# S-89530A/89531A Series

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## MINI ANALOG SERIES
## 0.7 µA Rail-to-Rail CMOS COMPARATOR

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Rev.4.1_02

The mini analog series is a group of ICs that incorporate a general-purpose analog circuit in an ultra-small package.
The S-89530A/89531A Series are CMOS type comparators that feature Rail-to-Rail*1 I/O and can be driven at a lower voltage and lower current consumpsion than existing comparators, making the S-89530A/89531A for use in battery-powered compact portable devices.

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

## ■ Features

- Can be driven lower voltage than existing general-purpose comparators: $V_{DD}$ = 0.9 V to 5.5 V
- Low current consumption: $I_{DD}$ = 0.7 µA (Typ.)
- Rail-to-Rail wide input and output voltage range: $V_{CMR}$ = $V_{SS}$ to $V_{DD}$
- Low input offset voltage: 5.0 mV max.
- Lead-free, Sn100%, halogen-free*1

***1.** Refer to "■ **Product Code List**" for details.

## ■ Applications

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

## ■ Package

| Package Name | Drawing Code | | |
|---|---|---|---|
| | Package | Tape | Reel |
| SC-88A | NP005-B-P-SD | NP005-B-C-SD | NP005-B-R-SD |

## ■ Product Code List

**Table 1**

| Input Offset Voltage | Product Name (Single) |
|---|---|
| $V_{IO}$ = 10 mV max. | S-89530ACNC-HCBTF□ |
| $V_{IO}$ = 5 mV max. | S-89531ACNC-HCCTF□ |

**Remark** □: G, S or U

## ■ Pin Configuration

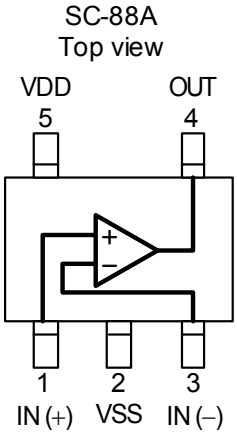



**Figure 1**

**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 Circuits

**(1) Output pin**

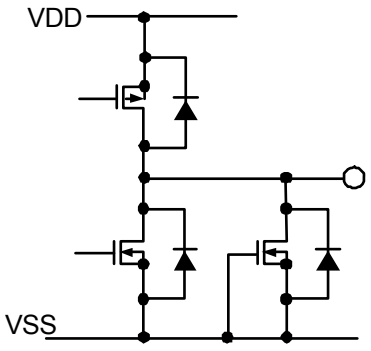



**Figure 2**

**(2) Input pin**

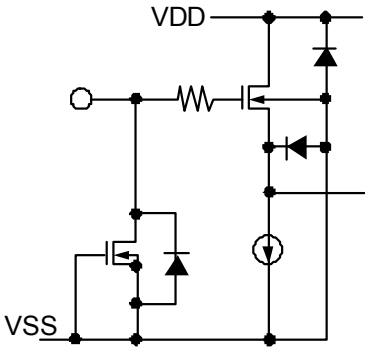



**Figure 3**

**(3) VDD pin**

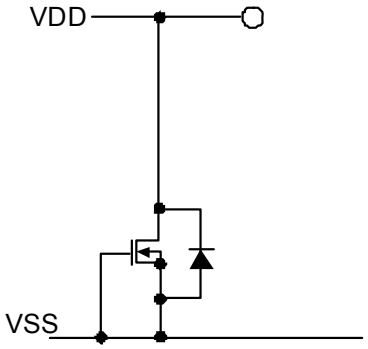



**Figure 4**

## ■ 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 |
| Power dissipation | $P_D$ | 200 (When not mounted on board) | mW |
| | | 350*1 | mW |
| Operating 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.**

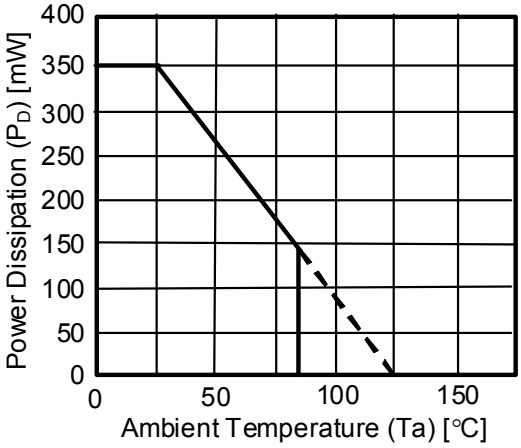



**Figure 5 Power Dissipation of Package (When Mounted on Board)**

## ■ Recommended Operating Voltage Range

**Table 4**

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

## ■ Electrical Characteristics

The S-89530ACNC and S-89531ACNC only differ in the input offset voltage. All other specifications are the same.

