National Semiconductor

January 7, 2008

LME49723
Dual High Fidelity Audio Operational Amplifier

General Description

The LME49723 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 LME49723 audio operational amplifiers deliver superior audio signal amplification for outstanding audio performance. The LME49723 combines extremely low voltage noise density (3.6nV/$\sqrt{Hz}$) with vanishingly low THD+N (0.0002%) to easily satisfy the most demanding audio applications. To ensure that the most challenging loads are driven without compromise, the LME49723 has a high slew rate of ±20V/μs and an output current capability of ±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 LME49723's outstanding CMRR (100dB), PSRR (100dB), and V_{OS} (0.3mV) give the amplifier excellent operational amplifier DC performance.

The LME49723 has a wide supply range of ±2.5V to ±17V. Over this supply range the LME49723's input circuitry maintains excellent common-mode and power supply rejection, as well as maintaining its low input bias current. The LME49723 is unity gain stable.

The LME49723 is available in an 8–lead narrow body SOIC. Demonstration boards are available for each package.

Key Specifications

■ Power Supply Voltage Range	±2.5V to ±17V
■ THD+N ($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1kHz$)	
$R_L = 2k\Omega$	0.0002% (typ)
$R_L = 600\Omega$	0.0002% (typ)
■ Input Noise Density	3.6nV/$\sqrt{Hz}$ (typ)
■ Slew Rate	±8V/μs (typ)
■ Gain Bandwidth Product	17MHz (typ)
■ Open Loop Gain ($R_L = 600\Omega$)	105dB (typ)
■ Input Bias Current	200nA (typ)
■ Input Offset Voltage	0.3mV (typ)

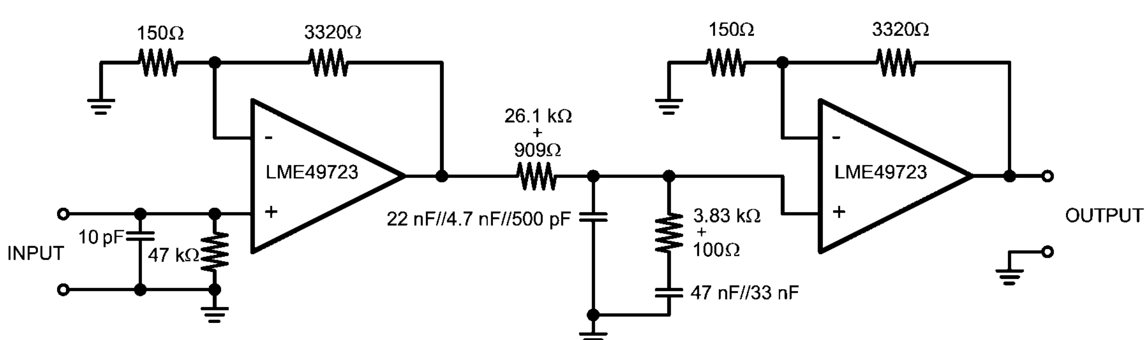
Features

- Easily drives 600Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- PSRR and CMRR exceed 100dB (typ)
- SOIC package

Applications

- High quality audio amplification
- High fidelity preamplifiers
- High fidelity multimedia
- 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

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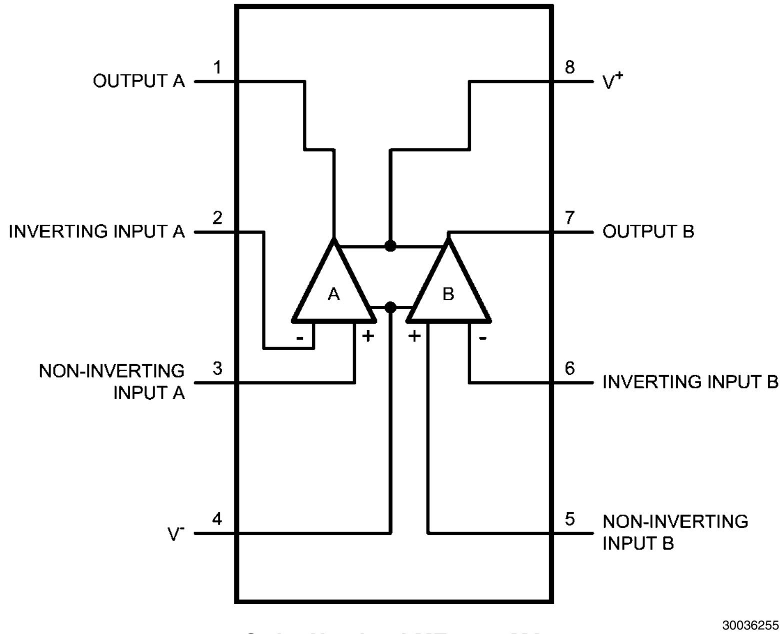
Passively Equalized RIAA Phono Preamplifier

Connection Diagram

Dual-In-Line Package



Order Number LME49723MA
See NS Package Number — M08A

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)	800V
ESD Susceptibility (Note 5)	180V
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (SO)	145°C/W
Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40°C \le T_A \le 85°C$
Supply Voltage Range	$\pm 2.5V \le V_S \le \pm 17V$

Electrical Characteristics for the LME49723 (Notes 1, 2)

The specifications apply for $V_S = \pm 7V$, $R_L = 2k\Omega$, $f_{IN} = 1kHz$, $T_A = 25°C$, unless otherwise specified.

Symbol	Parameter	Conditions	LME49723 Typical (Note 6)	LME49723 Limit (Note 7)	Units (Limits)
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, $V_{OUT} = 3V_{rms}$; $R_L = 2k\Omega$	0.0002		% (max)
		$R_L = 600\Omega$	0.0002	0.0004	
IMD	Intermodulation Distortion	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.0005		%
GBWP	Gain Bandwidth Product		19	15	MHz (min)
SR	Slew Rate		±8	±6	V/μs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$, –3dB referenced to output magnitude at f = 1kHz	4		MHz
e_n	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.45	0.65	μV_{RMS} (max)
	Equivalent Input Noise Density	f = 1kHz	3.2	5	$nV/\sqrt{Hz}$ (max)
		f = 10Hz	8.5		
i_n	Current Noise Density	f = 1kHz	0.7		$pA/\sqrt{Hz}$
		f = 10Hz	1.3		
V_{OS}	Offset Voltage		±0.3	1	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.2		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	ΔV_S = 20V (Note 8)	100	95	dB (min)
ISO_{CH-CH}	Channel-to-Channel Isolation	f_{IN} = 1kHz	118		dB
		f_{IN} = 20kHz	112		
I_B	Input Bias Current	V_{CM} = 0V	200	300	nA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.1		nA/°C
I_{OS}	Input Offset Current	V_{CM} = 0V	7	100	nA (max)
V_{IN-CM}	Common-Mode Input Voltage Range		±14	(V+) – 2.0 (V-) + 2.0	V (min)
CMRR	Common-Mode Rejection	–10V<Vcm<10V	100	90	dB (min)
Z_{IN}	Differential Input Impedance		30		kΩ
	Common Mode Input Impedance	–10V<Vcm<10V	1000		MΩ
A_{VOL}	Open Loop Voltage Gain	–10V<Vout<10V, $R_L = 600\Omega$	100	98	dB (min)
		–10V<Vout<10V, $R_L = 2k\Omega$	105		
		–10V<Vout<10V, $R_L = 10k\Omega$	105		

Symbol	Parameter	Conditions	LME49723 Typical (Note 6)	LME49723 Limit (Note 7)	Units (Limits)
V_{OUTMAX}	Maximum Output Voltage Swing	$R_L = 600\Omega$	±13.5	±12.5	V (min)
		$R_L = 2k\Omega$	±14.0		
		$R_L = 10k\Omega$	±14.1		
I_{OUT}	Output Current	$R_L = 600\Omega$, $V_S = \pm 17V$	±25	±21	mA (min)
I_{OUT-CC}	Instantaneous Short Circuit Current		+53 –42		mA
R_{OUT}	Output Impedance	$f_{IN} = 10kHz$ Closed-Loop Open-Loop	 0.01 13		Ω
C_{LOAD}	Capacitive Load Drive Overshoot	100pF	16		%
I_S	Total Quiescent Current	$I_{OUT} = 0mA$	6.7	7.5	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).

