National Semiconductor

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.

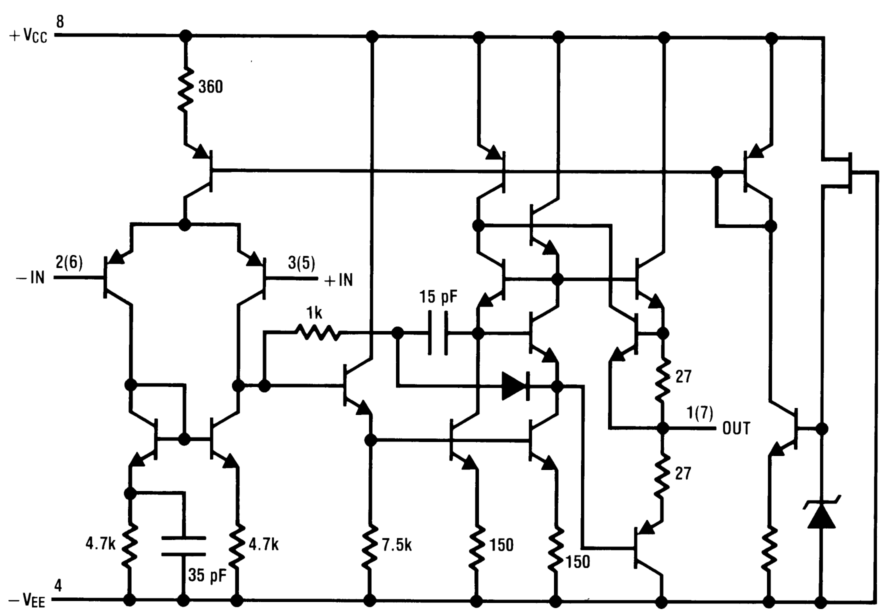
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level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



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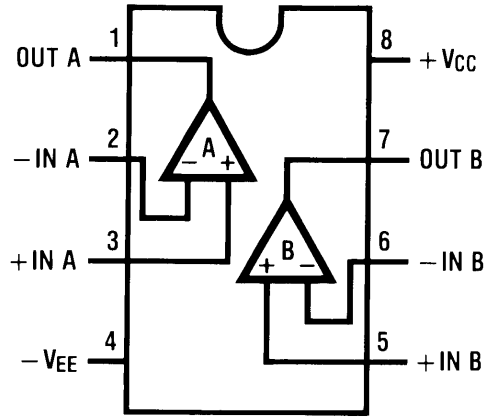
Connection Diagram



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 ~ 85˚C
Storage Temperature Range T_{STG}	−60 ~ 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
ESD tolerance (Note 5)	1600V

DC Electrical Characteristics (Notes 1, 2)

(T_A = 25˚C, V_S = ±15V)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{OS}	Input Offset Voltage	R_S = 10Ω		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 kΩ, V_O = ±10V	90	110		dB
V_{OM}	Output Voltage Swing	R_L = 10 kΩ	±12	±13.5		V
		R_L = 2 kΩ	±10	±13.4		V
V_{CM}	Input Common-Mode Range		±12	±14.0		V
CMRR	Common-Mode Rejection Ratio	V_{IN} = ±12V	80	100		dB
PSRR	Power Supply Rejection Ratio	V_S = 15~5V, −15~−5V	80	100		dB
I_Q	Supply Current	V_O = 0V, Both Amps		5	8	mA

AC Electrical Characteristics

(T_A = 25˚C, V_S = ±15V, R_L = 2 kΩ)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
SR	Slew Rate	R_L = 2 kΩ	5	7		V/μs
GBW	Gain Bandwidth Product	f = 100 kHz	10	15		MHz

Design Electrical Characteristics

(T_A = 25˚C, V_S = ±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	μV/˚C
THD	Distortion	R_L = 2 kΩ, f = 20~20 kHz V_{OUT} = 3 Vrms, A_V = 1	0.002	%
e_n	Input Referred Noise Voltage	R_S = 100Ω, f = 1 kHz	4.5	$nV/\sqrt{Hz}$
i_n	Input Referred Noise Current	f = 1 kHz	0.7	$pA/\sqrt{Hz}$
PBW	Power Bandwidth	V_O = 27 V_{pp}, R_L = 2 kΩ, THD ≤ 1%	120	kHz
f_U	Unity Gain Frequency	Open Loop	9	MHz
ϕ_M	Phase Margin	Open Loop	60	deg
	Input Referred Cross Talk	f = 20~20 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.

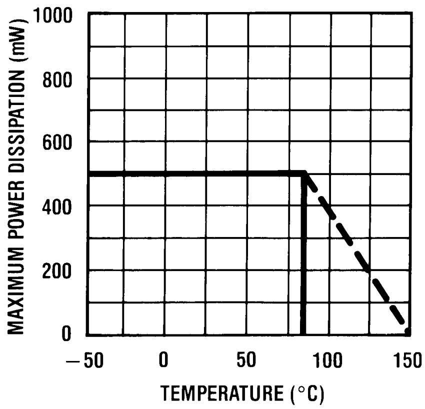
Note 3: If supply voltage is less than ±15V, it is equal to supply voltage.

