Datasheet

Operational Amplifier Series

# Automotive Excellent EMI Characteristics Ground Sense Operational Amplifiers

**BA82904Yxxx-C BA82902Yxxx-C**

## General Description

BA82904Yxxx-C and BA82902Yxxx-C are high-gain, ground sense input Op-Amps. These ICs are monolithic ICs integrated dual or quad independent Op-Amps on a single chip. These Op-Amps have some features of low power consumption, and can operate from 3V to 36V (single power supply). BA82904Yxxx-C and BA82902Yxxx-C are manufactured for automotive requirements of engine control unit, electric power steering, and so on.
Furthermore, they have the advantage of EMI tolerance dose. It is easy to replace with conventional products, and the EMI design is simple.

## Features

- AEC-Q100 Qualified*(Note 1)*
- Single or Dual Power Supply Operation
- Wide Operating Supply Voltage Range
- Standard Op-Amp Pin-assignments
- Operable from Almost GND Level for Both Input and Output
- Low Supply Current
- High Open Loop Voltage Gain
- Internal ESD Protection Circuit
- Wide Operating Temperature Range
- Integrated EMI Filter

*(Note 1)* Grade 1

## Applications

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

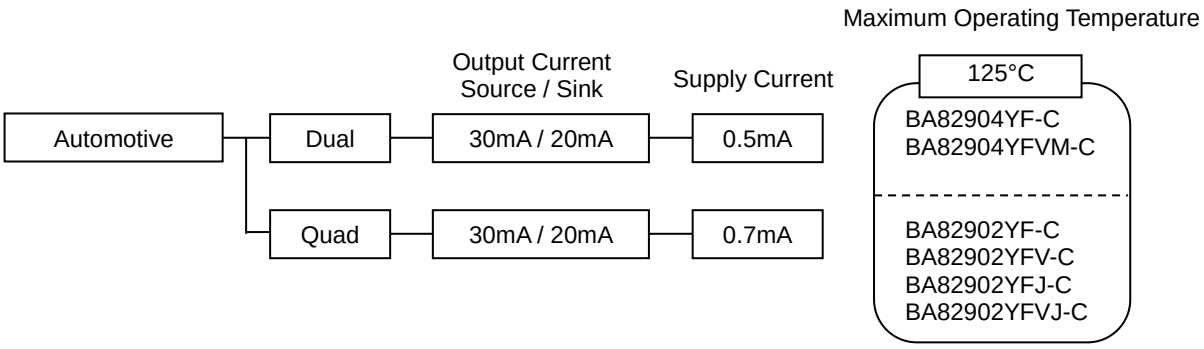
## Key Specifications

- Operating Supply Voltage Range
  Single Supply: 3V to 36V
  Dual Supply: ±1.5V to ±18.0V
- Low Supply Current
  BA82904Yxxx-C 0.5mA (Typ)
  BA82902Yxxx-C 0.7mA (Typ)
- Input Bias Current: 20nA (Typ)
- Input Offset Current: 2nA (Typ)
- Operating Temperature Range: -40°C to +125°C

## Packages

| Packages | W(Typ) x D(Typ) x H(Max) |
|---|---|
| SOP8 | 5.00mm x 6.20mm x 1.71mm |
| SOP14 | 8.70mm x 6.20mm x 1.71mm |
| SSOP-B14 | 5.00mm x 6.40mm x 1.35mm |
| MSOP8 | 2.90mm x 4.00mm x 0.90mm |
| SOP-J14 | 8.65mm x 6.00mm x 1.65mm |
| TSSOP-B14J | 5.00mm x 6.40mm x 1.20mm |

## Selection Guide




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

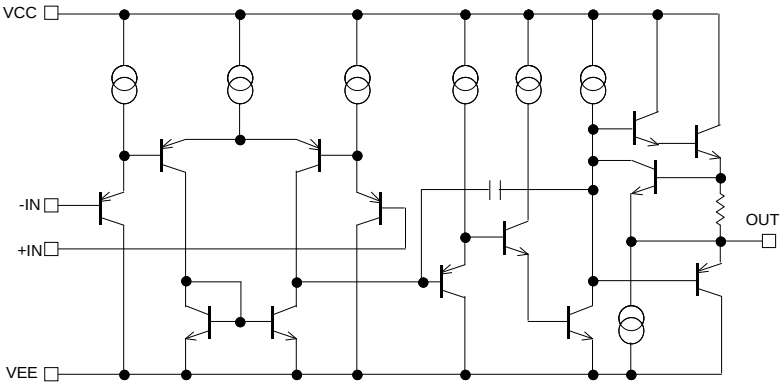
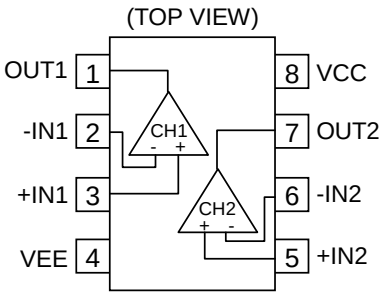



Figure 1. Equivalent Circuit (One Channel Only)

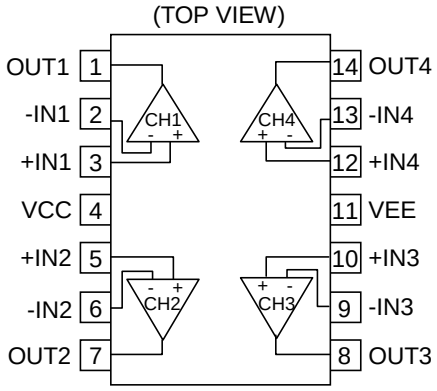
### Pin Configuration

BA82904YF-C: SOP8
BA82904YFVM-C: MSOP8




| Pin No. | Pin Name |
|---|---|
| 1 | OUT1 |
| 2 | -IN1 |
| 3 | +IN1 |
| 4 | VEE |
| 5 | +IN2 |
| 6 | -IN2 |
| 7 | OUT2 |
| 8 | VCC |

BA82902YF-C: SOP14
BA82902YFV-C: SSOP-B14
BA82902YFJ-C: SOP-J14
BA82902YFVJ-C: TSSOP-B14J




| Pin No. | Pin Name |
|---|---|
| 1 | OUT1 |
| 2 | -IN1 |
| 3 | +IN1 |
| 4 | VCC |
| 5 | +IN2 |
| 6 | -IN2 |
| 7 | OUT2 |
| 8 | OUT3 |
| 9 | -IN3 |
| 10 | +IN3 |
| 11 | VEE |
| 12 | +IN4 |
| 13 | -IN4 |
| 14 | OUT4 |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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 |
| Input Common-mode Voltage Range | $V_{ICM}$ | ($V_{EE}$-0.3) to ($V_{EE}$+36) | V |
| Input Current | $I_I$ | -10 | mA |
| Storage Temperature Range | Tstg | -55 to +150 | °C |
| Maximum Junction Temperature | Tjmax | 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 PCB boards 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 voltage difference between inverting input and non-inverting input is the differential input voltage. Then the input pin voltage is set to $V_{EE}$ or more.

### Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operating Supply Voltage | Vopr | 3 (±1.5) | 5 (±2.5) | 36 (±18) | V |
| Operating Temperature | Topr | -40 | +25 | +125 | °C |


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**Thermal Resistance*(Note 1)***

| Parameter | Symbol | Thermal Resistance (Typ) | | Unit |
|---|---|---|---|---|
| | | 1s*(Note 3)* | 2s2p*(Note 4)* | |
| MSOP8 | | | | |
| Junction to Ambient | $\theta_{JA}$ | 284.1 | 135.4 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 21 | 11 | °C/W |
| SOP8 | | | | |
| Junction to Ambient | $\theta_{JA}$ | 197.4 | 109.8 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 21 | 19 | °C/W |
| SOP14 | | | | |
| Junction to Ambient | $\theta_{JA}$ | 166.5 | 108.1 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 26 | 22 | °C/W |
| SSOP-B14 | | | | |
| Junction to Ambient | $\theta_{JA}$ | 159.6 | 92.8 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 13 | 9 | °C/W |
| SOP-J14 | | | | |
| Junction to Ambient | $\theta_{JA}$ | 118.5 | 67.2 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 10 | 10 | °C/W |
| TSSOP-B14J | | | | |
| Junction to Ambient | $\theta_{JA}$ | 185.4 | 98.4 | °C/W |
| Junction to Top Characterization Parameter*(Note 2)* | $\Psi_{JT}$ | 16 | 14 | °C/W |

*(Note 1)* Based on JESD51-2A(Still-Air).
*(Note 2)* 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 3)* Using a PCB board based on JESD51-3.
*(Note 4)* Using a PCB board based on JESD51-7.

| Layer Number of Measurement Board | Material | Board Size |
|---|---|---|
| Single | FR-4 | 114.3mm x 76.2mm x 1.57mmt |

| Top | |
|---|---|
| Copper Pattern | Thickness |
| Footprints and Traces | 70µm |

| Layer Number of Measurement Board | Material | Board Size |
|---|---|---|
| 4 Layers | FR-4 | 114.3mm x 76.2mm x 1.6mmt |

| Top | | 2 Internal Layers | | Bottom | |
|---|---|---|---|---|---|
| Copper Pattern | Thickness | Copper Pattern | Thickness | Copper Pattern | Thickness |
| Footprints and Traces | 70µm | 74.2mm x 74.2mm | 35µm | 74.2mm x 74.2mm | 70µm |


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## Electrical Characteristics

○BA82904Yxxx-C (Unless otherwise specified $V_{CC}$=5V, $V_{EE}$=0V)

| Parameter | Symbol | Temperature Range | Limits | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Input Offset Voltage*(Note 1)* | $V_{IO}$ | 25°C | - | 2 | 6 | mV | $V_{OUT}$=1.4V |
| | | Full range | - | - | 9 | | $V_{CC}$=5V to 30V, $V_{OUT}$=1.4V |
| Input Offset Current*(Note 1)* | $I_{IO}$ | 25°C | - | 2 | 40 | nA | $V_{OUT}$=1.4V |
| | | Full range | - | - | 50 | | |
| Input Bias Current*(Note 1)* | $I_B$ | 25°C | - | 20 | 60 | nA | $V_{OUT}$=1.4V |
| | | Full range | - | - | 100 | | |
| Supply Current | $I_{CC}$ | 25°C | - | 0.5 | 1.2 | mA | $R_L$=∞, All Op-Amps |
| | | Full range | - | - | 1.2 | | |
| Maximum Output Voltage (High) | $V_{OH}$ | 25°C | 3.5 | - | - | V | $R_L$=2kΩ |
| | | Full range | 3.2 | - | - | | |
| | | | 27 | 28 | - | | $V_{CC}$=30V, $R_L$=10kΩ |
| Maximum Output Voltage(Low) | $V_{OL}$ | Full range | - | 5 | 20 | mV | $R_L$=∞, All Op-Amps |
| Large Signal Voltage Gain | $A_V$ | 25°C | 25 | 100 | - | dB | $R_L$≥2kΩ, $V_{CC}$=15V<br>$V_{OUT}$=1.4V to 11.4V |
| | | Full range | 25 | - | - | | |
| Input Common-mode Voltage Range | $V_{ICM}$ | 25°C | 0 | - | $V_{CC}$-1.5 | V | ($V_{CC}$-$V_{EE}$)=5V<br>$V_{OUT}$=$V_{EE}$+1.4V |
| | | Full range | 0 | - | $V_{CC}$-2.0 | | |
| Common-mode Rejection Ratio | CMRR | Full range | 70 | 80 | - | dB | $V_{OUT}$=1.4V |
| Power Supply Rejection Ratio | PSRR | Full range | 70 | 100 | - | dB | $V_{CC}$=5V to 30V |
| Output Source Current*(Note 2)* | $I_{SOURCE}$ | 25°C | 20 | 30 | - | mA | $V_{+IN}$=1V, $V_{-IN}$=0V<br>$V_{OUT}$=0V<br>1CH is short circuit |
| | | Full range | 10 | - | - | | |
| Output Sink Current*(Note 2)* | $I_{SINK}$ | 25°C | 10 | 20 | - | mA | $V_{+IN}$=0V, $V_{-IN}$=1V<br>$V_{OUT}$=5V<br>1CH is short circuit |
| | | Full range | 2 | - | - | | |
| | | 25°C | 12 | 40 | - | µA | $V_{+IN}$=0V, $V_{-IN}$=1V<br>$V_{OUT}$=200mV |
| Slew Rate | SR | 25°C | - | 0.2 | - | V/µs | $V_{CC}$=15V, $A_V$=0dB<br>$R_L$=2kΩ, $C_L$=100pF |
| Gain Bandwidth Product | GBW | 25°C | - | 0.5 | - | MHz | $V_{CC}$=30V, $R_L$=2kΩ<br>$C_L$=100pF |
| Channel Separation | CS | 25°C | - | 120 | - | dB | f=1kHz, input referred |

*(Note 1)* Absolute value

*(Note 2)* Under high temperatures, it is important to consider the Tjmax and Thermal Resistance when selecting the output current.
When the output pin is continuously shorted, the output current may reduce because of the internal temperature rise by heating.


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**Electrical Characteristics - continued**

○BA82902Yxxx-C (Unless otherwise specified $V_{CC}$=5V, $V_{EE}$=0V)

| Parameter | Symbol | Temperature Range | Limits | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Input Offset Voltage*(Note 1)* | $V_{IO}$ | 25°C | - | 2 | 6 | mV | $V_{OUT}$=1.4V |
| | | Full range | - | - | 9 | | $V_{CC}$=5V to 30V, $V_{OUT}$=1.4V |
| Input Offset Current*(Note 1)* | $I_{IO}$ | 25°C | - | 2 | 40 | nA | $V_{OUT}$=1.4V |
| | | Full range | - | - | 50 | | |
| Input Bias Current*(Note 1)* | $I_B$ | 25°C | - | 20 | 60 | nA | $V_{OUT}$=1.4V |
| | | Full range | - | - | 100 | | |
| Supply Current | $I_{CC}$ | 25°C | - | 0.7 | 2 | mA | $R_L$=∞, All Op-Amps |
| | | Full range | - | - | 3 | | |
| Maximum Output Voltage (High) | $V_{OH}$ | 25°C | 3.5 | - | - | V | $R_L$=2kΩ |
| | | Full range | 3.2 | - | - | | |
| | | | 27 | 28 | - | | $V_{CC}$=30V, $R_L$=10kΩ |
| Maximum Output Voltage(Low) | $V_{OL}$ | Full range | - | 5 | 20 | mV | $R_L$=∞, All Op-Amps |
| Large Signal Voltage Gain | $A_V$ | 25°C | 25 | 100 | - | dB | $R_L$≥2kΩ, $V_{CC}$=15V<br>$V_{OUT}$=1.4V to 11.4V |
| | | Full range | 25 | - | - | | |
| Input Common-mode Voltage Range | $V_{ICM}$ | 25°C | 0 | - | $V_{CC}$-1.5 | V | ($V_{CC}$-$V_{EE}$)=5V<br>$V_{OUT}$=$V_{EE}$+1.4V |
| | | Full range | 0 | - | $V_{CC}$-2.0 | | |
| Common-mode Rejection Ratio | CMRR | Full range | 70 | 80 | - | dB | $V_{OUT}$=1.4V |
| Power Supply Rejection Ratio | PSRR | Full range | 70 | 100 | - | dB | $V_{CC}$=5V to 30V |
| Output Source Current*(Note 2)* | $I_{SOURCE}$ | 25°C | 20 | 30 | - | mA | $V_{+IN}$=1V, $V_{-IN}$=0V<br>$V_{OUT}$=0V<br>1CH is short circuit |
| | | Full range | 10 | - | - | | |
| Output Sink Current*(Note 2)* | $I_{SINK}$ | 25°C | 10 | 20 | - | mA | $V_{+IN}$=0V, $V_{-IN}$=1V<br>$V_{OUT}$=5V<br>1CH is short circuit |
| | | Full range | 2 | - | - | | |
| | | 25°C | 12 | 40 | - | µA | $V_{+IN}$=0V, $V_{-IN}$=1V<br>$V_{OUT}$=200mV |
| Slew Rate | SR | 25°C | - | 0.2 | - | V/µs | $V_{CC}$=15V, Av=0dB<br>$R_L$=2kΩ, $C_L$=100pF |
| Gain Bandwidth Product | GBW | 25°C | - | 0.5 | - | MHz | $V_{CC}$=30V, $R_L$=2kΩ<br>$C_L$=100pF |
| Channel Separation | CS | 25°C | - | 120 | - | dB | f=1kHz, input referred |

*(Note 1)* Absolute value

*(Note 2)* Under high temperatures, it is important to consider the Tjmax and Thermal Resistance when selecting the output current.
When the output pin is continuously shorted, the output current may reduce because of the internal temperature rise by heating.


