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S-89430/89431 Series

MINI ANALOG SERIES
0.5 µA Rail-to-Rail CMOS OPERATIONAL AMPLIFIER

www.sii-ic.com

Rev.2.0_00

The mini-analog series is a group of ICs that incorporate a general purpose analog circuit in a small package.
The S-89430/89431 Series is a CMOS type operational amplifier that feature Rail-to-Rail*1 I/O and an internal phase compensation circuit, and operates at a lower voltage with lower current consumption. 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 Series is a single operational amplifier (one circuit).
The S-89430B/89431B Series is a dual operational amplifier (two circuits).

***1.** Rail-to-Rail is a trademark of Motorola, Inc.

■ Features

- Lower operating voltage than the conventional general-purpose: V_{DD} = 0.9 V to 5.5 V
- Low current consumption (per circuit): I_{DD} = 0.5 µA Typ.
- Wide I/O voltage range (Rail-to-Rail): V_{CMR} = V_{SS} to V_{DD}
- Low input offset voltage: V_{IO} = 10.0 mV Max. (S-89430 Series)
  V_{IO} = 5.0 mV Max. (S-89431 Series)
- No external capacitors required for internal phase compensation
- Lead-free, Sn 100%, halogen-free*1

***1.** Refer to "■ **Product Name Structure**" for details.

■ Application

- Mobile phones
- Notebook PCs
- Digital cameras
- Digital video cameras

■ Package

- SC-88A
- SOT-23-5
- SNT-8A
- TMSOP-8

■ Block Diagram

1. S-89430A/89431A Series single operational amplifier (one circuit)

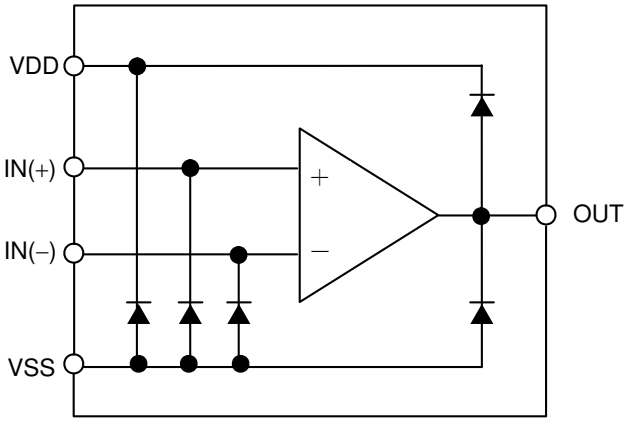


Figure 1

2. S-89430B/89431B Series dual operational amplifier (two circuits)

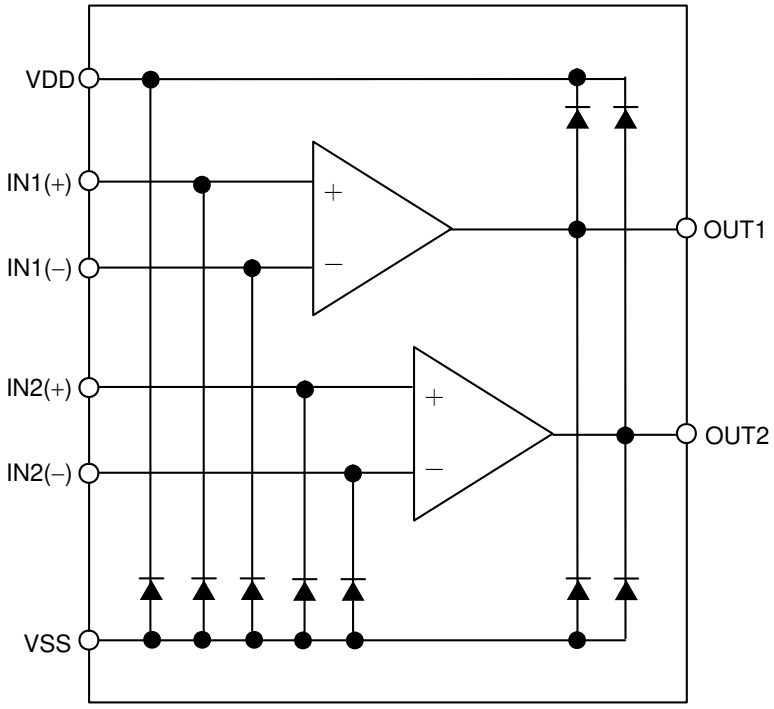


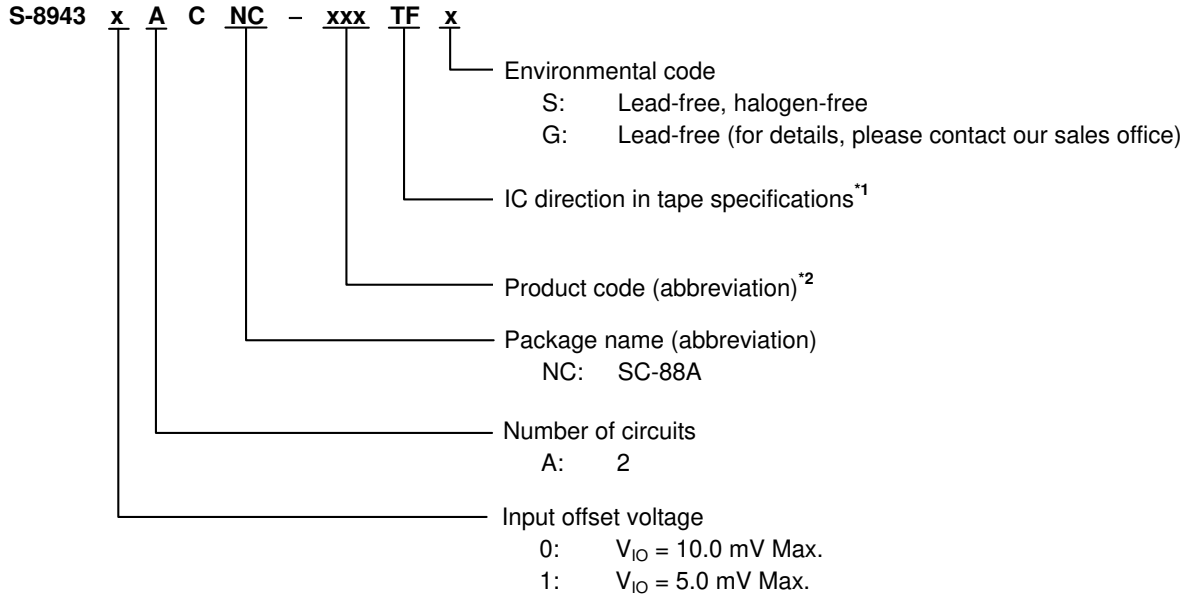
Figure 2

■ Product Name Structure

Users can select the product type for the S-89430/89431 Series. Refer to "**1. Product name**" regarding the contents of product name, "**2. Package**" regarding the package drawings and "**3. Product name list**" regarding the product type.