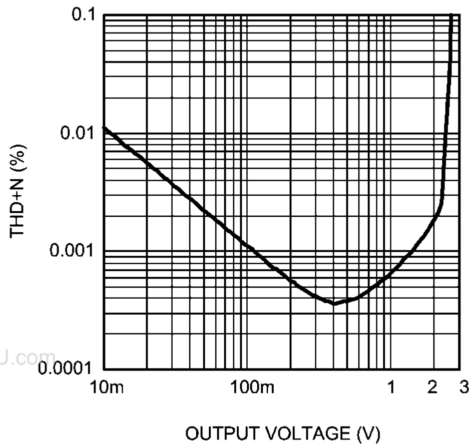
Note 6: Typical specifications are specified at +25ºC and represent the most likely parametric norm.

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

Note 8: 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
$V_S = \pm5V$, $R_L = 2k\Omega$



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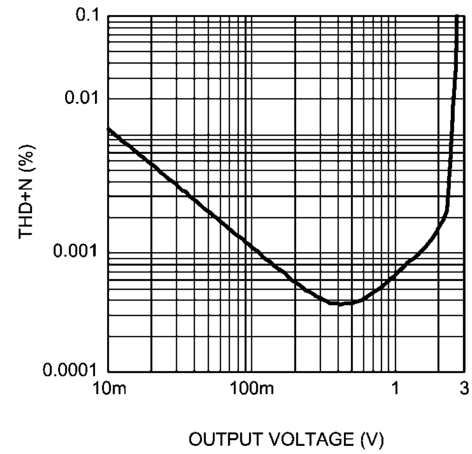
THD+N vs Output Voltage
$V_S = \pm5V$, $R_L = 10k\Omega$



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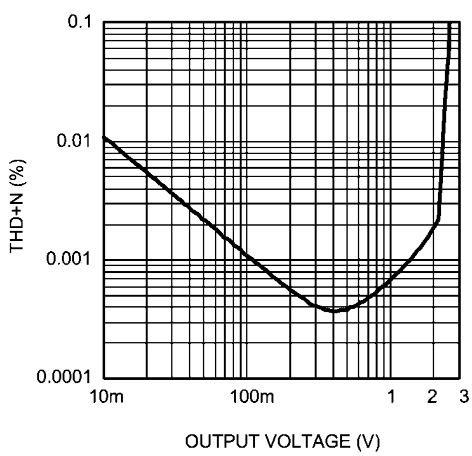
THD+N vs Output Voltage
$V_S = \pm5V$, $R_L = 600\Omega$



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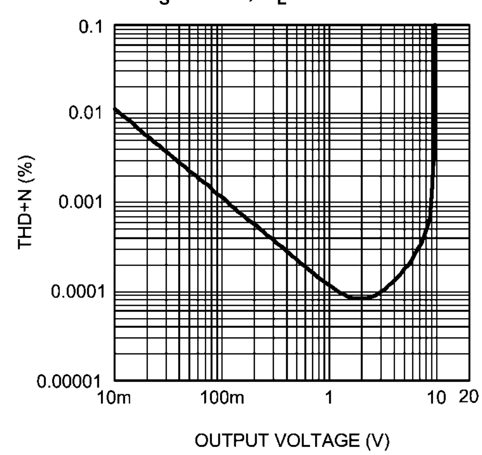
THD+N vs Output Voltage
$V_S = \pm15V$, $R_L = 2k\Omega$



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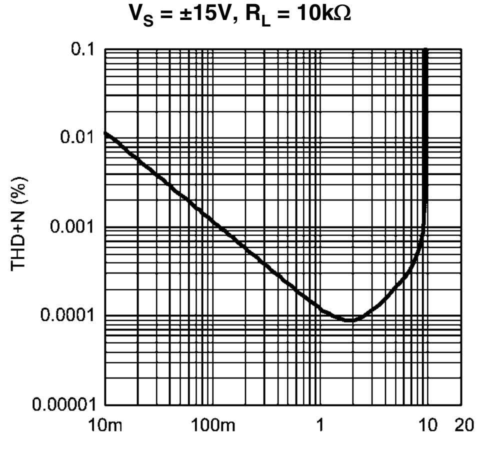
THD+N vs Output Voltage
$V_S = \pm15V$, $R_L = 10k\Omega$



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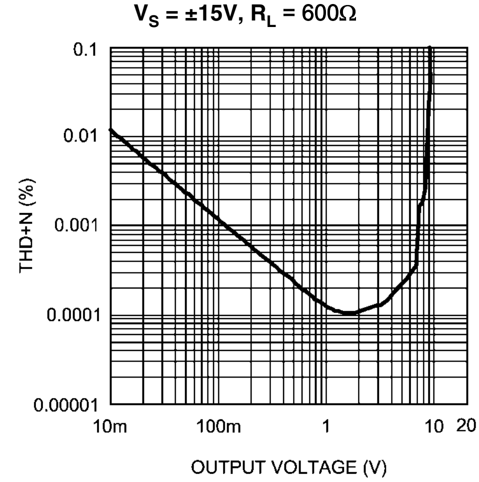
THD+N vs Output Voltage
$V_S = \pm15V$, $R_L = 600\Omega$



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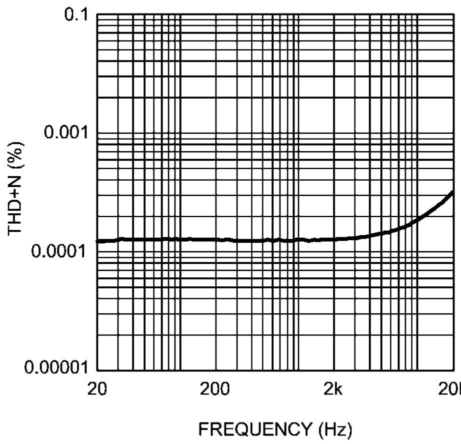
THD+N vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 2k\Omega$



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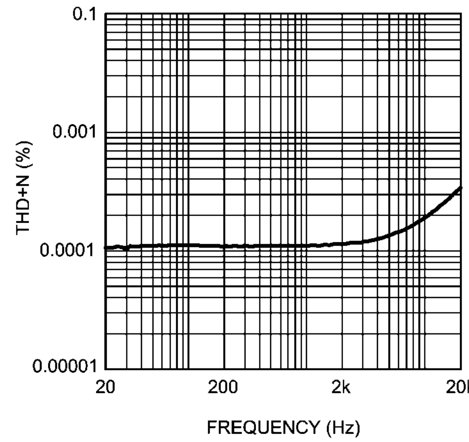
THD+N vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 10k\Omega$



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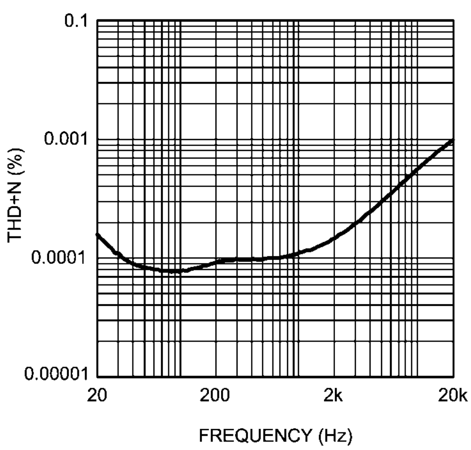
THD+N vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 600\Omega$



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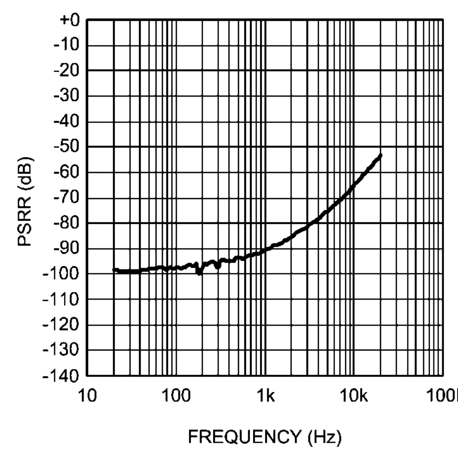
PSRR+ vs Frequency
$V_S = \pm 15V$, $R_L = 2k\Omega$, $V_{RIPPLE} = 200mV_{PP}$



