

## 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.

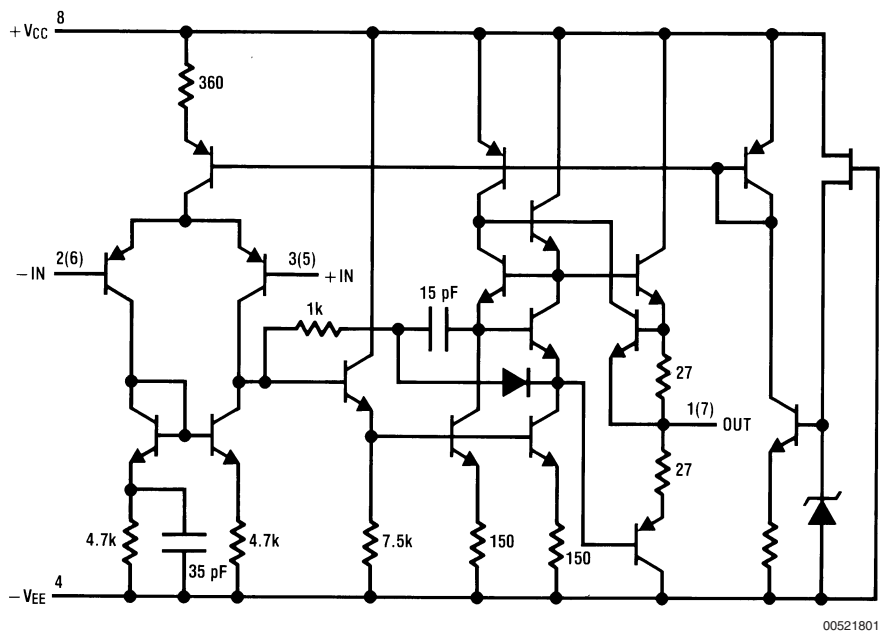
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level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

The LM833 is pin-for-pin compatible with industry standard dual operational amplifiers.

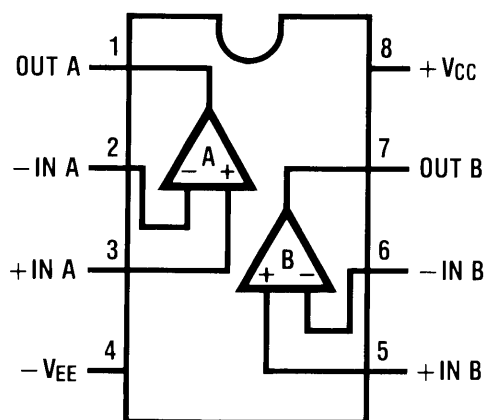
#### Features

- 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



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	$R_L = 2\text{ k}\Omega, f = 20\sim 20\text{ kHz}$ $V_{OUT} = 3\text{ Vrms}, A_V = 1$	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.

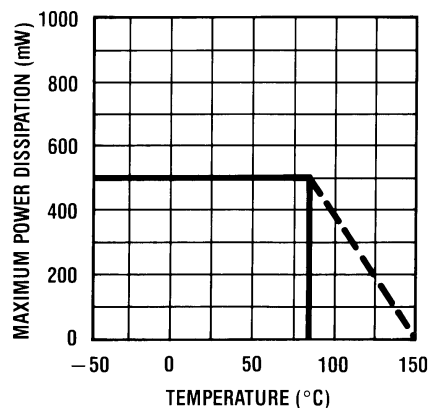
**Note 3:** If supply voltage is less than  $\pm 15\text{V}$ , it is equal to supply voltage.

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

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

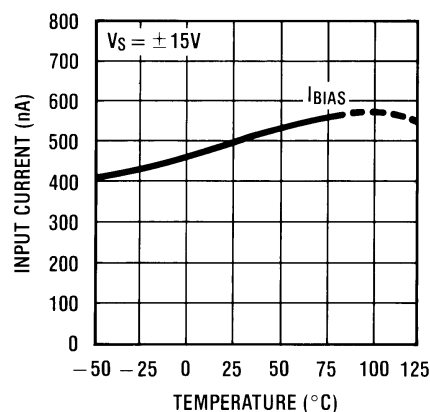
## Typical Performance Characteristics

Maximum Power  
Dissipation  
vs Ambient Temperature



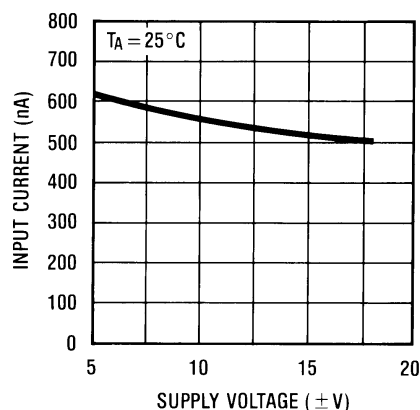
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Input Bias Current vs  
Ambient Temperature



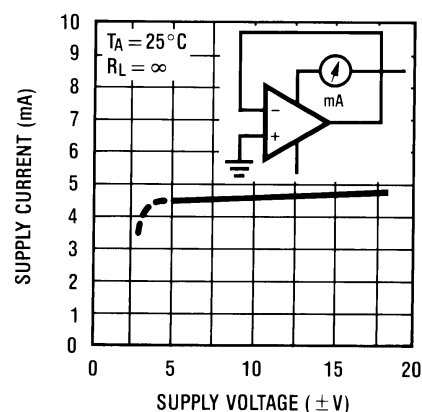
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Input Bias Current vs  
Supply Voltage



