LM725 Operational Amplifier

General Description
The LM725/LM725A/LM725C are operational amplifiers featuring superior performance in applications where low noise, low drift, and accurate closed-loop gain are required. With high common mode rejection and offset null capability, it is especially suited for low level instrumentation applications over a wide supply voltage range.

The LM725A has tightened electrical performance with higher input accuracy and like the LM725, is guaranteed over a −55˚C to +125˚C temperature range. The LM725C has slightly relaxed specifications and has its performance guaranteed over a 0˚C to 70˚C temperature range.

Features
- High open loop gain 3,000,000
- Low input voltage drift 0.6 µV/˚C
- High common mode rejection 120 dB
- Low input noise current 0.15 pA/√Hz
- Low input offset current 2 nA
- High input voltage range ±14V
- Wide power supply range ±3V to ±22V
- Offset null capability
- Output short circuit protection

Connection Diagrams
Metal Can Package
Order Number LM725H/883, LM725CH or LM725AH/883
See NS Package Number H08C

Dual-In-Line Package
Order Number LM725CN
See NS Package Number N08E

Typical Applications
Thermocouple Amplifier

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### Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Supply Voltage</th>
<th>Internal Power Dissipation (Note 2)</th>
<th>Differential Input Voltage</th>
<th>Input Voltage (Note 3)</th>
<th>Storage Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>±22V</td>
<td>500 mW</td>
<td>±5V</td>
<td>±22V</td>
<td>−65˚C to +150˚C</td>
</tr>
</tbody>
</table>

### Lead Temperature

Soldering, 10 Sec. 260˚C

### Maximum Junction Temperature

150˚C

### Operating Temperature Range

<table>
<thead>
<tr>
<th>LM725</th>
<th>T_a(min)</th>
<th>T_a(max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>−55˚C to +125˚C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Electrical Characteristics (Note 4)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM725A</th>
<th>LM725</th>
<th>LM725C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>Input Offset Voltage</td>
<td>T_A = 25˚C, R_S ≤ 10 kΩ</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Input Offset Current</td>
<td>T_A = 25˚C</td>
<td>2.0</td>
<td>5.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>T_A = 25˚C</td>
<td>42</td>
<td>80</td>
<td>42</td>
<td>100</td>
</tr>
<tr>
<td>Input Noise Voltage</td>
<td>T_A = 25˚C, f_o = 10 Hz</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>f_o = 100 Hz</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>f_o = 1 kHz</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Input Noise Current</td>
<td>T_A = 25˚C, f_o = 10 Hz</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>f_o = 100 Hz</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>f_o = 1 kHz</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>T_A = 25˚C</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>T_A = 25˚C</td>
<td>±13.5</td>
<td>±14</td>
<td>±13.5</td>
<td>±14</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>T_A = 25˚C, R_L ≥ 2 kΩ, V_OUT = ±10V</td>
<td>1000</td>
<td>3000</td>
<td>1000</td>
<td>3000</td>
</tr>
<tr>
<td>Common-Mode Rejection Ratio</td>
<td>T_A = 25˚C, R_S ≤ 10 kΩ</td>
<td>120</td>
<td>110</td>
<td>120</td>
<td>94</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>T_A = 25˚C, R_S ≤ 10 kΩ</td>
<td>2.0</td>
<td>5.0</td>
<td>2.0</td>
<td>10</td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>T_A = 25˚C, R_L ≥ 10 kΩ</td>
<td>±12.5</td>
<td>±13.5</td>
<td>±12</td>
<td>±13.5</td>
</tr>
<tr>
<td></td>
<td>R_L ≥ 2 kΩ</td>
<td>±12.0</td>
<td>±13.5</td>
<td>±12</td>
<td>±13.5</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>T_A = 25˚C</td>
<td>80</td>
<td>105</td>
<td>80</td>
<td>105</td>
</tr>
<tr>
<td>Average Input Offset Voltage Drift</td>
<td>R_S ≤ 10 kΩ</td>
<td>0.7</td>
<td>1.5</td>
<td>3.5</td>
<td>mV</td>
</tr>
<tr>
<td>Average Input Offset Voltage Drift</td>
<td>R_S = 50Ω</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Average Input Offset Voltage Drift</td>
<td>R_S = 50Ω</td>
<td>0.6</td>
<td>1.0</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Average Input Offset Current Drift</td>
<td>T_A = T_MAX</td>
<td>1.2</td>
<td>4.0</td>
<td>1.2</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>T_A = T_MIN</td>
<td>7.5</td>
<td>18.0</td>
<td>7.5</td>
<td>40</td>
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<tr>
<td>Average Input Offset Current Drift</td>
<td>T_A = T_MAX</td>
<td>35</td>
<td>90</td>
<td>35</td>
<td>150</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>T_A = T_MAX</td>
<td>20</td>
<td>70</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>T_A = T_MIN</td>
<td>80</td>
<td>180</td>
<td>80</td>
<td>200</td>
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</table>

