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Comparator

Automotive Excellent EMI Immunity Ground Sense Comparators

LM8391EYG-C

General Description

LM8391EYG-C is high-gain and ground sense input comparator.
An operating voltage range is wide with 3 V to 36 V. This comparator is the most suitable for automotive requirements such as engine control unit, electric power steering, anti-lock braking system and so on because it has features of low supply current.
Furthermore, they have the advantage of EMI tolerance. It makes easier replacing with conventional products or simpler designing EMI.

Features

- EMARMOUR™ Series
- AEC-Q100 Qualified*(Note 1)*
- 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

(Note 1) Grade 1

Applications

- Engine Control Unit
- Electric Power Steering (EPS)
- Anti-lock Braking System (ABS)
- Automotive Electronics

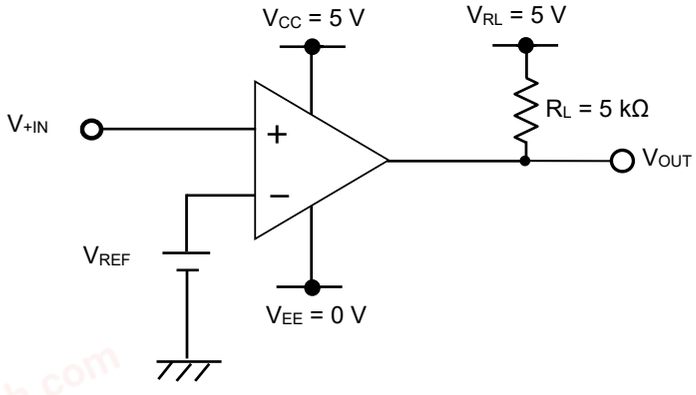
Key Specifications

- Operating Supply Voltage Range
  - Single Supply: 3.0 V to 36.0 V
  - Dual Supply: ±1.5 V to ±18.0 V
- Operating Temperature Range: -40 °C to +150 °C
- Low Supply Current: 0.3 mA (Typ)
- Input Offset Current: 5 nA (Typ)
- Input Bias Current: 50 nA (Typ)

Package	W (Typ) x D (Typ) x H (Max)
SSOP5:	2.9 mm x 2.8 mm x 1.25 mm



Typical Application Circuit

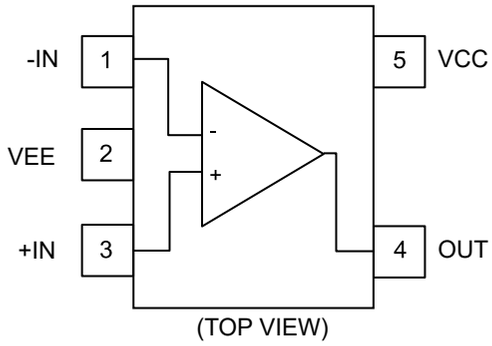


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Pin Configuration

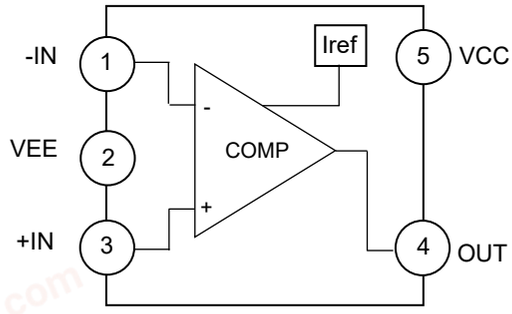


(TOP VIEW)

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.

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Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{CC}-V_{EE}	36	V
Differential Input Voltage(Note 1)	V_{ID}	36	V
Common-mode Input Voltage Range	V_{ICMR}	(V_{EE} - 0.3) to (V_{EE} + 36)	V
Input Current	I_I	±10	mA
Maximum Junction Temperature	Tjmax	150	°C
Storage Temperature Range	Tstg	-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_{EE} or more.

Thermal Resistance(Note 2)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s(Note 4)	2s2p(Note 5)	
SSOP5				
Junction to Ambient	θ_{JA}	376.5	185.4	°C/W
Junction to Top Characterization Parameter(Note 3)	Ψ_{JT}	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	Material	Board Size
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	V_{CC}	3.0	-	36.0	V
	Dual Supply		±1.5	-	±18.0	
Operating Temperature		Topr	-40	+25	+150	°C

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Function Explanation

1. EMARMOUR™

EMARMOUR™ is the brand name given to ROHM products developed by leveraging proprietary technologies covering layout, process, and circuit design to achieve ultra-high noise immunity that limits output voltage fluctuation to ±300 mV or less across the entire noise frequency band during noise evaluation testing under the international ISO11452-2 standard. This unprecedented noise immunity reduces design load while improving reliability by solving issues related to noise in the development of vehicle electrical systems.

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Electrical Characteristics (Unless otherwise specified V_{CC} = 5 V, V_{EE} = 0 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 V Absolute value
		-40 °C to +150 °C	-	-	9		V_{CC} = 5 V to 36 V V_{OUT} = 1.4 V Absolute value
Input Offset Current	I_{IO}	25 °C	-	5	40	nA	V_{OUT} = 1.4 V Absolute value
		-40 °C to +150 °C	-	-	50		
Input Bias Current	I_B	25 °C	-	50	250	nA	V_{OUT} = 1.4 V Absolute value
		-40 °C to +150 °C	-	-	275		
Common-mode Input Voltage Range	V_{ICMR}	25 °C	0	-	3.5	V	(V_{CC}-V_{EE}) = 5 V
		-40 °C to +150 °C	0	-	3.0		
Large Signal Voltage Gain	A_V	25 °C	80	120	-	dB	V_{CC} = 15 V V_{OUT} = 1.4 V to 11.4 V R_L = 15 kΩ, V_{RL} = 15 V
		-40 °C to +150 °C	74	-	-		
Supply Current	I_{CC}	25 °C	-	0.3	0.5	mA	V_{OUT} = Open
		-40 °C to +150 °C	-	-	1.0		V_{OUT} = Open, V_{CC} = 36 V
Output Sink Current*(Note 1)*	I_{OL}	25 °C	8	16	-	mA	V_{+IN} = 0 V, V_{-IN} = 1 V V_{OUT} = 1.5 V Absolute value
		-40 °C to +150 °C	2	-	-		
Output Saturation Voltage (Low Level Output Voltage)	V_{OL}	25 °C	-	80	200	mV	V_{+IN} = 0 V, V_{-IN} = 1 V I_{OL} = 4 mA
		-40 °C to +150 °C	-	-	400		
Output Leak Current*(Note 1)* (High Level Output Current)	I_{LEAK}	25 °C	-	0.1	-	nA	V_{+IN} = 1 V, V_{-IN} = 0 V V_{OUT} = 5 V Absolute value
		-40 °C to +150 °C	-	-	1	μA	V_{+IN} = 1 V, V_{-IN} = 0 V V_{OUT} = 36 V Absolute value
Response Time	t_{RE}	25 °C	-	1.3	-	μs	R_L = 5.1 kΩ, V_{RL} = 5 V V_{IN} = 100 mV_{P-P} Overdrive = 5 mV
			-	0.4	-		R_L = 5.1 kΩ, V_{RL} = 5 V V_{IN} = TTL Logic Swing, V_{REF} = 1.4 V
Operable Frequency	fopr	25 °C	100	-	-	kHz	R_L = 2 kΩ, V_{+IN} = 1.5 V V_{-IN} = 5 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.

