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/$\sqrt{\text{Hz}}$) 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 ±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, $V_{OUT}$ = 3$V_{RMS}$, $f_{IN}$ = 1kHz) | |
| $R_L$ = 2kΩ | 0.0001% (typ) |
| $R_L$ = 600Ω | 0.0001% (typ) |
| ■ Input Noise Density | 3.5nV/$\sqrt{\text{Hz}}$ (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

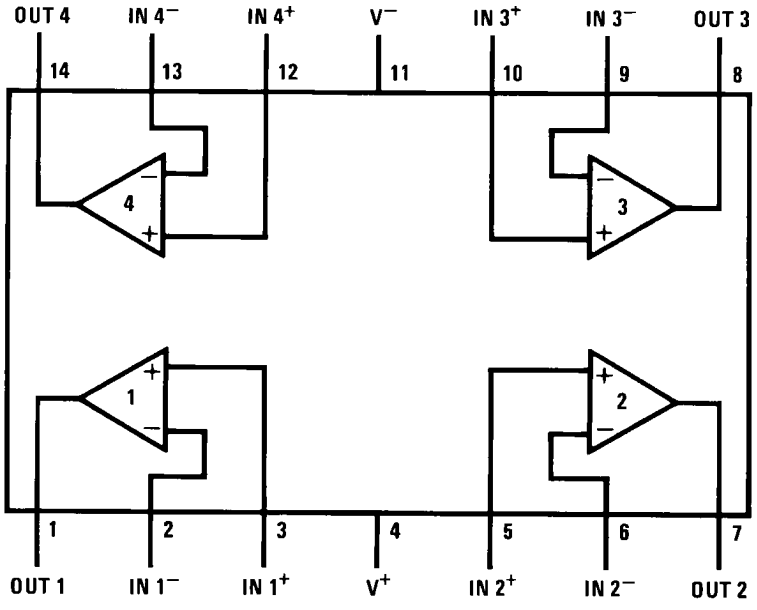
## Applications

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



## Connection Diagram




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 | |
| $T_{MIN} \le T_A \le T_{MAX}$ | $-40°C \le T_A \le 85°C$ |
| Supply Voltage Range | $\pm 4.0V \le V_S \le \pm 17V$ |

## Electrical Characteristics (Notes 1, 2)

The following specifications apply for $V_S = \pm 15V$, $R_L = 2k\Omega$, $f_{IN} = 1kHz$, and $T_A = 25C$, unless otherwise specified.

| Symbol | Parameter | Conditions | LME49743 Typical (Note 6) | LME49743 Limit (Notes 7, 8) | Units (Limits) |
|---|---|---|---|---|---|
| THD+N | Total Harmonic Distortion + Noise | $A_V = 1$, $V_{OUT} = 3V_{RMS}$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$ | <br>0.0001<br>0.0001 | <br><br>0.0002 | <br><br>% (max) |
| IMD | Intermodulation Distortion | $A_V = 1$, $V_{OUT} = 3V_{RMS}$<br>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, $C_L = 100pF$<br>0.1% error range | <br>1.2 | | <br>μs |
| $e_n$ | Equivalent Input Noise Voltage | $f_{BW}$ = 20Hz to 20kHz | 0.48 | 0.65 | $\mu V_{RMS}$ |
| | Equivalent Input Noise Density | f = 1kHz<br>f = 10Hz | 3.5<br>6.4 | 4.5 | $nV/\sqrt{Hz}$ (max)<br>$nV/\sqrt{Hz}$ |
| $i_n$ | Current Noise Density | f = 1kHz<br>f = 10Hz | 1.6<br>3.1 | | $pA/\sqrt{Hz}$<br>$pA/\sqrt{Hz}$ |
| $V_{OS}$ | 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 | $\Delta V_S = 20V$ (Note 9) | 98 | 94 | dB (min) |
| $ISO_{CH-CH}$ | Channel-to-Channel Isolation | $f_{IN} = 1kHz$<br>$f_{IN} = 20kHz$ | 118<br>112 | | dB<br>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<br>(V-)+2.0 | V (min)<br>V (min) |
| CMRR | Common-Mode Rejection | $-10V<V_{CM}<10V$ | 106 | 98 | dB (min) |
| $Z_{IN}$ | Differential Input Impedance | | 30 | | kΩ |
| | 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) |
| | | $-10V<V_{OUT}<10V$, $R_L = 2k\Omega$ | 110 | | dB (min) |
| | | $-10V<V_{OUT}<10V$, $R_L = 10k\Omega$ | 110 | 100 | dB (min) |

| Symbol | Parameter | Conditions | LME49743 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical (Note 6) | Limit (Notes 7, 8) | |
| $V_{OUTMAX}$ | 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<br>–38 | | mA<br>mA |
| $R_{OUT}$ | Output Impedance | $f_{IN}$ = 10kHz<br>Closed-Loop<br>Open-Loop | <br>0.01<br>13 | | <br>Ω<br>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.

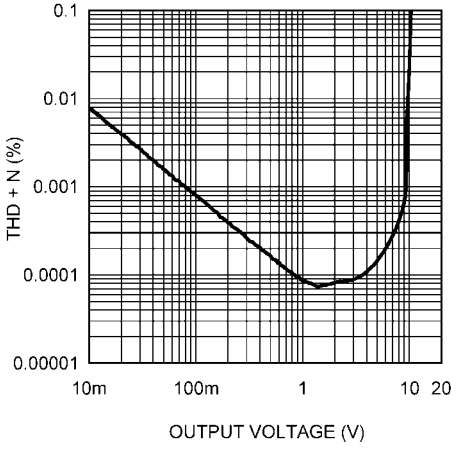
**Note 7:** Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

