



**THE DATASHEET OF
LME49860MAX/NOPB**



LME49860 44V Dual High Performance, High Fidelity Audio Operational Amplifier

Check for Samples: [LME49860](#), [LME49860MABD](#), [LME49860NABD](#)

FEATURES

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

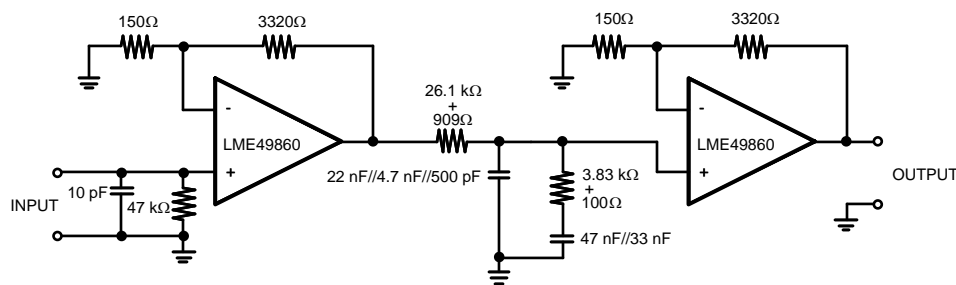
KEY SPECIFICATIONS

- Power Supply Voltage Range: ± 2.5 to ± 22 V
- THD+N ($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1$ kHz)
 - $R_L = 2k\Omega$: 0.00003% (Typ)
 - $R_L = 600\Omega$: 0.00003% (Typ)
- Input Noise Density: 2.7 nV/ \sqrt{Hz} (Typ)
- Slew Rate: ± 20 V/ μ 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 LME49860 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 LME49860 audio operational amplifiers deliver superior audio signal amplification for outstanding audio performance. The LME49860 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.

TYPICAL APPLICATION



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

Figure 1. Passively Equalized RIAA Phono Preamplifier


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.

All trademarks are the property of their respective owners.

DESCRIPTION (CONTINUED)

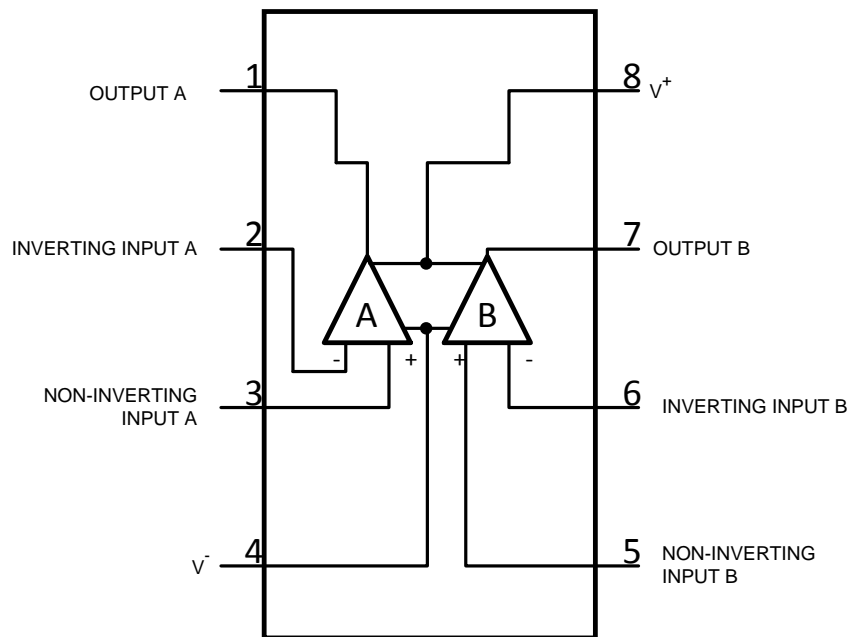
To ensure that the most challenging loads are driven without compromise, the LME49860 has a high slew rate of $\pm 20V/\mu s$ and an output current capability of $\pm 26mA$. Further, dynamic range is maximized by an output stage that drives $2k\Omega$ loads to within 1V of either power supply voltage and to within 1.4V when driving 600Ω loads.

The LME49860's outstanding CMRR (120dB), PSRR (120dB), and V_{OS} (0.1mV) give the amplifier excellent operational amplifier DC performance.

The LME49860 has a wide supply range of $\pm 2.5V$ to $\pm 22V$. Over this supply range the LME49860 maintains excellent common-mode rejection, power supply rejection, and low input bias current. The LME49860 is unity gain stable. This Audio Operational Amplifier achieves outstanding AC performance while driving complex loads with values as high as $100pF$.

The LME49860 is available in 8-lead narrow body SOIC and 8-lead PDIP packages. Demonstration boards are available for each package.

Connection Diagrams



**Figure 2. 8-Pin SOIC or PDIP
See D or P 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 ($V_S = V^+ - V^-$) | | 46V |
| Storage Temperature | | -65°C to 150°C |
| Input Voltage | | (V-) - 0.7V to (V+) + 0.7V |
| Output Short Circuit ⁽⁴⁾ | | Continuous |
| ESD Susceptibility ⁽⁵⁾ | | 2000V |
| ESD Susceptibility ⁽⁶⁾ | Pins 1, 4, 7 and 8 | 200V |
| | Pins 2, 3, 5 and 6 | 100V |
| Junction Temperature | | 150°C |
| Thermal Resistance | θ_{JA} (SOIC) | 145°C/W |
| | θ_{JA} (PDIP) | 102°C/W |

- (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 Instrument 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).

OPERATING RATINGS

| | | |
|----------------------|---------------------------------|----------------------------------|
| Temperature Range | $T_{MIN} \leq T_A \leq T_{MAX}$ | -40°C \leq T_A \leq 85°C |
| Supply Voltage Range | | $\pm 2.5V \leq V_S \leq \pm 22V$ |

ELECTRICAL CHARACTERISTICS FOR THE LME49860⁽¹⁾

The following specifications apply for $V_S = \pm 18V$ and $\pm 22V$, $R_L = 2k\Omega$, $R_{SOURCE} = 10\Omega$, $f_{IN} = 1kHz$, $T_A = 25^\circ C$, unless otherwise specified.

| Symbol | Parameter | Conditions | LME49860 | | Units (Limits) |
|---|---|--|------------------------|----------------------|------------------------------|
| | | | Typical ⁽²⁾ | Limit ⁽³⁾ | |
| THD+N | Total Harmonic Distortion + Noise | $A_V = 1$, $V_{OUT} = 3V_{rms}$ | 0.00003 | | % |
| | | $R_L = 2k\Omega$ $R_L = 600\Omega$ | 0.00003 | 0.00009 | (max) |
| IMD | Intermodulation Distortion | $A_V = 1$, $V_{OUT} = 3V_{RMS}$, Two-tone, 60Hz & 7kHz 4:1 | 0.00005 | | % |
| 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} (max) |
| | Equivalent Input Noise Density | $f = 1kHz$ $f = 10Hz$ | 2.7 6.4 | 4.7 | $\frac{nV}{\sqrt{Hz}}$ (max) |
| i_n | Current Noise Density | $f = 1kHz$ $f = 10Hz$ | 1.6 3.1 | | $\frac{pA}{\sqrt{Hz}}$ |
| V_{OS} | Offset Voltage | $V_S = \pm 18V$ | ± 0.12 | ± 0.7 | mV (max) |
| | | $V_S = \pm 22V$ | ± 0.14 | ± 0.7 | mV (max) |
| $\frac{\Delta V_{OS}}{\Delta T}$ m_p | Average Input Offset Voltage Drift vs Temperature | -40°C \leq T_A \leq 85°C | 0.2 | | $\mu V/^\circ C$ |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.
- (2) Typical specifications are specified at +25°C and represent the most likely parametric norm.
- (3) Tested limits are ensured to AOQL (Average Outgoing Quality Level).

ELECTRICAL CHARACTERISTICS FOR THE LME49860⁽¹⁾ (continued)

The following specifications apply for $V_S = \pm 18V$ and $\pm 22V$, $R_L = 2k\Omega$, $R_{SOURCE} = 10\Omega$, $f_{IN} = 1kHz$, $T_A = 25^\circ C$, unless otherwise specified.

| Symbol | Parameter | Conditions | LME49860 | | Units (Limits) |
|--------------------------------|--|---|--------------------------|--------------------------|-------------------------|
| | | | Typical ⁽²⁾ | Limit ⁽³⁾ | |
| PSRR | Average Input Offset Voltage Shift vs Power Supply Voltage | See ⁽⁴⁾ $V_S = \pm 18V$, $\Delta V_S = 24V$ $V_S = \pm 22V$, $\Delta V_S = 30V$ | 120 120 | 110 | dB dB (min) |
| ISO _{CH-CH} | Channel-to-Channel Isolation | $f_{IN} = 1kHz$ $f_{IN} = 20kHz$ | 118 112 | | dB |
| I_B | Input Bias Current | $V_{CM} = 0V$ | 10 | 72 | nA (max) |
| $\Delta I_{OS}/\Delta T_{emp}$ | 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 | $V_S = \pm 18V$ | +17.1 -16.9 | (V+) - 2.0 (V-) + 2.0 | V (min) V (min) |
| | | $V_S = \pm 22V$ | +21.0 -20.8 | (V+) - 2.0 (V-) + 2.0 | V (min) V (min) |
| CMRR | Common-Mode Rejection | $V_S = \pm 18V$ $-12V \leq V_{CM} \leq 12V$ | 120 | | dB |
| | | $V_S = \pm 22V$ $-15V \leq V_{CM} \leq 15V$ | 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 | $V_S = \pm 18V$ $-12V \leq V_{out} \leq 12V$ $R_L = 600\Omega$ $R_L = 2k\Omega$ $R_L = 10k\Omega$ | 140 140 140 | | dB dB dB |
| | | $V_S = \pm 22V$ $-15V \leq V_{out} \leq 15V$ $R_L = 600\Omega$ $R_L = 2k\Omega$ $R_L = 10k\Omega$ | 140 140 140 | 125 | dB (min) dB dB |
| V_{OUTMAX} | Maximum Output Voltage Swing | $R_L = 600\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$ | ± 16.7 ± 20.4 | ± 19.0 | V V (min) |
| | | $R_L = 2k\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$ | ± 17.0 ± 21.0 | | V V |
| | | $R_L = 10k\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$ | ± 17.1 ± 21.2 | | V V |
| I_{OUT} | Output Current | $R_L = 600\Omega$ $V_S = \pm 20V$ $V_S = \pm 22V$ | ± 31 ± 37 | ± 30 | mA 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 | $I_{OUT} = 0mA$ $V_S = \pm 18V$ $V_S = \pm 22V$ | 10.2 10.5 | 13 | mA mA (max) |

(4) PSRR is measured as follows: For $V_S = \pm 22V$, V_{OS} is measured at two supply voltages, $\pm 7V$ and $\pm 22V$. $PSRR = |20 \log(\Delta V_{OS}/\Delta V_S)|$.

TYPICAL PERFORMANCE CHARACTERISTICS

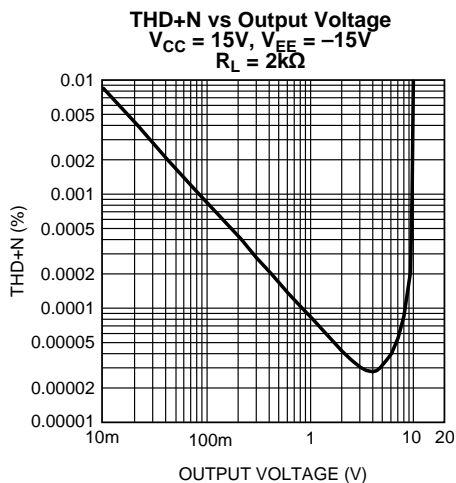


Figure 3.

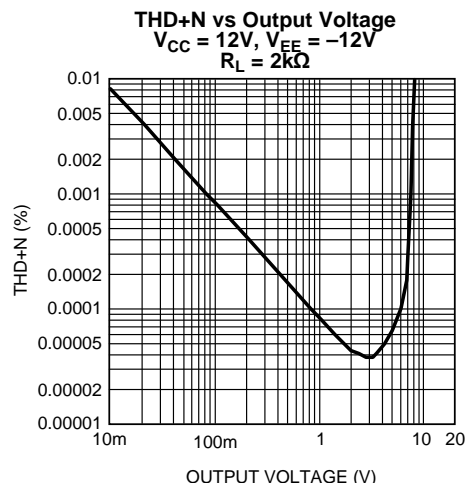


Figure 4.

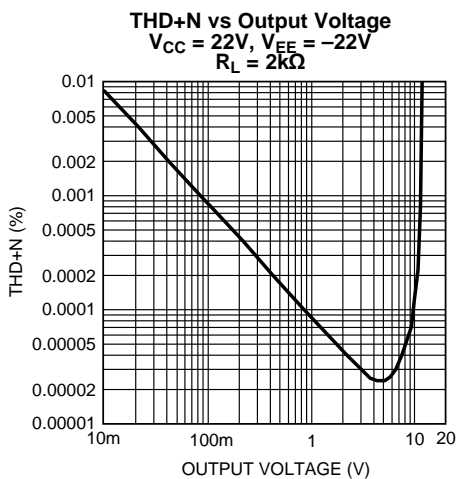


Figure 5.

