LME49740 Quad High Performance, High Fidelity Audio Operational Amplifier



Literature Number: SNAS377A



±2.5V to ±17V

0.00003% (typ)

0.00003% (typ)

±20V/µs (typ)

55MHz (typ)

140dB (typ)

0.000009%



# LME49740 Quad High Performance, High Fidelity Audio Operational Amplifier

## **General Description**

The LME49740 is part of the ultra-low distortion, low noise, high slew rate operational amplifier series optimized and fully specified for high performance, high fidelity applications. Combining advanced leading-edge process technology with state-of-the-art circuit design, the LME49740 audio operational amplifiers deliver superior audio signal amplification for outstanding audio performance. The LME49740 combines extremely low voltage noise density (2.7nV/ $\sqrt{HZ}$ ) with vanishingly low THD+N (0.00003%) to easily satisfy the most demanding audio applications. To ensure that the most challenging loads are driven without compromise, the LME49740 has a high slew rate of  $\pm 20V/\mu$ s and an output current capability of  $\pm 26$ mA. Further, dynamic range is maximized by an output stage that drives  $2k\Omega$  loads to within 1V of either power supply voltage and to within 1.4V when driving  $600\Omega$  loads.

The LME49740's outstanding CMRR(120dB), PSRR(120dB), and  $V_{OS}$ (0.1mV) give the amplifier excellent operational amplifier DC performance.

The LME49740 has a wide supply range of  $\pm 2.5V$  to  $\pm 17V$ . Over this supply range the LME49740's input circuitry maintains excellent common-mode and power supply rejection, as well as maintaining its low input bias current. The LME49740 is unity gain stable. The Audio Operational Amplifier achieves outstanding AC performance while driving complex loads with values as high as 100pF.

The LME49740 is available in 14–lead narrow body SOIC and 14–lead plastic DIP. Demonstration boards are available for each package.

## **Key Specifications**

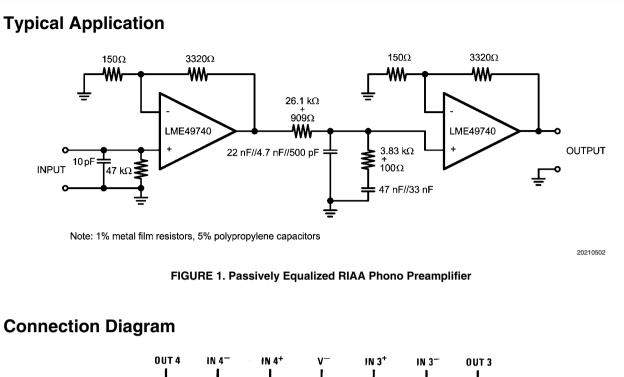
- Power Supply Voltage Range
- THD+N ( $A_V = 1$ ,  $V_{OUT} = 3V_{RMS}$ ,  $f_{IN} = 1kHz$ )
  - $R_L = 2k\Omega$
- R<sub>L</sub> = 600Ω
- Input Noise Density 2.7nV/√Hz (typ)
- Slew Rate
- Gain Bandwidth Product
- Open Loop Gain (R<sub>L</sub> = 600Ω)
- Input Bias Current
  10nA (typ)
- Input Offset Voltage 0.1mV (typ)
- DC Gain Linearity Error

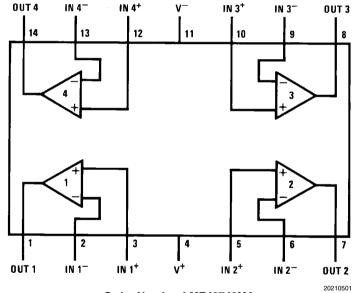
#### **Features**

- Easily drives 600Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- PSRR and CMRR exceed 120dB (typ)
- SOIC and DIP packages

### **Applications**

- Ultra high quality audio amplification
- High fidelity preamplifiers
- High fidelity multimedia
- State of the art phono pre amps
- High performance professional audio
- High fidelity equalization and crossover networks
- High performance line drivers
- High performance line receivers
- High fidelity active filters





