Operational Amplifiers

# Input/Output Full Swing Low Input Offset Voltage Operational Amplifier

## BD5291G

### General Description

The BD5291G is ideally suited for sensor signal conditioning. This feature input/output full-swing operation with a supply voltage as low as 1.7V. In addition, high common-mode rejection ratio, ultra low input bias current (1pA typical) and low input offset voltage increase the precision that can be achieved using these operational amplifiers.

### Features

- Low Operating Supply Voltage
- Input Output Fullswing
- Low Input Offset Voltage
- High Common Mode Rejection Ratio
- High Slew Rate

### Applications

- Buffer
- Active Filter
- Sensor Amplifier
- Mobile Equipment

### Key Specifications

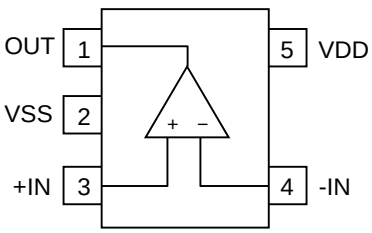
- Low Operating Supply Voltage (Single Supply): +1.7V to +5.5V
- Slew Rate: 2.5V/µs
- Temperature Range: -40°C to +85°C
- Input Voltage Range: VSS to VDD
- Input Offset Voltage: ±2.5mV (Max)
- Common Mode Rejection Ratio: 70dB (Min)

### Package

| | W(Typ) x D(Typ) x H(Max) |
|---|---|
| SSOP5 | 2.90mm x 2.80mm x 1.25mm |

### Pin Configuration

BD5291G : SSOP5




| Pin No. | Pin Name |
|---|---|
| 1 | OUT |
| 2 | VSS |
| 3 | +IN |
| 4 | -IN |
| 5 | VDD |

Figure 1. Pin Configuration

| Package |
|---|
| SSOP5 |
| BD5291G |

○Product structure : Silicon monolithic integrated circuit ○This product is not designed protection against radioactive rays.

## Ordering Information

B D 5 2 9 1 G - T L

| Part Number | Package | Packaging and forming specification |
|---|---|---|
| BD5291 | G:SSOP5 | TL: Embossed tape and reel (SSOP5) |

## Line-up

| Topr | Package | | Operable Part Number |
|---|---|---|---|
| -40°C to +85°C | SSOP5 | Reel of 3000 | BD5291G-TL |

## Absolute Maximum Ratings($T_A$=25°C)

| Parameter | Symbol | | Ratings | Unit |
|---|---|---|---|---|
| Supply voltage | VDD-VSS | | +7 | V |
| Power dissipation | $P_D$ | SSOP5 | 0.67(Note 1,2) | W |
| Differential input voltage(Note 3) | $V_{ID}$ | | VDD - VSS | V |
| Input common-mode voltage range | $V_{ICM}$ | | (VSS – 0.3) to (VDD + 0.3 ) | V |
| Input current(Note 4) | $I_I$ | | ±10 | mA |
| Operating supply voltage | $V_{opr}$ | | +1.7 to +5.5 | V |
| Operating temperature | $T_{opr}$ | | - 40 to +85 | °C |
| Storage temperature | $T_{stg}$ | | - 55 to +150 | °C |
| Maximum junction temperature | $T_{Jmax}$ | | +150 | °C |

(Note 1) To use at temperature above $T_A$=25°C reduce 5.4mW/°C.
(Note 2) Mounted on a FR4 glass epoxy PCB 70mm×70mm×1.6mm (Copper foil area less than 3%).
(Note 3) The voltage difference between inverting input and non-inverting input is the differential input voltage.
Then input pin voltage is set to more than VSS.
(Note 4) An excessive input current will flow when input voltages of more than VDD+0.6V or less than VSS-0.6V are applied.
The input current can be set to less than the rated current by adding a limiting resistor.
Caution: 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.

## Electrical Characteristics

○BD5291G (Unless otherwise specified VDD=+3.3V, VSS=0V, $T_A$=25°C)

| Parameter | Symbol | Temperature Range | Limits | | | Unit | Condition |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Input offset voltage(Note 5,6) | $V_{IO}$ | 25°C | - | 0.1 | 2.5 | mV | VDD=+1.8V ,+3.3V |
| | | Full range | - | - | 3.8 | | |
| Input offset voltage drift(Note 5) | $\Delta V_{IO}/\Delta T$ | Full range | - | 0.8 | - | μV/°C | - |
| Input offset current(Note 5,6) | $I_{IO}$ | 25°C | - | 1 | 220 | pA | - |
| | | Full range | - | - | 1700 | | |
| Input bias current(Note 5,6) | $I_B$ | 25°C | - | 1 | 220 | pA | - |
| | | Full range | - | - | 1700 | | |
| Supply current(Note 5,6) | $I_{DD}$ | 25°C | - | 650 | 900 | μA | RL=∞, Av=0dB, +IN=VDD/2 |
| | | Full range | - | - | 970 | | |
| Maximum output voltage(High) (Note 6) | $V_{OH}$ | 25°C | VDD-0.1 | - | - | V | RL=10kΩ |
| | | Full range | VDD-0.1 | - | - | | |
| Maximum output voltage(Low) (Note 6) | $V_{OL}$ | 25°C | - | - | VSS+0.1 | V | RL=10kΩ |
| | | Full range | - | - | VSS+0.1 | | |
| Large signal voltage gain(Note 6) | $A_V$ | 25°C | 80 | 105 | - | dB | VDD=+1.8V |
| | | Full range | 80 | - | - | | |
| | | 25°C | 80 | 110 | - | | VDD=+3.3V |
| | | Full range | 80 | - | - | | |
| Input common mode voltage | $V_{ICM}$ | 25°C | 0 | - | 1.8 | V | VDD=+1.8V, VSS to VDD |
| | | | 0 | - | 3.3 | | VDD=+3.3V, VSS to VDD |
| Common mode rejection ratio(Note 6) | CMRR | 25°C | 70 | 90 | - | dB | - |
| | | Full range | 68 | - | - | | |
| Power supply rejection ratio(Note 6) | PSRR | 25°C | 70 | 90 | - | dB | - |
| | | Full range | 68 | - | - | | |
| Output source current(Note 7) | $I_{source}$ | 25°C | 4 | 6 | - | mA | OUT=VDD-0.4V |
| | | | - | 17 | - | | output current |
| Output sink current (Note 7) | $I_{sink}$ | 25°C | 9 | 15 | - | mA | OUT=VSS+0.4V |
| | | | - | 35 | - | | output current |
| Slew rate | SR | 25°C | - | 2.5 | - | V/μs | CL=25pF |
| Gain bandwidth | GBW | 25°C | - | 3.0 | - | MHz | VDD=+1.8V, f=100kHz, Open loop |
| | | | - | 3.2 | - | MHz | VDD=+3.3V, f=100kHz, Open loop |
| Phase margin | θ | 25°C | - | 40 | - | deg | Open loop |
| Input referred noise voltage | Vn | 25°C | - | 18 | - | nV/√Hz | Av=40dB, f=1kHz |
| Total harmonics distortion | THD+N | 25°C | - | 0.005 | - | % | OUT=0.4$V_{P-P}$, f=1kHz |

(Note 5) Absolute value
(Note 6) Full range: $T_A$=-40°C to +85°C
(Note 7) Under the high temperature environment, consider the power dissipation of IC when selecting the output current.
When the terminal short circuits are continuously output, the output current is reduced to climb to the temperature inside IC.

## Description of electrical characteristics

Described here are the terms of electric characteristics 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 manufacture's document or general document.

1. Absolute maximum ratings

Absolute maximum rating item indicates the condition which must not be exceeded. Application of voltage in excess of absolute maximum rating or use out of absolute maximum rated temperature environment may cause deterioration of characteristics.

(1) Power supply voltage (VDD/VSS)
Indicates the maximum voltage that can be applied between the positive power supply terminal and negative power supply terminal without deterioration or destruction of characteristics of internal circuit.

(2) Differential input voltage ($V_{ID}$)
Indicates the maximum voltage that can be applied between non-inverting terminal and inverting terminal without deterioration and destruction of characteristics of IC.

(3) Input common-mode voltage range ($V_{ICM}$)
Indicates the maximum voltage that can be applied to non-inverting terminal and inverting terminal without deterioration or destruction of characteristics. Input common-mode voltage range of the maximum ratings not assures normal operation of IC. When normal Operation of IC is desired, the input common-mode voltage of characteristics item must be followed.

(4) Power dissipation ($P_D$)
Indicates the power that can be consumed by specified mounted board at the ambient temperature 25°C(normal temperature). As for package product, Pd is determined by the temperature that can be permitted by IC chip in the package (maximum junction temperature) and thermal resistance of the package.

2.Electrical characteristics item

(1) Input offset voltage ($V_{IO}$)
Indicates the voltage difference between non-inverting terminal and inverting terminal. It can be translated into the input voltage difference required for setting the output voltage at 0 V.

(2) Input offset voltage drift ($\triangle V_{IO}/\triangle T$)
Denotes the ratio of the input offset voltage fluctuation to the ambient temperature fluctuation.

(3) Input offset current ($I_{IO}$)
Indicates the difference of input bias current between non-inverting terminal and inverting terminal.

(4) Input bias current ($I_B$)
Indicates the current that flows into or out of the input terminal. It is defined by the average of input bias current at non-inverting terminal and input bias current at inverting terminal.

(5) Supply current (IDD)
Indicates the IC current that flows under specified conditions and no-load steady status.

(6) Maximum Output Voltage(High) / Maximum Output Voltage(Low) ($V_{OH}/V_{OL}$)
Indicates the voltage range that can be output by the IC under specified load condition. It is typically divided into maximum output voltage High and low. Maximum output voltage high indicates the upper limit of output voltage. Maximum output voltage low indicates the lower limit.

(7) Large signal voltage gain (Av)
Indicates the amplifying rate (gain) of output voltage against the voltage difference between non-inverting terminal and inverting terminal. It is normally the amplifying rate (gain) with reference to DC voltage.
Av = (Output voltage) / (Differential Input voltage)

(8) Input common-mode voltage range ($V_{ICM}$)
Indicates the input voltage range where IC operates normally.