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



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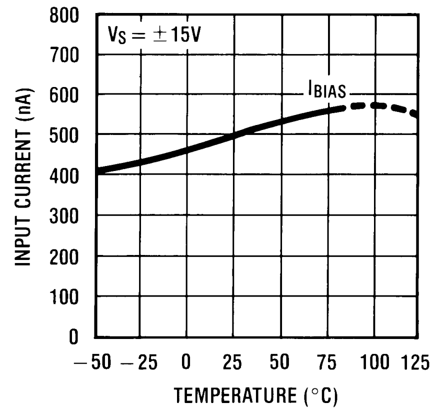
Input Bias Current vs Ambient Temperature



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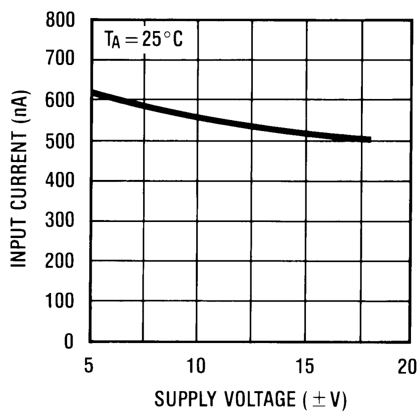
Input Bias Current vs Supply Voltage



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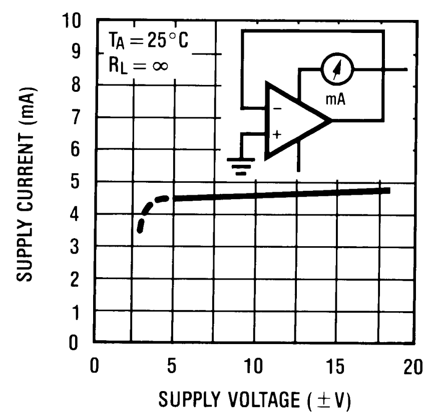
Supply Current vs Supply Voltage



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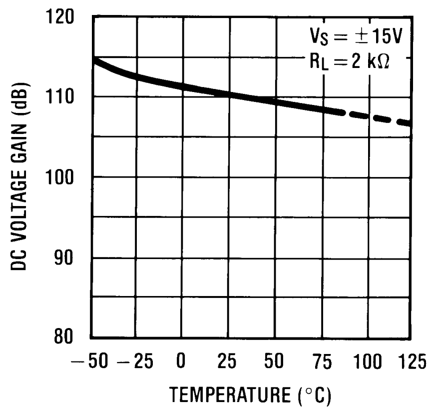
Typical Performance Characteristics (Continued)

DC Voltage Gain vs Ambient Temperature



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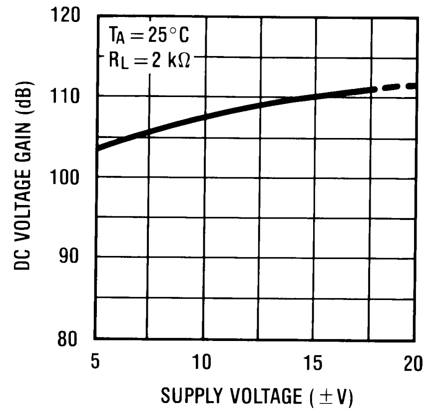
DC Voltage Gain vs Supply Voltage



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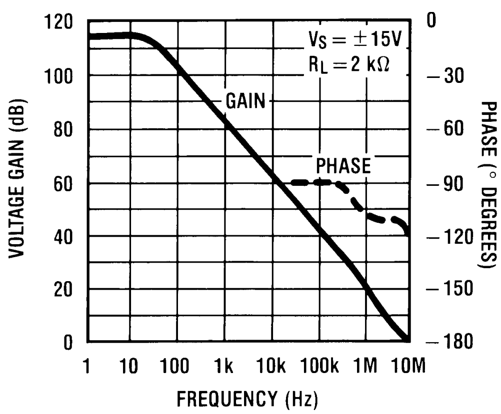
Voltage Gain & Phase vs Frequency



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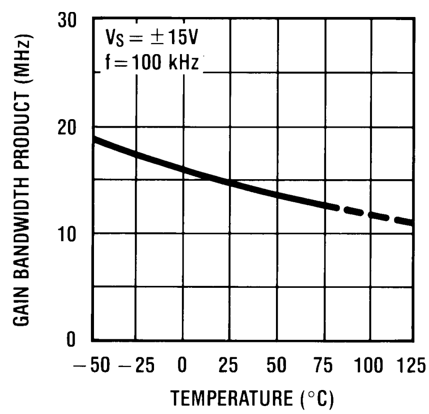
Gain Bandwidth Product vs Ambient Temperature



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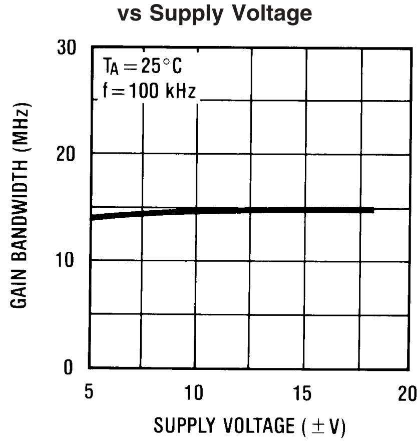
Gain Bandwidth vs Supply Voltage



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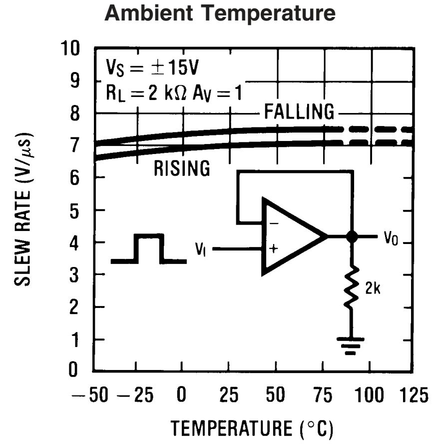
Slew Rate vs Ambient Temperature



