

LME49740 Quad High-Performance, High-Fidelity Audio Operational Amplifier

Check for Samples: [LME49740](#)

FEATURES

- Easily Drives 600Ω Loads
- Optimized for Superior Audio Signal Fidelity
- Output Short Circuit Protection
- PSRR and CMRR Exceed 120dB (Typ)
- SOIC and PDIP 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

KEY SPECIFICATIONS

- Power Supply Voltage Range: $\pm 2.5V$ to $\pm 17V$
- THD+N ($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1kHz$)
 - $R_L = 2k\Omega$: 0.00003% (typ)
 - $R_L = 600\Omega$: 0.00003% (typ)
- Input Noise Density: $2.7nV/\sqrt{Hz}$ (typ)
- Slew Rate: $\pm 20V/\mu s$ (typ)
- Gain Bandwidth Product: 55MHz (typ)
- Open Loop Gain ($R_L = 600\Omega$): 140dB (typ)
- Input Bias Current: 10nA (typ)
- Input Offset Voltage: 0.1mV (typ)
- DC Gain Linearity Error: 0.000009%

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 $\pm 26mA$. Further, dynamic range is maximized by an output stage that drives 2kΩ 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 $\pm 2.5V$ 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.

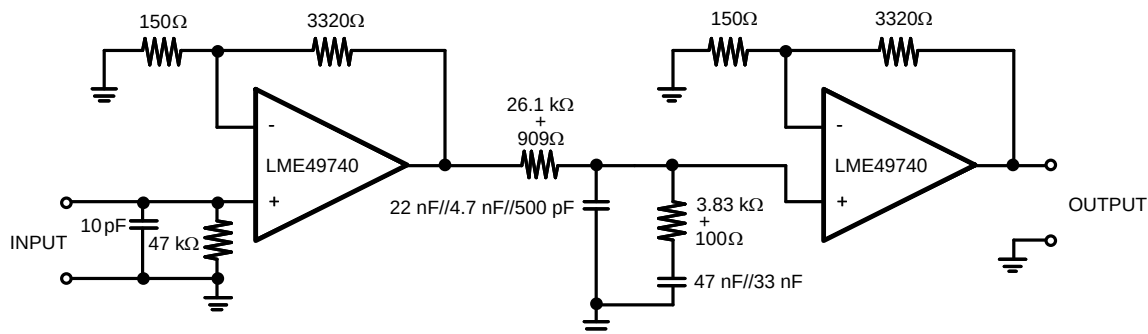
The LME49740 is available in 14-lead narrow body SOIC and 14-lead PDIP. Demonstration boards are available for each package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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TYPICAL APPLICATION



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

Figure 1. Passively Equalized RIAA Phono Preamplifier

CONNECTION DIAGRAM

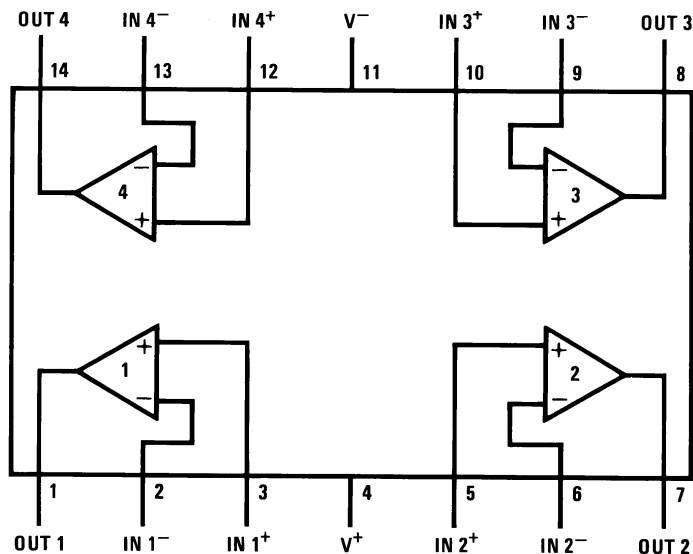


**Figure 2. 14-Lead SOIC (D Package)
14-Lead PDIP (NFF Package)**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾⁽²⁾⁽³⁾

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 ⁽⁴⁾	Continuous
Power Dissipation	Internally Limited
ESD Susceptibility ⁽⁵⁾	2000V
ESD Susceptibility ⁽⁶⁾	200V
Junction Temperature	150°C
Thermal Resistance	
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	$\pm 2.5V \leq V_S \leq \pm 17V$

- (1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur.
- (2) Operating Ratings indicate conditions for which the device is functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (4) Amplifier output connected to GND, any number of amplifiers within a package.
- (5) Human body model, 100pF discharged through a 1.5k Ω resistor.
- (6) 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 Ω).

ELECTRICAL CHARACTERISTICS⁽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	LME49740		Units (Limits)
			Typical ⁽³⁾	Limit ⁽⁴⁾⁽⁵⁾	
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/ μs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$, $-3dB$ referenced to output magnitude at $f = 1kHz$	10		MHz
t_s	Settling time	$A_V = 1$, 10V step, $C_L = 100pF$ 0.1% error range	1.2		μs
e_n	Equivalent Input Noise Voltage	$f_{BW} = 20Hz$ to $20kHz$	0.34	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	$f = 1kHz$ $f = 10Hz$	1.6 3.1		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
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	$\Delta V_S = 20V^{(6)}$	120	110	dB (min)
ISO _{CH-CH}	Channel-to-Channel Isolation	$f_{IN} = 1kHz$ $f_{IN} = 20kHz$	118 112		dB dB
I_B	Input Bias Current	$V_{CM} = 0V$	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)
V_{OUTMAX}	Maximum Output Voltage Swing	$R_L = 600\Omega$	± 13.6	± 12.5	V (min)
		$R_L = 2k\Omega$	± 14.0		V (min)
		$R_L = 10k\Omega$	± 14.1		V (min)
I_{OUT}	Output Current	$R_L = 600\Omega$, $V_S = \pm 17V$	± 26	± 23	mA (min)
I_{OUT-CC}	Short Circuit Current		+30 -38		mA mA
R_{OUT}	Output Impedance	$f_{IN} = 10kHz$	0.01		Ω
		Closed-Loop Open-Loop	13		Ω

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

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

(3) Typical specifications are specified at $+25^\circ C$ and represent the most likely parametric norm.

(4) Tested limits are specified to AOQL (Average Outgoing Quality Level).

(5) Datasheet min/max specification limits are specified by design, test, or statistical analysis.

