LME49860, LME49860MABD, LME49860NABD

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 ±22V
- THD+N (AV = 1, VOUT = 3VRMS, fIN = 1kHz)
  - RL = 2kΩ: 0.00003% (Typ)
  - RL = 600Ω: 0.00003% (Typ)
- Input Noise Density: 2.7 nV/√Hz (Typ)
- Slew Rate: ±20V/μs (Typ)
- Gain Bandwidth Product: 55MHz (Typ)
- Open Loop Gain (RL = 600Ω): 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/√Hz) with vanishingly low THD+N (0.00003%) to easily satisfy the most demanding audio applications.

TYPICAL APPLICATION

Figure 1. Passively Equalized RIAA Phono Preamplifier

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

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DESCRIPTION (CONTINUED)

To ensure that the most challenging loads are driven without compromise, the LME49860 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 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 ±2.5V to ±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

![Connection Diagrams](image-url)

> 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\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LME49860</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Typical(^{(2)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Limits)</td>
</tr>
<tr>
<td>Power Supply Voltage</td>
<td>(V_S = V^+ - V^-)</td>
<td>46V</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td>-65°C to 150°C</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>((V^-) - 0.7V to (V^+) + 0.7V)</td>
<td></td>
</tr>
<tr>
<td>Output Short Circuit</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>ESD Susceptibility</td>
<td>Pins 1, 4, 7 and 8</td>
<td>2000V</td>
</tr>
<tr>
<td>ESD Susceptibility</td>
<td>Pins 2, 3, 5 and 6</td>
<td>200V</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td></td>
<td>150°C</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>(\theta_{JA}) (SOIC)</td>
<td>145°C/W</td>
</tr>
<tr>
<td></td>
<td>(\theta_{JA}) (PDIP)</td>
<td>102°C/W</td>
</tr>
</tbody>
</table>

(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.

OPERATING RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Range</td>
<td>(T_{MIN} \leq T_A \leq T_{MAX})</td>
</tr>
<tr>
<td>Supply Voltage Range</td>
<td>(\pm 2.5V \leq V_S \leq \pm 22V)</td>
</tr>
</tbody>
</table>

ELECTRICAL CHARACTERISTICS FOR THE LME49860\(^{(1)}\)

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>LME49860</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Typical(^{(2)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Limits)</td>
</tr>
<tr>
<td>THD+N</td>
<td>Total Harmonic Distortion + Noise</td>
<td>(A_V = 1, V_{OUT} = 3V_{rms})</td>
<td>0.00003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_L = 2k\Omega)</td>
<td>(max)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{L} = 600\Omega)</td>
<td></td>
</tr>
<tr>
<td>IMD</td>
<td>Intermodulation Distortion</td>
<td>(A_V = 1, V_{OUT} = 3V_{RMS}), Two-tone, 60Hz &amp; 7kHz 4:1</td>
<td>0.00005</td>
</tr>
<tr>
<td>GBWP</td>
<td>Gain Bandwidth Product</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MHz (min)</td>
</tr>
<tr>
<td>SR</td>
<td>Slew Rate</td>
<td></td>
<td>\pm 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V/\mu s</td>
</tr>
<tr>
<td>FPBW</td>
<td>Full Power Bandwidth</td>
<td>(V_{OUT} = 1V_{P-P}, -3dB)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>referenced to output magnitude at (f = 1kHz)</td>
<td>MHz (min)</td>
</tr>
<tr>
<td>(t_s)</td>
<td>Settling time</td>
<td>(A_V = -1, 10V) step, (C_L = 100pF), 0.1% error range</td>
<td>1.2</td>
</tr>
<tr>
<td>(e_n)</td>
<td>Equivalent Input Noise Voltage</td>
<td>(f_{BW} = 20Hz) to 20kHz</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\mu V_{RMS} (max)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equivalent Input Noise Density</td>
<td>(f = 1kHz), (f = 10Hz)</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nV/\sqrt{HZ} (max)</td>
</tr>
<tr>
<td>(l_n)</td>
<td>Current Noise Density</td>
<td>(f = 1kHz), (f = 10Hz)</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>(V_{OS})</td>
<td>Offset Voltage</td>
<td>(V_S = \pm 18V)</td>
<td>\pm 0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\pm 0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(V_S = \pm 22V)</td>
<td>\pm 0.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\pm 0.7</td>
</tr>
<tr>
<td>(\Delta V_{OS}/\Delta T_{mp})</td>
<td>Average Input Offset Voltage Drift vs Temperature</td>
<td>(-40°C \leq T_A \leq 85°C)</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\mu V/°C</td>
</tr>
</tbody>
</table>

(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).

