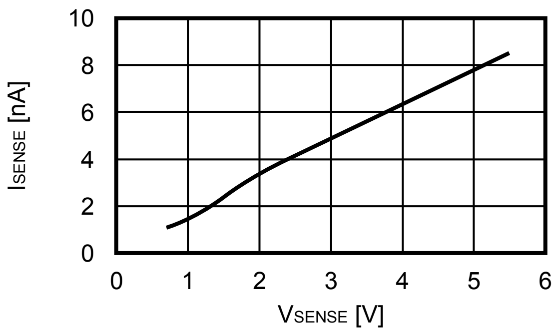
7. Input current vs. Temperature

V_{SENSE} = 1.0 V

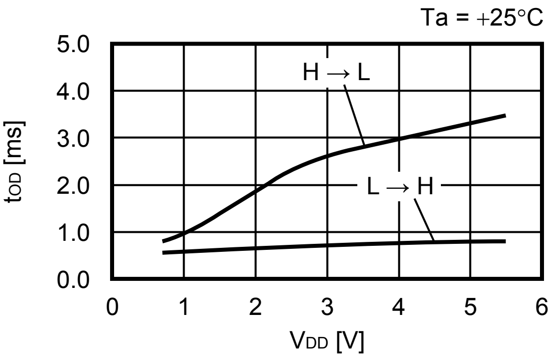


8. Input current vs. Input voltage

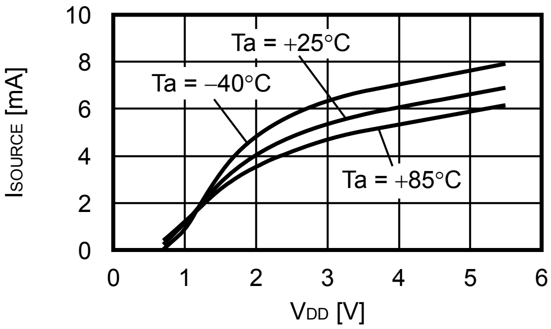
Ta = +25°C



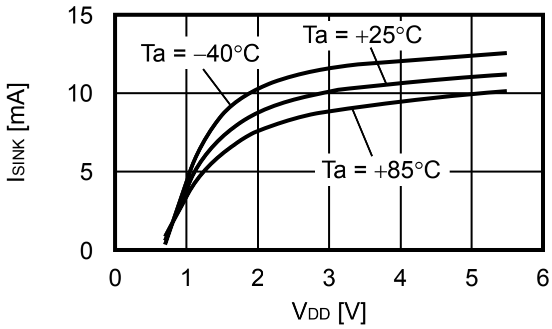
9. Output response time vs. Power supply voltage



