**MINI ANALOG SERIES**
**CMOS SINGLE OPERATIONAL AMPLIFIER**

# S-891xxA Series

The mini-analog series is a group of ICs that incorporate a general purpose analog circuit in an ultra-small package.
The S-891xxA Series is a CMOS type single operational amplifier that has a 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.

## ■ Features

- CMOS operational amplifier
- Low operating voltage: $V_{DD}$ = 1.8 to 5.5 V
- Low current consumption: $I_{DD}$ = 50 μA (S-89110ANC)
  $I_{DD}$ = 10 μA (S-89120ANC)
- Low input offset voltage (4.0 mV max.)
- No external capaciters required for internal phase compensation
- Output full swing
- Small package (SC-88A: 2.0 mm × 2.1 mm)

## ■ Application

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

## ■ Package

SC-88A (PKG drawing code: NP005-B)

## ■ Selection Guide

**Table 1**

| Current consumption | Product Name |
|---|---|
| $I_{DD}$ = 50 μA | S-89110ANC-1A1-TF |
| $I_{DD}$ = 10 μA | S-89120ANC-1A2-TF |

## ■ Absolute Maximum Ratings

**Table 2**

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Power supply voltage | $V_{DD} - V_{SS}$ | 10.0 | V |
| Input voltage | $V_{IN}$ | $V_{SS}$ to $V_{DD}$ (7.0 max.) | V |
| Output voltage | $V_{OUT}$ | $V_{SS}$ to $V_{DD}$ (7.0 max.) | V |
| Differential input voltage | $V_{IND}$ | ±7.0 | V |
| Power dissipation | $P_D$ | 200 | mW |
| Operating temperature range | $T_{opr}$ | −40 to +85 | °C |
| Storage temperature range | $T_{stg}$ | −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.**

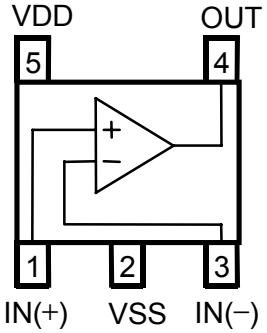
## ■ Recommended Operating Power Supply Voltage Range

**Table 3**

| Parameter | Symbol | Range |
|---|---|---|
| Operating power supply voltage range | $V_{DD}$ | 1.8 to 5.5 V |

