Datasheet

Operational Amplifiers Series

Input/Output Full Swing High Slew Rate Low Voltage CMOS Operational Amplifiers

BU7291G, BU7291SG, BU7294xx, BU7294Sxx

●General Description

BU7291G/BU7294xx and BU7291SG/BU7294Sxx are low supply voltage CMOS operational single/quad Amplifiers. This series is a Input/Output full swing, high slew rate, low supply current and high speed operation. Input bias current is very low at 1pA (Typ) . Especially,BU7291SG and BU7294Sxx, it has wide temperature range from -40°C to +105°C.

●Features

- High slew rate
- Input/Output full swing
- Large DC voltage gain
- Low input bias current

●Application

- Battery equipment
- Consumer electronics

●Key Specifications

- Low Operating Supply Voltage (single supply): +2.4V to +5.5V
- High Slew Rate: 3.0V/µs
- Wide Temperature Range:
  - BU7291G/BU7294xx -40°C to +85°C
  - BU7291SG/BU7294Sxx -40°C to +105°C
- Low Input Offset Current: 1pA (Typ)
- Low Input Bias Current: 1pA (Typ)

●Package

Package	W(Typ) x D(Typ) x H(Max)
SSOP5	2.90mm x 2.80mm x 1.25mm
SOP14	8.70mm x 6.20mm x 1.71mm
SSOP-B14	5.00mm x 6.40mm x 1.35mm

●Simplified schematic

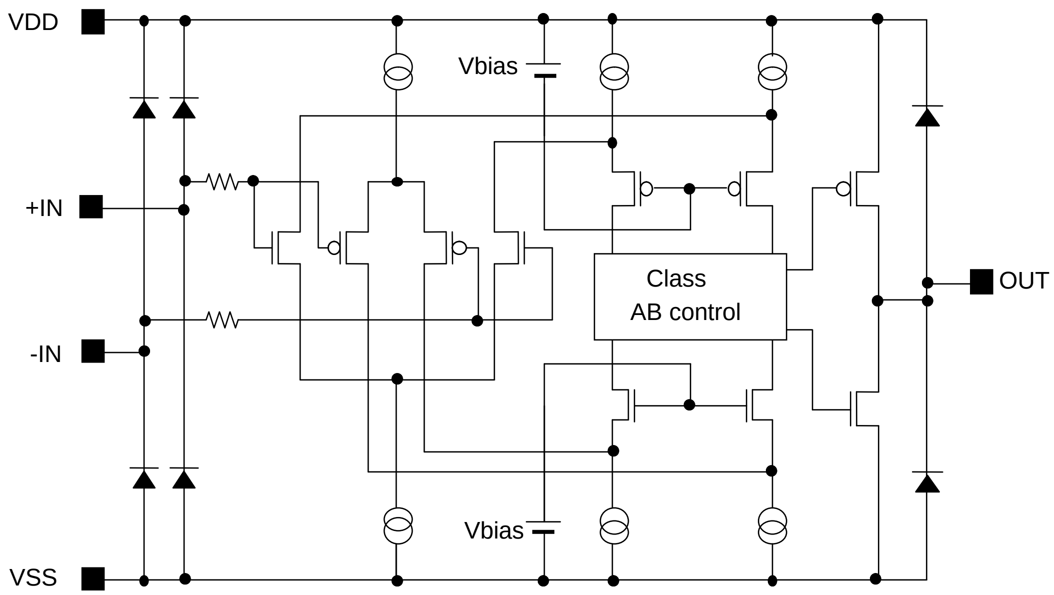
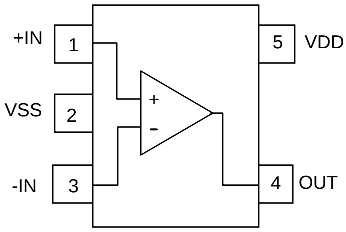


Figure 1. Simplified schematic (1 channel only)

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

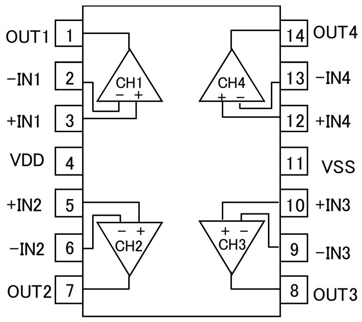
●Pin Configuration

BU7291G, BU7291SG : SSOP5



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

BU7294F, BU7294SF : SOP14
BU7294FV, BU7294SFV : SSOP-B14



Pin No.	Pin Name
1	OUT1
2	-IN1
3	+IN1
4	VDD
5	+IN2
6	-IN2
7	OUT2
8	OUT3
9	-IN3
10	+IN3
11	VSS
12	+IN4
13	-IN4
14	OUT4

Package		
SSOP5	SOP14	SSOP-B14
BU7291G BU7291SG	BU7294F BU7294SF	BU7294FV BU7294SFV

●Ordering Information

B U 7 2 9 x x x x - x x

Part Number
BU7291G
BU7291SG
BU7294xx
BU7294Sxx

Package
G:SSOP5
F:SOP14
FV:SSOP-B14

Packaging and forming specification
E2: Embossed tape and reel
(SOP14/ SSOP-B14)
TR: Embossed tape and reel
(SSOP5)

●Line-up

Topr	Package		Operable Part Number
-40°C to +85°C	SSOP5	Reel of 3000	BU7291G-TR
-40°C to +105°C	SSOP5	Reel of 3000	BU7291SG-TR
-40°C to +85°C	SOP14	Reel of 2500	BU7294F-E2
-40°C to +105°C	SOP14	Reel of 2500	BU7294SF-E2
-40°C to +85°C	SSOP-B14	Reel of 2500	BU7294FV-E2
-40°C to +105°C	SSOP-B14	Reel of 2500	BU7294SFV-E2

●Absolute Maximum Ratings(Ta=25°C)

Parameter	Symbol		Ratings		Unit
			BU7291 BU7294	BU7291S BU7294S	
Supply Voltage	VDD-VSS		+7		V
Power dissipation	Pd	SSOP5	0.54 *1*4		W
		SOP14	0.45 *2*4		
		SSOP-B14	0.70 *3*4		
Differential Input Voltage *5	Vid		VDD - VSS		V
Input Common-mode Voltage Range	Vicm		(VSS - 0.3) to VDD + 0.3		V
Input Current *6	Ii		±10		mA
Operating Supply Voltage	Vopr		+2.4 to +5.5		V
Operating Temperature	Topr		- 40 to +85	- 40 to +105	°C
Storage Temperature	Tstg		- 55 to +125		°C
Maximum Junction Temperature	Tjmax		+125		°C

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

*1 To use at temperature above Ta＝25°C reduce 5.4mW.
*2 To use at temperature above Ta＝25°C reduce 4.5mW.
*3 To use at temperature above Ta＝25°C reduce 7.0mW.
*4 Mounted on a FR4 glass epoxy PCB(70mm×70mm×1.6mm).
*5 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.
*6 An excessive input current will flow when input voltages of more than VDD+0.6V or lesser than VSS-0.6V are applied.
The input current can be set to less than the rated current by adding a limiting resistor.

●Electrical Characteristics

○BU7291, BU7291S (Unless otherwise specified VDD=+3V, VSS=0V, Ta=25°C)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage *7	Vio	25°C	-	1	9	mV	-
Input Offset Current*7	Iio	25°C	-	1	-	pA	-
Input Bias Current *7	Ib	25°C	-	1	-	pA	-
Supply Current*8	IDD	25°C	-	470	800	μA	RL=∞ Av=0dB, +IN=1.5V
		Full range	-	-	1100		
Maximum Output Voltage(High)	VOH	25°C	VDD-0.1	-	-	V	RL=10kΩ
Maximum Output Voltage(Low)	VOL	25°C	-	-	VSS+0.1	V	RL=10kΩ
Large Signal Voltage Gain	Av	25°C	70	105	-	dB	RL=10kΩ
Input Common-mode Voltage Range	Vicm	25°C	0	-	3	V	VSS to VDD
Common-mode Rejection Ratio	CMRR	25°C	40	60	-	dB	-
Power Supply Rejection Ratio	PSRR	25°C	45	80	-	dB	-
Output Source Current *9	Isource	25°C	5	8	-	mA	VDD-0.4V
Output Sink Current *9	Isink	25°C	9	16	-	mA	VSS+0.4V
Slew Rate	SR	25°C	-	3.0	-	V/μs	CL=25pF
Gain Band Width	GBW	25°C	-	2.8	-	MHz	CL=25pF, f=100kHz
Unity Gain Frequency	f_T	25°C	-	2.8	-	MHz	CL=25pF
Phase Margin	θ	25°C	-	50	-	deg	CL=25pF
Total Harmonic Distortion +Noise	THD+N	25°C	-	0.03	-	%	OUT=0.8V_{P-P}, f=1kHz

*7 Absolute value
*8 Full range BU7291: Ta=-40°C to +85°C BU7291S: Ta=-40°C to +105°C
*9 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.

○BU7294, BU7294S (Unless otherwise specified VDD=+3V, VSS=0V, Ta=25°C)

Parameter	Symbol	Temperature Range	Limits			Unit	Condition
			Min.	Typ.	Max.		
Input Offset Voltage *10	Vio	25°C	-	1	9	mV	-
Input Offset Current*10	Iio	25°C	-	1	-	pA	-
Input Bias Current *10	Ib	25°C	-	1	-	pA	-
Supply Current*11	IDD	25°C	-	2000	3200	μA	RL=∞, All Op-Amps Av=0dB, +IN=1.5V
		Full range	-	-	4400		
Maximum Output Voltage(High)	VOH	25°C	VDD-0.1	-	-	V	RL=10kΩ
Maximum Output Voltage(Low)	VOL	25°C	-	-	VSS+0.1	V	RL=10kΩ
Large Signal Voltage Gain	Av	25°C	70	105	-	dB	RL=10kΩ
Input Common-mode Voltage Range	Vicm	25°C	0	-	3	V	VSS to VDD
Common-mode Rejection Ratio	CMRR	25°C	40	60	-	dB	-
Power Supply Rejection Ratio	PSRR	25°C	45	80	-	dB	-
Output Source Current *12	Isource	25°C	5	8	-	mA	VDD-0.4V
Output Sink Current *12	Isink	25°C	9	16	-	mA	VSS+0.4V
Slew Rate	SR	25°C	-	3.0	-	V/μs	CL=25pF
Gain Band Width	GBW	25°C	-	2.8	-	MHz	CL=25pF, f=100kHz
Unity Gain Frequency	f_T	25°C	-	2.8	-	MHz	CL=25pF
Phase Margin	θ	25°C	-	50	-	deg	CL=25pF
Total Harmonic Distortion +Noise	THD+N	25°C	-	0.03	-	%	OUT=0.8V_{P-P}, f=1kHz
Channel Separation	CS	25°C	-	100	-	dB	f=1kHz, OUT=0.5Vrms

*10 Absolute value
*11 Full range BU7294: Ta=-40°C to +85°C BU7294S: Ta=-40°C to +105°C
*12 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 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 document or general document.

1. Absolute maximum ratings

Absolute maximum rating items indicate 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.

1.1 Supply Voltage (VDD/VSS)
Indicates the maximum voltage that can be applied between the VDD terminal and VSS terminal without deterioration or destruction of characteristics of internal circuit.

1.2 Differential Input Voltage (Vid)
Indicates the maximum voltage that can be applied between non-inverting and inverting terminals without damaging the IC.

1.3 Input Common-mode Voltage Range (Vicm)
Indicates the maximum voltage that can be applied to the non-inverting and inverting terminals without deterioration or destruction of electrical characteristics. Input common-mode voltage range of the maximum ratings does not assure normal operation of IC. For normal operation, use the IC within the input common-mode voltage range characteristics.

1.4 Power dissipation (Pd)
Indicates the power that can be consumed by the IC when mounted on a specific board at the ambient temperature 25°C (normal temperature). As for package product, Pd is determined by the temperature that can be permitted by the IC in the package (maximum junction temperature) and the thermal resistance of the package.

2. Electrical characteristics

2.1 Input Offset Voltage (Vio)
Indicates the voltage difference between non-inverting terminal and inverting terminals. It can be translated into the input voltage difference required for setting the output voltage at 0 V.

2.2 Input Offset Current (Iio)
Indicates the difference of input bias current between the non-inverting and inverting terminals.

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

2.4 Supply Current (IDD)
Indicates the current that flows within the IC under specified no-load conditions.

2.5 Maximum Output Voltage(High) / Maximum Output Voltage(Low) (VOH/VOL)
Indicates the voltage range of the output 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.

2.6 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)

2.7 Input Common-mode Voltage Range (Vicm)
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 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 fluctuation)

2.10 Output Source Current/ Output Sink Current (Isource / Isink)
The maximum current that can be output from the IC under specific output conditions. 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)
Indicates the ratio of the change in output voltage with time when a step input signal is applied.

2.12 Gain Band Width (GBW)
The product of the open-loop voltage gain and the frequency at which the voltage gain decreases 6dB/octave.

2.13 Unity Gain Frequency (f_T)
Indicates a frequency where the voltage gain of operational amplifier is 1.

2.14 Phase Margin (θ)
Indicates the margin of phase from 180 degree phase lag at unity gain frequency.

2.16 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.