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## ELECTRICAL CHARACTERISTICS FOR THE LME49860 (1)

The following specifications apply for $V_S = \pm 18V$ and $\pm 22V$, $R_L = 2k\Omega$, $R_{\text{SOURCE}} = 100\Omega$, $f_{\text{IN}} = 1kHz$, $T_A = 25^\circ C$, unless otherwise specified.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>LME49860</th>
<th>Units (Limits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Typical(2)</td>
<td>Limit(3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>dB</td>
<td>dB (min)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nA</td>
<td>nA/°C</td>
</tr>
<tr>
<td>PSRR</td>
<td>Average Input Offset Voltage Shift vs Power Supply Voltage</td>
<td>$V_S = \pm 18V$, $\Delta V_S = 24V$</td>
<td>120</td>
<td>110 dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$, $\Delta V_S = 30V$</td>
<td>118</td>
<td>112 dB</td>
</tr>
<tr>
<td>ISO_CH-CH</td>
<td>Channel-to-Channel Isolation</td>
<td>$I_{\text{IN}} = 1kHz$</td>
<td>10</td>
<td>72 nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_{\text{IN}} = 20kHz$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_B$</td>
<td>Input Bias Current</td>
<td>$V_{CM} = 0V$</td>
<td>11</td>
<td>65 nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\Delta I_{\text{OS}}/\Delta T$</td>
<td>0.1</td>
<td>nA/°C</td>
</tr>
<tr>
<td>$V_{IN-CM}$</td>
<td>Common-Mode Input Voltage Range</td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>125 dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common-Mode Rejection</td>
<td>$V_S = \pm 18V$, $\pm 12V \leq V_{CM} \leq 12V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$, $\pm 15V \leq V_{CM} \leq 15V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>$Z_{IN}$</td>
<td>Differential Input Impedance</td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>1000 MΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>$A_{VOL}$</td>
<td>Open Loop Voltage Gain</td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 12V \leq V_{\text{out}} \leq 12V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 600\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 2k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 10k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 15V \leq V_{CM} \leq 15V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 600\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 2k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$R_L = 10k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>$V_{OUTMAX}$</td>
<td>Maximum Output Voltage Swing</td>
<td>$R_L = 600\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>Output Current</td>
<td>$R_L = 2k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>$I_{OUT-CC}$</td>
<td>Instantaneous Short Circuit Current</td>
<td>$R_L = 10k\Omega$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td>$I_S$</td>
<td>Total Quiescent Current</td>
<td>$I_{OUT} = 0mA$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 18V$</td>
<td>140</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_S = \pm 22V$</td>
<td>140</td>
<td>dB</td>
</tr>
</tbody>
</table>

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

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(1) LME49860, LME49860MABD, LME49860NABD

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Product Folder Links: LME49860 LME49860MABD LME49860NABD
TYPICAL PERFORMANCE CHARACTERISTICS

THD+N vs Output Voltage

\( V_{CC} = 15V, V_{EE} = -15V \)
\( R_L = 2k\Omega \)

Figure 3.

\( V_{CC} = 12V, V_{EE} = -12V \)
\( R_L = 2k\Omega \)

Figure 4.

\( V_{CC} = 22V, V_{EE} = -22V \)
\( R_L = 2k\Omega \)

Figure 5.

\( V_{CC} = 2.5V, V_{EE} = -2.5V \)
\( R_L = 2k\Omega \)

Figure 6.

\( V_{CC} = 15V, V_{EE} = -15V \)
\( R_L = 600\Omega \)

Figure 7.

\( V_{CC} = 12V, V_{EE} = -12V \)
\( R_L = 600\Omega \)

Figure 8.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

THD+N vs Frequency

\( V_{CC} = 15\, V, \, V_{EE} = -15\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 2\, k\Omega \)

Figure 15.

\( V_{CC} = 12\, V, \, V_{EE} = -12\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 2\, k\Omega \)

Figure 16.

\( V_{CC} = 22\, V, \, V_{EE} = -22\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 2\, k\Omega \)

Figure 17.

\( V_{CC} = 15\, V, \, V_{EE} = -15\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 600\, \Omega \)

Figure 18.