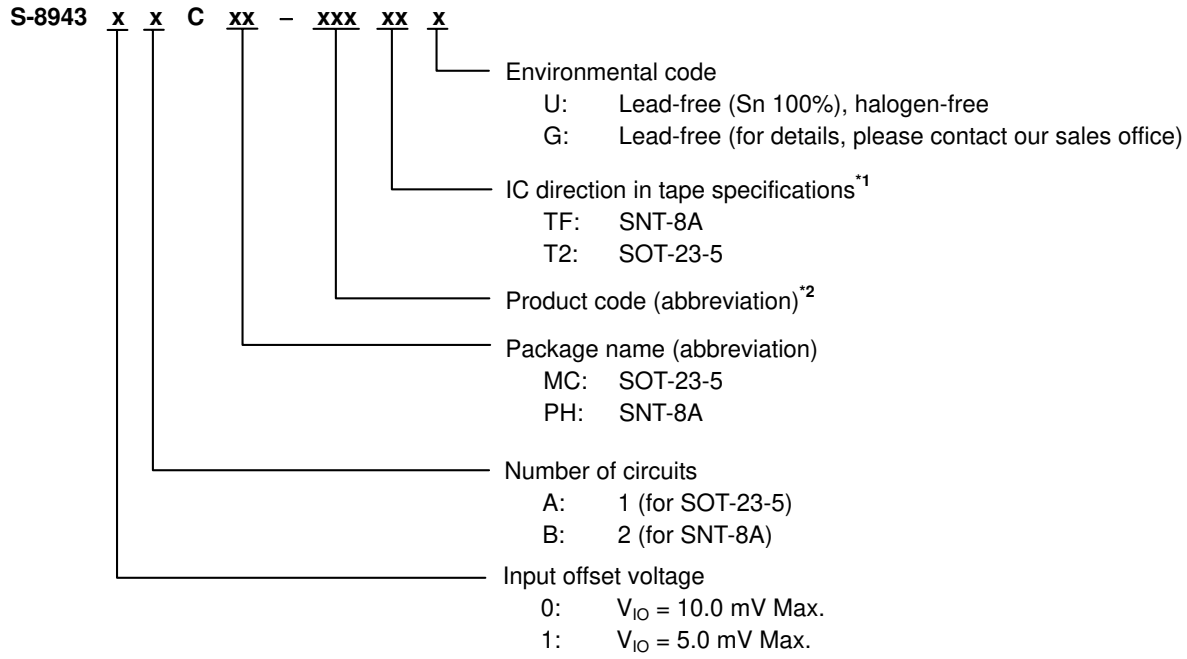
1. Product name

(1) SC-88A



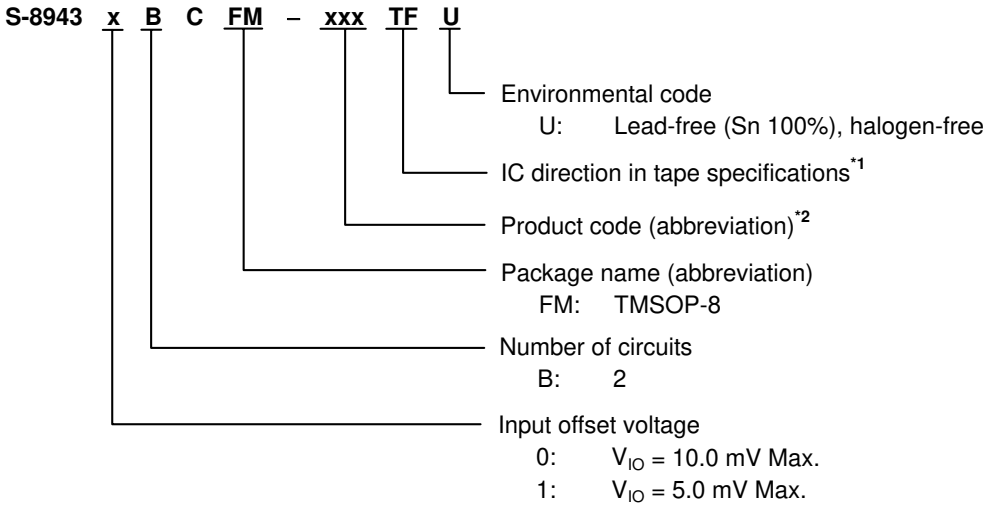
***1.** Refer to the tape specifications.
***2.** Refer to **"3. Product name list"**

(2) SOT-23-5, SNT-8A



***1.** Refer to the tape specifications.
***2.** Refer to **"3. Product name list"**

(3) TMSOP-8



***1.** Refer to the tape specifications.
***2.** Refer to **"3. Product name list"**

2. Package

Package Name	Drawing Code			
	Package	Tape	Reel	Land
SC-88A	NP005-B-P-SD	NP005-B-C-SD	NP005-B-R-SD	–
SOT-23-5	MP005-A-P-SD	MP005-A-C-SD	MP005-A-R-SD	–
SNT-8A	PH008-A-P-SD	PH008-A-C-SD	PH008-A-R-SD	PH008-A-L-SD
TMSOP-8	FM008-A-P-SD	FM008-A-C-SD	FM008-A-R-SD	–

3. Product name list

Table 1

Product name	Input offset voltage	Number of circuits	Package
S-89430ACNC-HBUTFz	10 mV Max.	1	SC-88A
S-89430ACMC-HBUT2x	10 mV Max.	1	SOT-23-5
S-89430BCPH-H4CTFx	10 mV Max.	2	SNT-8A
S-89430BCFM-H4CTFU	10 mV Max.	2	TMSOP-8
S-89431ACNC-HBVTFz	5 mV Max.	1	SC-88A
S-89431ACMC-HBVT2x	5 mV Max.	1	SOT-23-5
S-89431BCPH-H4DTFx	5 mV Max.	2	SNT-8A
S-89431BCFM-H4DTFU	5 mV Max.	2	TMSOP-8

Remark 1. x: G or U
2. z: G or S
3. Please select products of environmental code = U for Sn 100%, halogen-free products.

■ Pin Configuration

SC-88A
Top view

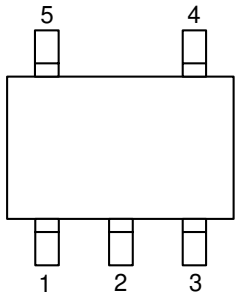


Figure 3

Table 2

(Product with 1 circuit)

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

SOT-23-5
Top view

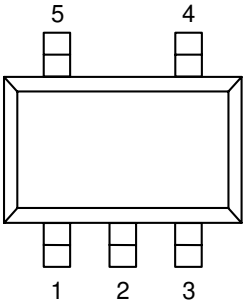


Figure 4

Table 3

(Product with 1 circuit)

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

SNT-8A
Top view

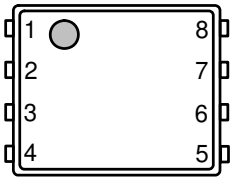


Figure 5

Table 4

(Product with 2 circuits)

Pin No.	Symbol	Description
1	OUT1	Output pin 1
2	IN1(–)	Inverted input pin 1
3	IN1(+)	Non-inverted input pin 1
4	VSS	GND pin
5	IN2(+)	Non-inverted input pin 2
6	IN2(–)	Inverted input pin 2
7	OUT2	Output pin 2
8	VDD	Positive power supply pin

TMSOP-8
Top view

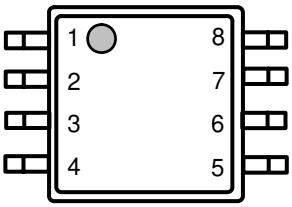


Figure 6

Table 5

(Product with 2 circuits)

Pin No.	Symbol	Description
1	OUT1	Output pin 1
2	IN1(−)	Inverted input pin 1
3	IN1(+)	Non-inverted input pin 1
4	VSS	GND pin
5	IN2(+)	Non-inverted input pin 2
6	IN2(−)	Inverted input pin 2
7	OUT2	Output pin 2
8	VDD	Positive power supply pin

■ Absolute Maximum Ratings

Table 6

(Ta = +25°C unless otherwise specified)

Parameter		Symbol	Absolute Maximum Rating	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}	7.0	mA
Power dissipation	SC-88A	P_D	350*1	mW
	SOT-23-5		600*1	mW
	SNT-8A		450*1	mW
	TMSOP-8		650*1	mW
Operating ambient temperature		T_{opr}	−40 to +85	°C
Storage temperature		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.

