National Semiconductor

LME49880 Overture® E-Series

April 22, 2010

Dual JFET Input Audio Operational Amplifier

General Description

The LME49880 is part of the ultra-low distortion, low noise, high slew rate operational amplifier series optimized and fully specified for high performance, high fidelity application. The LME49880 is developed in JFET technology and reducing the flicker noise as well as the noise corner frequency significantly. It combines low voltage noise density ($7nV/\sqrt{Hz}$) with very low THD+N (0.00003%). The LME49880 has a high slew rate of ±17 V/μs and an output current capability of ±22mA. It drives 600Ω loads to within 1.3V of either power supply voltage.

The LME49880 has a wide supply range of ±5V to ±17V. Its outstanding GAIN (120dB), and low input bias current (5pA) give the amplifier excellent operational amplifier DC performance. The LME49880 is unity gain stable and capable of driving complex loads with values as high as 100pF. It is available in an 8-lead narrow body PSOP.

Key Specifications

- Input Bias Current 5pA (typ)
- Power Supply Voltage Range ±5V to ±17V
- THD+N
  (A_V = 1, V_{OUT} = $3V_{RMS}$, f_{IN} = 1kHz)
  - R_L = 2kΩ 0.00003% (typ)
  - R_L = 600Ω 0.00003% (typ)
- Slew Rate ±17V/μs (typ)
- Gain Bandwidth Product 25MHz (typ)
- Open Loop Gain (R_L = 600Ω) 115dB (typ)
- Input Noise Density $7nV/\sqrt{Hz}$ (typ)
- Input Offset Voltage 5mV (typ)
- CMRR 110dB (typ)

Features

- Easily drives 600Ω loads
- Output short circuit protection

Applications

- Ultra high quality audio signal processing
- Preamplifier
- Spectrum analyzers
- Ultrasound preamplifier
- Active filters

Typical Application

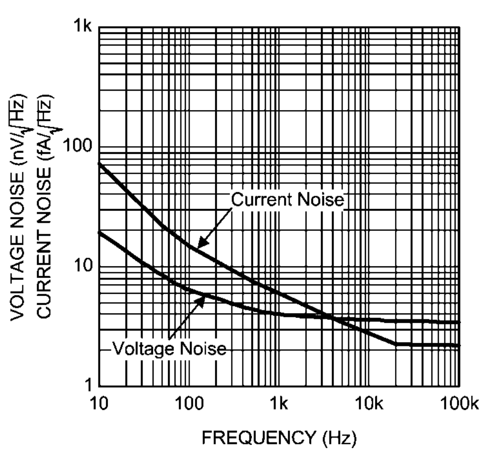

FIGURE 1: Current Noise and Voltage Spectral Density

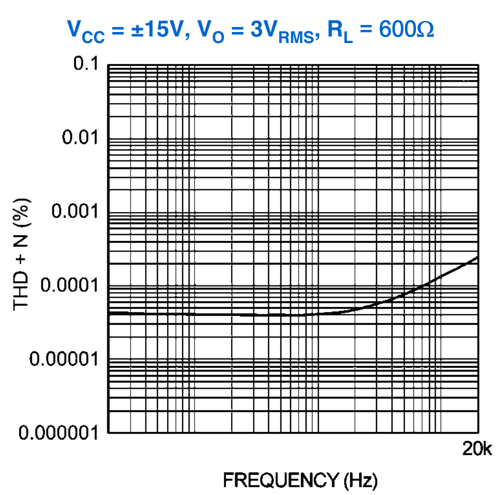

FIGURE 2: THD+N vs Frequency

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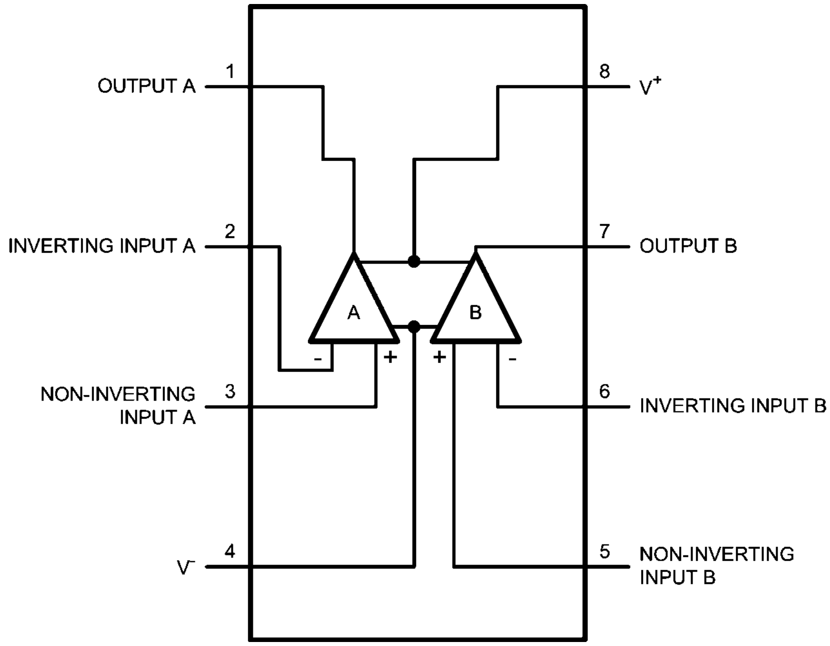
Connection Diagram