## ■ Pin Configuration

**5-Pin SC-88A Top View**




**(S-89110ANC, S-89120ANC)**

**Figure 1**

**Table 4**

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

**[Internal equivalent circuits]**

<1> Output pin

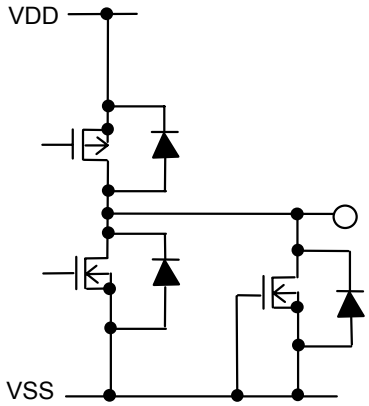



**Figure 2**

<2> Input pin

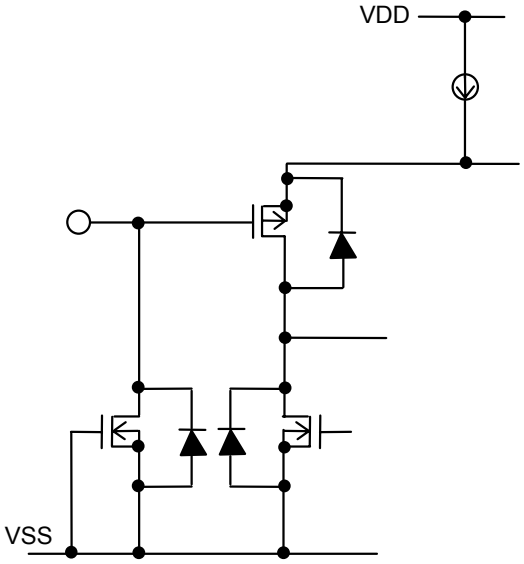



**Figure 3**

<3> VDD pin

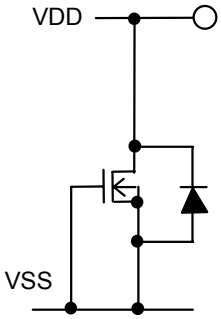



**Figure 4**

## ■ Electrical Characteristics

1. $V_{DD}$ = 5.0 V

DC Characteristics ($V_{DD}$ = 5.0 V) **Table 5** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit | Measurement Circuit |
|---|---|---|---|---|---|---|---|---|
| Input offset voltage | — | $V_{IO}$ | — | — | ±3 | ±4 | mV | Figure 5 |
| Input offset current | — | $I_{IO}$ | — | — | 1 | — | pA | — |
| Input bias current | — | $I_{BIAS}$ | — | — | 1 | — | pA | — |
| Common-mode input voltage range | — | $V_{CMR}$ | — | 0 | — | 4.3 | V | — |
| Voltage gain (open loop) | — | $G_V$ | — | 70 | 80 | — | dB | — |
| Maximum output swing voltage | — | $V_{OH}$ | $R_L$ = 1.0 MΩ | 4.9 | — | — | V | Figure 7 |
| | — | $V_{OL}$ | $R_L$ = 1.0 MΩ | | | 0.1 | V | Figure 8 |
| Common-mode input signal rejection ratio | — | CMRR | — | 60 | 70 | — | dB | Figure 6 |
| Power supply voltage rejection ratio | — | PSRR | — | 60 | 70 | — | dB | Figure 5 |
| Supply current | S-89110A | $I_{DD}$ | — | — | 50 | 120 | µA | Figure 9 |
| | S-89120A | $I_{DD}$ | — | — | 10 | 30 | µA | Figure 9 |
| Source current | S-89110A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 120 | — | — | µA | Figure 10 |
| | S-89120A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 25 | — | — | µA | Figure 10 |
| Sink current | — | $I_{SINK}$ | $V_{OL}$ = $V_{DD}$ | 20 | — | — | mA | Figure 11 |

AC Characteristics ($V_{DD}$ = 5.0 V) **Table 6** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | S-89110A | SR | $R_L$ = 1.0 MΩ<br>$C_L$ = 15 pF<br>(Refer to **Figure 12.**) | — | 0.07 | — | V/µs |
| | S-89120A | SR | | — | 0.015 | — | V/µs |
| Gain-bandwidth product | S-89110A | GBP | — | — | 180 | — | kHz |
| | S-89120A | GBP | | — | 40 | — | kHz |

2. $V_{DD}$ = 3.0 V

DC Characteristics ($V_{DD}$ = 3.0 V) **Table 7** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit | Measurement Circuit |
|---|---|---|---|---|---|---|---|---|
| Input offset voltage | — | $V_{IO}$ | — | — | ±3 | ±4 | mV | Figure 5 |
| Input offset current | — | $I_{IO}$ | | — | 1 | — | pA | — |
| Input bias current | — | $I_{BIAS}$ | — | — | 1 | — | pA | — |
| Common-mode input voltage range | — | $V_{CMR}$ | — | 0 | — | 2.3 | V | — |
| Voltage gain (open loop) | — | $G_V$ | — | 70 | 80 | — | dB | — |
| Maximum output swing voltage | — | $V_{OH}$ | $R_L$ = 1.0 MΩ | 2.9 | — | — | V | Figure 7 |
| | — | $V_{OL}$ | $R_L$ = 1.0 MΩ | — | — | 0.1 | V | Figure 8 |
| Common-mode input signal rejection ratio | — | CMRR | — | 60 | 70 | — | dB | Figure 6 |
| Power supply voltage rejection ratio | — | PSRR | — | 60 | 70 | — | dB | Figure 5 |
| Supply current | S-89110A | $I_{DD}$ | — | — | 50 | 120 | µA | Figure 9 |
| | S-89120A | $I_{DD}$ | — | — | 10 | 30 | µA | Figure 9 |
| Source current | S-89110A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 120 | — | — | µA | Figure 10 |
| | S-89120A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 25 | — | — | µA | Figure 10 |
| Sink current | — | $I_{SINK}$ | $V_{OL}$ = $V_{DD}$ | 15 | — | — | mA | Figure 11 |

AC Characteristics ($V_{DD}$ = 3.0 V) **Table 8** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | S-89110A | SR | $R_L$ = 1.0 MΩ<br>$C_L$ = 15 pF<br>(Refer to **Figure 12.**) | — | 0.07 | — | V/µs |
| | S-89120A | SR | | — | 0.015 | — | V/µs |
| Gain-bandwidth product | S-89110A | GBP | — | — | 175 | — | kHz |
| | S-89120A | GBP | | — | 35 | — | kHz |

3. $V_{DD}$ = 1.8 V

DC Characteristics ($V_{DD}$ = 1.8 V) **Table 9** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit | Measurement Circuit |
|---|---|---|---|---|---|---|---|---|
| Input offset voltage | — | $V_{IO}$ | — | — | ±3 | ±4 | mV | Figure 5 |
| Input offset current | — | $I_{IO}$ | — | — | 1 | — | pA | — |
| Input bias current | — | $I_{BIAS}$ | — | — | 1 | — | pA | — |
| Common-mode input voltage range | — | $V_{CMR}$ | — | 0 | — | 1.1 | V | — |
| Voltage gain (open loop) | — | $G_V$ | — | 70 | 80 | — | dB | — |
| Maximum output swing voltage | — | $V_{OH}$ | $R_L$ = 1.0 MΩ | 1.7 | — | — | V | Figure 7 |
| | — | $V_{OL}$ | $R_L$ = 1.0 MΩ | — | — | 0.1 | V | Figure 8 |
| Common-mode input signal rejection ratio | — | CMRR | — | 60 | 70 | — | dB | Figure 6 |
| Power supply voltage rejection ratio | — | PSRR | — | 60 | 70 | — | dB | Figure 5 |
| Supply current | S-89110A | $I_{DD}$ | — | — | 50 | 120 | µA | Figure 9 |
| | S-89120A | $I_{DD}$ | — | — | 10 | 30 | µA | Figure 9 |
| Source current | S-89110A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 100 | — | — | µA | Figure 10 |
| | S-89120A | $I_{SOURCE}$ | $V_{OH}$ = 0 V | 20 | — | — | µA | Figure 10 |
| Sink current | — | $I_{SINK}$ | $V_{OL}$ = $V_{DD}$ | 5 | — | — | mA | Figure 11 |

