

## Comparator

# Ground Sense Comparators

## LM8391G-LB

### General Description

This product guarantees long time support in industrial market. And it is suitable for usage of industrial applications.

LM8391G-LB is high-gain and ground sense input comparator.

An operating voltage range is wide with 3 V to 36 V. This operational amplifier is the most suitable for industrial requirements such as current-monitor, battery-monitor and so on because it has features of low supply current.

### Features

- Long Time Support Product for Industrial Applications.
- Operable from Almost GND Level for Input
- Single or Dual Power Supply Operation
- Standard Comparator Pin-assignments
- Low Supply Current
- Wide Operating Supply Voltage Range
- Wide Operating Temperature Range

### Applications

- Industrial Equipment
- Current Monitor
- Battery Monitor
- Multi Vibrators

### Key Specifications

- Operating Supply Voltage Range  
Single Supply: 3.0 V to 36.0 V  
Dual Supply:  $\pm 1.5$  V to  $\pm 18.0$  V
- Operating Temperature Range:  $-40$  °C to  $+125$  °C
- Low Supply Current: 0.3 mA (Typ)
- Input Offset Current: 5 nA (Typ)
- Input Bias Current: 50 nA (Typ)

### Package

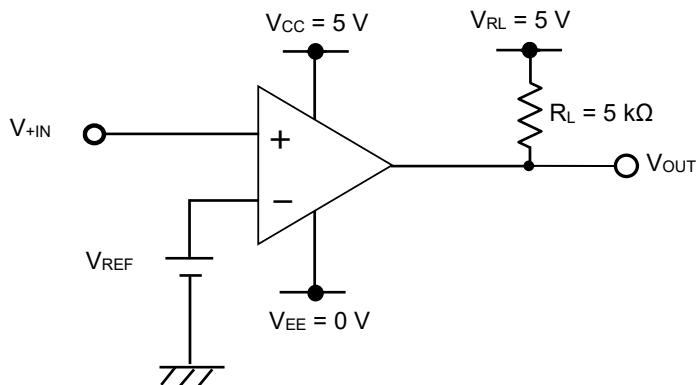
SSOP5:

W (Typ) x D (Typ) x H (Max)

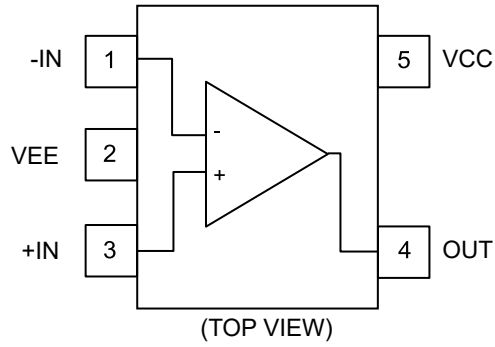
2.9 mm x 2.8 mm x 1.25 mm



### Typical Application Circuit



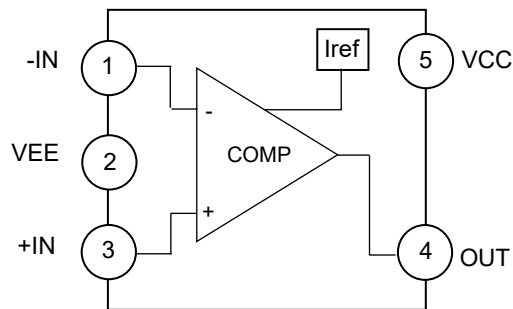
## Pin Configuration



## Pin Description

Pin No.	Pin Name	Function
1	-IN	Inverting input
2	VEE	Negative power supply / Ground
3	+IN	Non-inverting input
4	OUT	Output
5	VCC	Positive power supply

## Block Diagram



## Description of Blocks

1. COMP:  
This block is a ground sense comparator with differential input stage.
2. Iref:  
This block supplies reference current which is needed to operate COMP block.

## Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V <sub>CC-V<sub>EE</sub></sub>	36	V
Differential Input Voltage <sup>(Note 1)</sup>	V <sub>ID</sub>	V <sub>CC-V<sub>EE</sub></sub>	V
Common-mode Input Voltage Range	V <sub>ICMR</sub>	(V <sub>EE</sub> - 0.3) to (V <sub>EE</sub> + 36)	V
Input Current	I <sub>I</sub>	±10	mA
Maximum Junction Temperature	T <sub>Jmax</sub>	150	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C

**Caution 1:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Caution 2:** Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.

(Note 1) The differential input voltage indicates the voltage difference between inverting input and non-inverting input.  
The input pin voltage is set to V<sub>EE</sub> or more.

Thermal Resistance<sup>(Note 2)</sup>

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s <sup>(Note 4)</sup>	2s2p <sup>(Note 5)</sup>	
SSOP5				
Junction to Ambient	θ <sub>JA</sub>	376.5	185.4	°C/W
Junction to Top Characterization Parameter <sup>(Note 3)</sup>	Ψ <sub>JT</sub>	40	30	°C/W

(Note 2) Based on JESD51-2A(Still-Air).

(Note 3) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 4) Using a PCB board based on JESD51-3.

(Note 5) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size			
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt			
Top					
Copper Pattern	Thickness				
Footprints and Traces	70 μm				
Layer Number of Measurement Board					
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt			
Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 μm	74.2 mm x 74.2 mm	35 μm	74.2 mm x 74.2 mm	70 μm

## Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating Supply Voltage	Single Supply	3.0	-	36.0	V
	Dual Supply	±1.5	-	±18.0	
Operating Temperature	Topr	-40	+25	+125	°C

Electrical Characteristics (Unless otherwise specified  $V_{CC} = 5\text{ V}$ ,  $V_{EE} = 0\text{ V}$ )

