

# 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.

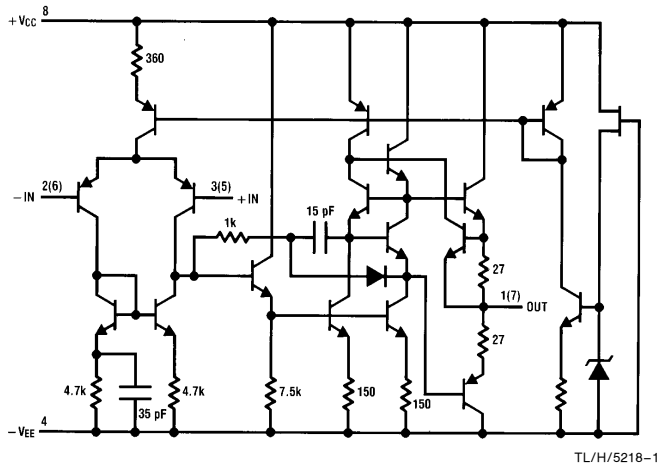
This dual amplifier IC utilizes new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 is internally compensated for all closed loop gains and is therefore optimized for all preamp and high level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

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

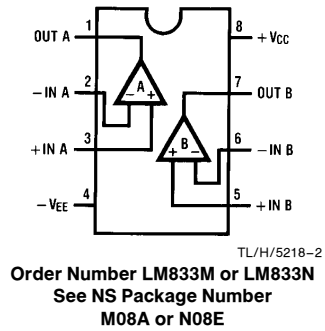
## Features

- Wide dynamic range > 140 dB
- Low input noise voltage 4.5 nV/ $\sqrt{\text{Hz}}$
- High slew rate 7 V/ $\mu\text{s}$  (typ)  
5 V/ $\mu\text{s}$  (min)
- High gain bandwidth product 15 MHz (typ)  
10 MHz (min)
- Wide power bandwidth 120 kHz
- Low distortion 0.002%
- Low offset voltage 0.3 mV
- Large phase margin 60°

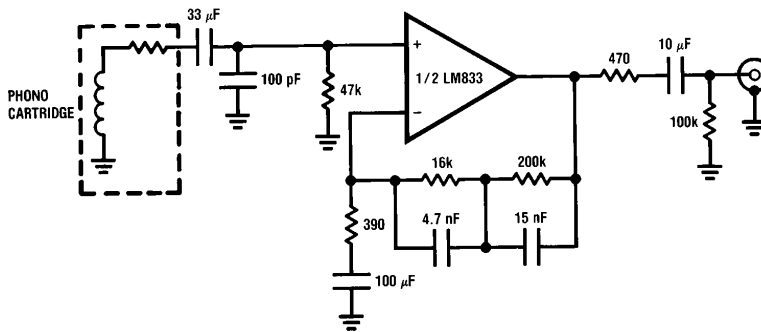
## Schematic Diagram (1/2 LM833)



## Connection Diagram



## Typical Application RIAA Preamp



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

## Absolute Maximum Ratings

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 1)	$V_{ID}$	$\pm 30V$
Input Voltage Range (Note 1)	$V_{IC}$	$\pm 15V$
Power Dissipation (Note 2)	$P_D$	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°C
Small Outline Package	
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 3)	1600V
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## DC Electrical Characteristics ( $T_A = 25^\circ C, V_S = \pm 15V$ )

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	$R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	$\pm 12$ $\pm 10$	$\pm 13.5$ $\pm 13.4$		V 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	$V_O = 0V, \text{ Both Amps}$		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	$R_L = 2\text{ k}\Omega, f = 20 \sim 20\text{ kHz}$ $V_{OUT} = 3\text{ V}_{rms}, A_V = 1$	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

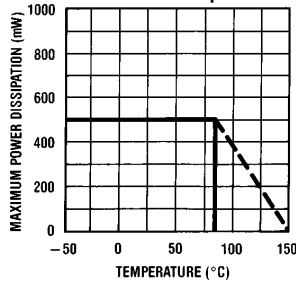
**Note 1:** If supply voltage is less than  $\pm 15V$ , it is equal to supply voltage.

