# MINI ANALOG SERIES CMOS OPERATIONAL AMPLIFIER

# S-89110A/89120A

The mini-analog series is a group of ICs that incorporate a general purpose analog circuit in a small package.
The S-89110A/89120A 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.
The S-89110A/89120A is a single operational amplifier.

## ■ Features

- Lower operating voltage than the conventional general-purpose operational amplifiers: $V_{DD}$ = 1.8 to 5.5 V
- Low current consumption: $I_{DD}$ = 50 μA (S-89110A)
  $I_{DD}$ = 10 μA (S-89120A)
- Low input offset voltage: 4.0 mV (max.)
- No external capaciters required for internal phase compensation
- Output full swing
- 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 |

## ■ Product Name List

**Table 1**

| Current consumption | SC-88A |
|---|---|
| $I_{DD}$ = 50 μA | S-89110ANC-1A1-TFG |
| $I_{DD}$ = 10 μA | S-89120ANC-1A2-TFG |

**Remark** Delivery form : Taping only

## ■ Pin Configuration

SC-88A
Top view

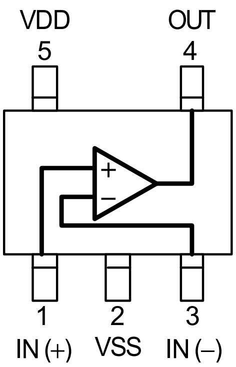



**Figure 1**

**Table 2**

| 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 Circuit

**<1> Output pin**

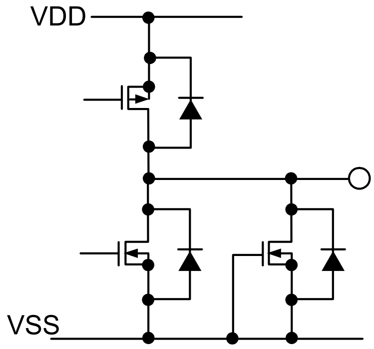



**Figure 2**

**<2> Input pin**

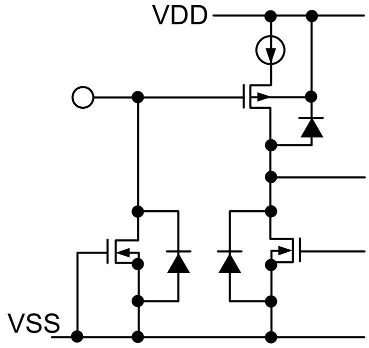



**Figure 3**

**<3> VDD pin**

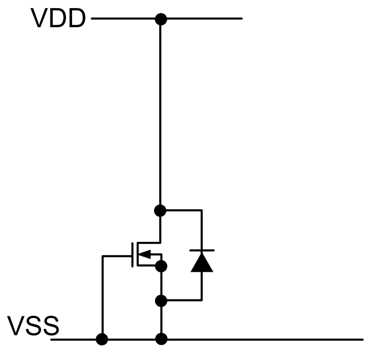



**Figure 4**

## ■ Absolute Maximum Ratings

**Table 3**

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Power supply voltage | $V_{DD}$ | $V_{SS}$–0.3 to $V_{SS}$+10.0 | 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 | $V_{IND}$ | ±7.0 | V |
| Power dissipation | $P_D$ | 200 (When not mounted on board) | mW |
| | | 350*1 | mW |
| Operating temperature range | $T_{opr}$ | –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.**

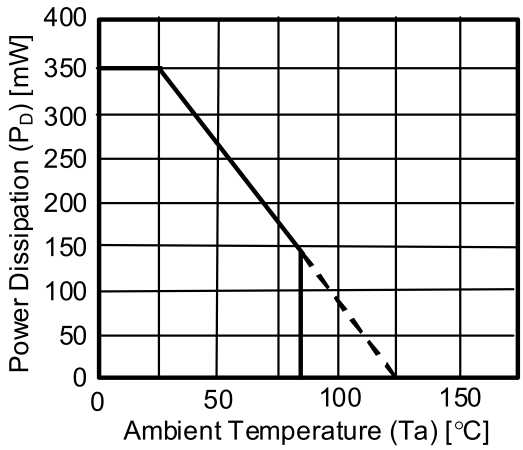



**Figure 5 Power Dissipation of Package (When Mounted on Board)**

## ■ Recommended Operating Power Supply Voltage Range

**Table 4**

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

## ■ Electrical Characteristics

**1. $V_{DD}$ = 5.0 V**

**Table 5**

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

| Parameter | Symbol | Measurement Conditions | | Min. | Typ. | Max. | Unit | Measurement Circuit |
|---|---|---|---|---|---|---|---|---|
| Current consumption | $I_{DD}$ | S-89110A | | — | 50 | 120 | μA | **Figure 10** |
| | | S-89120A | | — | 10 | 30 | μA | |
| Input offset voltage | $V_{IO}$ | — | | −4 | ±3 | +4 | mV | **Figure 6** |
| 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 | **Figure 7** |
| Voltage gain (open loop) | $G_V$ | — | | 70 | 80 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1.0 MΩ | | 4.9 | — | — | V | **Figure 8** |
| | $V_{OL}$ | $R_L$ = 1.0 MΩ | | | | 0.1 | | **Figure 9** |
| Common-mode input signal rejection ratio | CMRR | — | | 60 | 70 | — | dB | **Figure 7** |
| Power supply voltage rejection ratio | PSRR | — | | 60 | 70 | — | dB | **Figure 6** |
| Source current | $I_{SOURCE}$ | S-89110A | $V_{OH}$ = 0 V | 120 | — | — | μA | **Figure 11** |
| | | S-89120A | | 25 | — | — | | |
| Sink current | $I_{SINK}$ | $V_{OL}$ = $V_{DD}$ | | 20 | — | — | mA | **Figure 12** |