Order Number LME49740MA See NS Package Number — M14A Order Number LME49740NA See NS Package Number — N14A

## 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.

Distributors for availability a	and specifications.	Thermal Resistance		
Power Supply Voltage		θ <sub>JA</sub> (MA)	107°C/W	
$(V_{S} = V^{+} - V^{-})$	36V	θ <sub>JA</sub> (NA)	74°C/W	
Storage Temperature	–65°C to 150°C	Temperature Range		
Input Voltage	(V-) - 0.7V to (V+) + 0.7V	$T_{MIN} \le T_A \le T_{MAX}$	$-40^{\circ}C \le T_A \le 85^{\circ}C$	
Output Short Circuit (Note 3)	Continuous	Supply Voltage Range	$\pm 2.5V \le V_s \le \pm 17V$	
Power Dissipation	Internally Limited		3	

ESD Susceptibility (Note 4) ESD Susceptibility (Note 5)

(Notes 1, 2) The following specifications apply for  $V_S$  = ±15V,  $R_L$  = 2k\Omega,  $f_{IN}$  = 1kHz,

Junction Temperature

## **Electrical Characteristics**

and  $T_A = 25C$ , unless otherwise specified.

			LME49740		11.211
Symbol	Parameter	Conditions	Typical Limit		Units
			(Note 6)	(Notes 7, 8)	(Limits)
		$A_V = 1, V_{OUT} = 3V_{RMS}$			
THD+N	Total Harmonic Distortion + Noise	$R_{L} = 2k\Omega$	0.00003		% (max)
		R <sub>L</sub> = 600Ω	0.00003	0.00009	% (max)
IMD	Intermodulation Distortion	A <sub>V</sub> = 1, V <sub>OUT</sub> = 3V <sub>RMS</sub> Two-tone, 60Hz & 7kHz 4:1	0.00005		% (max)
GBWP	Gain Bandwidth Product		55	45	MHz (min)
SR	Slew Rate		±20	±15	V/µs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$ , -3dB referenced to output magnitude at f = 1kHz	10		MHz
t <sub>s</sub>	Settling time	$A_V = 1$ , 10V step, $C_L = 100 pF$ 0.1% error range	1.2		μs
	Equivalent Input Noise Voltage	f <sub>BW</sub> = 20Hz to 20kHz	0.34	0.65	μV <sub>RMS</sub>
e <sub>n</sub>		f = 1kHz	2.7	4.7	nV/√Hz
	Equivalent Input Noise Density	f = 10Hz	6.4		nV/√Hz
		f = 1kHz	1.6		pAI√Hz
i <sub>n</sub>	Current Noise Density	f = 10Hz	3.1		pAl√Hz
V <sub>OS</sub>	Offset Voltage		±0.1	±0.7	mV (max)
ΔV <sub>OS</sub> /ΔTemp	Average Input Offset Voltage Drift vs Temperature	40°C ≤ T <sub>A</sub> ≤ 85°C	0.2		µV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$\Delta V_{\rm S} = 20 V \text{ (Note 9)}$	120	110	dB (min)
190	Channel-to-Channel Isolation	f <sub>IN</sub> = 1kHz	118		dB
ISO <sub>CH-CH</sub>		f <sub>IN</sub> = 20kHz	112		dB
I <sub>B</sub>	Input Bias Current	V <sub>CM</sub> = 0V	10	72	nA (max)
ΔI <sub>OS</sub> /ΔTemp	Input Bias Current Drift vs Temperature	–40°C ≤ T <sub>A</sub> ≤ 85°C	0.1		nA/°C
I <sub>OS</sub>	Input Offset Current	$V_{CM} = 0V$	11	65	nA (max)
V <sub>IN-CM</sub>	Common-Mode Input Voltage Range		+14.1 -13.9	(V+)–2.0 (V-)+2.0	V (min) V (min)
CMRR	Common-Mode Rejection	-10V <v<sub>CM&lt;10V</v<sub>	120	110	dB (min)
7	Differential Input Impedance		30		kΩ
Z <sub>IN</sub>	Common Mode Input Impedance	-10V <v<sub>CM&lt;10V</v<sub>	1000		MΩ
		–10V <v<sub>OUT&lt;10V, R<sub>L</sub> = 600Ω</v<sub>	140		dB (min)
A <sub>VOL</sub>	Open Loop Voltage Gain	$-10V < V_{OUT} < 10V, R_{L} = 2k\Omega$	140		dB (min)
-		-10V <v<sub>OUT&lt;10V, R<sub>L</sub> = 10kΩ</v<sub>	140	125	dB (min)