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Typical Performance Curves

V_{EE} = 0 V

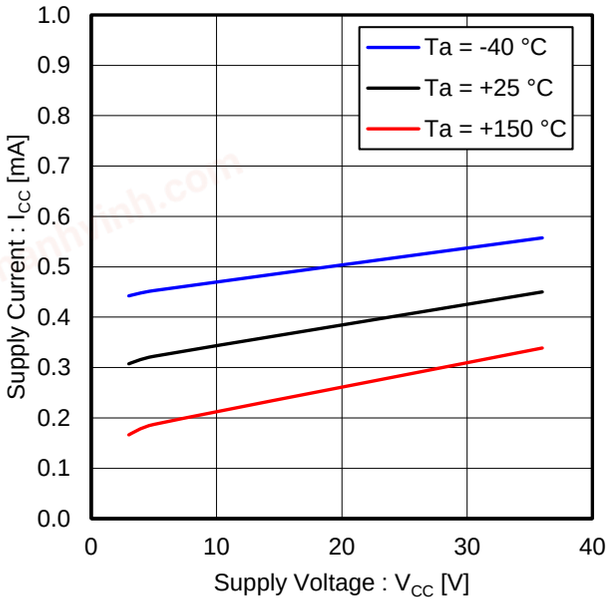


Figure 1. Supply Current vs Supply Voltage

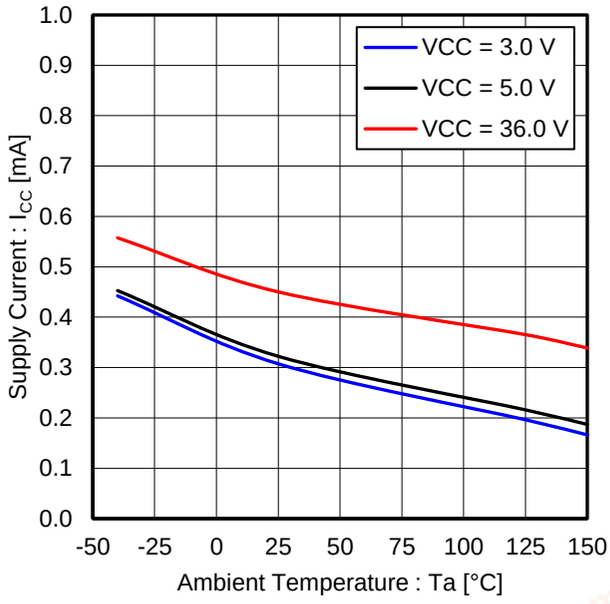


Figure 2. Supply Current vs Ambient Temperature

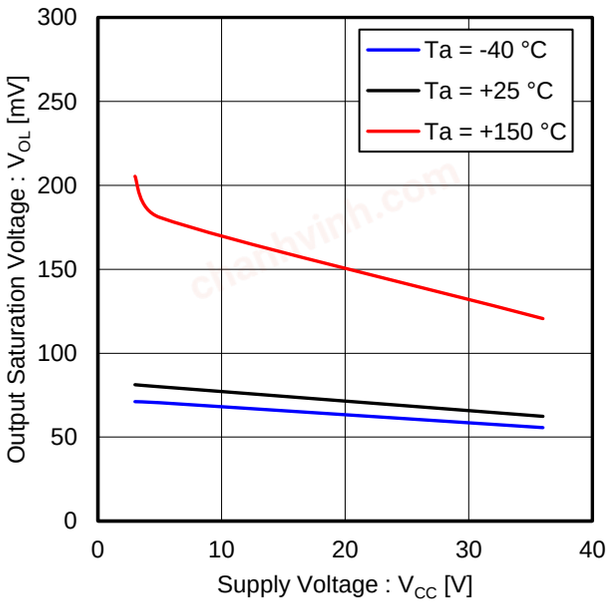


Figure 3. Output Saturation Voltage vs Supply Voltage (I_{OL} = 4 mA)

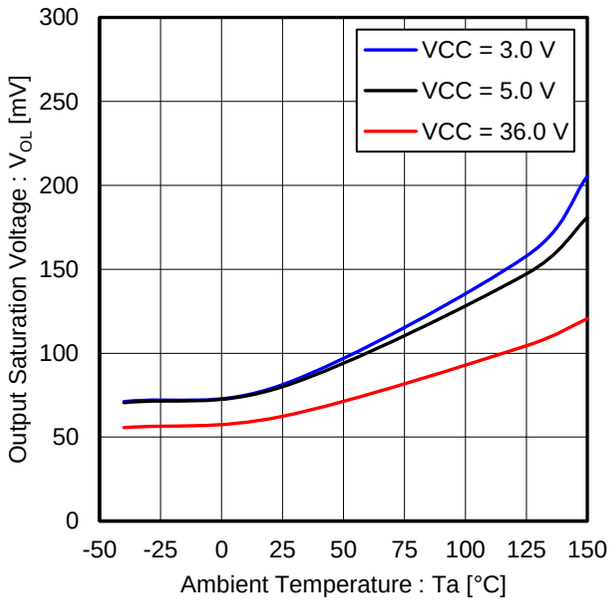


Figure 4. Output Saturation Voltage vs Ambient Temperature (I_{OL} = 4 mA)