**Table 6**

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

| Parameter | Symbol | Measurement Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | SR | S-89110A | $R_L$ = 1.0 MΩ, $C_L$ = 15 pF (Refer to **Figure 13.**) | — | 0.07 | — | V/μs |
| | | S-89120A | | — | 0.015 | — | |
| Gain-bandwidth product | GBP | S-89110A | — | — | 180 | — | kHz |
| | | S-89120A | | — | 40 | — | |

**2. $V_{DD}$ = 3.0 V**

**Table 7**

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 | $I_{DD}$ | S-89110A | | — | 50 | 120 | μA | **Figure 10** |
| | | S-89120A | | — | 10 | 30 | μA | |
| Input offset voltage | $V_{IO}$ | — | | –4 | ±3 | +4 | mV | **Figure 6** |
| 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 | **Figure 7** |
| Voltage gain (open loop) | $G_V$ | — | | 70 | 80 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1.0 MΩ | | 2.9 | — | — | V | **Figure 8** |
| | $V_{OL}$ | $R_L$ = 1.0 MΩ | | — | — | 0.1 | V | **Figure 9** |
| Common-mode input signal rejection ratio | CMRR | — | | 60 | 70 | — | dB | **Figure 7** |
| Power supply voltage rejection ratio | PSRR | — | | 60 | 70 | — | dB | **Figure 6** |
| Source current | $I_{SOURCE}$ | S-89110A | $V_{OH}$ = 0 V | 120 | — | — | μA | **Figure 11** |
| | $I_{SOURCE}$ | S-89120A | | 25 | — | — | | |
| Sink current | $I_{SINK}$ | $V_{OL}$ = $V_{DD}$ | | 15 | — | — | mA | **Figure 12** |

**Table 8**

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

| Parameter | Symbol | Measurement Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | SR | S-89110A | $R_L$ = 1.0 MΩ, $C_L$ = 15 pF (Refer to **Figure 13.**) | — | 0.07 | — | V/μs |
| | | S-89120A | | — | 0.015 | — | |
| Gain-bandwidth product | GBP | S-89110A | — | — | 175 | — | kHz |
| | | S-89120A | | — | 35 | — | |

### 3. $V_{DD}$ = 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 |
|---|---|---|---|---|---|---|---|---|
| Current consumption | $I_{DD}$ | S-89110A | | — | 50 | 120 | μA | **Figure 10** |
| | | S-89120A | | — | 10 | 30 | μA | |
| Input offset voltage | $V_{IO}$ | — | | −4 | ±3 | +4 | mV | **Figure 6** |
| 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 | **Figure 7** |
| Voltage gain (open loop) | $G_V$ | — | | 70 | 80 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1.0 MΩ | | 1.7 | — | — | V | **Figure 8** |
| | $V_{OL}$ | $R_L$ = 1.0 MΩ | | — | — | 0.1 | V | **Figure 9** |
| Common-mode input signal rejection ratio | CMRR | — | | 60 | 70 | — | dB | **Figure 7** |
| Power supply voltage rejection ratio | PSRR | — | | 60 | 70 | — | dB | **Figure 6** |
| Source current | $I_{SOURCE}$ | S-89110A | $V_{OH}$ = 0 V | 100 | — | — | μA | **Figure 11** |
| | $I_{SOURCE}$ | S-89120A | | 20 | — | — | | |
| Sink current | $I_{SINK}$ | $V_{OL} = V_{DD}$ | | 5 | — | — | mA | **Figure 12** |

**Table 10**

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

| Parameter | Symbol | Measurement Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Slew rate | SR | S-89110A | $R_L$ = 1.0 MΩ, $C_L$ = 15 pF (Refer to **Figure 13.**) | — | 0.07 | — | V/μs |
| | | S-89120A | | — | 0.015 | — | |
| Gain-bandwidth product | GBP | S-89110A | — | — | 160 | — | kHz |
| | | S-89120A | | — | 30 | — | |

## ■ Measurement Circuit

### 1. Power supply voltage rejection ratio, input offset voltage

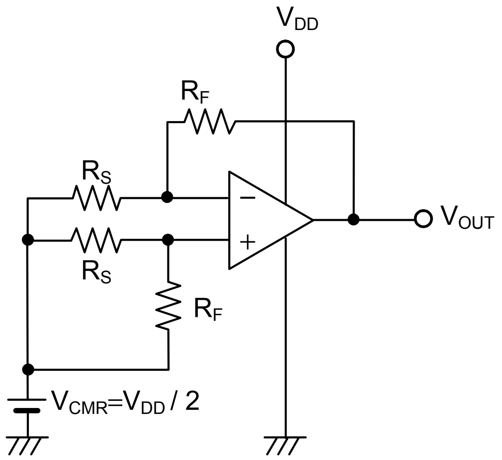



Figure 6

- **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 $V_{DD}$ = 1.8 V: $V_{DD} = V_{DD1}$, $V_{OUT} = V_{OUT1}$
  When $V_{DD}$ = 5.0 V: $V_{DD} = V_{DD2}$, $V_{OUT} = V_{OUT2}$

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

- 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

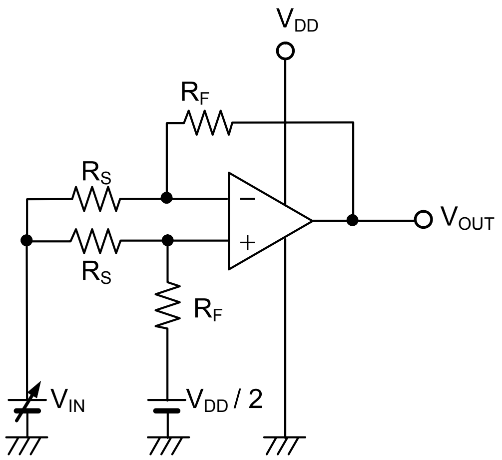



Figure 7

- **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 $V_{IN} = V_{DD}/2$: $V_{IN} = V_{IN2}$, $V_{OUT} = V_{OUT2}$

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

- **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.