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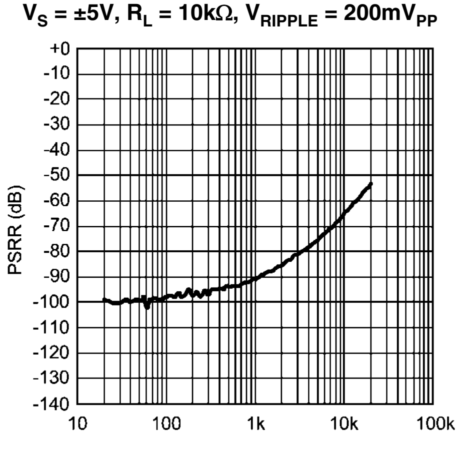
PSRR+ vs Frequency
$V_S = \pm 5V$, $R_L = 10k\Omega$, $V_{RIPPLE} = 200mV_{PP}$



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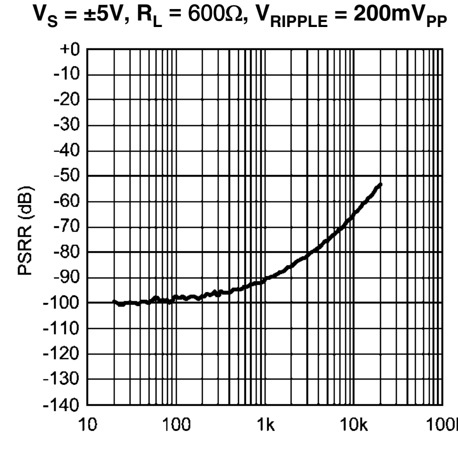
PSRR+ vs Frequency
$V_S = \pm 5V$, $R_L = 600\Omega$, $V_{RIPPLE} = 200mV_{PP}$



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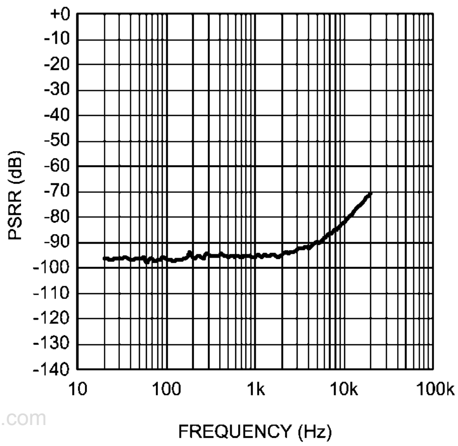
PSRR+ vs Frequency
V_S = ±15V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{PP}



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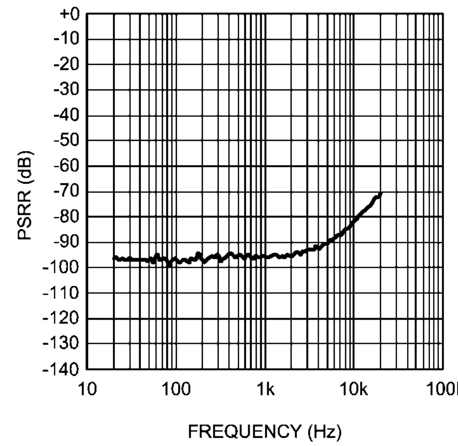
PSRR+ vs Frequency
V_S = ±15V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{PP}



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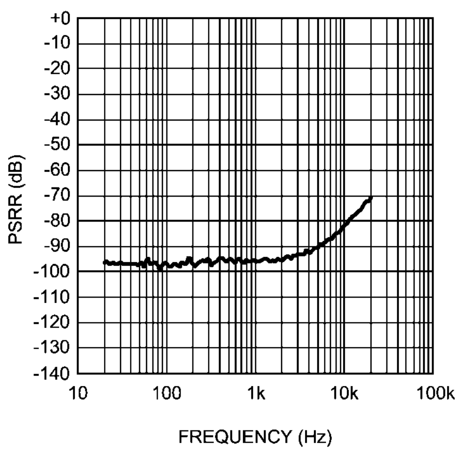
PSRR+ vs Frequency
V_S = ±15V, R_L = 600Ω, V_{RIPPLE} = 200mV_{PP}



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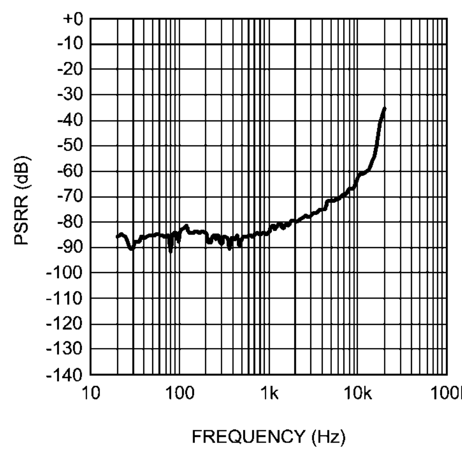
PSRR- vs Frequency
V_S = ±5V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{PP}



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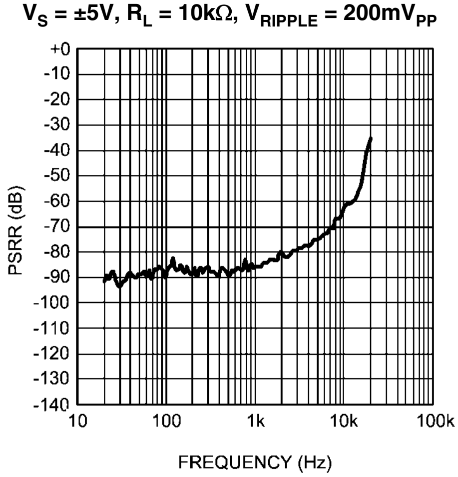
PSRR- vs Frequency
V_S = ±5V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{PP}



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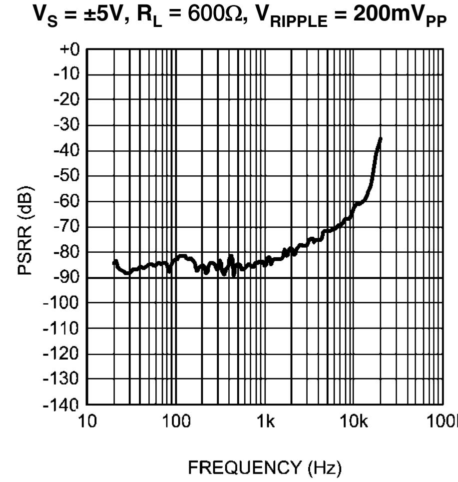
PSRR- vs Frequency
V_S = ±5V, R_L = 600Ω, V_{RIPPLE} = 200mV_{PP}



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PSRR- vs Frequency
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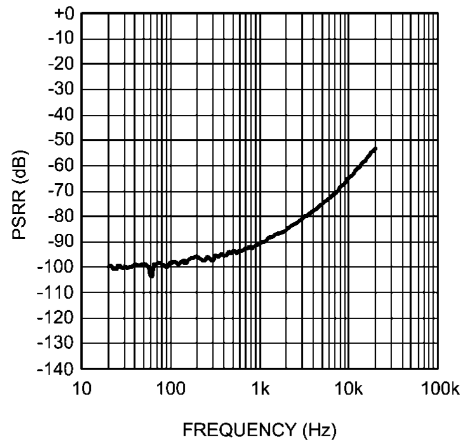

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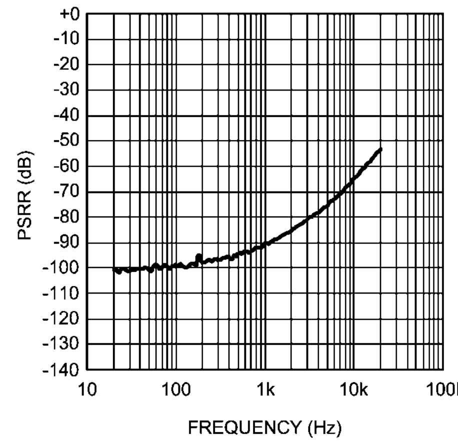
PSRR- vs Frequency
$V_S = \pm15V$, $R_L = 10k\Omega$, $V_{RIPPLE} = 200mV_{PP}$



