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
- SSOP5: W(Typ) x D(Typ) x H(Max) 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)
**Pin Configuration**

**BU7291G, BU7291SG : SSOP5**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+IN</td>
</tr>
<tr>
<td>2</td>
<td>VSS</td>
</tr>
<tr>
<td>3</td>
<td>-IN</td>
</tr>
<tr>
<td>4</td>
<td>OUT</td>
</tr>
<tr>
<td>5</td>
<td>VDD</td>
</tr>
</tbody>
</table>

**BU7294F, BU7294SF : SOP14**

**BU7294FV, BU7294SFV : SSOP-B14**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OUT1</td>
</tr>
<tr>
<td>2</td>
<td>-IN1</td>
</tr>
<tr>
<td>3</td>
<td>+IN1</td>
</tr>
<tr>
<td>4</td>
<td>VDD</td>
</tr>
<tr>
<td>5</td>
<td>+IN2</td>
</tr>
<tr>
<td>6</td>
<td>-IN2</td>
</tr>
<tr>
<td>7</td>
<td>OUT2</td>
</tr>
<tr>
<td>8</td>
<td>OUT3</td>
</tr>
<tr>
<td>9</td>
<td>-IN3</td>
</tr>
<tr>
<td>10</td>
<td>+IN3</td>
</tr>
<tr>
<td>11</td>
<td>VSS</td>
</tr>
<tr>
<td>12</td>
<td>+IN4</td>
</tr>
<tr>
<td>13</td>
<td>-IN4</td>
</tr>
<tr>
<td>14</td>
<td>OUT4</td>
</tr>
</tbody>
</table>

**Ordering Information**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Packaging and forming specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>BU7291G</td>
<td>SSOP5</td>
<td>E2: Embossed tape and reel (SSOP5)</td>
</tr>
<tr>
<td>BU7291SG</td>
<td>SOP14</td>
<td>TR: Embossed tape and reel (SOP14/ SSOP-B14)</td>
</tr>
<tr>
<td>BU7294xx</td>
<td>F:SOP14</td>
<td></td>
</tr>
<tr>
<td>BU7294Sxx</td>
<td>FV:SSOP-B14</td>
<td></td>
</tr>
</tbody>
</table>

**Package**

<table>
<thead>
<tr>
<th></th>
<th>SSOP5</th>
<th>SOP14</th>
<th>SSOP-B14</th>
</tr>
</thead>
<tbody>
<tr>
<td>BU7291G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BU7291SG</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Line-up**

<table>
<thead>
<tr>
<th>Topr</th>
<th>Package</th>
<th>Operable Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40°C to +85°C</td>
<td>SSOP5</td>
<td>Reel of 3000</td>
</tr>
<tr>
<td>-40°C to +105°C</td>
<td>SSOP5</td>
<td>Reel of 3000</td>
</tr>
<tr>
<td>-40°C to +85°C</td>
<td>SOP14</td>
<td>Reel of 2500</td>
</tr>
<tr>
<td>-40°C to +105°C</td>
<td>SOP14</td>
<td>Reel of 2500</td>
</tr>
<tr>
<td>-40°C to +85°C</td>
<td>SSOP-B14</td>
<td>Reel of 2500</td>
</tr>
<tr>
<td>-40°C to +105°C</td>
<td>SSOP-B14</td>
<td>Reel of 2500</td>
</tr>
</tbody>
</table>

**Absolute Maximum Ratings (Ta=25°C)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>BU7291</th>
<th>BU7291S</th>
<th>BU7294</th>
<th>BU7294S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>VDD-VSS</td>
<td>+7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td>Pd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSOP5</td>
<td></td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOP14</td>
<td></td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSOP-B14</td>
<td></td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>Vid</td>
<td>VDD-VSS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Common-mode Voltage Range</td>
<td>Vicm</td>
<td>(VSS - 0.3) to VDD + 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Current</td>
<td>Li</td>
<td>±10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Supply Voltage</td>
<td>Vopr</td>
<td>+2.4 to +5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>Topr</td>
<td>-40 to +85</td>
<td></td>
<td>-40 to +105</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>Tstg</td>
<td>-55 to +125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tjmax</td>
<td>+125</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
- To use at temperature above Ta=25°C, reduce 5.4mW.
- To use at temperature above Ta=25°C, reduce 4.5mW.
- To use at temperature above Ta=25°C, reduce 7.0mW.
- Mounted on a FR4 glass epoxy PCB(70mm×70mm×1.6mm).
- The voltage difference between inverting input and non-inverting input is the differential input voltage.
- 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