### 3.Maximum output swing voltage

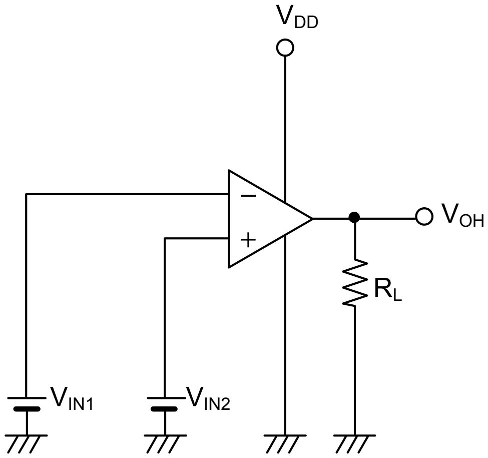


**Figure 8**

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

  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} - 0.5\ V$

  $V_{IN2} = \frac{V_{DD}}{2} + 0.5\ V$

  $R_L = 1\ M\Omega$

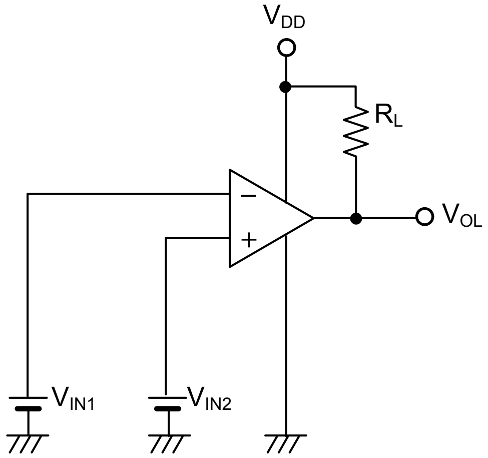


**Figure 9**

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

  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} + 0.5\ V$

  $V_{IN2} = \frac{V_{DD}}{2} - 0.5\ V$

  $R_L = 1\ M\Omega$

### 4. Current consumption

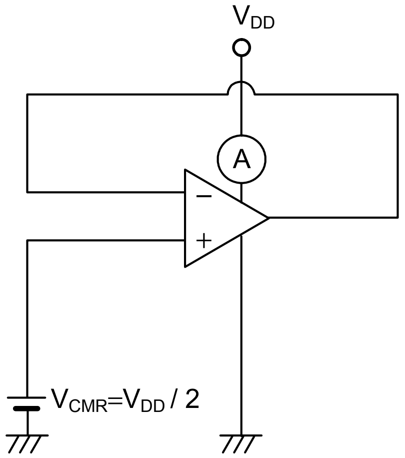


**Figure 10**

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

**5. Source current**

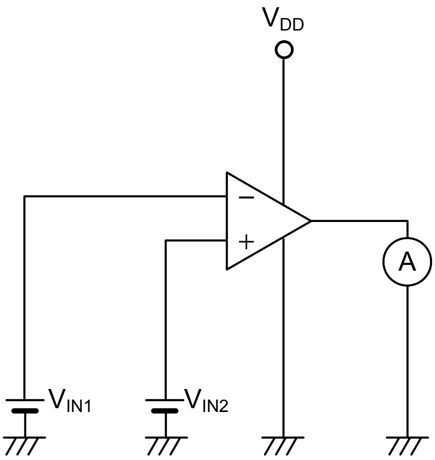



**Figure 11**

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

**6. Sink current**

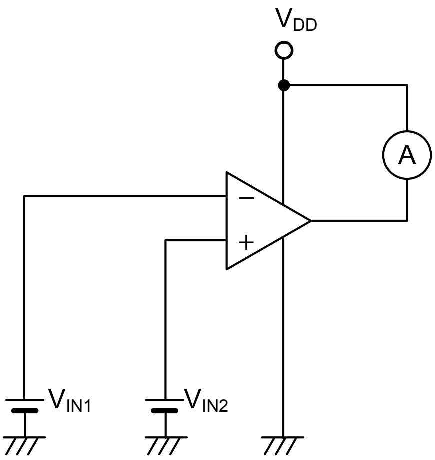
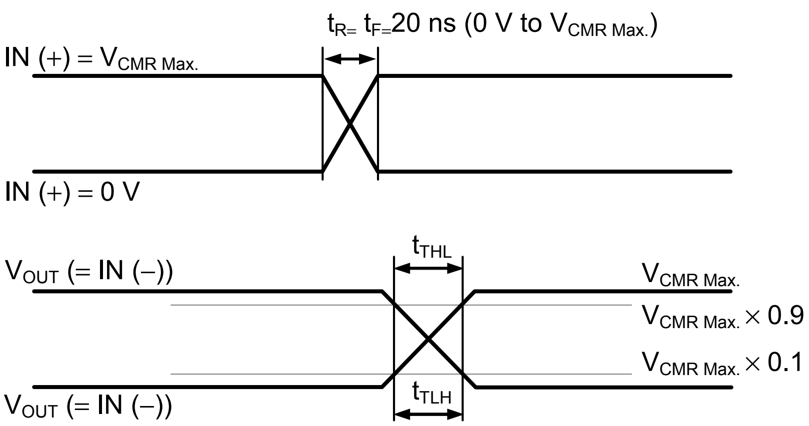



