

MINI ANALOG SERIES**0.5 μ A Rail-to-Rail CMOS OPERATIONAL AMPLIFIER****S-8943xA/B Series**

The mini-analog series is a group of ICs that incorporate a general-purpose analog circuit in an ultra-small package.

The S-8943xA/B series are CMOS type operational amplifiers that feature Rail-to-Rail* I/O and an internal phase compensation circuit. These features enable driving at a lower voltage (from 0.9 V) and with lower current consumption (0.5 μ A typ.) than existing general-purpose operational amplifiers, making the S-8943xA/B series ideal for use in battery-powered compact portable devices. The S-8943xA series is a single operational amplifier, with one circuit incorporated in the ultra-small SC-88A. The S-8943xB series is a dual operational amplifier, with two circuits incorporated in the slim and small 8-pin SON(A) package and 8-pin MSOP package.

* Rail-to-Rail is a registered trademark of Motorola Inc.

■ Features

- Can be driven at lower voltage than existing general-purpose operational amplifiers: $V_{DD} = 0.9$ to 5.5 V
- Ultra-low current consumption: $I_{DD} = 0.5$ μ A (typ.)
- Rail-to-rail wide I/O voltage range: $V_{CMR} = V_{SS}$ to V_{DD}
- Low input offset voltage: 5.0 mV (max.)
- No external devices required due to an internal phase compensation
- Small package:

5-Pin SC-88A	2.0 mm $\times$ 2.1 mm
8-Pin SON(A)	2.9 mm $\times$ 3.0 mm
8-Pin MSOP	2.95 mm $\times$ 4.0 mm

■ Applications

- Cellular phones
- PDAs
- Notebook PCs
- Digital cameras
- Digital camcorders

■ Packages

- 5-pin SC-88A (package drawing code: NP005-B)
- 8-pin SON(A) (package drawing code: PN008-A)
- 8-pin MSOP (package drawing code: FN008-A)

■ Selection Guide

Table 1

Package	SC-88A	8-Pin SON (A)	8-Pin MSOP
Input Offset Voltage	Product Name (Single)	Product Name (Dual)	Product Name (Dual)
$V_{IO} = 10$ mV max.	S-89430ACNC-HBU-TF	S-89430BCPN-HEU-TF	S-89430BCFN-HEU-T2
$V_{IO} = 5$ mV max.	S-89431ACNC-HBV-TF	S-89431BCPN-HEV-TF	S-89431BCFN-HEV-T2

Pin Configurations

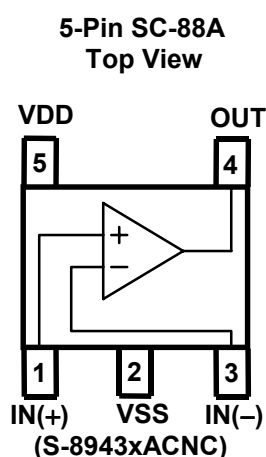


Figure 1

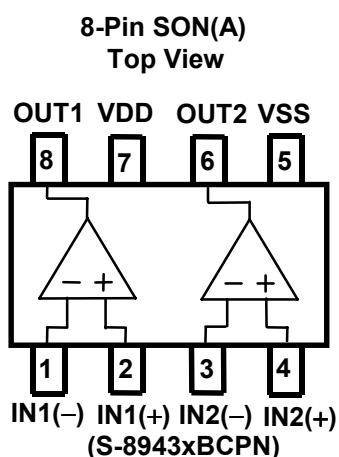


Figure 2

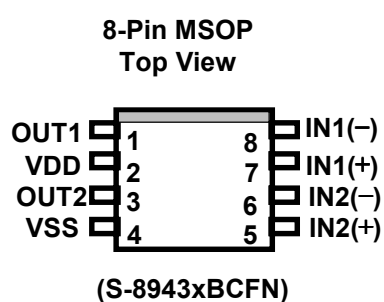


Figure 3

Table 2 Pin Descriptions
(S-8943xACNC)

Pin No.	Symbol	Function	Internal Equivalent Circuit
1	IN(+)	Non-inverted input pin	Figure 5
2	VSS	GND pin	—
3	IN(-)	Inverted input pin	Figure 5
4	OUT	Output pin	Figure 4
5	VDD	Positive power pin	Figure 6

Table 3 Pin Descriptions
(S-8943xBCPN)

Pin No.	Symbol	Function	Internal Equivalent Circuit
1	IN1(-)	Inverted input pin 1	Figure 5
2	IN1(+)	Non-inverted input pin 1	Figure 5
3	IN2(-)	Inverted input pin 2	Figure 5
4	IN2(+)	Non-inverted input pin 2	Figure 5
5	VSS	GND pin	—
6	OUT2	Output pin 2	Figure 4
7	VDD	Positive power pin	Figure 6
8	OUT1	Output pin 1	Figure 4

Table 4 Pin Descriptions
(S-8943xBCFN)

Pin No.	Symbol	Function	Internal Equivalent Circuit
1	OUT1	Output pin 1	Figure 4
2	VDD	Positive power pin	Figure 6
3	OUT2	Output pin 2	Figure 4
4	VSS	GND pin	—
5	IN2(+)	Non-inverted input pin 2	Figure 5
6	IN2(-)	Inverted input pin 2	Figure 5
7	IN1(+)	Non-inverted input pin 1	Figure 5
8	IN1(-)	Inverted input pin 1	Figure 5

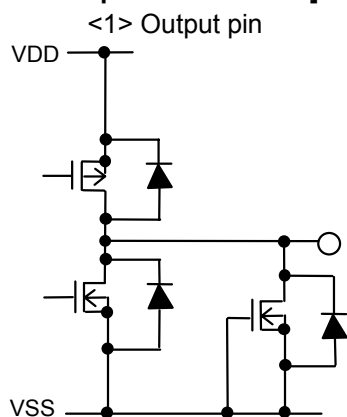
[Internal equivalent circuits]

Figure 4

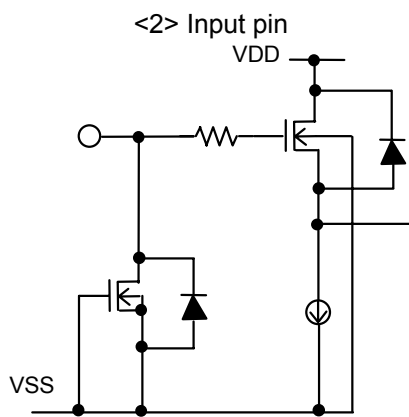


Figure 5

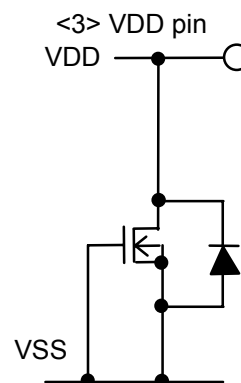


Figure 6

Absolute Maximum Ratings

Table 5

(Ta = 25°C unless otherwise specified)

Parameter		Symbol	Ratings	Unit
Power supply voltage		$V_{DD} - V_{SS}$	7.0	V
Input voltage		V_{IN}	V_{SS} to V_{DD}	V
Output voltage		V_{OUT}	V_{SS} to V_{DD}	V
Differential input voltage		V_{IND}	± 5.5	V
Output pin current		I_{SOURCE}	7	mA
		I_{SINK}		
Power dissipation	SC-88A	P_D	200	mW
	8-pin SON (A)		300	
	8-pin MSOP		300	
Operating temperature		T_{opr}	-40 to +85	°C
Storage temperature		T_{stg}	-55 to +125	°C

Caution: Although the IC contains a static electricity protection circuit, excessive static electricity or voltage exceeding the limit of the protection circuit should not be applied.

