**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)
Small Outline Package
Vapor Phase (60 seconds)
Infrared (15 seconds)
ESD tolerance (Note 5)

DC Electrical Characteristics (Notes 1, 2)

$(T_A = 25°C, V_S = ±15V)$

<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>mA</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>1000</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>$A_V$</td>
<td>Voltage Gain</td>
<td>$R_L = 2, k\Omega, V_O = ±10V$</td>
<td>90</td>
<td>110</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>$V_{CM}$</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>$V_{IN} = ±12V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>PSRR</td>
<td>Power Supply Rejection Ratio</td>
<td>$V_S = ±5V$</td>
<td>80</td>
<td>100</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>$I_O$</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

$(T_A = 25°C, V_S = ±15V, R_L = 2\, k\Omega)$

<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

$(T_A = 25°C, V_S = ±15V)$ 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>$\Delta V_{OS}/\Delta T$</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>$R_L = 2, k\Omega, f = 20–20, kHz$</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></td>
<td></td>
<td></td>
<td></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 $T_A \leq 85°C$.

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

Typical Performance Characteristics

![Graphs showing Maximum Power Dissipation vs Ambient Temperature and Input Bias Current vs Ambient Temperature](00521804, 00521805)

![Graphs showing Input Bias Current vs Supply Voltage and Supply Current vs Supply Voltage](00521806, 00521807)
Typical Performance Characteristics (Continued)

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

Slew Rate vs Ambient Temperature
Typical Performance Characteristics (Continued)

Slew Rate vs Supply Voltage

Power Bandwidth

CMR vs Frequency

Distortion vs Frequency

PSRR vs Frequency

Maximum Output Voltage vs Supply Voltage

www.national.com
Typical Performance Characteristics (Continued)

Maximum Output Voltage vs Ambient Temperature

Spot Noise Voltage vs Frequency

Spot Noise Current vs Frequency

Input Referred Noise Voltage vs Source Resistance

Noninverting Amp

Noninverting Amp
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 = V0/560,000 (V)
**Typical Applications**

### NAB Preamp

![NAB Preamp Diagram](image1)

\[ AV = 34.5 \]

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

\[ E_n = 0.38 \mu V \]

*A Weighted*

### Balanced to Single Ended Converter

![Balanced to Single Ended Converter Diagram](image2)

\[ V_O = V1 - V2 \]

### Adder/Subracter

![Adder/Subracter Diagram](image3)

\[ V_O = V1 + V2 - V3 - V4 \]
Typical Applications (Continued)

Sine Wave Oscillator

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

Second Order High Pass Filter (Butterworth)

\[
\begin{align*}
\text{C1} &= 0.01 \mu F \\
\text{C2} &= 0.01 \mu F \\
\text{R1} &= 11k \\
\text{R2} &= 22k \\
\text{V1} &\rightarrow \text{1/2 LM833} \rightarrow \text{V0} \\
\end{align*}
\]

if \( C1 = C2 = C \)

\[
\begin{align*}
\text{R1} &= \frac{\sqrt{2}}{2\omega_0 C} \\
\text{R2} &= 2\pi R1 \\
\end{align*}
\]

Illustration is \( f_0 = 1 \) kHz

Second Order Low Pass Filter (Butterworth)

\[
\begin{align*}
\text{C1} &= 0.022 \mu F \\
\text{C2} &= 0.011 \mu F \\
\text{R1} &= 10k \\
\text{R2} &= 10k \\
\text{V1} &\rightarrow \text{1/2 LM833} \rightarrow \text{V0} \\
\end{align*}
\]

if \( R1 = R2 = R \)

\[
\begin{align*}
\text{C1} &= \frac{\sqrt{2}}{\omega_0 R} \\
\text{C2} &= \frac{C1}{2} \\
\end{align*}
\]

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

State Variable Filter

\[ f_0 = \frac{1}{2\pi C_1 R_1} Q \left(1 + \frac{R_2}{R_0} + \frac{R_2}{R_G}\right) \]
\[ A_{BP} = \frac{Q_{A,L,F}}{Q_{A,H}} \frac{R_2}{R_G} \]