2.12 Channel Separation (CS)
Indicates the fluctuation in the output voltage of the driven channel with reference to the change of output voltage of the channel which is not driven.

●Typical Performance Curves

○BU7291, BU7291S

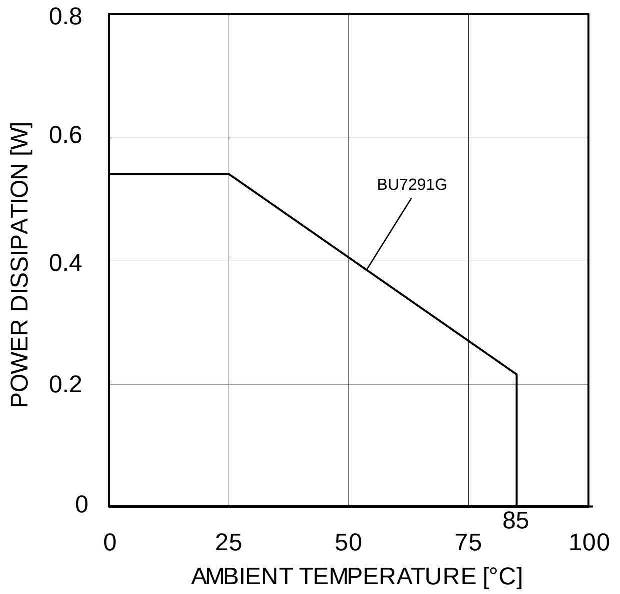


Figure 2.
Derating curve

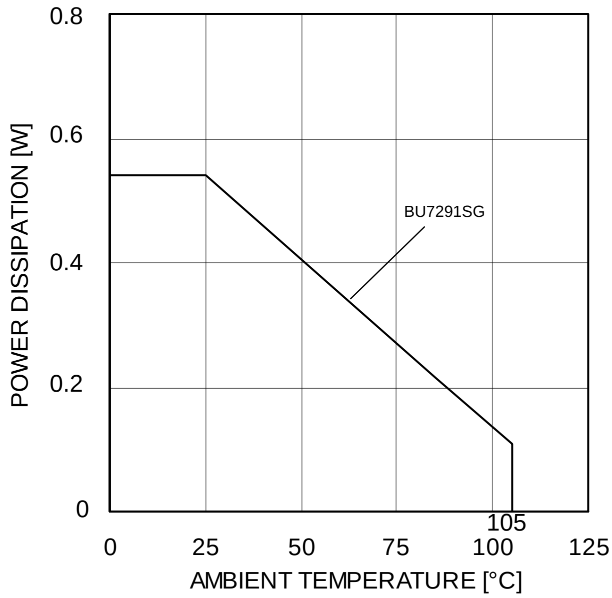


Figure 3.
Derating curve

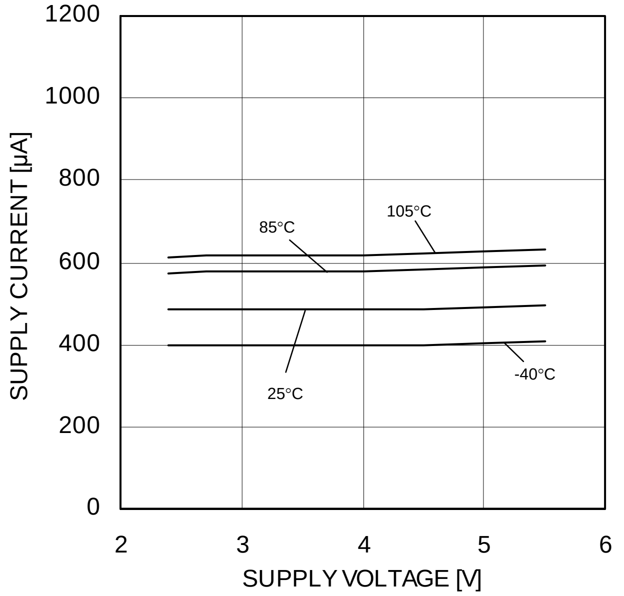


Figure 4.
Supply Current – Supply Voltage

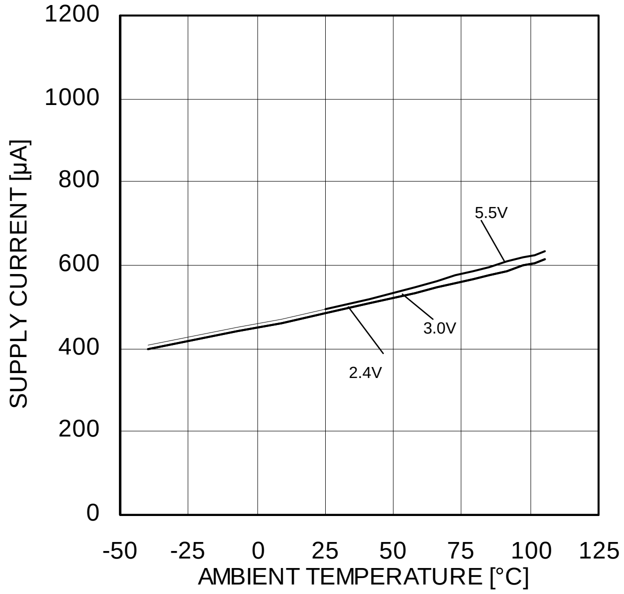


Figure 5.
Supply Current – Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

● **Typical Performance Curves - Continued**

○BU7291, BU7291S

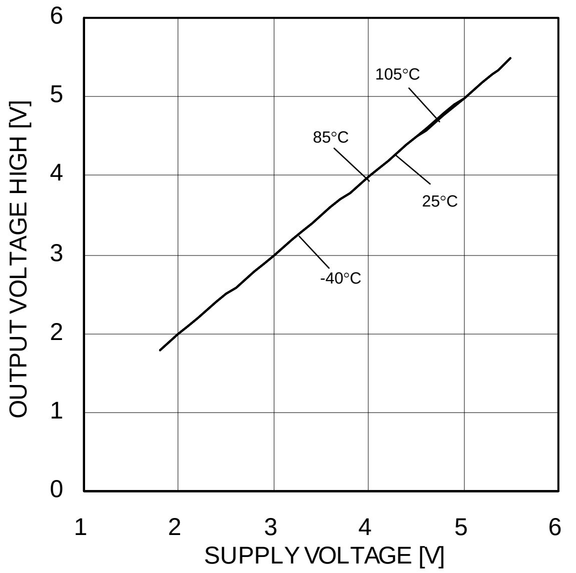


Figure 6.
Maximum Output Voltage High – Supply Voltage
(RL=10kΩ)

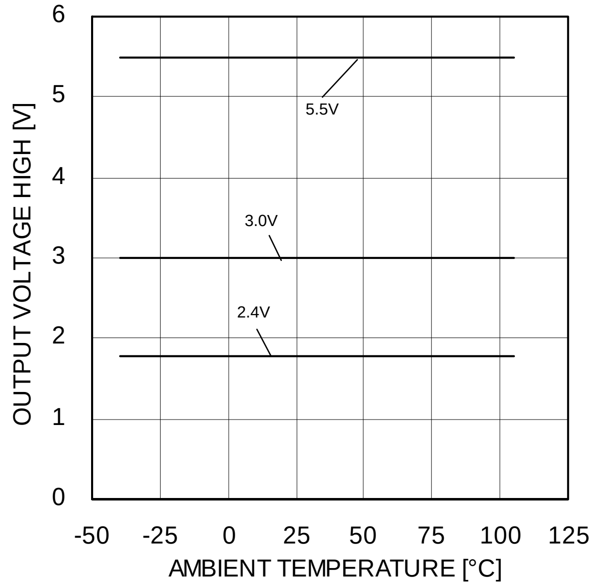


Figure 7.
Maximum Output Voltage High – Ambient Temperature
(RL=10kΩ)

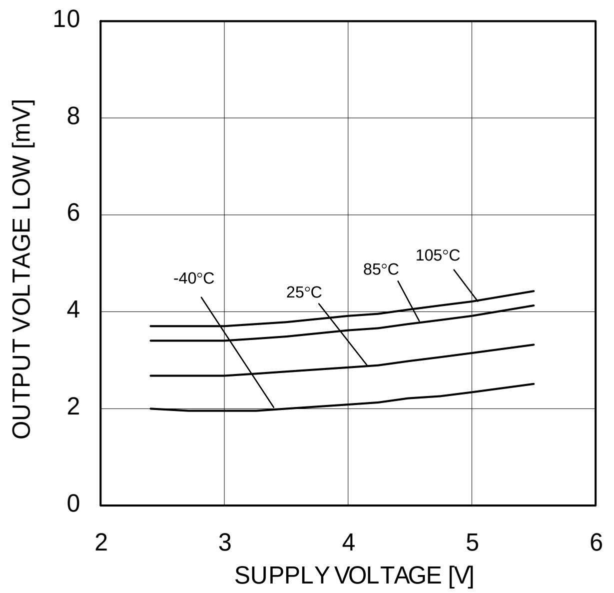


Figure 8.
Maximum Output Voltage Low - Supply Voltage
(RL=10kΩ)

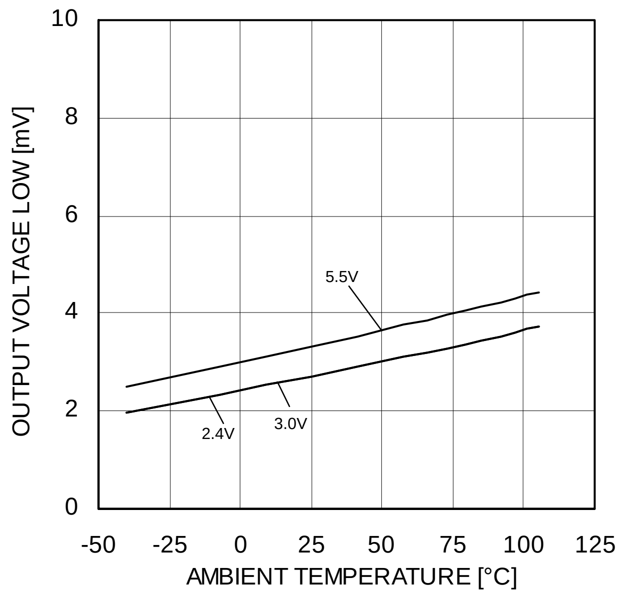


Figure 9.
Maximum Output Voltage Low – Ambient Temperature
(RL=10kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7291, BU7291S

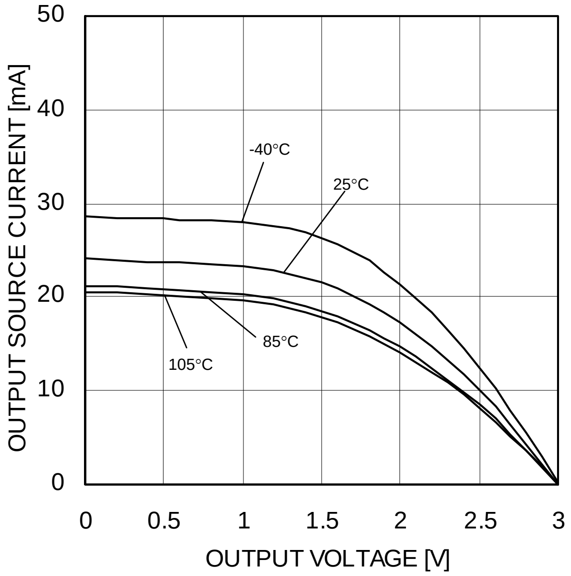


Figure 10.
Output Source Current – Output Voltage
(VDD=3V)

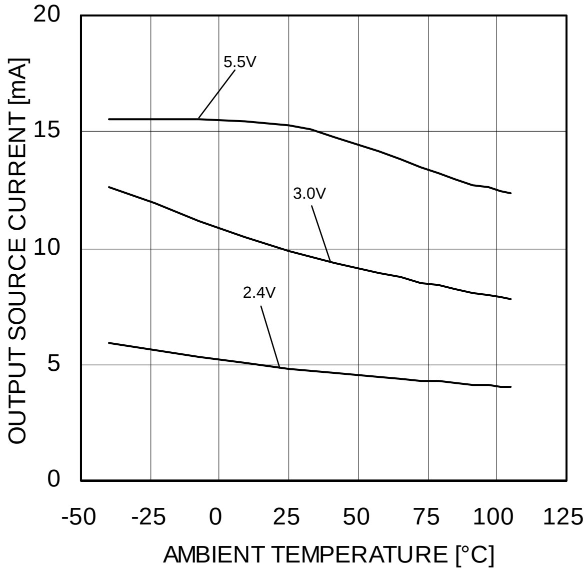


Figure 11.
Output Source Current – Ambient Temperature
(OUT=VDD-0.4V)