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

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Typical Performance Curves - continued

V_{EE} = 0 V

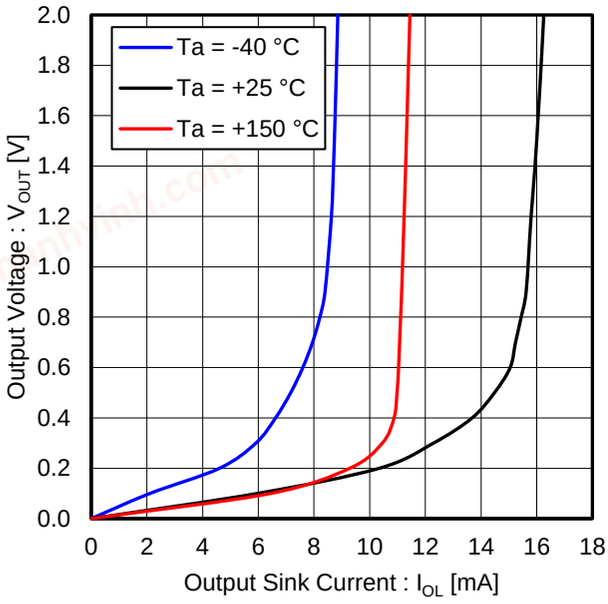


Figure 5. Output Voltage vs Output Sink Current (V_{CC} = 5 V)

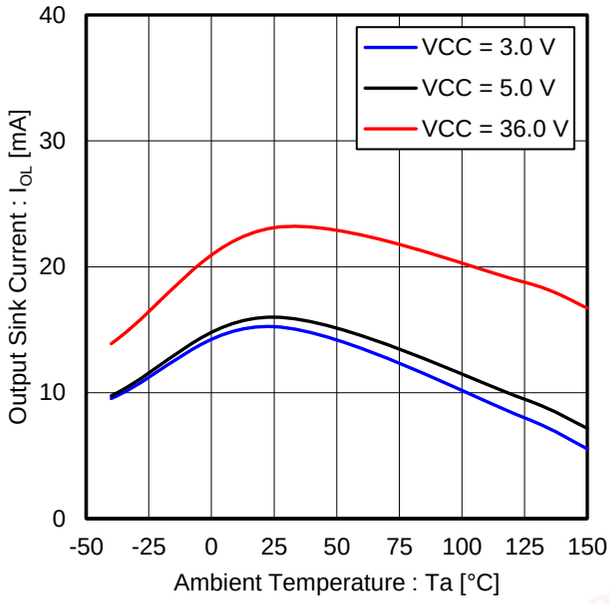


Figure 6. Output Sink Current vs Ambient Temperature (V_{OUT} = 1.5 V)

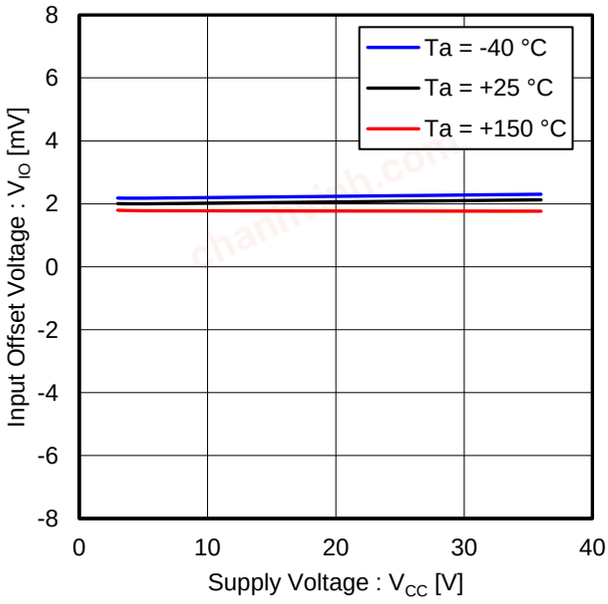


Figure 7. Input Offset Voltage vs Supply Voltage

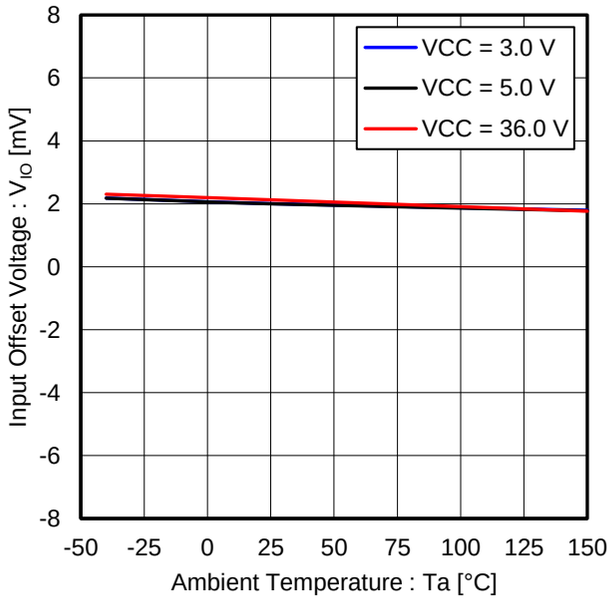


Figure 8. Input Offset Voltage vs Ambient Temperature

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

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Typical Performance Curves - continued