Recommended Operating Power Supply Voltage Range

Table 6

Item	Symbol	Range
Operational power supply voltage range	V_{DD}	0.9 to 5.5 V

Electrical Characteristics

S-89430ACNC and S-89431ACNC, S-89430BCPN and S-89431BCPN, and S-89430BCFN and S-89431BCFN, differ only in the input offset voltage; all other specifications are the same.

1. $V_{DD} = 3.0$ V

Table 7

DC Characteristics ($V_{DD} = 3.0$ V)

($T_a = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Power supply current ^{*1} (per circuit)	I_{DD}	$V_{CMR} = V_{OUT} = 1.5$ V	—	0.5	0.9	μA	Figure 12
Input offset voltage	V_{IO}	S-89430A/B: $V_{CMR} = 1.5$ V	−10	± 5	+10	mV	Figure 8
		S-89431A/B: $V_{CMR} = 1.5$ V	−5	± 3	+5		
Input offset current	I_{IO}	—	—	1	—	pA	—
Input bias current	I_{BIAS}	—	—	1	—	pA	—
Common-mode input voltage	V_{CMR}	—	0	—	3.0	V	—
Voltage gain (open loop)	A_{VOL}	$V_{SS} + 0.1$ V $\leq V_{OUT} \leq V_{DD} - 0.1$ V; $V_{CMR} = 1.5$ V, $R_L = 1$ M Ω	70	80	—	dB	Figure 16
Maximum output swing voltage	V_{OH}	$R_L = 100$ k Ω	2.95	—	—	V	Figure 10
	V_{OL}	$R_L = 100$ k Ω	—	—	0.05	V	Figure 11
Common mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	45	65	—	dB	Figure 9
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ to 5.5 V	70	80	—	dB	Figure 7
Source current	I_{SOURCE}	$V_{OUT} = V_{DD} - 0.1$ V	400	500	—	μA	Figure 13
		$V_{OUT} = 0$ V	4800	6000	—		
Sink current	I_{SINK}	$V_{OUT} = 0.1$ V	400	550	—	μA	Figure 14
		$V_{OUT} = V_{DD}$	4800	6000	—		

*1 When the output is saturated on the V_{DD} side, a power supply current of up to 3 to 5 μA may flow.
(Refer to 4. Power supply current vs. Common-mode input voltage characteristics in the operational amplifier characteristics graphs.)

Table 8

AC Characteristics ($V_{DD} = 3.0$ V)

($T_a = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	$R_L = 1.0$ M Ω , $C_L = 15$ pF (Refer to Figure 15.)	—	5	—	V/ms
Gain-bandwidth product	GBP	$C_L = 0$ pF	—	4.8	—	kHz
Maximum load capacitance	C_L	—	—	47	—	pF

2. $V_{DD} = 1.8$ V**Table 9**DC Characteristics ($V_{DD} = 1.8$ V)

(Ta = 25°C unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Power supply current ^{*1} (per circuit)	I_{DD}	$V_{CMR} = V_{OUT} = 0.9$ V	—	0.5	0.9	μ A	Figure 12
Input offset voltage	V_{IO}	S-89430A/B: $V_{CMR} = 0.9$ V	-10	± 5	+10	mV	Figure 8
		S-89431A/B: $V_{CMR} = 0.9$ V	-5	± 3	+5		
Input offset current	I_{IO}	—	—	1	—	pA	—
Input bias current	I_{BIAS}	—	—	1	—	pA	—
Common-mode input voltage	V_{CMR}	—	0	—	1.8	V	—
Voltage gain (open loop)	A_{VOL}	$V_{SS} + 0.1$ V $\leq V_{OUT} \leq V_{DD} - 0.1$ V; $V_{CMR} = 0.9$ V, $R_L = 1$ M Ω	66	75	—	dB	Figure 16
Maximum output swing voltage	V_{OH}	$R_L = 100$ k Ω	1.75	—	—	V	Figure 10
	V_{OL}	$R_L = 100$ k Ω	—	—	0.05	V	Figure 11
Common-mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	35	55	—	dB	Figure 9
		$V_{SS} \leq V_{CMR} \leq V_{DD} - 0.3$ V	45	60	—		
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ to 5.5 V	70	80	—	dB	Figure 7
Source current	I_{SOURCE}	$V_{OUT} = V_{DD} - 0.1$ V	220	300	—	μ A	Figure 13
		$V_{OUT} = 0$ V	1200	1800	—		
Sink current	I_{SINK}	$V_{OUT} = 0.1$ V	220	300	—	μ A	Figure 14
		$V_{OUT} = V_{DD}$	1200	1800	—		

*1 When the output is saturated on the V_{DD} side, a power supply current of up to 3 to 5 μ A may flow.
(Refer to 4. Power supply current vs. Common-mode input voltage characteristics in the operational amplifier characteristics graphs.)

Table 10AC Characteristics ($V_{DD} = 1.8$ V)

(Ta = 25°C unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	$R_L = 1.0$ M Ω , $C_L = 15$ pF (Refer to Figure 15.)	—	4.5	—	V/ms
Gain-bandwidth product	GBP	$C_L = 0$ pF	—	5	—	kHz
Maximum load capacitance	C_L	—	—	47	—	pF

3. $V_{DD} = 0.9$ V

Table 11

DC Characteristics ($V_{DD} = 0.9$ V)

($T_a = 25^\circ\text{C}$ unless otherwise specified)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Power supply current ^{*1} (per circuit)	I_{DD}	$V_{CMR} = V_{OUT} = 0.45$ V	—	0.5	0.9	μ A	Figure 12
Input offset voltage	V_{IO}	S-89430A/B: $V_{CMR} = 0.45$ V	−10	± 5	+10	mV	Figure 8
		S-89431A/B: $V_{CMR} = 0.45$ V	−5	± 3	+5		
Input offset current	I_{IO}	—	—	1	—	pA	—
Input bias current	I_{BIAS}	—	—	1	—	pA	—
Common-mode input voltage	V_{CMR}	—	0	—	0.9	V	—
Voltage gain (open loop)	A_{VOL}	$V_{SS} + 0.1$ V $\leq V_{OUT} \leq V_{DD} - 0.1$ V; $V_{CMR} = 0.45$ V, $R_L = 1$ M Ω	60	75	—	dB	Figure 16
Maximum output swing voltage	V_{OH}	$R_L = 100$ k Ω	0.85	—	—	V	Figure 10
	V_{OL}	$R_L = 100$ k Ω	—	—	0.05	V	Figure 11
Common-mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	25	55	—	dB	Figure 9
		$V_{SS} \leq V_{CMR} \leq V_{DD} - 0.35$ V	40	60	—		
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ to 5.5 V	70	80	—	dB	Figure 7
Source current	I_{SOURCE}	$V_{OUT} = V_{DD} - 0.1$ V	25	65	—	μ A	Figure 13
		$V_{OUT} = 0$ V	40	140	—		
Sink current	I_{SINK}	$V_{OUT} = 0.1$ V	10	65	—	μ A	Figure 14
		$V_{OUT} = V_{DD}$	12	120	—		

*1 When the output is saturated on the V_{DD} side, a power supply current of up to 3 to 5 μ A may flow.
(Refer to 4. Power supply current vs. Common-mode input voltage characteristics in the operational amplifier characteristics graphs.)

