LM108/LM208/LM308 Operational Amplifiers

General Description

The LM108 series are precision operational amplifiers having specifications a factor of ten better than FET amplifiers over a −55°C to +125°C temperature range. The devices operate with supply voltages from ±2V to ±20V and have sufficient supply rejection to use unregulated supplies. Although the circuit is interchangeable with and uses the same compensation as the LM101A, an alternate compensation scheme can be used to make it particularly insensitive to power supply noise and to make supply bypass capacitors unnecessary. The low current error of the LM108 series makes possible many designs that are not practical with conventional amplifiers. In fact, it operates from 10 MΩ source resistances, introducing less error than devices like the 709 with 10 kΩ sources. Integrators with drifts less than 500 μV/sec and analog time delays in excess of one hour can be made using capacitors no larger than 1 μF. The LM108 is guaranteed from −55°C to +125°C, the LM208 from −25°C to +85°C, and the LM308 from 0°C to +70°C.

Features

- Maximum input bias current of 3.0 nA over temperature
- Offset current less than 400 pA over temperature
- Supply current of only 300 μA, even in saturation
- Guaranteed drift characteristics

Compensation Circuits

**Standard Compensation Circuit**

![Standard Compensation Circuit Diagram](image1)

**Alternate Frequency Compensation**

![Alternate Frequency Compensation Diagram](image2)

**Feedforward Compensation**

![Feedforward Compensation Diagram](image3)

**Bandwidth and slew rate are proportional to 1/Cf**

*Improves rejection of power supply noise by a factor of ten.

**Bandwidth and slew rate are proportional to 1/Cz**
Absolute Maximum Ratings
If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.
(Note 5)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LM108/LM208</th>
<th>LM308</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>±20V</td>
<td>±18V</td>
</tr>
<tr>
<td>Power Dissipation (Note 1)</td>
<td>500 mW</td>
<td>500 mW</td>
</tr>
<tr>
<td>Differential Input Current (Note 2)</td>
<td>±10 mA</td>
<td>±10 mA</td>
</tr>
<tr>
<td>Input Voltage (Note 3)</td>
<td>±15V</td>
<td>±15V</td>
</tr>
<tr>
<td>Output Short-Circuit Duration</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Operating Temperature Range (LM108)</td>
<td>–55°C to +125°C</td>
<td>0°C to +70°C</td>
</tr>
<tr>
<td>(LM208)</td>
<td>–25°C to +85°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>–65°C to +150°C</td>
<td>–65°C to +150°C</td>
</tr>
<tr>
<td>Lead Temperature (Soldering, 10 sec)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIP</td>
<td>260°C</td>
<td>260°C</td>
</tr>
<tr>
<td>H Package Lead Temp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Soldering 10 seconds)</td>
<td>300°C</td>
<td>300°C</td>
</tr>
</tbody>
</table>

Soldering Information
- Dual-In-Line Package
- Soldering (10 seconds) 260°C
- Small Outline Package
- Vapor Phase (60 seconds) 215°C
- Infrared (15 seconds) 220°C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

ESD Tolerance (Note 6) 2000V

Electrical Characteristics (Note 4)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>LM108/LM208</th>
<th>LM308</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Offset Voltage</td>
<td>$T_A = 25°C$</td>
<td>0.7</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>$T_A = 25°C$</td>
<td>0.05</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>$T_A = 25°C$</td>
<td>0.8</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>$T_A = 25°C$</td>
<td>30</td>
<td>70</td>
<td>10</td>
</tr>
<tr>
<td>Supply Current</td>
<td>$T_A = 25°C$</td>
<td>0.3</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>$T_A = 25°C, V_S = ±15V, V_OUT = ±10V, R_L ≥ 10 kΩ$</td>
<td>50</td>
<td>300</td>
<td>25</td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td></td>
<td>3.0</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Average Temperature Coefficient of Input Offset Voltage</td>
<td>$T_A = 25°C, V_S = ±15V, V_OUT = ±10V, R_L ≥ 10 kΩ$</td>
<td>3.0</td>
<td>15</td>
<td>6.0</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td></td>
<td>0.4</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Average Temperature Coefficient of Input Offset Current</td>
<td></td>
<td>0.5</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>$T_A = 125°C$</td>
<td>3.0</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Supply Current</td>
<td></td>
<td>0.15</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>$V_S = ±15V, V_OUT = ±10V, R_L ≥ 10 kΩ$</td>
<td>25</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>$V_S = ±15V, R_L = 10 kΩ$</td>
<td>±13</td>
<td></td>
<td>±13</td>
</tr>
</tbody>
</table>
### Electrical Characteristics (Note 4) (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>LM108/LM208 (Min)</th>
<th>LM108/LM208 (Typ)</th>
<th>LM308 (Min)</th>
<th>LM308 (Typ)</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range</td>
<td>$V_S$ $\pm$ 15V</td>
<td>± 13.5</td>
<td>± 14</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td></td>
<td>85</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>dB</td>
</tr>
<tr>
<td>Supply Voltage Rejection Ratio</td>
<td></td>
<td>80</td>
<td>96</td>
<td>80</td>
<td>96</td>
<td>dB</td>
</tr>
</tbody>
</table>