2000V

200V

150°C

		Conditions	LME	LME49740	
Symbol	Parameter		Typical	Limit	Units (Limits)
			(Note 6)	(Notes 7, 8)	(Linnes)
		R <sub>L</sub> = 600Ω	±13.6	±12.5	V (min)
V <sub>OUTMAX</sub>	Maximum Output Voltage Swing	$R_L = 2k\Omega$	±14.0		V (min)
		$R_L = 10k\Omega$	±14.1		V (min)
I <sub>OUT</sub>	Output Current	$R_{L} = 600\Omega, V_{S} = \pm 17V$	±26	±23	mA (min)
1	OUT-CC Short Circuit Current		+30		mA
'OUT-CC			-38		mA
		f <sub>IN</sub> = 10kHz			
R <sub>OUT</sub>	Output Impedance	Closed-Loop	0.01		Ω
		Open-Loop	13		Ω
CLOAD	Capacitive Load Drive Overshoot	100pF	16		%
I <sub>S</sub>	Total Quiescent Current	I <sub>OUT</sub> = 0mA	18.5	20	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 50Ω).

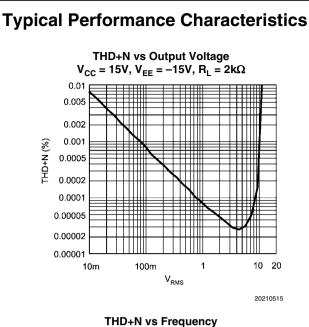
Note 6: Typical specifications are specified at +25 $^{\circ}$ C and represent the most likely parametric norm.

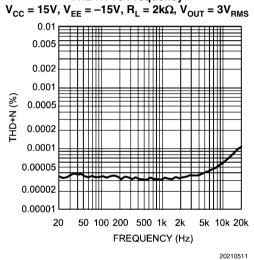
Note 7: Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

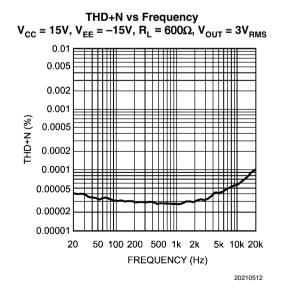
Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

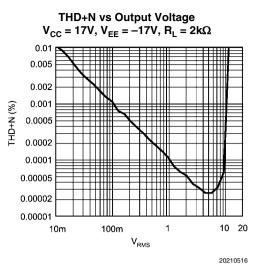
Note 9: PSRR is measured as follows:  $V_{OS}$  is measured at two supply voltages, ±5V and ±15V. PSRR = |20log( $\Delta V_{OS}/\Delta V_{S}$ )|.