**Note 2:** This is the permissible value at  $T_A \leq 85^\circ C$ .

**Note 3:** Human body model, 1.5 k $\Omega$  in series with 100 pF.

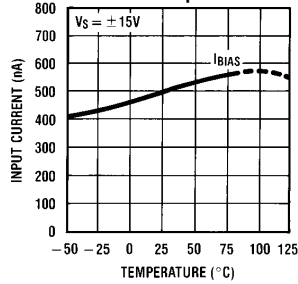
# Typical Performance Characteristics

**Maximum Power Dissipation vs Ambient Temperature**



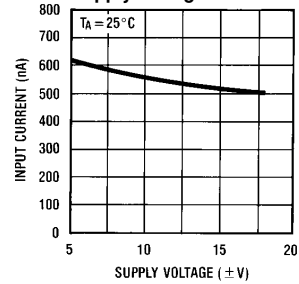
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**Input Bias Current vs Ambient Temperature**



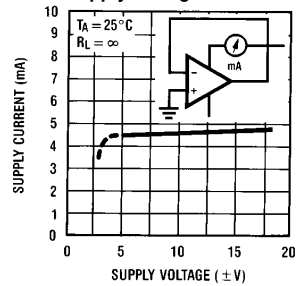
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**Input Bias Current vs Supply Voltage**



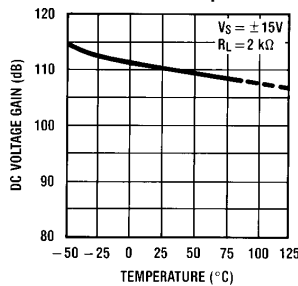
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**Supply Current vs Supply Voltage**



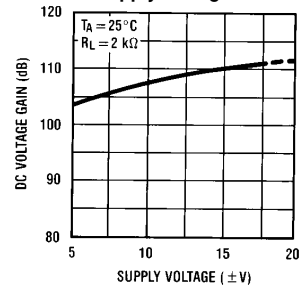
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**DC Voltage Gain vs Ambient Temperature**



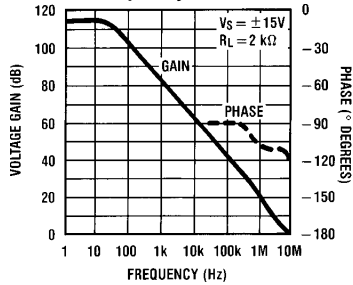
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**DC Voltage Gain vs Supply Voltage**



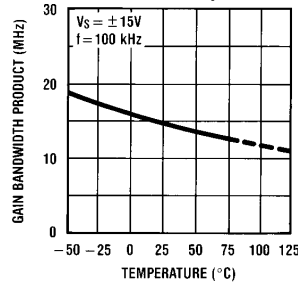
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**Voltage Gain & Phase vs Frequency**



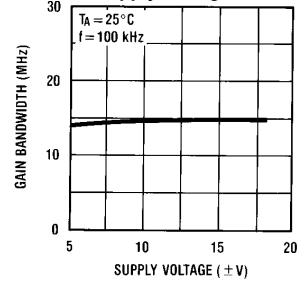
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**Gain Bandwidth Product vs Ambient Temperature**