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## Description of Electrical Characteristics

Described below are descriptions of the relevant electrical terms used in this datasheet. Items and symbols used are also shown. Note that item name and symbol and their meaning may differ from those on another manufacturer's or general document.

### 1. Absolute Maximum Ratings

Absolute maximum rating items indicate the condition which must not be exceeded even momentarily. Applying of voltage in excess of absolute maximum rating or use at outside the temperature range which is provided in the absolute maximum ratings may cause deteriorating the characteristics of the IC or destroying it.

1.1 Supply Voltage ($V_{CC}$-$V_{EE}$)
Indicates the maximum voltage that can be applied between the positive power supply pin and negative power supply pin without deteriorating the characteristics of internal circuit or destroying the IC.

1.2 Differential Input Voltage ($V_{ID}$)
Indicates the maximum voltage that can be applied between non-inverting pin and inverting pin without deteriorating the characteristics of the IC or without destroying it.

1.3 Input Common-mode Voltage Range ($V_{ICM}$)
Indicates the voltage range that can be applied to the non-inverting pin and inverting pin without deteriorating the characteristics of the IC or without destroying it. Input common-mode voltage range of the maximum ratings does not assure normal operation of the IC. For normal operation, use the IC within the input common-mode voltage range of electrical characteristics.

1.4 Storage Temperature Range (Tstg)
The storage temperature range denotes the range of temperatures the IC can be stored without causing excessive deteriorating the characteristics of the IC.

### 2. Electrical Characteristics

2.1 Input Offset Voltage ($V_{IO}$)
Indicates the voltage difference between non-inverting pin and inverting pin. It can be translated as the input voltage difference required for setting the output voltage at 0V.

2.2 Input Offset Current ($I_{IO}$)
Indicates the difference of input bias current between the non-inverting and inverting pins.

2.3 Input Bias Current ($I_B$)
Indicates the current that flows into or out of the input pin. It is defined by the average of input bias currents at the non-inverting and inverting pins.

2.4 Supply Current ($I_{CC}$)
Indicates the current that flows within the IC under no-load conditions.

2.5 Maximum Output Voltage (High) / Maximum Output Voltage (Low) ($V_{OH}$/$V_{OL}$)
Indicates the voltage range of the output under specified load condition. It is typically divided into maximum output voltage High and maximum output voltage Low. Maximum output voltage (High) indicates the upper limit of output voltage while maximum output voltage (Low) indicates the lower limit.

2.6 Large Signal Voltage Gain ($A_V$)
Indicates the amplifying rate (gain) of output voltage regarding the voltage difference between non-inverting pin and inverting pin. It is normally the amplifying rate (gain) with reference to DC voltage.

$A_V$ = (Output Voltage) / (Differential Input Voltage)

2.7 Input Common-mode Voltage Range ($V_{ICM}$)
Indicates the input voltage range where IC normally operates.

2.8 Common-mode Rejection Ratio (CMRR)
Indicates the ratio of fluctuation of input offset voltage when the input common mode voltage is changed. It is normally the fluctuation of DC.

CMRR = (Change of Input Common-mode Voltage) / (Input Offset Voltage Fluctuation)

2.9 Power Supply Rejection Ratio (PSRR)
Indicates the ratio of fluctuation of input offset voltage when supply voltage is changed. It is normally the fluctuation of DC.

PSRR = (Change of Power Supply Voltage) / (Input Offset Voltage Fluctuation)


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**Description of Electrical Characteristics - continued**

2.10 Output Source Current / Output Sink Current ($I_{SOURCE}$ / $I_{SINK}$)
The maximum current that can be output from the IC under specific output conditions. It is typically divided into output source current and output sink current. The output source current indicates the current flowing out from the IC, and the output sink current indicates the current flowing into the IC.

2.11 Slew Rate (SR)
This parameter indicates the operation speed of the Op-Amps. Indicates the rate at which the output voltage can change per specified unit time.

2.12 Gain Bandwidth Product (GBW)
This indicates the product of an arbitrary frequency and its gain in the range of the gain slope of 6 dB/octave.

2.13 Channel Separation (CS)
Indicates the fluctuation in the output voltage of the other channel regarding the change of output voltage of the channel which is driven.


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**Typical Performance Curves**

○BA82904Yxxx-C

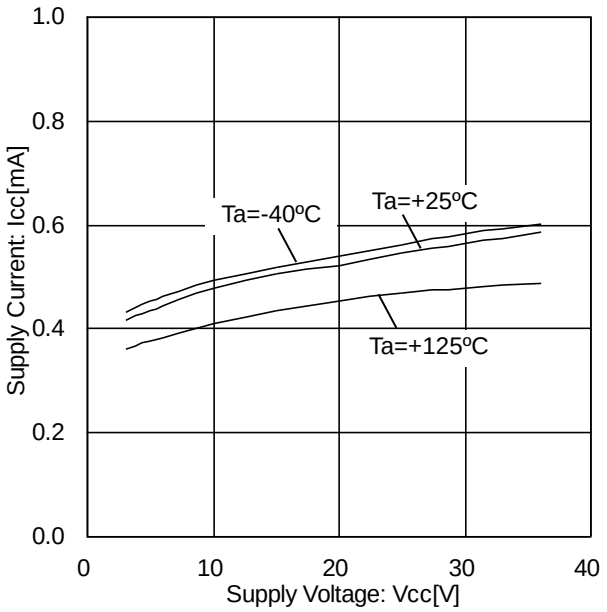


Figure 2. Supply Current vs Supply Voltage

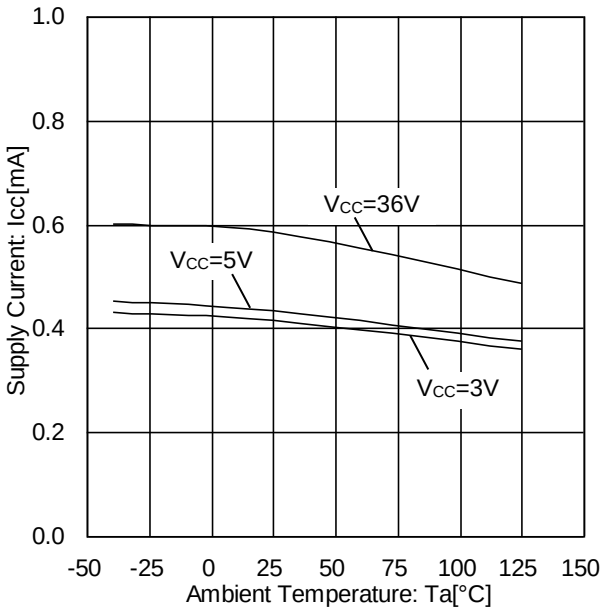


Figure 3. Supply Current vs Ambient Temperature

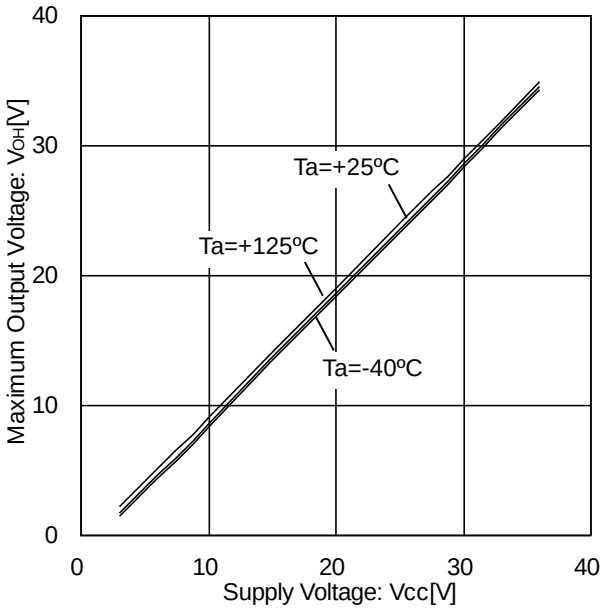


Figure 4. Maximum Output Voltage vs Supply Voltage
($R_L$=10kΩ)

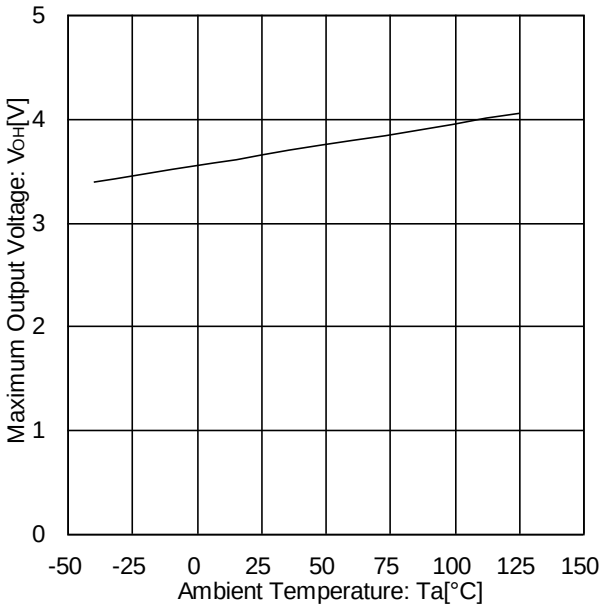


Figure 5. Maximum Output Voltage vs Ambient Temperature
($V_{CC}$=5V, $R_L$=2kΩ)

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


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**Typical Performance Curves - continued**

○BA82904Yxxx-C

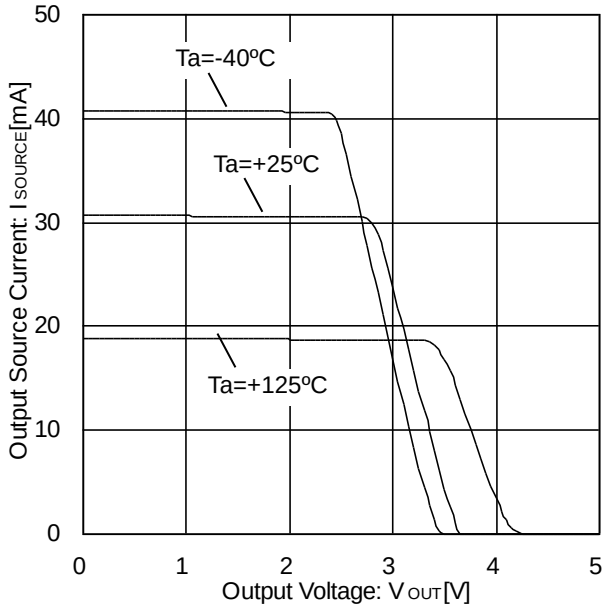


Figure 6. Output Source Current vs Output Voltage
($V_{CC}$=5V)

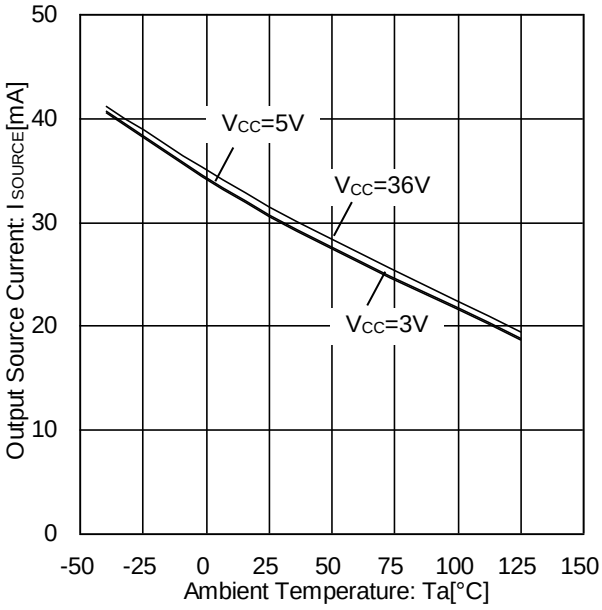


Figure 7. Output Source Current vs Ambient Temperature
($V_{OUT}$=0V)

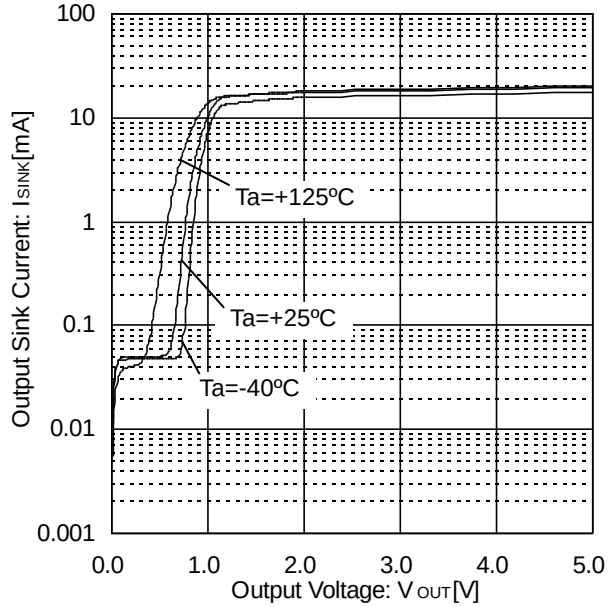


Figure 8. Output Sink Current vs Output Voltage
($V_{CC}$=5V)

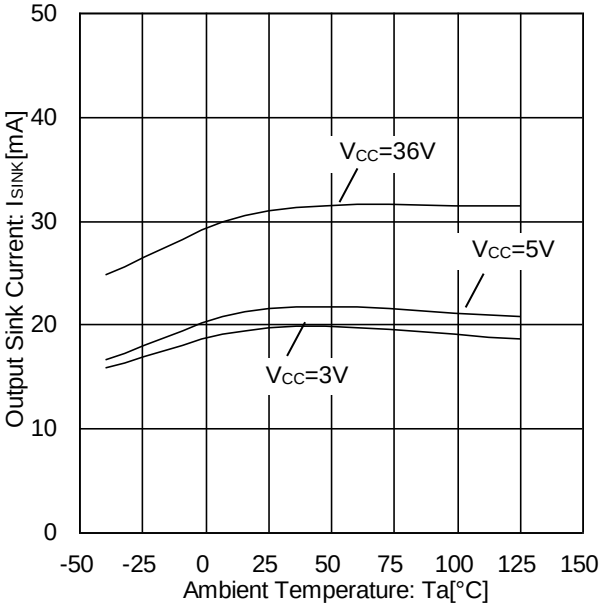


Figure 9. Output Sink Current vs Ambient Temperature
($V_{OUT}$=$V_{CC}$)

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


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**Typical Performance Curves - continued**

○BA82904Yxxx-C

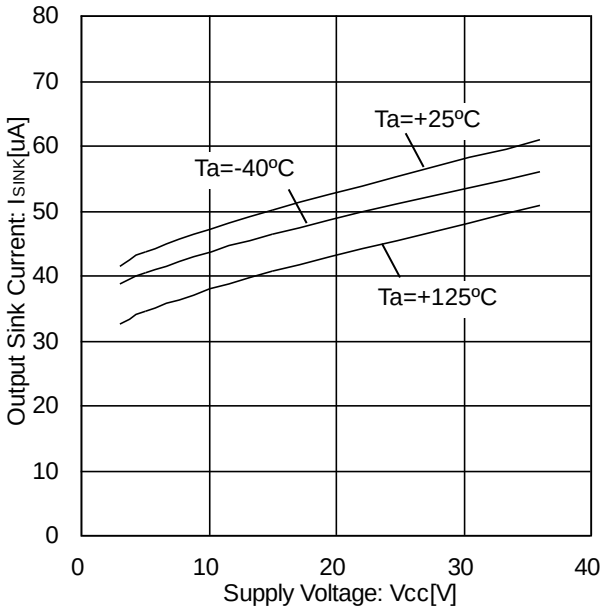


Figure 10. Output Sink Current vs Supply Voltage
($V_{OUT}$=0.2V)

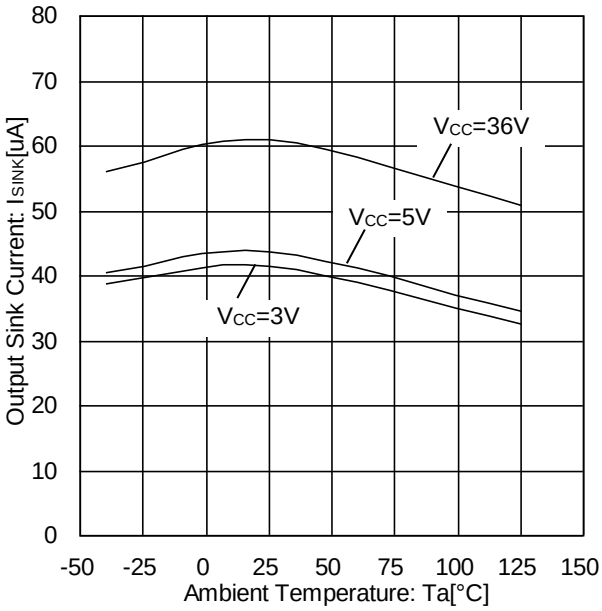


Figure 11. Output Sink Current vs Ambient Temperature
($V_{OUT}$=0.2V)

