National Semiconductor

January 12, 2009

LME49743
Quad High Performance, High Fidelity Audio Operational Amplifier

General Description

The LME49743 is a low distortion, low noise, high slew rate operational amplifier optimized and fully specified for high performance, high fidelity applications. The LME49743 audio operational amplifier delivers superior audio signal amplification for outstanding audio performance. The LME49743 combines low voltage noise density (3.5nV/$\sqrt{Hz}$) and THD+N (0.0001%) to easily satisfy demanding audio applications. To ensure that the most challenging loads are driven without compromise, the LME49743 has a slew rate of ±12V/μs and an output current capability of ±21mA.

The LME49743's outstanding CMRR(106dB), PSRR(98dB), and V_{OS} (±0.15mV) give the amplifier excellent operational amplifier DC performance.

The LME49743 has a wide supply range of ±4.0V to ±17V. Over this supply range the LME49743's input circuitry maintains excellent common-mode, power supply rejection, and low input bias current. The LME49743 is unity gain stable.

The LME49743 is available in 14–lead TSSOP.

Key Specifications

■ Power Supply Voltage Range	±4.0V to ±17V
■ THD+N (A_V = 1, V_{OUT} = $3V_{RMS}$, f_{IN} = 1kHz)	
R_L = 2kΩ	0.0001% (typ)
R_L = 600Ω	0.0001% (typ)
■ Input Noise Density	3.5nV/$\sqrt{Hz}$ (typ)
■ Slew Rate	±12V/μs (typ)
■ Gain Bandwidth Product	30MHz (typ)
■ Open Loop Gain (R_L = 600Ω)	110dB (typ)
■ Input Bias Current	190nA (typ)
■ Input Offset Voltage	±0.15mV (typ)

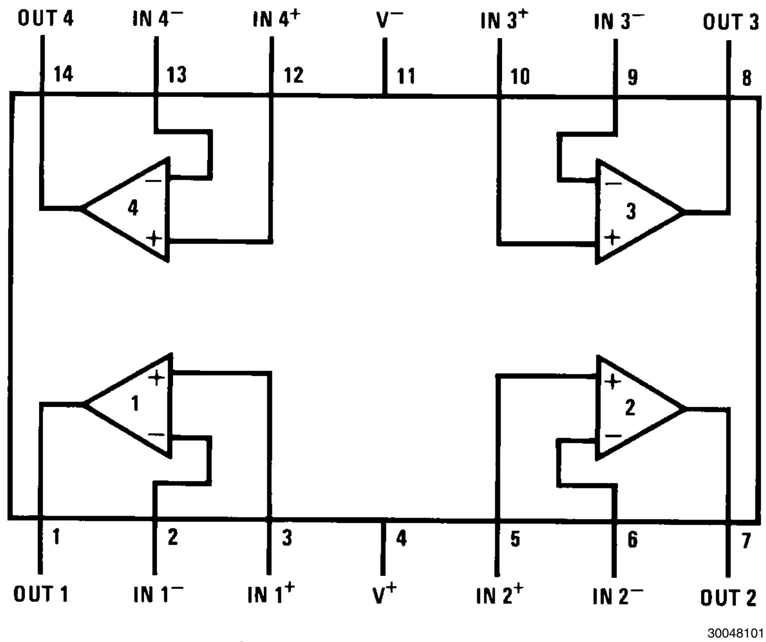
Features

- Easily drives 600Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- 98dB (typ) PSRR and 106dB (typ) CMRR
- TSSOP package

Applications

- Audio amplifiers and preamplifiers
- Professional Audio
- Equalization and crossover networks
- Line drivers and receivers
- Active filters

Connection Diagram



Order Number LME49743MT
See NS Package Number — MTC14

Absolute Maximum Ratings (Notes 1, 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Supply Voltage (V_S = V+ - V-)	36V
Storage Temperature	–65°C to 150°C
Input Voltage	(V-) - 0.7V to (V+) + 0.7V
Output Short Circuit (Note 3)	Continuous
Power Dissipation	Internally Limited
ESD Susceptibility (Note 4)	750V
ESD Susceptibility (Note 5)	175V
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (MT)	140°C/W
Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40°C \le T_A \le 85°C$
Supply Voltage Range	$\pm4.0V \le V_S \le \pm 17V$

Electrical Characteristics

(Notes 1, 2) The following specifications apply for $V_S = \pm15V$, $R_L = 2k\Omega$, $f_{IN} = 1kHz$, and T_A = 25C, unless otherwise specified.

Symbol	Parameter	Conditions	LME49743 Typical (Note 6)	LME49743 Limit (Notes 7, 8)	Units (Limits)
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ $R_L = 2k\Omega$ $R_L = 600\Omega$	 0.0001 0.0001	 0.0002	% (max)
IMD	Intermodulation Distortion	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.0005		% (max)
GBWP	Gain Bandwidth Product		30	25	MHz (min)
SR	Slew Rate		12	9.5	V/μs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$, –3dB referenced to output magnitude at f = 1kHz	10		MHz
t_s	Settling time	$A_V = 1$, 10V step, C_L = 100pF 0.1% error range	1.2		μs
e_n	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.48	0.65	μV_{RMS}
e_n	Equivalent Input Noise Density	f = 1kHz f = 10Hz	3.5 6.4	4.5	$nV/\sqrt{Hz}$ (max) $nV/\sqrt{Hz}$
i_n	Current Noise Density	f = 1kHz f = 10Hz	1.6 3.1		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
V_{OS}	Offset Voltage		±0.15	±1.0	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$40°C \le T_A \le 85°C$	0.05		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	ΔV_S = 20V (Note 9)	98	94	dB (min)
ISO_{CH-CH}	Channel-to-Channel Isolation	f_{IN} = 1kHz f_{IN} = 20kHz	118 112		dB dB
I_B	Input Bias Current	V_{CM} = 0V	190	250	nA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.05		nA/°C
I_{OS}	Input Offset Current	V_{CM} = 0V	7	40	nA (max)
V_{IN-CM}	Common-Mode Input Voltage Range		±13.2	(V+)–2.0 (V-)+2.0	V (min) V (min)
CMRR	Common-Mode Rejection	$-10V<V_{CM}<10V$	106	98	dB (min)
Z_{IN}	Differential Input Impedance		30		kΩ
Z_{IN}	Common Mode Input Impedance	$-10V<V_{CM}<10V$	1000		MΩ
A_{VOL}	Open Loop Voltage Gain	$-10V<V_{OUT}<10V$, $R_L = 600\Omega$	110		dB (min)
A_{VOL}	Open Loop Voltage Gain	$-10V<V_{OUT}<10V$, $R_L = 2k\Omega$	110		dB (min)
A_{VOL}	Open Loop Voltage Gain	$-10V<V_{OUT}<10V$, $R_L = 10k\Omega$	110	100	dB (min)

Symbol	Parameter	Conditions	LME49743 Typical (Note 6)	LME49743 Limit (Notes 7, 8)	Units (Limits)
V_{OUTMAX}	Maximum Output Voltage Swing	R_L = 600Ω	±12.4	±12.0	V (min)
		R_L = 2kΩ	±13.0		V (min)
		R_L = 10kΩ	±13.0		V (min)
I_{OUT}	Output Current	R_L = 600Ω, V_S = ±17V	±21	±20	mA (min)
I_{OUT-CC}	Short Circuit Current		+30 –38		mA mA
R_{OUT}	Output Impedance	f_{IN} = 10kHz Closed-Loop Open-Loop	 0.01 13		 Ω Ω
C_{LOAD}	Capacitive Load Drive Overshoot	100pF	16		%
I_S	Total Quiescent Current	I_{OUT} = 0mA	10	14	mA (max)

Note 1: *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur.