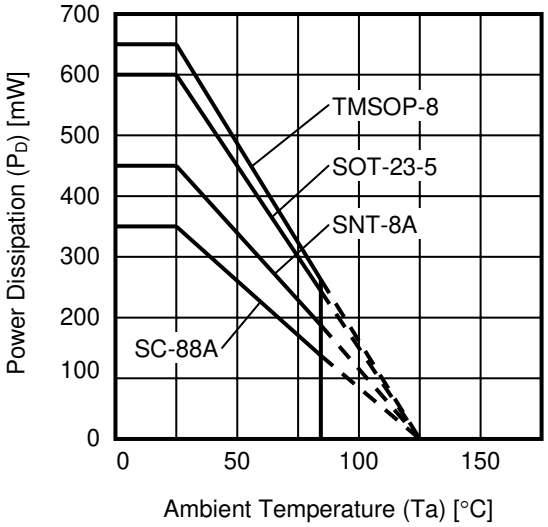


Figure 7 Power Dissipation of Package (When Mounted on Board)

■ Electrical Characteristics

Table 7

(Ta = +25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Test Circuit
Range of operating power supply voltage	V_{DD}	–	0.9	–	5.5	V	–

1. V_{DD} = 3.0 V

Table 8

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

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
Current consumption (per circuit)*1	I_{DD}	V_{CMR} = V_{OUT} = 1.5 V		–	0.50	0.75	μA	6
Input offset voltage	V_{IO}	V_{CMR} = 1.5 V	S-89430 Series	−10	±5	+10	mV	2
			S-89431 Series	−5	±3	+5	mV	2
Input offset current	I_{IO}	–		–	1	–	pA	–
Input bias current	I_{BIAS}	–		–	1	–	pA	–
Common-mode input voltage range	V_{CMR}	–		0	–	3	V	3
Voltage gain (open loop)	A_{VOL}	V_{SS} + 0.1 V ≤ V_{OUT} ≤ V_{DD} − 0.1 V, V_{CMR} = 1.5 V, R_L = 1.0 MΩ		70	80	–	dB	9
Maximum output swing voltage	V_{OH}	R_L = 100 kΩ		2.95	–	–	V	4
	V_{OL}	R_L = 100 kΩ		–	–	0.05	V	5
Common-mode input signal rejection ratio	CMRR	V_{SS} ≤ V_{CMR} ≤ V_{DD}		45	65	–	dB	3
Power supply voltage rejection ratio	PSRR	V_{DD} = 0.9 V to 5.5 V		70	80	–	dB	1
Source current	I_{SOURCE}	V_{OUT} = V_{DD} − 0.1 V		400	500	–	μA	7
		V_{OUT} = 0 V		4800	6000	–	μA	7
Sink current	I_{SINK}	V_{OUT} = 0.1 V		400	550	–	μA	8
		V_{OUT} = V_{DD}		4800	6000	–	μA	8

***1.** When the output is saturated on the V_{DD} side, a current consumption of up to 3 μA to 5 μA may flow.
Refer to "**4. Current consumption (per circuit) vs. Common-mode input voltage range characteristics (voltage follower configuration)**" in "■ **Characteristics (Typical Data)**".

Table 9

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

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, C_L = 15 pF (Refer to **Figure 17**)	–	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 10

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

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
Current consumption (per circuit)*1	I_{DD}	V_{CMR} = V_{OUT} = 0.9 V		–	0.50	0.75	μA	6
Input offset voltage	V_{IO}	V_{CMR} = 0.9 V	S-89430 Series	−10	±5	+10	mV	2
			S-89431 Series	−5	±3	+5	mV	2
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	3
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 = 1.0 MΩ		66	75	–	dB	9
Maximum output swing voltage	V_{OH}	R_L = 100 kΩ		1.75	–	–	V	4
	V_{OL}	R_L = 100 kΩ		–	–	0.05	V	5
Common-mode input signal rejection ratio	CMRR	V_{SS} ≤ V_{CMR} ≤ V_{DD}		35	55	–	dB	3
		V_{SS} ≤ V_{CMR} ≤ V_{DD} − 0.3 V		45	60	–	dB	3
Power supply voltage rejection ratio	PSRR	V_{DD} = 0.9 V to 5.5 V		70	80	–	dB	1
Source current	I_{SOURCE}	V_{OUT} = V_{DD} − 0.1 V		220	300	–	μA	7
		V_{OUT} = 0 V		1200	1800	–	μA	7
Sink current	I_{SINK}	V_{OUT} = 0.1 V		220	300	–	μA	8
		V_{OUT} = V_{DD}		1200	1800	–	μA	8

***1.** When the output is saturated on the V_{DD} side, a current consumption of up to 3 μA to 5 μA may flow.
Refer to "**4. Current consumption (per circuit) vs. Common-mode input voltage range characteristics (voltage follower configuration)**" in "■ **Characteristics (Typical Data)**".

Table 11

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

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, C_L = 15 pF (Refer to **Figure 17**)	–	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 12

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

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit	Test Circuit
Current consumption (per circuit)*1	I_{DD}	V_{CMR} = V_{OUT} = 0.45 V		–	0.50	0.75	μA	6
Input offset voltage	V_{IO}	V_{CMR} = 0.45 V	S-89430 Series	−10	±5	+10	mV	2
			S-89431 Series	−5	±3	+5	mV	2
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	3
Voltage gain (open loop)	A_{VOL}	V_{SS} + 0.1 V ≤ V_{OUT} ≤ V_{DD} − 0.1 V, V_{CMR} = 0.45 V, R_L = 1.0 MΩ		60	75	–	dB	9
Maximum output swing voltage	V_{OH}	R_L = 100 kΩ		0.85	–	–	V	4
	V_{OL}	R_L = 100 kΩ		–	–	0.05	V	5
Common-mode input signal rejection ratio	CMRR	V_{SS} ≤ V_{CMR} ≤ V_{DD}		25	55	–	dB	3
		V_{SS} ≤ V_{CMR} ≤ V_{DD} − 0.35 V		40	60	–	dB	3
Power supply voltage rejection ratio	PSRR	V_{DD} = 0.9 V to 5.5 V		70	80	–	dB	1
Source current	I_{SOURCE}	V_{OUT} = V_{DD} − 0.1 V		25	65	–	μA	7
		V_{OUT} = 0 V		40	140	–	μA	7
Sink current	I_{SINK}	V_{OUT} = 0.1 V		10	65	–	μA	8
		V_{OUT} = V_{DD}		12	120	–	μA	8

***1.** When the output is saturated on the V_{DD} side, a current consumption of up to 3 μA to 5 μA may flow.
Refer to "**4. Current consumption (per circuit) vs. Common-mode input voltage range characteristics (voltage follower configuration)**" in "■ **Characteristics (Typical Data)**".