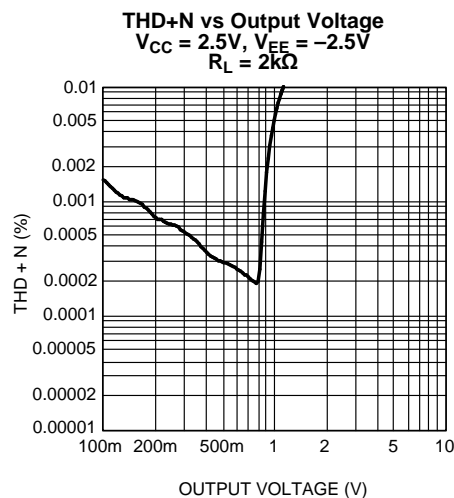


Figure 6.

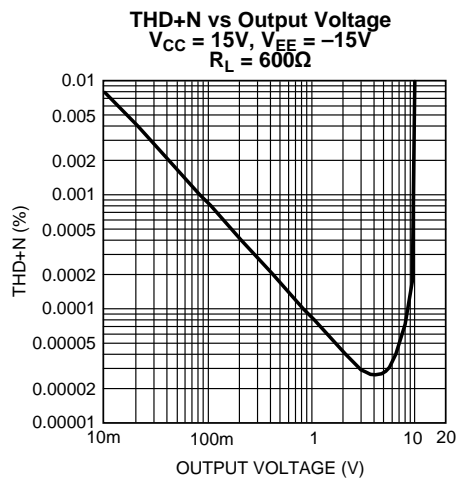


Figure 7.

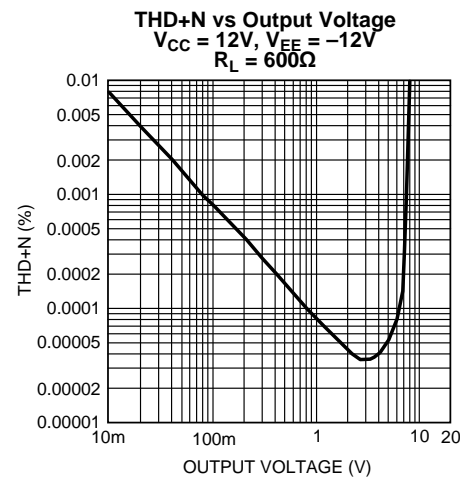


Figure 8.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

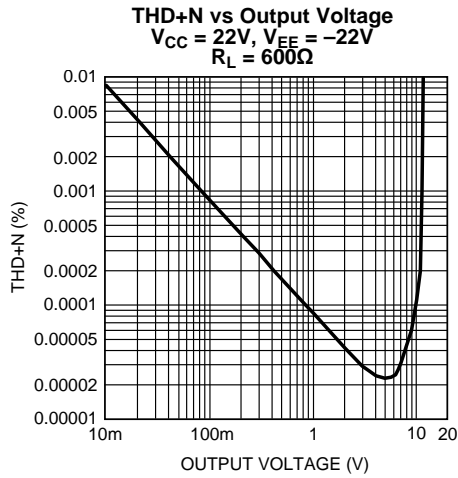


Figure 9.

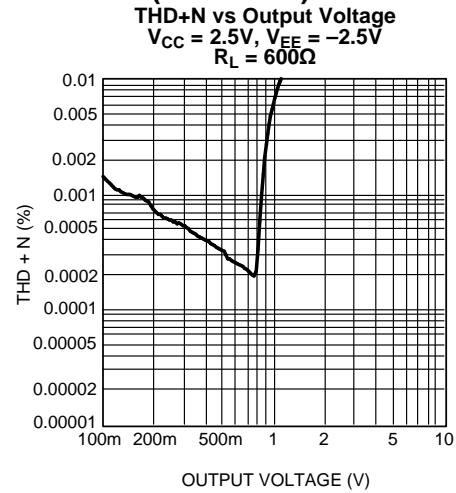


Figure 10.

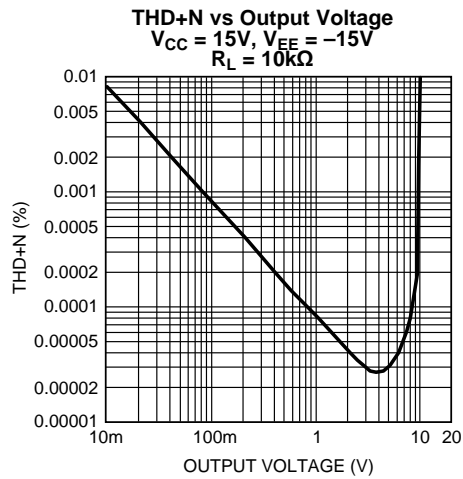


Figure 11.

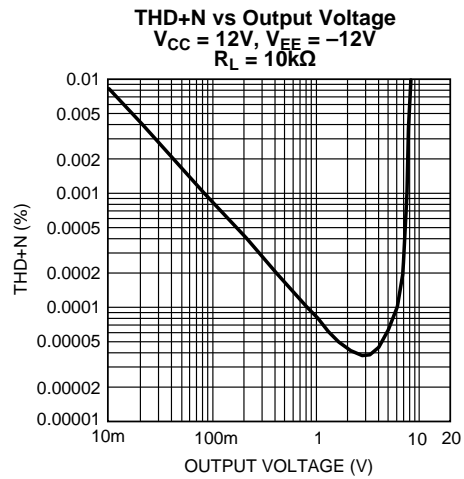


Figure 12.

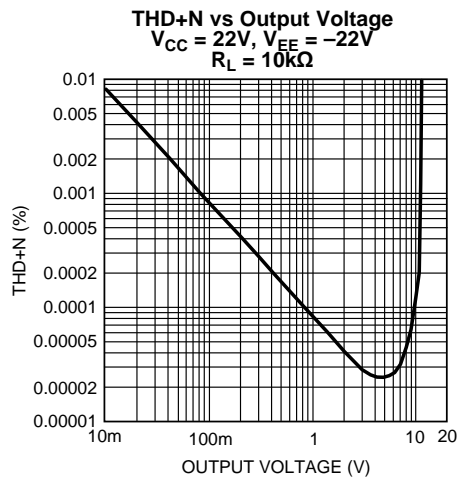


Figure 13.

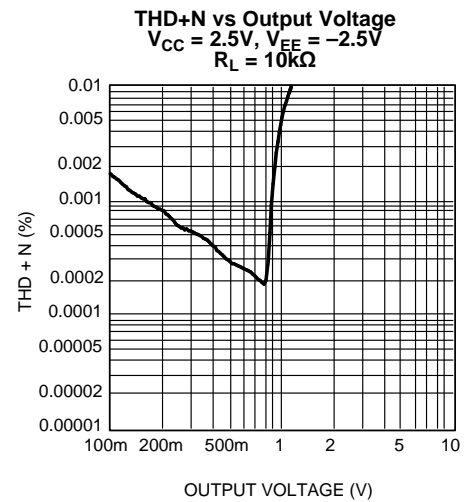


Figure 14.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

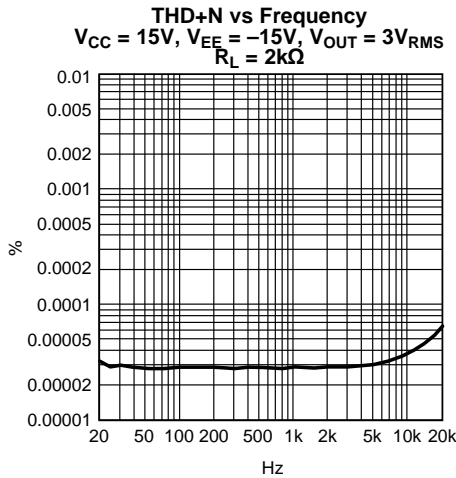


Figure 15.

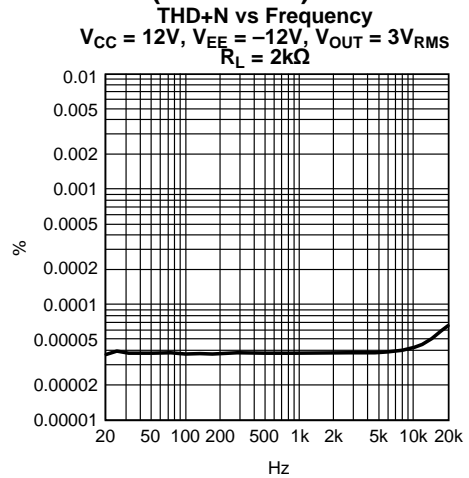


Figure 16.

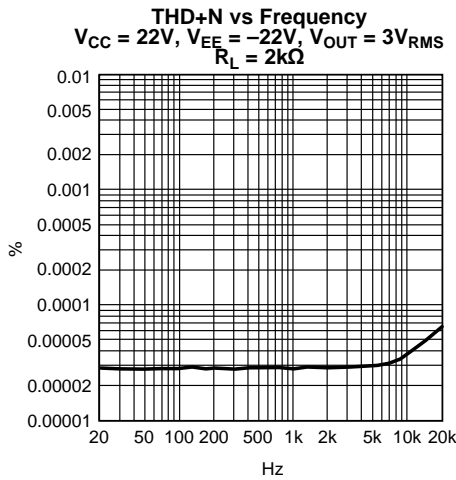


Figure 17.

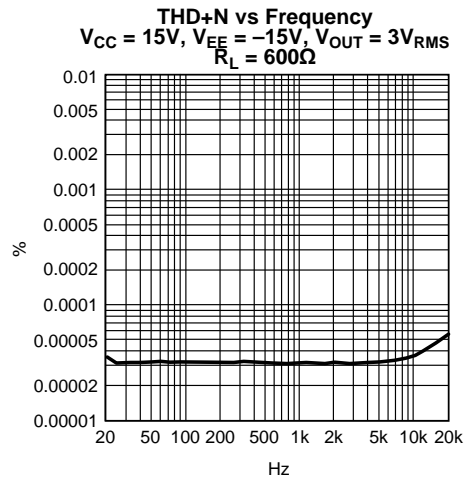


Figure 18.

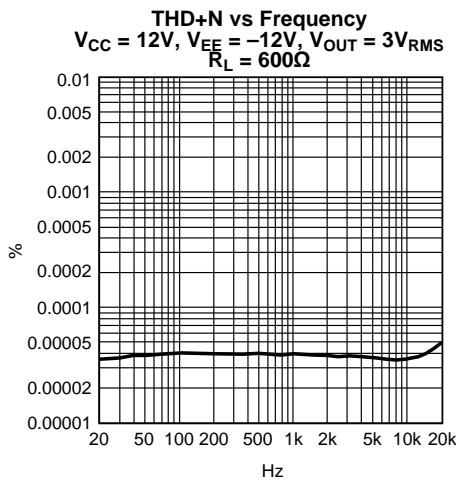


Figure 19.

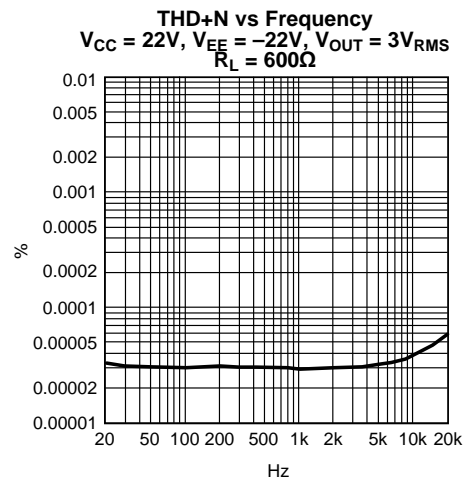


Figure 20.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

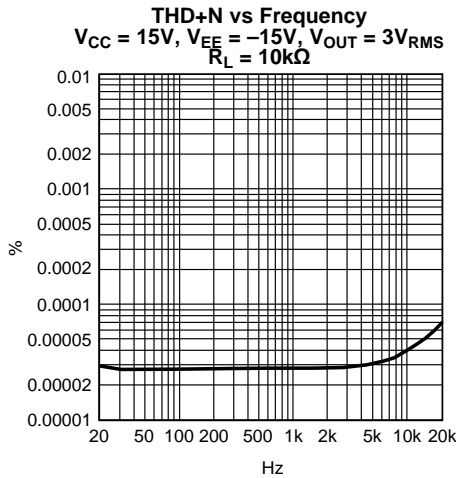


Figure 21.

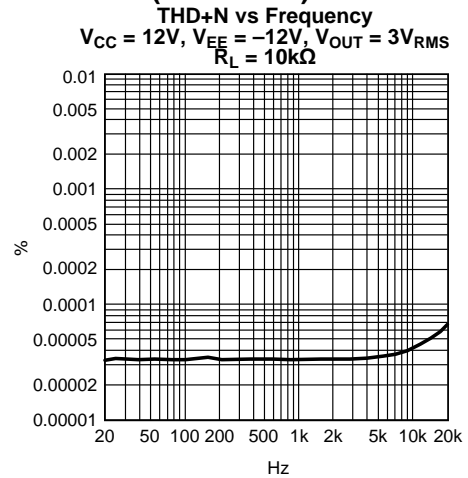


Figure 22.