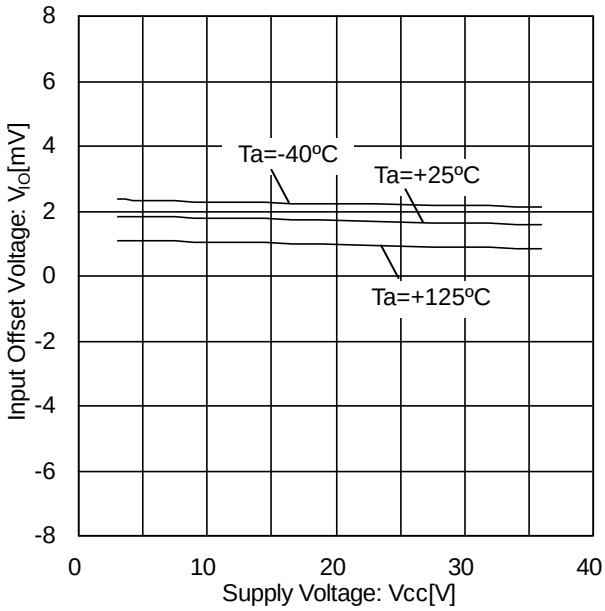


Figure 12. Input Offset Voltage vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

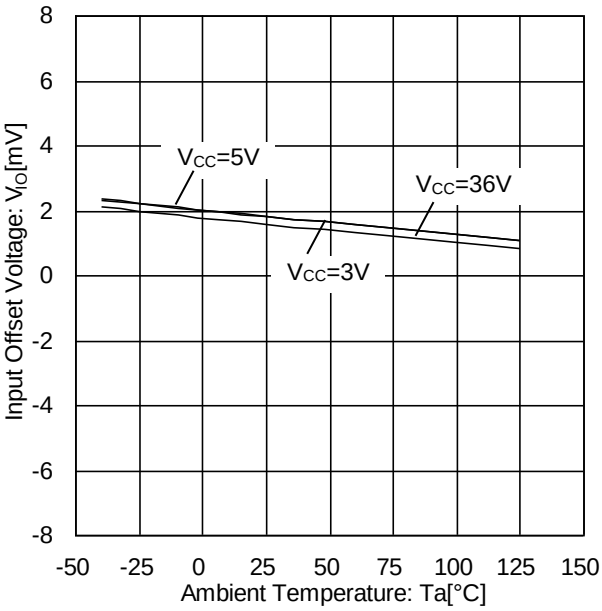


Figure 13. Input Offset Voltage vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

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


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**Typical Performance Curves - continued**

○BA82904Yxxx-C

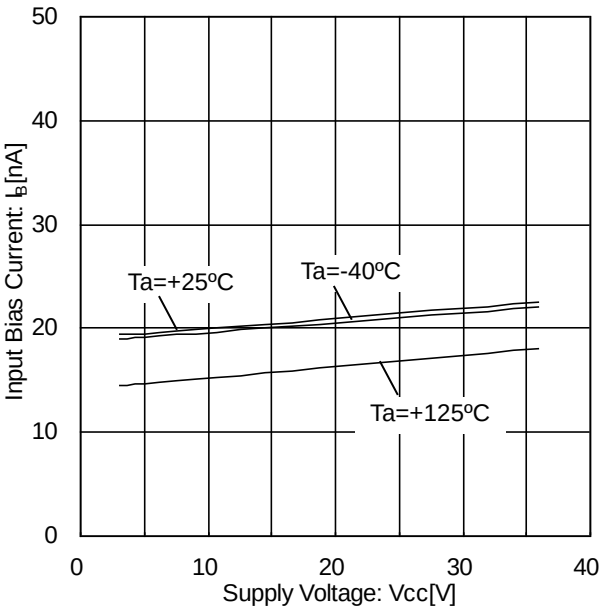


Figure 14. Input Bias Current vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

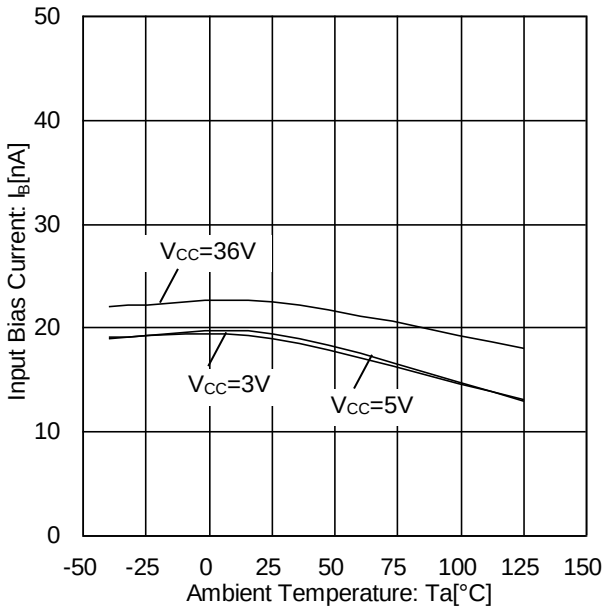


Figure 15. Input Bias Current vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

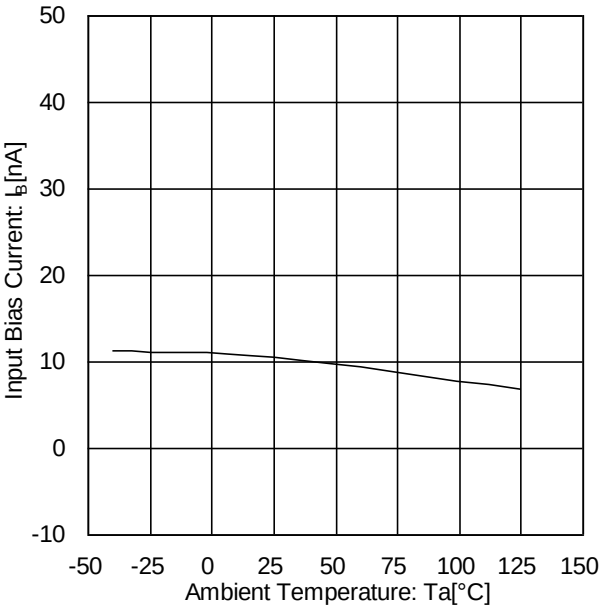


Figure 16. Input Bias Current vs Ambient Temperature
($V_{CC}$=30V, $V_{ICM}$=28V, $V_{OUT}$=1.4V)

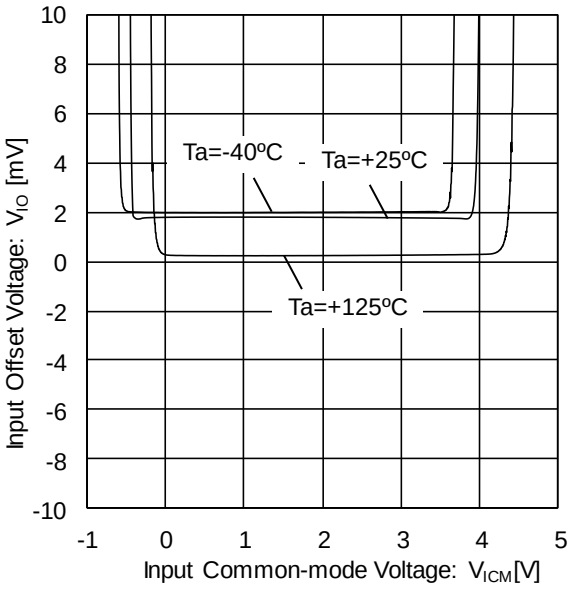


Figure 17. Input Offset Voltage vs Input Common-mode Voltage
($V_{CC}$=5V)

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


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**Typical Performance Curves - continued**

○BA82904Yxxx-C

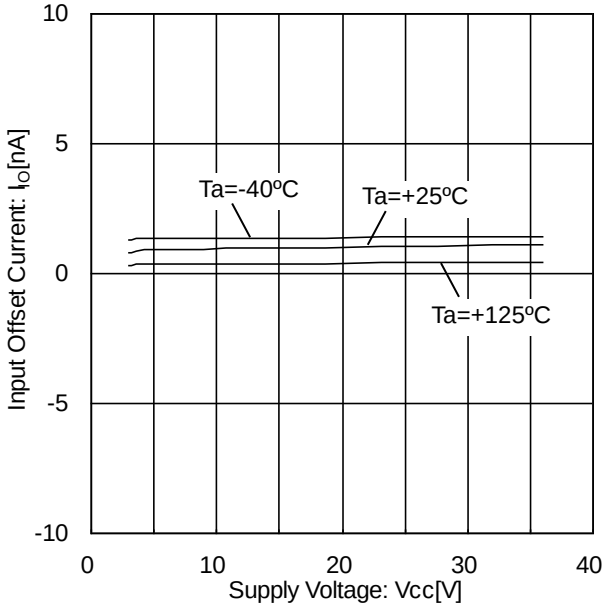


Figure 18. Input Offset Current vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

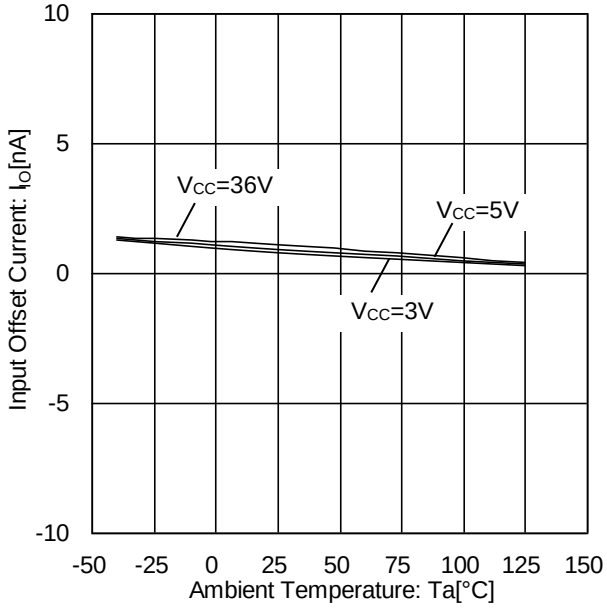


Figure 19. Input Offset Current vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

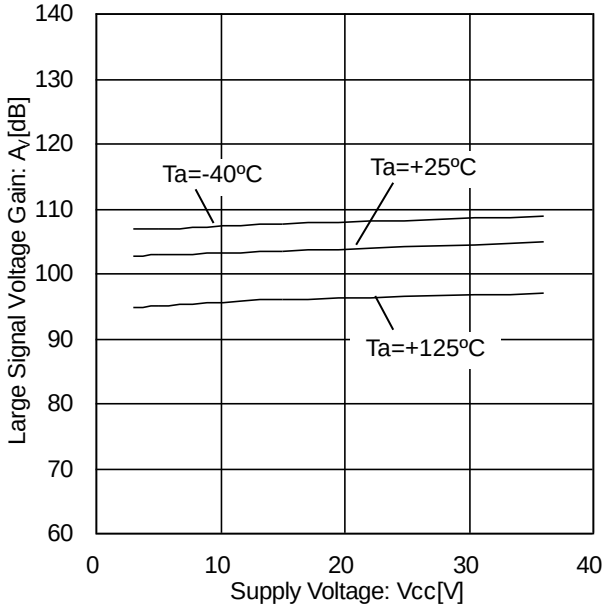


Figure 20. Large Signal Voltage Gain vs Supply Voltage
($R_L$=2kΩ)

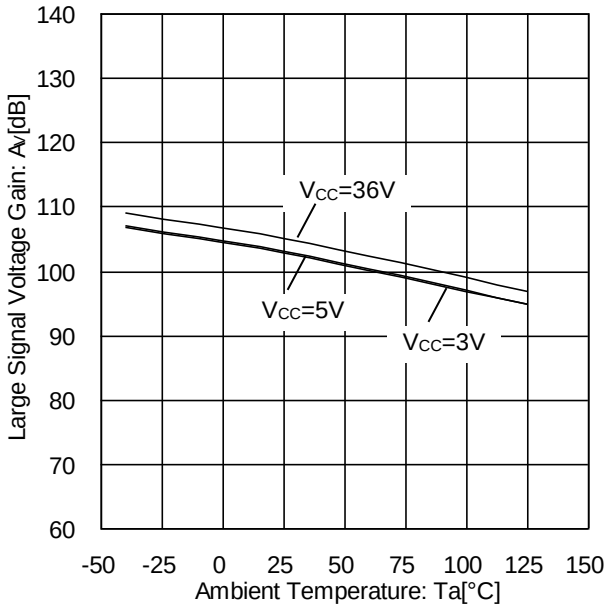


Figure 21. Large Signal Voltage Gain vs Ambient Temperature
($R_L$=2kΩ)

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


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**Typical Performance Curves - continued**

○BA82904Yxxx-C

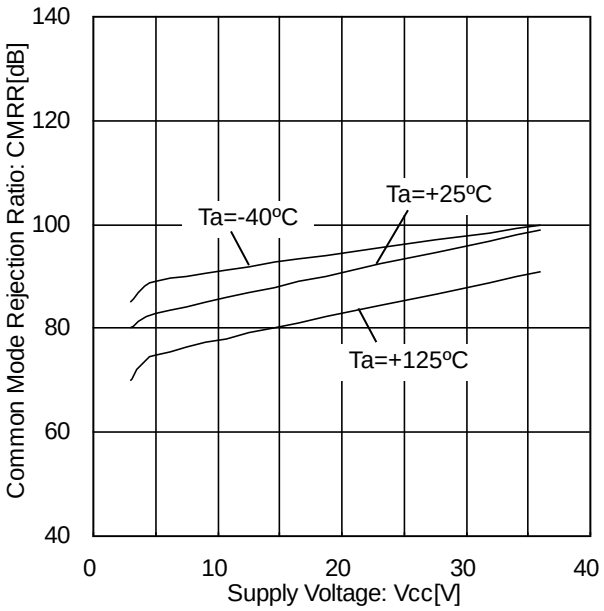


Figure 22. Common Mode Rejection Ratio vs Supply Voltage
($V_{OUT}$=1.4V)

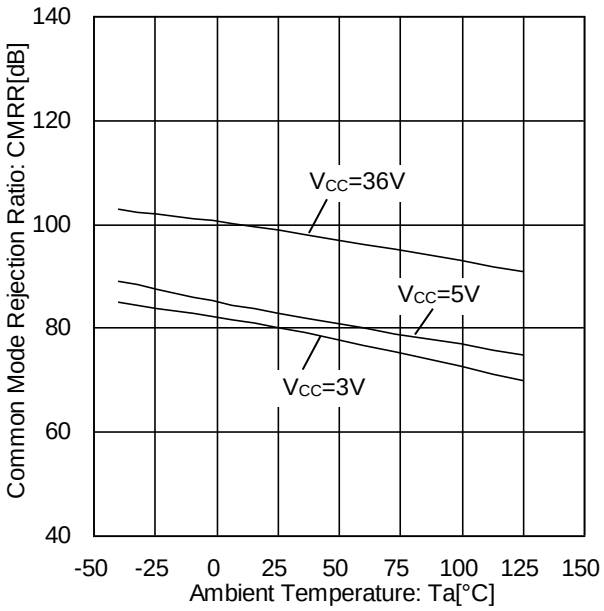


Figure 23. Common Mode Rejection Ratio vs Ambient Temperature
($V_{OUT}$=1.4V)

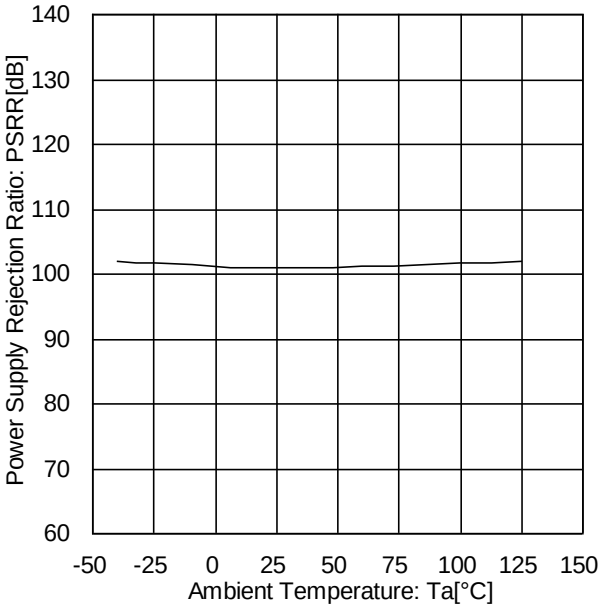


Figure 24. Power Supply Rejection Ratio vs Ambient Temperature
($V_{CC}$=5V)

