National Semiconductor

August 2000

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.

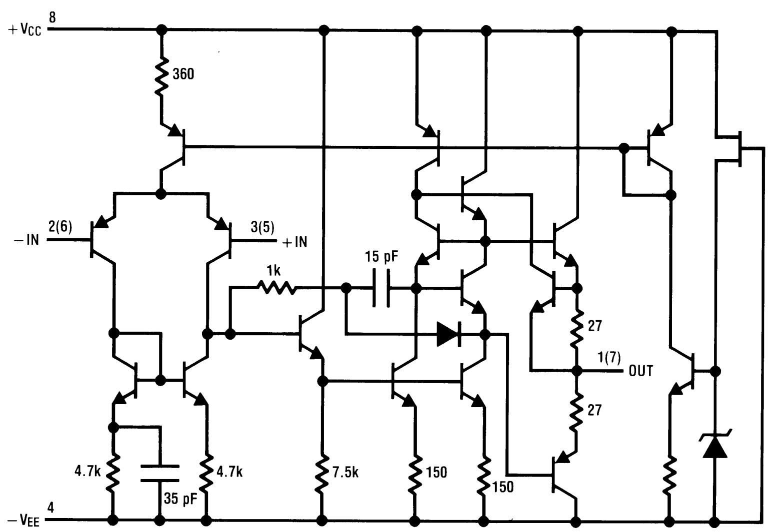
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level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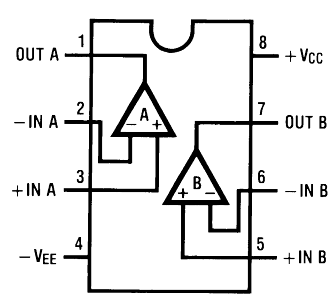
Connection Diagram



DS005218-2

Order Number LM833M, LM833MX, LM833N, LM833MM or LM833MMX
See NS Package Number
M08A, N08E or MUA08A

 DS005218

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

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)

(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.

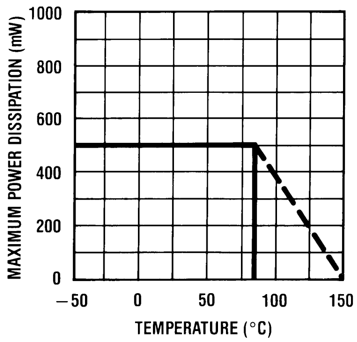
Note 3: If supply voltage is less than ±15V, it is equal to supply voltage.

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

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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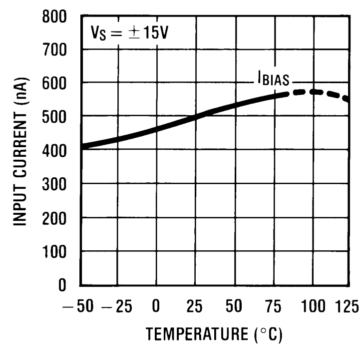
Input Bias Current vs Ambient Temperature



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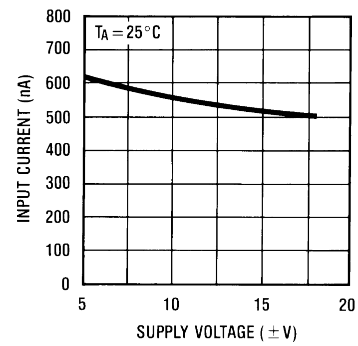
Input Bias Current vs Supply Voltage



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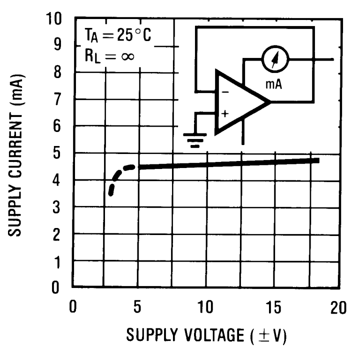
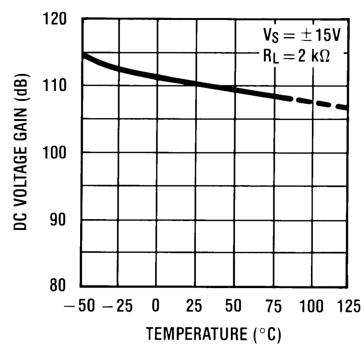
Supply Current vs Supply Voltage



