



January 2003

# 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.

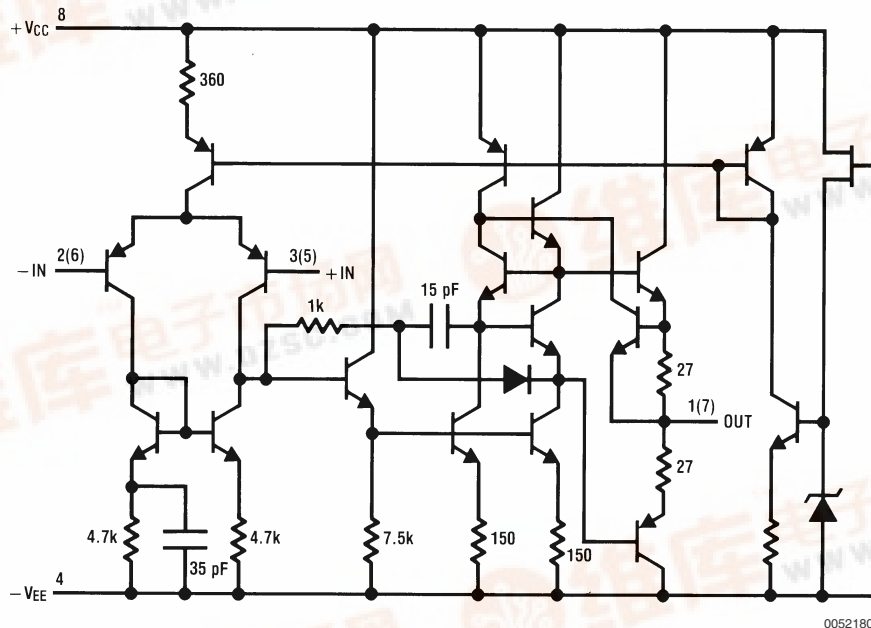
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level 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

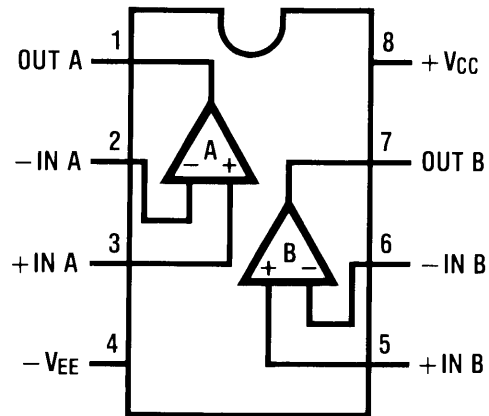
### Schematic Diagram (1/2 LM833)



LM833 Dual Audio Operational Amplifier



## Connection Diagram



00521802

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) $V_I$ | $\pm 30V$             |
| Input Voltage Range (Note 3) $V_{IC}$     | $\pm 15V$             |
| Power Dissipation (Note 4) $P_D$          | 500 mW                |
| Operating Temperature Range $T_{OPR}$     | $-40 \sim 85^\circ C$ |

|                                       |                        |
|---------------------------------------|------------------------|
| Storage Temperature Range $T_{STG}$   | $-60 \sim 150^\circ C$ |
| Soldering Information                 |                        |
| Dual-In-Line Package                  |                        |
| Soldering (10 seconds)                | $260^\circ C$          |
| Small Outline Package (SOIC and MSOP) |                        |
| Vapor Phase (60 seconds)              | $215^\circ C$          |
| Infrared (15 seconds)                 | $220^\circ C$          |
| ESD tolerance (Note 5)                | 1600V                  |

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

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

| Symbol   | Parameter                    | Conditions                                 | Min      | Typ        | Max  | Units |
|----------|------------------------------|--|----------|------------|------|-------|
| $V_{OS}$ | Input Offset Voltage         | $R_S = 10\Omega$                           |          | 0.3        | 5    | mV    |
| $I_{OS}$ | Input Offset Current         |  |          | 10         | 200  | nA    |
| $I_B$    | Input Bias Current           |  |          | 500        | 1000 | nA    |
| $A_V$    | Voltage Gain                 | $R_L = 2\text{ k}\Omega$ , $V_O = \pm 10V$ | 90       | 110        |      | dB    |
| $V_{OM}$ | Output Voltage Swing         | $R_L = 10\text{ k}\Omega$                  | $\pm 12$ | $\pm 13.5$ |      | V     |
|          |                              | $R_L = 2\text{ k}\Omega$                   | $\pm 10$ | $\pm 13.4$ |      | V     |
| $V_{CM}$ | Input Common-Mode Range      |  | $\pm 12$ | $\pm 14.0$ |      | V     |
| CMRR     | Common-Mode Rejection Ratio  | $V_{IN} = \pm 12V$                         | 80       | 100        |      | dB    |
| PSRR     | Power Supply Rejection Ratio | $V_S = 15\sim 5V, -15\sim -5V$             | 80       | 100        |      | dB    |
| $I_Q$    | Supply Current               | $V_O = 0V$ , Both Amps                     |          | 5          | 8    | mA    |

**AC Electrical Characteristics**

( $T_A = 25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 2\text{ k}\Omega$ )

| Symbol | Parameter              | Conditions               | Min | Typ | Max | Units      |
|--------|------------------------|--------------------------|-----|-----|-----|------------|
| SR     | Slew Rate              | $R_L = 2\text{ k}\Omega$ | 5   | 7   |     | V/ $\mu s$ |
| GBW    | Gain Bandwidth Product | $f = 100\text{ kHz}$     | 10  | 15  |     | MHz        |

**Design Electrical Characteristics**

( $T_A = 25^\circ C$ ,  $V_S = \pm 15V$ ) The following parameters are not tested or guaranteed.

| Symbol                   | Parameter   | Conditions  | Typ   | Units            |
|--------------------------|---|---|-------|------------------|
| $\Delta V_{OS}/\Delta T$ | Average Temperature Coefficient of Input Offset Voltage |   | 2     | $\mu V/^\circ C$ |
| THD                      | Distortion  | $R_L = 2\text{ k}\Omega$ , $f = 20\sim 20\text{ kHz}$<br>$V_{OUT} = 3\text{ V}_{rms}$ , $A_V = 1$ | 0.002 | %                |
| $e_n$                    | Input Referred Noise Voltage                            | $R_S = 100\Omega$ , $f = 1\text{ kHz}$  | 4.5   | $nV/\sqrt{Hz}$   |
| $i_n$                    | Input Referred Noise Current                            | $f = 1\text{ kHz}$  | 0.7   | $pA/\sqrt{Hz}$   |
| PBW                      | Power Bandwidth   | $V_O = 27\text{ V}_{pp}$ , $R_L = 2\text{ k}\Omega$ , $THD \leq 1\%$                              | 120   | kHz              |
| $f_U$                    | Unity Gain Frequency                                    | Open Loop   | 9     | MHz              |
| $\phi_M$                 | Phase Margin  | Open Loop   | 60    | deg              |
|                          | Input Referred Cross Talk                               | $f = 20\sim 20\text{ kHz}$  | -120  | dB               |