Note 2: Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 3: Amplifier output connected to GND, any number of amplifiers within a package.

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Machine Model ESD test is covered by specification EIAJ IC-121-1981. A 200pF cap is charged to the specified voltage and then discharged directly into the IC with no external series resistor (resistance of discharge path must be under 50Ω).

Note 6: Typical specifications are specified at +25ºC and represent the most likely parametric norm.

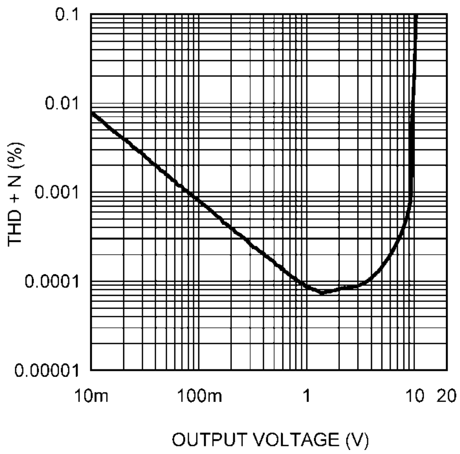
Note 7: Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Note 9: PSRR is measured as follows: V_{OS} is measured at two supply voltages, ±5V and ±15V. PSRR = $|20\log(\Delta V_{OS}/\Delta V_S)|$.

Typical Performance Characteristics

THD+N vs Output Voltage
V_S = ±15V, R_L = 2kΩ, f = 1kHz
30kHz BW



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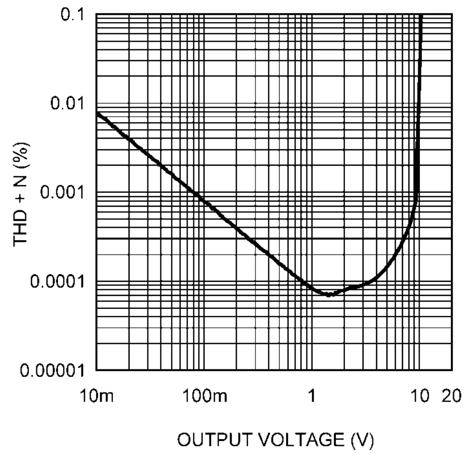
THD+N vs Output Voltage
V_S = ±15V, R_L = 10kΩ, f = 1kHz
30kHz BW



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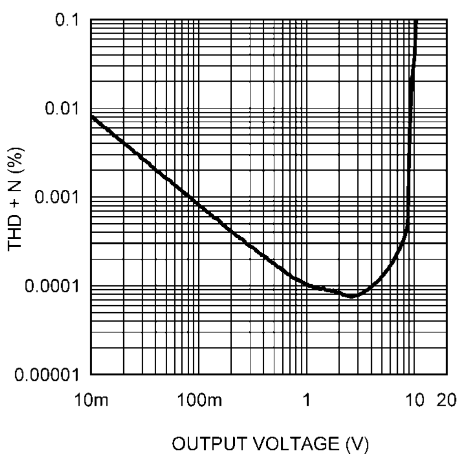
THD+N vs Output Voltage
V_S = ±15V, R_L = 600Ω, f = 1kHz
30kHz BW



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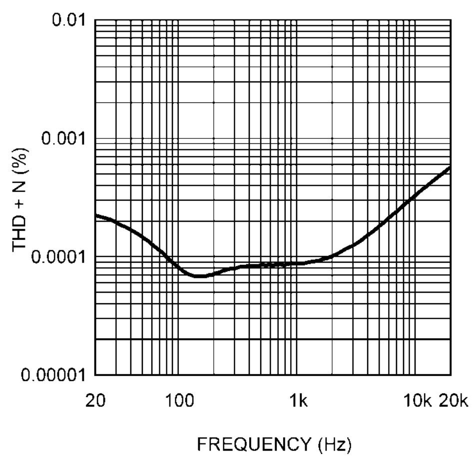
THD+N vs Frequency
V_S = ±15V, V_{OUT} = $3V_{RMS}$, R_L = 2kΩ
80kHz BW



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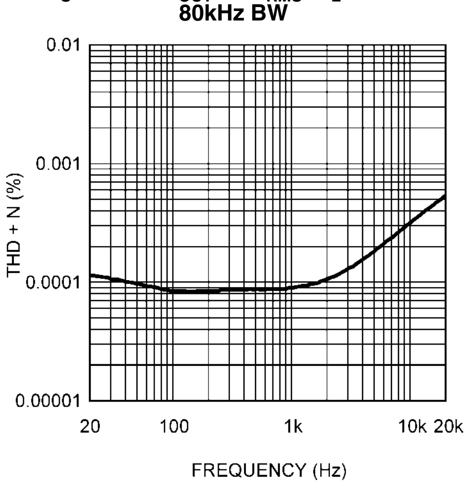
THD+N vs Frequency
V_S = ±15V, V_{OUT} = $3V_{RMS}$, R_L = 10kΩ
80kHz BW



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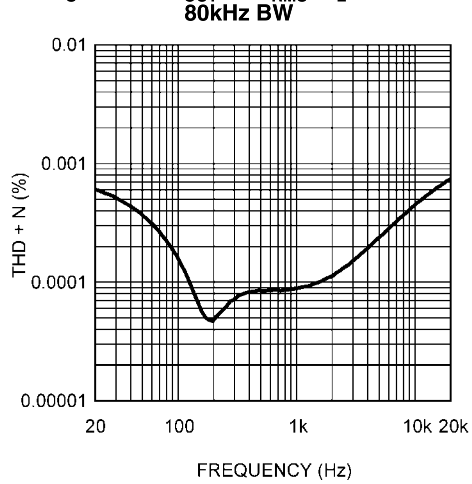
THD+N vs Frequency
V_S = ±15V, V_{OUT} = $3V_{RMS}$, R_L = 600Ω
80kHz BW



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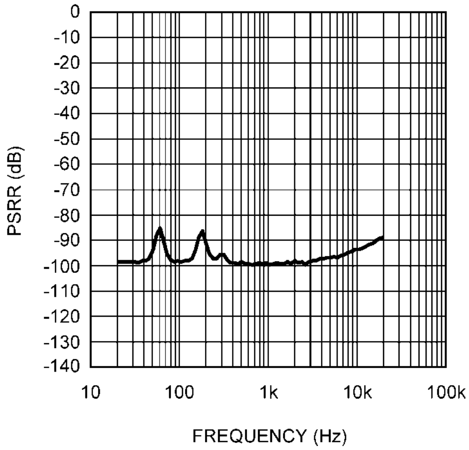
+PSRR vs Frequency
V_S = ±15V, R_L = 2kΩ, V_{RIPPLE} = 200mV$_{PP}$



