



# S-89530A/89531A Series

## MINI ANALOG SERIES 0.7 $\mu$ A 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<sup>\*1</sup> I/O and can be driven at a lower voltage and lower current consumption 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:  $V_{DD} = 0.9 \text{ V to } 5.5 \text{ V}$
- Low current consumption:  $I_{DD} = 0.7 \mu\text{A} (\text{Typ.})$
- Rail-to-Rail wide input and output voltage range:  
 $V_{CMR} = V_{SS} \text{ to } V_{DD}$
- Low input offset voltage: 5.0 mV max.
- Lead-free, Sn100%, halogen-free<sup>\*1</sup>

\*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)
$V_{IO} = 10 \text{ mV max.}$	S-89530ACNC-HCBTF□
$V_{IO} = 5 \text{ mV max.}$	S-89531ACNC-HCCTF□

Remark □: G, S or U

## ■ Pin Configuration

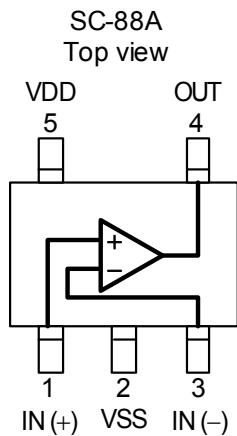


Figure 1

Table 2

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

## ■ Internal Equivalent Circuits

(1) Output pin

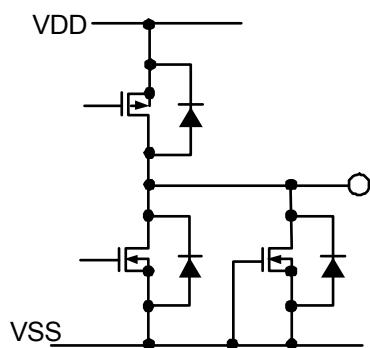


Figure 2

(2) Input pin

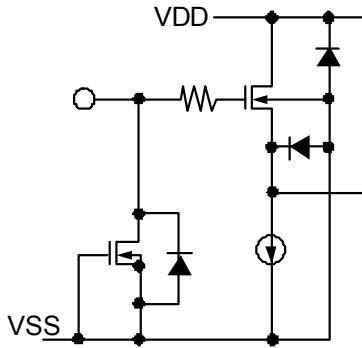


Figure 3

(3) VDD pin

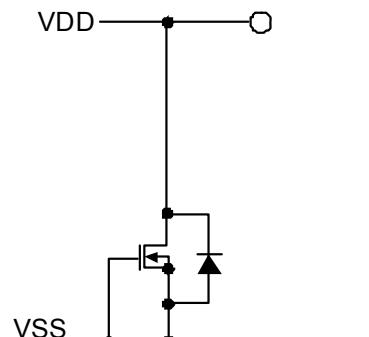


Figure 4

■ Absolute Maximum Ratings

Table 3

( $T_a = 25^\circ\text{C}$  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	$V_{IND}$	$\pm 5.5$	V
Power dissipation	$P_D$	200 (When not mounted on board) 350 <sup>*1</sup>	mW
Operating temperature	$T_{opr}$	-40 to +85	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55 to +125	$^\circ\text{C}$

\*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.

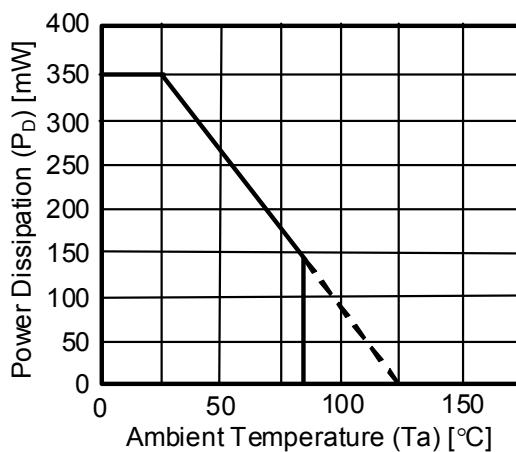


Figure 5 Power Dissipation of Package (When Mounted on Board)

■ 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)

