

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 ($2.7\text{nV}/\sqrt{\text{Hz}}$) 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 $\pm 20\text{V}/\mu\text{s}$ and an output current capability of $\pm 26\text{mA}$. Further, dynamic range is maximized by an output stage that drives $2\text{k}\Omega$ loads to within 1V of either power supply voltage and to within 1.4V when driving 600Ω 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 $\pm 2.5\text{V}$ to $\pm 17\text{V}$. 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	$\pm 2.5\text{V}$ to $\pm 17\text{V}$
■ THD+N ($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1\text{kHz}$)	0.00003% (typ)
$R_L = 2\text{k}\Omega$	0.00003% (typ)
$R_L = 600\Omega$	2.7nV/ $\sqrt{\text{Hz}}$ (typ)
■ Input Noise Density	$\pm 20\text{V}/\mu\text{s}$ (typ)
■ Slew Rate	55MHz (typ)
■ Gain Bandwidth Product	140dB (typ)
■ Open Loop Gain ($R_L = 600\Omega$)	10nA (typ)
■ Input Bias Current	0.1mV (typ)
■ Input Offset Voltage	0.000009%
■ DC Gain Linearity Error	

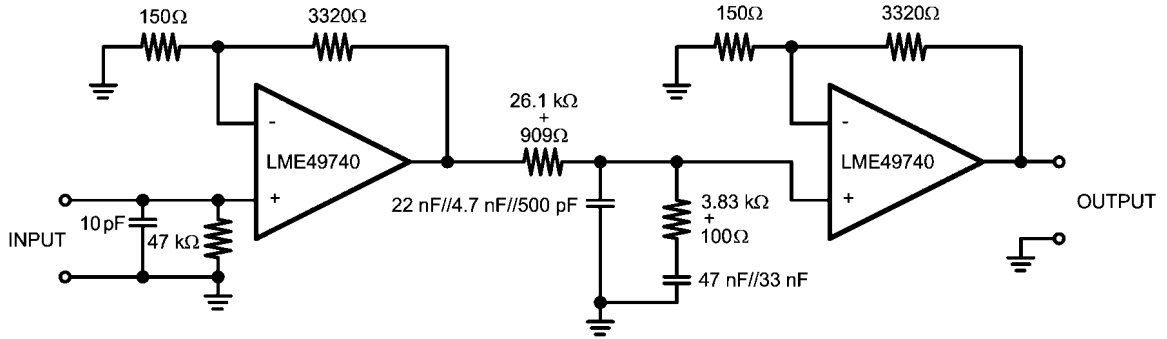
Features

- 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

Typical Application

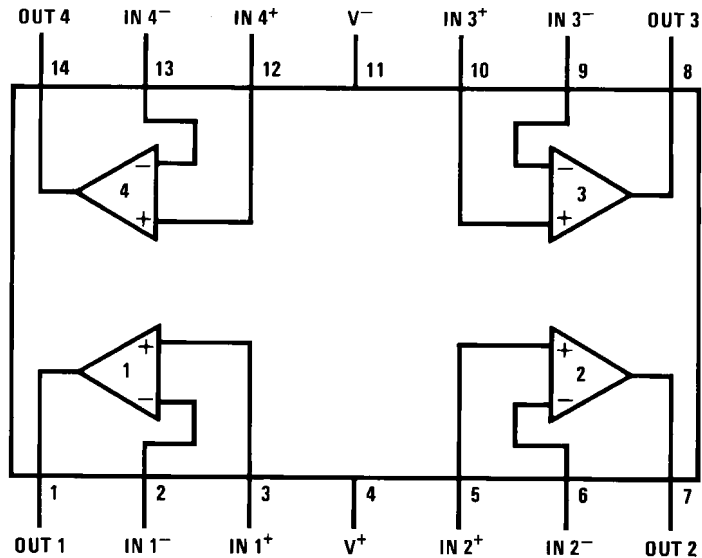


Note: 1% metal film resistors, 5% polypropylene capacitors

20210502

FIGURE 1. Passively Equalized RIAA Phono Preamplifier

Connection Diagram



20210501

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.

Power Supply Voltage ($V_S = V^+ - V^-$)	36V	ESD Susceptibility (Note 4)	2000V
Storage Temperature	-65°C to 150°C	ESD Susceptibility (Note 5)	200V
Input Voltage ($V^- - 0.7V$ to (V^+) + 0.7V)		Junction Temperature	150°C
Output Short Circuit (Note 3)	Continuous	Thermal Resistance	
Power Dissipation	Internally Limited	θ_{JA} (MA)	107°C/W
		θ_{JA} (NA)	74°C/W
		Temperature Range	
		$T_{MIN} \leq T_A \leq T_{MAX}$	-40°C $\leq T_A \leq$ 85°C
		Supply Voltage Range	$\pm 2.5V \leq V_S \leq \pm 17V$

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

Symbol	Parameter	Conditions	LME49740		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ $R_L = 2k\Omega$ $R_L = 600\Omega$	0.00003 0.00003	0.00009	% (max) % (max)
IMD	Intermodulation Distortion	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.00005		% (max)
GBWP	Gain Bandwidth Product		55	45	MHz (min)
SR	Slew Rate		± 20	± 15	V/ μ 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		μ s
e_n	Equivalent Input Noise Voltage	$f_{BW} = 20Hz$ to 20kHz	0.34	0.65	μV_{RMS}
	Equivalent Input Noise Density	$f = 1kHz$ $f = 10Hz$	2.7 6.4	4.7	nV/\sqrt{Hz} 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		± 0.1	± 0.7	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$40^\circ C \leq T_A \leq 85^\circ C$	0.2		$\mu V/^\circ C$
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$\Delta V_S = 20V$ (Note 9)	120	110	dB (min)
ISO _{CH-CH}	Channel-to-Channel Isolation	$f_{IN} = 1kHz$	118		dB
		$f_{IN} = 20kHz$	112		dB
I_B	Input Bias Current	$V_{CM} = 0V$	10	72	nA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40^\circ C \leq T_A \leq 85^\circ C$	0.1		nA/ $^\circ C$
I_{OS}	Input Offset Current	$V_{CM} = 0V$	11	65	nA (max)
V_{IN-CM}	Common-Mode Input Voltage Range		+14.1 -13.9	(V^+)-2.0 (V^-)+2.0	V (min) V (min)
CMRR	Common-Mode Rejection	$-10V < V_{CM} < 10V$	120	110	dB (min)
Z_{IN}	Differential Input Impedance		30		k Ω
	Common Mode Input Impedance	$-10V < V_{CM} < 10V$	1000		M Ω
A_{VOL}	Open Loop Voltage Gain	$-10V < V_{OUT} < 10V$, $R_L = 600\Omega$	140		dB (min)
		$-10V < V_{OUT} < 10V$, $R_L = 2k\Omega$	140		dB (min)
		$-10V < V_{OUT} < 10V$, $R_L = 10k\Omega$	140	125	dB (min)

Symbol	Parameter	Conditions	LME49740		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
V _{OUTMAX}	Maximum Output Voltage Swing	R _L = 600Ω	±13.6	±12.5	V (min)
		R _L = 2kΩ	±14.0		V (min)
		R _L = 10kΩ	±14.1		V (min)
I _{OUT}	Output Current	R _L = 600Ω, V _S = ±17V	±26	±23	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	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 1.5kΩ 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).