Parameter	Symbol	Temperature Range	Limit			Unit	Conditions
			Min	Typ	Max		
Input Offset Voltage	$V_{IO}$	25 °C	-	2	5	mV	$V_{OUT} = 1.4\text{ V}$ Absolute value
		-40 °C to +125 °C	-	-	9		$V_{CC} = 5\text{ V to }36\text{ V}$ $V_{OUT} = 1.4\text{ V}$ Absolute value
Input Offset Current	$I_{IO}$	25 °C	-	5	40	nA	$V_{OUT} = 1.4\text{ V}$ Absolute value
		-40 °C to +125 °C	-	-	50		
Input Bias Current	$I_B$	25 °C	-	50	250	nA	$V_{OUT} = 1.4\text{ V}$ Absolute value
		-40 °C to +125 °C	-	-	275		
Common-mode Input Voltage Range	$V_{ICMR}$	25 °C	0	-	3.5	V	$(V_{CC}-V_{EE}) = 5\text{ V}$
		-40 °C to +125 °C	0	-	3.0		
Large Signal Voltage Gain	$A_v$	25 °C	80	120	-	dB	$V_{CC} = 15\text{ V}$ $V_{OUT} = 1.4\text{ V to }11.4\text{ V}$ $R_L = 15\text{ k}\Omega$ , $V_{RL} = 15\text{ V}$
		-40 °C to +125 °C	74	-	-		
Supply Current	$I_{CC}$	25 °C	-	0.3	0.5	mA	$V_{OUT} = \text{Open}$
		-40 °C to +125 °C	-	-	1.0		$V_{OUT} = \text{Open}$ , $V_{CC} = 36\text{ V}$
Output Sink Current <sup>(Note 1)</sup>	$I_{OL}$	25 °C	8	16	-	mA	$V_{+IN} = 0\text{ V}$ , $V_{-IN} = 1\text{ V}$ $V_{OUT} = 1.5\text{ V}$ Absolute value
		-40 °C to +125 °C	2	-	-		
Output Saturation Voltage (Low Level Output Voltage)	$V_{OL}$	25 °C	-	80	200	mV	$V_{+IN} = 0\text{ V}$ , $V_{-IN} = 1\text{ V}$ $I_{OL} = 4\text{ mA}$
		-40 °C to +125 °C	-	-	400		
Output Leak Current <sup>(Note 1)</sup> (High Level Output Current)	$I_{LEAK}$	25 °C	-	0.1	-	nA	$V_{+IN} = 1\text{ V}$ , $V_{-IN} = 0\text{ V}$ $V_{OUT} = 5\text{ V}$ Absolute value
		-40 °C to +125 °C	-	-	1	$\mu\text{A}$	$V_{+IN} = 1\text{ V}$ , $V_{-IN} = 0\text{ V}$ $V_{OUT} = 36\text{ V}$ Absolute value
Response Time	$t_{RE}$	25 °C	-	1.3	-	$\mu\text{s}$	$R_L = 5.1\text{ k}\Omega$ , $V_{RL} = 5\text{ V}$ $V_{IN} = 100\text{ mV}_{P-P}$ Overdrive = 5 mV
			-	0.4	-		$R_L = 5.1\text{ k}\Omega$ , $V_{RL} = 5\text{ V}$ $V_{IN} = \text{TTL}$ Logic Swing, $V_{REF} = 1.4\text{ V}$
Operable Frequency	$f_{opr}$	25 °C	100	-	-	kHz	$R_L = 2\text{ k}\Omega$ , $V_{+IN} = 1.5\text{ V}$ $V_{-IN} = 5\text{ V}_{P-P}$ (Duty 50 % Rectangular Pulse)

(Note 1) Consider the power dissipation of the IC under high temperature environment when selecting the output current value. When the output pin is short-circuited continuously, the output current may decrease due to the temperature rise by the heat generation of inside the IC.

