# LME49720 Dual High Performance, High Fidelity Audio Operational Amplifier

**Check for Samples: LME49720**

## FEATURES

- **Easily drives 600Ω loads**
- **Optimized for superior audio signal fidelity**
- **Output short circuit protection**
- **PSRR and CMRR exceed 120dB (typ)**
- **SOIC, DIP, TO-99 metal can 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**

## DESCRIPTION

The LME49720 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 LME49720 audio operational amplifiers deliver superior audio signal amplification for outstanding audio performance. The LME49720 combines extremely low voltage noise density (2.7nV/$\sqrt{Hz}$) with vanishingly low THD+N (0.00003%) to easily satisfy the most demanding audio applications. To ensure that the most challenging loads are driven without compromise, the LME49720 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 LME49720's outstanding CMRR (120dB), PSRR (120dB), and $V_{OS}$ (0.1mV) give the amplifier excellent operational amplifier DC performance.

The LME49720 has a wide supply range of ±2.5V to ±17V. Over this supply range the LME49720's input circuitry maintains excellent common-mode and power supply rejection, as well as maintaining its low input bias current. The LME49720 is unity gain stable. This Audio Operational Amplifier achieves outstanding AC performance while driving complex loads with values as high as 100pF.

The LME49720 is available in 8–lead narrow body SOIC, 8–lead Plastic DIP, and 8–lead Metal Can TO-99. Demonstration boards are available for each package.

**Table 1. Key Specifications**

| | VALUE | UNIT |
|---|---|---|
| ■ Power Supply Voltage Range | ±2.5 to ±17 | V |
| ■ THD+N ($A_V$ = 1, $V_{OUT}$ = 3$V_{RMS}$, $f_{IN}$ = 1kHz) | | |
| $R_L$ = 2kΩ | 0.00003% (typ) | |
| $R_L$ = 600Ω | 0.00003% (typ) | |
| ■ Input Noise Density | 2.7nV/$\sqrt{Hz}$ (typ) | |
| ■ Slew Rate | ±20V/µs (typ) | |
| ■ Gain Bandwidth Product | 55 | MHz (typ) |
| ■ Open Loop Gain ($R_L$ = 600Ω) | 140 | dB (typ) |
| ■ Input Bias Current | 10nA (typ) | |
| ■ Input Offset Voltage | 0.1mV (typ) | |

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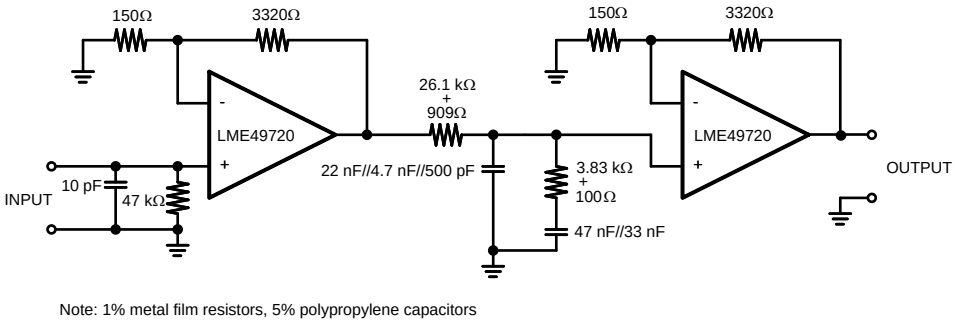
PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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**Table 1. Key Specifications (continued)**

