Operational Amplifier

Automotive Excellent EMI Immunity Ground Sense Operational Amplifier

LM2904EYxxx-C

General Description

LM2904EYxxx-C is high-gain and ground sense input operational amplifier. This IC is monolithic IC integrated dual independent operational amplifier on a single chip.
An operating voltage range is wide with 3 V to 36 V. This operational amplifier 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 Both Input and Output
- Single or Dual Power Supply Operation
- Standard Op-Amp Pin-assignments
- Low Supply Current
- Wide Operating Supply Voltage Range
- High Open Loop Voltage Gain
- 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: 0.6 mA (Typ)
- Input Offset Current: 2 nA (Typ)
- Input Bias Current: 20 nA (Typ)

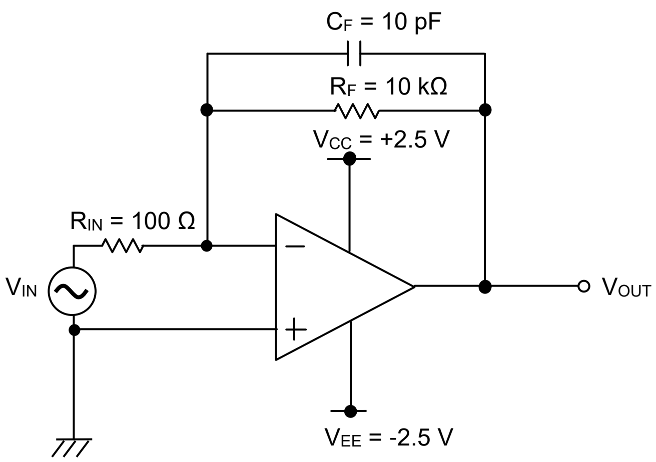
Package	W (Typ) x D (Typ) x H (Max)
SOP8	5.0 mm x 6.2 mm x 1.71 mm
SOP-J8	4.9 mm x 6.0 mm x 1.65 mm
MSOP8	2.9 mm x 4.0 mm x 0.9 mm

SOP8

SOP-J8

MSOP8

Typical Application Circuit

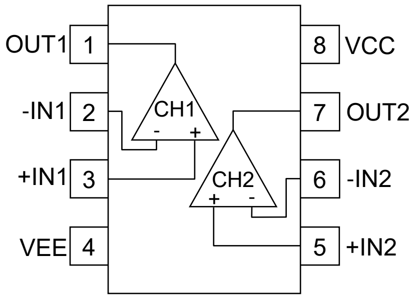


$$V_{OUT} = -\frac{R_F}{R_{IN}} V_{IN}$$

EMARMOUR™ is a trademark or a registered trademark of ROHM Co., Ltd.

○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays

Pin Configuration
LM2904EYF-C: SOP8
LM2904EYFJ-C: SOP-J8
LM2904EYFVM-C: MSOP8

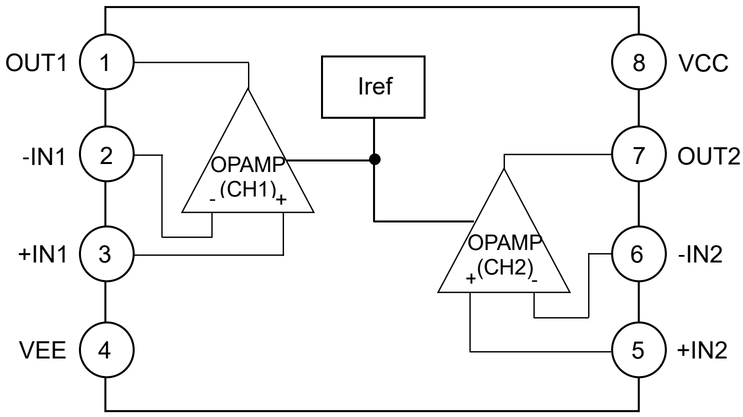


(TOP VIEW)

Pin Description
LM2904EYF-C: SOP8
LM2904EYFJ-C: SOP-J8
LM2904EYFVM-C: MSOP8

Pin No.	Pin Name	Function
1	OUT1	Output (1 ch)
2	-IN1	Inverting input (1 ch)
3	+IN1	Non-inverting input (1 ch)
4	VEE	Negative power supply / Ground
5	+IN2	Non-inverting input (2 ch)
6	-IN2	Inverting input (2 ch)
7	OUT2	Output (2 ch)
8	VCC	Positive power supply

Block Diagram
LM2904EYF-C: SOP8
LM2904EYFJ-C: SOP-J8
LM2904EYFVM-C: MSOP8



Description of Blocks

1. OPAMP:
   This block is a ground sense operational amplifier with differential input stage.

2. Iref:
   This block supplies reference current which is needed to operate OPAMP block.

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}	V_{CC}-V_{EE}	V
Common-mode Input Voltage Range	V_{ICMR}	(V_{EE} - 0.3) to (V_{EE} + 36)	V
Output Current(Note 2)	I_{OUT}	±40	mA
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.

(Note 2) The excessive heat generation may occur due to the short-circuit from the output pin to the power supply pin. Do not use the output pin short to power supply. Use the output current less than 40mA regardless of the power supply voltage.

Thermal Resistance(Note 3)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s(Note 5)	2s2p(Note 6)	
SOP8				
Junction to Ambient	θ_{JA}	197.4	109.8	°C/W
Junction to Top Characterization Parameter(Note 4)	Ψ_{JT}	21	19	°C/W
SOP-J8				
Junction to Ambient	θ_{JA}	149.3	76.9	°C/W
Junction to Top Characterization Parameter(Note 4)	Ψ_{JT}	18	11	°C/W
MSOP8				
Junction to Ambient	θ_{JA}	284.1	135.4	°C/W
Junction to Top Characterization Parameter(Note 4)	Ψ_{JT}	21	11	°C/W

(Note 3) Based on JESD51-2A(Still-Air).

(Note 4) 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 5) Using a PCB board based on JESD51-3.

(Note 6) 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

<table>
<tr><th colspan="2">Parameter</th><th>Symbol</th><th>Min</th><th>Typ</th><th>Max</th><th>Unit</th></tr>
<tr><td rowspan="2">Operating Supply Voltage</td><td>Single Supply</td><td rowspan="2">V_{CC}</td><td>3.0</td><td>-</td><td>36.0</td><td rowspan="2">V</td></tr>
<tr><td>Dual Supply</td><td>±1.5</td><td>-</td><td>±18.0</td></tr>
<tr><td colspan="2">Operating Temperature</td><td>Topr</td><td>-40</td><td>+25</td><td>+150</td><td>°C</td></tr>
</table>

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.

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	6	mV	V_{OUT} = 1.4 V Absolute value
		-40 °C to +150 °C	-	-	9		V_{CC} = 5 V to 30 V V_{OUT} = 1.4 V Absolute value
Input Offset Current	I_{IO}	25 °C	-	2	40	nA	V_{OUT} = 1.4 V Absolute value
		-40 °C to +150 °C	-	-	50		
Input Bias Current	I_B	25 °C	-	20	60	nA	V_{OUT} = 1.4 V Absolute value
		-40 °C to +150 °C	-	-	100		
Supply Current	I_{CC}	25 °C	-	0.6	1.2	mA	R_L = ∞, All Op-Amps
		-40 °C to +150 °C	-	-	1.2		
Output Voltage High	V_{OH}	25 °C	3.5	-	-	V	R_L = 2 kΩ
		-40 °C to +150 °C	3.2	-	-		
		-40 °C to +150 °C	27	28			V_{CC} = 30 V, R_L = 10 kΩ
Output Voltage Low	V_{OL}	-40 °C to +150 °C	-	5	20	mV	R_L = ∞
Large Signal Voltage Gain	A_V	25 °C	88	100	-	dB	R_L ≥ 2 kΩ, V_{CC} = 15 V V_{OUT} = 1.4 V to 11.4 V
		-40 °C to +150 °C	88	-	-		
Common-mode Input Voltage Range	V_{ICMR}	25 °C	0	-	3.5	V	(V_{CC}-V_{EE}) = 5 V V_{OUT} = V_{EE} + 1.4 V
		-40 °C to +125 °C	0	-	3.0		
		-40 °C to +150 °C	0.2	-	3.0		
Common-mode Rejection Ratio	CMRR	-40 °C to +150 °C	60	80	-	dB	V_{OUT} = 1.4 V
Power Supply Rejection Ratio	PSRR	-40 °C to +150 °C	70	100	-	dB	V_{CC} = 5 V to 30 V
Output Source Current*(Note 1)*	I_{OH}	25 °C	20	30	40	mA	V_{+IN} = 1 V, V_{-IN} = 0 V V_{OUT} = 0 V 1 ch is short circuit Absolute value
		-40 °C to +150 °C	10	-	-		
Output Sink Current*(Note 1)*	I_{OL}	25 °C	20	27	40	mA	V_{+IN} = 0 V, V_{-IN} = 1 V V_{OUT} = 5 V 1 ch is short circuit Absolute value
		-40 °C to +150 °C	2	-	-		
		25 °C	20	50	-	µA	V_{+IN} = 0 V, V_{-IN} = 1 V V_{OUT} = 200 mV
Slew Rate	SR	25 °C	-	0.2	-	V/µs	V_{CC} = 15 V, A_V = 0 dB R_L = 2 kΩ, C_L = 100 pF
Gain Bandwidth Product	GBW	25 °C	-	0.5	-	MHz	V_{CC} = +15 V, V_{EE} = -15 V R_L = 2 kΩ, C_L = 100 pF
Channel Separation	CS	25 °C	-	120	-	dB	f = 1 kHz, Input Referred