**Figure 12**

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

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




$$SR = \frac{V_{CMR\,Max.} \times 0.8}{t_{TLH}}$$

$$SR = \frac{V_{CMR\,Max.} \times 0.8}{t_{THL}}$$

**Figure 13**

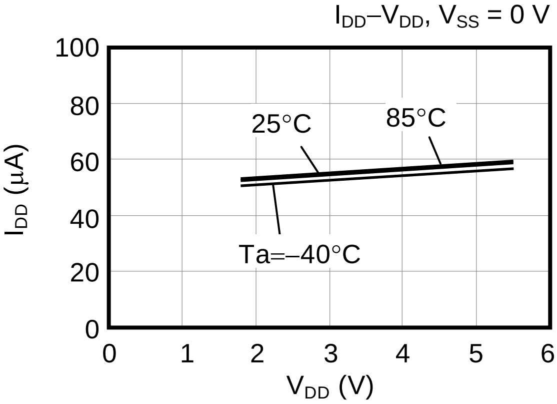
## ■ Precaution

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

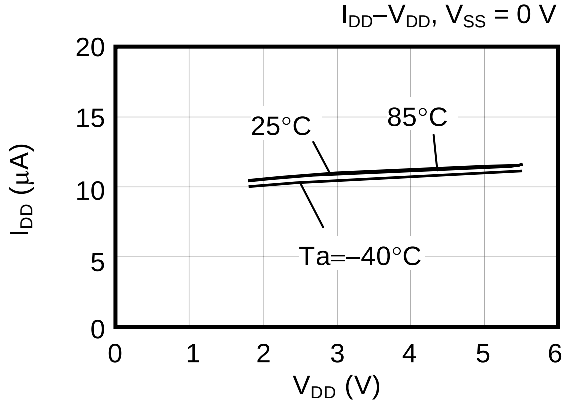
## ■ Characteristics (Reference Data)