V_{EE} = 0 V

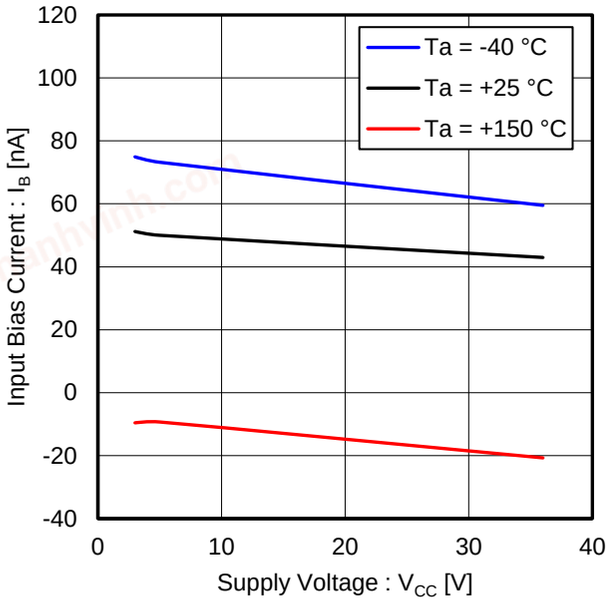


Figure 9. Input Bias Current vs Supply Voltage

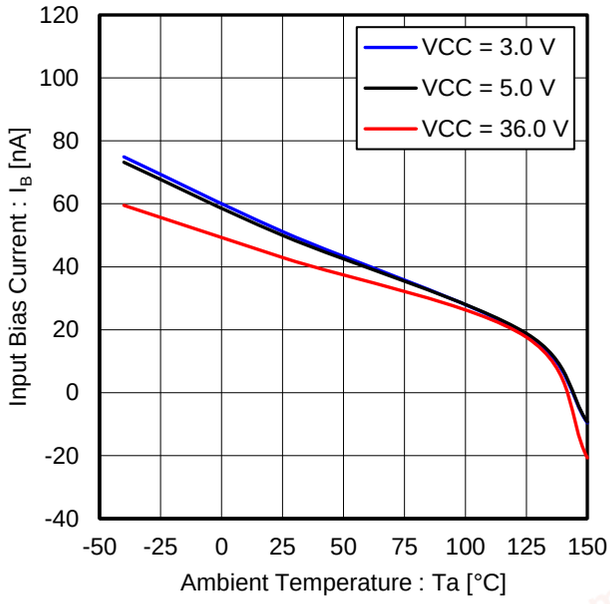


Figure 10. Input Bias Current vs Ambient Temperature

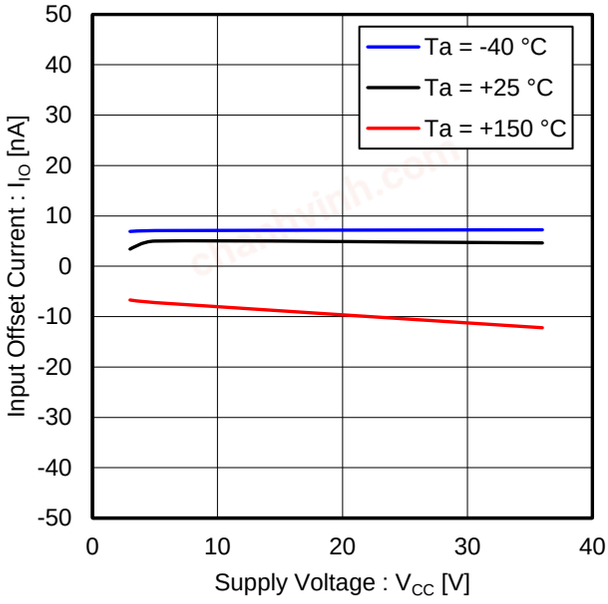


Figure 11. Input Offset Current vs Supply Voltage

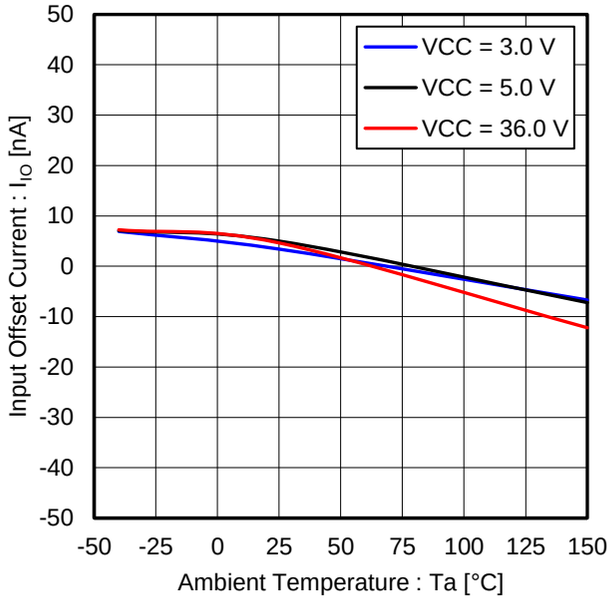


Figure 12. Input Offset Current vs Ambient Temperature

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

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Typical Performance Curves - continued