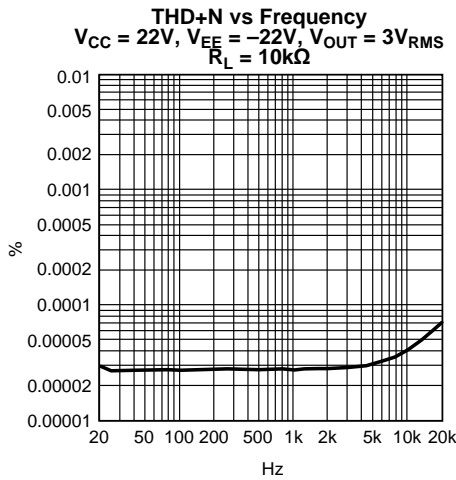


Figure 23.

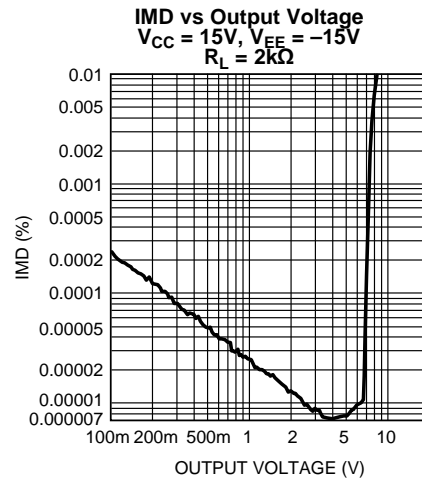


Figure 24.

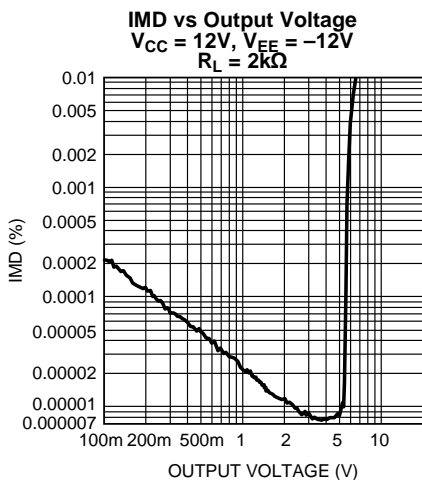


Figure 25.

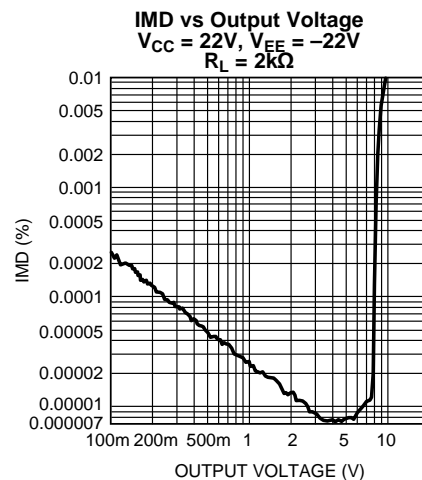


Figure 26.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

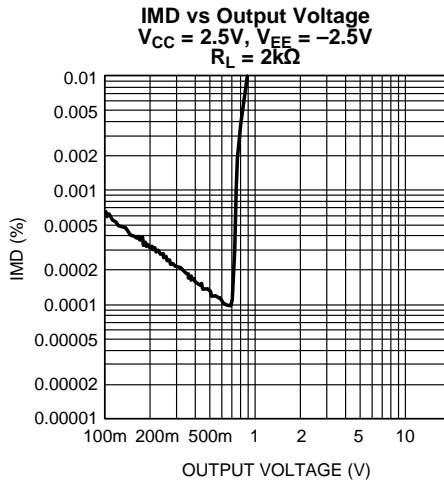


Figure 27.

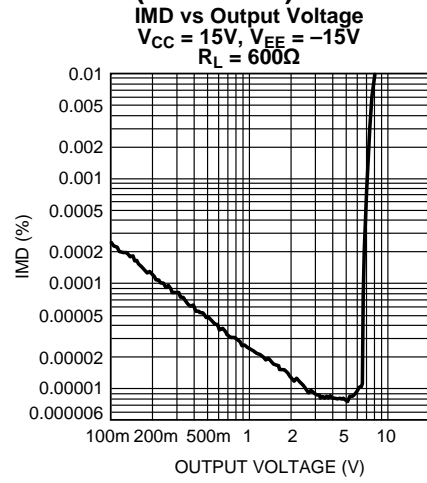


Figure 28.

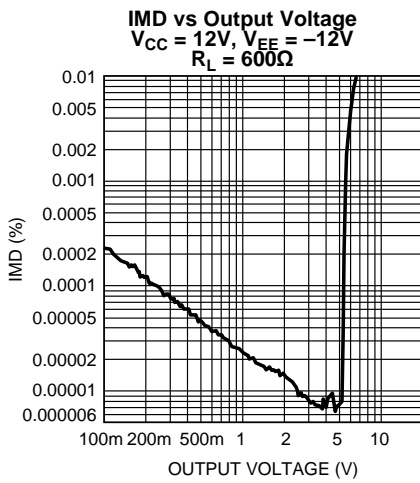


Figure 29.

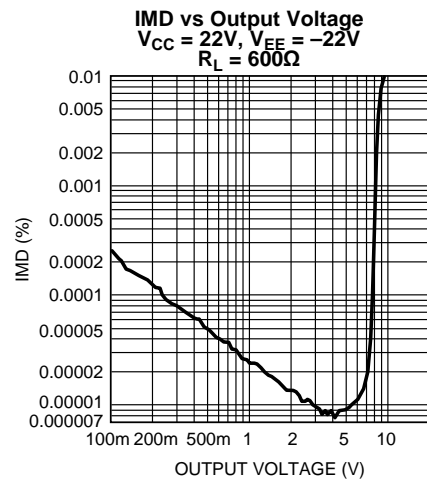


Figure 30.

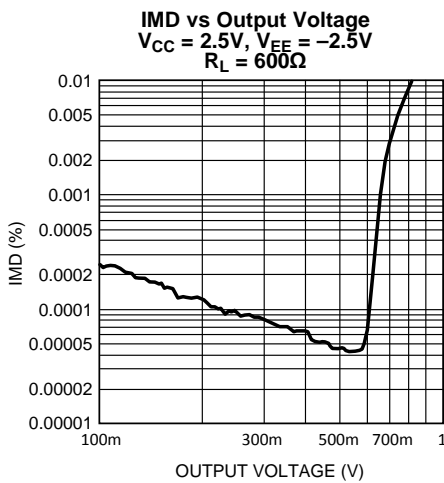


Figure 31.

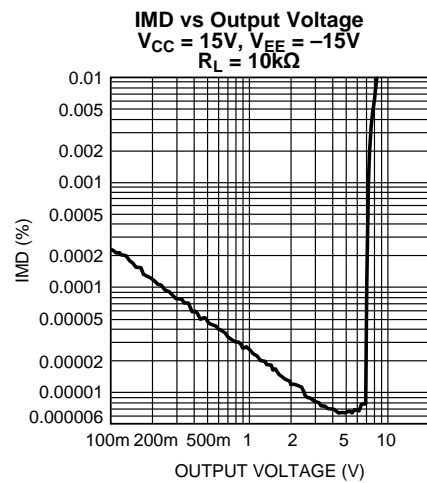


Figure 32.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

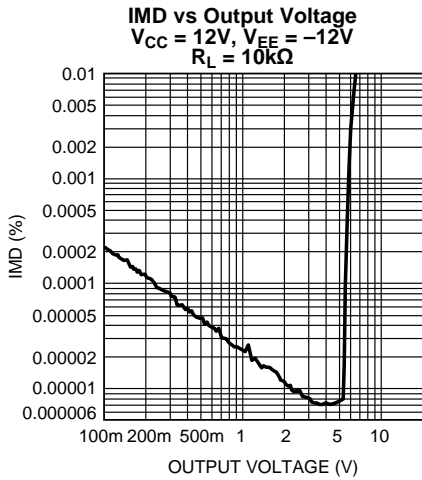


Figure 33.

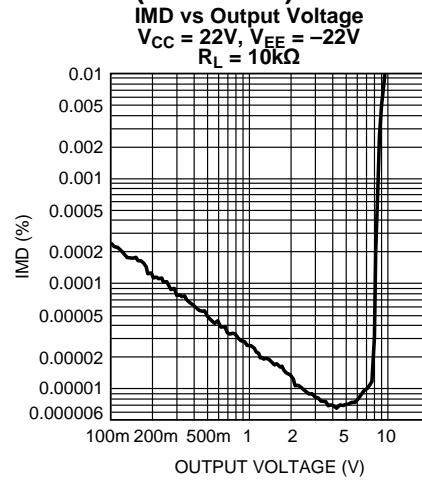


Figure 34.

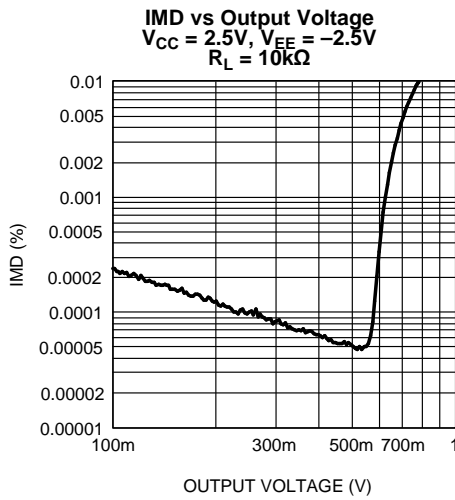


Figure 35.

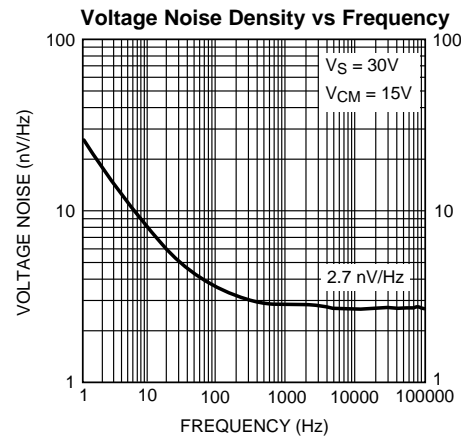


Figure 36.

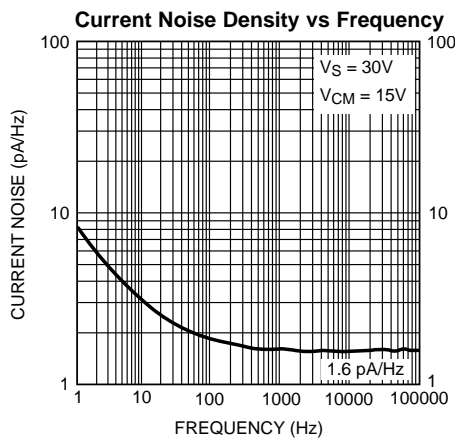


Figure 37.

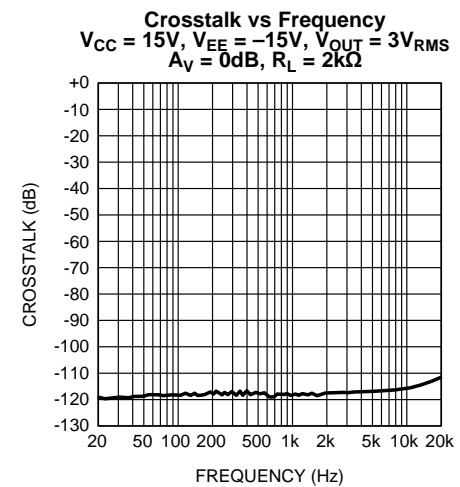


Figure 38.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

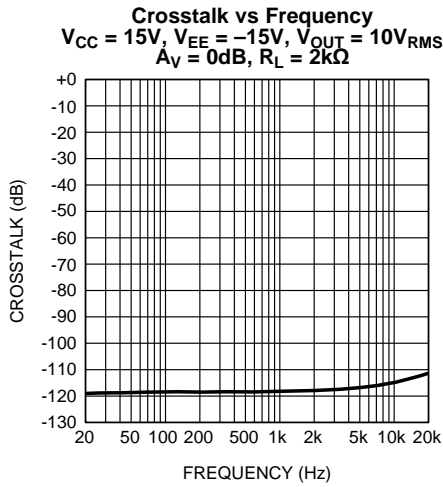


Figure 39.

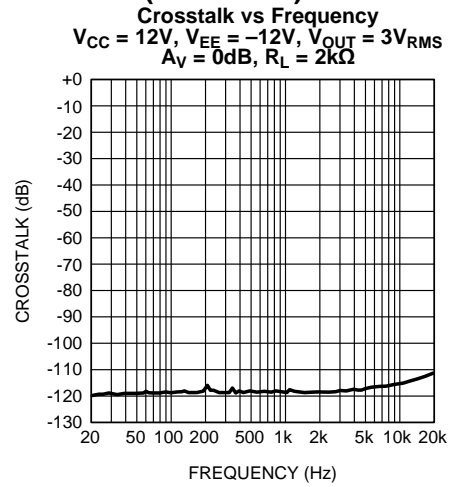


Figure 40.