\( V_{CC} = 12\, V, \, V_{EE} = -12\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 600\, \Omega \)

Figure 19.

\( V_{CC} = 22\, V, \, V_{EE} = -22\, V, \, V_{OUT} = 3V_{RMS} \)

\( R_L = 600\, \Omega \)

Figure 20.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

Figure 21.

THD+N vs Frequency
$V_{CC} = 12V, V_{EE} = -12V, V_{OUT} = 3V_{RMS}$
$R_L = 10k\Omega$

Figure 22.

THD+N vs Frequency
$V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 3V_{RMS}$
$R_L = 10k\Omega$

Figure 23.

IMD vs Output Voltage
$V_{CC} = 15V, V_{EE} = -15V$
$R_L = 2k\Omega$

Figure 24.

IMD vs Output Voltage
$V_{CC} = 12V, V_{EE} = -12V$
$R_L = 2k\Omega$

Figure 25.

IMD vs Output Voltage
$V_{CC} = 22V, V_{EE} = -22V$
$R_L = 2k\Omega$

Figure 26.
<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE (V)</th>
<th>IMD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00001</td>
<td>0.01</td>
</tr>
<tr>
<td>0.00002</td>
<td>0.02</td>
</tr>
<tr>
<td>0.00005</td>
<td>0.005</td>
</tr>
<tr>
<td>0.0001</td>
<td>0.01</td>
</tr>
<tr>
<td>0.0002</td>
<td>0.02</td>
</tr>
<tr>
<td>0.0005</td>
<td>0.005</td>
</tr>
<tr>
<td>0.001</td>
<td>0.01</td>
</tr>
<tr>
<td>0.002</td>
<td>0.02</td>
</tr>
</tbody>
</table>

IMD vs Output Voltage

**Figure 27.**

**Figure 28.**

**Figure 29.**

**Figure 30.**

**Figure 31.**

**Figure 32.**
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

IMD vs Output Voltage

V\textsubscript{CC} = 12V, V\textsubscript{EE} = –12V
R\textsubscript{L} = 10k\Omega

![IMD vs Output Voltage](image)

IMD vs Output Voltage

V\textsubscript{CC} = 22V, V\textsubscript{EE} = –22V
R\textsubscript{L} = 10k\Omega

![IMD vs Output Voltage](image)

IMD vs Output Voltage

V\textsubscript{CC} = 2.5V, V\textsubscript{EE} = –2.5V
R\textsubscript{L} = 10k\Omega

![IMD vs Output Voltage](image)

Voltage Noise Density vs Frequency

V\textsubscript{S} = 30V
V\textsubscript{CM} = 15V

![Voltage Noise Density vs Frequency](image)

Current Noise Density vs Frequency

V\textsubscript{S} = 30V
V\textsubscript{CM} = 15V

![Current Noise Density vs Frequency](image)

Crosstalk vs Frequency

V\textsubscript{CC} = 15V, V\textsubscript{EE} = –15V, V\textsubscript{OUT} = 3V\textsubscript{RMS}
A\textsubscript{V} = 0dB, R\textsubscript{L} = 2k\Omega

![Crosstalk vs Frequency](image)

Figure 33.

Figure 34.

Figure 35.

Figure 36.

Figure 37.

Figure 38.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Crosstalk vs Frequency

\( V_{CC} = 15V, V_{EE} = -15V, V_{OUT} = 10V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 39.

Crosstalk vs Frequency

\( V_{CC} = 12V, V_{EE} = -12V, V_{OUT} = 3V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 40.

Crosstalk vs Frequency

\( V_{CC} = 12V, V_{EE} = -22V, V_{OUT} = 10V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 41.

Crosstalk vs Frequency

\( V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 3V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 42.

Crosstalk vs Frequency

\( V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 10V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 43.

Crosstalk vs Frequency

\( V_{CC} = 2.5V, V_{EE} = -2.5V, V_{OUT} = 1V_{RMS} \)
\( A_V = 0dB, R_L = 2k\Omega \)

Figure 44.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Crosstalk vs Frequency

\( V_{CC} = 15V, V_{EE} = -15V, V_{OUT} = 3V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 45.

Crosstalk vs Frequency

\( V_{CC} = 15V, V_{EE} = -15V, V_{OUT} = 10V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 46.