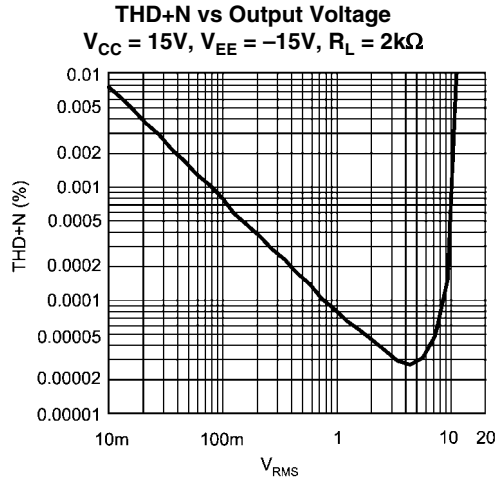
Note 6: Typical specifications are specified at +25°C and represent the most likely parametric norm.

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

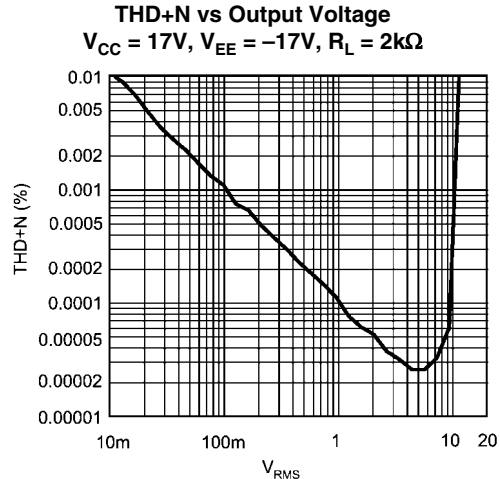
Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