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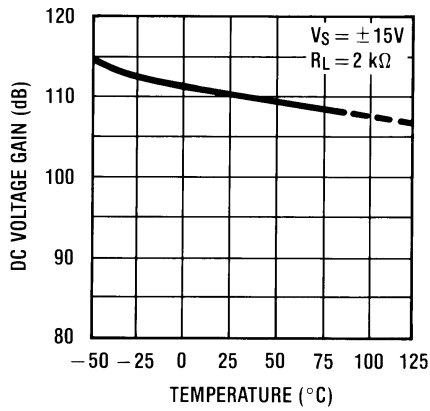
Supply Current vs  
Supply Voltage



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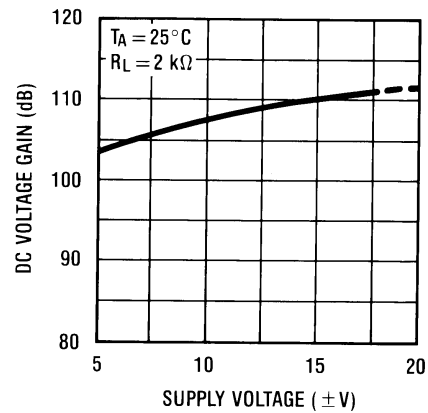
# Typical Performance Characteristics (Continued)

DC Voltage Gain  
vs Ambient Temperature



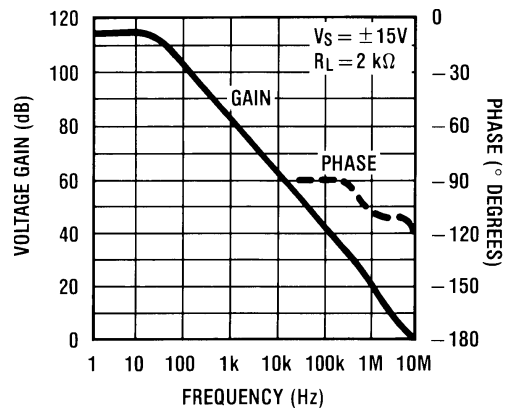
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DC Voltage Gain  
vs Supply Voltage



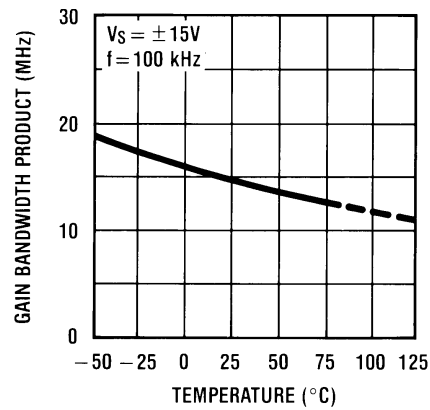
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Voltage Gain & Phase  
vs Frequency



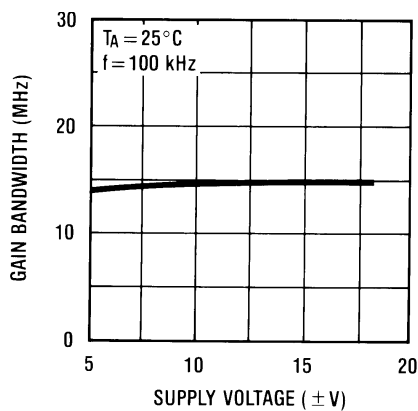
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Gain Bandwidth Product  
vs Ambient Temperature



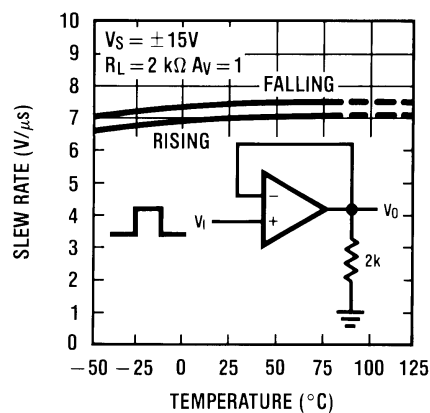
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Gain Bandwidth  
vs Supply Voltage