( $T_a = 25^\circ\text{C}$  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	$\mu\text{A}$	<b>Figure 11</b>
	$I_{DDL}$	$V_{IN1} = V_{DD}$ , $V_{IN2} = V_{SS}$ , $R_L = \infty$	—	0.25	0.5	$\mu\text{A}$	
Input offset voltage	$V_{IO}$	S-89530A: $V_{CMR} = 1.5$ V	-10	$\pm 5$	+10	mV	<b>Figure 7</b>
		S-89531A: $V_{CMR} = 1.5$ V	-5	$\pm 3$	+5		
Input offset current	$I_{IO}$	—	—	1	—	pA	—
Input bias current	$I_{BIAS}$	—	—	1	—	pA	—
Common-mode input voltage range	$V_{CMR}$	—	0	—	3.0	V	<b>Figure 8</b>
Voltage gain (open loop)	$A_{VOL}$	$V_{CMR} = 1.5$ V, $R_L = 1\text{ M}\Omega$	—	86	—	dB	—
Maximum output swing voltage	$V_{OH}$	$R_L = 1\text{ M}\Omega$	2.98	—	—	V	<b>Figure 9</b>
	$V_{OL}$	$R_L = 1\text{ M}\Omega$	—	—	0.02		<b>Figure 10</b>
Common-mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	45	65	—	dB	<b>Figure 8</b>
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ V to 5.5 V	66	75	—	dB	<b>Figure 6</b>
Source current <sup>*1</sup>	$I_{SOURCE}$	$V_{OUT} = V_{DD} - 0.1$ V	380	500	—	$\mu\text{A}$	<b>Figure 12</b>
		$V_{OUT} = 0$ V	4000	5500	—		
Sink current	$I_{SINK}$	$V_{OUT} = 0.1$ V	400	550	—	$\mu\text{A}$	<b>Figure 13</b>
		$V_{OUT} = V_{DD}$	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)

( $T_a = 25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Rise propagation delay time	$t_{PLH}$	Overdrive = 100 mV $C_L = 15\text{ pF}$ (Refer to <b>Figure 14</b> )	—	110	—	$\mu\text{s}$
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)

( $T_a = 25^\circ\text{C}$  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	$\mu\text{A}$	<b>Figure 11</b>
	$I_{DDL}$	$V_{IN1} = V_{DD}, V_{IN2} = V_{SS}, R_L = \infty$	—	0.25	0.5		
Input offset voltage	$V_{IO}$	S-89530A: $V_{CMR} = 0.9$ V	-10	$\pm 5$	+10	$\text{mV}$	<b>Figure 7</b>
		S-89531A: $V_{CMR} = 0.9$ V	-5	$\pm 3$	+5		
Input offset current	$I_{IO}$	—	—	1	—	$\text{pA}$	—
Input bias current	$I_{BIAS}$	—	—	1	—		
Common-mode input voltage range	$V_{CMR}$	—	0	—	1.8	V	<b>Figure 8</b>
Voltage gain (open loop)	$A_{VOL}$	$V_{CMR} = 0.9$ V, $R_L = 1 \text{ M}\Omega$	—	80	—	dB	—
Maximum output swing voltage	$V_{OH}$	$R_L = 1 \text{ M}\Omega$	1.78	—	—	V	<b>Figure 9</b>
	$V_{OL}$	$R_L = 1 \text{ M}\Omega$	—	—	0.02		<b>Figure 10</b>
Common-mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	35	55	—	dB	<b>Figure 8</b>
		$V_{SS} \leq V_{CMR} \leq V_{DD} - 0.2$ V	45	60	—		
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ V to 5.5 V	66	75	—	dB	<b>Figure 6</b>
Source current	$I_{SOURCE}$	$V_{OUT} = V_{DD} - 0.1$ V	200	250	—	$\mu\text{A}$	<b>Figure 12</b>
		$V_{OUT} = 0$ V	1000	1500	—		
Sink current	$I_{SINK}$	$V_{OUT} = 0.1$ V	220	300	—	$\mu\text{A}$	<b>Figure 13</b>
		$V_{OUT} = V_{DD}$	1200	1800	—		

**Table 8**

AC Characteristics ( $V_{DD} = 1.8$  V)