### 1. Current consumption vs. Power supply voltage

**(a) S-89110A**

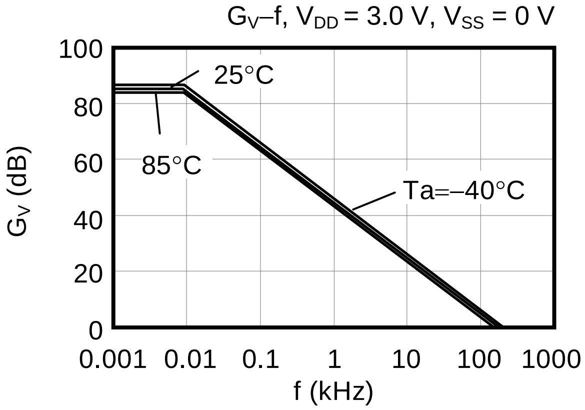



**(b) S-89120A**

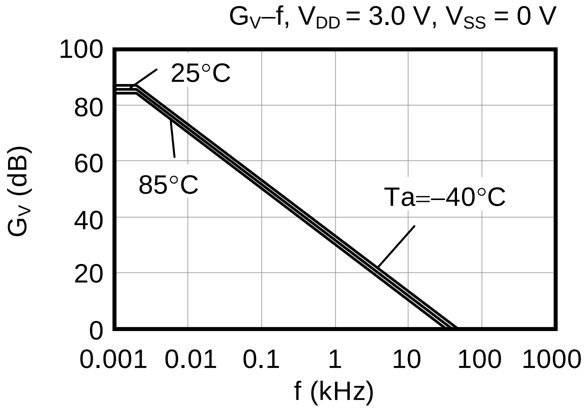



### 2. Voltage gain vs. Frequency

**(a) S-89110A**



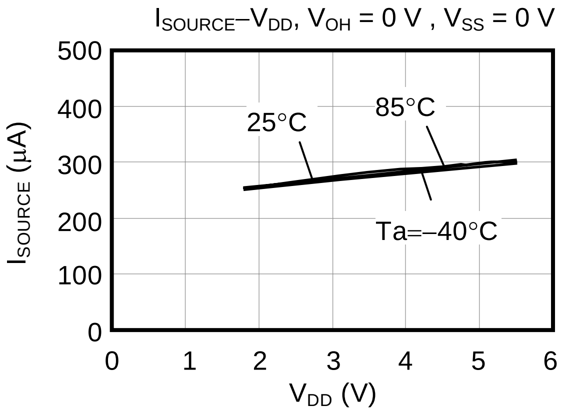

**(b) S-89120A**



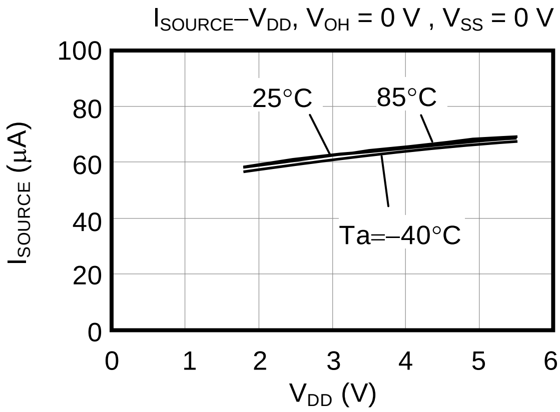

### 3. Output current

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

**(a) S-89110A**



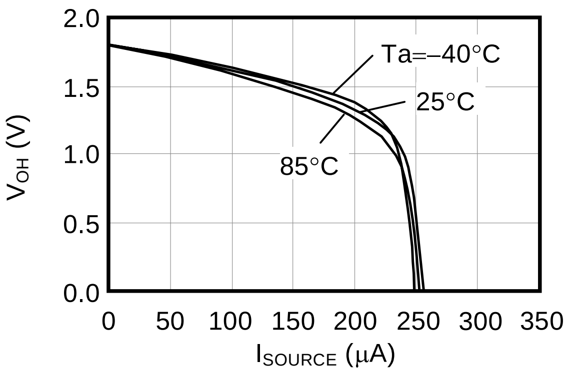

**(b) S-89120A**



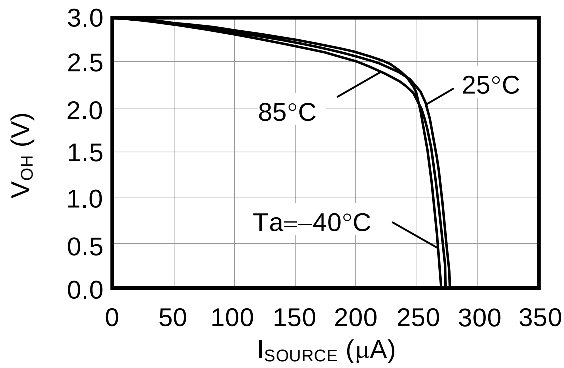
### 3-2. Output voltage ($V_{OH}$) vs. $I_{SOURCE}$

**(a) S-89110A**

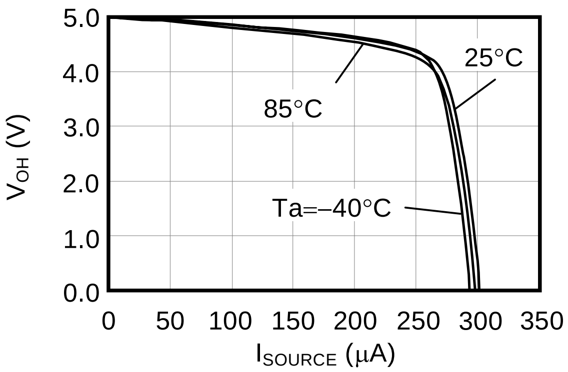
$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 1.8 V , $V_{SS}$ = 0 V




$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 3.0 V , $V_{SS}$ = 0 V

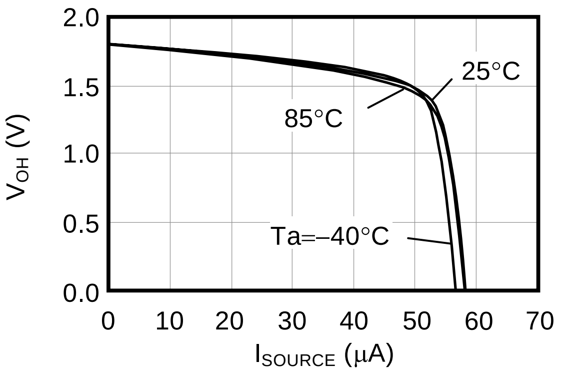



$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 5.0 V , $V_{SS}$ = 0 V

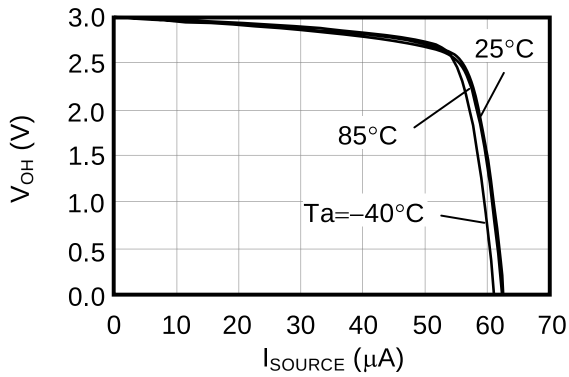



**(b) S-89120A**

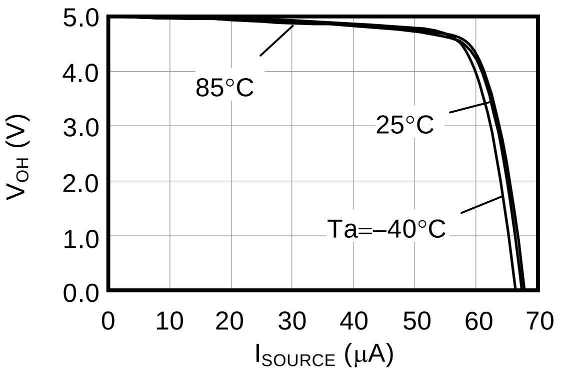
$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 1.8 V , $V_{SS}$ = 0 V




