MINI ANALOG SERIES
0.5 μA Rail-to-Rail CMOS OPERATIONAL AMPLIFIER S-89430A/89431A

The mini-analog series is a group of ICs that incorporate a general purpose analog circuit in a small package.
The S-89430A/89431A is a CMOS type operational amplifier that feature Rail-to-Rail*1 I/O and an internal phase compensation circuit, and that can be driven at a lower voltage with lower current consumption than existing bipolar operational amplifiers. These features make this product the ideal solution for small battery-powered portable equipment.
These features enable driving at a lower voltage (from 0.9 V) and with lower current consumption (0.5 μA)
The S-89430A/89431A is a single operational amplifier.
*1. Rail-to-Rail is a registered trademark of Motorola Inc.

■ Features

- Lower operating voltage than the conventional general-purpose operational amplifiers: V_{DD} = 0.9 to 5.5 V
- Low current consumption: I_{DD} = 0.5 μA
- Wide I/O voltage range: $V_{CMR} = V_{SS}$ to V_{DD} (Rail-to-Rail)
- Low input offset voltage: 10.0 mV (max.) (S-89430A)
  5.0 mV (max.) (S-89431A)
- No external capaciters required for internal phase compensation
- Lead-free products

■ Application

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

■ Package

Package Name	Drawing Code		
	Package	Tape	Reel
SC-88A	NP005-B	NP005-B	NP005-B
SOT-23-5	MP005-A	MP005-A	MP005-A

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■ Product Name List

Table 1

Input Offset Voltage	SC-88A (Single)	SOT-23-5 (Single)
V_{IO} = 10 mV	S-89430ACNC-HBUTFG	S-89430ACMC-HBUT2G
V_{IO} = 5 mV	S-89431ACNC-HBVTFG	S-89431ACMC-HBVT2G

Remark Delivery form : Taping only

■ Pin Configuration

SC-88A
Top view

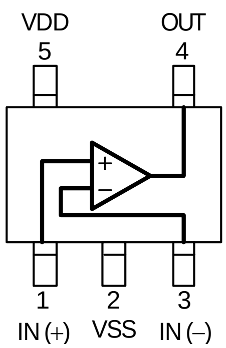

Figure 1

SOT-23-5
Top view

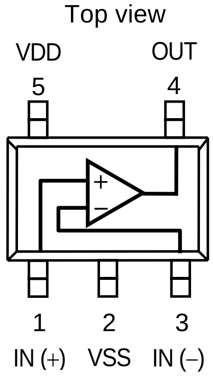

Figure 2

Table 2

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

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■ Internal Equivalent Circuit

(1) Output pin

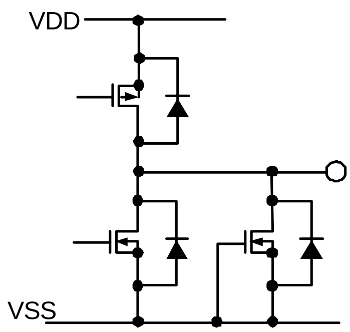

Figure 3

(2) Input pin

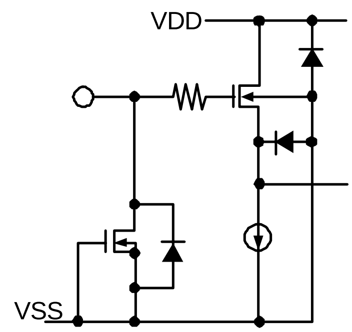

Figure 4

(3) VDD pin

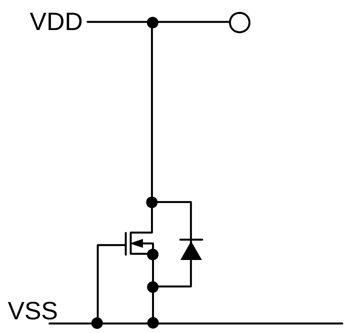

Figure 5

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■ Absolute Maximum Ratings

Table 3

(Ta = 25°C unless otherwise specified)

Parameter		Symbol	Ratings	Unit
Power supply voltage		V_{DD}	V_{SS} − 0.3 to V_{SS} + 7.0	V
Input voltage		V_{IN}	V_{SS} − 0.3 to V_{SS} + 7.0 (7.0 max.)	V
Output voltage		V_{OUT}	V_{SS} − 0.3 to V_{DD} + 0.3 (7.0 max.)	V
Differential input voltage		V_{IND}	±5.5	V
Output pin current		I_{SOURCE}	7.0	mA
		I_{SINK}		
Power dissipation	SC-88A	P_D	200 (When not mounted on board)	mW
			350*1	mW
	SOT-23-5		250 (When not mounted on board)	mW
			600*1	mW
Operating temperature range		T_{opr}	−40 to +85	°C
Storage temperature range		T_{stg}	−55 to +125	°C

***1.** When mounted on board
[Mounted board]
(1) Board size : 114.3 mm × 76.2 mm × t1.6 mm
(2) Board name : JEDEC STANDARD51-7

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.

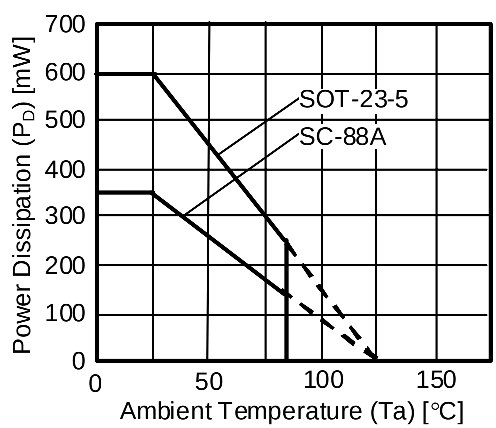

Figure 6 Power Dissipation of Package (When Mounted on Board)

■ Recommended Operating Voltage Range

Table 4

Parameter	Symbol	Range	Unit
Operating power supply voltage range	V_{DD}	0.9 to 5.5	V

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■ Electrical Characteristics

1. V_{DD} = 3.0 V

Table 5

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

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Current consumption*1	I_{DD}	$V_{CMR} = V_{OUT} = 1.5$ V	—	0.5	0.9	μA	**Figure 12**
Input offset voltage	V_{IO}	S-89430A : V_{CMR} = 1.5 V	−10	±5	+10	mV	**Figure 8**
		S-89431A : 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 range	V_{CMR}	—	0	—	3	V	**Figure 9**
Voltage gain (open loop)	A_{VOL}	$V_{SS} + 0.1 \text{ V} \le V_{OUT} \le V_{DD} - 0.1$ V, V_{CMR} = 1.5 V, R_L = 1 MΩ	70	80	—	dB	**Figure 16**
Maximum output swing voltage	V_{OH}	R_L = 100 KΩ	2.95	—	—	V	**Figure 10**
	V_{OL}	R_L = 100 KΩ	—	—	0.05		**Figure 11**
Common-mode input signal rejection ratio	CMRR	$V_{SS} \le V_{CMR} \le V_{DD}$	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 current consumption of up to 3 to 5 μA may flow. (Refer to **4. Current consumption vs. Common-mode input voltage characteristics** graphs in the characteristics data.)