(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 V

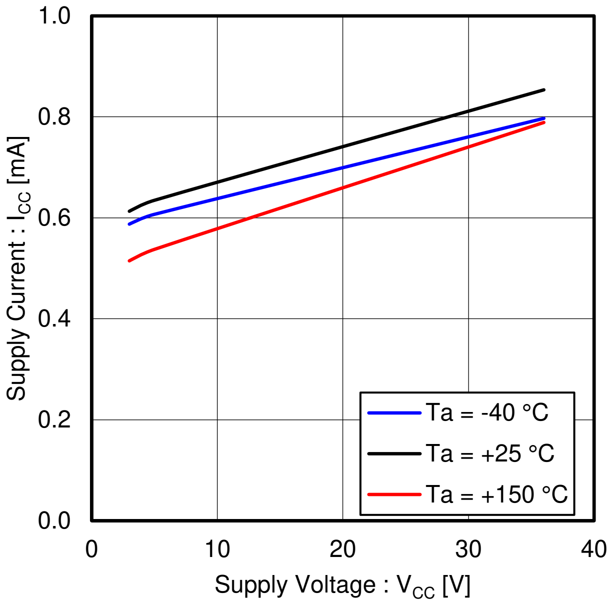


Figure 1. Supply Current vs Supply Voltage

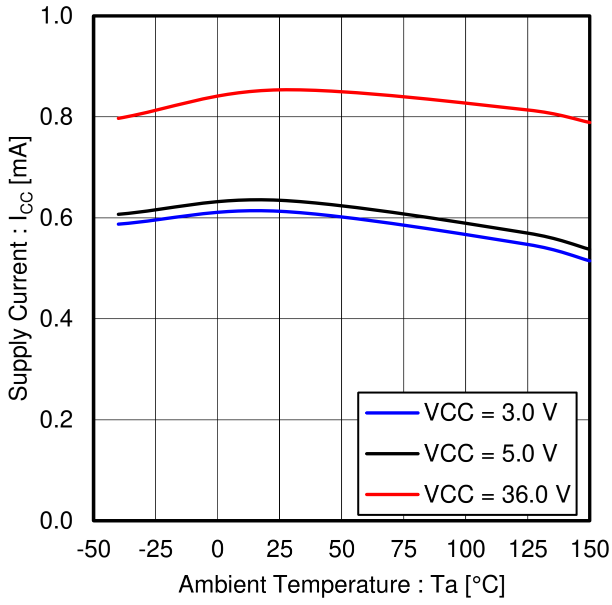


Figure 2. Supply Current vs Ambient Temperature

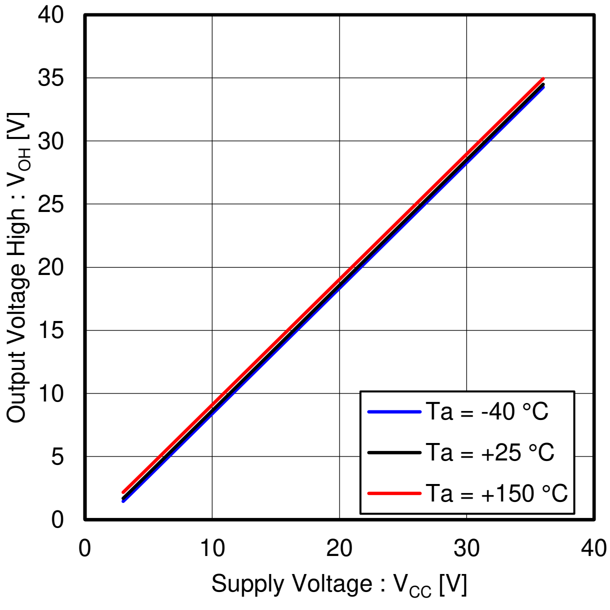


Figure 3. Output Voltage High vs Supply Voltage
(R_L = 10 kΩ)

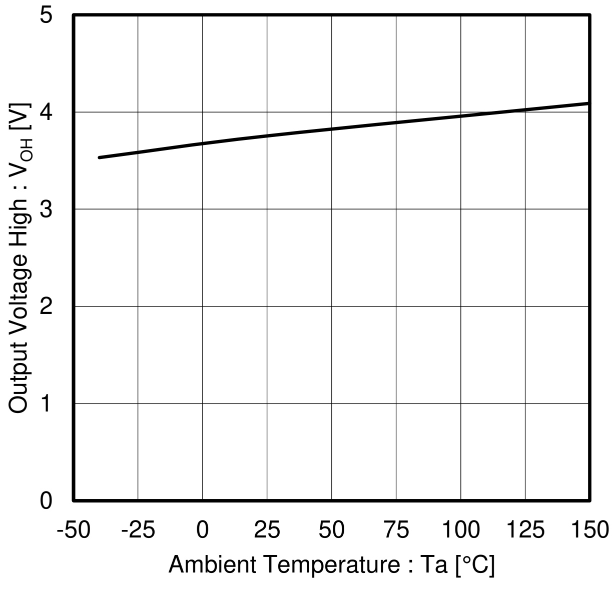


Figure 4. Output Voltage High vs Ambient Temperature
(V_{CC} = 5 V, R_L = 2 kΩ)

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

Typical Performance Curves - continued
V_{EE} = 0 V

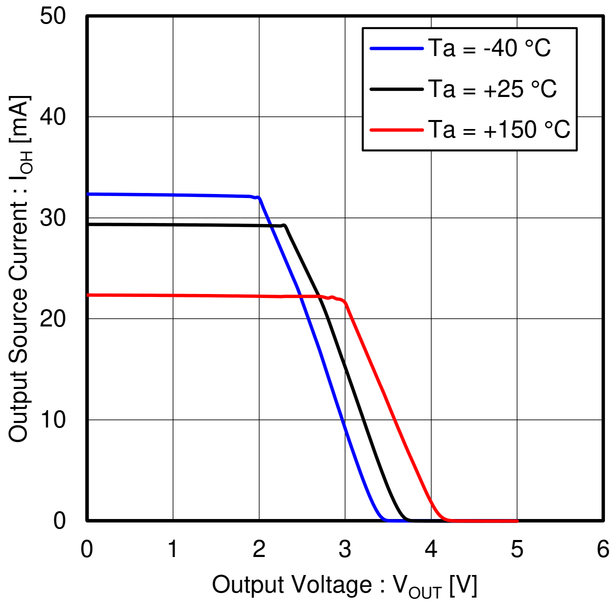


Figure 5. Output Source Current vs Output Voltage
(V_{CC} = 5 V)

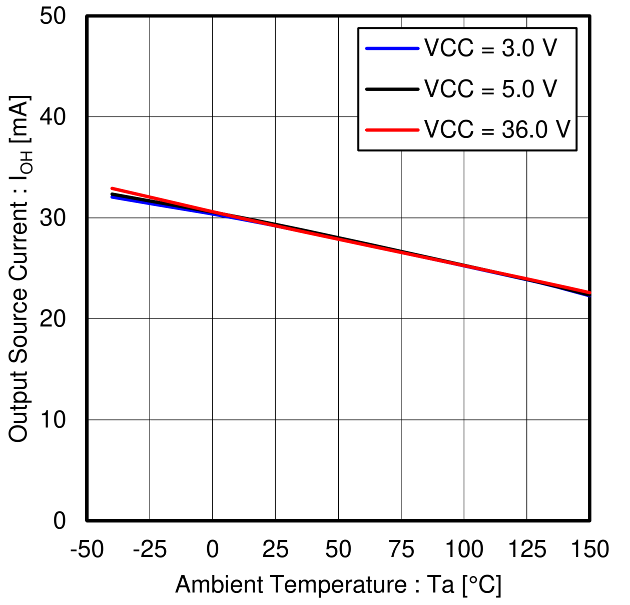


Figure 6. Output Source Current vs Ambient Temperature
(V_{OUT} = 0 V)