**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 = $|20\log(\Delta V_{OS}/\Delta V_S)|$.

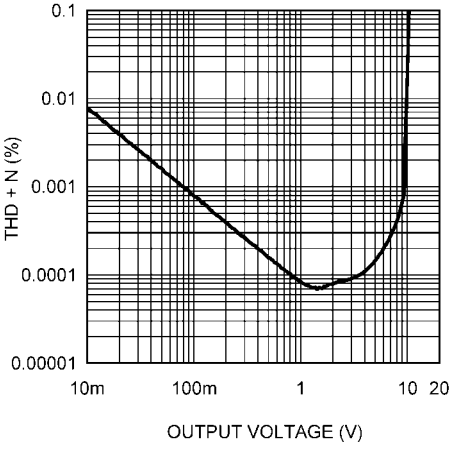
# Typical Performance Characteristics

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



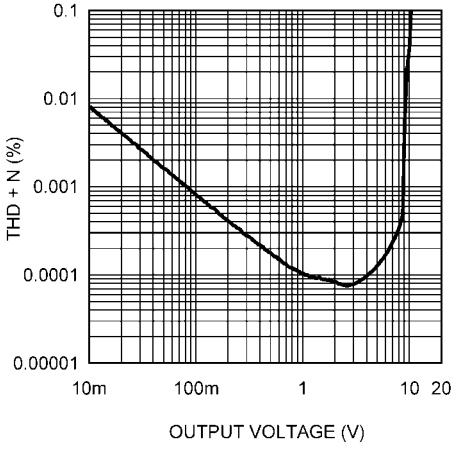

300481b6

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



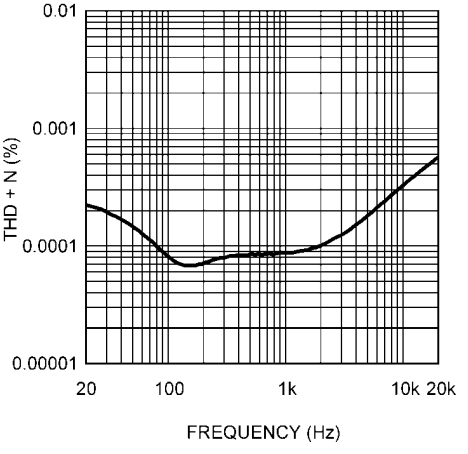

300481b7

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



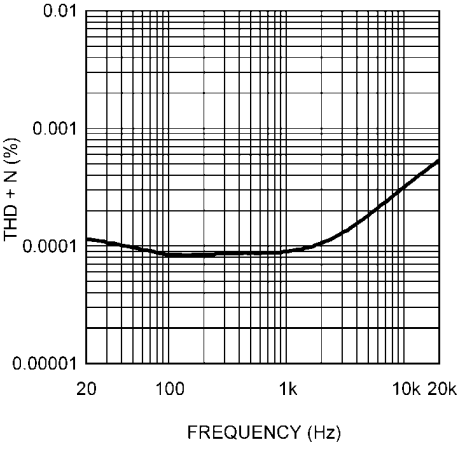

300481b8

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



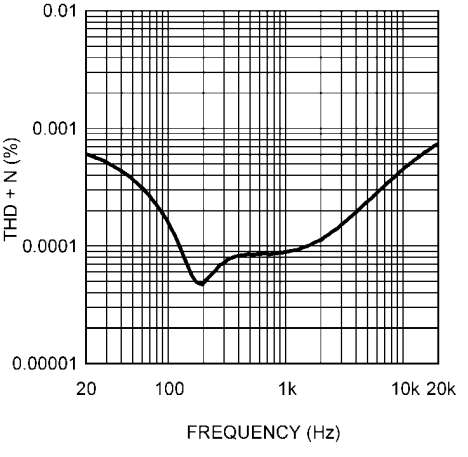

300481b0

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



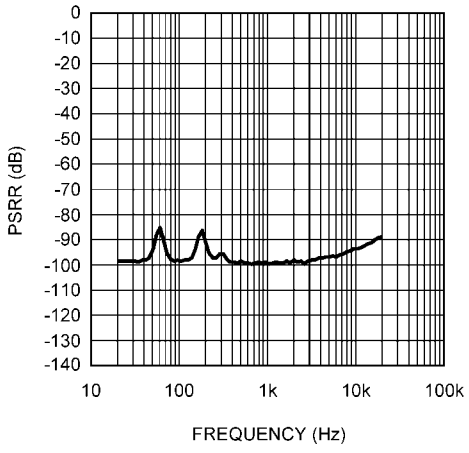

300481b1

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



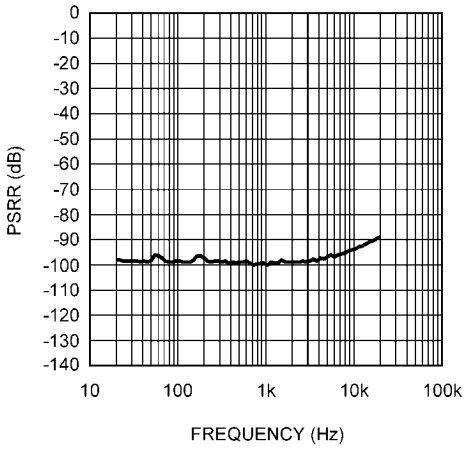

300481b2

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



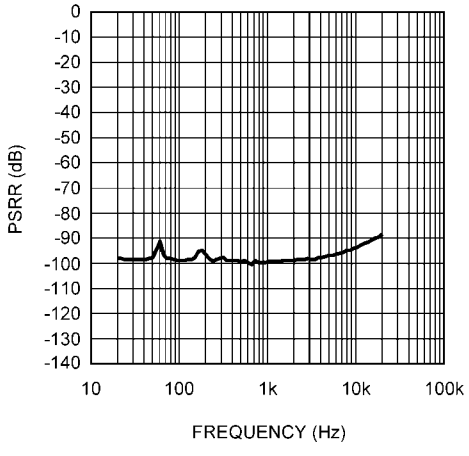

300481a1

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



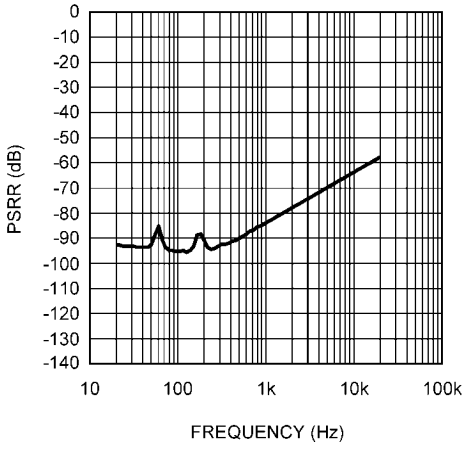

300481a2

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



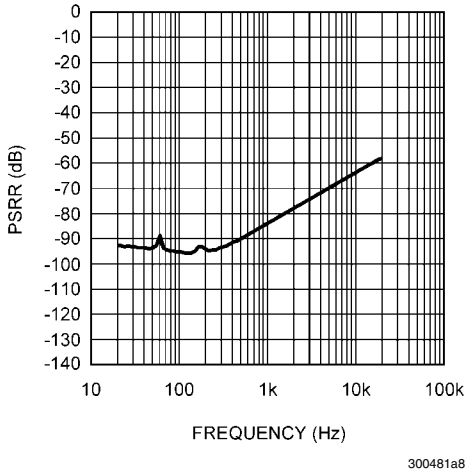

300481a3

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



