National Semiconductor

PRELIMINARY

LM833 Dual Audio Operational Amplifier

General Description

The LM833 and LM833A are dual general purpose operational amplifiers designed with particular emphasis on performance in audio systems.

These dual amplifier ICs utilize new circuit and processing techniques to deliver low noise, high speed and wide bandwidth without increasing external components or decreasing stability. The LM833 and LM833A are internally compensated for all closed loop gains and are therefore optimized for all preamp and high level stages in PCM and HiFi systems.

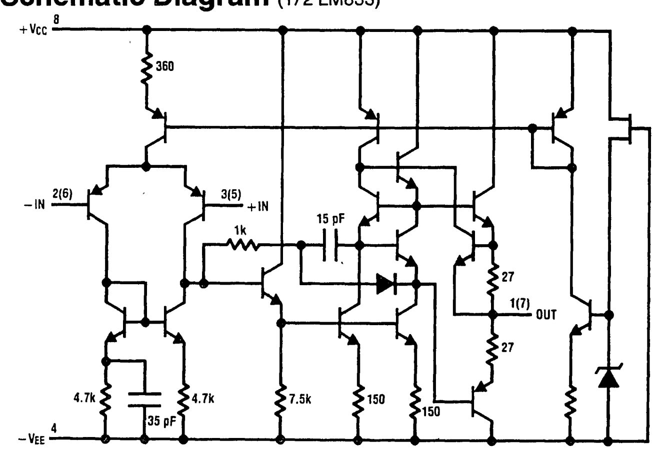
The LM833 and LM833A are pin for pin compatible with industry standard dual operational amplifiers.

The LM833A guarantees low noise for noise critical applications by 100% noise testing.

Features

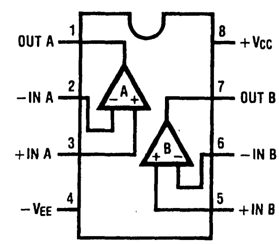
■ Wide dynamic range	> 140 dB
■ Low input noise voltage	4.5 nV/$\sqrt{Hz}$
■ High slew rate	7 V/μs (typ) 5 V/μs (min)
■ High gain bandwidth product	15 MHz (typ) 10 MHz (min)
■ Wide power bandwidth	120 kHz
■ Low distortion	0.002%
■ Low offset voltage	0.3 mV
■ Large phase margin	60°

Schematic Diagram (1/2 LM833)



TL/H/5218-1

Connection Diagram



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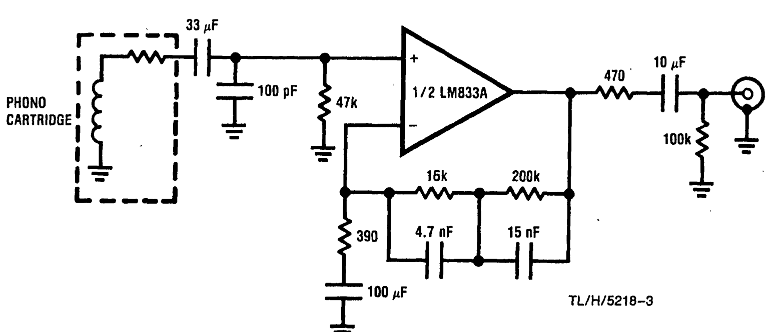
Order Number LM833N
See NS Package N08E

Typical Application RIAA Preamp



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A_V = 35 dB	f = 1 kHz
E_n = 0.33 μV	A Weighted
S/N = 90 dB	A Weighted, V_{IN} = 10 mV @ f = 1 kHz

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Absolute Maximum Ratings

Supply Voltage	V_{CC}/V_{EE}	±18V	Power Dissipation (Note 2)	P_D	500 mW
Differential Input Voltage (Note 1)	V_{ID}	±30V	Operating Temperature Range	T_{OPR}	−40 ~ 85°C
Input Voltage Range (Note 1)	V_{IC}	±15V	Storage Temperature Range	T_{STG}	−60 ~ 150°C

DC Electrical Characteristics (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 R_L = 2 kΩ	±12 ±10	±13.5 ±13.4		V 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
GBWP	Gain Bandwidth Product	f = 100 kHz	10	15		MHz
e_{n1}	LM833A Equivalent Input Noise Voltage (Note 3)	RIAA, R_S = 470Ω		0.5	0.8	μV