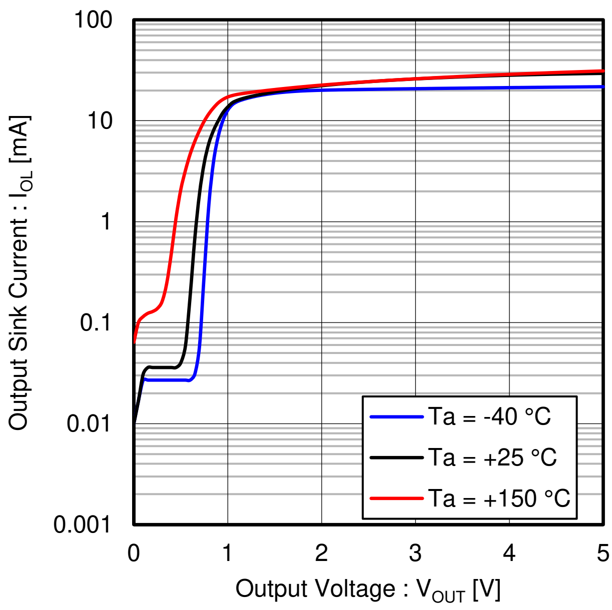


Figure 7. Output Sink Current vs Output Voltage
(V_{CC} = 5 V)

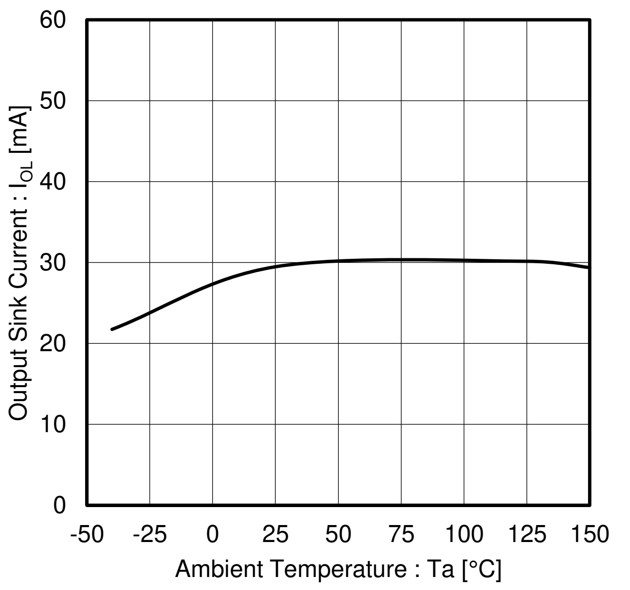


Figure 8. Output Sink Current vs Ambient Temperature
(V_{CC} = 5 V, V_{OUT} = 5 V)

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

Typical Performance Curves - continued

V_{EE} = 0 V

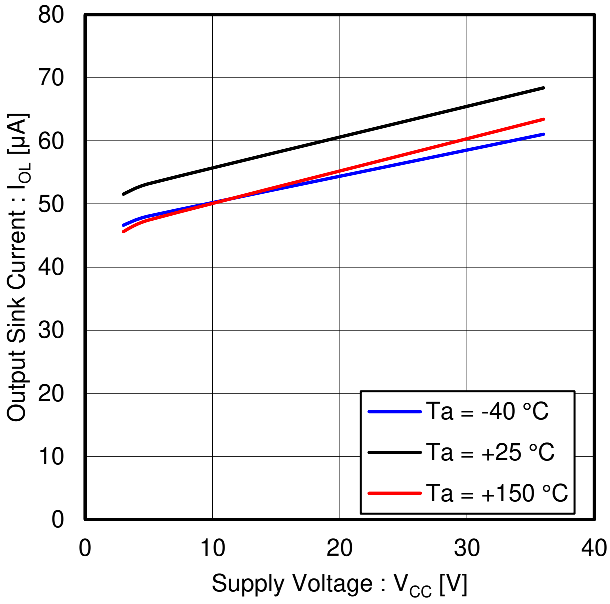


Figure 9. Output Sink Current vs Supply Voltage
(V_{OUT} = 0.2 V)

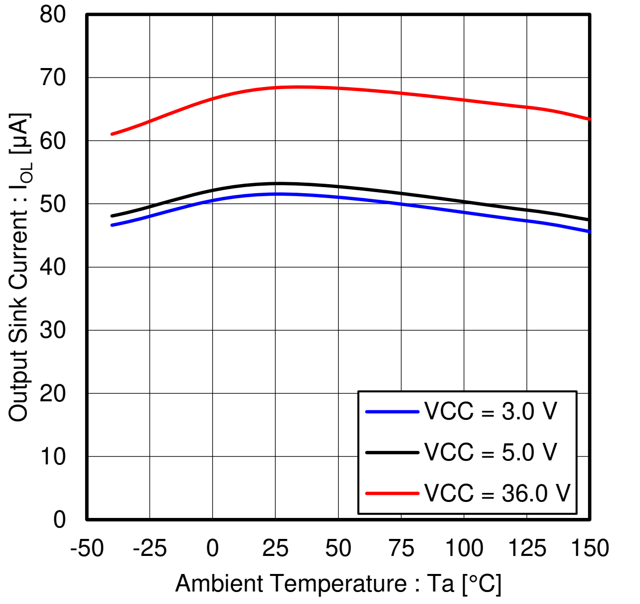


Figure 10. Output Sink Current vs Ambient Temperature
(V_{OUT} = 0.2 V)

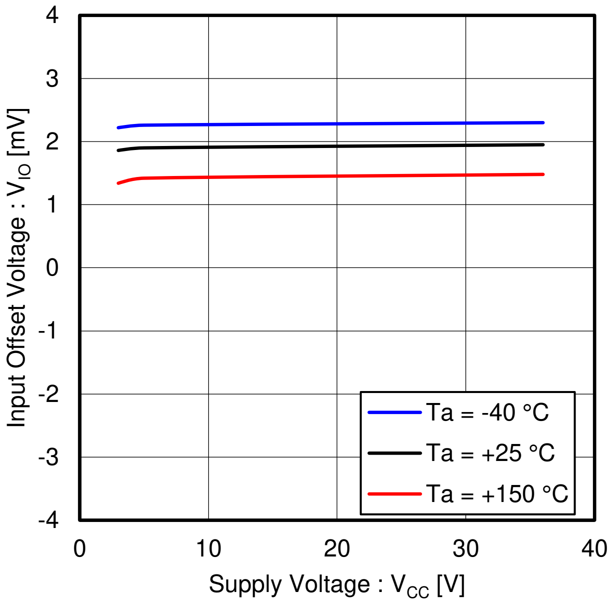


Figure 11. Input Offset Voltage vs Supply Voltage
(V_{ICM} = V_{CC}/2)

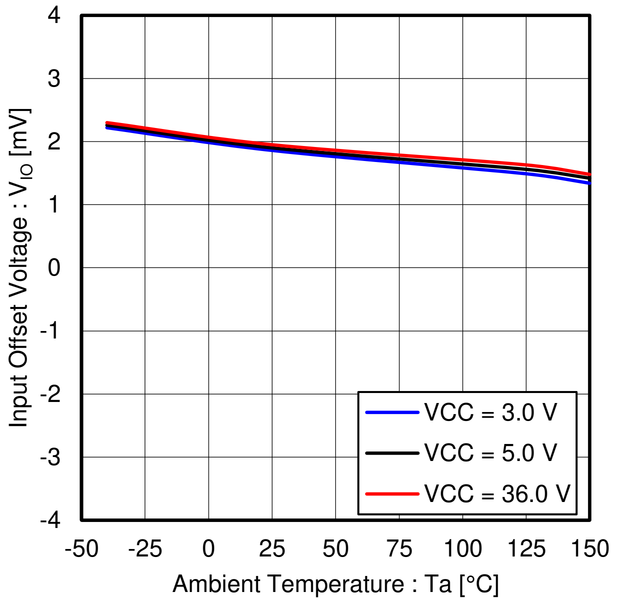


Figure 12. Input Offset Voltage vs Ambient Temperature
(V_{ICM} = V_{CC}/2)

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

Typical Performance Curves - continued
V_{EE} = 0 V

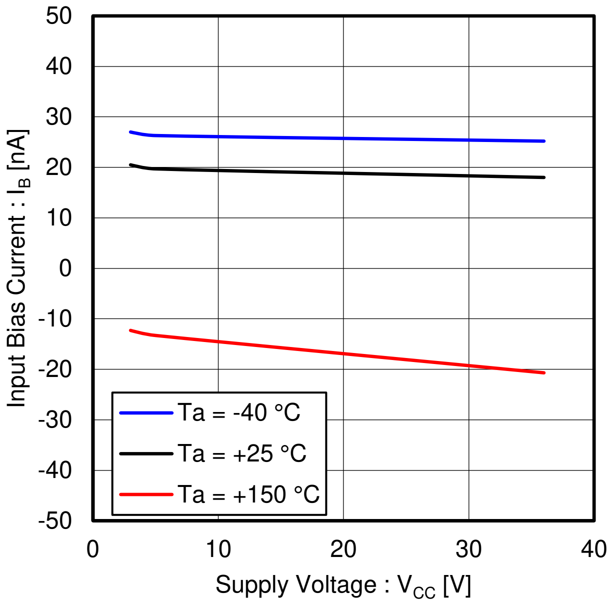


Figure 13. Input Bias Current vs Supply Voltage
(V_{ICM} = V_{CC}/2)