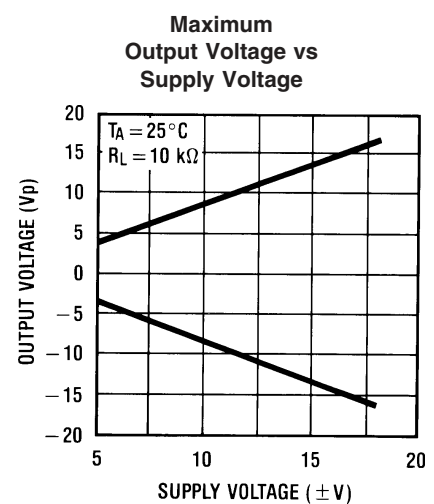
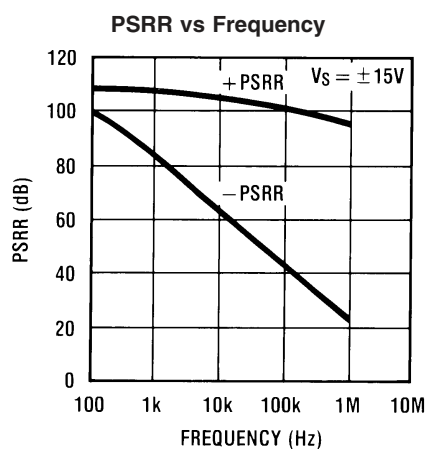
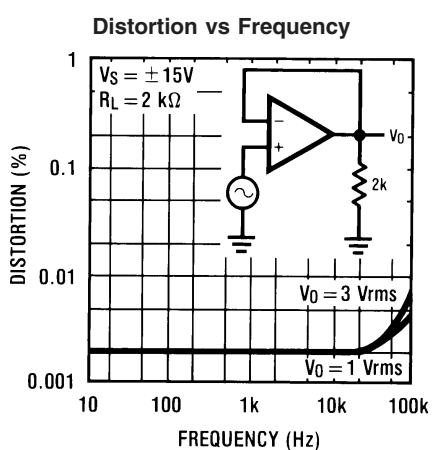
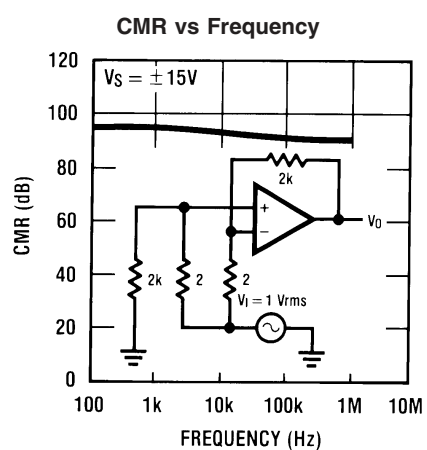
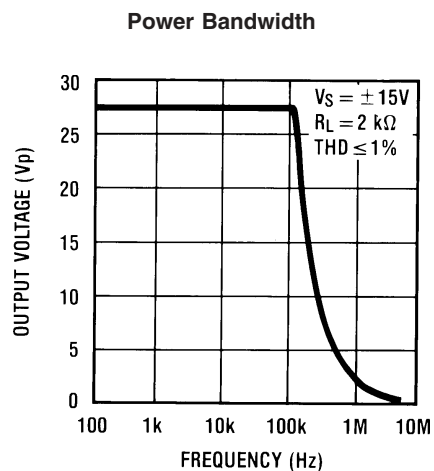
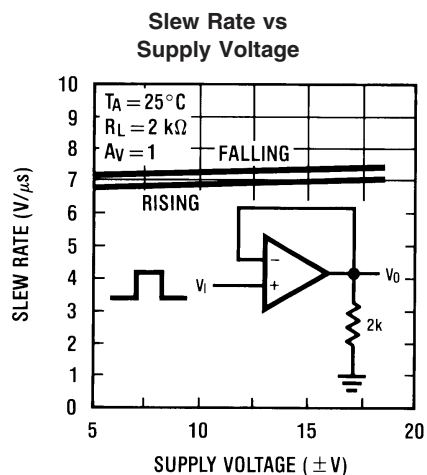
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Slew Rate vs  
Ambient Temperature

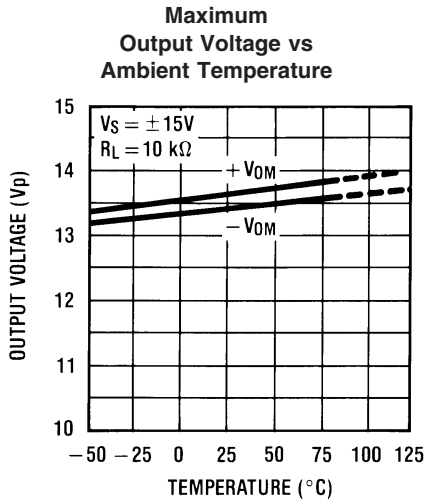


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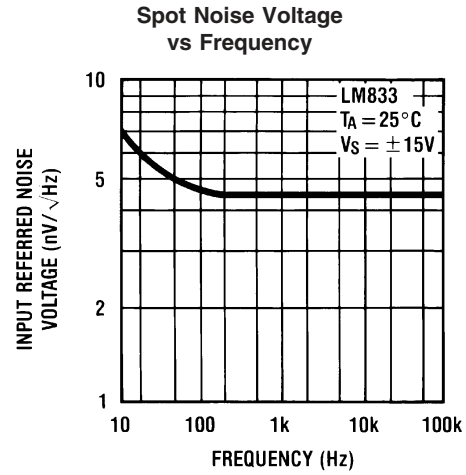
# Typical Performance Characteristics (Continued)



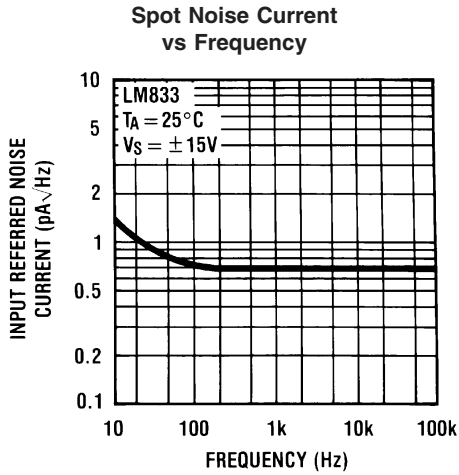
# Typical Performance Characteristics (Continued)