DS005218-7

DC Voltage Gain vs Ambient Temperature



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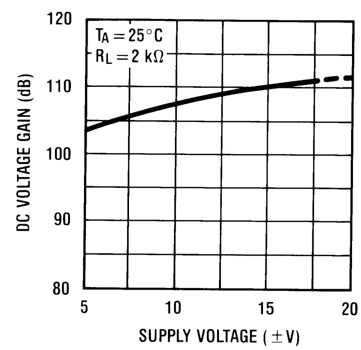
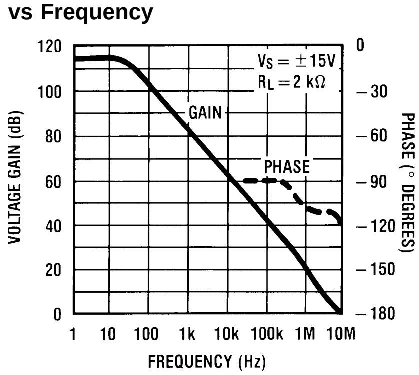
DC Voltage Gain vs Supply Voltage



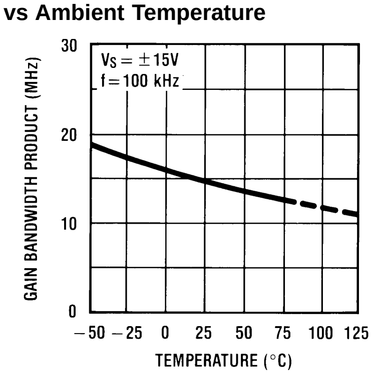
DS005218-9

Voltage Gain & Phase vs Frequency



DS005218-10

Gain Bandwidth Product vs Ambient Temperature



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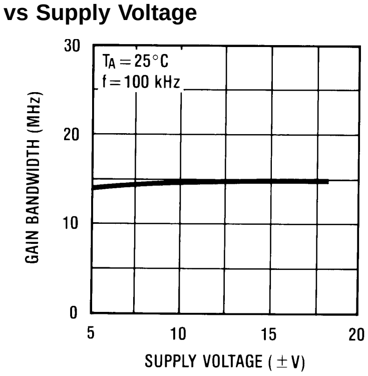
Gain Bandwidth vs Supply Voltage



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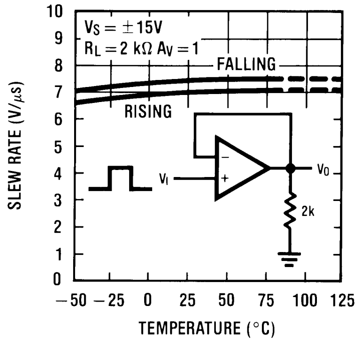
Typical Performance Characteristics (Continued)

Slew Rate vs Ambient Temperature



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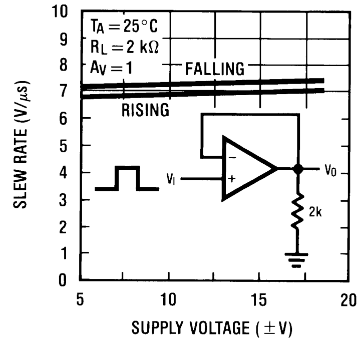
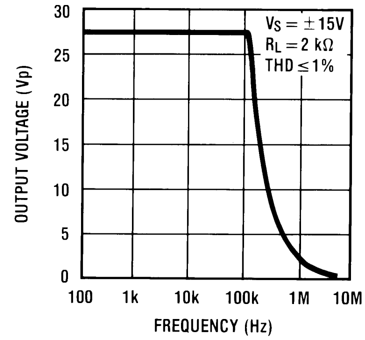
Slew Rate vs Supply Voltage



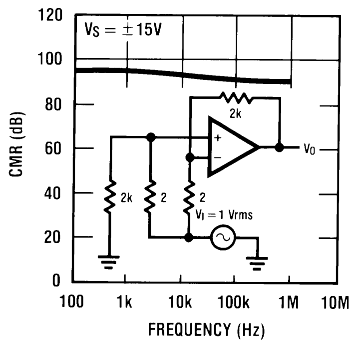
DS005218-14

Power Bandwidth



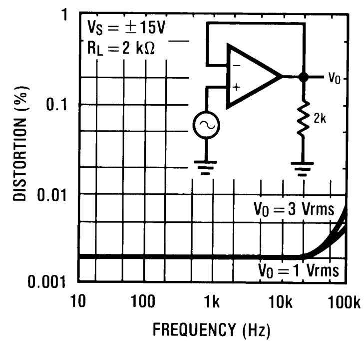
DS005218-15

CMR vs Frequency



DS005218-19

Distortion vs Frequency



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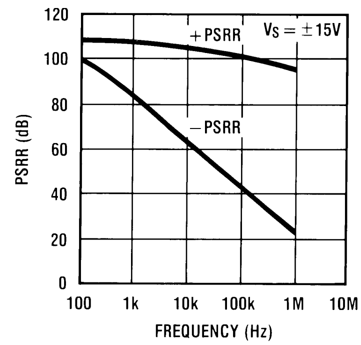
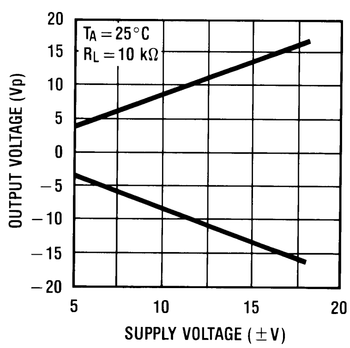
PSRR vs Frequency