### 1. $V_{DD}$ = 3.0 V

**Table 5**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|
| Supply current | $I_{DDH}$ | $V_{IN1} = V_{SS}$, $V_{IN2} = V_{DD}$, $R_L = \infty$ | — | 0.7 | 1.4 | μA | **Figure 11** |
| | $I_{DDL}$ | $V_{IN1} = V_{DD}$, $V_{IN2} = V_{SS}$, $R_L = \infty$ | — | 0.25 | 0.5 | | |
| Input offset voltage | $V_{IO}$ | S-89530A: $V_{CMR}$ = 1.5 V | −10 | ±5 | +10 | mV | **Figure 7** |
| | | S-89531A: $V_{CMR}$ = 1.5 V | −5 | ±3 | +5 | | |
| Input offset current | $I_{IO}$ | — | — | 1 | — | pA | — |
| Input bias current | $I_{BIAS}$ | — | — | 1 | — | | |
| Common-mode input voltage range | $V_{CMR}$ | — | 0 | — | 3.0 | V | **Figure 8** |
| Voltage gain (open loop) | $A_{VOL}$ | $V_{CMR}$ = 1.5 V, $R_L$ = 1 MΩ | — | 86 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1 MΩ | 2.98 | — | — | V | **Figure 9** |
| | $V_{OL}$ | $R_L$ = 1 MΩ | — | — | 0.02 | | **Figure 10** |
| Common-mode input signal rejection ratio | CMRR | $V_{SS} \le V_{CMR} \le V_{DD}$ | 45 | 65 | — | dB | **Figure 8** |
| Power supply voltage rejection ratio | PSRR | $V_{DD}$ = 0.9 V to 5.5 V | 66 | 75 | — | dB | **Figure 6** |
| Source current*1 | $I_{SOURCE}$ | $V_{OUT} = V_{DD}$ − 0.1 V | 380 | 500 | — | μA | **Figure 12** |
| | | $V_{OUT}$ = 0 V | 4000 | 5500 | — | | |
| Sink current | $I_{SINK}$ | $V_{OUT}$ = 0.1 V | 400 | 550 | — | μA | **Figure 13** |
| | | $V_{OUT} = V_{DD}$ | 4800 | 6000 | — | | |

***1.** Be sure to use the product with a source current of no more than 7 mA.

**Table 6**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Rise propagation delay time | $t_{PLH}$ | Overdrive = 100 mV<br>$C_L$ = 15 pF<br>(Refer to **Figure 14**) | — | 110 | — | μs |
| Fall propagation delay time | $t_{PHL}$ | | — | 280 | — | |
| Rise response time | $t_{TLH}$ | | — | 10 | — | |
| Fall response time | $t_{THL}$ | | — | 30 | — | |

**2. $V_{DD}$ = 1.8 V**

**Table 7**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|
| Supply current | $I_{DDH}$ | $V_{IN1} = V_{SS}$, $V_{IN2} = V_{DD}$, $R_L = \infty$ | — | 0.7 | 1.4 | μA | **Figure 11** |
| | $I_{DDL}$ | $V_{IN1} = V_{DD}$, $V_{IN2} = V_{SS}$, $R_L = \infty$ | — | 0.25 | 0.5 | | |
| Input offset voltage | $V_{IO}$ | S-89530A: $V_{CMR}$ = 0.9 V | −10 | ±5 | +10 | mV | **Figure 7** |
| | | S-89531A: $V_{CMR}$ = 0.9 V | −5 | ±3 | +5 | | |
| Input offset current | $I_{IO}$ | — | — | 1 | — | pA | — |
| Input bias current | $I_{BIAS}$ | — | — | 1 | — | | |
| Common-mode input voltage range | $V_{CMR}$ | — | 0 | — | 1.8 | V | **Figure 8** |
| Voltage gain (open loop) | $A_{VOL}$ | $V_{CMR}$ = 0.9 V, $R_L$ = 1 MΩ | — | 80 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1 MΩ | 1.78 | — | — | V | **Figure 9** |
| | $V_{OL}$ | $R_L$ = 1 MΩ | — | — | 0.02 | | **Figure 10** |
| Common-mode input signal rejection ratio | CMRR | $V_{SS} \le V_{CMR} \le V_{DD}$ | 35 | 55 | — | dB | **Figure 8** |
| | | $V_{SS} \le V_{CMR} \le V_{DD}$ − 0.2 V | 45 | 60 | — | | |
| Power supply voltage rejection ratio | PSRR | $V_{DD}$ = 0.9 V to 5.5 V | 66 | 75 | — | dB | **Figure 6** |
| Source current | $I_{SOURCE}$ | $V_{OUT} = V_{DD}$ − 0.1 V | 200 | 250 | — | μA | **Figure 12** |
| | | $V_{OUT}$ = 0 V | 1000 | 1500 | — | | |
| Sink current | $I_{SINK}$ | $V_{OUT}$ = 0.1 V | 220 | 300 | — | μA | **Figure 13** |
| | | $V_{OUT} = V_{DD}$ | 1200 | 1800 | — | | |

**Table 8**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Rise propagation delay time | $t_{PLH}$ | Overdrive = 100 mV<br>$C_L$ = 15 pF<br>(Refer to **Figure 14**) | — | 90 | — | μs |
| Fall propagation delay time | $t_{PHL}$ | | — | 160 | — | |
| Rise response time | $t_{TLH}$ | | — | 8 | — | |
| Fall response time | $t_{THL}$ | | — | 25 | — | |