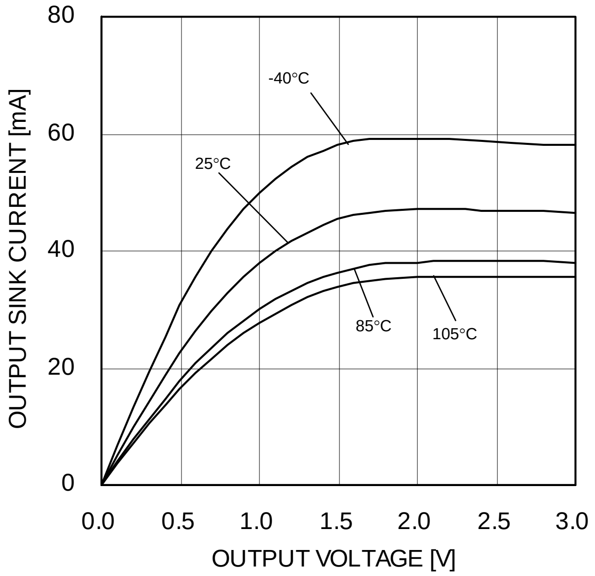


Figure 12.
Output Sink Current – Output Voltage
(VDD=3V)

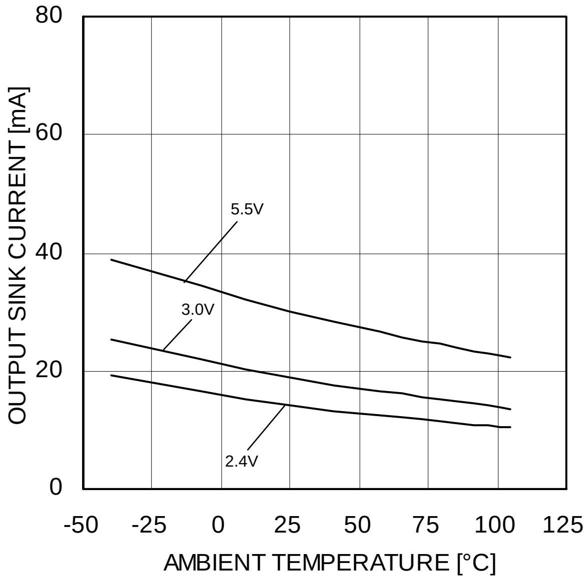


Figure 13.
Output Sink Current – Ambient Temperature
(OUT=VSS+0.4V)

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7291, BU7291S

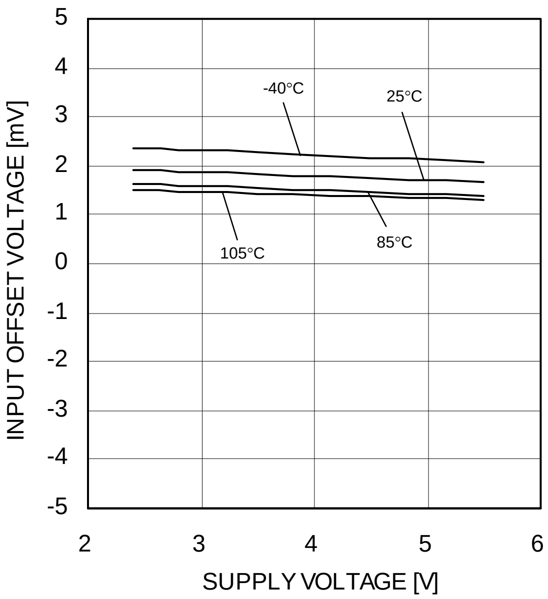


Figure 14.
Input Offset Voltage – Supply Voltage
(Vicm=VDD, OUT=1.5V)

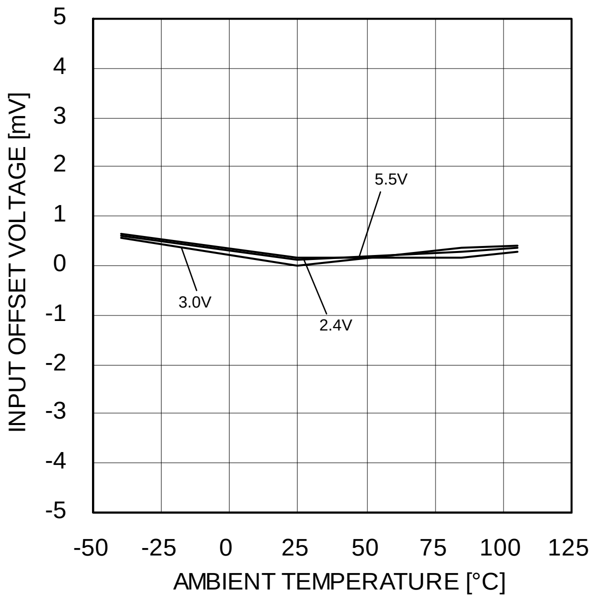


Figure 15.
Input Offset Voltage – Ambient Temperature
(Vicm=VDD, OUT=1.5V)

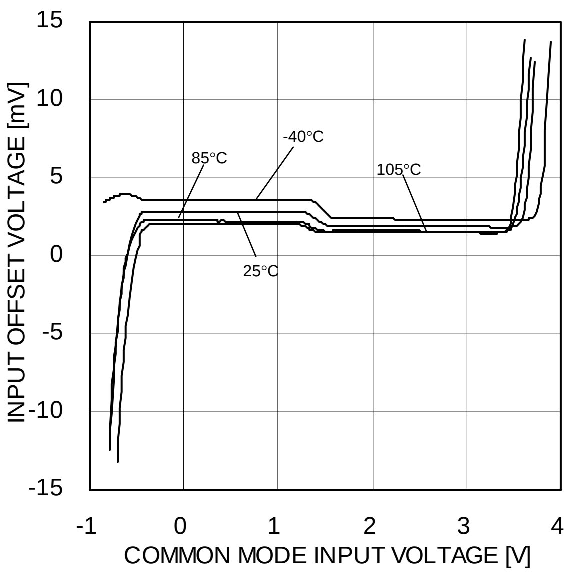


Figure 16.
Input Offset Voltage –
Common Mode Input Voltage
(VDD=3V)

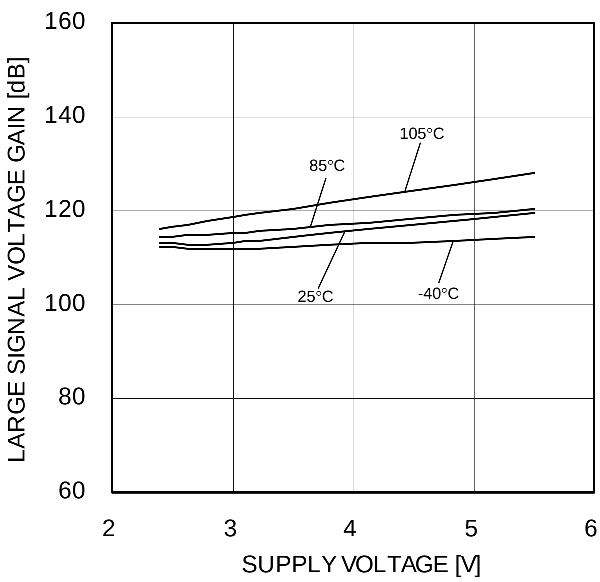


Figure 17.
Large Signal Voltage Gain – Supply Voltage

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

●Typical Performance Curves - Continued

○BU7291, BU7291S

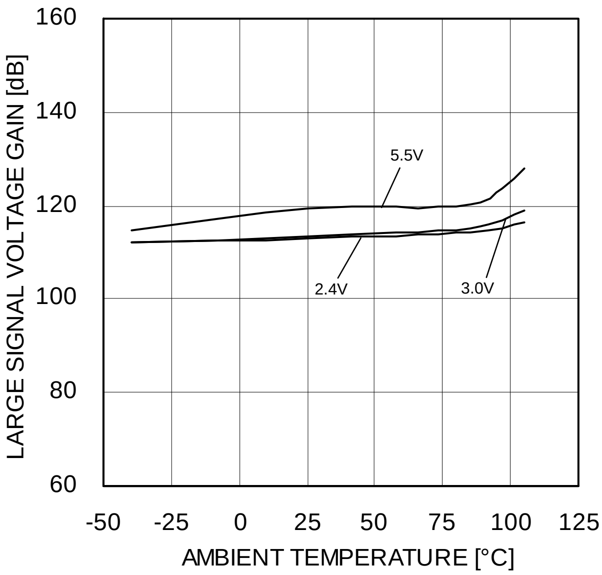


Figure 18.
Large Signal Voltage Gain – Ambient Temperature

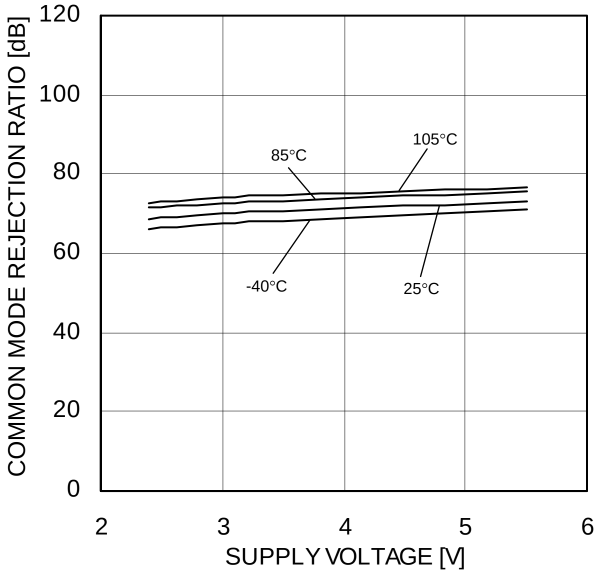


Figure 19.
Common Mode Rejection Ratio – Supply Voltage

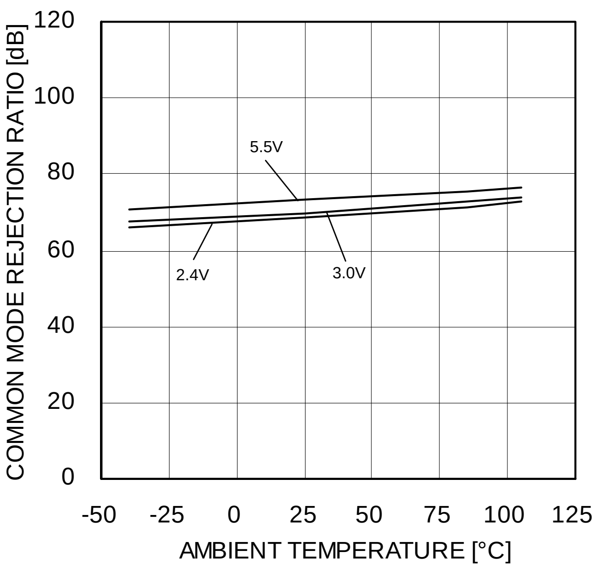


Figure 20.
Common Mode Rejection Ratio – Ambient Temperature

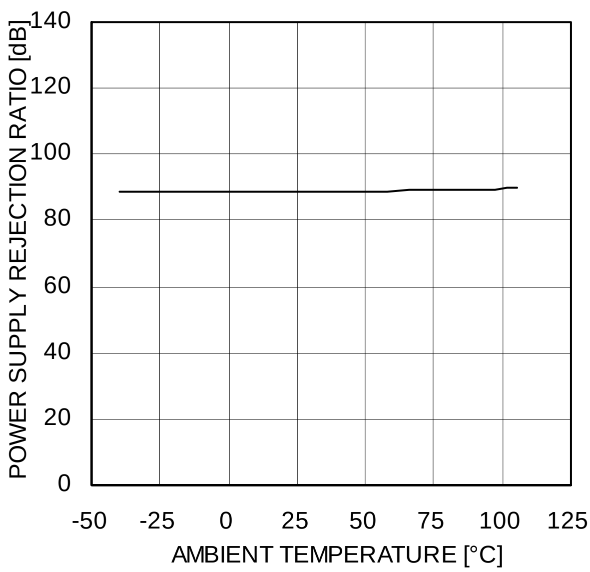


Figure 21.
Power Supply Rejection Ratio – Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