Order Number LME49880MR
See NS Package Number — MRA08B

Ordering Information

Ordering Information

Order Number	Package	Package DWG #	Transport Media	MSL Level	Green Status
LME49880MR	8 Ld PSOP with Exposed Pad	MRA08B	95 units	3	RoHS and noSb/Br
LME49880MRX	8 Ld PSOP with Exposed Pad	MRA08B	2500 units on rail	3	RoHS and noSb/Br

Absolute Maximum Ratings (Note 1)

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-) - 0.3V to (V+) + 0.3V
Output Short Circuit (Note 3)	Continuous
Power Dissipation	Internally Limited
ESD Rating (Note 4)	2000V
ESD Rating (Note 5)	200V
ESD Rating (Note 8)	1000V
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (PSOP)	55°C/W
Solder Information	
Infrared or Convection (20 sec)	260°C

Operating Ratings (Note 1)

Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40°C \le T_A \le 85°C$
Supply Voltage Range	$\pm 5V \le V_S \le \pm 17V$

Electrical Characteristics (Note 2)

The following specifications apply for $V_S = \pm 15V$, $T_A = 25°C$, unless otherwise specified.

Symbol	Parameter	Conditions	LME49880 Typical (Note 6)	LME49880 Limit (Note 7)	Unit s (Limits)
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)
GBWP	Gain Bandwidth Product	$A_V = 1k$, $R_L = 2k$	25	19	MHz (min)
SR	Slew Rate	$R_L = 2k$	±17	±12	V/μs (min)
t_s	Settling time	$A_V = -1$, 10V step, $C_L = 100pF$ 0.1% error range	0.8		μs
e_N	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.7	1.6	μV_{RMS} (max)
	Equivalent Input Noise Density	f = 1kHz f = 10Hz	7 16	11	$nV/\sqrt{Hz}$ (max)
i_N	Current Noise Density	f = 1kHz	6		$fA/\sqrt{Hz}$
V_{OS}	Offset Voltage		±5	±10	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$-40°C \le T_A \le 85°C$	3		μV/°C
PSRR	Power Supply Rejection Ratio	V_{CC} = ±5V to ±15V	110		dB
I_B	Input Bias Current	V_{CM} = 0V	5	150	pA (max)
I_{OS}	Input Offset Current	V_{CM} = 0V	2	100	pA (max)
V_{IN-CM}	Common-Mode Input Voltage Range	CMRR > 55dB	+11.5 –11.5	(V+) –5V (V-) +5V	V (min)
CMRR	Common-Mode Rejection	–10V<Vcm<10V	110	90	dB (min)
A_{VOL}	Open Loop Voltage Gain	–10V<Vout<10V, $R_L = 600\Omega$	115	100	dB (min)
		–10V<Vout<10V, $R_L = 2k\Omega$	120	100	dB (min)
		–10V<Vout<10V, $R_L = 10k\Omega$	120	100	dB (min)
V_{OUTMAX}	Maximum Output Voltage Swing	$R_L = 600\Omega$	±13.2	±12.0	V (min)
		$R_L = 2k\Omega$	±13.2	±12.5	V (min)
		$R_L = 10k\Omega$	±13.2	±12.5	V (min)
I_{OUT}	Output Current	$R_L = 600\Omega$, $V_S = \pm 17V$	±26		mA
I_{OUT-CC}	Instantaneous Short Circuit Current		±48		mA
R_{OUT}	Output Impedance	f_{IN} = 10kHz, Open-Loop	15		Ω
I_S	Total Quiescent Current	I_{OUT} = 0mA	14	18	mA (max)

Note 1: "*Absolute Maximum Ratings*" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the *Absolute Maximum Ratings* or other conditions beyond those indicated in the *Recommended Operating Conditions* is not implied. The *Recommended Operating Conditions* indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: The *Electrical Characteristics* tables list guaranteed specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics Conditions* and/or Notes. Typical specifications are estimations only and are not guaranteed.

Note 3: Amplifier output connected to GND, any number of amplifiers within a package.

Note 4: Human body model, applicable std. JESD22-A114C.

Note 5: Machine model, applicable std. JESD22-A115-A.