DS005218-18

Maximum Output Voltage vs Supply Voltage



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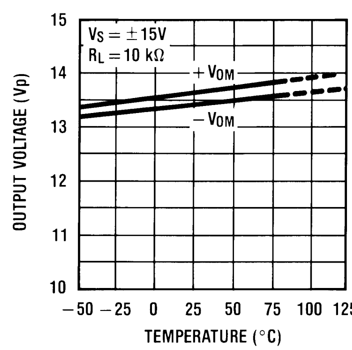
Maximum Output Voltage vs Ambient Temperature



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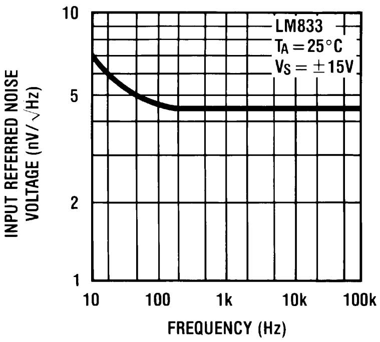
Typical Performance Characteristics (Continued)

Spot Noise Voltage vs Frequency



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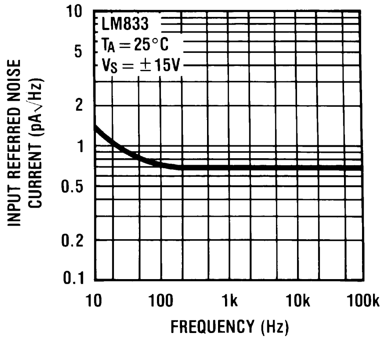
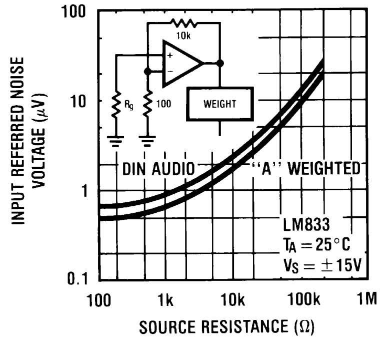
Spot Noise Current vs Frequency



DS005218-22

Input Referred Noise Voltage vs Source Resistance



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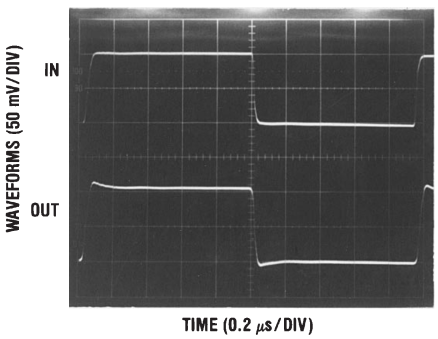
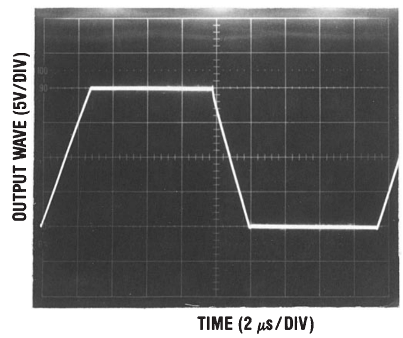
Noninverting Amp