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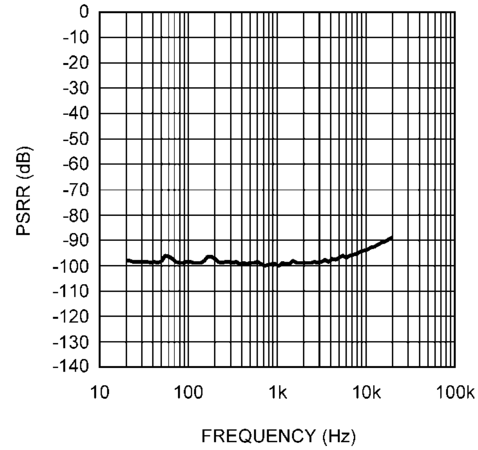
+PSRR vs Frequency
V_S = ±15V, R_L = 10kΩ, V_{RIPPLE} = 200mV$_{PP}$



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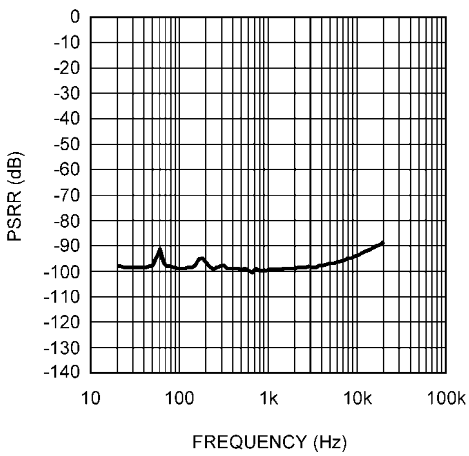
+PSRR vs Frequency
V_S = ±15V, R_L = 600Ω, V_{RIPPLE} = 200mV$_{PP}$



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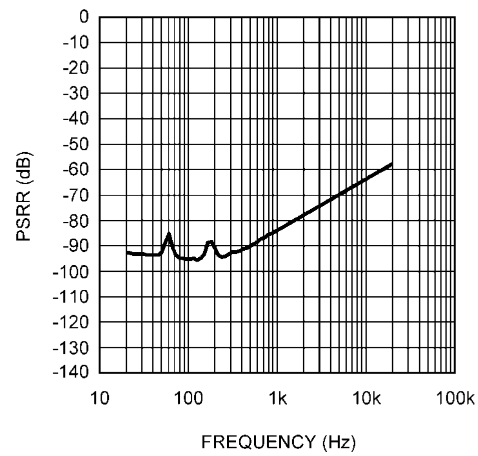
–PSRR vs Frequency
V_S = ±15V, R_L = 2kΩ, V_{RIPPLE} = 200mV$_{PP}$



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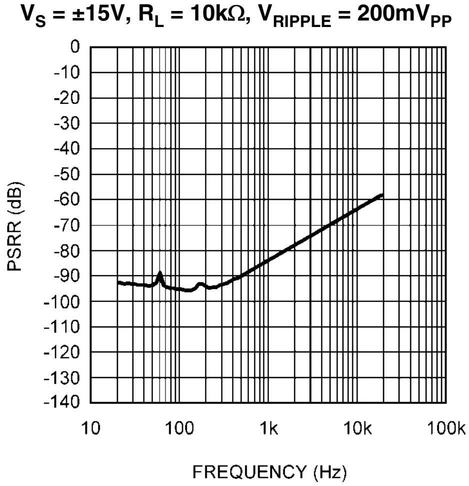
–PSRR vs Frequency
V_S = ±15V, R_L = 10kΩ, V_{RIPPLE} = 200mV$_{PP}$



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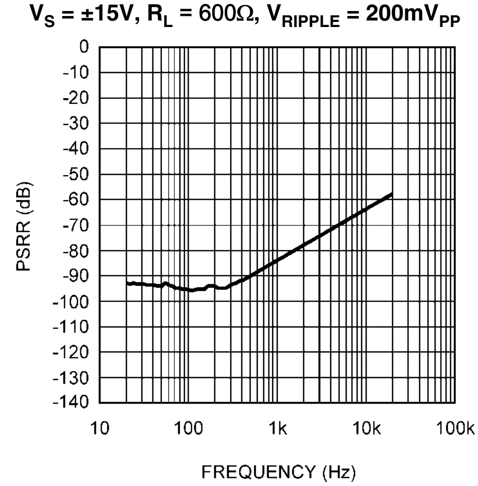
–PSRR vs Frequency
V_S = ±15V, R_L = 600Ω, V_{RIPPLE} = 200mV$_{PP}$



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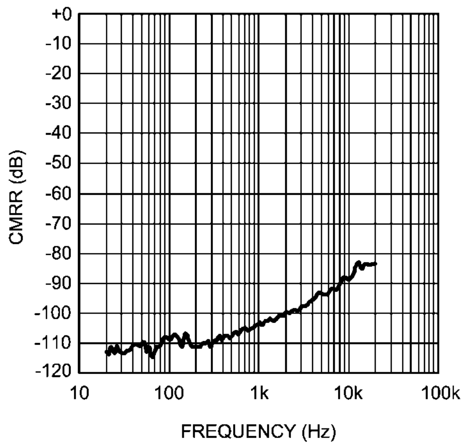
CMRR vs Frequency
$V_S = \pm15V$, $R_L = 2k\Omega$, $V_{IN} = 200mV_{PP}$



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CMRR vs Frequency
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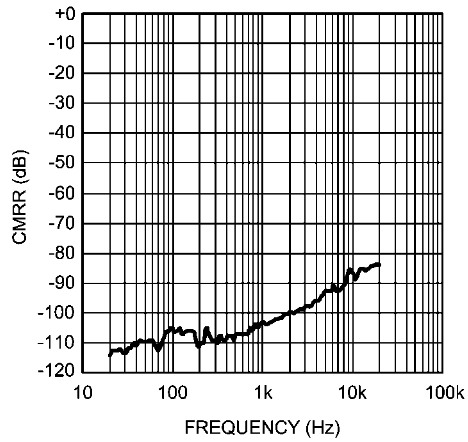

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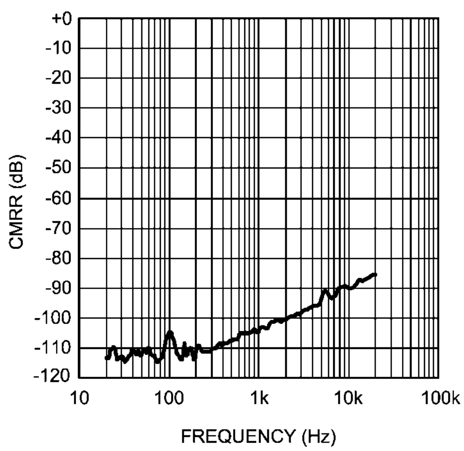
CMRR vs Frequency
$V_S = \pm15V$, $R_L = 600\Omega$, $V_{IN} = 200mV_{PP}$