Table 12

AC Characteristics ($V_{DD} = 0.9$ V)

($T_a = 25^\circ\text{C}$ unless otherwise specified)

Item	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	$R_L = 1.0$ M Ω , $C_L = 15$ pF (Refer to Figure 15 .)	—	4	—	V/ms
Gain-bandwidth product	GBP	$C_L = 0$ pF	—	5	—	kHz
Maximum load capacitance	C_L	—	—	47	—	pF

■ Measurement Circuits

1. Power supply voltage rejection ratio

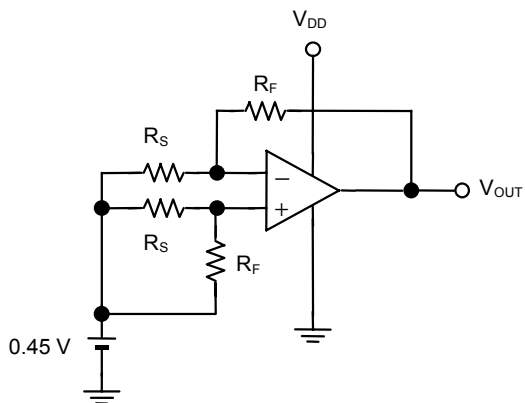


Figure 7

2. Input offset voltage

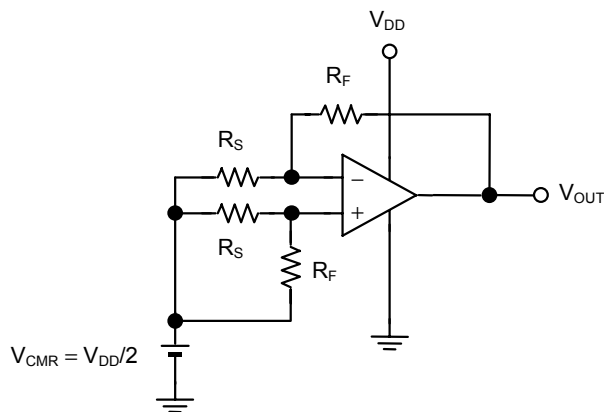


Figure 8

• Power supply voltage rejection ratio (PSRR)

The power supply rejection ratio (PSRR) can be calculated by the following formula, with the value of V_{OUT} measured at each V_{DD} .

Measurement conditions:

When $V_{DD} = 0.9\text{ V}$: $V_{DD} = V_{DD1}$, $V_{OUT} = V_{OUT1}$

When $V_{DD} = 5.5\text{ V}$: $V_{DD} = V_{DD2}$, $V_{OUT} = V_{OUT2}$

$$\text{PSRR} = 20\log\left(\left|\frac{V_{DD1} - V_{DD2}}{V_{OUT1} - V_{OUT2}}\right| \times \frac{R_F + R_S}{R_S}\right)$$

• Input offset voltage (V_{IO})

$$V_{IO} = \left(V_{OUT} - \frac{V_{DD}}{2}\right) \times \frac{R_S}{R_F + R_S}$$

3. Common-mode input signal rejection ratio, common-mode input voltage

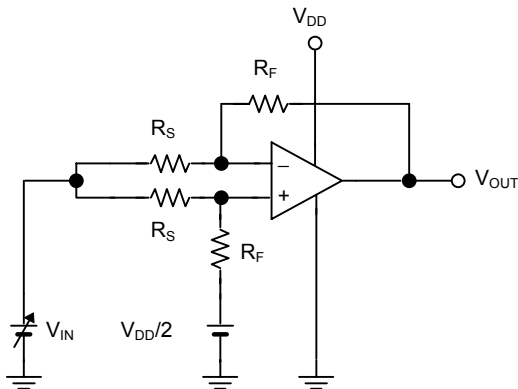


Figure 9

- Common-mode input signal rejection ratio (CMRR)
The common-mode input signal rejection ratio (CMRR) can be calculated by the following formula, with the value of V_{OUT} measured at each V_{IN} .

Measurement conditions:

When $V_{IN} = V_{CMR}$ (Max.): $V_{IN} = V_{IN1}$, $V_{OUT} = V_{OUT1}$

When $V_{IN} = V_{CMR}$ (Min.): $V_{IN} = V_{IN2}$, $V_{OUT} = V_{OUT2}$

$$CMRR = 20 \log \left(\left| \frac{V_{IN1} - V_{IN2}}{V_{OUT1} - V_{OUT2}} \right| \times \frac{(R_F + R_S)}{R_S} \right)$$

- Common-mode input voltage (V_{CMR})
The common-mode input voltage (V_{CMR}) is the range of input voltage within which V_{OUT} satisfies the common-mode rejection ratio specification when V_{IN2} is varied.

4. Maximum output swing voltage

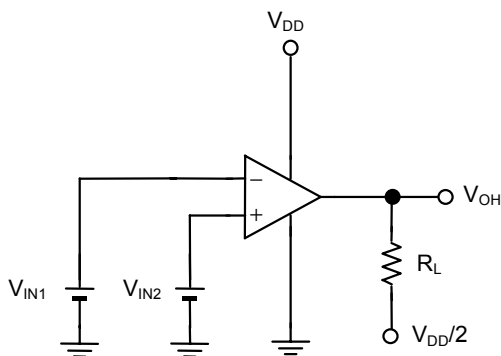


Figure 10

- Maximum output swing voltage (V_{OH})

Measurement conditions:

$$V_{IN1} = \frac{V_{DD}}{2} - 0.1 \text{ V}$$

$$V_{IN2} = \frac{V_{DD}}{2} + 0.1 \text{ V}$$

$$R_L = 100 \text{ k}\Omega$$

- Maximum output swing voltage (V_{OL})