**OBU7291, BU7291S (Unless otherwise specified VDD=+3V, VSS=0V, Ta=25°C)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Temperature Range</th>
<th>Limits</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Offset Voltage</strong> <em>7</em>*</td>
<td>Vio</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>9 mV</td>
</tr>
<tr>
<td><strong>Input Offset Current</strong> <em>7</em>*</td>
<td>Iio</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>pA</td>
</tr>
<tr>
<td><strong>Input Bias Current</strong> <em>7</em>*</td>
<td>Ib</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>pA</td>
</tr>
<tr>
<td><strong>Supply Current</strong> <em>8</em>*</td>
<td>IDD</td>
<td>25°C</td>
<td>-</td>
<td>470</td>
<td>800 μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full range</td>
<td>-</td>
<td>-</td>
<td>1100 μA</td>
</tr>
<tr>
<td><strong>Maximum Output Voltage (High)</strong></td>
<td>VOH</td>
<td>25°C</td>
<td>VDD-0.1</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td><strong>Maximum Output Voltage (Low)</strong></td>
<td>VOL</td>
<td>25°C</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td><strong>Large Signal Voltage Gain</strong></td>
<td>Av</td>
<td>25°C</td>
<td>70</td>
<td>105</td>
<td>- dB</td>
</tr>
<tr>
<td><strong>Input Common-mode Voltage Range</strong></td>
<td>Vicm</td>
<td>25°C</td>
<td>0</td>
<td>3</td>
<td>V</td>
</tr>
<tr>
<td><strong>Common-mode Rejection Ratio</strong></td>
<td>CMRR</td>
<td>25°C</td>
<td>40</td>
<td>60</td>
<td>- dB</td>
</tr>
<tr>
<td><strong>Power Supply Rejection Ratio</strong></td>
<td>PSRR</td>
<td>25°C</td>
<td>45</td>
<td>80</td>
<td>- dB</td>
</tr>
<tr>
<td><strong>Output Source Current</strong> <em>9</em>*</td>
<td>Isource</td>
<td>25°C</td>
<td>5</td>
<td>8</td>
<td>- mA</td>
</tr>
<tr>
<td><strong>Output Sink Current</strong> <em>9</em>*</td>
<td>Isink</td>
<td>25°C</td>
<td>9</td>
<td>16</td>
<td>- mA</td>
</tr>
<tr>
<td><strong>Slew Rate</strong></td>
<td>SR</td>
<td>25°C</td>
<td>3.0</td>
<td>-</td>
<td>V/μs</td>
</tr>
<tr>
<td><strong>Gain Band Width</strong></td>
<td>GBW</td>
<td>25°C</td>
<td>2.8</td>
<td>-</td>
<td>MHz</td>
</tr>
<tr>
<td><strong>Unity Gain Frequency</strong></td>
<td>fT</td>
<td>25°C</td>
<td>2.8</td>
<td>-</td>
<td>MHz</td>
</tr>
<tr>
<td><strong>Phase Margin</strong></td>
<td>θ</td>
<td>25°C</td>
<td>50</td>
<td>-</td>
<td>deg</td>
</tr>
<tr>
<td><strong>Total Harmonic Distortion +Noise</strong></td>
<td>THD+N</td>
<td>25°C</td>
<td>0.03</td>
<td>-</td>
<td>%</td>
</tr>
</tbody>
</table>