Typical Performance Curves

$V_{EE} = 0\text{ V}$

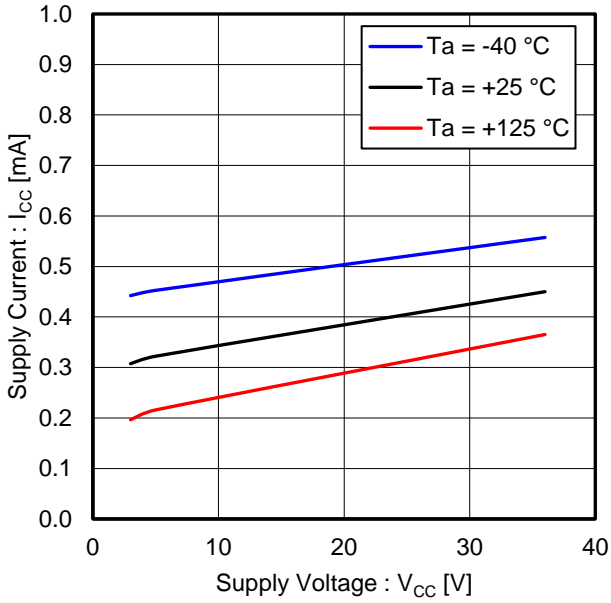


Figure 1. Supply Current vs Supply Voltage

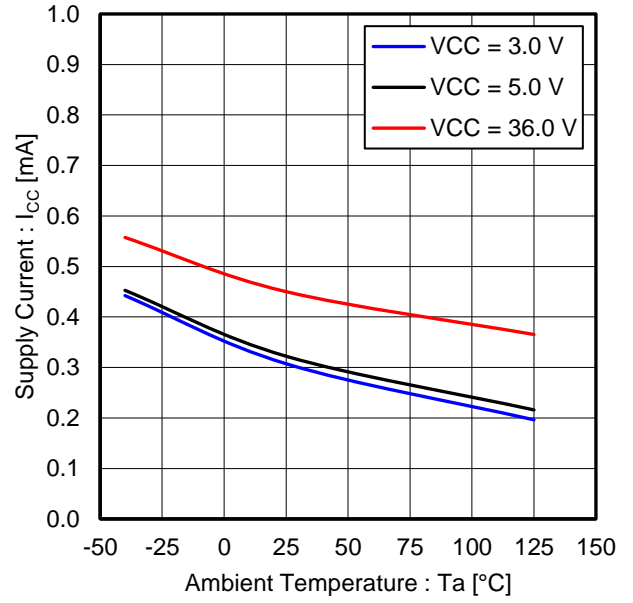


Figure 2. Supply Current vs Ambient Temperature

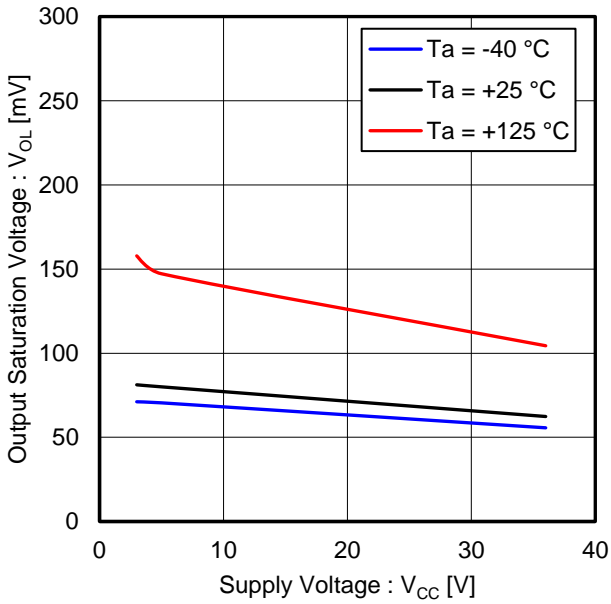


Figure 3. Output Saturation Voltage vs Supply Voltage ( $I_{OL} = 4\text{ mA}$ )

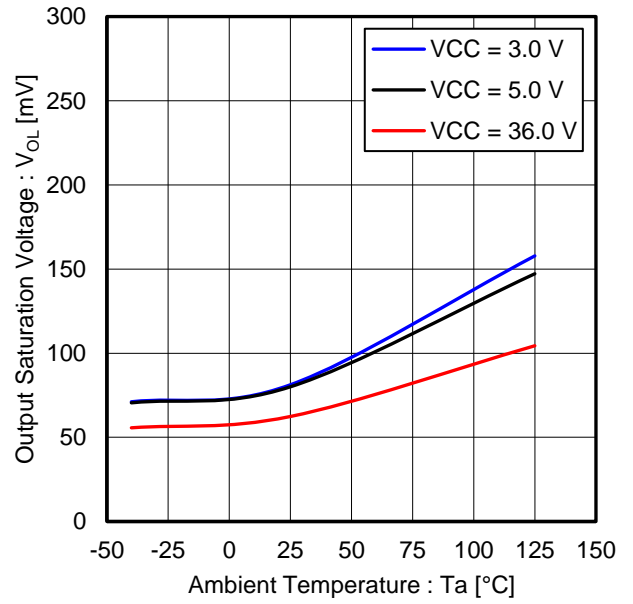


Figure 4. Output Saturation Voltage vs Ambient Temperature ( $I_{OL} = 4\text{ mA}$ )

(Note) The above data are measurement value of typical sample; it is not guaranteed.

Typical Performance Curves - continued

$V_{EE} = 0\text{ V}$

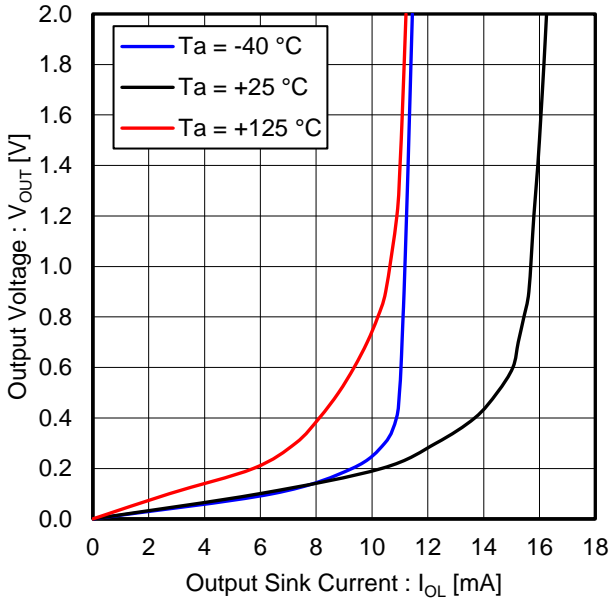


Figure 5. Output Voltage vs Output Sink Current ( $V_{CC} = 5\text{ V}$ )

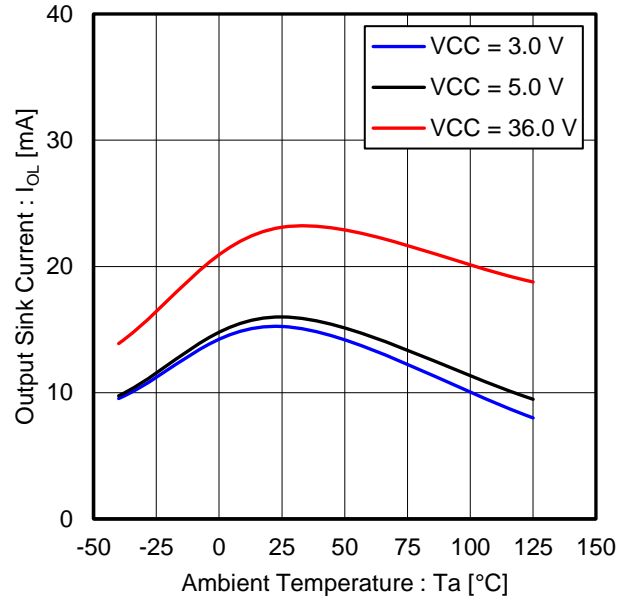


Figure 6. Output Sink Current vs Ambient Temperature ( $V_{out} = 1.5\text{ V}$ )