V_{EE} = 0 V

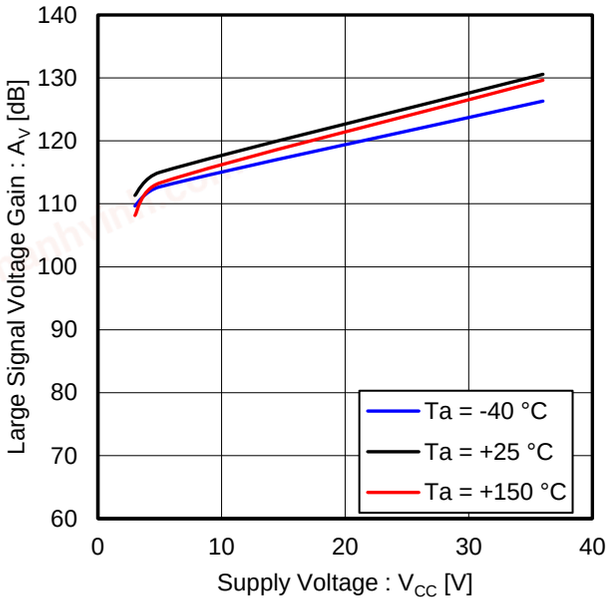


Figure 13. Large Signal Voltage Gain vs Supply Voltage

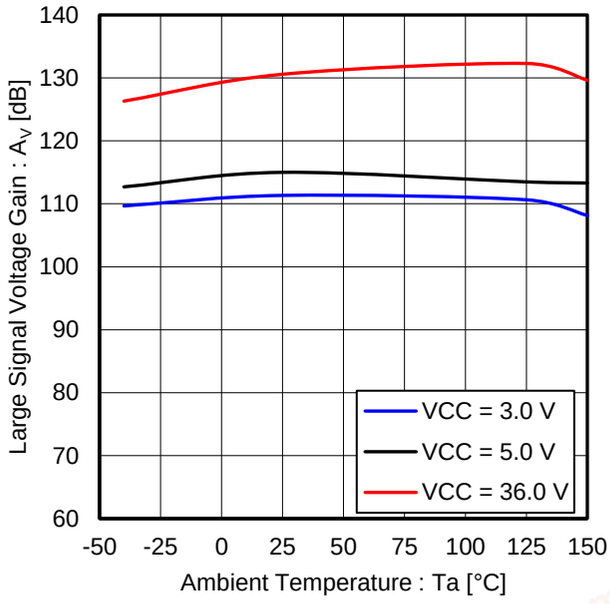


Figure 14. Large Signal Voltage Gain vs Ambient Temperature

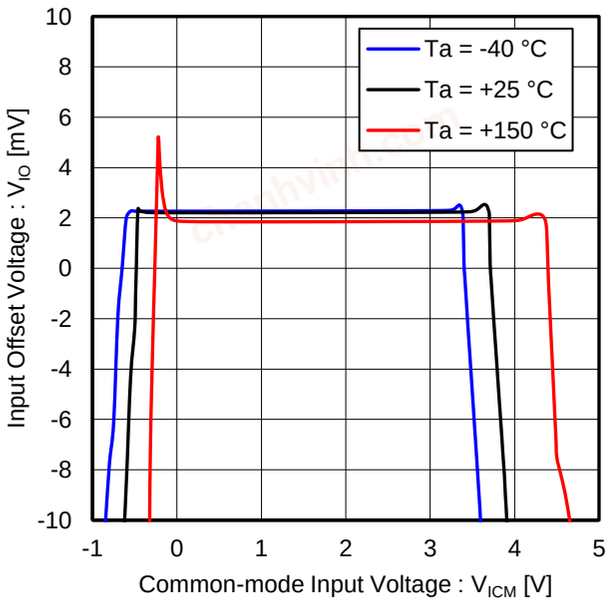


Figure 15. Input Offset Voltage vs Common-mode Input Voltage
(V_{CC} = 5 V)

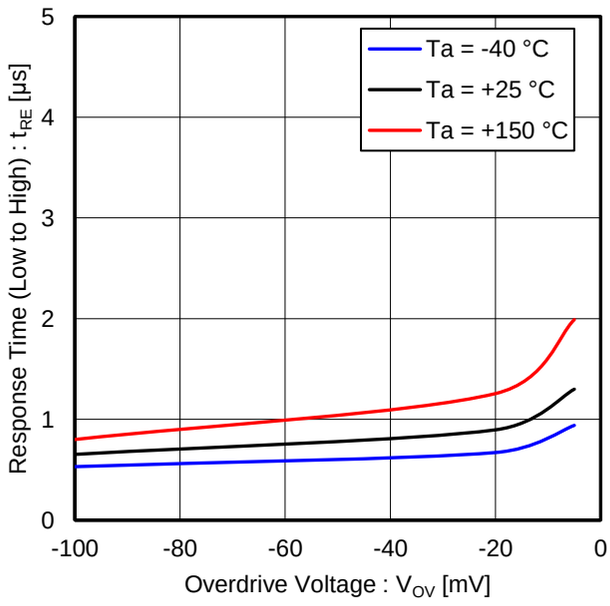


Figure 16. Response Time (Low to High) vs Overdrive Voltage
(V_{CC} = 5 V, V_{RL} = 5 V, R_L = 5.1 kΩ)

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

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Typical Performance Curves - continued

V_{EE} = 0 V

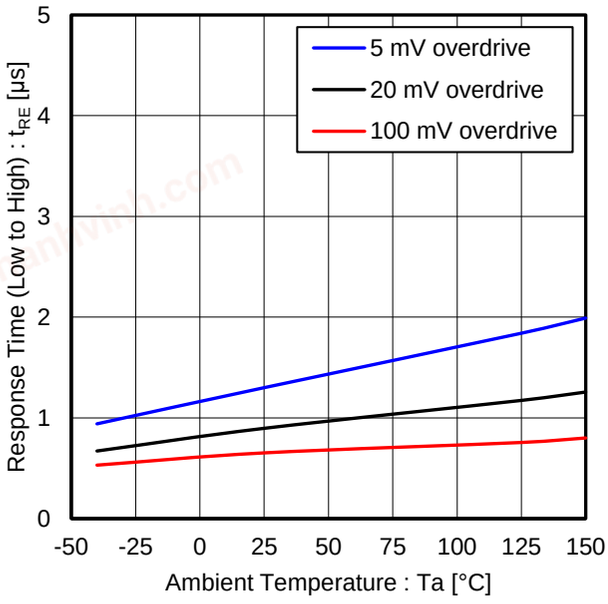


Figure 17. Response Time (Low to High) vs Ambient Temperature
(V_{CC} = 5 V, V_{RL} = 5 V, R_L = 5.1 kΩ)

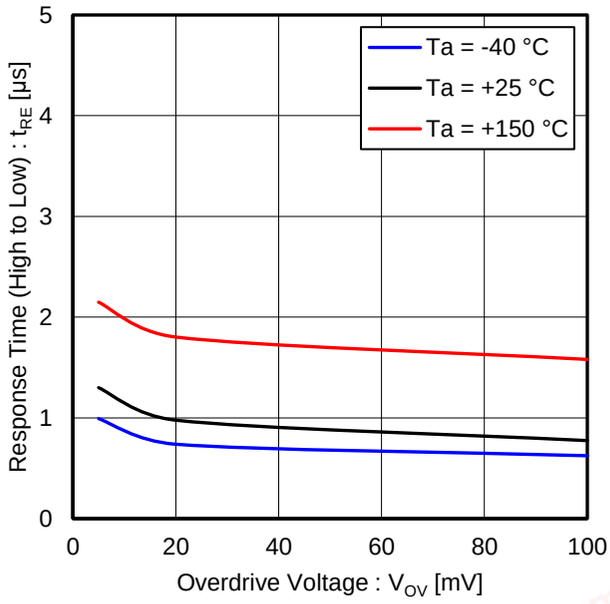


Figure 18. Response Time (High to Low) vs Overdrive Voltage
(V_{CC} = 5 V, V_{RL} = 5 V, R_L = 5.1 kΩ)