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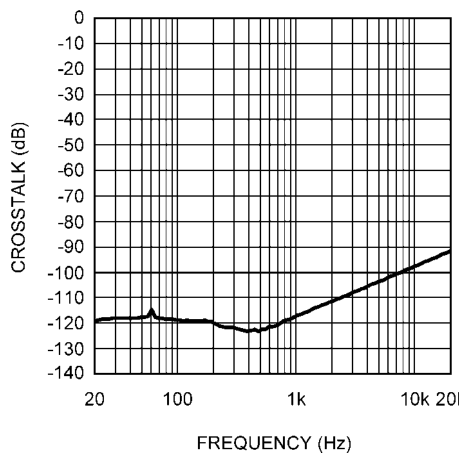
Crosstalk vs Frequency
$V_S = \pm15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 2k\Omega$



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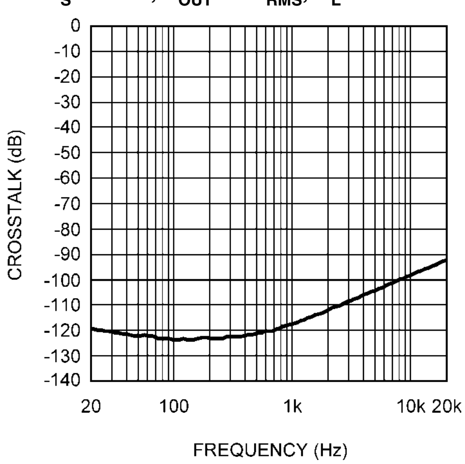
Crosstalk vs Frequency
$V_S = \pm15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 10k\Omega$



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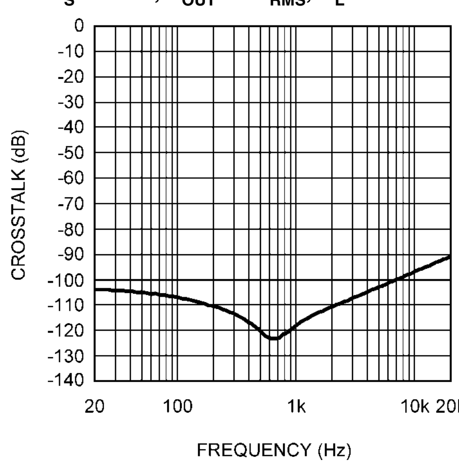
Crosstalk vs Frequency
$V_S = \pm15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 600\Omega$



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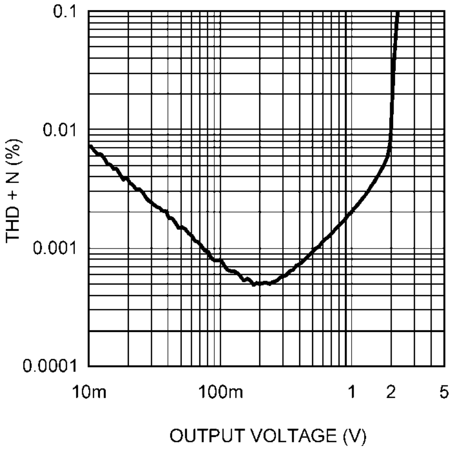
IMD vs Output Voltage
V_S = ±5V, R_L = 2kΩ
7kHz/60Hz 4:1 SMPTE



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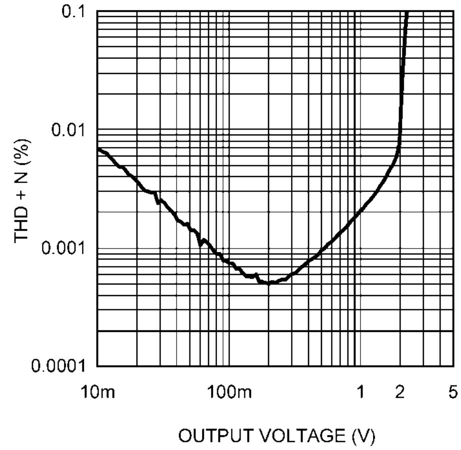
IMD vs Output Voltage
V_S = ±5V, R_L = 10kΩ
7kHz/60Hz 4:1 SMPTE



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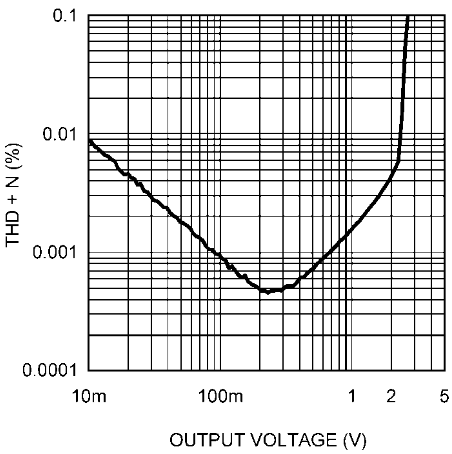
IMD vs Output Voltage
V_S = ±5V, R_L = 600Ω
7kHz/60Hz 4:1 SMPTE



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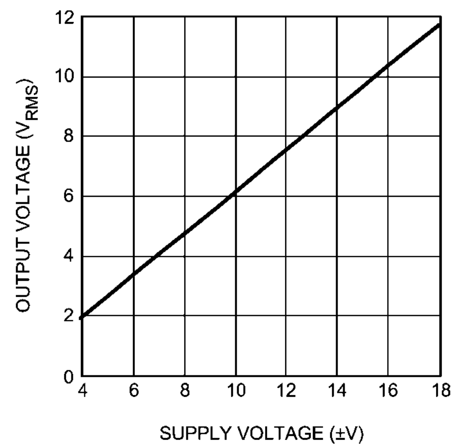
Output Voltage vs Supply Voltage
R_L = 2kΩ, THD+N = 0.1%



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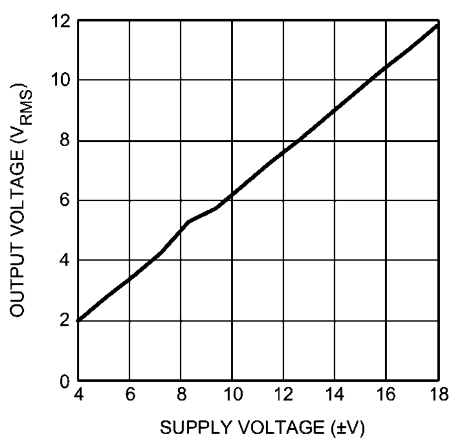
Output Voltage vs Supply Voltage
R_L = 10kΩ, THD+N = 0.1%



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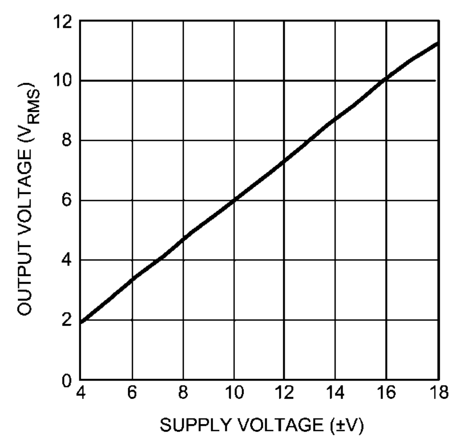
Output Voltage vs Supply Voltage
R_L = 600Ω, THD+N = 0.1%