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


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**Typical Performance Curves - continued**

○BA82902Yxxx-C

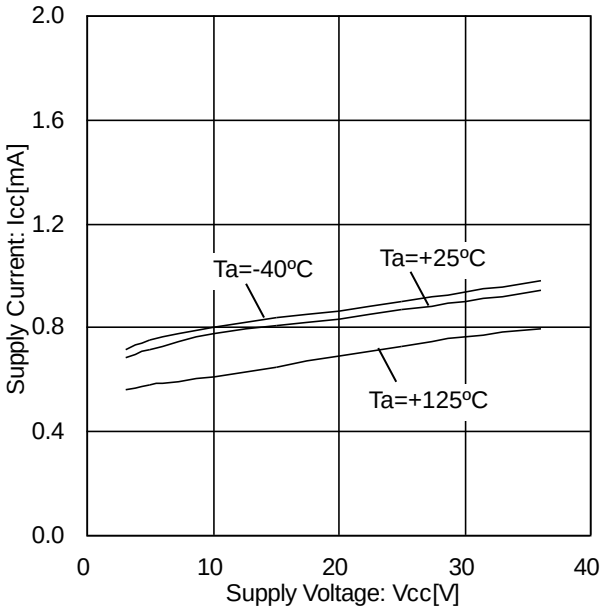


Figure 25. Supply Current vs Supply Voltage

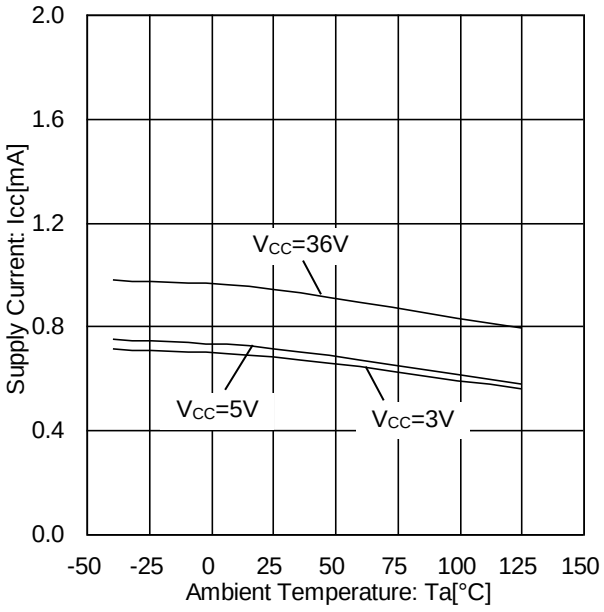


Figure 26. Supply Current vs Ambient Temperature

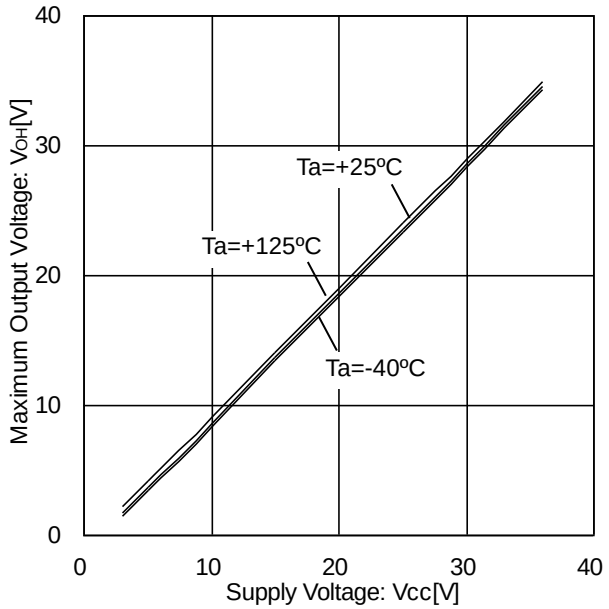


Figure 27. Maximum Output Voltage vs Supply Voltage
($R_L$=10kΩ)

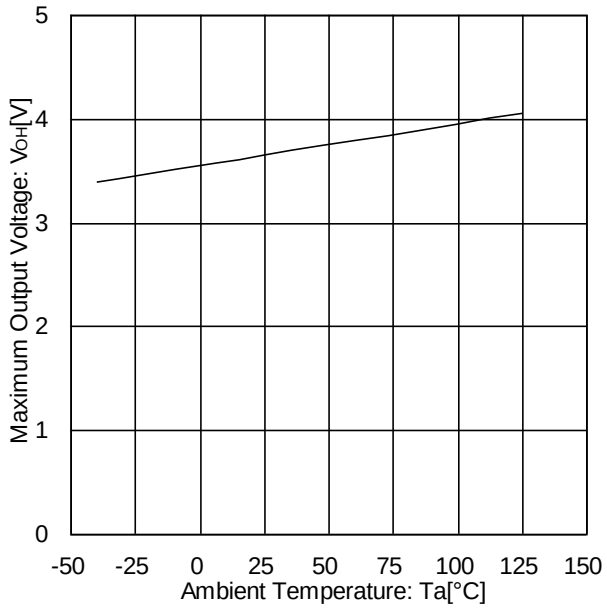


Figure 28. Maximum Output Voltage vs Ambient Temperature
($V_{CC}$=5V, $R_L$=2kΩ)

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


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**Typical Performance Curves - continued**

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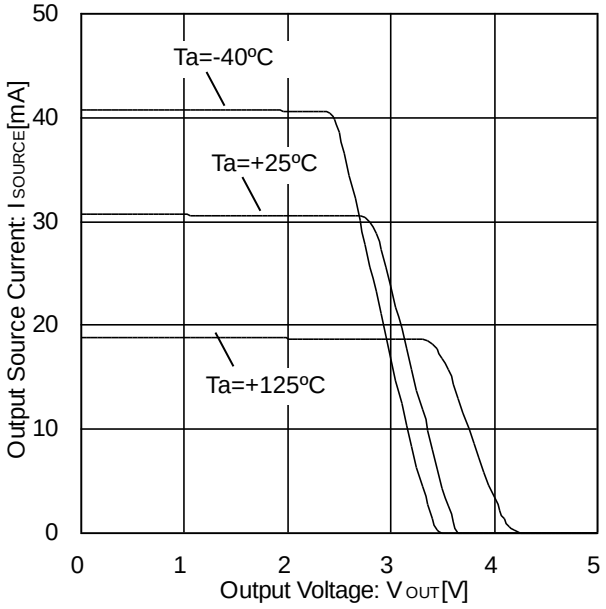


Figure 29. Output Source Current vs Output Voltage
($V_{CC}$=5V)

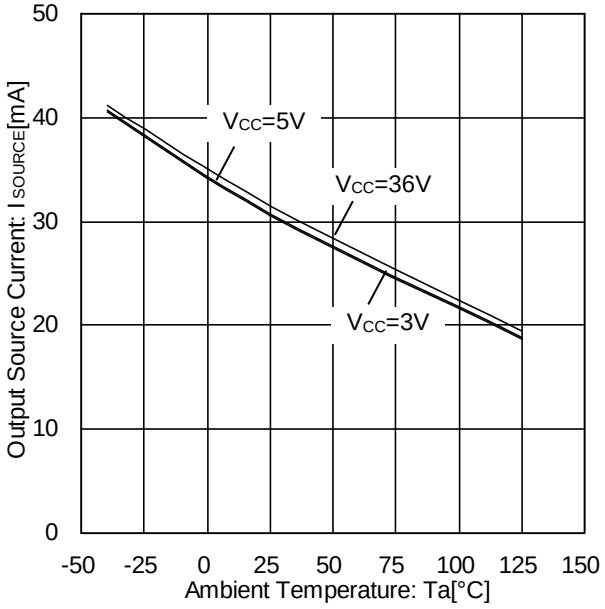


Figure 30. Output Source Current vs Ambient Temperature
($V_{OUT}$=0V)

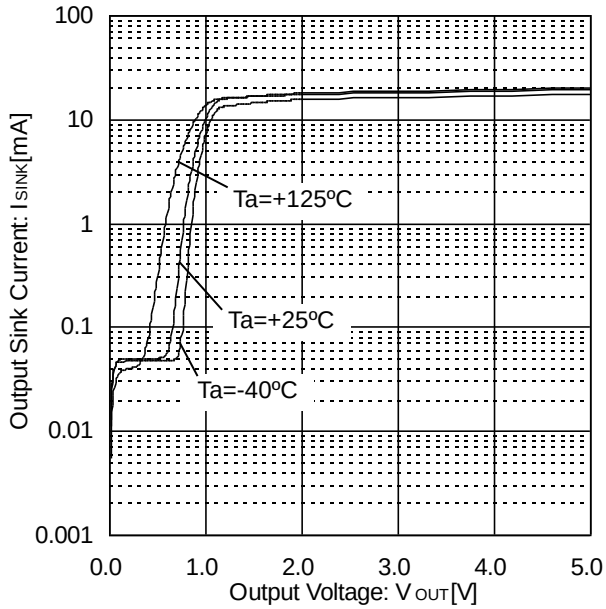


Figure 31. Output Sink Current vs Output Voltage
($V_{CC}$=5V)

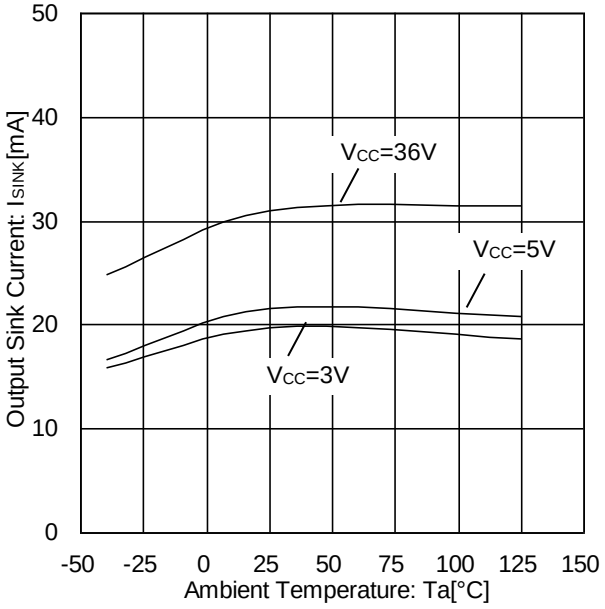


Figure 32. Output Sink Current vs Ambient Temperature
($V_{OUT}$=$V_{CC}$)

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


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**Typical Performance Curves - continued**

○BA82902Yxxx-C

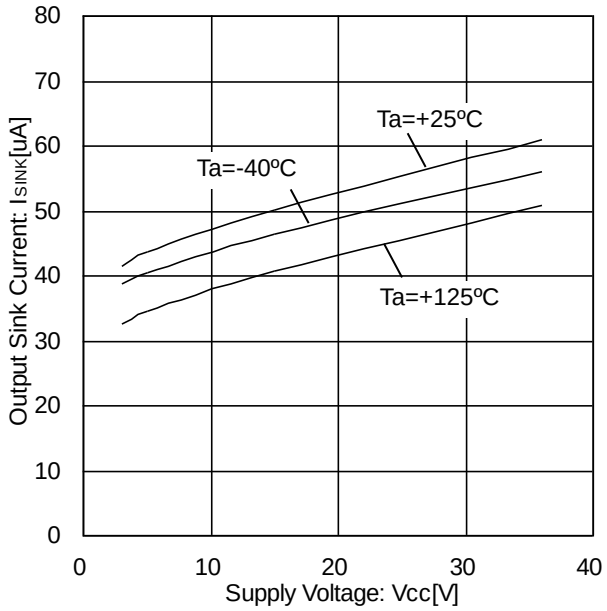


Figure 33. Output Sink Current vs Supply Voltage
($V_{OUT}$=0.2V)

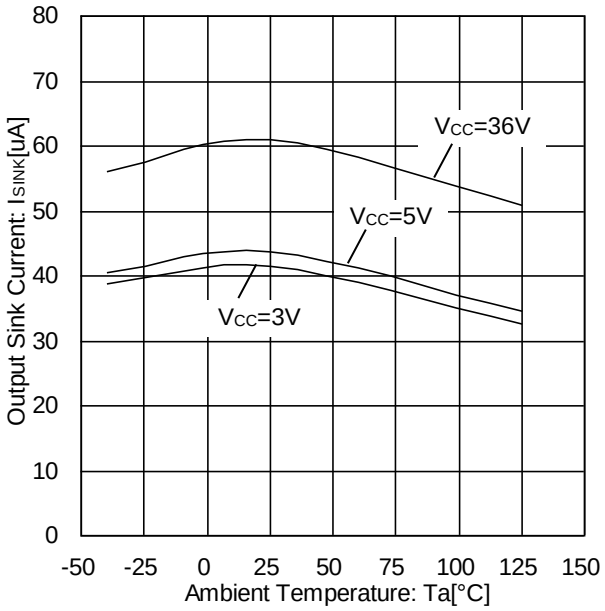


Figure 34. Output Sink Current vs Ambient Temperature
($V_{OUT}$=0.2V)

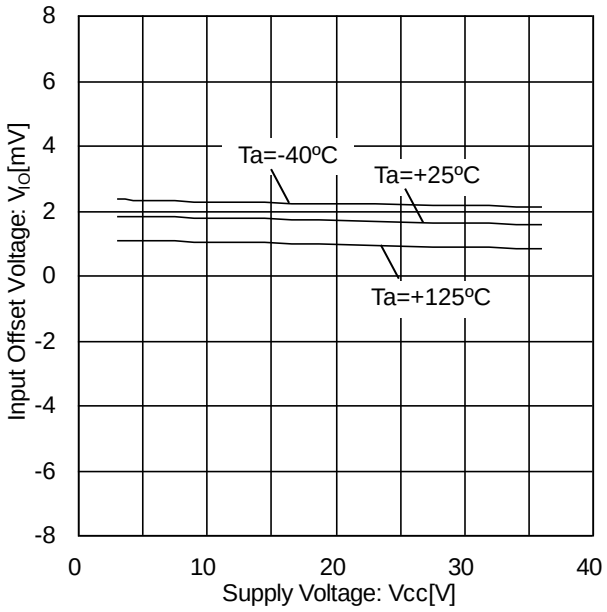


Figure 35. Input Offset Voltage vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

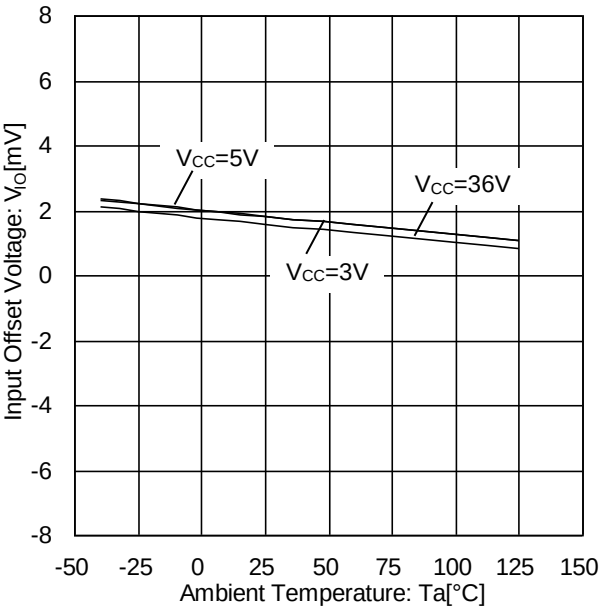


Figure 36. Input Offset Voltage vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

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


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**Typical Performance Curves - continued**

○BA82902Yxxx-C

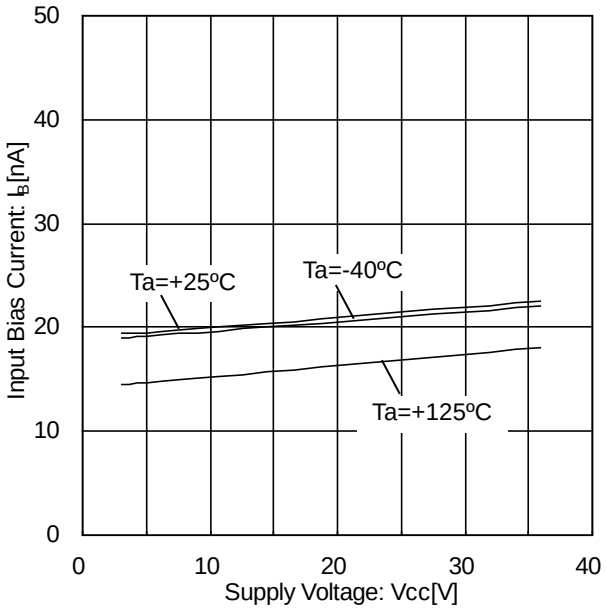


Figure 37. Input Bias Current vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