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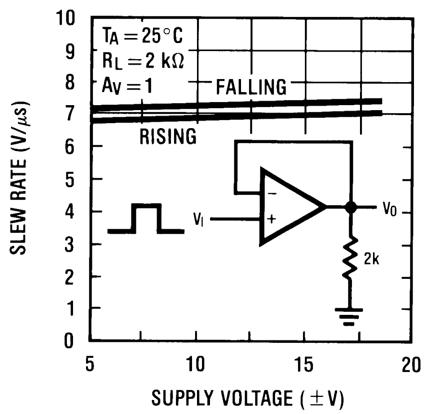
Typical Performance Characteristics (Continued)

Slew Rate vs Supply Voltage



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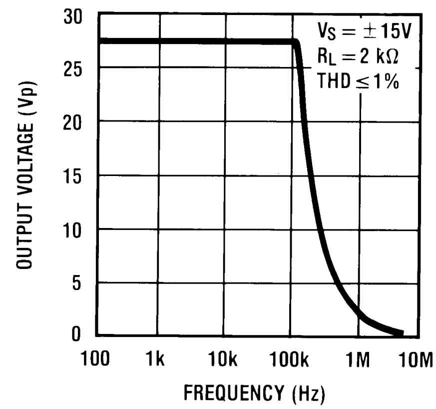
Power Bandwidth



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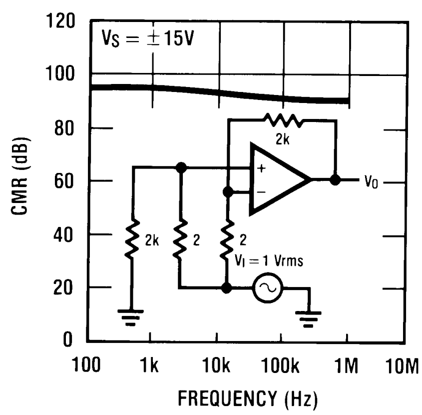
CMR vs Frequency



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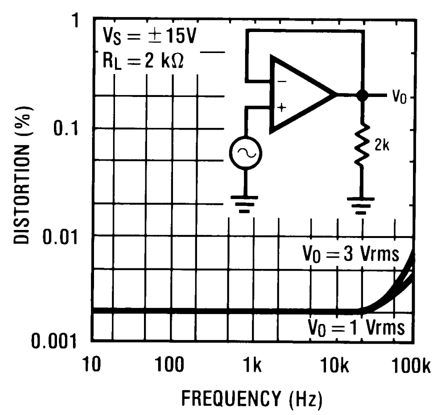
Distortion vs Frequency



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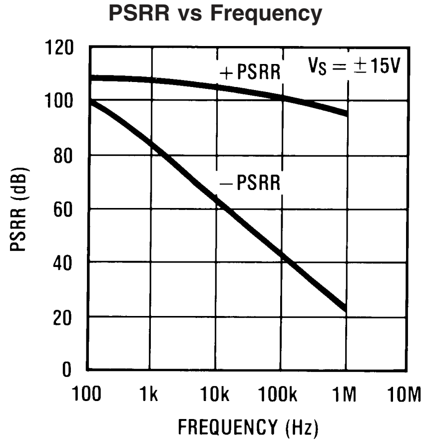
PSRR vs Frequency



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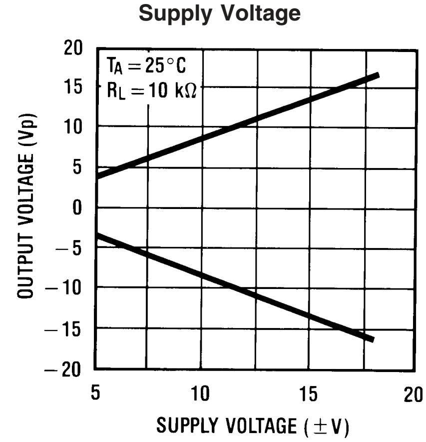
Maximum Output Voltage vs Supply Voltage



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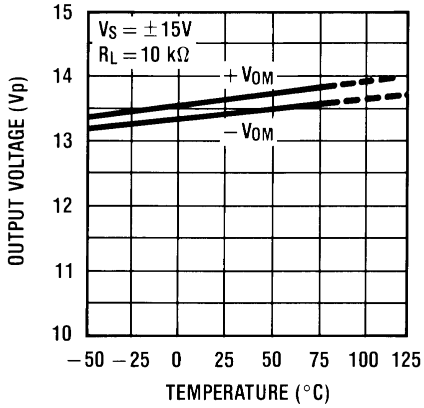
Typical Performance Characteristics (Continued)

Maximum Output Voltage vs Ambient Temperature



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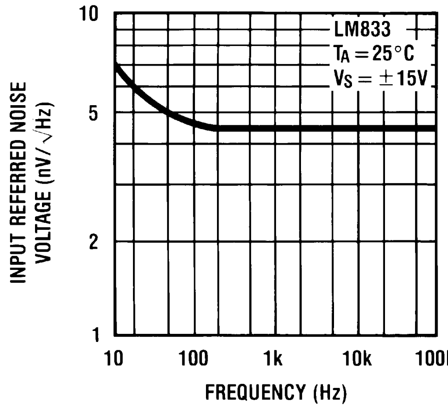
Spot Noise Voltage vs Frequency



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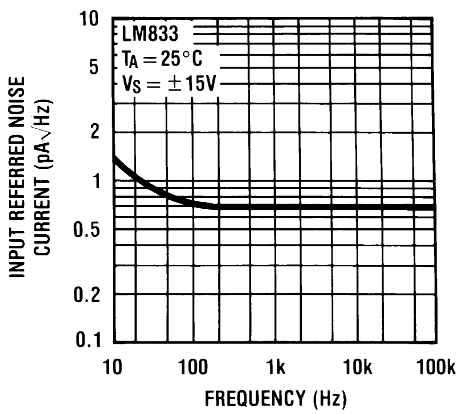
Spot Noise Current vs Frequency