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 2	Input Referred Noise Voltage 2	R_S = 100Ω, JISA	0.5	μV
e_n 3	Input Referred Noise Voltage 3	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

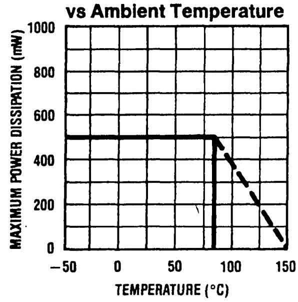
Note 1: If supply voltage is less than 15V, it is equal to supply voltage.

Note 2: This is the permissible value at T_A ≤ 85°C.

Note 3: Only the LM833A is noise tested and guaranteed.
See "Noise Measurement Circuit" for test conditions.

Typical Performance Characteristics

Maximum Power Dissipation vs Ambient Temperature



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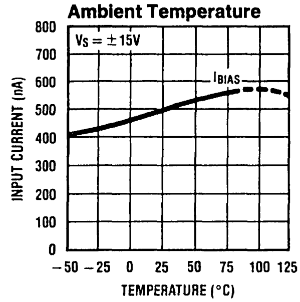
Input Bias Current vs Ambient Temperature



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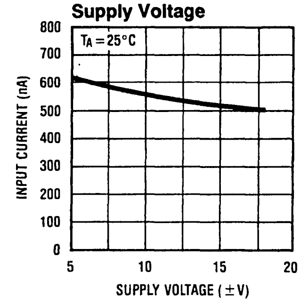
Input Bias Current vs Supply Voltage



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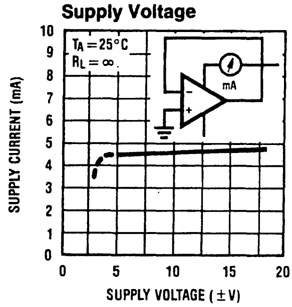
Supply Current vs Supply Voltage



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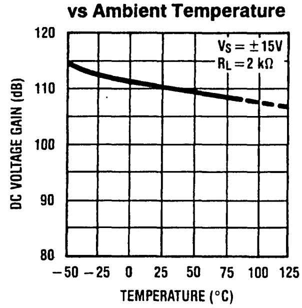
DC Voltage Gain vs Ambient Temperature



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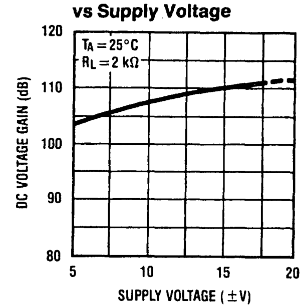
DC Voltage Gain vs Supply Voltage



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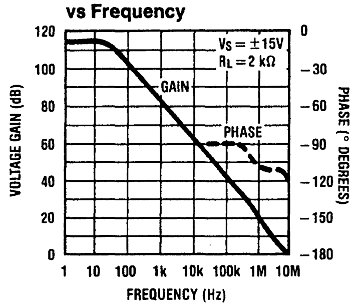
Voltage Gain & Phase vs Frequency



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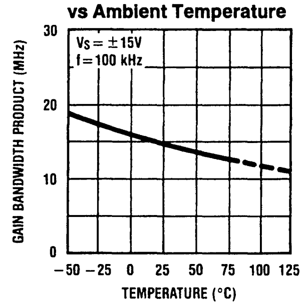
Gain Bandwidth Product vs Ambient Temperature



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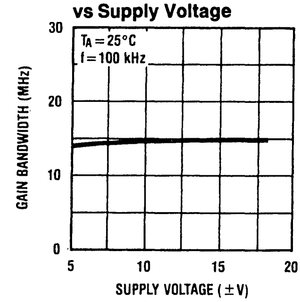
Gain Bandwidth vs Supply Voltage



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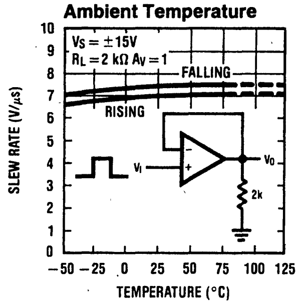
Typical Performance Characteristics (Continued)