*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.
## Parameter Symbols

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Temperature Range</th>
<th>Limits</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Offset Voltage (^{10})</td>
<td>(V_{io})</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>9 mV</td>
</tr>
<tr>
<td>Input Offset Current (^{10})</td>
<td>(I_{io})</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>- pA</td>
</tr>
<tr>
<td>Input Bias Current (^{10})</td>
<td>(I_{b})</td>
<td>25°C</td>
<td>-</td>
<td>1</td>
<td>- pA</td>
</tr>
<tr>
<td>Supply Current (^{11})</td>
<td>(I_{DD})</td>
<td>Full range</td>
<td>-</td>
<td>2000</td>
<td>3200 (\mu)A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RL=(+\infty), All Op-Amps (A_{v}=0)dB, (+\text{IN}=1.5)V</td>
</tr>
<tr>
<td>Maximum Output Voltage (High)</td>
<td>(V_{OH})</td>
<td>25°C, VDD-0.1</td>
<td>-</td>
<td>-</td>
<td>V RL=10kΩ</td>
</tr>
<tr>
<td>Maximum Output Voltage (Low)</td>
<td>(V_{OL})</td>
<td>25°C</td>
<td>-</td>
<td>-</td>
<td>V RL=10kΩ</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>(A_{v})</td>
<td>25°C, 70, 105</td>
<td>-</td>
<td>-</td>
<td>dB RL=10kΩ</td>
</tr>
<tr>
<td>Input Common-mode Voltage Range</td>
<td>(V_{icm})</td>
<td>25°C</td>
<td>0</td>
<td>3</td>
<td>V VSS to VDD</td>
</tr>
<tr>
<td>Common-mode Rejection Ratio</td>
<td>(CMRR)</td>
<td>25°C</td>
<td>40</td>
<td>60</td>
<td>dB</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>(PSRR)</td>
<td>25°C</td>
<td>45</td>
<td>80</td>
<td>dB</td>
</tr>
<tr>
<td>Output Source Current (^{12})</td>
<td>(I_{source})</td>
<td>25°C</td>
<td>5</td>
<td>8</td>
<td>mA VDD-0.4V</td>
</tr>
<tr>
<td>Output Sink Current (^{12})</td>
<td>(I_{sink})</td>
<td>25°C</td>
<td>9</td>
<td>16</td>
<td>mA VSS+0.4V</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>(SR)</td>
<td>25°C</td>
<td>-</td>
<td>3.0</td>
<td>(V/\mu)s CL=25pF</td>
</tr>
<tr>
<td>Gain Band Width</td>
<td>(GBW)</td>
<td>25°C</td>
<td>-</td>
<td>2.8</td>
<td>MHz CL=25pF, (f=100)kHz</td>
</tr>
<tr>
<td>Unity Gain Frequency</td>
<td>(f_{t})</td>
<td>25°C</td>
<td>-</td>
<td>2.8</td>
<td>MHz CL=25pF</td>
</tr>
<tr>
<td>Phase Margin</td>
<td>(\theta)</td>
<td>25°C</td>
<td>-</td>
<td>50</td>
<td>deg CL=25pF</td>
</tr>
<tr>
<td>Total Harmonic Distortion + Noise</td>
<td>(THD+N)</td>
<td>25°C</td>
<td>-</td>
<td>0.03</td>
<td>% OUT=0.8Vp.p., (f=1)kHz</td>
</tr>
<tr>
<td>Channel Separation</td>
<td>(CS)</td>
<td>25°C</td>
<td>-</td>
<td>100</td>
<td>dB (f=1)kHz, OUT=0.5Vrms</td>
</tr>
</tbody>
</table>

\(^{10}\) 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 (fT)

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

(*) 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

OBU7291, BU7291S

(*) 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
OBU7291, BU7291S

(*)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**

OBU7291, BU7291S

(*)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

OBU7291, BU7291S

(*)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

(*)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
OBU7294, BU7294S

(*) 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
BU7294FV: -85°C to +105°C
BU7294SF: 25°C to +85°C

Figure 25. Derating curve
Figure 26. Derating curve
Figure 27. Supply Current – Supply Voltage
Figure 28. Supply Current – Ambient Temperature
Typical Performance Curves - Continued

OBU7294, BU7294S

(*)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

(*) 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

(*) 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

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
Typical Performance Curves - Continued
OBU7294, BU7294S

(*) 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

(*)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**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>VF</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>VDD</th>
<th>VSS</th>
<th>EK</th>
<th>Vicm</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Offset Voltage</td>
<td>VF1</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>3</td>
<td>0</td>
<td>-1.5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>VF2</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>3</td>
<td>0</td>
<td>-0.5</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Common-mode Rejection Ratio (Input Common-mode Voltage Range)</td>
<td>VF4</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>3</td>
<td>0</td>
<td>-1.5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>VF6</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>2.4</td>
<td>0</td>
<td>-1.2</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

---

#### Calculation

1. Input Offset Voltage (\( V_{io} \))

\[
V_{io} = \left| \frac{V_{F1}}{1+RF/RS} \right| [V]
\]

2. Large Signal Voltage Gain (\( A_{v} \))

\[
A_{v} = 20 \log \left( \frac{2 \times (1+RF/RS)}{|V_{F2}-V_{F3}|} \right) [\text{dB}]
\]