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PSRR- vs Frequency
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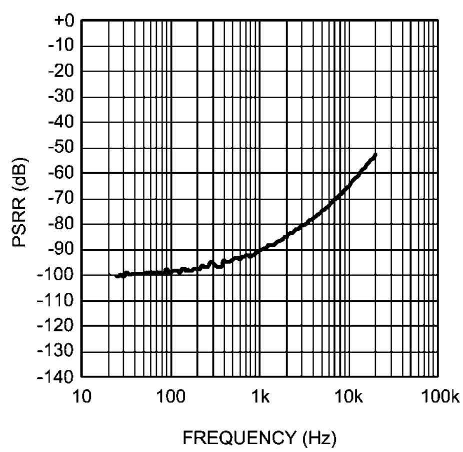

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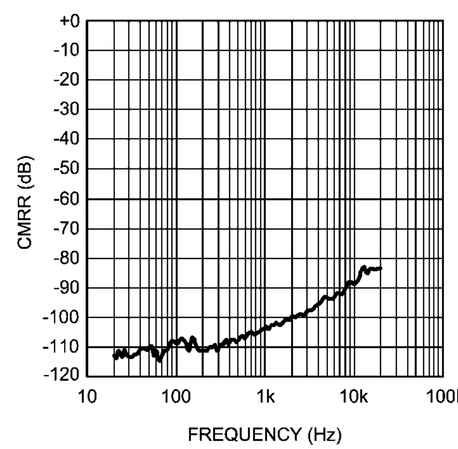
CMRR vs Frequency
$V_S = \pm15V$, $R_L = 2k\Omega$, $V_{IN} = 200mV_{PP}$



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CMRR vs Frequency
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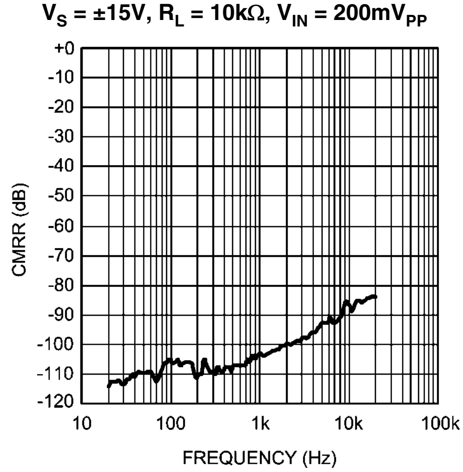

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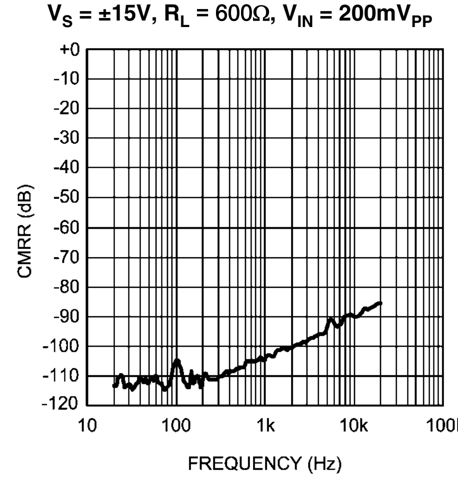
CMRR vs Frequency
$V_S = \pm15V$, $R_L = 600\Omega$, $V_{IN} = 200mV_{PP}$



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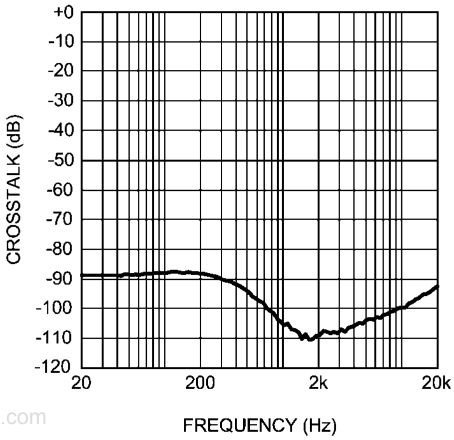
Crosstalk vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 2k\Omega$,



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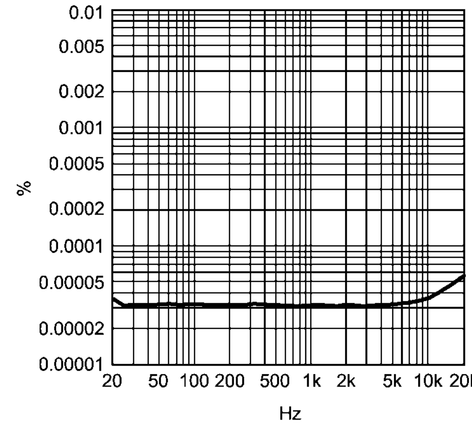
Crosstalk vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 10k\Omega$,



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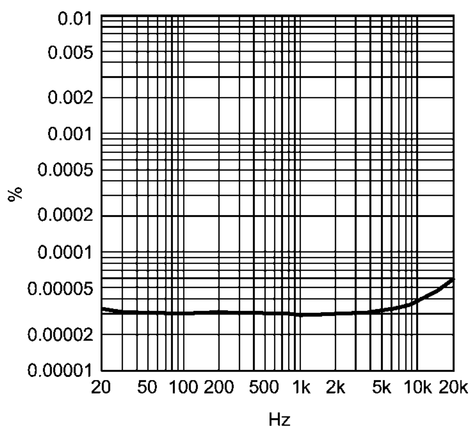
Crosstalk vs Frequency
$V_S = \pm 15V$, $V_{OUT} = 3V_{RMS}$, $R_L = 600\Omega$,



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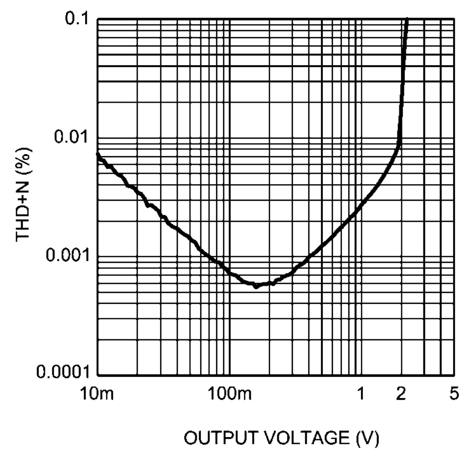
IMD vs Output Voltage
$V_S = \pm 5V$, $R_L = 2k\Omega$,



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IMD vs Output Voltage
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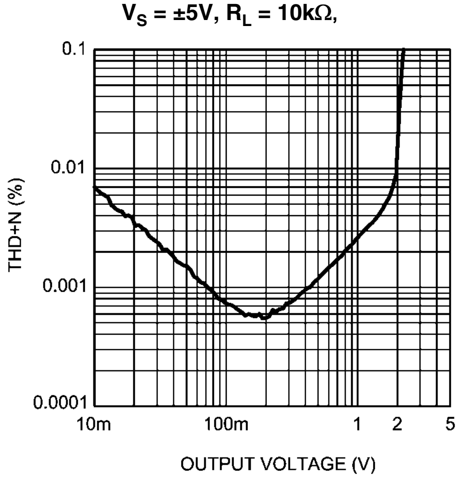

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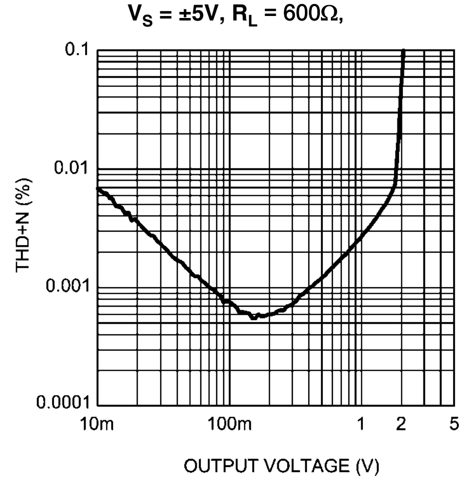
IMD vs Output Voltage
$V_S = \pm 5V$, $R_L = 600\Omega$,