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

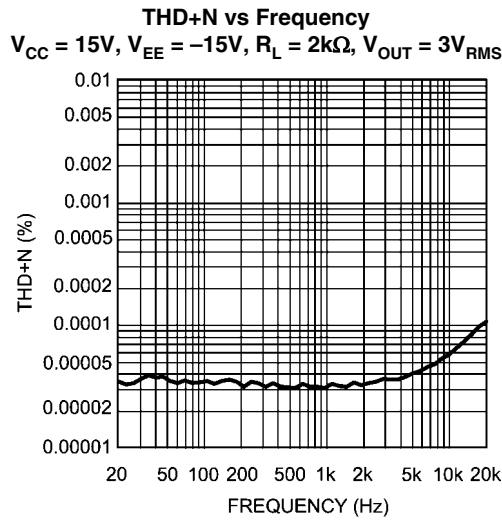
Typical Performance Characteristics



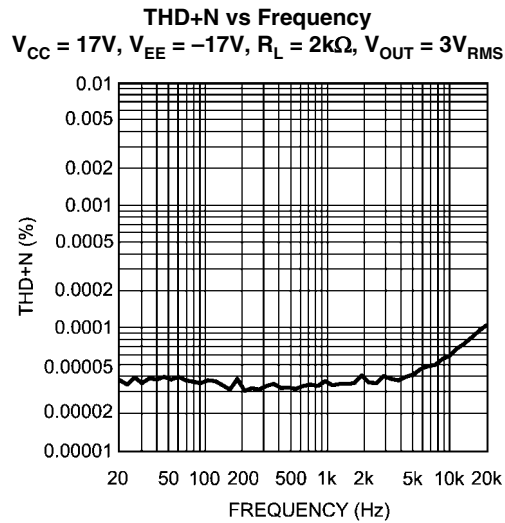
20210515



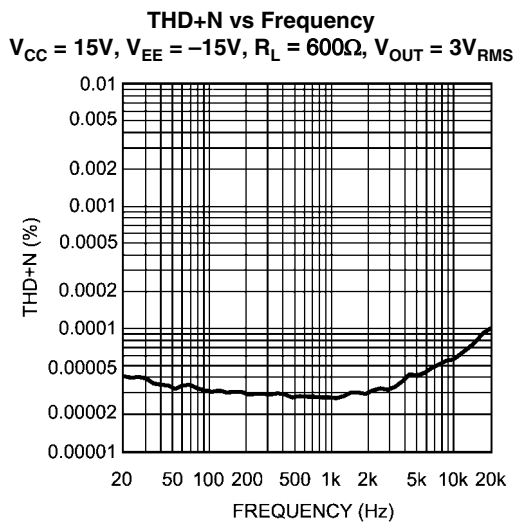
20210516



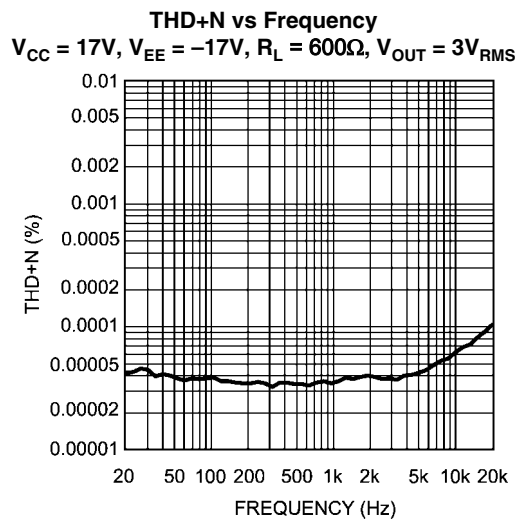
20210511



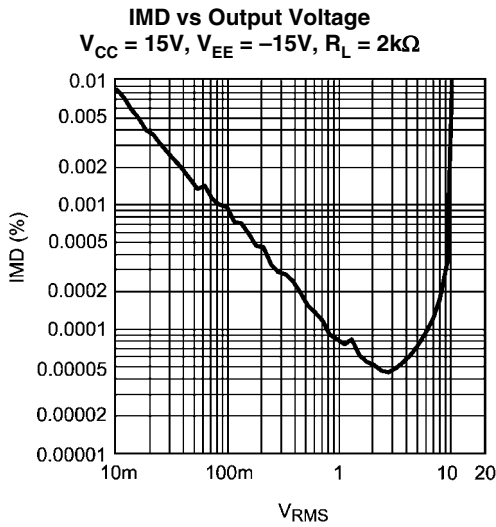
20210513



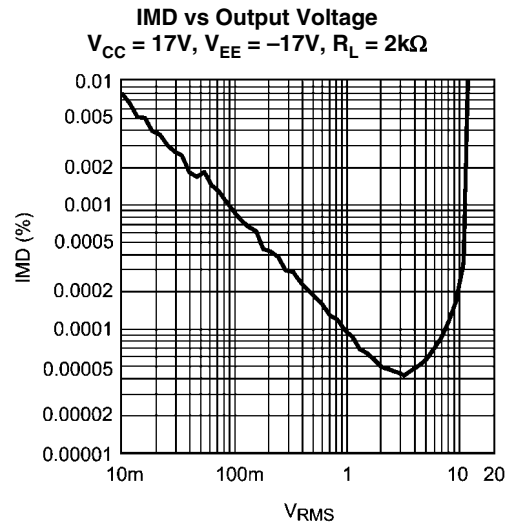
20210512



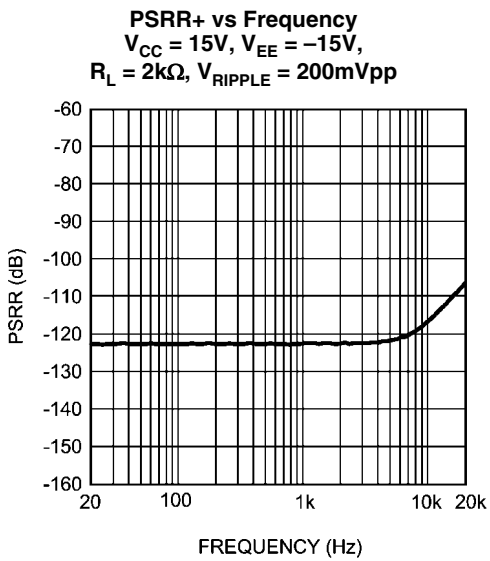
20210514



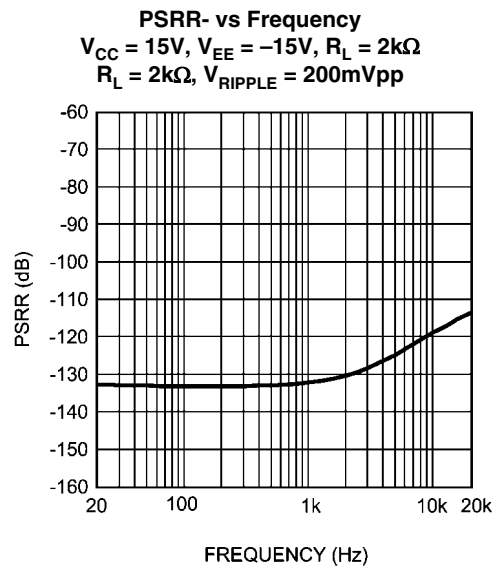
20210553



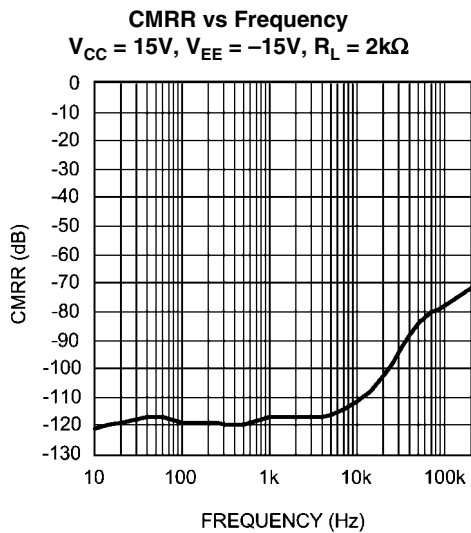
20210554



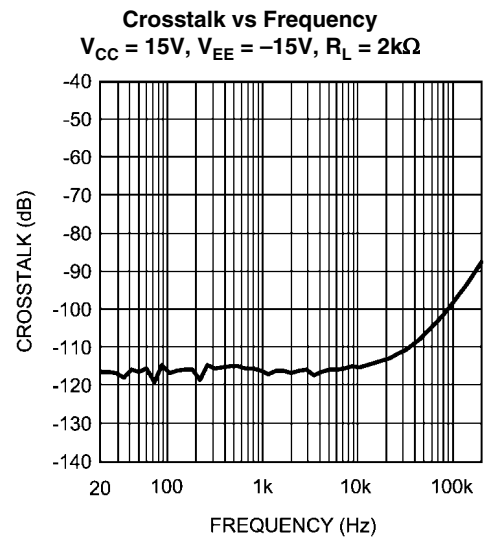
20210559



20210560

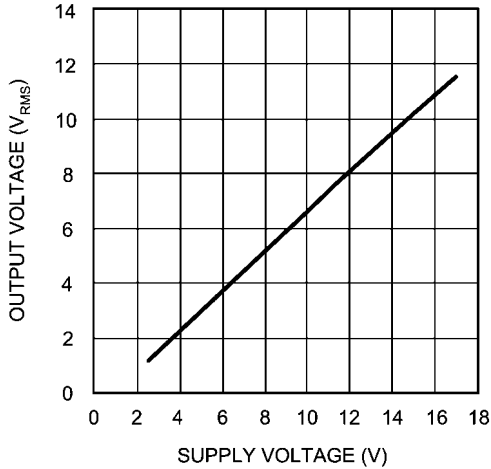


20210552



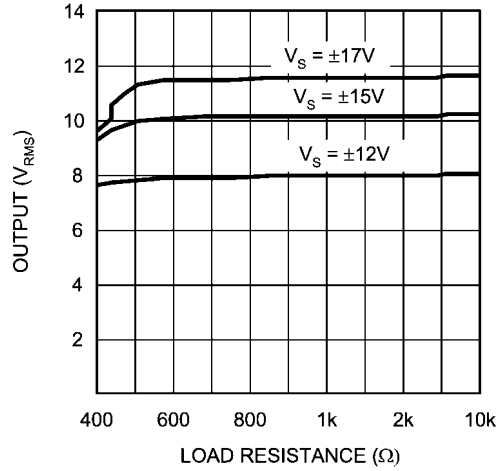
20210519

Output Voltage vs Supply Voltage
 $R_L = 2k\Omega$, THD+N = 1%



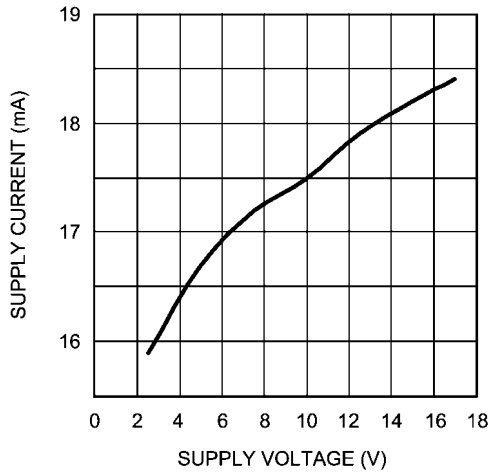
20210518

Output Voltage vs Load Resistance