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

ELECTRICAL CHARACTERISTICS⁽¹⁾⁽²⁾ (continued)

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 ⁽³⁾	Limit ⁽⁴⁾⁽⁵⁾	
C_{LOAD}	Capacitive Load Drive Overshoot	100pF	16		%
I_S	Total Quiescent Current	$I_{OUT} = 0mA$	18.5	20	mA (max)

TYPICAL PERFORMANCE CHARACTERISTICS

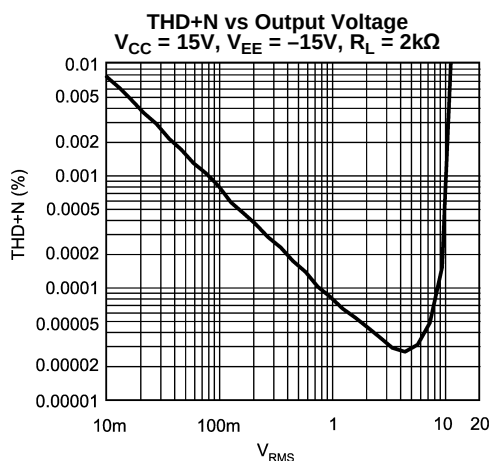


Figure 3.

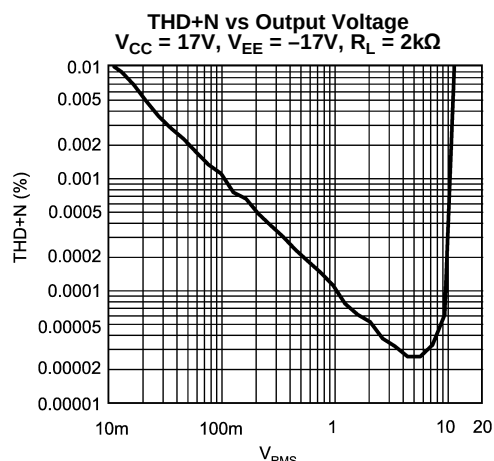


Figure 4.

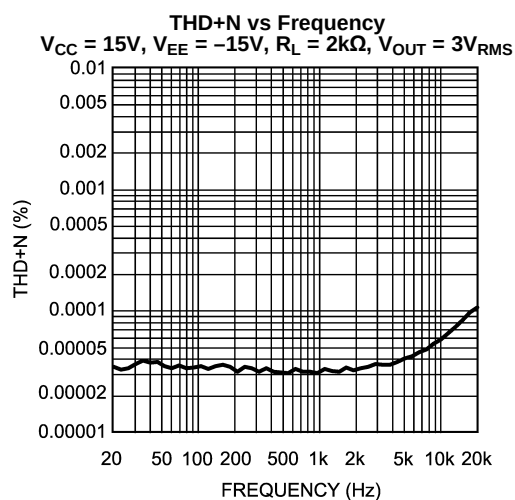


Figure 5.

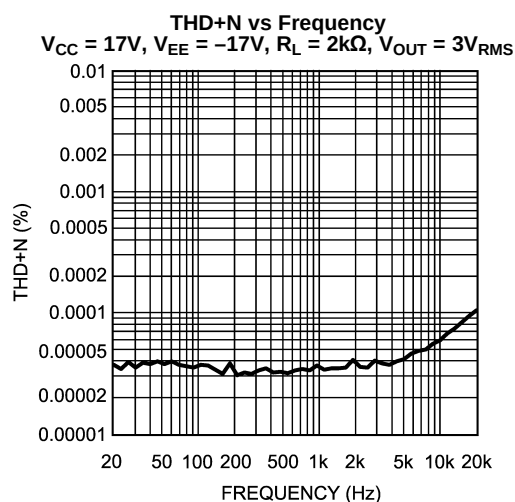


Figure 6.

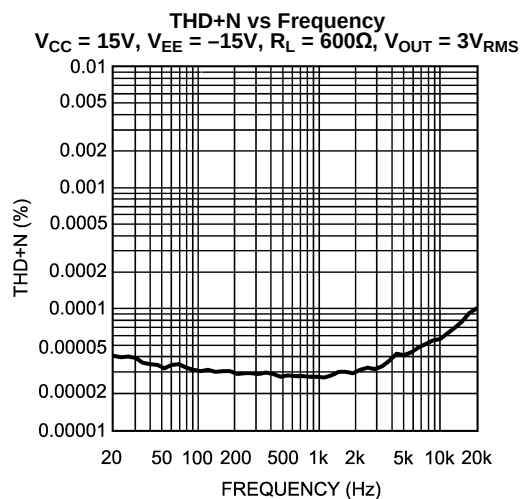


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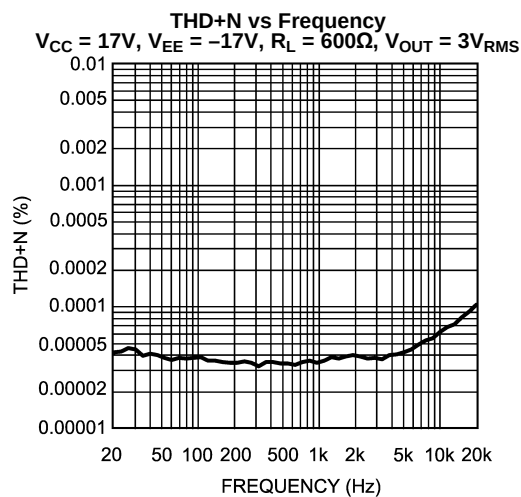


Figure 8.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

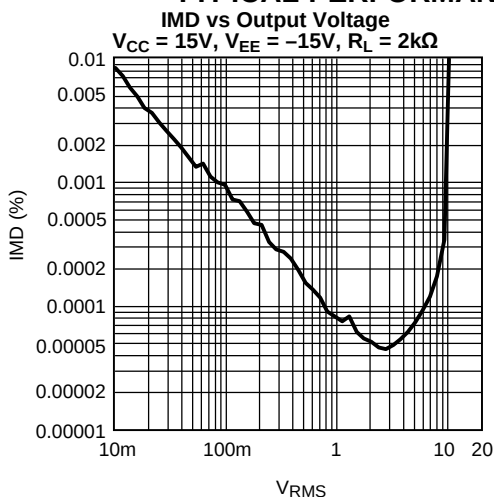


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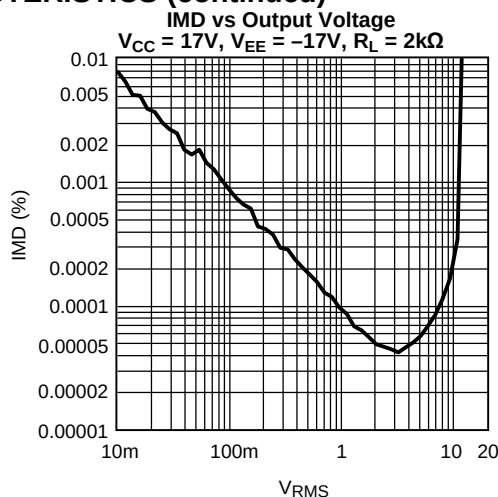


Figure 10.