(9) Common-mode rejection ratio (CMRR)
Indicates the ratio of fluctuation of input offset voltage when in-phase input voltage is changed. It is normally the fluctuation of DC.
CMRR = (Change of Input common-mode voltage)/(Input offset fluctuation)

(10) 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 fluctuation)

(11) Output source current/ output sink current ($I_{source}$ / $I_{sink}$)
The maximum current that can be output under specific output conditions, it is divided into output source current and output sink current. The output source current indicates the current flowing out of the IC, and the output sink current the current flowing into the IC.

(12) Slew Rate (SR)
SR is a parameter that shows movement speed of operational amplifier. It indicates rate of variable output voltage as unit time.

(13) Gain Bandwidth (GBW)
Indicates to multiply by the frequency and the gain where the voltage gain decreases 6dB/octave.

(14) Phase Margin (θ)
Indicates the margin of phase from 180 degree phase lag at unity gain frequency.
(15) Input referred noise voltage (Vn)
Indicates a noise voltage generated inside the operational amplifier equivalent by ideal voltage source connected in series with input terminal.
(16) Total harmonic distortion + Noise (THD+N)
Indicates the fluctuation of input offset voltage or that of output voltage with reference to the change of output voltage of driven channel.

## Typical Performance Curves

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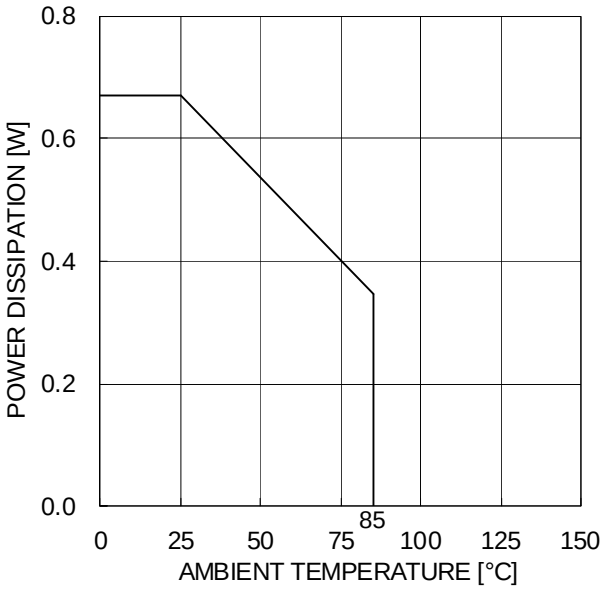


Figure 2.
Derating curve

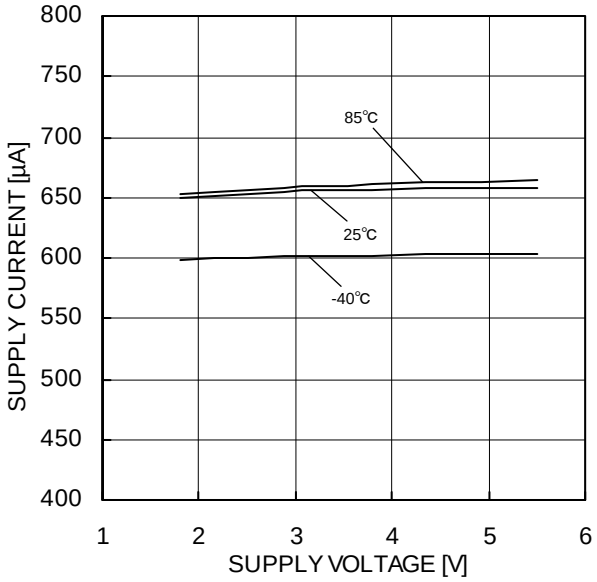


Figure 3.
Supply Current – Supply Voltage

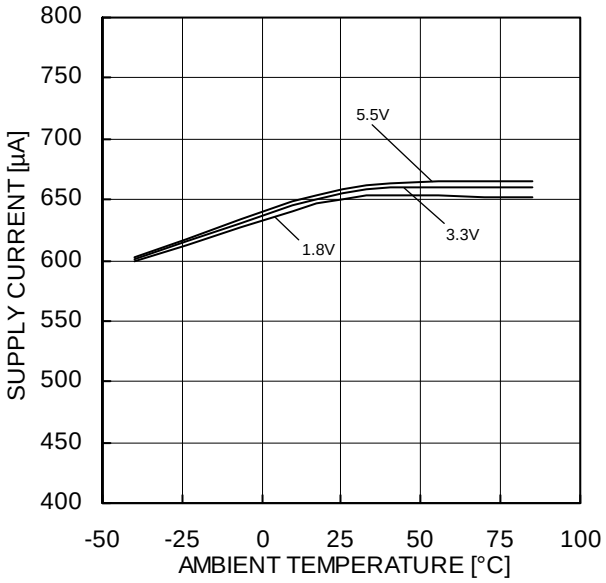


Figure 4.
Supply Current – Ambient Temperature

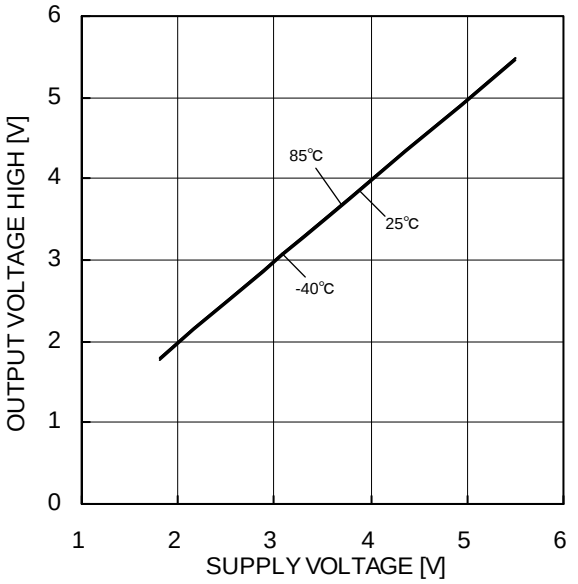


Figure 5.
Maximum Output Voltage (High) – Supply Voltage
(RL=10kΩ)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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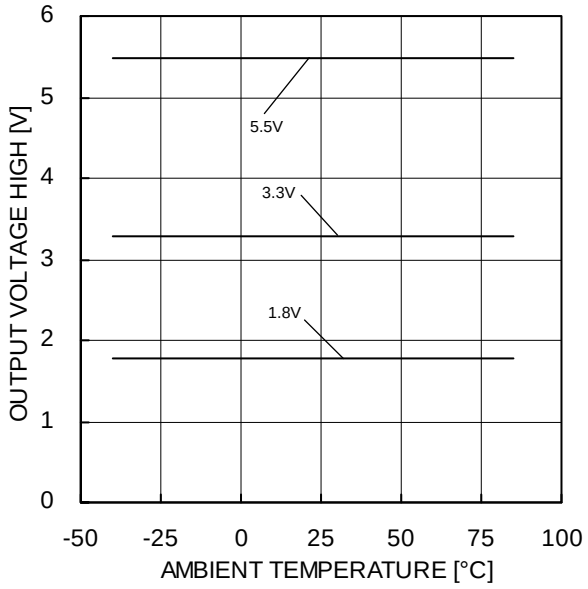


Figure 6.
Maximum Output Voltage (High) – Ambient Temperature
(RL=10kΩ)

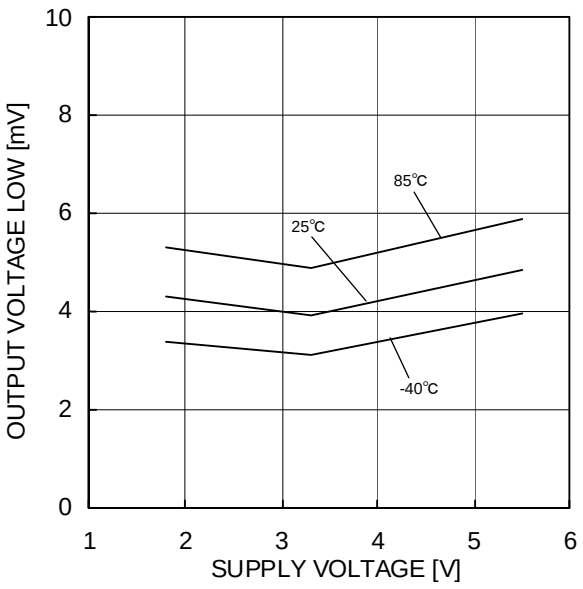


Figure 7.
Maximum Output Voltage (Low) – Supply Voltage
(RL=10kΩ)

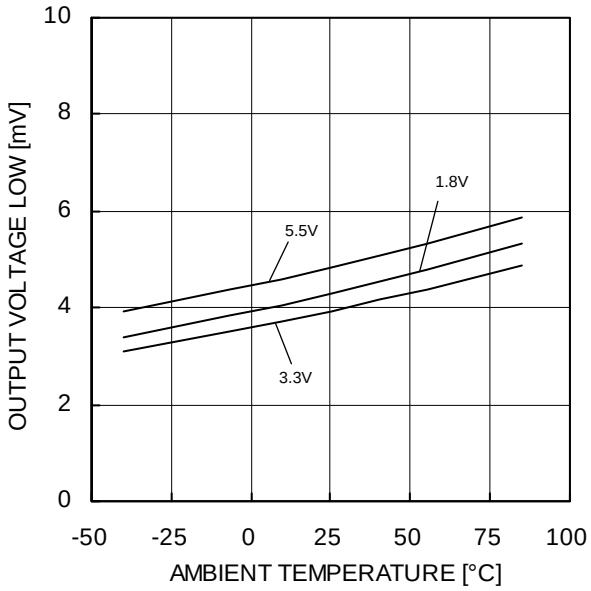


Figure 8.
Maximum Output Voltage (Low) – Ambient Temperature
(RL=10kΩ)