 THD+N = 1%



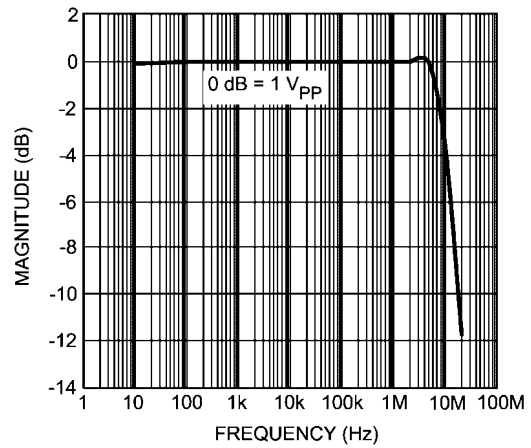
20210517

Supply Current vs Supply Voltage
 $R_L = 2k\Omega$, THD+N = 1%



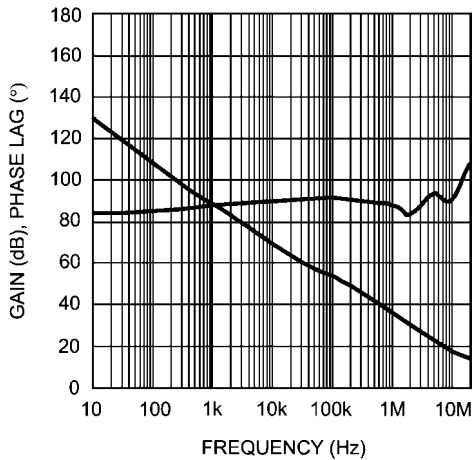
20210507

Full Power Bandwidth vs Frequency



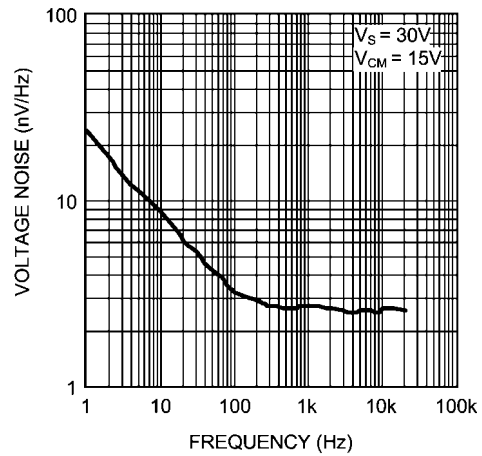
20210520

Gain Phase vs Frequency



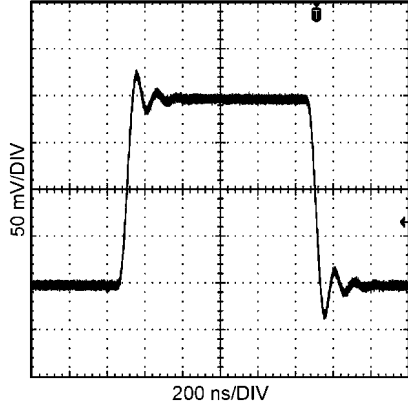
20210551

Voltage Noise Density vs Frequency



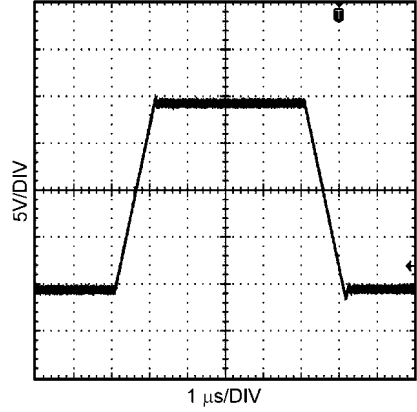
20210557

Small-Signal Transient Response
 $A_V = 1, C_L = 100\text{pF}$



20210556

Large-Signal Transient Response
 $A_V = 1, C_L = 100\text{pF}$



20210555

Application Information

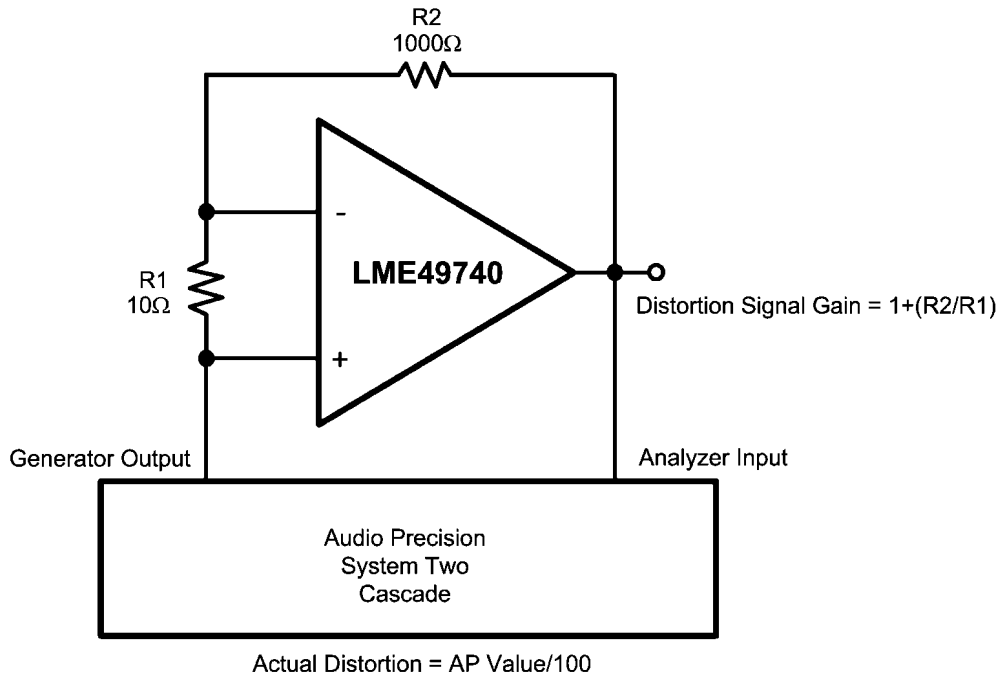
DISTORTION MEASUREMENTS

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 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 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.