( $T_a = 25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Rise propagation delay time	$t_{PLH}$	Overdrive = 100 mV $C_L = 15 \text{ pF}$ (Refer to <b>Figure 14</b> )	—	90	—	$\mu\text{s}$
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	$\mu$ A	<b>Figure 11</b>
	$I_{DDL}$	$V_{IN1} = V_{DD}$ , $V_{IN2} = V_{SS}$ , $R_L = \infty$	—	0.25	0.5		
Input offset voltage	$V_{IO}$	S-89530A: $V_{CMR} = 0.45$ V	-10	$\pm 5$	+10	mV	<b>Figure 7</b>
		S-89531A: $V_{CMR} = 0.45$ V	-5	$\pm 3$	+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	<b>Figure 8</b>
Voltage gain (open loop)	$A_{VOL}$	$V_{CMR} = 0.45$ V, $R_L = 1$ M $\Omega$	—	74	—	dB	—
Maximum output swing voltage	$V_{OH}$	$R_L = 1$ M $\Omega$	0.88	—	—	V	<b>Figure 9</b>
	$V_{OL}$	$R_L = 1$ M $\Omega$	—	—	0.02		<b>Figure 10</b>
Common-mode input signal rejection ratio	CMRR	$V_{SS} \leq V_{CMR} \leq V_{DD}$	25	50	—	dB	<b>Figure 8</b>
		$V_{SS} \leq V_{CMR} \leq V_{DD} - 0.3$ V	40	60	—		
Power supply voltage rejection ratio	PSRR	$V_{DD} = 0.9$ V to 5.5 V	66	75	—	dB	<b>Figure 6</b>
Source current	$I_{SOURCE}$	$V_{OUT} = V_{DD} - 0.1$ V	10	45	—	$\mu$ A	<b>Figure 12</b>
		$V_{OUT} = 0$ V	12	70	—		
Sink current	$I_{SINK}$	$V_{OUT} = 0.1$ V	10	65	—	$\mu$ A	<b>Figure 13</b>
		$V_{OUT} = V_{DD}$	12	120	—		

**Table 10**

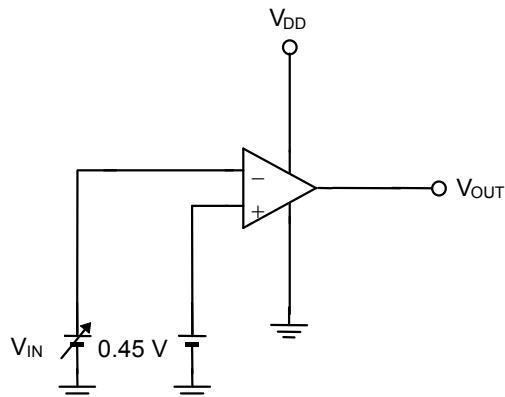
AC Characteristics ( $V_{DD} = 0.9$  V)

(Ta = 25°C unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Rise propagation delay time	$t_{PLH}$	Overdrive = 100 mV $C_L = 15$ pF (Refer to <b>Figure 14</b> )	—	65	—	$\mu$ s
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



- 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:

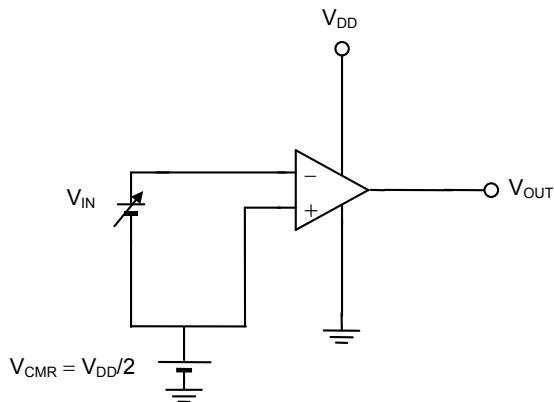
When  $V_{DD} = 0.9$  V:  $V_{DD} = V_{DD1}$ ,  $V_{IO} = V_{IO1}$

