LM833
Dual Audio Operational Amplifier

General Description
The LM833 is a dual general purpose operational amplifier designed with particular emphasis on performance in audio systems.
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level stages in PCM and HiFi systems.
The LM833 is pin-for-pin compatible with industry standard dual operational amplifiers.

Features
- Wide dynamic range: 140dB
- Low input noise voltage: 4.5nV/√Hz
- High slew rate: 7 V/µs (typ); 5V/µs (min)
- High gain bandwidth: 15MHz (typ); 10MHz (min)
- Wide power bandwidth: 120KHz
- Low distortion: 0.002%
- Low offset voltage: 0.3mV
- Large phase margin: 60°
- Available in 8 pin MSOP package

Schematic Diagram
(1/2 LM833)

Connection Diagram

Order Number LM833M, LM833MX, LM833N, LM833MM or LM833MMX
See NS Package Number M08A, N08E or MUA08A
### Absolute Maximum Ratings (Note 1)

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

- Supply Voltage $V_{CC} - V_{EE}$: 36V
- Differential Input Voltage (Note 3) $V_i$: ±30V
- Input Voltage Range (Note 3) $V_{IC}$: ±15V
- Power Dissipation (Note 4) $P_D$: 500 mW
- Operating Temperature Range $T_{OPR}$: −40 to 85°C
- Storage Temperature Range $T_{STG}$: −60 to 150°C

### Soldering Information

- Dual-In-Line Package: Soldering (10 seconds) 260°C
- Small Outline Package (SOIC and MSOP): 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 5): 1600V

### DC Electrical Characteristics (Notes 1, 2)

$\left(T_A = 25^\circ C, V_S = \pm 15V\right)$

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{OS}$</td>
<td>Input Offset Voltage</td>
<td>$R_S = 10\Omega$</td>
<td>0.3</td>
<td>5</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$I_{OS}$</td>
<td>Input Offset Current</td>
<td></td>
<td>10</td>
<td>200</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>$I_B$</td>
<td>Input Bias Current</td>
<td></td>
<td>500</td>
<td>100</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>$A_V$</td>
<td>Voltage Gain</td>
<td>$R_L = 2\ k\Omega, V_O = \pm 10V$</td>
<td>90</td>
<td>110</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>$V_{OM}$</td>
<td>Output Voltage Swing</td>
<td>$R_L = 10\ k\Omega$</td>
<td>±12</td>
<td>±13.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 2\ k\Omega$</td>
<td>±10</td>
<td>±13.4</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{CM}$</td>
<td>Input Common-Mode Range</td>
<td></td>
<td>±12</td>
<td>±14.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-Mode Rejection Ratio</td>
<td>$V_{IN} = \pm 12V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>$V_S = \pm 5V, \pm 5V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>$I_Q$</td>
<td>Supply Current</td>
<td>$V_O = 0V, Both Amps$</td>
<td>5</td>
<td>8</td>
<td>mA</td>
<td></td>
</tr>
</tbody>
</table>

### AC Electrical Characteristics

$\left(T_A = 25^\circ C, V_S = \pm 15V, R_L = 2\ k\Omega\right)$

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>Slew Rate</td>
<td>$R_L = 2\ k\Omega$</td>
<td>5</td>
<td>7</td>
<td>V/µs</td>
<td></td>
</tr>
<tr>
<td>GBW</td>
<td>Gain Bandwidth Product</td>
<td>$f = 100\ kHz$</td>
<td>10</td>
<td>15</td>
<td>MHz</td>
<td></td>
</tr>
</tbody>
</table>