## 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.

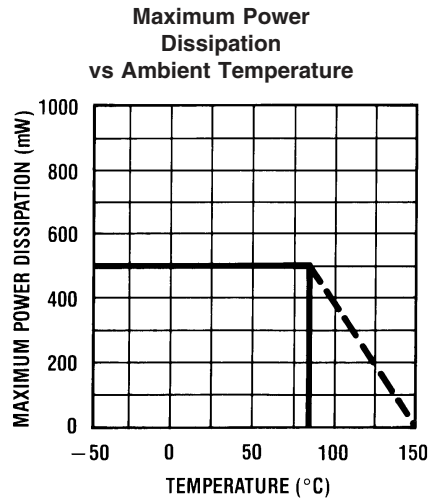
**Note 2:** All voltages are measured with respect to the ground pin, unless otherwise specified.

**Note 3:** If supply voltage is less than  $\pm 15V$ , it is equal to supply voltage.

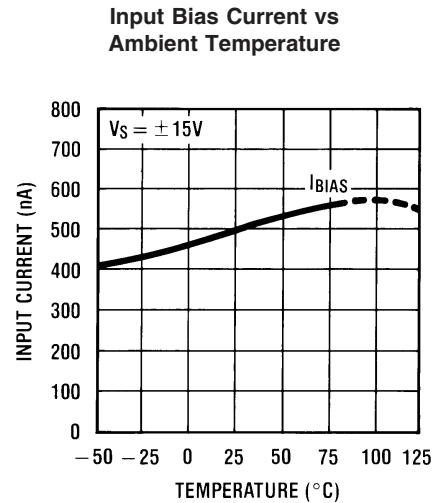
**Note 4:** This is the permissible value at  $T_A \leq 85^\circ C$ .

**Note 5:** Human body model, 1.5 k $\Omega$  in series with 100 pF.

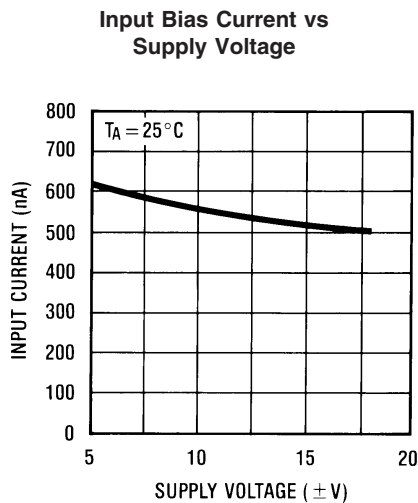
## Typical Performance Characteristics



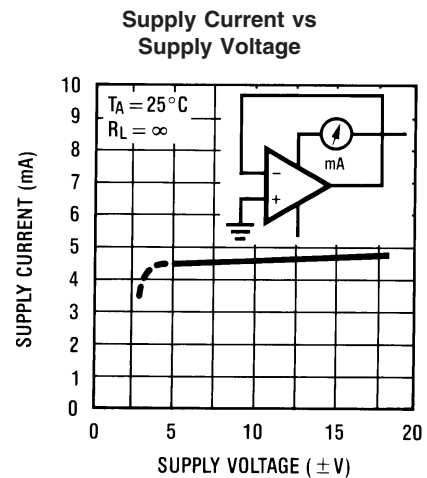
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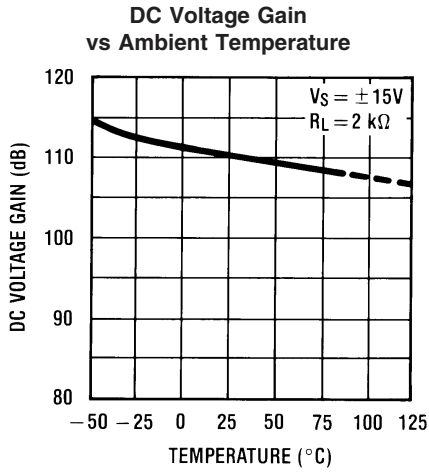


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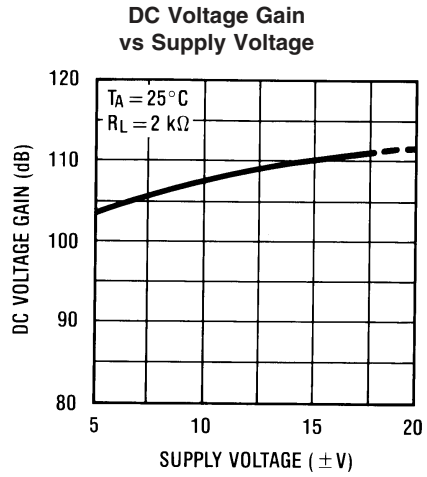


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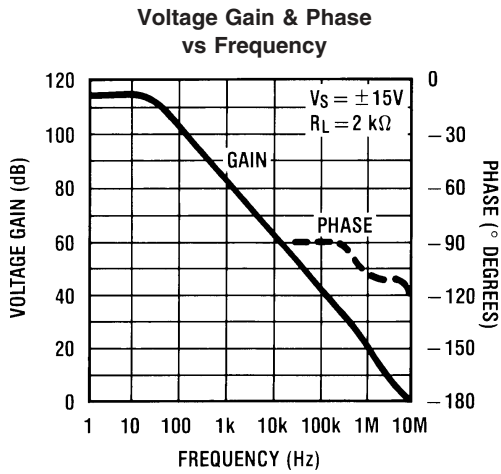
Typical Performance Characteristics (Continued)