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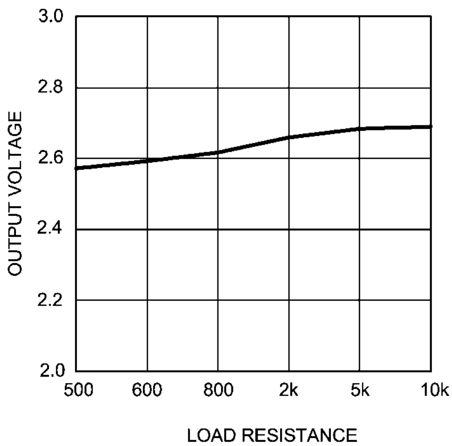
Output Voltage vs Load Resistance
V_S = ±5V, THD+N = 1%



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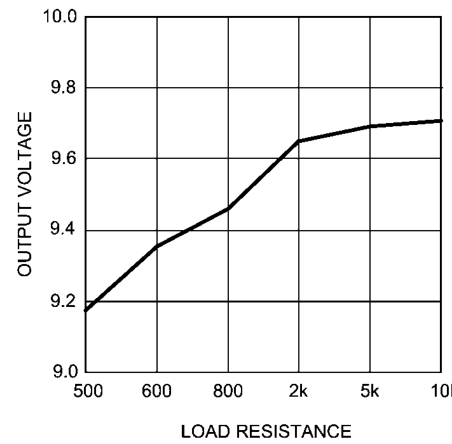
Output Voltage vs Load Resistance
V_{DD} = 15V, V_{SS} = –15V, THD+N = 0.1%



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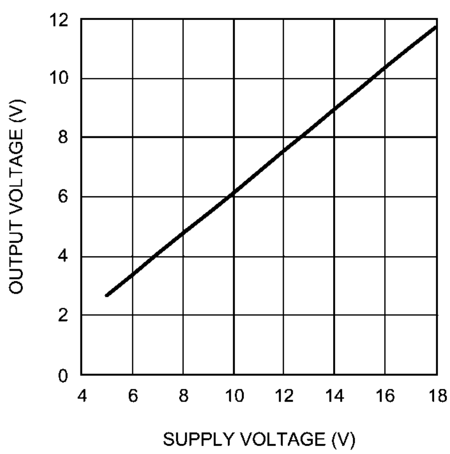
Output Voltage vs Supply Voltage
R_L = 2kΩ, THD+N = 0.1%



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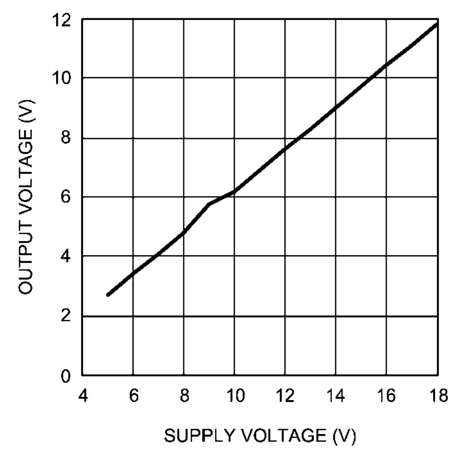
Output Voltage vs Supply Voltage
R_L = 10kΩ, THD+N = 0.1%



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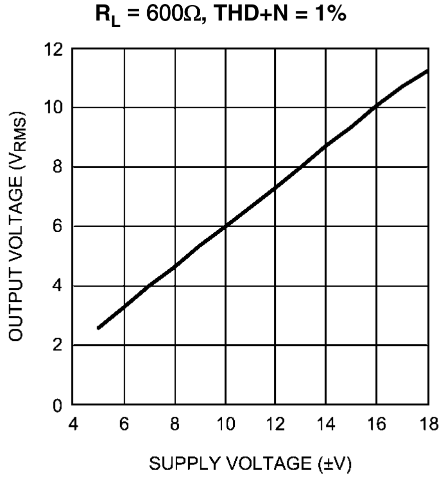
Output Voltage vs Supply Voltage
R_L = 600Ω, THD+N = 1%



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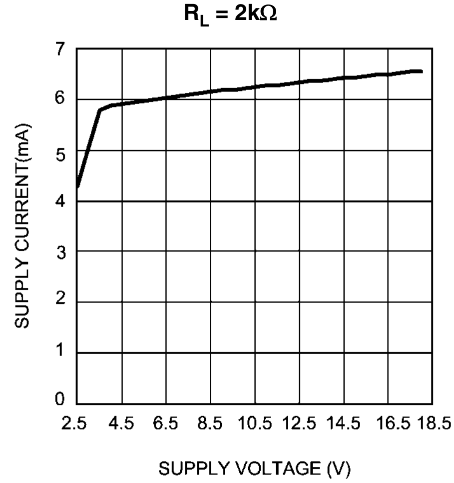
Supply Current vs Supply Voltage
R_L = 2kΩ



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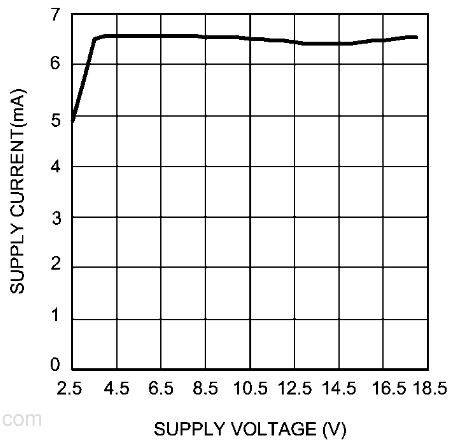
Supply Current vs Supply Voltage
R_L = 10kΩ



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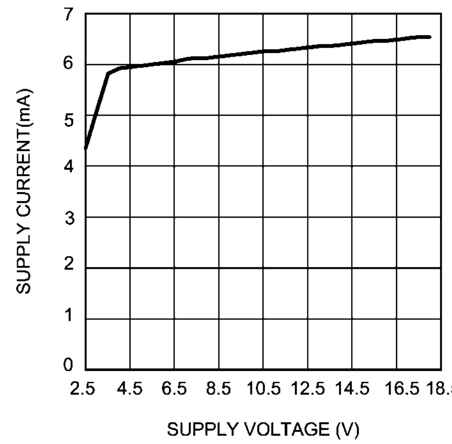
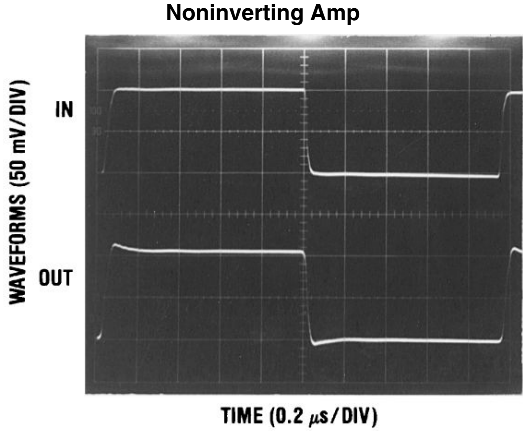
Supply Current vs Supply Voltage
R_L = 600Ω