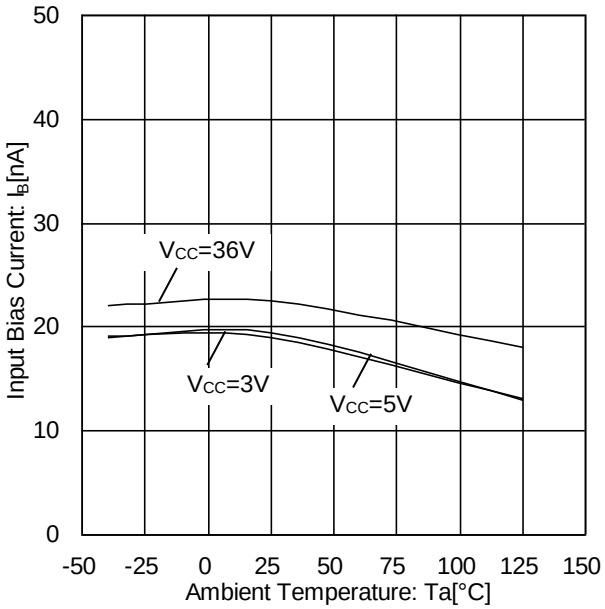


Figure 38. Input Bias Current vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

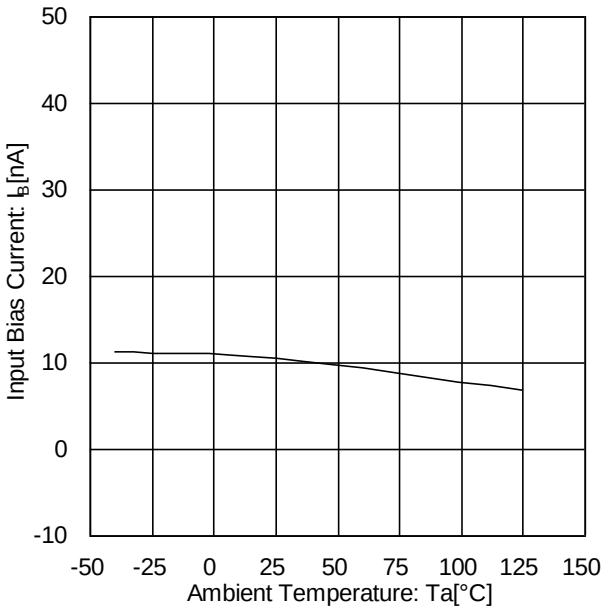


Figure 39. Input Bias Current vs Ambient Temperature
($V_{CC}$=30V, $V_{ICM}$=28V, $V_{OUT}$=1.4V)

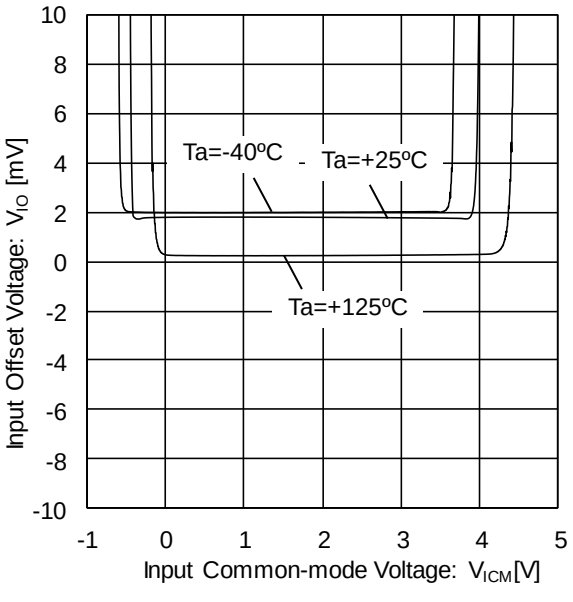


Figure 40. Input Offset Voltage vs Input Common-mode Voltage
($V_{CC}$=5V)

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


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**Typical Performance Curves - continued**

○BA82902Yxxx-C

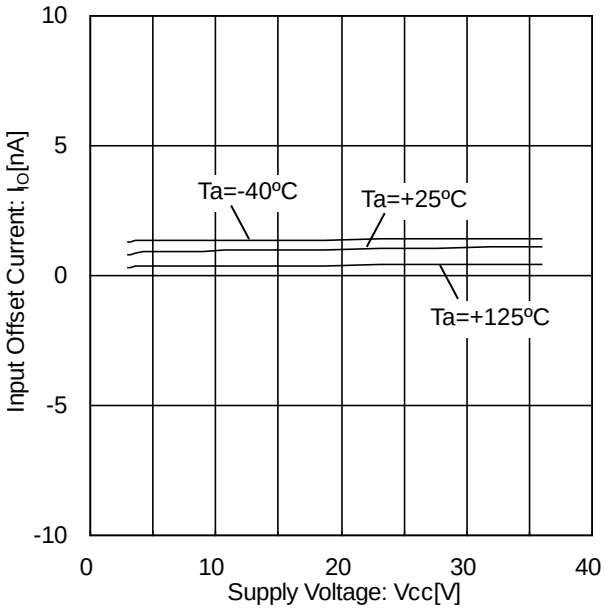


Figure 41. Input Offset Current vs Supply Voltage
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

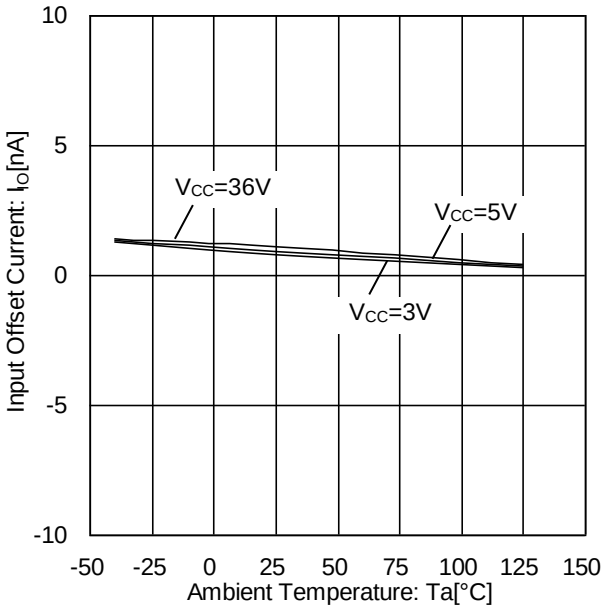


Figure 42. Input Offset Current vs Ambient Temperature
($V_{ICM}$=0V, $V_{OUT}$=1.4V)

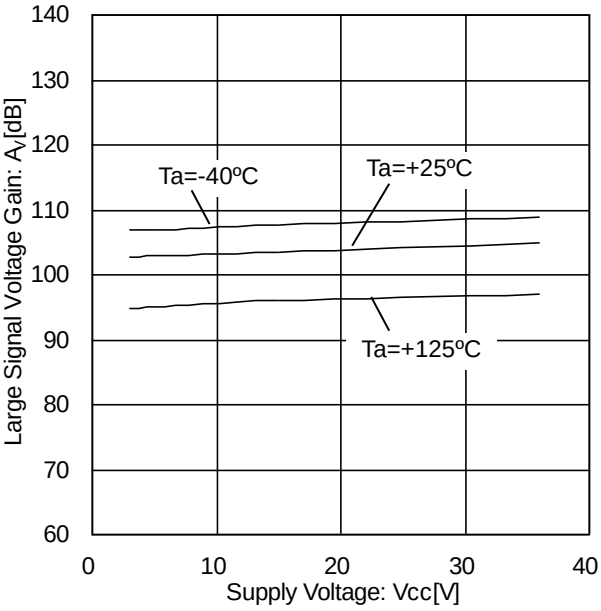


Figure 43. Large Signal Voltage Gain vs Supply Voltage
($R_L$=2kΩ)

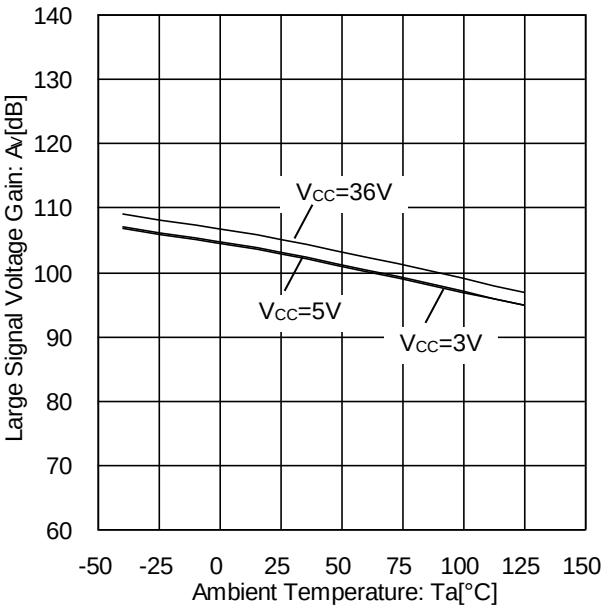


Figure 44. Large Signal Voltage Gain vs Ambient Temperature
($R_L$=2kΩ)

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


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**Typical Performance Curves - continued**

○BA82902Yxxx-C

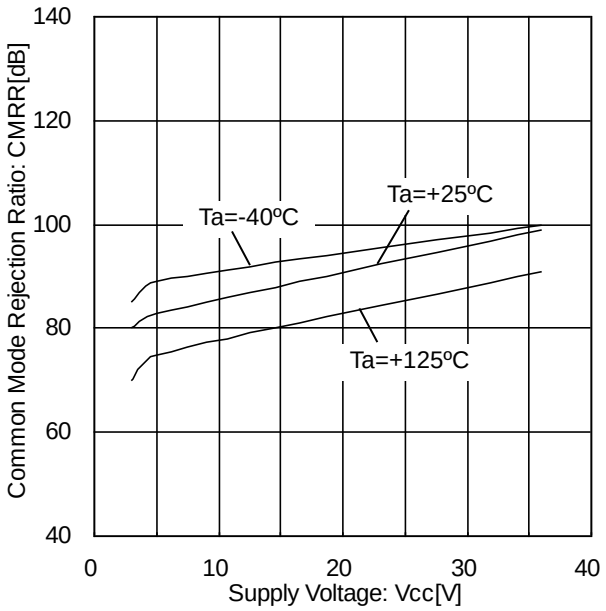


Figure 45. Common Mode Rejection Ratio vs Supply Voltage
($V_{OUT}$=1.4V)

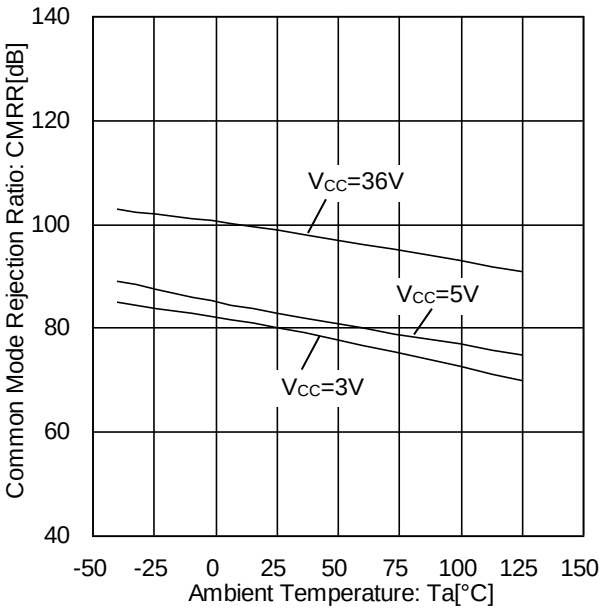


Figure 46. Common Mode Rejection Ratio vs Ambient Temperature
($V_{OUT}$=1.4V)

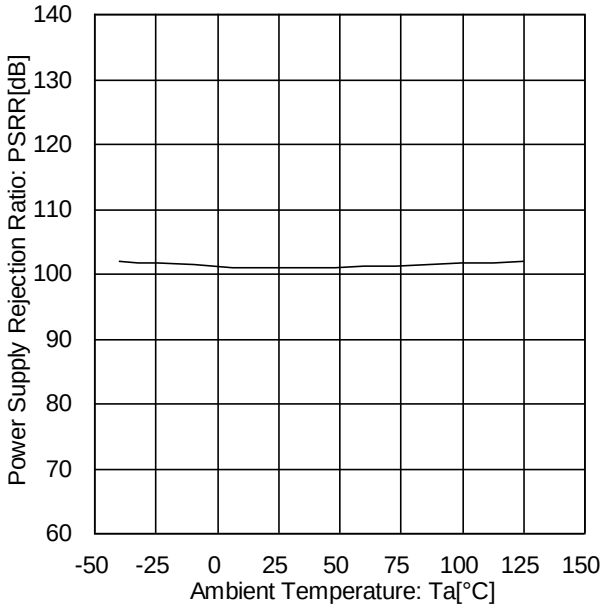


Figure 47. Power Supply Rejection Ratio vs Ambient Temperature

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


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## Application Information

### Test Circuit 1: Measurement Condition

$V_{CC}$, $V_{EE}$, $V_{EK}$, $V_{ICM}$ Unit: V

| Parameter | $V_F$ | SW1 | SW2 | SW3 | $V_{CC}$ | $V_{EE}$ | $V_{EK}$ | $V_{ICM}$ | Calculation |
|---|---|---|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{F1}$ | ON | ON | OFF | 5 to 30 | 0 | -1.4 | 0 | 1 |
| Input Offset Current | $V_{F2}$ | OFF | OFF | OFF | 5 | 0 | -1.4 | 0 | 2 |
| Input Bias Current | $V_{F3}$ | OFF | ON | OFF | 5 | 0 | -1.4 | 0 | 3 |
| | $V_{F4}$ | ON | OFF | | | | | | |
| Large Signal Voltage Gain | $V_{F5}$ | ON | ON | ON | 15 | 0 | -1.4 | 0 | 4 |
| | $V_{F6}$ | | | | 15 | 0 | -11.4 | 0 | |
| Common-mode Rejection Ratio (Input Common-mode Voltage Range) | $V_{F7}$ | ON | ON | OFF | 5 | 0 | -1.4 | 0 | 5 |
| | $V_{F8}$ | | | | 5 | 0 | -1.4 | 3.5 | |
| Power Supply Rejection Ratio | $V_{F9}$ | ON | ON | OFF | 5 | 0 | -1.4 | 0 | 6 |
| | $V_{F10}$ | | | | 30 | 0 | -1.4 | 0 | |

- Calculation -

1. Input Offset Voltage ($V_{IO}$)

$$V_{IO} = \frac{|V_{F1}|}{1 + R_F / R_S} \quad [V]$$

2. Input Offset Current ($I_{IO}$)

$$I_{IO} = \frac{|V_{F2} - V_{F1}|}{R_I \times (1 + R_F / R_S)} \quad [A]$$

3. Input Bias Current ($I_B$)

$$I_B = \frac{|V_{F4} - V_{F3}|}{2 \times R_I \times (1 + R_F / R_S)} \quad [A]$$

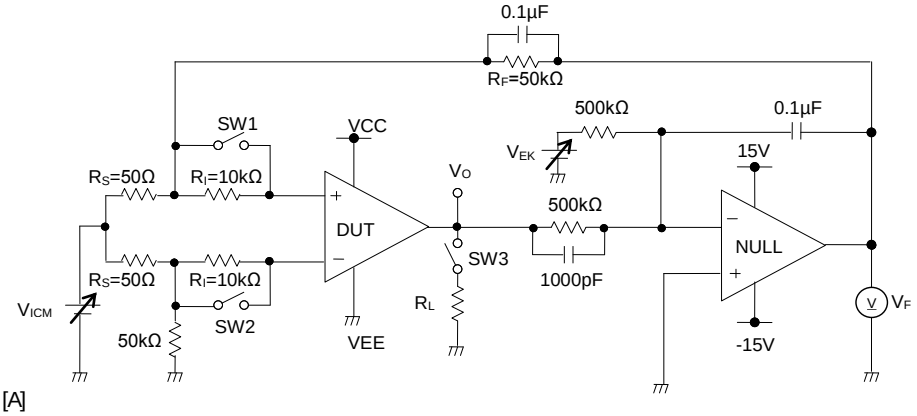


Figure 48. Test Circuit 1 (One Channel Only)

4. Large Signal Voltage Gain ($A_V$)

$$A_V = 20 \times Log \frac{\Delta V_{EK} \times (1 + R_F / R_S)}{|V_{F5} - V_{F6}|} \quad [dB]$$

5. Common-mode Rejection Ration (CMRR)

$$CMRR = 20 \times Log \frac{\Delta V_{ICM} \times (1 + R_F / R_S)}{|V_{F8} - V_{F7}|} \quad [dB]$$