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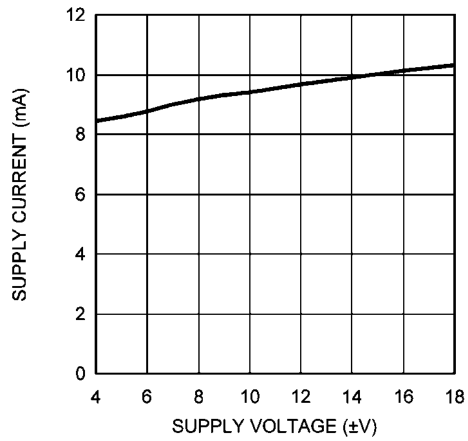
Supply Current vs Supply Voltage



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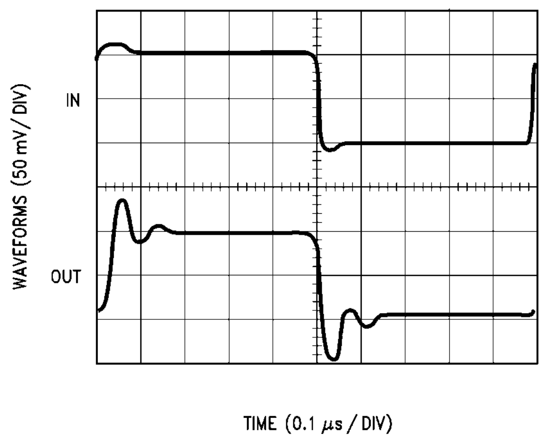
Scope Photo Small Signal



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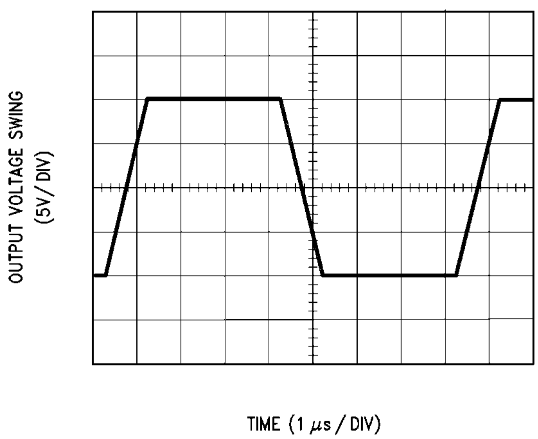
Scope Photo Large Signal, Non-Inverting



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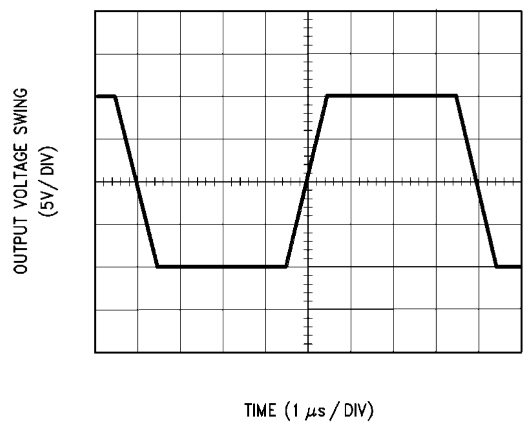
Scope Photo Large Signal, Inverting



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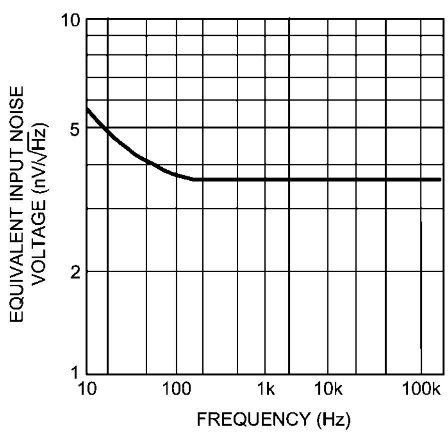
Equivalent Input Noise vs Frequency



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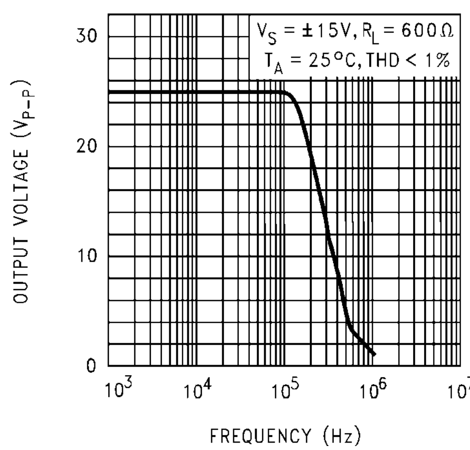
Power Bandwidth



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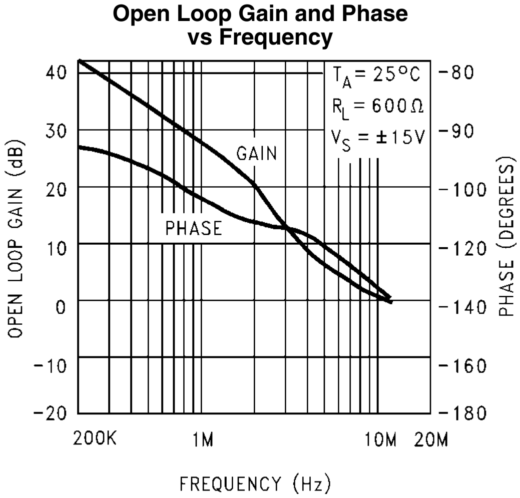

Open Loop Gain and Phase
vs Frequency
T_A = 25°C
R_L = 600Ω
V_S = ±15V
GAIN
PHASE
OPEN LOOP GAIN (dB)
PHASE (DEGREES)
40
30
20
10
0
-10
-20
-80
-90
-100
-120
-140
-160
-180
200K
1M
10M
20M
FREQUENCY (Hz)
30048193

Application Information

DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49743 is below the capabilities of all commercially available equipment. This makes distortion measurements just slightly more difficult than simply connecting a distortion meter to the amplifier's inputs and outputs. The solution, however, is quite simple: an additional resistor. Adding this resistor extends the resolution of the distortion measurement equipment.

The LME49743's low residual distortion is an input referred internal error. As shown in Figure 1, adding the 10Ω resistor connected between the amplifier's inverting and non-inverting inputs changes the amplifier's noise gain. The result is that the error signal (distortion) is amplified by a factor of 101. Although the amplifier's closed-loop gain is unaltered, the feedback available to correct distortion errors is reduced by 101, which means that measurement resolution increases by 101. To ensure minimum effects on distortion measurements, keep the value of R1 low as shown in Figure 1.

This technique is verified by duplicating the measurements with high closed loop gain and/or making the measurements at high frequencies. Doing so produces distortion components that are within the measurement equipment's capabilities. This datasheet's THD+N and IMD values were generated using the above described circuit connected to an Audio Precision System Two Cascade.