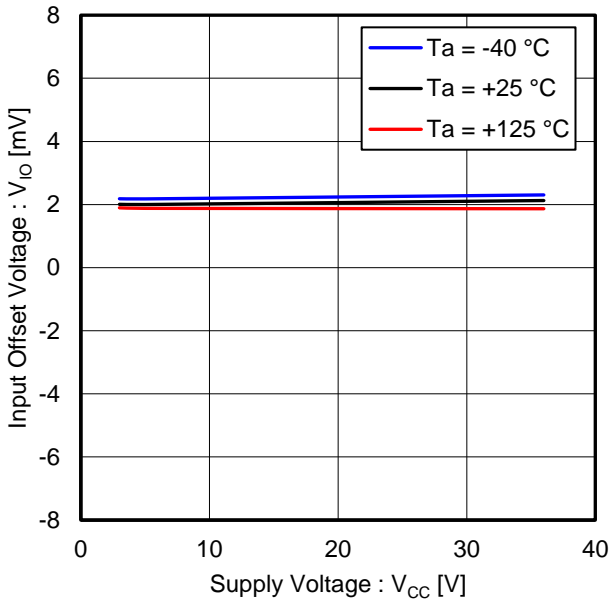


Figure 7. Input Offset Voltage vs Supply Voltage

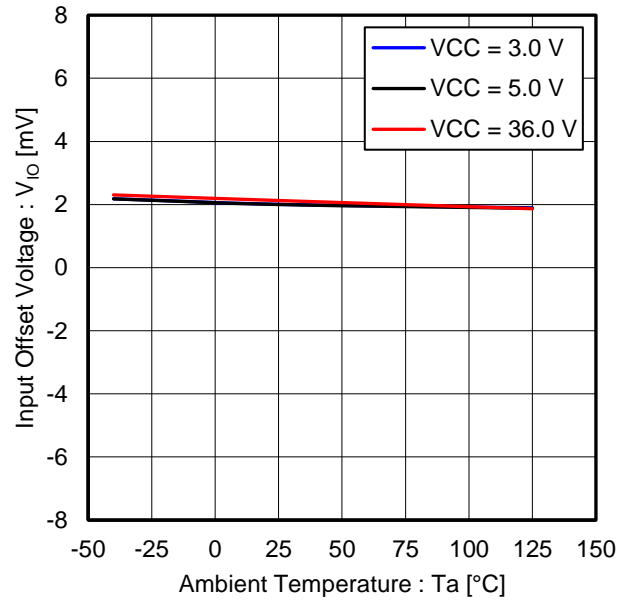


Figure 8. Input Offset Voltage vs Ambient Temperature

(Note) The above data are measurement value of typical sample; it is not guaranteed.