●Typical Performance Curves - Continued

○BU7291, BU7291S

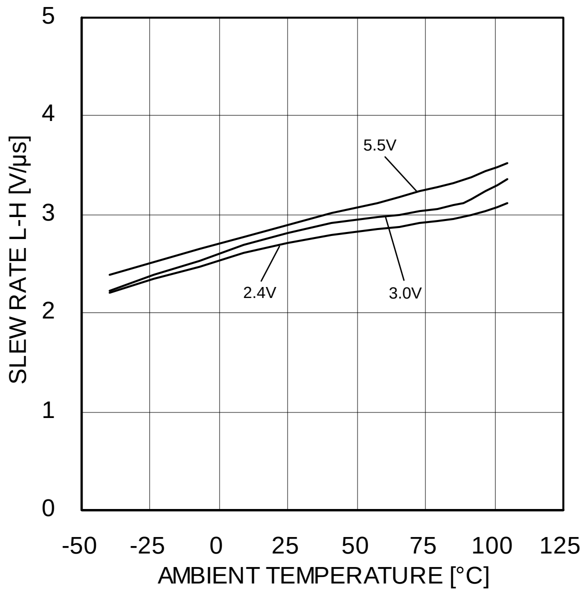


Figure 22.
Slew Rate L-H – Ambient Temperature

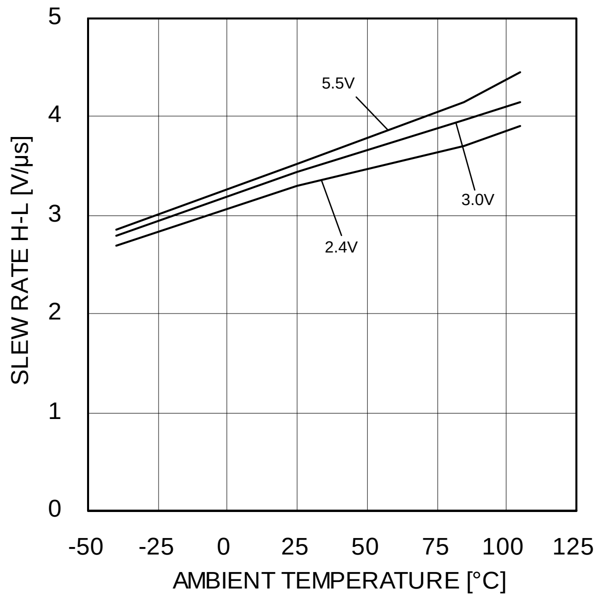


Figure 23.
Slew Rate H-L – Ambient Temperature

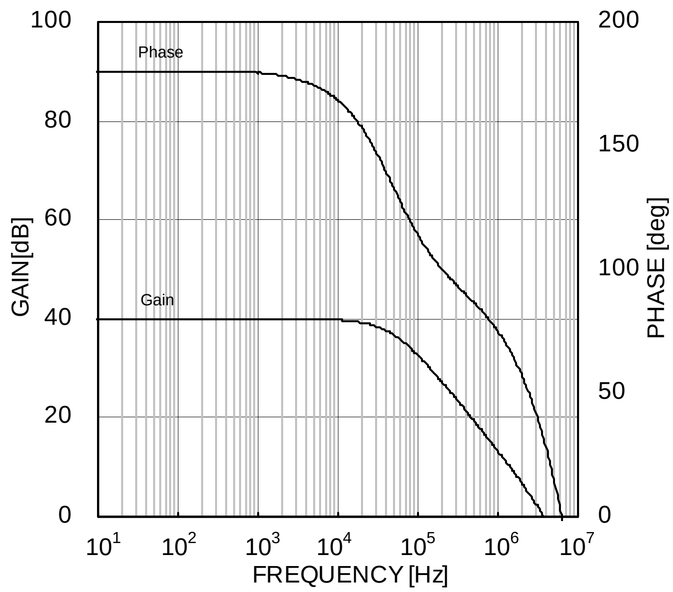


Figure 24.
Voltage Gain・Phase－Frequency

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7291G: -40°C to +85°C BU7291SG: -40°C to +105°C

●Typical Performance Curves - Continued

○BU7294, BU7294S

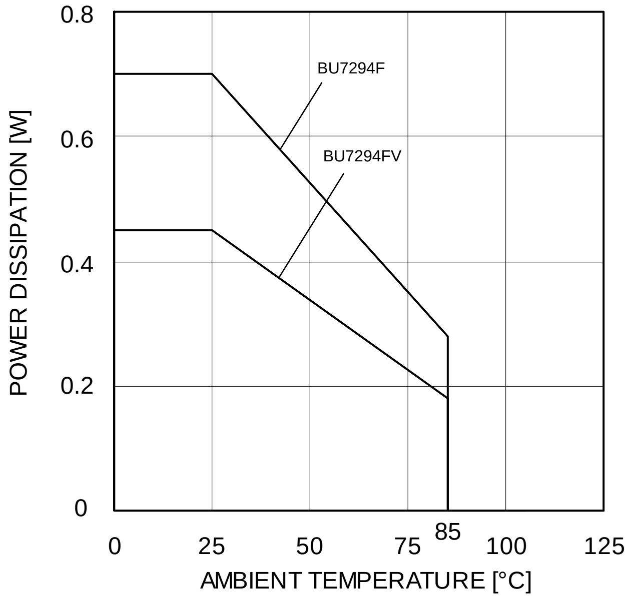


Figure 25.
Derating curve

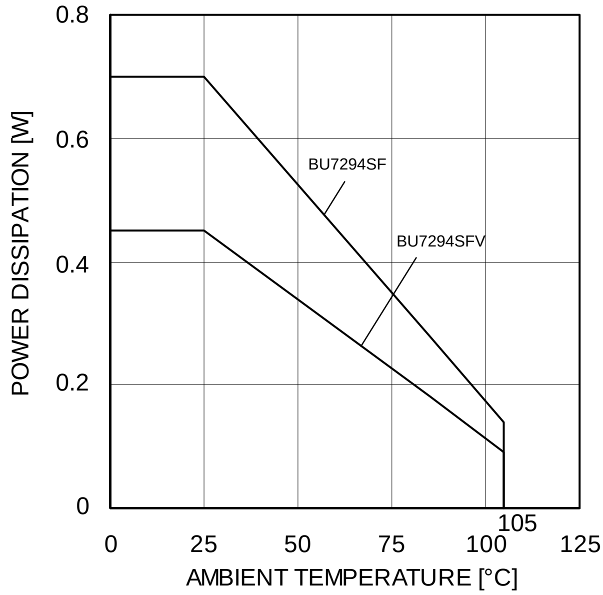


Figure 26.
Derating curve

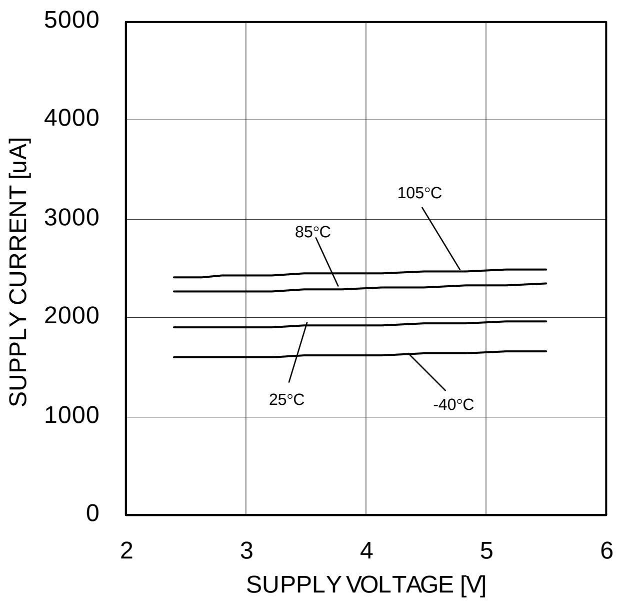


Figure 27.
Supply Current – Supply Voltage

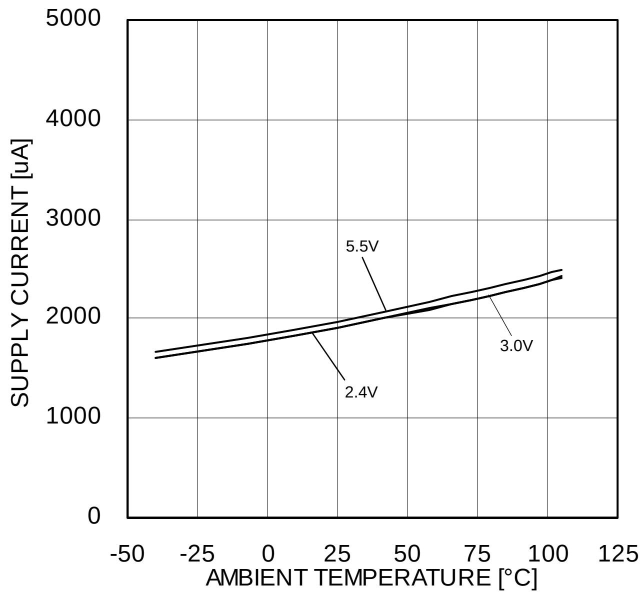


Figure 28.
Supply Current – Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294G: -40°C to +85°C BU7294SG: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7294, BU7294S

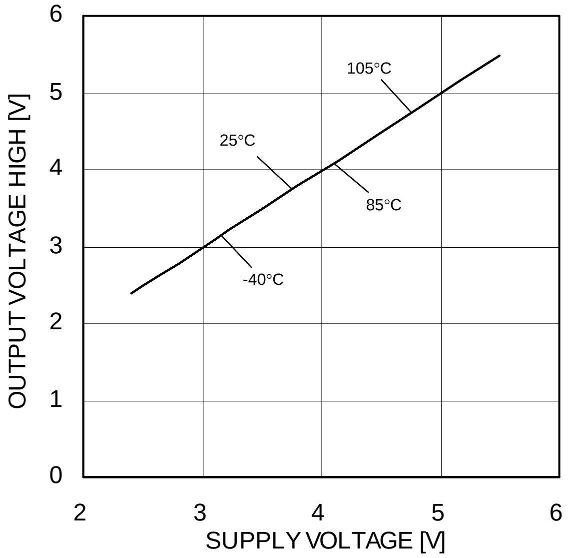


Figure 29.
Maximum Output Voltage High –
Supply Voltage
(RL=10kΩ)

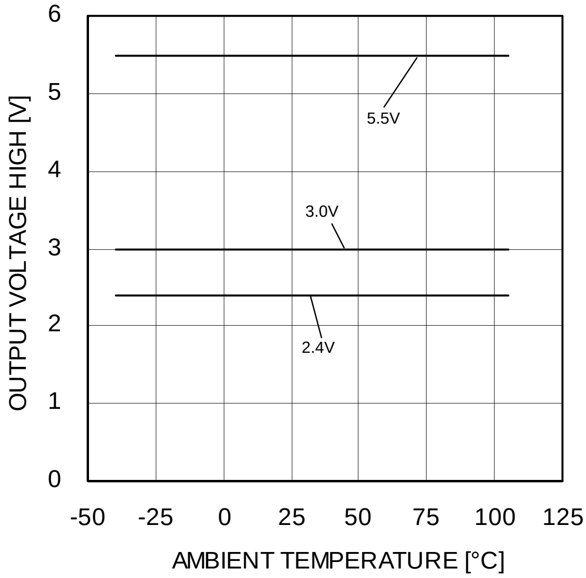


Figure 30.
Maximum Output Voltage High –
Ambient Temperature
(RL=10kΩ)

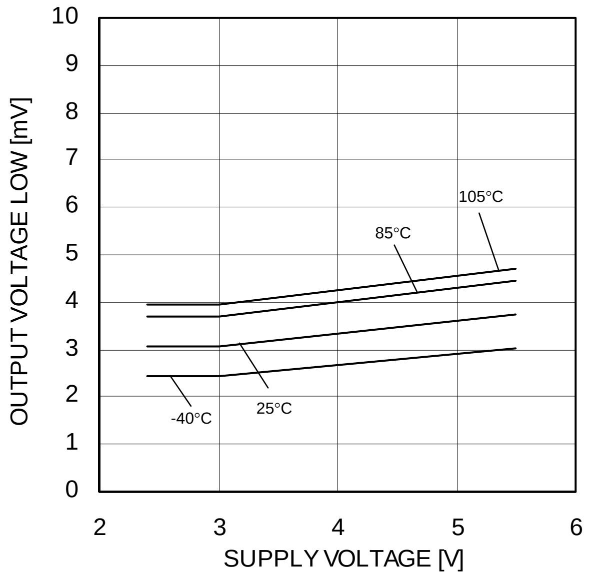


Figure 31.
Maximum Output Voltage Low –
Supply Voltage
(RL=10kΩ)

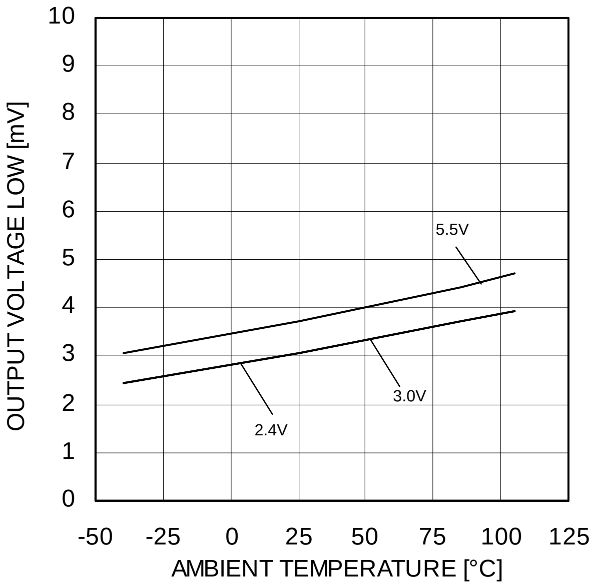


Figure 32.
Maximum Output Voltage Low –
Ambient Temperature
(RL=10kΩ)

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294G: -40°C to +85°C BU7294SG: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7294, BU7294S