Table 6

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

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, 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

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2. V_{DD} = 1.8 V

Table 7

DC Characteristics (V_{DD} = 1.8 V) (Ta = 25°C unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Current consumption*1	I_{DD}	V_{CMR} = V_{OUT} = 0.9 V	—	0.5	0.9	μA	**Figure 12**
Input offset voltage	V_{IO}	S-89430A : V_{CMR} = 0.9V	−10	±5	+10	mV	**Figure 8**
		S-89431A : V_{CMR} = 0.9V	−5	±3	+5		
Input offset current	I_{IO}	—	—	1	—	pA	—
Input bias current	I_{BIAS}	—	—	1	—	pA	—
Common-mode input voltage range	V_{CMR}	—	0	—	1.8	V	**Figure 9**
Voltage gain (open loop)	A_{VOL}	V_{SS} + 0.1 V ≤ V_{OUT} ≤ V_{DD} − 0.1 V, V_{CMR} = 0.9 V, R_L = 1 MΩ	66	75	—	dB	**Figure 16**
Maximum output swing voltage	V_{OH}	R_L = 100 KΩ	1.75	—	—	V	**Figure 10**
	V_{OL}	R_L = 100 KΩ	—	—	0.05		**Figure 11**
Common-mode input signal rejection ratio	CMRR	V_{SS} ≤ V_{CMR} ≤ V_{DD}	35	55	—	dB	**Figure 9**
		V_{SS} ≤ V_{CMR} ≤ 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	—	μA	**Figure 13**
		V_{OUT} = 0 V	1200	1800	—		
Sink current	I_{SINK}	V_{OUT} = 0.1 V	220	300	—	μA	**Figure 14**
		V_{OUT} = V_{DD}	1200	1800	—		

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

Table 8

AC 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 MΩ, 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

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3. V_{DD} = 0.9 V

Table 9

DC Characteristics (V_{DD} = 0.9 V) (Ta = 25°C unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit	Measurement Circuit
Current consumption*1	I_{DD}	$V_{CMR} = V_{OUT}$ = 0.45 V	—	0.5	0.9	μA	**Figure 12**
Input offset voltage	V_{IO}	S-89430A : V_{CMR} = 0.45V	–10	±5	+10	mV	**Figure 8**
		S-89431A : V_{CMR} = 0.45V	–5	±3	+5		
Input offset current	I_{IO}	—	—	1	—	pA	—
Input bias current	I_{BIAS}	—	—	1	—	pA	—
Common-mode input voltage range	V_{CMR}	—	0	—	0.9	V	**Figure 9**
Voltage gain (open loop)	A_{VOL}	$V_{SS} + 0.1 V \le V_{OUT} \le V_{DD} - 0.1 V$, V_{CMR} = 0.45 V, R_L = 1 MΩ	60	75	—	dB	**Figure 16**
Maximum output swing voltage	V_{OH}	R_L = 100 KΩ	0.85	—	—	V	**Figure 10**
	V_{OL}	R_L = 100 KΩ	—	—	0.05		**Figure 11**
Common-mode input signal rejection ratio	CMRR	$V_{SS} \le V_{CMR} \le V_{DD}$	25	55	—	dB	**Figure 9**
		$V_{SS} \le V_{CMR} \le V_{DD} - 0.35 V$	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	—	μA	**Figure 13**
		V_{OUT} = 0 V	40	140	—		
Sink current	I_{SINK}	V_{OUT} = 0.1 V	10	65	—	μA	**Figure 14**
		$V_{OUT} = V_{DD}$	12	120	—		

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

Table 10

AC Characteristics (V_{DD} = 0.9 V) (Ta = 25°C unless otherwise specified)

Parameter	Symbol	Measurement Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, 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

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■ Measurement Circuit

1. Power supply voltage rejection ratio

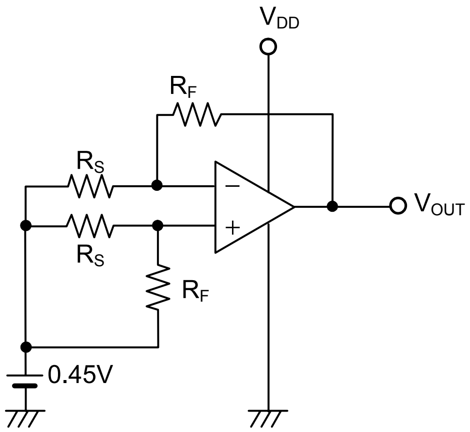

Figure 7

- **Power supply voltage rejection ratio (PSRR)**
  The power supply voltage rejection ratio (PSRR) can be calculated by the following expression, with V_{OUT} measured at each V_{DD}.

  Measurement conditions:
  When V_{DD} = 0.9 V: $V_{DD} = V_{DD1}$, $V_{OUT} = V_{OUT1}$
  When V_{DD} = 5.5 V: $V_{DD} = V_{DD2}$, $V_{OUT} = V_{OUT2}$