Typical Performance Curves - continued

$V_{EE} = 0\text{ V}$

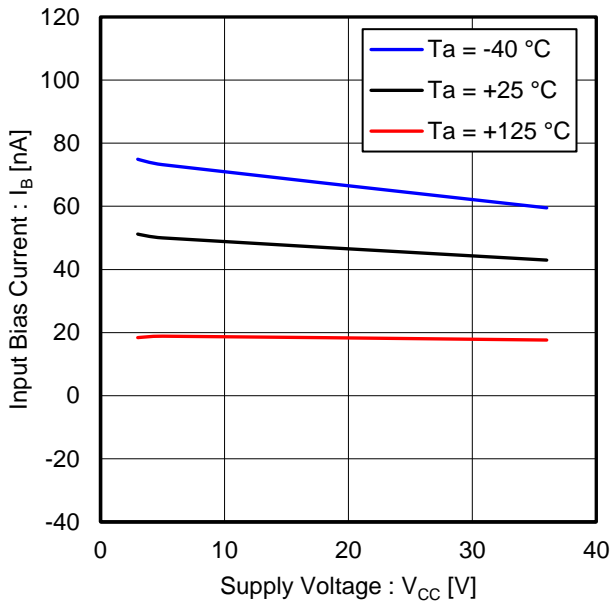


Figure 9. Input Bias Current vs Supply Voltage

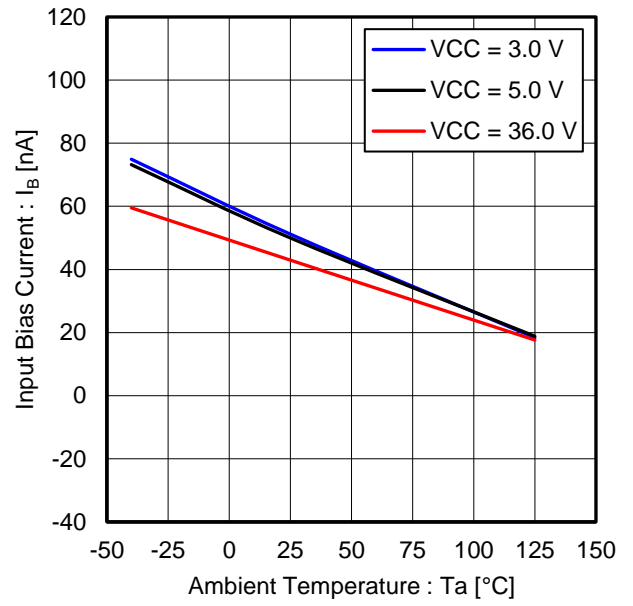


Figure 10. Input Bias Current vs Ambient Temperature

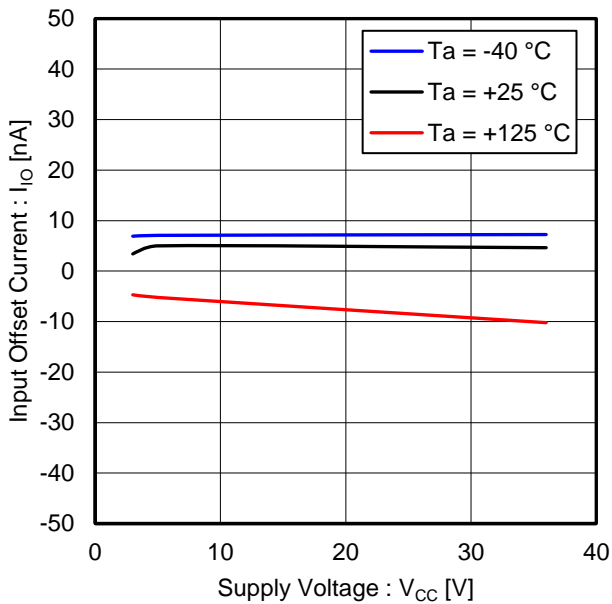


Figure 11. Input Offset Current vs Supply Voltage

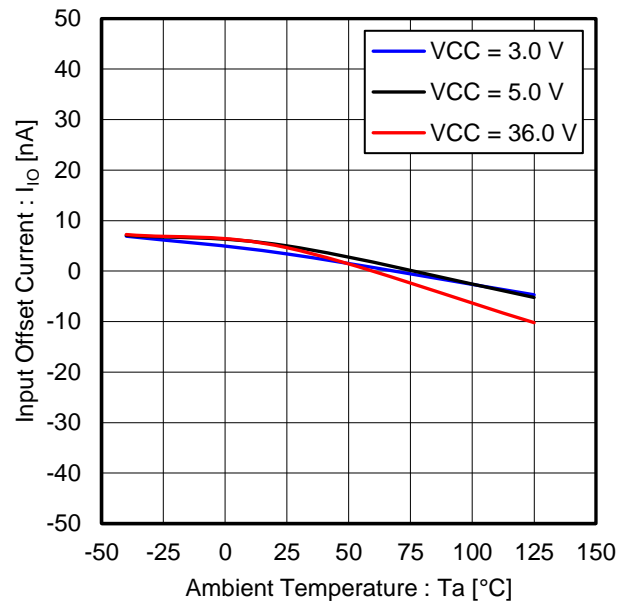


Figure 12. Input Offset Current vs Ambient Temperature

(Note) The above data are measurement value of typical sample; it is not guaranteed.

Typical Performance Curves - continued

$V_{EE} = 0\text{ V}$

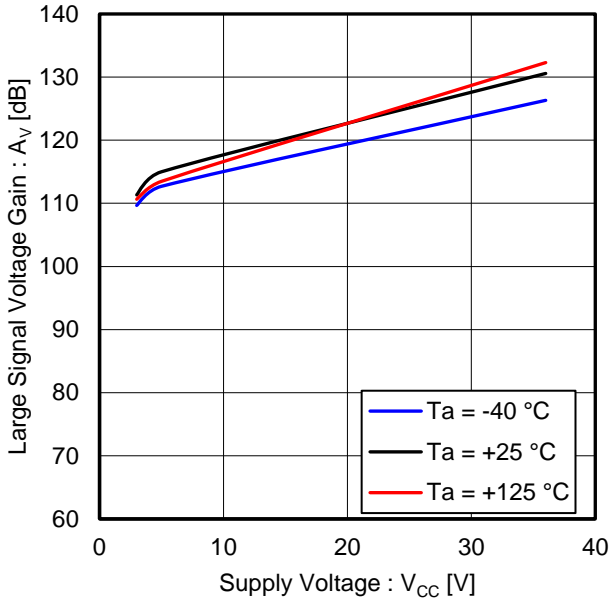


Figure 13. Large Signal Voltage Gain vs Supply Voltage

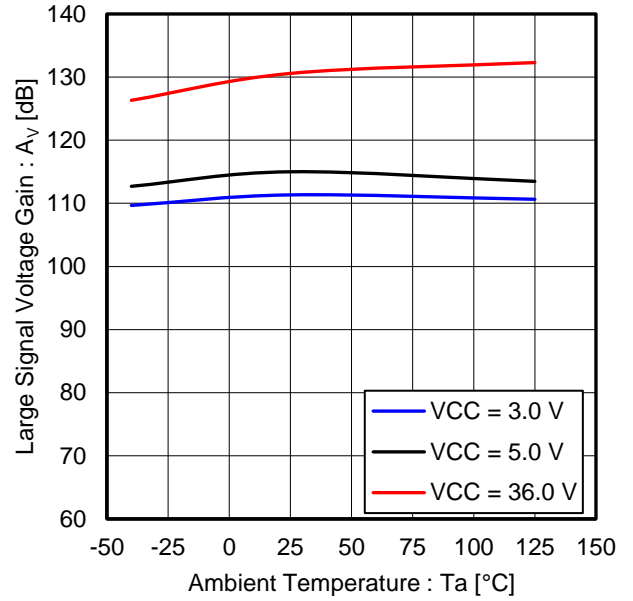


Figure 14. Large Signal Voltage Gain vs Ambient Temperature

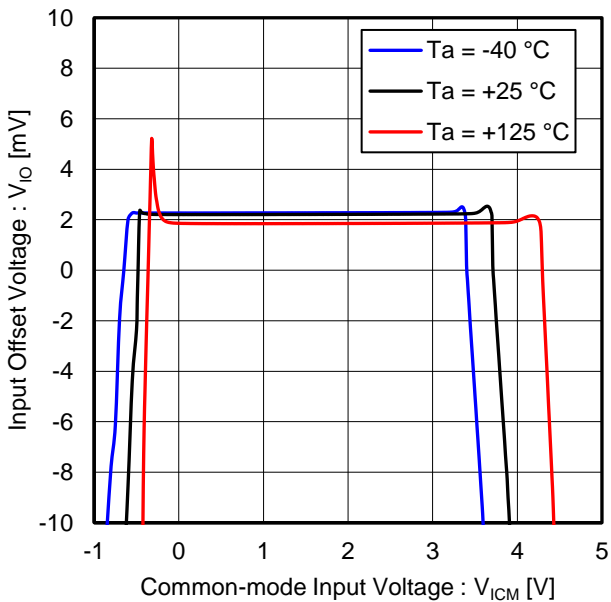


Figure 15. Input Offset Voltage vs Common-mode Input Voltage  
( $V_{CC} = 5\text{ V}$ )

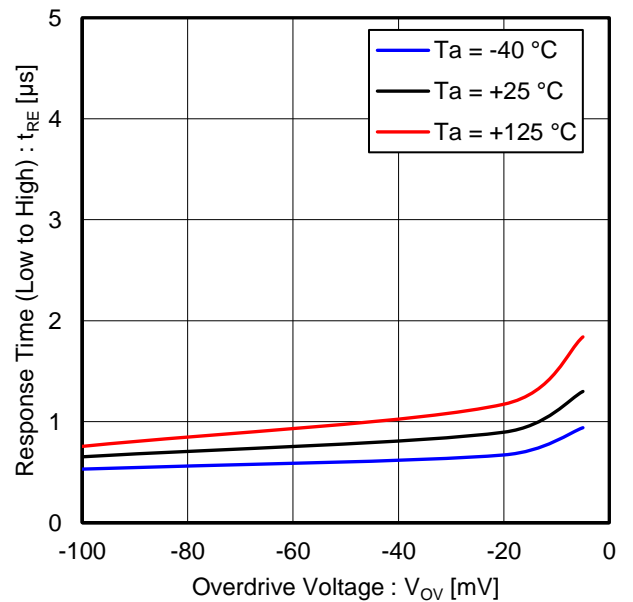


Figure 16. Response Time (Low to High) vs Overdrive Voltage  
( $V_{CC} = 5\text{ V}$ ,  $V_{RL} = 5\text{ V}$ ,  $R_L = 5.1\text{ k}\Omega$ )

(Note) The above data are measurement value of typical sample; it is not guaranteed.