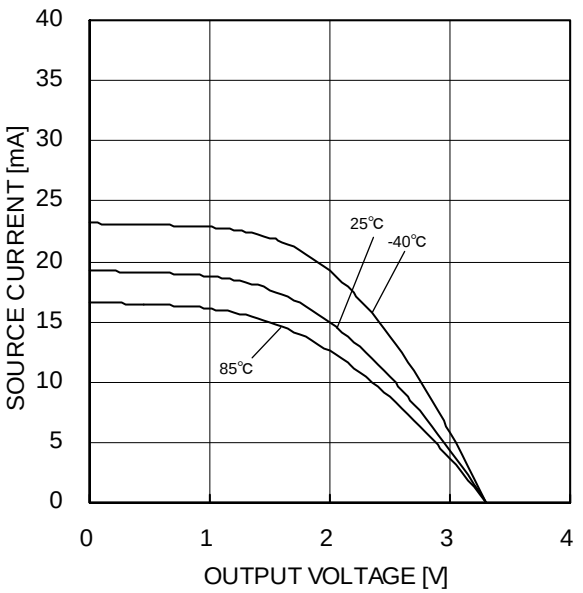


Figure 9.
Output Source Current – Output Voltage
(VDD=3.3V)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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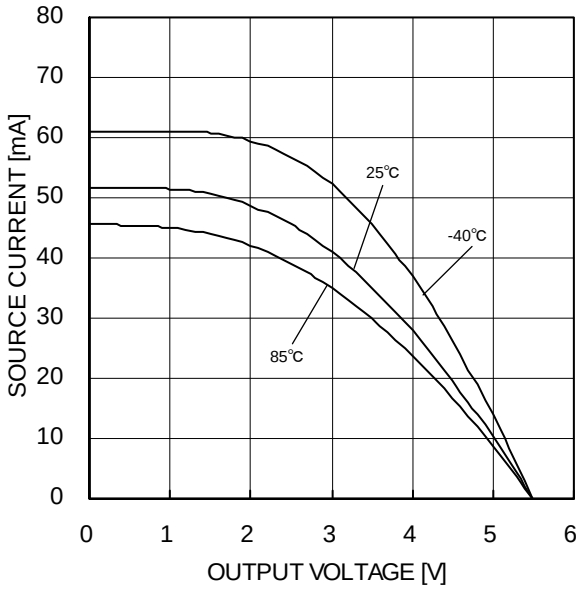


Figure 10.
Output Source Current – Output Voltage
(VDD=5.5V)

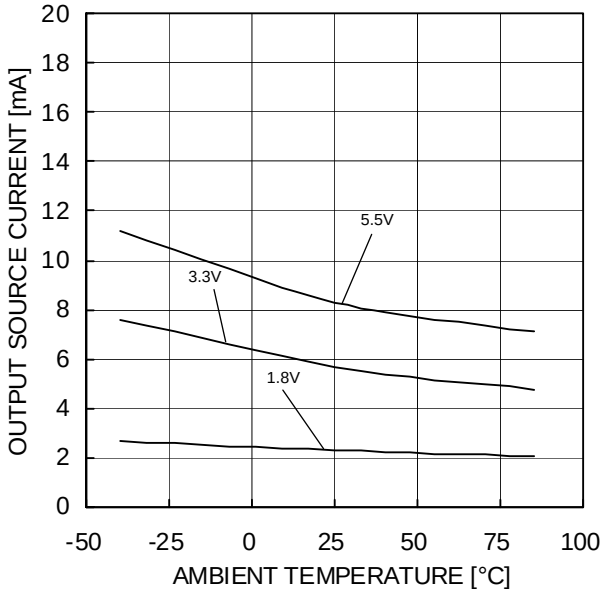


Figure 11.
Output Source Current –Ambient Temperature
(OUT=VDD-0.4V)

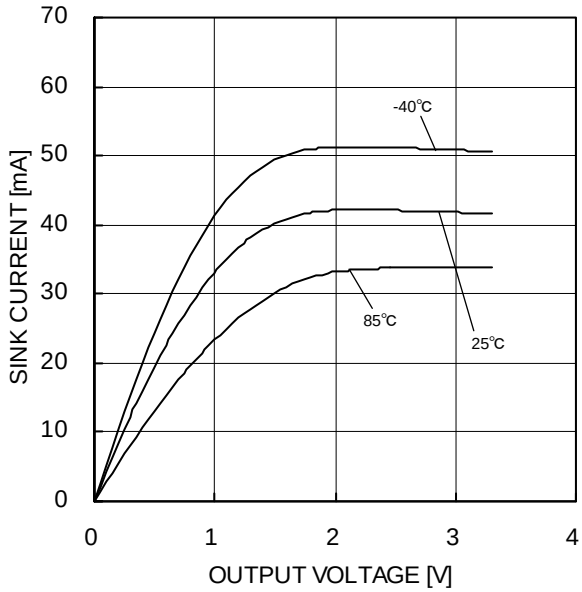


Figure 12.
Output Sink Current – Output Voltage
(VDD=3.3V)

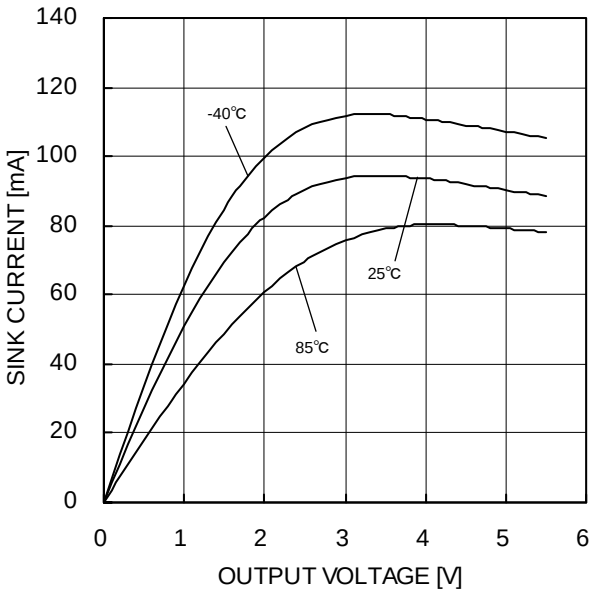


Figure 13.
Output Sink Current – Output Voltage
(VDD=5.5V)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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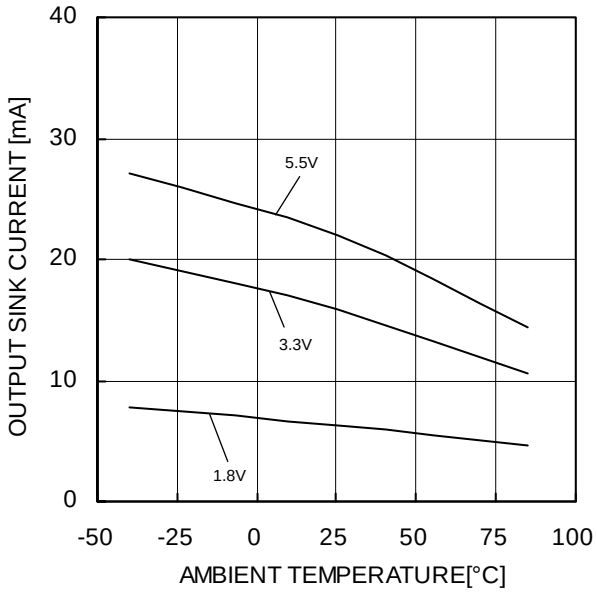


Figure 14.
Output Sink Current – Ambient Temperature
(OUT=VSS+0.4V)