20210562

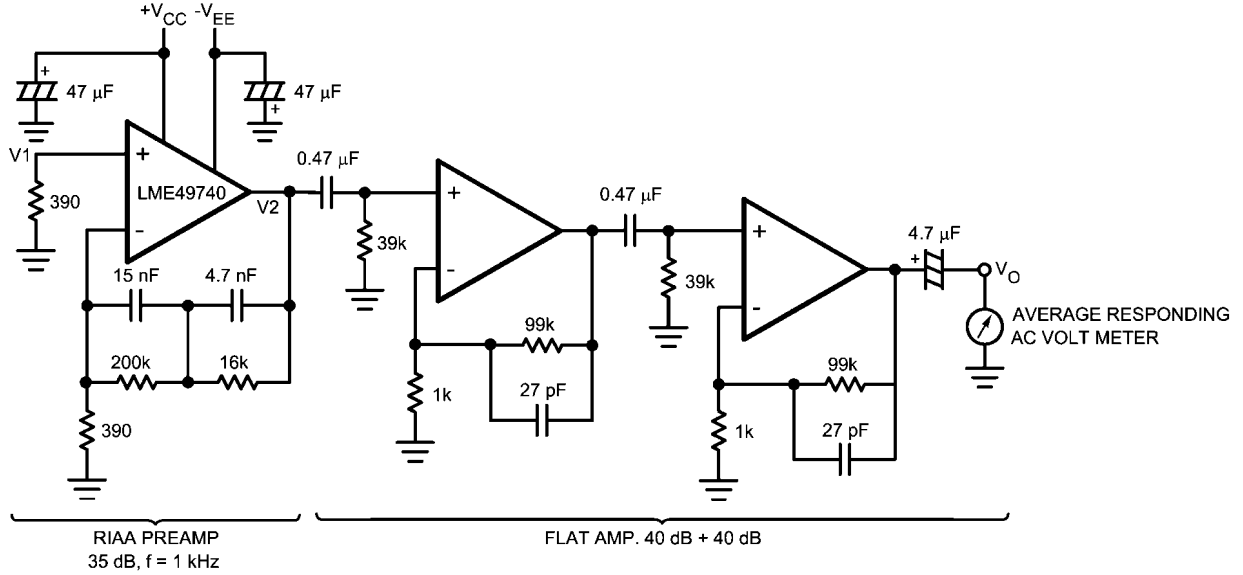
FIGURE 2. THD+N and IMD Distortion Test Circuit

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.

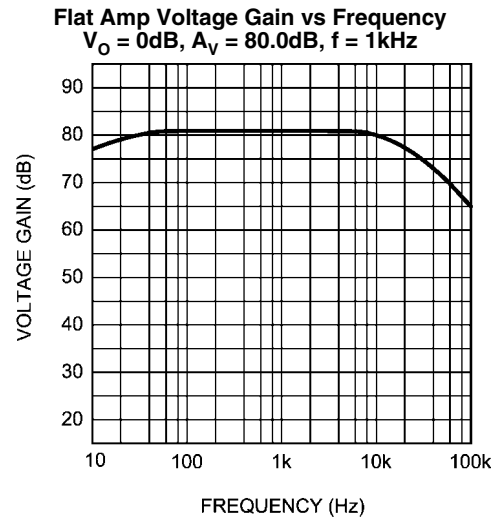
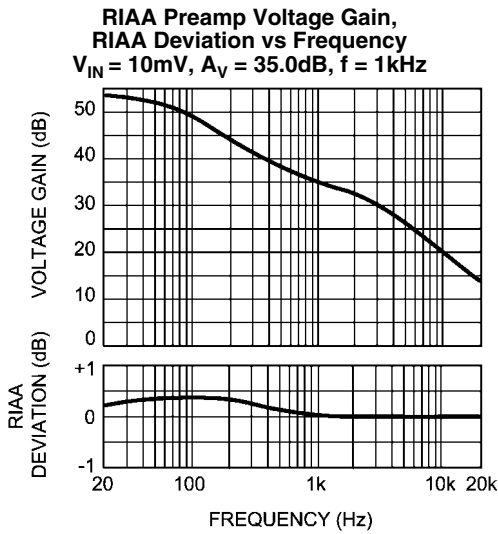
Noise Measurement Circuit



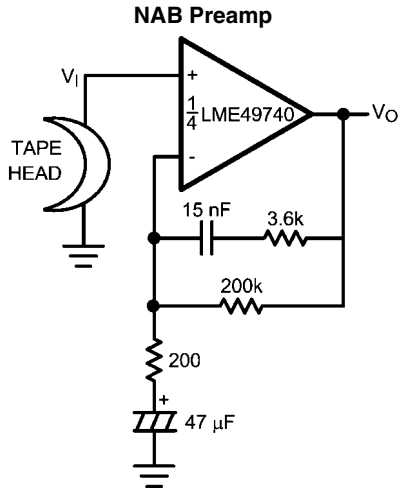
20210527

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

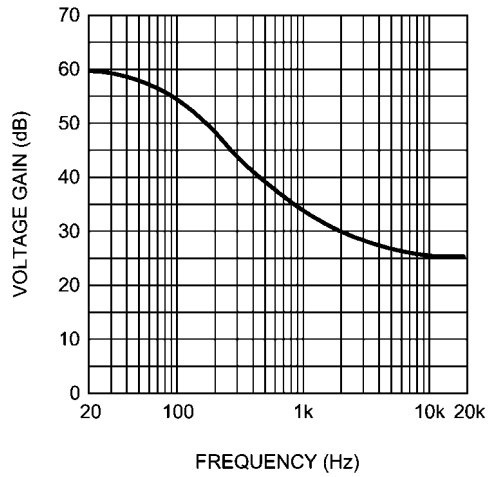
Total Gain: 115 dB at f = 1 kHz
Input Referred Noise Voltage: $e_n = V_o/560,000$ (V)



Typical Applications



NAB Preamp Voltage Gain vs Frequency
 $V_{IN} = 10\text{mV}$, $A_V = 34.5\text{dB}$, $f = 1\text{kHz}$