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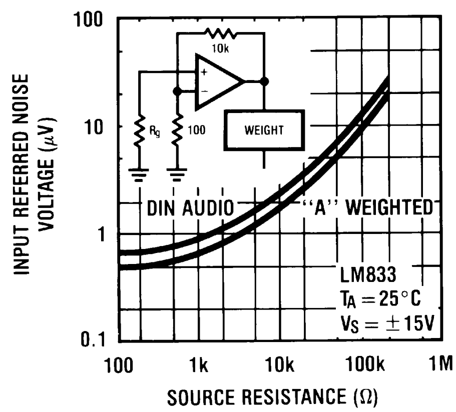
Input Referred Noise Voltage vs Source Resistance



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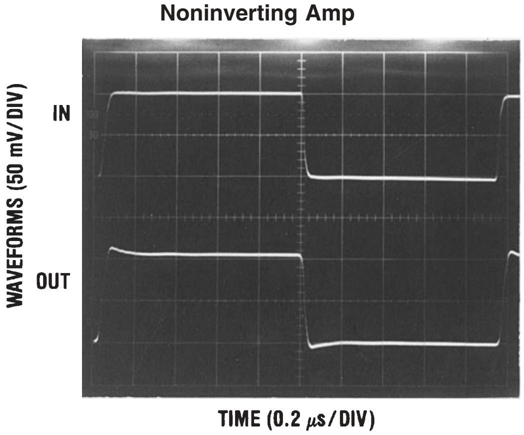
Noninverting Amp



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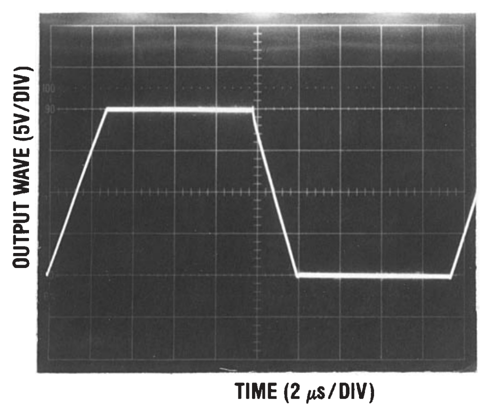
Noninverting Amp



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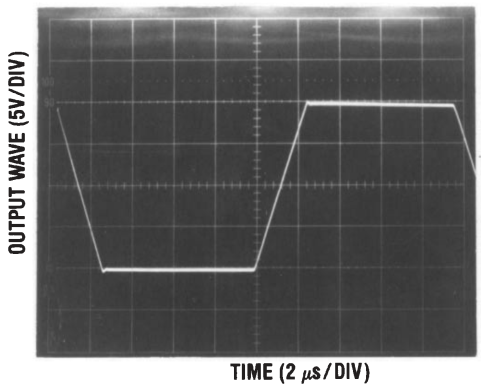
Typical Performance Characteristics (Continued)

Inverting Amp



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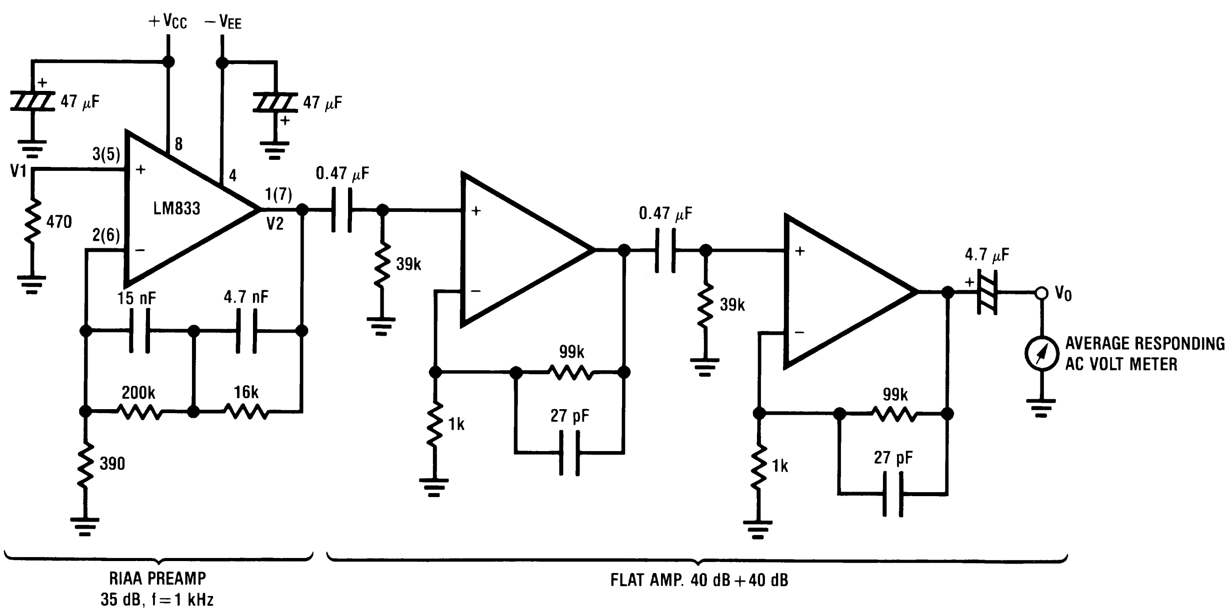
Application Hints

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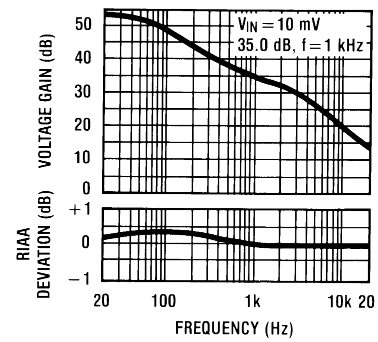
Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