AC Characteristics ($V_{DD}$ = 1.8 V) **Table 10** (Ta = 25°C unless otherwise specified)

| Parameter | Model No. | Symbol | Measurement Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | S-89110A | SR | $R_L$ = 1.0 MΩ<br>$C_L$ = 15 pF<br>(Refer to **Figure 12.**) | — | 0.07 | — | V/µs |
| | S-89120A | SR | | — | 0.015 | — | V/µs |
| Gain-bandwidth product | S-89110A | GBP | — | — | 160 | — | kHz |
| | S-89120A | GBP | | — | 30 | — | kHz |

## ■ Measurement Circuit

1. Power supply voltage rejection ratio, input offset voltage

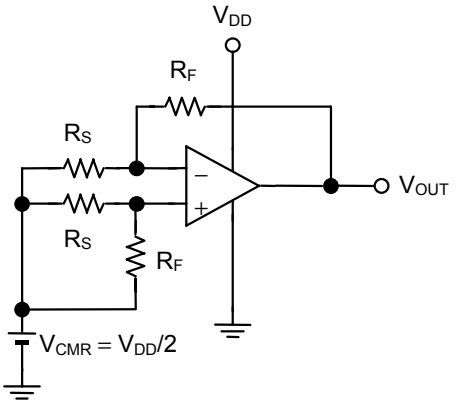



**Figure 5**

- Power supply voltage rejection ratio
  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 $V_{DD}$ = 1.8 V: $V_{DD} = V_{DD1}$, $V_{OUT} = V_{OUT1}$
  When $V_{DD}$ = 5.0 V: $V_{DD} = V_{DD2}$, $V_{OUT} = V_{OUT2}$

$$PSRR = 20\log\left(\left|\frac{V_{DD1}-V_{DD2}}{\left(V_{OUT1}-\frac{V_{DD1}}{2}\right)-\left(V_{OUT2}-\frac{V_{DD2}}{2}\right)}\right|\times\frac{R_F+R_S}{R_S}\right)$$

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

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

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

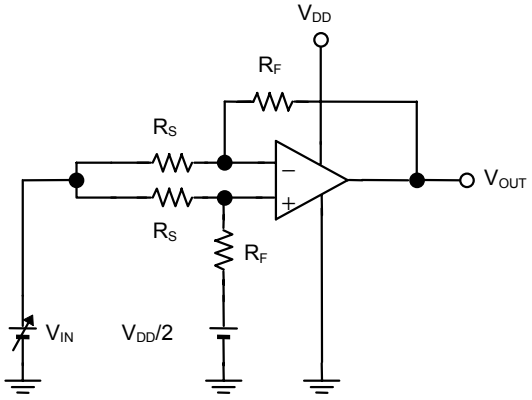



**Figure 6**

- Common-mode input signal rejection ratio
  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 $V_{IN} = V_{DD}/2$: $V_{IN} = V_{IN2}$, $V_{OUT} = V_{OUT2}$

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

- Common-mode input voltage range
  The common-mode input voltage range is the range of $V_{IN2}$ in which $V_{OUT}$ satisfies the common-mode input signal rejection ratio specifications.

3. Maximum output swing voltage ($V_{OH}$)

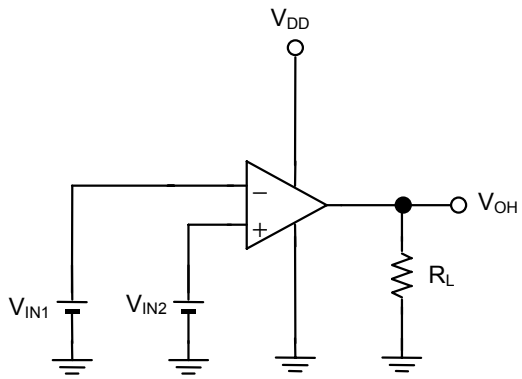



**Figure 7**

- Maximum output swing voltage ($V_{OH}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} - 0.5\ V$
  $V_{IN2} = \frac{V_{DD}}{2} + 0.5\ V$
  $R_L = 1\ M\Omega$

4. Maximum output swing voltage ($V_{OL}$)

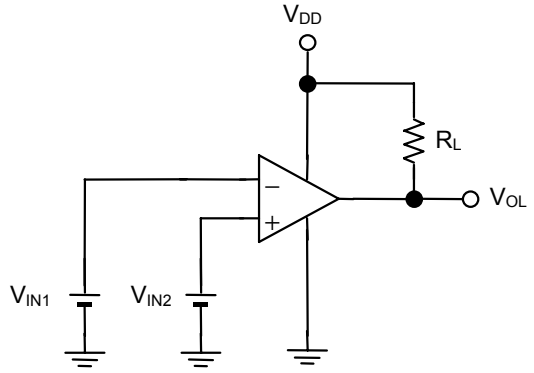



**Figure 8**

- Maximum output swing voltage ($V_{OL}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} + 0.5\ V$
  $V_{IN2} = \frac{V_{DD}}{2} - 0.5\ V$
  $R_L = 1\ M\Omega$