### 3. $V_{DD}$ = 0.9 V

**Table 9**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit | Measurement circuit |
|---|---|---|---|---|---|---|---|
| Supply current | $I_{DDH}$ | $V_{IN1} = V_{SS}$, $V_{IN2} = V_{DD}$, $R_L = \infty$ | — | 0.7 | 1.3 | μA | **Figure 11** |
| | $I_{DDL}$ | $V_{IN1} = V_{DD}$, $V_{IN2} = V_{SS}$, $R_L = \infty$ | — | 0.25 | 0.5 | | |
| Input offset voltage | $V_{IO}$ | S-89530A: $V_{CMR}$ = 0.45 V | −10 | ±5 | +10 | mV | **Figure 7** |
| | | S-89531A: $V_{CMR}$ = 0.45 V | −5 | ±3 | +5 | | |
| Input offset current | $I_{IO}$ | — | — | 1 | — | pA | — |
| Input bias current | $I_{BIAS}$ | — | — | 1 | — | | |
| Common-mode input voltage range | $V_{CMR}$ | — | 0 | — | 0.9 | V | **Figure 8** |
| Voltage gain (open loop) | $A_{VOL}$ | $V_{CMR}$ = 0.45 V, $R_L$ = 1 MΩ | — | 74 | — | dB | — |
| Maximum output swing voltage | $V_{OH}$ | $R_L$ = 1 MΩ | 0.88 | — | — | V | **Figure 9** |
| | $V_{OL}$ | $R_L$ = 1 MΩ | — | — | 0.02 | | **Figure 10** |
| Common-mode input signal rejection ratio | CMRR | $V_{SS} \le V_{CMR} \le V_{DD}$ | 25 | 50 | — | dB | **Figure 8** |
| | | $V_{SS} \le V_{CMR} \le V_{DD} - 0.3$ V | 40 | 60 | — | | |
| Power supply voltage rejection ratio | PSRR | $V_{DD}$ = 0.9 V to 5.5 V | 66 | 75 | — | dB | **Figure 6** |
| Source current | $I_{SOURCE}$ | $V_{OUT} = V_{DD} - 0.1$ V | 10 | 45 | — | μA | **Figure 12** |
| | | $V_{OUT}$ = 0 V | 12 | 70 | — | | |
| Sink current | $I_{SINK}$ | $V_{OUT}$ = 0.1 V | 10 | 65 | — | μA | **Figure 13** |
| | | $V_{OUT} = V_{DD}$ | 12 | 120 | — | | |

**Table 10**

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

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Rise propagation delay time | $t_{PLH}$ | Overdrive = 100 mV<br>$C_L$ = 15 pF<br>(Refer to **Figure 14**) | — | 65 | — | μs |
| Fall propagation delay time | $t_{PHL}$ | | — | 65 | — | |
| Rise response time | $t_{TLH}$ | | — | 5 | — | |
| Fall response time | $t_{THL}$ | | — | 20 | — | |

## ■ Measurement Circuits

### 1. Power supply voltage rejection ratio

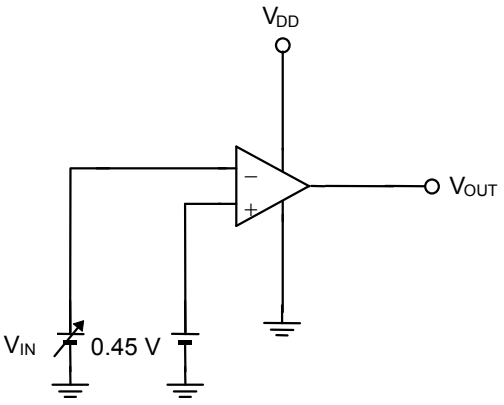



**Figure 6**

- The power supply voltage rejection ratio (PSRR) is calculated by the following expression, with the value of $V_{IO}$ measured at each $V_{DD}$.

  Measurement conditions:
  When $V_{DD}$ = 0.9 V: $V_{DD} = V_{DD1}$, $V_{IO} = V_{IO1}$
  When $V_{DD}$ = 5.5 V: $V_{DD} = V_{DD2}$, $V_{IO} = V_{IO2}$

$$PSRR = 20\log\left(\left|\frac{V_{DD1} - V_{DD2}}{V_{IO1} - V_{IO2}}\right|\right)$$

### 2. Input offset voltage

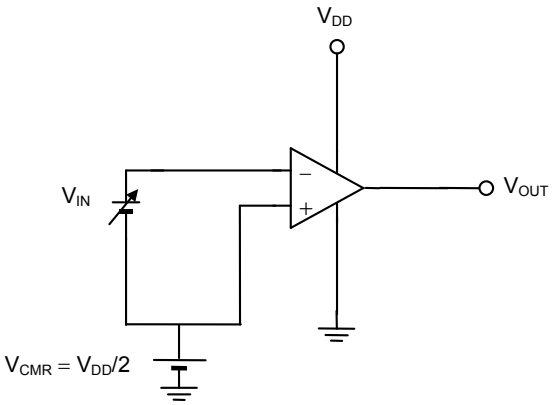



**Figure 7**

- Input offset voltage ($V_{IO}$)
  The input offset voltage ($V_{IO}$) is defined as $V_{IN}$ at which $V_{OUT}$ changes by changing $V_{IN}$.

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

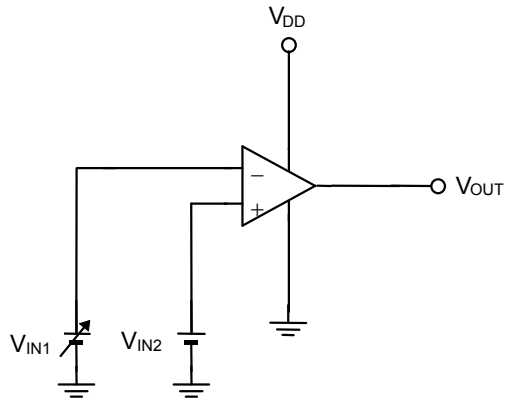



**Figure 8**

- Common-mode input signal rejection ratio (CMRR)
  The common-mode input signal rejection ratio, CMRR, can be calculated by the following expression, with the offset voltage ($V_{IO}$) defined as $V_{IN1}$ minus $V_{IN2}$ at which $V_{OUT}$ is changed by changing $V_{IN1}$.