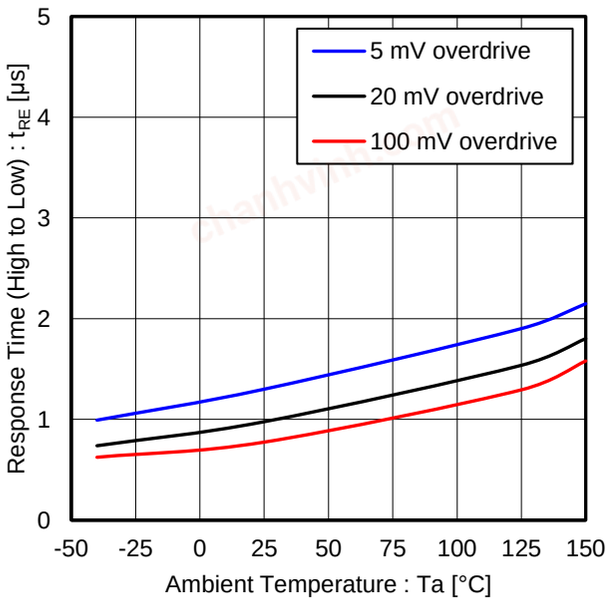


Figure 19. Response Time (High to Low) vs Ambient Temperature
(V_{CC} = 5 V, V_{RL} = 5 V, R_L = 5.1 kΩ)

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

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Application Information

EMI Immunity

LM8391EYG-C has high tolerance for electromagnetic interference from the outside because they have EMI filter, and the EMI design is simple. They are most suitable to replace from conventional products. The data of the IC simple substance on ROHM board are as follows. The test condition is based on ISO11452-2.

<Test Condition> Based on ISO11452-2
V_{CC}: 12 V, V_{RL}: 6 V, R_L: 5.1 kΩ
H Level Output V_{+IN}: 6 V, V_{-IN}: 5.8 V
L Level Output V_{+IN}: 5.8 V, V_{-IN}: 6 V
Test Method: Substituted Law
(Progressive Wave)
Field Intensity: 200 V/m
Test Wave: CW (Continuous Wave)
Frequency: 200 MHz – 1000 MHz (2 % step)

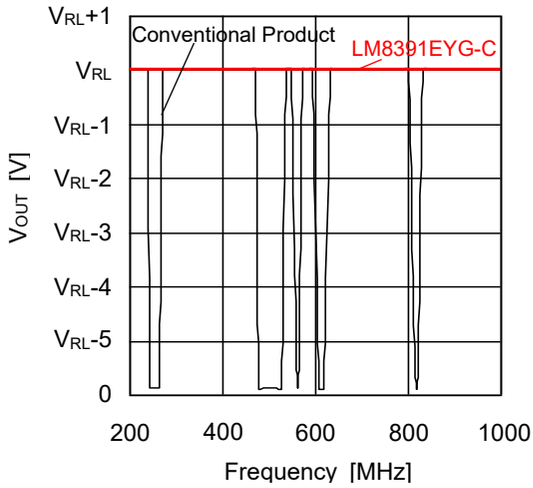


Figure 20. EMI Characteristics (H Level Output)



Figure 22. EMI Evaluation Board

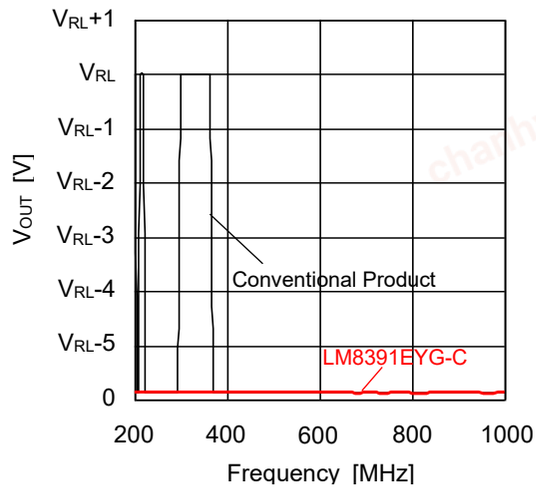


Figure 21. EMI Characteristics (L Level Output)

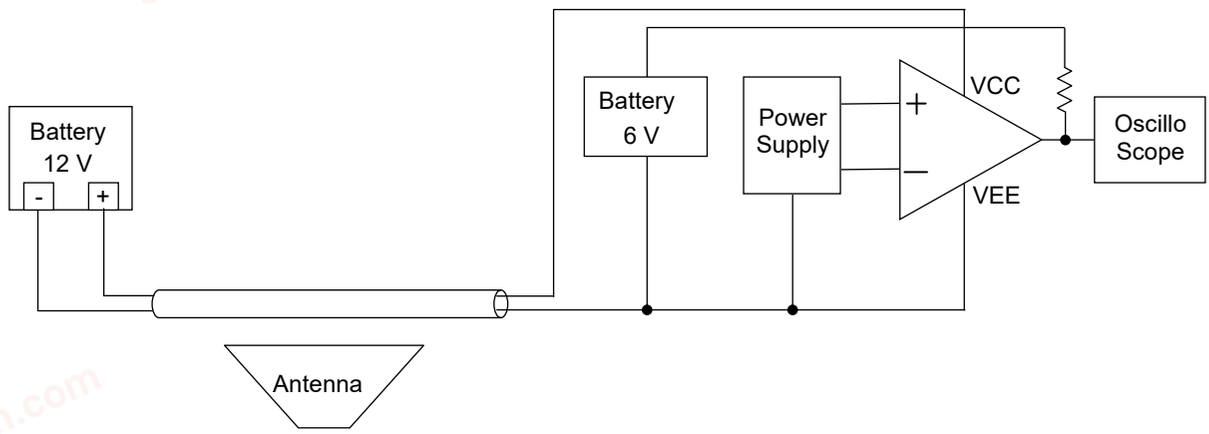


Figure 23. Measurement Circuit of EMI Evaluation

(Note) The above data is obtained using typical IC simple substance on ROHM board. These values are not guaranteed. Design and Evaluate in actual application before use.

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Application Information - continued

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}).