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

2. Input offset voltage

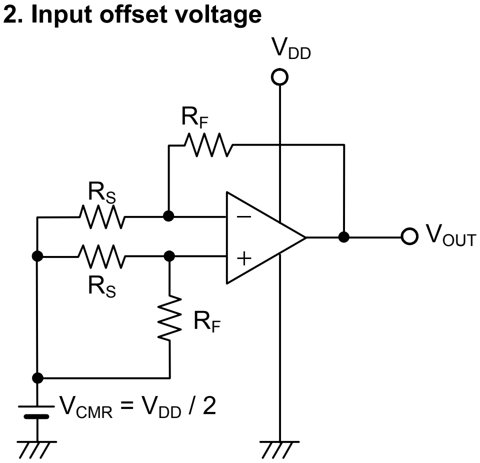

Figure 8

- **Input offset voltage (V_{IO})**

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

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

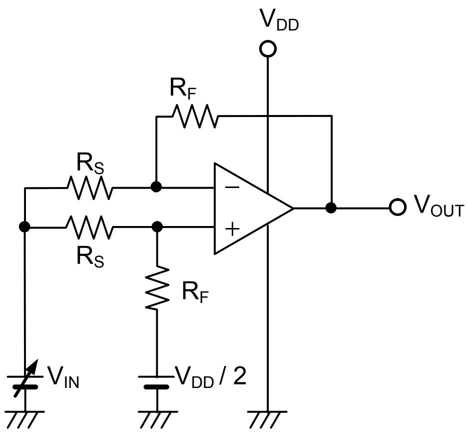

Figure 9

- **Common-mode input signal rejection ratio (CMRR)**
  The common-mode input signal rejection ratio (CMRR) can be calculated by the following expression, with 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.): $V_{IN} = V_{IN2}$, $V_{OUT} = V_{OUT2}$

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

- **Common-mode input voltage range (V_{CMR})**
  The common-mode input voltage range is the range of V_{IN} in which V_{OUT} satisfies the common-mode input signal rejection ratio specifications.

4. Maximum output swing voltage

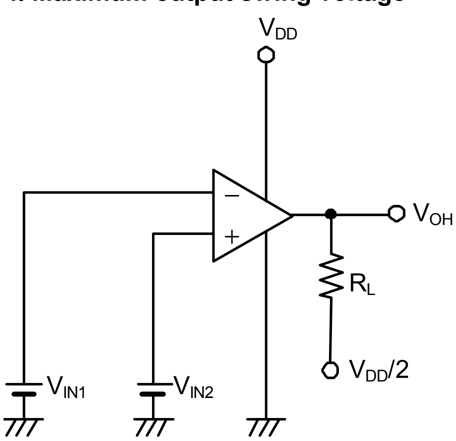

Figure 10

- **Maximum output swing voltage (V_{OH})**
  Measurement conditions:

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

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

R_L = 100 KΩ

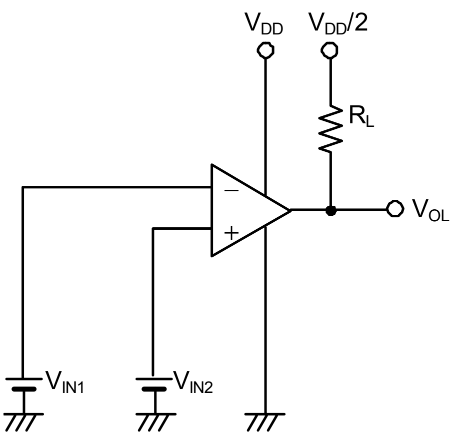

Figure 11

- **Maximum output swing voltage (V_{OL})**
  Measurement conditions:

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

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

R_L = 100 KΩ

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5. Current consumption

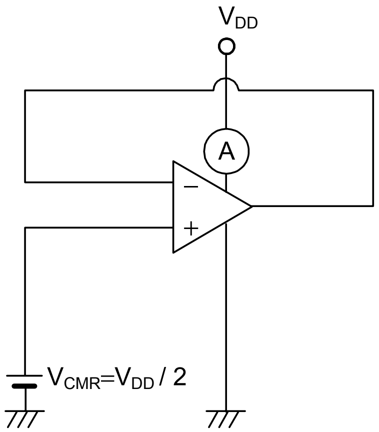

Figure 12

- **Current consumption (I_{DD})**

6. Source current

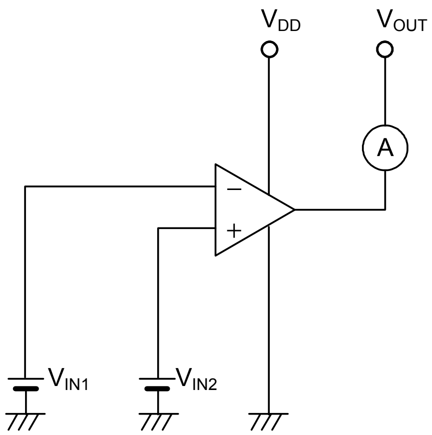

Figure 13

- **Source current (I_{SOURCE})**
  Measurement conditions:
  $V_{OUT} = V_{DD} - 0.1$ V or $V_{OUT} = 0$ V
  $V_{IN1} = \frac{V_{DD}}{2} - 0.1$ V
  $V_{IN2} = \frac{V_{DD}}{2} + 0.1$ V

7. Sink current

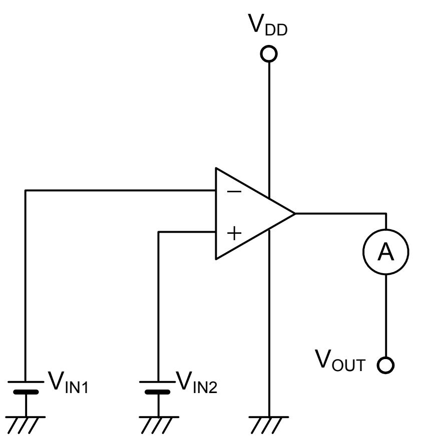

Figure 14

- **Sink current (I_{SINK})**
  Measurement conditions:
  $V_{OUT} = 0.1$ V or $V_{OUT} = V_{DD}$
  $V_{IN1} = \frac{V_{DD}}{2} + 0.1$ V
  $V_{IN2} = \frac{V_{DD}}{2} - 0.1$ V

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8. Slew rate (SR):
Measured by the voltage follower circuit

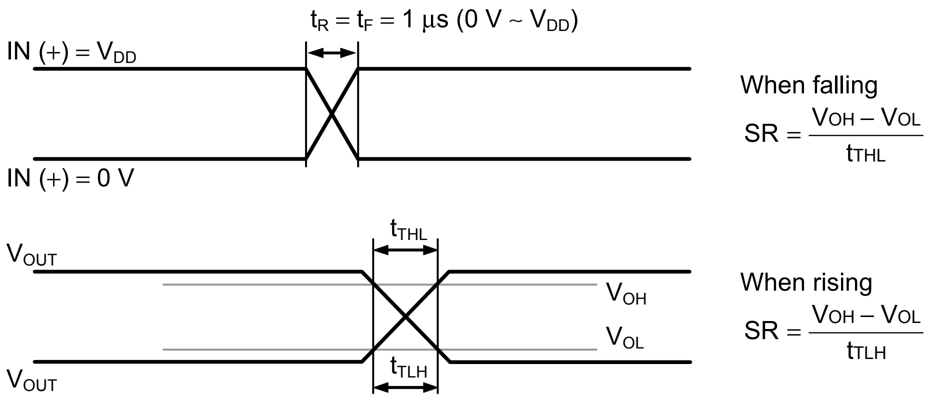

Figure 15

	When V_{DD}=3.0 V	When V_{DD}=1.8 V	When V_{DD}=0.9 V
V_{OH}	2.7 V	1.62 V	0.81 V
V_{OL}	0.3 V	0.18 V	0.09 V