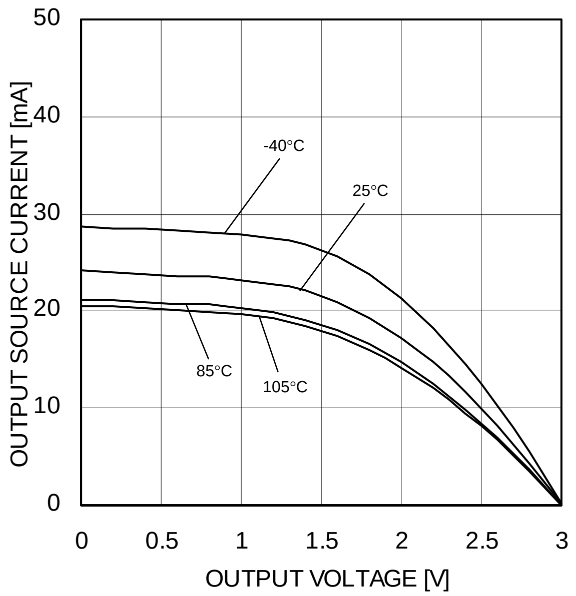


Figure 33.
Output Source Current – Output Voltage
(VDD=3V)

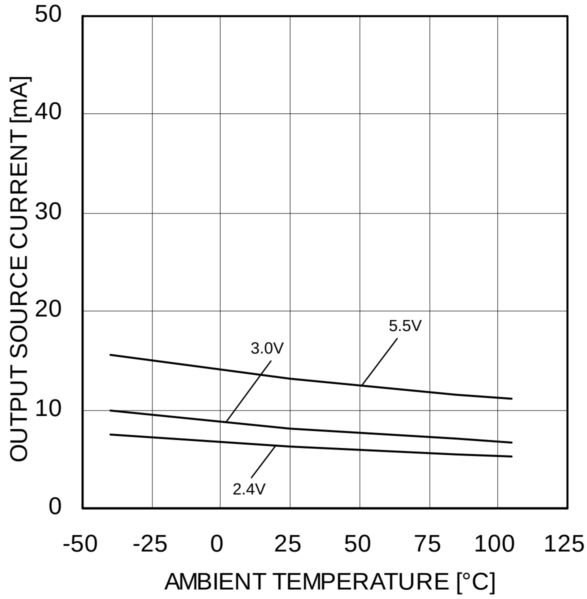


Figure 34.
Output Source Current –Ambient Temperature
(OUT=VDD-0.4V)

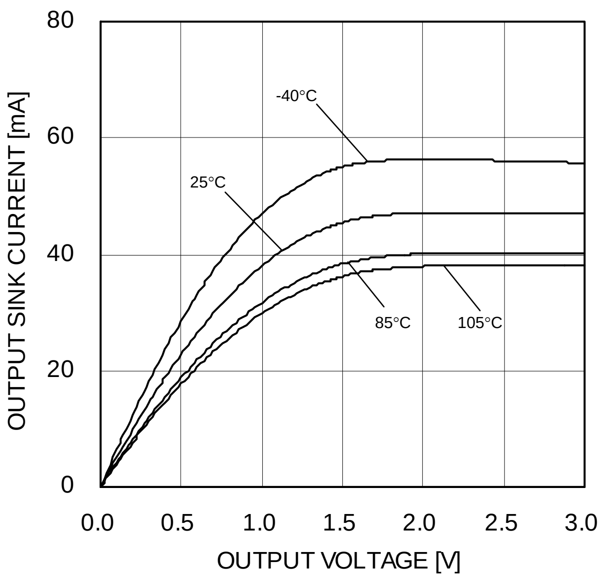


Figure 35.
Output Sink Current – Output Voltage
(VDD=3V)

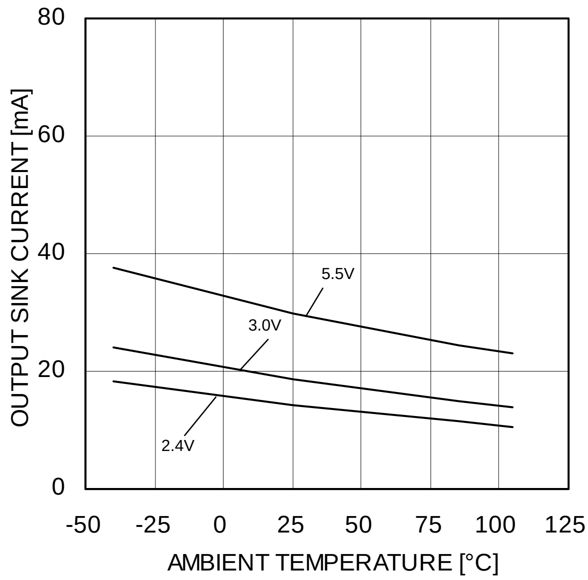


Figure 36.
Output Sink Current – Ambient Temperature
(OUT=VSS+0.4V)

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294: -40°C to +85°C BU7294S: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7294, BU7294S

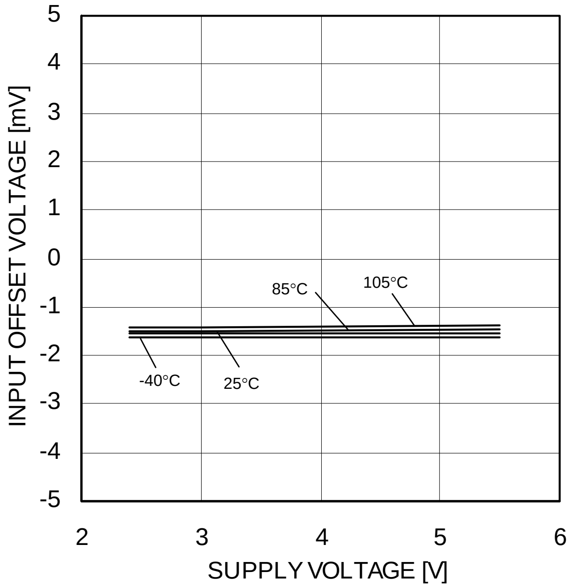


Figure 37.
Input Offset Voltage – Supply Voltage

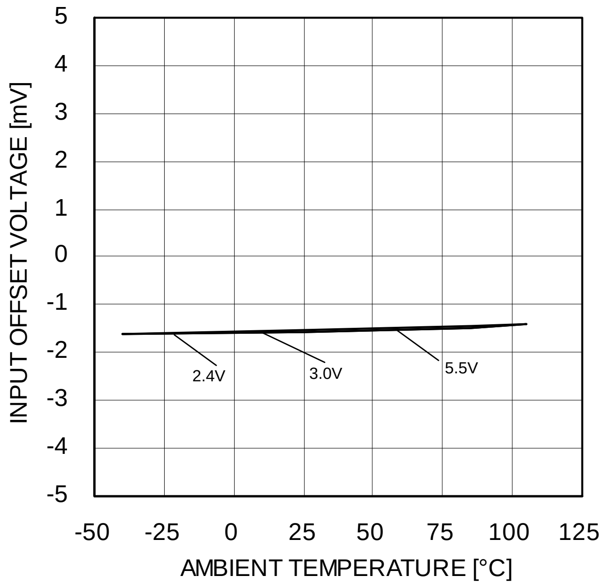


Figure 38.
Input Offset Voltage – Ambient Temperature

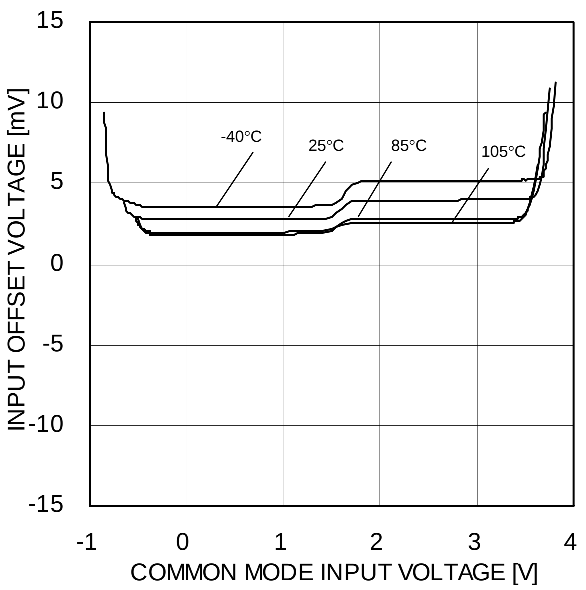


Figure 39.
Input Offset Voltage –
Common Mode Input Voltage
(VDD=3V)

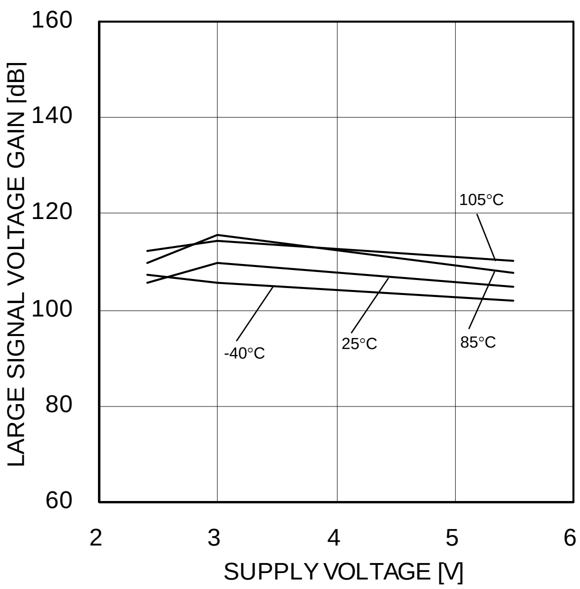


Figure 40.
Large Signal Voltage Gain – Supply Voltage

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294: -40°C to +85°C BU7294S: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7294, BU7294S

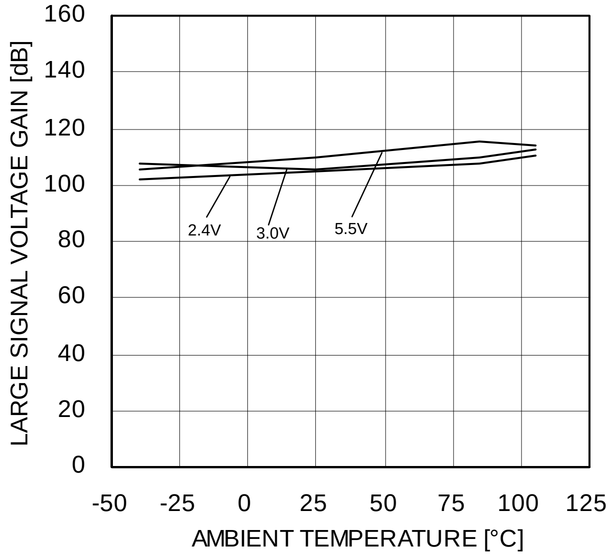


Figure 41.
Large Signal Voltage Gain – Ambient Temperature

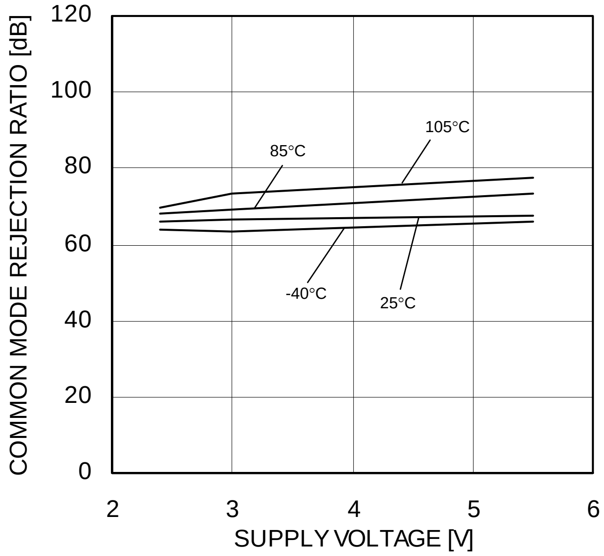


Figure 42.
Common Mode Rejection Ratio – Supply Voltage

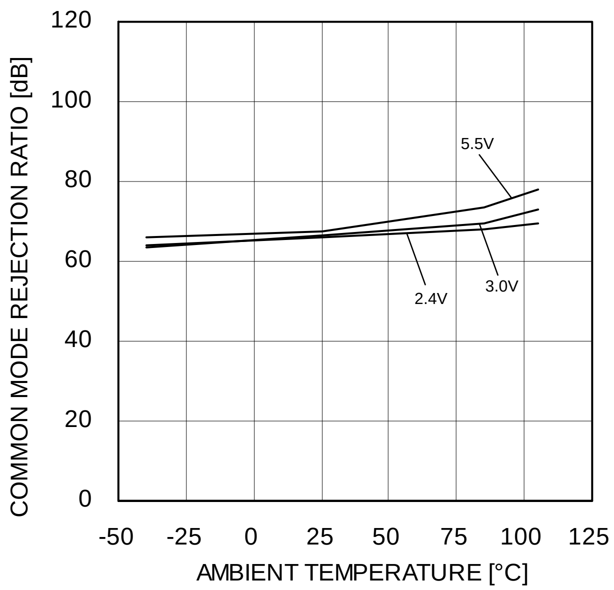


Figure 43.
Common Mode Rejection Ratio – Ambient Temperature

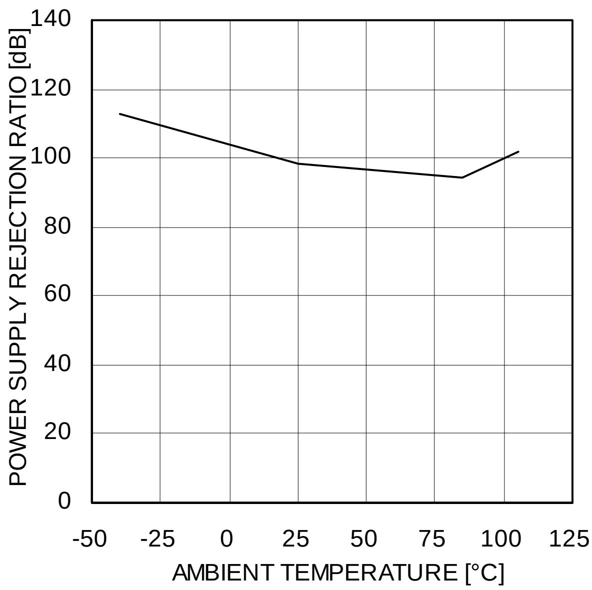


Figure 44.
Power Supply Rejection Ratio – Ambient Temperature

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294: -40°C to +85°C BU7294S: -40°C to +105°C

