

## 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 ( $3.5\text{nV}/\sqrt{\text{Hz}}$ ) 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  $\pm 12\text{V}/\mu\text{s}$  and an output current capability of  $\pm 21\text{mA}$ .

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

The LME49743 has a wide supply range of  $\pm 4.0\text{V}$  to  $\pm 17\text{V}$ . 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	$\pm 4.0\text{V}$ to $\pm 17\text{V}$
■ THD+N ( $A_V = 1$ , $V_{\text{OUT}} = 3V_{\text{RMS}}$ , $f_{\text{IN}} = 1\text{kHz}$ )	
$R_L = 2\text{k}\Omega$	0.0001% (typ)
$R_L = 600\Omega$	0.0001% (typ)
■ Input Noise Density	$3.5\text{nV}/\sqrt{\text{Hz}}$ (typ)
■ Slew Rate	$\pm 12\text{V}/\mu\text{s}$ (typ)
■ Gain Bandwidth Product	30MHz (typ)
■ Open Loop Gain ( $R_L = 600\Omega$ )	110dB (typ)
■ Input Bias Current	190nA (typ)
■ Input Offset Voltage	$\pm 0.15\text{mV}$ (typ)

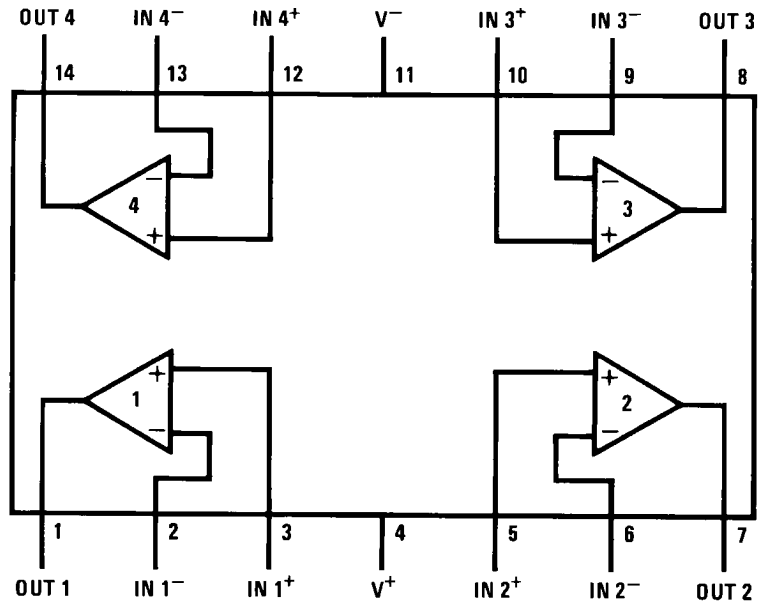
### Features

- Easily drives  $600\Omega$  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



30048101

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 $\theta_{JA}$ (MT)	140°C/W
Temperature Range $T_{MIN} \leq T_A \leq T_{MAX}$	-40°C $\leq T_A \leq$ 85°C
Supply Voltage Range	$\pm 4.0V \leq V_S \leq \pm 17V$

**Electrical Characteristics** (Notes 1, 2) The following specifications apply for  $V_S = \pm 15V$ ,  $R_L = 2k\Omega$ ,  $f_{IN} = 1kHz$ , and  $T_A = 25^\circ C$ , unless otherwise specified.

Symbol	Parameter	Conditions	LME49743		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
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/ $\mu s$ (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		$\mu s$
$e_n$	Equivalent Input Noise Voltage	$f_{BW} = 20Hz$ to 20kHz	0.48	0.65	$\mu V_{RMS}$
	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	$f = 1kHz$	1.6		$pA/\sqrt{Hz}$
		$f = 10Hz$	3.1		$pA/\sqrt{Hz}$
$V_{OS}$	Offset Voltage		$\pm 0.15$	$\pm 1.0$	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$40^\circ C \leq T_A \leq 85^\circ C$	0.05		$\mu V/^\circ C$
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$\Delta V_S = 20V$ (Note 9)	98	94	dB (min)
$ISO_{CH-CH}$	Channel-to-Channel Isolation	$f_{IN} = 1kHz$	118		dB
		$f_{IN} = 20kHz$	112		dB
$I_B$	Input Bias Current	$V_{CM} = 0V$	190	250	nA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40^\circ C \leq T_A \leq 85^\circ C$	0.05		nA/ $^\circ C$
$I_{OS}$	Input Offset Current	$V_{CM} = 0V$	7	40	nA (max)
$V_{IN-CM}$	Common-Mode Input Voltage Range		$\pm 13.2$	( $V^+$ )-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		k $\Omega$
	Common Mode Input Impedance	$-10V < V_{CM} < 10V$	1000		M $\Omega$
$A_{VOL}$	Open Loop Voltage Gain	$-10V < V_{OUT} < 10V$ , $R_L = 600\Omega$	110		dB (min)
		$-10V < V_{OUT} < 10V$ , $R_L = 2k\Omega$	110		dB (min)
		$-10V < V_{OUT} < 10V$ , $R_L = 10k\Omega$	110	100	dB (min)

Symbol	Parameter	Conditions	LME49743		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
$V_{OUTMAX}$	Maximum Output Voltage Swing	$R_L = 600\Omega$	$\pm 12.4$	$\pm 12.0$	V (min)
		$R_L = 2k\Omega$	$\pm 13.0$		V (min)
		$R_L = 10k\Omega$	$\pm 13.0$		V (min)
$I_{OUT}$	Output Current	$R_L = 600\Omega$ , $V_S = \pm 17V$	$\pm 21$	$\pm 20$	mA (min)
$I_{OUT-CC}$	Short Circuit Current		+30 -38		mA mA
$R_{OUT}$	Output Impedance	$f_{IN} = 10kHz$			
		Closed-Loop	0.01		$\Omega$
		Open-Loop	13		$\Omega$
$C_{LOAD}$	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 1.5k $\Omega$  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 50 $\Omega$ ).

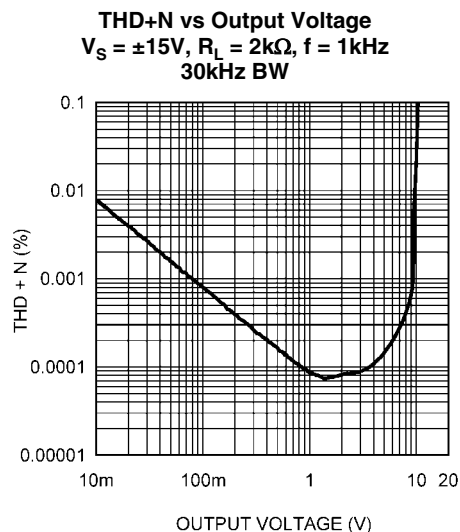
**Note 6:** Typical specifications are specified at +25°C and represent the most likely parametric norm.