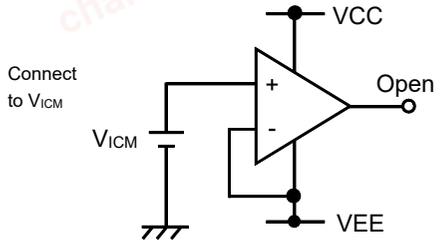


Figure 24. Example of application unused circuit processing

2. Input Voltage
   Applying V_{EE} + 36 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 VCC and VEE pin. Therefore, the comparator can operate from single supply or dual supplies.

4. Pin Short-circuits
   When the output and the VCC pins are shorted, excessive output current may flow, resulting in undue heat generation and, subsequently, destruction.

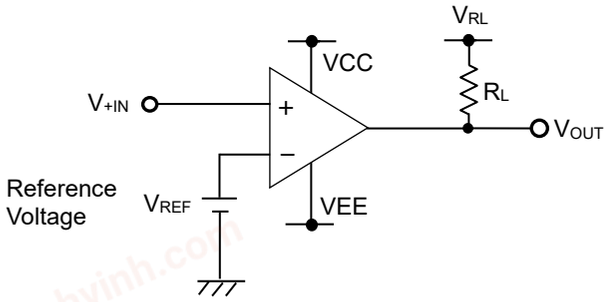
5. Handling the IC
   Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations of the electrical characteristics due to the piezo resistance effects. Pay attention to defecting or bending the board.

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Application Examples

○Reference voltage is -IN



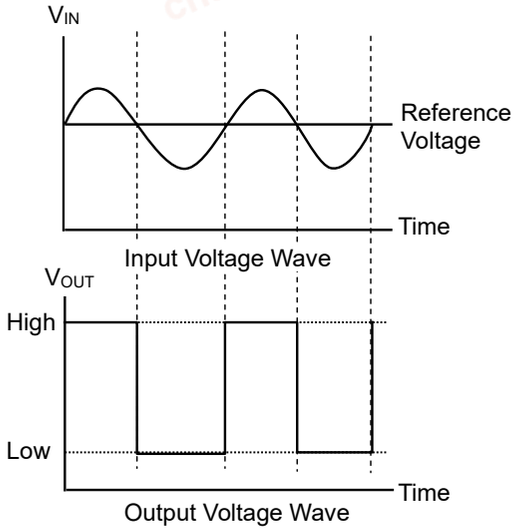
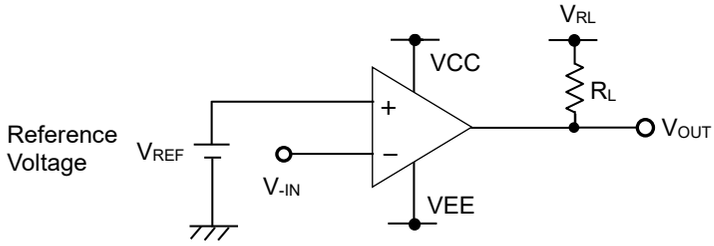


Figure 25. Circuit example when reference voltage is -IN

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



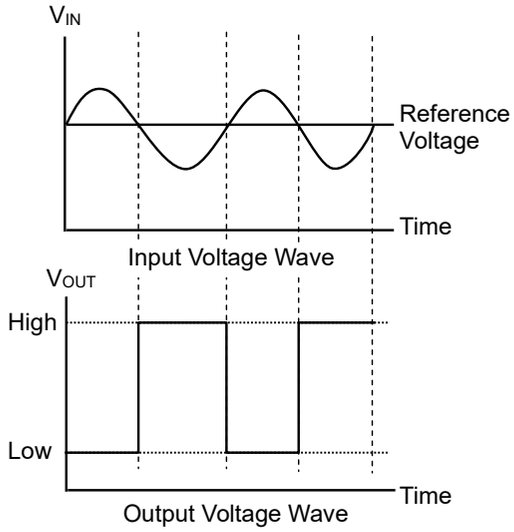


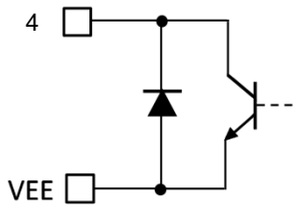
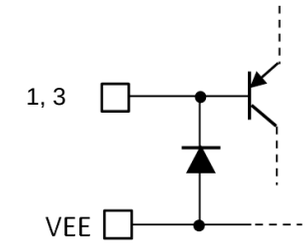
Figure 26. Circuit example when reference voltage is +IN

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.

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I/O Equivalence Circuits

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

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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.

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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.

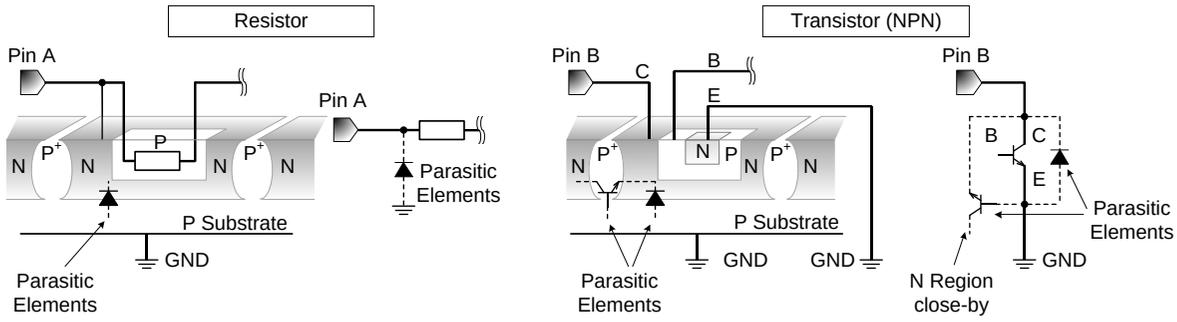


Figure 27. Example of Monolithic IC Structure

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.