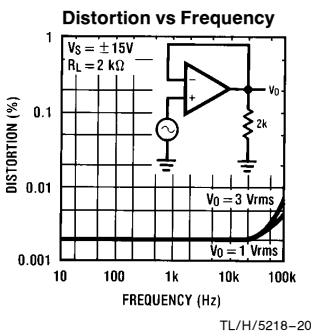
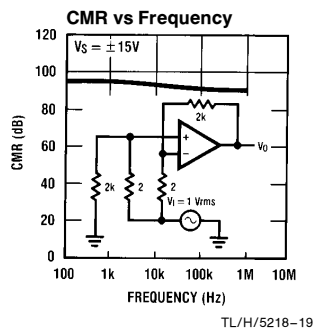
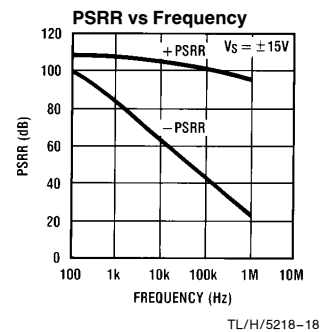
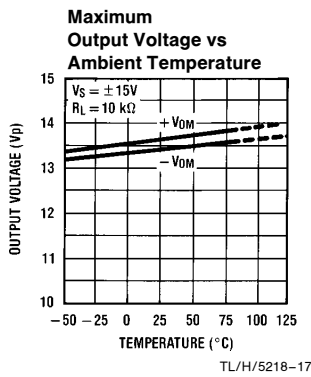
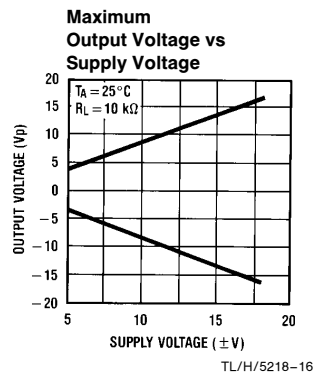
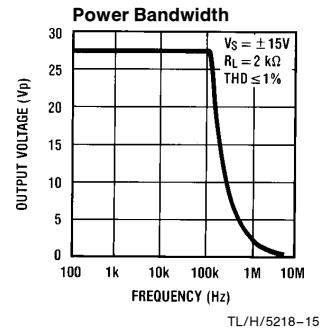
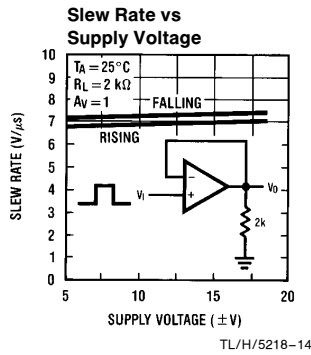
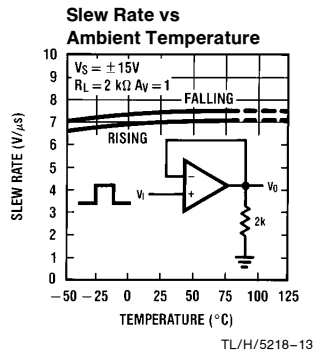
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**Gain Bandwidth vs Supply Voltage**

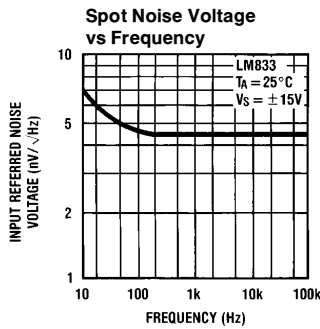


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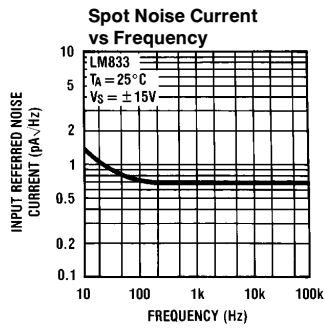
## Typical Performance Characteristics (Continued)



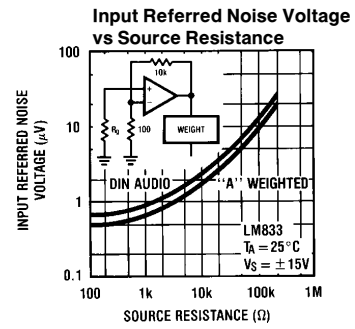
## Typical Performance Characteristics (Continued)