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

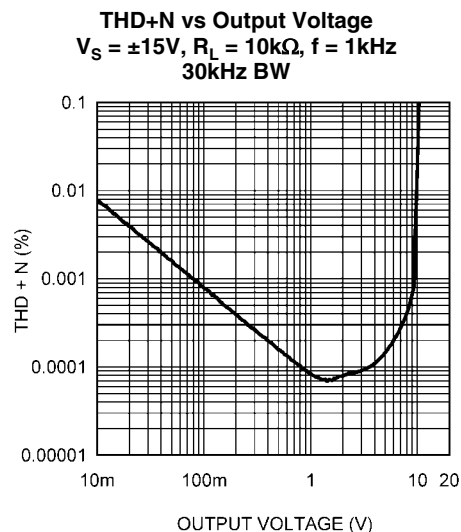
**Note 8:** Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

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

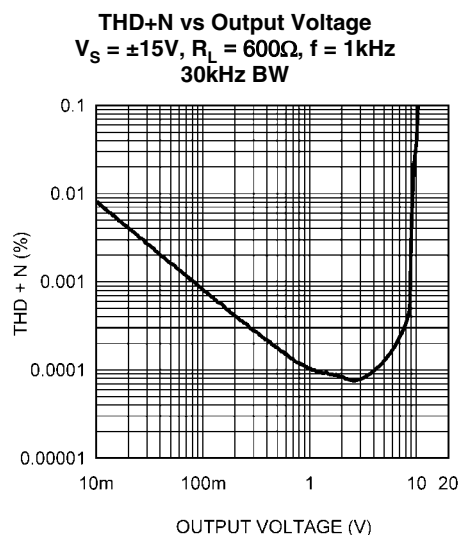
# Typical Performance Characteristics



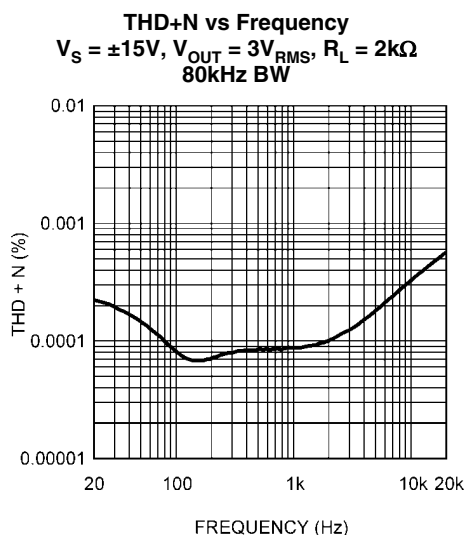
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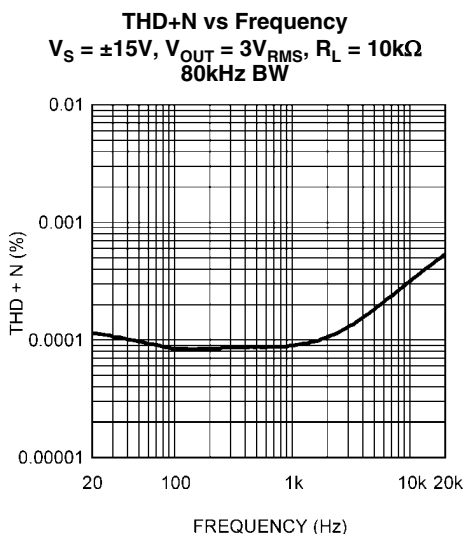
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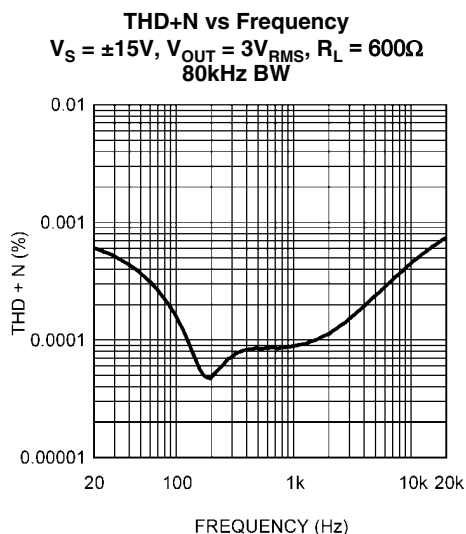
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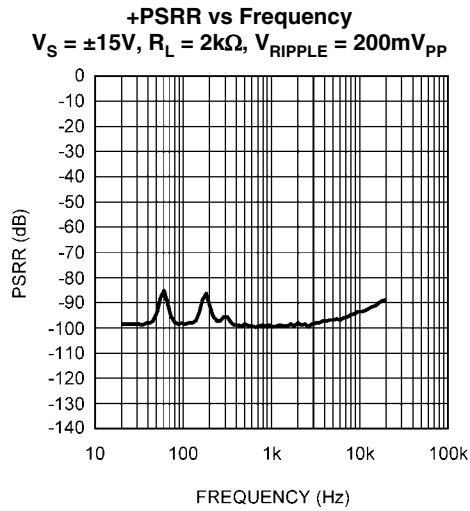
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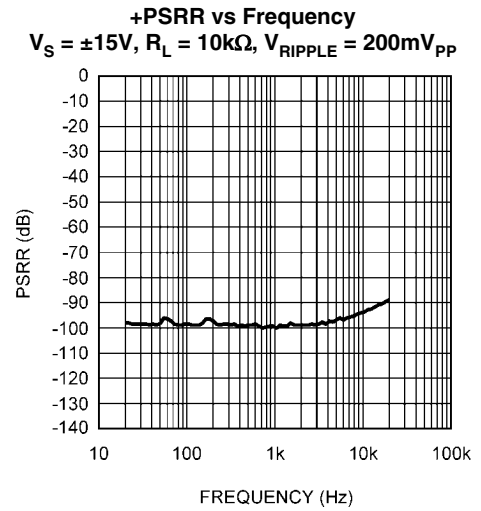
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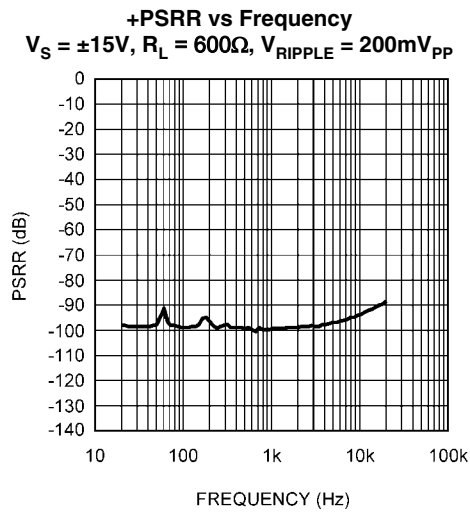
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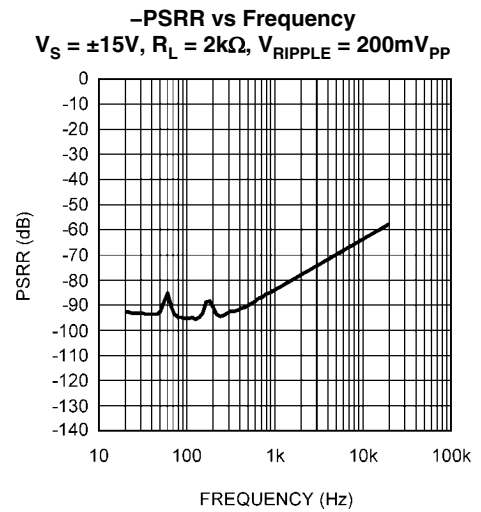