10. Source current vs. Power supply voltage

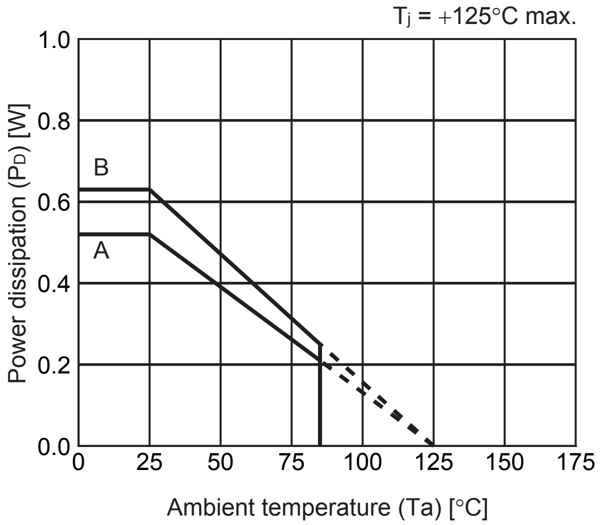


11. Sink current vs. Power supply voltage



■ Power Dissipation

SOT-23-5

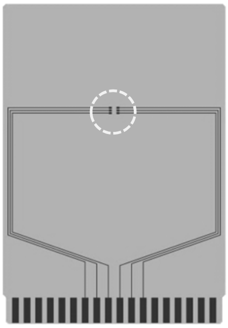


Board	Power Dissipation (P_D)
A	0.52 W
B	0.63 W
C	−
D	−
E	−

SOT-23-3/3S/5/6 Test Board

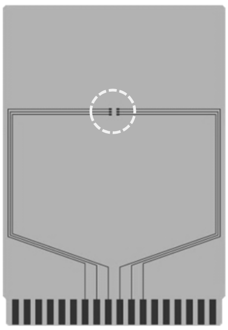
IC Mount Area

(1) Board A



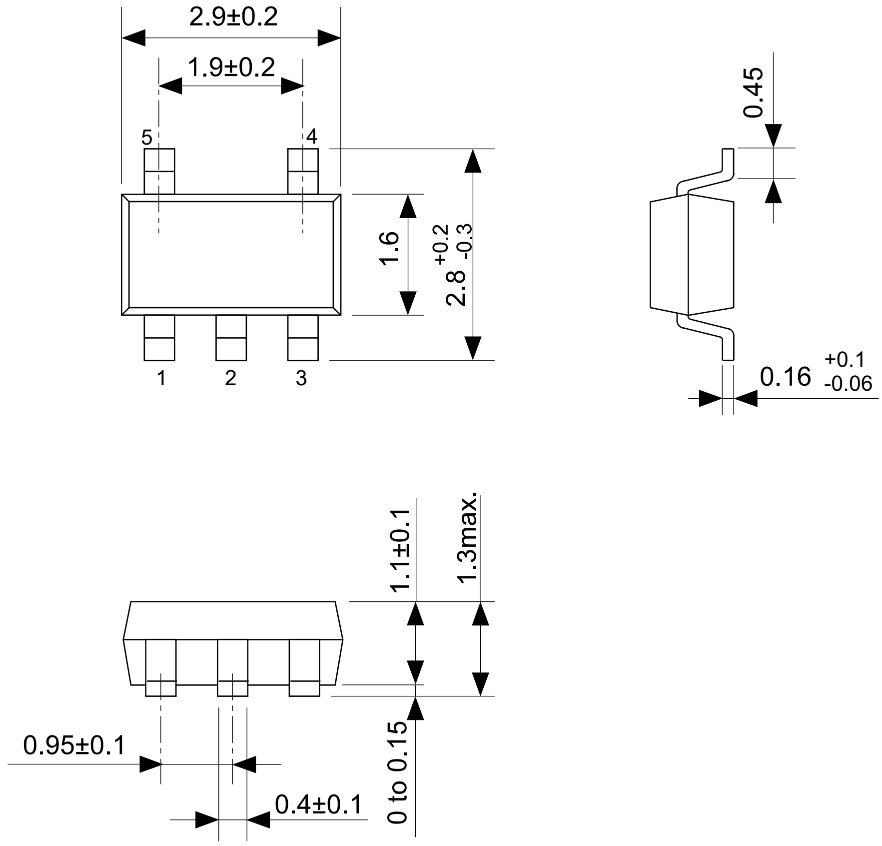
Item		Specification
Size [mm]		114.3 x 76.2 x t1.6
Material		FR-4
Number of copper foil layer		2
Copper foil layer [mm]	1	Land pattern and wiring for testing: t0.070
	2	-
	3	-
	4	74.2 x 74.2 x t0.070
Thermal via		-