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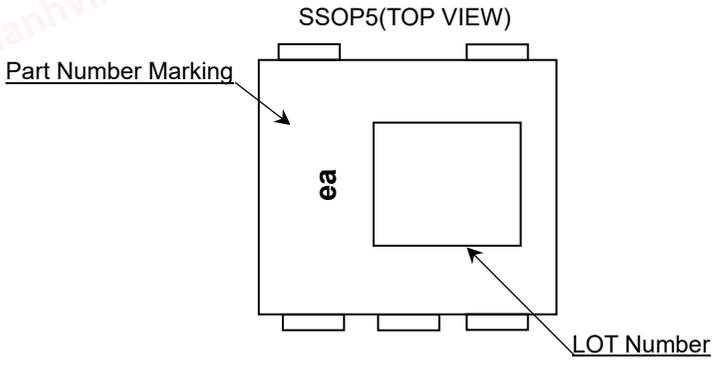
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Ordering Information

L M 8 3 9 1 E Y G - C T R

- Package: G: SSOP5
- Product Rank: C: for Automotive
- Packaging and forming specification: TR: Embossed tape and reel

Marking Diagram

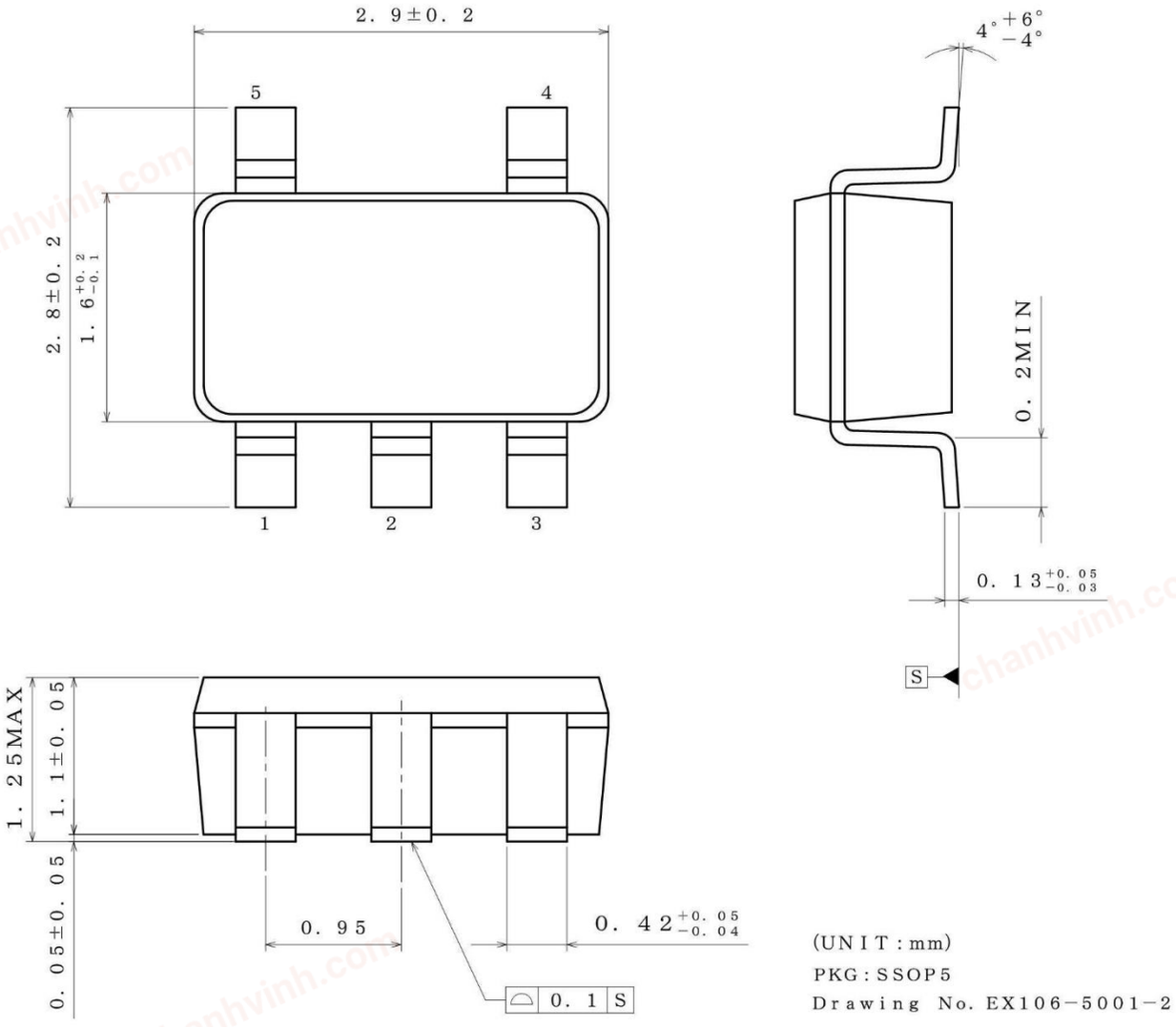


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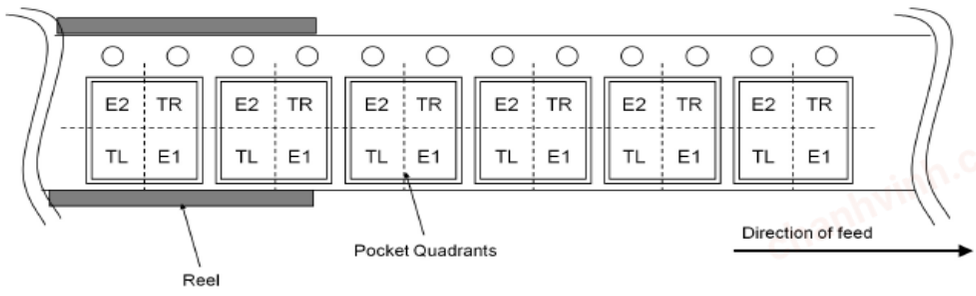
Physical Dimension and Packing Information

Package Name	SSOP5



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	TR (The direction is the 1pin of product is at the upper right when you hold reel on the left hand and you pull out the tape on the right hand)



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Revision History

Date	Revision	Changes
20.Feb.2023	001	New Release
05.Sep.2023	002	Modified the description error in Figure 16 and Figure 18.
18.Dec.2023	003	Changed the "Absolute Maximum Ratings" of the Differential Input Voltage.

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(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
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   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse, is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

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Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   - [b] the temperature or humidity exceeds those recommended by ROHM
   - [c] the Products are exposed to direct sunshine or condensation
   - [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

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