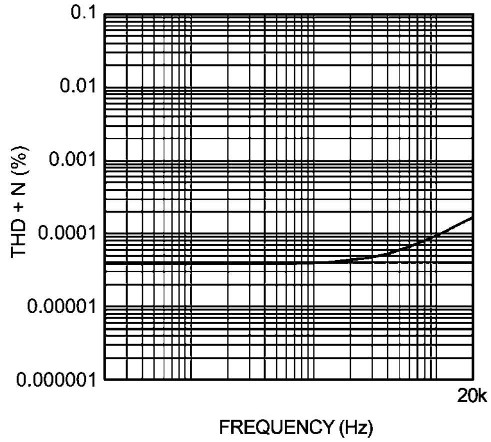
Note 6: Typical values represent most likely parametric norms at T_A = +25ºC, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

Note 7: Datasheet min/max specification limits are guaranteed by test or statistical analysis.

Note 8: Charge device model, applicable std JESD22-C101-A.

Typical Performance Characteristics

THD+N vs Frequency
V_{CC} = 15V, V_{OUT} = 3V
R_L = 2kΩ



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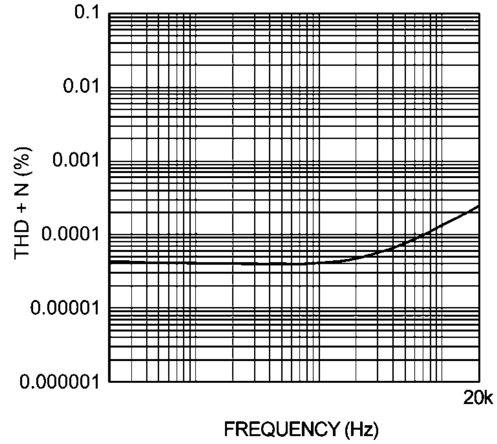
THD+N vs Frequency
V_{CC} = 15V, V_{OUT} = 3V
R_L = 600Ω



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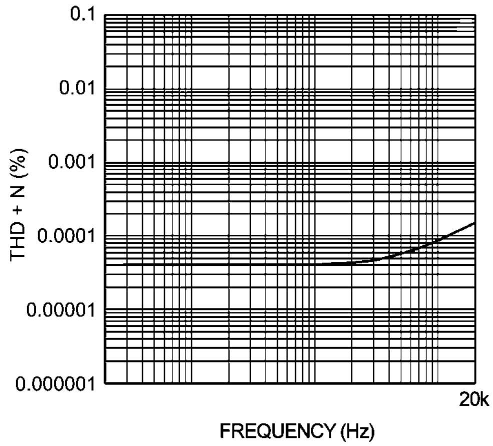
THD+N vs Frequency
V_{CC} = 18V, V_{OUT} = 3V
R_L = 2kΩ



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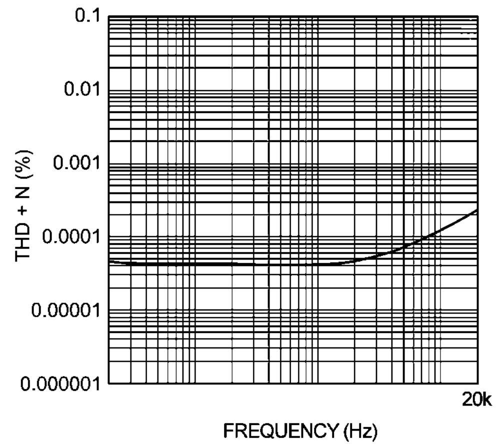
THD+N vs Frequency
V_{CC} = 18V, V_{OUT} = 3V
R_L = 600Ω



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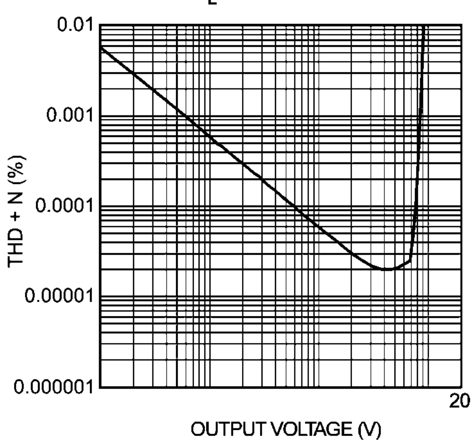
THD+N vs Output Voltage
V_{CC} = 15V
R_L = 2kΩ