LME49740

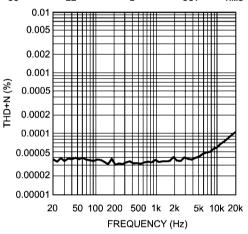




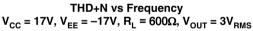


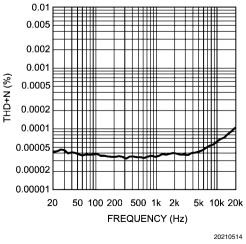


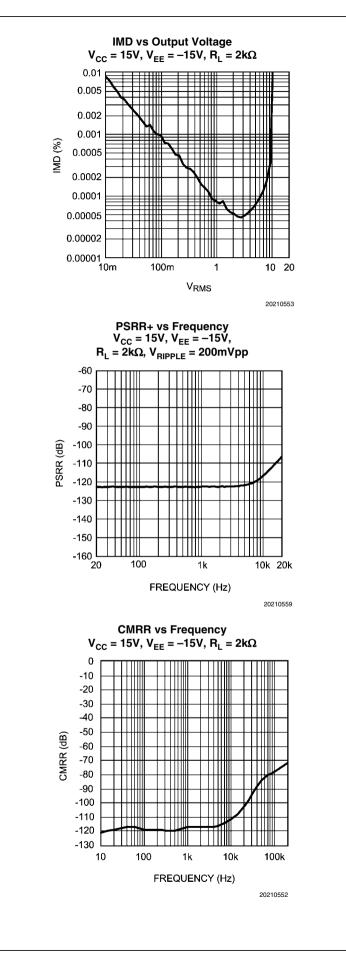
THD+N vs Frequency  $V_{cc} = 17V, V_{EE} = -17V, R_L = 2k\Omega, V_{OUT} = 3V_{RMS}$ 