9. Voltage gain (open loop)

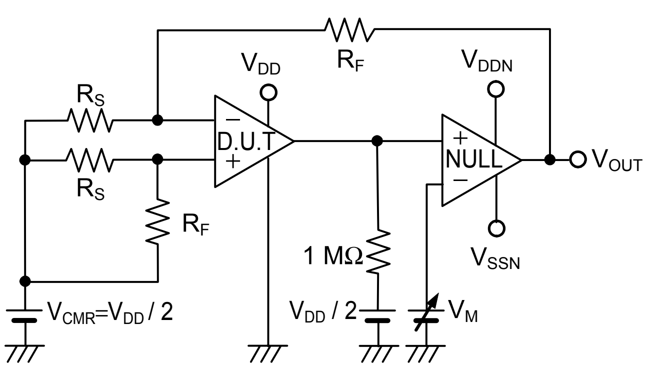

Figure 16

- **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: $V_M = V_{M2}$, $V_{OUT} = V_{OUT2}$

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

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■ Precaution

- Note that 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. Current consumption vs. Common-mode input voltage characteristics** graphs in the characteristics data)
- Do not apply an electrostatic discharge to this IC that exceeds performance ratings of the built-in electrostatic protection circuit.
- Be sure to use the product with an output current of no more than 7 mA.
- SII 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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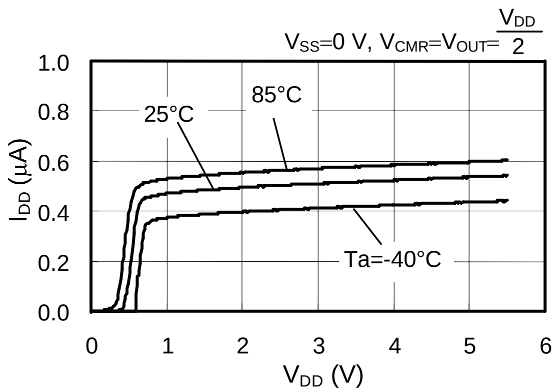
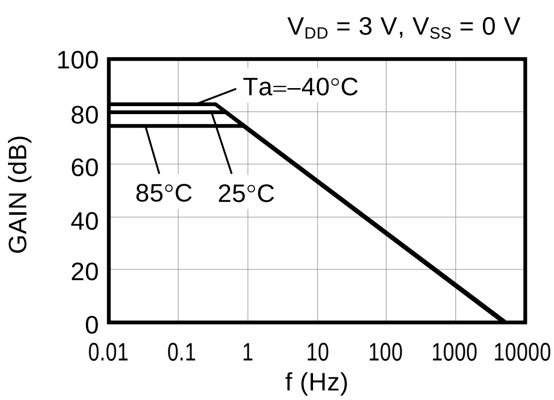
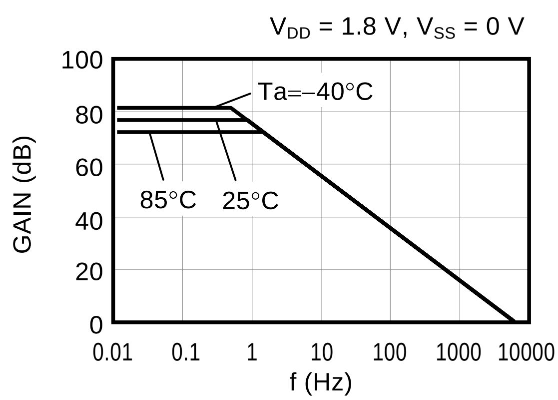
■ Characteristics (Reference Data)

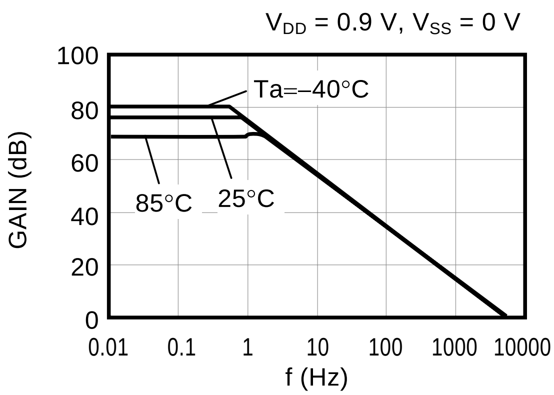
1. Current consumption vs. Power supply voltage



2. Voltage gain vs. Frequency







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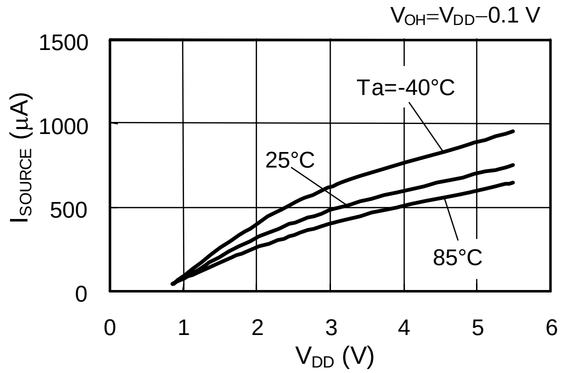
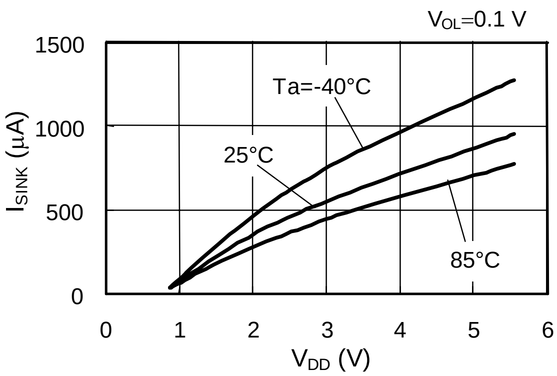
3. Output current