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

\[
\begin{align*}
&f_L = \frac{1}{2\pi R2C1}, \quad f_{LB} = \frac{1}{2\pi R1C1} \\
&f_H = \frac{1}{2\pi R5C2}, \quad f_{HB} = \frac{1}{2\pi(R1 + R5 + 2R3)C2}
\end{align*}
\]

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

RIAA Preamp

\(A_p = 35 \text{ dB}\)
\(E_n = 0.33 \mu\text{V}\)
\(S/N = 90 \text{ dB}\)
\(f = 1 \text{ kHz}\)
\(A \text{ Weighted}\)
\(A \text{ Weighted, } V_{IN} = 10 \text{ mV}\)
\(f = 1 \text{ kHz}\)
Typical Applications (Continued)

Balanced Input Mic Amp

\[
V_0 = 101(V_2 - V_1)
\]

Illustration is:

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:

\( V_0 = 101(V_2 - V_1) \)
### 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  
$Q = 1.7$  
Typical Applications  (Continued)

LM833 MDC MWC
DUAL AUDIO OPERATIONAL AMPLIFIER

DIE/WAFER CHARACTERISTICS

<table>
<thead>
<tr>
<th>Fabrication Attributes</th>
<th>General Die Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Die Identification</td>
<td>LM833A</td>
</tr>
<tr>
<td>Die Step</td>
<td>A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Attributes</th>
<th>Physical Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafer Diameter</td>
<td>150mm</td>
</tr>
<tr>
<td>Die Size (Drawn)</td>
<td>1219µm x 1270µm 48mils x 50mils</td>
</tr>
<tr>
<td>Thickness</td>
<td>406µm Nominal</td>
</tr>
<tr>
<td>Min Pitch</td>
<td>288µm Nominal</td>
</tr>
</tbody>
</table>

Special Assembly Requirements:
Note: Actual die size is rounded to the nearest micron.

Die Bond Pad Coordinate Locations (A - Step)
(Referenced to die center, coordinates in µm) NC = No Connection

<table>
<thead>
<tr>
<th>SIGNAL NAME</th>
<th>PAD# NUMBER</th>
<th>X/Y COORDINATES</th>
<th>PAD SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT A</td>
<td>1</td>
<td>-476 500 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>INPUT A-</td>
<td>2</td>
<td>-476 -212 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>INPUT A+</td>
<td>3</td>
<td>-476 -500 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>VEE-</td>
<td>4</td>
<td>-0 -500 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>INPUT B+</td>
<td>5</td>
<td>476 -500 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>INPUT B-</td>
<td>6</td>
<td>476 -212 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>OUTPUT B</td>
<td>7</td>
<td>476 500 110 x 110</td>
<td>X Y</td>
</tr>
<tr>
<td>VCC+</td>
<td>8</td>
<td>0 500 110 x 110</td>
<td>X Y</td>
</tr>
</tbody>
</table>
## Typical Applications (Continued)

<table>
<thead>
<tr>
<th>Location</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IN U.S.A</strong></td>
<td>Tel #: 1 877 Dial Die 1 877 342 5343</td>
</tr>
<tr>
<td></td>
<td>Fax: 1 207 541 6140</td>
</tr>
<tr>
<td><strong>IN EUROPE</strong></td>
<td>Tel: 49 (0) 8141 351492 / 1495</td>
</tr>
<tr>
<td></td>
<td>Fax: 49 (0) 8141 351470</td>
</tr>
<tr>
<td><strong>IN ASIA PACIFIC</strong></td>
<td>Tel: (852) 27371701</td>
</tr>
<tr>
<td><strong>IN JAPAN</strong></td>
<td>Tel: 81 043 299 2308</td>
</tr>
</tbody>
</table>
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
Physical Dimensions

8-Lead (0.118" Wide) Molded Mini Small Outline Package
Order Number LM833MM or LM833MMX
NS Package Number MUA08A

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