Table 13

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

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, C_L = 15 pF (Refer to **Figure 17**)	–	4	–	V/ms
Gain-bandwidth product	GBP	C_L = 0 pF	–	5	–	kHz
Maximum load capacitance	C_L	–	–	47	–	pF

■ Test Circuit (Per Circuit)

1. Power supply voltage rejection ratio

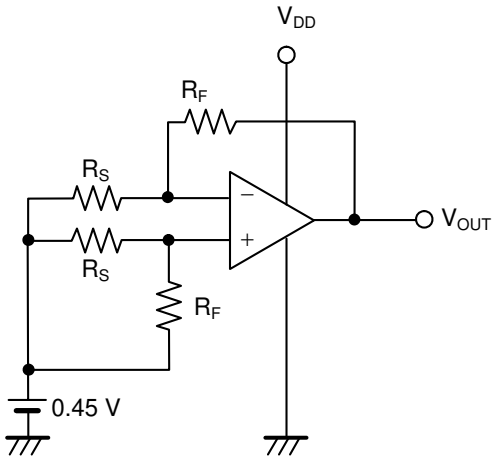


Figure 8

- **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}.

  Test 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

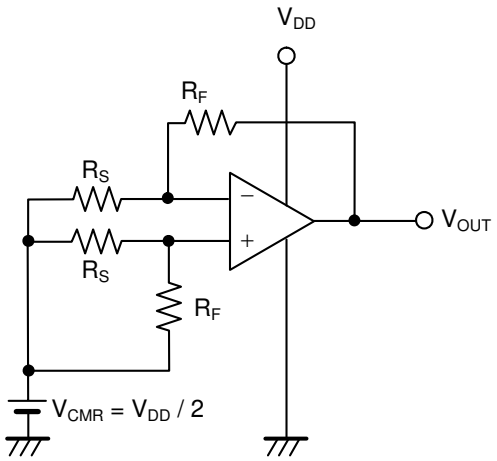


Figure 9

- **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 range

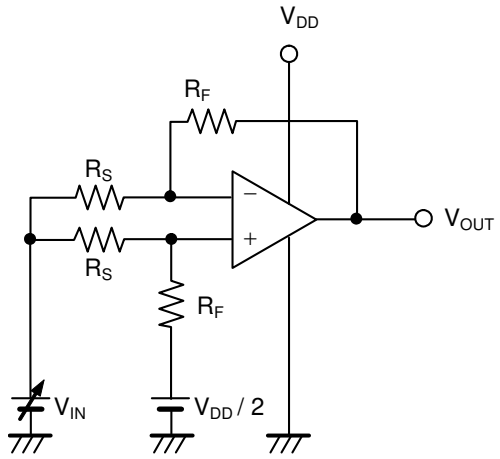


Figure 10

- **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}.

  Test 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 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 (V_{OH})

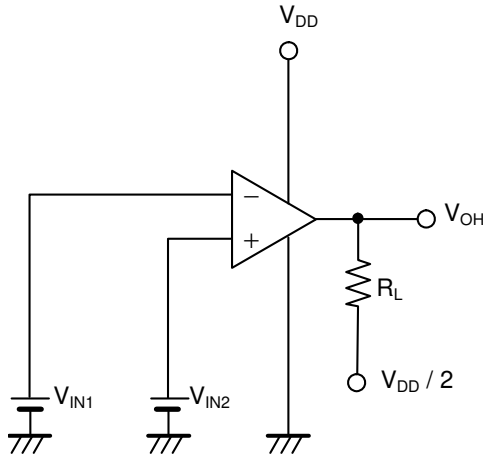


Figure 11

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

  Test conditions:
  $V_{IN1} = \frac{V_{DD}}{2} - 0.1$ V
  $V_{IN2} = \frac{V_{DD}}{2} + 0.1$ V
  $R_L = 100$ kΩ

5. Maximum output swing voltage (V_{OL})

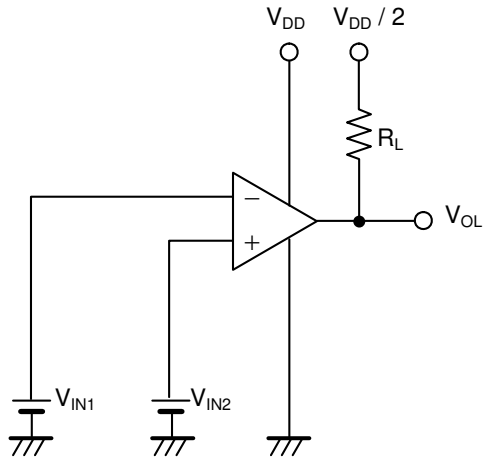


Figure 12

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

  Test conditions:
  $V_{IN1} = \frac{V_{DD}}{2} + 0.1$ V
  $V_{IN2} = \frac{V_{DD}}{2} - 0.1$ V
  $R_L = 100$ kΩ