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



3-2. I_{SINK} vs. Power supply voltage



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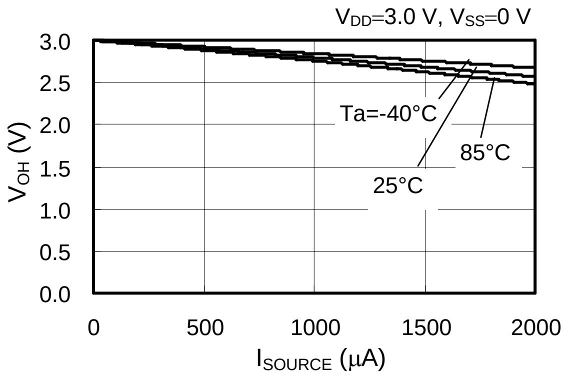
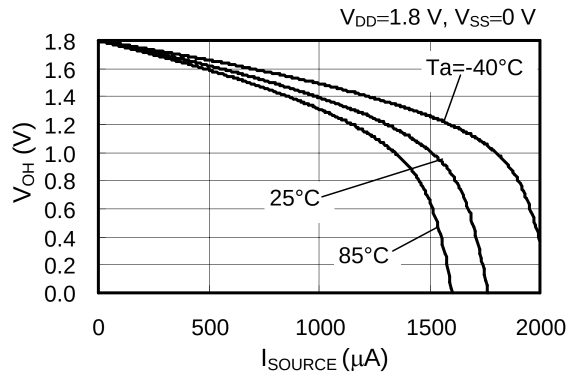
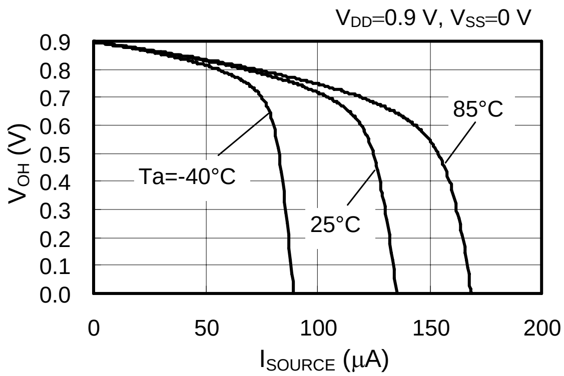
3-3. Output voltage (V_{OH}) vs I_{SOURCE}







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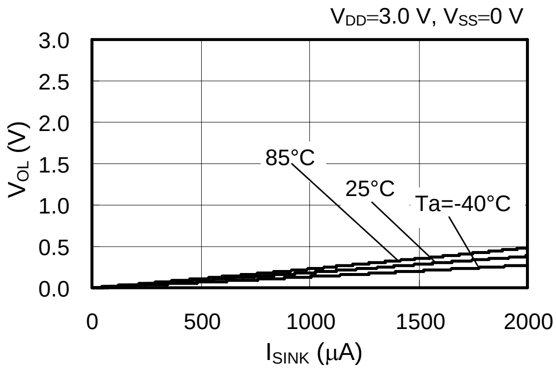
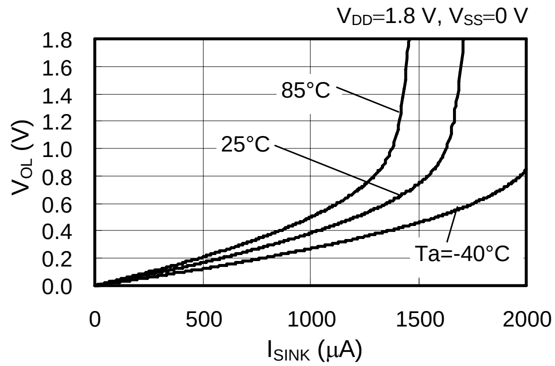
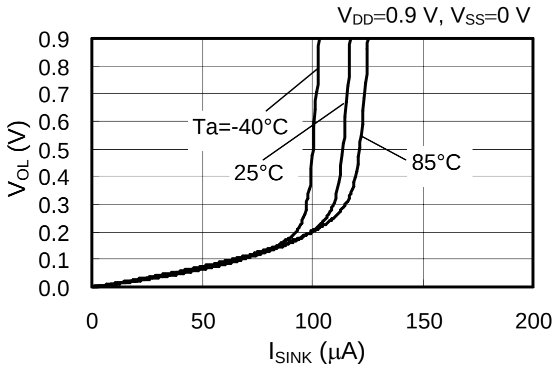
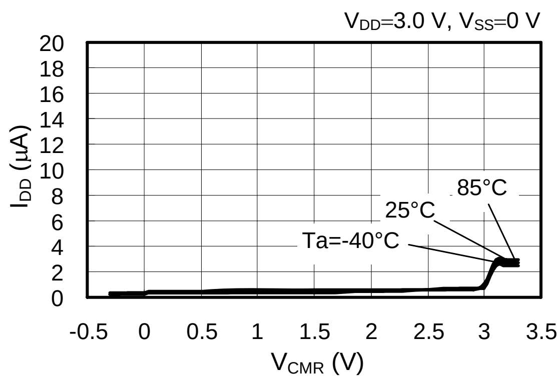
3-4. Output voltage (V_{OL}) vs. I_{SINK}