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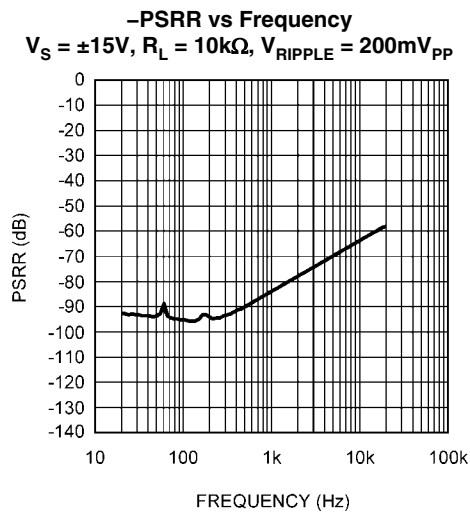
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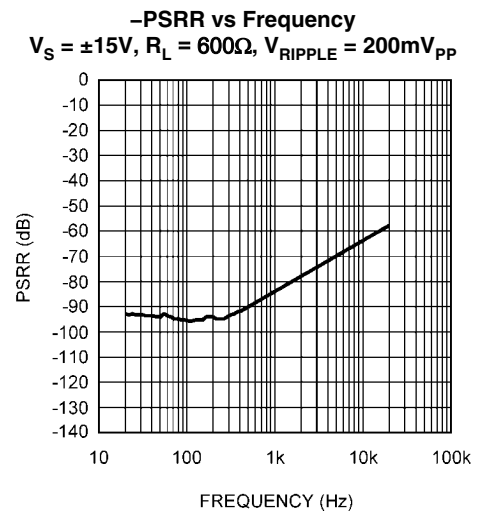
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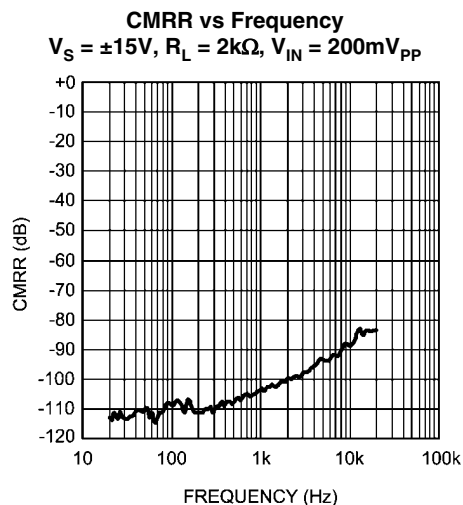
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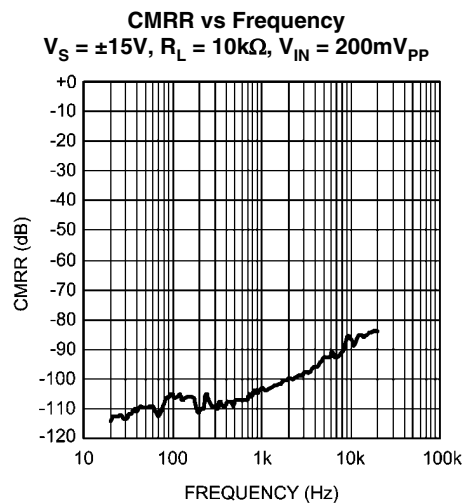
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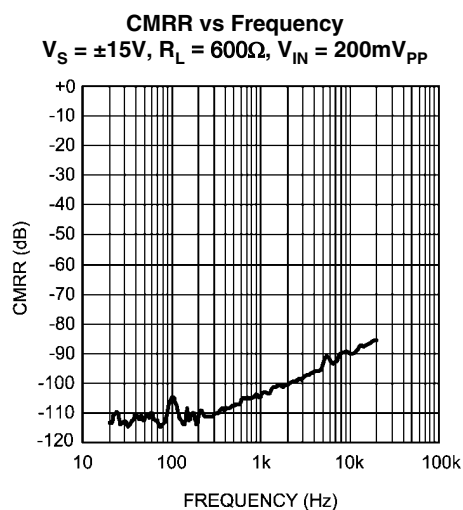
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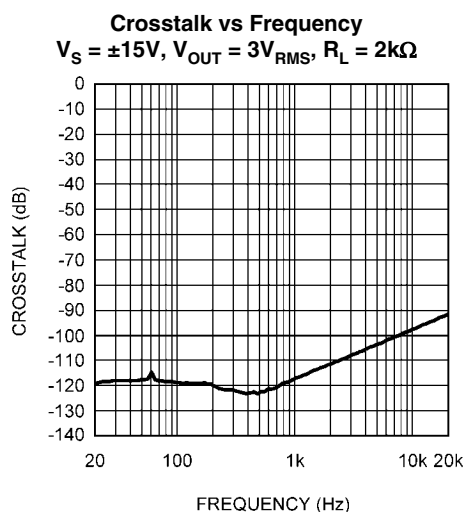
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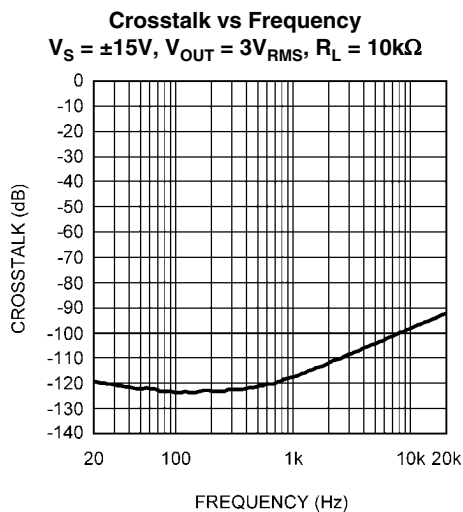
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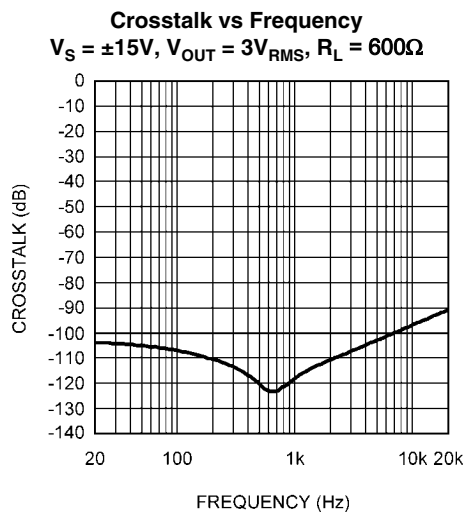
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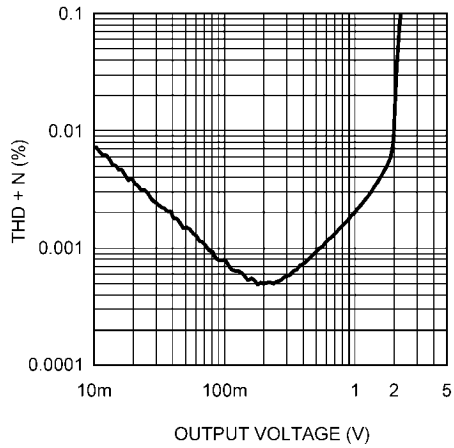