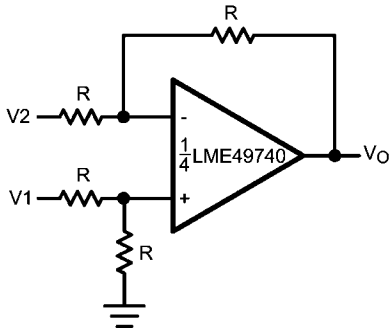


$A_V = 34.5$
 $F = 1\text{ kHz}$
 $E_n = 0.38\ \mu\text{V}$
 A Weighted

20210530

20210531

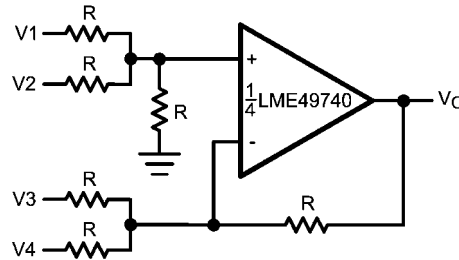
Balanced to Single Ended Converter



$V_O = V1 - V2$

20210532

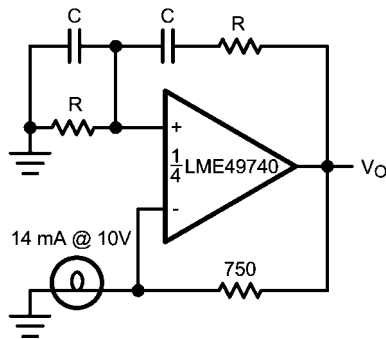
Adder/Subtractor



$V_O = V1 + V2 - V3 - V4$

20210533

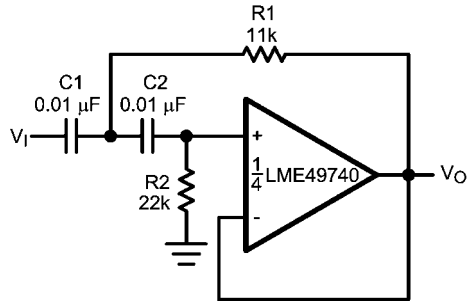
Sine Wave Oscillator



20210534

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

Second Order High Pass Filter (Butterworth)



20210535

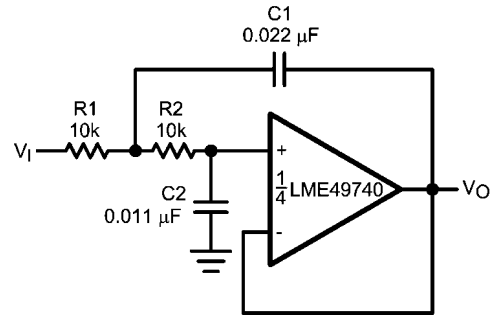
if $C1 = C2 = C$

$$R1 = \frac{\sqrt{2}}{2\omega_0 C}$$

$$R2 = 2 \cdot R1$$

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

Second Order Low Pass Filter (Butterworth)



20210536

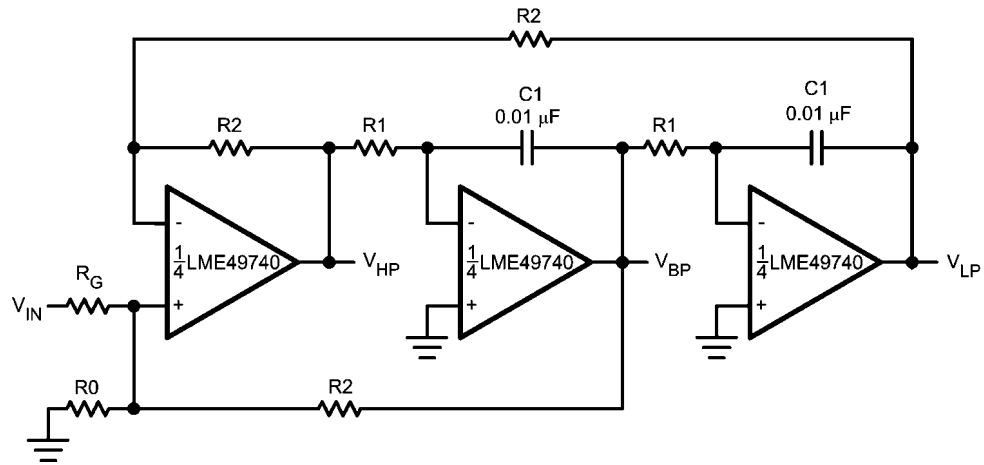
if $R1 = R2 = R$

$$C1 = \frac{\sqrt{2}}{\omega_0 R}$$

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

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

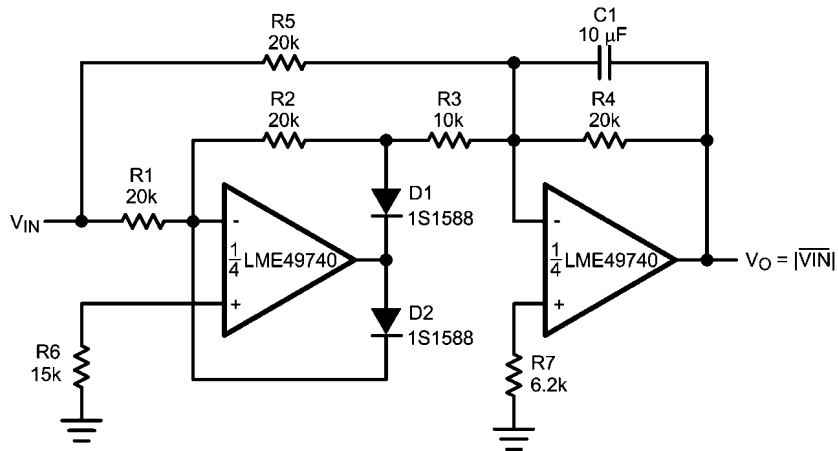
State Variable Filter



20210537

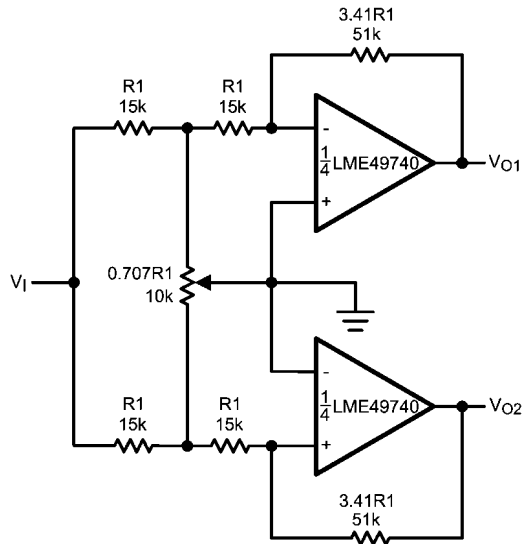
$$f_0 = \frac{1}{2\pi C1 R1}, Q = \frac{1}{2} \left(1 + \frac{R2}{R0} + \frac{R2}{RG} \right), A_{BP} = Q A_{LP} = Q A_{LH} = \frac{R2}{RG}$$