●**Typical Performance Curves - Continued**

○BU7294, BU7294S

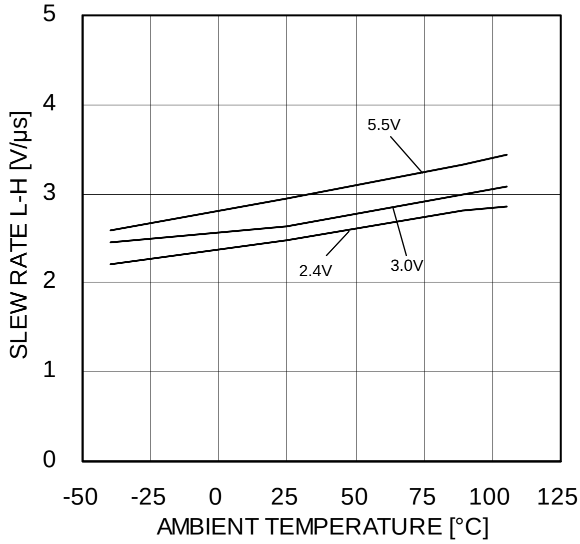


Figure 45.
Slew Rate L-H – Ambient Temperature

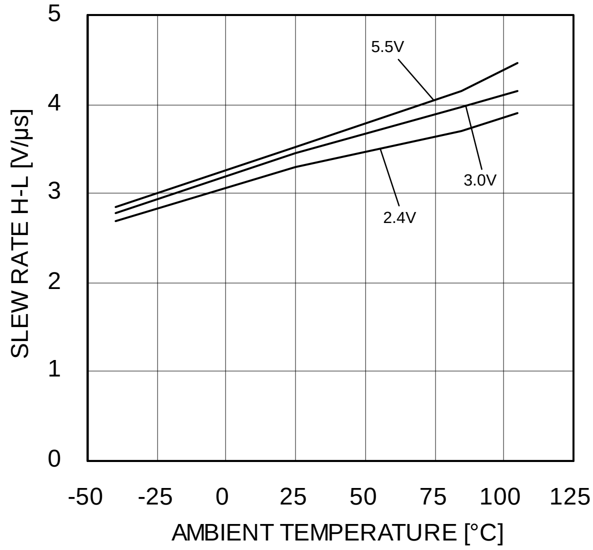


Figure 46.
Slew Rate H-L – Ambient Temperature

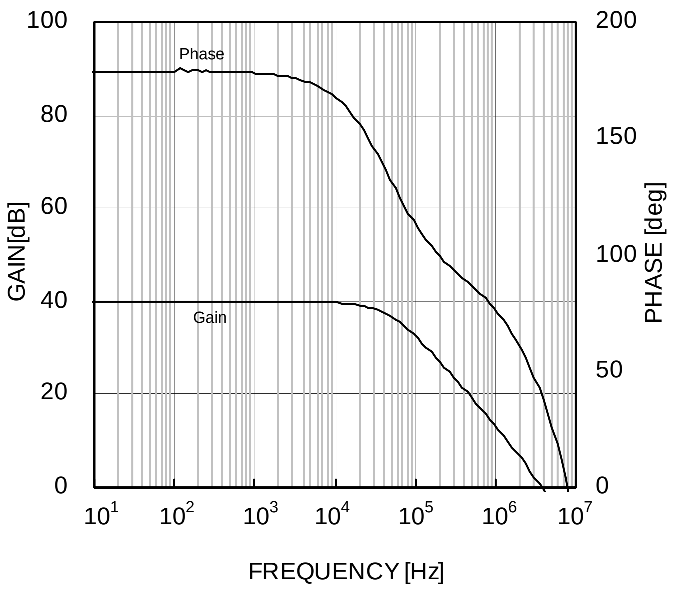


Figure 47.
Voltage Gain・Phase－Frequency

(*)The data above is measurement value of typical sample, it is not guaranteed.
BU7294: -40°C to +85°C BU7294S: -40°C to +105°C

● **Application Information**

NULL method condition for Test circuit1

VDD, VSS, EK, Vicm Unit:V

Parameter	VF	S1	S2	S3	VDD	VSS	EK	Vicm	Calculation
Input Offset Voltage	VF1	ON	ON	OFF	3	0	-1.5	3	1
Large Signal Voltage Gain	VF2	ON	ON	ON	3	0	-0.5	1.5	2
	VF3						-2.5		
Common-mode Rejection Ratio (Input Common-mode Voltage Range)	VF4	ON	ON	OFF	3	0	-1.5	0	3
	VF5							3	
Power Supply Rejection Ratio	VF6	ON	ON	OFF	2.4	0	-1.2	0	4
	VF7				5.5				

－ Calculation－

1. Input Offset Voltage (Vio)

$$Vio = \frac{|VF1|}{1+RF/RS} \quad [V]$$

2. Large Signal Voltage Gain(Av)

$$Av = 20Log \frac{2 \times (1+RF/RS)}{|VF2-VF3|} \quad [dB]$$

3. Common-mode Rejection Ratio (CMRR)

$$CMRR = 20Log \frac{1.8 \times (1+RF/RS)}{|VF4 - VF5|} \quad [dB]$$

4. Power Supply Rejection Ratio (PSRR)

$$PSRR = 20Log \frac{3.8 \times (1+ RF/RS)}{|VF6 - VF7|} \quad [dB]$$

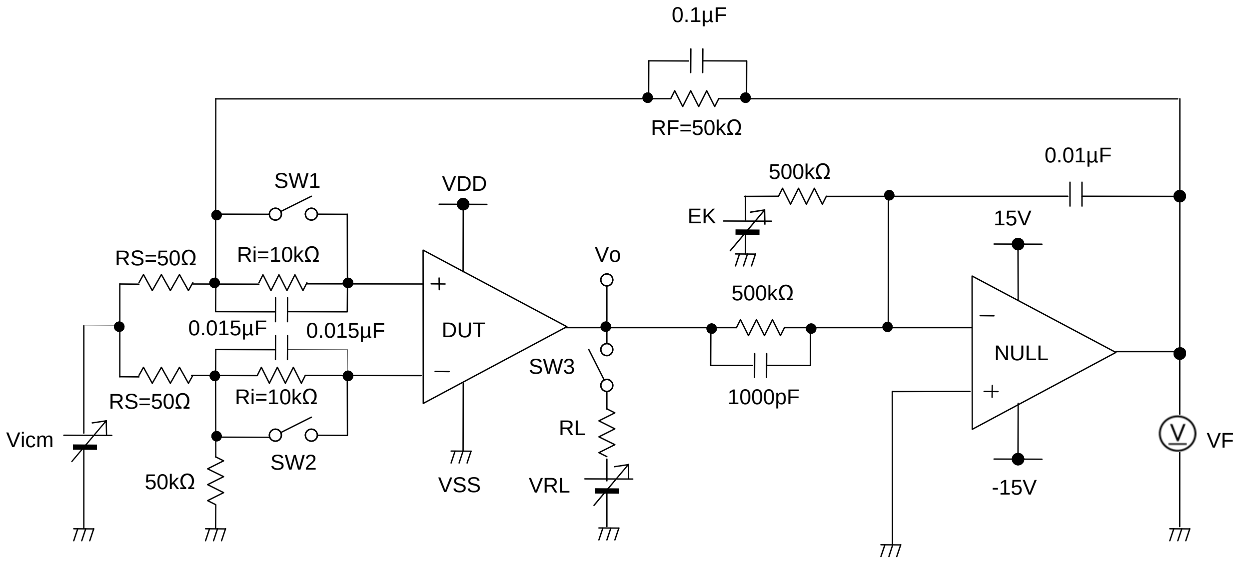


Figure 48. Test circuit 1 (one channel only)

Switch Condition for Test circuit2

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
Unity Gain Frequency	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON

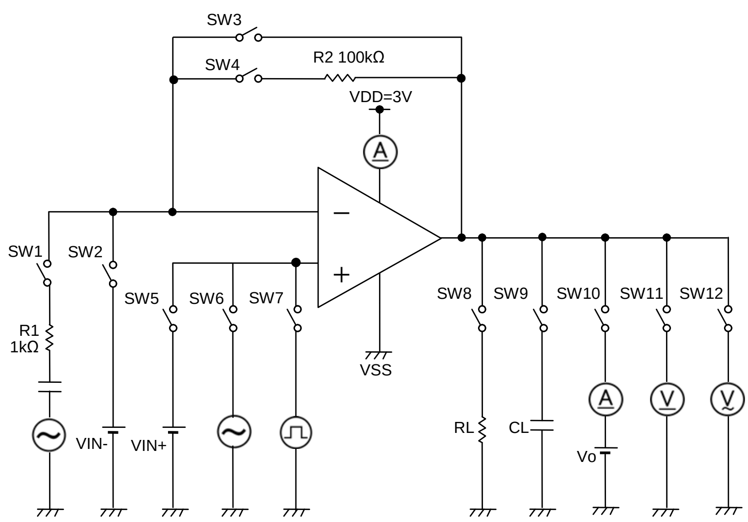


Figure 49. Test circuit 2

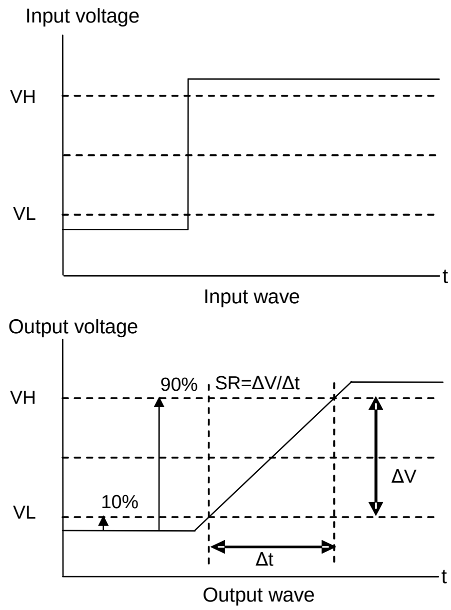
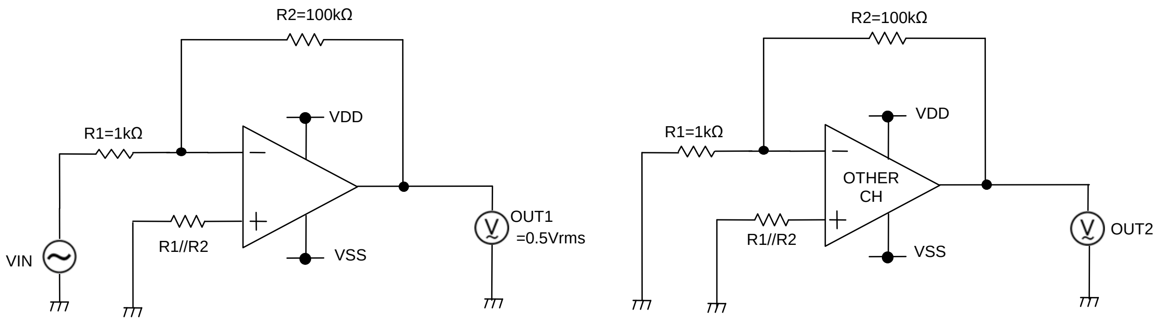


Figure 50. Slew rate input output wave



$$CS = 20Log\frac{100\times OUT1}{OUT2}$$

Figure 51. Test circuit 3 (Channel Separation)

●Application example

○Voltage follower

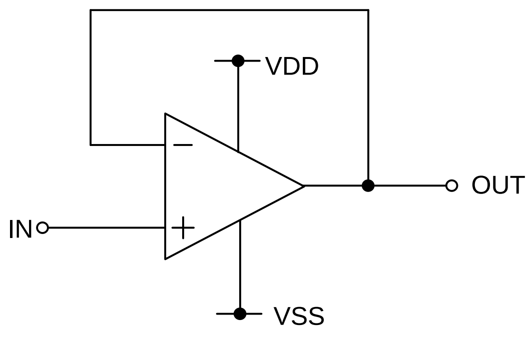


Figure 52. Voltage follower

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. Computation for output voltage (OUT) is shown below.
OUT=IN