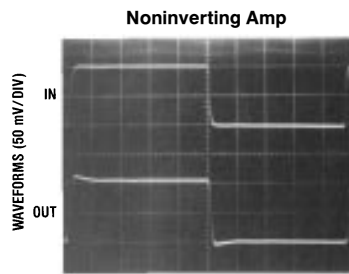
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TL/H/5218-22

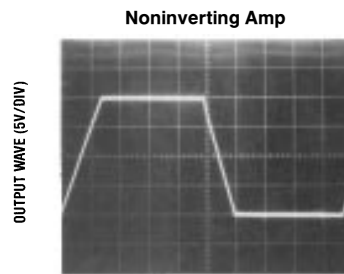


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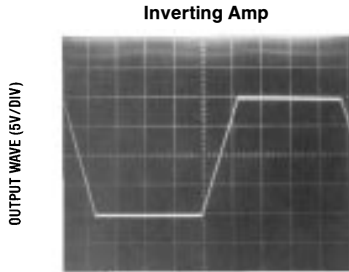
TIME (0.2 µs/DIV)

TL/H/5218-24



TIME (2 µs/DIV)

TL/H/5218-25



TIME (2 µs/DIV)

TL/H/5218-26

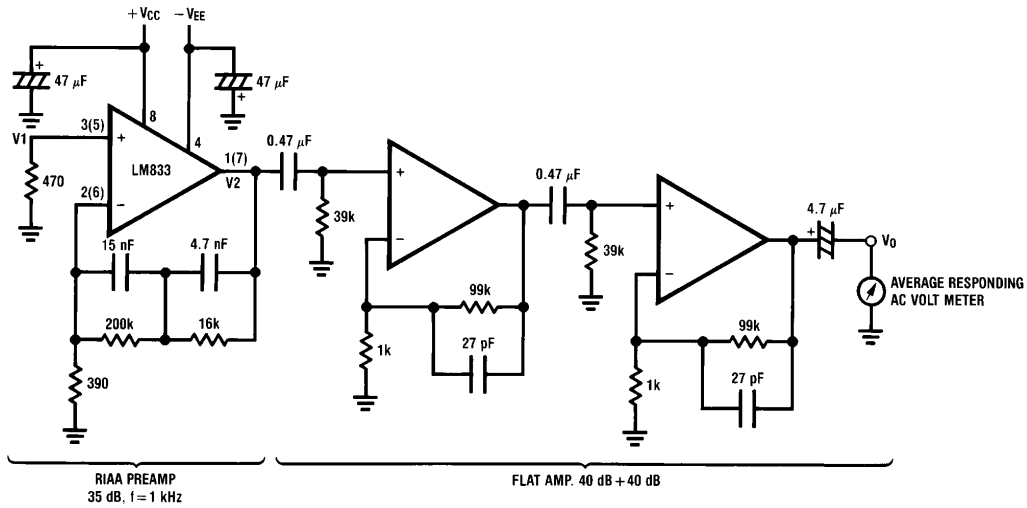
## Application Hints

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.