4. Current consumption vs. Common-mode input voltage (voltage follower configuration)



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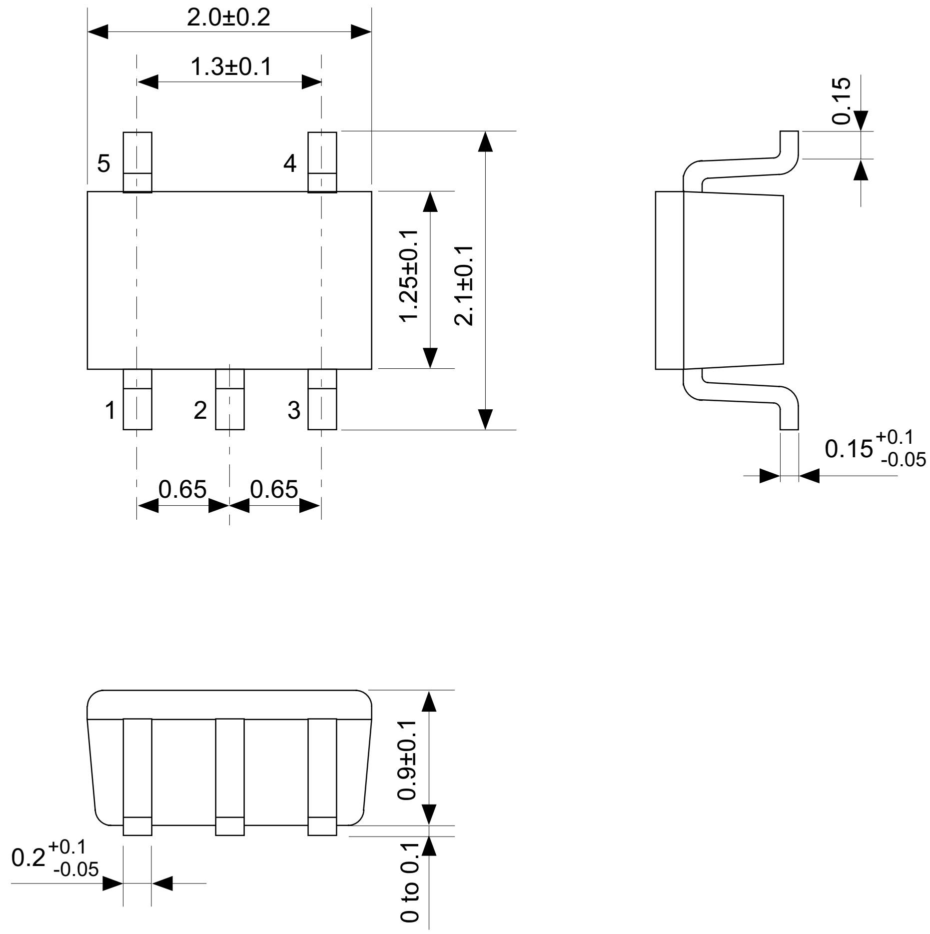

No. NP005-B-P-SD-1.1

TITLE	SC88A-B-PKG Dimensions
No.	NP005-B-P-SD-1.1
SCALE	
UNIT	mm

Seiko Instruments Inc.

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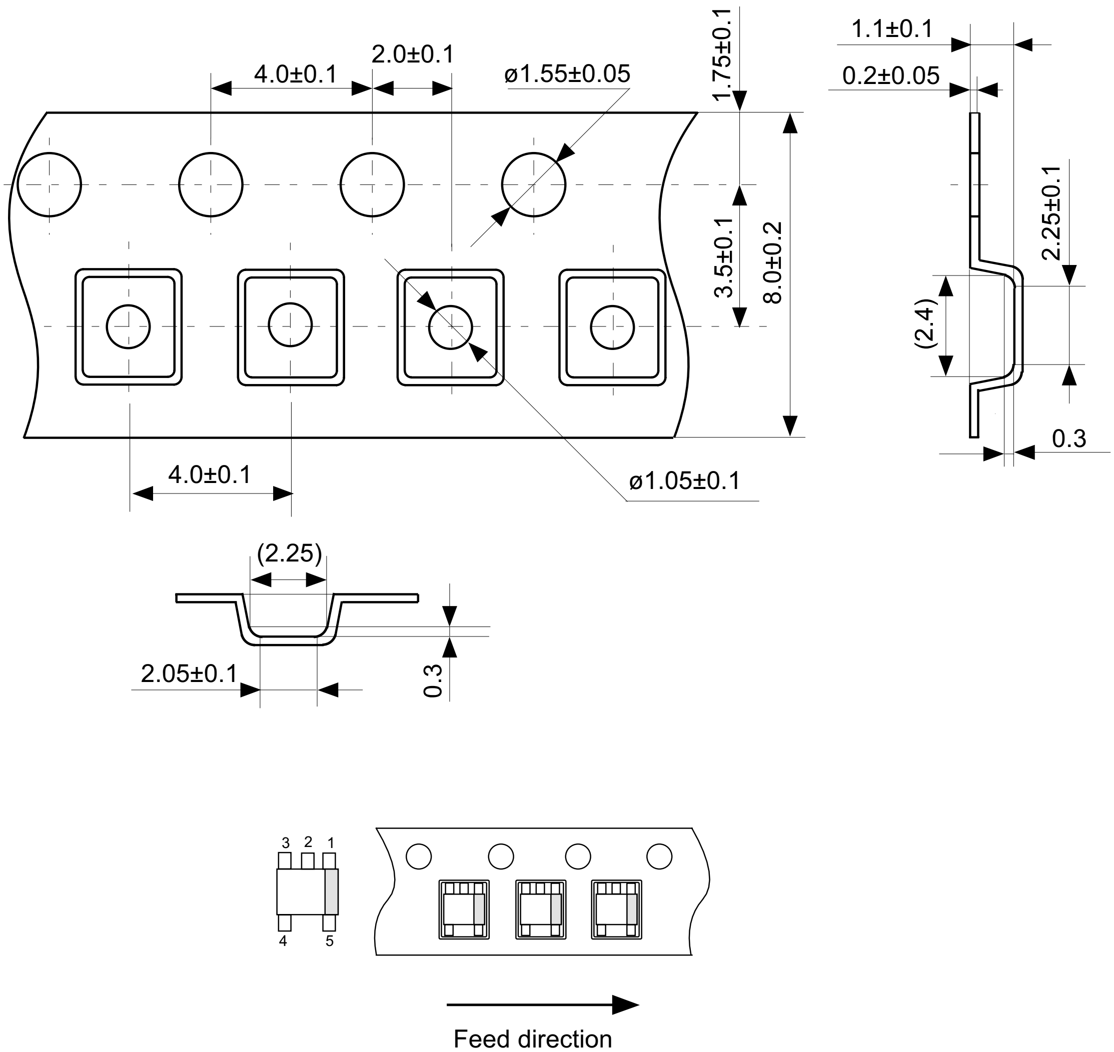

No. NP005-B-C-SD-2.0

TITLE	SC88A-B-Carrier Tape
No.	NP005-B-C-SD-2.0
SCALE	
UNIT	mm
Seiko Instruments Inc.	