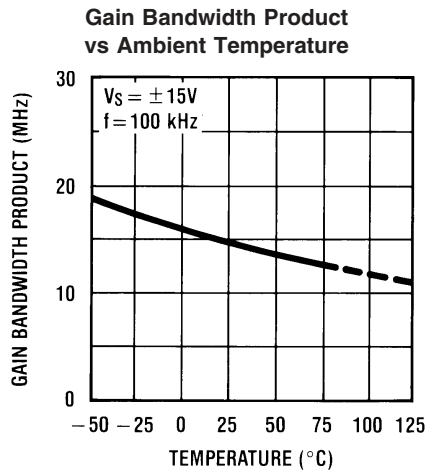
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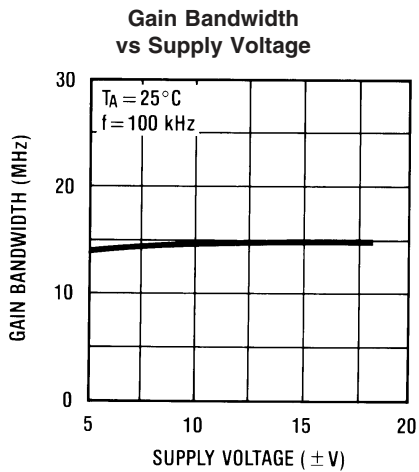
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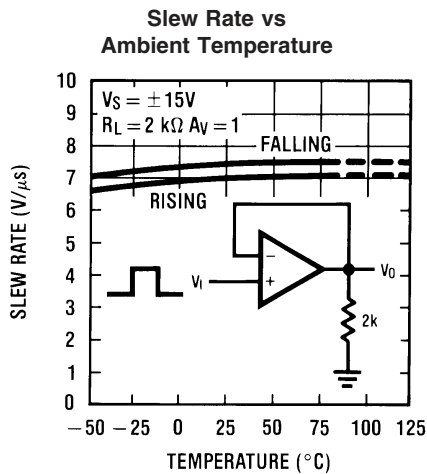
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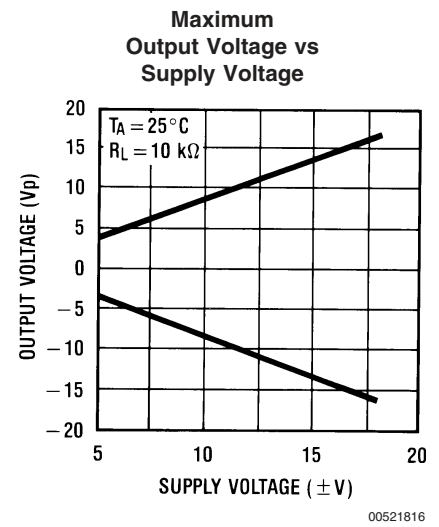
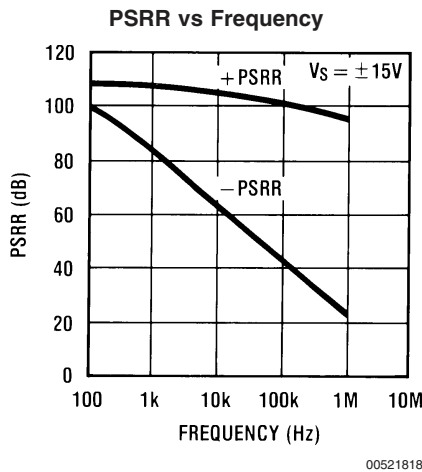
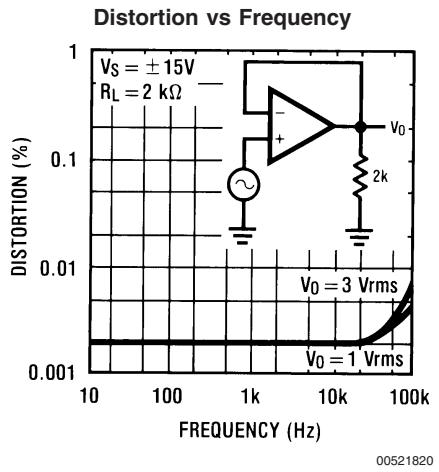
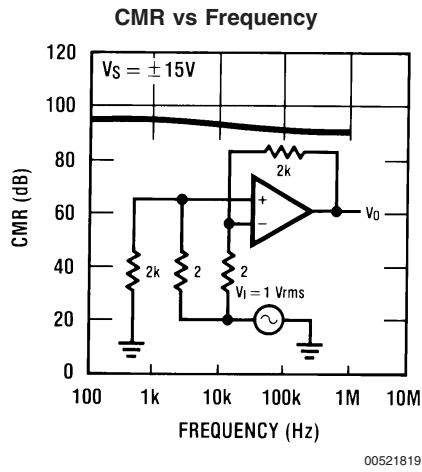
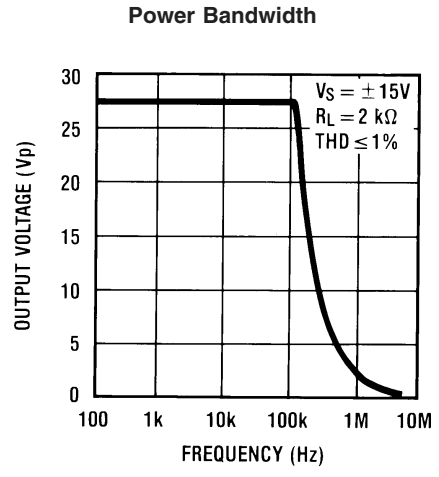
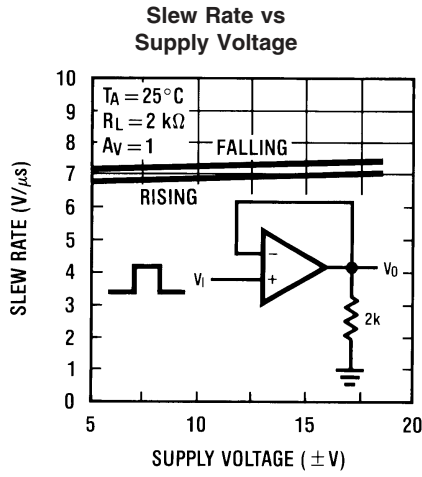