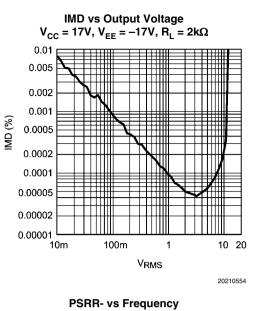


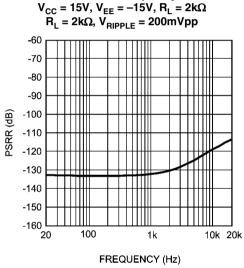
20210513



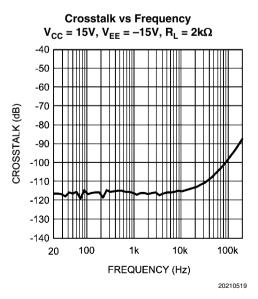


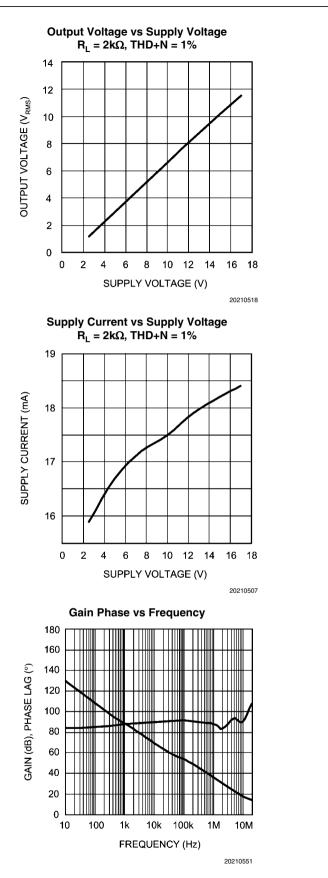


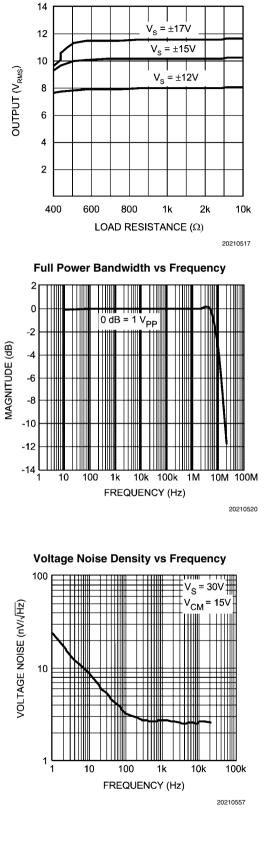




20210560

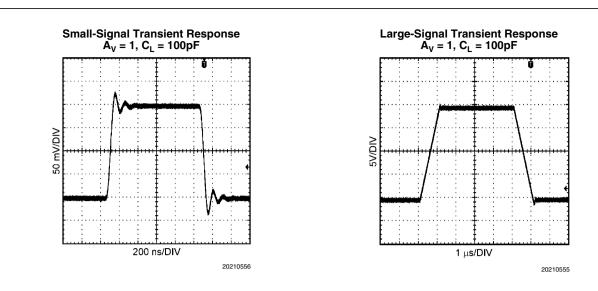






Output Voltage vs Load Resistance THD+N = 1%





## **Application Information**

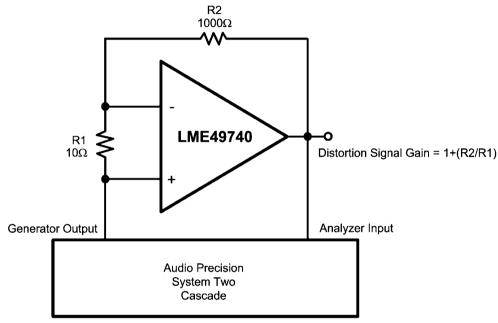
#### DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49740 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 LME49740's low residual distortion is an input referred internal error. As shown in Figure 2, 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 2.

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.



Actual Distortion = AP Value/100

20210562

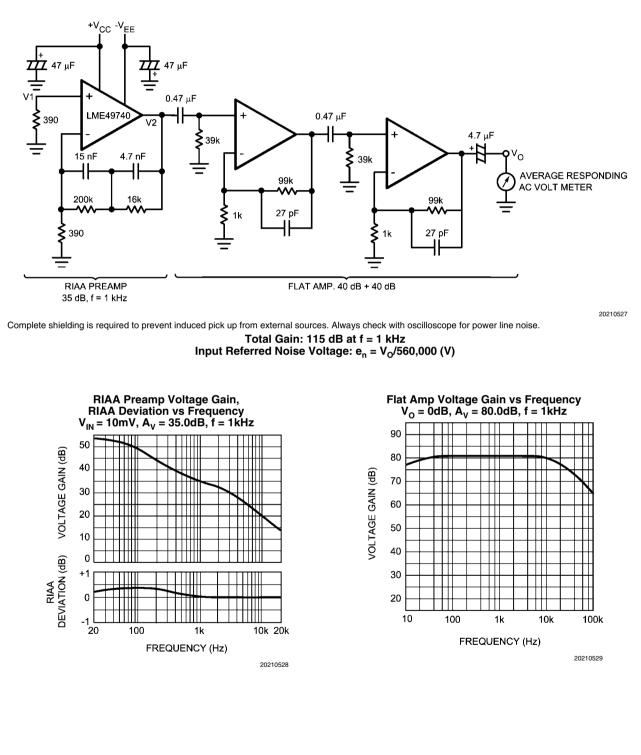
#### FIGURE 2. THD+N and IMD Distortion Test Circuit