Measurement conditions:

$$V_{IN1} = \frac{V_{DD}}{2} + 0.1 \text{ V}$$

$$V_{IN2} = \frac{V_{DD}}{2} - 0.1 \text{ V}$$

$$R_L = 100 \text{ k}\Omega$$

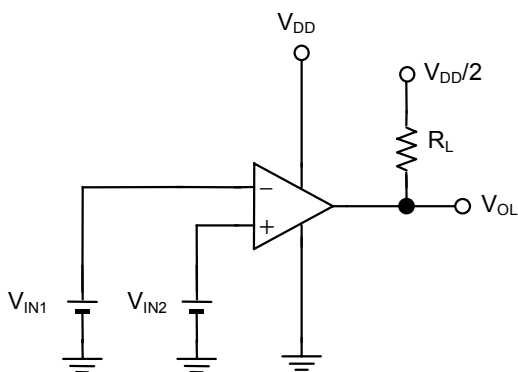


Figure 11

5. Power supply current

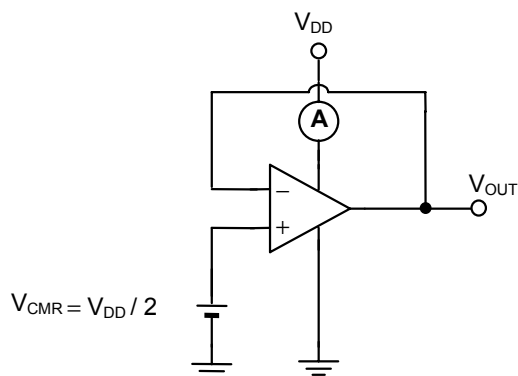


Figure 12

• Power supply current (I_{DD})

Measurement conditions:

$$V_{CMR} = \frac{V_{DD}}{2}$$

6. Source current

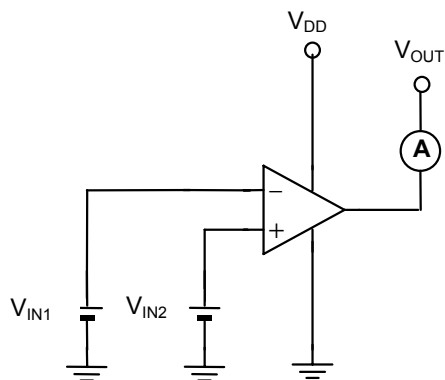


Figure 13

• Source current (I_{SOURCE})

Measurement conditions:

$$V_{OUT} = V_{DD} - 0.1 \text{ V or } V_{OUT} = 0 \text{ V}$$

$$V_{IN1} = \frac{V_{DD}}{2} - 0.1 \text{ V}$$

$$V_{IN2} = \frac{V_{DD}}{2} + 0.1 \text{ V}$$

7. Sink current

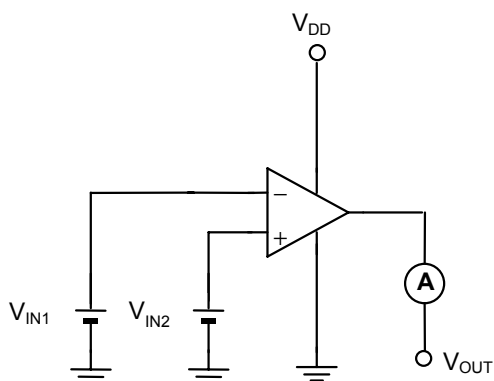


Figure 14

• Sink current (I_{SINK})

Measurement conditions:

$$V_{OUT} = 0.1 \text{ V or } V_{OUT} = V_{DD}$$

$$V_{IN1} = \frac{V_{DD}}{2} + 0.1 \text{ V}$$

$$V_{IN2} = \frac{V_{DD}}{2} - 0.1 \text{ V}$$

8. Slew rate (SR)

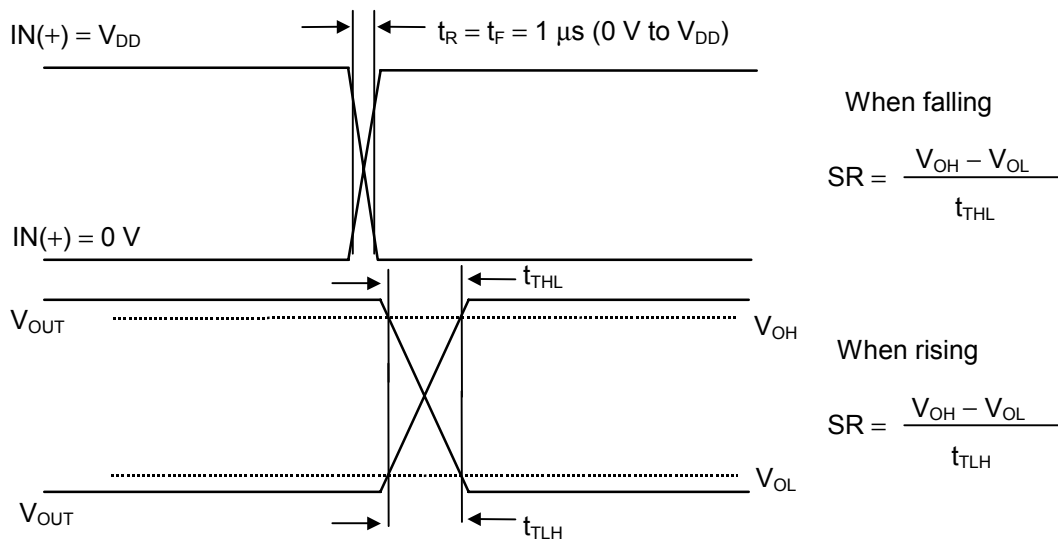


Figure 15

$V_{OH} = 2.7$ V (when $V_{DD} = 3.0$ V), 1.62 V (when $V_{DD} = 1.8$ V), 0.81 V (when $V_{DD} = 0.9$ V)
 $V_{OL} = 0.3$ V (when $V_{DD} = 3.0$ V), 0.18 V (when $V_{DD} = 1.8$ V), 0.09 V (when $V_{DD} = 0.9$ V)

9. Voltage gain (open loop)

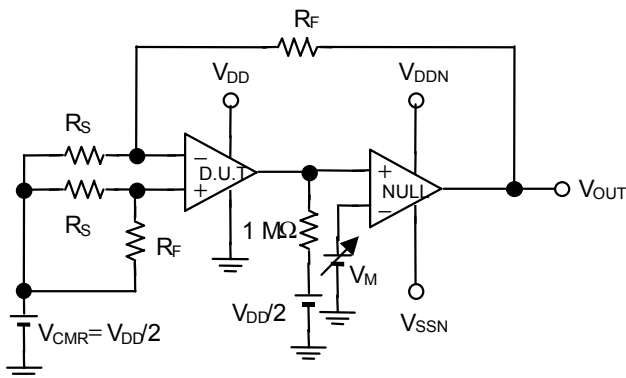


Figure 16

• Voltage gain (open loop) (A_{VOL})

The voltage gain (A_{VOL}) can be calculated by the following formula, with the value of V_{OUT} measured at each V_M .