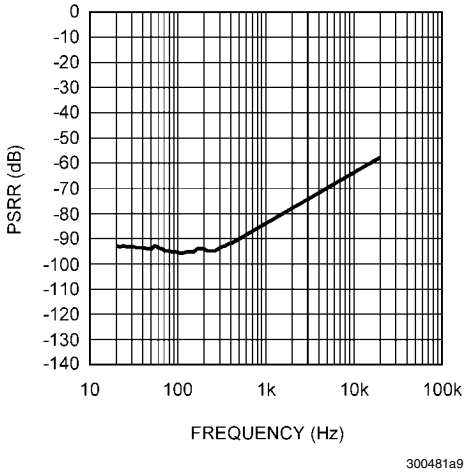

300481a7

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



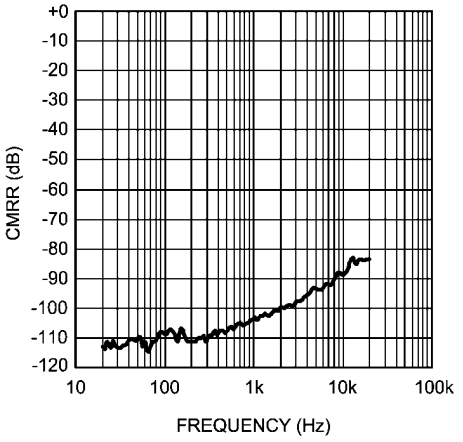

300481a8

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



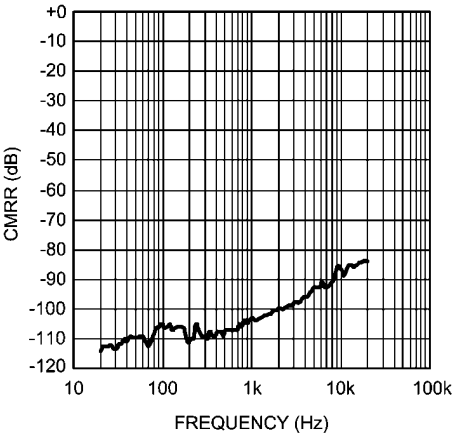

300481a9

**CMRR vs Frequency**
**$V_S$ = ±15V, $R_L$ = 2kΩ, $V_{IN}$ = 200m$V_{PP}$**



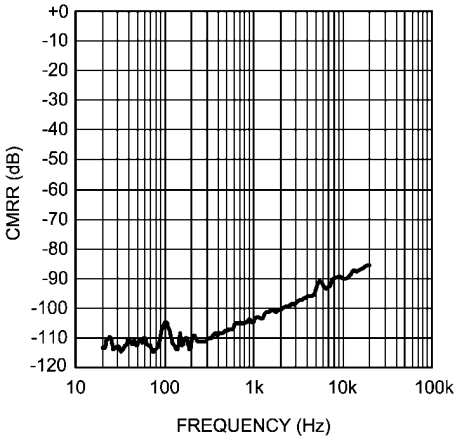

30048189

**CMRR vs Frequency**
**$V_S$ = ±15V, $R_L$ = 10kΩ, $V_{IN}$ = 200m$V_{PP}$**



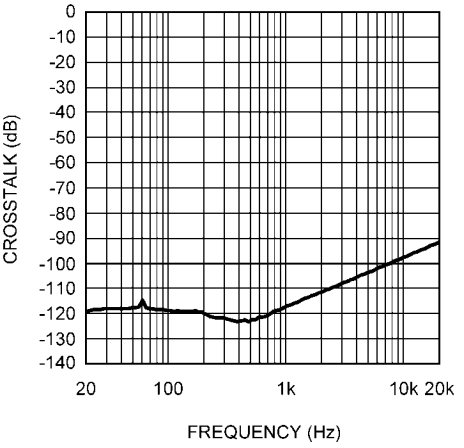

30048190

**CMRR vs Frequency**
**$V_S$ = ±15V, $R_L$ = 600Ω, $V_{IN}$ = 200m$V_{PP}$**



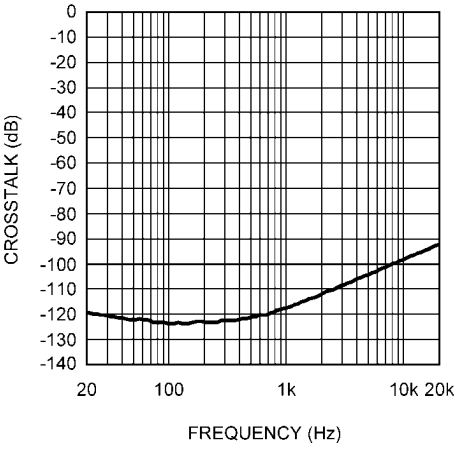

30048191

**Crosstalk vs Frequency**
**$V_S$ = ±15V, $V_{OUT}$ = 3$V_{RMS}$, $R_L$ = 2kΩ**



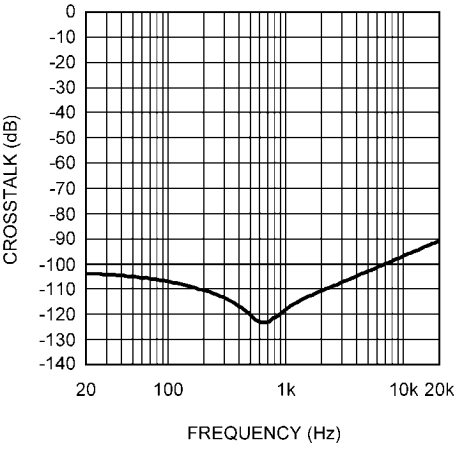

300481b9

**Crosstalk vs Frequency**
**$V_S$ = ±15V, $V_{OUT}$ = 3$V_{RMS}$, $R_L$ = 10kΩ**



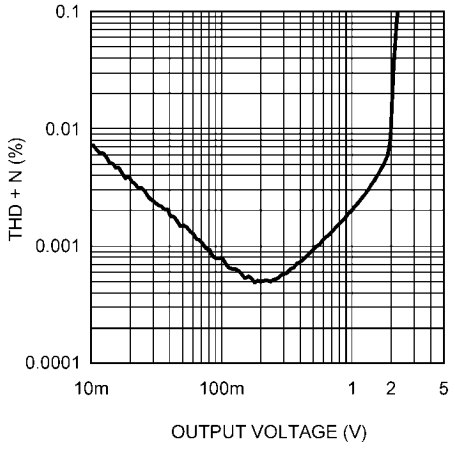

300481c0

**Crosstalk vs Frequency**
**$V_S$ = ±15V, $V_{OUT}$ = 3$V_{RMS}$, $R_L$ = 600Ω**



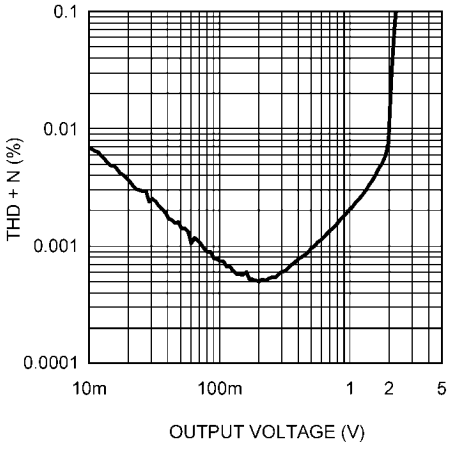

300481c1

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



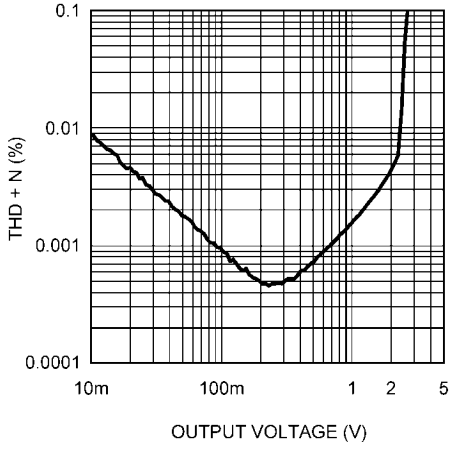