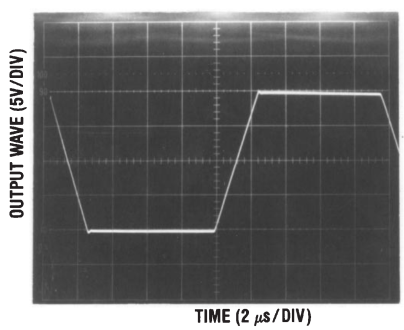
DS005218-24

Noninverting Amp



DS005218-25

Inverting Amp



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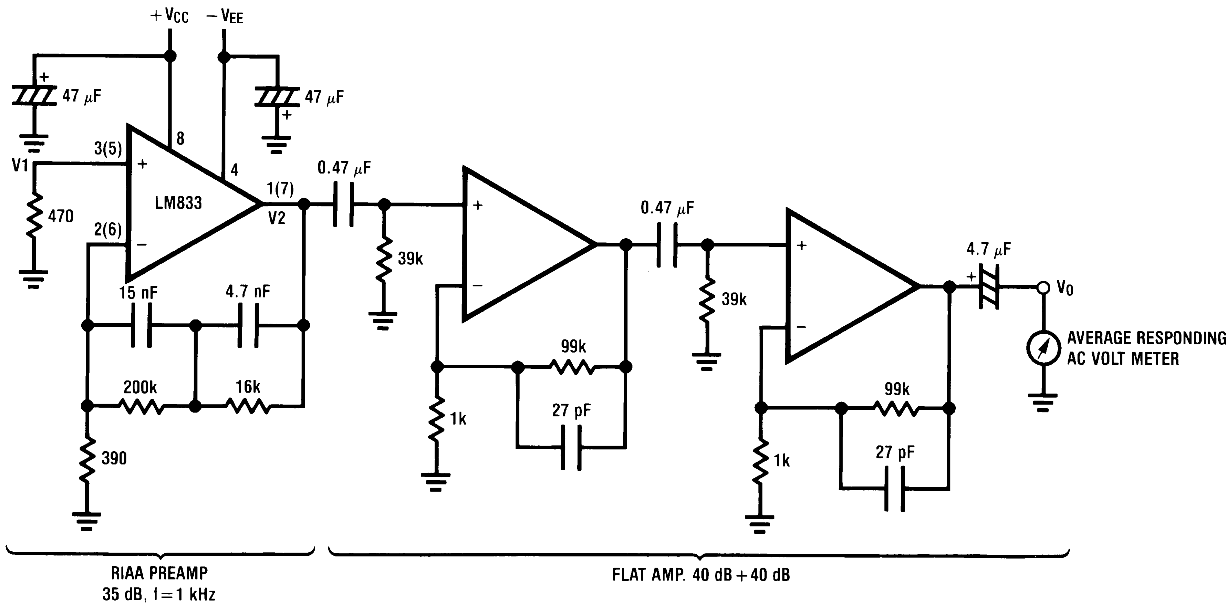
Application Hints

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



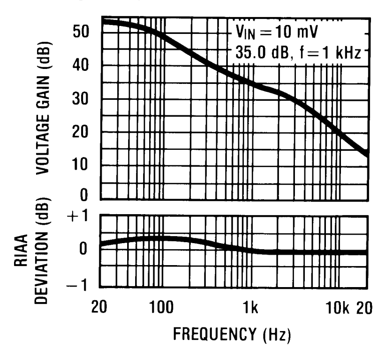
DS005218-27

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

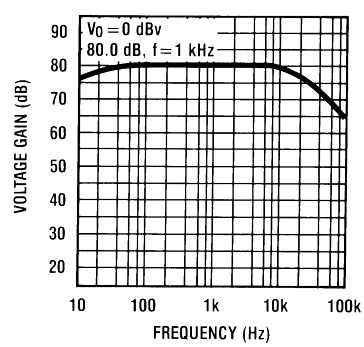
Input Referred Noise Voltage: e_n = V0/560,000 (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



DS005218-28

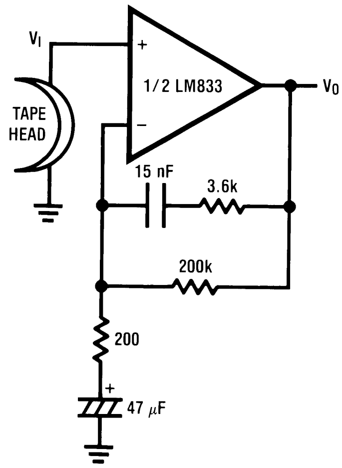
Flat Amp Voltage Gain vs Frequency



DS005218-29

Typical Applications

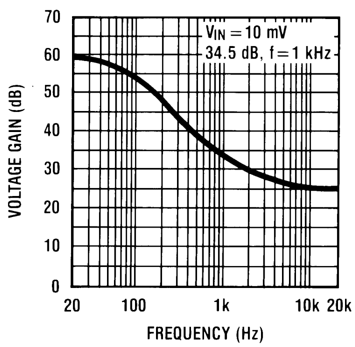
NAB Preamp



DS005218-30

$A_V = 34.5$
F = 1 kHz
$E_n = 0.38$ µV
A Weighted

NAB Preamp Voltage Gain vs Frequency



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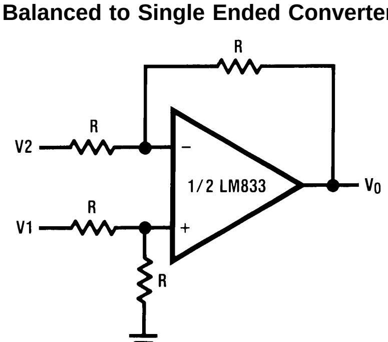
Balanced to Single Ended Converter