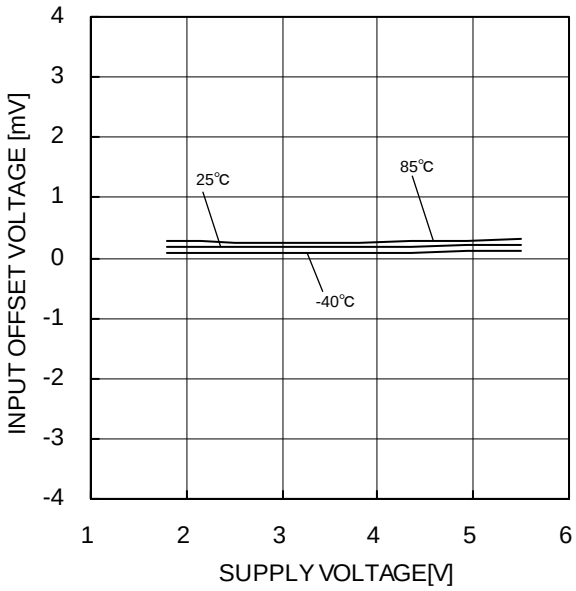


Figure 15.
Input Offset Voltage – Supply Voltage

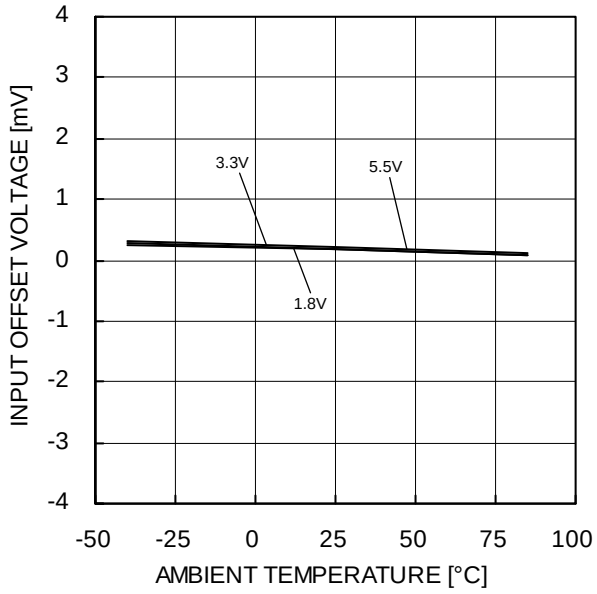


Figure 16.
Input Offset Voltage – Ambient Temperature

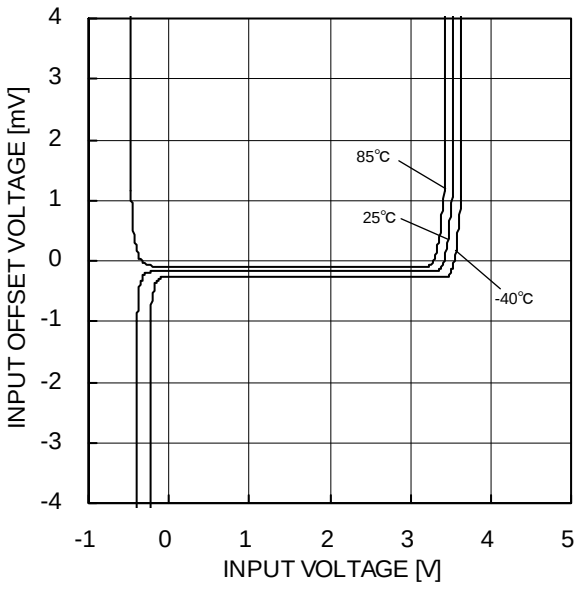


Figure 17.
Input Offset Voltage – Input Voltage
(VDD=3.3V)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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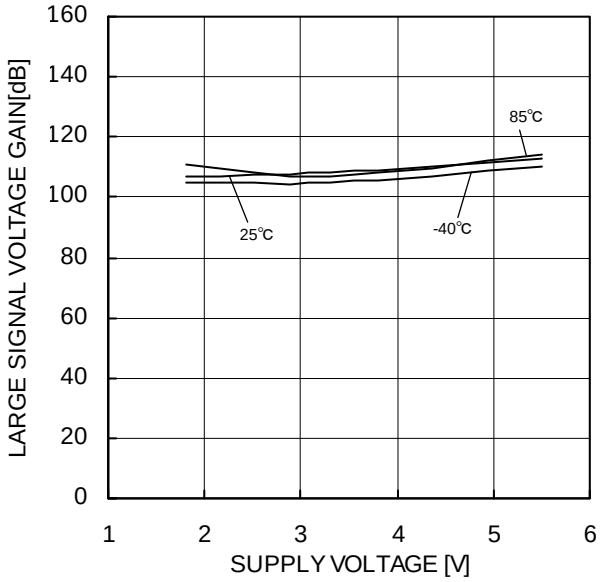


Figure 18.
Large Signal Voltage Gain – Supply Voltage

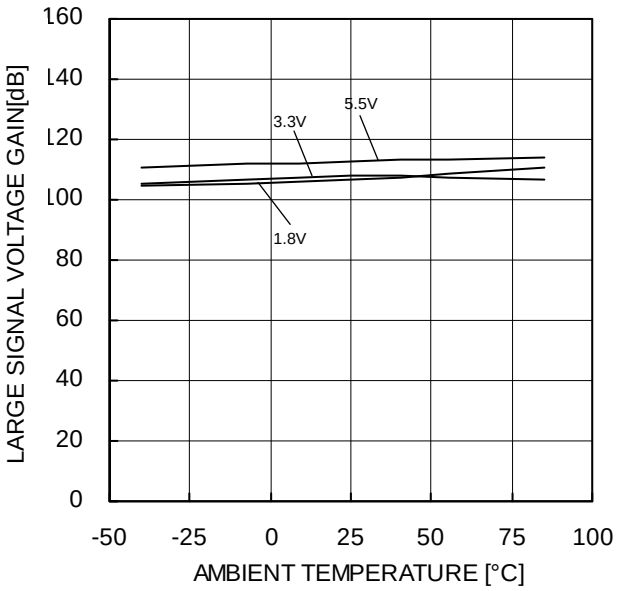


Figure 19.
Large Signal Voltage Gain – Ambient Temperature

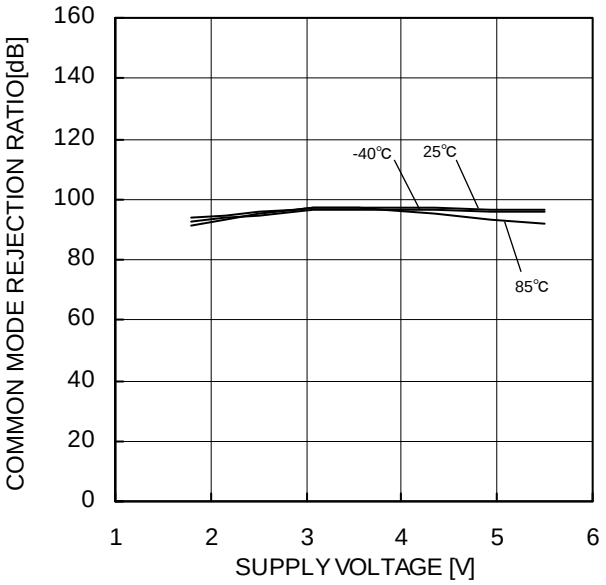


Figure 20.
Common Mode Rejection Ratio – Supply Voltage

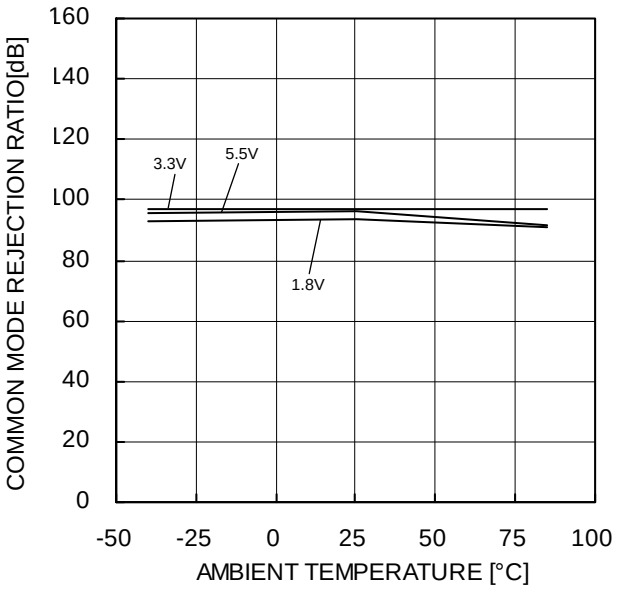


Figure 21.
Common Mode Rejection Ratio – Ambient Temperature

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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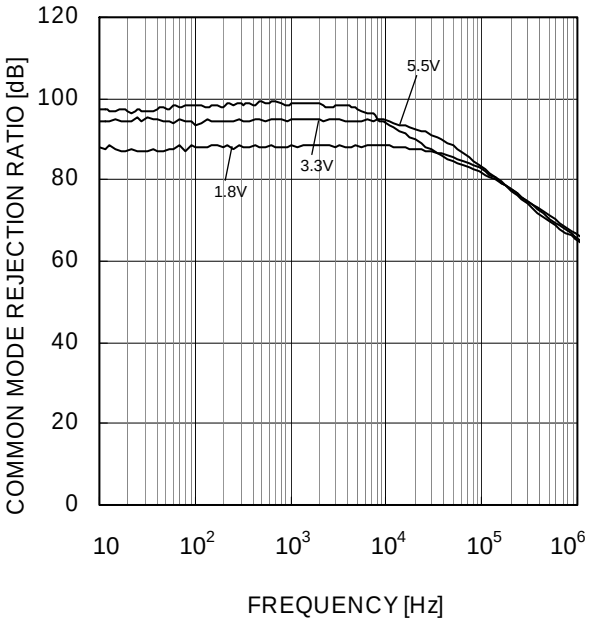


Figure 22.
Common Mode Rejection Ratio – Frequency

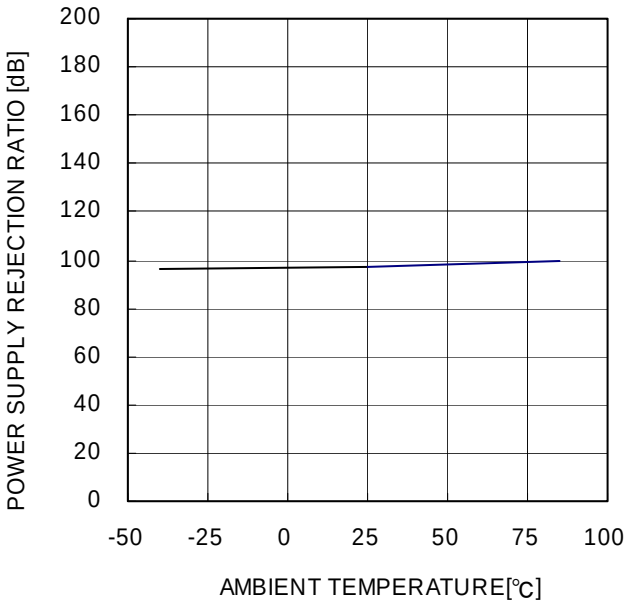


Figure 23.
Power Supply Rejection Ratio – Ambient Temperature
(VDD=1.7V to 5.5V)

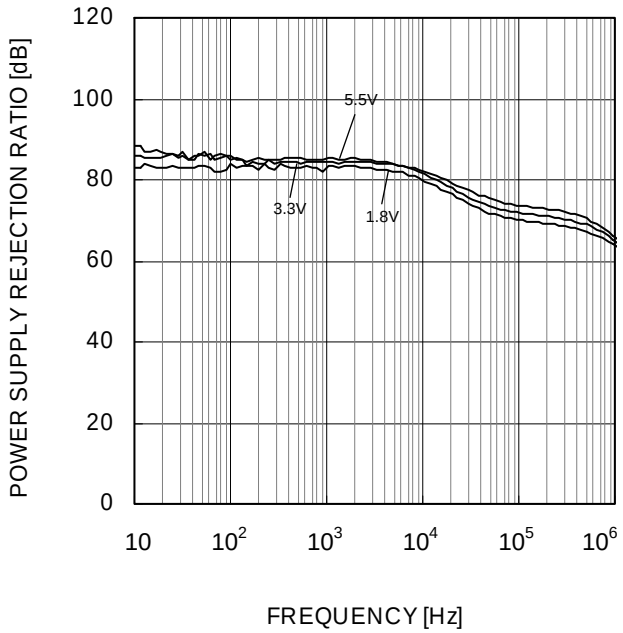


Figure 24.
Power Supply Rejection Ratio – Ambient Temperature
(VDD=3.3V)