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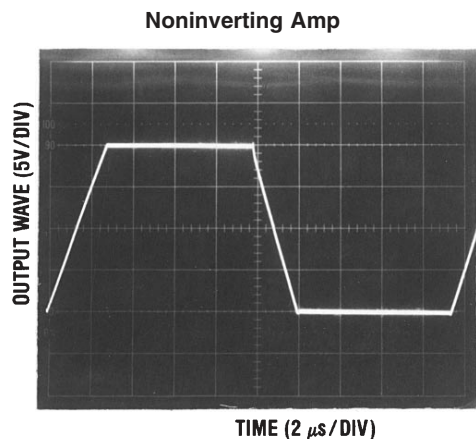
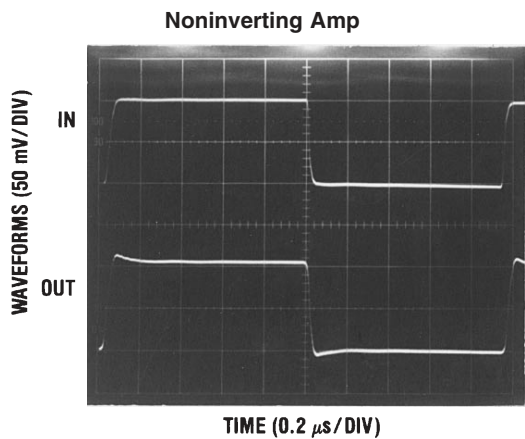
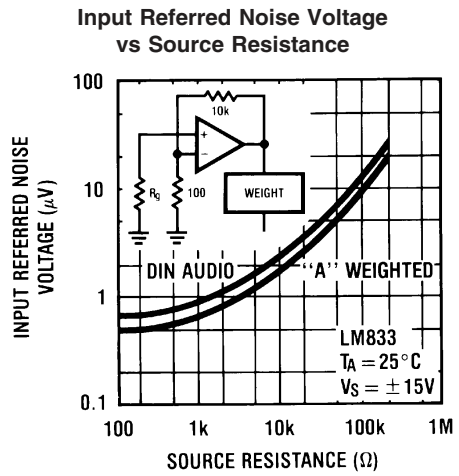
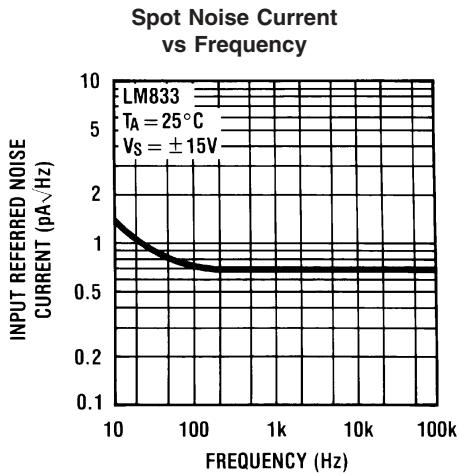
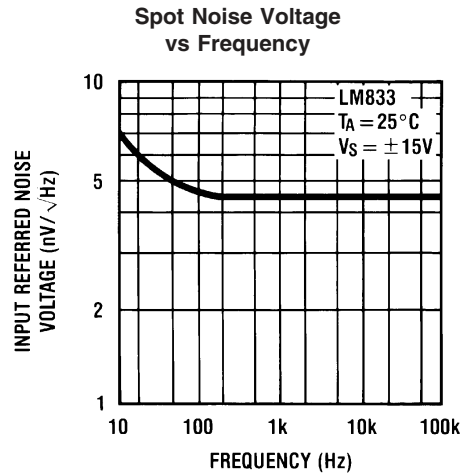
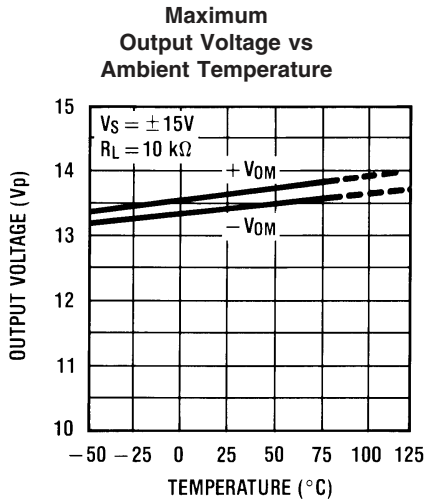


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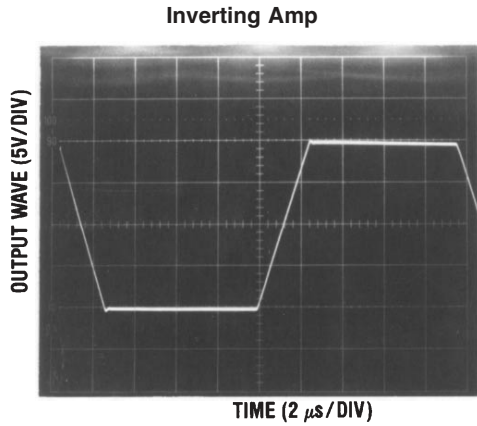
# Typical Performance Characteristics (Continued)



Typical Performance Characteristics (Continued)



## Typical Performance Characteristics (Continued)



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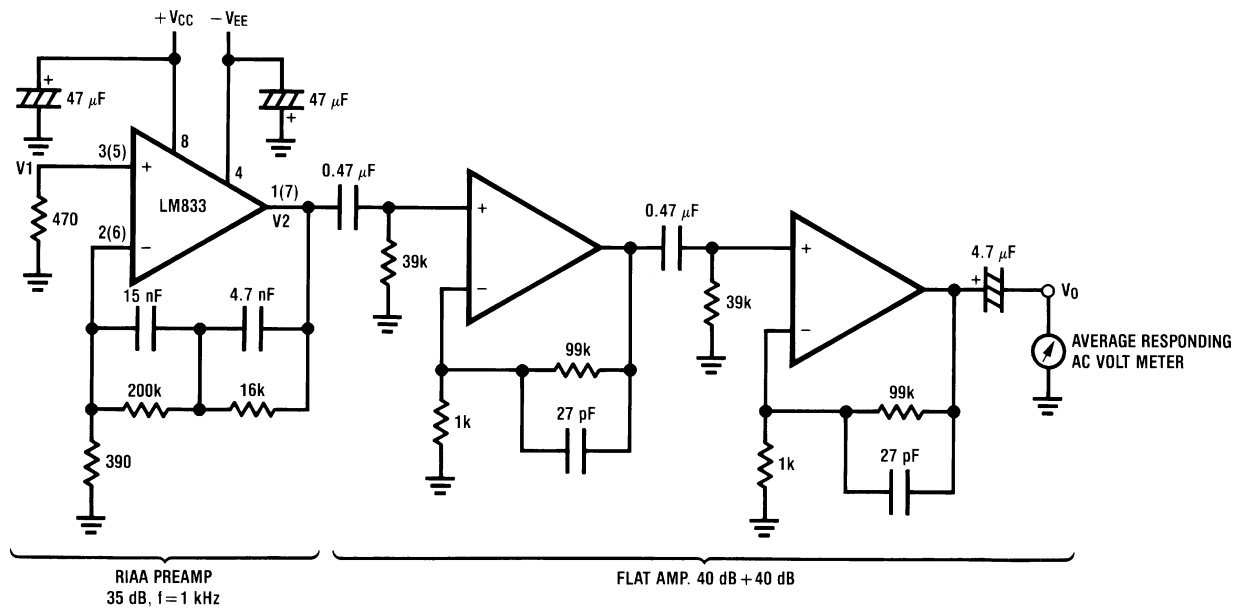
### Application Hints