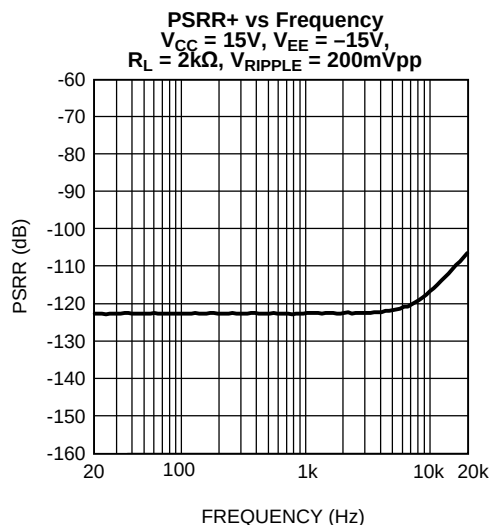


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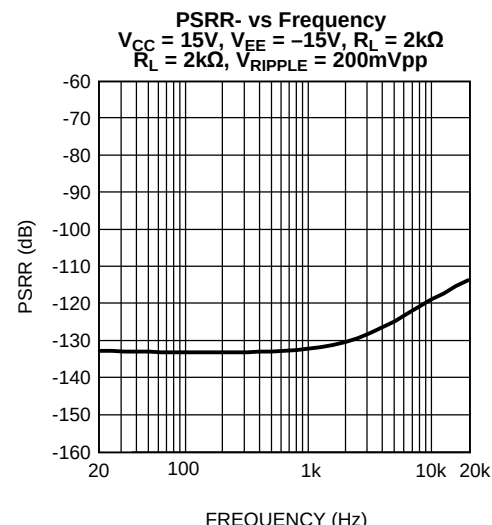


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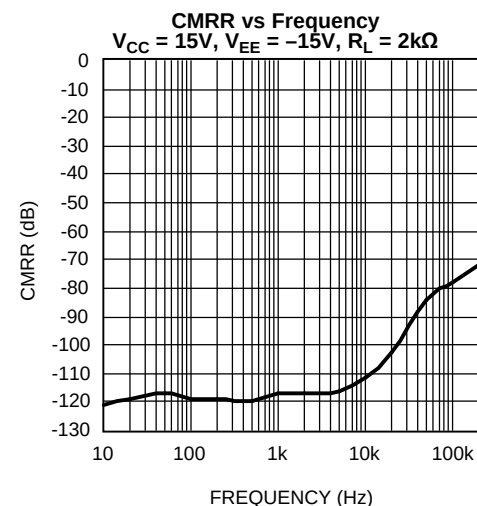


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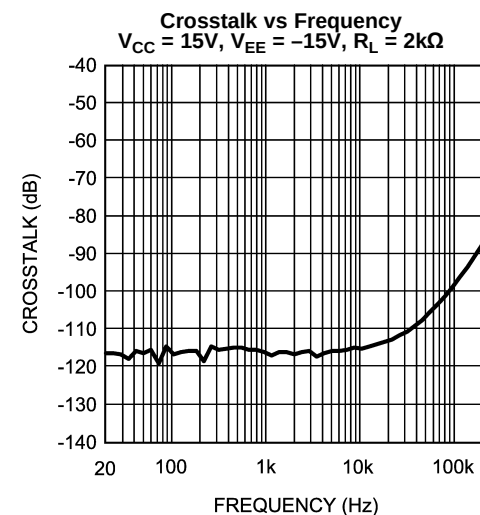


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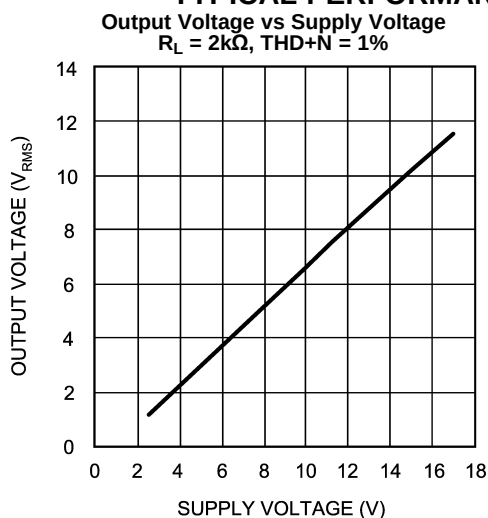
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Figure 15.

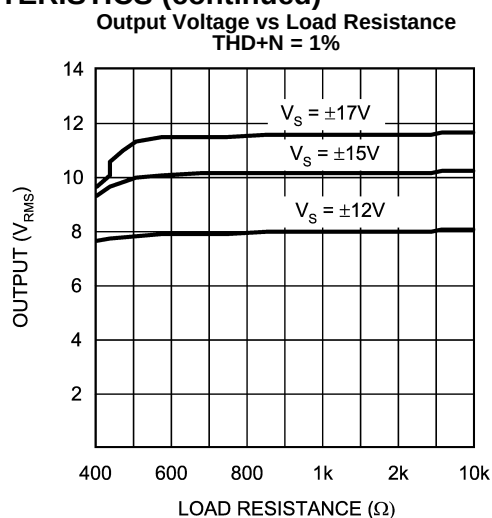


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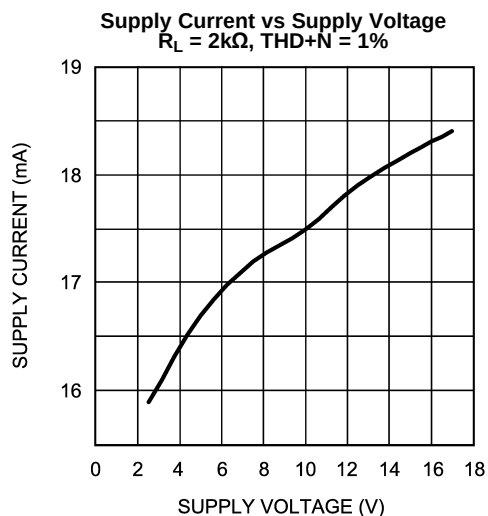