Crosstalk vs Frequency

\( V_{CC} = 12V, V_{EE} = -12V, V_{OUT} = 3V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 47.

Crosstalk vs Frequency

\( V_{CC} = 12V, V_{EE} = -12V, V_{OUT} = 10V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 48.

Crosstalk vs Frequency

\( V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 3V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 49.

Crosstalk vs Frequency

\( V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 10V_{RMS} \)
\( A_{V} = 0dB, R_{L} = 600\Omega \)

Figure 50.
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

**Crosstalk vs Frequency**

- **Figure 51.**
  - $V_{CC} = 2.5V$, $V_{EE} = -2.5V$, $V_{OUT} = 1V_{RMS}$
  - $A_V = 0dB$, $R_L = 600\Omega$

- **Figure 52.**
  - $V_{CC} = 15V$, $V_{EE} = -15V$, $V_{OUT} = 3V_{RMS}$
  - $A_V = 0dB$, $R_L = 10k\Omega$

- **Figure 53.**
  - $V_{CC} = 15V$, $V_{EE} = -15V$, $V_{OUT} = 10V_{RMS}$
  - $A_V = 0dB$, $R_L = 10k\Omega$

- **Figure 54.**
  - $V_{CC} = 12V$, $V_{EE} = -12V$, $V_{OUT} = 3V_{RMS}$
  - $A_V = 0dB$, $R_L = 10k\Omega$

- **Figure 55.**
  - $V_{CC} = 12V$, $V_{EE} = -12V$, $V_{OUT} = 10V_{RMS}$
  - $A_V = 0dB$, $R_L = 10k\Omega$

- **Figure 56.**
  - $V_{CC} = 22V$, $V_{EE} = -22V$, $V_{OUT} = 3V_{RMS}$
  - $A_V = 0dB$, $R_L = 10k\Omega$
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Crosstalk vs Frequency

$V_{CC} = 22V, V_{EE} = -22V, V_{OUT} = 10\text{V}_{\text{RMS}}$
$A_{V} = 0\text{dB}, R_{L} = 10\Omega$

Figure 57.

Crosstalk vs Frequency

$V_{CC} = 2.5V, V_{EE} = -2.5V, V_{OUT} = 1\text{V}_{\text{RMS}}$
$A_{V} = 0\text{dB}, R_{L} = 10\Omega$

Figure 58.

PSRR+ vs Frequency

$V_{CC} = 15V, V_{EE} = -15V$
$R_{L} = 2\Omega, V_{RIPPLE} = 200\text{mV}_{\text{pp}}$

Figure 59.

PSRR- vs Frequency

$V_{CC} = 15V, V_{EE} = -15V$
$R_{L} = 2\Omega, V_{RIPPLE} = 200\text{mV}_{\text{pp}}$

Figure 60.

PSRR+ vs Frequency

$V_{CC} = 12V, V_{EE} = -12V$
$R_{L} = 2\Omega, V_{RIPPLE} = 200\text{mV}_{\text{pp}}$

Figure 61.

PSRR- vs Frequency

$V_{CC} = 12V, V_{EE} = -12V$
$R_{L} = 2\Omega, V_{RIPPLE} = 200\text{mV}_{\text{pp}}$

Figure 62.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

PSRR+ vs Frequency
$V_{CC} = 22V$, $V_{EE} = -22V$
$R_L = 2k\Omega$, $V_{RIPPLE} = 200mVpp$

PSRR- vs Frequency
$V_{CC} = 22V$, $V_{EE} = -22V$
$R_L = 2k\Omega$, $V_{RIPPLE} = 200mVpp$

Figure 63.

$V_{CC} = 2.5V$, $V_{EE} = -2.5V$
$R_L = 2k\Omega$, $V_{RIPPLE} = 200mVpp$

$V_{CC} = 2.5V$, $V_{EE} = -2.5V$
$R_L = 2k\Omega$, $V_{RIPPLE} = 200mVpp$

Figure 64.

$V_{CC} = 15V$, $V_{EE} = -15V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

$V_{CC} = 15V$, $V_{EE} = -15V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

Figure 65.

Figure 66.

Figure 67.