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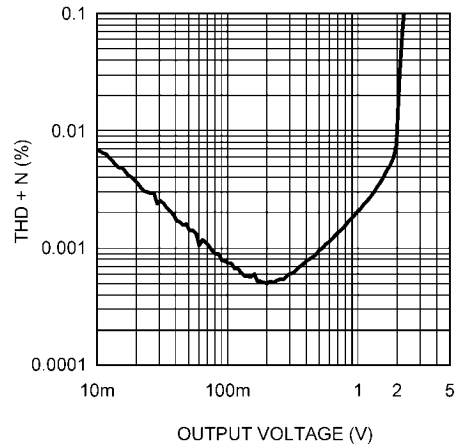
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**IMD vs Output Voltage**  
 $V_S = \pm 5V$ ,  $R_L = 2k\Omega$   
 7kHz/60Hz 4:1 SMPTE



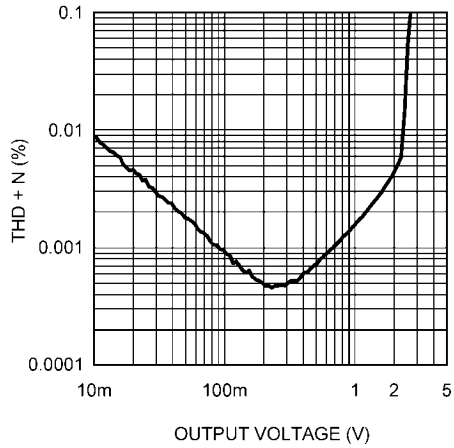
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**IMD vs Output Voltage**  
 $V_S = \pm 5V$ ,  $R_L = 10k\Omega$   
 7kHz/60Hz 4:1 SMPTE



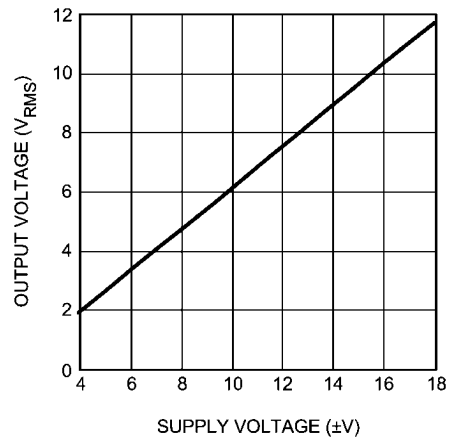
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**IMD vs Output Voltage**  
 $V_S = \pm 5V$ ,  $R_L = 600\Omega$   
 7kHz/60Hz 4:1 SMPTE



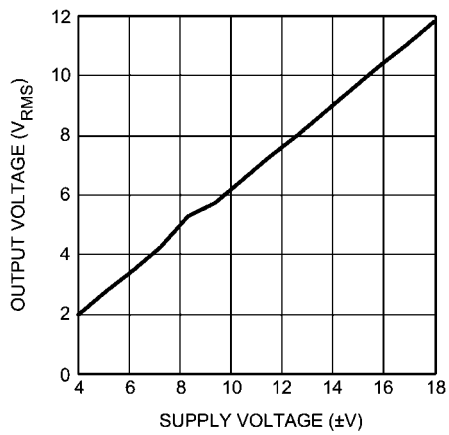
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**Output Voltage vs Supply Voltage**  
 $R_L = 2k\Omega$ , THD+N = 0.1%



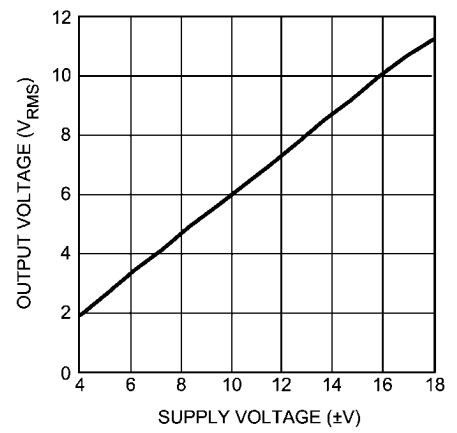
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**Output Voltage vs Supply Voltage**  
 $R_L = 10k\Omega$ , THD+N = 0.1%



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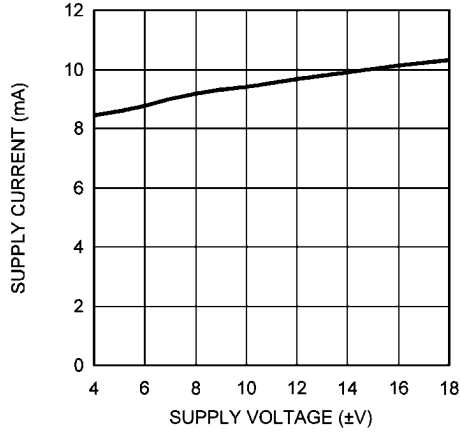
**Output Voltage vs Supply Voltage**  
 $R_L = 600\Omega$ , THD+N = 0.1%