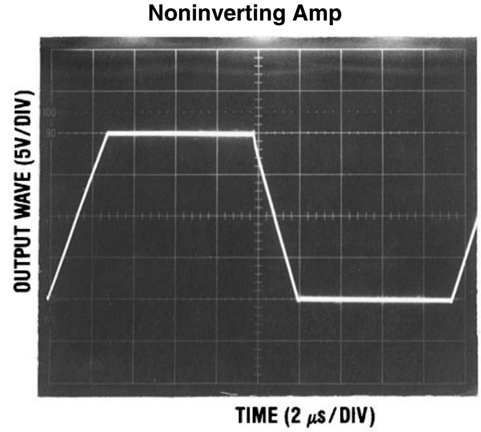
30036280

Noninverting Amp



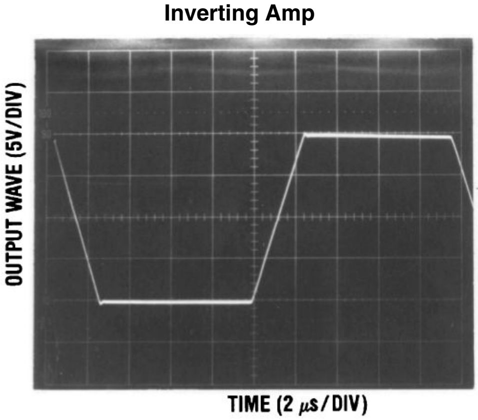
30036224

Noninverting Amp



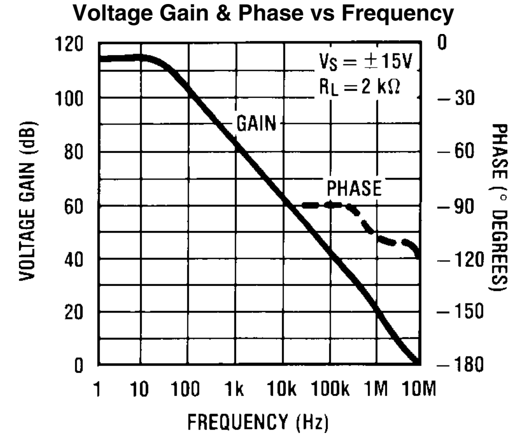
30036225

Inverting Amp



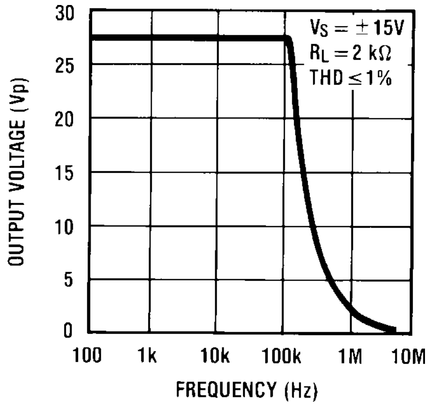
30036226

Voltage Gain & Phase vs Frequency



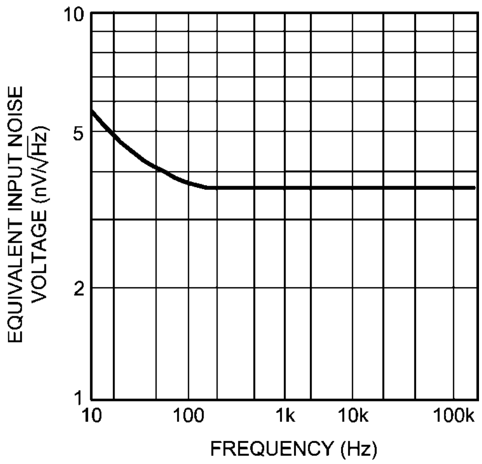
30036210

Power Bandwidth



30036215

Equivalent Input Noise vs Frequency



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Application Information

DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49723 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 LME49723'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.

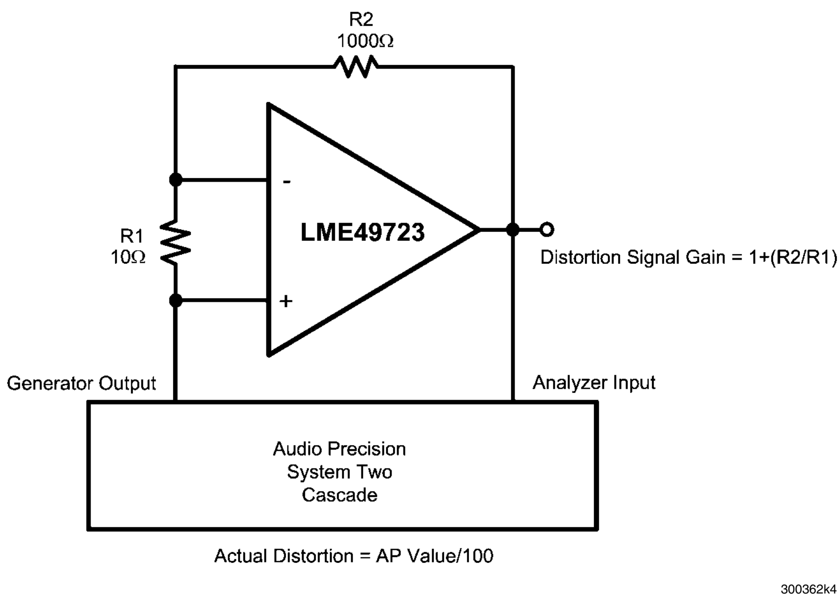
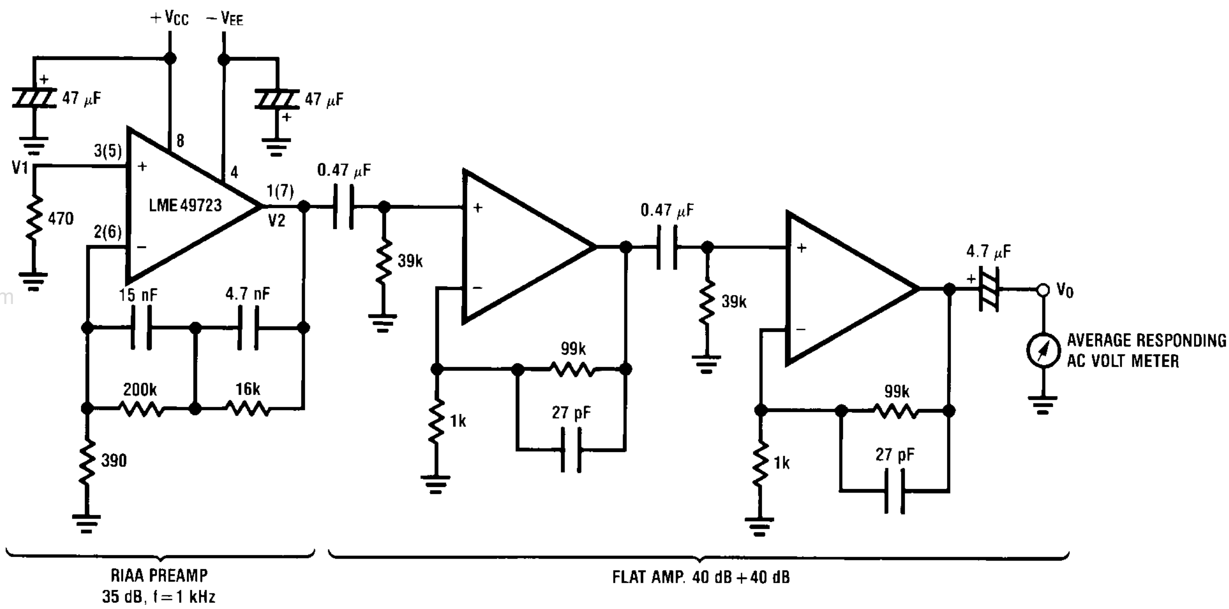


FIGURE 1. THD+N and IMD Distortion Test Circuit

The LME49723 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.

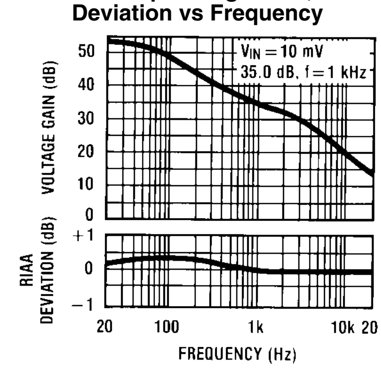


30036227

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

Noise Measurement Circuit
Total Gain: 115 dB @f = 1 kHz
Input Referred Noise Voltage: e_n = V0/560,000 (V)

RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



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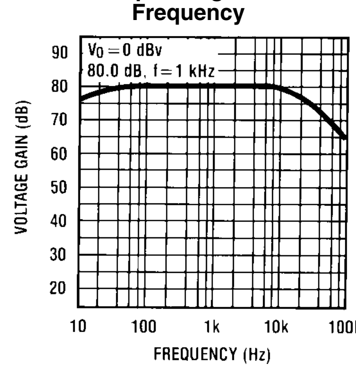
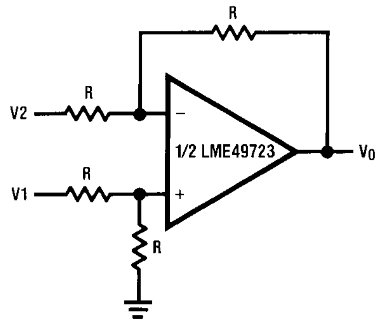
Flat Amp Voltage Gain vs Frequency