6. Current consumption

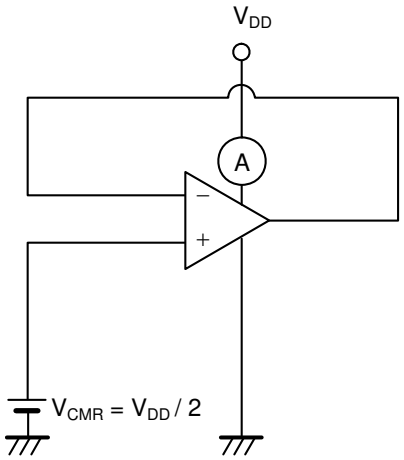


Figure 13

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

7. Source current

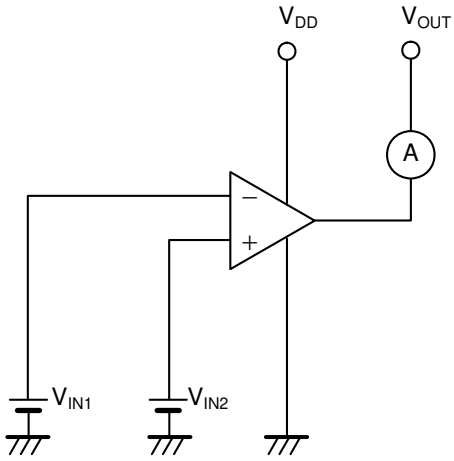


Figure 14

- **Source current (I_{SOURCE})**

  Test 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

8. Sink current

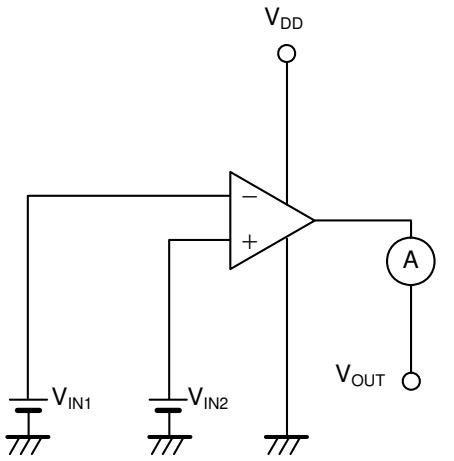


Figure 15

- **Sink current (I_{SINK})**

  Test 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

9. Voltage gain (open loop)

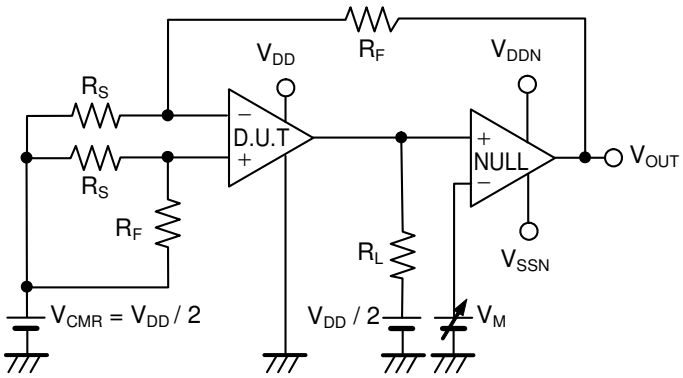


Figure 16

- **Voltage gain (open loop) (A_{VOL})**

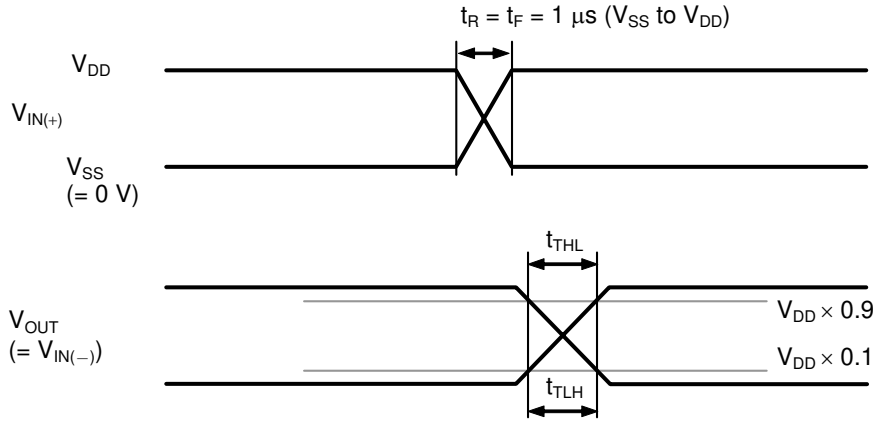
  The voltage gain (A_{VOL}) can be calculated by the following expression, with measured V_{OUT} at each V_M.

  Test conditions:
  When $V_M = V_{DD} - 0.1$ V: $V_M = V_{M1}$, $V_{OUT} = V_{OUT1}$,
  When $V_M = V_{SS} - 0.1$ V: $V_M = V_{M2}$, $V_{OUT} = V_{OUT2}$
  R_L = 1 MΩ

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

10. Slew rate (SR)

Measured by the voltage follower circuit.



At fall
$SR = \frac{V_{DD} \times 0.8}{t_{THL}}$

At rise
$SR = \frac{V_{DD} \times 0.8}{t_{TLH}}$

Figure 17

■ Precautions

- When the output is saturated on the V_{DD} side, a current consumption of up to 3 μA to 5 μA may flow.
  Refer to "**4. Current consumption (per circuit) vs. Common-mode input voltage range characteristics (voltage follower configuration)**" in "**■ Characteristics (Typical Data)**".

- Do not apply an electrostatic discharge to this IC that exceeds performance ratings of the built-in electrostatic protection circuit.

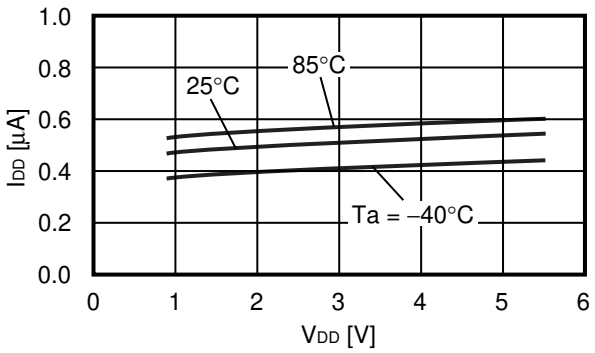
- Use this IC with the output current 7 mA or less.

- 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.

■ Characteristics (Typical Data)

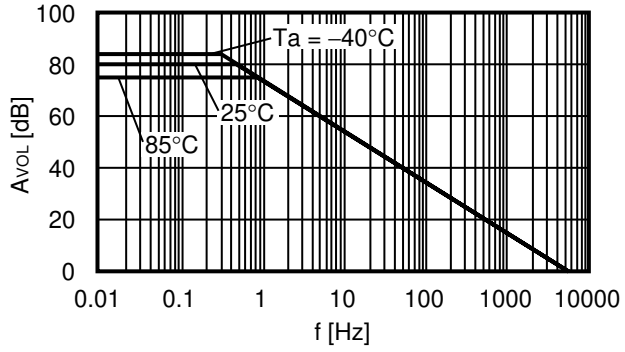
1. Current consumption (per circuit) vs. Power supply voltage