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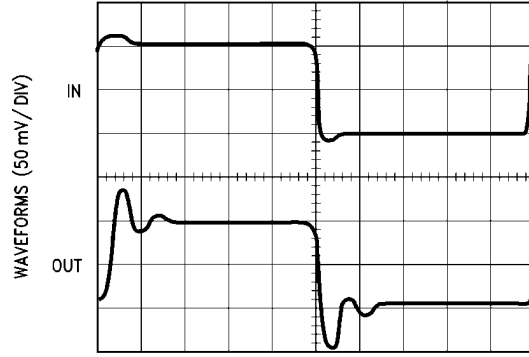


Supply Current vs Supply Voltage



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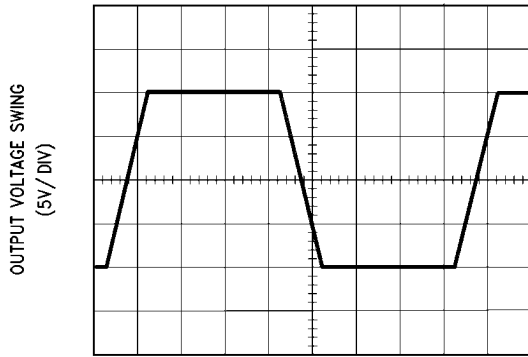
Scope Photo  
Small Signal



TIME (0.1  $\mu$ s / DIV)

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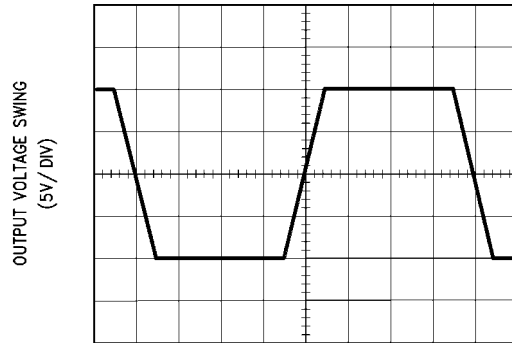
Scope Photo  
Large Signal, Non-Inverting



TIME (1  $\mu$ s / DIV)

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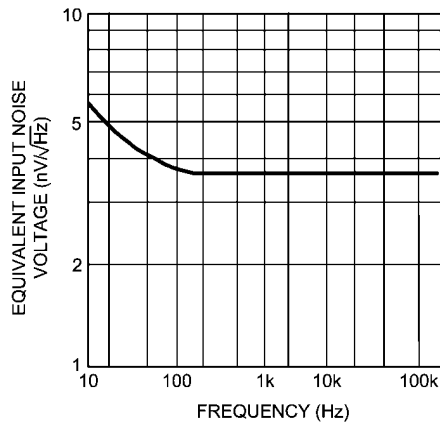
Scope Photo  
Large Signal, Inverting



TIME (1  $\mu$ s / DIV)

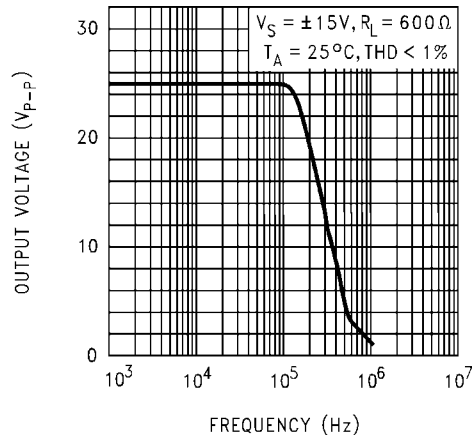
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Equivalent Input Noise vs Frequency

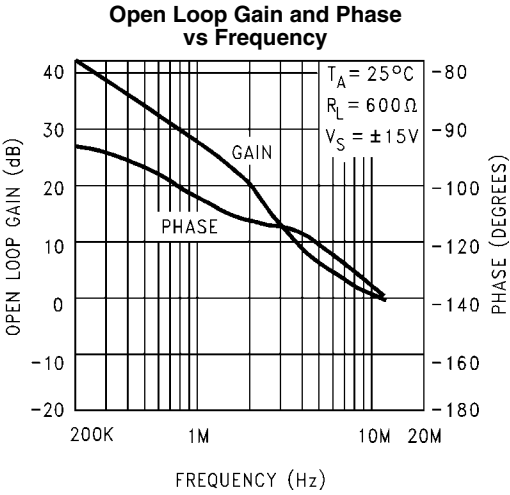


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Power Bandwidth



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## Application Information

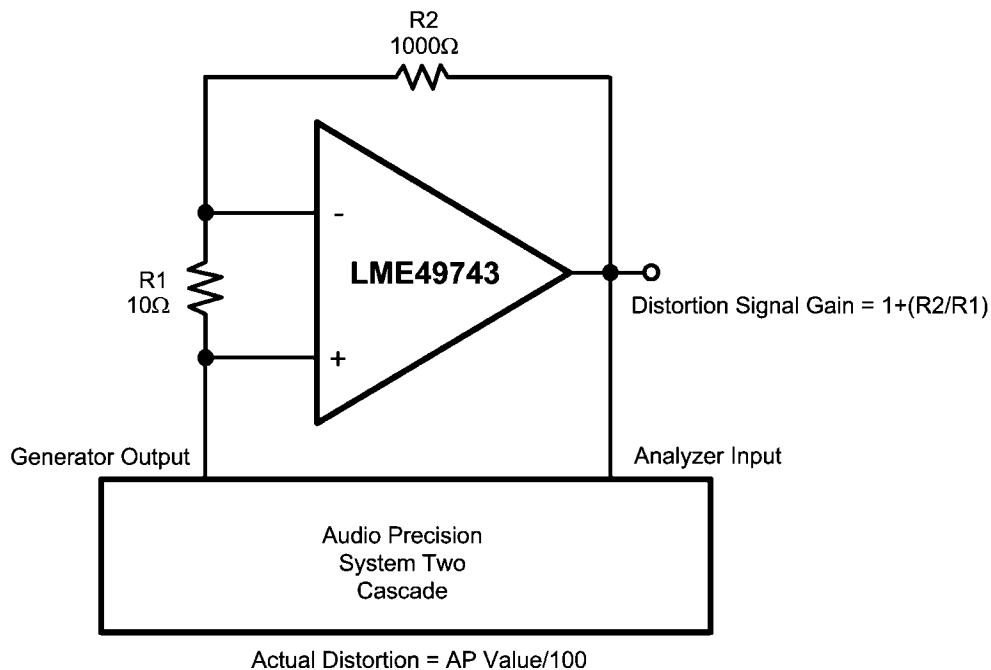
### DISTORTION MEASUREMENTS

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  $10\Omega$  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.