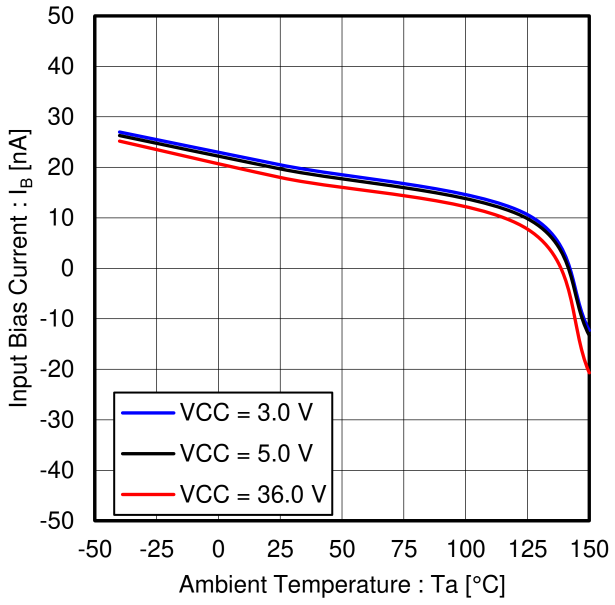


Figure 14. Input Bias Current vs Ambient Temperature
(V_{ICM} = V_{CC}/2)

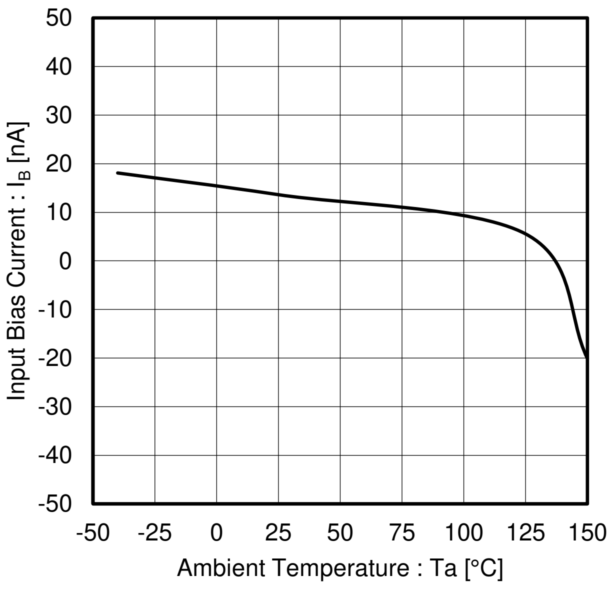


Figure 15. Input Bias Current vs Ambient Temperature
(V_{CC} = 30 V, V_{ICM} = 28 V, V_{OUT} = 1.4 V)

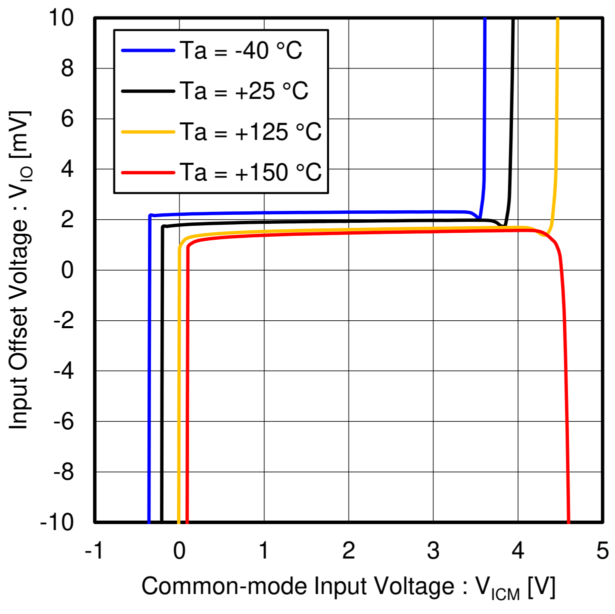


Figure 16. Input Offset Voltage vs Common-mode Input Voltage
(V_{CC} = 5 V)

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

Typical Performance Curves - continued

V_{EE} = 0 V

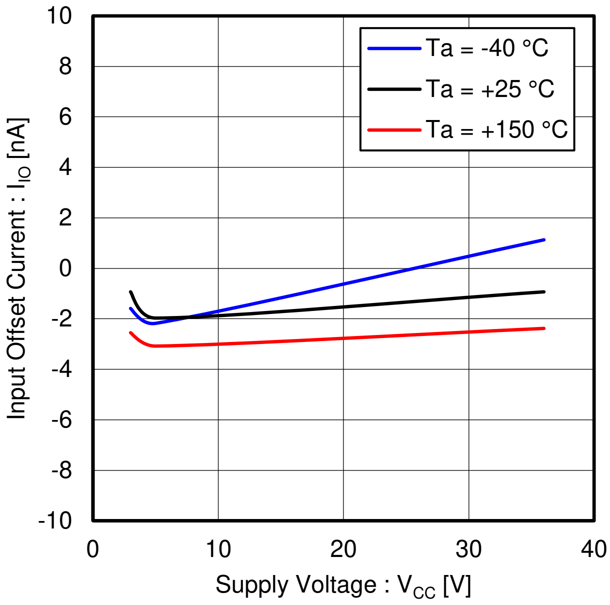


Figure 17. Input Offset Current vs Supply Voltage
(V_{ICM} = V_{CC}/2)

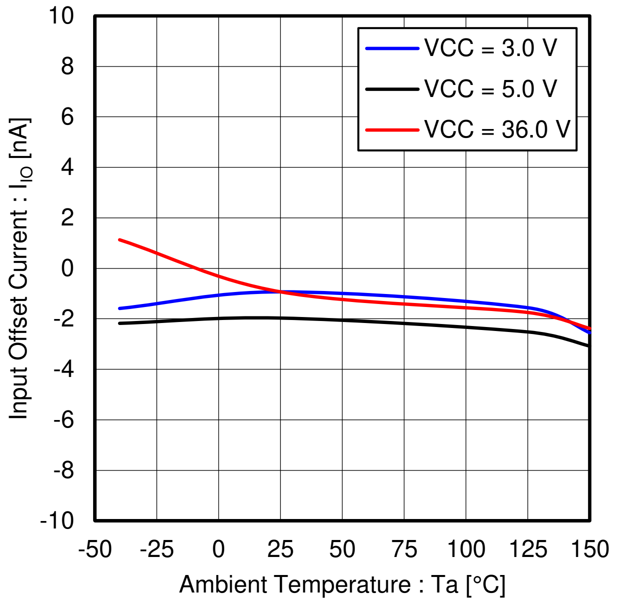


Figure 18. Input Offset Current vs Ambient Temperature
(V_{ICM} = V_{CC}/2)

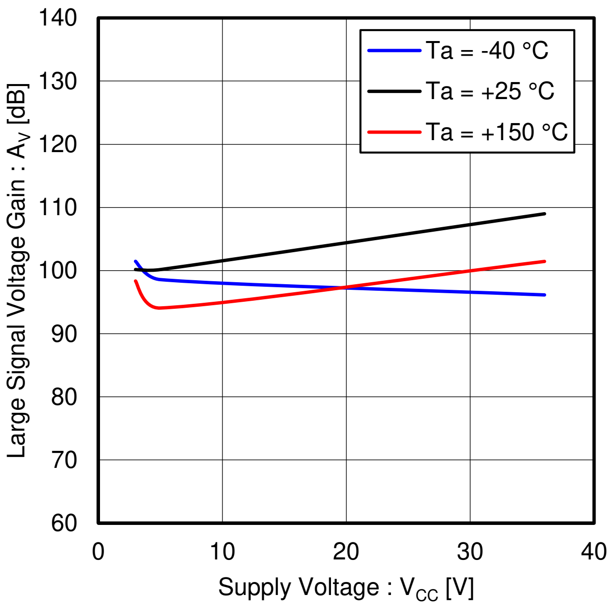


Figure 19. Large Signal Voltage Gain vs Supply Voltage
(R_L = 2 kΩ)

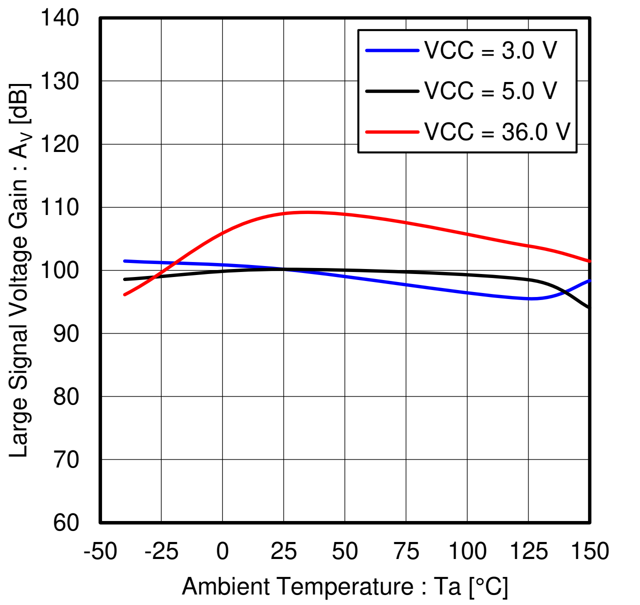


Figure 20. Large Signal Voltage Gain vs Ambient Temperature
(R_L = 2 kΩ)