Figure 68.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**Figure 69.**
PSRR+ vs Frequency
$V_{CC} = 12V$, $V_{EE} = -12V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

**Figure 70.**
PSRR+ vs Frequency
$V_{CC} = 12V$, $V_{EE} = -12V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

**Figure 71.**
PSRR+ vs Frequency
$V_{CC} = 22V$, $V_{EE} = -22V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

**Figure 72.**
PSRR+ vs Frequency
$V_{CC} = 22V$, $V_{EE} = -22V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

**Figure 73.**
PSRR+ vs Frequency
$V_{CC} = 2.5V$, $V_{EE} = -2.5V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$

**Figure 74.**
PSRR- vs Frequency
$V_{CC} = 2.5V$, $V_{EE} = -2.5V$
$R_L = 600\Omega$, $V_{RIPPLE} = 200mVpp$
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

PSRR+ vs Frequency
$V_{CC} = 16V, V_{EE} = -15V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 75.

PSRR- vs Frequency
$V_{CC} = 16V, V_{EE} = -15V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 76.

PSRR+ vs Frequency
$V_{CC} = 12V, V_{EE} = -12V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 77.

PSRR- vs Frequency
$V_{CC} = 12V, V_{EE} = -12V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 78.

PSRR+ vs Frequency
$V_{CC} = 22V, V_{EE} = -22V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 79.

PSRR- vs Frequency
$V_{CC} = 22V, V_{EE} = -22V$
$R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

Figure 80.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**PSRR+ vs Frequency**
\[ V_{CC} = 2.5\text{V}, \quad V_{EE} = -2.5\text{V} \]
\[ R_L = 10\text{k}\Omega, \quad V_{RIPPLE} = 200\text{mV}_{\text{pp}} \]

**PSRR- vs Frequency**
\[ V_{CC} = 2.5\text{V}, \quad V_{EE} = -2.5\text{V} \]
\[ R_L = 10\text{k}\Omega, \quad V_{RIPPLE} = 200\text{mV}_{\text{pp}} \]

**CMRR vs Frequency**
\[ V_{CC} = 22\text{V}, \quad V_{EE} = -22\text{V} \]
\[ R_L = 2\text{k}\Omega \]

**CMRR vs Frequency**
\[ V_{CC} = 2.5\text{V}, \quad V_{EE} = -2.5\text{V} \]
\[ R_L = 2\text{k}\Omega \]

---

Figure 81.

Figure 82.

Figure 83.

Figure 84.

Figure 85.

Figure 86.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

CMRR vs Frequency

**V\text{CC} = 15\text{V}, V\text{EE} = -15\text{V}\**

\[ R_L = 600\Omega \]

**Figure 87.**

CMRR vs Frequency

**V\text{CC} = 12\text{V}, V\text{EE} = -12\text{V}\**

\[ R_L = 600\Omega \]

**Figure 88.**

CMRR vs Frequency

**V\text{CC} = 22\text{V}, V\text{EE} = -22\text{V}\**

\[ R_L = 600\Omega \]

**Figure 89.**

CMRR vs Frequency

**V\text{CC} = 2.5\text{V}, V\text{EE} = -2.5\text{V}\**

\[ R_L = 600\Omega \]

**Figure 90.**

CMRR vs Frequency

**V\text{CC} = 15\text{V}, V\text{EE} = -15\text{V}\**

\[ R_L = 10\text{k}\Omega \]

**Figure 91.**

CMRR vs Frequency

**V\text{CC} = 12\text{V}, V\text{EE} = -12\text{V}\**

\[ R_L = 10\text{k}\Omega \]

**Figure 92.**
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**CMRR vs Frequency**

- **V\text{CC} = 22V, V\text{EE} = -22V**
- **R\text{L} = 10kΩ**

![CMRR vs Frequency Graph](image)

**Figure 93.**

- **V\text{CC} = 2.5V, V\text{EE} = -2.5V**
- **R\text{L} = 10kΩ**

![CMRR vs Frequency Graph](image)

**Figure 94.**

**Output Voltage vs Load Resistance**

- **V\text{CC} = 15V, V\text{EE} = -15V**
- **THD+N = 1%**

![Output Voltage vs Load Resistance Graph](image)

**Figure 95.**

- **V\text{CC} = 12V, V\text{EE} = -12V**
- **THD+N = 1%**

![Output Voltage vs Load Resistance Graph](image)

**Figure 96.**

- **V\text{CC} = 22V, V\text{EE} = -22V**
- **THD+N = 1%**

![Output Voltage vs Load Resistance Graph](image)

**Figure 97.**

- **V\text{CC} = 2.5V, V\text{EE} = -2.5V**
- **THD+N = 1%**

![Output Voltage vs Load Resistance Graph](image)

**Figure 98.**

---

LME49860, LME49860MABD, LME49860NABD

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TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Voltage vs Total Power Supply Voltage

\[ R_L = 2\, \text{k}\Omega, \ THD+N = 1\% \]

\[ R_L = 600\, \Omega, \ THD+N = 1\% \]

Figure 99.