Slew Rate vs Ambient Temperature



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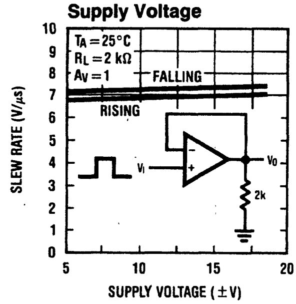
Slew Rate vs Supply Voltage



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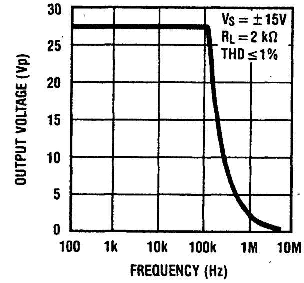
Power Bandwidth



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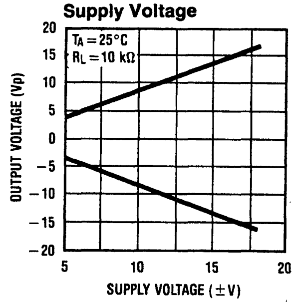
Maximum Output Voltage vs Supply Voltage



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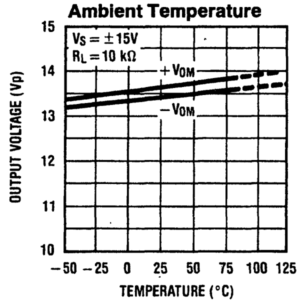
Maximum Output Voltage vs Ambient Temperature



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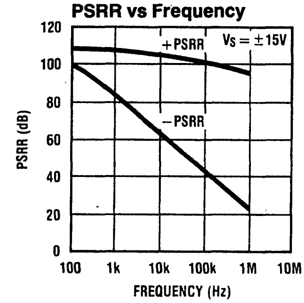
PSRR vs Frequency



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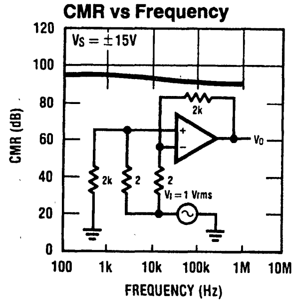
CMR vs Frequency



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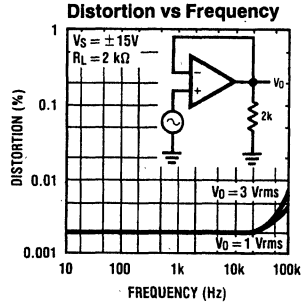
Distortion vs Frequency



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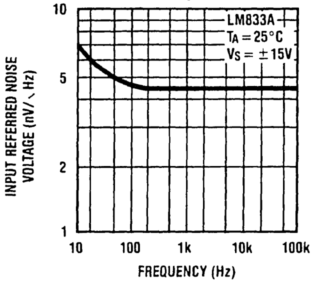
Typical Performance Characteristics (Continued)

Spot Noise Voltage vs Frequency



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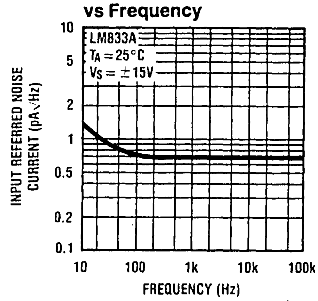
Spot Noise Current vs Frequency



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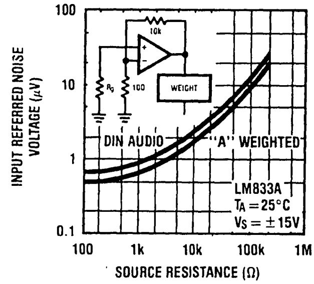
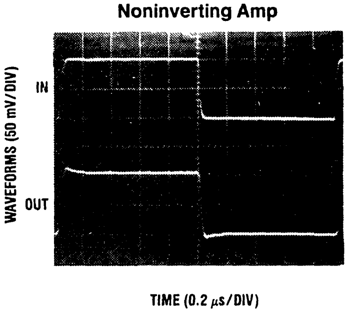
Input Referred Noise Voltage vs Source Resistance