(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. SOT23x-A-Board-SD-2.0



No. MP005-A-P-SD-1.3

TITLE	SOT235-A-PKG Dimensions
No.	MP005-A-P-SD-1.3
ANGLE	
UNIT	mm

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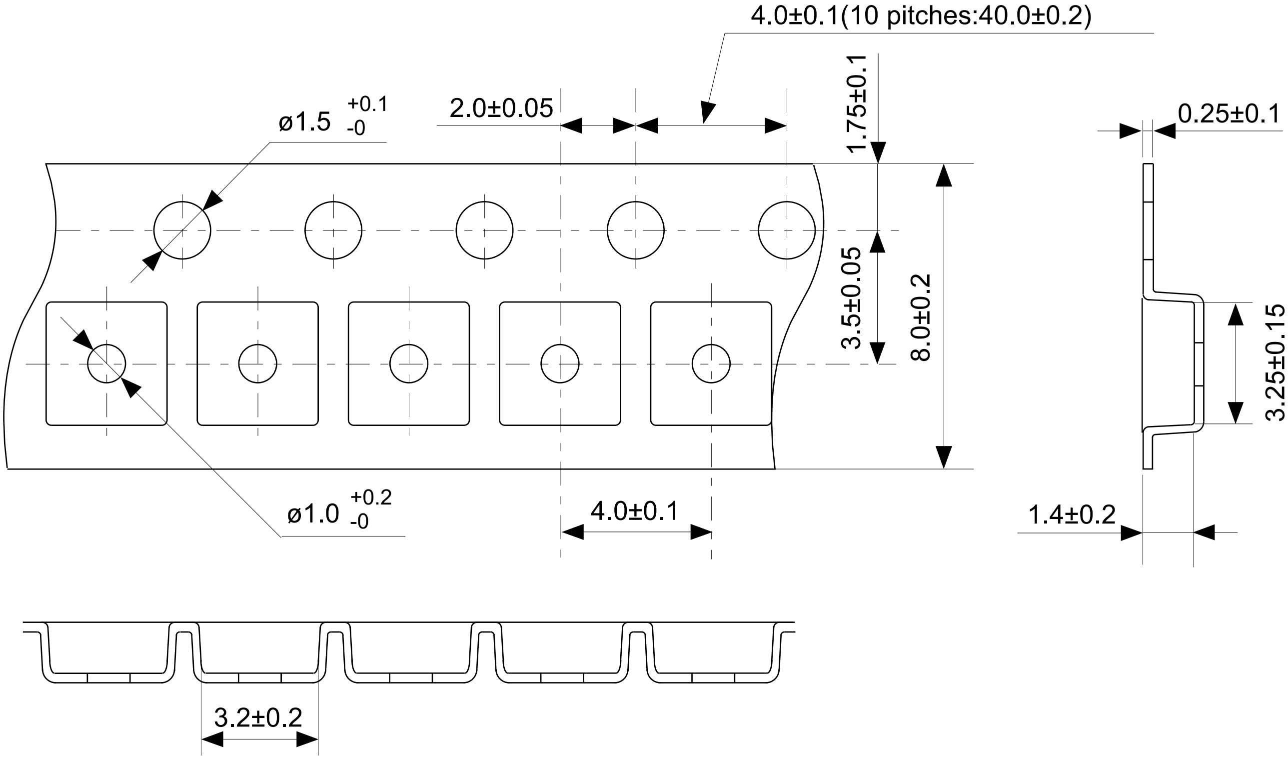