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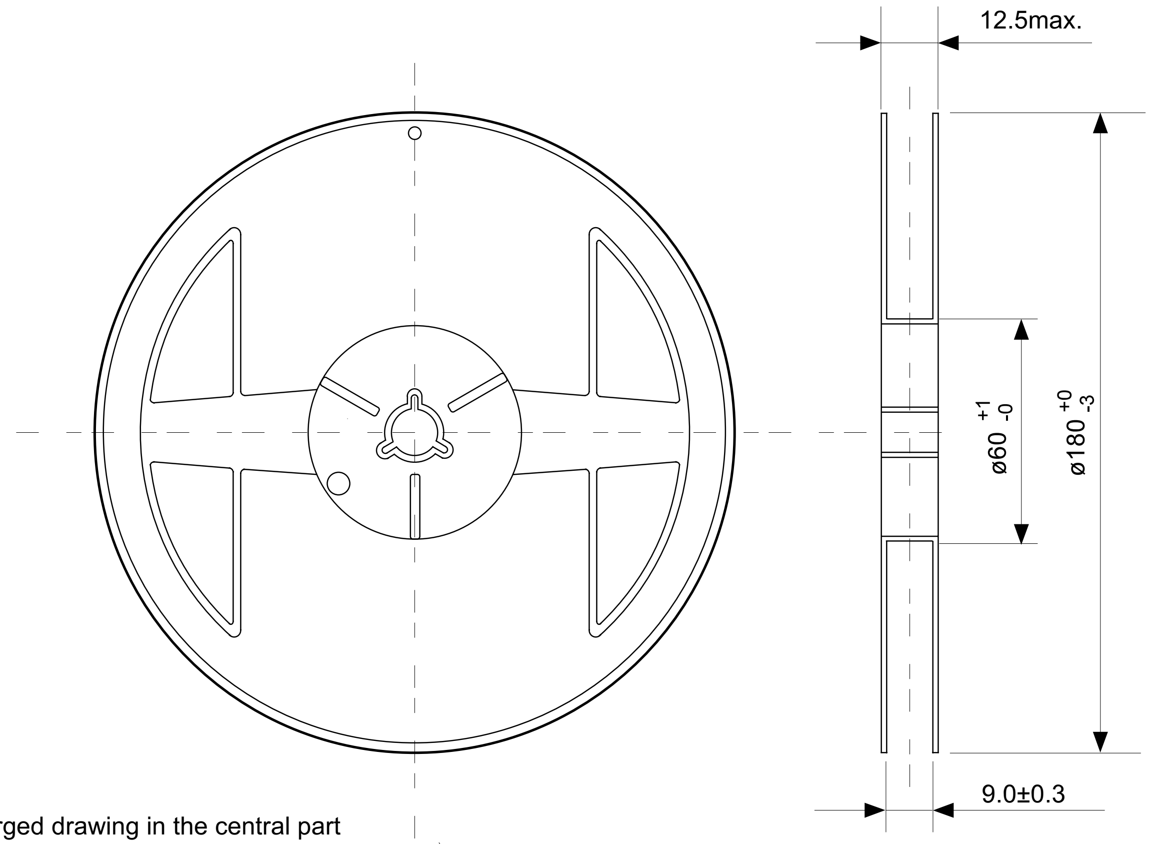
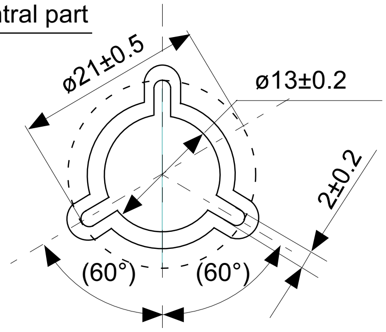


Enlarged drawing in the central part



No. NP005-B-R-SD-2.1

TITLE	SC88A-B-Reel		
No.	NP005-B-R-SD-2.1		
SCALE		QTY.	3000
UNIT	mm		

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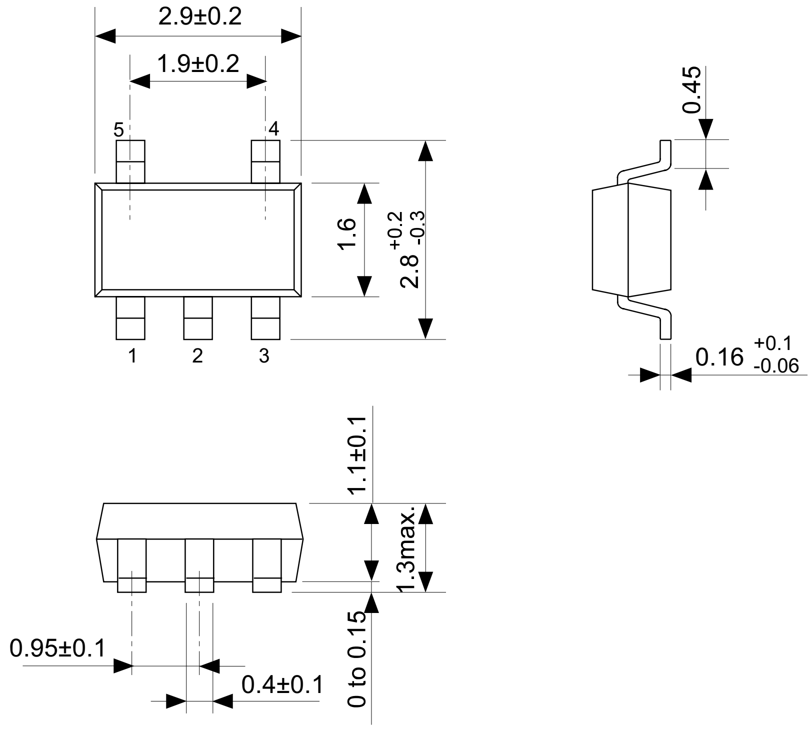