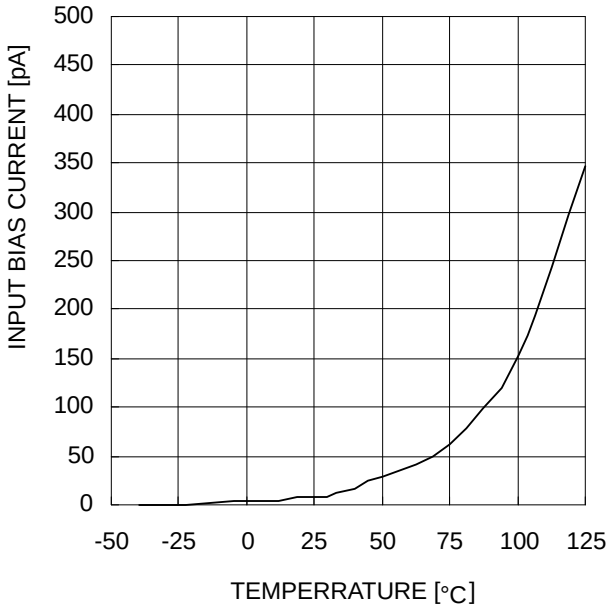


Figure 25.
Bias CURRENT – Ambient Temperature
(VDD=3.3V)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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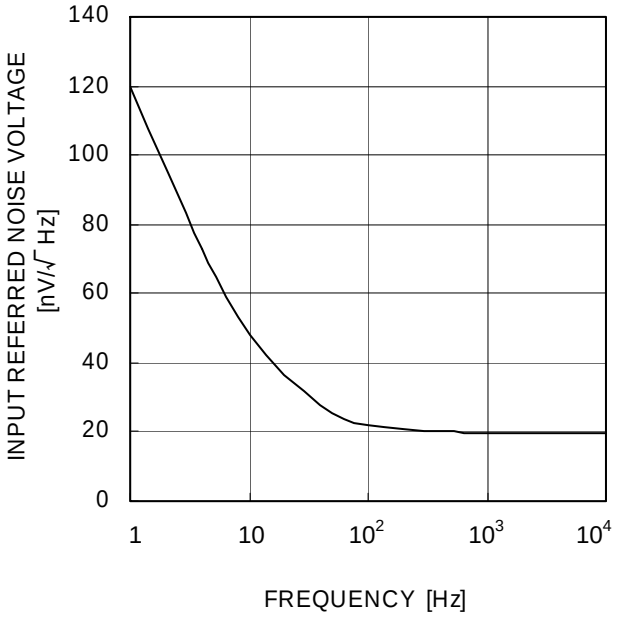


Figure 26.
Input Referred Noise Voltage－Frequency
(VDD=3.3V)

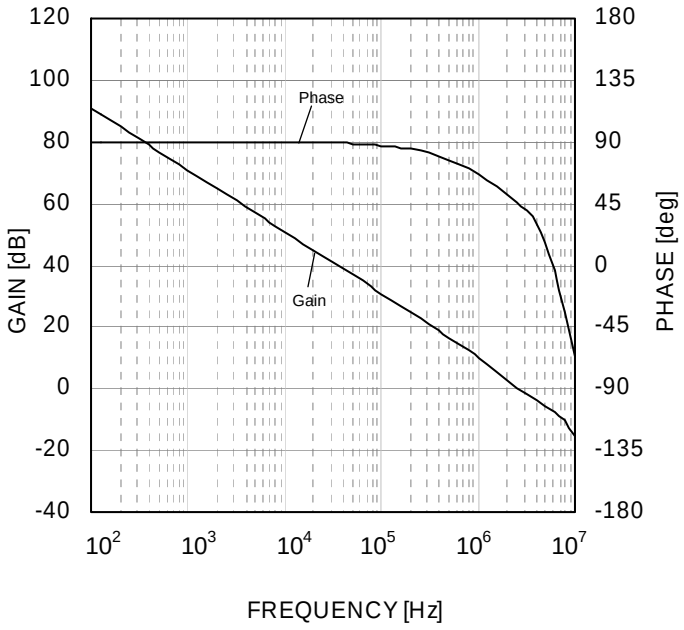


Figure 27.
Voltage Gain, Phase – Frequency
(VDD=3.3V , Open loop)

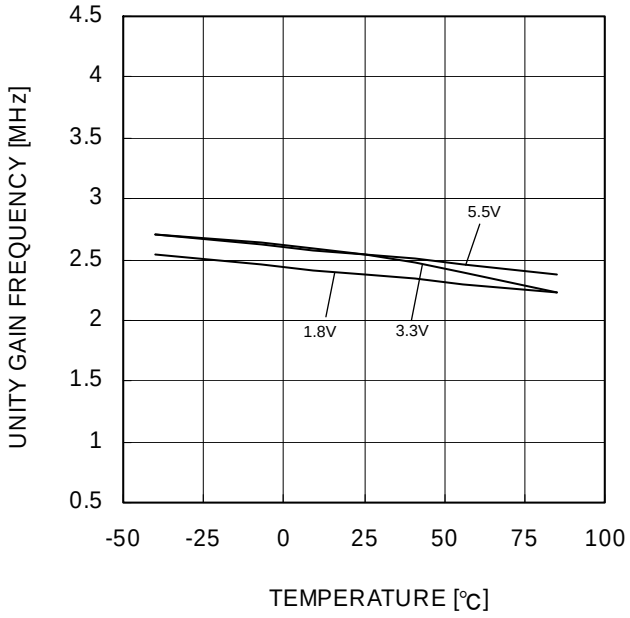


Figure 28.
Unity Gain Frequency – Ambient Temperature

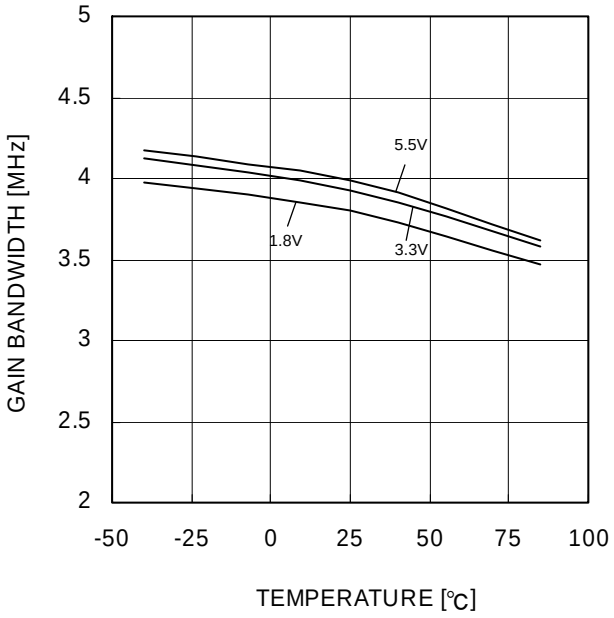


Figure 29.
Gain Bandwidth – Ambient Temperature

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

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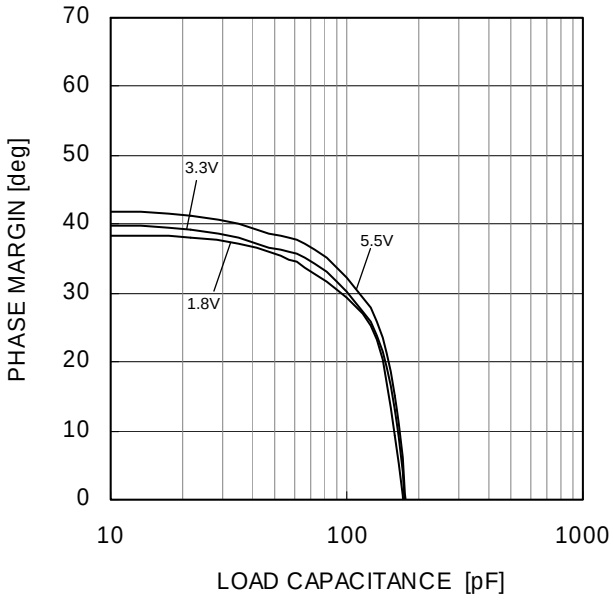



Figure 30.
Phase Margin－Load Capacitance

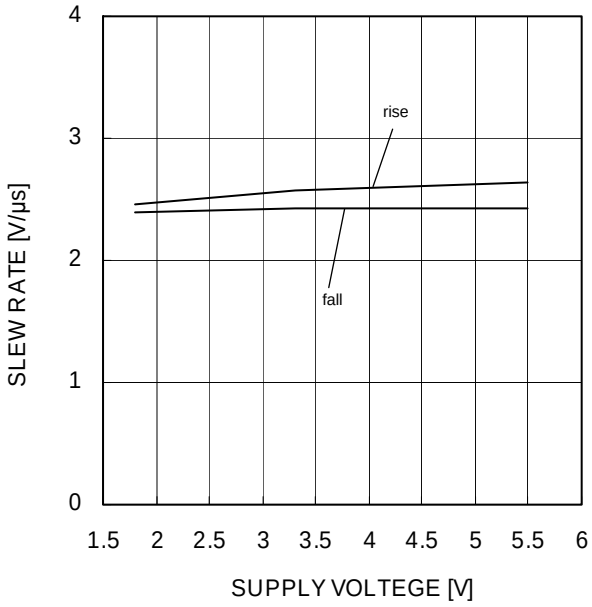



Figure 31.
Slew Rate－Supply Voltage

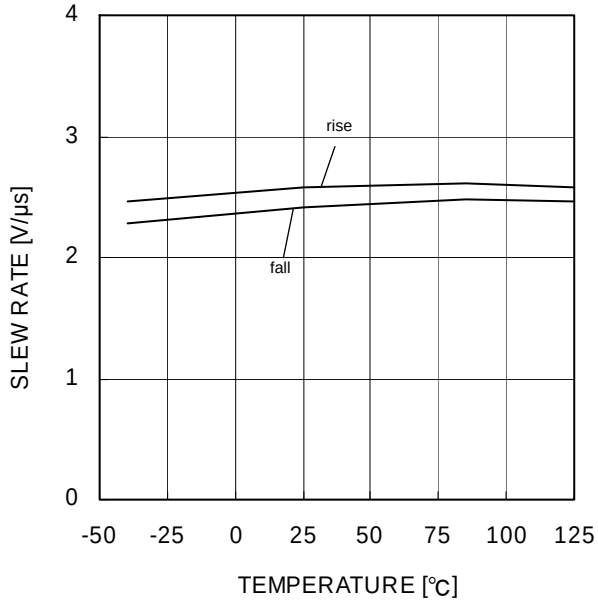



Figure 32.
Slew Rate – Ambient Temperature
(VDD=3.3V)