5. Supply current ($I_{DD}$)

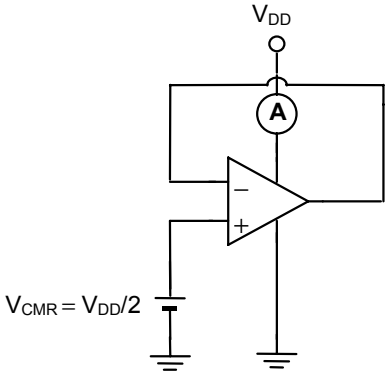



**Figure 9**

6. Source current ($I_{SOURCE}$)

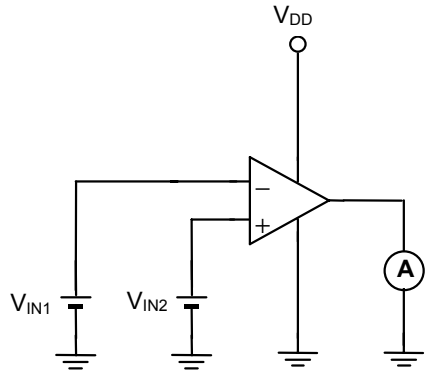



**Figure 10**

- Source current ($I_{SOURCE}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} - 0.5\ V$
  $V_{IN2} = \frac{V_{DD}}{2} + 0.5\ V$

7. Sink current ($I_{SINK}$)

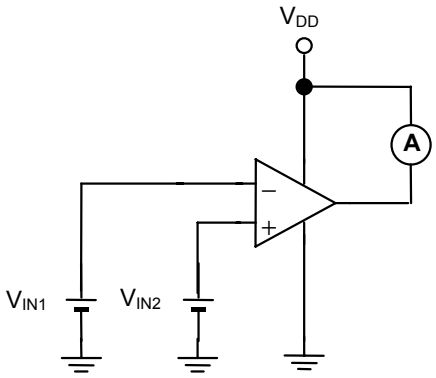



**Figure 11**

- Sink current ($I_{SINK}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} + 0.5\ V$
  $V_{IN2} = \frac{V_{DD}}{2} - 0.5\ V$

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

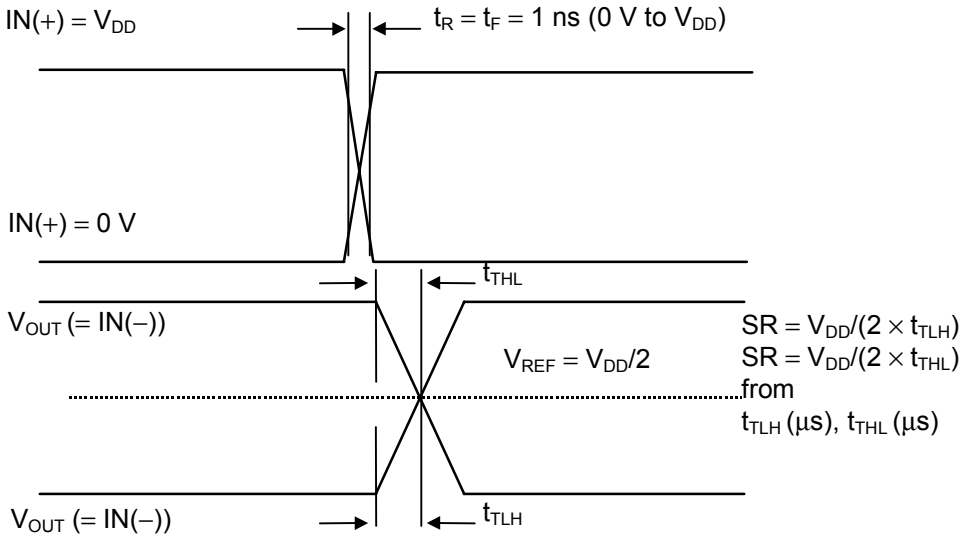
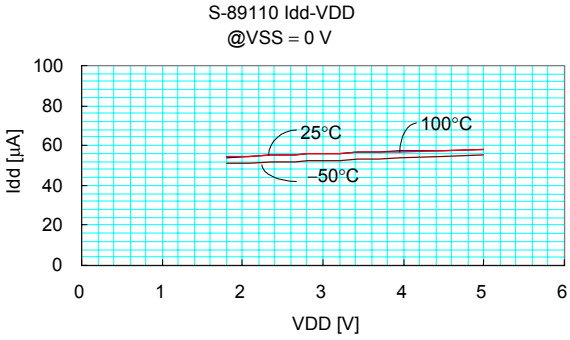
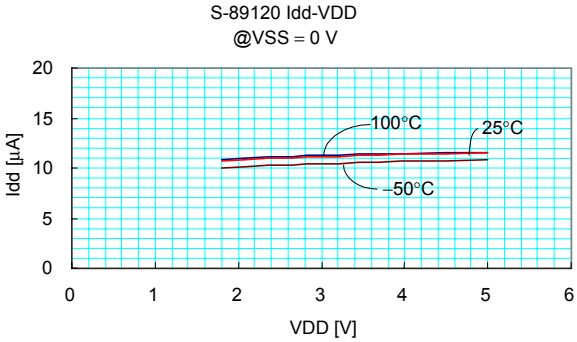