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## Electrical Characteristics (Note 4) (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM725A</th>
<th>LM725</th>
<th>LM725C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>$R_L \geq 2,\text{k}\Omega$</td>
<td>1,000,000</td>
<td>1,000,000</td>
<td>125,000</td>
</tr>
<tr>
<td></td>
<td>$T_A = T_{\text{MAX}}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$R_L \geq 2,\text{k}\Omega$</td>
<td>500,000</td>
<td>250,000</td>
<td>125,000</td>
</tr>
<tr>
<td></td>
<td>$T_A = T_{\text{MIN}}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common-Mode Rejection Ratio</td>
<td>$R_S \leq 10,\text{k}\Omega$</td>
<td>110</td>
<td>100</td>
<td>115</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>$R_S \leq 10,\text{k}\Omega$</td>
<td>8.0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>$R_L \geq 2,\text{k}\Omega$</td>
<td>±12</td>
<td>±10</td>
<td>±10</td>
</tr>
</tbody>
</table>

**Note 1:** “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

**Note 2:** Derate at 150˚C/W for operation at ambient temperatures above 75˚C.

**Note 3:** For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

**Note 4:** These specifications apply for $V_S = ±15\text{V}$ unless otherwise specified.

**Note 5:** For Military electrical specifications RETS725AX are available for LM725AH and RETS725X are available for LM725H.

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### Schematic Diagram

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

Voltage Gain vs Temperature for Supply Voltages

Untrimmed Input Offset Voltage vs Temperature

Input Bias Current vs Temperature

Change in Trimmed Input Offset Voltage vs Temperature

Input Offset Current vs Temperature

Stabilization Time of Input Offset Voltage from Power Turn-On
Typical Performance Characteristics (Continued)

Change in Input Offset Voltage Due to Thermal Shock vs Time

- Change in Input Offset Voltage: \( -30 \mu V \) to \( +30 \mu V \)
- Thermal Shock Conditions: \( V_{CC} = \pm 15V \), Previous Quiescent \( V_D \leq 1 \mu V \)
- Time from Heat Application: \( T \) seconds

Input Noise Voltage vs Frequency

- Input Noise Voltage: \( 10^{-13} \) to \( 10^{-17} \)
- Frequency Range: 1 Hz to 100 kHz

Power Consumption vs Temperature

- Power Consumption: 0 to 160 mW
- Temperature Range: \(-60^\circ C \) to \(140^\circ C \)

Open Loop Frequency Response for Values of Compensation (Note 6)

- Open Loop Voltage Gain: -30 dB to 150 dB
- Frequency Range: 1 Hz to \( 10^6 \) Hz

Values for Suggested Compensation Networks vs Various Close Loop Voltage Gains

- Resistance: 1 to 10 \( \Omega \)
- Capacitance: 1 to 100 \( \mu F \)
- Closed Loop Voltage Gain: 1 to 100k
Typical Performance Characteristics

Frequency Response for Various Close Loop Gain (Note 6)

Output Voltage Swing vs Frequency (Note 6)

Transient Response

Note 6: Performance is shown using recommended compensation networks.

Transient Response Test Circuit
Auxiliary Circuits

Voltage Offset Null Circuit

Frequency Compensation Circuit

Compensation Component Values

<table>
<thead>
<tr>
<th>$A_V$</th>
<th>$R_1$ (Ω)</th>
<th>$C_1$ (µF)</th>
<th>$R_2$ (Ω)</th>
<th>$C_2$ (µF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>10k</td>
<td>50 pF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>470</td>
<td>0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>47</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>27</td>
<td>0.05</td>
<td>270</td>
<td>0.0015</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>0.05</td>
<td>39</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Typical Applications

Photodiode Amplifier

DC Gains = 10,000; 1,000; 100; and 10
Bandwidth = Determined by value of C1

Thermocouple Amplifier

Note: Indicates ±1% metal film resistors recommended for temperature stability.
Typical Applications (Continued)

±100V Common Mode Range Differential Amplifier

![Circuit Diagram for ±100V Common Mode Range Differential Amplifier]
Typical Applications (Continued)

Instrumentation Amplifier with High Common Mode Rejection

Precision Amplifier $A_{VCL} = 1000$

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Physical Dimensions inches (millimeters) unless otherwise noted

Order Number LM725H/883, LM725CH or LM725AH/883
NS Package Number H08C

Order Number LM725CN
NS Package Number N08E
Notes

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National Semiconductor
Americas Customer Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959
www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
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National Semiconductor
Asia Pacific Customer Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560