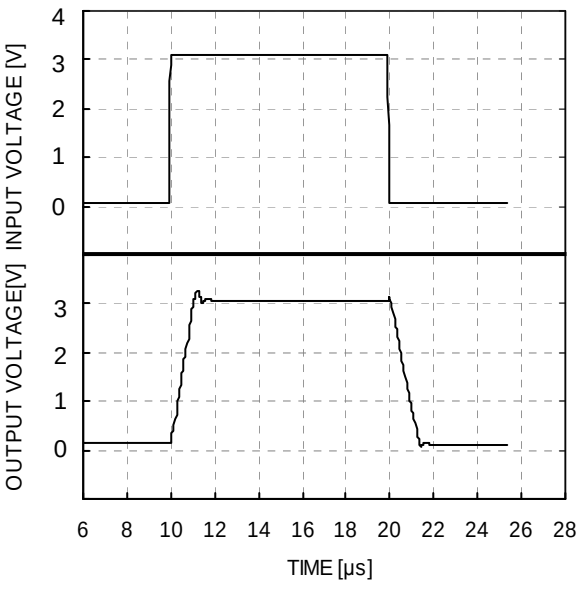



Figure 33.
Input and Output Wave Form
(VDD=5V, $A_V$=1, $R_L$=2kΩ, $C_L$=10pF
IN=3$V_{P-P}$, $T_A$=25℃)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

○BD5291G

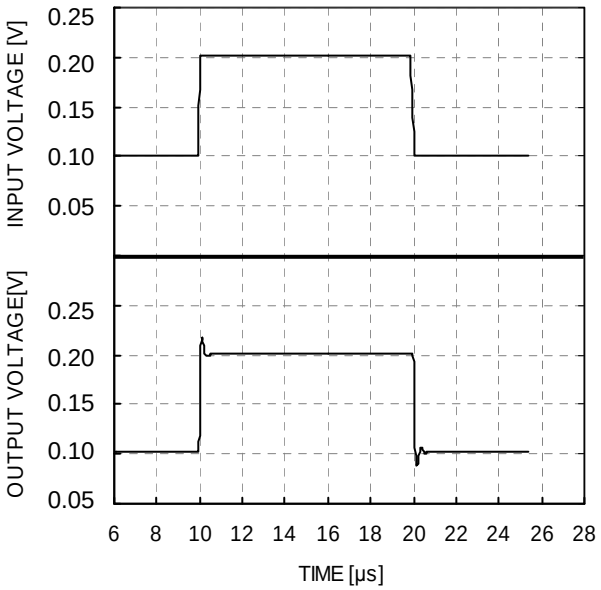



Figure 34.
Input and Output Wave Form
(VDD=5V, $A_V$=1, $R_L$=2kΩ, $C_L$=10pF
IN=100m$V_{P-P}$, $T_A$=25°C)

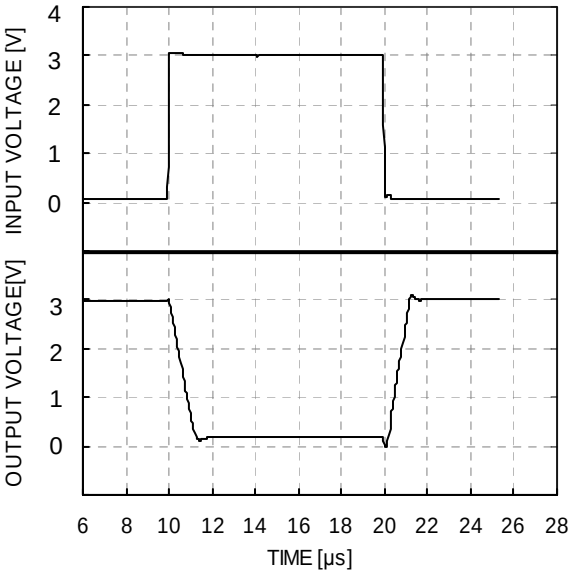



Figure 35.
Input and Output Wave Form
(VDD=5V, $A_V$=-1, $R_L$=2kΩ, $C_L$=10pF
IN=3$V_{P-P}$, $T_A$=25°C)

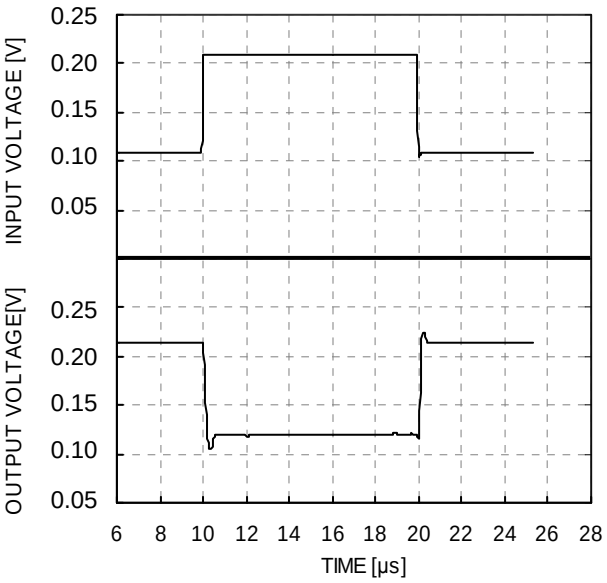



Figure 36.
Input and Output Wave Form
(VDD=5V, $A_V$=-1, $R_L$=2kΩ, $C_L$=10pF
IN=100m$V_{P-P}$, $T_A$=25°C)

(*)The above characteristics are measurements of typical sample, they are not guaranteed.

## Application Information

### NULL method condition for Test Circuit 1

VDD, VSS, $E_K$, $V_{ICM}$ Unit:V

| Parameter | $V_F$ | S1 | S2 | S3 | VDD | VSS | $E_K$ | $V_{ICM}$ | Calculation |
|---|---|---|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{F1}$ | ON | ON | OFF | 3.3 | 0 | -1.65 | 1.65 | 1 |
| Large Signal Voltage Gain | $V_{F2}$ | ON | ON | ON | 3.3 | 0 | -0.5 | 0.9 | 2 |
| | $V_{F3}$ | | | | | | -2.5 | | |
| Common-mode Rejection Ratio (Input Common-mode Voltage Range) | $V_{F4}$ | ON | ON | OFF | 3.3 | 0 | -1.5 | 0 | 3 |
| | $V_{F5}$ | | | | | | | 3.3 | |
| Power Supply Rejection Ratio | $V_{F6}$ | ON | ON | OFF | 1.7 | 0 | -0.9 | 0 | 4 |
| | $V_{F7}$ | | | | 5.5 | | | | |

－ Calculation－

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

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

2. Large Signal Voltage Gain (Av)

$$Av = 20Log \frac{\Delta V_{EK} \times (1+R_F/R_S)}{|V_{F2}-V_{F3}|} \ [dB]$$

3. Common-mode Rejection Ratio (CMRR)

$$CMRR = 20Log \frac{\Delta V_{ICM} \times (1+R_F/R_S)}{|V_{F4} - V_{F5}|} \ [dB]$$

4. Power Supply Rejection Ratio (PSRR)

$$PSRR = 20Log \frac{\Delta VDD \times (1+ R_F/R_S)}{|V_{F6} - V_{F7}|} \ [dB]$$

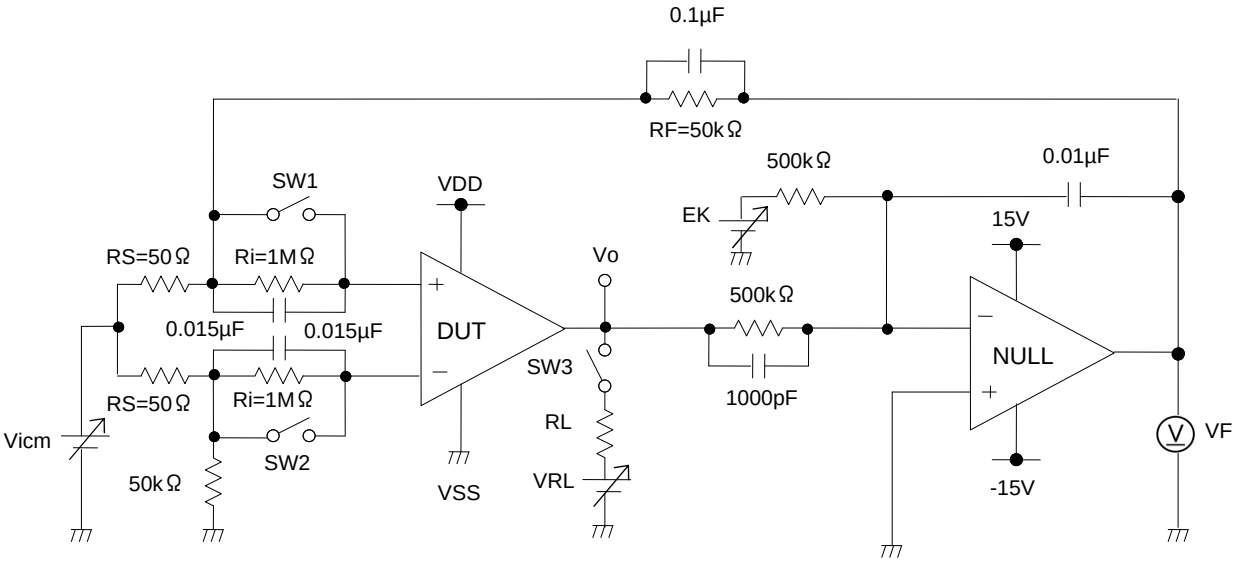



Figure 37. Test circuit 1

**Switch Condition for Test Circuit 2**

| SW No. | SW1 | SW2 | SW3 | SW4 | SW5 | SW6 | SW7 | SW8 | SW9 | SW10 | SW11 | SW12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Supply Current | OFF | OFF | ON | OFF | ON | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Maximum Output Voltage RL=10kΩ | OFF | ON | OFF | OFF | ON | OFF | OFF | ON | OFF | OFF | ON | OFF |
| Output Current | OFF | ON | OFF | OFF | ON | OFF | OFF | OFF | OFF | ON | OFF | OFF |
| Slew Rate | OFF | OFF | ON | OFF | OFF | OFF | ON | OFF | ON | OFF | OFF | ON |
| Unit gain frequency | ON | OFF | OFF | ON | ON | OFF | OFF | OFF | ON | OFF | OFF | ON |