**Figure 12**

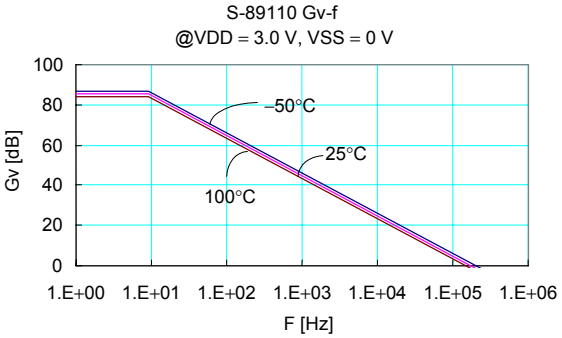
## ■ Operational Amplifier Characteristics (All Data Indicates Typical Values for One Circuit )

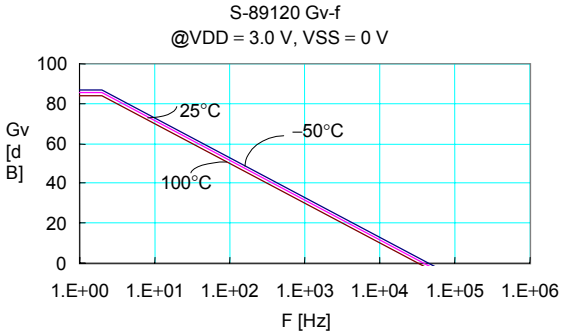
1. Current consumption vs. Power supply voltage



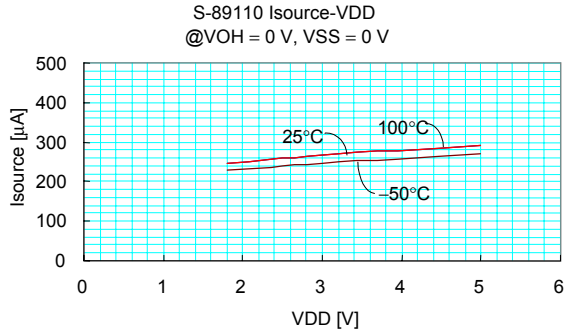

2. Voltage gain vs. Frequency

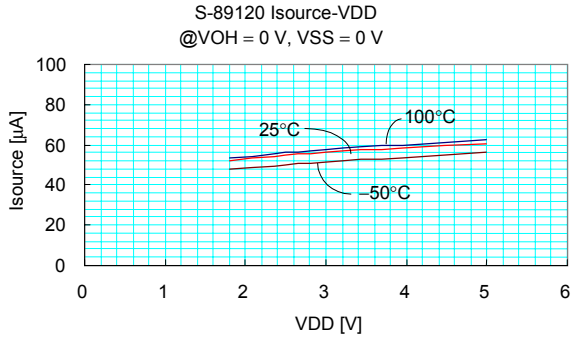



3. Output current

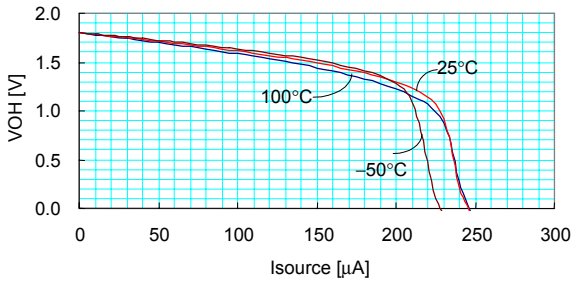
3-1. $I_{SOURCE}$ vs. Power supply voltage



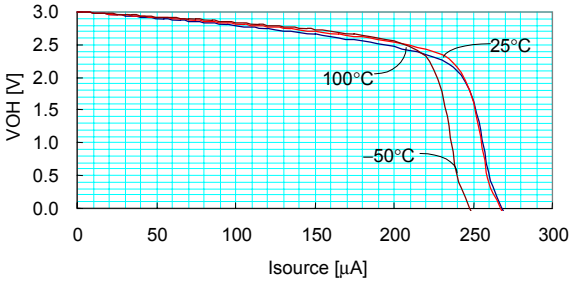



### 3-2. $I_{SOURCE}$ vs. Output voltage ($V_{OH}$)

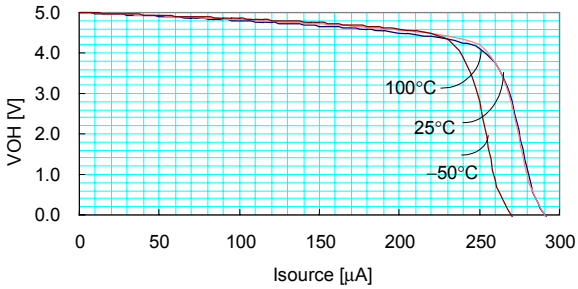
S-89110 Isource-VOH
@VDD = 1.8 V, VSS = 0 V