  Measurement conditions:
  When $V_{IN2} = V_{CMR}$ (max.): $V_{IO} = V_{IO1}$
  When $V_{IN2} = V_{CMR}$ (min.): $V_{IO} = V_{IO2}$

$$CMRR = 20\log\left(\left|\frac{V_{CMR}(max.) - V_{CMR}(min.)}{V_{IO1} - V_{IO2}}\right|\right)$$

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

### 4. Maximum output swing voltage

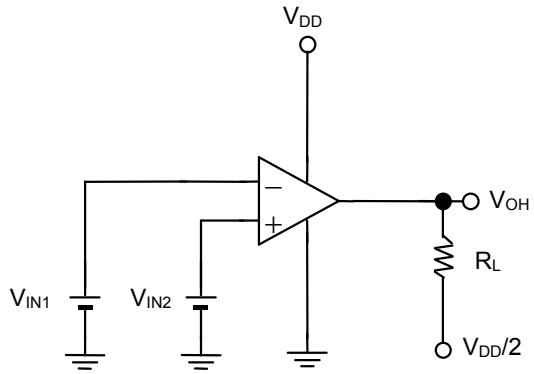



**Figure 9**

- Maximum output swing voltage ($V_{OH}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} - 0.1\,V$
  $V_{IN2} = \frac{V_{DD}}{2} + 0.1\,V$
  $R_L = 1\ M\Omega$

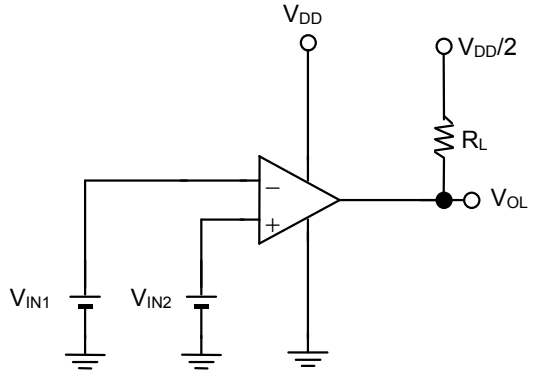



**Figure 10**

- Maximum output swing voltage ($V_{OL}$)
  Measurement conditions: $V_{IN1} = \frac{V_{DD}}{2} + 0.1\,V$
  $V_{IN2} = \frac{V_{DD}}{2} - 0.1\,V$
  $R_L = 1\ M\Omega$

**5. Supply current**

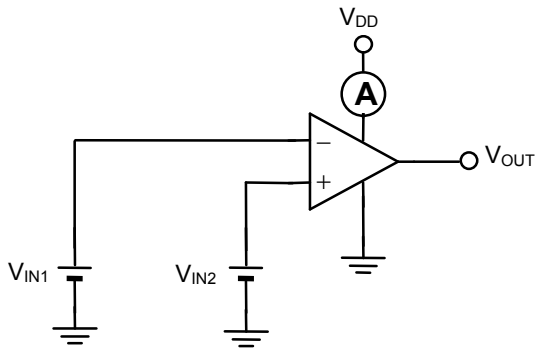



**Figure 11**

- Supply current ($I_{DDH}$)
  Measurement conditions: $V_{IN1} = V_{SS}$
  $V_{IN2} = V_{DD}$
- Supply current ($I_{DDL}$)
  Measurement conditions: $V_{IN1} = V_{DD}$
  $V_{IN2} = V_{SS}$