6. Power Supply Rejection Ratio (PSRR)

$$PSRR = 20 \times Log \frac{\Delta V_{CC} \times (1 + R_F / R_S)}{|V_{F10} - V_{F9}|} \quad [dB]$$


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## Application Information - continued

**Test Circuit 2: Switch Condition**

| SW No. | SW 1 | SW 2 | SW 3 | SW 4 | SW 5 | SW 6 | SW 7 | SW 8 | SW 9 | SW 10 | SW 11 | SW 12 | SW 13 | SW 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Supply Current | OFF | OFF | OFF | ON | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Maximum Output Voltage (High) | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | OFF | ON | OFF |
| Maximum Output Voltage (Low) | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | ON | OFF |
| Output Source Current | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON |
| Output Sink Current | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON |
| Slew Rate | OFF | OFF | OFF | ON | OFF | OFF | OFF | ON | ON | ON | ON | OFF | OFF | OFF |
| Gain Bandwidth Product | OFF | ON | OFF | OFF | ON | ON | OFF | OFF | ON | ON | ON | OFF | OFF | OFF |
| Equivalent Input Noise Voltage | ON | OFF | OFF | OFF | ON | ON | OFF | OFF | OFF | OFF | ON | OFF | OFF | OFF |

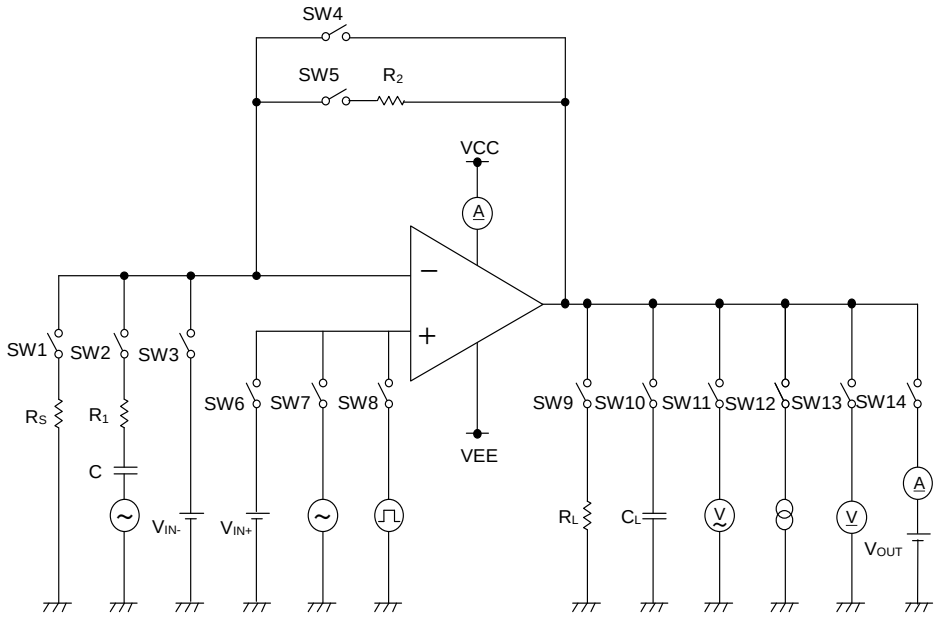


Figure 49. Test Circuit 2 (One Channel Only)

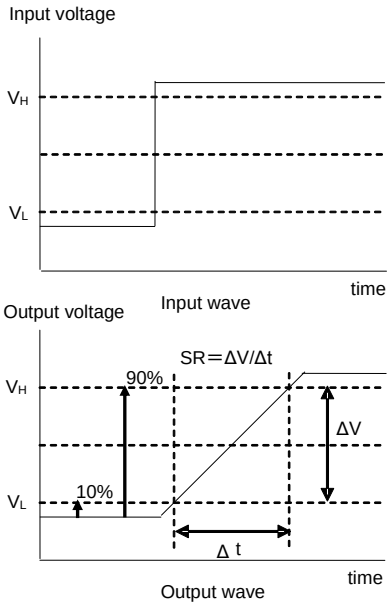


Figure 50. Slew Rate Waveform

**Test Circuit 3: Channel Separation Measurement Condition**

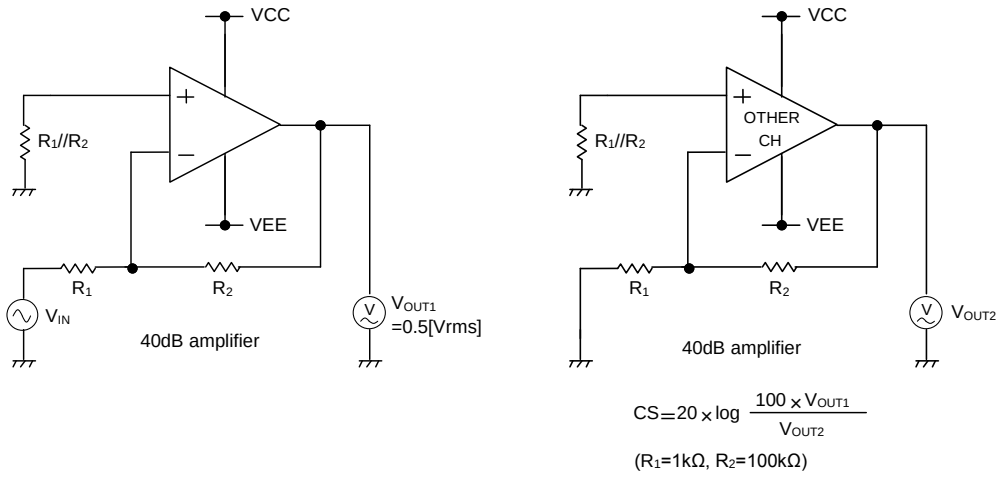


Figure 51. Test Circuit 3


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## Application Information - continued

### EMI Immunity

BA82904Yxxx-C and BA82902Yxxx-C have high tolerance for electromagnetic interference from the outside because they have EMI filter, and the EMI design is simple. The data of the IC simple substance on ROHM board are as follows. They are most suitable to replace from conventional products. The test condition is based on ISO11452-2.

<Test Condition> Based on ISO11452-2
Test Circuit: Voltage Follower
$V_{CC}$: 12V
$V_{IN+}$: 6V
Test Method: Substituted Law
(Progressive Wave)
Field Intensity: 200V/m
Test Wave: CW (Continuous Wave)
Frequency: 200MHz – 1000MHz (2% step)

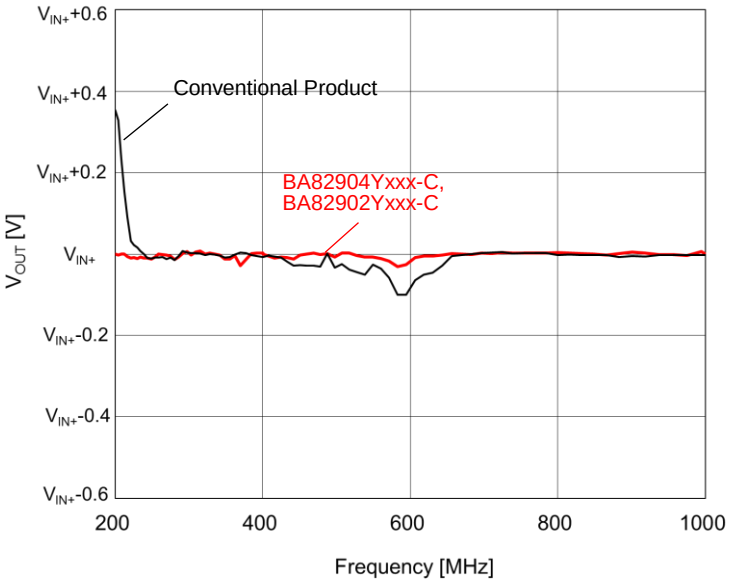


Figure 52. EMI Characteristics

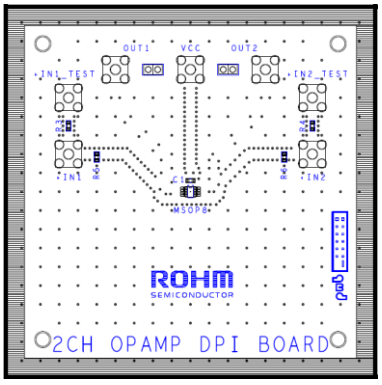


Figure 53. EMI Evaluation Board (BA82904Yxxx-C)

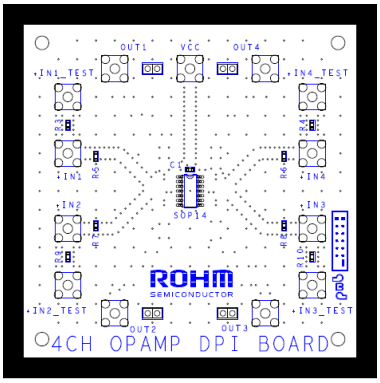


Figure 54. EMI Evaluation Board (BA82902Yxxx-C)

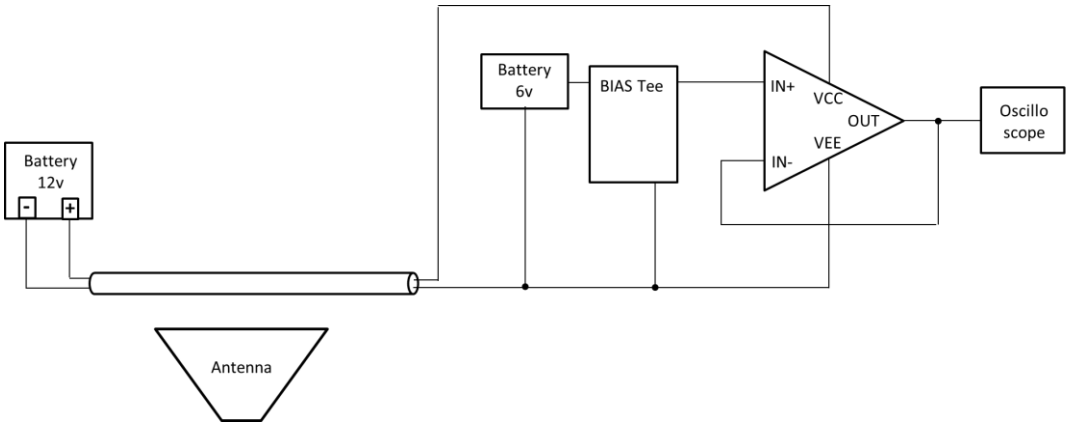


Figure 55. Measurement Circuit of EMI Evaluation

(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 Figure 56, and set the non-inverting input pin to electric potential within the input common-mode voltage range ($V_{ICM}$).

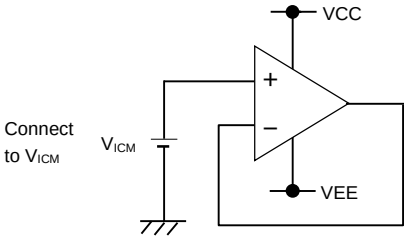


Figure 56. Example of Application Circuit for Unused Op-amp

2. Input Voltage
   Applying $V_{EE}$+36V 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 normal 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 supplied is between the VCC and VEE pin. Therefore, the single supply Op-Amp can be used as dual supply Op-Amp as well.

4. IC Operation
   The output stage of the IC is configured using Class C push-pull circuits. Therefore, when the load resistor is connected to the middle potential of $V_{CC}$ and $V_{EE}$, crossover distortion occurs at the changeover between discharging and charging of the output current. Connecting a resistor between the output pin and the VEE pin, and increasing the bias current for Class A operation will suppress crossover distortion.

5. 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 will 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, set the value of the capacitor connected to the output pin to 0.1uF or less to prevent IC damage caused by the accumulation of electric charge as mentioned above.

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

7. IC handling
   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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## 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. **Operation Under Strong Electromagnetic Field**
   Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

8. **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.

9. **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.

10. **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

**11. 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.

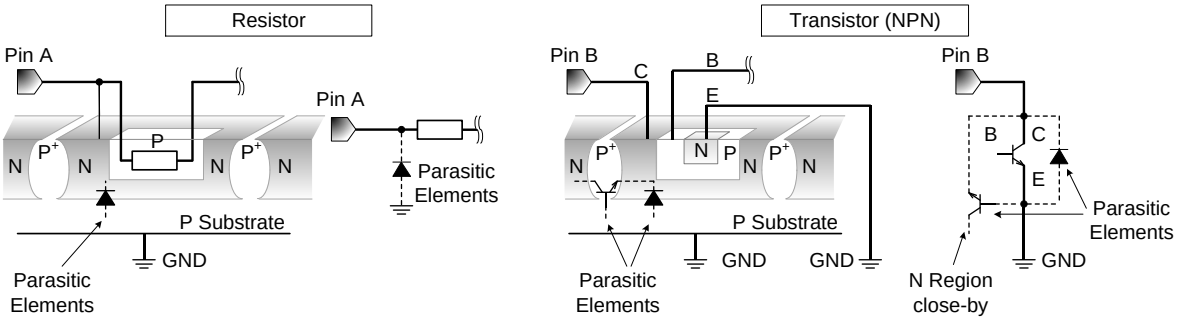


Figure 57. Example of monolithic IC structure

**12. 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.

**13. Area of Safe Operation (ASO)**

Operate the IC such that the output voltage, output current, and the maximum junction temperature rating are all within the Area of Safe Operation (ASO).


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**Ordering Information**

B A 8 2 9 0 x Y x x x - C x x

Part Number
BA82904Yxxx
BA82902Yxxx

Package
F : SOP8
SOP14
FV : SSOP-B14
FVM: MSOP8
FJ : SOP-J14
FVJ : TSSOP-B14J

Packaging and forming specification
C: Automotive (Engine control unit, EPS, ABS, and so on)
E2: Embossed tape and reel
(SOP8/SOP14/SSOP-B8/SSOP-B14 /SOP-J14/TSSOP-B14J)
TR: Embossed tape and reel
(MSOP8)

**Lineup**

| Operating Temperature Range | Operating Supply Voltage | Number of Channels | Package | | Orderable Part Number |
|---|---|---|---|---|---|
| -40°C to +125°C | 3V to 36V | Dual | SOP8 | Reel of 2500 | BA82904YF-CE2 |
| | | | MSOP8 | Reel of 3000 | BA82904YFVM-CTR |
| | | Quad | SOP14 | Reel of 2500 | BA82902YF-CE2 |
| | | | SSOP-B14 | Reel of 2500 | BA82902YFV-CE2 |
| | | | SOP-J14 | Reel of 2500 | BA82902YFJ-CE2 |
| | | | TSSOP-B14J | Reel of 2500 | BA82902YFVJ-CE2 |


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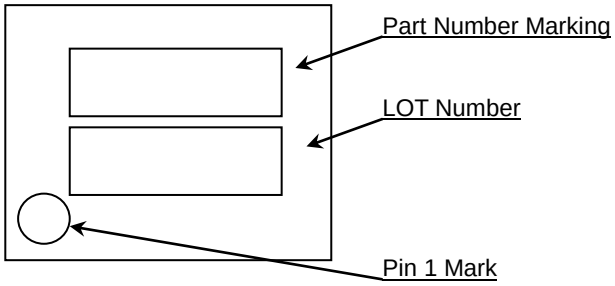
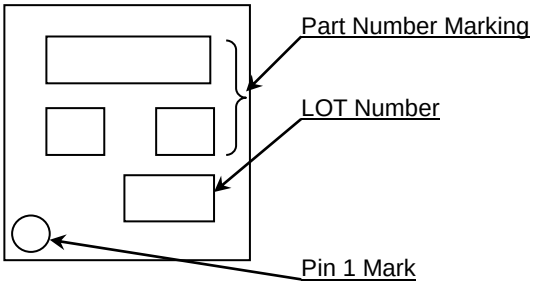
**Marking Diagrams**

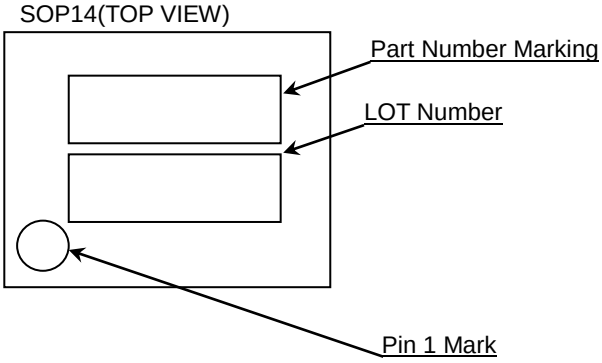
SOP8(TOP VIEW)