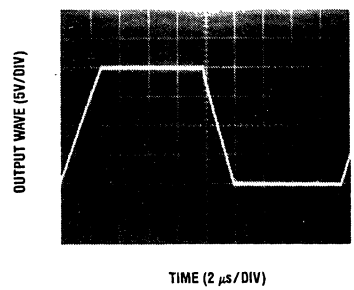
TL/H/5218-23

Noninverting Amp



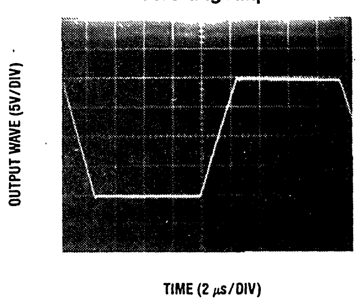
TL/H/5218-24

Noninverting Amp



TL/H/5218-25

Inverting Amp



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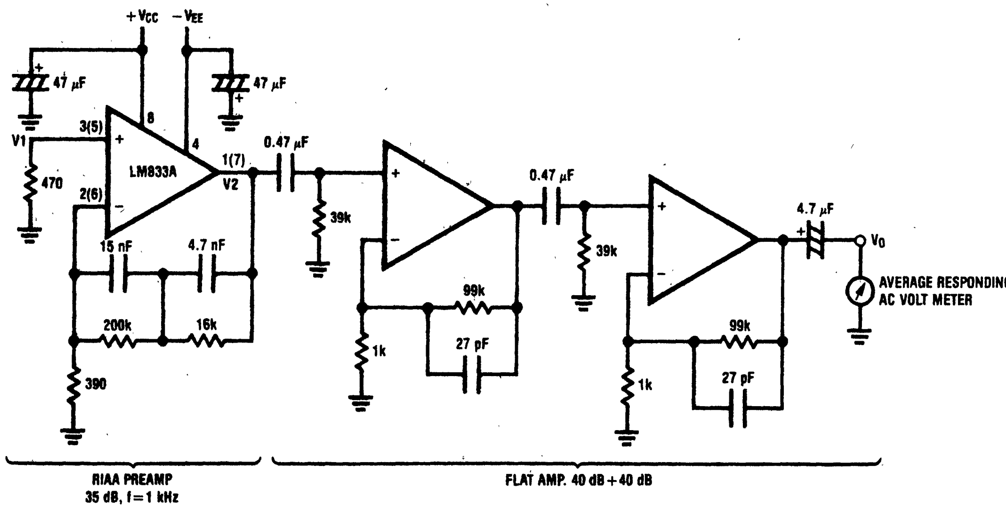
Application Hints

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

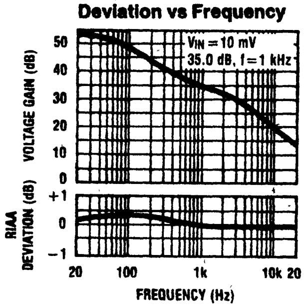
Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.



TL/H/5218–27

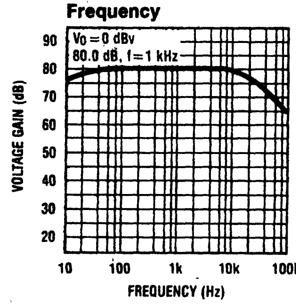
Total Gain: 115 dB @f = 1 kHz
Input Referred Noise Voltage: e_n = V0/560,000 (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



TL/H/5218–28

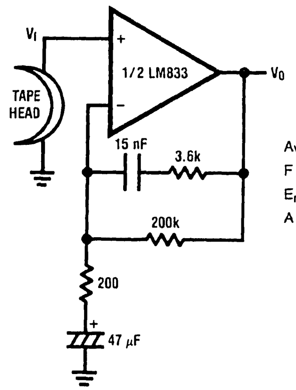
Flat Amp Voltage Gain vs Frequency



TL/H/5218–29

Typical Applications

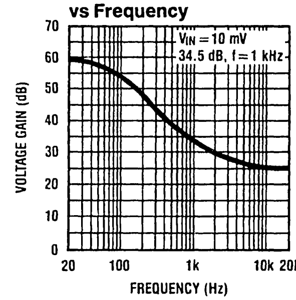
NAB Preamp



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

TL/H/5218-30

NAB Preamp Voltage Gain vs Frequency



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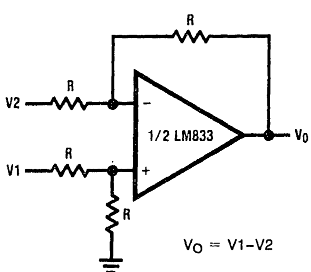
Balanced to Single Ended Converter