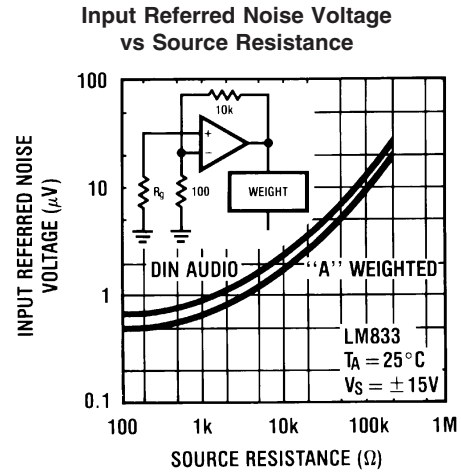
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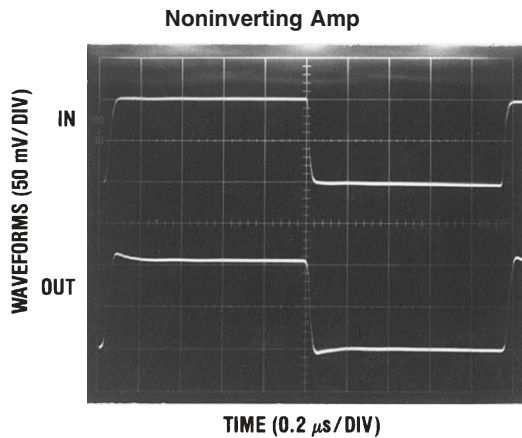
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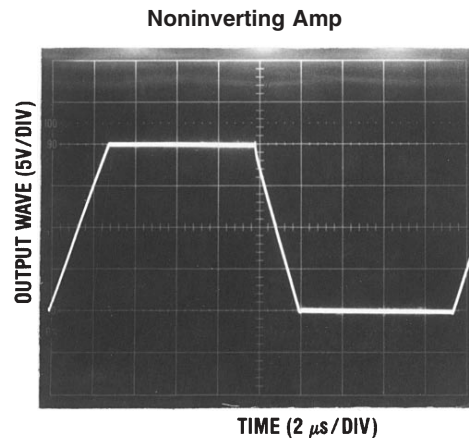
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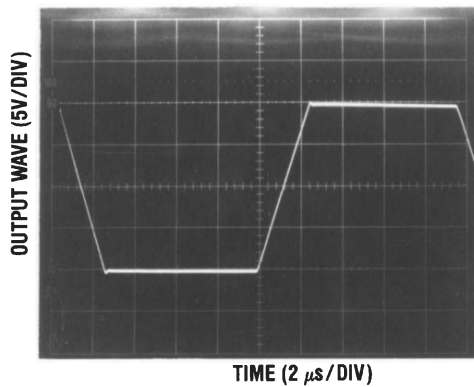
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## Typical Performance Characteristics (Continued)

Inverting Amp



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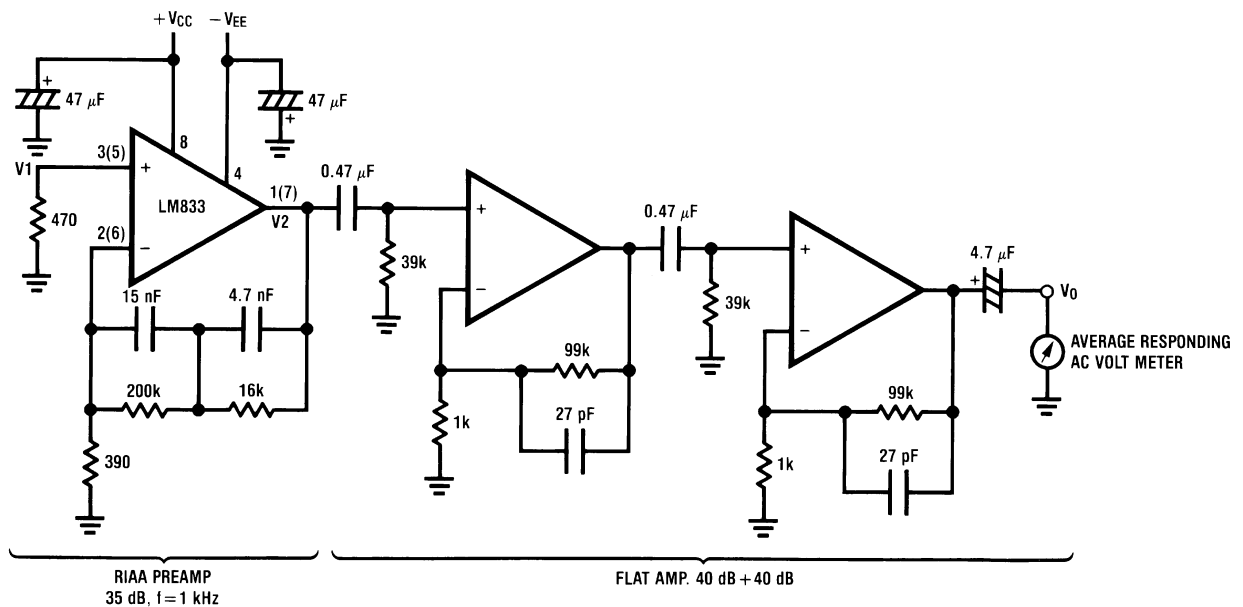
### Application Hints

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

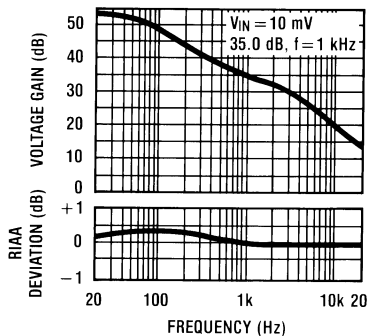


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Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

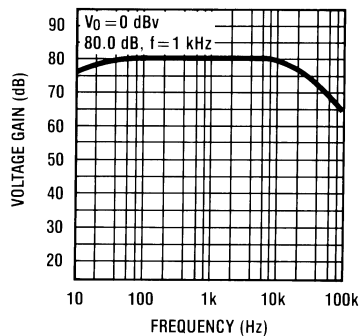
**Total Gain: 115 dB @  $f = 1$  kHz**  
**Input Referred Noise Voltage:  $e_n = V_0/560,000$  (V)**

**RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency**



00521828

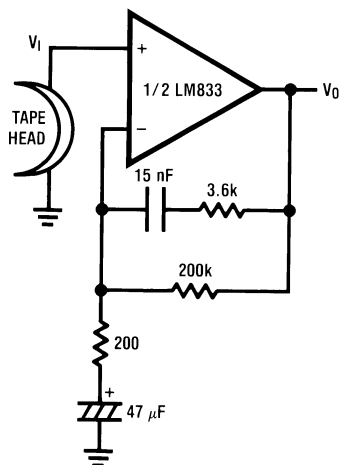
**Flat Amp Voltage Gain vs Frequency**



00521829

## Typical Applications

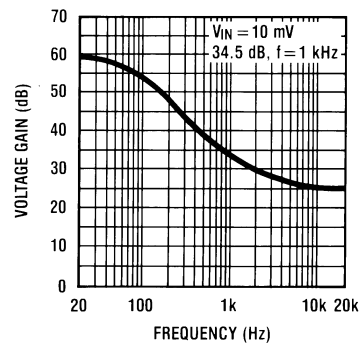
**NAB Preamp**



00521830

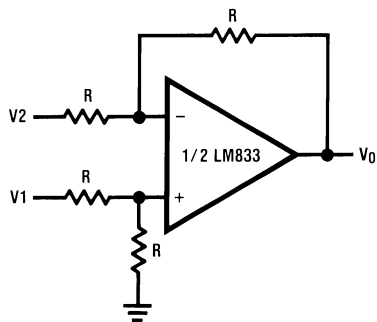
$A_V = 34.5$   
 $F = 1 \text{ kHz}$   
 $E_n = 0.38 \mu\text{V}$   
 A Weighted