3. Common-mode Rejection Ratio (\( CMRR \))

\[
CMRR = 20 \log \left( \frac{1.8 \times (1+RF/RS)}{|V_{F4}-V_{F5}|} \right) [\text{dB}]
\]

4. Power Supply Rejection Ratio (\( PSRR \))

\[
PSRR = 20 \log \left( \frac{3.8 \times (1+RF/RS)}{|V_{F6}-V_{F7}|} \right) [\text{dB}]
\]

---

**Figure 48. Test circuit 1 (one channel only)**
Switch Condition for Test circuit2

<table>
<thead>
<tr>
<th>SW No.</th>
<th>SW1</th>
<th>SW2</th>
<th>SW3</th>
<th>SW4</th>
<th>SW5</th>
<th>SW6</th>
<th>SW7</th>
<th>SW8</th>
<th>SW9</th>
<th>SW10</th>
<th>SW11</th>
<th>SW12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Maximum Output Voltage RL=10kΩ</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Output Current</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Unity Gain Frequency</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

Figure 49. Test circuit 2

Figure 50. Slew rate input output wave

Figure 51. Test circuit 3 (Channel Separation)
● Application example
  ○ Voltage follower

![Voltage follower](image1)

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 circuit](image2)

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.

\[ \text{OUT} = -(\frac{R2}{R1}) \cdot \text{IN} \]

This circuit has input impedance equal to R1.

![Non-inverting amplifier circuit](image3)

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.

\[ \text{OUT} = (1 + \frac{R2}{R1}) \cdot \text{IN} \]

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).

\[
θja = \frac{(Tjmax - Ta)}{Pd} \quad °C/W
\]

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.

<table>
<thead>
<tr>
<th>(*13)</th>
<th>(*14)</th>
<th>(*15)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0</td>
<td>5.4</td>
<td>4.5</td>
<td>mW/°C</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Package Name</th>
<th>SSOP5</th>
</tr>
</thead>
</table>

**Dimensions (UNIT: mm)**

- **PKG: SSOP5**
- **Drawing No. EX106-5001-2**

### Tape and Reel Information

<table>
<thead>
<tr>
<th>Tape</th>
<th>Embossed carrier tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>3000pcs</td>
</tr>
<tr>
<td>Direction of feed</td>
<td>TR</td>
</tr>
</tbody>
</table>

The direction is the 1 pin 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.
### Tape and Reel Information

<table>
<thead>
<tr>
<th>Tape</th>
<th>Embossed carrier tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>2500pcs</td>
</tr>
<tr>
<td>Direction of feed</td>
<td>E2</td>
</tr>
<tr>
<td></td>
<td>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</td>
</tr>
</tbody>
</table>

**Direction of feed**

- **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

**Dimensions (UNIT: mm)**

- **PKG**: SOP14
- **Drawing No.**: EX113-5001

- **Max 9.05 (include BURR)**
**Package Name | SSOP-B14**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>2500pcs</th>
</tr>
</thead>
</table>

**<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)
- Part Number Marking
- LOT Number

#### SOP14 (TOP VIEW)
- Part Number Marking
- LOT Number

#### SSOP-B14 (TOP VIEW)
- Part Number Marking
- LOT Number
- 1PIN MARK

### Land pattern data

<table>
<thead>
<tr>
<th>PKG</th>
<th>Land pitch</th>
<th>Land space</th>
<th>Land length</th>
<th>Land width</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSOP5</td>
<td>0.95</td>
<td>2.4</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>SOP14</td>
<td>1.27</td>
<td>4.60</td>
<td>1.10</td>
<td>0.76</td>
</tr>
<tr>
<td>SSOP-B14</td>
<td>0.65</td>
<td>4.60</td>
<td>1.20</td>
<td>0.35</td>
</tr>
</tbody>
</table>

### Revision History

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.May.2013</td>
<td>001</td>
<td>New Release</td>
</tr>
</tbody>
</table>
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   (Note1) Medical Equipment Classification of the Specific Applications

<table>
<thead>
<tr>
<th>JAPAN</th>
<th>USA</th>
<th>EU</th>
<th>CHINA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS III</td>
<td>CLASS III</td>
<td>CLASS II b</td>
<td>CLASS III</td>
</tr>
</tbody>
</table>

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   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [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.

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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
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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).

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   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

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

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

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

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