| | VALUE | UNIT |
|---|---|---|
| ■ DC Gain Linearity Error | 0.000009% | |

## Typical Application




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

**Figure 1. Passively Equalized RIAA Phono Preamplifier**

## Connection Diagram

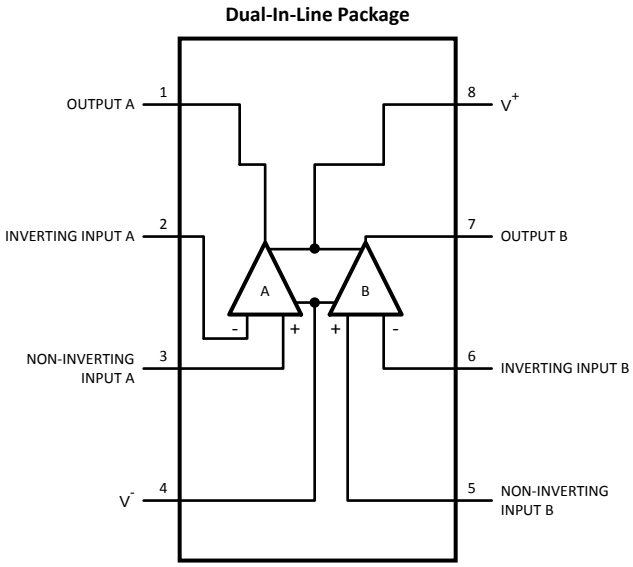



**Figure 2. Dual-In-Line Package**


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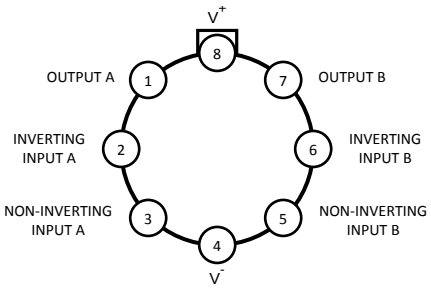



**Figure 3. Metal Can**

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)

| | |
|---|---|
| Power Supply Voltage ($V_S = V^+ - V^-$) | 36V |
| Storage Temperature | −65°C to 150°C |
| Input Voltage | (V-) - 0.7V to (V+) + 0.7V |
| Output Short Circuit (Note 3) | Continuous |
| Power Dissipation | Internally Limited |
| ESD Susceptibility (Note 4) | 2000V |
| ESD Susceptibility (Note 5) | |
| Pins 1, 4, 7 and 8 | 200V |
| Pins 2, 3, 5 and 6 | 100V |
| Junction Temperature | 150°C |
| Thermal Resistance | |
| $\theta_{JA}$ (SO) | 145°C/W |
| $\theta_{JA}$ (NA) | 102°C/W |
| $\theta_{JA}$ (HA) | 150°C/W |
| $\theta_{JC}$ (HA) | 35°C/W |
| Temperature Range | |
| $T_{MIN} \le T_A \le T_{MAX}$ | –40°C ≤ $T_A$ ≤ 85°C |
| Supply Voltage Range | ±2.5V ≤ $V_S$ ≤ ± 17V |

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur.
(2) Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

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## Electrical Characteristics for the LME49720 (1) (2)

The following specifications apply for $V_S$ = ±15V, $R_L$ = 2kΩ, $f_{IN}$ = 1kHz, and $T_A$ = 25°C, unless otherwise specified.