**NAB Preamp Voltage Gain vs Frequency**



00521831

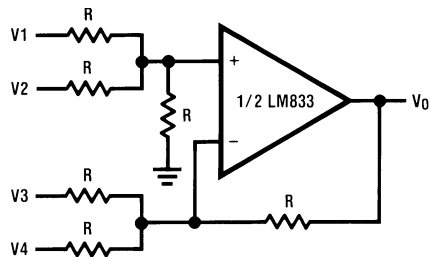
**Balanced to Single Ended Converter**



00521832

$$V_O = V_1 - V_2$$

**Adder/Subtractor**

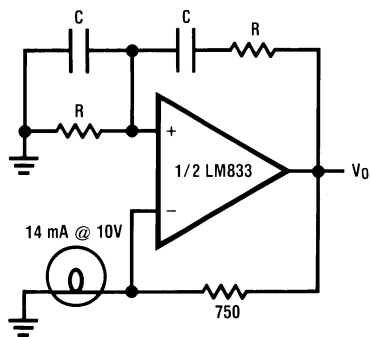


00521833

$$V_O = V_1 + V_2 - V_3 - V_4$$

# Typical Applications (Continued)

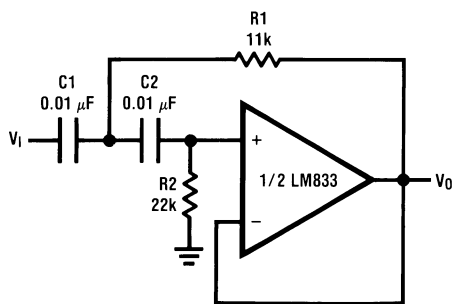
## Sine Wave Oscillator



00521834

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

## Second Order High Pass Filter (Butterworth)



00521835

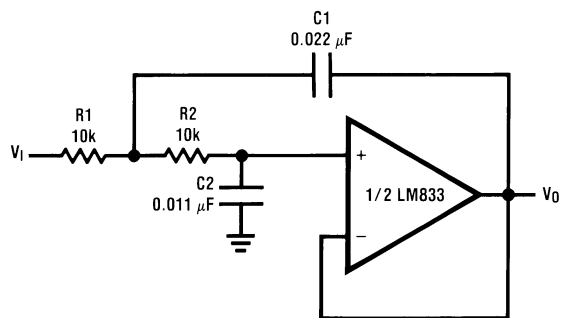
$$\text{if } C1 = C2 = C$$

$$R1 = \frac{\sqrt{2}}{2\omega_o C}$$

$$R2 = 2 \cdot R1$$

Illustration is  $f_o = 1 \text{ kHz}$

## Second Order Low Pass Filter (Butterworth)



00521836

$$\text{if } R1 = R2 = R$$

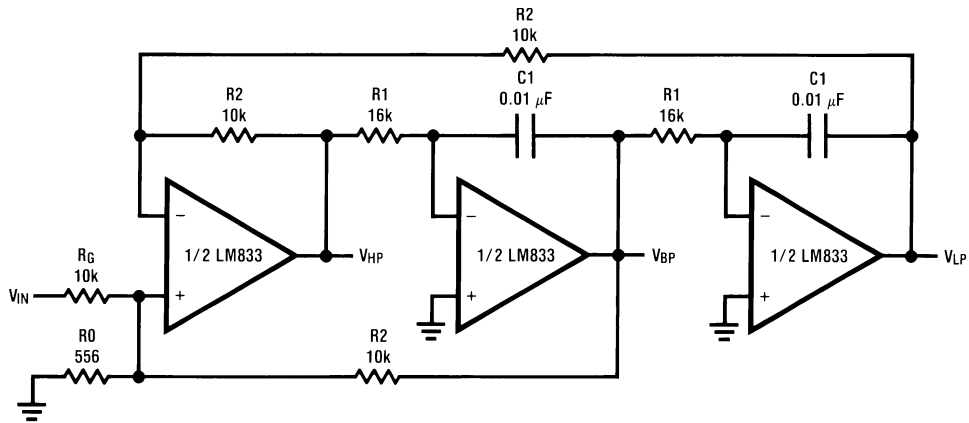
$$C1 = \frac{\sqrt{2}}{\omega_o R}$$

$$C2 = \frac{C1}{2}$$

Illustration is  $f_o = 1 \text{ kHz}$

# Typical Applications (Continued)

## State Variable Filter

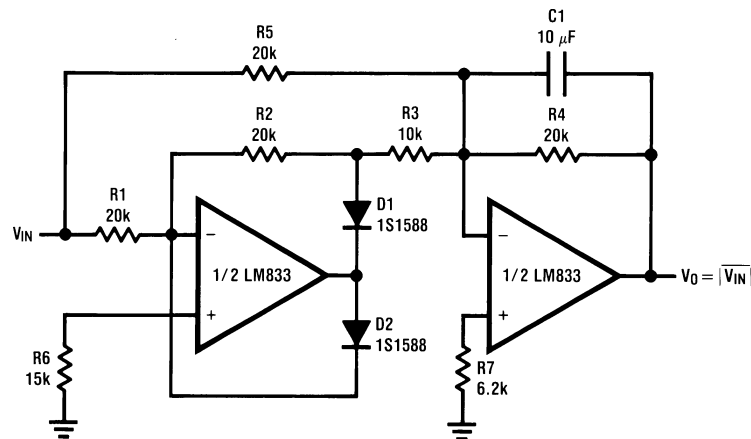


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$$f_0 = \frac{1}{2\pi C_1 R_1}, Q = \frac{1}{2} \left( 1 + \frac{R_2}{R_0} + \frac{R_2}{R_G} \right), A_{BP} = Q A_{LP} = Q A_{LH} = \frac{R_2}{R_G}$$

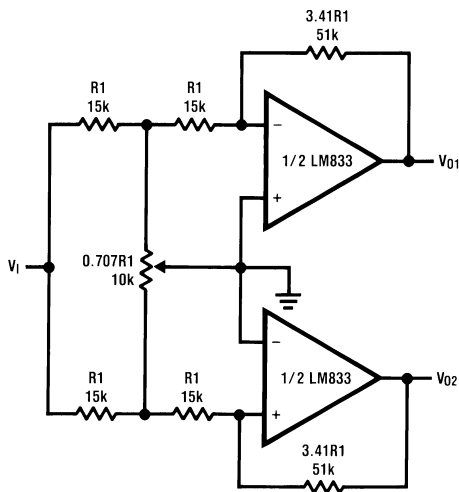
Illustration is  $f_0 = 1 \text{ kHz}$ ,  $Q = 10$ ,  $A_{BP} = 1$

## AC/DC Converter



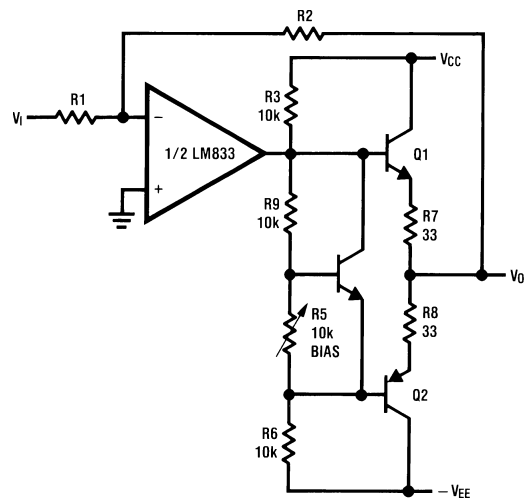
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## 2 Channel Panning Circuit (Pan Pot)



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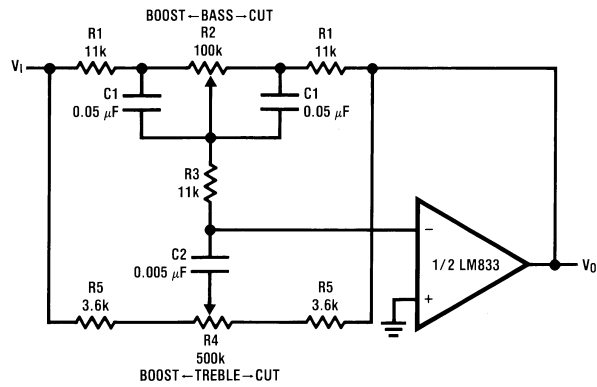
## Line Driver



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# Typical Applications (Continued)

## Tone Control



00521841

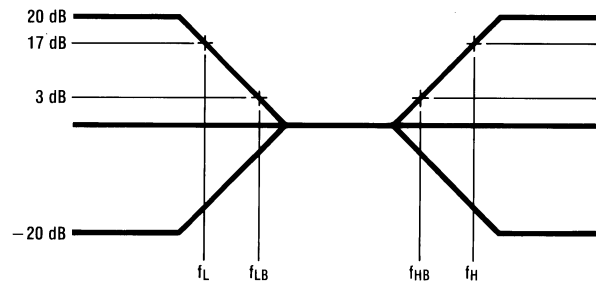
$$f_L = \frac{1}{2\pi R_2 C_1}, f_{LB} = \frac{1}{2\pi R_1 C_1}$$

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

Illustration is:

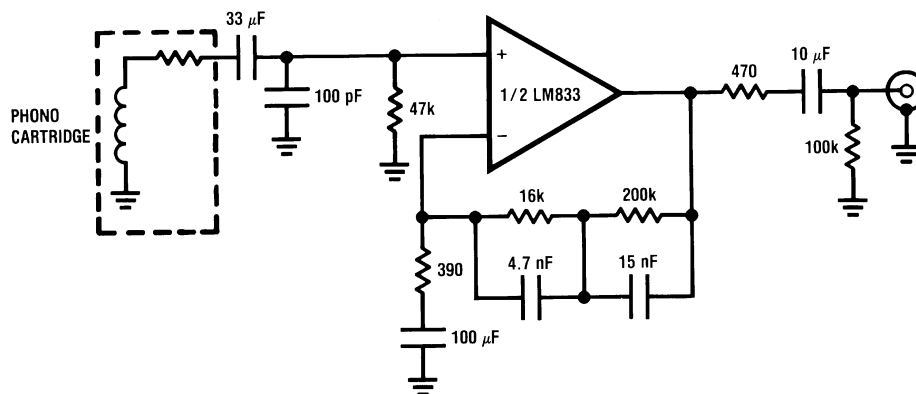
$$f_L = 32 \text{ Hz}, f_{LB} = 320 \text{ Hz}$$

$$f_H = 11 \text{ kHz}, f_{HB} = 1.1 \text{ kHz}$$



00521842

## RIAA Preamp



00521803

$$A_v = 35 \text{ dB}$$

$$E_n = 0.33 \text{ } \mu\text{V}$$

$$S/N = 90 \text{ dB}$$

$$f = 1 \text{ kHz}$$

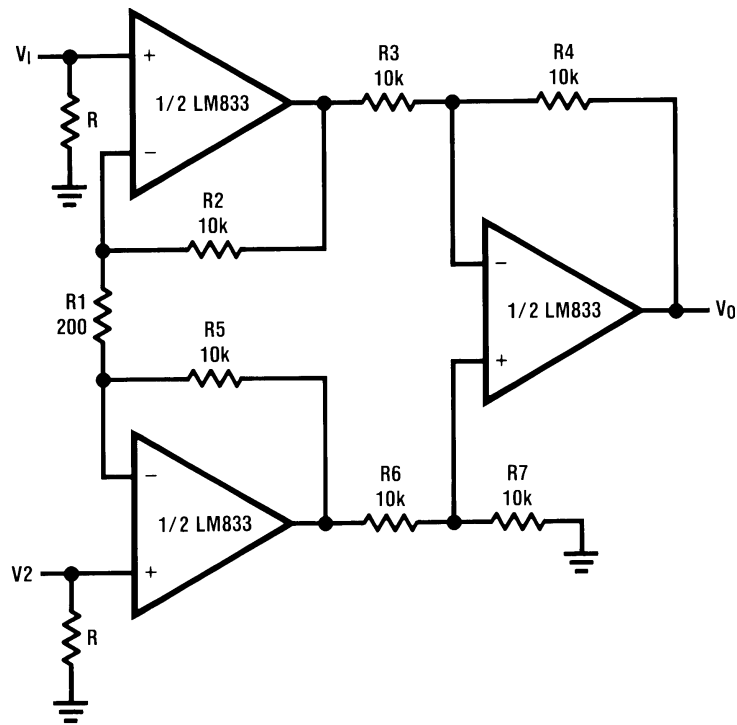
$$A \text{ Weighted}$$

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

$$@f = 1 \text{ kHz}$$

# Typical Applications (Continued)

## Balanced Input Mic Amp



00521843

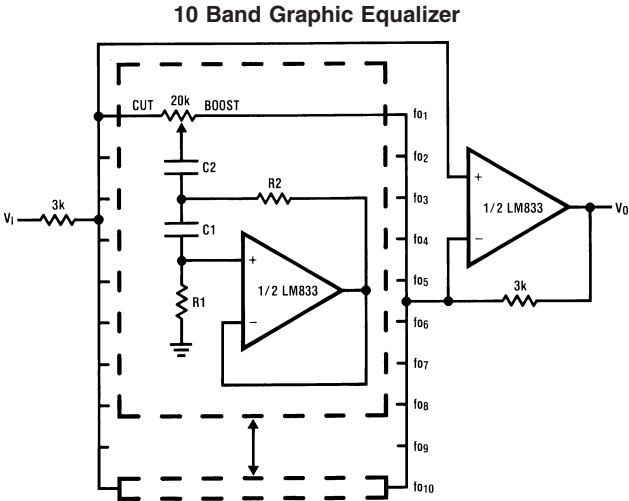
If  $R2 = R5$ ,  $R3 = R6$ ,  $R4 = R7$

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

Illustration is:

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

Typical Applications (Continued)

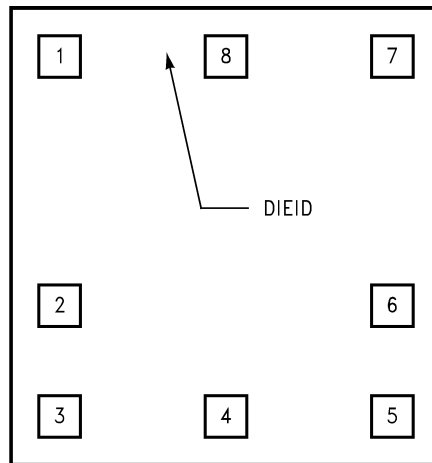


fo(Hz)	C <sub>1</sub>	C <sub>2</sub>	R <sub>1</sub>	R <sub>2</sub>
32	0.12μF	4.7μF	75kΩ	500Ω
64	0.056μF	3.3μF	68kΩ	510Ω
125	0.033μF	1.5μF	62kΩ	510Ω
250	0.015μF	0.82μF	68kΩ	470Ω
500	8200pF	0.39μF	62kΩ	470Ω
1k	3900pF	0.22μF	68kΩ	470Ω
2k	2000pF	0.1μF	68kΩ	470Ω
4k	1100pF	0.056μF	62kΩ	470Ω
8k	510pF	0.022μF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