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



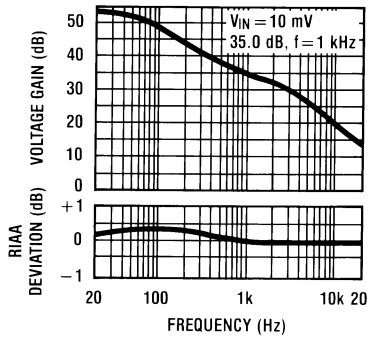
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Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

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

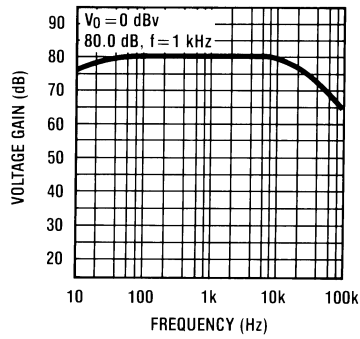


RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



00521828

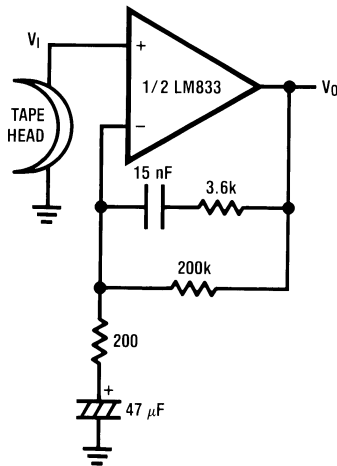
Flat Amp Voltage Gain vs Frequency



00521829

Typical Applications

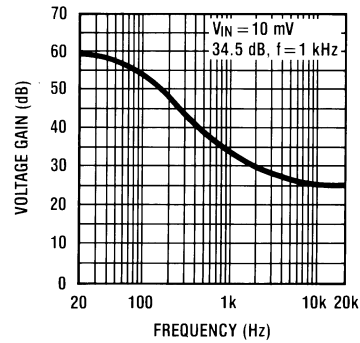
NAB Preamp



00521830

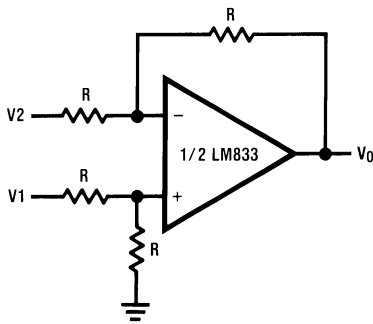
$A_V = 34.5$   
 $F = 1 \text{ kHz}$   
 $E_n = 0.38 \mu\text{V}$   
 A Weighted

NAB Preamp Voltage Gain vs Frequency



00521831

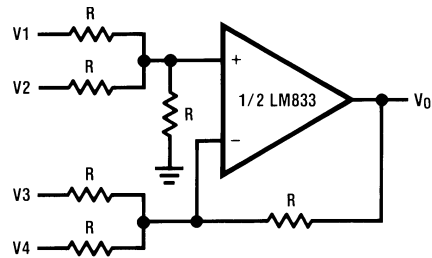
Balanced to Single Ended Converter



00521832

$V_O = V_1 - V_2$

Adder/Subtractor

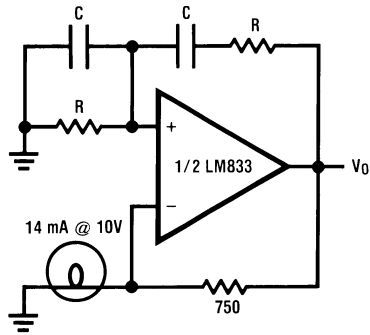


00521833

$V_O = V_1 + V_2 - V_3 - V_4$

# Typical Applications (Continued)

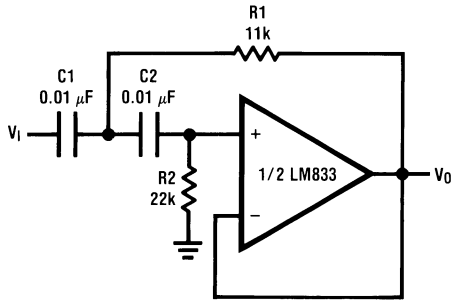
Sine Wave Oscillator



00521834

$$f_o = \frac{1}{2\pi RC}$$

Second Order High Pass Filter (Butterworth)



00521835

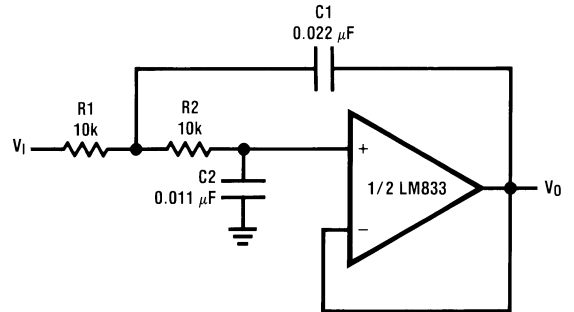
if  $C_1 = C_2 = C$

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

$$R_2 = 2 \cdot R_1$$

Illustration is  $f_0 = 1$  kHz

Second Order Low Pass Filter (Butterworth)



00521836

if  $R_1 = R_2 = R$

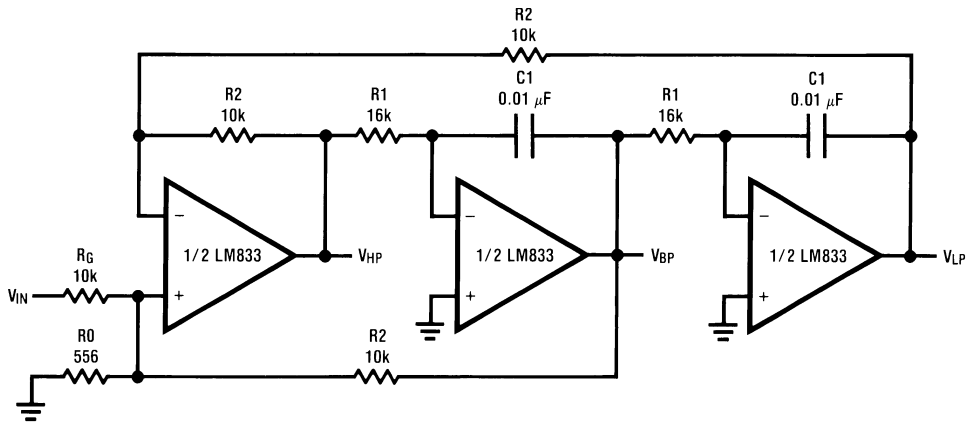
$$C_1 = \frac{\sqrt{2}}{\omega_0 R}$$

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

Illustration is  $f_0 = 1$  kHz

Typical Applications (Continued)