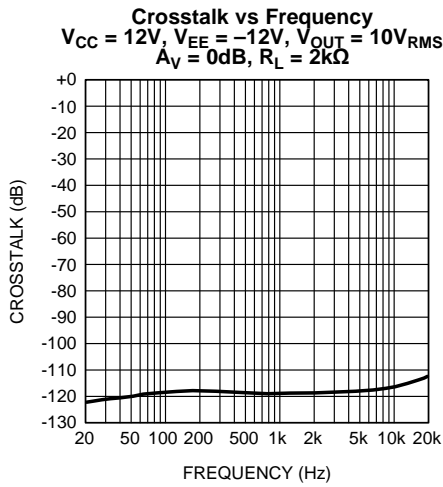


Figure 41.

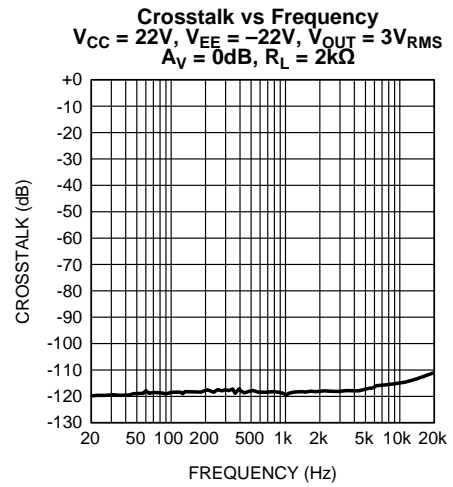


Figure 42.

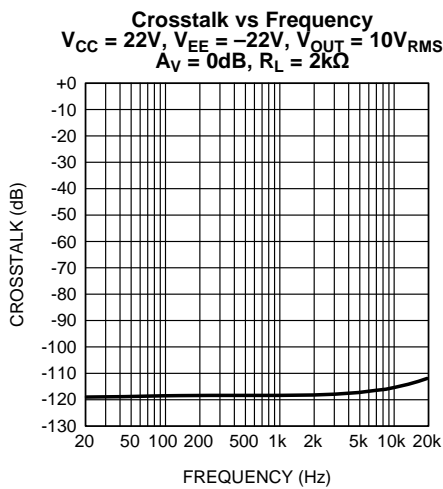


Figure 43.

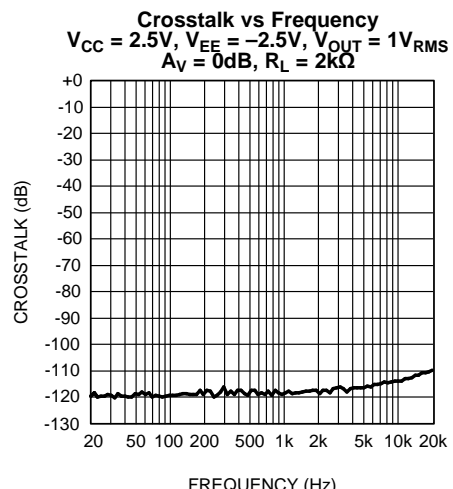


Figure 44.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

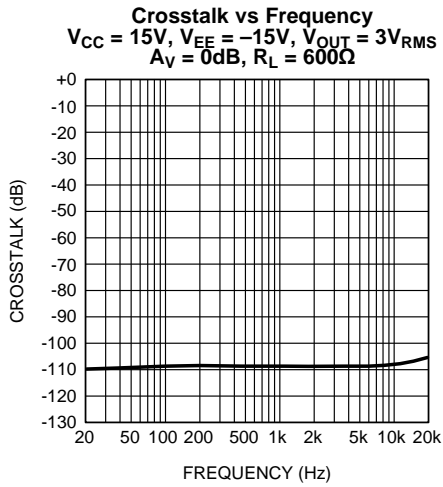


Figure 45.

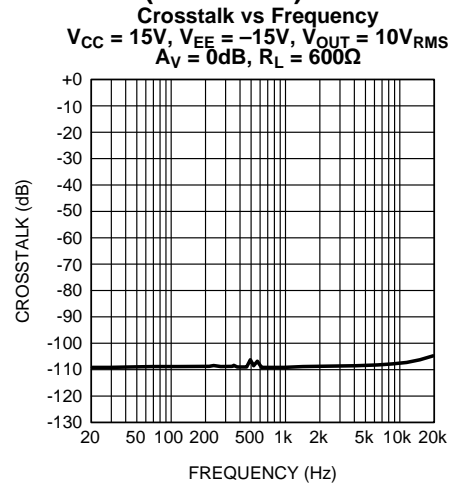


Figure 46.

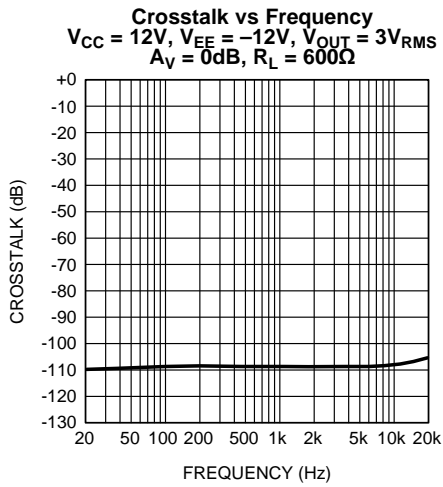


Figure 47.

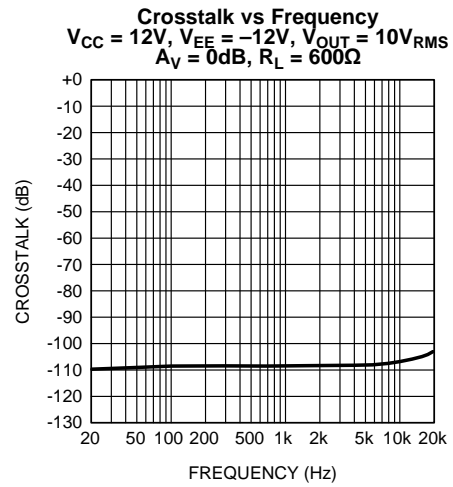


Figure 48.

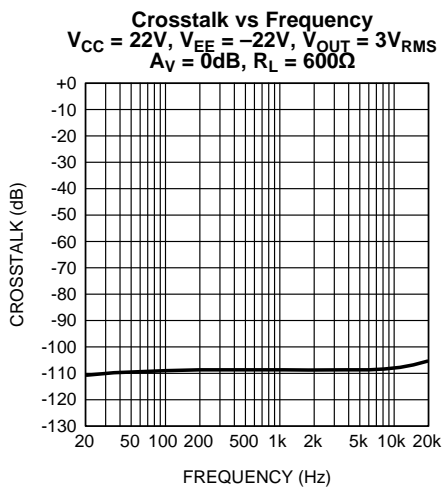


Figure 49.

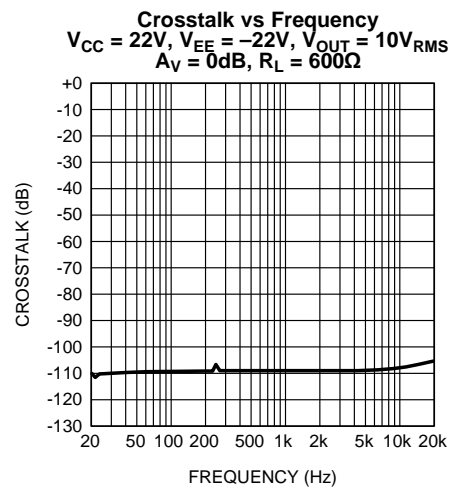


Figure 50.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

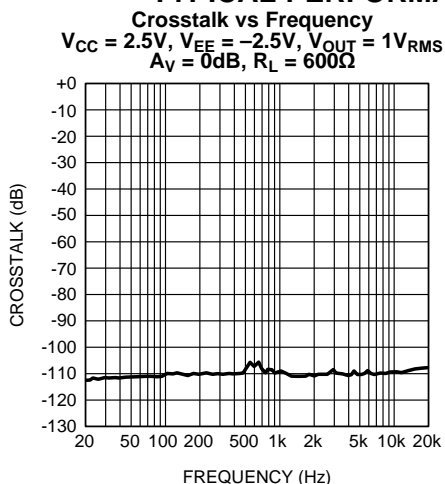


Figure 51.

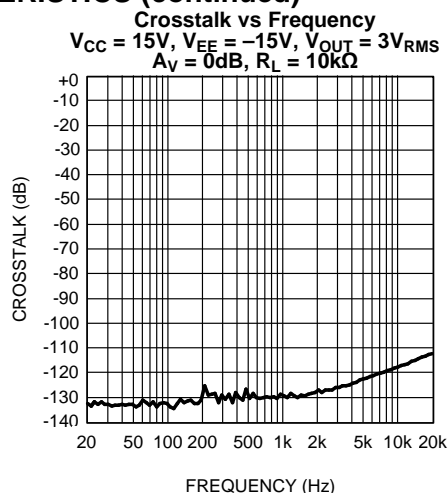


Figure 52.

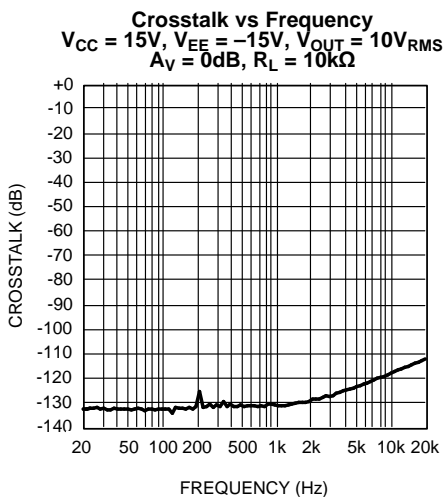


Figure 53.

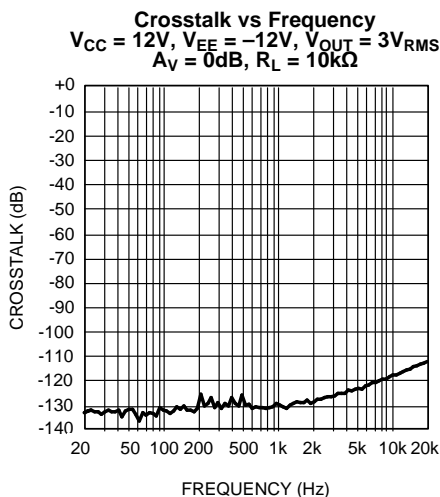


Figure 54.

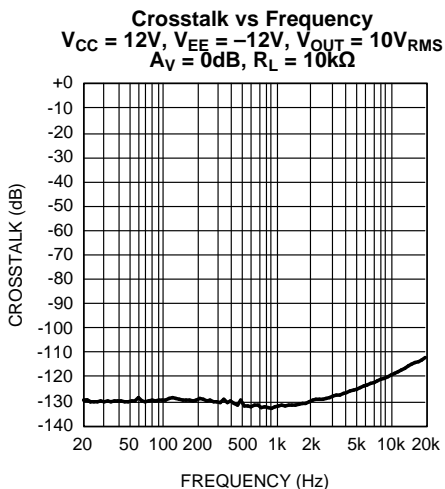


Figure 55.

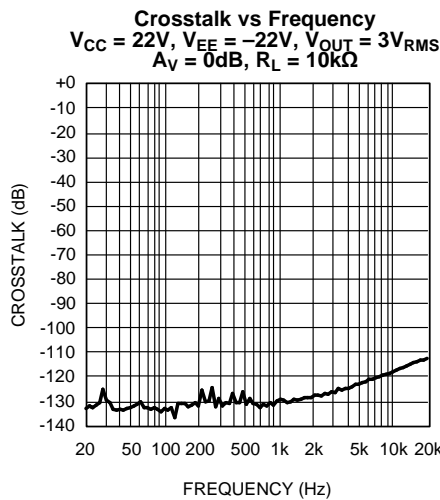
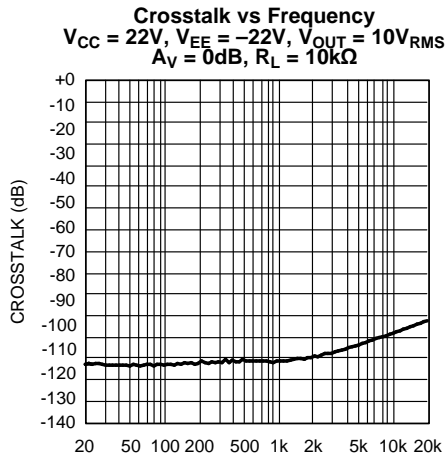


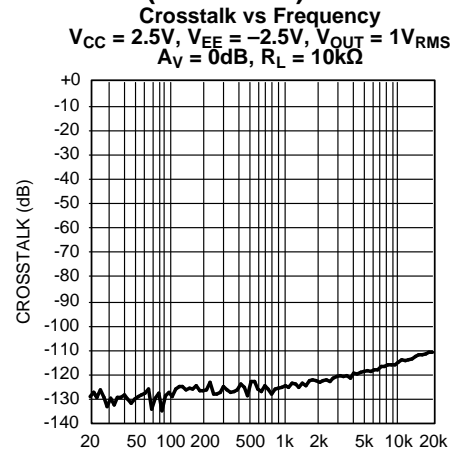
Figure 56.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)



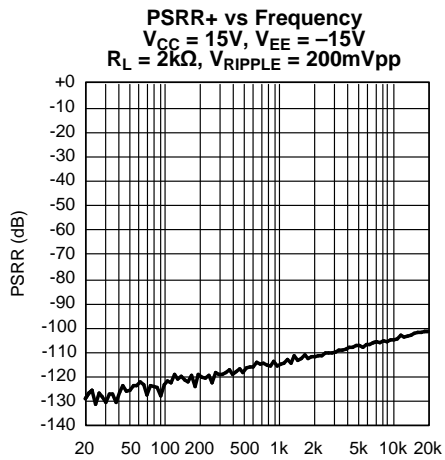
FREQUENCY (Hz)

Figure 57.