Total Gain: 115 dB @f = 1 kHz

Input Referred Noise Voltage: e_n = V0/560,000 (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



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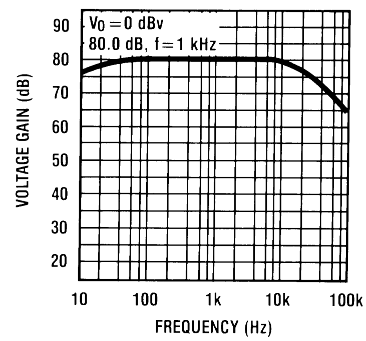
Flat Amp Voltage Gain vs Frequency



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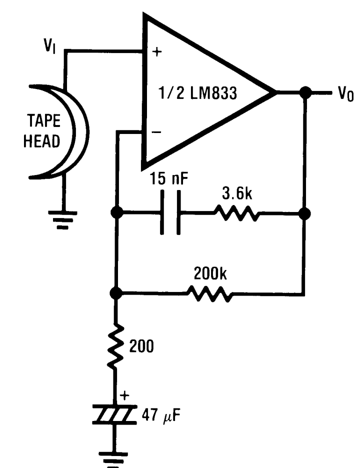
Typical Applications

NAB Preamp



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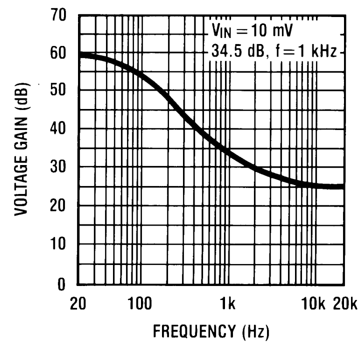
$A_V = 34.5$

F = 1 kHz

$E_n = 0.38\ \mu V$

A Weighted

NAB Preamp Voltage Gain vs Frequency



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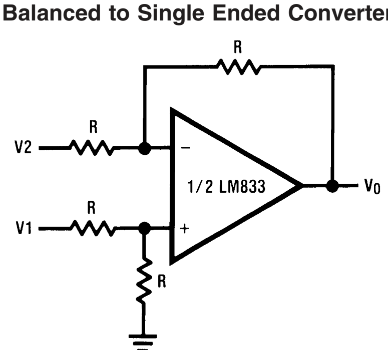
Balanced to Single Ended Converter



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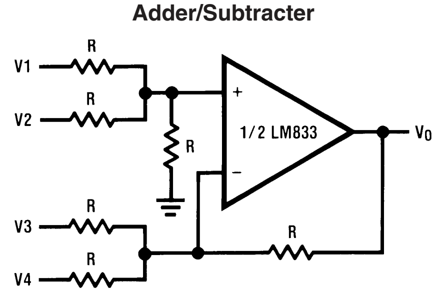
$V_O = V1 - V2$

Adder/Subtracter



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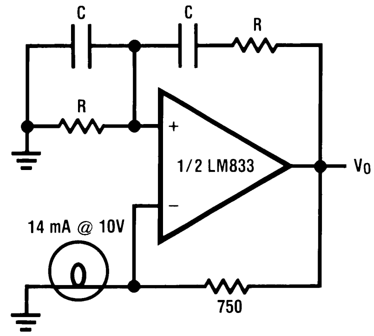
$V_O = V1 + V2 - V3 - V4$

Typical Applications (Continued)

Sine Wave Oscillator



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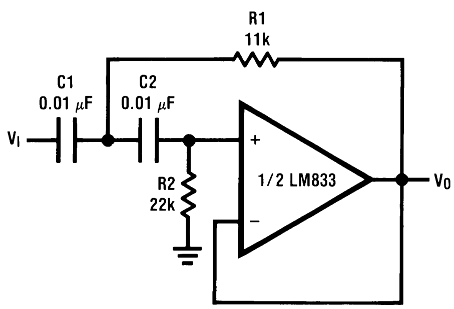
$$f_o = \frac{1}{2\pi RC}$$

Second Order High Pass Filter (Butterworth)



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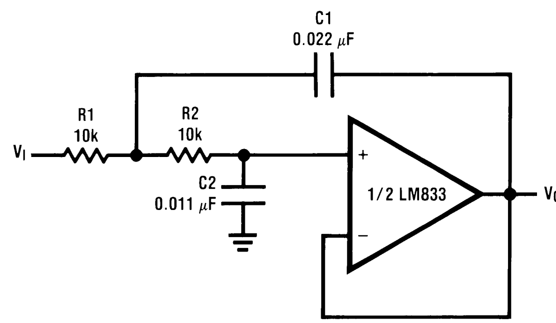
if C1 = C2 = C

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

$$R2 = 2 \bullet R1$$

Illustration is $f_0 = 1$ kHz

Second Order Low Pass Filter (Butterworth)