**6. Source current**

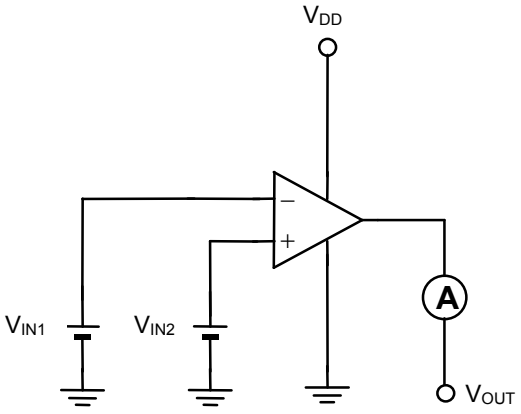



**Figure 12**

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

**7. Sink current**

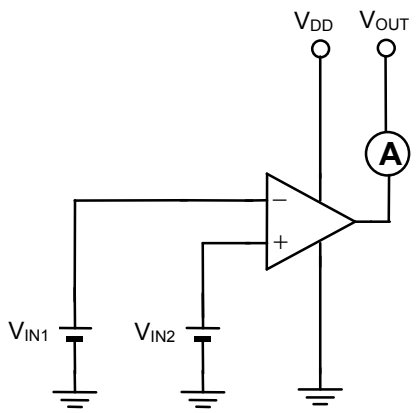



**Figure 13**

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

**8. Propagation delay time/transient response time**

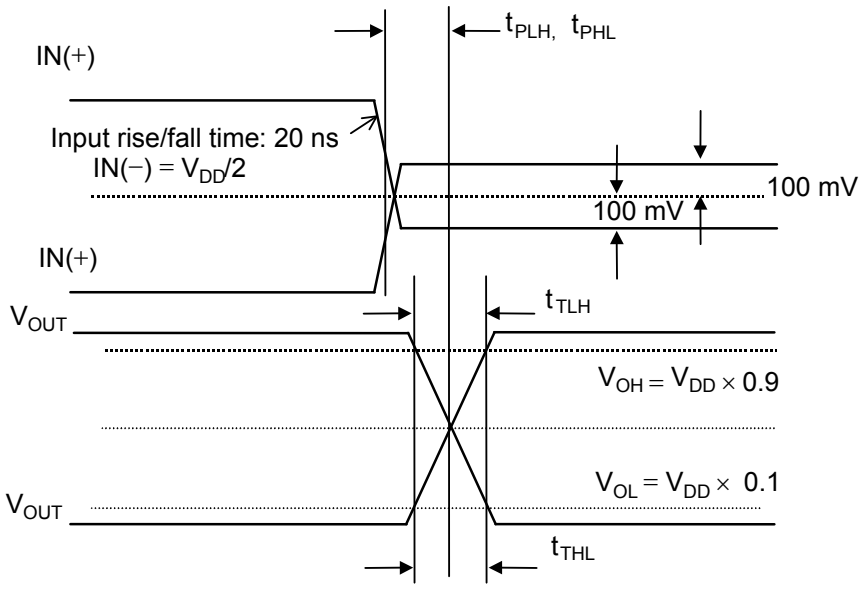



**Figure 14**

## ■ Cautions

- When $R_L$ = 100 kΩ, $V_{OH}$ may rise only 0.65 V if the temperature is −40°C and $V_{DD}$ = 0.9 V.

  If the temperature is −20°C, however, $V_{OH}$ rises to 0.8 V, which is 100 mV below $V_{DD}$, when $V_{DD}$ = 0.9 V, even if $R_L$ = 100 kΩ.

  If $V_{DD}$ is 1.2 V, $V_{OH}$ rises to 0.88 V, which is 20 mV below $V_{DD}$ when $R_L$ = 100 kΩ, even at −40°C.

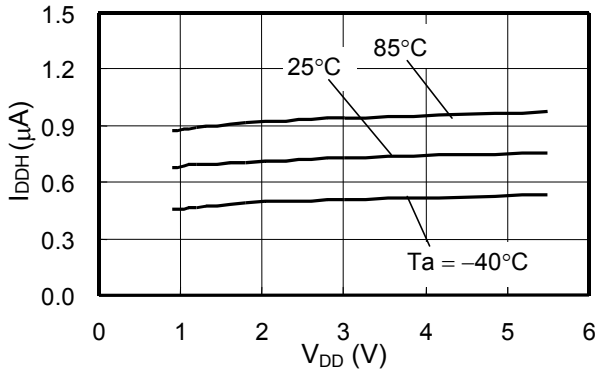
  The temperature characteristics data described above can be used as reference data. Note that 100% testing under these conditions has not been performed.

- Be sure to use the product with a source current of no more than 7 mA.
- Do not apply an electrostatic discharge to this IC that exceeds the performance ratings of the built-in electrostatic protection circuit.

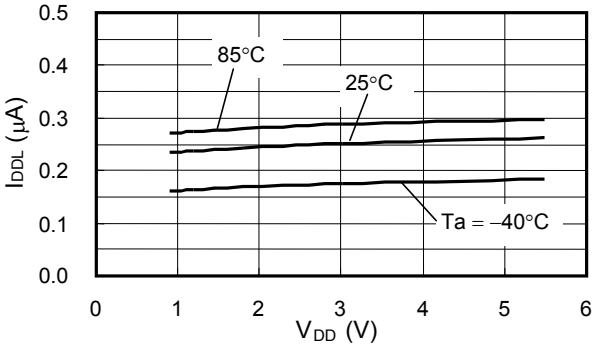
## ■ Characteristics (Reference Data)

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

$I_{DDH}$ vs. $V_{DD}$



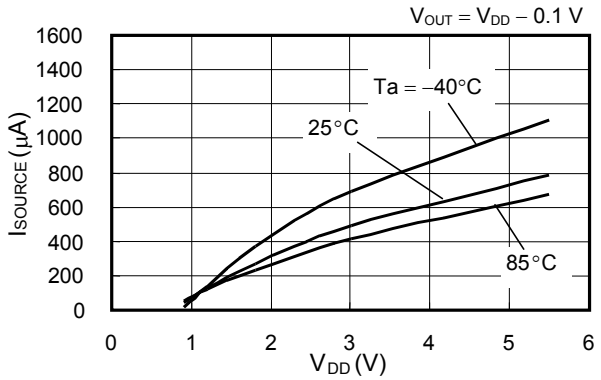

$I_{DDL}$ vs. $V_{DD}$




### 2. Output current

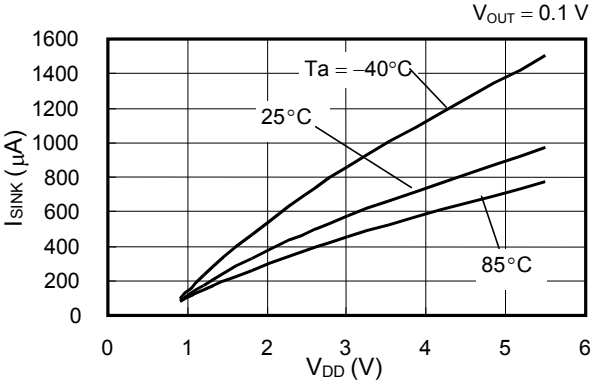
#### 2-1. $I_{SOURCE}$ vs. Power supply voltage