AC/DC Converter



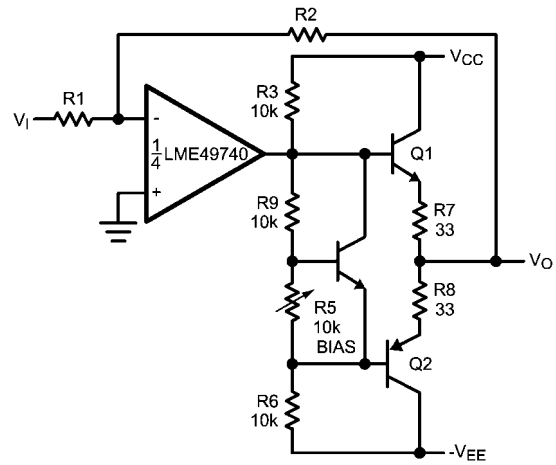
20210538

2 Channel Panning Circuit (Pan Pot)



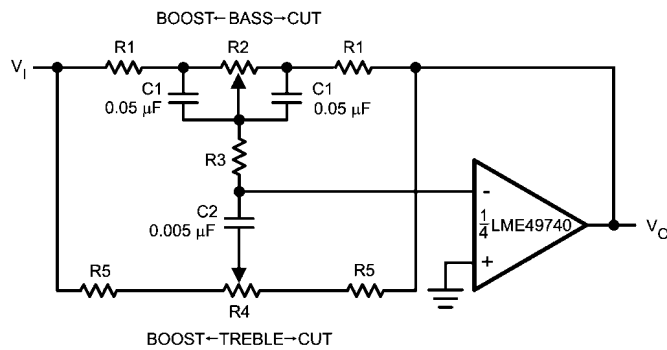
20210539

Line Driver



20210540

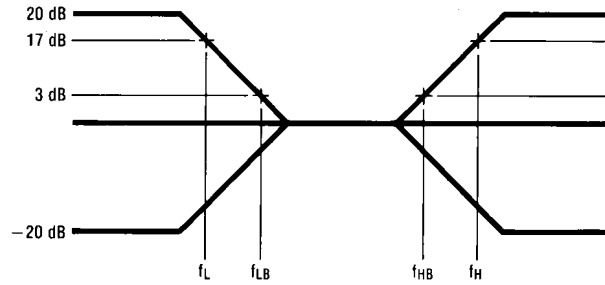
Tone Control



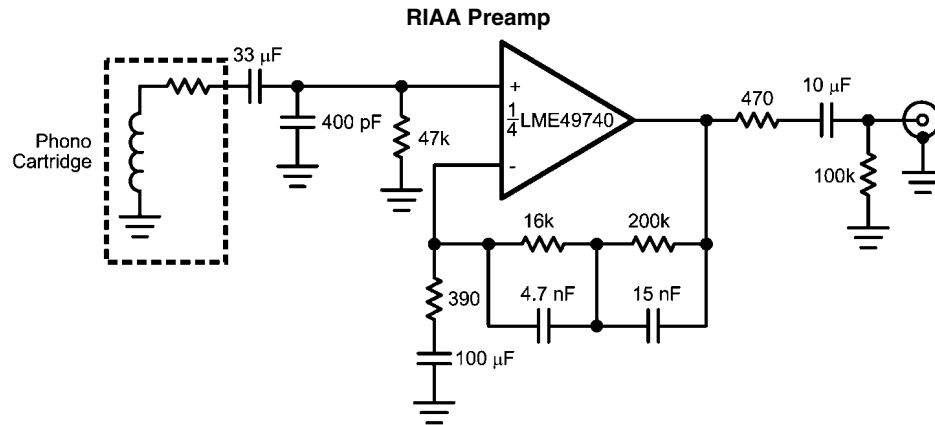
20210541

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

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

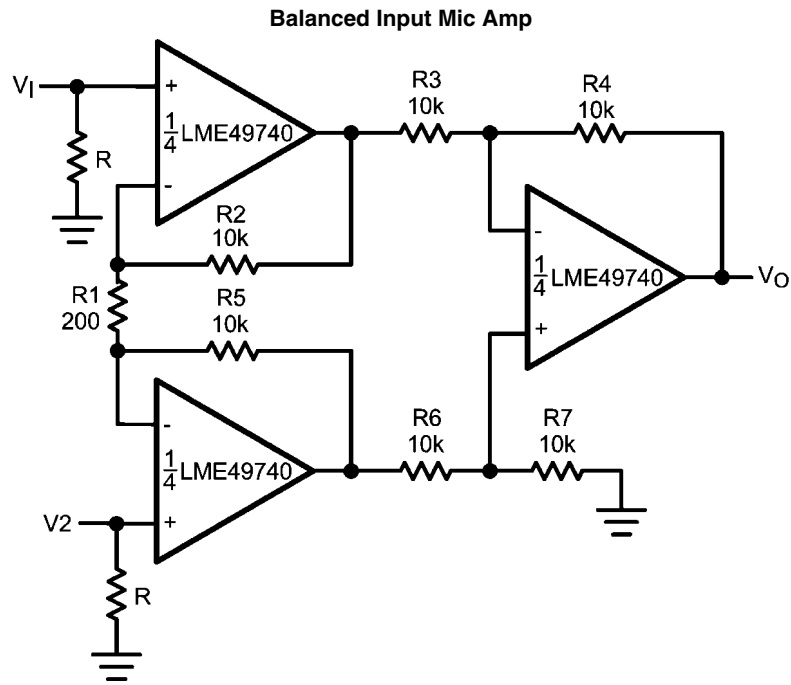


20210542



20210503

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



20210543

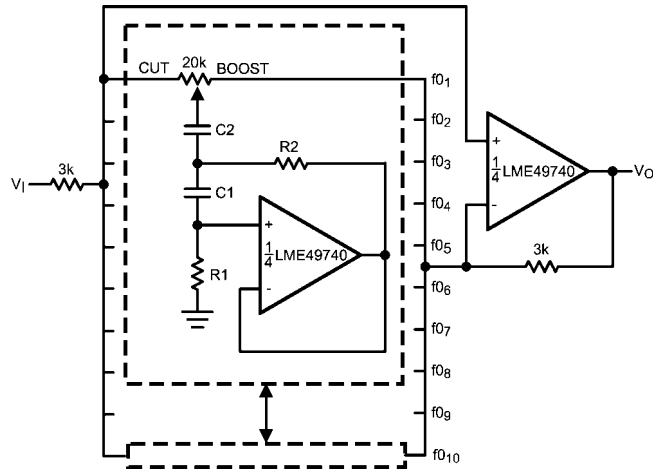
If $R_2 = R_5$, $R_3 = R_6$, $R_4 = R_7$