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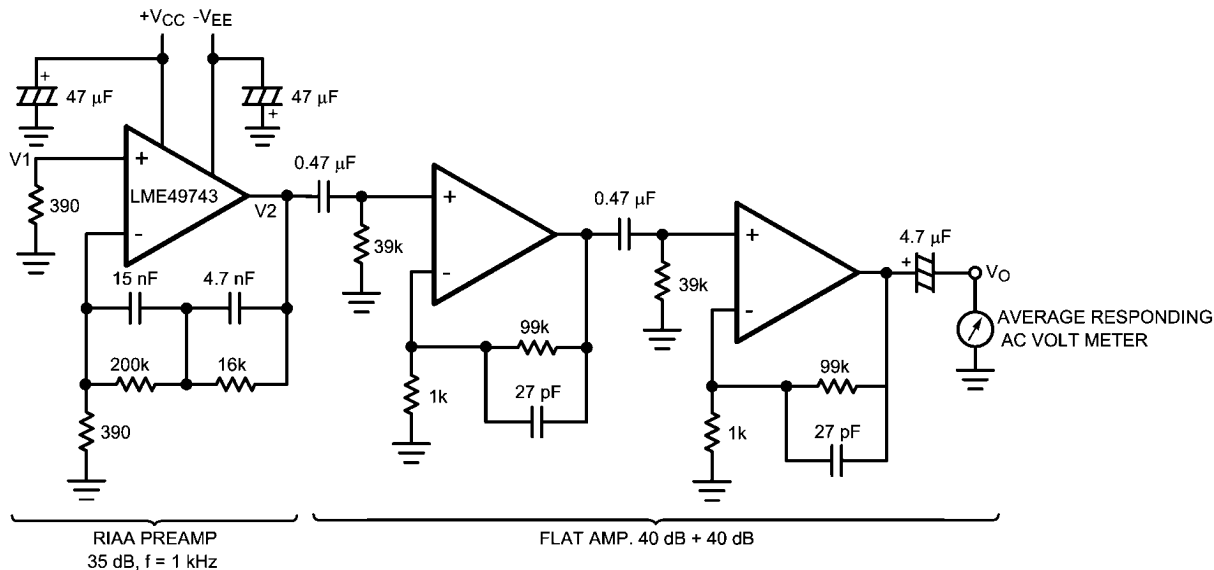
**FIGURE 1. THD+N and IMD Distortion Test Circuit**

## 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.

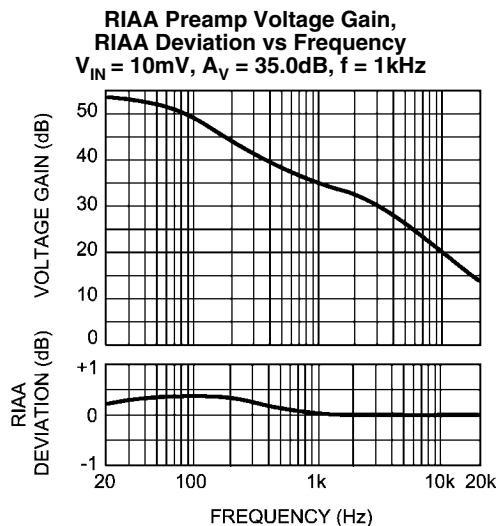
## Noise Measurement Circuit



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

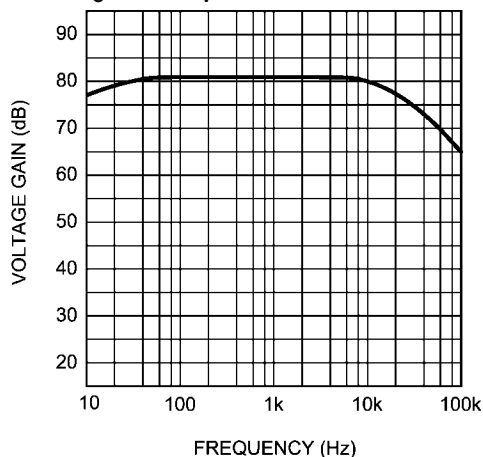
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**Total Gain: 115 dB at  $f = 1 \text{ kHz}$**   
**Input Referred Noise Voltage:  $e_n = V_o/560,000 \text{ (V)}$**



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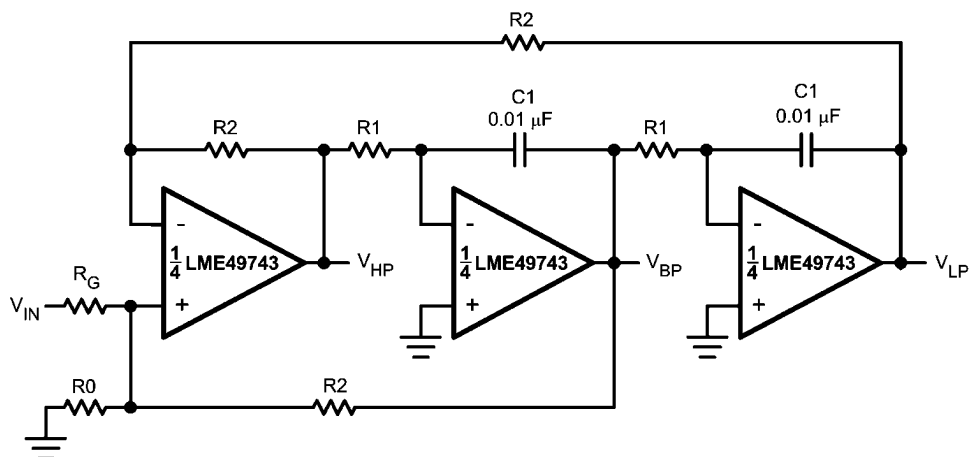
**Flat Amp Voltage Gain vs Frequency**  
 $V_o = 0\text{dB}$ ,  $A_V = 80.0\text{dB}$ ,  $f = 1\text{kHz}$