○Inverting amplifier

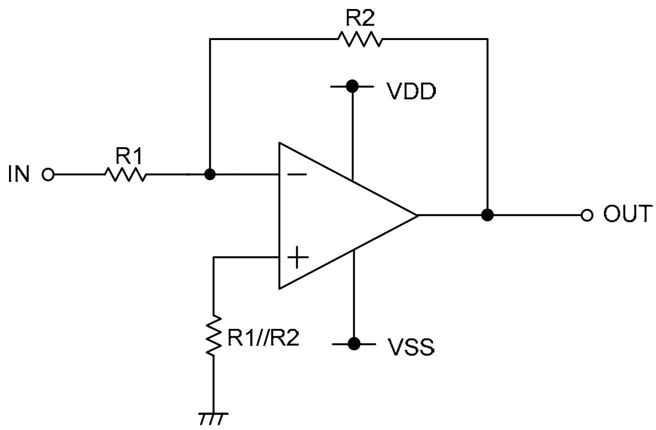


Figure 53. Inverting amplifier circuit

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

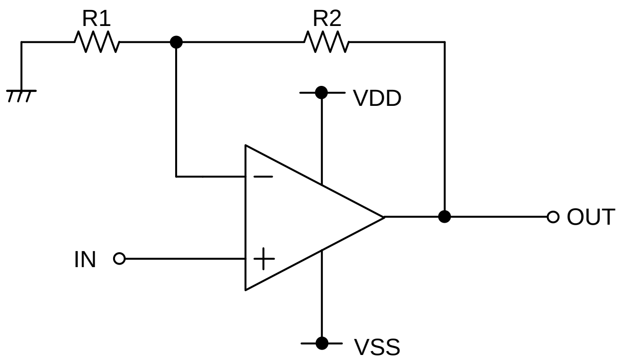


Figure 54. Non-inverting amplifier circuit

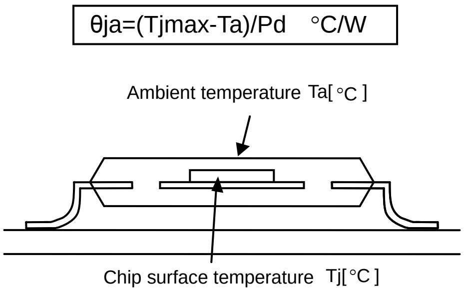
For non-inverting amplifier, input voltage (IN) is amplified by a voltage gain, which depends on the ratio of R1 and R2. The output voltage (OUT) is in-phase with the input voltage (IN) and is shown in the next expression.
OUT=(1 + R2/R1)・IN
Effectively, this circuit has high input impedance since its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

●Power Dissipation

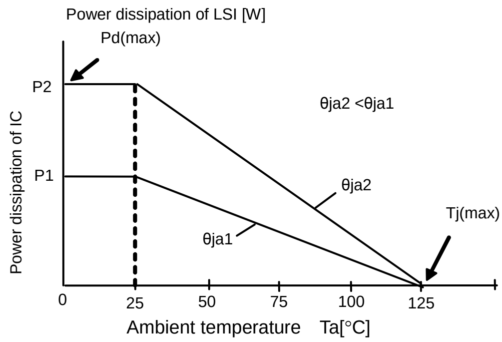
Power dissipation (total loss) indicates the power that the IC can consume at Ta=25°C (normal temperature). As the IC consumes power, it heats up, causing its temperature to be higher than the ambient temperature. The allowable temperature that the IC can accept is limited. This depends on the circuit configuration, manufacturing process, and consumable power.
Power dissipation is determined by the allowable temperature within the IC (maximum junction temperature) and the thermal resistance of the package used (heat dissipation capability). Maximum junction temperature is typically equal to the maximum storage temperature. The heat generated through the consumption of power by the IC radiates from the mold resin or lead frame of the package. Thermal resistance, represented by the symbol θja°C/W, indicates this heat dissipation capability. Similarly, the temperature of an IC inside its package can be estimated by thermal resistance.
Figure 55. (a) shows the model of the thermal resistance of a package. The equation below shows how to compute for the Thermal resistance (θja), given the ambient temperature (Ta), maximum junction temperature (Tjmax), and power dissipation (Pd).

$$\theta ja = (Tjmax - Ta) / Pd \quad °C/W \quad \cdots\cdots \quad (I)$$

The Derating curve in Figure 55. (b) indicates the power that the IC can consume with reference to ambient temperature. Power consumption of the IC begins to attenuate at certain temperatures. This gradient is determined by Thermal resistance (θja), which depends on the chip size, power consumption, package, ambient temperature, package condition, wind velocity, etc. This may also vary even when the same of package is used. Thermal reduction curve indicates a reference value measured at a specified condition. Figure 56. (c) to (d) shows an example of the derating curve for BU7291, BU7291S, BU7294, BU7294S.

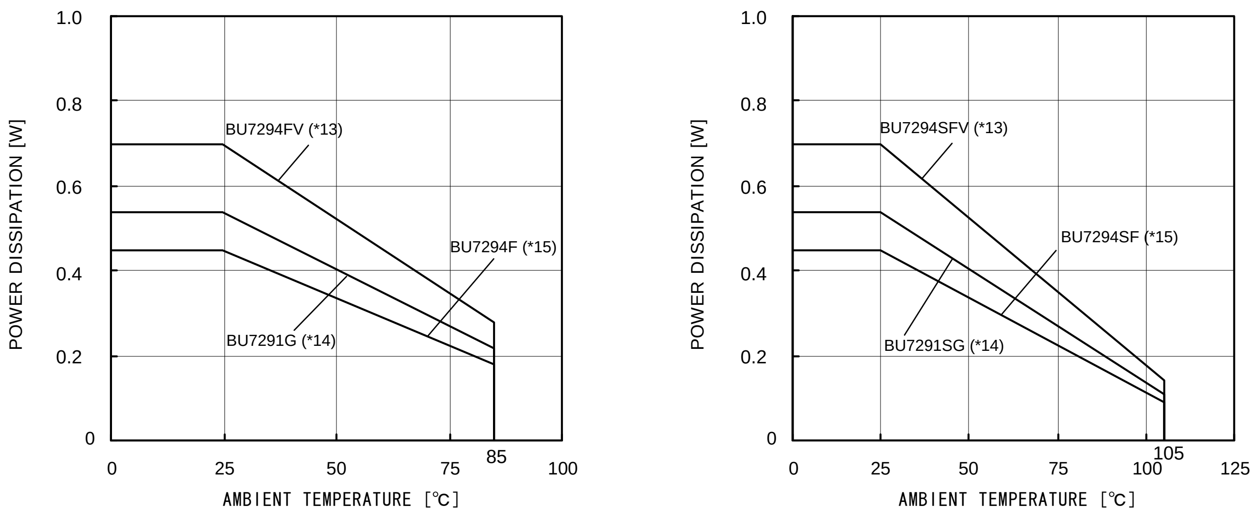


(a) Thermal resistance



(b) Derating curve

Figure 55. Thermal resistance and Derating Curve



(*13)	(*14)	(*15)	Unit
7.0	5.4	4.5	mW/°C

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

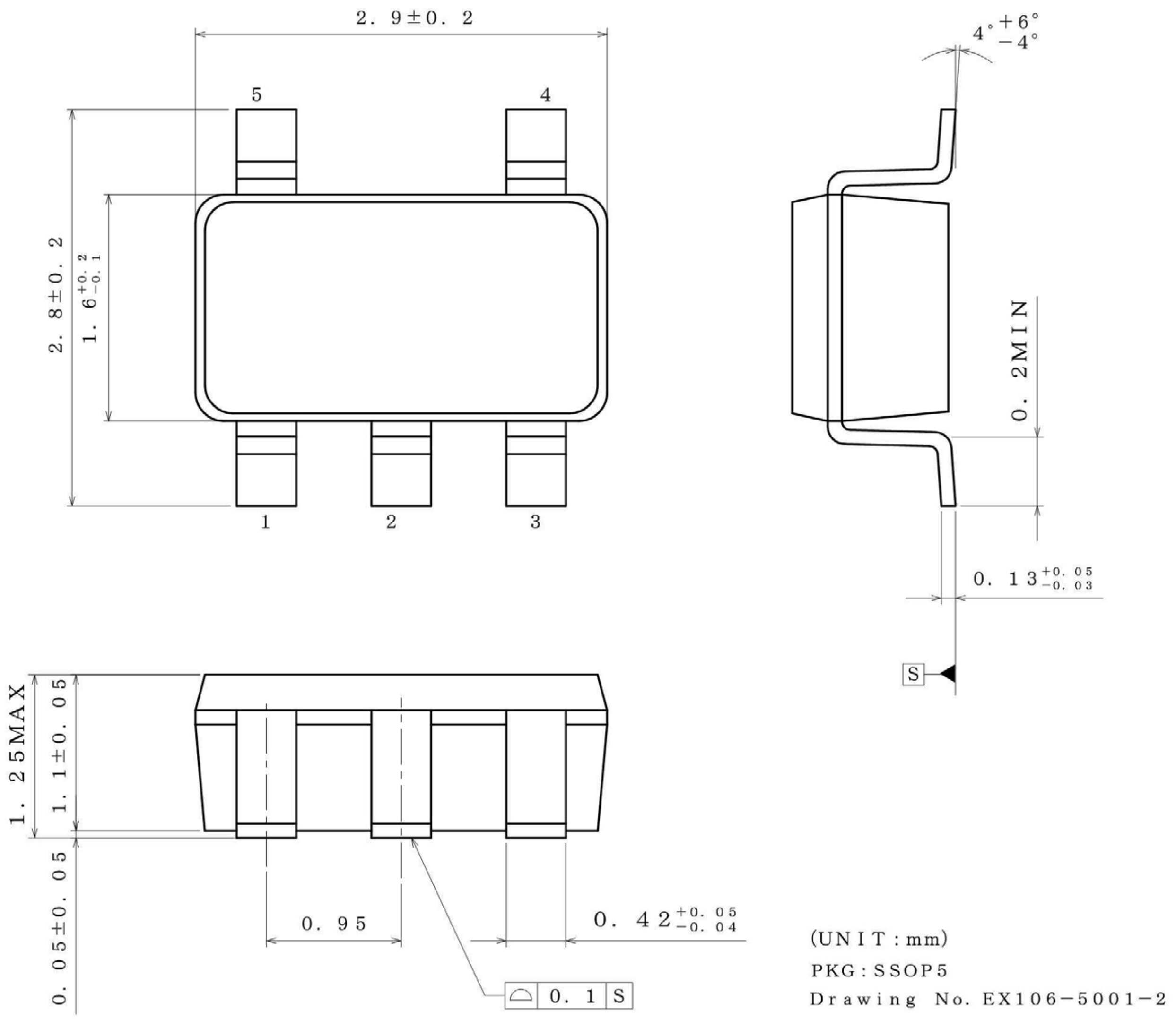
Figure 56. Derating Curve

●Operational Notes

1) Absolute maximum ratings
Absolute maximum ratings are the values which indicate the limits, within which the given voltage range can be safely charged to the terminal. However, it does not guarantee the circuit operation.
2) Applied voltage to the input terminal
For normal circuit operation of voltage comparator, please input voltage for its input terminal within input common mode voltage VDD + 0.3V. Then, regardless of power supply voltage,VSS - 0.3V can be applied to input terminals without deterioration or destruction of its characteristics.
3) Power supply (single / dual)
The op-amp operates when the voltage supplied is between VDD and VSS.
Therefore, the single supply op-amp can be used as dual supply op-amp as well.
4) Power dissipation Pd
Using the unit in excess of the rated power dissipation may cause deterioration in electrical characteristics including reduced current capability due to the rise of chip temperature. Therefore, please take into consideration the power dissipation (Pd) under actual operating conditions and apply a sufficient margin in thermal design. Refer to the thermal derating curves for more information.
5) Short-circuit between pins and erroneous mounting
Be careful when mounting the IC on printed circuit boards. The IC may be damaged if it is mounted in a wrong orientation or if pins are shorted together. Short circuit may be caused by conductive particles caught between the pins.
6) Short-circuit between pins and erroneous mounting
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.
7) IC handling
Applying mechanical stress to the IC by deflecting or bending the board may cause fluctuations in the electrical characteristics due to piezo resistance effects.
8) Board inspection
Connecting a capacitor to a pin with low impedance may stress the IC. Therefore, discharging the capacitor after every process is recommended. In addition, when attaching and detaching the jig during the inspection phase, make sure that the power is turned OFF before inspection and removal. Furthermore, please take measures against ESD in the assembly process as well as during transportation and storage.
9) Output capacitor
If a large capacitor is connected between the output pin and VSS pin, current from the charged capacitor will flow into the output pin and may destroy the IC when the VDD pin or VIN pin is shorted to ground or pulled down to 0V. Use a capacitor smaller than 0.1μF between output pin and VSS pin.
10) 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.
11) Latch up
Be careful of input voltage that exceed the VDD and VSS. When CMOS device have sometimes occur latch up and protect the IC from abnormaly noise.