$V_O = V1 - V2$

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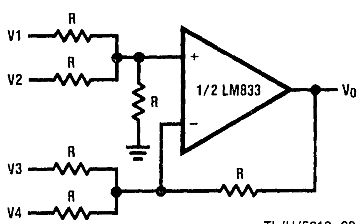
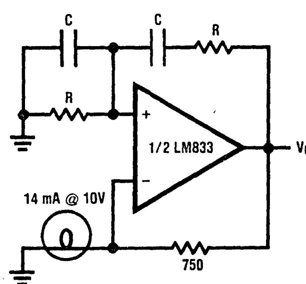
Adder/Subtracter



$V_O = V1 + V2 - V3 - V4$

TL/H/5218-33

Sine Wave Oscillator



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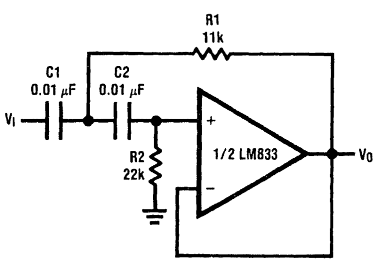
$$f_o = \frac{1}{2\pi R_c}$$

Second Order High Pass Filter (Butterworth)



TL/H/5218-35

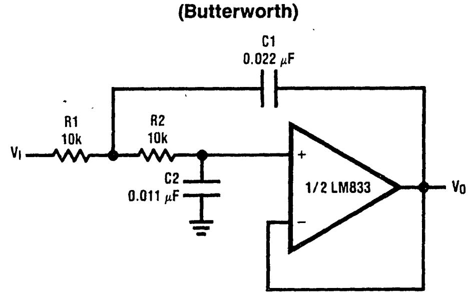
if C1 = C2 = C

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

R2 = 2•R1

Illustration is $f_O = 1$ kHz

Second Order Low Pass Filter (Butterworth)



TL/H/5218-36

if R1 = R2 = R

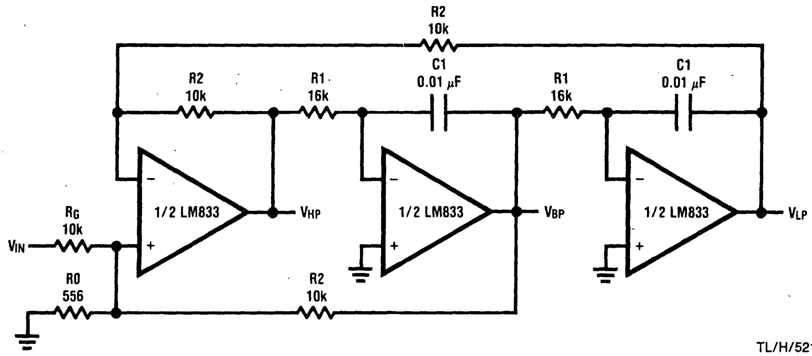
$$C1 = \frac{\sqrt{2}}{\omega_o R}$$

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

Illustration is $f_O = 1$ kHz

Typical Applications (Continued)

State Variable Filter



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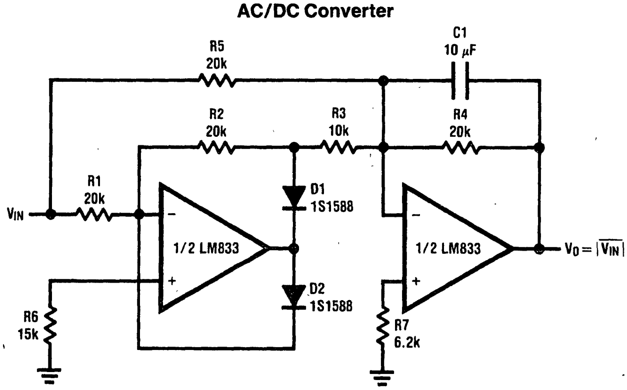
$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{RQ} + \frac{R2}{RQ}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