When  $V_{DD} = 5.5$  V:  $V_{DD} = V_{DD2}$ ,  $V_{IO} = V_{IO2}$

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

Figure 6

### 2. Input offset voltage



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

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

Figure 7

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

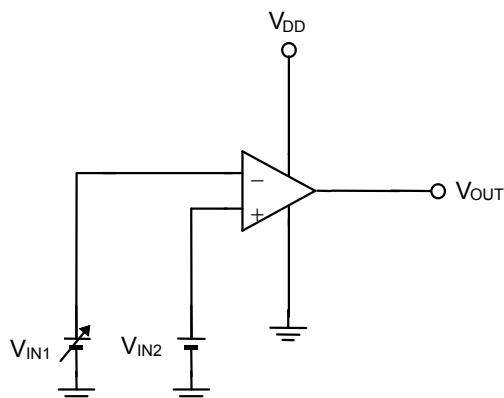


Figure 8

- 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.):  $V_{IO} = V_{IO2}$

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

- 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

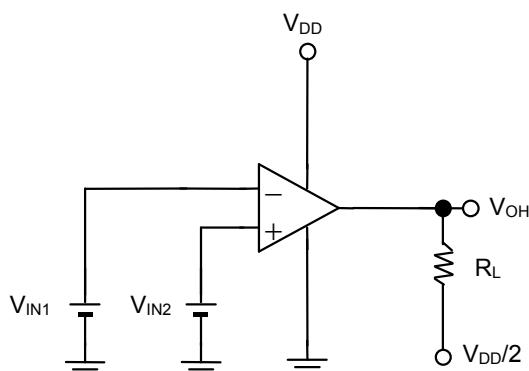


Figure 9

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

Measurement conditions:  $V_{IN1} = \frac{V_{DD}}{2} - 0.1V$

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

$$R_L = 1 \text{ M}\Omega$$

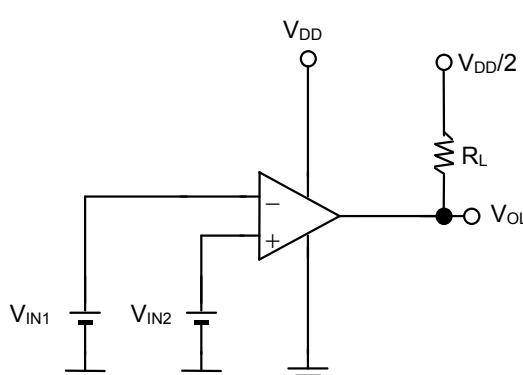


Figure 10

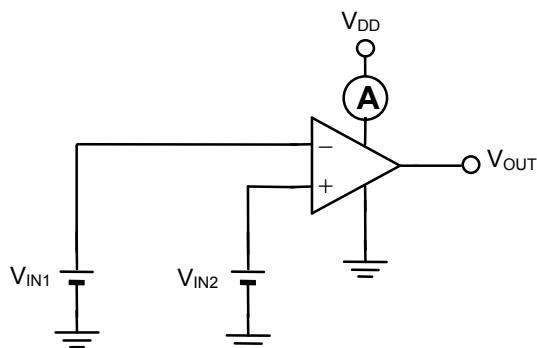
- Maximum output swing voltage ( $V_{OL}$ )

Measurement conditions:  $V_{IN1} = \frac{V_{DD}}{2} + 0.1V$

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

$$R_L = 1 \text{ M}\Omega$$

## 5. Supply current

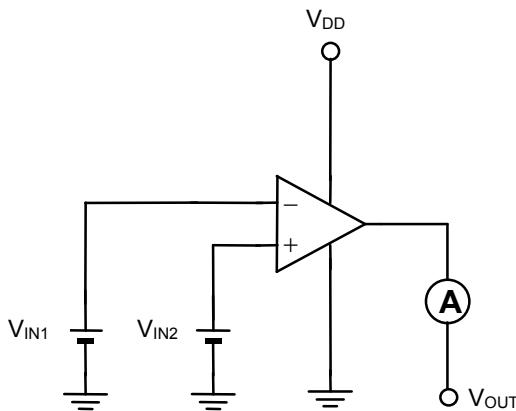


- Supply current ( $I_{DDH}$ )  
 Measurement conditions:  $V_{IN1} = V_{SS}$   
 $V_{IN2} = V_{DD}$