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

Typical Performance Curves - continued

V_{EE} = 0 V

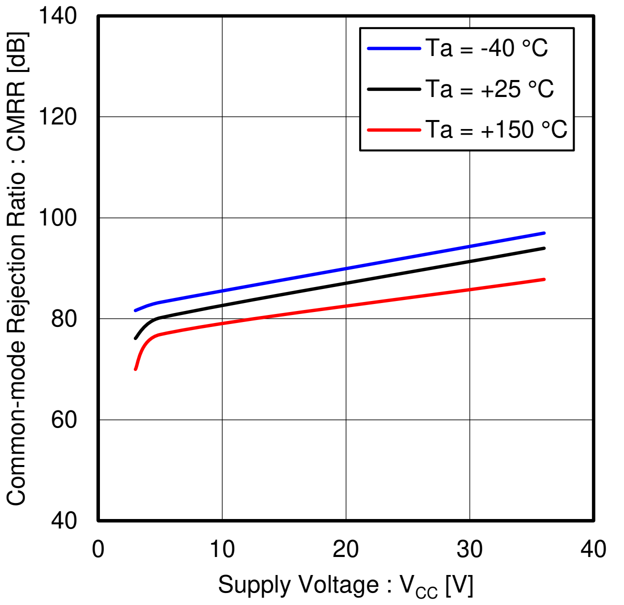


Figure 21. Common-mode Rejection Ratio vs Supply Voltage
(V_{OUT} = 1.4 V)

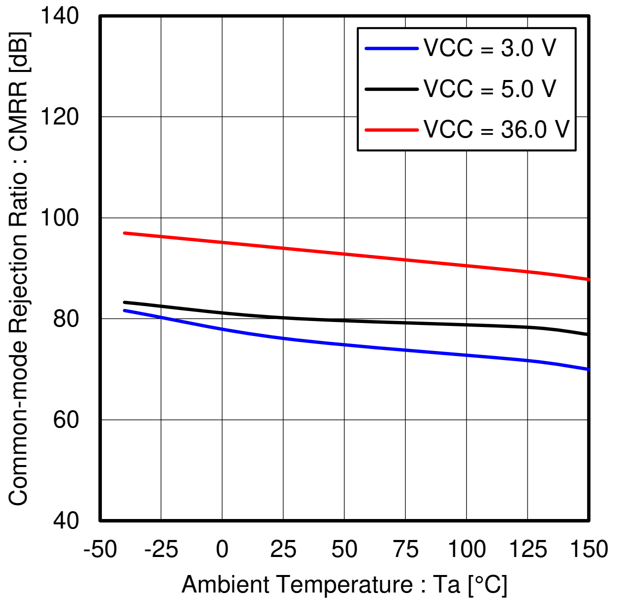


Figure 22. Common-mode Rejection Ratio vs Ambient Temperature
(V_{OUT} = 1.4 V)

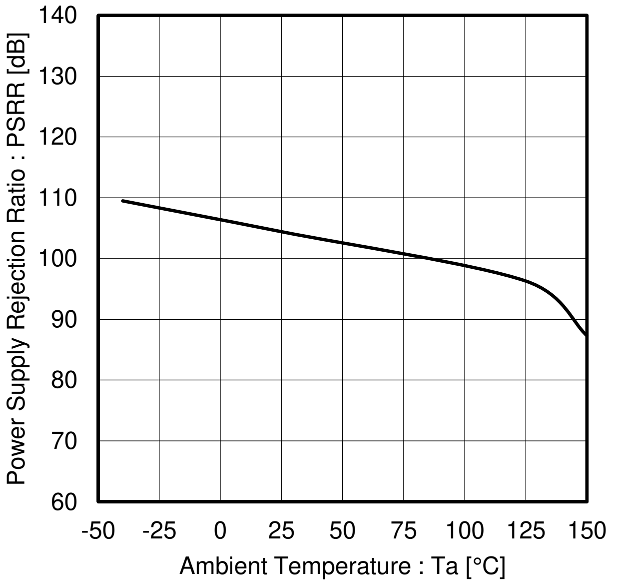


Figure 23. Power Supply Rejection Ratio vs Ambient Temperature
(V_{CC} = 5 V)

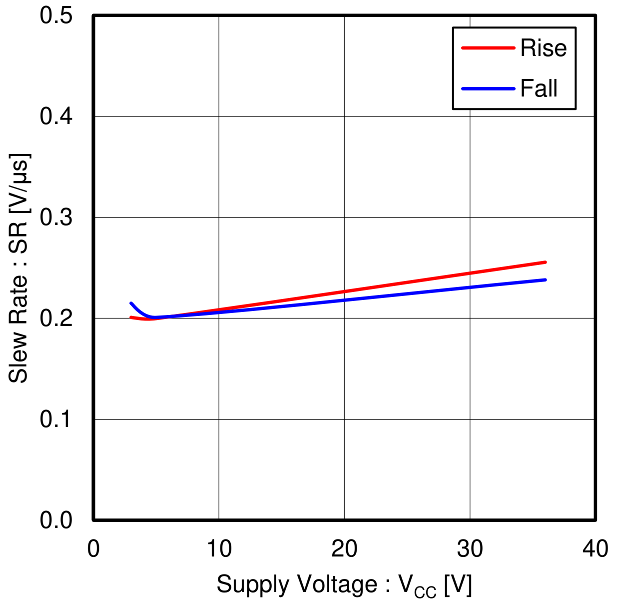


Figure 24. Slew Rate vs Supply Voltage
(Ta = 25 °C, R_L = 2 kΩ)

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

Typical Performance Curves - continued

V_{EE} = 0 V

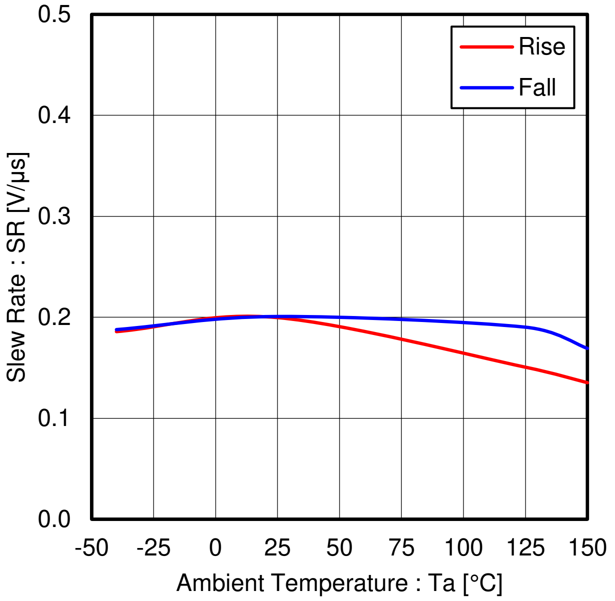


Figure 25. Slew Rate vs Ambient Temperature
(V_{CC} = 5 V, R_L = 2 kΩ)

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

Application Information

EMI Immunity

LM2904EYxxx-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
Test Circuit: Voltage Follower
V_{CC}: 12 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)