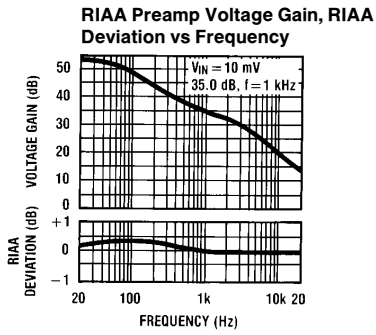
# Noise Measurement Circuit

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

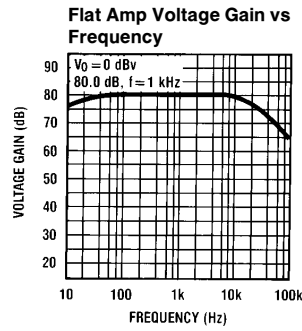


TL/H/5218-27

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



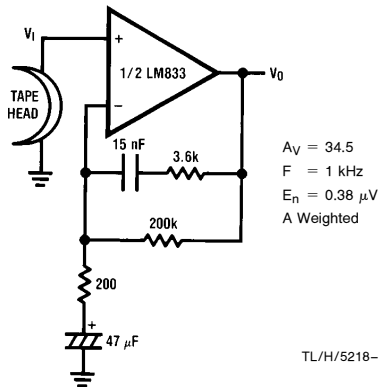
TL/H/5218-28



TL/H/5218-29

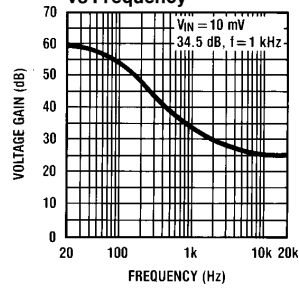
# Typical Applications

**NAB Preamp**



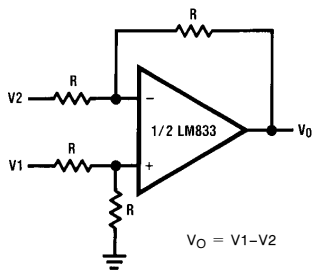
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**NAB Preamp Voltage Gain vs Frequency**



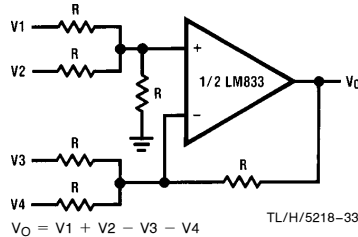
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**Balanced to Single Ended Converter**