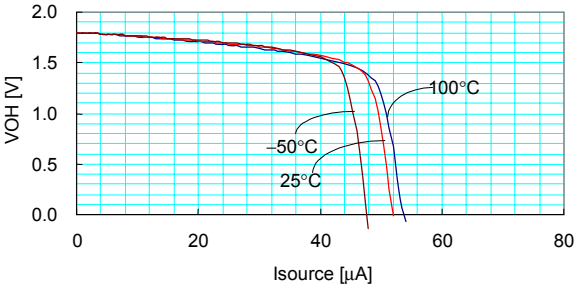

S-89110 Isource-VOH
@VDD = 3.0 V, VSS = 0 V



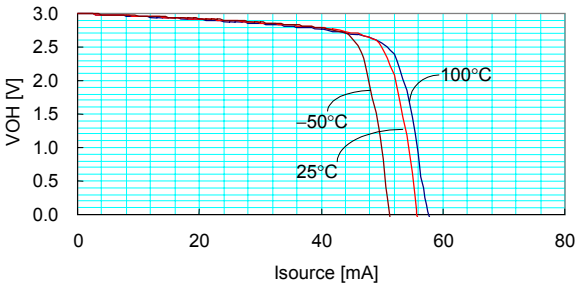

S-89110 Isource-VOH
@VDD = 5.0 V, VSS = 0 V



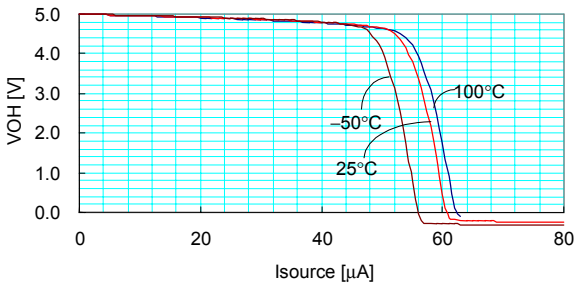

S-89120 Isource-VOH
@VDD = 1.8 V, VSS = 0V



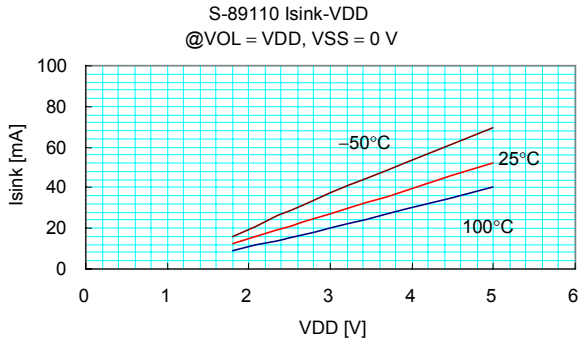

S-89120 Isource-VOH
@VDD = 3.0 V, VSS = 0 V

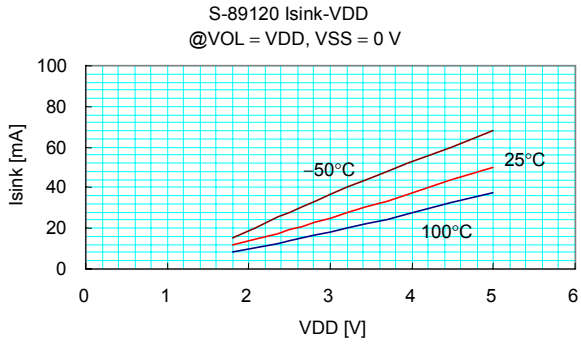



S-89120 Isource-VOH
@VDD = 5.0 V, VSS = 0 V

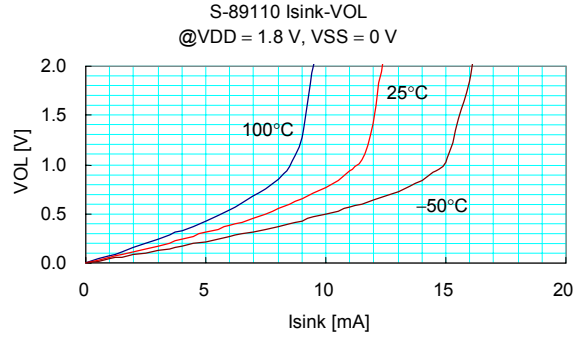


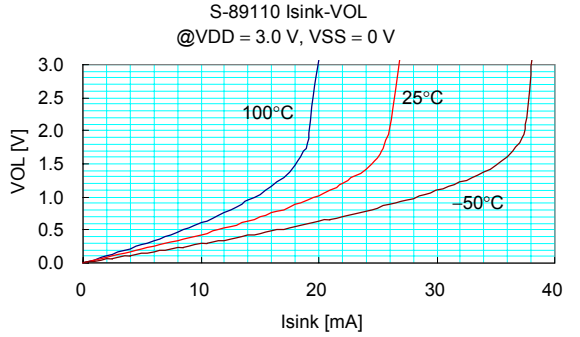
### 3-3. $I_{SINK}$ vs. Power supply voltage