$V_{OUT} = V_{DD} - 0.1$ V

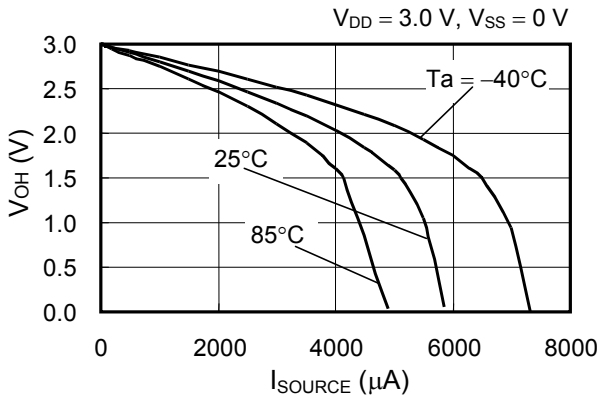


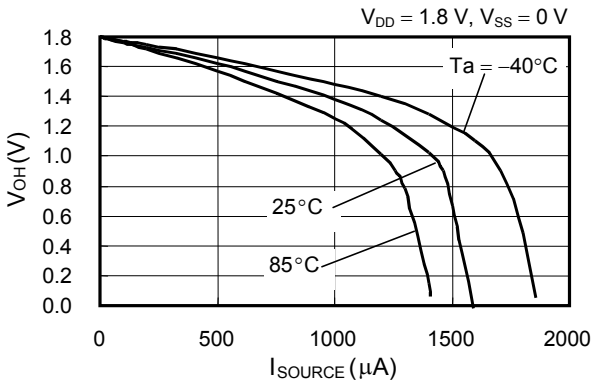

#### $I_{SINK}$ vs. Power supply voltage

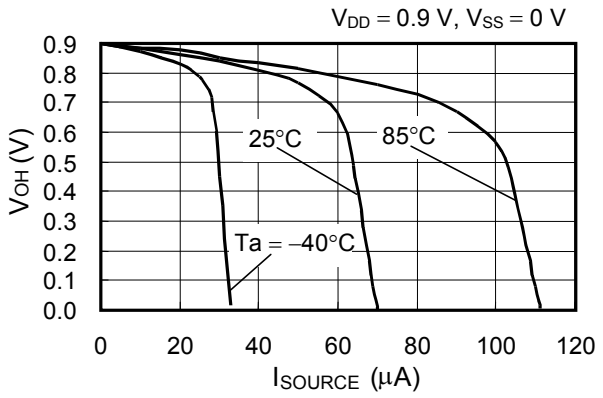
$V_{OUT} = 0.1$ V



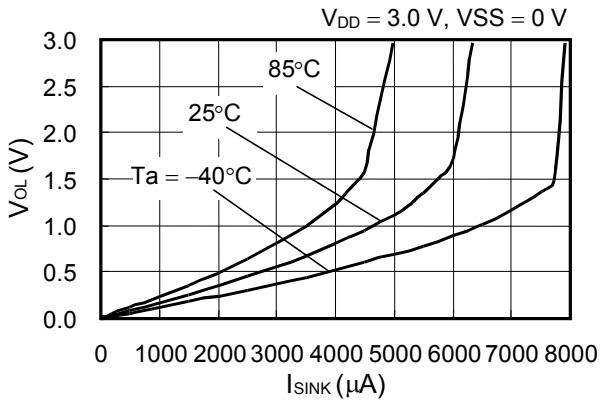
### 2-2. Output voltage ($V_{OH}$) vs. $I_{SOURCE}$