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## Typical Applications

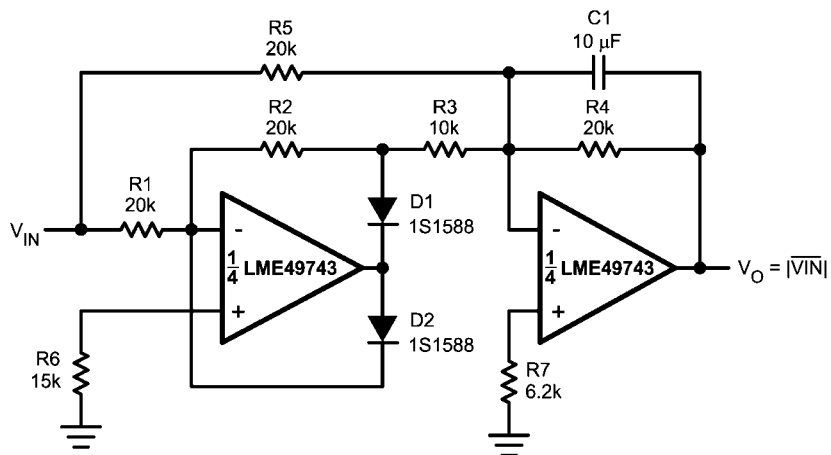
### State Variable Filter



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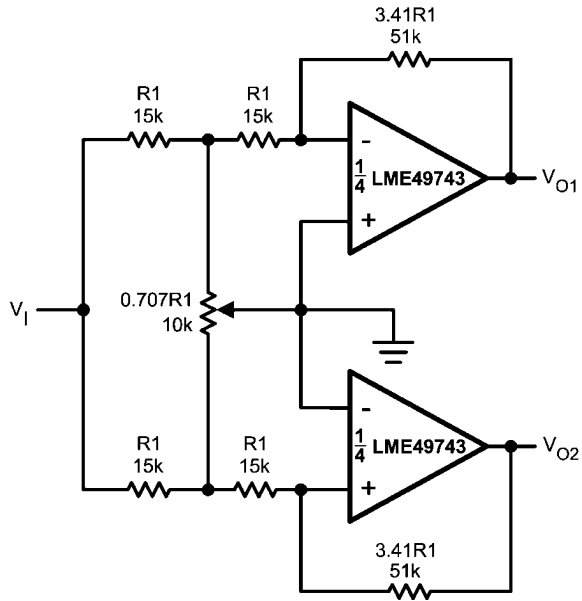
$$f_0 = \frac{1}{2\pi C_1 R_1}, Q = \frac{1}{2} \left( 1 + \frac{R_2}{R_0} + \frac{R_2}{R_G} \right), A_{BP} = Q A_{LP} = Q A_{LH} = \frac{R_2}{R_G}$$

### AC/DC Converter



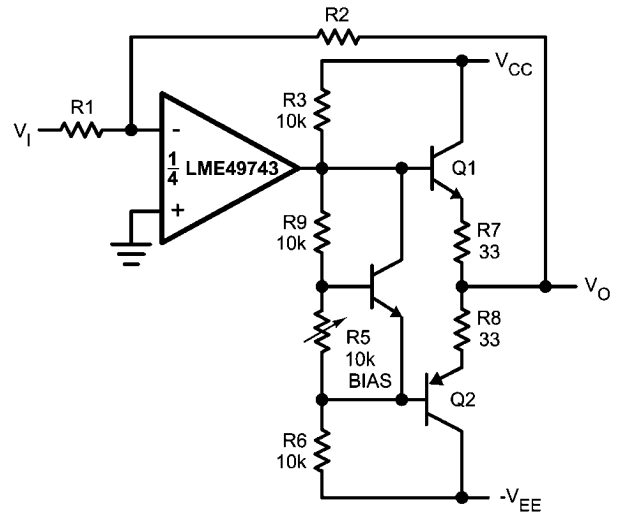
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## 2 Channel Panning Circuit (Pan Pot)



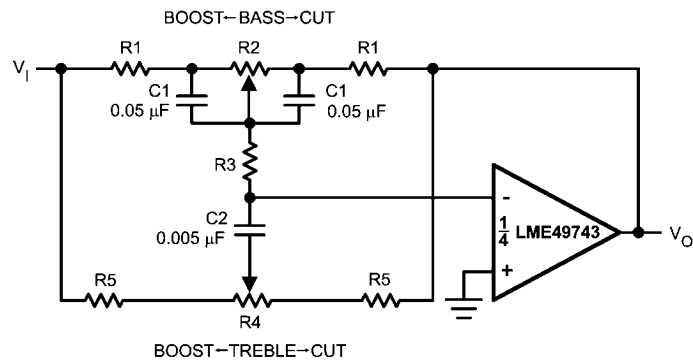
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## Line Driver



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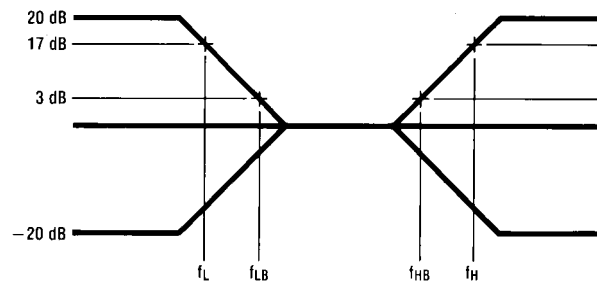
## Tone Control



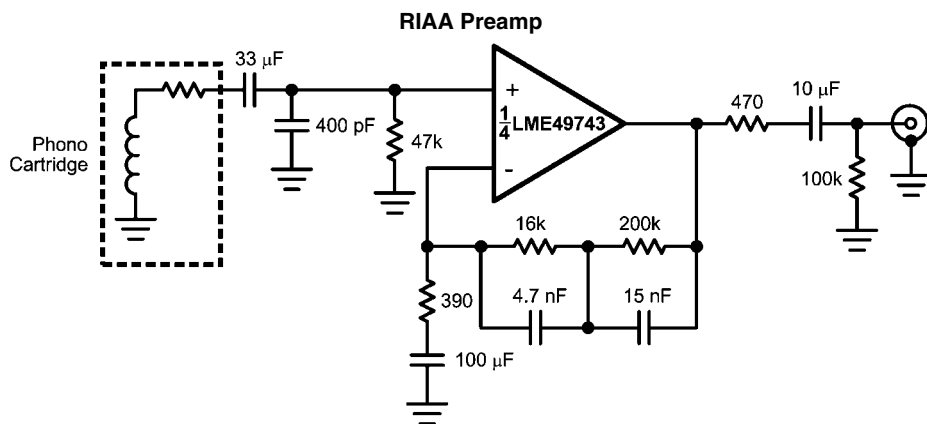
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$$f_L = \frac{1}{2\pi R_2 C_1}, f_{LB} = \frac{1}{2\pi R_1 C_1}$$