Measurement conditions:

When $V_M = V_{DD} - 0.1$ V: $V_M = V_{M1}$, $V_{OUT} = V_{OUT1}$

When $V_M = 0.1$ V: $V_M = V_{M2}$, $V_{OUT} = V_{OUT2}$

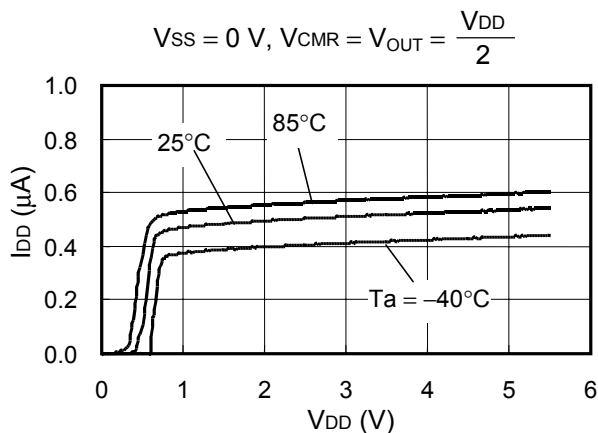
$$A_{VOL} = 20 \log \left(\left| \frac{V_{M1} - V_{M2}}{V_{OUT1} - V_{OUT2}} \right| \times \frac{(R_F + R_S)}{R_S} \right)$$

■ Cautions

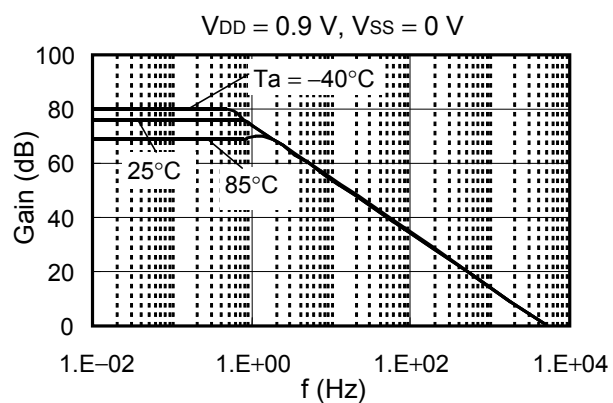
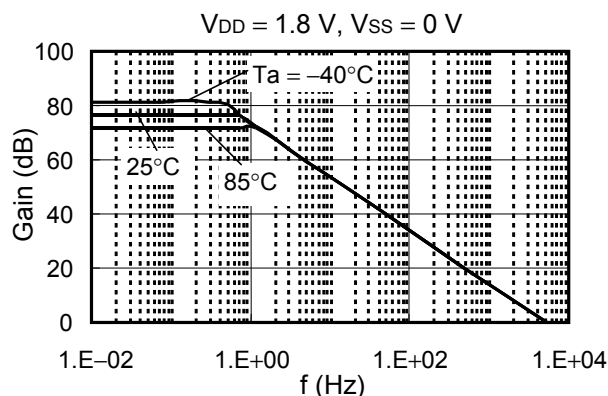
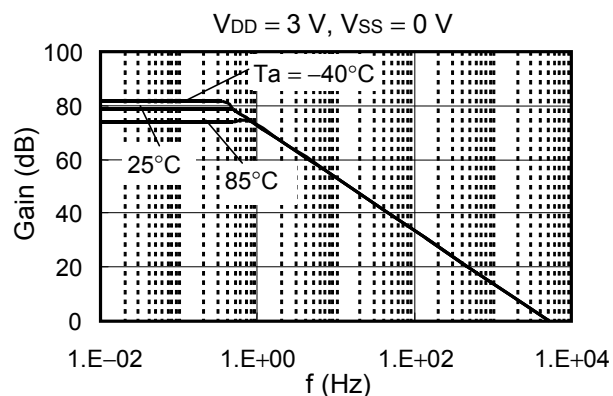
- Note that when the output is saturated on the V_{DD} side, a power supply current of up to 3 to 5 μ A may flow. (Refer to 4. Power Supply Current vs. Common-mode input voltage characteristics in the operational amplifier characteristics graphs.)
- Be sure to use the product with an output current of no more than 7 mA

Operational Amplifier Characteristics (All Data Indicates Typical Values for One Circuit)