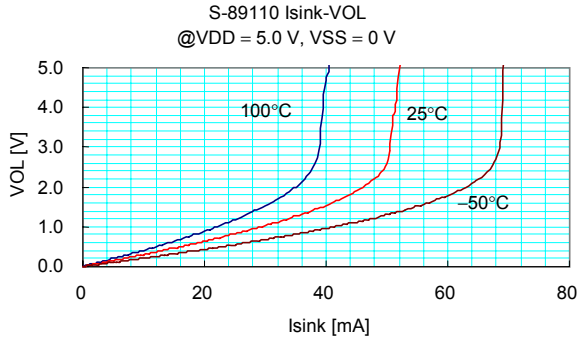


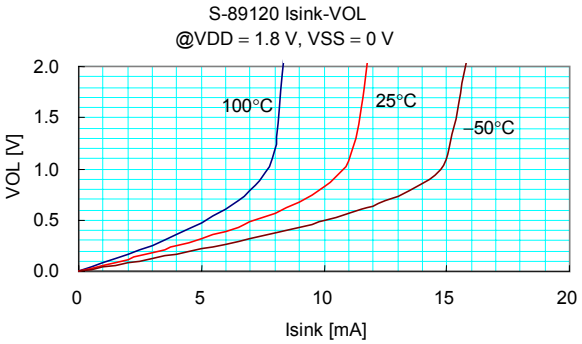



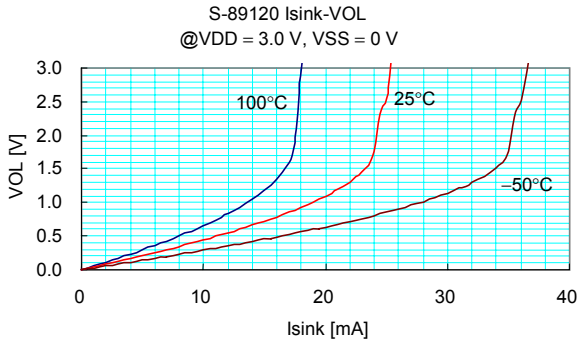

### 3-4. Output voltage ($V_{OL}$) vs. $I_{SINK}$

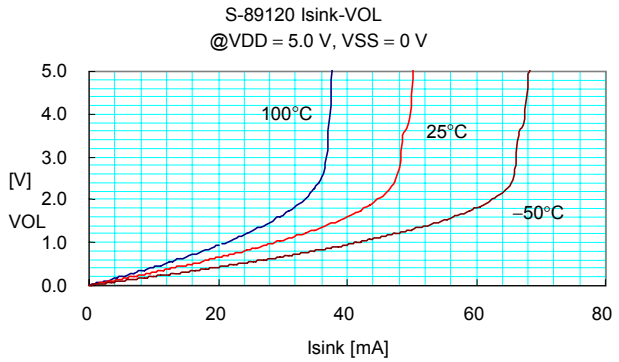



S-89120 Isink-VOL
@VDD = 5.0 V, VSS = 0 V
5.0
4.0
3.0
2.0
1.0
0.0
[V]
VOL
100°C
25°C
−50°C
0
20
40
60
80
Isink [mA]