I_{DD}–V_{DD}, V_{SS} = 0 V, V_{CMR} = V_{OUT} = $\frac{V_{DD}}{2}$

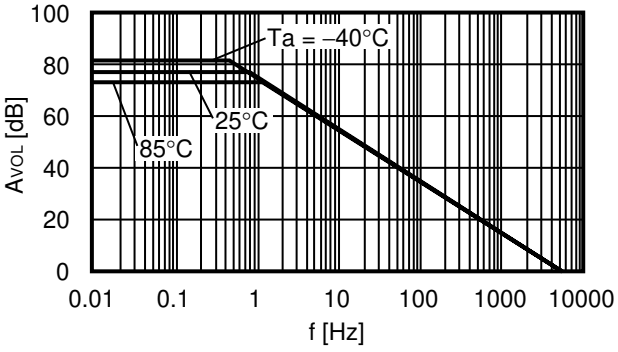


2. Voltage gain vs. Frequency

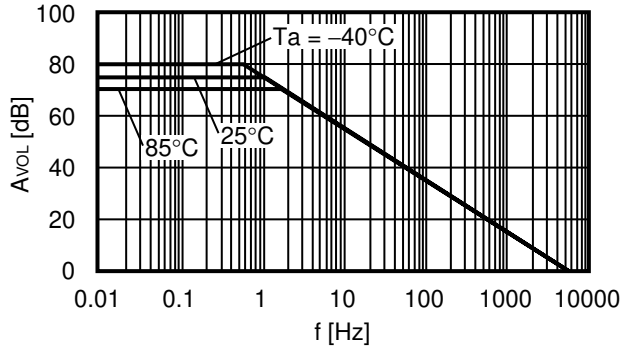
A_{VOL}–f, V_{DD} = 3.0 V, V_{SS} = 0 V



A_{VOL}–f, V_{DD} = 1.8 V, V_{SS} = 0 V

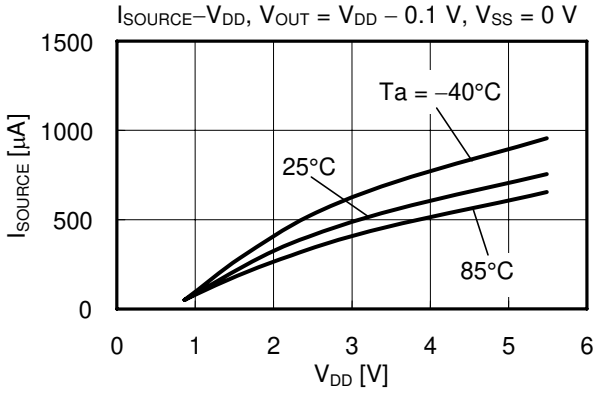


A_{VOL}–f, V_{DD} = 0.9 V, V_{SS} = 0 V

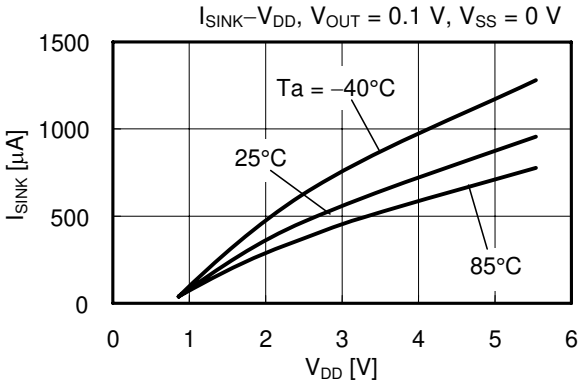


3. Output current

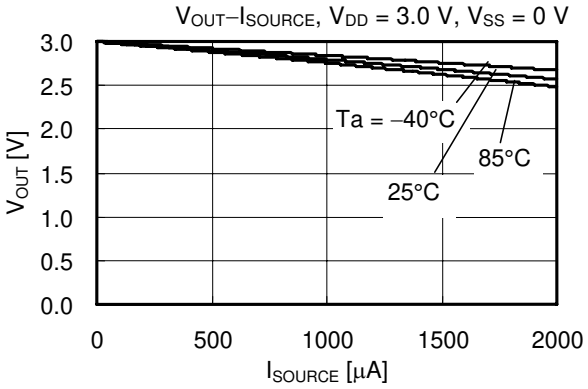
3. 1 I_{SOURCE} vs. Power supply voltage

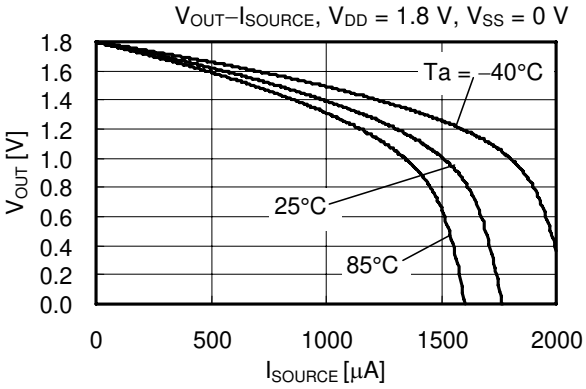


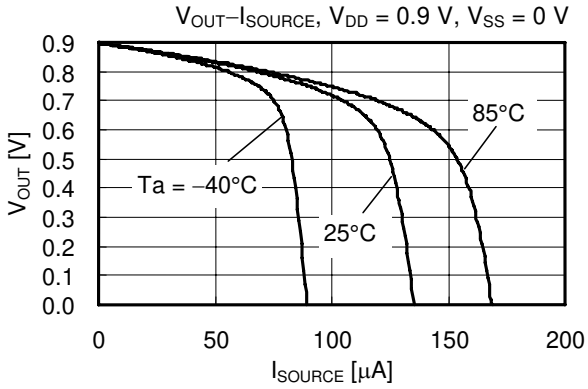
3. 2 I_{SINK} vs. Power supply voltage



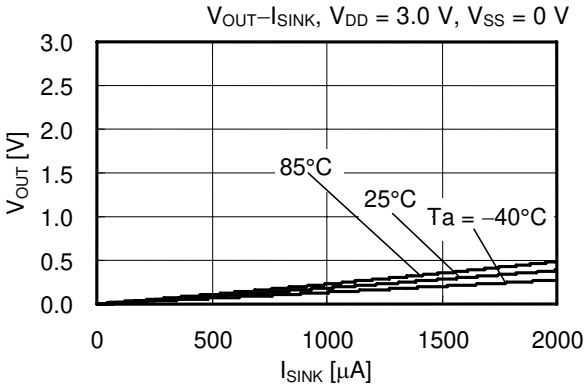
3. 3 Output voltage (V_{OUT}) vs. I_{SOURCE}

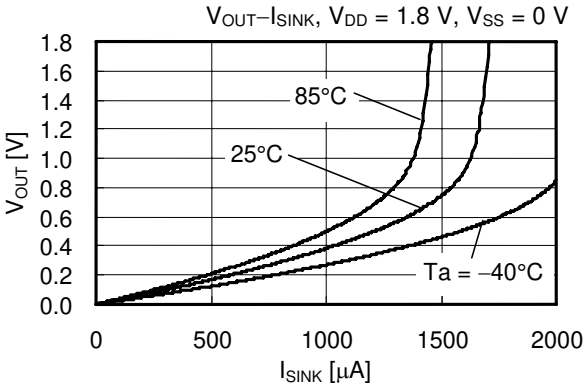


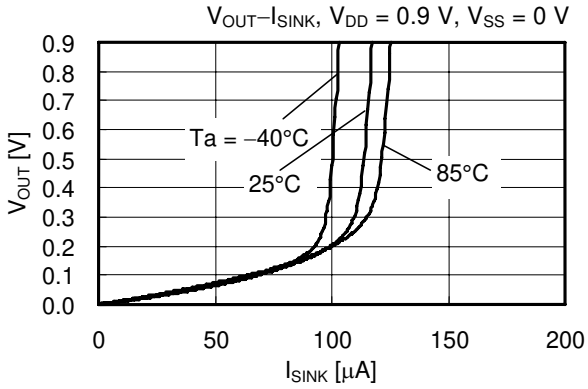




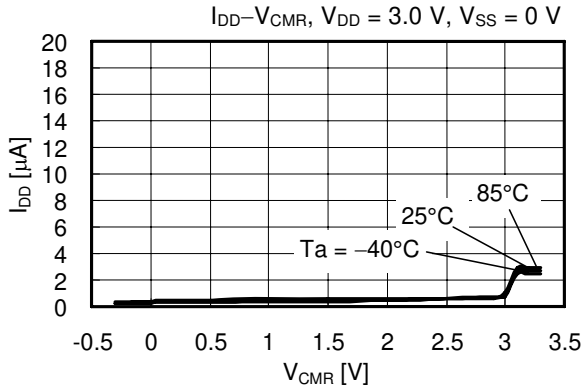
3. 4 Output voltage (V_{OUT}) vs. I_{SINK}