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

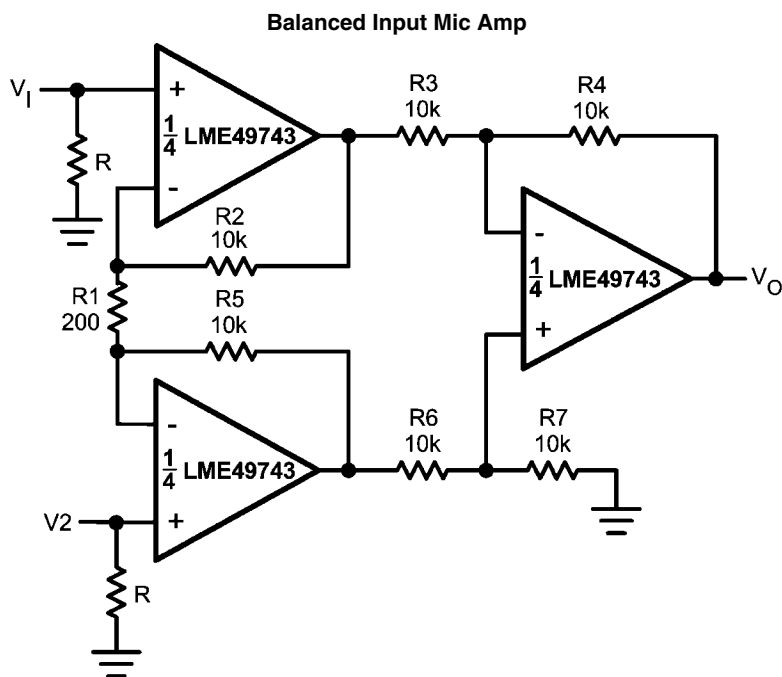


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$A_v = 35 \text{ dB}$   
 $E_n = 0.33 \mu\text{V}$   
 $S/N = 90 \text{ dB}$   
 $f = 1 \text{ kHz}$   
 A Weighted  
 A Weighted,  $V_{IN} = 10 \text{ mV}$   
 @  $f = 1 \text{ kHz}$



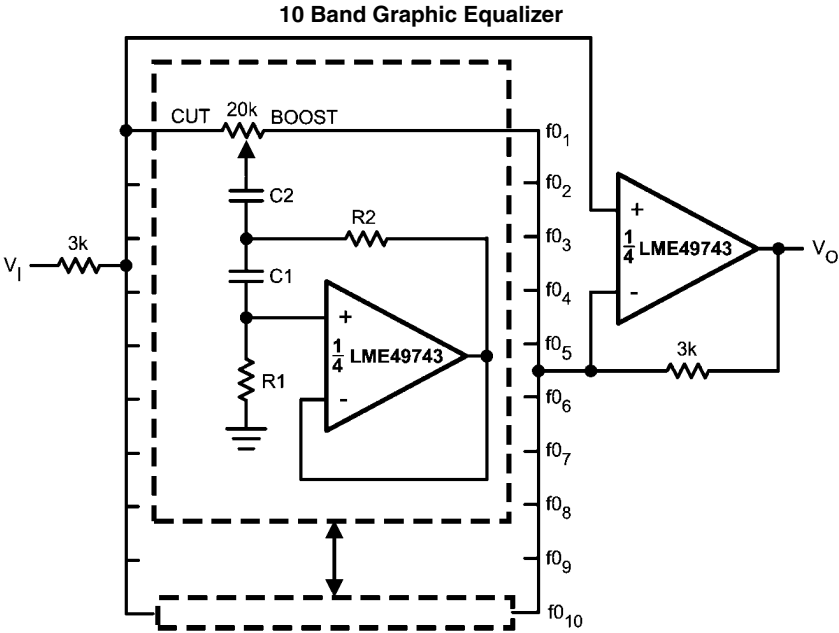
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If  $R_2 = R_5$ ,  $R_3 = R_6$ ,  $R_4 = R_7$

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

Illustration is:

$$V_0 = 101(V_2 - V_1)$$



30048144

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

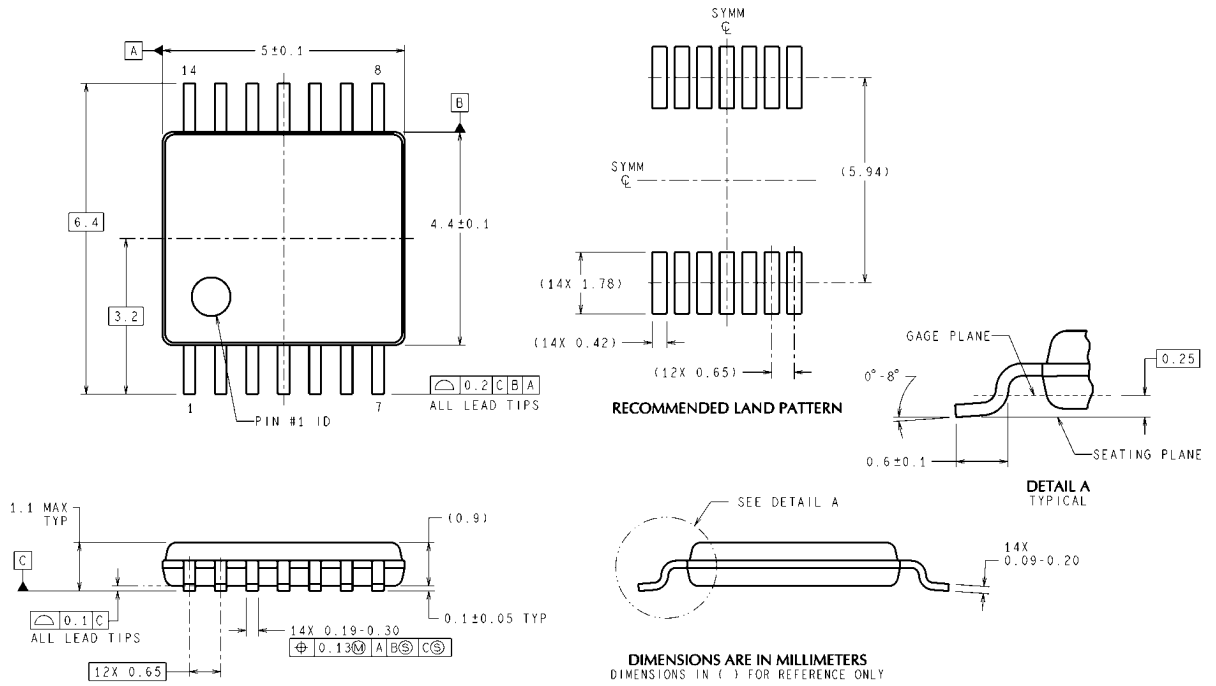
**Note 10:** At volume of change = ±12 dB  
Q = 1.7  
Reference: "AUDIO/RADIO HANDBOOK", National Semiconductor, 1980, Page 2–61



## 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



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

MTC14 (Rev D)

## Notes

## Notes

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LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>	Feedback/Support	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Voltage Reference	<a href="http://www.national.com/vref">www.national.com/vref</a>	Design Made Easy	<a href="http://www.national.com/easy">www.national.com/easy</a>
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