No. MP005-A-P-SD-1.2

TITLE	SOT235-A-PKG Dimensions
No.	MP005-A-P-SD-1.2
SCALE	
UNIT	mm

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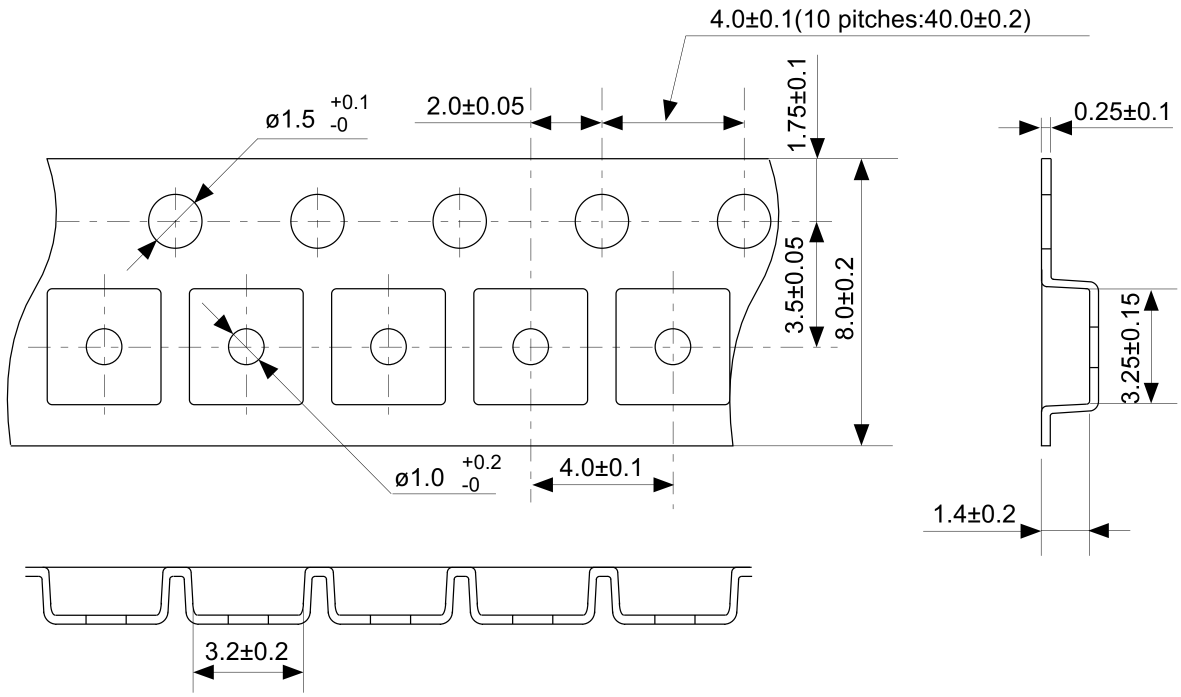

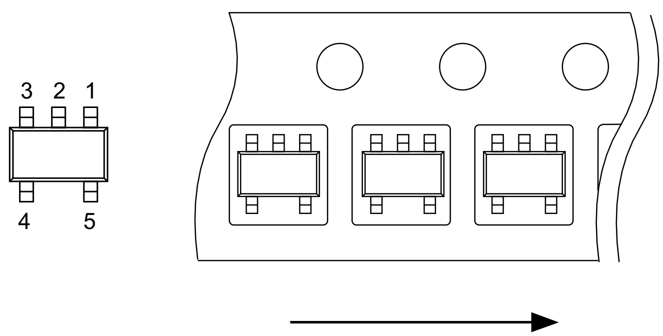

Feed direction

No. MP005-A-C-SD-2.1

TITLE	SOT235-A-Carrier Tape
No.	MP005-A-C-SD-2.1
SCALE	
UNIT	mm
Seiko Instruments Inc.	

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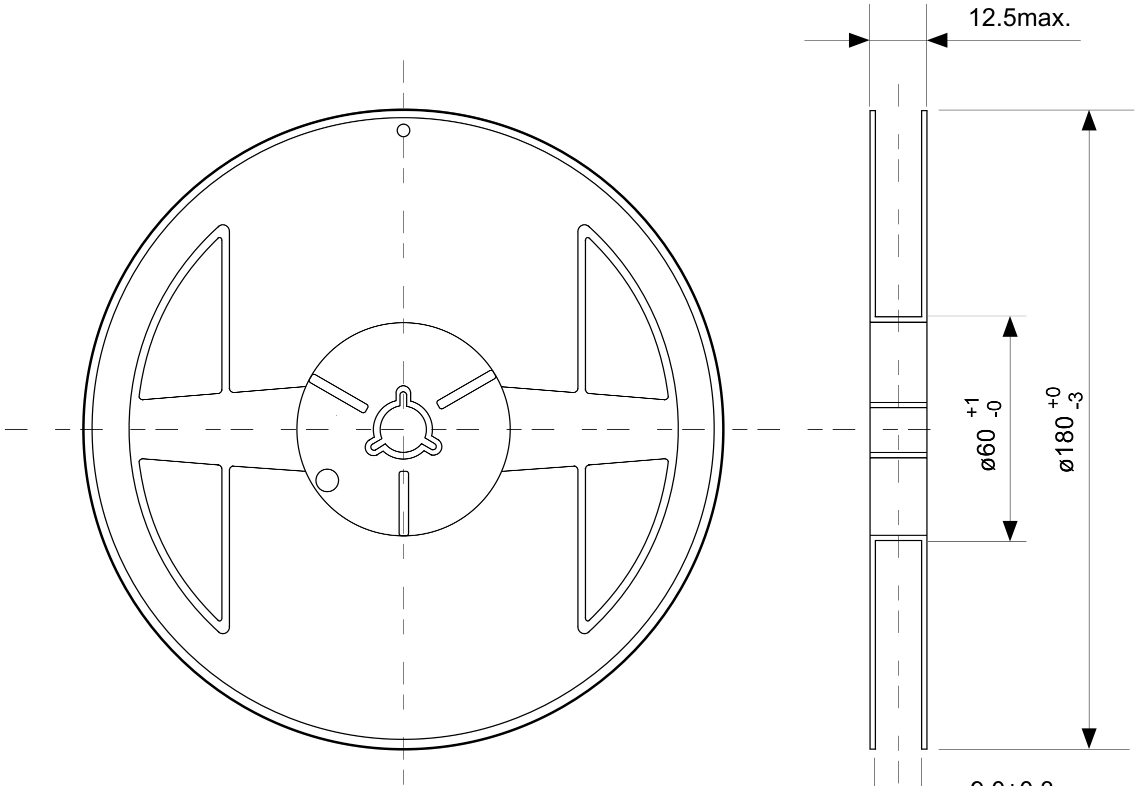
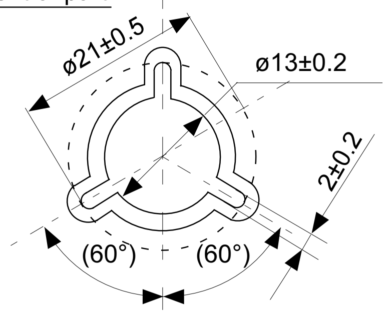


Enlarged drawing in the central part



No. MP005-A-R-SD-1.1

TITLE	SOT235-A-Reel		
No.	MP005-A-R-SD-1.1		
SCALE		QTY.	3,000
UNIT	mm		
Seiko Instruments Inc.			

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