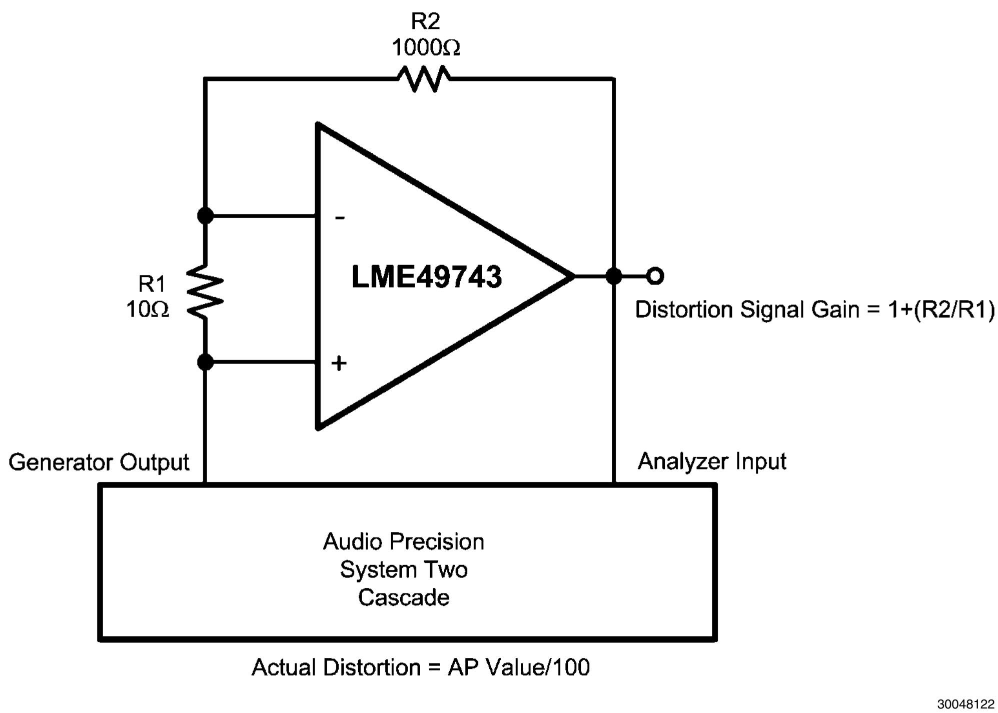


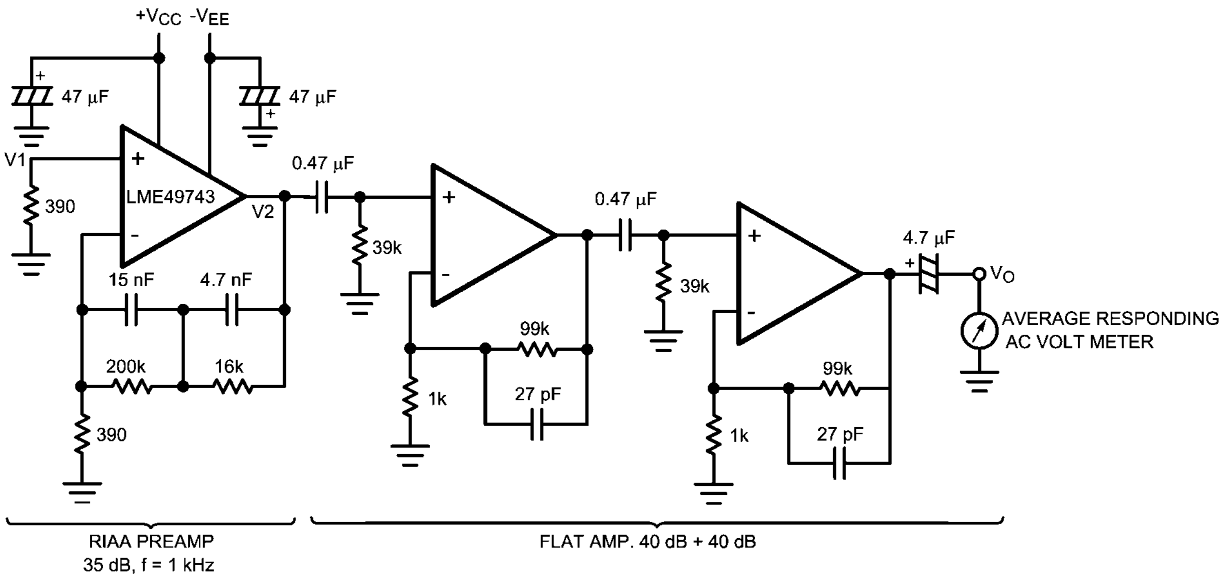
FIGURE 1. THD+N and IMD Distortion Test Circuit

Application Hints

The LME49743 is a high speed op amp with excellent phase margin and stability. Capacitive loads up to 100pF will cause little change in the phase characteristics of the amplifiers and are therefore allowable.

Capacitive loads greater than 100pF 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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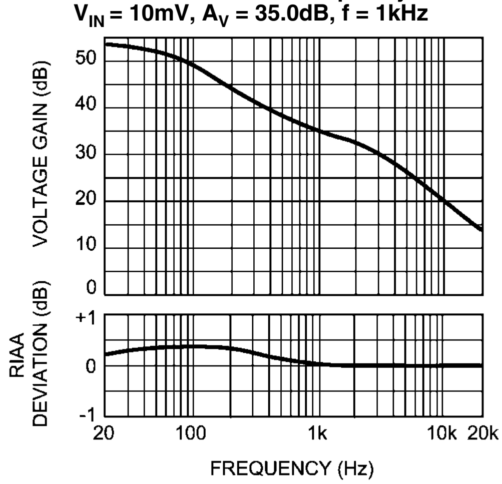
Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

Total Gain: 115 dB at f = 1 kHz

Input Referred Noise Voltage: $e_n = V_O/560{,}000$ (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency V_{IN} = 10mV, A_V = 35.0dB, f = 1kHz



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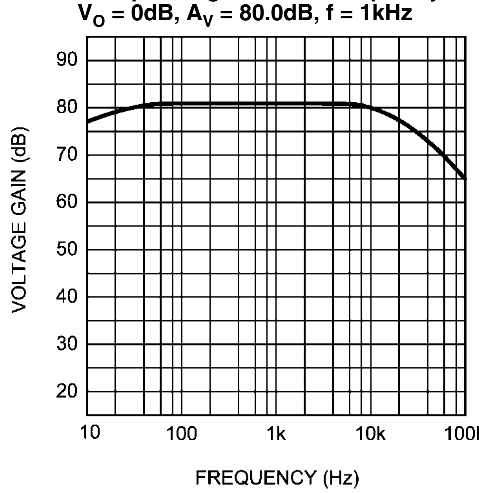
Flat Amp Voltage Gain vs Frequency V_O = 0dB, A_V = 80.0dB, f = 1kHz