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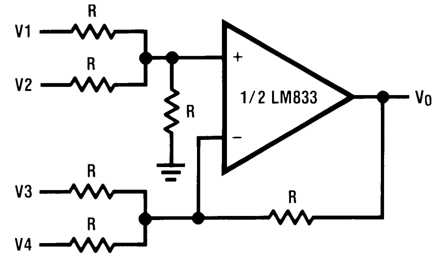
$V_O = V1–V2$

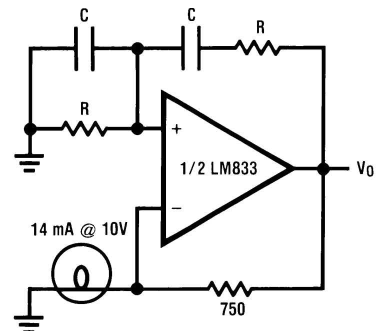
Adder/Subtracter



DS005218-33

$V_O = V1 + V2 − V3 − V4$

Sine Wave Oscillator

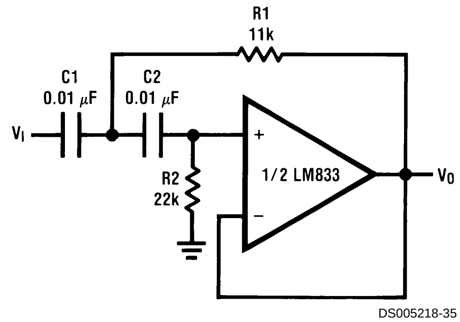


DS005218-34

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

Typical Applications (Continued)

Second Order High Pass Filter (Butterworth)



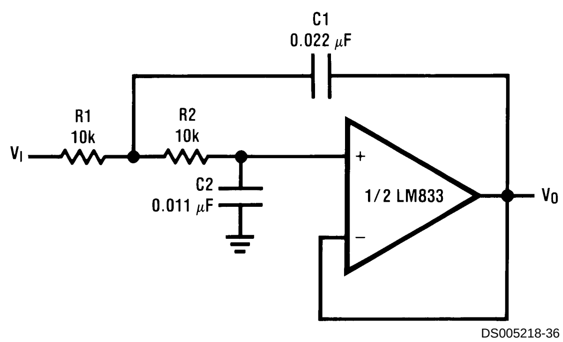
if C1 = C2 = C

$$R1 = \frac{\sqrt{2}}{2\omega_0 C}$$

$$R2 = 2 \bullet R1$$

Illustration is f_0 = 1 kHz

Second Order Low Pass Filter (Butterworth)



if R1 = R2 = R

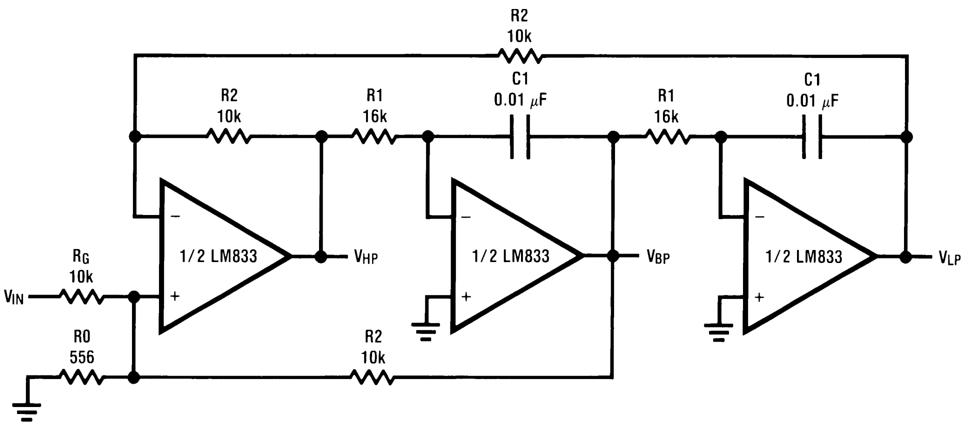
$$C1 = \frac{\sqrt{2}}{\omega_0 R}$$

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

Illustration is f_0 = 1 kHz

Typical Applications (Continued)

State Variable Filter



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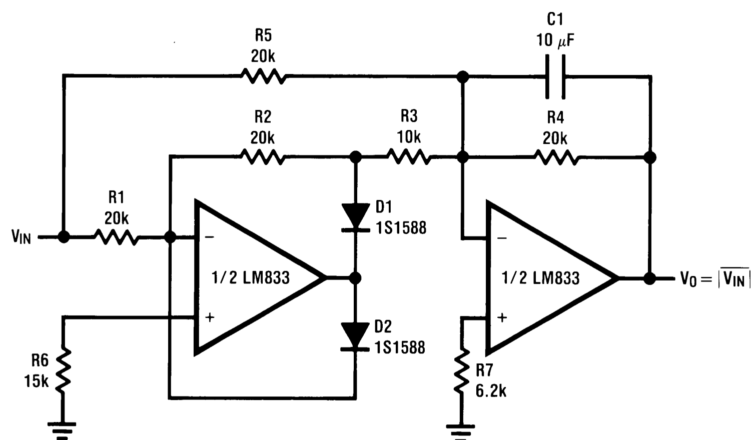
$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{R0} + \frac{R2}{RG}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