Typical Performance Curves - continued

$V_{EE} = 0\text{ V}$

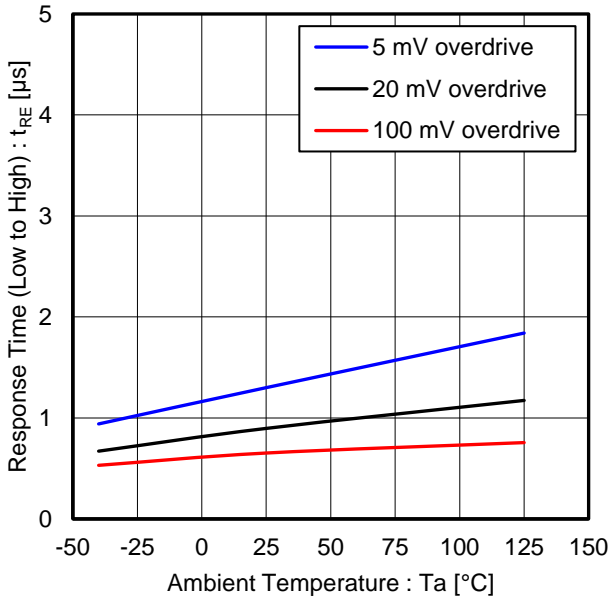


Figure 17. Response Time (Low to High) vs Ambient Temperature  
 $(V_{CC} = 5\text{ V}, V_{RL} = 5\text{ V}, R_L = 5.1\text{ k}\Omega)$

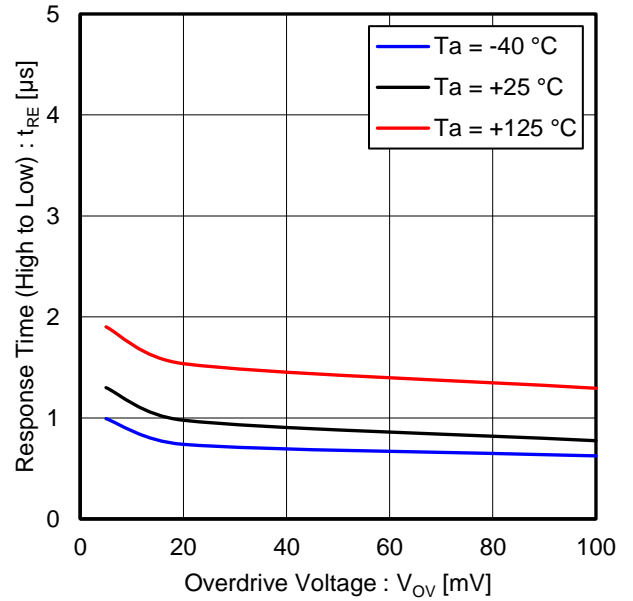


Figure 18. Response Time (High to Low) vs Overdrive Voltage  
 $(V_{CC} = 5\text{ V}, V_{RL} = 5\text{ V}, R_L = 5.1\text{ k}\Omega)$

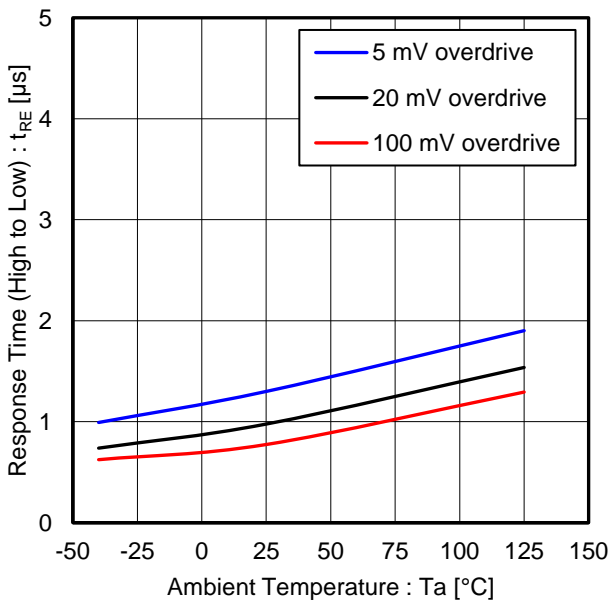


Figure 19. Response Time (High to Low) vs Ambient Temperature  
 $(V_{CC} = 5\text{ V}, V_{RL} = 5\text{ V}, R_L = 5.1\text{ k}\Omega)$

(Note) The above data are measurement value of typical sample; it is not guaranteed.

## Application Information

### 1. Unused Circuits

When there are unused circuits, it is recommended that they are connected as in right figure, and set the non-inverting input pin to electric potential within the input common-mode voltage range ( $V_{ICMR}$ ).

### 2. Input Voltage

Applying  $V_{EE} + 36\text{ V}$  to the input pin is possible without causing deterioration of the electrical characteristics or destruction, regardless of the supply voltage. However, this does not ensure circuit operation. Note that the circuit operates normally only when the input voltage is within the common-mode input voltage range of the electric characteristics.

### 3. Power Supply (single/dual)

The comparator operates when the voltage is supplied between the  $V_{CC}$  and  $V_{EE}$  pin. Therefore, the comparator can operate from single supply or dual supplies.

### 4. Pin Short-circuits

When the output and the  $V_{CC}$  pins are shorted, excessive output current may flow, resulting in undue heat generation and, subsequently, destruction.