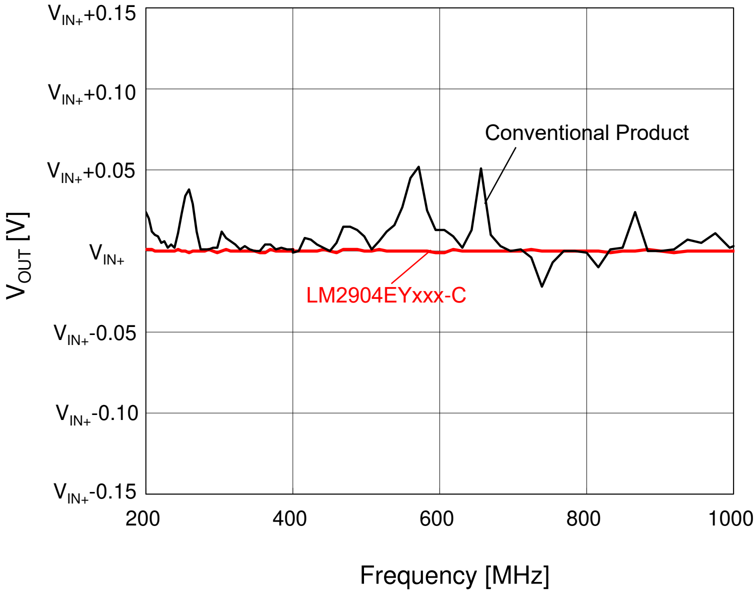


Figure 26. EMI Characteristics

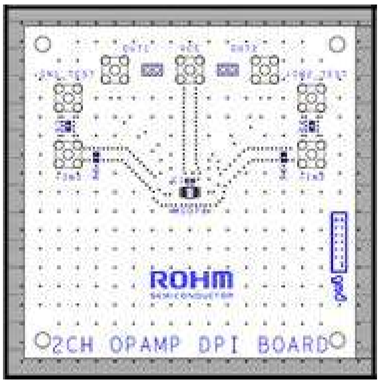


Figure 27. EMI Evaluation Board

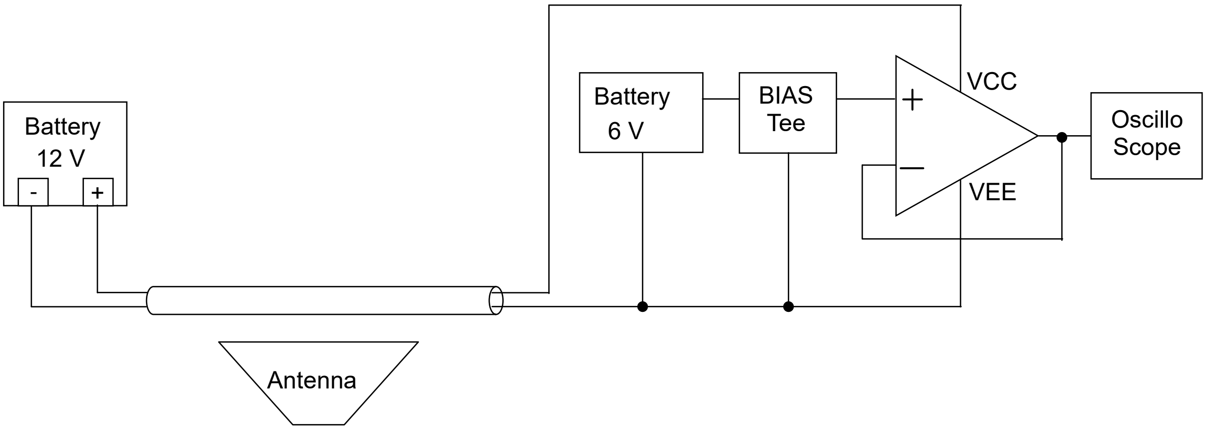


Figure 28. Measurement Circuit of EMI Evaluation

(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.

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}).

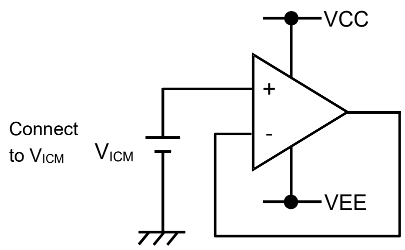


Figure 29. Example of application unused circuit processing

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 Op-Amp operates when the voltage is supplied between the VCC and VEE pin. Therefore, the single supply Op-Amp can be used as dual supply Op-Amp as well.

4. Output Capacitor
   When the VCC pin is shorted to V_{EE} (GND) electric potential in a state where electric charge is accumulated in the external capacitor that is connected to the output pin, the accumulated electric charge flow through parasitic elements or pin protection elements inside the circuit and discharges to the VCC pin. It may cause damage to the elements inside the circuit (thermal destruction). When using this IC as an application circuit which does not constitute a negative feedback circuit and does not occur the oscillation by an output capacitive load such as a voltage comparator, connect a capacitor of 0.1 µF or less to the output pin to prevent IC damage caused by the accumulation of electric charge as mentioned above.

5. Oscillation by Output Capacitor
   Pay attention to the oscillation by capacitive load in designing an application which constitutes a negative feedback loop circuit with this IC.

6. 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.

Application Examples

○Voltage Follower

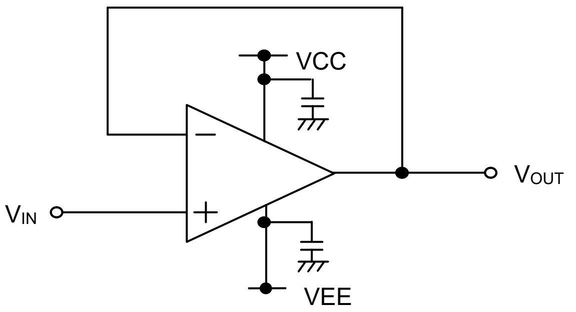


Figure 30. Voltage Follower Circuit

Using this circuit, the output voltage (V_{OUT}) is configured to be equal to the input voltage (V_{IN}). This circuit also stabilizes the output voltage (V_{OUT}) due to high input impedance and low output impedance. Computation for output voltage (V_{OUT}) is shown below.

$$V_{OUT} = V_{IN}$$

○Inverting Amplifier

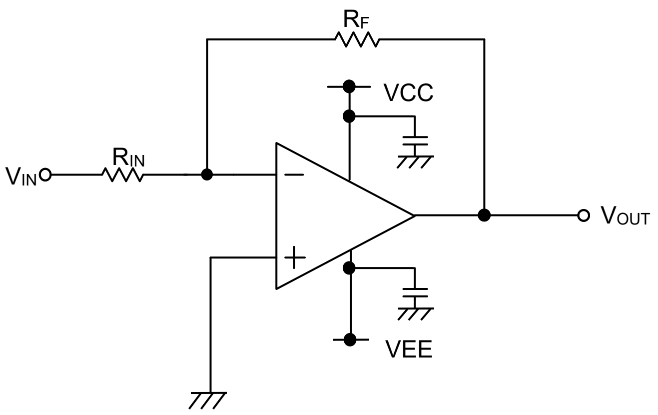


Figure 31. Inverting Amplifier Circuit

For inverting amplifier, input voltage (V_{IN}) is amplified by a voltage gain which depends on the ratio of R_{IN} and R_F, and then it outputs phase-inverted voltage. The output voltage is shown in the next expression.

$$V_{OUT} = -\frac{R_F}{R_{IN}} V_{IN}$$

This circuit has input impedance equal to R_{IN}.

○Non-inverting Amplifier

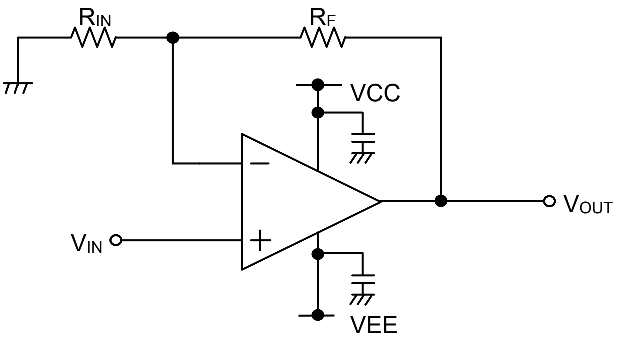


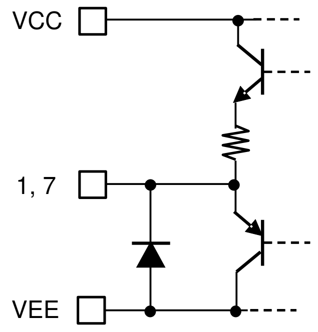
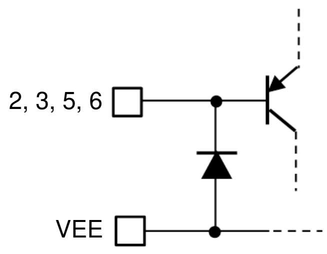
Figure 32. Non-inverting Amplifier Circuit

For non-inverting amplifier, input voltage (V_{IN}) is amplified by a voltage gain, which depends on the ratio of R_{IN} and R_F. The output voltage (V_{OUT}) is in-phase with the input voltage (V_{IN}) and is shown in the next expression.

$$V_{OUT} = \left(1 + \frac{R_F}{R_{IN}}\right) V_{IN}$$

Effectively, this circuit has high input impedance since its input side is the same as that of the operational amplifier.

I/O Equivalence Circuits

Pin No.	Pin Name	Pin Description	Equivalence Circuit
1 7	OUT1 OUT2	Output	
2 3 5 6	-IN1 +IN1 +IN2 -IN2	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.