| Symbol | Parameter | Conditions | LME49720 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical (3) | Limit (4) | |
| THD+N | Total Harmonic Distortion + Noise | $A_V$ = 1, $V_{OUT}$ = 3$V_{rms}$<br>$R_L$ = 2kΩ<br>$R_L$ = 600Ω | 0.00003<br>0.00003 | <br>0.00009 | % (max) |
| IMD | Intermodulation Distortion | $A_V$ = 1, $V_{OUT}$ = 3$V_{RMS}$<br>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 | $V_{OUT}$ = 1$V_{P-P}$, –3dB<br>referenced to output magnitude<br>at f = 1kHz | 10 | | MHz |
| $t_s$ | Settling time | $A_V$ = –1, 10V step, $C_L$ = 100pF<br>0.1% error range | 1.2 | | µs |
| $e_n$ | Equivalent Input Noise Voltage | $f_{BW}$ = 20Hz to 20kHz | 0.34 | 0.65 | µ$V_{RMS}$ (max) |
| | Equivalent Input Noise Density | f = 1kHz<br>f = 10Hz | 2.7<br>6.4 | 4.7 | nV/√Hz (max) |
| $i_n$ | Current Noise Density | f = 1kHz<br>f = 10Hz | 1.6<br>3.1 | | pA/√Hz |
| $V_{OS}$ | Offset Voltage | | ±0.1 | ±0.7 | mV (max) |
| $\Delta V_{OS}/\Delta Temp$ | Average Input Offset Voltage Drift vs Temperature | –40°C ≤ $T_A$ ≤ 85°C | 0.2 | | µV/°C |
| PSRR | Average Input Offset Voltage Shift vs Power Supply Voltage | $\Delta V_S$ = 20V (Note 8) | 120 | 110 | dB (min) |
| $ISO_{CH-CH}$ | Channel-to-Channel Isolation | $f_{IN}$ = 1kHz<br>$f_{IN}$ = 20kHz | 118<br>112 | | dB |
| $I_B$ | Input Bias Current | $V_{CM}$ = 0V | 10 | 72 | nA (max) |
| $\Delta I_{OS}/\Delta Temp$ | Input Bias Current Drift vs Temperature | –40°C ≤ $T_A$ ≤ 85°C | 0.1 | | nA/°C |
| $I_{OS}$ | Input Offset Current | $V_{CM}$ = 0V | 11 | 65 | nA (max) |
| $V_{IN-CM}$ | Common-Mode Input Voltage Range | | +14.1<br>–13.9 | (V+) – 2.0<br>(V-) + 2.0 | V (min) |
| CMRR | Common-Mode Rejection | –10V<Vcm<10V | 120 | 110 | dB (min) |
| $Z_{IN}$ | Differential Input Impedance | | 30 | | kΩ |
| | Common Mode Input Impedance | –10V<Vcm<10V | 1000 | | MΩ |
| $A_{VOL}$ | Open Loop Voltage Gain | –10V<Vout<10V, $R_L$ = 600Ω | 140 | 125 | dB (min) |
| | | –10V<Vout<10V, $R_L$ = 2kΩ | 140 | | |
| | | –10V<Vout<10V, $R_L$ = 10kΩ | 140 | | |
| $V_{OUTMAX}$ | Maximum Output Voltage Swing | $R_L$ = 600Ω | ±13.6 | ±12.5 | V (min) |
| | | $R_L$ = 2kΩ | ±14.0 | | |
| | | $R_L$ = 10kΩ | ±14.1 | | |
| $I_{OUT}$ | Output Current | $R_L$ = 600Ω, $V_S$ = ±17V | ±26 | ±23 | mA (min) |
| $I_{OUT-CC}$ | Instantaneous Short Circuit Current | | +53<br>–42 | | mA |

(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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(3) Typical specifications are specified at +25ºC and represent the most likely parametric norm.
(4) Tested limits are guaranteed to National's AOQL (Average Outgoing Quality Level).


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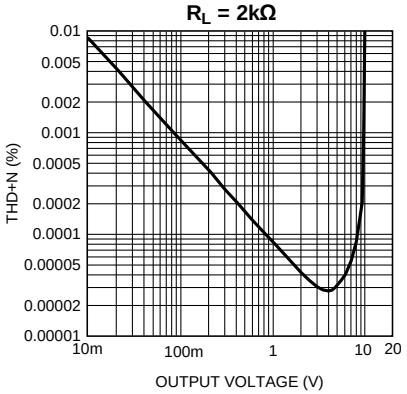
## Electrical Characteristics for the LME49720 (1) (2) (continued)

The following specifications apply for $V_S$ = ±15V, $R_L$ = 2kΩ, $f_{IN}$ = 1kHz, and $T_A$ = 25°C, unless otherwise specified.

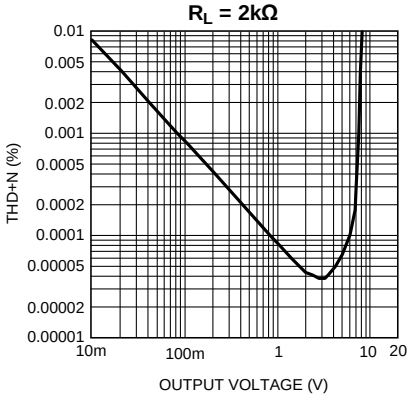
| Symbol | Parameter | Conditions | LME49720 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical (3) | Limit (4) | |
| $R_{OUT}$ | Output Impedance | $f_{IN}$ = 10kHz<br>Closed-Loop<br>Open-Loop | 0.01<br>13 | | Ω |
| $C_{LOAD}$ | Capacitive Load Drive Overshoot | 100pF | 16 | | % |
| $I_S$ | Total Quiescent Current | $I_{OUT}$ = 0mA | 10 | 12 | mA (max) |