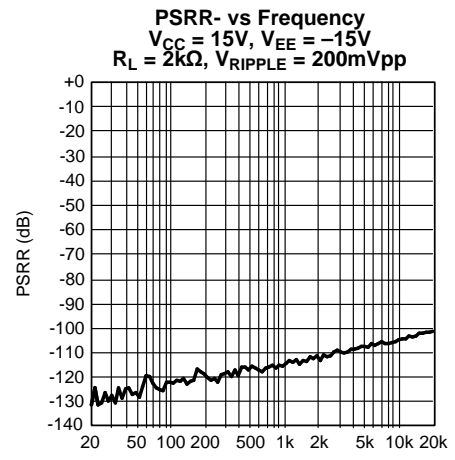
FREQUENCY (Hz)

Figure 58.



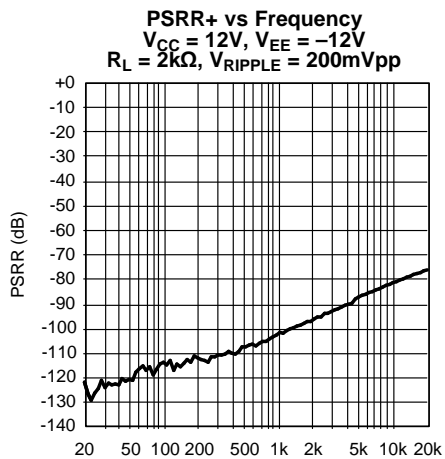
FREQUENCY (Hz)

Figure 59.



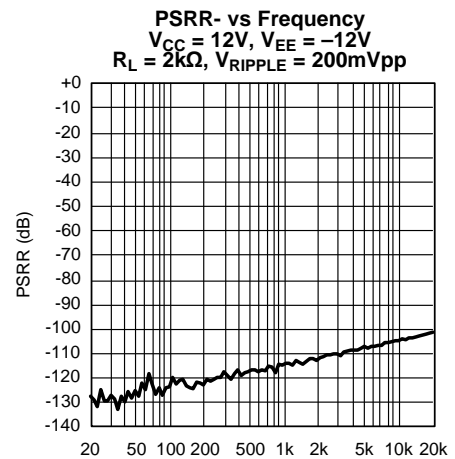
FREQUENCY (Hz)

Figure 60.



FREQUENCY (Hz)

Figure 61.



FREQUENCY (Hz)

Figure 62.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

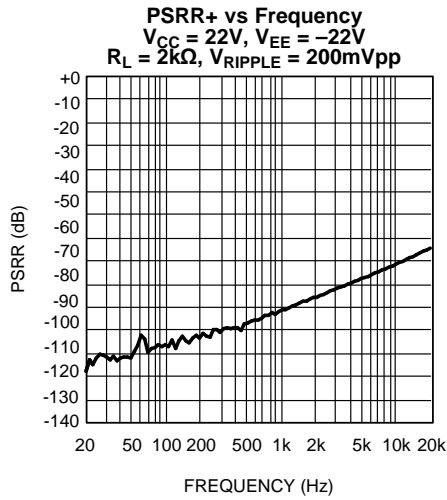


Figure 63.

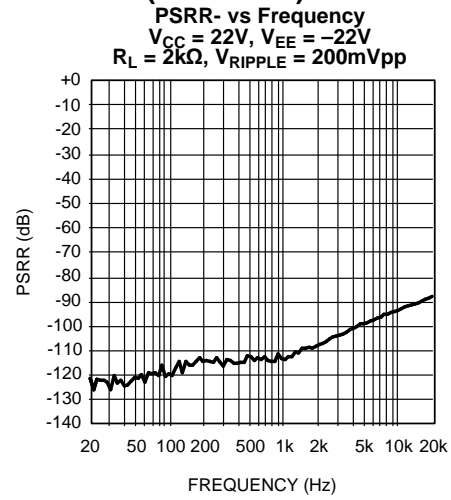


Figure 64.

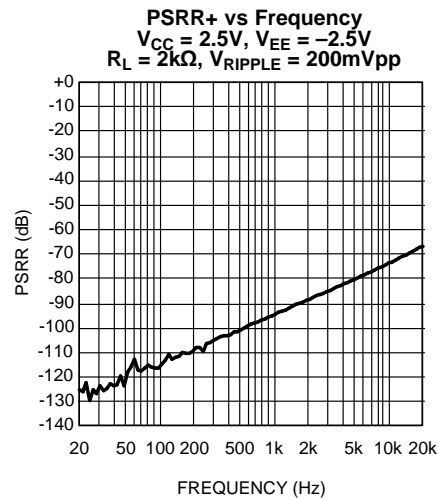


Figure 65.

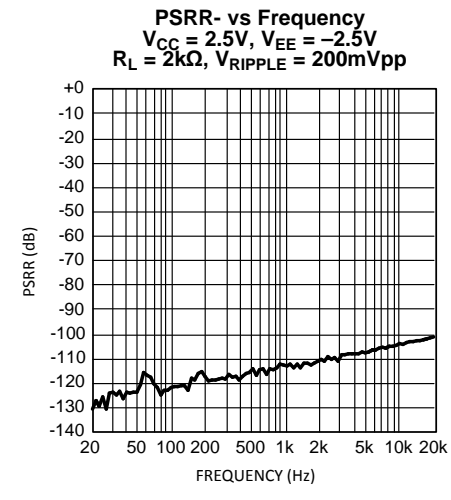


Figure 66.

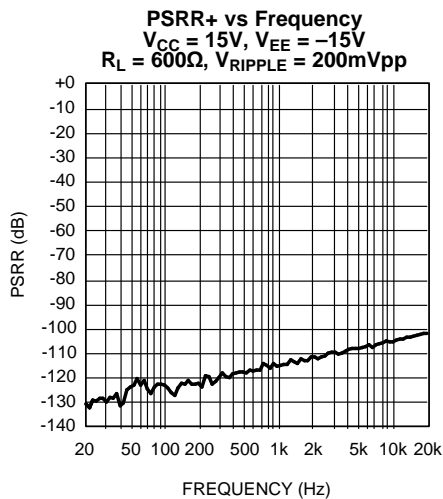


Figure 67.

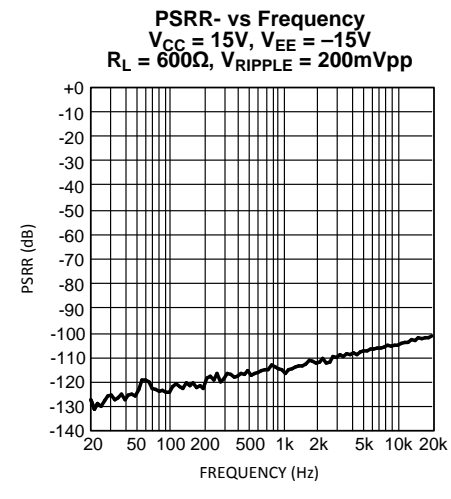


Figure 68.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

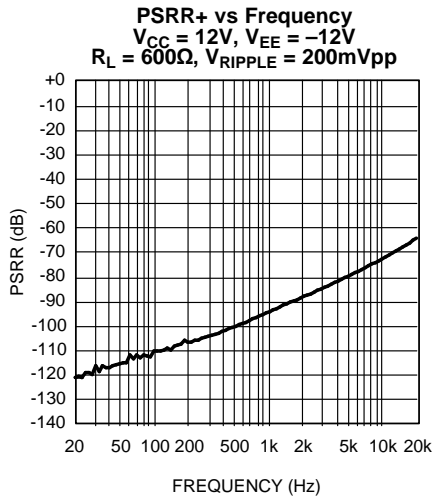


Figure 69.

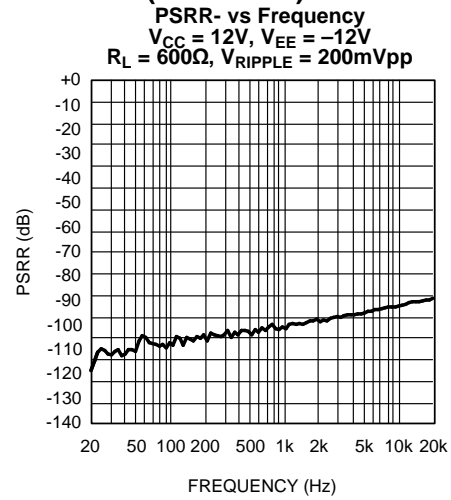


Figure 70.

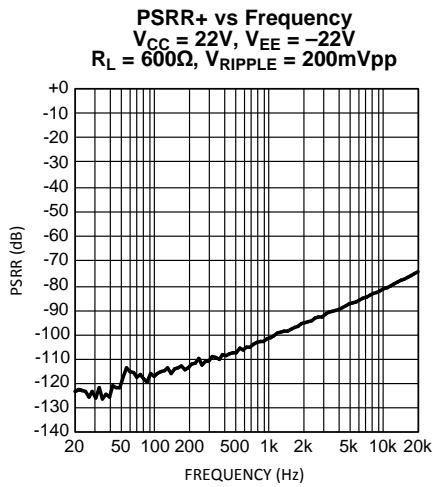


Figure 71.

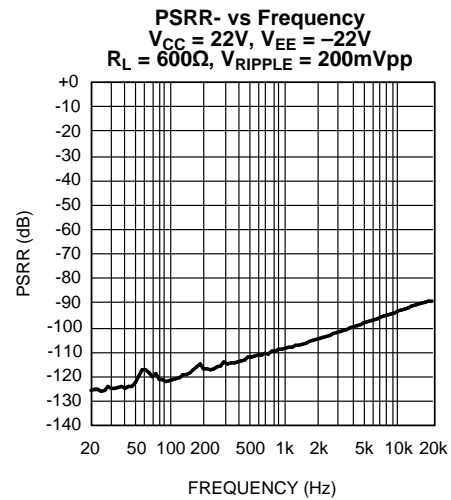


Figure 72.

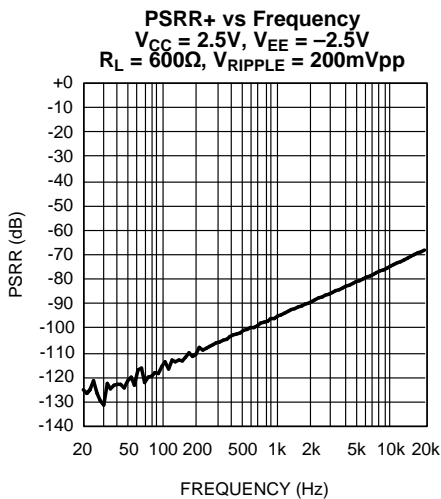


Figure 73.

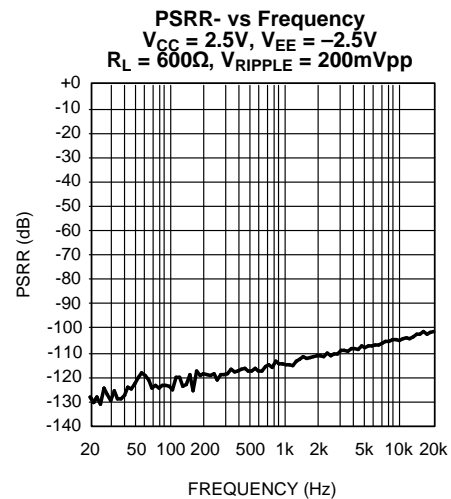


Figure 74.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

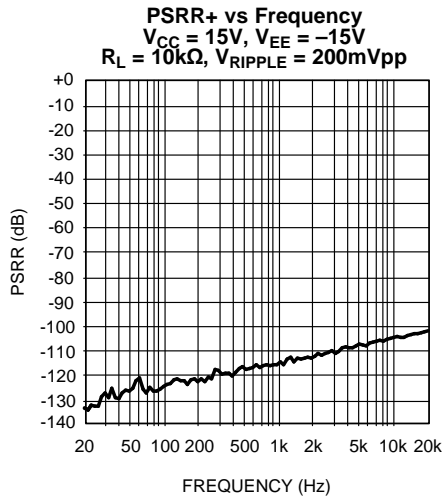


Figure 75.

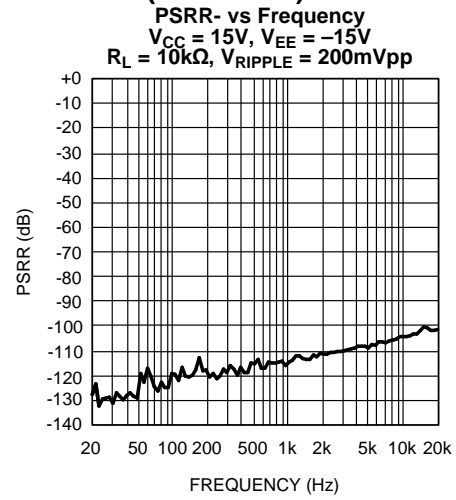


Figure 76.