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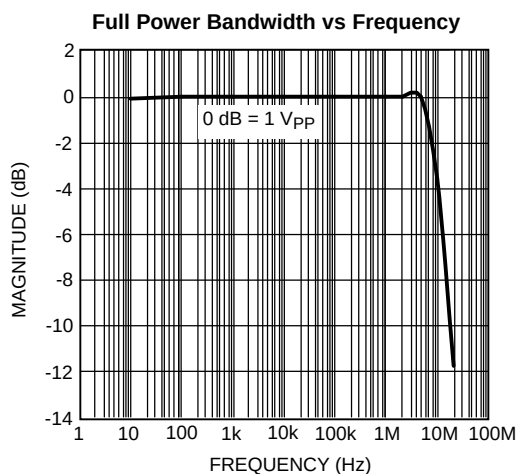


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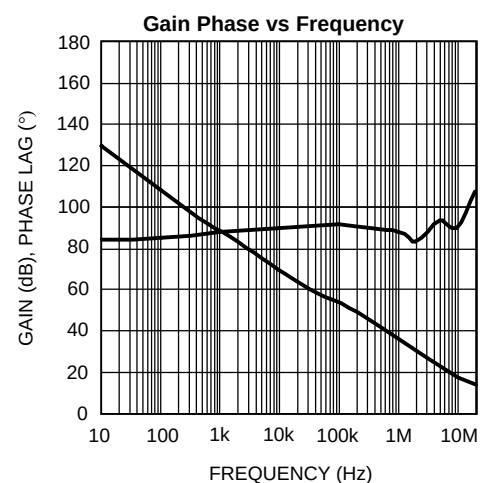


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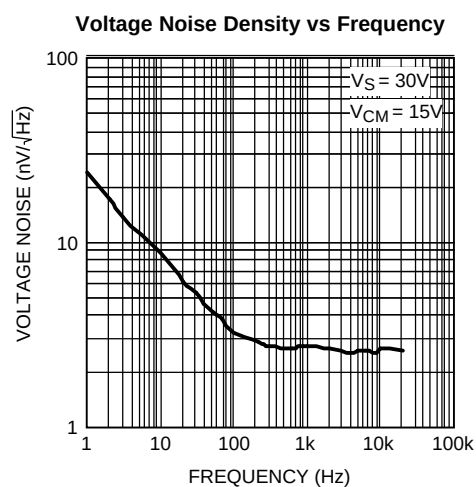
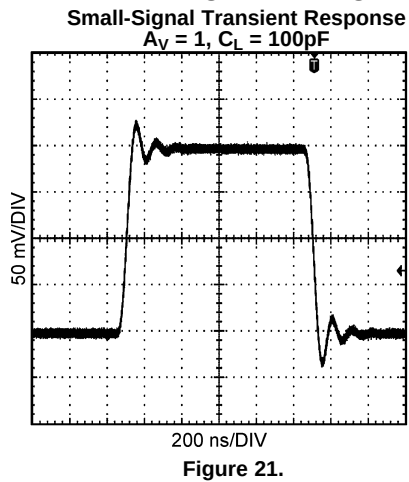
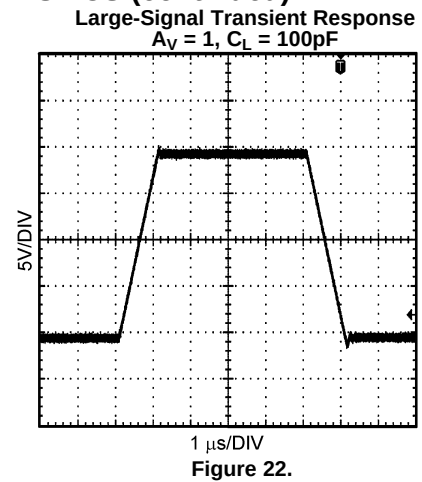


Figure 20.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)



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 23, 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 23.

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.