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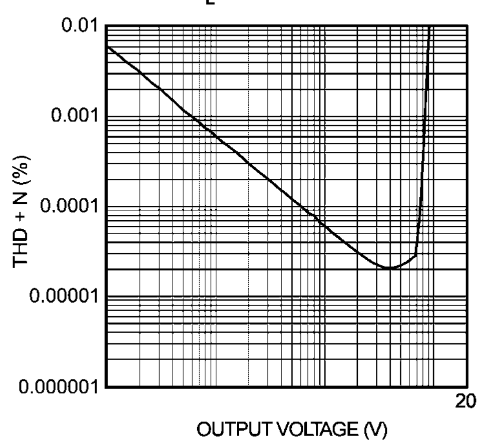
THD+N vs Output Voltage
V_{CC} = 15V
R_L = 600Ω



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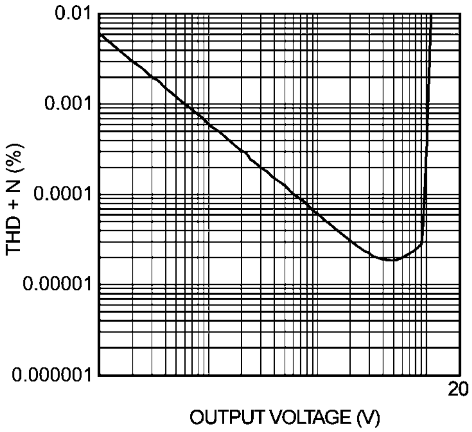
THD+N vs Output Voltage
V_{CC} = 18V
R_L = 2kΩ



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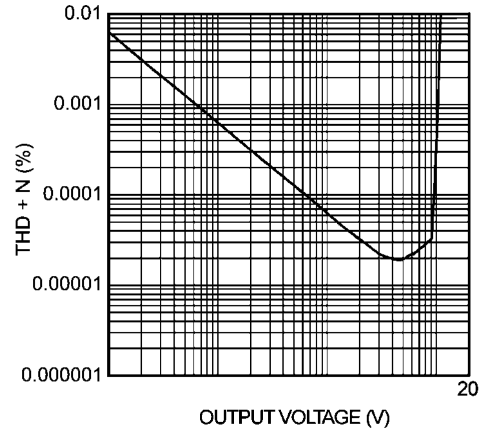
THD+N vs Output Voltage
V_{CC} = 18V
R_L = 600Ω



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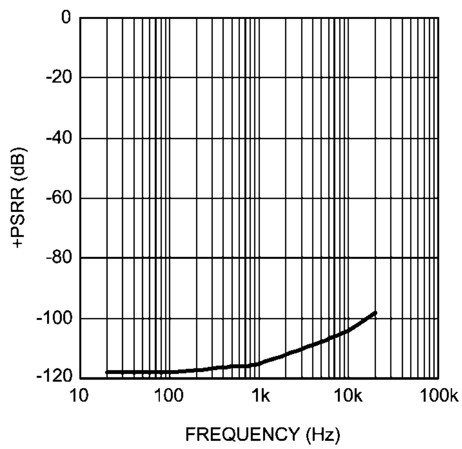
+PSRR vs Frequency



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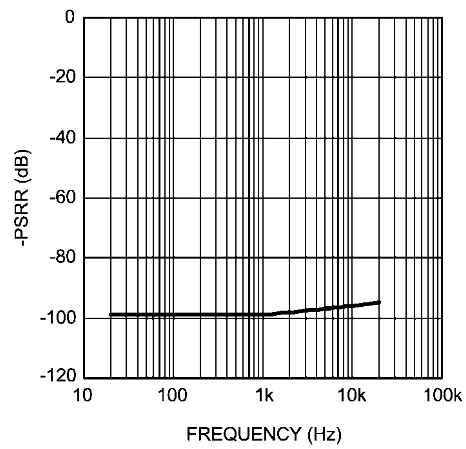
–PSRR vs Frequency



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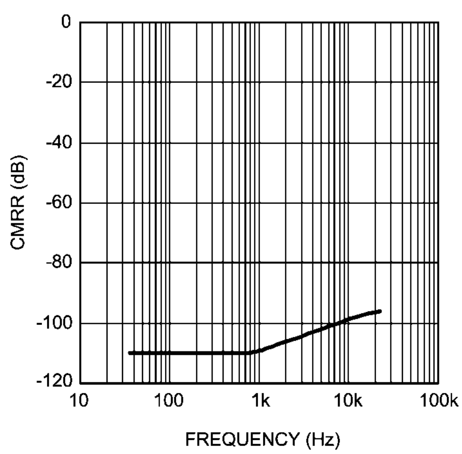
CMRR vs Frequency



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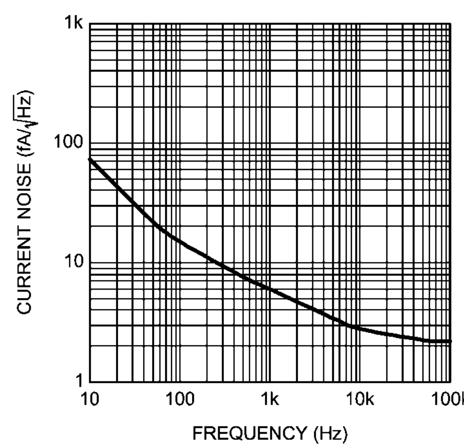
Current Noise vs Frequency