### 5. Handling the IC

Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations of the electrical characteristics due to the piezo resistance effects. Pay attention to defecting or bending the board.

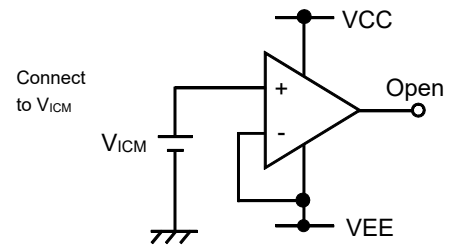


Figure 20. Example of application unused circuit processing

Application Examples

○Reference voltage is -IN

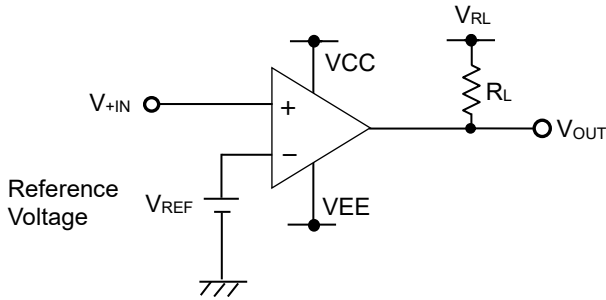
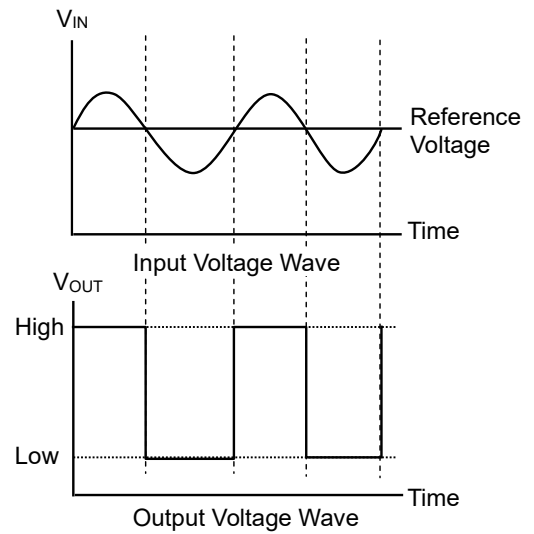


Figure 21. Circuit example when reference voltage is -IN

While the input voltage ( $V_{IN}$ ) is higher than the reference voltage, the output voltage remains high. In case the input voltage becomes lower than the reference voltage, the output voltage will turn low.



○Reference voltage is +IN

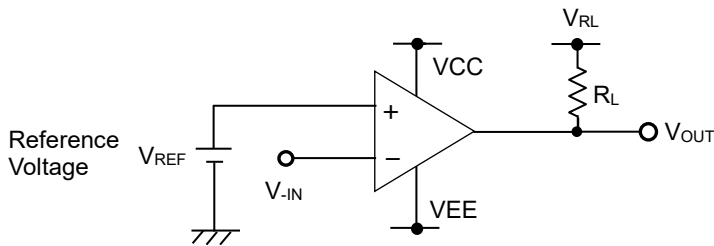
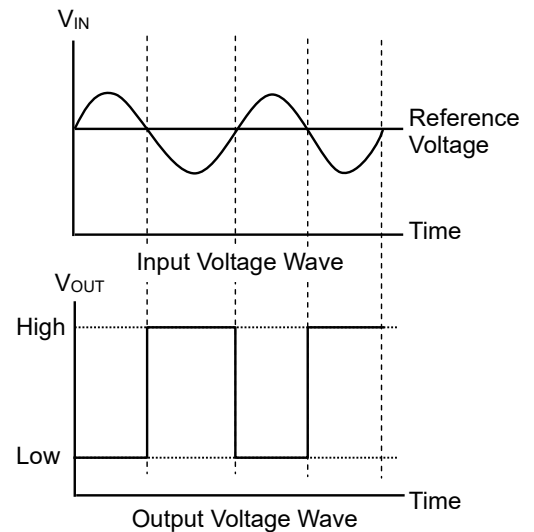
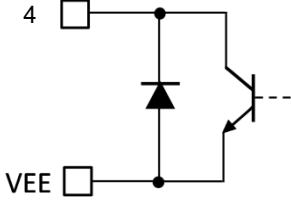
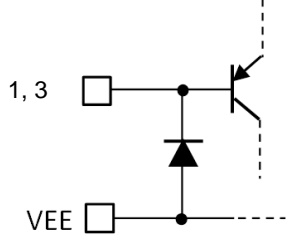


Figure 22. Circuit example when reference voltage is +IN

While the input voltage ( $V_{IN}$ ) is lower than the reference voltage, the output voltage remains high. In case the input voltage becomes higher than the reference voltage, the output voltage will turn low.



I/O Equivalence Circuits

I/O Equivalence Circuits Pin No.	Pin Name	Pin Description	Equivalence Circuit
4	OUT	Output	
1 3	-IN +IN	Input	

## Operational Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Recommended Operating Conditions

The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

### 6. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 7. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

### 8. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

### 9. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

## Operational Notes – continued

**10. Regarding the Input Pin of the IC**

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When  $GND > Pin\ A$  and  $GND > Pin\ B$ , the P-N junction operates as a parasitic diode.