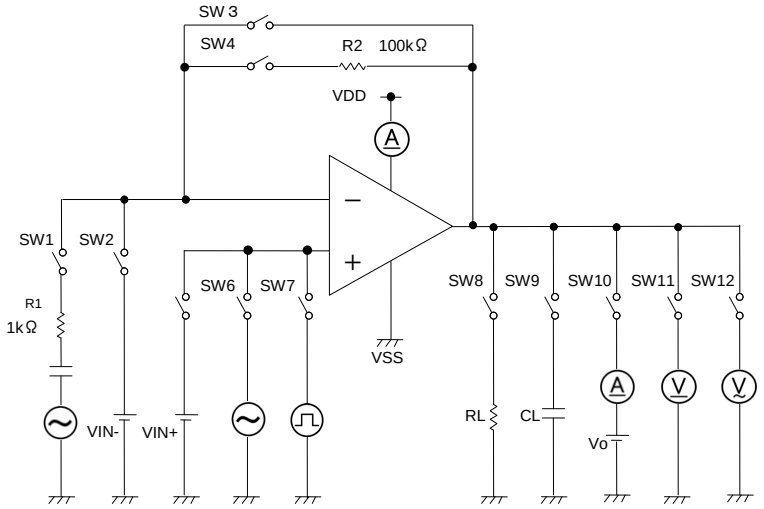



Figure 38. Test circuit 2

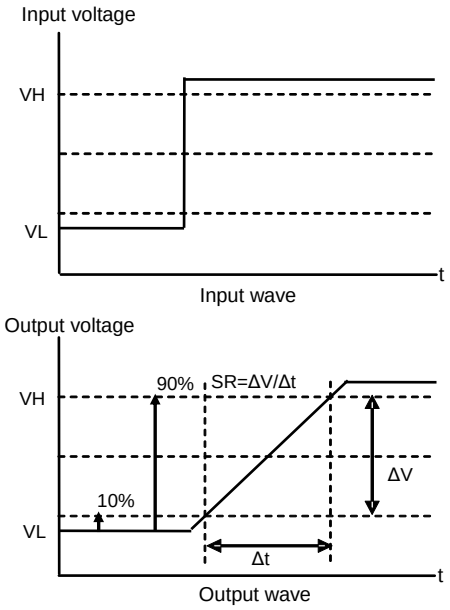



Figure 39. Slew rate input output wave

## Application example

○Voltage follower

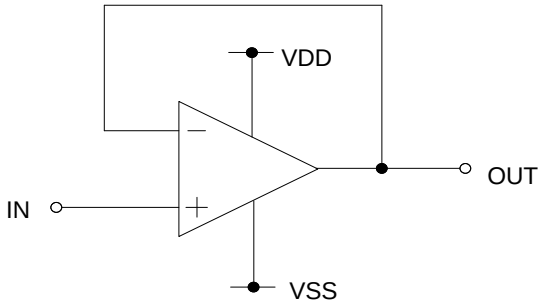



Figure 40. Voltage follower

Voltage gain is 0dB.
Using this circuit, the output voltage (OUT) is configured to be equal to the input voltage (IN). This circuit also stabilizes the output voltage (OUT) due to high input impedance and low output impedance. Expression for output voltage (OUT) is shown below.
OUT=IN

○Inverting amplifier

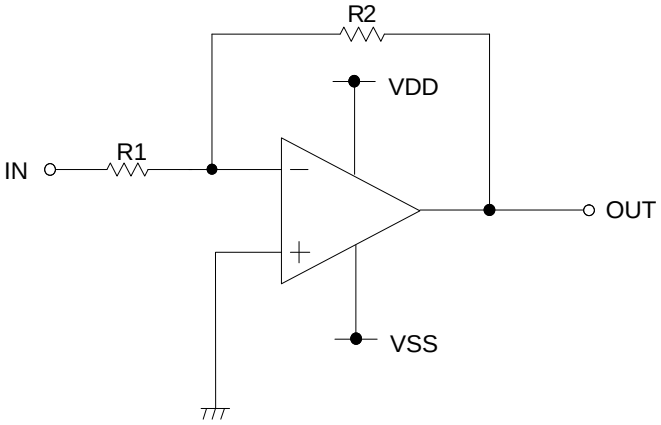



Figure 41. Inverting amplifier circuit

For inverting amplifier, input voltage (IN) is amplified by a voltage gain and depends on the ratio of R1 and R2. The out-of-phase output voltage is shown in the next expression
OUT=-(R2/R1)・IN
This circuit has input impedance equal to R1.

○Non-inverting amplifier

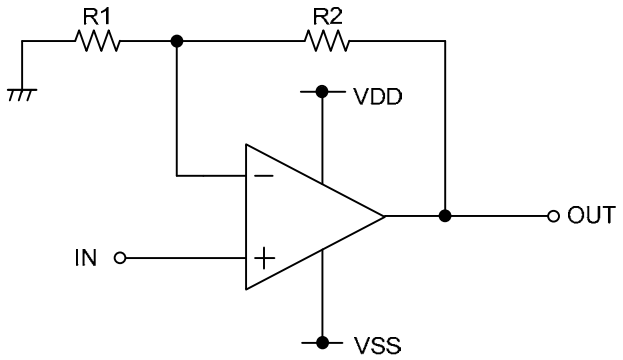



Figure 42. Non-inverting amplifier circuit

For non-inverting amplifier, input voltage (IN) is amplified by a voltage gain, which depends on the ratio of R1 and R2. The output voltage (OUT) is in-phase with the input voltage (IN) and is shown in the next expression.
OUT=(1 + R2/R1)・IN
Effectively, this circuit has high input impedance since its input side is the same as that of the operational amplifier.

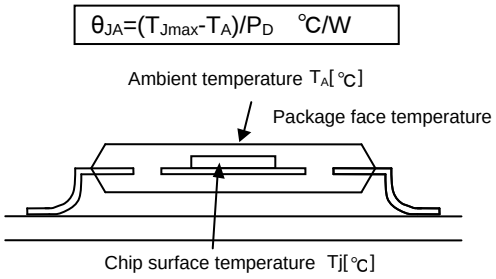
## Power Dissipation

Power dissipation (total loss) indicates the power that can be consumed by IC at $T_A$=25°C(normal temperature).IC is heated when it consumed power, and the temperature of IC ship becomes higher than ambient temperature. The temperature that can be accepted by IC chip depends on circuit configuration, manufacturing process, and consumable power is limited. Power dissipation is determined by the temperature allowed in IC chip (maximum junction temperature) and thermal resistance of package (heat dissipation capability). The maximum junction temperature is typically equal to the maximum value in the storage package (heat dissipation capability). The maximum junction temperature is typically equal to the maximum value in the storage temperature range. Heat generated by consumed power of IC radiates from the mold resin or lead frame of the package. The parameter which indicates this heat dissipation capability (hardness of heat release) is called thermal resistance, represented by the symbol $\theta_{JA}$°C/W. The temperature of IC inside the package can be estimated by this thermal resistance.

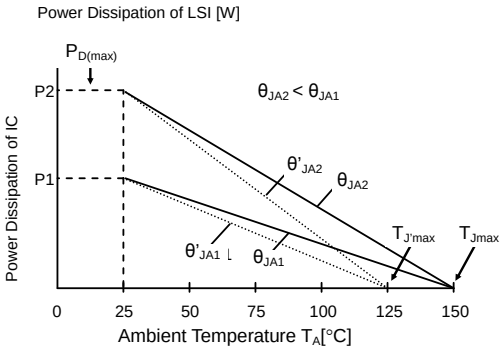
Figure 43.(a) shows the model of thermal resistance of the package. Thermal resistance $\theta_{JA}$, ambient temperature $T_A$, maximum junction temperature Tjmax, and power dissipation Pd can be calculated by the equation below:

$$\theta_{JA} = (T_{Jmax} - T_A) / P_D \quad °C/W$$

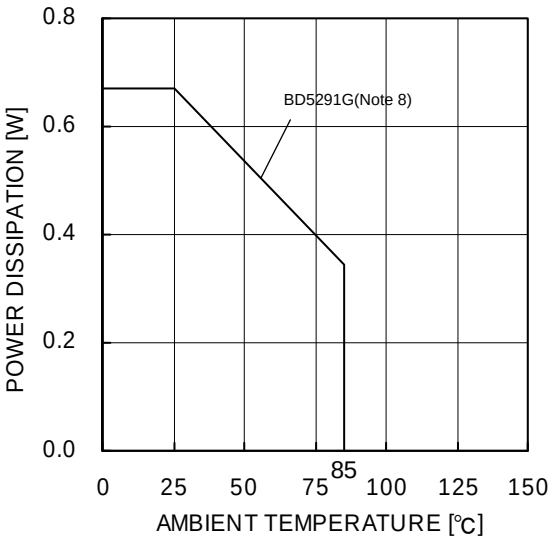
Derating curve in Figure 43.(b) indicates power that can be consumed by IC with reference to ambient temperature. Power that can be consumed by IC begins to attenuate at certain ambient temperature. This gradient is determined by thermal resistance $\theta_{JA}$. Thermal resistance $\theta_{JA}$ depends on chip size, power consumption, package, ambient temperature, package condition, wind velocity, etc even when the same of package is used. Thermal reduction curve indicates a reference value measured at a specified condition. Figure 43.(c) show a derating curve for an example of BD5291G.