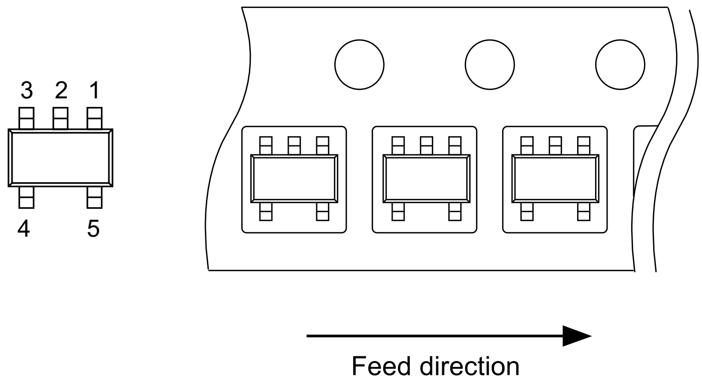

No. MP005-A-C-SD-2.1

TITLE	SOT235-A-Carrier Tape
No.	MP005-A-C-SD-2.1
ANGLE	
UNIT	mm

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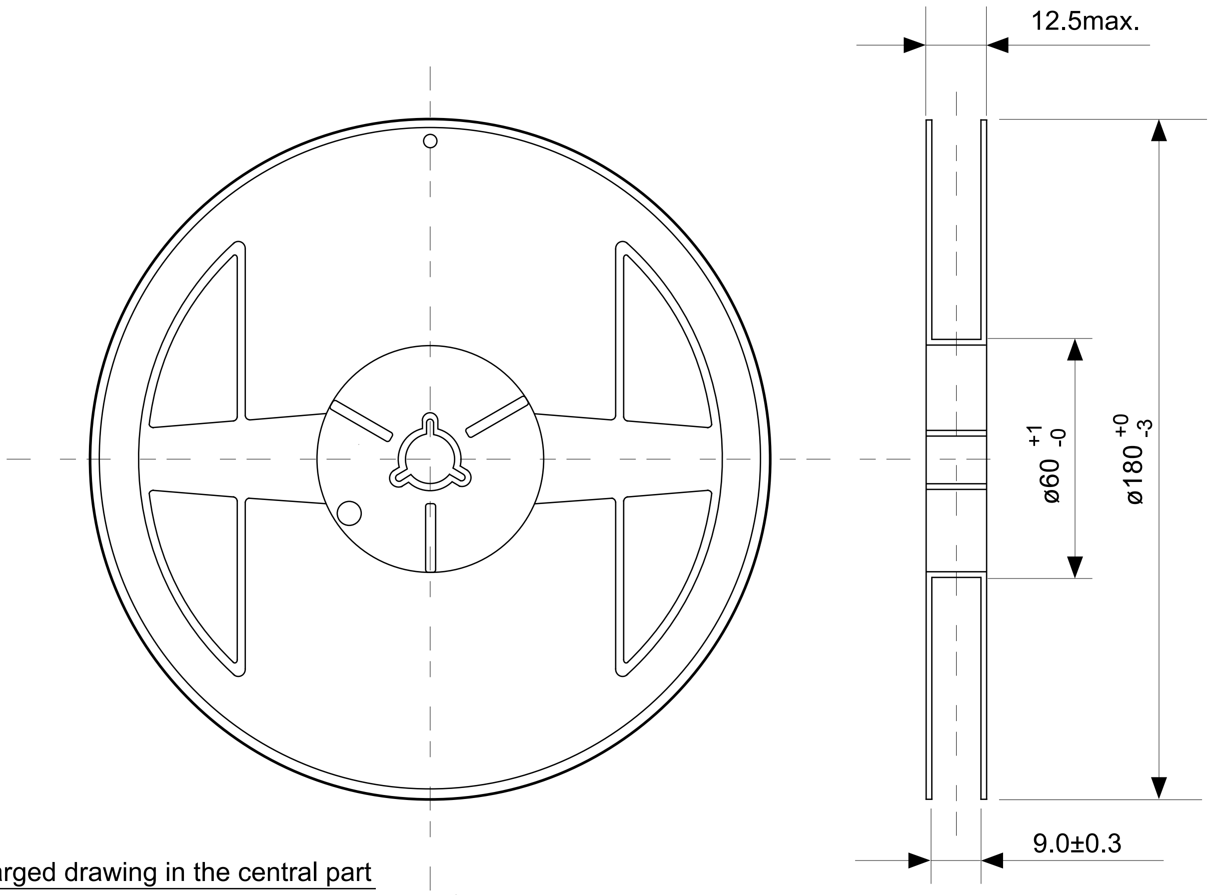
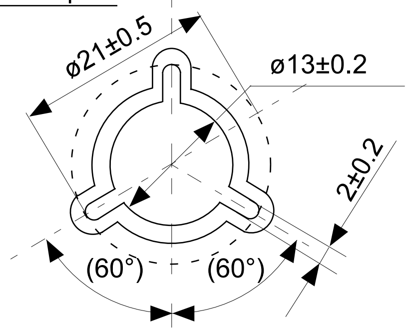


Enlarged drawing in the central part



No. MP005-A-R-SD-1.1

TITLE	SOT235-A-Reel		
No.	MP005-A-R-SD-1.1		
ANGLE		QTY.	3,000
UNIT	mm		

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   The entire system must be sufficiently evaluated and applied on customer's own responsibility.
10. The products are not designed to be radiation-proof. The necessary radiation measures should be taken in the product design by the customer depending on the intended use.
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