1. Power supply current vs. Power supply voltage

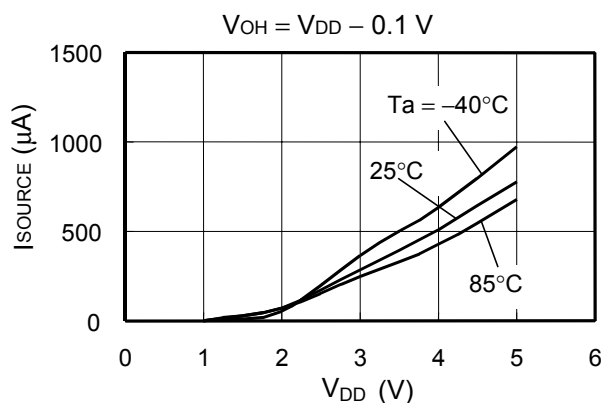


2. Voltage gain vs. Frequency

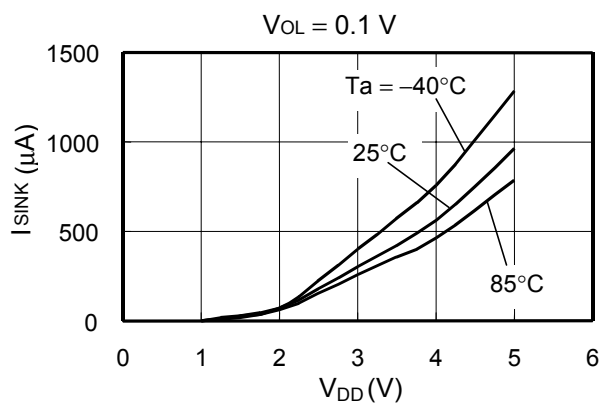


3. Output Current Characteristics

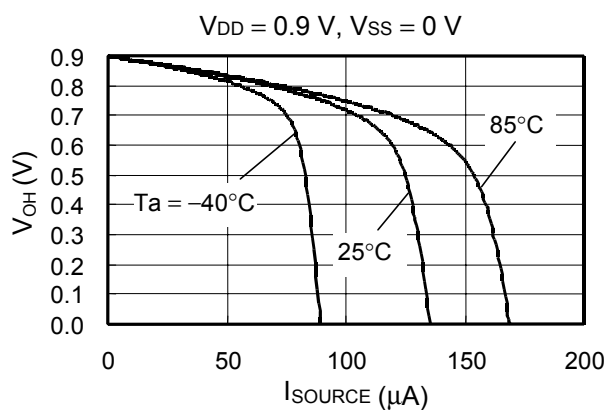
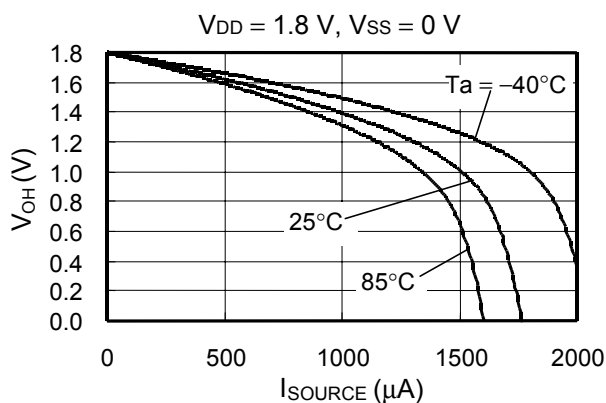
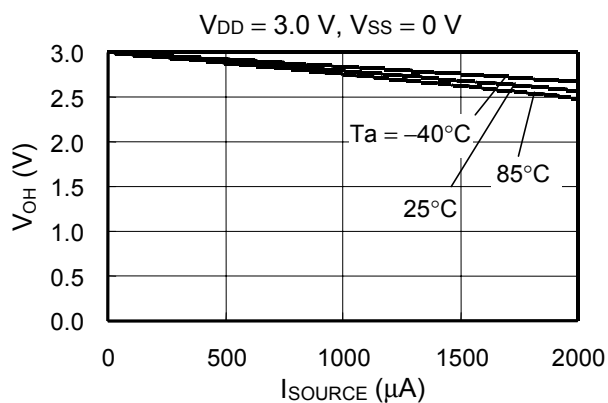
3-1. I_{SOURCE} vs. Power supply voltage

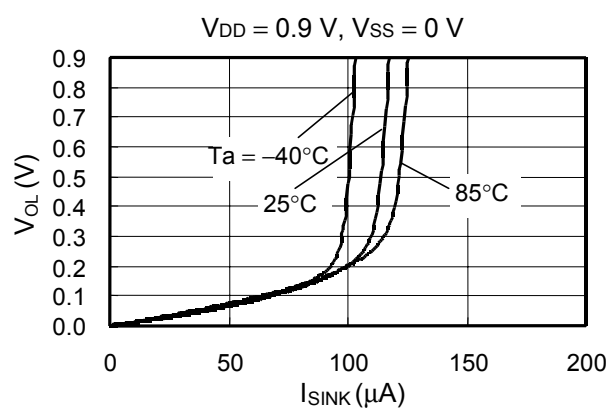
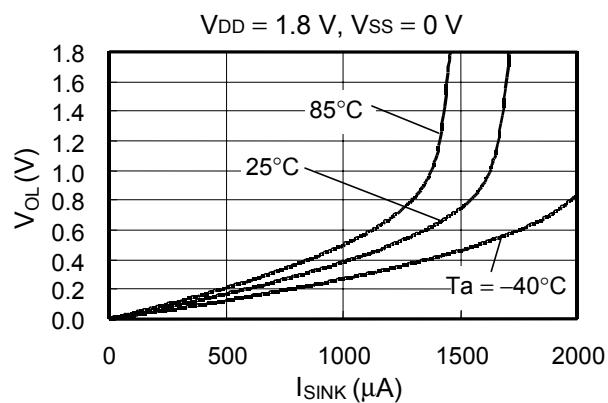
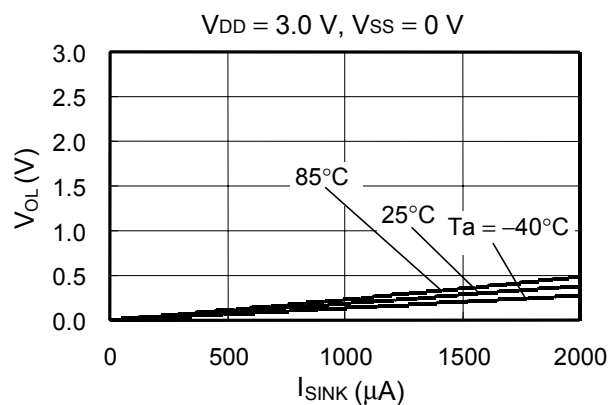


I_{SINK} vs. Power supply voltage

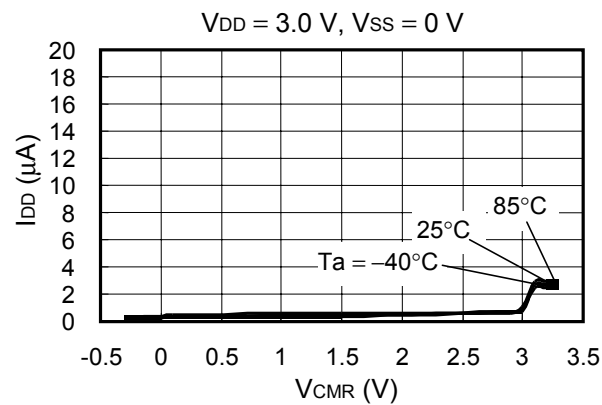


3-2. I_{SOURCE} vs. Output voltage (V_{OH})



3-3. I_{SINK} vs. Output voltage (V_{OL})