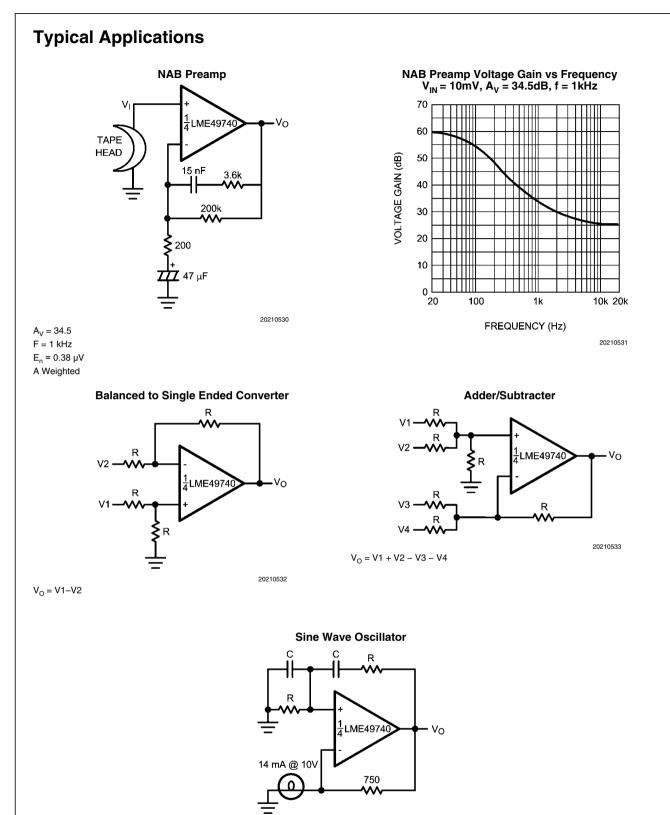
## **Application Hints**

The LME49740 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





20210534

LME49740

 $f_0 = \frac{1}{2\pi RC}$ 

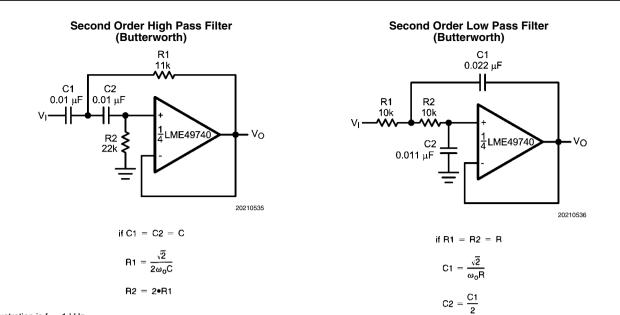
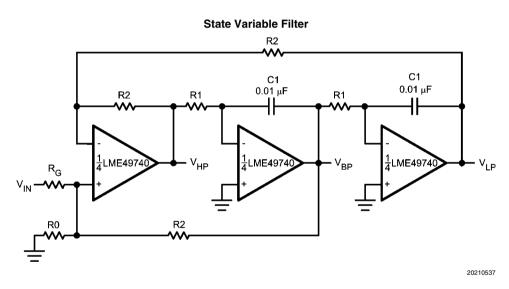
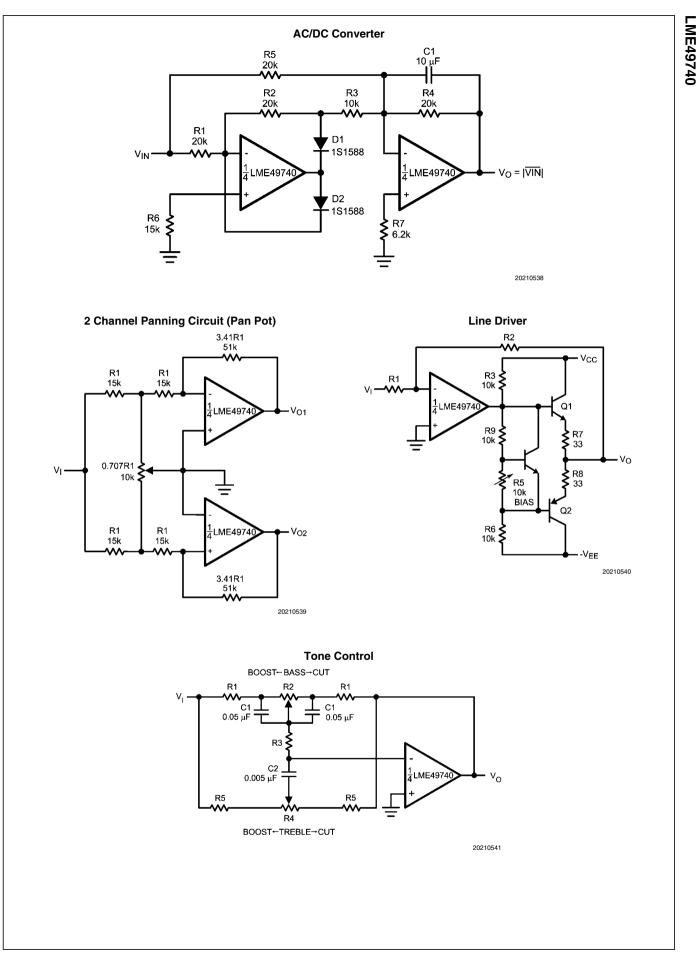