State Variable Filter

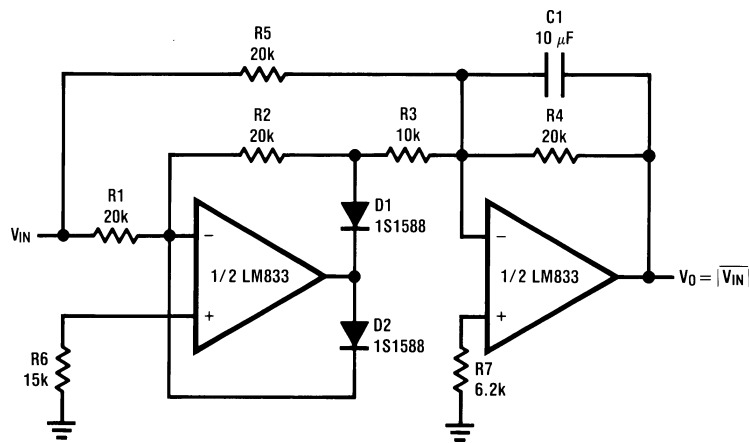


00521837

$$f_0 = \frac{1}{2\pi C_1 R_1}, Q = \frac{1}{2} \left( 1 + \frac{R_2}{R_0} + \frac{R_2}{R_G} \right), A_{BP} = Q A_{LP} = Q A_{LH} = \frac{R_2}{R_G}$$

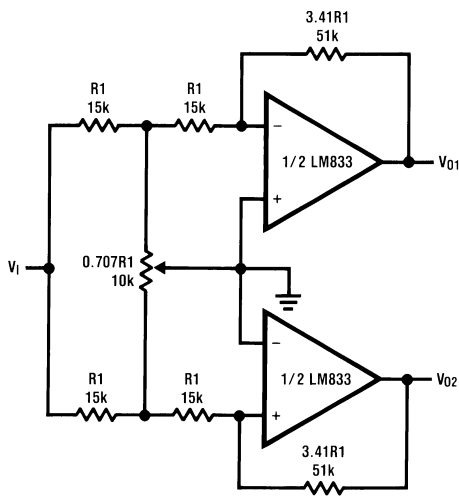
Illustration is  $f_0 = 1$  kHz,  $Q = 10$ ,  $A_{BP} = 1$

AC/DC Converter



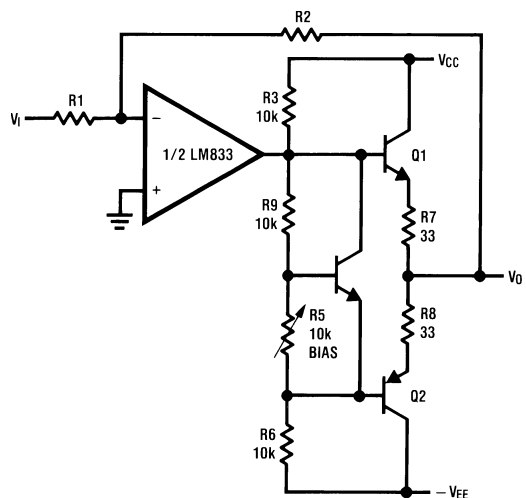
00521838

2 Channel Panning Circuit (Pan Pot)



00521839

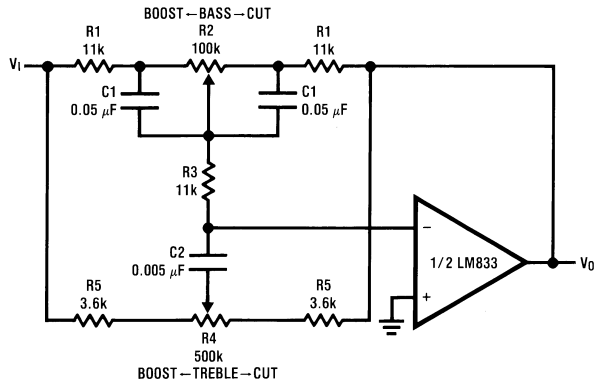
Line Driver



00521840

# Typical Applications (Continued)

## Tone Control



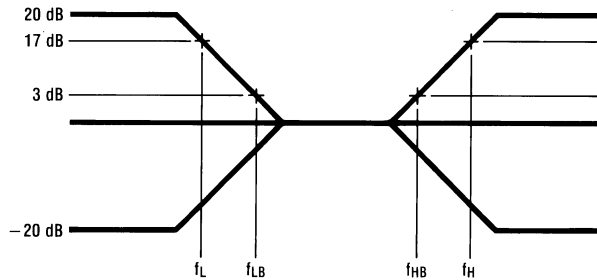
00521841

$$f_L = \frac{1}{2\pi R_2 C_1}, f_{LB} = \frac{1}{2\pi R_1 C_1}$$

$$f_H = \frac{1}{2\pi R_5 C_2}, f_{HB} = \frac{1}{2\pi (R_1 + R_5 + 2R_3) C_2}$$

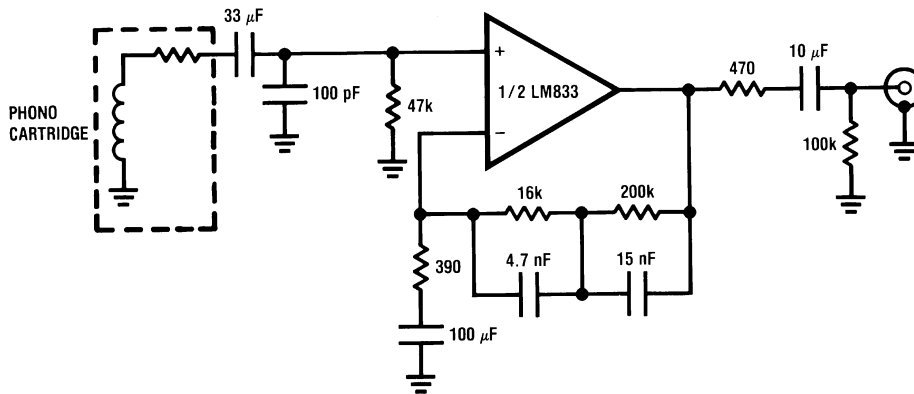
Illustration is:

$f_L = 32 \text{ Hz}, f_{LB} = 320 \text{ Hz}$   
 $f_H = 11 \text{ kHz}, f_{HB} = 1.1 \text{ kHz}$