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if R1 = R2 = R

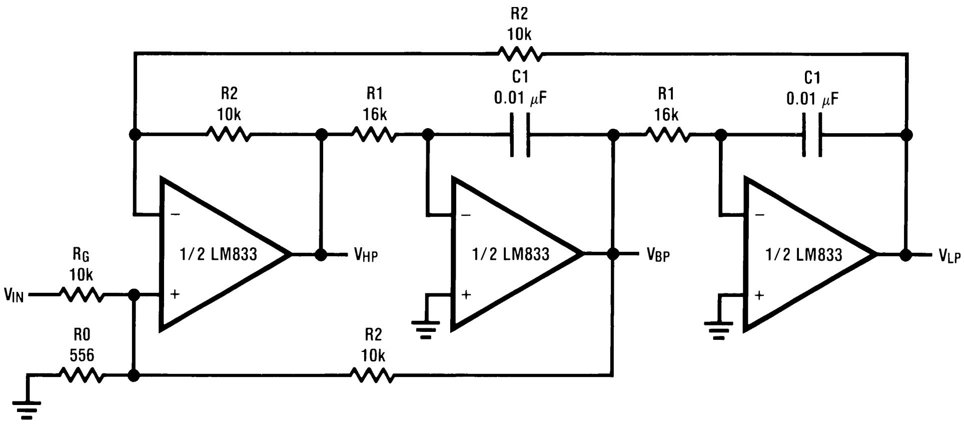
$$C1 = \frac{\sqrt{2}}{\omega_o R}$$

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

Illustration is $f_0 = 1$ kHz

Typical Applications (Continued)

State Variable Filter



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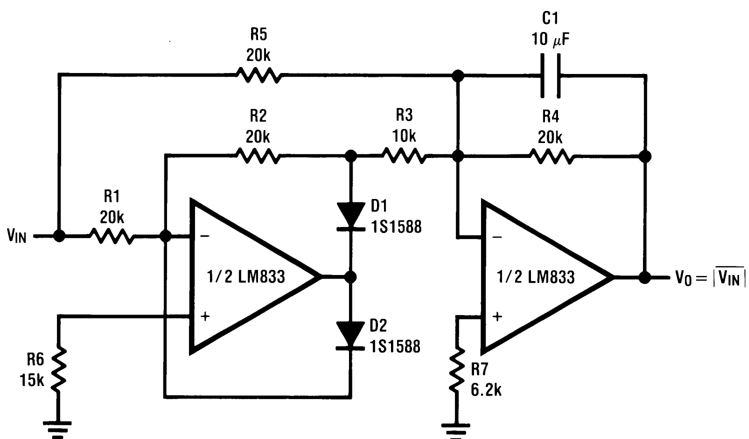
$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{R0} + \frac{R2}{RG}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

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

AC/DC Converter



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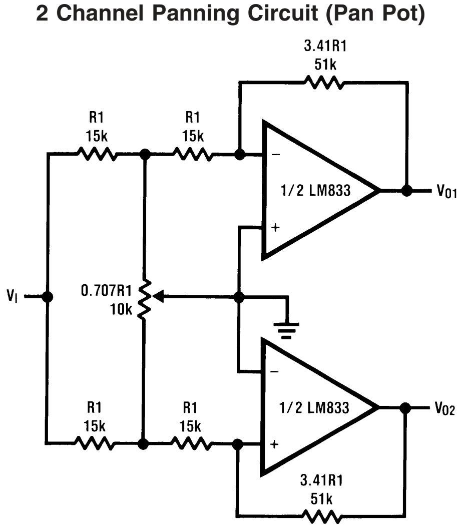
2 Channel Panning Circuit (Pan Pot)



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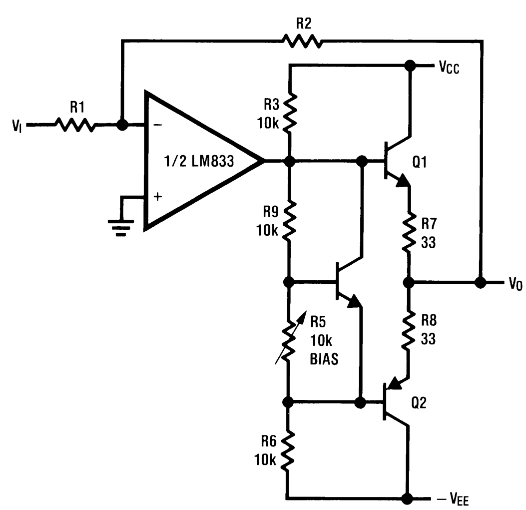
Line Driver



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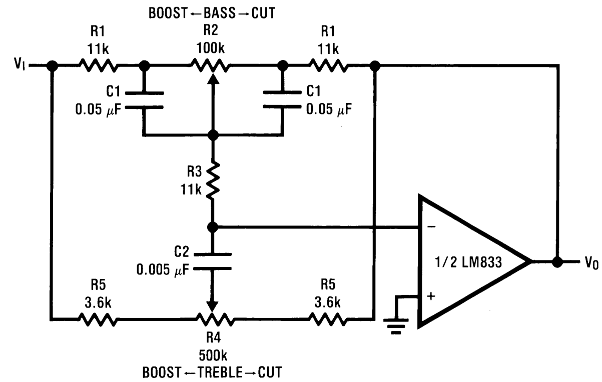
Typical Applications (Continued)

Tone Control



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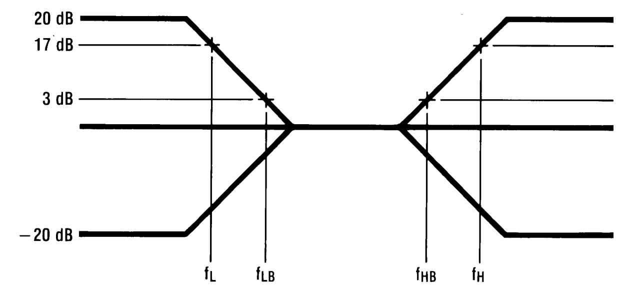
$$f_L = \frac{1}{2\pi R2C1}, f_{LB} = \frac{1}{2\pi R1C1}$$

$$f_H = \frac{1}{2\pi R5C2}, f_{HB} = \frac{1}{2\pi (R1 + R5 + 2R3)C2}$$

Illustration is:

f_L = 32 Hz, f_{LB} = 320 Hz

f_H =11 kHz, f_{HB} = 1.1 kHz



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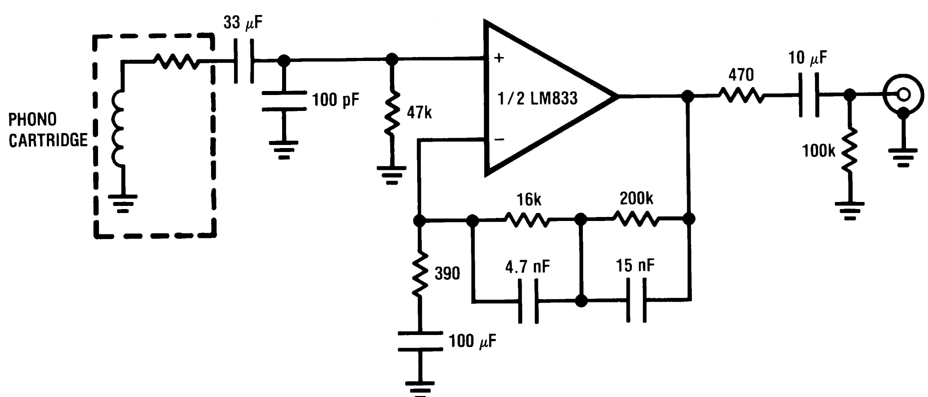
RIAA Preamp



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A_v = 35 dB

E_n = 0.33 μV

S/N = 90 dB

f = 1 kHz

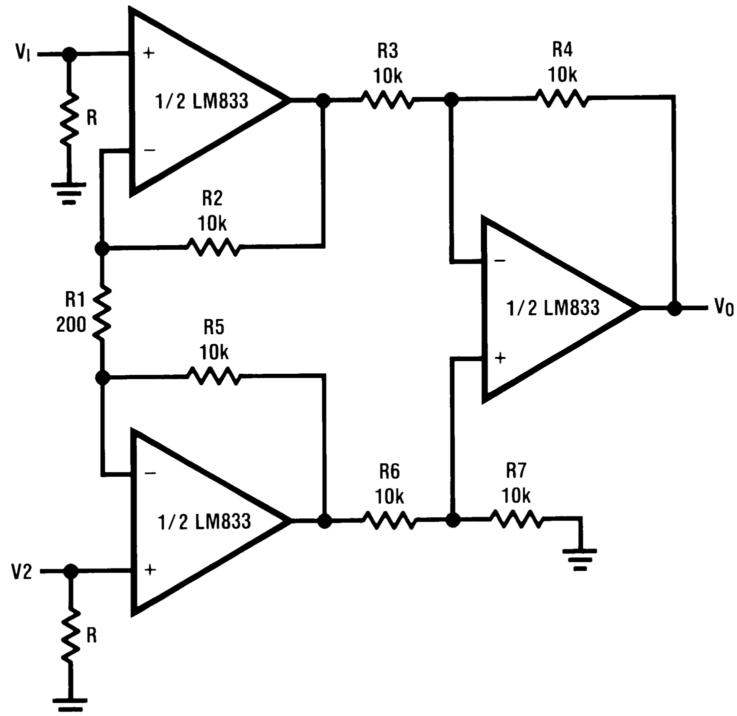
A Weighted

A Weighted, V_{IN} = 10 mV

@f = 1 kHz

Typical Applications (Continued)

Balanced Input Mic Amp



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

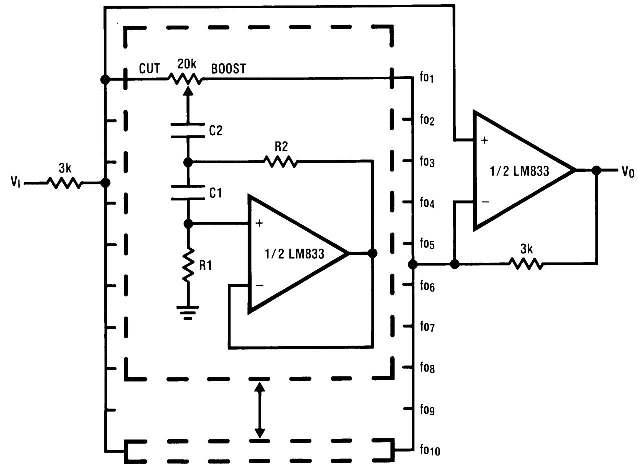
$$V0 = \left(1 + \frac{2R2}{R1}\right)\frac{R4}{R3}(V2 - V1)$$

Illustration is:

V0 = 101(V2 − V1)

Typical Applications (Continued)

10 Band Graphic Equalizer



fo(Hz)	C_1	C_2	R_1	R_2
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

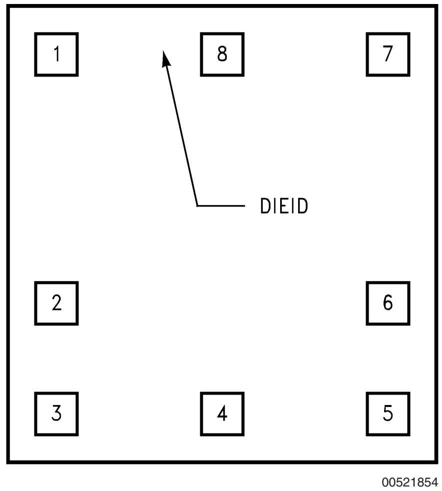
Note 6: At volume of change = ±12 dB

Q = 1.7

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

Typical Applications (Continued)

LM833 MDC MWC
DUAL AUDIO OPERATIONAL AMPLIFIER



Die Layout (A - Step)