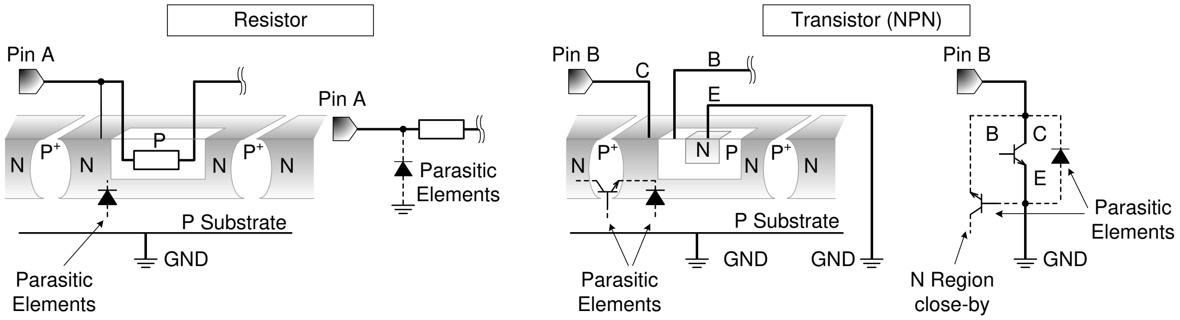


Figure 33. Example of Monolithic IC Structure

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

L M 2 9 0 4 E Y x x x - C x x

Package
F: SOP8
FJ: SOP-J8
FVM: MSOP8

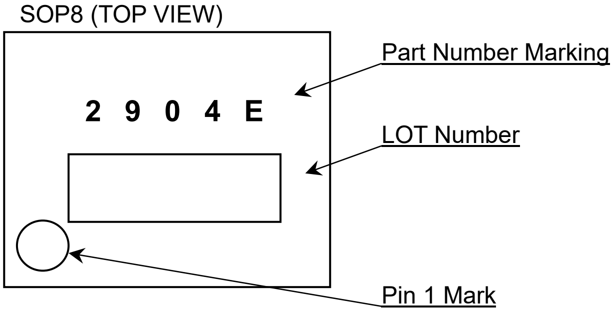
Product Rank
C: for Automotive
Packaging and forming specification
E2: Embossed tape and reel
TR: Embossed tape and reel

Lineup

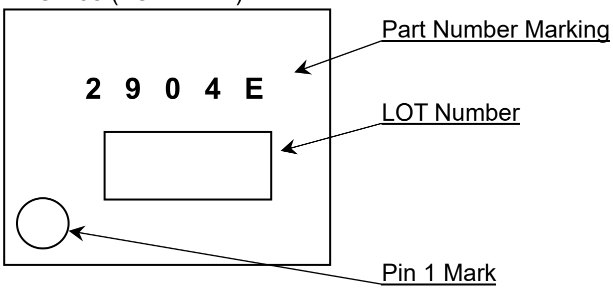
Temperature Range	Operating Supply Voltage Range	Number of Channels	Package		Orderable Part Number
-40 °C to +150 °C	3 V to 36 V	Dual	SOP8	Reel of 2500	LM2904EYF-CE2
			SOP-J8	Reel of 2500	LM2904EYFJ-CE2
			MSOP8	Reel of 3000	LM2904EYFVM-CTR

Marking Diagram

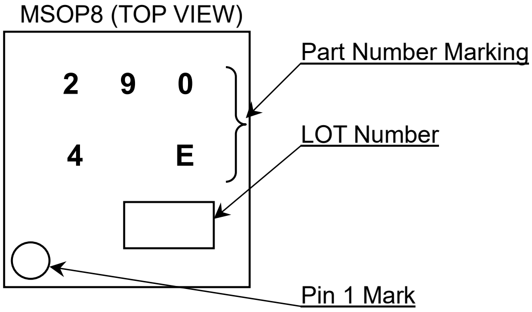
SOP8 (TOP VIEW)



SOP-J8 (TOP VIEW)

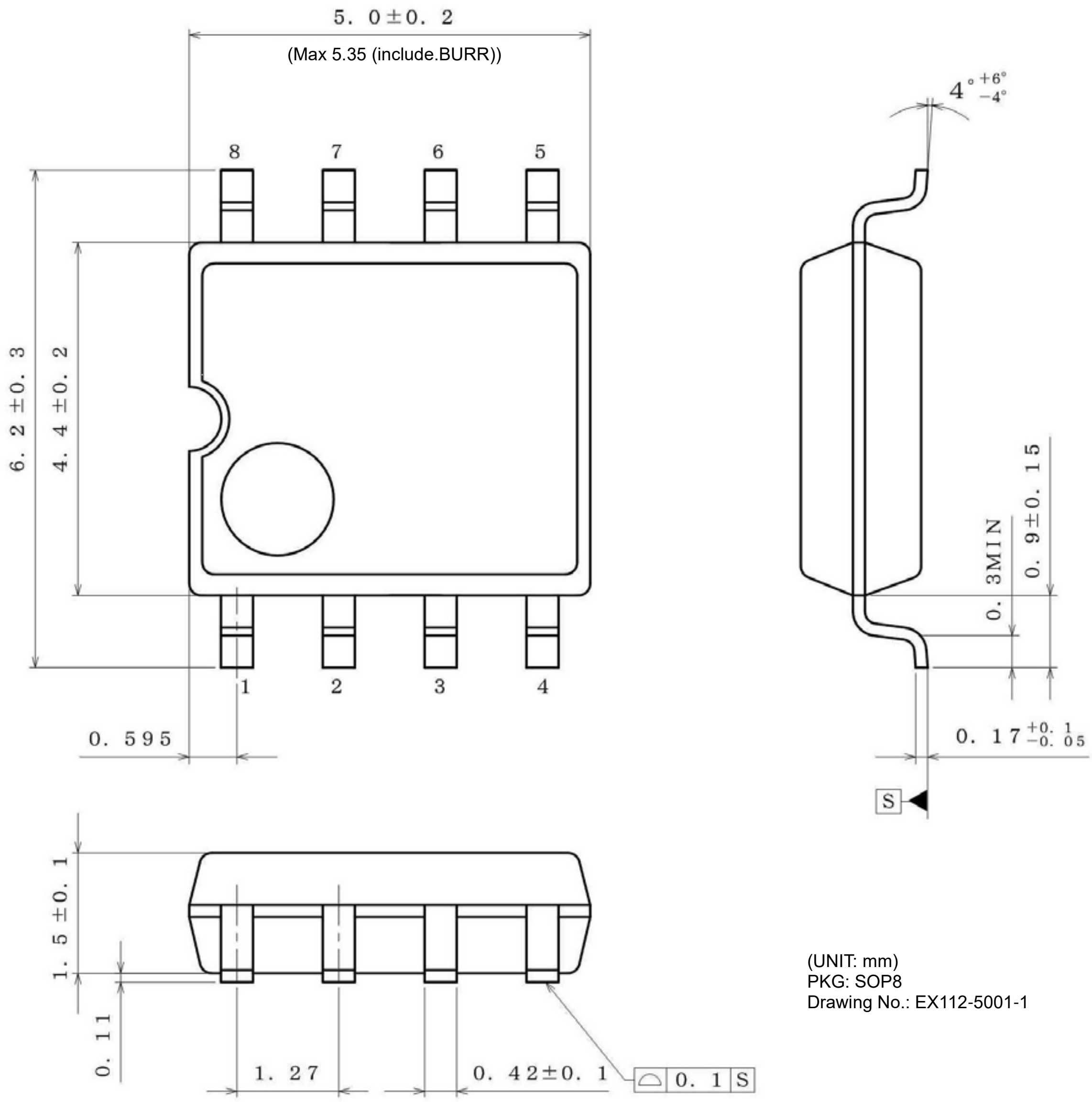


MSOP8 (TOP VIEW)



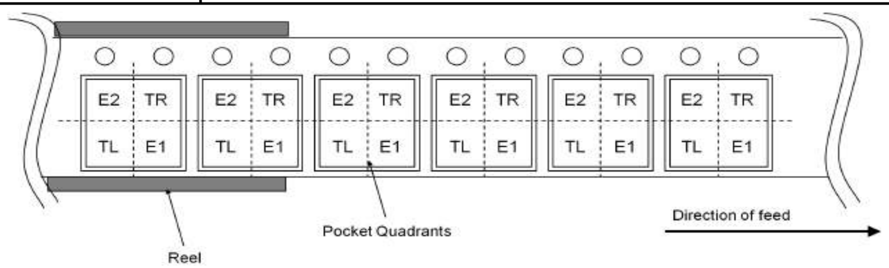
Physical Dimension and Packing Information