$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 3.0 V , $V_{SS}$ = 0 V

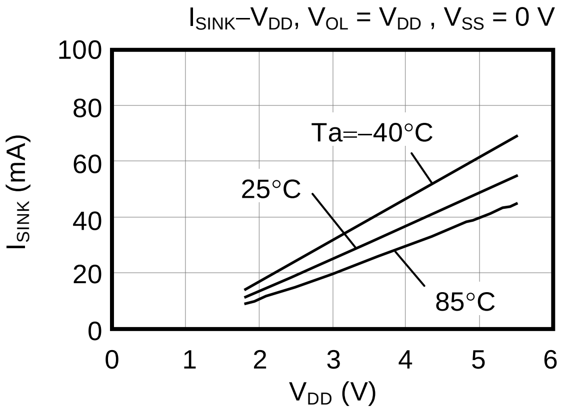



$V_{OH}$–$I_{SOURCE}$, $V_{DD}$ = 5.0 V , $V_{SS}$ = 0 V

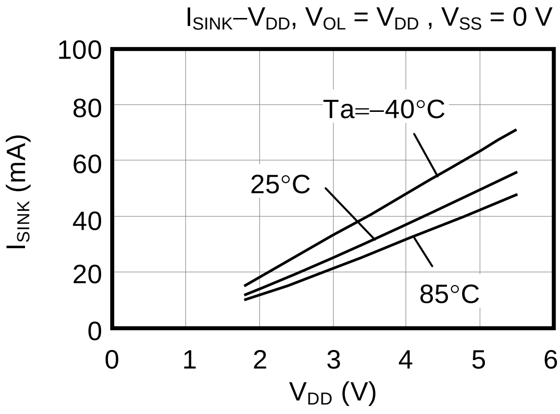


**3-3. $I_{SINK}$ vs. Power supply voltage**

**(a) S-89110A**



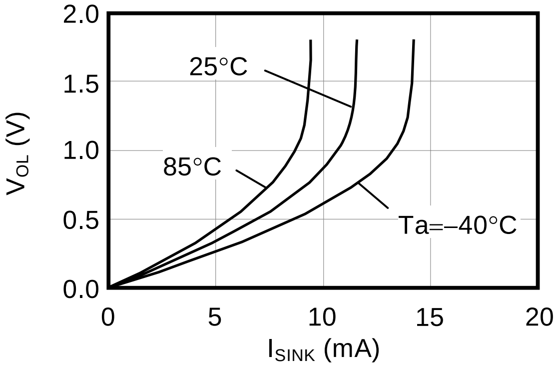

**(b) S-89120A**



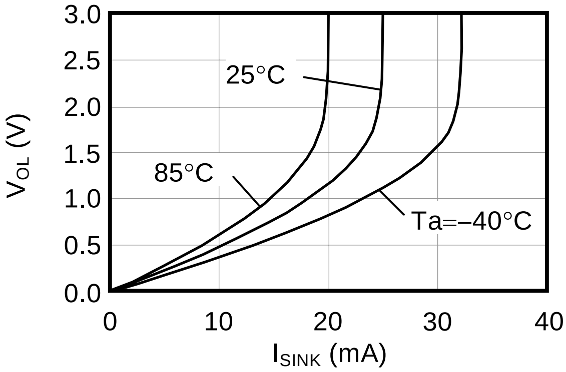
### 3-4. Output voltage ($V_{OL}$) vs. $I_{SINK}$

**(a) S-89110A**

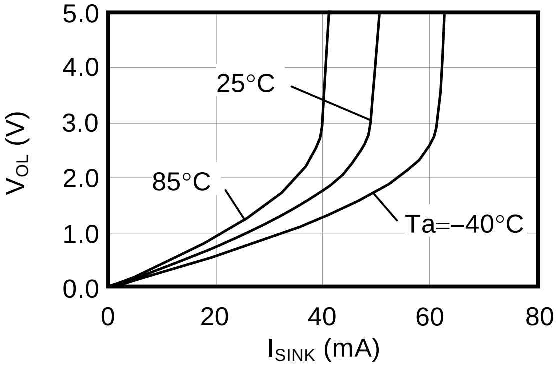
$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 1.8 V, $V_{SS}$ = 0 V




$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 3.0 V, $V_{SS}$ = 0 V

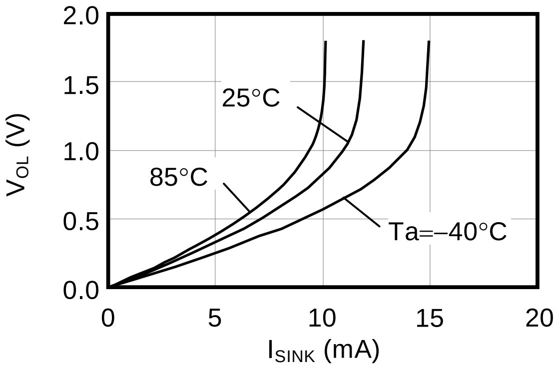



$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 5.0 V, $V_{SS}$ = 0 V

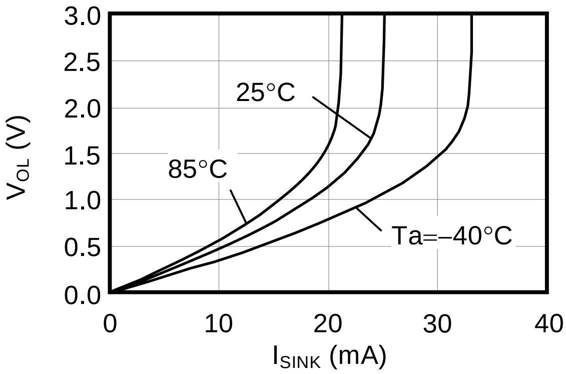



**(b) S-89120A**

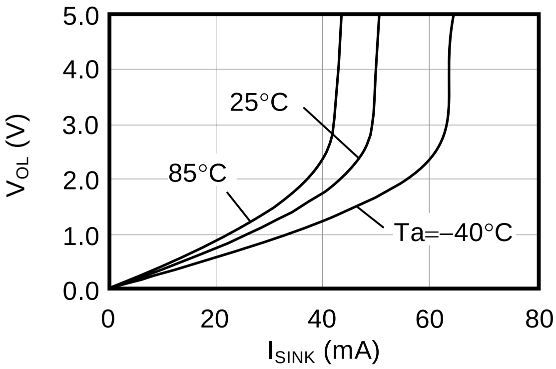
$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 1.8 V, $V_{SS}$ = 0 V