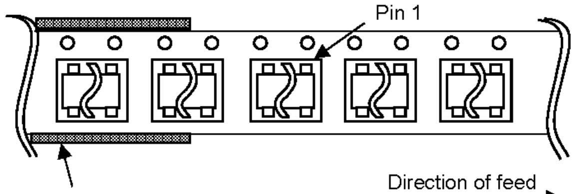
●Physical Dimensions Tape and Reel Information

Package Name	SSOP5

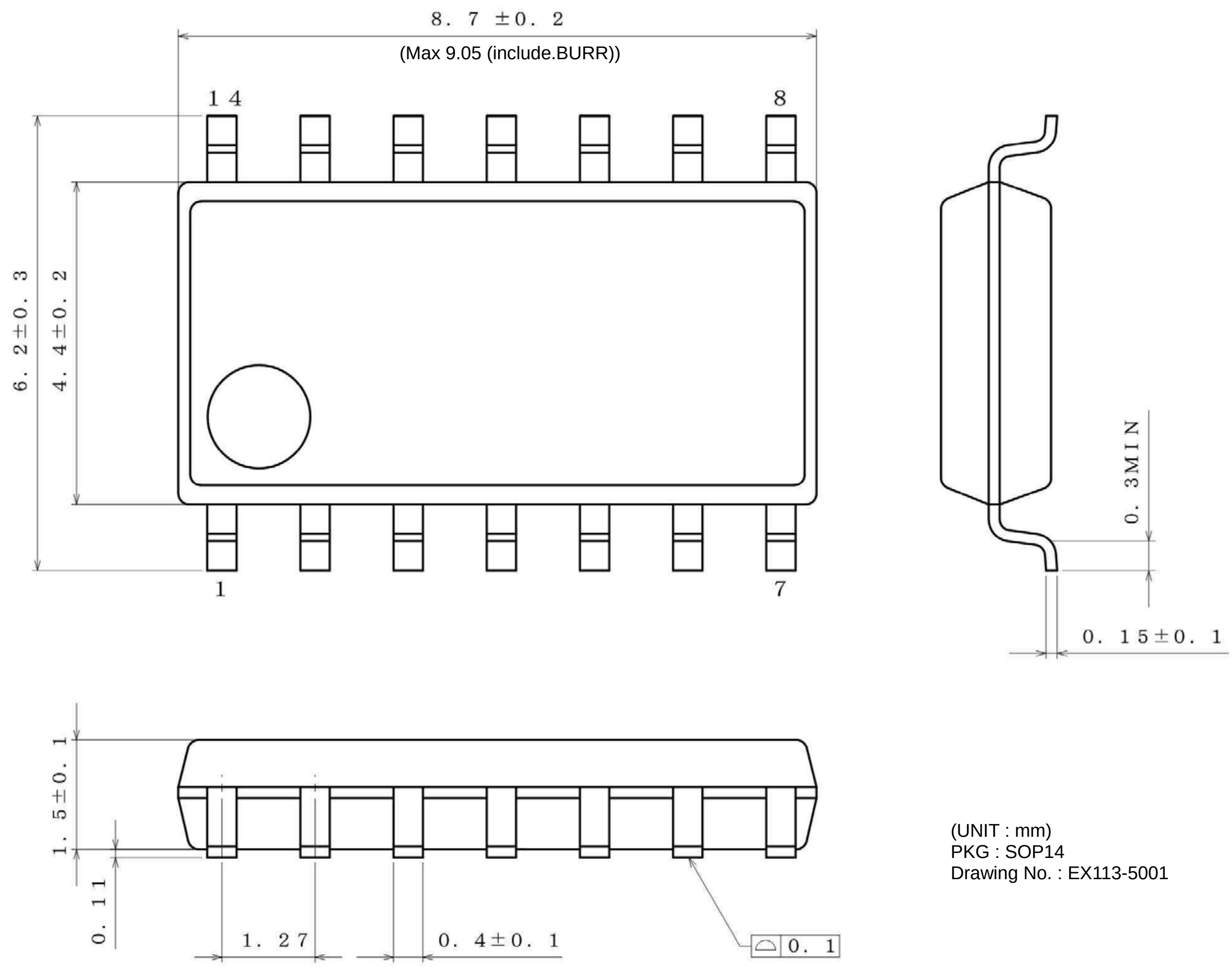


< Tape and Reel Information >

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



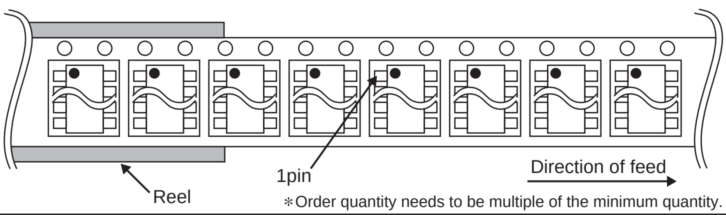
Package Name	SOP14



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

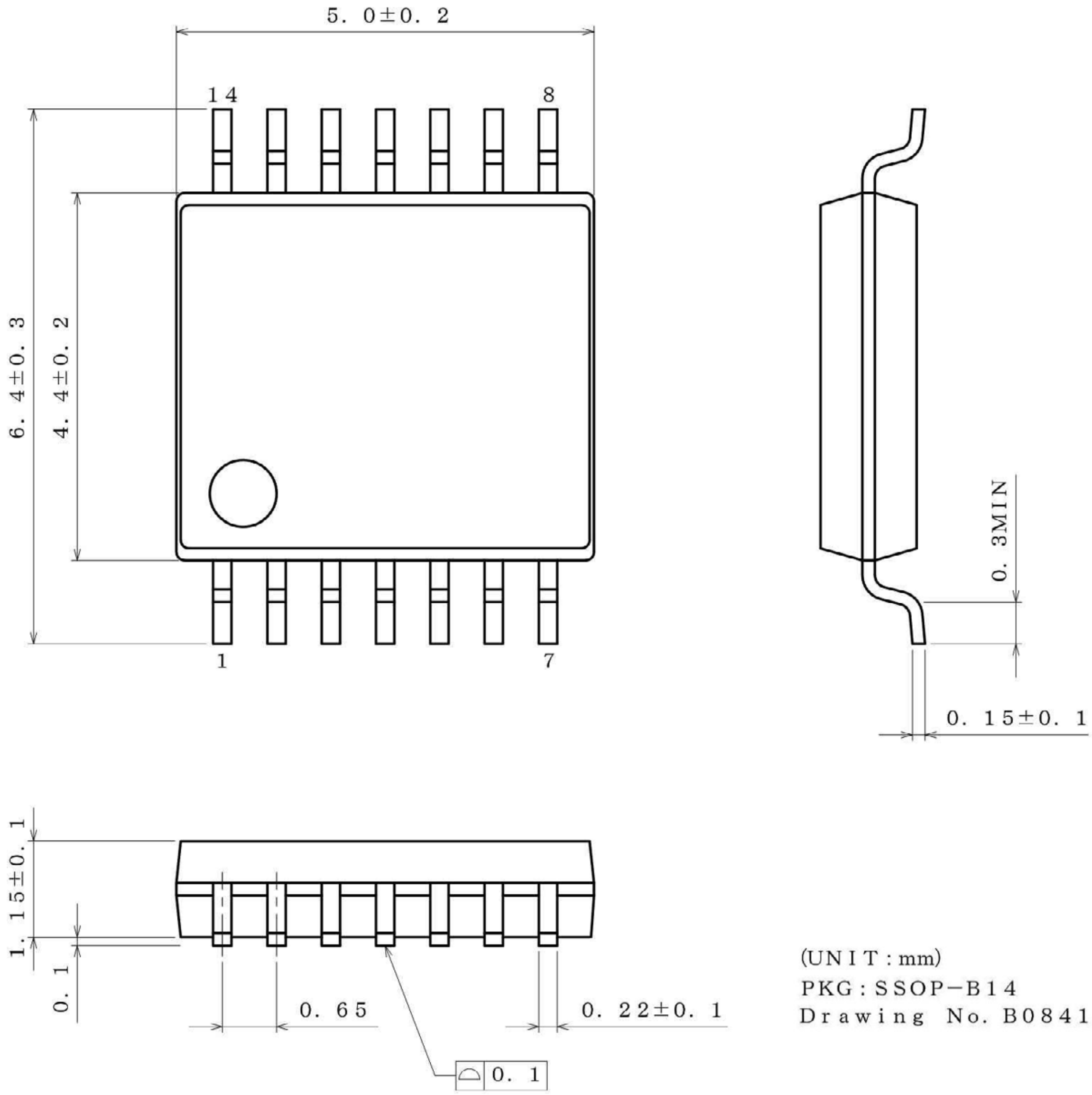
<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (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)



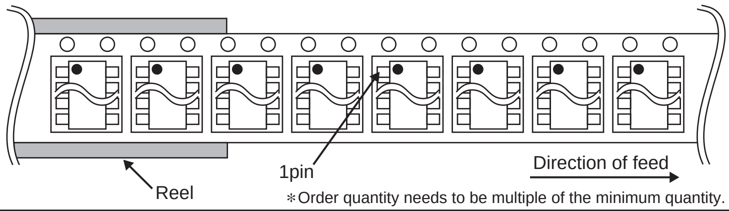
∗Order quantity needs to be multiple of the minimum quantity.

Package Name	SSOP-B14



<Tape and Reel information>

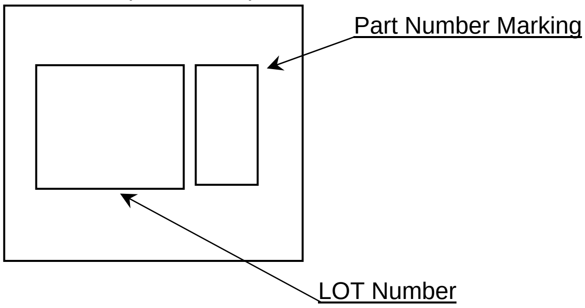
Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



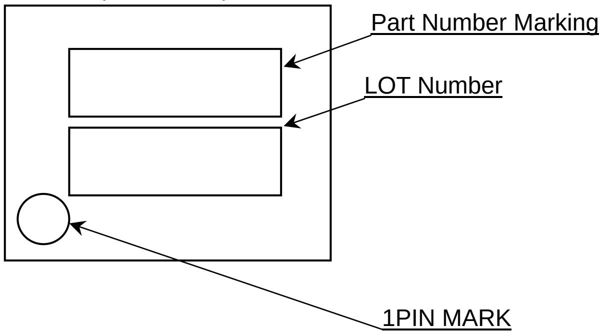
*Order quantity needs to be multiple of the minimum quantity.

●Marking Diagram

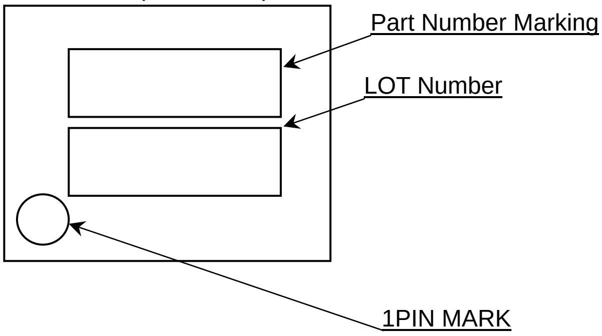
SSOP5(TOP VIEW)



SOP14(TOP VIEW)



SSOP-B14(TOP VIEW)



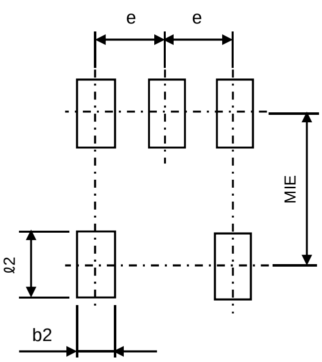
Product Name		Package Type	Marking
BU7291	G	SSOP5	D1
BU7291S	G	SSOP5	FB
BU7294	F	SOP14	BU7294F
BU7294	FV	SSOP-B14	7294
BU7294S	F	SOP14	BU7294SF
BU7294S	FV	SSOP-B14	7294S

●Land pattern data

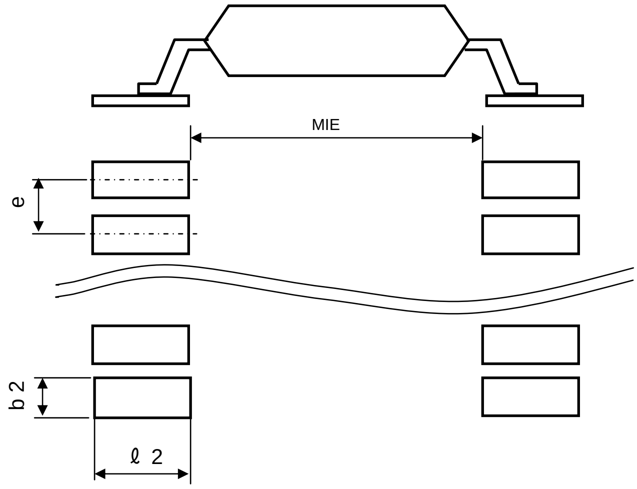
all dimensions in mm

PKG	Land pitch e	Land space MIE	Land length ≧ℓ 2	Land width b2
SSOP5	0.95	2.4	1.0	0.6
SOP14	1.27	4.60	1.10	0.76
SSOP-B14	0.65	4.60	1.20	0.35

SSOP5



SOP14, SSOP-B14



●Revision History

Date	Revision	Changes
22.May.2013	001	New Release

Notice

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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

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data. ROHM shall not be in any way responsible or liable for infringement of any intellectual property rights or other damages arising from use of such information or data.:

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Other Precaution

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2. The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.

3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.

4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

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