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

Illustration is:

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

10 Band Graphic Equalizer



20210544

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

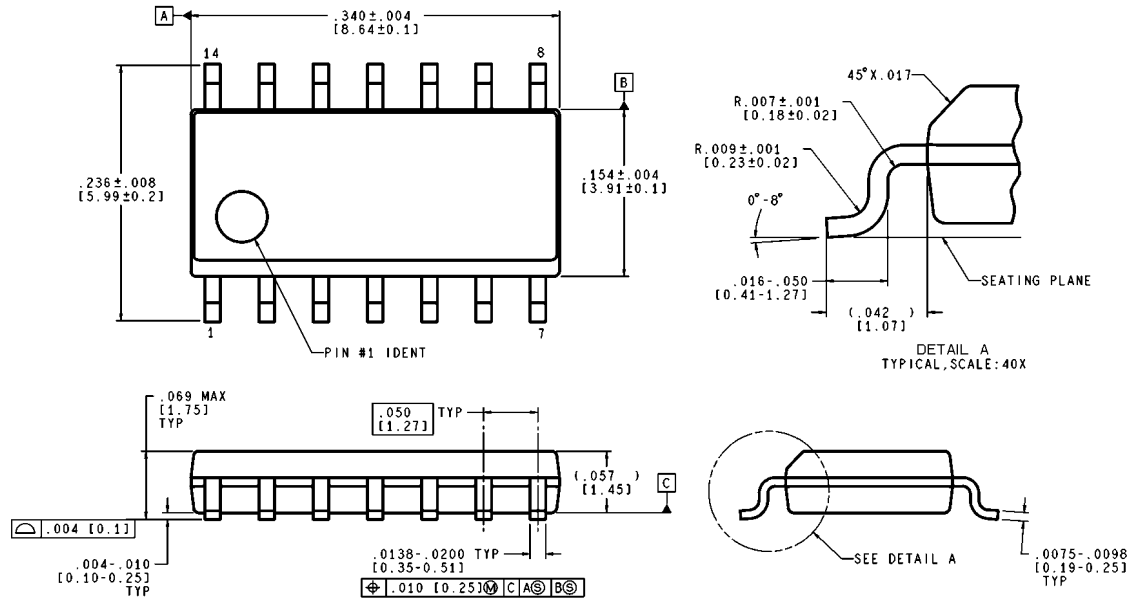
Q = 1.7

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

Revision History

Rev	Date	Description
1.0	02/28/07	Initial WEB release.

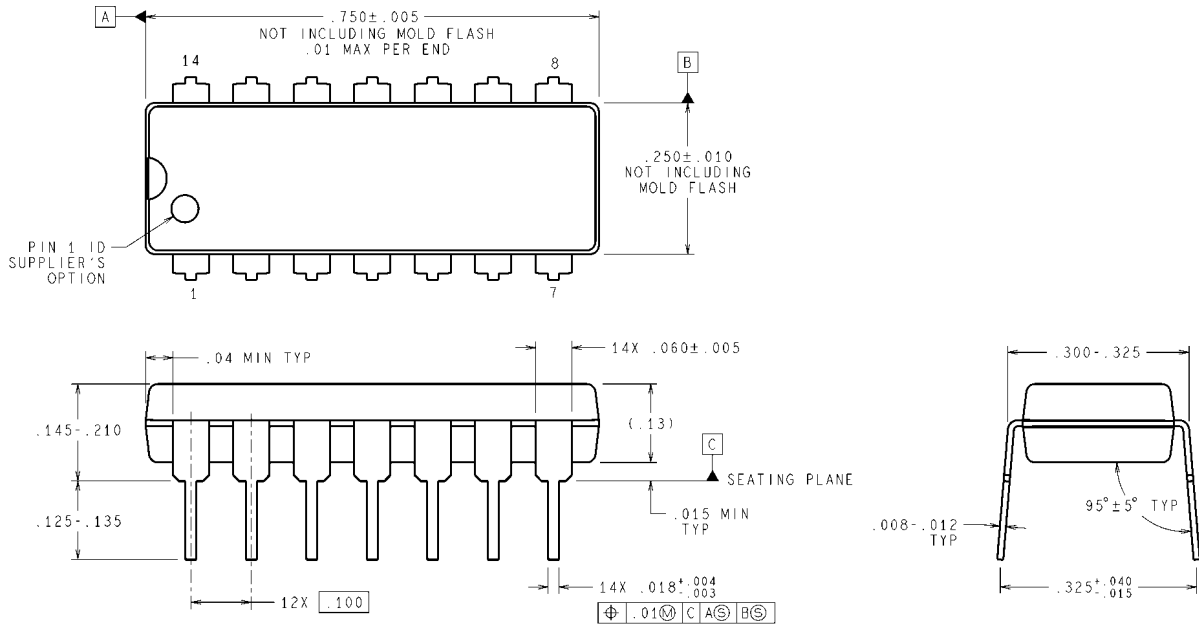
Physical Dimensions inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS INCH
VALUES IN () ARE MILLIMETERS

M14A (Rev J)

Dual-In-Line Package
Order Number LME49740MA
NS Package Number M14A



DIMENSIONS ARE IN INCHES
DIMENSIONS IN () FOR REFERENCE ONLY

N14A (Rev G)

Dual-In-Line Package
Order Number LME49740NA
NS Package Number N14A

Notes

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© 2007 National Semiconductor Corporation

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



National Semiconductor Americas Customer Support Center
 Email: new.feedback@nsc.com
 Tel: 1-800-272-9959

National Semiconductor Europe Customer Support Center
 Fax: +49 (0) 180-530-85-86
 Email: europe.support@nsc.com
 Deutsch Tel: +49 (0) 69 9508 6208
 English Tel: +49 (0) 870 24 0 2171
 Français Tel: +33 (0) 1 41 91 8790

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

National Semiconductor Japan Customer Support Center
 Fax: 81-3-5639-7507
 Email: jpn.feedback@nsc.com
 Tel: 81-3-5639-7560