DIE/WAFER CHARACTERISTICS

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

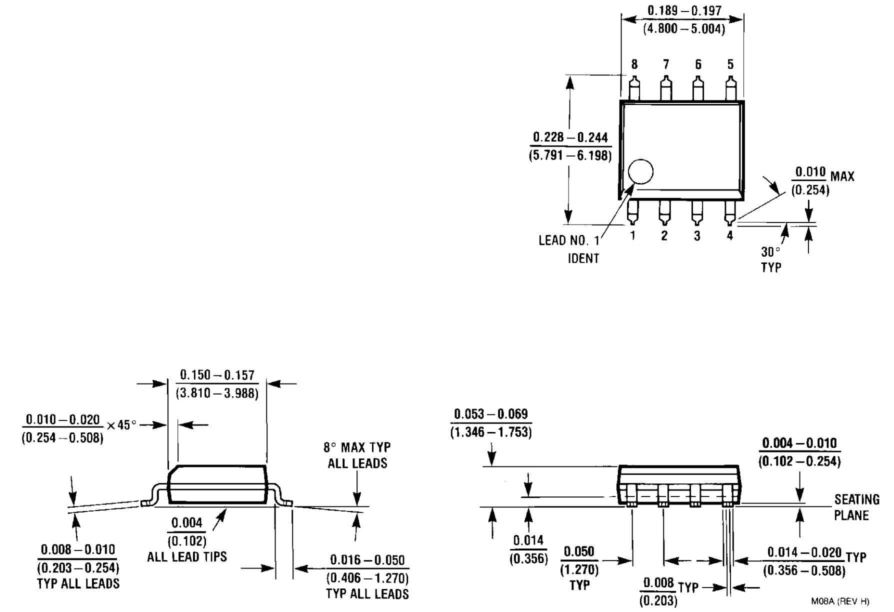
Special Assembly Requirements:
Note: Actual die size is rounded to the nearest micron.

Die Bond Pad Coordinate Locations (A - Step)						
(Referenced to die center, coordinates in µm) 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

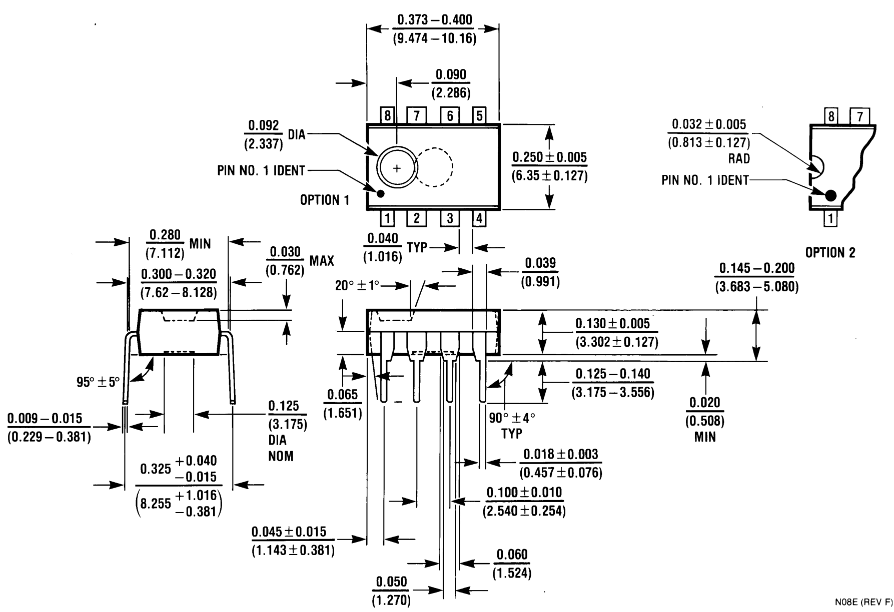
Typical Applications (Continued)

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

Physical Dimensions inches (millimeters) unless otherwise noted

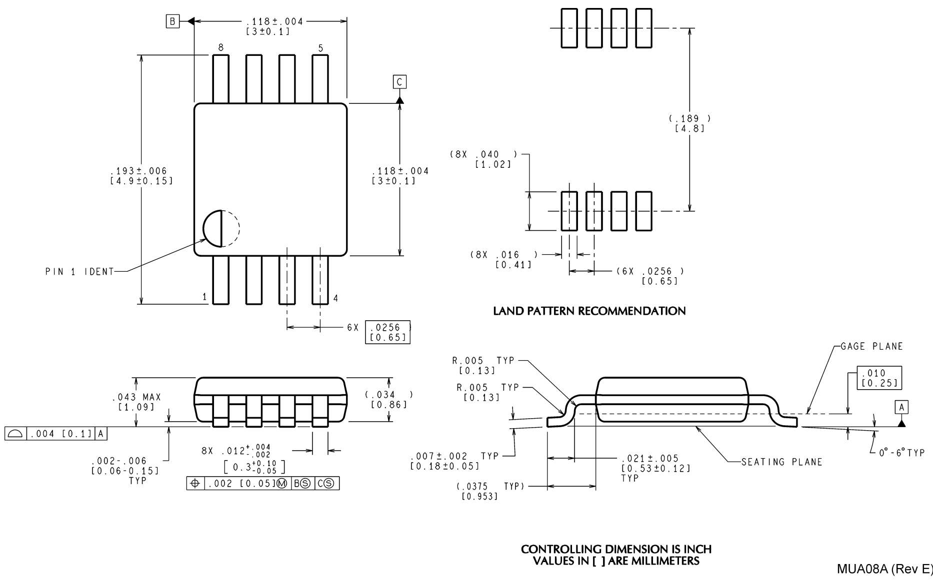


Molded Small Outline Package (M)
Order Number LM833M or LM833MX
NS Package Number M08A



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

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



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

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