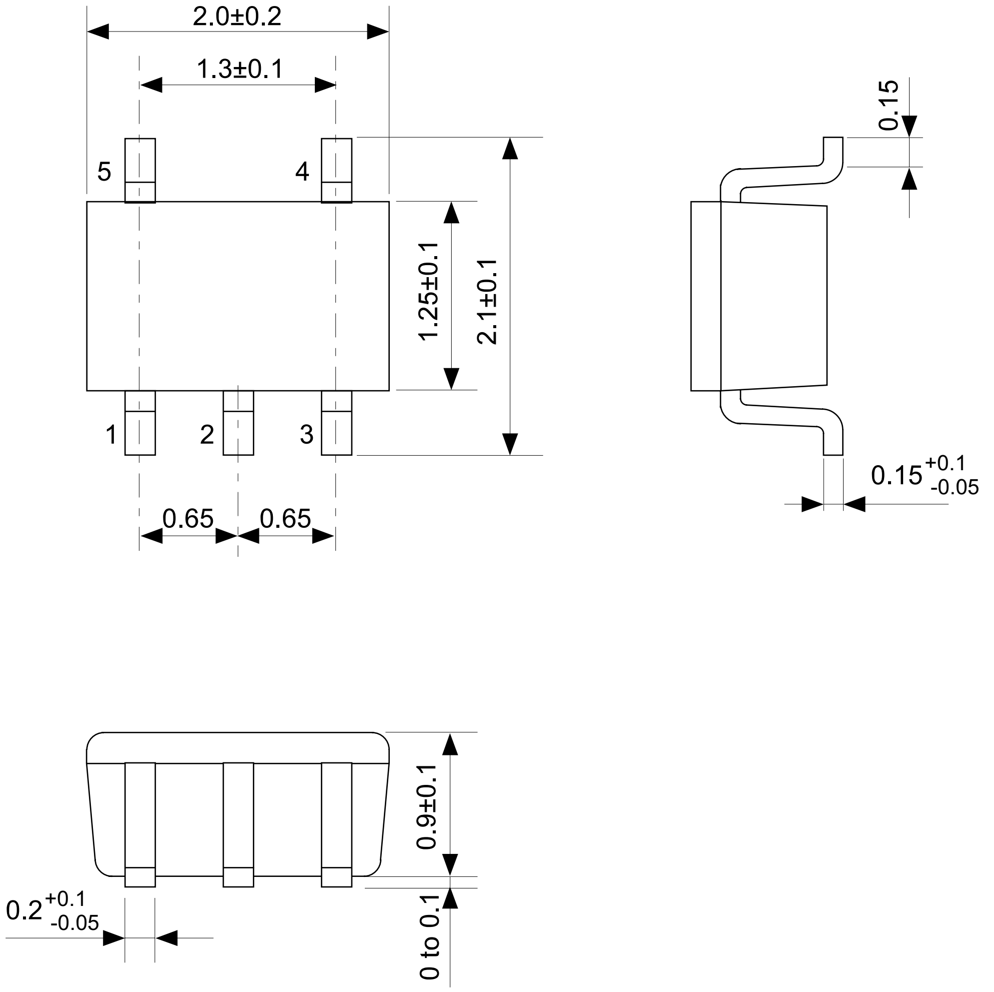



$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 3.0 V, $V_{SS}$ = 0 V




$V_{OL}$–$I_{SINK}$, $V_{DD}$ = 5.0 V, $V_{SS}$ = 0 V






No. NP005-B-P-SD-1.1

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

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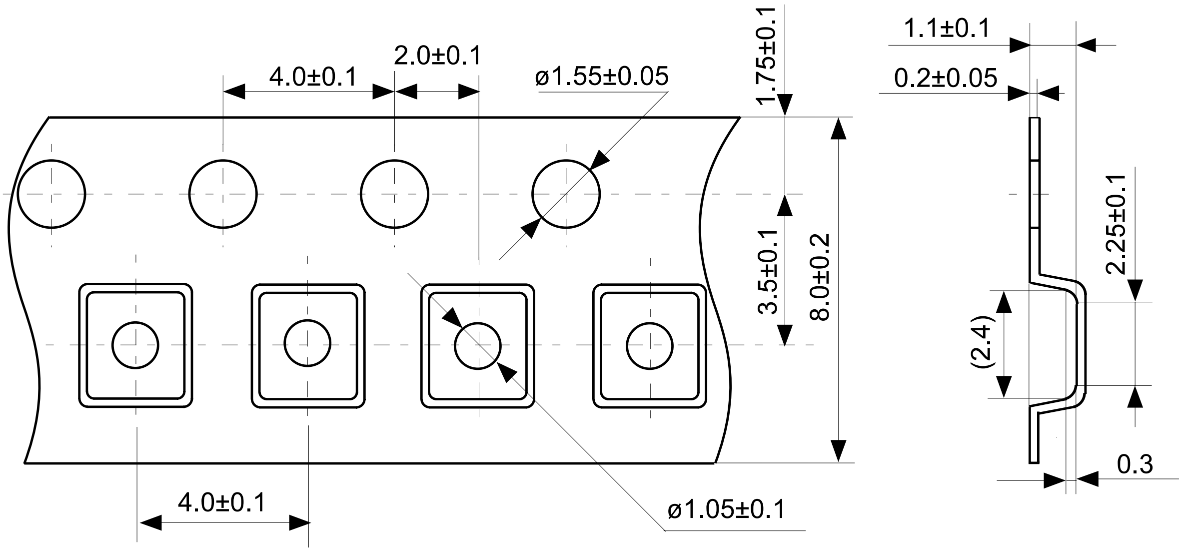