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

Figure 11

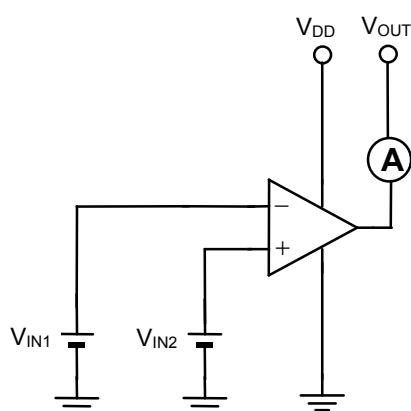
## 6. Source current



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

Figure 12

## 7. Sink current



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

Figure 13

8. Propagation delay time/transient response time

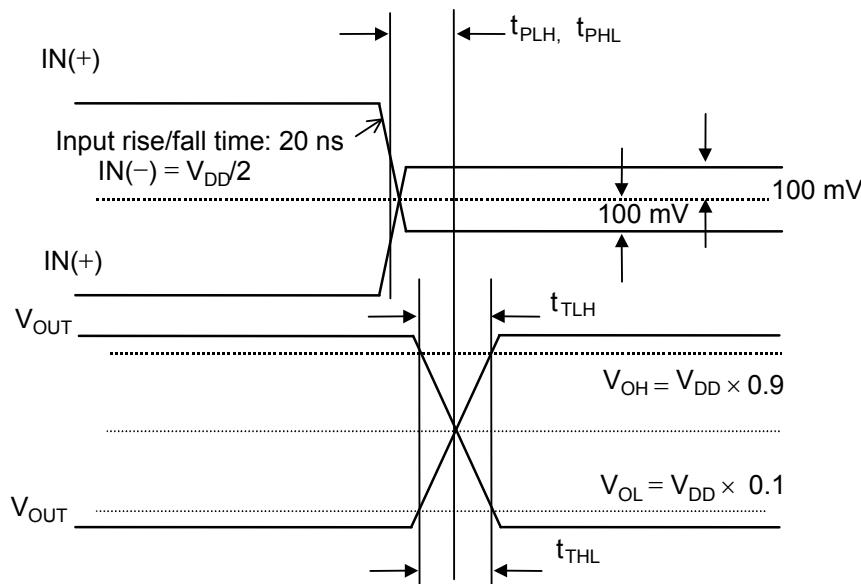


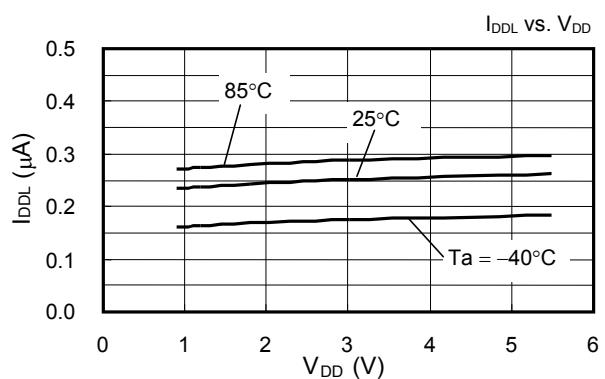
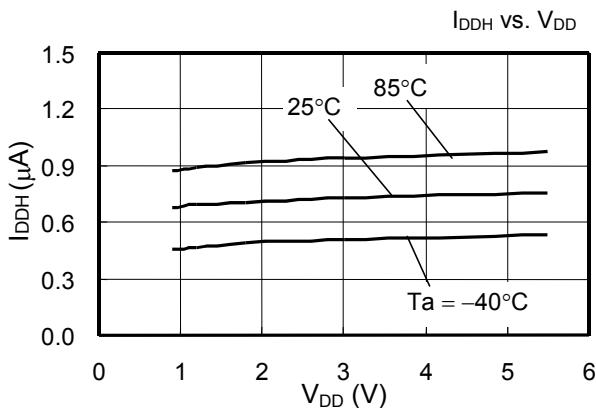
Figure 14

■ Cautions

- When  $R_L = 100 \text{ k}\Omega$ ,  $V_{OH}$  may rise only 0.65 V if the temperature is  $-40^\circ\text{C}$  and  $V_{DD} = 0.9 \text{ V}$ . If the temperature is  $-20^\circ\text{C}$ , however,  $V_{OH}$  rises to 0.8 V, which is 100 mV below  $V_{DD}$ , when  $V_{DD} = 0.9 \text{ V}$ , even if  $R_L = 100 \text{ k}\Omega$ . If  $V_{DD}$  is 1.2 V,  $V_{OH}$  rises to 0.88 V, which is 20 mV below  $V_{DD}$  when  $R_L = 100 \text{ k}\Omega$ , even at  $-40^\circ\text{C}$ . 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.

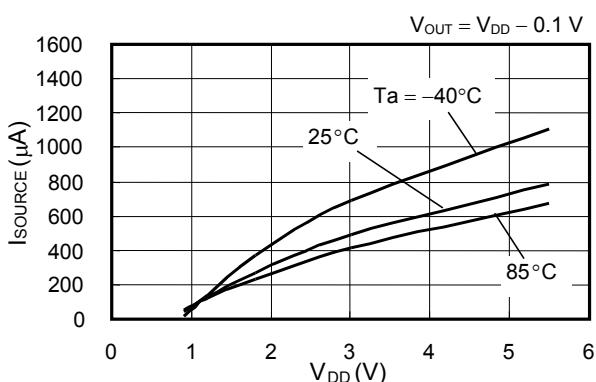
## ■ Characteristics (Reference Data)