00521842

## RIAA Preamp

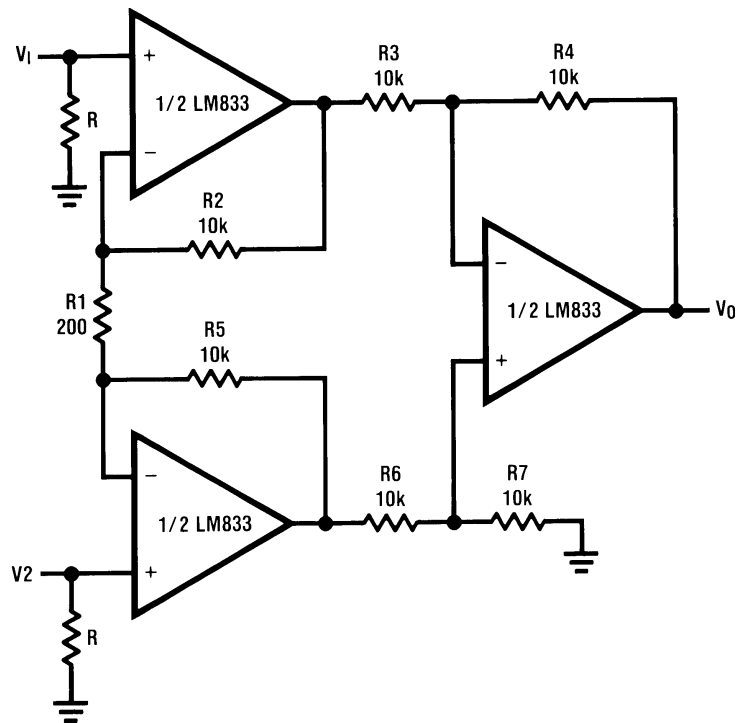


00521803

$A_v = 35 \text{ dB}$   
 $E_n = 0.33 \mu\text{V}$   
 $S/N = 90 \text{ dB}$   
 $f = 1 \text{ kHz}$   
 A Weighted  
 A Weighted,  $V_{IN} = 10 \text{ mV}$   
 @  $f = 1 \text{ kHz}$

## Typical Applications (Continued)

### Balanced Input Mic Amp



00521843

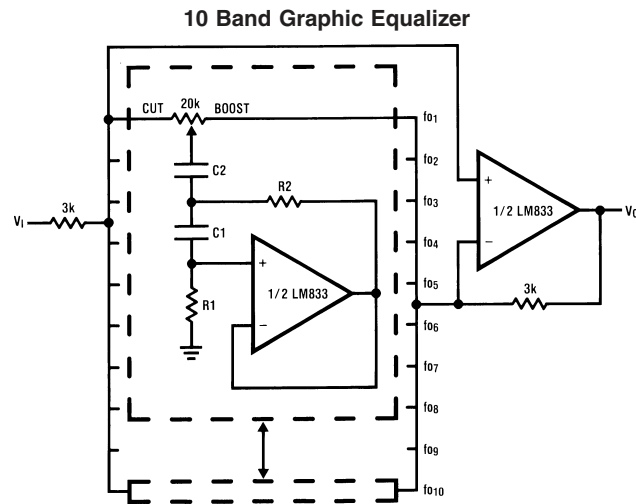
If  $R2 = R5$ ,  $R3 = R6$ ,  $R4 = R7$

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

Illustration is:

$$V_0 = 101(V_2 - V_1)$$

## Typical Applications (Continued)



00521844

| fo(Hz) | C <sub>1</sub> | C <sub>2</sub> | R <sub>1</sub> | R <sub>2</sub> |
|--------|----------------|----------------|----------------|----------------|
| 32     | 0.12 $\mu$ F   | 4.7 $\mu$ F    | 75k $\Omega$   | 500 $\Omega$   |
| 64     | 0.056 $\mu$ F  | 3.3 $\mu$ F    | 68k $\Omega$   | 510 $\Omega$   |
| 125    | 0.033 $\mu$ F  | 1.5 $\mu$ F    | 62k $\Omega$   | 510 $\Omega$   |
| 250    | 0.015 $\mu$ F  | 0.82 $\mu$ F   | 68k $\Omega$   | 470 $\Omega$   |
| 500    | 8200pF         | 0.39 $\mu$ F   | 62k $\Omega$   | 470 $\Omega$   |
| 1k     | 3900pF         | 0.22 $\mu$ F   | 68k $\Omega$   | 470 $\Omega$   |
| 2k     | 2000pF         | 0.1 $\mu$ F    | 68k $\Omega$   | 470 $\Omega$   |
| 4k     | 1100pF         | 0.056 $\mu$ F  | 62k $\Omega$   | 470 $\Omega$   |
| 8k     | 510pF          | 0.022 $\mu$ F  | 68k $\Omega$   | 510 $\Omega$   |
| 16k    | 330pF          | 0.012 $\mu$ F  | 51k $\Omega$   | 510 $\Omega$   |

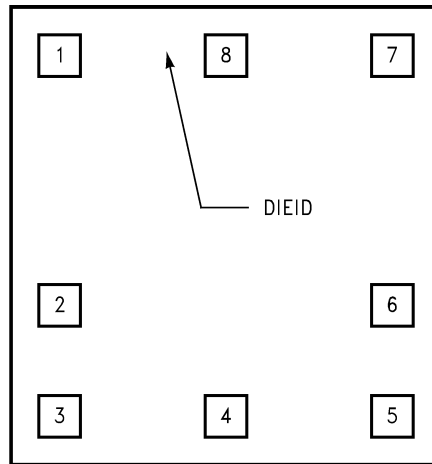
**Note 6:** At volume of change =  $\pm 12$  dB

Q = 1.7

Reference: "AUDIO/RADIO HANDBOOK", National Semiconductor, 1980, Page 2-61

## Typical Applications (Continued)

### LM833 MDC MWC DUAL AUDIO OPERATIONAL AMPLIFIER



00521854

Die Layout (A - Step)

## DIE/WAFER CHARACTERISTICS

| Fabrication Attributes      |  | General Die Information     |                           |
|-----------------------------|--|-----------------------------|---------------------------|
| Physical Die Identification | LM833A   | Bond Pad Opening Size (min) | 110 $\mu$ m x 110 $\mu$ m |
| Die Step                    | A  | Bond Pad Metalization       | ALUMINUM                  |
| Physical Attributes         |  | Passivation                 | VOM NITRIDE               |
| Wafer Diameter              | 150mm  | Back Side Metal             | BARE BACK                 |
| Dise Size (Drawn)           | 1219 $\mu$ m x 1270 $\mu$ m<br>48mils x 50mils | Back Side Connection        | Floating                  |
| Thickness                   | 406 $\mu$ m Nominal                            |                             |                           |
| Min Pitch                   | 288 $\mu$ m Nominal                            |                             |                           |