Package Name	SOP8



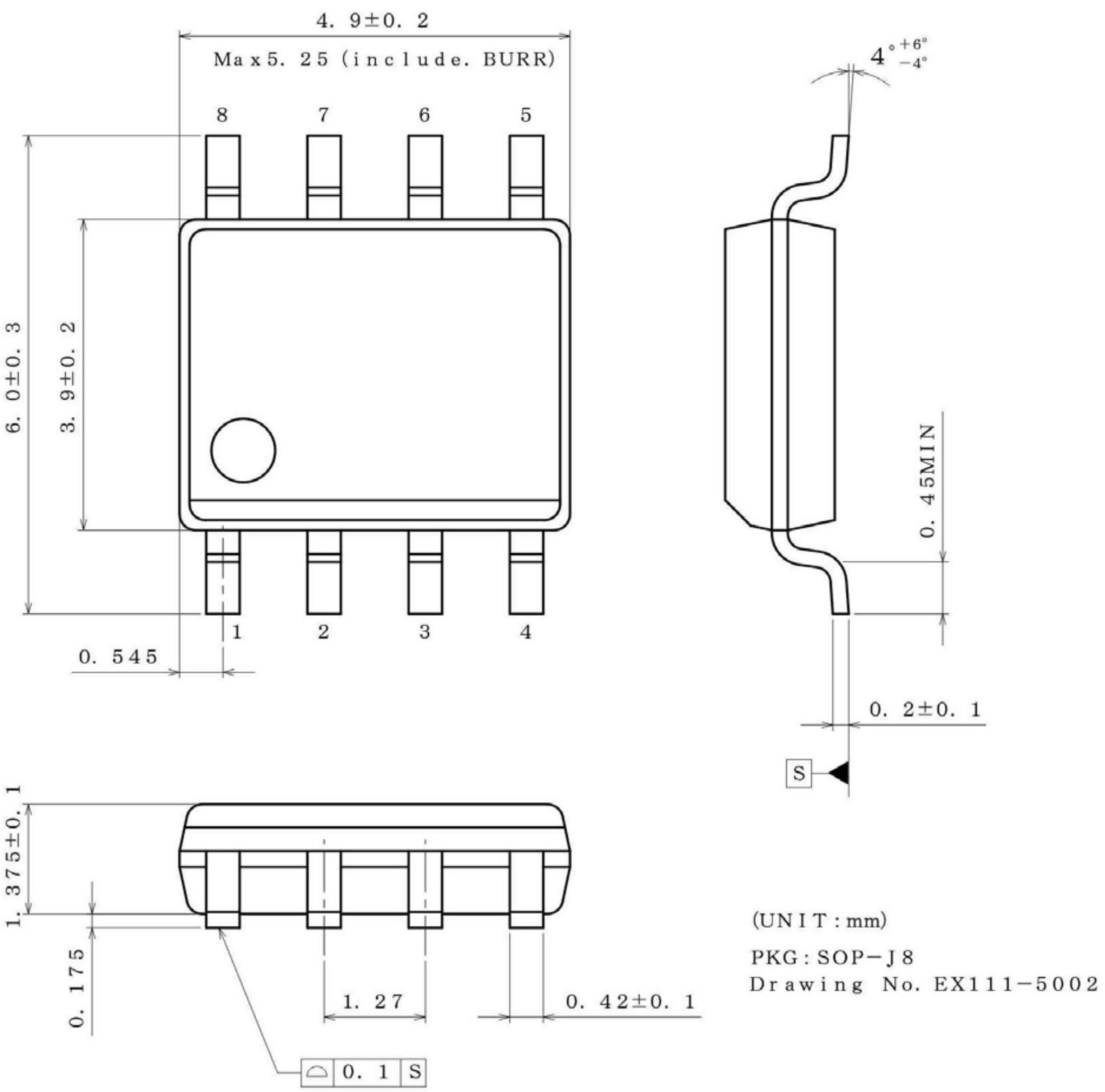
< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



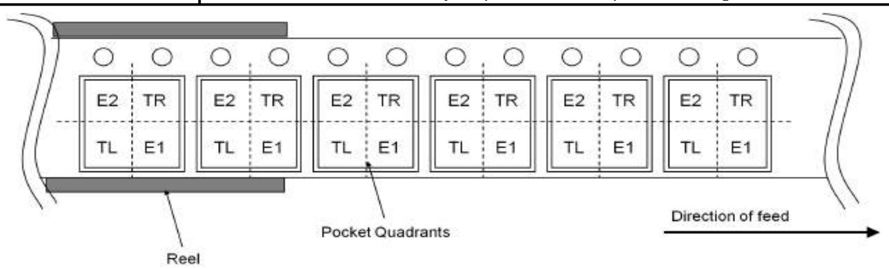
Physical Dimension and Packing Information – continued

Package Name	SOP-J8



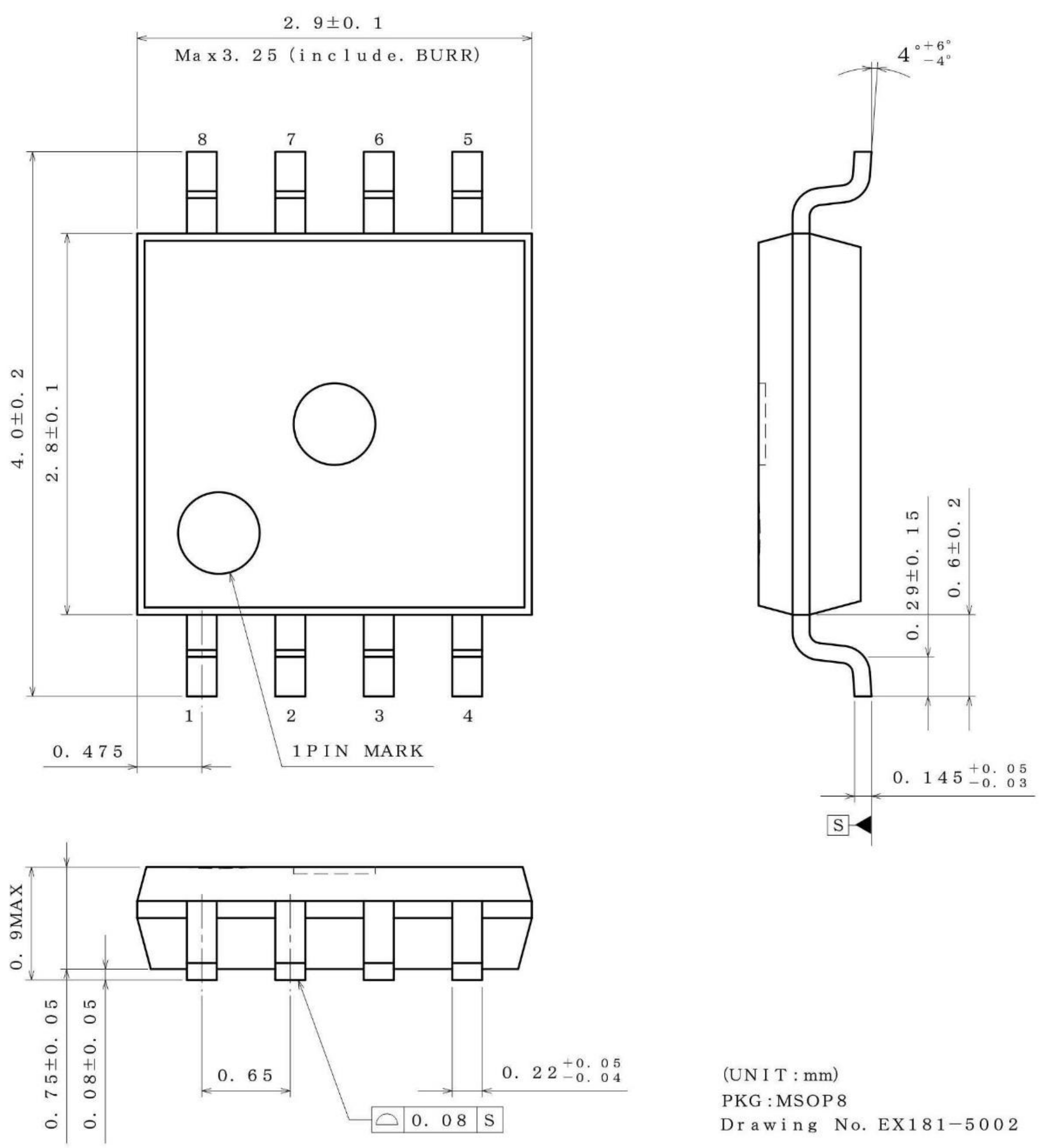
< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



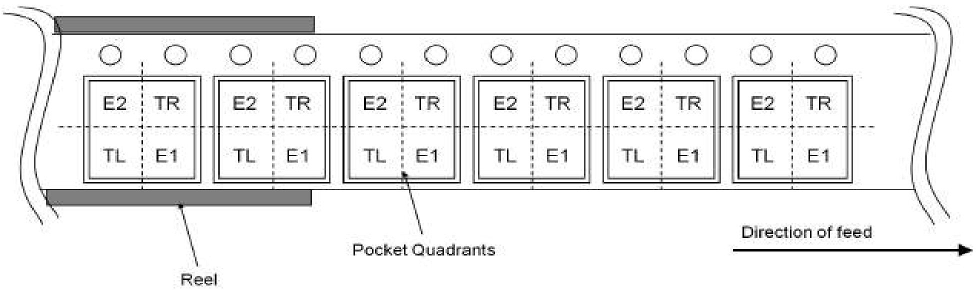
Physical Dimension and Packing Information – continued

Package Name	MSOP8



< 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)



Revision History

Date	Revision	Changes
13.Feb.2020	001	New Release
17.Jan.2022	002	Changed the "Absolute Maximum Ratings" and "Recommended Operating Conditions" of the supply voltage.
29.Jun.2022	003	Added Lineup
01.Oct.2022	004	Modified title

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<table>
<tr><th>JAPAN</th><th>USA</th><th>EU</th><th>CHINA</th></tr>
<tr><td>CLASSⅢ</td><td rowspan="2">CLASSⅢ</td><td>CLASSⅡb</td><td rowspan="2">CLASSⅢ</td></tr>
<tr><td>CLASSⅣ</td><td>CLASSⅢ</td></tr>
</table>

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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [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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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:
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   [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.

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