## ■ SC-88A

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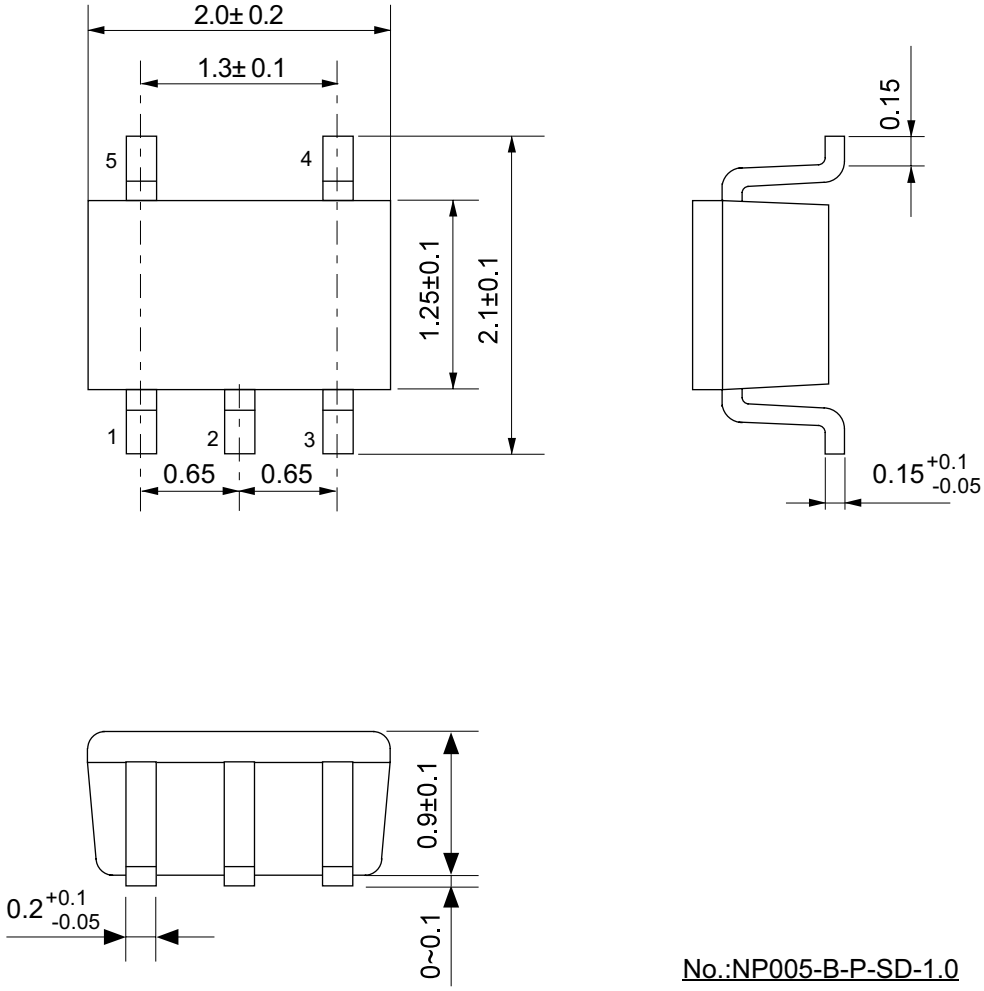
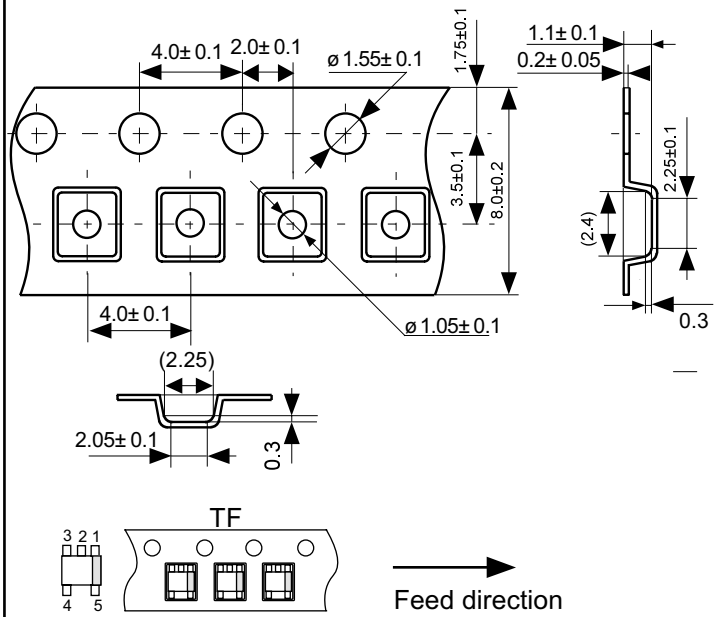
### ●Dimensions

Unit：mm



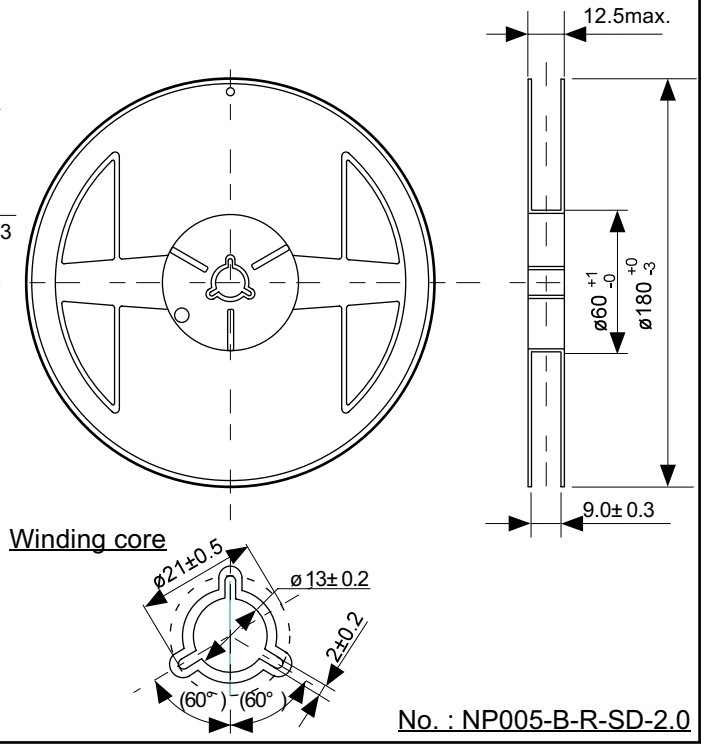

No.:NP005-B-P-SD-1.0

### ●Taping Specifications




### ●Reel Specifications

3000 pcs/reel




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

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

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