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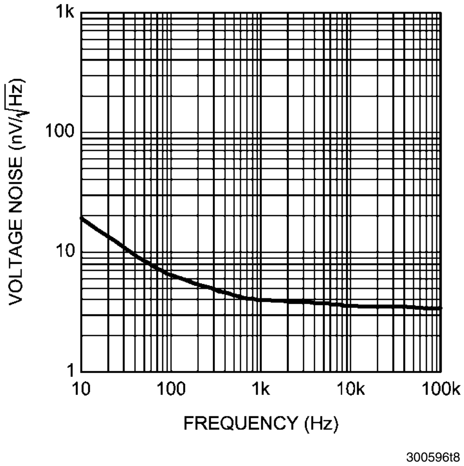
Voltage Noise vs Frequency



Application Hints

OUTPUT DRIVE AND STABILITY

The LME49880 is unity gain stable within the part's common-mode range. Some instabilities may occur near the limit of the common-mode range. It can drive resistive load 600Ω with output circuit with a typical 26mA. 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 straight forward 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. The internal short-circuit protection of LME49880 also prevent the device from damage when the either outputs are being shorted.

The effective load impedance (including feedback resistance) should be kept above 600Ω for fast settling. Load capacitance should also be minimized if good settling time is to be optimized. Large feedback resistors will make the circuit more susceptible to stray capacitance, so in high-speed applications keep the feedback resistors in the 1kΩ to 2kΩ range whenever practical.

OUTPUT COMPENSATION

In most of the audio applications, the device will be operated in a room temperature and compensation networks are not necessary. However, the consideration of network as shown in Figure 3 may be taken into account for some of the high performance audio applications such as high speed data conversion or when operating in a relatively low junction temperature. The compensation network will also provide a small improvement in settling time for the response time demanding applications.

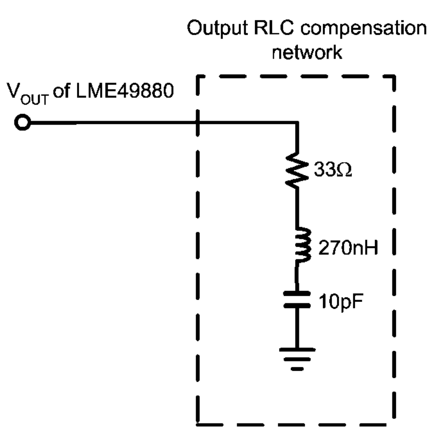


FIGURE 3: LME49880 Output Compensation Network

PSOP EXPOSED PAD PACKAGE

The LME49880 has an exposed pad on the bottom side of the IC package. Connect the exposed pad to pin 4 (V-) of the IC. The PCB footprint for the exposed pad should be a open polygon of copper to provide a good thermal path away from the LME49880. Use multiple vias on the exposed pad to create better thermal conductivity. Do not route traces below the exposed pad as they risk shorting to the exposed pad.

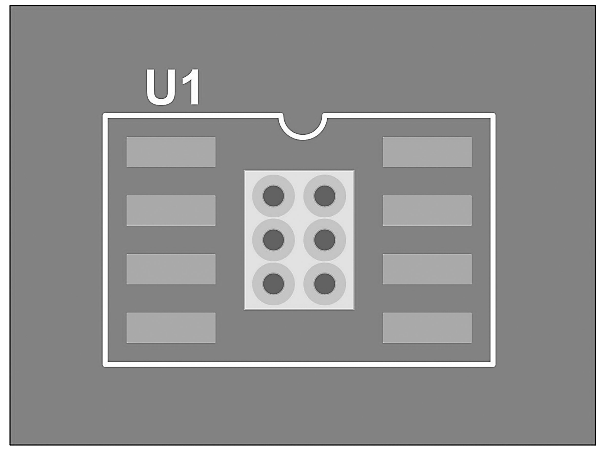


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FIGURE 4: LME49880 Output Compensation Network

SUPPLY BYPASSING

To achieve a low noise and high-speed audio performance, power supply bypassing is extremely important. Applying multiple bypass capacitors is highly recommended. From experiment results, a 10μF tantalum, 2.2μF ceramic, and a 0.47μF ceramic work well. All bypass capacitors leads should be very short. The ground leads of capacitors should also be separated to reduce the inductance to ground. To obtain the best result, a large ground plane layout technique is recommended and it was applied in the LME49880 evaluation board.