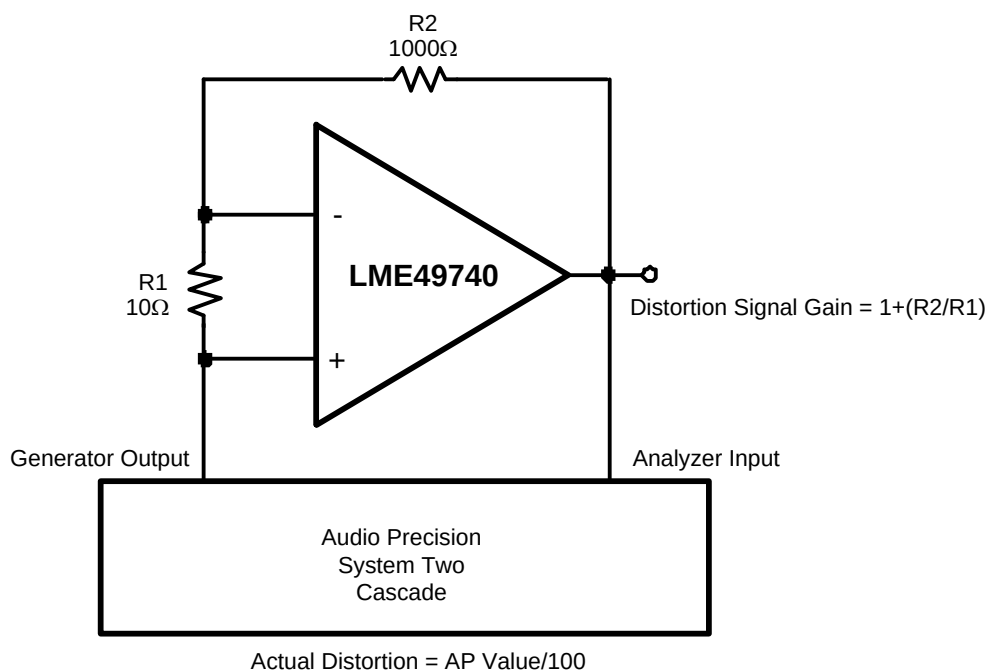


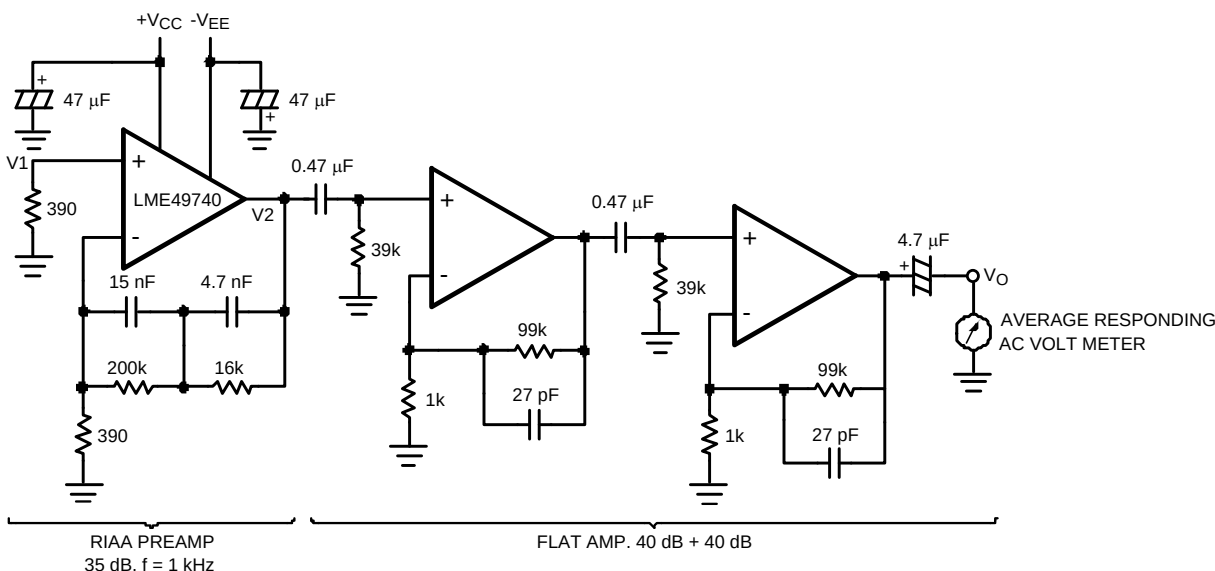
Figure 23. THD+N and IMD Distortion Test Circuit

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



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

Figure 24. Total Gain: 115 dB at $f = 1$ kHz
Input Referred Noise Voltage: $e_n = V_o/560,000$ (V)

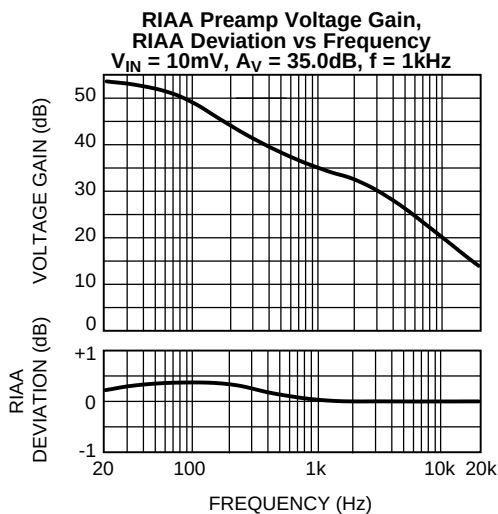


Figure 25.

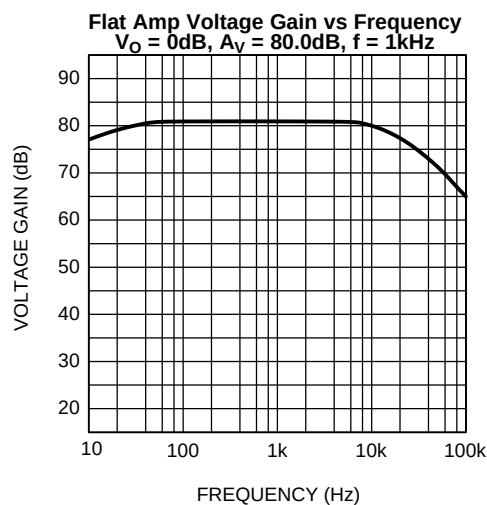
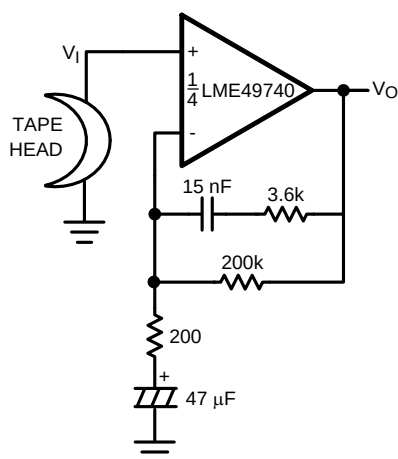


Figure 26.

TYPICAL APPLICATIONS



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

Figure 27. NAB Preamp

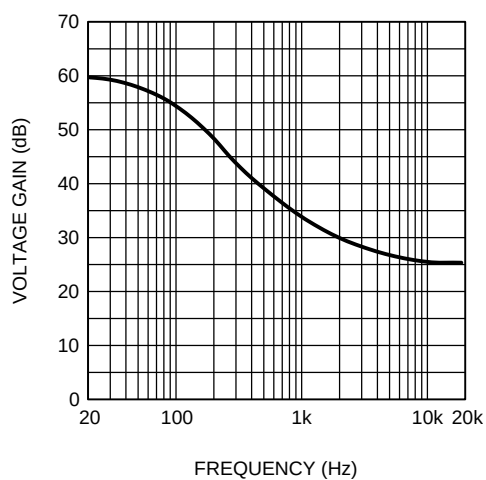
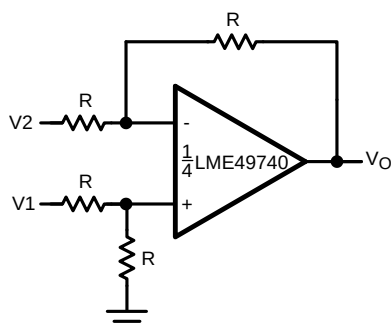
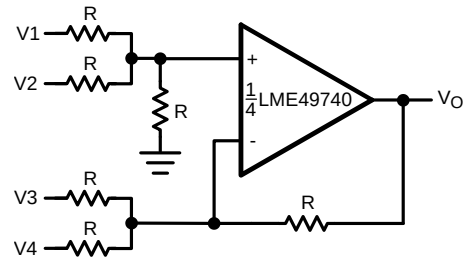


Figure 28. NAB Preamplifier Voltage Gain vs Frequency
 $V_{IN} = 10\text{mV}$, $A_V = 34.5\text{dB}$, $f = 1\text{kHz}$