(a) Thermal resistance




(b) Derating curve




(c) BD5291G

| Note 8 | Unit |
|---|---|
| 5.4 | mW/°C |

When using the unit above $T_A$=25°C, subtract the value above per °C. Permissible dissipation is the value when FR4 glass epoxy board 70mm × 70mm × 1.6mm (copper foil area below 3%) is mounted

Figure 43. Derating Curve

## 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. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. 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. However, pins that drive inductive loads (e.g. motor driver outputs, DC-DC converter outputs) may inevitably go below ground due to back EMF or electromotive force. In such cases, the user should make sure that such voltages going below ground will not cause the IC and the system to malfunction by examining carefully all relevant factors and conditions such as motor characteristics, supply voltage, operating frequency and PCB wiring to name a few.

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. **Thermal Consideration**
   Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the Pd stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

6. **Recommended Operating Conditions**
   These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. **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.

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

9. **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.

10. **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.

11. **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

**12. 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.

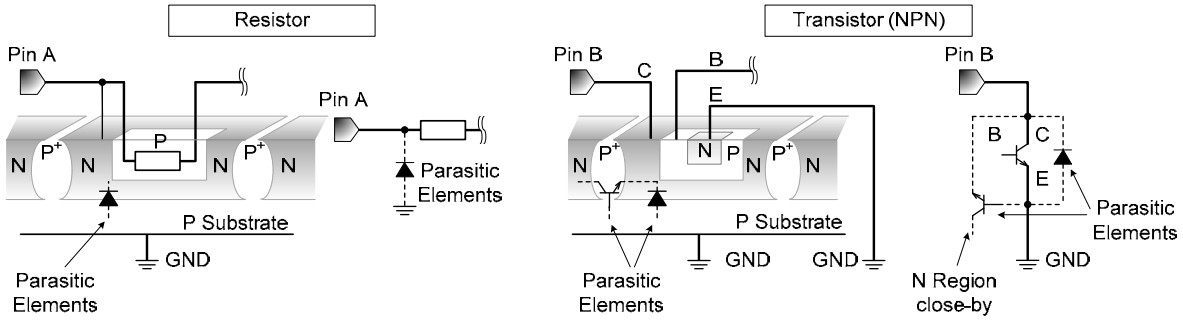



Figure 44. Example of monolithic IC structure

**13. Oscillation for feed back circuit**

Be careful when using the IC in feed back circuit. Phase margin of this IC is 40°.Oscillation is caused by large size capacitive load connecting to output terminal. If the circuits has large size capacitor that is connected to output terminal. Please insert of isolation resistor between output terminal and capacitive load.

**14. Input Voltage**

Applying VDD+0.3V to the input terminal is possible without causing deterioration of the electrical characteristics or destruction, regardless of the supply voltage. However, this does not ensure normal circuit operation. Please note that the circuit operates normally only when the input voltage is within the common mode input voltage range of the electric characteristics.

**15. Power supply(single/dual)**

The operational amplifiers operate when the voltage supplied is between VDD and VSS. Therefore, the single supply operational amplifiers can be used as dual supply operational amplifiers as well.

**16. Output capacitor**

Discharge of the external output capacitor to VDD is possible via internal parasitic elements when VDD is shorted to VSS, causing damage to the internal circuitry due to thermal stress. Therefore, when using this IC in circuits where oscillation due to output capacitive load does not occur, such as in voltage comparators, use an output capacitor with a capacitance less than 0.1µF.
Designed negative feedback circuit using this IC, verify output oscillation caused by capacitive load.

**17. Oscillation by output capacitor**

Please pay attention to the oscillation by output capacitor and in designing an application of negative feedback loop circuit with these ICs.

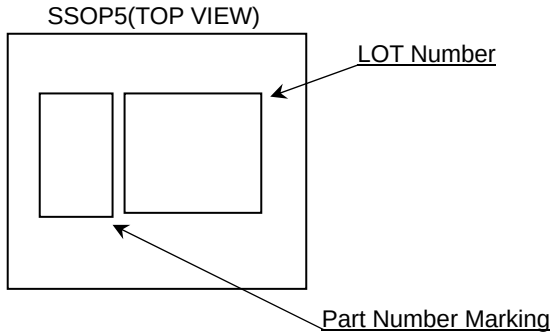
**18. Latch up**

Be careful of input voltage that exceed the VDD and VSS. When CMOS device have sometimes occur latch up operation. And protect the IC from abnormaly noise.

**19. Decupling Capacitor**

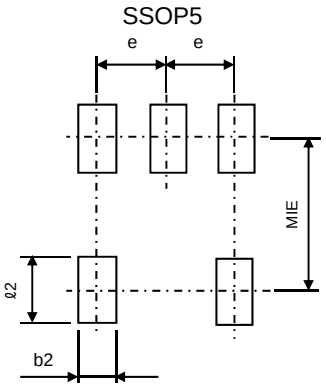
Insert the decupling capacitance between VDD and VSS, for stable operation of operational amplifier.

### Marking Diagram




| Product Name | | Package Type | Marking |
|---|---|---|---|
| BD5291 | G | SSOP5 | L7 |

### Land Pattern data

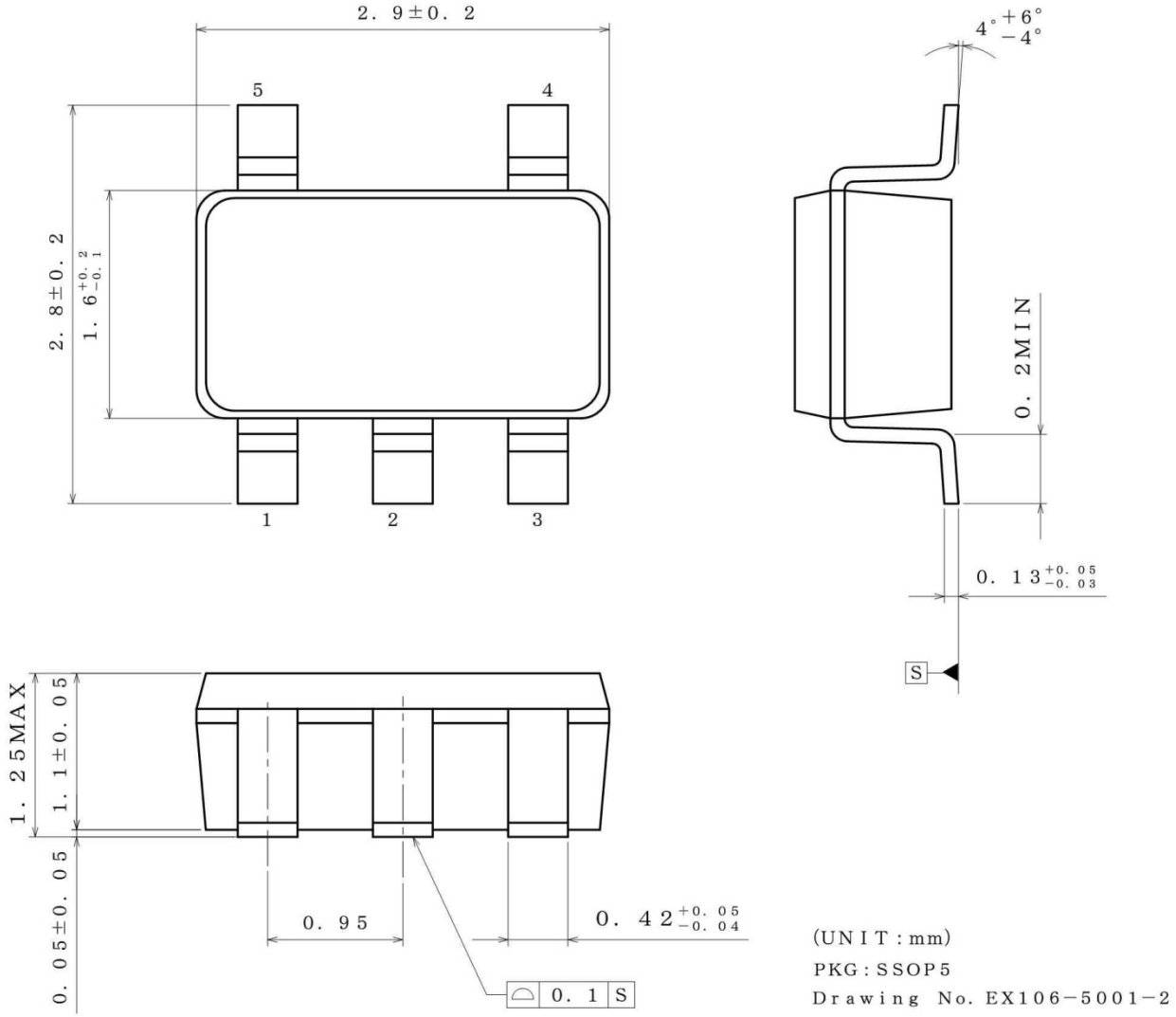



Unit：mm

| PKG | Land Pitch e | Land Space MIE | Land Length ≧ℓ 2 | Land Width b2 |
|---|---|---|---|---|
| SSOP5 | 0.95 | 2.4 | 1.0 | 0.6 |

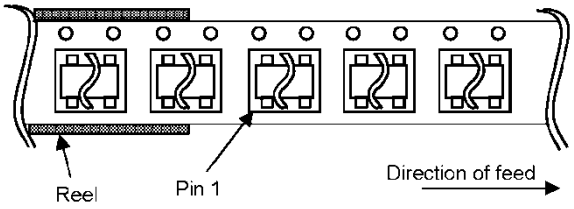
**Physical Dimensions Tape and Reel Information**

| Package Name | SSOP5 |
|---|---|




< Tape and Reel Information >

| | |
|---|---|
| Tape | Embossed carrier tape |
| Quantity | 3000pcs |
| Direction of feed | TL<br>( The direction is the 1pin of product is at the lower left when you hold reel on the left hand and you pull out the tape on the right hand ) |



**Revision History**

| Date | Revision | Changes |
|---|---|---|
| 10.JUN.2013 | 001 | New Release |
| 26.NOV.2013 | 002 | Add BD5291FVE, Delete Simplified Schematic |
| 13.FEB.2014 | 003 | General Description is modified. |
| 22.APR.2014 | 004 | Delete BD5291FVE. |

# Notice

## Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, 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 designed and manufactured for use under standard conditions and not 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 (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient 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; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

## 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

QR code 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

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