Application Information

SETTLING TIME AND SLEW RATE MEASUREMENTS

The settling time of LME49880 may be verified using the test circuit in Figure 5. The LME49880 is connected for inverting operation, and the output voltage is summed with the input voltage step. When the LME49880's output voltage is equal to the input voltage, the voltage on the PROBE 1 will be zero. Any voltage appearing at this point will represent an error. And the settling time is equal to the time required for the error signal displayed on the oscilloscope to decay to less than one-half the necessary accuracy (See Settling Time – Output Swing photo). For a 10V input signal, settling time to 0.01% (1mV) will occur when the displayed error is less than 0.5mV. Since settling time is strongly dependent on slew rate, settling will be faster for smaller signal swings. The LME49880's inverting slew rate is faster than its non-inverting slew rate, so settling will be faster for inverting applications, as well. It is important to note that the oscilloscope input amplifier may be overdriven during a settling time measurement, so the oscilloscope must be capable of recovering from overdrive very quickly. The signal generator used for this measurement must be able to drive 50Ω with a very clean ±10V_{PP} square wave.

The Slew Rate of LME49880 tells how fast it responses to a transient or a step input. It may be measured by the test circuit in Figure 6. The Slew Rate of LME49880 is specified in close-loop gain = -1 when the output driving a 1kΩ load at 20V_{PP}. The LME49880 behaves very stable in shape step response and have a minimal ringing in both small and large signal step response (See Typical Performance Characteristic). The slew rate typical value reach as high as ±18V/μS was measured when the output reach -20V refer to the start point when input voltage equals to zero.

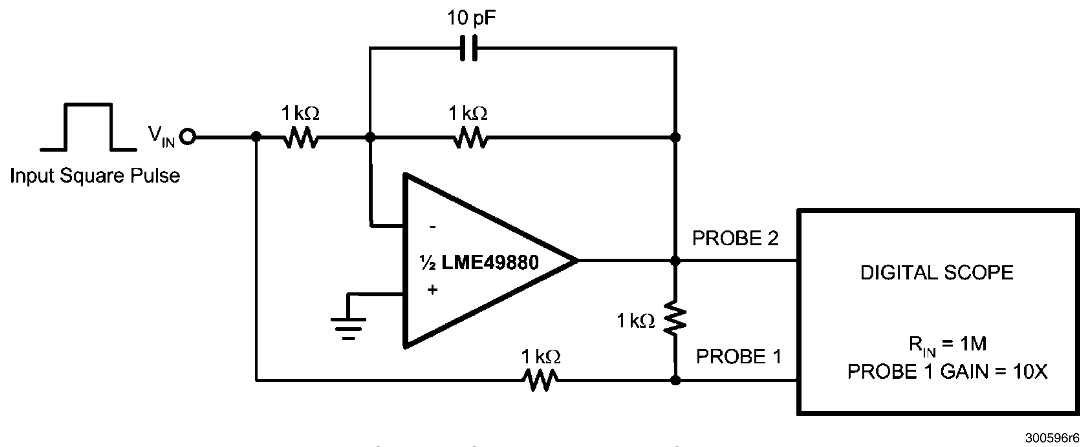


FIGURE 5: Settling Time Test Circuit

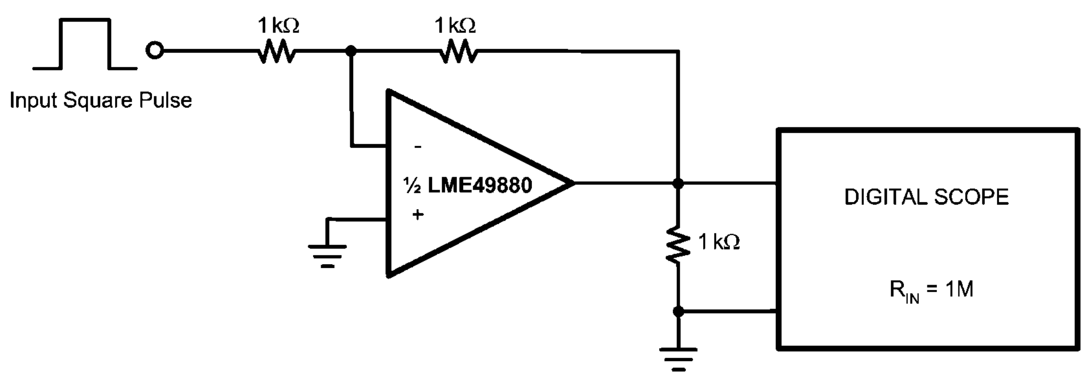


FIGURE 6: Slew Rate Test Circuit

DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49880 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 LME49880's low residual distortion is an input referred internal error. As shown in Figure 7, 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 7.

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.