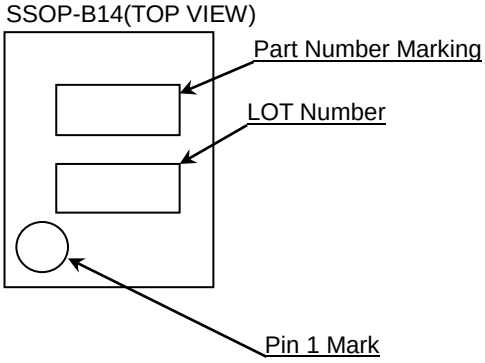

MSOP8(TOP VIEW)



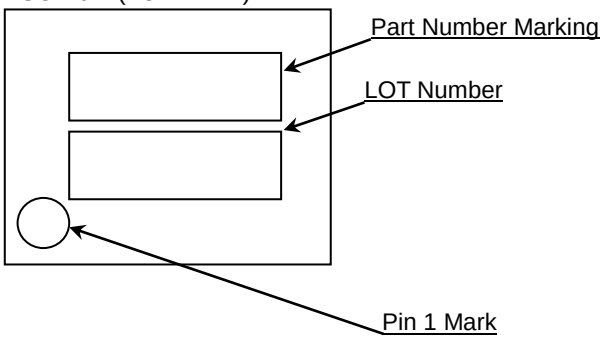

SOP14(TOP VIEW)



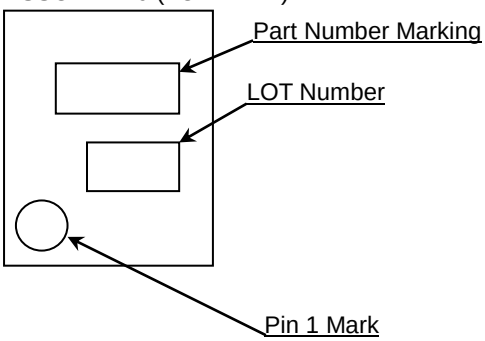

SSOP-B14(TOP VIEW)




SOP-J14(TOP VIEW)




TSSOP-B14J (TOP VIEW)




| Product Name | | Package Type | Marking |
|---|---|---|---|
| BA82904Y | F-C | SOP8 | 82904 |
| | FVM-C | MSOP8 | 82904 |
| BA82902Y | F-C | SOP14 | BA82902YF |
| | FV-C | SSOP-B14 | 802Y |
| | FJ-C | SOP-J14 | 82902YFJ |
| | FVJ-C | TSSOP-B14J | 802YJ |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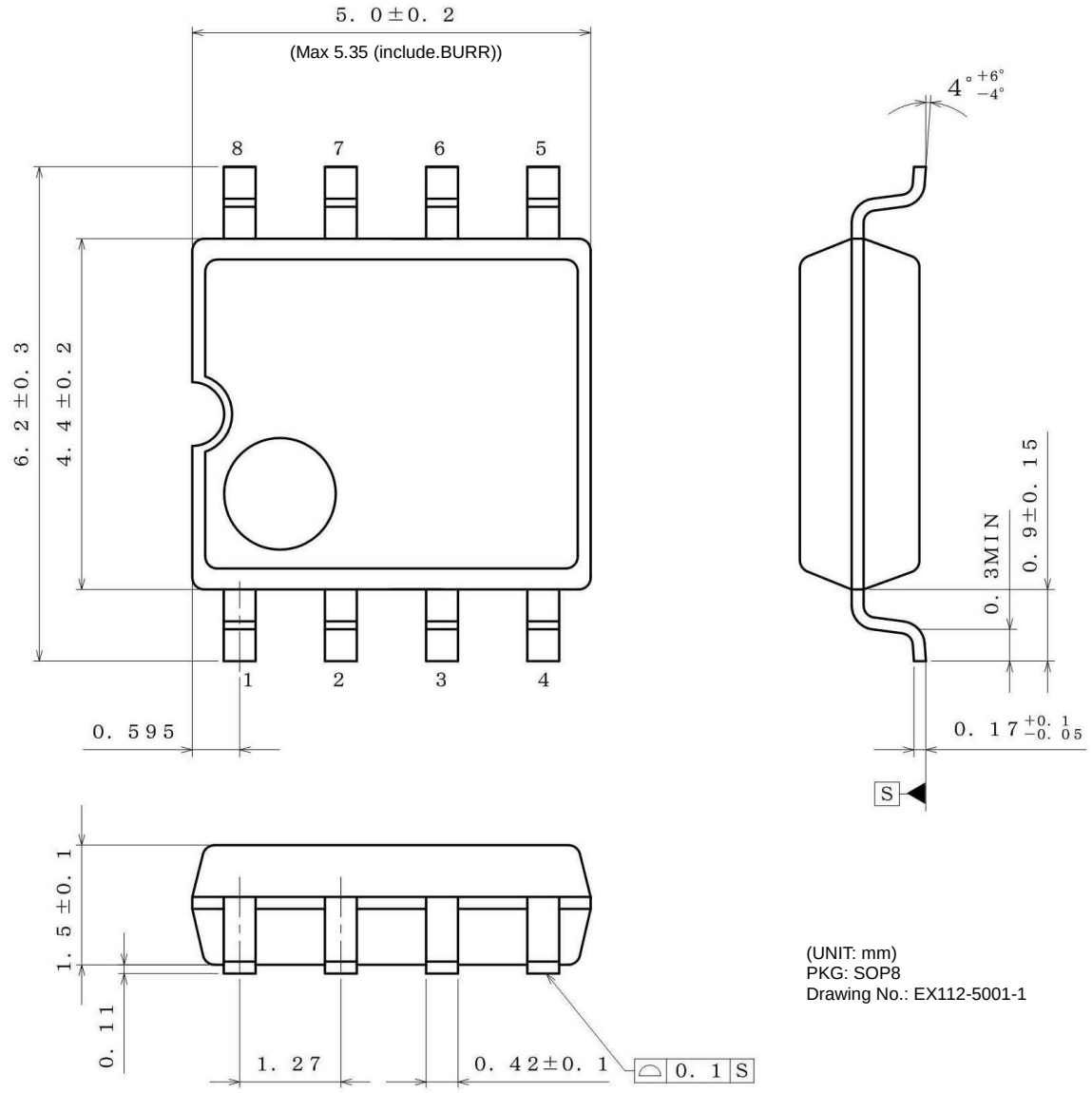
**Physical Dimension and Packing Information**

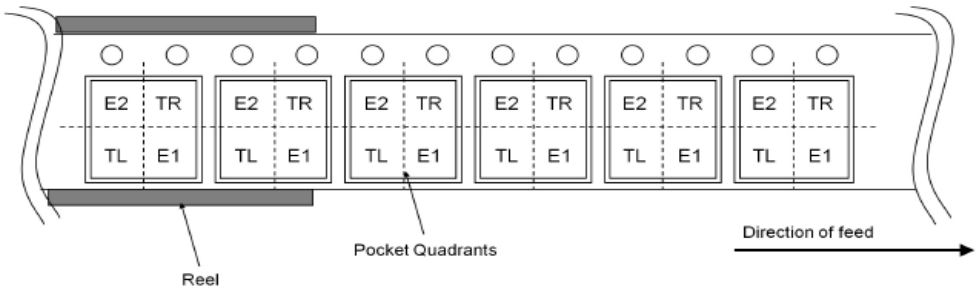
| Package Name | SOP8 |
|---|---|




(UNIT: mm)
PKG: SOP8
Drawing No.: EX112-5001-1

**<Tape and Reel information>**

| | |
|---|---|
| **Tape** | **Embossed carrier tape** |
| **Quantity** | **2500pcs** |
| **Direction of feed** | **E2**<br>**( The direction is the 1pin 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 )** |





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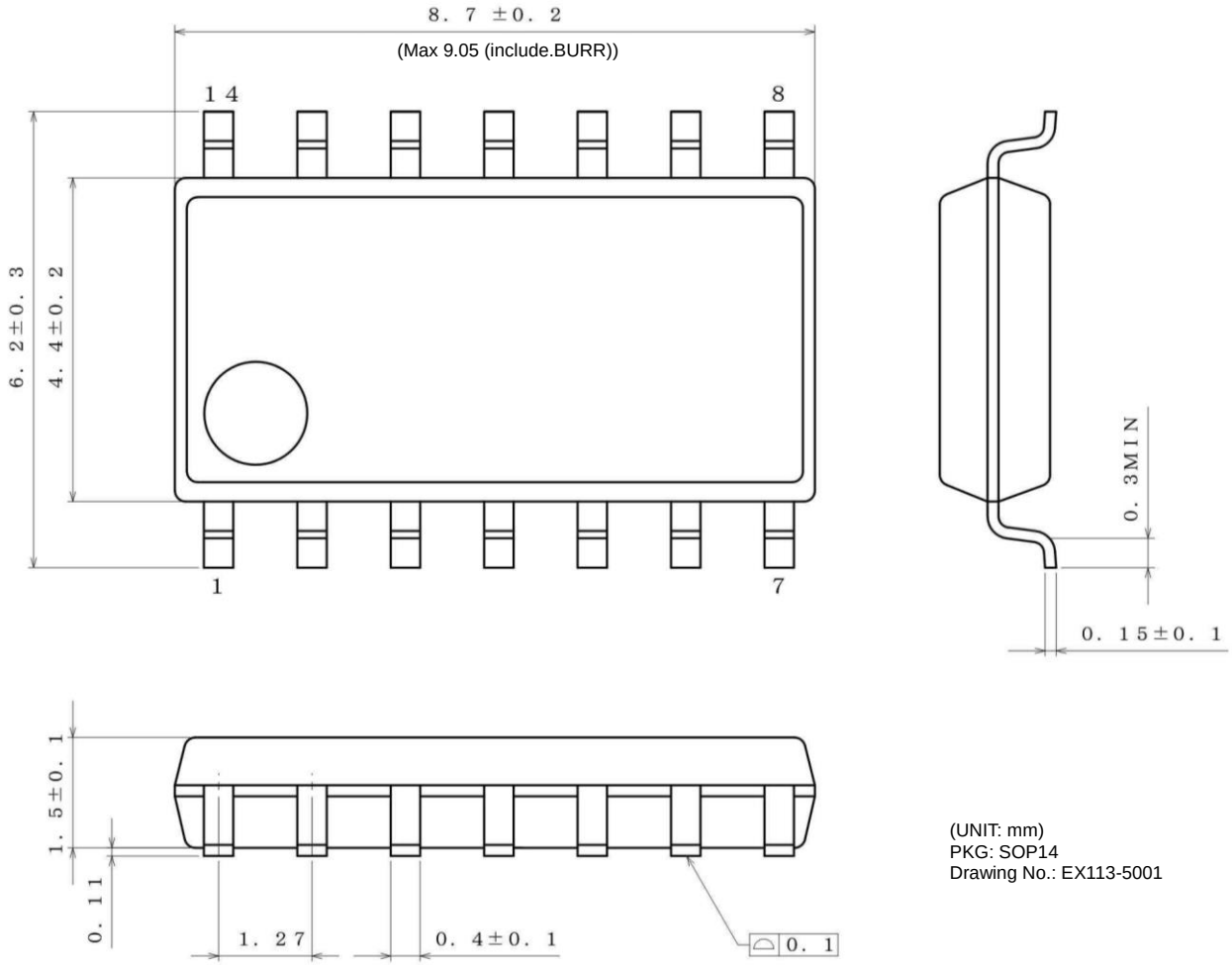
**Physical Dimension and Packing Information - continued**

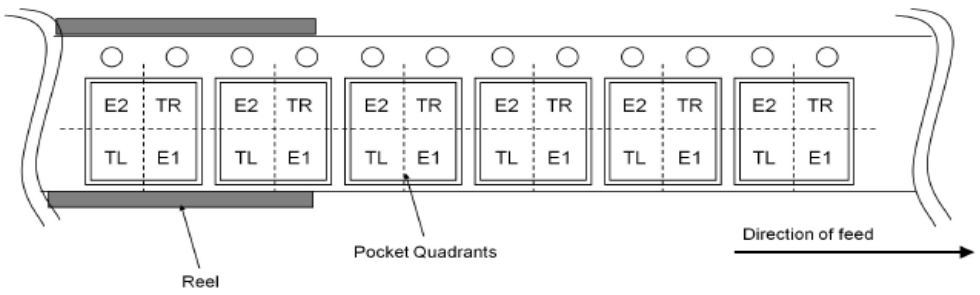
| Package Name | SOP14 |
|---|---|




(UNIT: mm)
PKG: SOP14
Drawing No.: EX113-5001

**<Tape and Reel information>**

| | |
|---|---|
| **Tape** | **Embossed carrier tape** |
| **Quantity** | **2500pcs** |
| **Direction of feed** | **E2**<br>**( The direction is the 1pin 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 )** |





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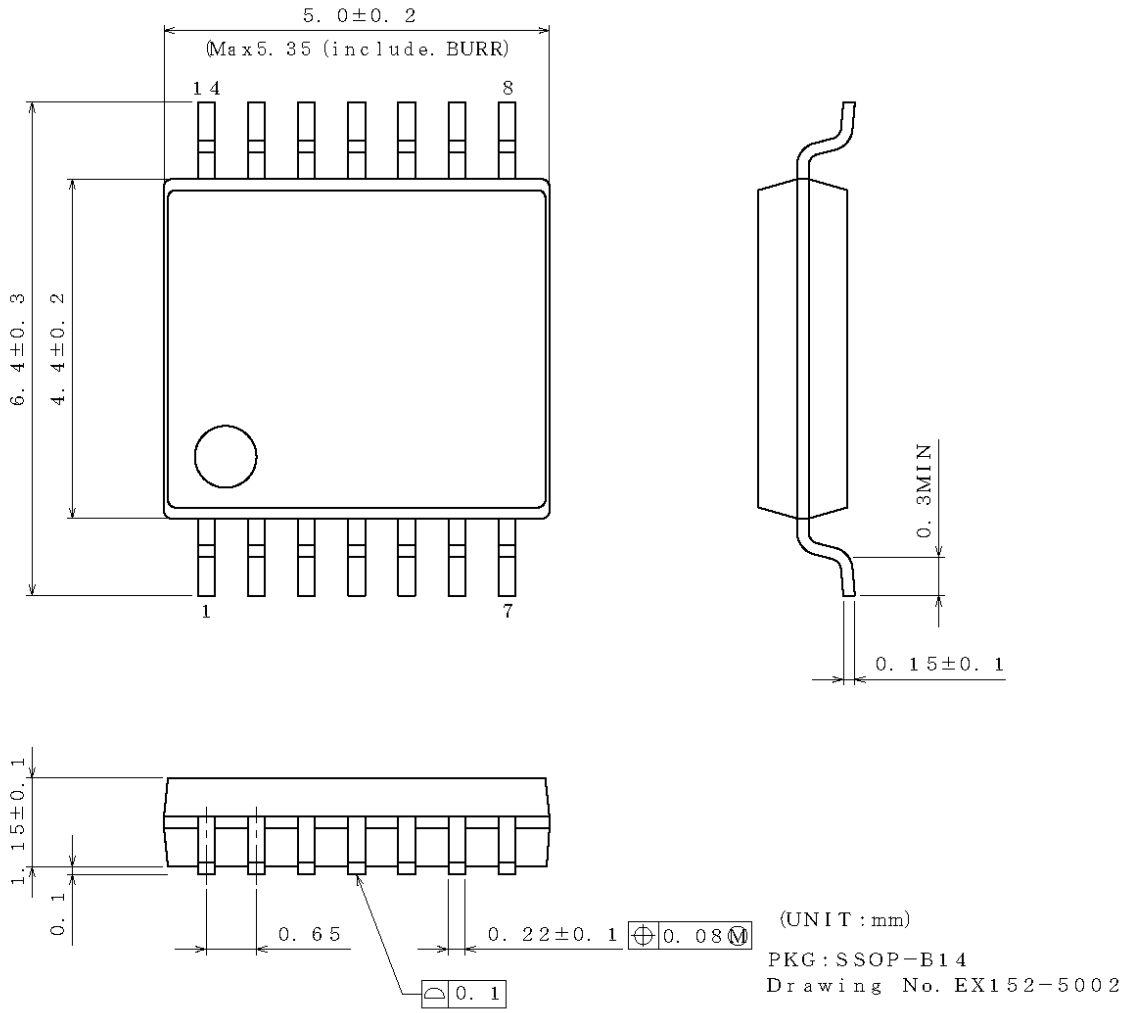
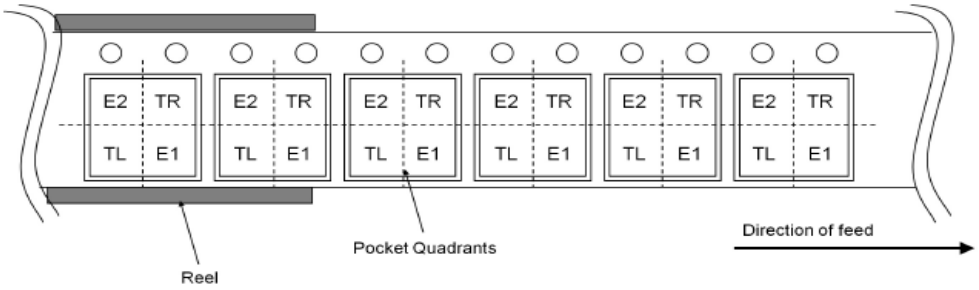
**Physical Dimension and Packing Information - continued**

| Package Name | SSOP-B14 |
|---|---|




**<Tape and Reel information>**

| | |
|---|---|
| **Tape** | **Embossed carrier tape** |
| **Quantity** | **2500pcs** |
| **Direction of feed** | **E2**<br>**( The direction is the 1pin 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 )** |