4. Power supply current vs. Common-mode input voltage (voltage follower configuration)

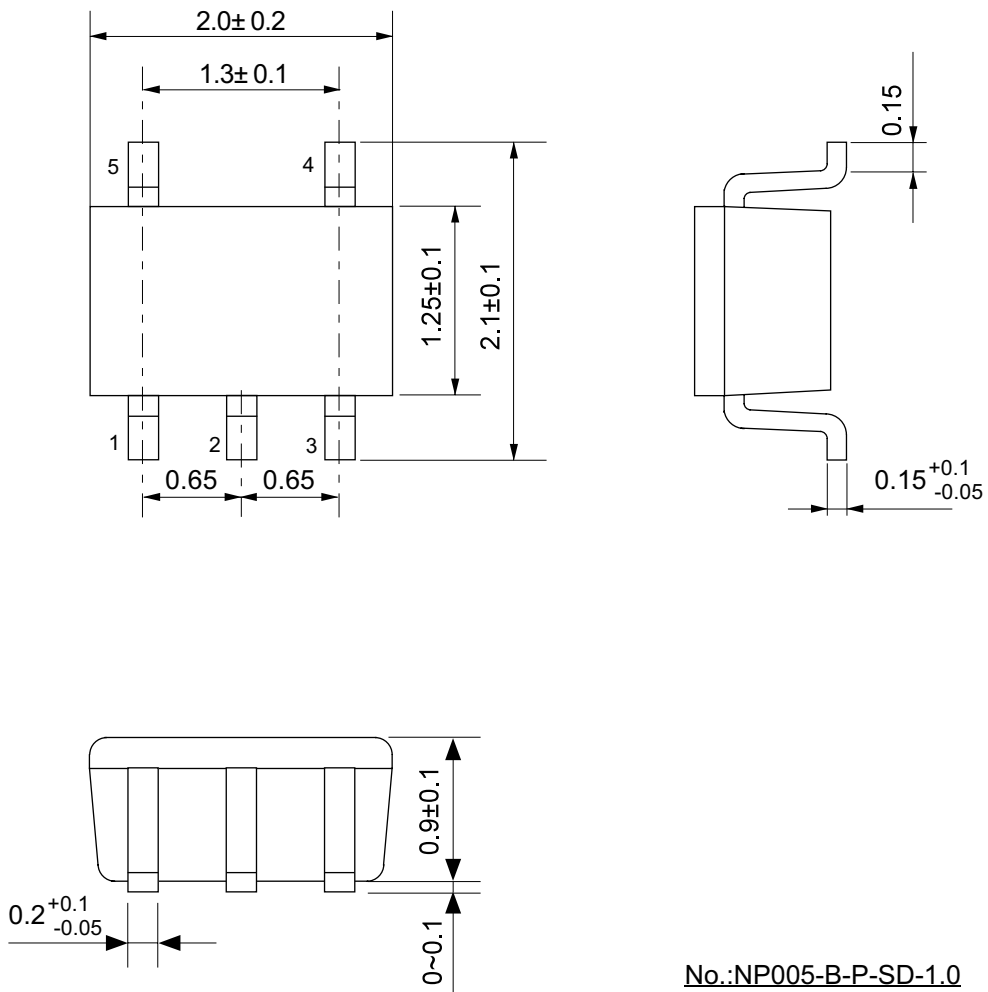


■ SC-88A

NP005-B Rev.1.1 020517

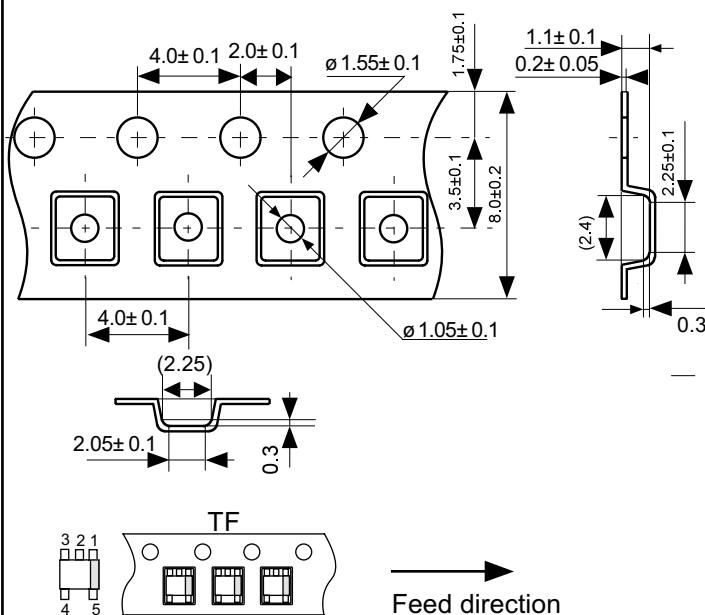
●Dimensions

Unit: mm



No.:NP005-B-P-SD-1.0

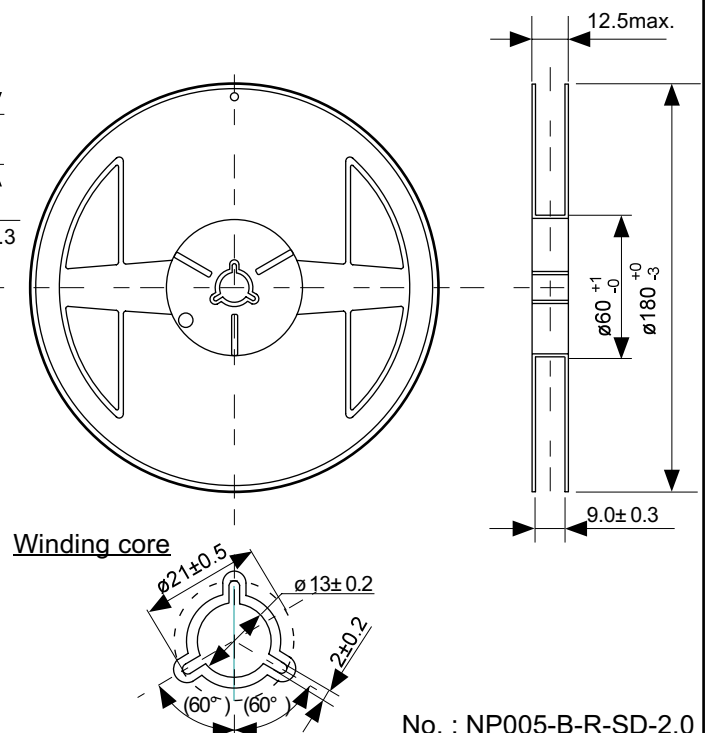
●Taping Specifications



No. : NP005-B-C-SD-1.0

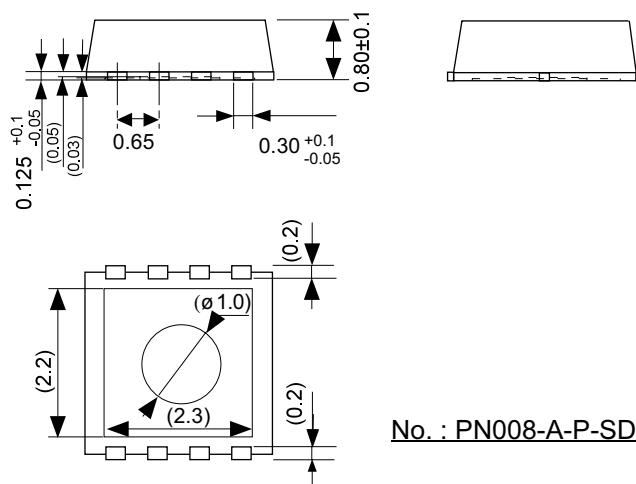
●Reel Specifications

3000 pcs/reel



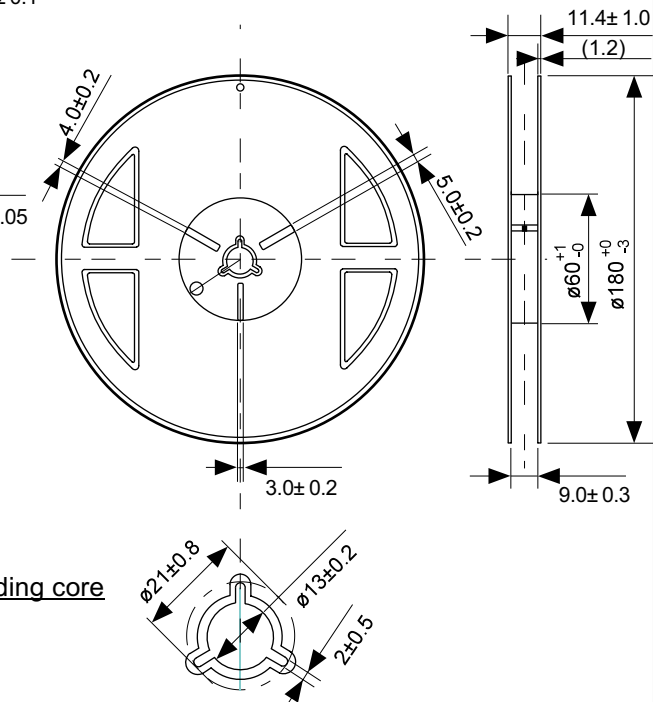
No. : NP005-B-R-SD-2.0

Unit : mm



No. : PN008-A-P-SD-1.0

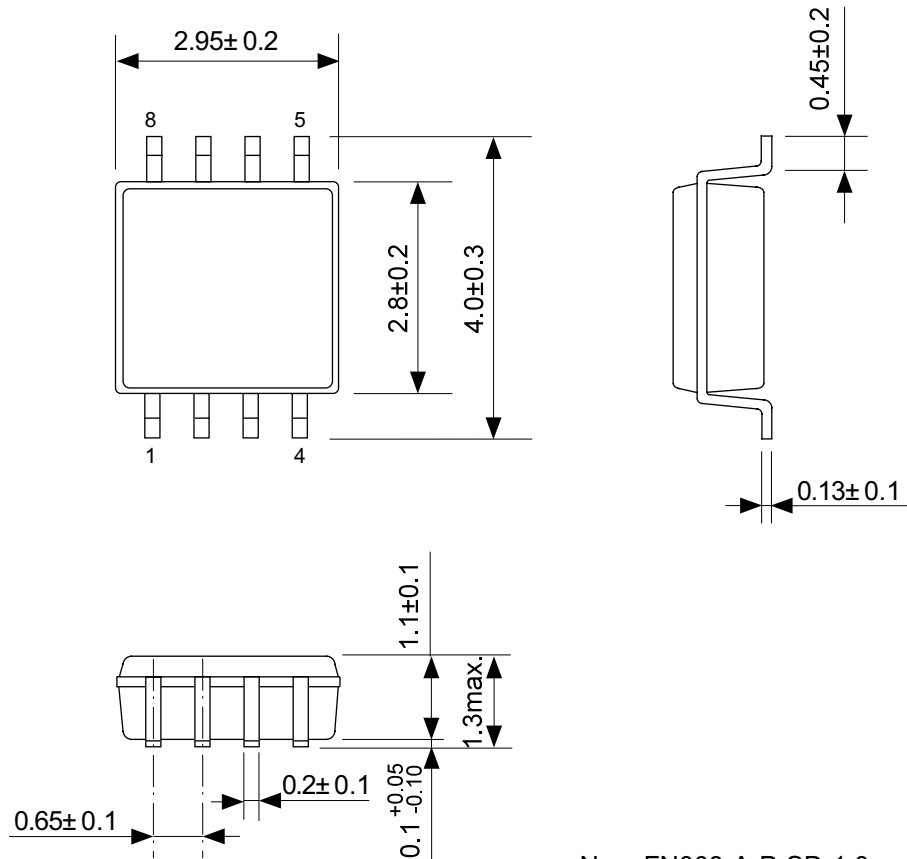
● Reel Specifications

[illegible]

Winding core

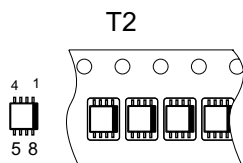
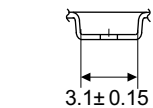
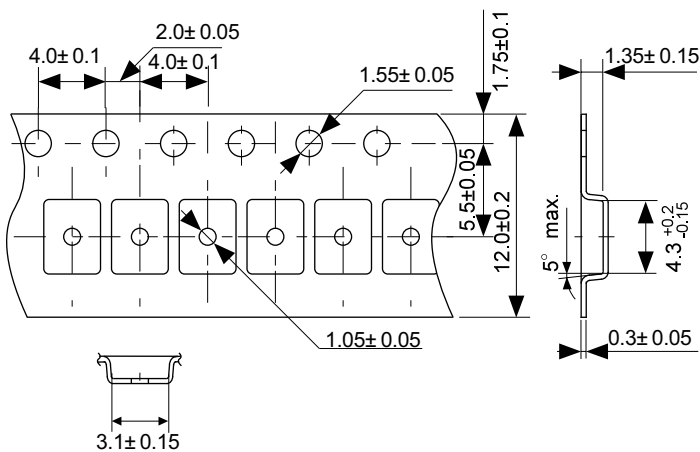
No. : PN008-A-R-SD-1.0

● Dimensions



No. : FN008-A-P-SD-1.0

● Tape Specifications

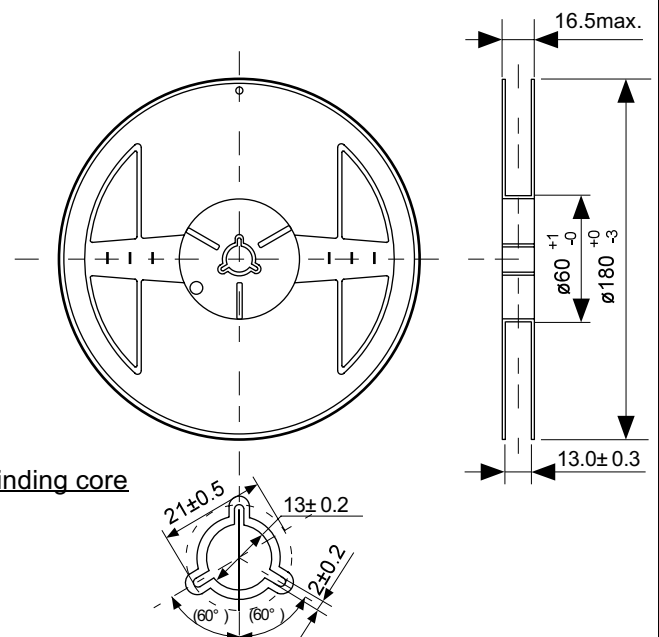


Feed direction

No. : FN008-A-C-SD-1.0

● Reel Specifications

3000 pcs/reel



Winding core

No. : FN008-A-R-SD-1.0

- The information described herein is subject to change without notice.
- Seiko Instruments Inc. is not responsible for any problems caused by circuits or diagrams described herein whose related industrial properties, patents, or other rights belong to third parties. The application circuit examples explain typical applications of the products, and do not guarantee the success of any specific mass-production design.
- When the products described herein are regulated products subject to the Wassenaar Arrangement or other agreements, they may not be exported without authorization from the appropriate governmental authority.
- Use of the information described herein for other purposes and/or reproduction or copying without the express permission of Seiko Instruments Inc. is strictly prohibited.
- The products described herein cannot be used as part of any device or equipment affecting the human body, such as exercise equipment, medical equipment, security systems, gas equipment, or any apparatus installed in airplanes and other vehicles, without prior written permission of Seiko Instruments Inc.
- Although Seiko Instruments Inc. exerts the greatest possible effort to ensure high quality and reliability, the failure or malfunction of semiconductor products may occur. The user of these products should therefore give thorough consideration to safety design, including redundancy, fire-prevention measures, and malfunction prevention, to prevent any accidents, fires, or community damage that may ensue.