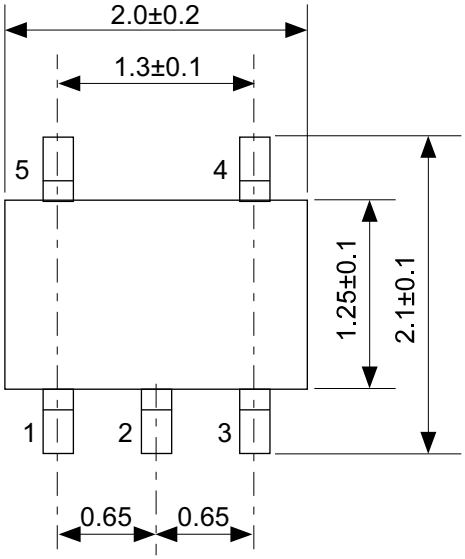


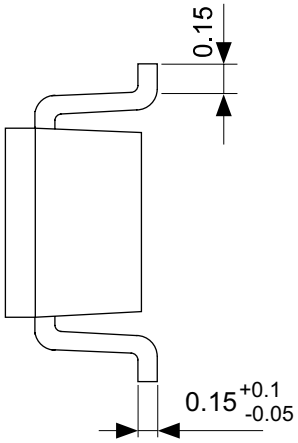


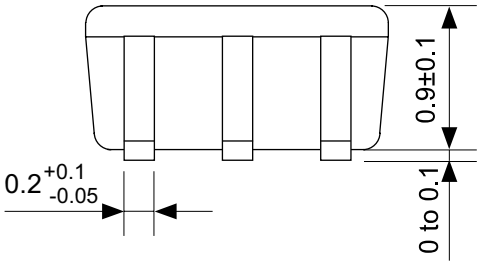


4. Current consumption (per circuit) vs. Common-mode input voltage range (voltage follower configuration)



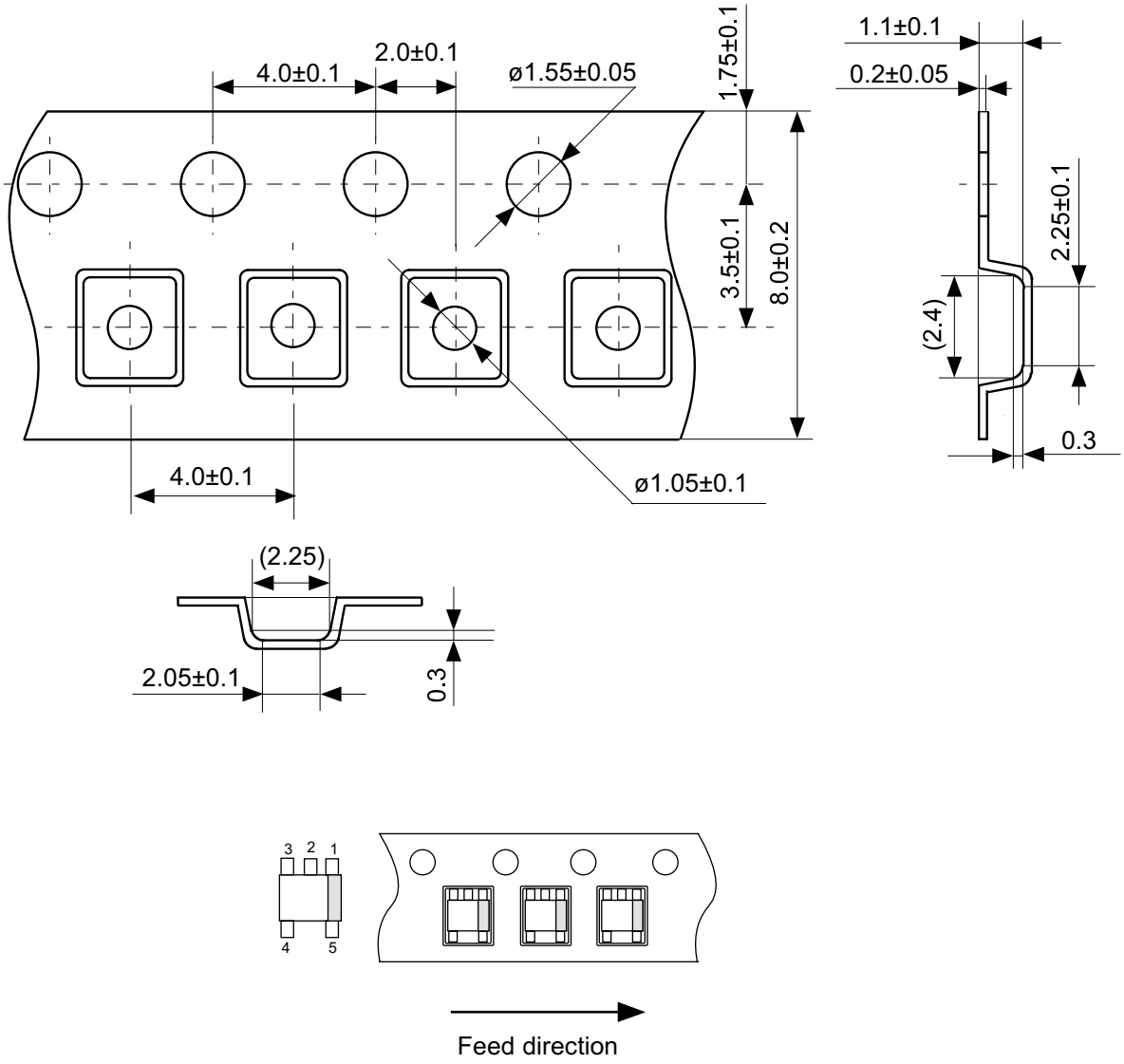






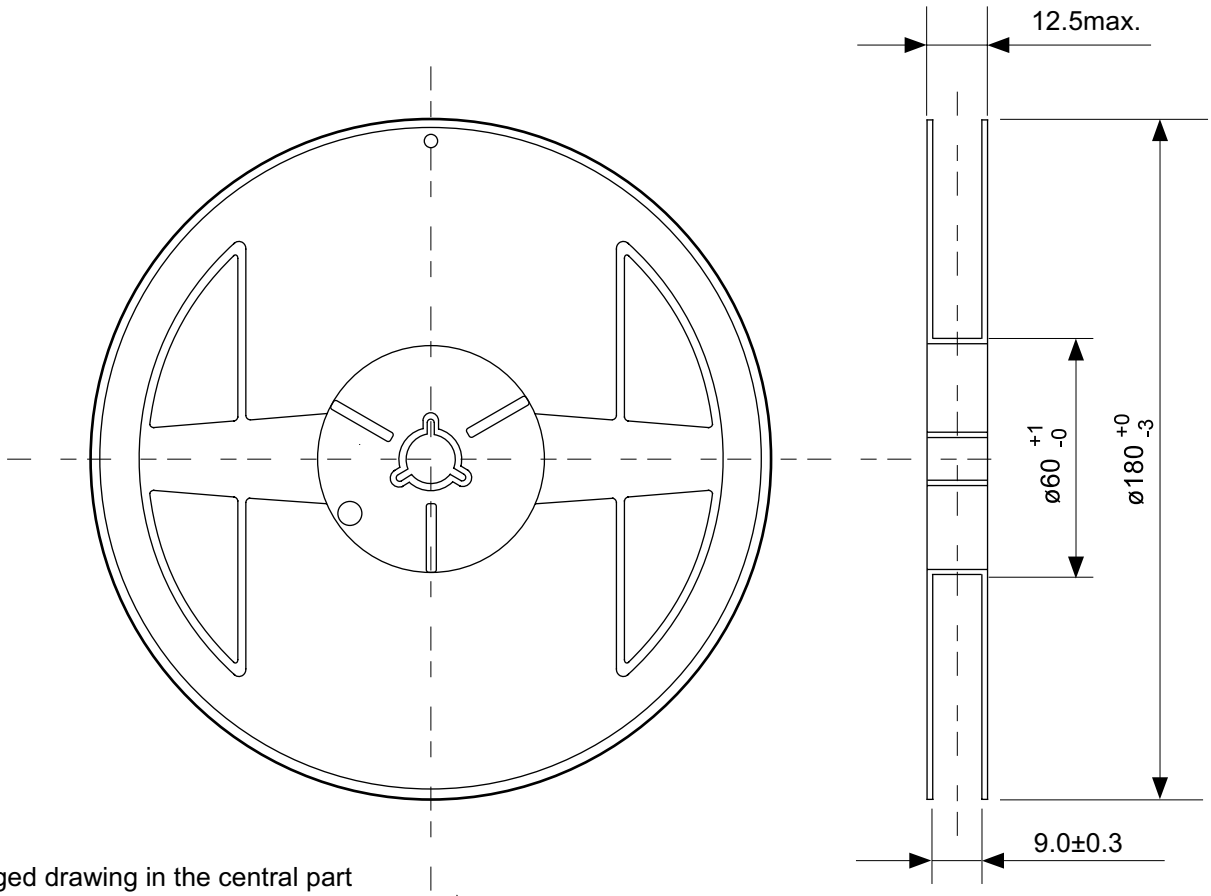
No. NP005-B-P-SD-1.1

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

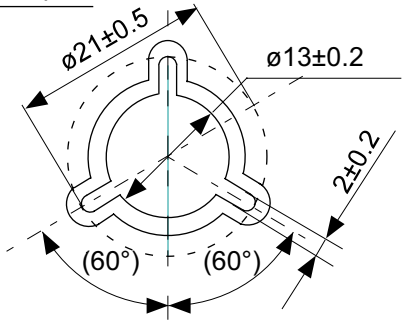


No. NP005-B-C-SD-2.0