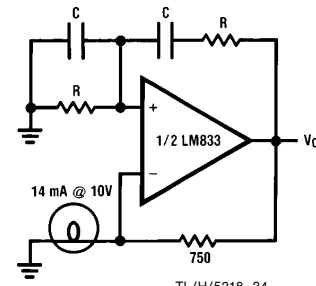
TL/H/5218-32

**Adder/Subtractor**



TL/H/5218-33

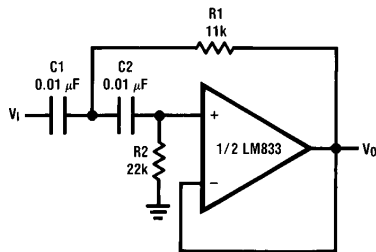
**Sine Wave Oscillator**



TL/H/5218-34

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

**Second Order High Pass Filter (Butterworth)**



TL/H/5218-35

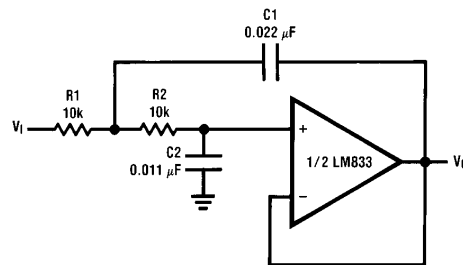
if  $C_1 = C_2 = C$

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

$$R_2 = 2 \cdot R_1$$

Illustration is  $f_0 = 1 \text{ kHz}$

**Second Order Low Pass Filter (Butterworth)**



TL/H/5218-36

if  $R_1 = R_2 = R$

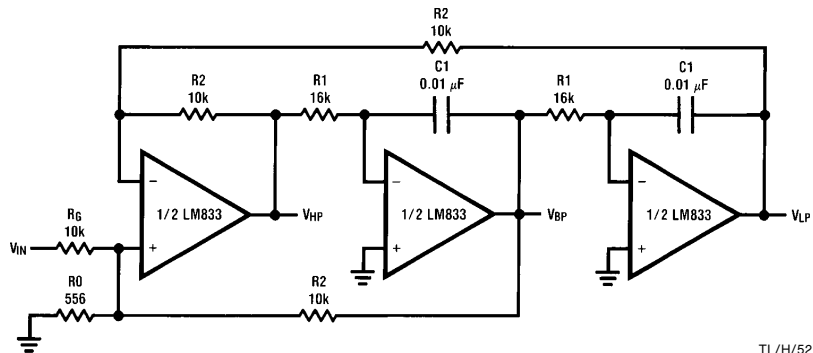
$$C_1 = \frac{\sqrt{2}}{\omega_0 R}$$

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

Illustration is  $f_0 = 1 \text{ kHz}$

## Typical Applications (Continued)

### State Variable Filter

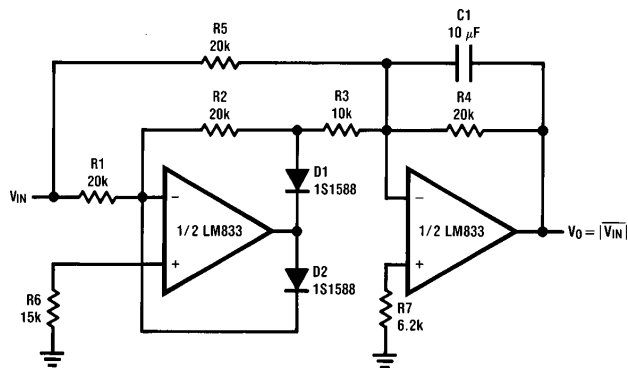


TL/H/5218-37

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

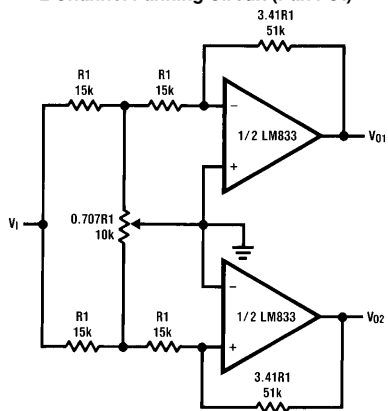
Illustration is  $f_0 = 1 \text{ kHz}$ ,  $Q = 10$ ,  $A_{BP} = 1$

### AC/DC Converter



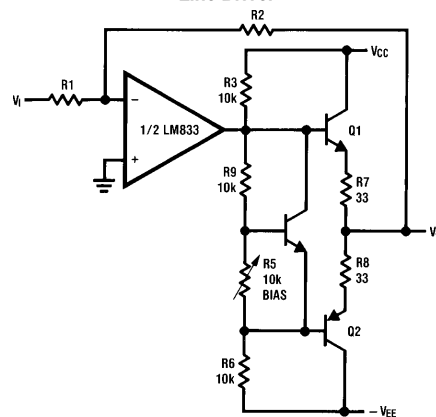
TL/H/5218-38

### 2 Channel Panning Circuit (Pan Pot)



TL/H/5218-39

### Line Driver

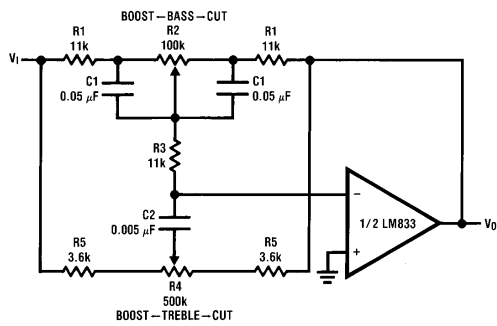


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## Typical Application (Continued)

### Tone Control



TL/H/5218-41

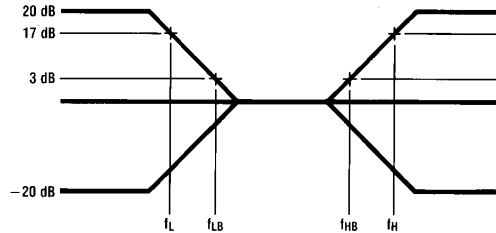
$$f_L = \frac{1}{2\pi R_2 C_1}, f_{LB} = \frac{1}{2\pi R_1 C_1}$$