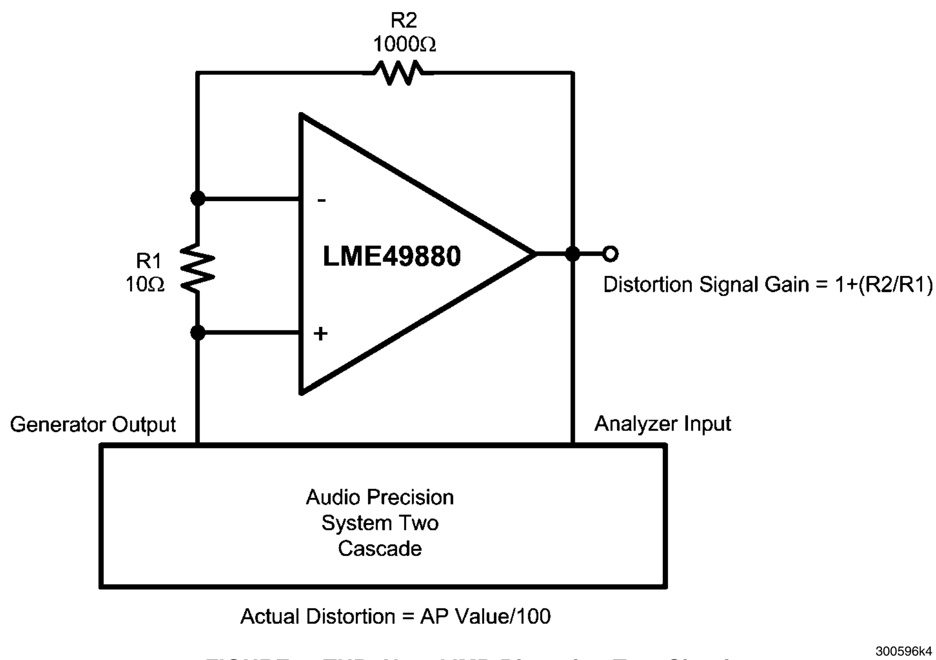
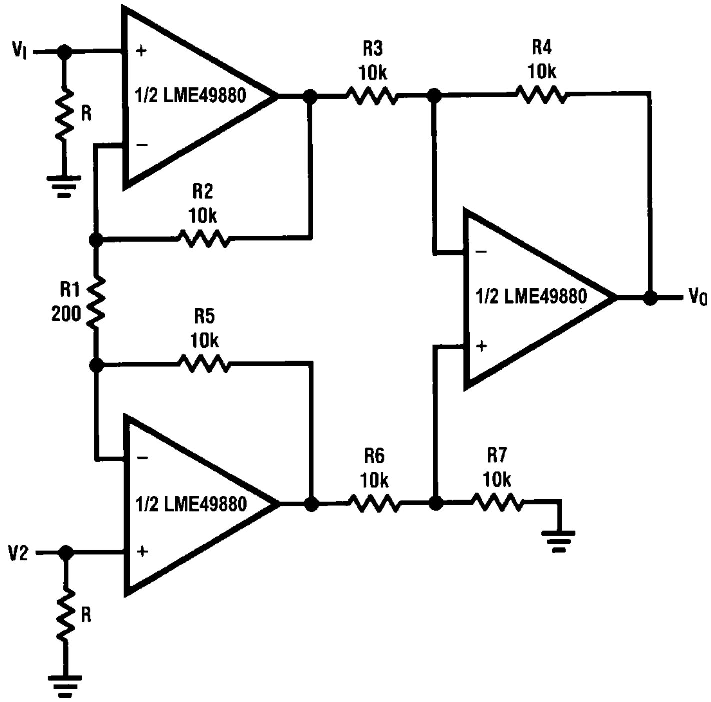