## Typical Performance Characteristics

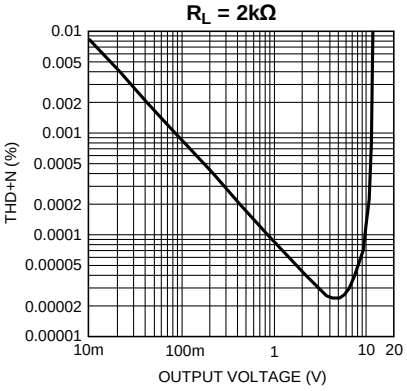
**THD+N vs Output Voltage $V_{CC}$ = 15V, $V_{EE}$ = –15V $R_L$ = 2kΩ**



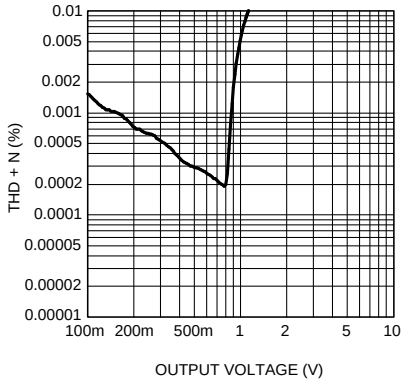

**THD+N vs Output Voltage $V_{CC}$ = 12V, $V_{EE}$ = –12V $R_L$ = 2kΩ**



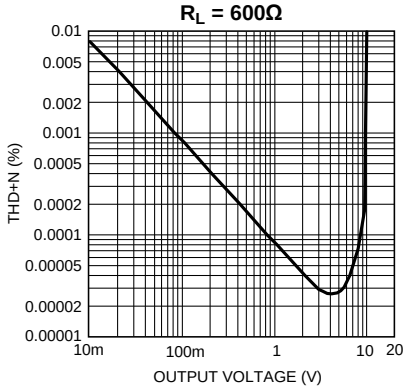

**THD+N vs Output Voltage $V_{CC}$ = 17V, $V_{EE}$ = –17V $R_L$ = 2kΩ**



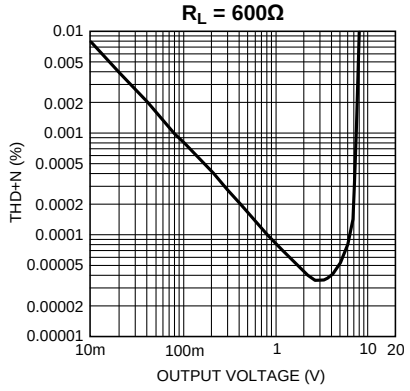

**THD+N vs Output Voltage $V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V $R_L$ = 2kΩ**




**THD+N vs Output Voltage $V_{CC}$ = 15V, $V_{EE}$ = –15V $R_L$ = 600Ω**




**THD+N vs Output Voltage $V_{CC}$ = 12V, $V_{EE}$ = –12V $R_L$ = 600Ω**

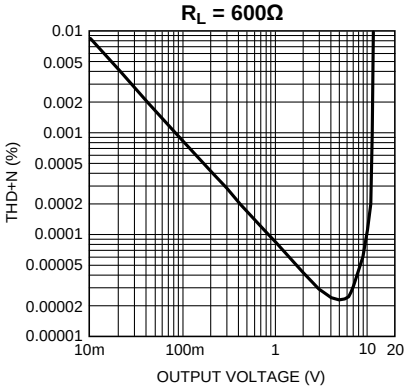




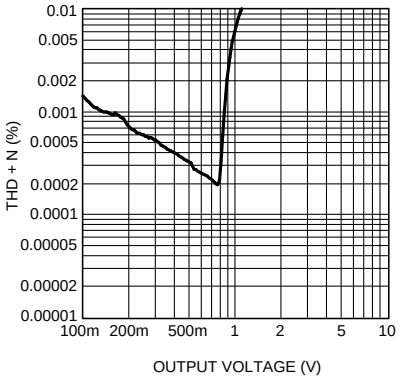
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## Typical Performance Characteristics (continued)