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

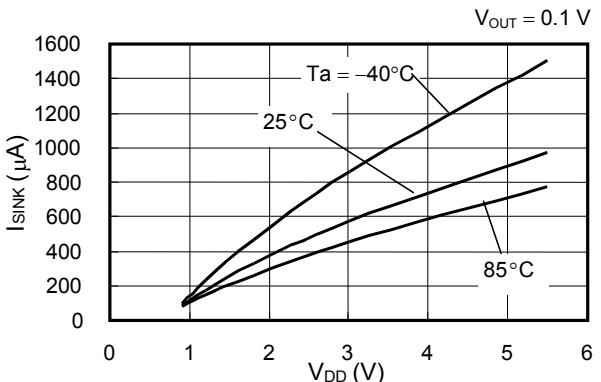


### 2. Output current

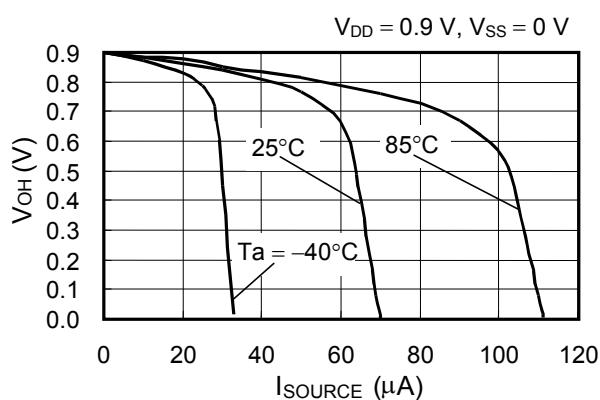
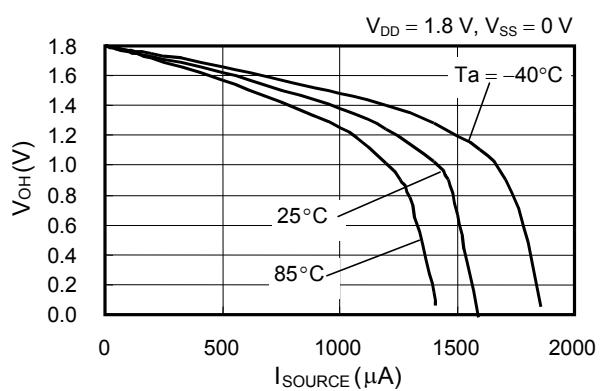
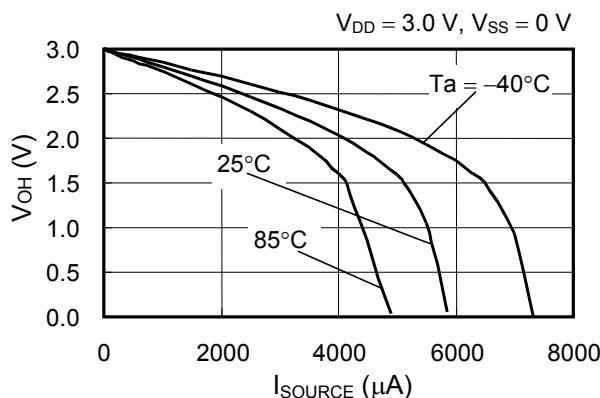
#### 2-1. $I_{SOURCE}$ vs. Power supply voltage



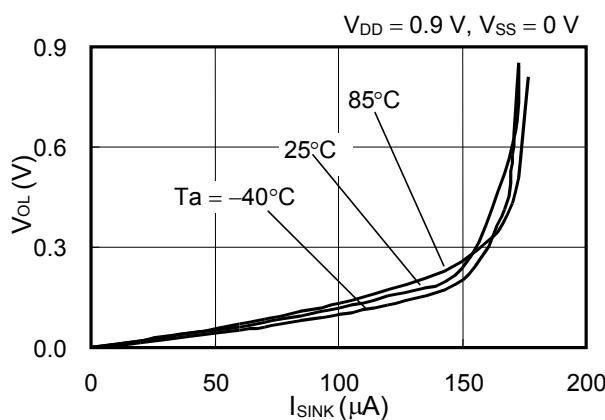
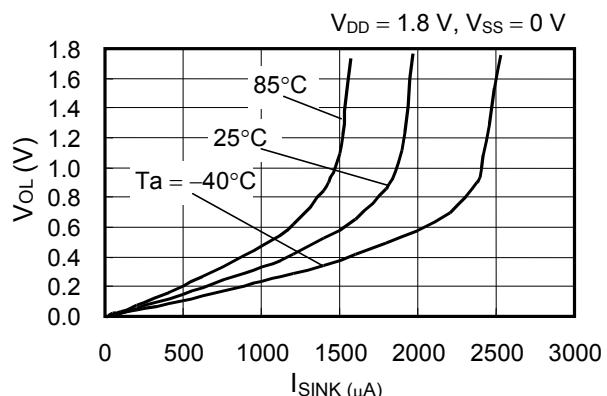
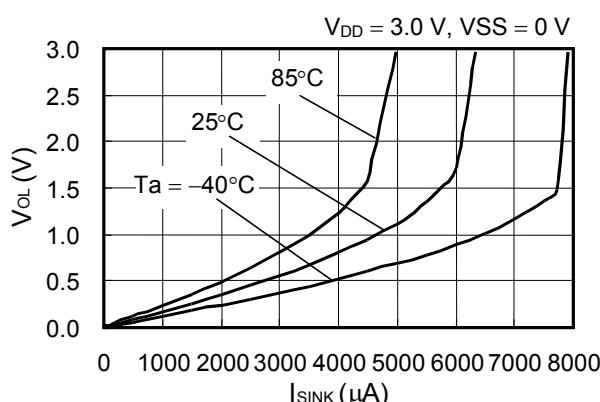
#### $I_{SINK}$ vs. Power supply voltage