Figure 100.

Output Voltage vs Total Power Supply Voltage

\[ R_L = 10\, \text{k}\Omega, \ THD+N = 1\% \]

\[ R_L = 2\, \text{k}\Omega \]

Figure 101.

Figure 102.

Power Supply Current vs Total Power Supply Voltage

\[ R_L = 600\, \Omega \]

\[ R_L = 10\, \text{k}\Omega \]

Figure 103.

Figure 104.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Full Power Bandwidth vs Frequency

Gain Phase vs Frequency

Small-Signal Transient Response
\( A_V = 1, \ C_L = 10\text{pF} \)

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

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.

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

Figure 113. NAB Preamp

Figure 114. NAB Preamp Voltage Gain vs Frequency

Figure 115. Balanced to Single Ended Converter

Figure 116. Adder/Subtractor

Figure 117. Sine Wave Oscillator

A_v = 34.5
F = 1 kHz
E_n = 0.38 \mu V
A Weighted
LME49860, LME49860MABD, LME49860NABD

Figure 118. Second Order High Pass Filter (Butterworth)

Illustration is \( f_0 = 1 \text{ kHz} \)

if \( C_1 = C_2 = C \)

\[
R_1 = \frac{3}{2\omega_0 C} \quad \text{and} \quad R_2 = 2R_1
\]

Illustration is \( f_0 = 1 \text{ kHz} \)

Figure 119. Second Order Low Pass Filter (Butterworth)

Illustration is \( f_0 = 1 \text{ kHz} \)

if \( R_1 = R_2 = R \)

\[
C_1 = \frac{3}{\omega_0 R} \quad \text{and} \quad C_2 = \frac{C_1}{2}
\]

Figure 120. State Variable Filter

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

\[
t_0 = \frac{1}{\mu R_1 R_2}, Q = \frac{1}{2} \left( 1 + \frac{R_2}{R_0} \right) A_{BP} = A_{LP} = A_{BH} = \frac{R_2}{R_0}
\]

Figure 121. AC/DC Converter
Figure 122. 2 Channel Panning Circuit (Pan Pot)

Figure 123. Line Driver

Figure 124. Tone Control

Illustration is:

\[ f_L = \frac{1}{2\pi R C_1} \]
\[ f_B = \frac{1}{2\pi R C_2} \]

\[ f_H = \frac{1}{2\pi R (R_1 + R_5 + 2R_3) C_2} \]

Illustration is:

- \( f_L = 32 \text{ Hz} \)
- \( f_B = 320 \text{ Hz} \)
- \( f_H = 11 \text{ kHz} \)
- \( f_{LB} = 1.1 \text{ kHz} \)
$A_v = 35$ dB
$E_n = 0.33 \mu V$
$S/N = 90$ dB
$f = 1$ kHz
A Weighted
A Weighted, $V_{IN} = 10$ mV
$@f = 1$ kHz

Figure 125. RIAA Preamp

\[
V_0 = 101(V_2 - V_1)
\]

Illustration is:
$V_0 = 101(V_2 - V_1)$

Figure 126. Balanced Input Mic Amp
Figure 127. 10 Band Graphic Equalizer

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<th>$C_1$</th>
<th>$C_2$</th>
<th>$R_1$</th>
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## REVISION HISTORY

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<td>06/01/07</td>
<td>Initial release.</td>
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<tr>
<td>1.1</td>
<td>06/11/07</td>
<td>Added the LME49860MA and LME49860NA Top Mark Information.</td>
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<tr>
<td>C</td>
<td>04/05/13</td>
<td>Changed layout of National Data Sheet to TI format.</td>
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## PACKAGING INFORMATION

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<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Lead finish/ Ball material</th>
<th>MSL Peak Temp</th>
<th>Op Temp (°C)</th>
<th>Device Marking</th>
<th>Samples</th>
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<td>2500</td>
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(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

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

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

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

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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TAPE AND REEL INFORMATION

*All dimensions are nominal.

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### TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

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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.

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.
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.
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