**Note 1:** The maximum junction temperature of the LM108 is 150°C, for the LM208, 100°C and for the LM308, 85°C. For operating at elevated temperatures, devices in the H08 package must be derated based on a thermal resistance of 160°C/W, junction to ambient, or 20°C/W, junction to case. The thermal resistance of the dual-in-line package is 100°C/W, junction to ambient.

**Note 2:** The inputs are shunted with back-to-back diodes for overvoltage protection. Therefore, excessive current will flow if a differential input voltage in excess of 1V is applied between the inputs unless some limiting resistance is used.

**Note 3:** For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

**Note 4:** These specifications apply for $\pm 9V \leq V_S \leq \pm 20V$ and $-55^\circ C \leq T_A \leq 125^\circ C$, unless otherwise specified. With the LM208, however, all temperature specifications are limited to $-25^\circ C \leq T_A \leq 85^\circ C$, and for the LM308 they are limited to $0^\circ C \leq T_A \leq 70^\circ C$.

**Note 5:** Refer to RETS108X for LM108 military specifications and RETs 108AX for LM108A military specifications.

**Note 6:** Human body model, 1.5 kΩ in series with 100 pF.

### Schematic Diagram

![Schematic Diagram](image-url)
Typical Performance Characteristics LM108/LM208

- Input Currents
- Offset Error
- Drift Error
- Input Noise Voltage
- Power Supply Rejection
- Closed Loop Output Impedance
- Voltage Gain
- Output Swing
- Supply Current
- Open Loop Frequency Response
- Large Signal Frequency Response
- Voltage Follower Pulse Response
Typical Performance Characteristics

Input Currents

Offset Error

Drift Error

Input Noise Voltage

Power Supply Rejection

Closed Loop

Output Impedance

Voltage Gain

Output Swing

Supply Current

Open Loop

Frequency Response

Large Signal

Frequency Response

Voltage Follower

Pulse Response
Typical Applications

Sample and Hold

![Sample and Hold diagram]

Teflon polyethylene or polycarbonate dielectric capacitor
Worst case drift less than 2.5 mV/sec

High Speed Amplifier with Low Drift and Low Input Current

![High Speed Amplifier with Low Drift and Low Input Current diagram]
Typical Applications (Continued)

Fast\(^{1}\) Summing Amplifier

*In addition to increasing speed, the LM101A raises high and low frequency gain, increases output drive capability and eliminates thermal feedback.

Connection Diagrams

Metal Can Package

COMP 2

COMP 1

INPUTS

V^+

V^-

NC

Dual-In-Line Package

Top View

Order Number LM108H, LM108H/883, LM308AH or LM308H
See NS Package Number H08C

Order Number LM108J/883
See NS Package Number J14A

\(^{1}\)Power Bandwidth: 250 KHz
Small Signal Bandwidth: 3.5 MHz
Slow Rate: 10V/\mu S

\(C_5 = 6 \times 10^{-8} \ \text{RT} \)

\[^{2}\]Also available per JM38510/10104

Unused pin (no internal connection) to allow for input anti-leakage guard ring on printed circuit board layout.

Order Number LM108J-8/883, LM308M or LM308N
See NS Package Number J06A, M08A or N08E

Order Number LM108W/883
See NS Package Number W10A
Physical Dimensions inches (millimeters) (Continued)

**Metal Can Package (H)**
Order Number LM108H, LM108H/883 or LM308H
NS Package Number H08C

**S.O. Package (M)**
Order Number LM308M
NS Package Number M08A
Physical Dimensions inches (millimeters) (Continued)

Molded Dual-In-Line Package (N)
Order Number LM308N
NS Package Number N08E

Ceramic Flatpack Package (W)
Order Number LM108AW/883 or
LM108W/883
NS Package Number W10A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system.