When  $GND > Pin\ B$ , the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

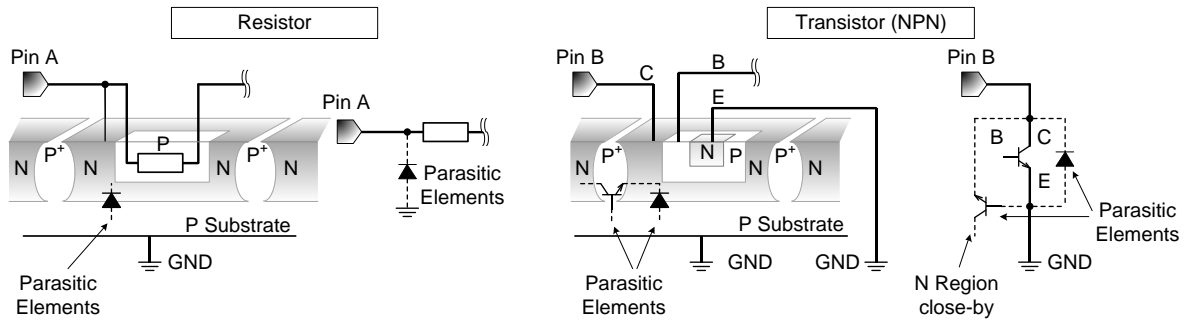
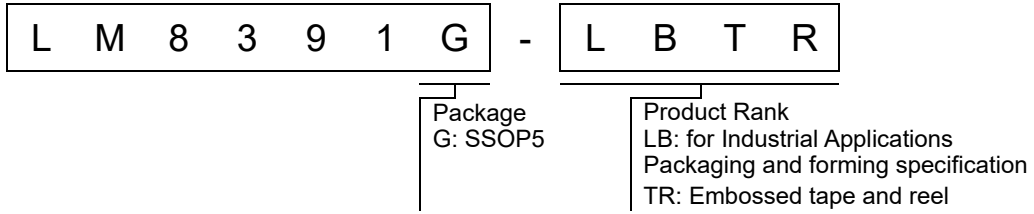


Figure 23. Example of Monolithic IC Structure

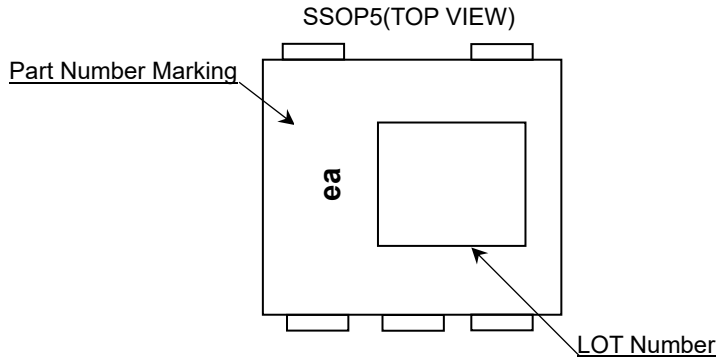
**11. Ceramic Capacitor**

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

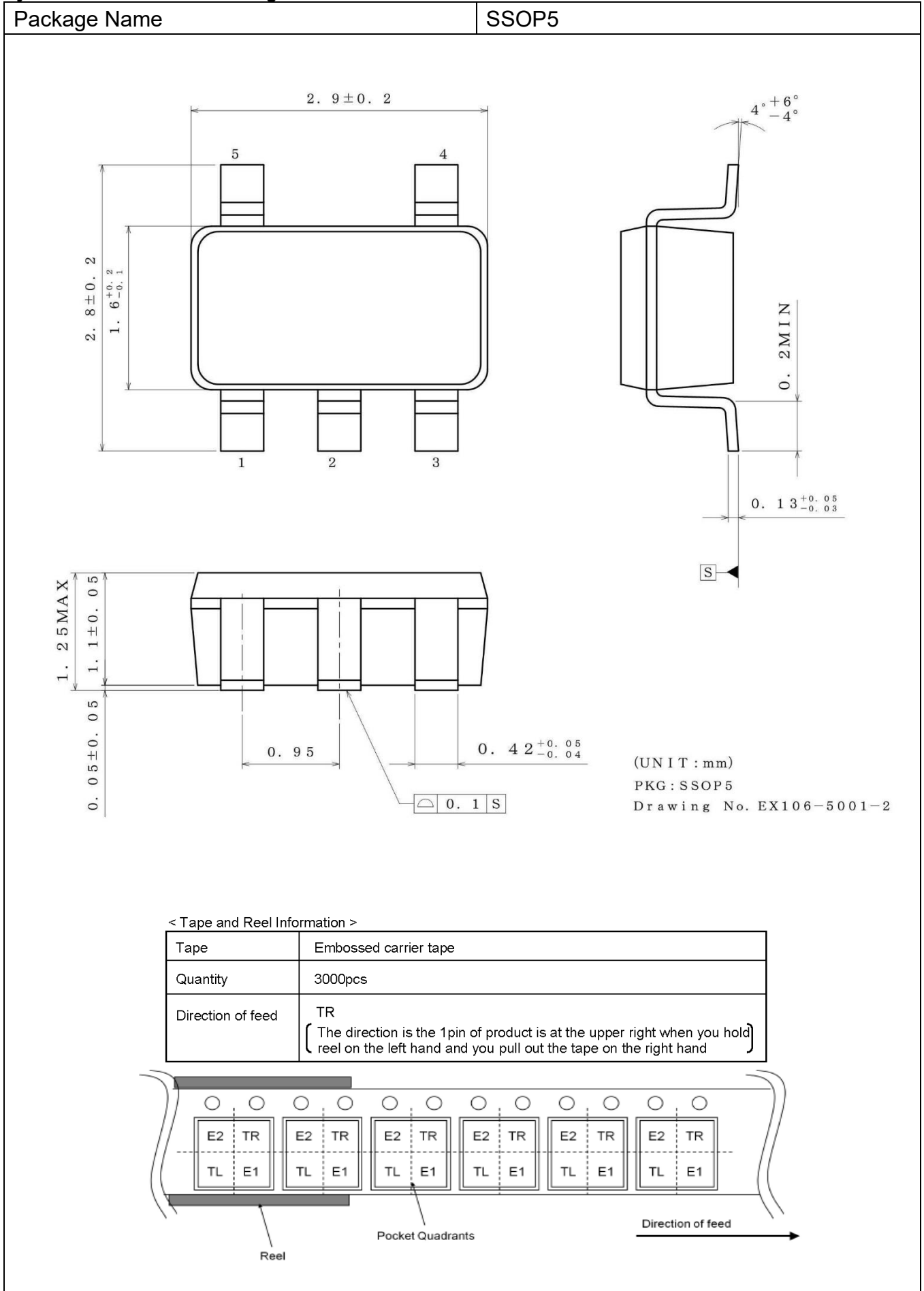
Ordering Information



Marking Diagram



Physical Dimension and Packing Information





Revision History

Date	Revision	Changes
30.Jun.2023	001	New Release