**Note 6:** At volume of change = ±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 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)

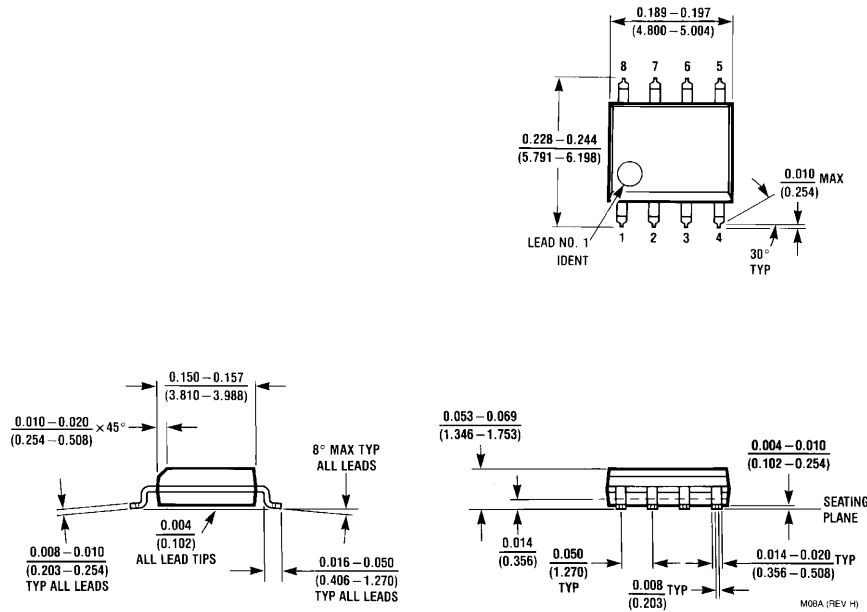
(Referenced to die center, coordinates in  $\mu$ m) NC = No Connection

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

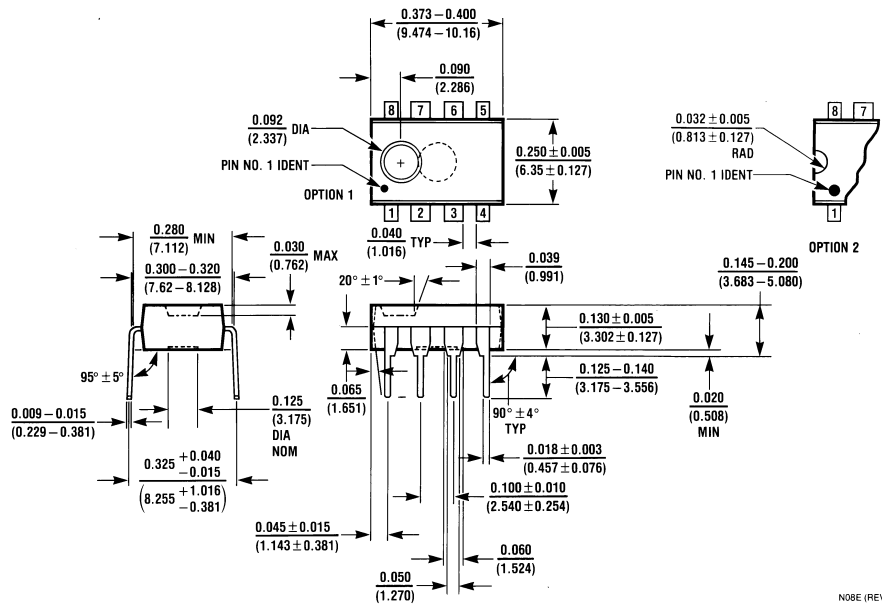
**Typical Applications** (Continued)

<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

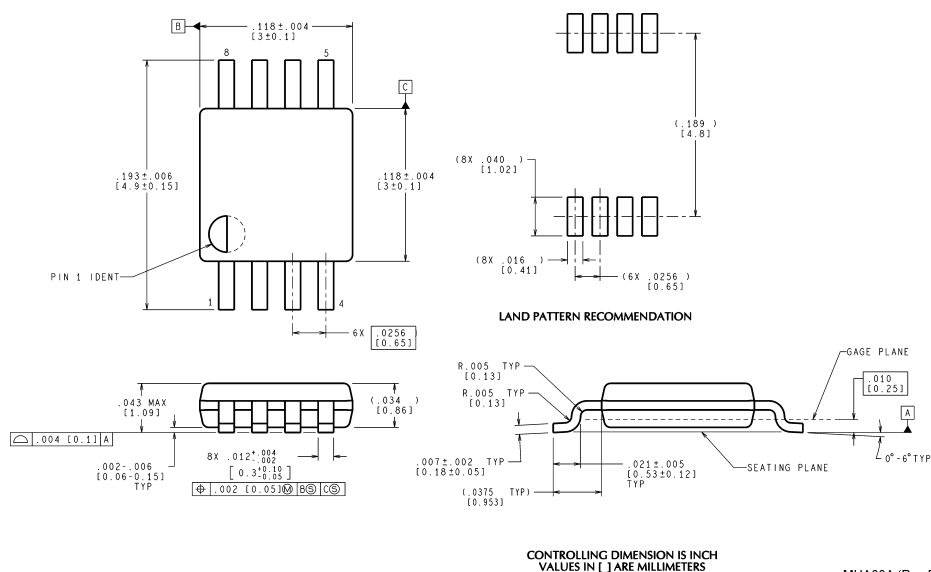


**Molded Small Outline Package (M)**  
**Order Number LM833M or LM833MX**  
**NS Package Number M08A**



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

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



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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