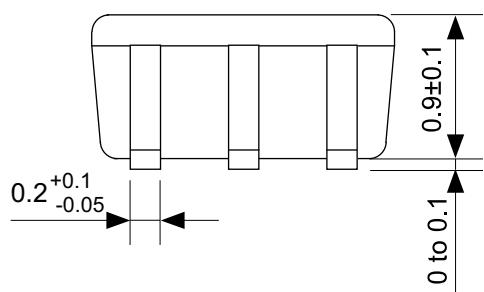
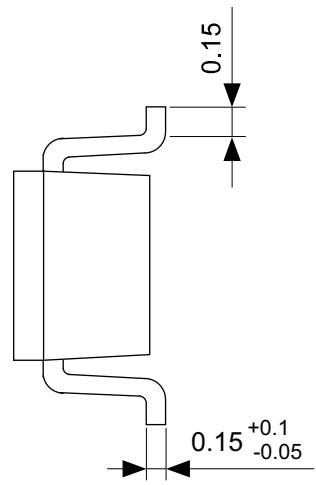
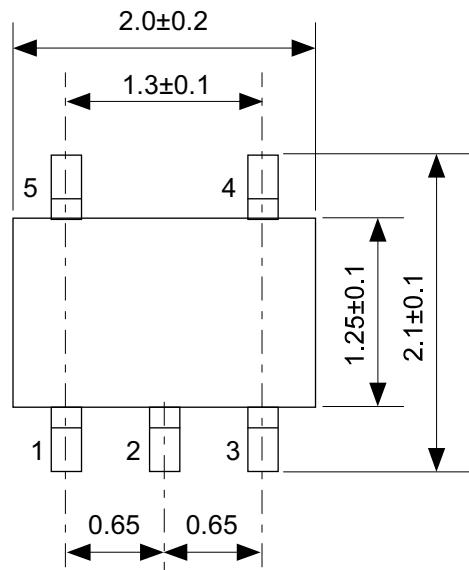


2-2. Output voltage ( $V_{OH}$ ) vs.  $I_{SOURCE}$



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

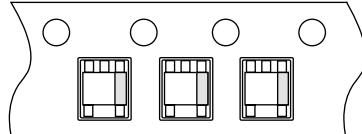
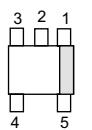
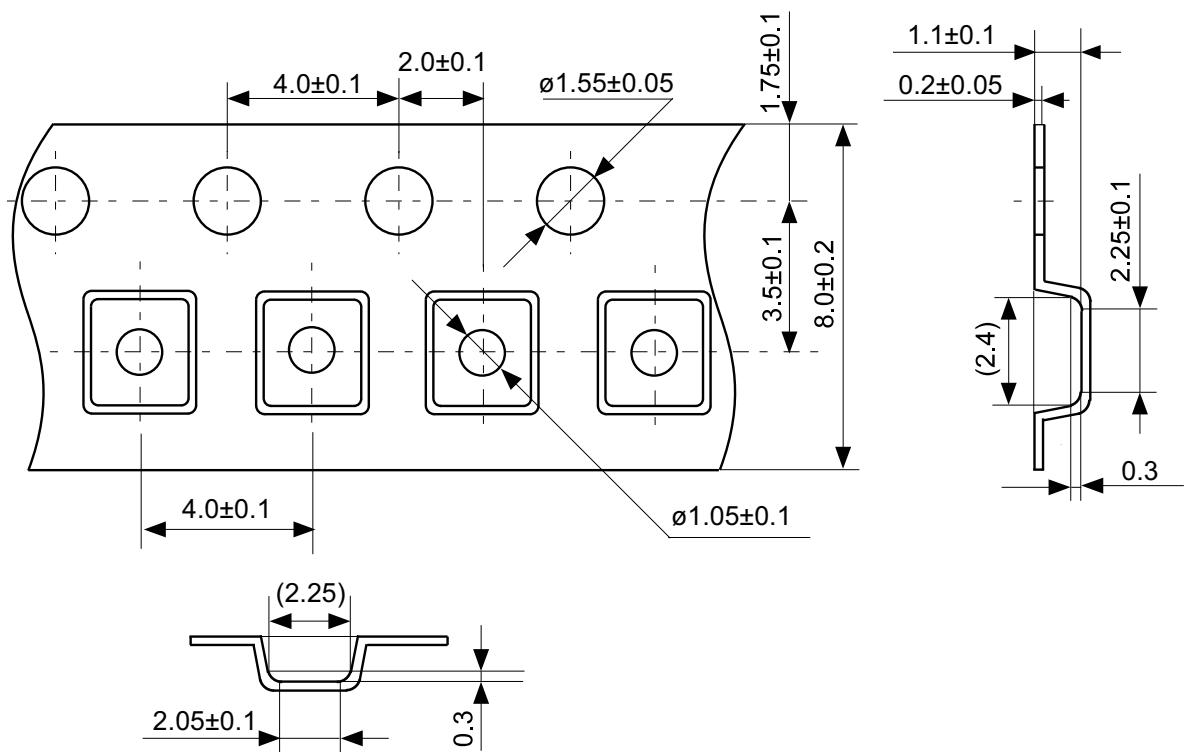