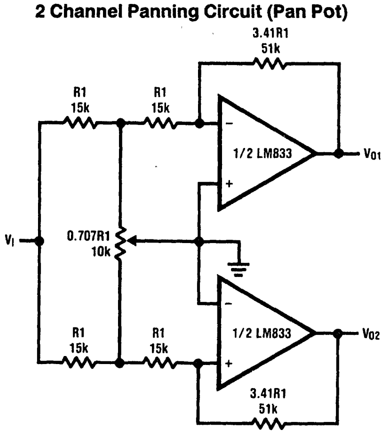
Illustration is $f_0 = 1$ kHz, $Q = 10$, $A_{BP} = 1$

AC/DC Converter



TL/H/5218-38

2 Channel Panning Circuit (Pan Pot)



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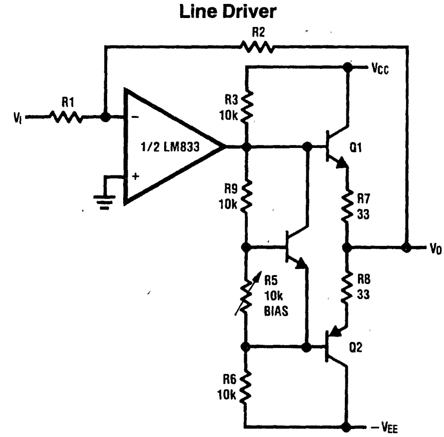
Line Driver



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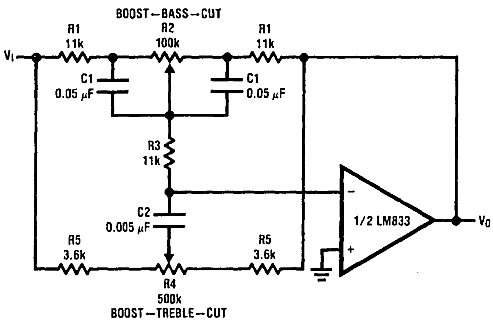
Typical Application (Continued)

Tone Control



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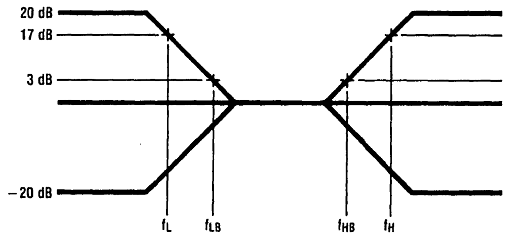
$f_L = \frac{1}{2\pi R2C1}$, $f_{LB} = \frac{1}{2\pi R1C1}$

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

Illustration is:
$f_L = 32$ Hz, $f_{LB} = 320$ Hz
$f_H = 11$ kHz, $f_{HB} = 1.1$ kHz



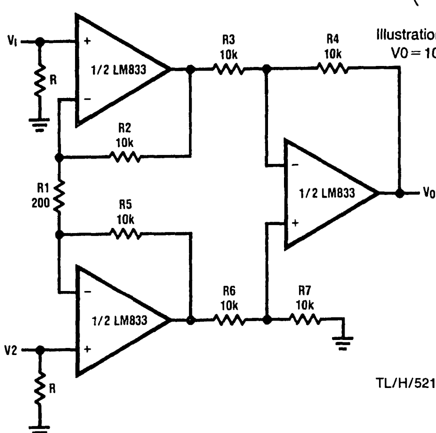
TL/H/5218-42

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)



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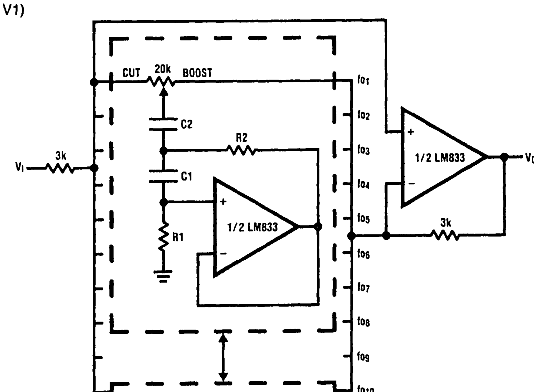
10 Band Graphic Equalizer



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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

At volume of change = ±12dB
Q = 1.7
Reference: "AUDIO/RADIO HANDBOOK", National Semiconductor, 1980, Page 2-61