FIGURE 7: THD+N and IMD Distortion Test Circuit

Typical Applications

Balanced Input Mic Amp



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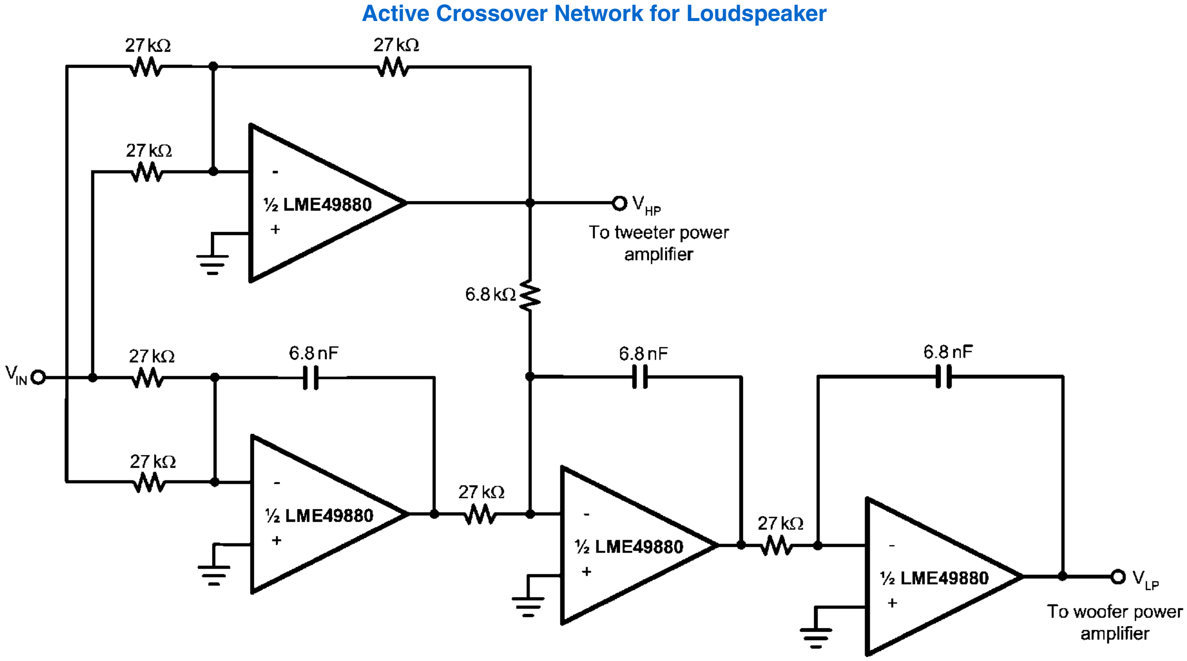
If R2 = R5, R3 = R6, R4 = R7

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

Illustration is:

V0 = 101(V2 – V1)

Active Crossover Network for Loudspeaker



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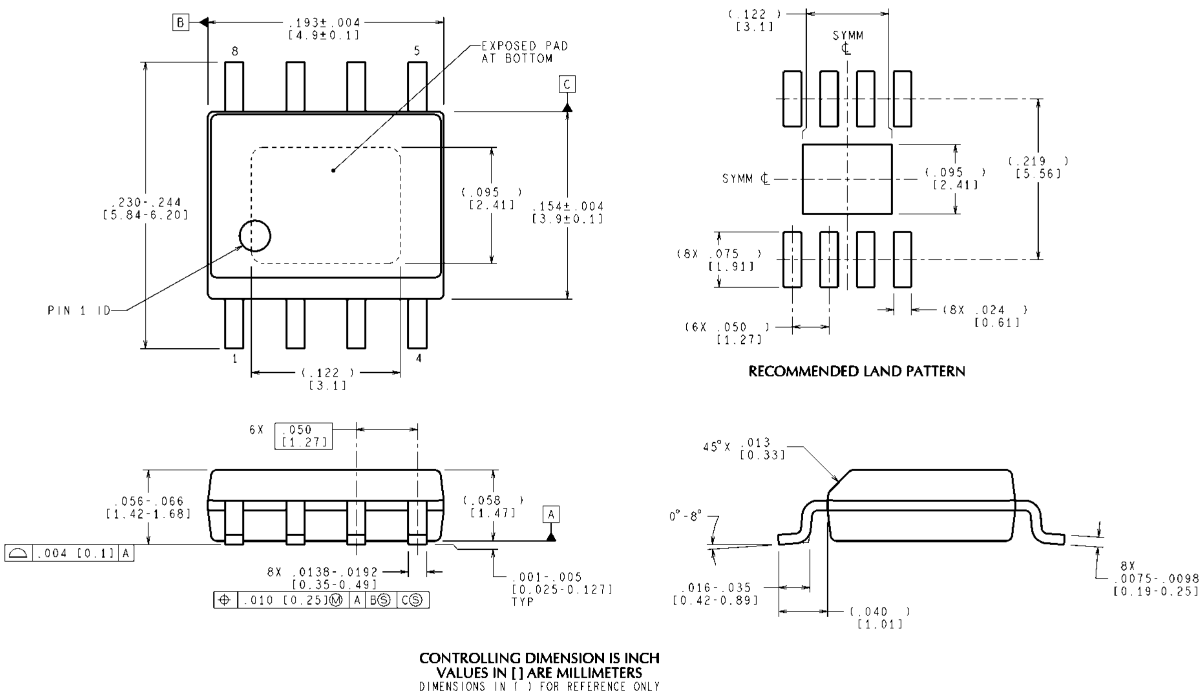
Revision History

Rev	Date	Description
1.0	12/16/09	Initial released.
1.01	01/08/10	Input text edits.
1.02	03/22/10	Edited the scaling (Y-axis) on the THD+N curves to match the limits described in the datasheet.

Physical Dimensions inches (millimeters) unless otherwise noted



MRA08B (Rev B)

Narrow PSOP Package
Order Number LME49880MR
NS Package Number MRA08B

Notes

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