30048195

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



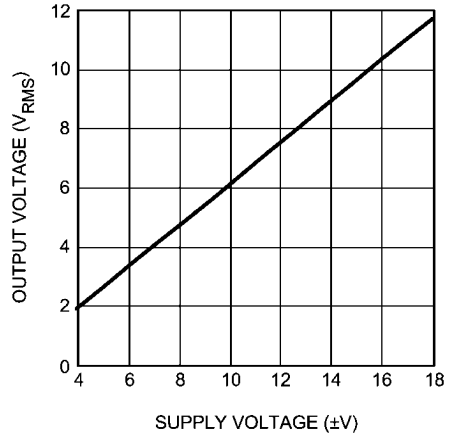

30048196

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



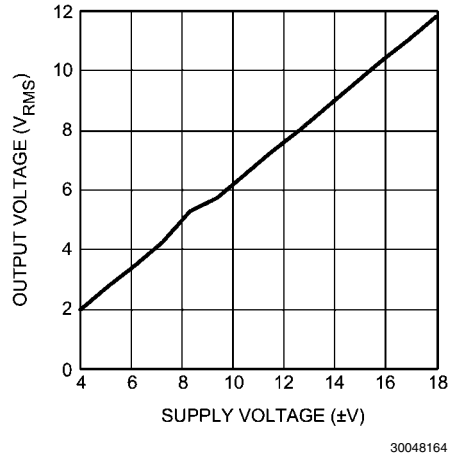

30048197

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



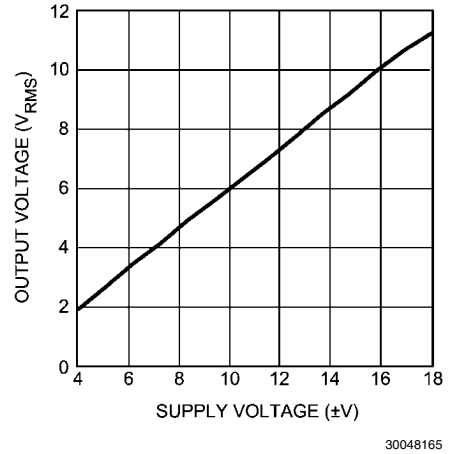

30048163

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



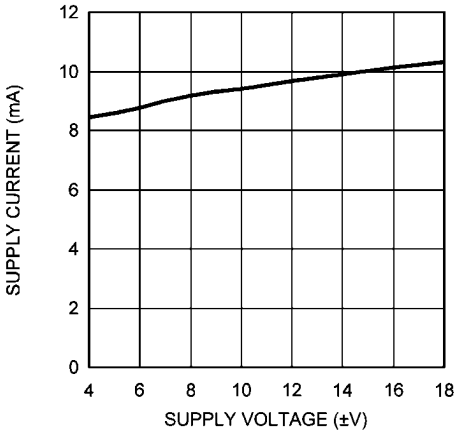

30048164

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



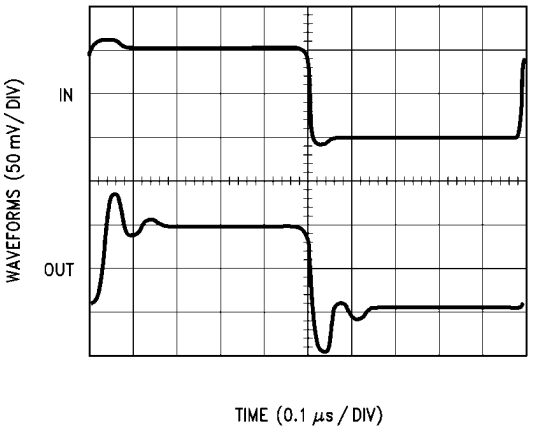

30048165

**Supply Current vs Supply Voltage**



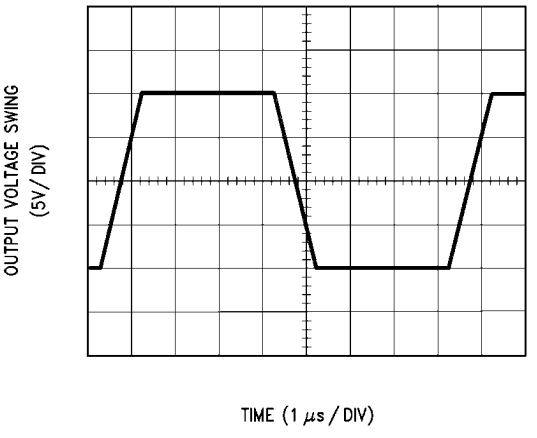

300481c4

**Scope Photo**
**Small Signal**



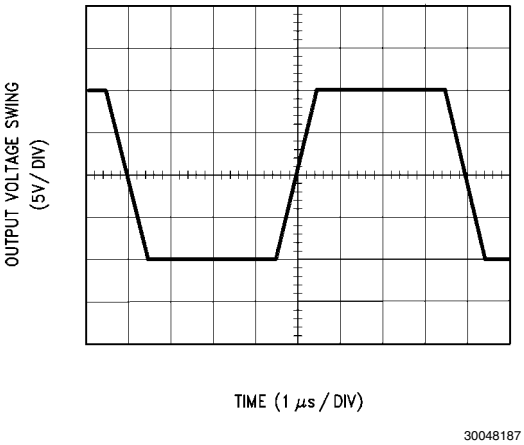

30048185

**Scope Photo**
**Large Signal, Non-Inverting**



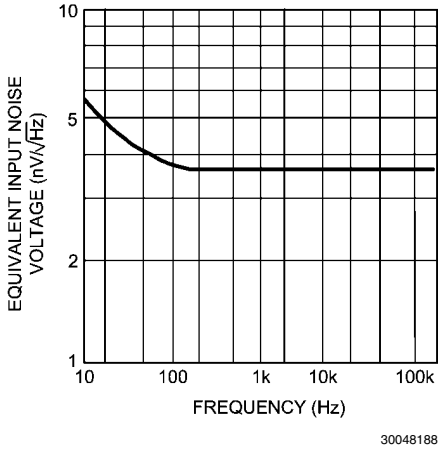

30048186

**Scope Photo**
**Large Signal, Inverting**



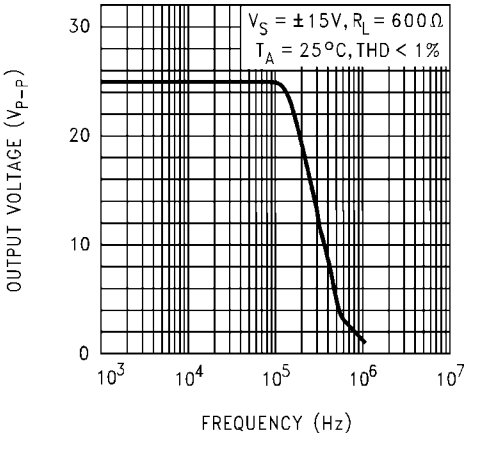

30048187

**Equivalent Input Noise vs Frequency**



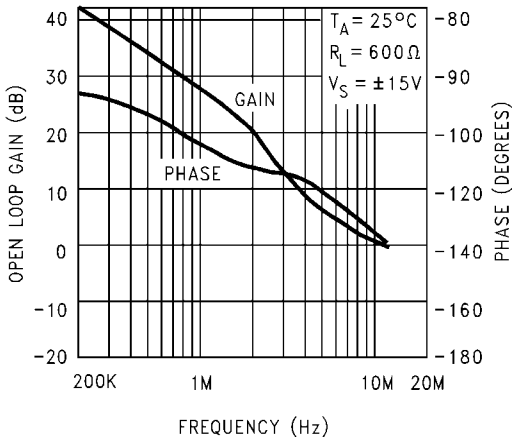

30048188

**Power Bandwidth**




30048192

**Open Loop Gain and Phase vs Frequency**




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.