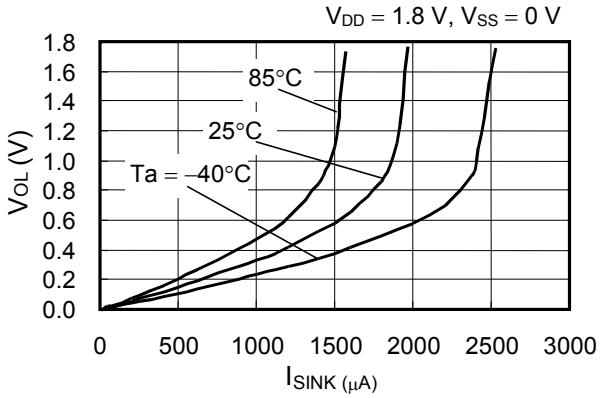


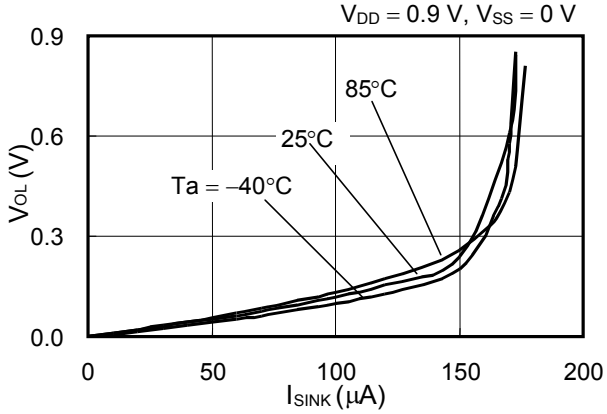



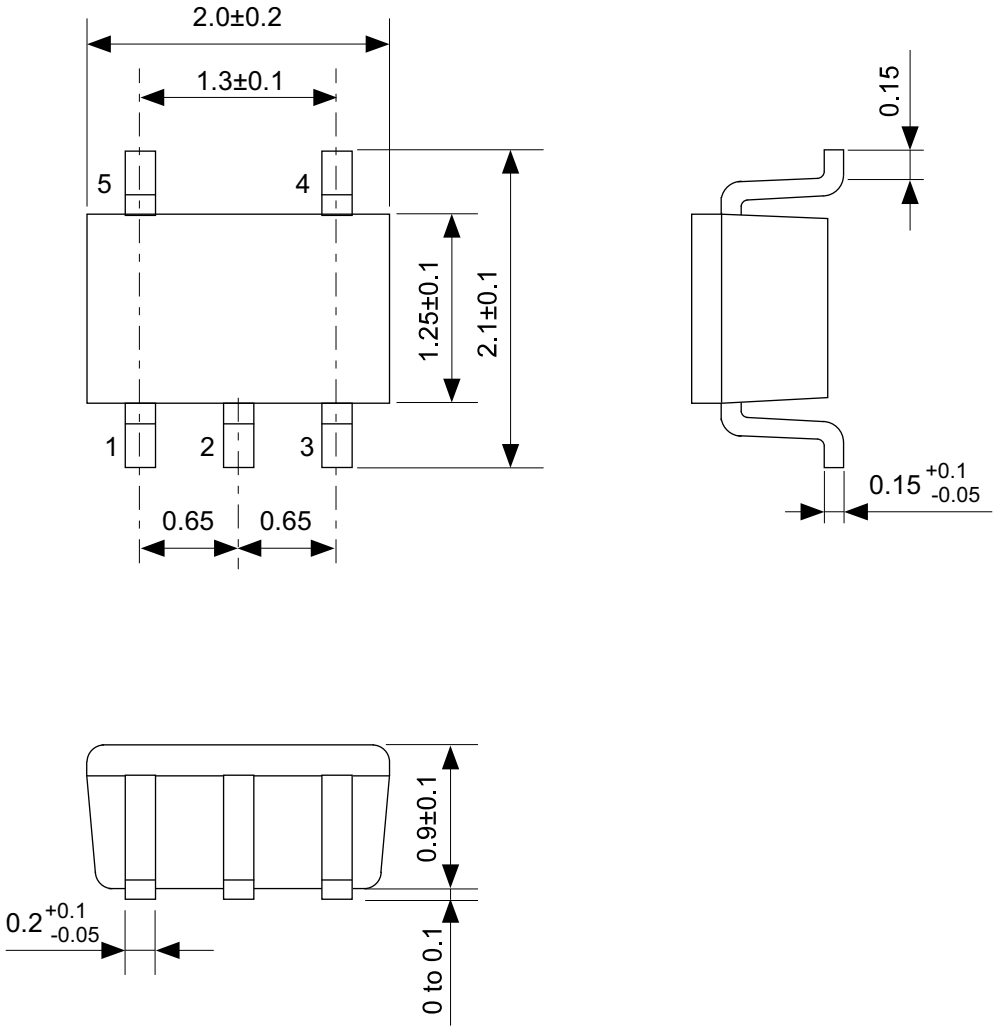




### 2-3. Output Voltage ($V_{OL}$) vs. $I_{SINK}$






No. NP005-B-P-SD-1.2

| | |
|---|---|
| TITLE | SC88A-B-PKG Dimensions |
| No. | NP005-B-P-SD-1.2 |
| ANGLE | |
| UNIT | mm |
| | |

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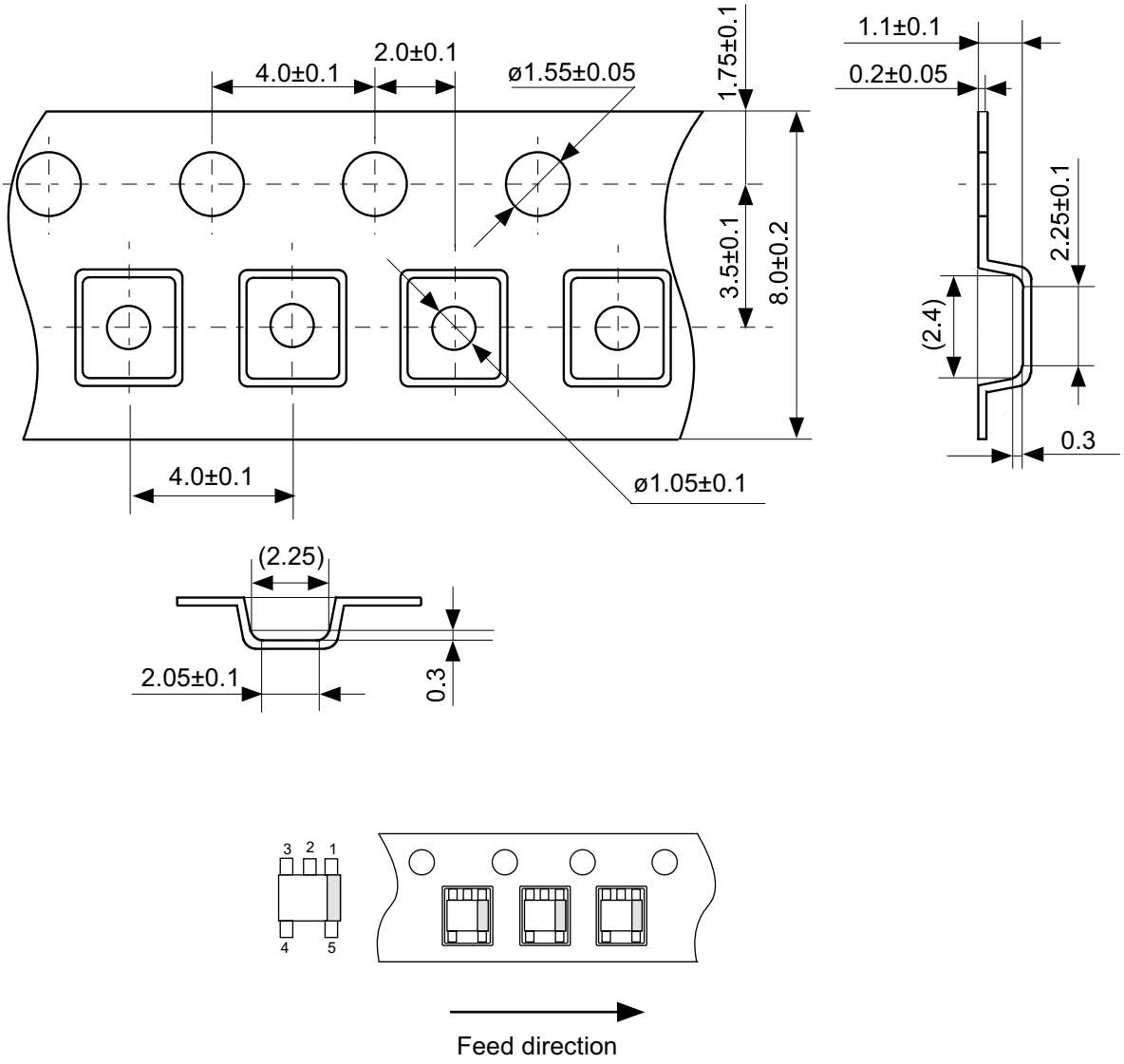