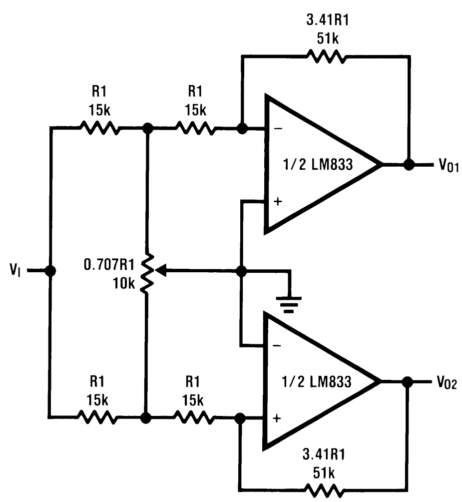
Illustration is f_0 = 1 kHz, Q = 10, A_{BP} = 1

AC/DC Converter



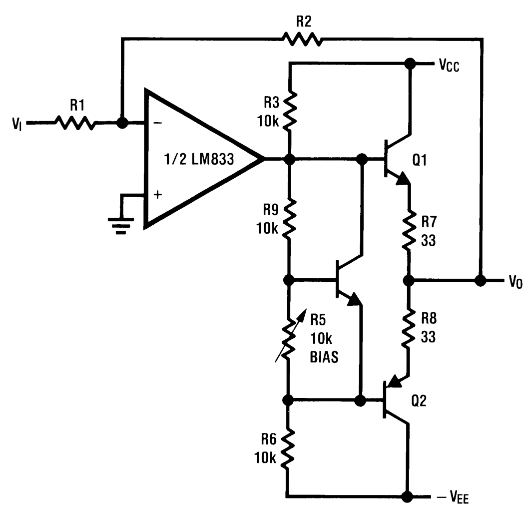
DS005218-38

2 Channel Panning Circuit (Pan Pot)



DS005218-39

Line Driver



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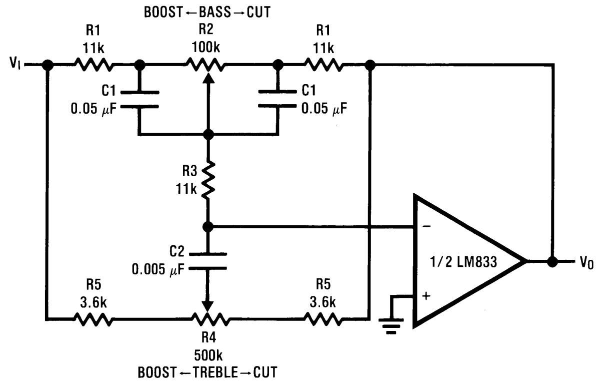
Typical Applications (Continued)

Tone Control



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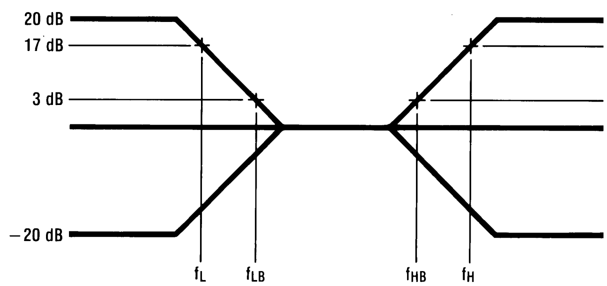
$$f_L = \frac{1}{2\pi R2C1},\ f_{LB} = \frac{1}{2\pi R1C1}$$

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

Illustration is:

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

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



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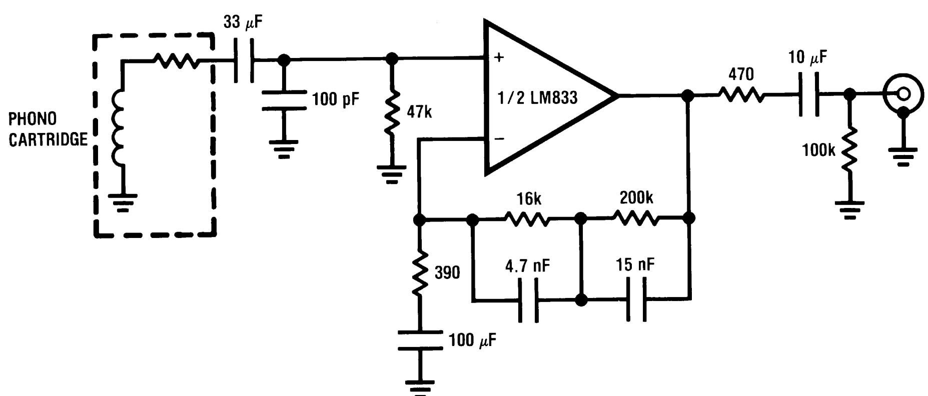
RIAA Preamp