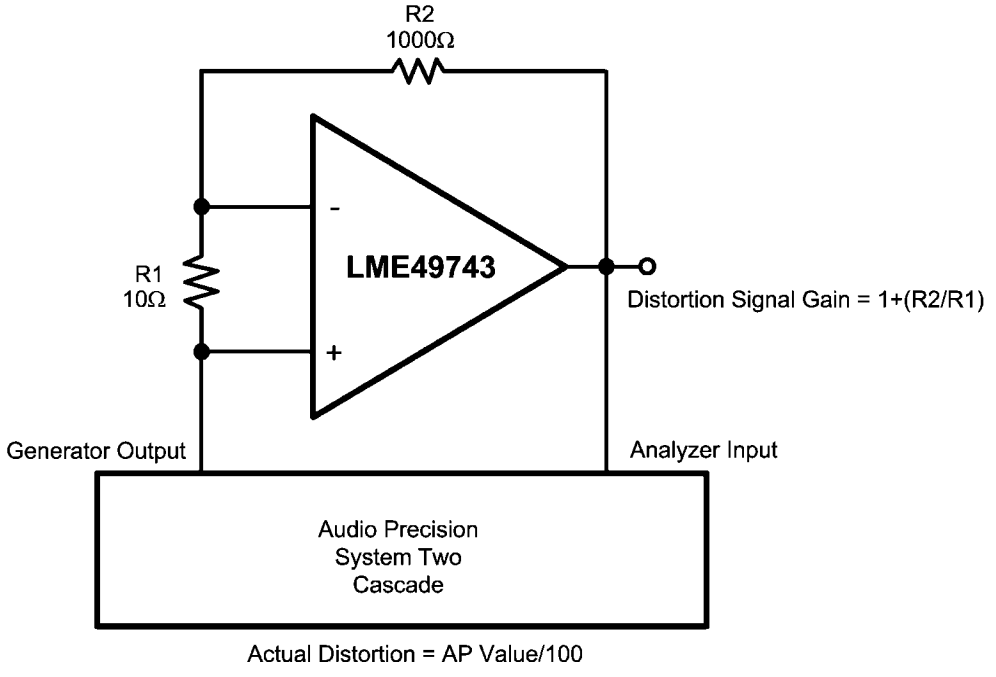


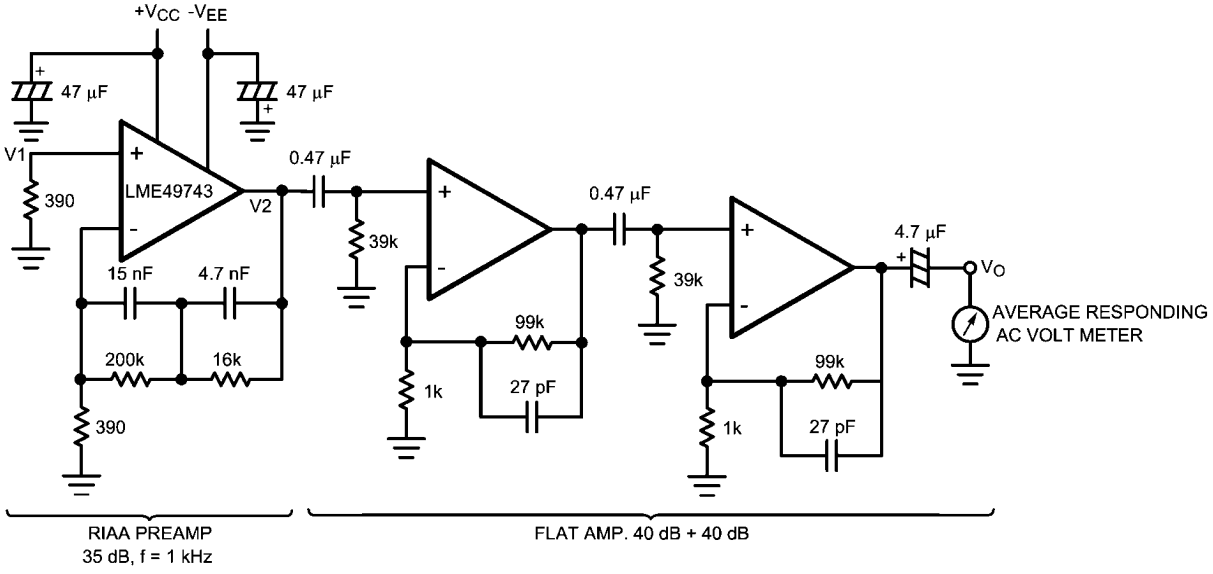

**FIGURE 1. THD+N and IMD Distortion Test Circuit**

## 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

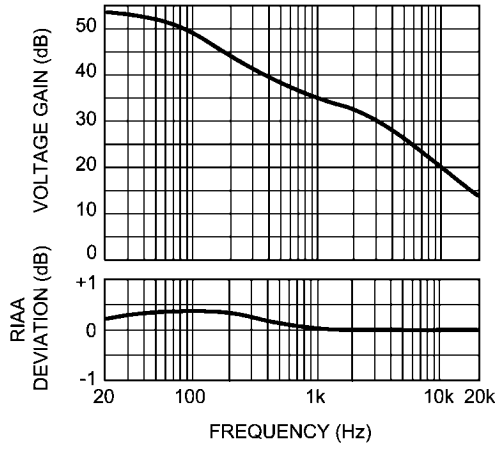



30048121

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

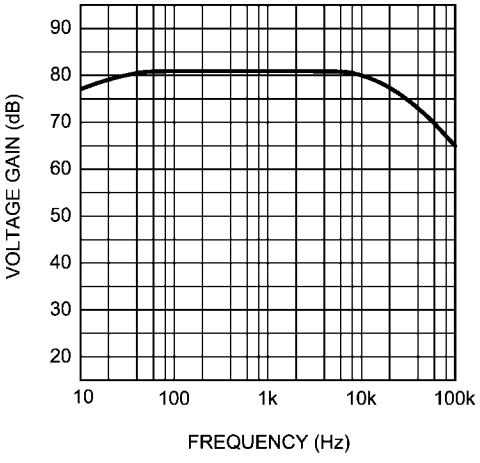
**Total Gain: 115 dB at f = 1 kHz**
**Input Referred Noise Voltage: $e_n = V_O/560{,}000$ (V)**

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