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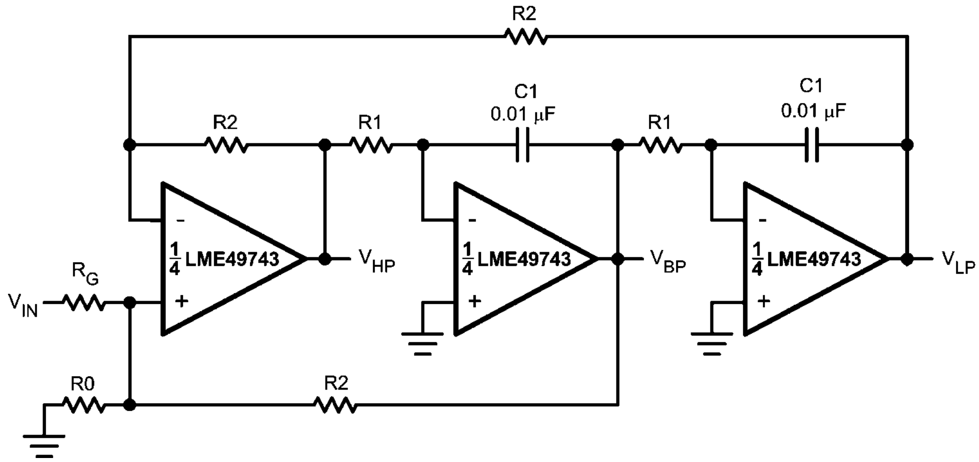
Typical Applications

State Variable Filter



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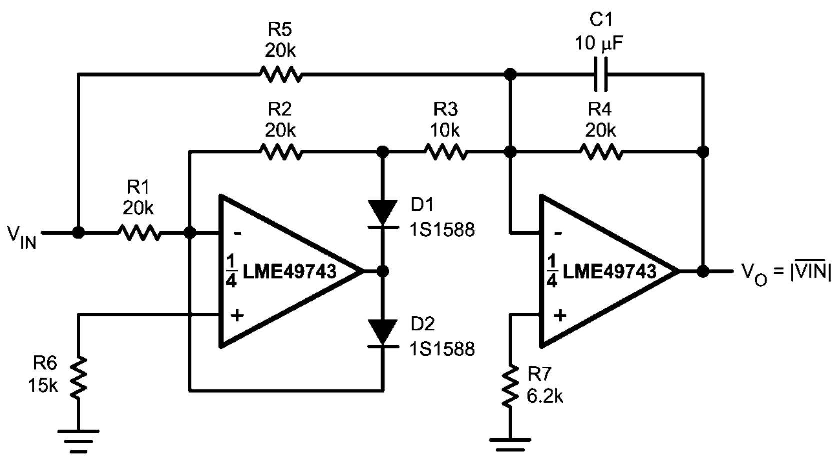
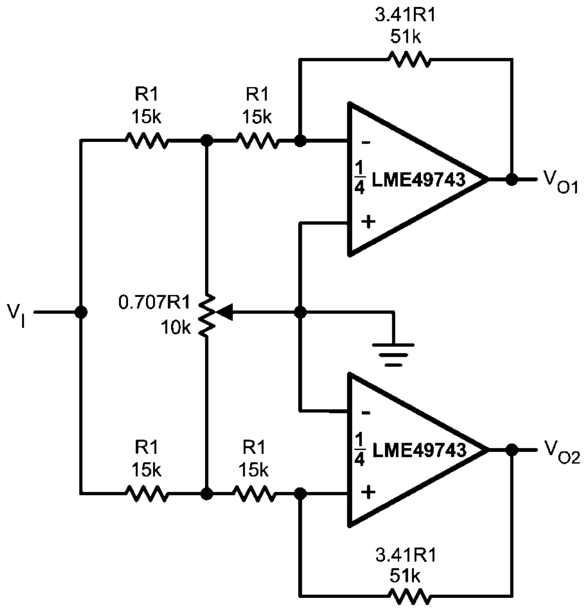
$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{R0} + \frac{R2}{RG}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

AC/DC Converter



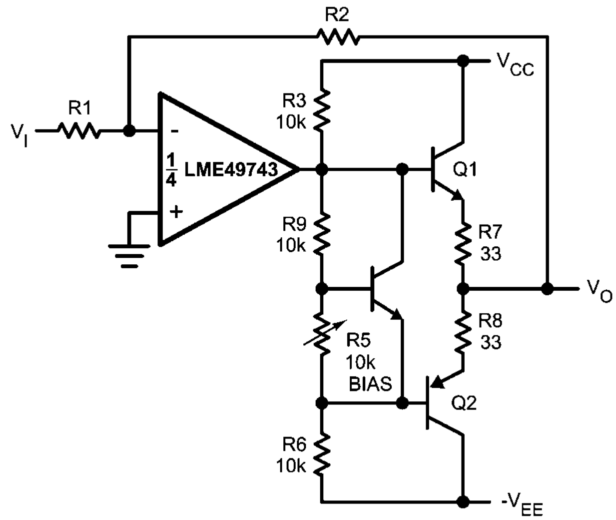
30048138

2 Channel Panning Circuit (Pan Pot)



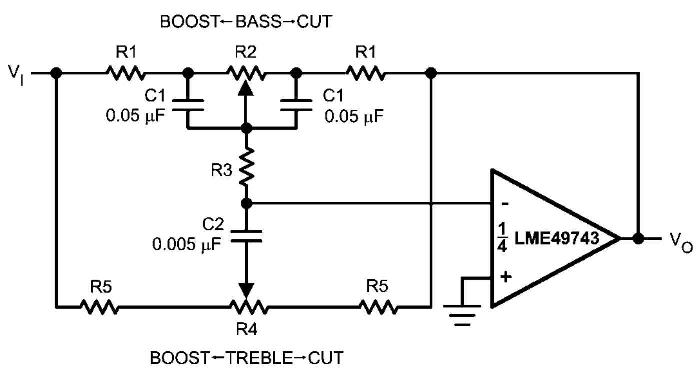
30048139

Line Driver



30048140

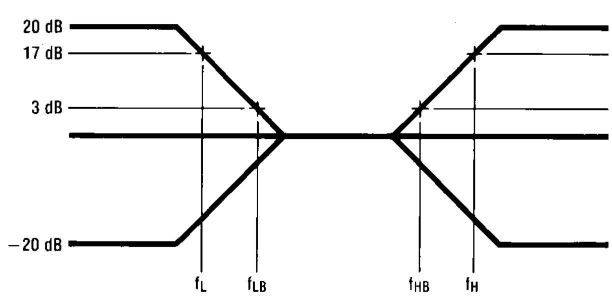
Tone Control



30048141

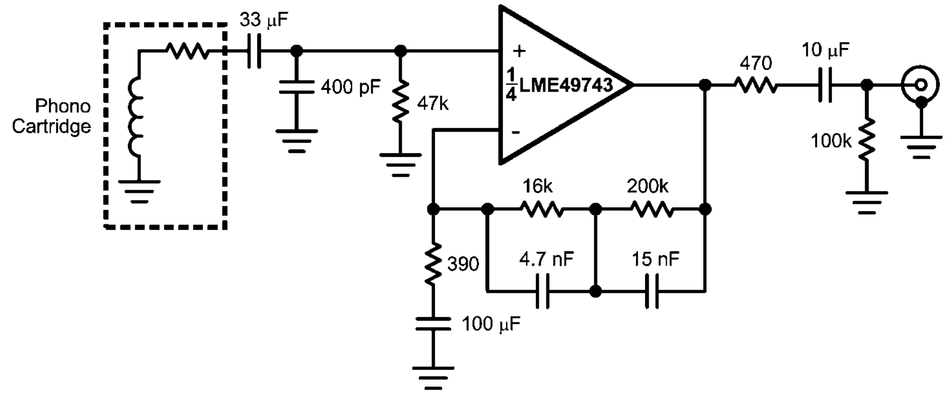
$$f_L = \frac{1}{2\pi R2C1},\ f_{LB} = \frac{1}{2\pi R1C1}$$