30036229

TYPICAL APPLICATIONS

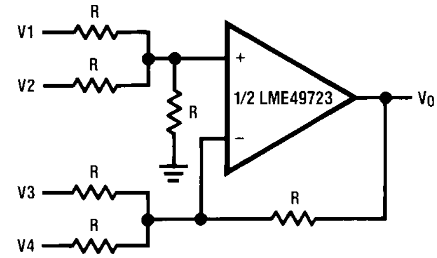
Balanced to Single Ended Converter



30036232

$V_O = V1 - V2$

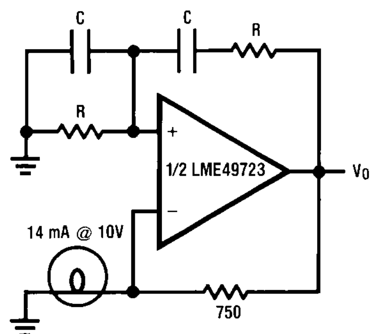
Adder/Subtracter



30036233

$V_O = V1 + V2 - V3 - V4$

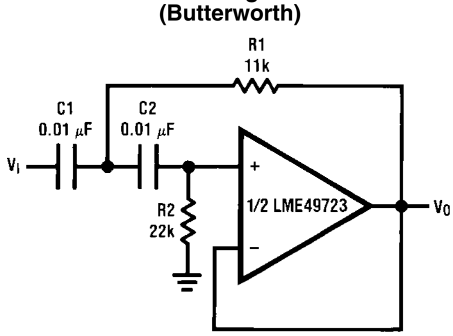
Sine Wave Oscillator



30036234

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

Second Order High Pass Filter (Butterworth)



30036235

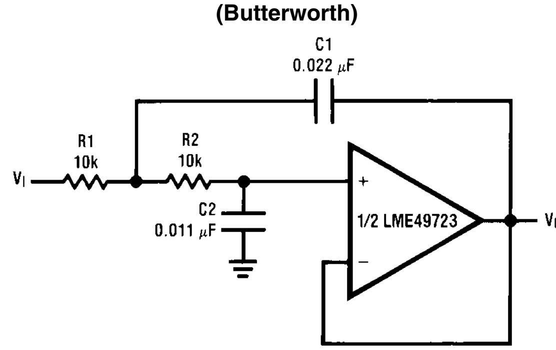
if C1 = C2 = C

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

$$R2 = 2 \bullet R1$$

Illustration is f_0 = 1 kHz

Second Order Low Pass Filter (Butterworth)



30036236

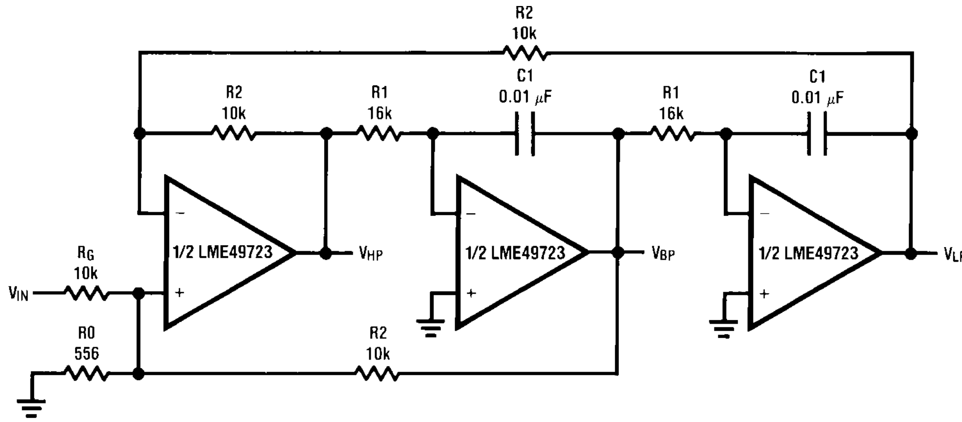
if R1 = R2 = R

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

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

Illustration is f_0 = 1 kHz

State Variable Filter

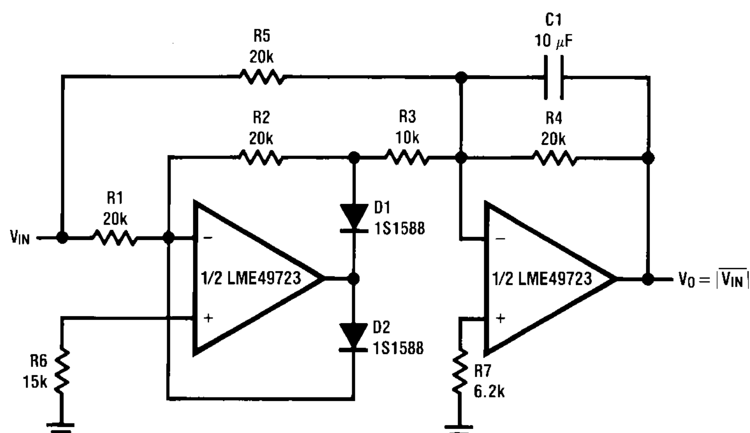


30036237

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

Illustration is f_0 = 1 kHz, Q = 10, A_{BP} = 1

AC/DC Converter



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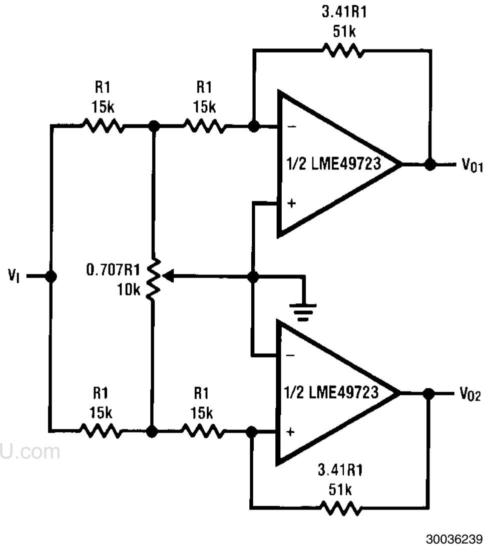
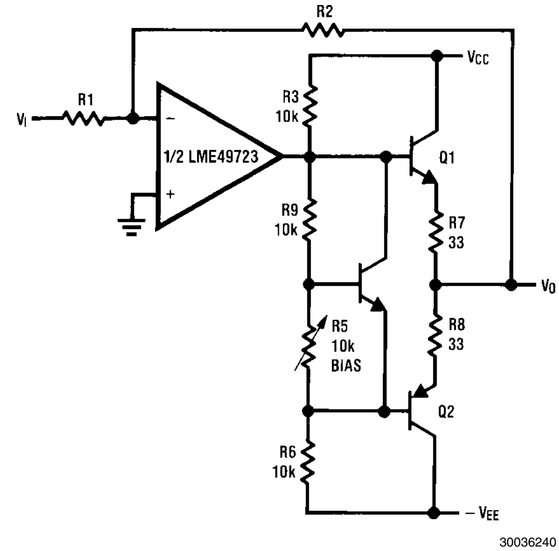
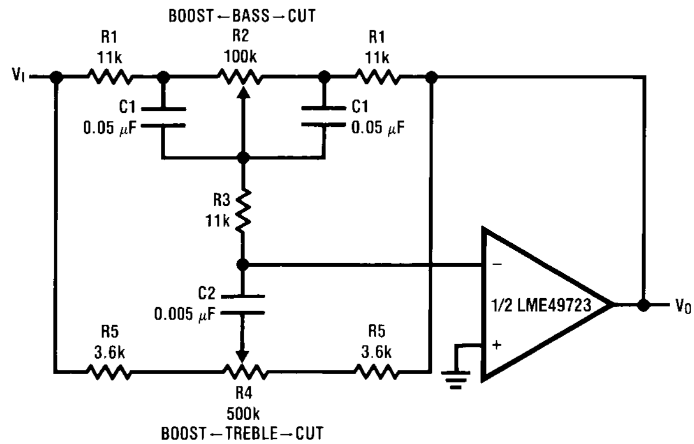
2 Channel Panning Circuit (Pan Pot)



Line Driver



Tone Control



30036241

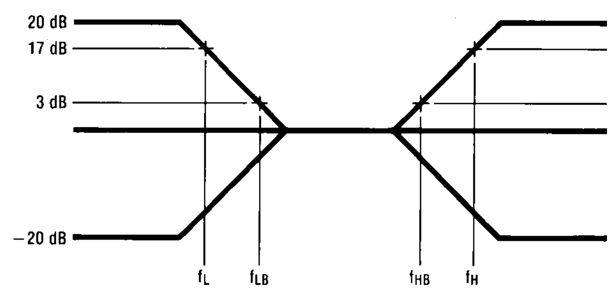
$$f_L = \frac{1}{2\pi R2C1}, f_{LB} = \frac{1}{2\pi R1C1}$$