30048128

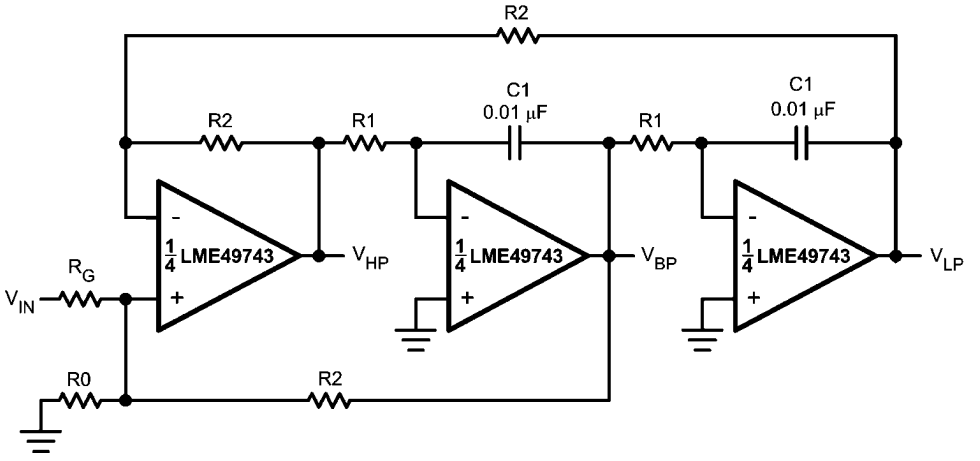
**Flat Amp Voltage Gain vs Frequency**
**$V_O$ = 0dB, $A_V$ = 80.0dB, f = 1kHz**




30048129

# Typical Applications

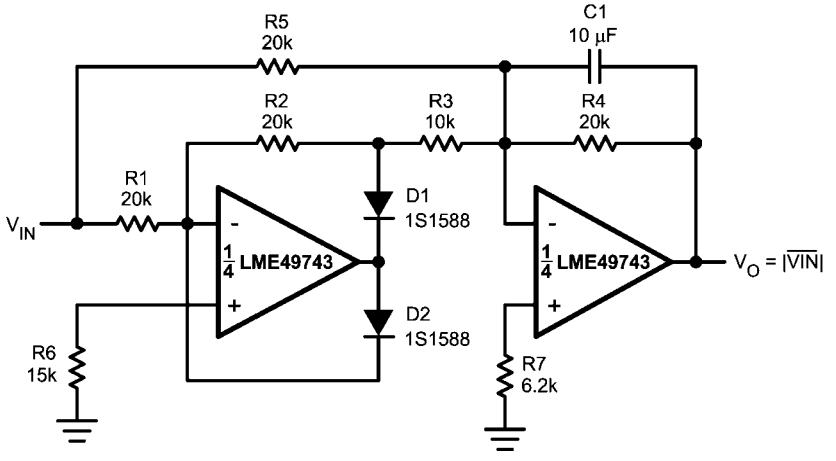
**State Variable Filter**




30048137

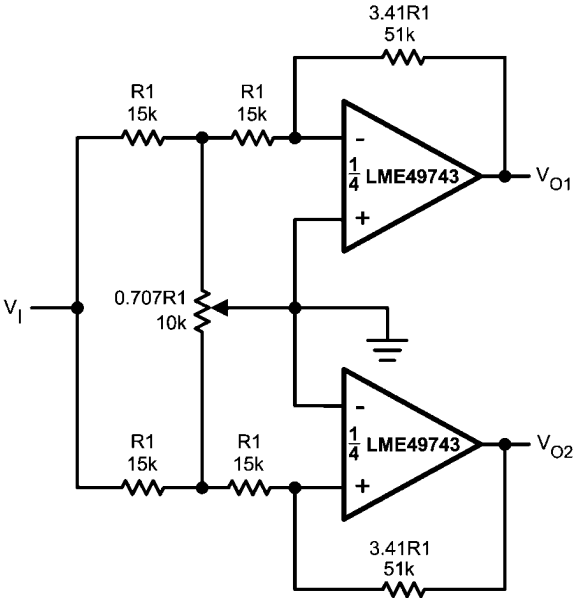
$$f_0 = \frac{1}{2\pi C1R1}, Q = \frac{1}{2}\left(1 + \frac{R2}{R0} + \frac{R2}{RG}\right), A_{BP} = QA_{LP} = QA_{LH} = \frac{R2}{RG}$$