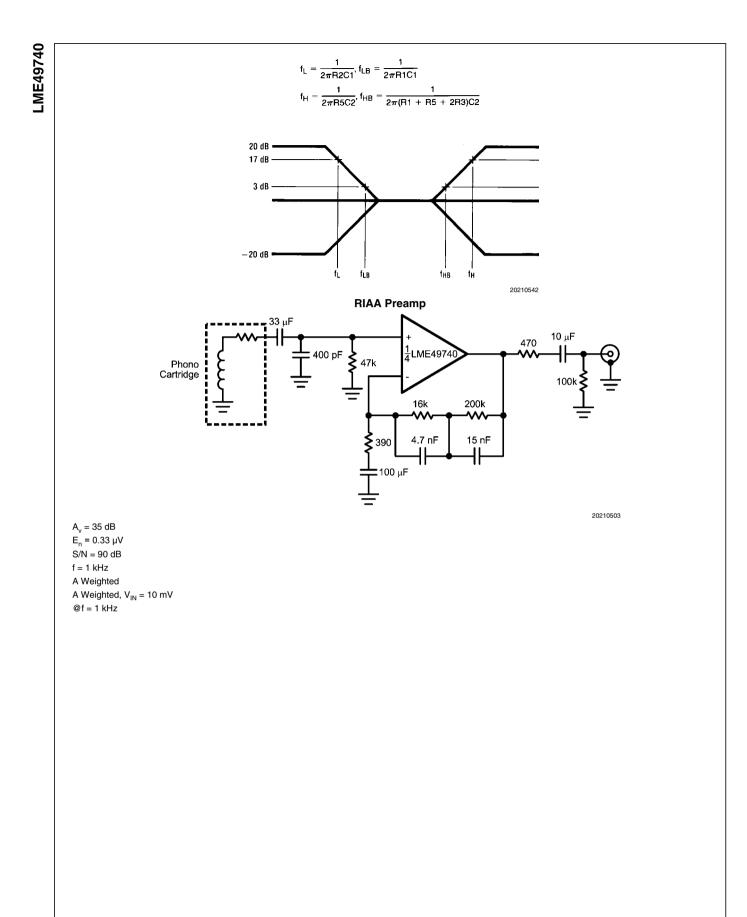
Illustration is  $f_0 = 1 \text{ kHz}$ 

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



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





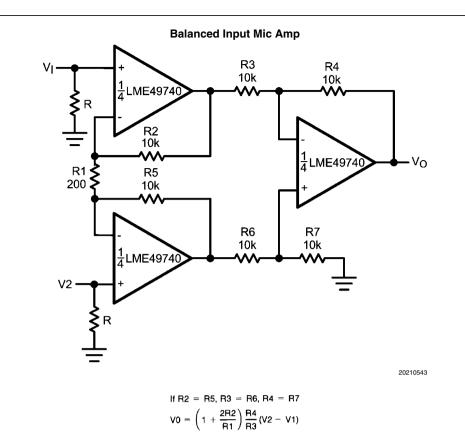


Illustration is: V0 = 101(V2 - V1) LME49740

10 Band Graphic Equalizer 20k BOOST CUT f01 f0<sub>2</sub> C2 R2 f03 -**3**k 1 LME49740 ٧o V C1 f04 I f05 3k 1 4LME497 **≶** R1 f0<sub>6</sub> I f07 I f08 f0g f0<sub>10</sub> 20210544

fo (Hz)	<b>C</b> <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 =  $\pm 12 \text{ dB}$ 