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



30048142

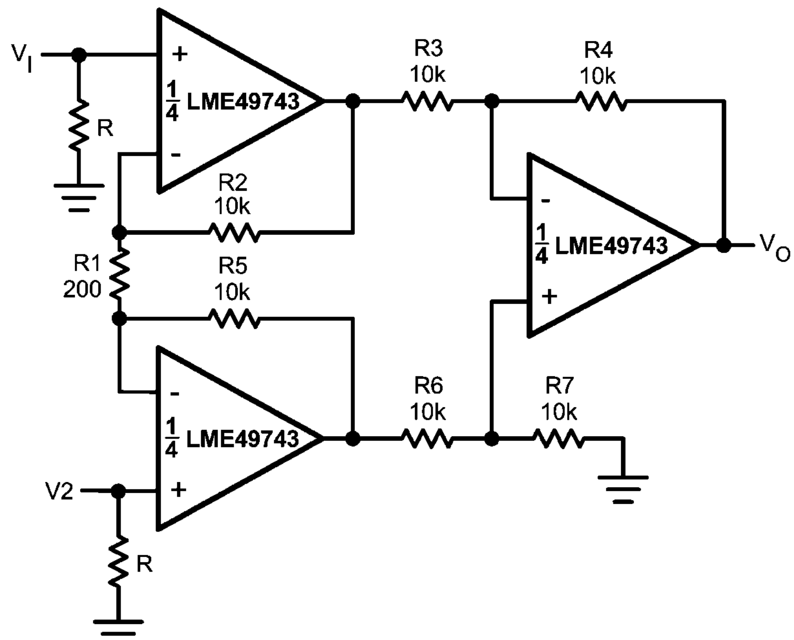
RIAA Preamp



30048103

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

Balanced Input Mic Amp



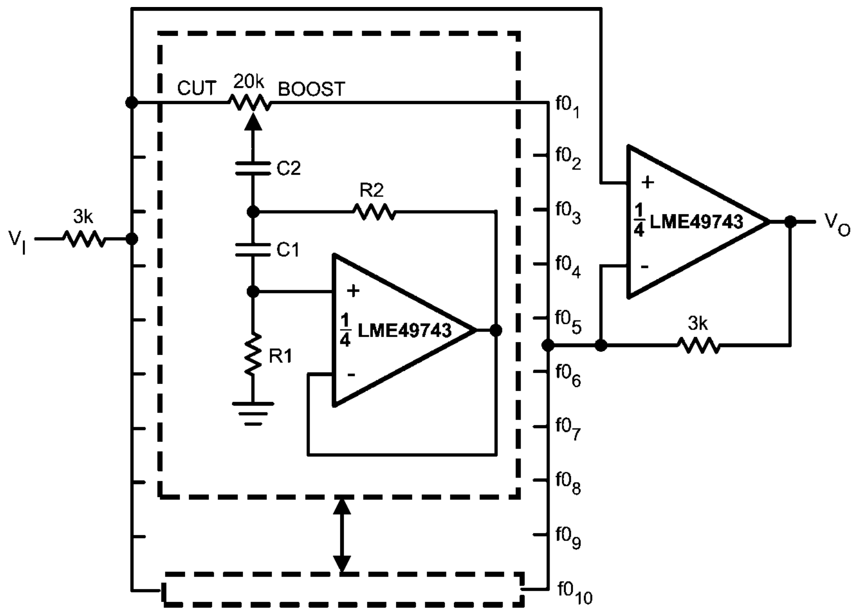
30048143

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)

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 10: At volume of change = ±12 dB

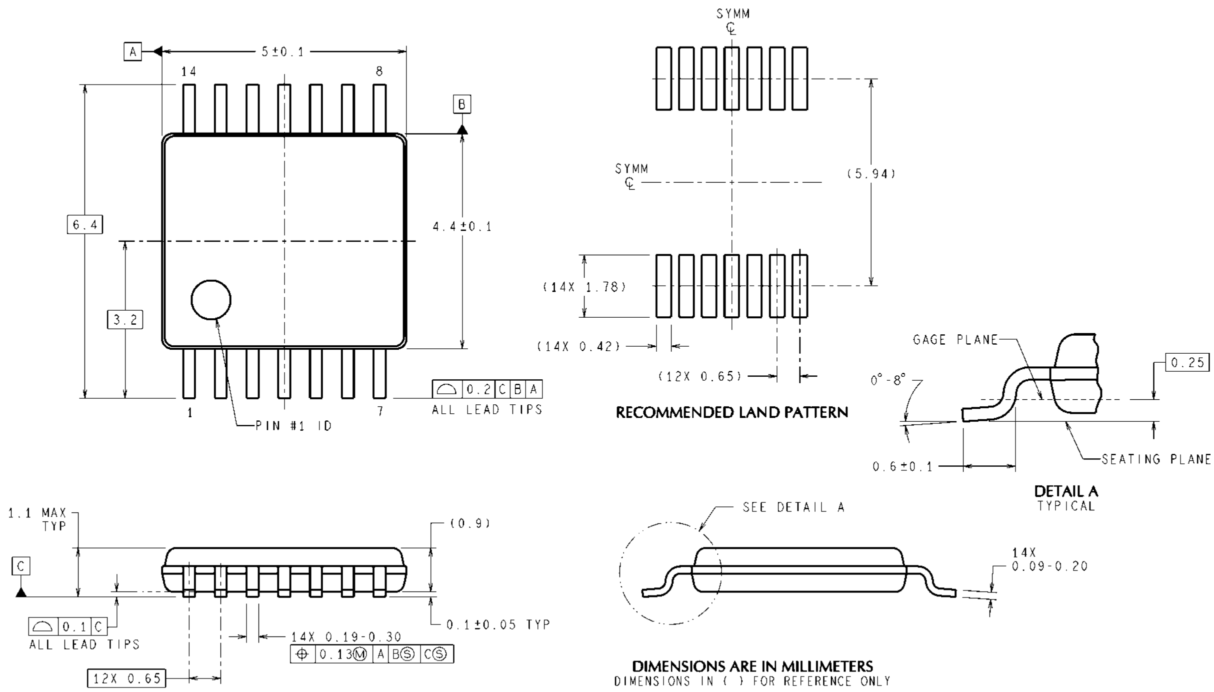
Q = 1.7

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

Revision History

Rev	Date	Description
1.0	03/26/08	Initial release.
1.01	01/12/09	Fixed a typo.

Physical Dimensions inches (millimeters) unless otherwise noted



MTC14 (Rev D)

Dual-In-Line Package
Order Number LME49743MT
NS Package Number MTC14

Notes

Notes

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