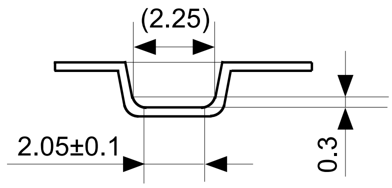


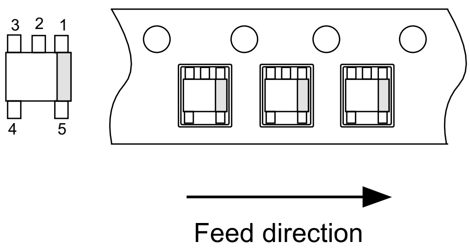


No. NP005-B-C-SD-2.0

| | |
|---|---|
| TITLE | SC88A-B-Carrier Tape |
| No. | NP005-B-C-SD-2.0 |
| SCALE | |
| UNIT | mm |
| | |

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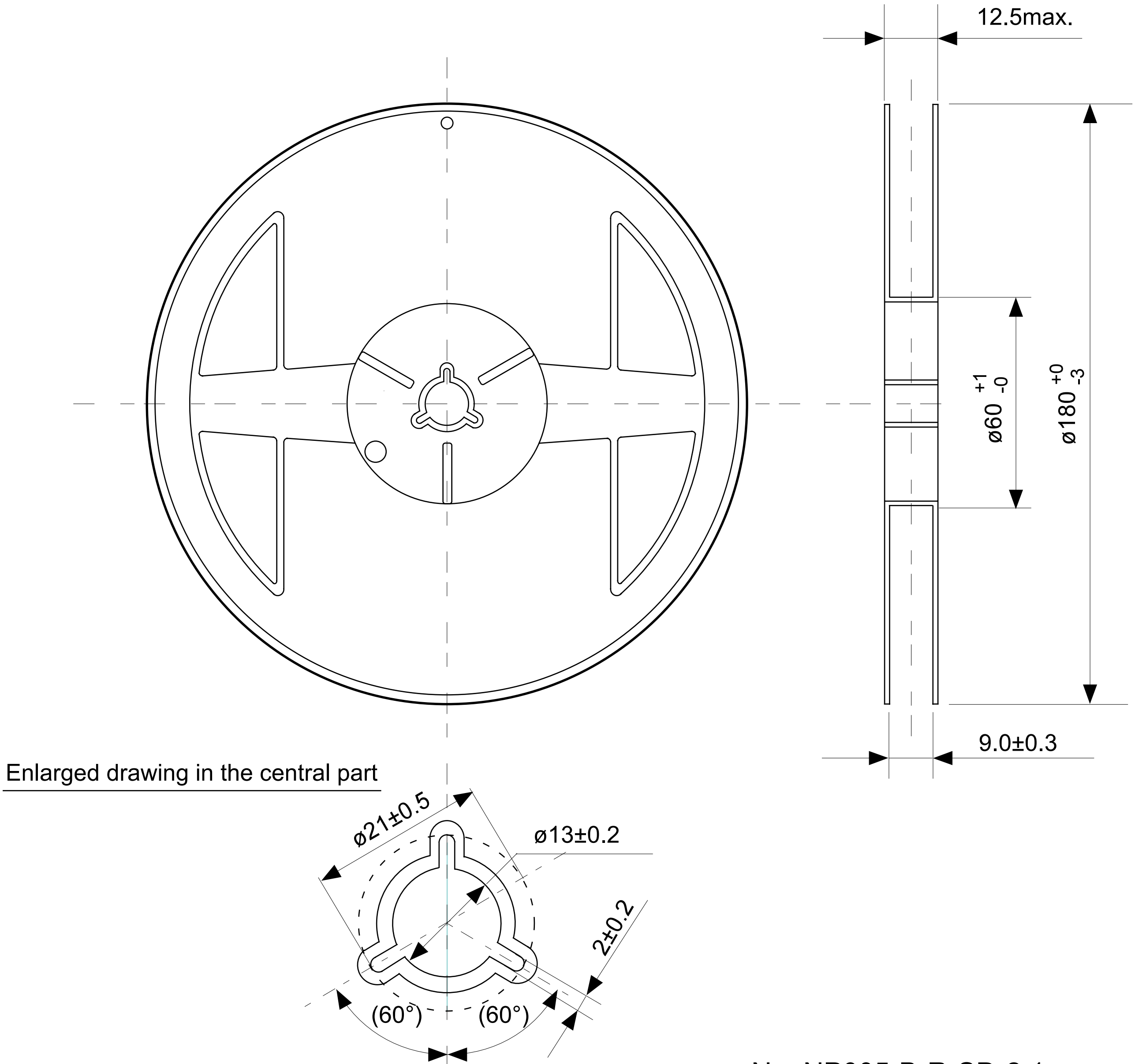


No. NP005-B-R-SD-2.1

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

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