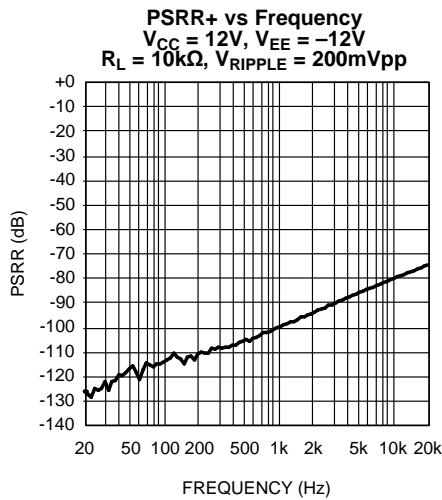


Figure 77.

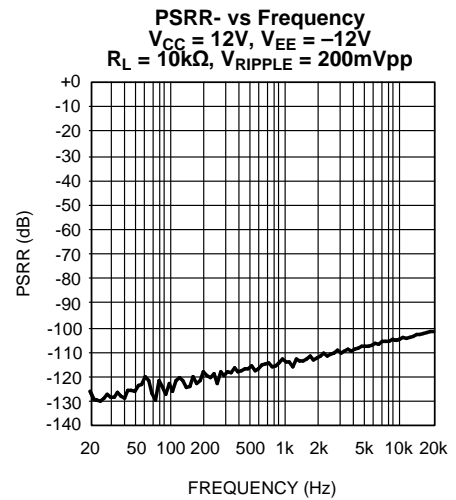


Figure 78.

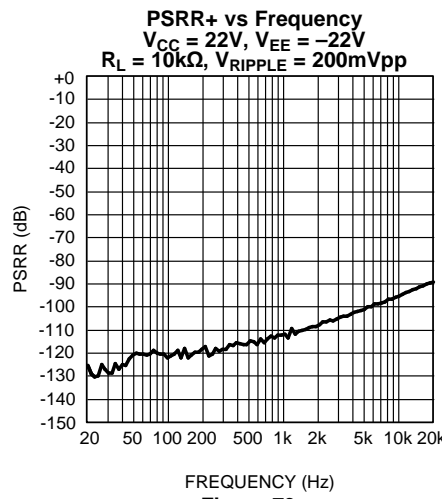


Figure 79.

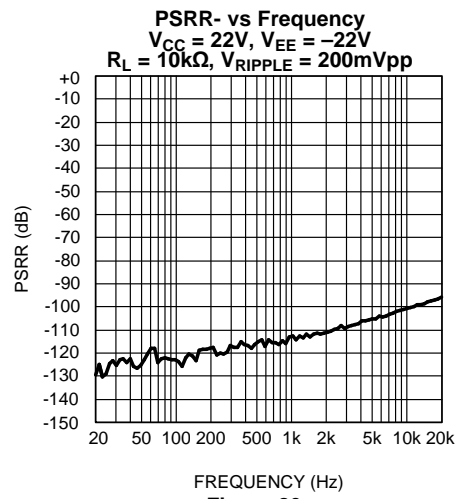


Figure 80.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

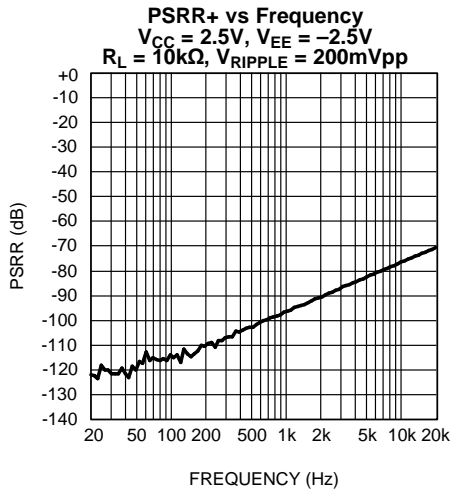


Figure 81.

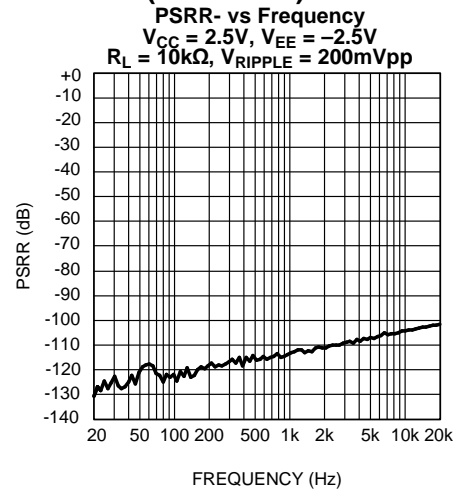


Figure 82.

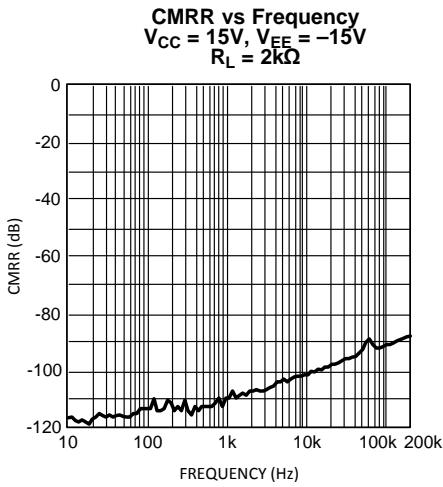


Figure 83.

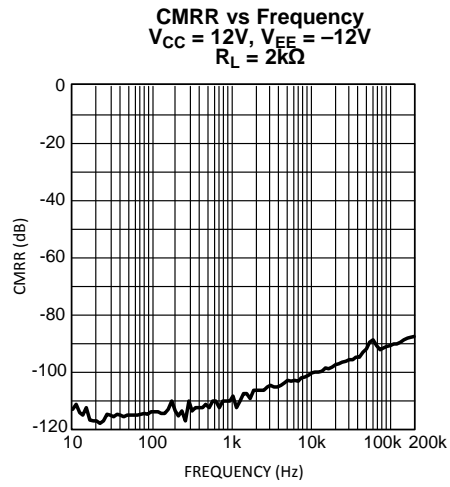


Figure 84.

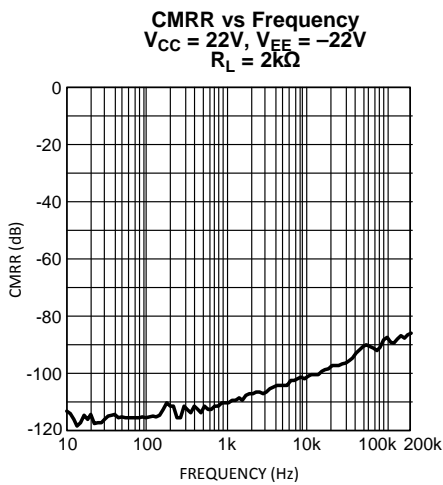


Figure 85.

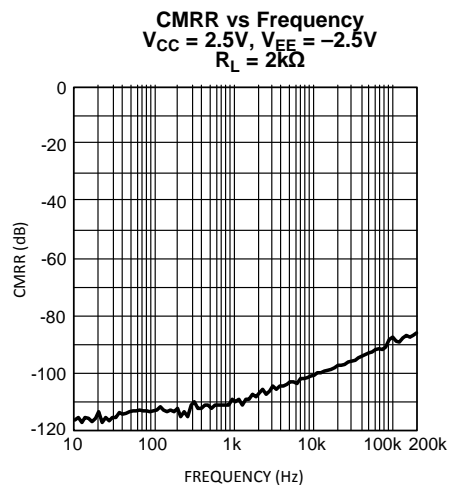


Figure 86.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

CMRR vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 600\Omega$

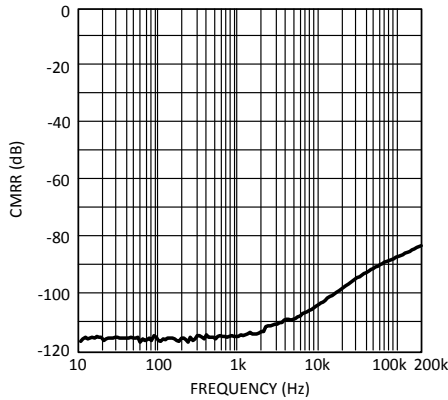


Figure 87.

CMRR vs Frequency
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 600\Omega$

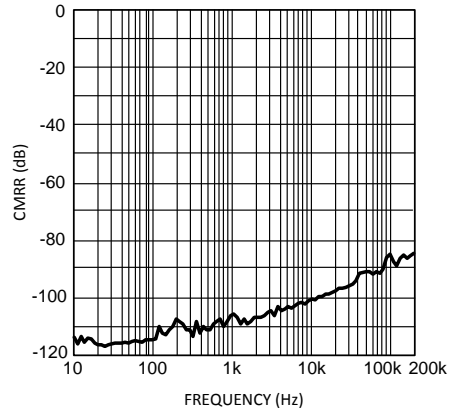


Figure 88.

CMRR vs Frequency
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 600\Omega$

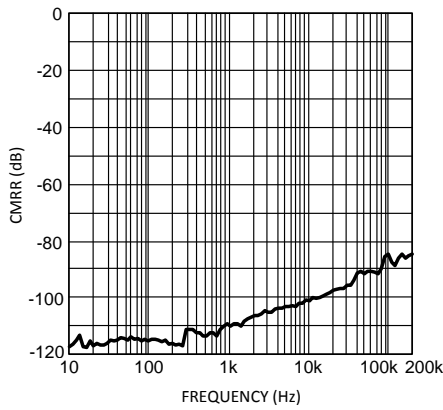


Figure 89.

CMRR vs Frequency
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 600\Omega$

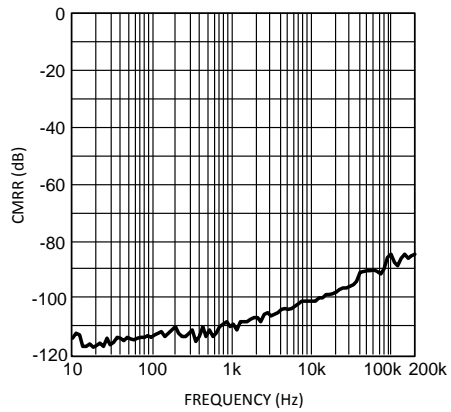


Figure 90.

CMRR vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 10k\Omega$

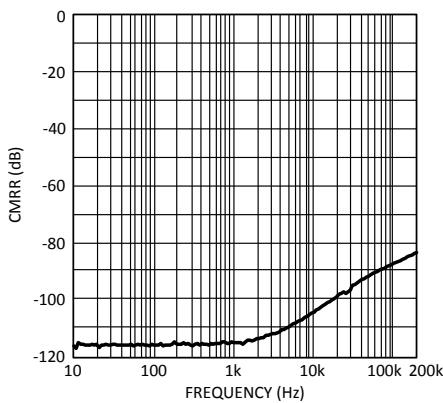


Figure 91.

CMRR vs Frequency
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 10k\Omega$

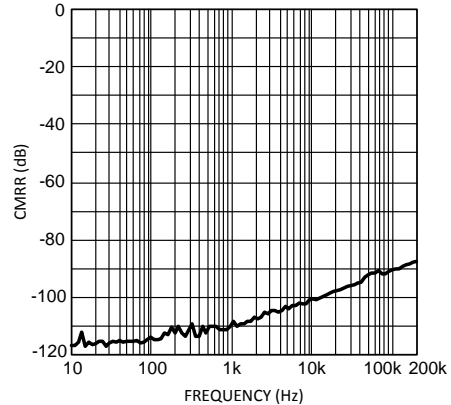


Figure 92.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

CMRR vs Frequency
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 10k\Omega$

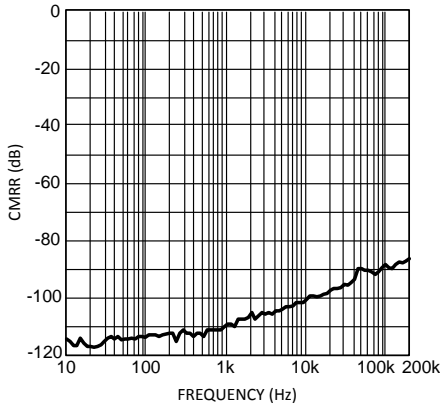


Figure 93.

CMRR vs Frequency
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 10k\Omega$

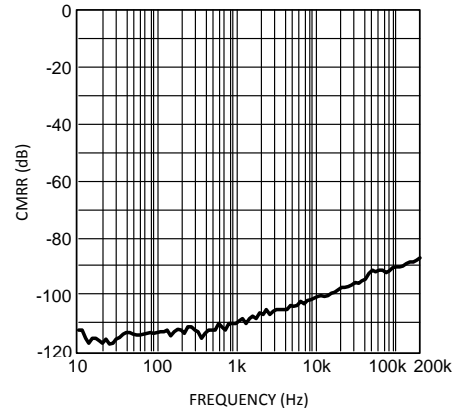


Figure 94.