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

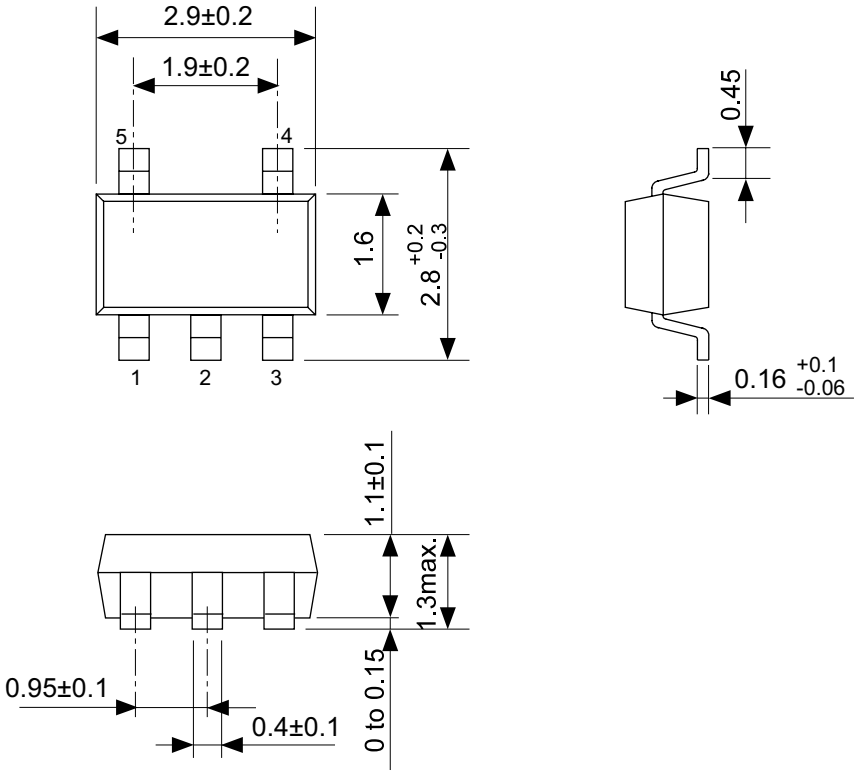


Enlarged drawing in the central part



No. NP005-B-R-SD-2.1

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



No. MP005-A-P-SD-1.2

TITLE	SOT235-A-PKG Dimensions
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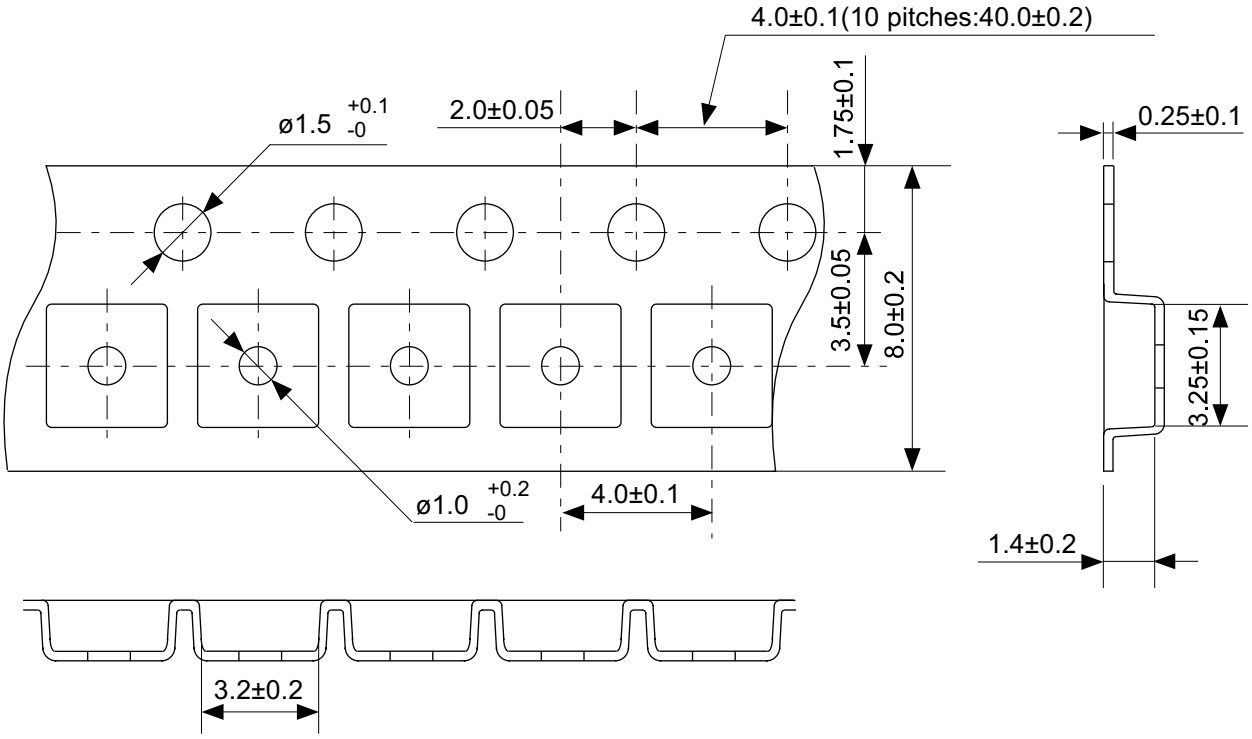
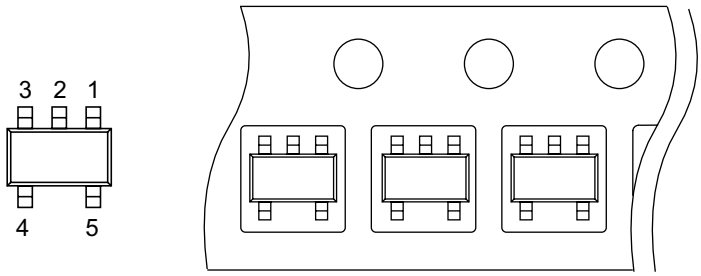
UNIT	mm
Seiko Instruments Inc.	





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.	