### Design Electrical Characteristics

$\left(T_A = 25^\circ C, V_S = \pm 15V\right)$

The following parameters are not tested or guaranteed.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$AV_{OS}/AT$</td>
<td>Average Temperature Coefficient of Input Offset Voltage</td>
<td></td>
<td>2</td>
<td>µV/°C</td>
</tr>
<tr>
<td>THD</td>
<td>Distortion</td>
<td>$R_L = 2\ k\Omega, f = 20\text{–}20\ kHz$</td>
<td>0.002</td>
<td>%</td>
</tr>
<tr>
<td>$e_n$</td>
<td>Input Referred Noise Voltage</td>
<td>$R_S = 100\Omega, f = 1\ kHz$</td>
<td>4.5</td>
<td>nV/√Hz</td>
</tr>
<tr>
<td>$i_n$</td>
<td>Input Referred Noise Current</td>
<td>$f = 1\ kHz$</td>
<td>0.7</td>
<td>pA/√Hz</td>
</tr>
<tr>
<td>PBW</td>
<td>Power Bandwidth</td>
<td>$V_O = 27 V_{pp}, R_L = 2\ k\Omega, THD \leq 1%$</td>
<td>120</td>
<td>kHz</td>
</tr>
<tr>
<td>$f_U$</td>
<td>Unity Gain Frequency</td>
<td>Open Loop</td>
<td>9</td>
<td>MHz</td>
</tr>
<tr>
<td>$\phi_M$</td>
<td>Phase Margin</td>
<td>Open Loop</td>
<td>60</td>
<td>deg</td>
</tr>
<tr>
<td></td>
<td>Input Referred Cross Talk</td>
<td>$f = 20\text{–}20\ kHz$</td>
<td>−120</td>
<td>dB</td>
</tr>
</tbody>
</table>
Design Electrical Characteristics (Continued)

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. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 2: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 3: If supply voltage is less than ±15V, it is equal to supply voltage.

Note 4: This is the permissible value at $T_A \leq 85^\circ C$.

Note 5: Human body model, 1.5 kΩ in series with 100 pF.

Typical Performance Characteristics

Maximum Power Dissipation vs Ambient Temperature

Input Bias Current vs Ambient Temperature

Input Bias Current vs Supply Voltage

Supply Current vs Supply Voltage

DC Voltage Gain vs Ambient Temperature

DC Voltage Gain vs Supply Voltage

Voltage Gain & Phase vs Frequency

Gain Bandwidth Product vs Ambient Temperature

Gain Bandwidth vs Supply Voltage
Typical Performance Characteristics (Continued)

Slew Rate vs Ambient Temperature

Slew Rate vs Supply Voltage

Power Bandwidth

CMR vs Frequency

Distortion vs Frequency

PSRR vs Frequency

Maximum Output Voltage vs Supply Voltage

Maximum Output Voltage vs Ambient Temperature
**Typical Performance Characteristics** (Continued)

### Application Hints

The LM833 is a high speed op amp with excellent phase margin and stability. Capacitive loads up to 50 pF will cause little change in the phase characteristics of the amplifiers and are therefore allowable.

Capacitive loads greater than 50 pF must be isolated from the output. The most straightforward way to do this is to put a resistor in series with the output. This resistor will also prevent excess power dissipation if the output is accidentally shorted.
Noise Measurement Circuit

Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

Total Gain: 115 dB @ f = 1 kHz
Input Referred Noise Voltage: \( e_n = V_0/560,000 \) (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency

Flat Amp Voltage Gain vs Frequency
Typical Applications

NAB Preamp

\[ V_0 = \frac{V_1}{2} \]

\[ R = 15 \text{ nF} \]

\[ C = 3.6k \]

\[ 200k \]

\[ 47 \mu F \]

\[ A_V = 34.5 \]

\[ F = 1 \text{ kHz} \]

\[ E_n = 0.38 \mu V \]

A Weighted

NAB Preamp Voltage Gain vs Frequency

\[ f_0 = \frac{1}{2\pi RC} \]

Adder/Subtractor

\[ V_O = V_1 + V_2 - V_3 - V_4 \]

Sine Wave Oscillator

\[ V_O = \frac{1}{2} \text{LM833} \]

\[ V_O = \frac{14 \text{ mA} \times 10V}{750} \]

Balanced to Single Ended Converter

\[ V_O = V_1 - V_2 \]
**Second Order High Pass Filter**  
(Butterworth)  
![Typical Applications](https://example.com/image.png)

if $C_1 = C_2 = C$

$$R_1 = \frac{\sqrt{2}}{2\omega_0 C}$$

$$R_2 = 2 \times R_1$$

Illustration is $f_0 = 1$ kHz

**Second Order Low Pass Filter**  
(Butterworth)  
![Typical Applications](https://example.com/image.png)

if $R_1 = R_2 = R$

$$C_1 = \frac{3}{\omega_0 R}$$

$$C_2 = \frac{C_1}{2}$$

Illustration is $f_0 = 1$ kHz
Typical Applications (Continued)