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

Illustration is:

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

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

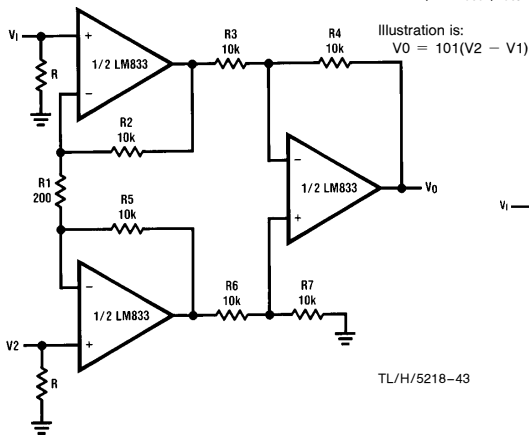


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### Balanced Input Mic Amp

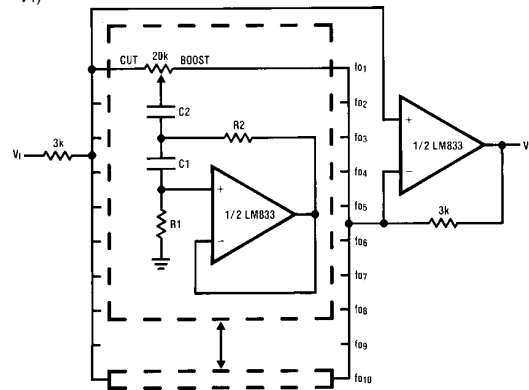
If  $R_2 = R_5, R_3 = R_6, R_4 = R_7$

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



TL/H/5218-43

### 10 Band Graphic Equalizer



TL/H/5218-44

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

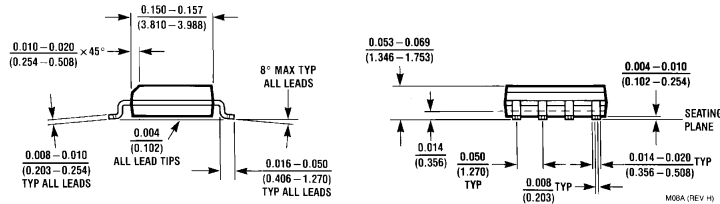
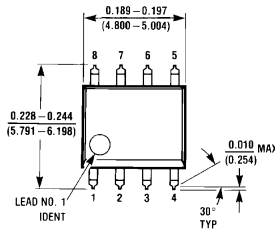
At volume of change = ±12 dB

Q = 1.7

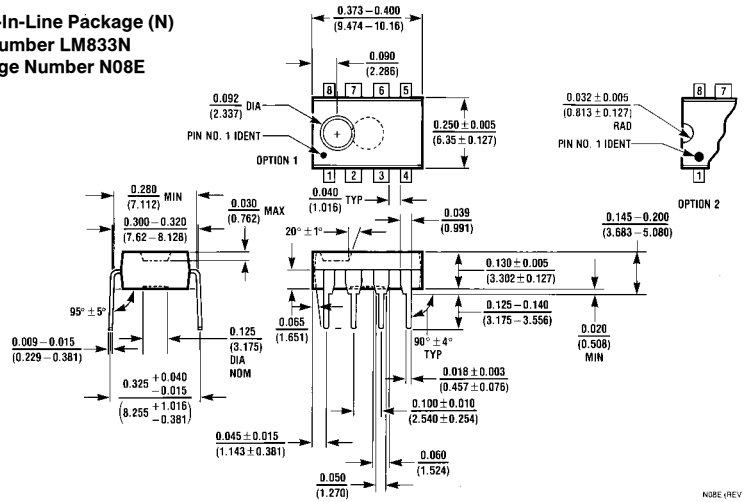
Reference: "AUDIO/RADIO HANDBOOK", National Semiconductor, 1980, Page 2-61

**Physical Dimensions** inches (millimeters)

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



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



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