**AC/DC Converter**



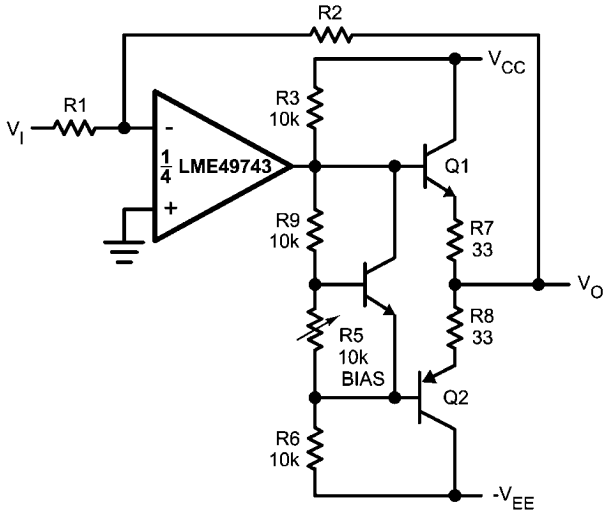

30048138

**2 Channel Panning Circuit (Pan Pot)**



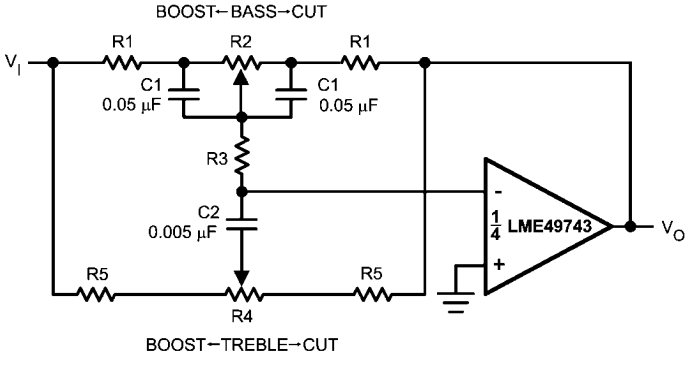

30048139

**Line Driver**




30048140

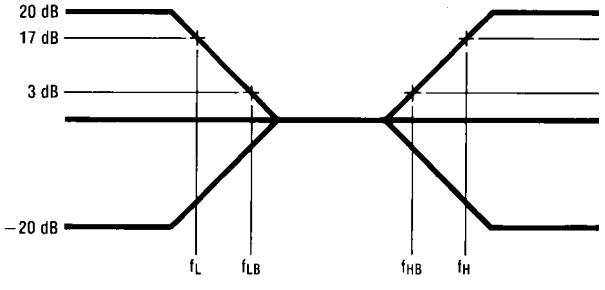
**Tone Control**




30048141

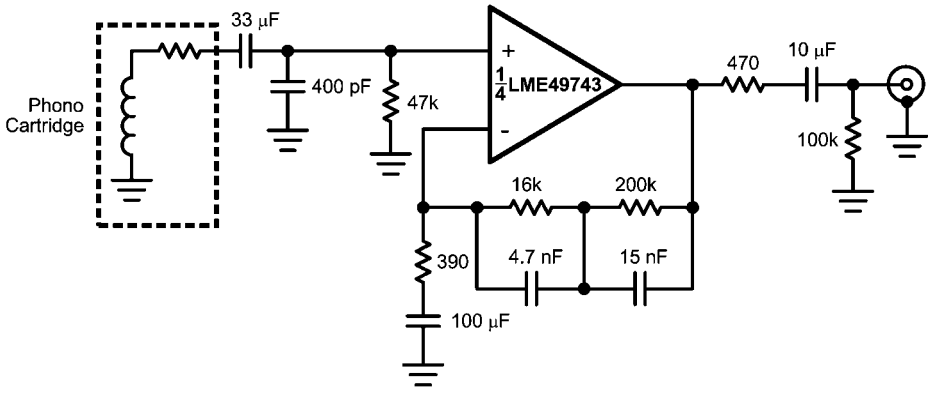
$$f_L = \frac{1}{2\pi R2C1},\ f_{LB} = \frac{1}{2\pi R1C1}$$