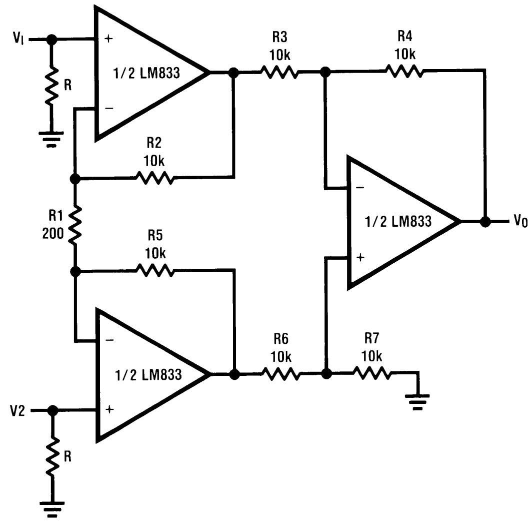


DS005218-3

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



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

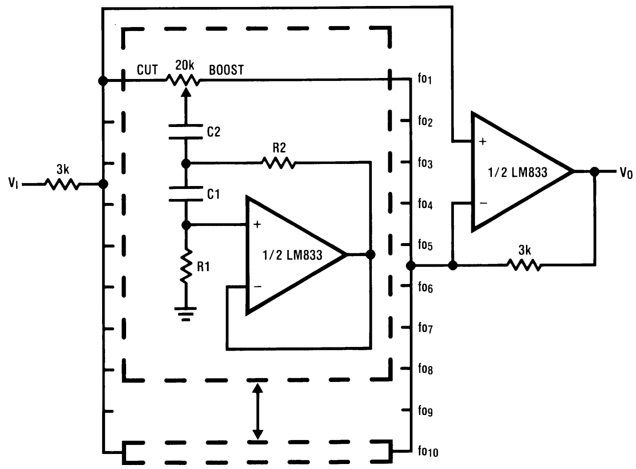
$$V0 = \left(1 + \frac{2R2}{R1}\right)\frac{R4}{R3}(V2 - V1)$$

Illustration is:

V0 = 101(V2 − V1)

Typical Applications (Continued)

10 Band Graphic Equalizer



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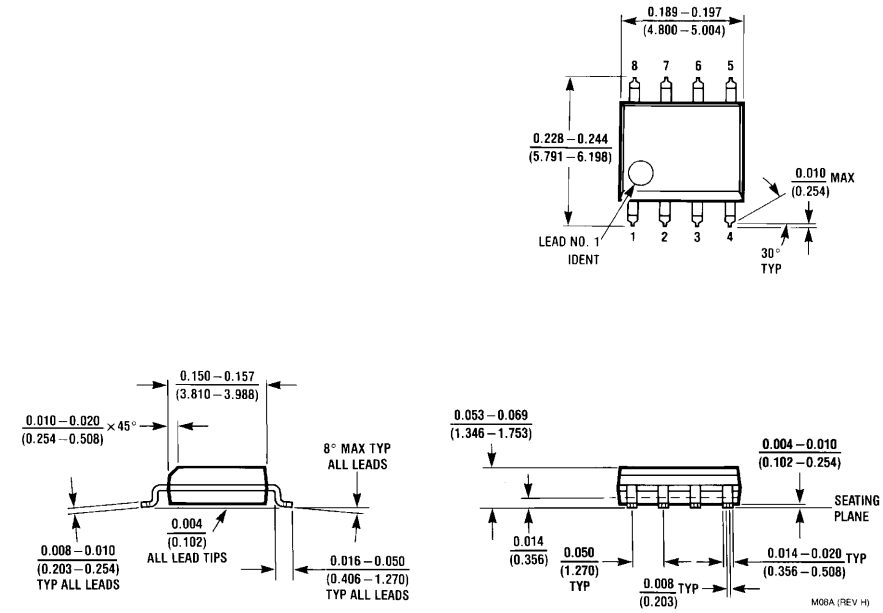
fo(Hz)	C_1	C_2	R_1	R_2
32	0.12µF	4.7µF	75kΩ	500Ω
64	0.056µF	3.3µF	68kΩ	510Ω
125	0.033µF	1.5µF	62kΩ	510Ω
250	0.015µF	0.82µF	68kΩ	470Ω
500	8200pF	0.39µF	62kΩ	470Ω
1k	3900pF	0.22µF	68kΩ	470Ω
2k	2000pF	0.1µF	68kΩ	470Ω
4k	1100pF	0.056µF	62kΩ	470Ω
8k	510pF	0.022µF	68kΩ	510Ω
16k	330pF	0.012µF	51kΩ	510Ω