No. NP005-B-P-SD-1.2

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

**ABLIC Inc.**

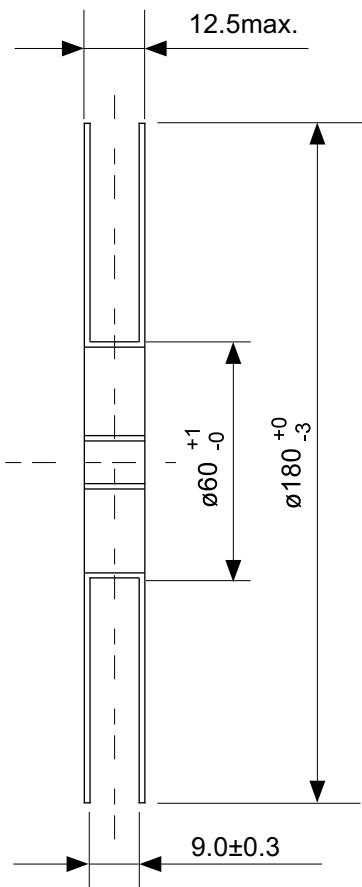
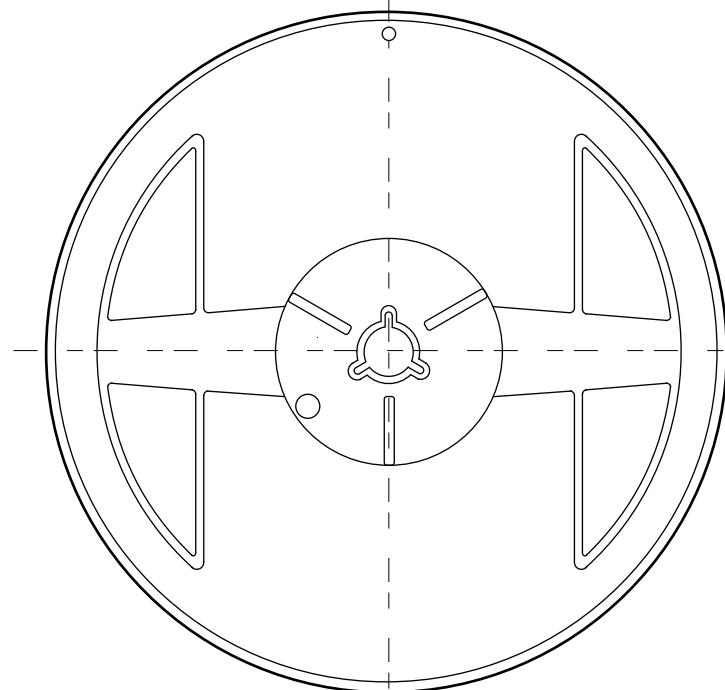


Feed direction

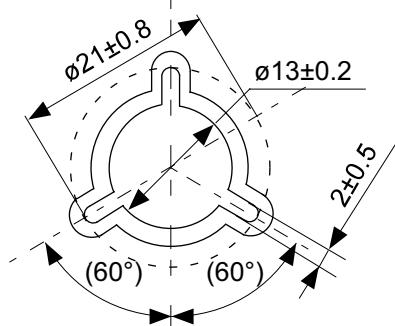
No. NP005-B-C-SD-2.0

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

**ABLIC 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		
ANGLE		QTY.	3,000
UNIT	mm		
<b>ABLIC Inc.</b>			

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