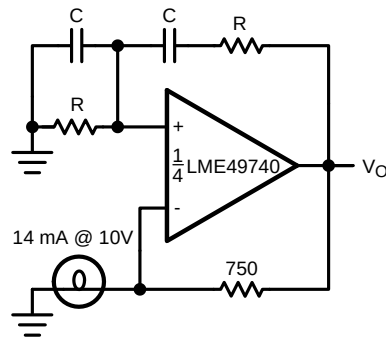
$$V_O = V_1 - V_2$$

Figure 29. Balanced to Single-Ended Converter



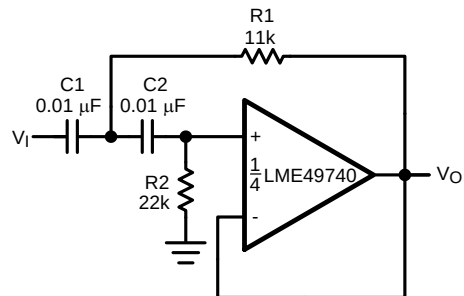
$$V_O = V_1 + V_2 - V_3 - V_4$$

Figure 30. Adder/Subtractor



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

Figure 31. Sine Wave Oscillator



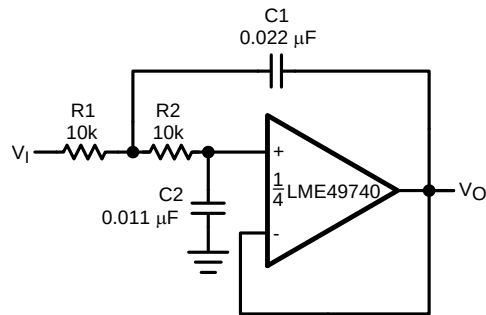
if $C_1 = C_2 = C$

$$R_1 = \frac{\sqrt{2}}{2\omega_o C}$$

$$R_2 = 2 \cdot R_1$$

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

Figure 32. Second-Order High-Pass Filter (Butterworth)



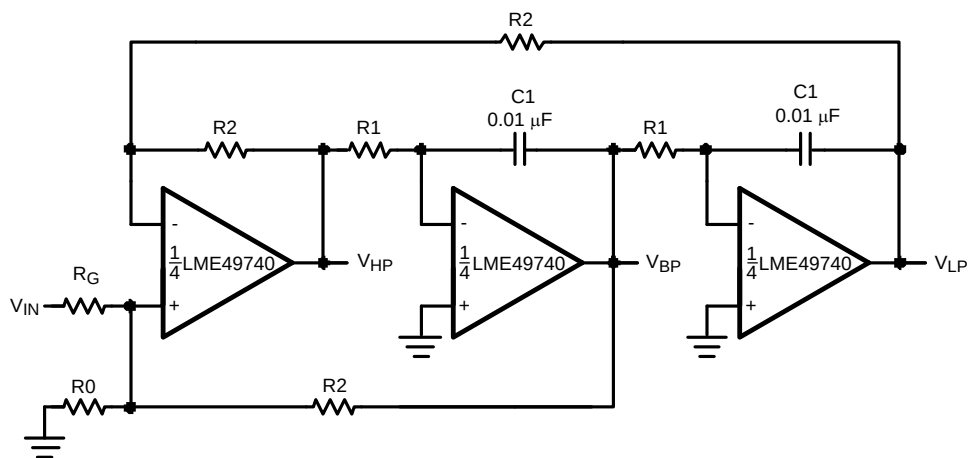
if $R1 = R2 = R$

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

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

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

Figure 33. Second-Order Low-Pass Filter (Butterworth)



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

Figure 34. State Variable Filter

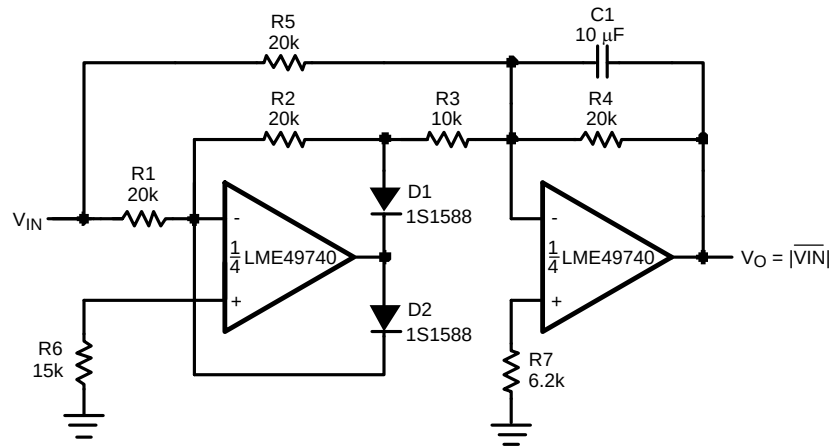


Figure 35. AC/DC Converter

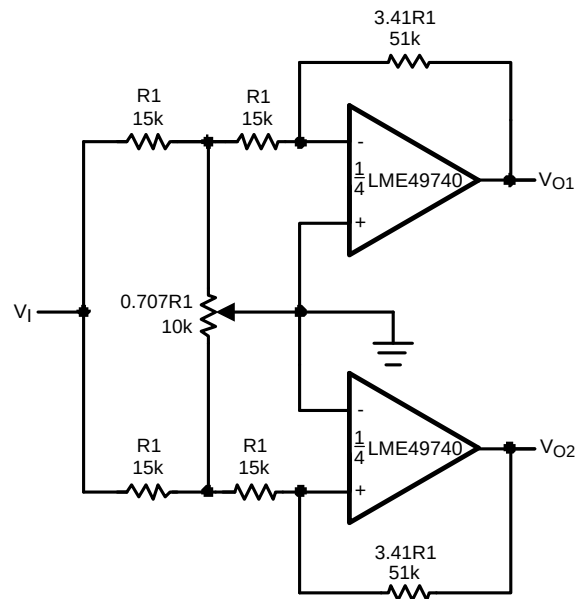


Figure 36. 2-Channel Panning Circuit (Pan Pot)