Output Voltage vs Load Resistance
 $V_{CC} = 15V, V_{EE} = -15V$
 $THD+N = 1\%$

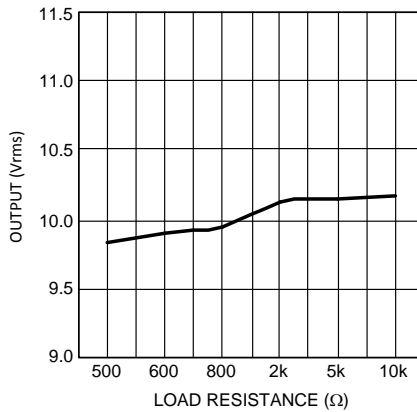


Figure 95.

Output Voltage vs Load Resistance
 $V_{CC} = 12V, V_{EE} = -12V$
 $THD+N = 1\%$

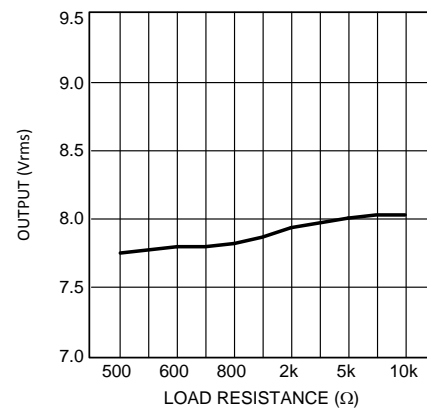


Figure 96.

Output Voltage vs Load Resistance
 $V_{CC} = 22V, V_{EE} = -22V$
 $THD+N = 1\%$

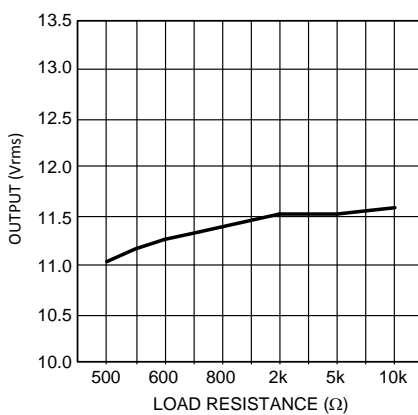


Figure 97.

Output Voltage vs Load Resistance
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $THD+N = 1\%$

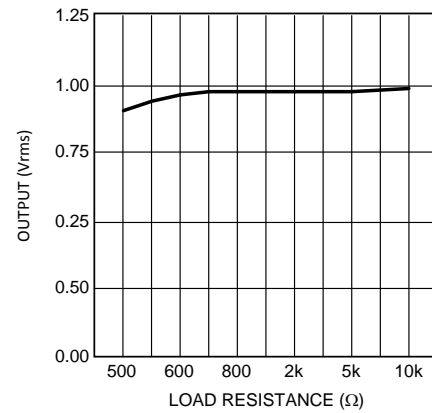


Figure 98.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

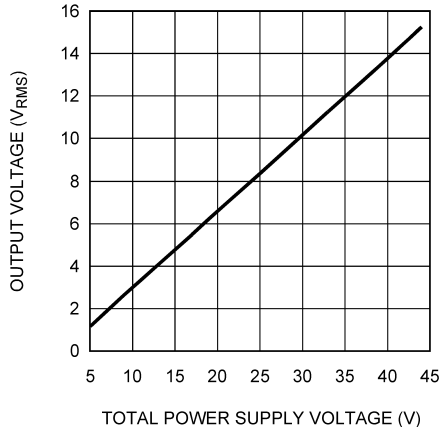


Figure 99.

Output Voltage vs Total Power Supply Voltage
 $R_L = 600\Omega$, THD+N = 1%

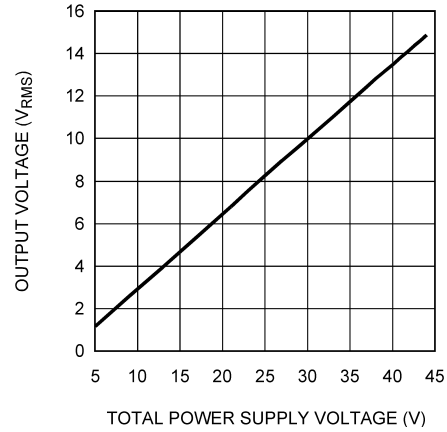


Figure 100.

Output Voltage vs Total Power Supply Voltage
 $R_L = 10k\Omega$, THD+N = 1%

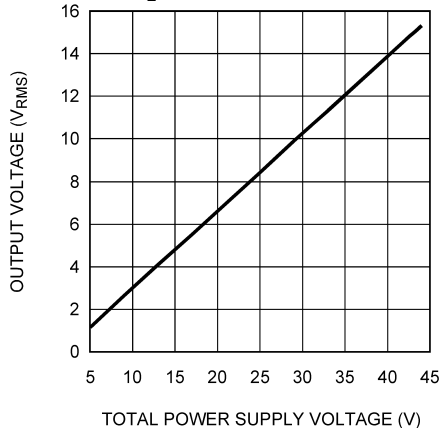


Figure 101.

Power Supply Current vs Total Power Supply Voltage
 $R_L = 2k\Omega$

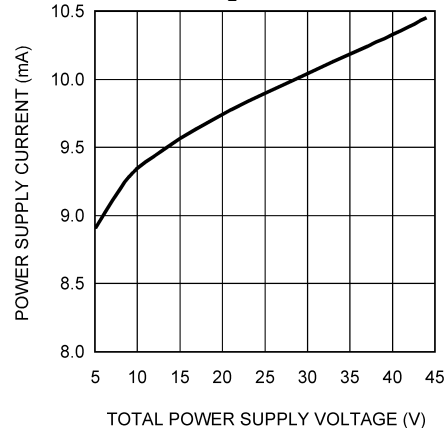


Figure 102.

Power Supply Current vs Total Power Supply Voltage
 $R_L = 600\Omega$

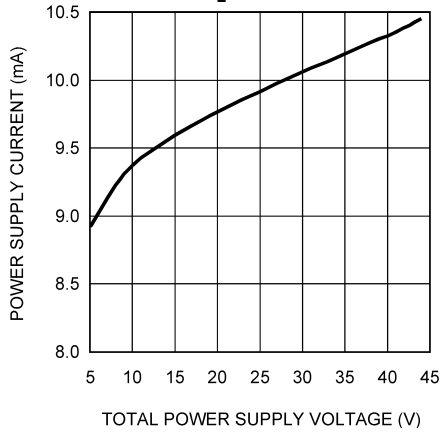


Figure 103.

Power Supply Current vs Total Power Supply Voltage
 $R_L = 10k\Omega$

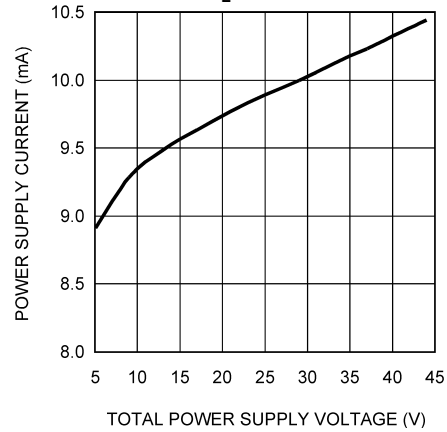


Figure 104.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

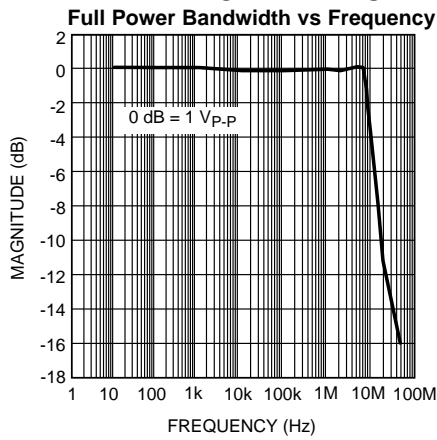


Figure 105.

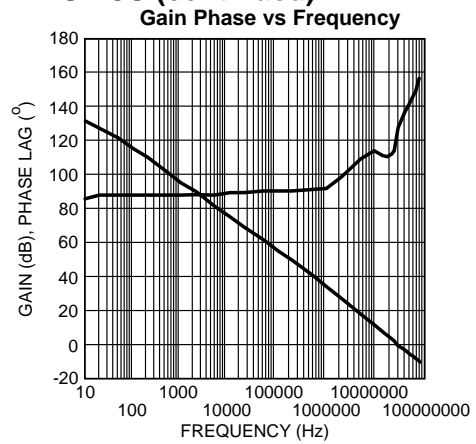


Figure 106.

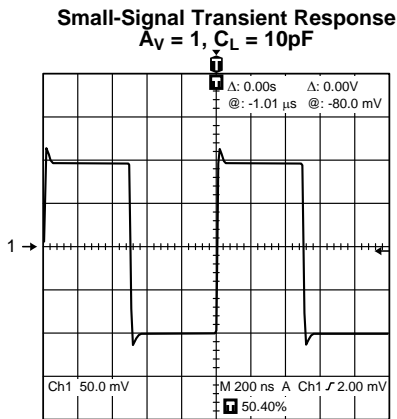


Figure 107.

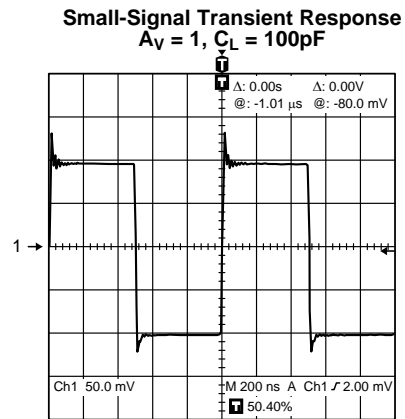


Figure 108.

APPLICATION INFORMATION

DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49860 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 LME49860's low residual distortion is an input referred internal error. As shown in [Figure 109](#), 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 109](#).

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.

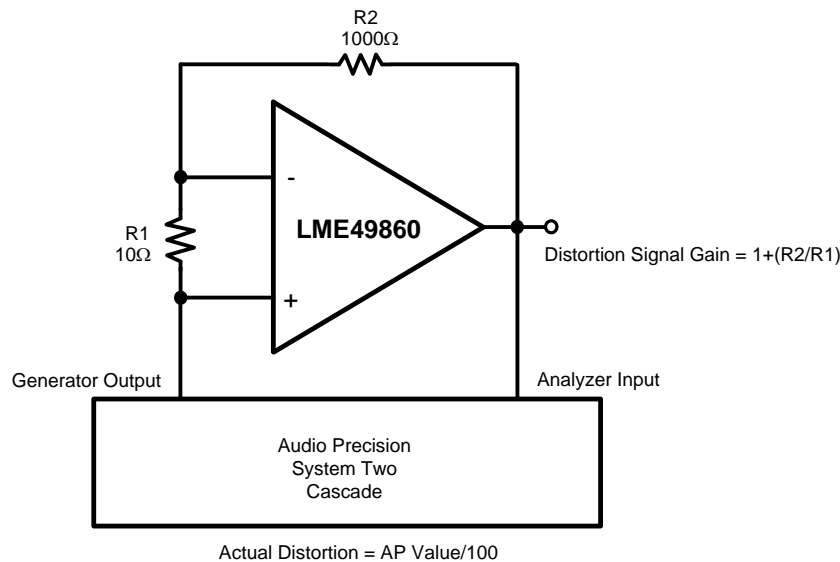
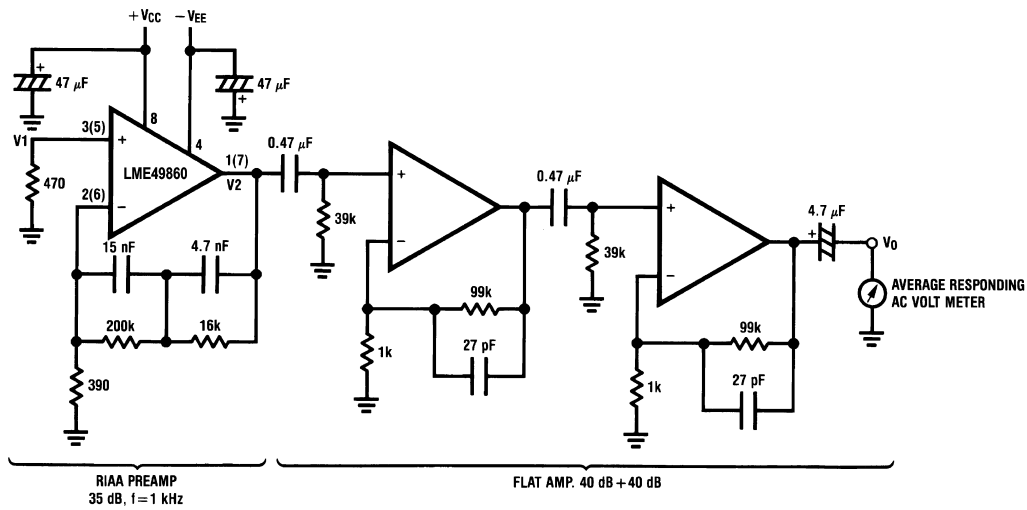


Figure 109. THD+N and IMD Distortion Test Circuit

The LME49860 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.