State Variable Filter

\[ f_0 = \frac{1}{2\pi \sqrt{C_1 R_1}}, Q = \frac{1}{\left(1 + \frac{R_2}{R_0} + \frac{R_2}{R_G}\right)} \]

\[ A_{BP} = \frac{Q_{ALP}}{Q_{ALH}} = \frac{R_2}{R_G} \]

Illustration is \( f_0 = 1 \text{ kHz}, Q = 10, A_{BP} = 1 \)

AC/DC Converter

2 Channel Panning Circuit (Pan Pot)

Line Driver
Typical Applications (Continued)

Tone Control

\[ f_L = \frac{1}{2\pi R_2 C_1}; \quad f_{LB} = \frac{1}{2\pi R_1 C_1} \]

\[ f_H = \frac{1}{2\pi R_5 C_2}; \quad f_{HB} = \frac{1}{2\pi (R_1 + R_5 + 2R_3) C_2} \]

Illustration is:
- \( f_L = 32 \) Hz, \( f_{LB} = 320 \) Hz
- \( f_H = 11 \) kHz, \( f_{HB} = 1.1 \) kHz

RIAA Preamp

\[ A_v = 35 \text{ dB} \]
\[ E_{CE} = 0.33 \mu \text{V} \]
\[ S/N = 90 \text{ dB} \]
\[ f = 1 \text{ kHz} \]

A Weighted
A Weighted, \( V_{IN} = 10 \text{ mV} \)

@f = 1 kHz

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Typical Applications (Continued)

If \( R_2 = R_5, R_3 = R_6, R_4 = R_7 \)

\[ V_0 = \left( 1 + \frac{2R_2}{R_1} \right) \frac{R_4}{R_3} (V_2 - V_1) \]

Illustration is:

\[ V_0 = 101(V_2 - V_1) \]
## Typical Applications (Continued)

### 10 Band Graphic Equalizer

<table>
<thead>
<tr>
<th>$f_0$(Hz)</th>
<th>$C_1$</th>
<th>$C_2$</th>
<th>$R_1$</th>
<th>$R_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0.12µF</td>
<td>4.7µF</td>
<td>75kΩ</td>
<td>500Ω</td>
</tr>
<tr>
<td>64</td>
<td>0.056µF</td>
<td>3.3µF</td>
<td>68kΩ</td>
<td>510Ω</td>
</tr>
<tr>
<td>125</td>
<td>0.033µF</td>
<td>1.5µF</td>
<td>62kΩ</td>
<td>510Ω</td>
</tr>
<tr>
<td>250</td>
<td>0.015µF</td>
<td>0.82µF</td>
<td>68kΩ</td>
<td>470Ω</td>
</tr>
<tr>
<td>500</td>
<td>8200pF</td>
<td>0.39µF</td>
<td>62kΩ</td>
<td>470Ω</td>
</tr>
<tr>
<td>1k</td>
<td>3900pF</td>
<td>0.22µF</td>
<td>68kΩ</td>
<td>470Ω</td>
</tr>
<tr>
<td>2k</td>
<td>2000pF</td>
<td>0.1µF</td>
<td>68kΩ</td>
<td>470Ω</td>
</tr>
<tr>
<td>4k</td>
<td>1100pF</td>
<td>0.056µF</td>
<td>62kΩ</td>
<td>470Ω</td>
</tr>
<tr>
<td>8k</td>
<td>510pF</td>
<td>0.022µF</td>
<td>68kΩ</td>
<td>510Ω</td>
</tr>
<tr>
<td>16k</td>
<td>330pF</td>
<td>0.012µF</td>
<td>51kΩ</td>
<td>510Ω</td>
</tr>
</tbody>
</table>

**Note 6:** At volume of change = ±12 dB  
$Q = 1.7$

Physical Dimensions inches (millimeters) unless otherwise noted

Molded Small Outline Package (M)
Order Number LM833M or LM833MX
NS Package Number M08A

Molded Dual-In-Line Package (N)
Order Number LM833N
NS Package Number N08E
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