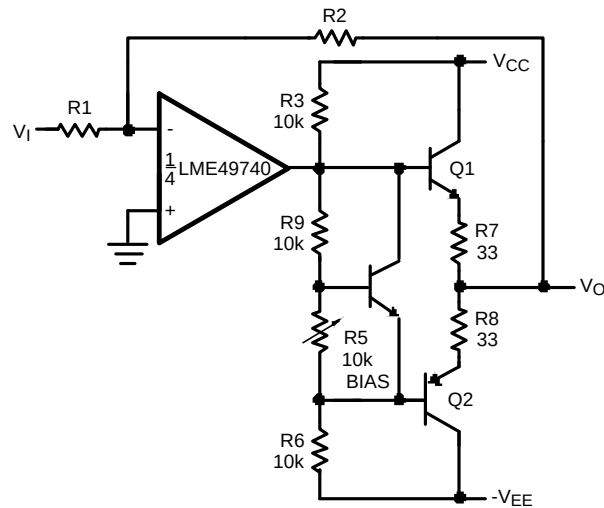
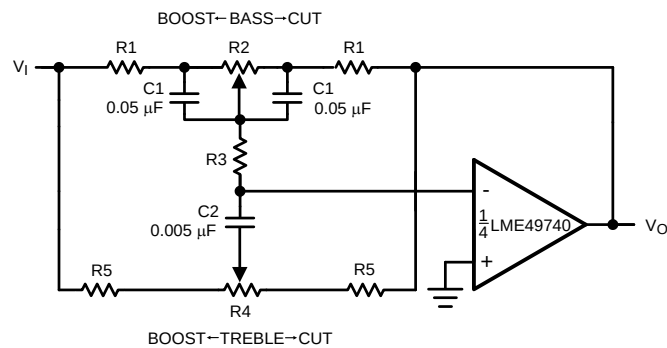


Figure 37. Line Driver



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

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

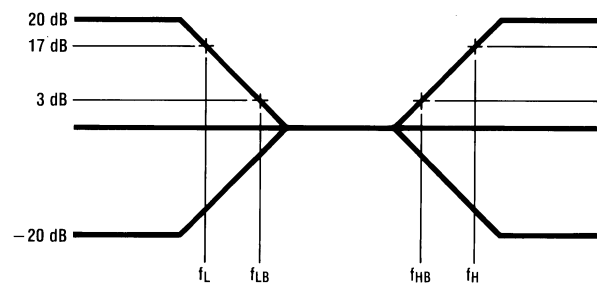
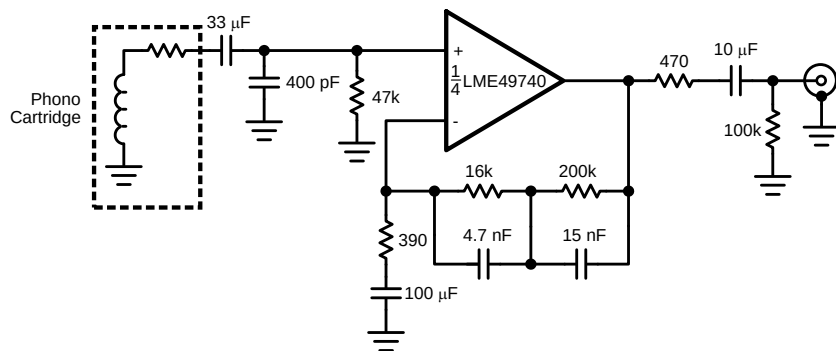
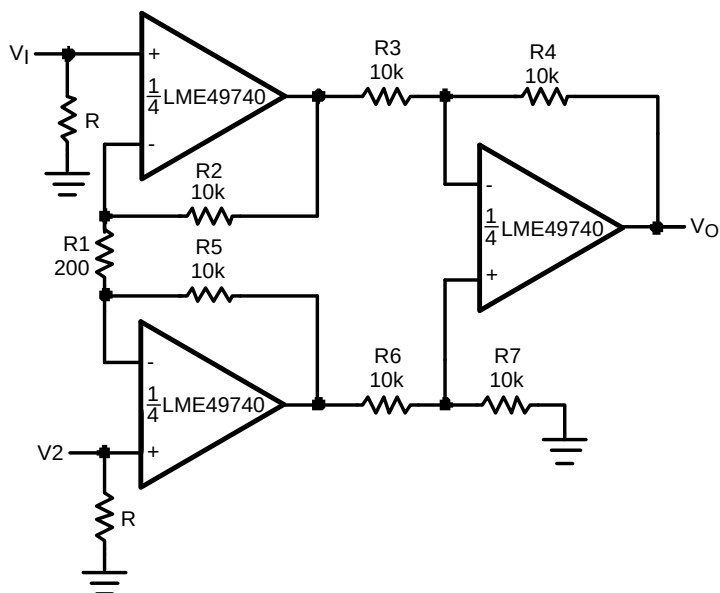


Figure 38. Tone Control



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

Figure 39. RIAA Preamp



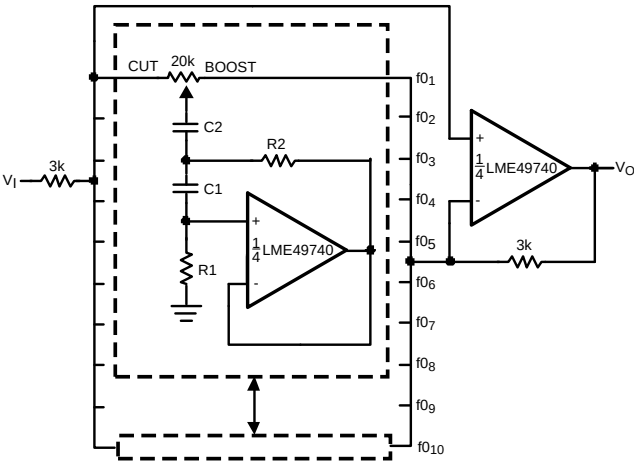
If $R2 = R5$, $R3 = R6$, $R4 = R7$

$$V_0 = \left(1 + \frac{2R2}{R1}\right) \frac{R4}{R3} (V2 - V1)$$

Illustration is:

$$V_0 = 101(V2 - V1)$$

Figure 40. Balanced Input Mic Amp



A. See [Table 1](#).

Figure 41. 10-Band Graphic Equalizer

Table 1. C₁, C₂, R₁, and R₂ Values for [Figure 41](#)⁽¹⁾

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

(1) At volume of change = ±12 dB Q = 1.7

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-Line to Molded Package (SO).
B	04/04/13	Changed layout of National Data Sheet to TI format.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LME49740MA/NOPB	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	-40 to 85	LME49740 MA	
LME49740MAX/NOPB	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	-40 to 85	LME49740 MA	
LME49740NA/NOPB	OBSOLETE	PDIP	NFF	14		TBD	Call TI	Call TI	-40 to 85	LME49740NA	