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




30048142

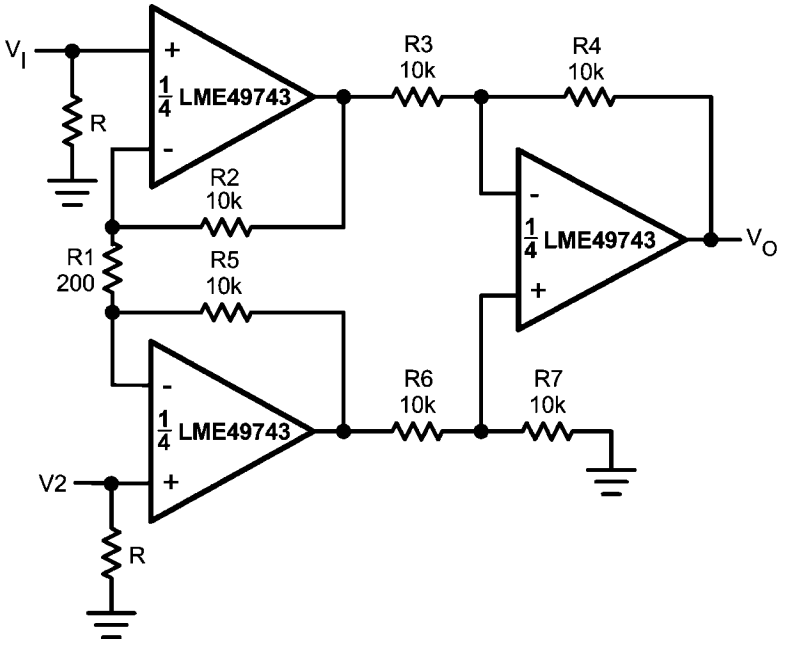
**RIAA Preamp**




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

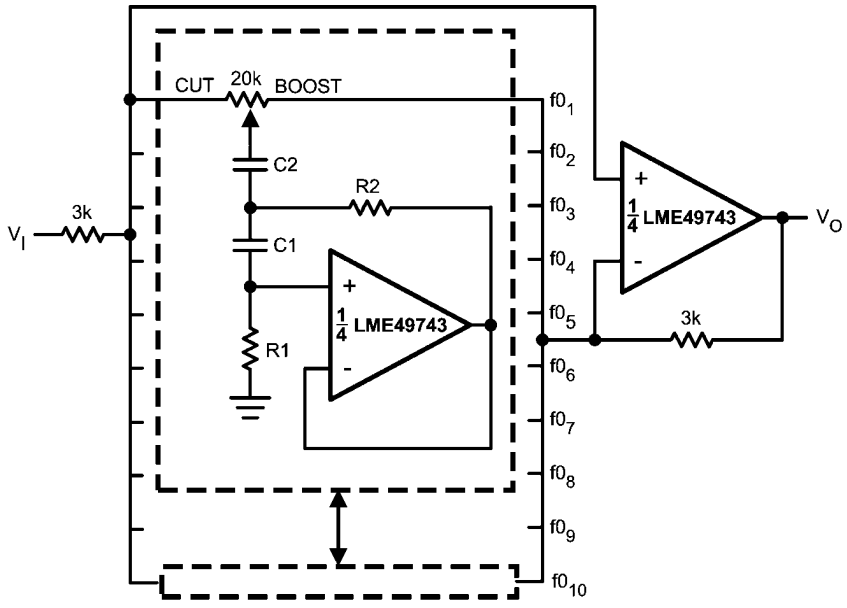
If R2 = R5, R3 = R6, R4 = R7

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

Illustration is:

V0 = 101(V2 – V1)

**10 Band Graphic Equalizer**




30048144

| 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

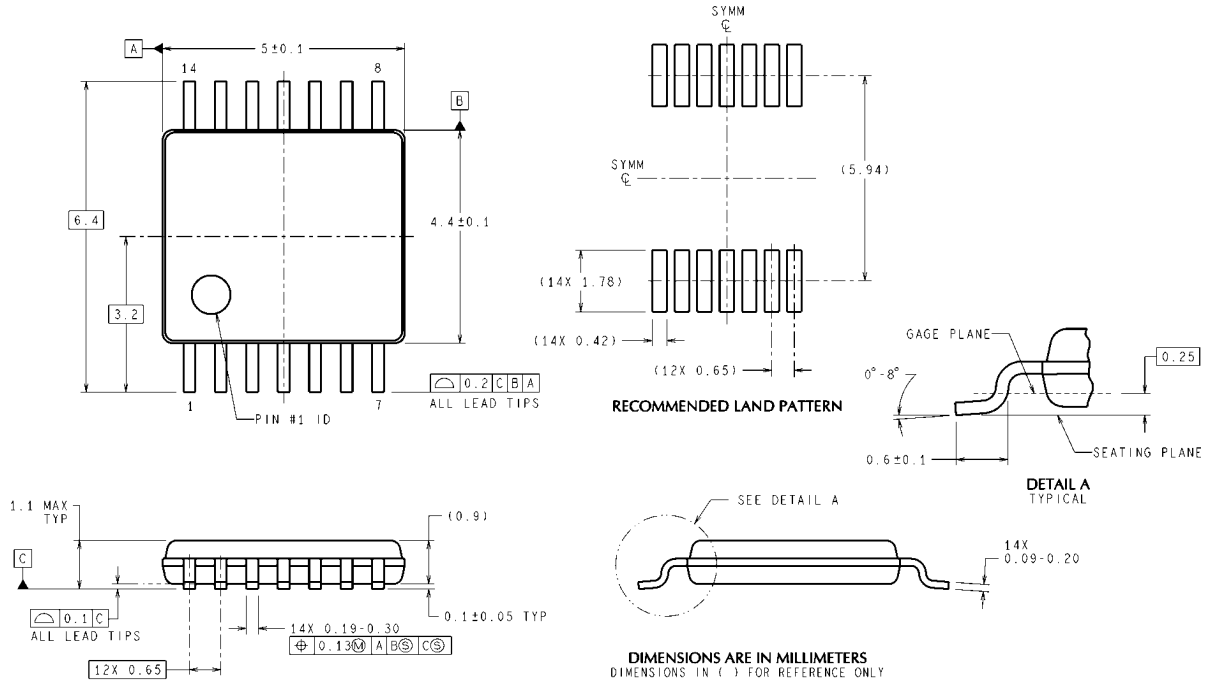
Q = 1.7

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

**For more National Semiconductor product information and proven design tools, visit the following Web sites at:**

| Products | | Design Support | |
|---|---|---|---|
| Amplifiers | www.national.com/amplifiers | WEBENCH® Tools | www.national.com/webench |
| Audio | www.national.com/audio | App Notes | www.national.com/appnotes |
| Clock and Timing | www.national.com/timing | Reference Designs | www.national.com/refdesigns |
| Data Converters | www.national.com/adc | Samples | www.national.com/samples |
| Interface | www.national.com/interface | Eval Boards | www.national.com/evalboards |
| LVDS | www.national.com/lvds | Packaging | www.national.com/packaging |
| Power Management | www.national.com/power | Green Compliance | www.national.com/quality/green |
| Switching Regulators | www.national.com/switchers | Distributors | www.national.com/contacts |
| LDOs | www.national.com/ldo | Quality and Reliability | www.national.com/quality |
| LED Lighting | www.national.com/led | Feedback/Support | www.national.com/feedback |
| Voltage Reference | www.national.com/vref | Design Made Easy | www.national.com/easy |
| PowerWise® Solutions | www.national.com/powerwise | Solutions | www.national.com/solutions |
| Serial Digital Interface (SDI) | www.national.com/sdi | Mil/Aero | www.national.com/milaero |
| Temperature Sensors | www.national.com/tempsensors | Solar Magic® | www.national.com/solarmagic |
| Wireless (PLL/VCO) | www.national.com/wireless | Analog University® | www.national.com/AU |



For the most current product information visit us at www.national.com

**National Semiconductor Americas Technical Support Center**
Email: support@nsc.com
Tel: 1-800-272-9959

**National Semiconductor Europe Technical Support Center**
Email: europe.support@nsc.com
German Tel: +49 (0) 180 5010 771
English Tel: +44 (0) 870 850 4288

**National Semiconductor Asia Pacific Technical Support Center**
Email: ap.support@nsc.com

**National Semiconductor Japan Technical Support Center**
Email: jpn.feedback@nsc.com