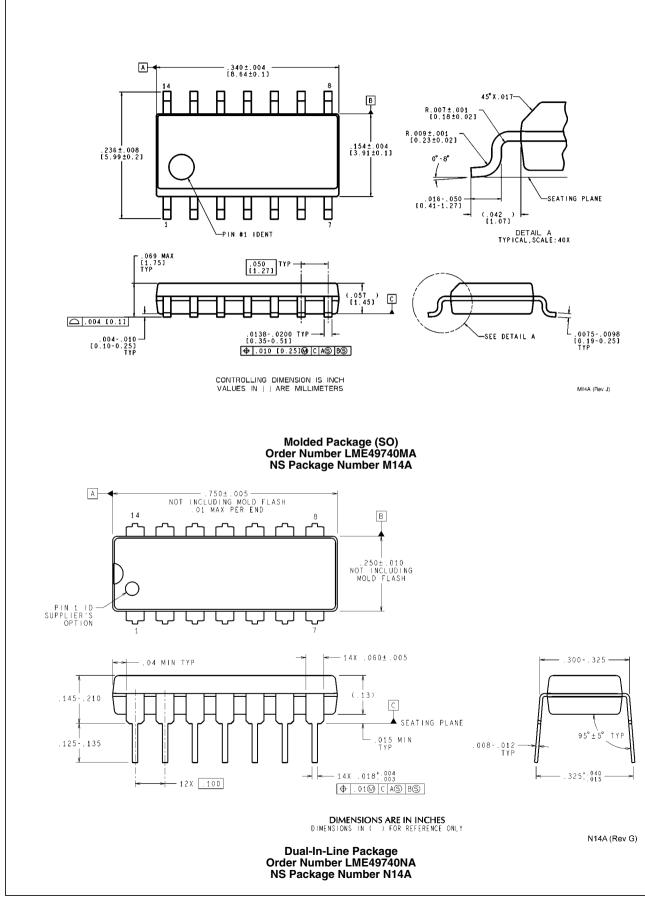
Q = 1.7

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

## **Revision History**

Rev	Date	Description
1.0	02/28/07	Initial WEB release.
1.01	02/08/08	Fixed the captions on the LME4970MA package (from Dual-In-
1.01	02/08/08	Line to Molded Package (SO).

## Physical Dimensions inches (millimeters) unless otherwise noted



# Notes

Pr	roducts Design Suppor		esign Support
Amplifiers	www.national.com/amplifiers	WEBENCH	www.national.com/webench
Audio	www.national.com/audio	Analog University	www.national.com/AU
Clock Conditioners	www.national.com/timing	App Notes	www.national.com/appnotes
Data Converters	www.national.com/adc	Distributors	www.national.com/contacts
Displays	www.national.com/displays	Green Compliance	www.national.com/quality/green
Ethernet	www.national.com/ethernet	Packaging	www.national.com/packaging
Interface	www.national.com/interface	Quality and Reliability	www.national.com/quality
LVDS	www.national.com/lvds	Reference Designs	www.national.com/refdesigns
Power Management	www.national.com/power	Feedback	www.national.com/feedback
Switching Regulators	www.national.com/switchers		
LDOs	www.national.com/ldo		
LED Lighting	www.national.com/led		
PowerWise	www.national.com/powerwise		
Serial Digital Interface (SDI)	www.national.com/sdi		
Temperature Sensors	www.national.com/tempsensors		
Wireless (PLL/VCO)	www.national.com/wireless		

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

#### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2008 National Semiconductor Corporation

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



National Semiconductor Americas Technical Support Center Email: new.feedback@nsc.com Tel: 1-800-272-9959 National Semiconductor Europe Technical Support Center Email: europe.support@nsc.com German Tei: +49 (0) 180 5010 771 English Tei: +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

#### **IMPORTANT NOTICE**

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
		u Hama Dawa	a O a Al a a m

**TI E2E Community Home Page** 

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2011, Texas Instruments Incorporated