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

⁽⁴⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

⁽⁵⁾ Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

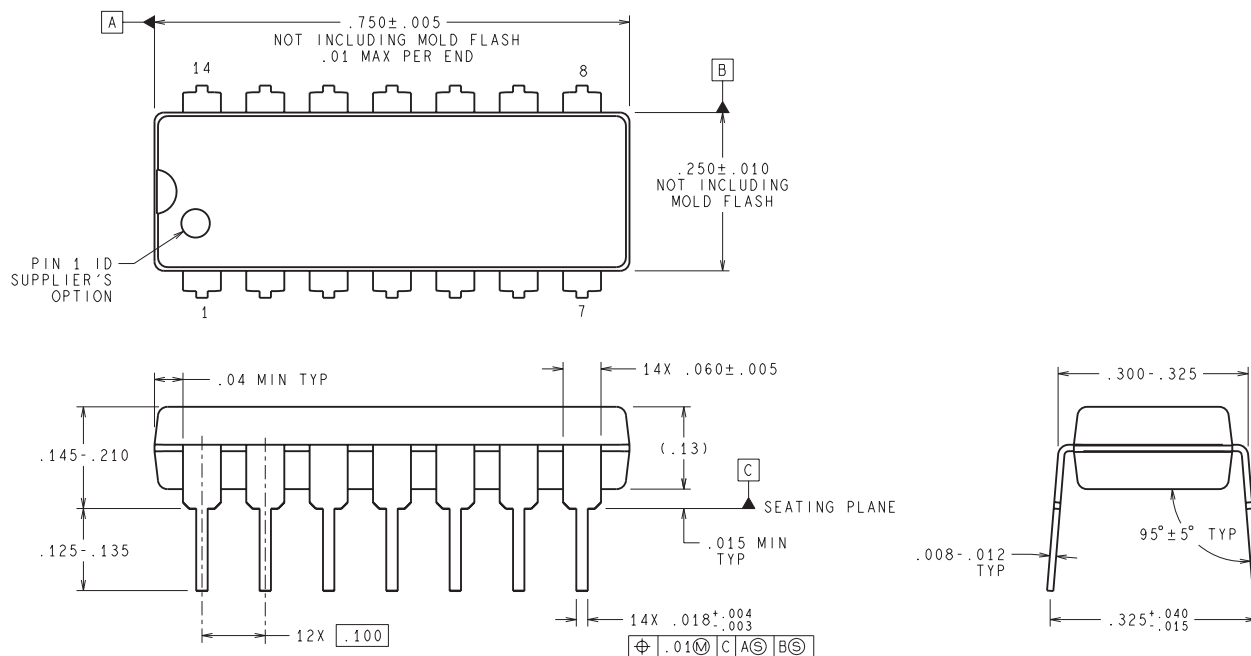
⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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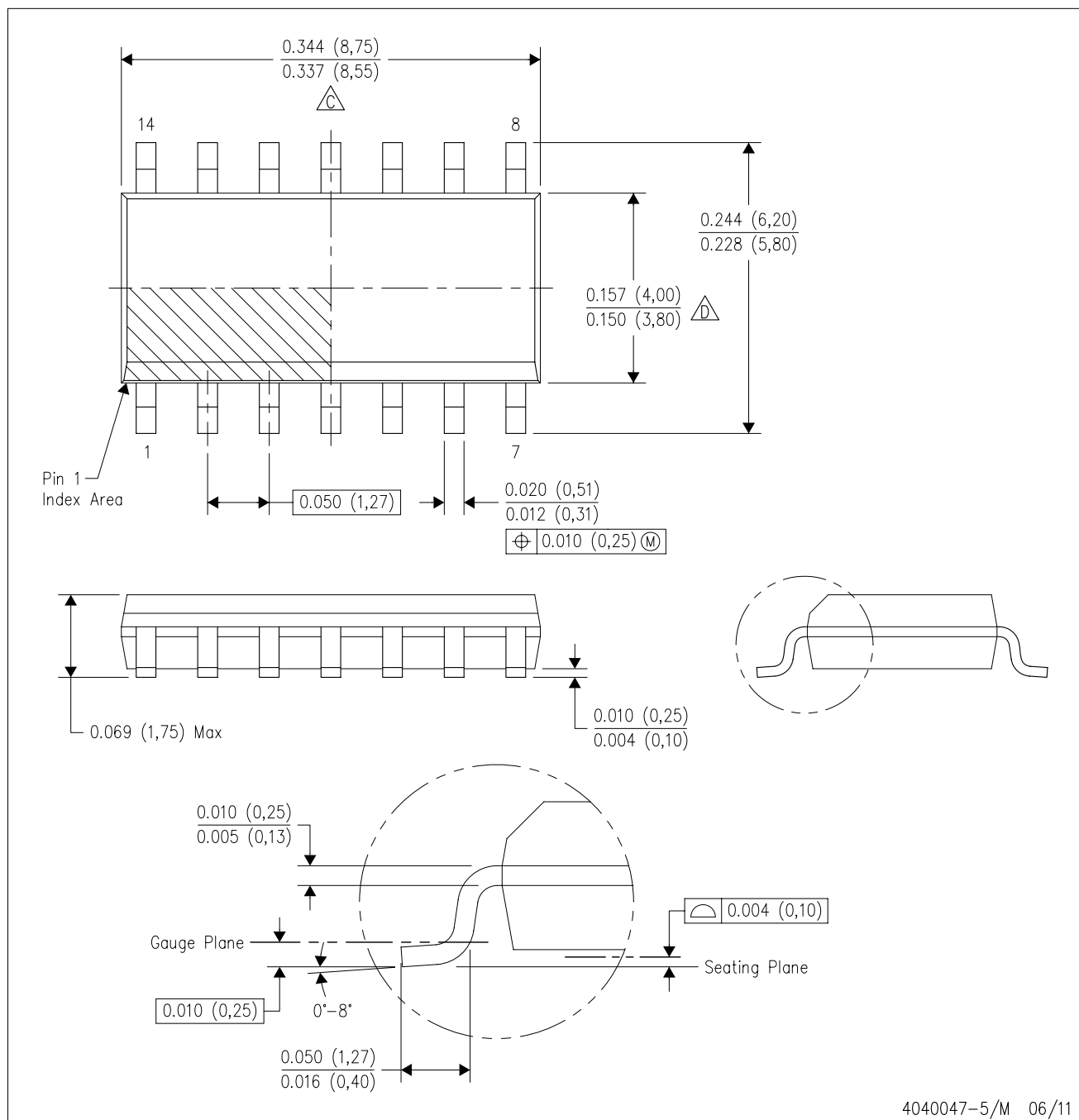


DIMENSIONS ARE IN INCHES
DIMENSIONS IN () FOR REFERENCE ONLY

N14A (Rev G)

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
 D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 E. Reference JEDEC MS-012 variation AB.

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