### 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  $\mu$ m) NC = No Connection

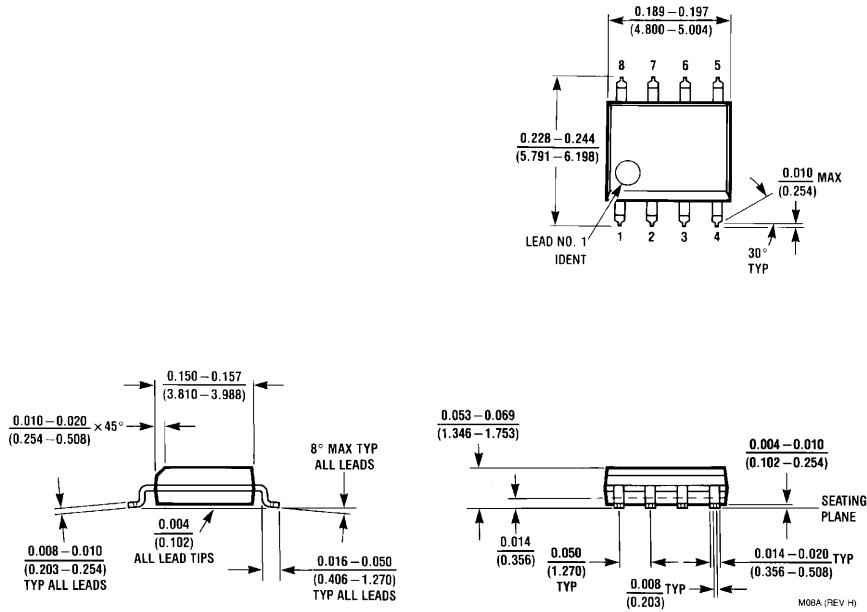
| SIGNAL NAME | PAD# NUMBER | X/Y COORDINATES |      | PAD SIZE |   |     |
|-------------|-------------|-----------------|------|----------|---|-----|
|             |             | X               | Y    | X        |   | Y   |
| OUTPUT A    | 1           | -476            | 500  | 110      | x | 110 |
| INPUT A-    | 2           | -476            | -212 | 110      | x | 110 |
| INPUT A+    | 3           | -476            | -500 | 110      | x | 110 |
| VEE-        | 4           | -0              | -500 | 110      | x | 110 |
| INPUT B+    | 5           | 476             | -500 | 110      | x | 110 |
| INPUT B-    | 6           | 476             | -212 | 110      | x | 110 |
| OUTPUT B    | 7           | 476             | 500  | 110      | x | 110 |
| VCC+        | 8           | 0               | 500  | 110      | x | 110 |

**Typical Applications** (Continued)

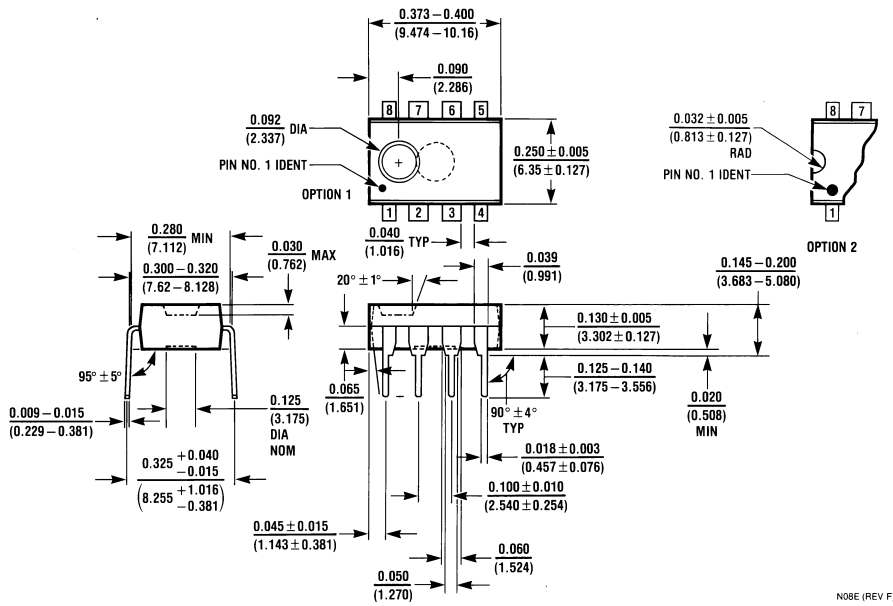
|                        |                               |
|------------------------|-------------------------------|
| <b>IN U.S.A</b>        |                               |
| Tel #:                 | 1 877 Dial Die 1 877 342 5343 |
| Fax:                   | 1 207 541 6140                |
|                        |                               |
| <b>IN EUROPE</b>       |                               |
| Tel:                   | 49 (0) 8141 351492 / 1495     |
| Fax:                   | 49 (0) 8141 351470            |
|                        |                               |
| <b>IN ASIA PACIFIC</b> |                               |
| Tel:                   | (852) 27371701                |
|                        |                               |
| <b>IN JAPAN</b>        |                               |
| Tel:                   | 81 043 299 2308               |



**Physical Dimensions** inches (millimeters) unless otherwise noted

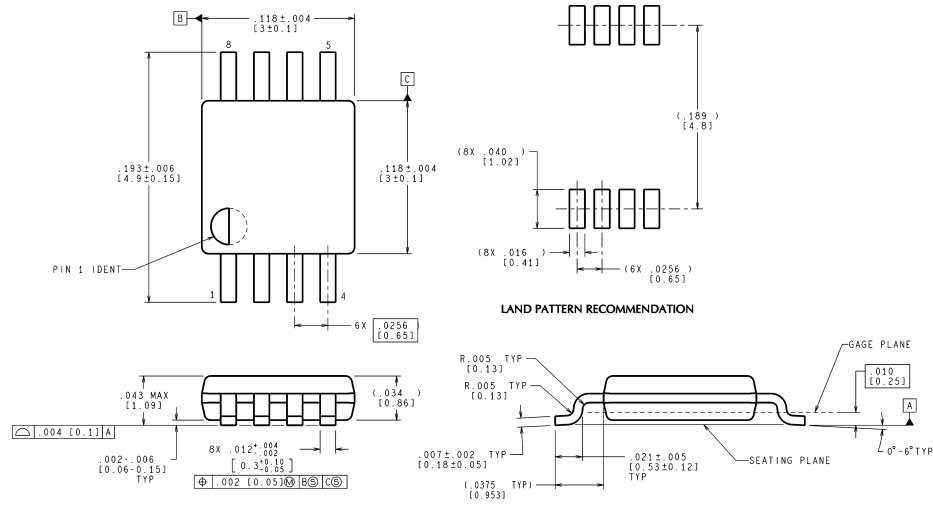


**Molded Small Outline Package (M)**  
**Order Number LM833M or LM833MX**  
**NS Package Number M08A**



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

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

MUA08A (Rev E)

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

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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, or to affect its safety or effectiveness.

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