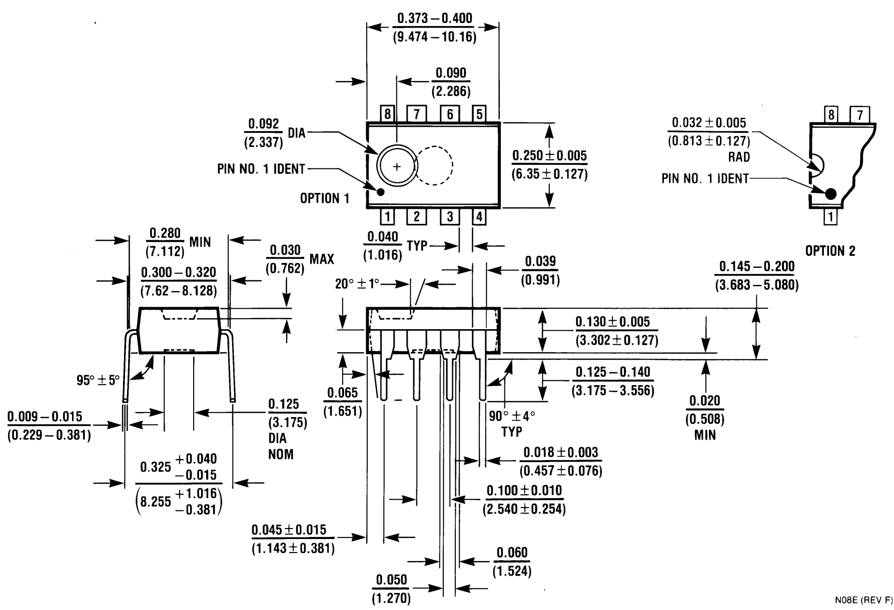
Note 6: At volume of change = ±12 dB
Q = 1.7

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

Physical Dimensions inches (millimeters) unless otherwise noted

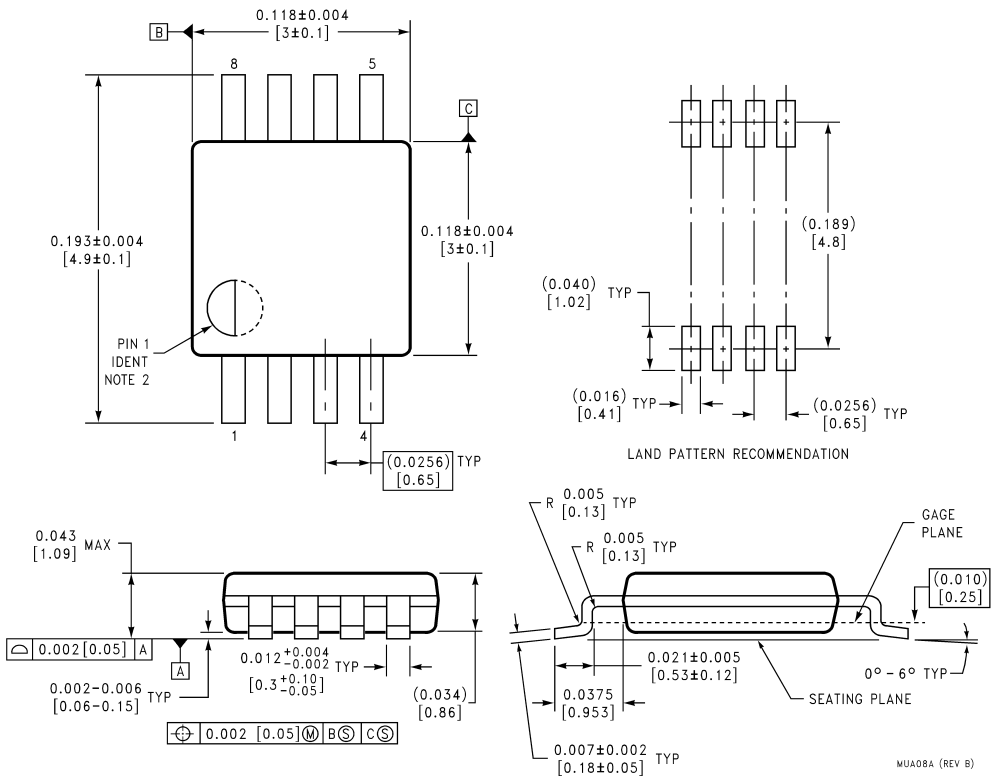


Molded Small Outline Package (M)
Order Number LM833M or LM833MX
NS Package Number M08A



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

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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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