No. NP005-B-C-SD-2.0

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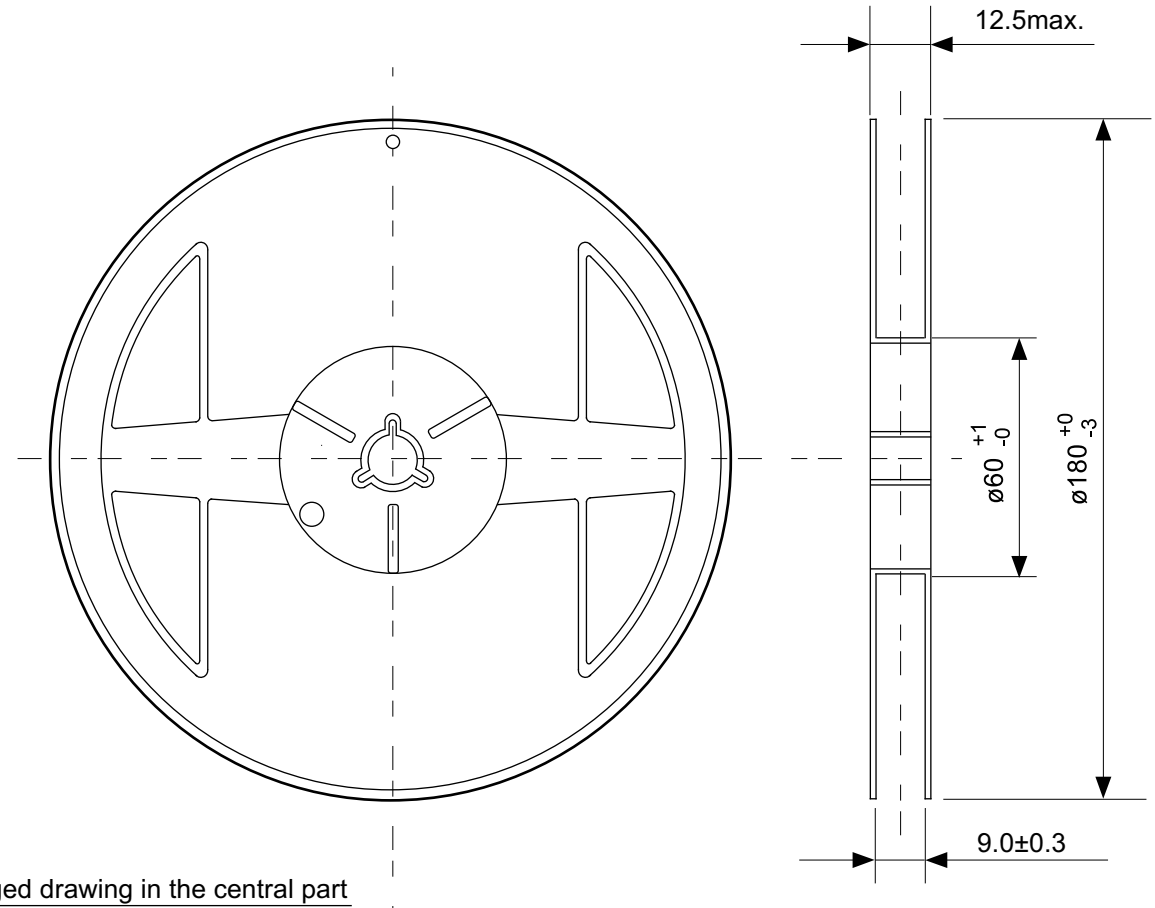
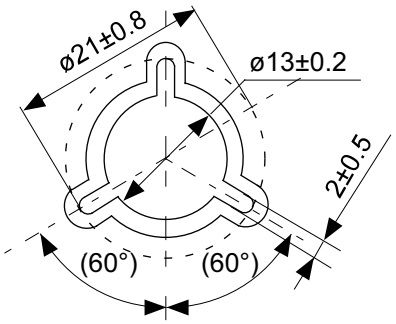



Enlarged drawing in the central part




No. NP005-B-R-SD-2.1

| | | | |
|---|---|---|---|
| TITLE | SC88A-B-Reel | | |
| No. | NP005-B-R-SD-2.1 | | |
| ANGLE | | QTY. | 3,000 |
| UNIT | mm | | |
| | | | |
| **ABLIC Inc.** | | | |

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2.4-2019.07

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