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

Illustration is:

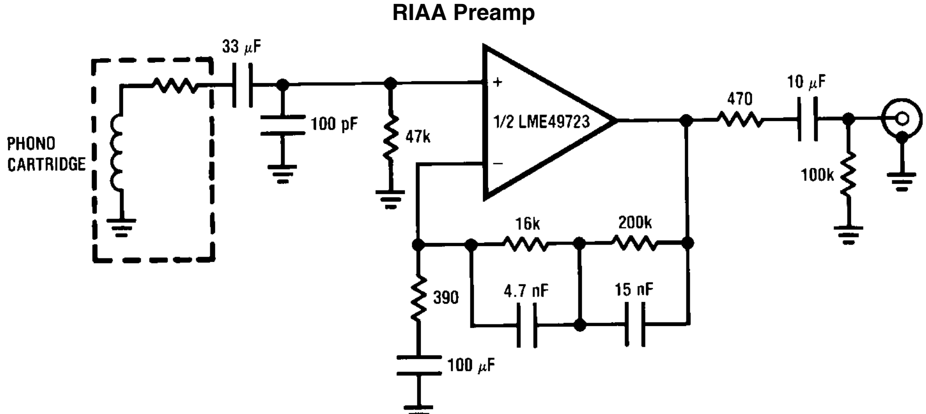
f_L = 32 Hz, f_{LB} = 320 Hz

f_H =11 kHz, f_{HB} = 1.1 kHz



30036242

RIAA Preamp



30036203

A_v = 35 dB

E_n = 0.33 μV

S/N = 90 dB

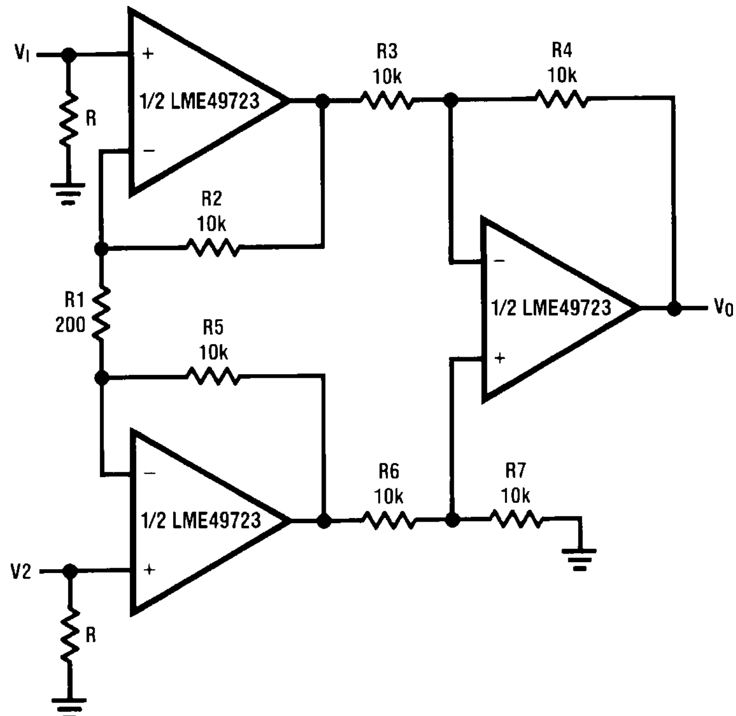
f = 1 kHz

A Weighted

A Weighted, V_{IN} = 10 mV

@f = 1 kHz

Balanced Input Mic Amp



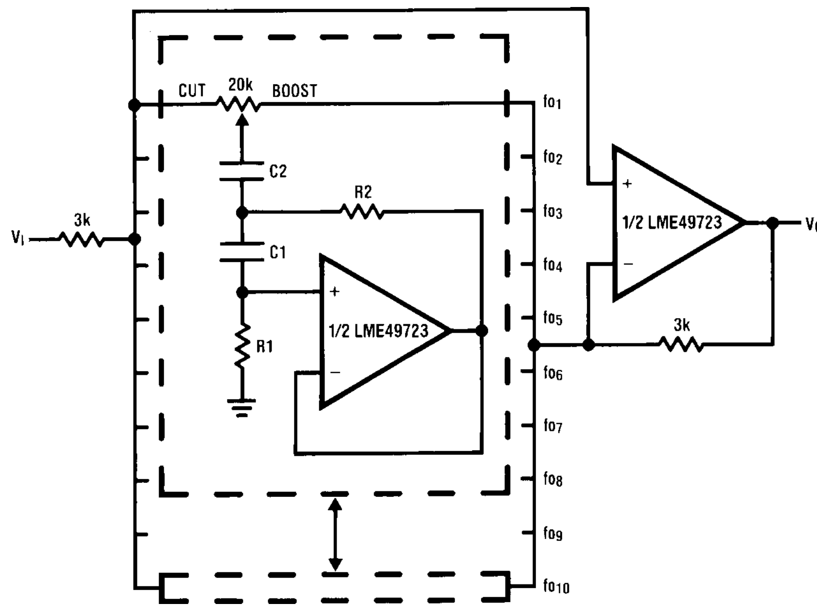
If R2 = R5, R3 = R6, R4 = R7

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

Illustration is:

V0 = 101(V2 – V1)

10 Band Graphic Equalizer



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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 9: At volume of change = ±12 dB

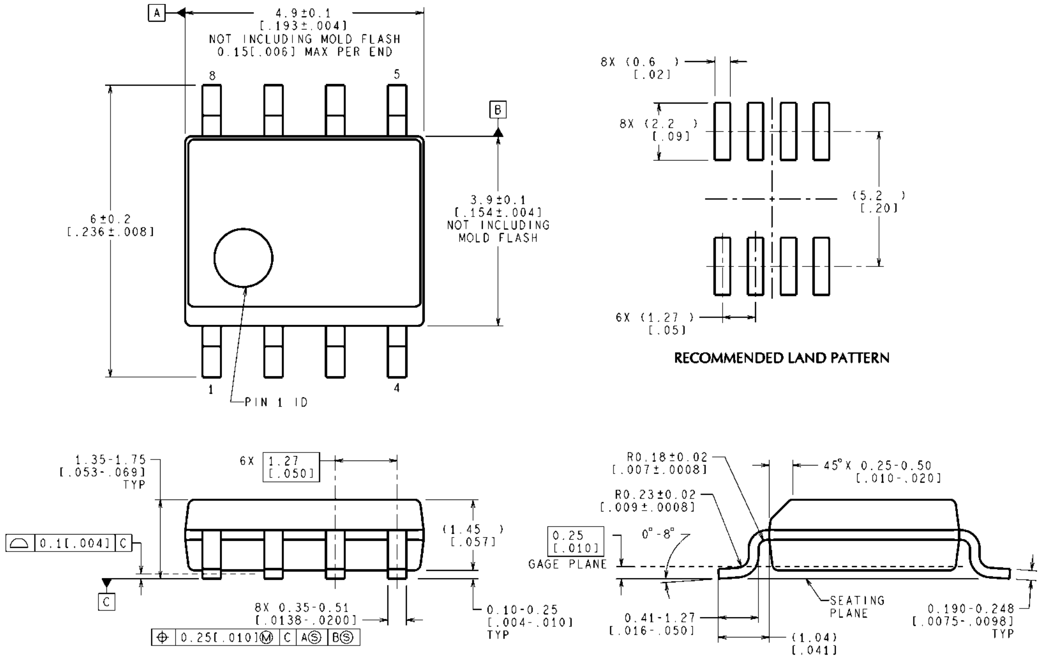
Q = 1.7

Reference: “AUDIO/RADIO HANDBOOK”, National Semiconductor, 1980, Page 2–61

Revision History

Rev	Date	Description
1.0	01/07/08	Initial release.

Physical Dimensions inches (millimeters) unless otherwise noted



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M08A (Rev L)

Narrow SOIC Package
Order Number LME49723MA
NS Package Number M08A

Notes

Notes

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