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

Figure 110. Noise Measurement Circuit
Total Gain: 115 dB @ f = 1 kHz
Input Referred Noise Voltage: $e_n = V_0/560,000$ (V)

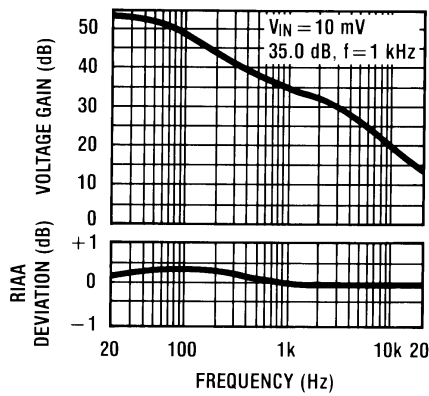


Figure 111. RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency

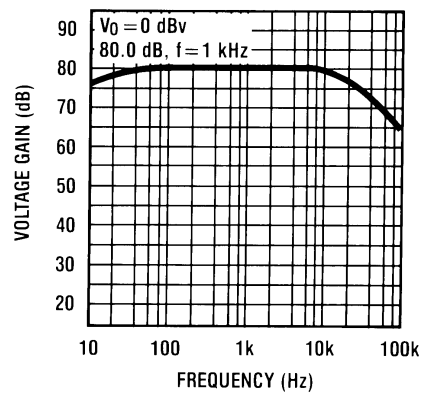
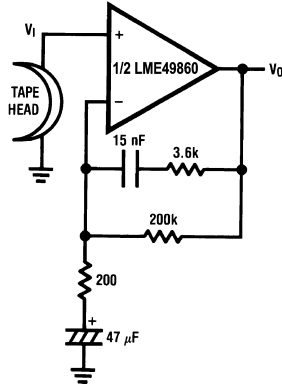


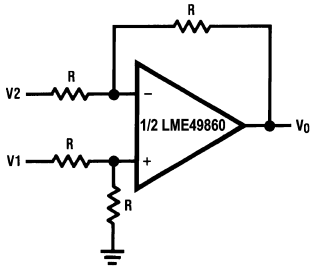
Figure 112. Flat Amp Voltage Gain vs Frequency

TYPICAL APPLICATIONS



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

Figure 113. NAB Preamp



$$V_O = V_1 - V_2$$

Figure 115. Balanced to Single Ended Converter

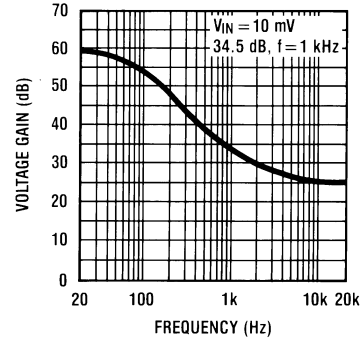
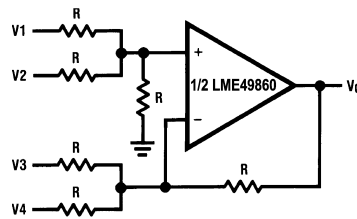
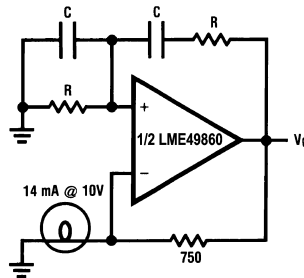


Figure 114. NAB Preamp Voltage Gain vs Frequency



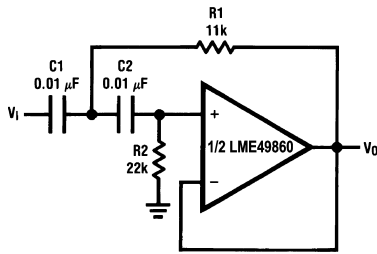
$$V_O = V_1 + V_2 - V_3 - V_4$$

Figure 116. Adder/Subtractor



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

Figure 117. Sine Wave Oscillator



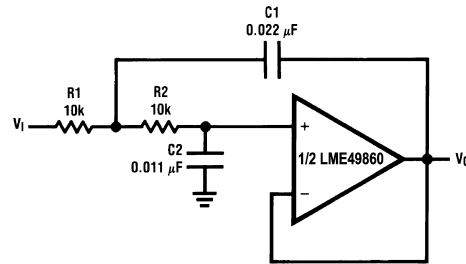
if $C1 = C2 = C$

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

$$R2 = 2 \cdot R1$$

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

Figure 118. Second Order High Pass Filter (Butterworth)



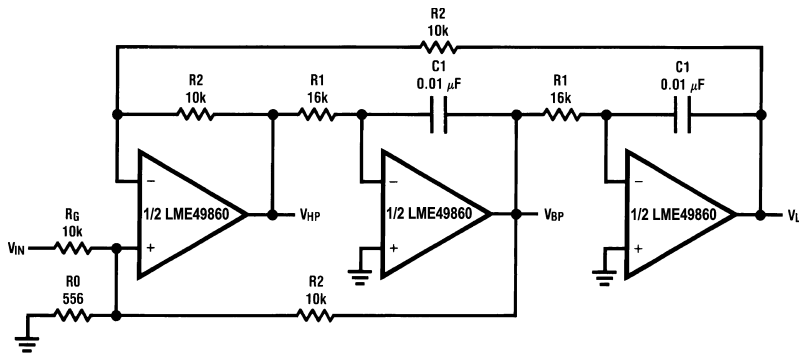
if $R1 = R2 = R$

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

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

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

Figure 119. Second Order Low Pass Filter (Butterworth)



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

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

Figure 120. State Variable Filter

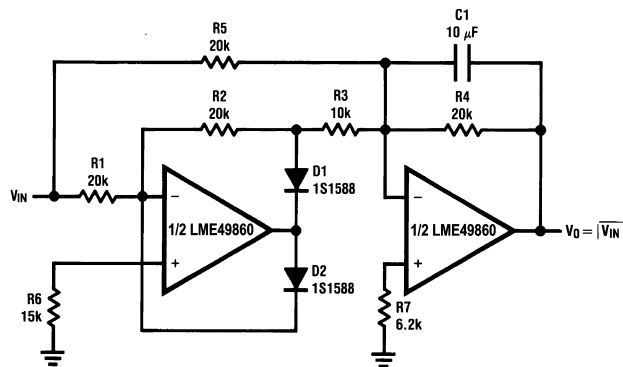


Figure 121. AC/DC Converter

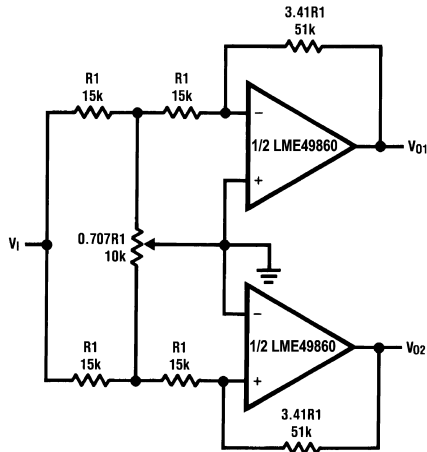


Figure 122. 2 Channel Panning Circuit (Pan Pot)

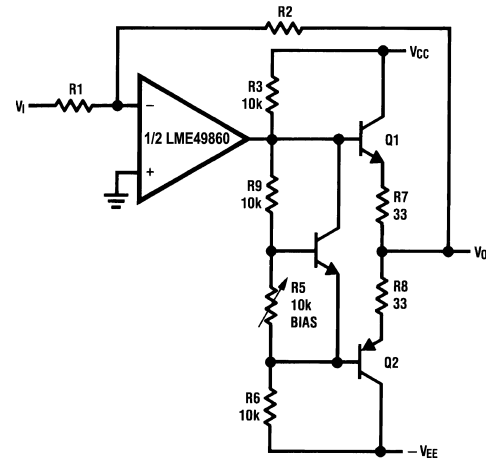
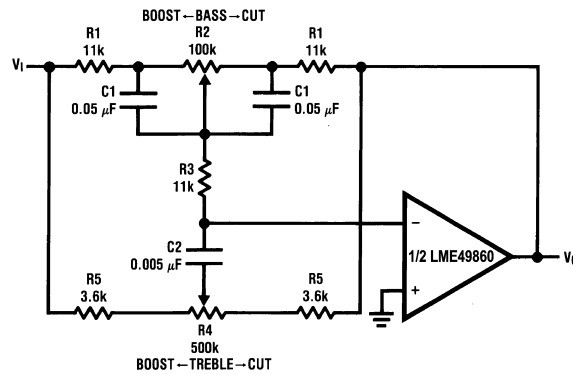


Figure 123. Line Driver



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

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

Illustration is:

$$f_L = 32 \text{ Hz}, f_{LB} = 320 \text{ Hz}$$

$$f_H = 11 \text{ kHz}, f_{HB} = 1.1 \text{ kHz}$$

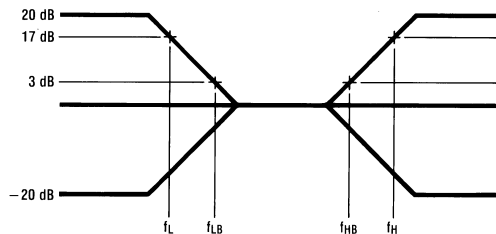
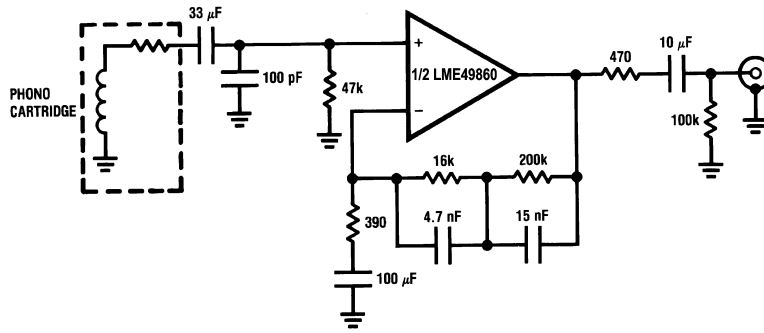
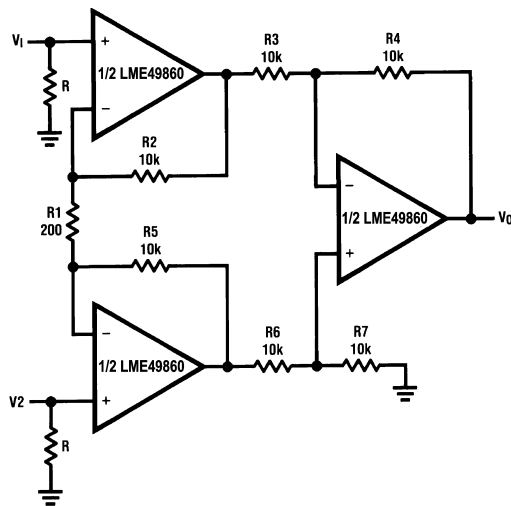


Figure 124. Tone Control



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

Figure 125. RIAA Preamp



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:

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

Figure 126. Balanced Input Mic Amp

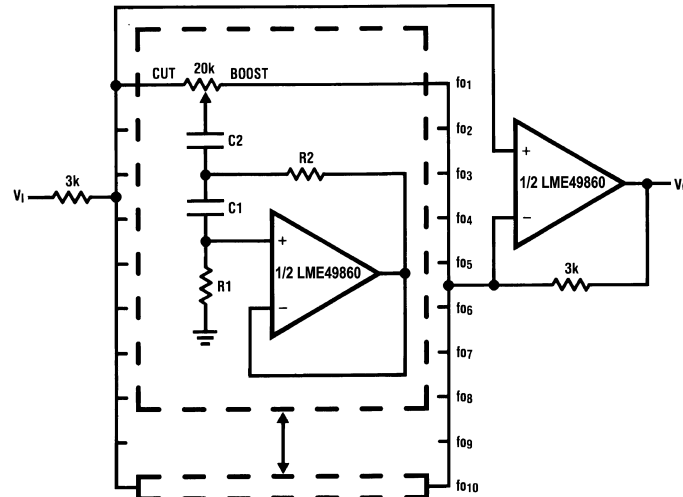


Figure 127. 10 Band Graphic Equalizer

| 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 |

REVISION HISTORY

| Rev | Date | Description |
|-----|----------|---|
| 1.0 | 06/01/07 | Initial release. |
| 1.1 | 06/11/07 | Added the LME49860MA and LME49860NA Top Mark Information. |
| C | 04/05/13 | 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 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|----------------|
| LME49860MAX/NOPB | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | -40 to 85 | L49860 MA | Samples |

(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.

OBSELETE: 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.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LME49860MAX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LME49860MAX/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
 EXPOSED METAL SHOWN
 SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated

Looking for pricing, stock, or lifecycle information?

Click below to explore more details on WIN SOURCE:

-  [View LME49860MAX/NOPB on WIN SOURCE](#)
-  [Texas Instruments](#) Information

Optimize Your Supply Chain with WIN SOURCE Solutions

-  Global Sourcing Solution
-  Obsolete Management
-  Cost Control Management
-  Shortage Management
-  Alternative Solution
-  Excess Inventory Management