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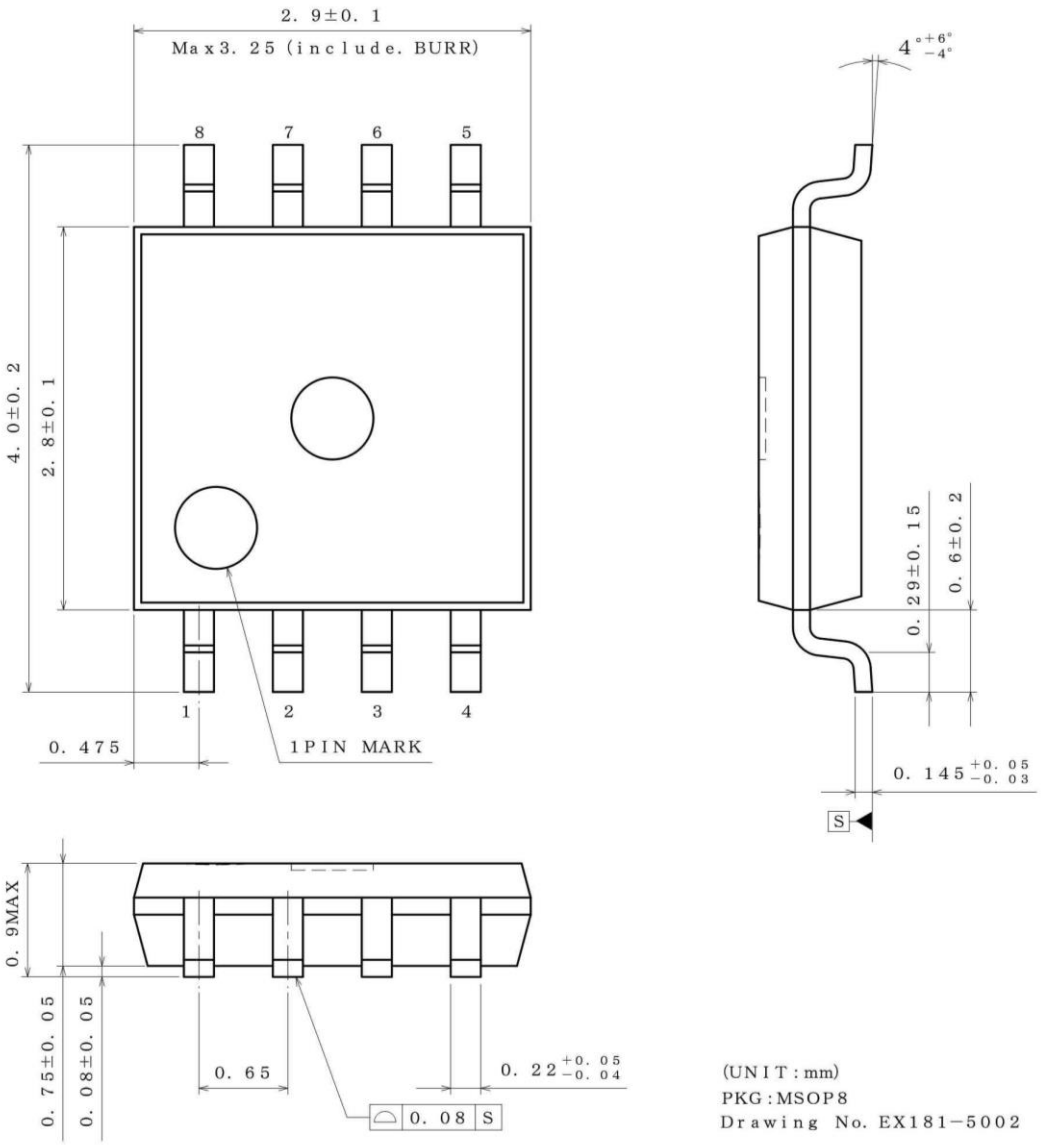
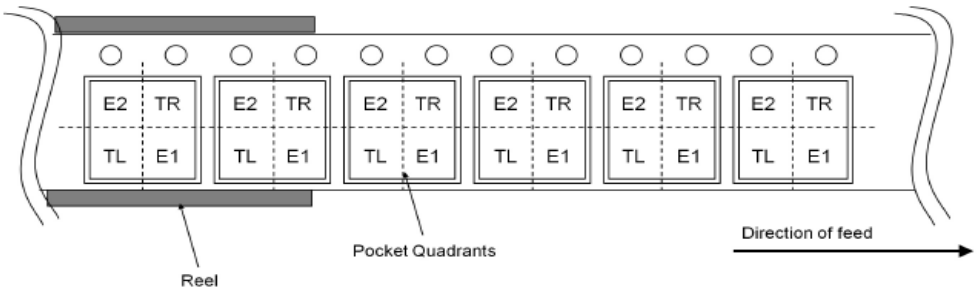
**Physical Dimension and Packing Information - continued**

| Package Name | MSOP8 |
|---|---|




<Tape and Reel information>

| Tape | Embossed carrier tape |
|---|---|
| Quantity | 3000pcs |
| Direction of feed | TR<br>( 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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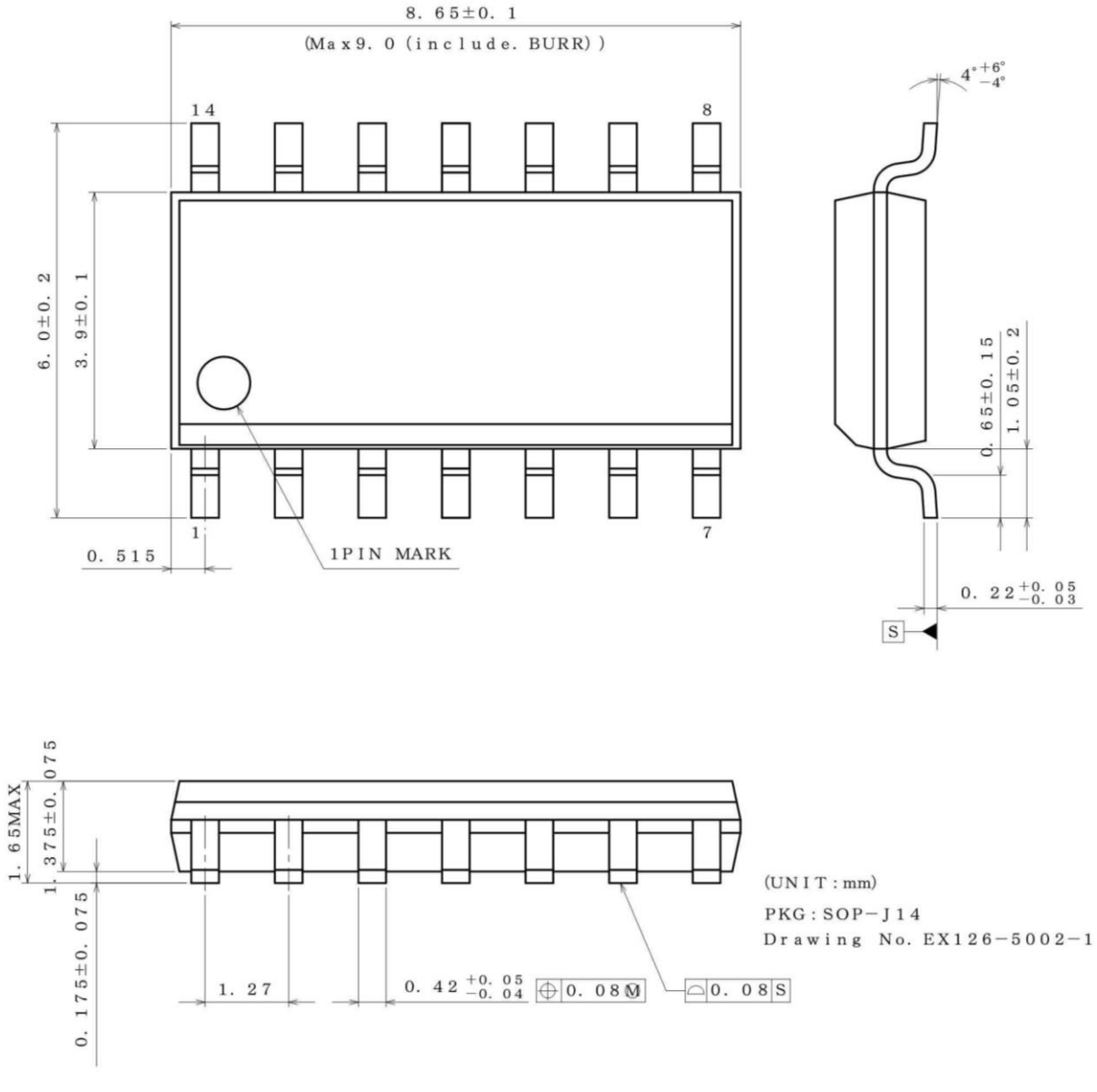
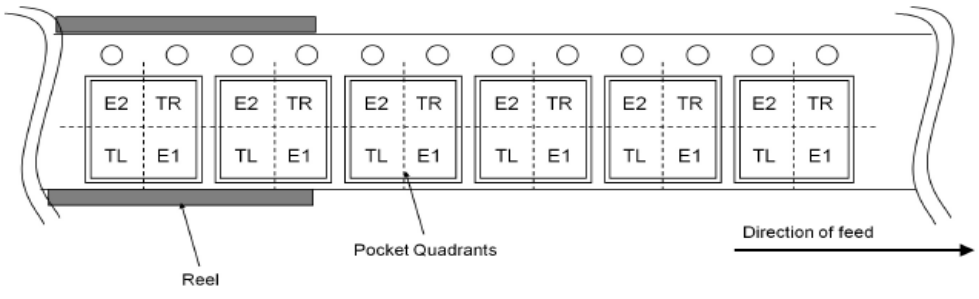
**Physical Dimensions and Packing Information – continued**

| Package Name | SOP-J14 |
|---|---|




<Tape and Reel information>

| Tape | Embossed carrier tape |
|---|---|
| Quantity | 2500pcs |
| Direction of feed | E2<br>( The direction is the 1pin 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 ) |





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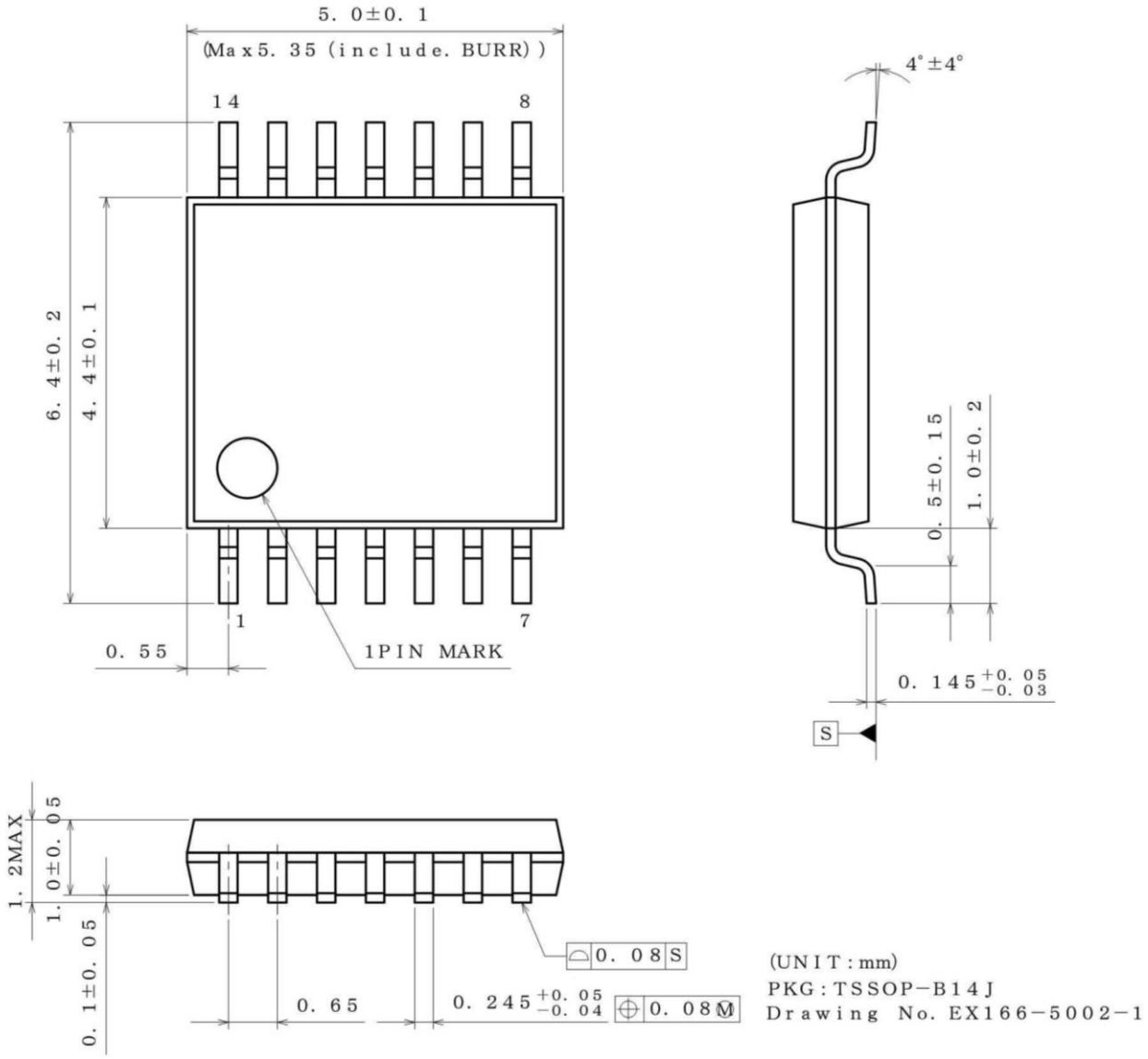
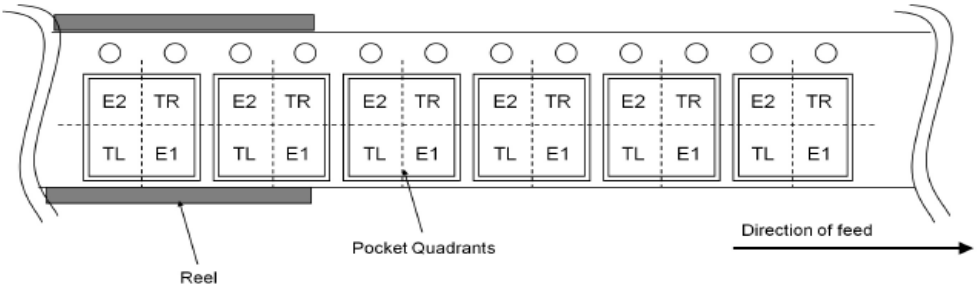
**Physical Dimensions and Packing Information – continued**

| Package Name | TSSOP-B14J |
|---|---|




**<Tape and Reel information>**

| | |
|---|---|
| Tape | Embossed carrier tape |
| Quantity | 2500pcs |
| Direction of feed | E2<br>( The direction is the 1pin 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 ) |





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**Revision History**

| Date | Revision | Changes |
|---|---|---|
| 10.May.2017 | 001 | New Release |
| 01.Jun.2017 | 002 | Correction of erroneous description : P.3 Delete *(Note 2)* |
| 14.Jun.2017 | 003 | P.3 Update Orderable Parts Number |
| 29.Jun.2017 | 004 | P.1 Update General description<br>P.23 Added application hint |
| 27.Jul.2017 | 005 | Update Physical Dimension and Packing Information |
| 31.Aug.2017 | 006 | P.5, 6 Change Limits |
| 20.Feb.2018 | 007 | Update Lineup (BA82902YFJ-C, BA82902YFVJ-C) |


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# Notice

## Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), aircraft/spacecraft, nuclear power controllers, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, 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 any ROHM's Products for Specific Applications.

(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:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are not designed under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [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 (even if you use no-clean type fluxes, cleaning residue of flux is recommended); 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 Cl2, H2S, NH3, SO2, and NO2
   - [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.

### Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

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