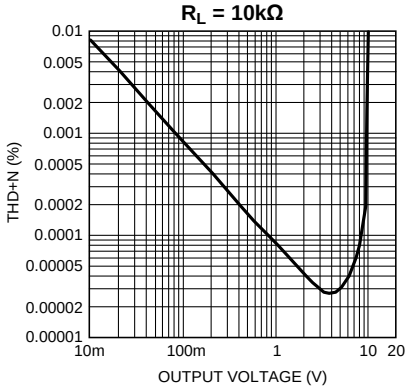
**THD+N vs Output Voltage**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 600Ω**



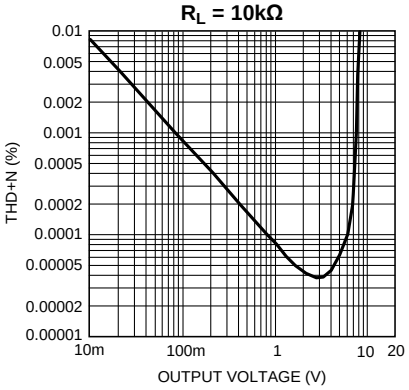

**THD+N vs Output Voltage**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 600Ω**



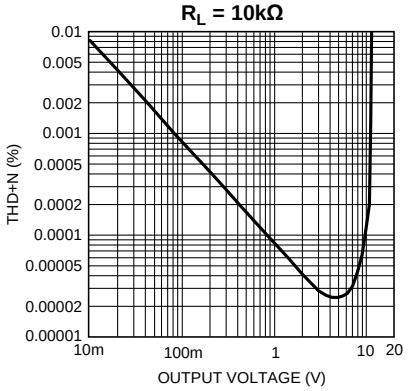

**THD+N vs Output Voltage**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 10kΩ**



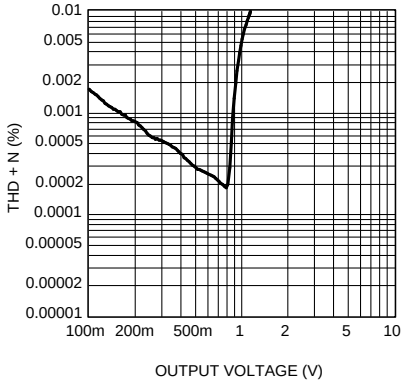

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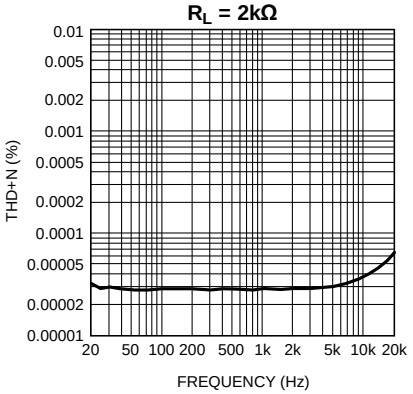

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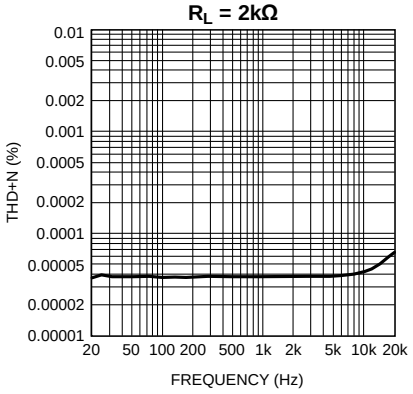

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## Typical Performance Characteristics (continued)

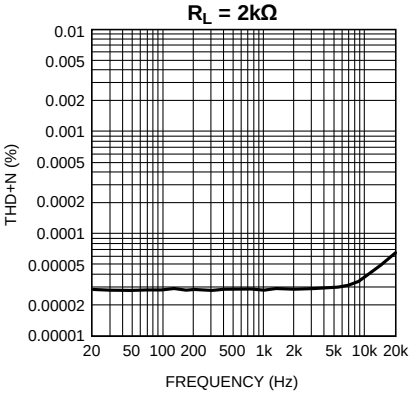
**THD+N vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 3$V_{RMS}$**
**$R_L$ = 2kΩ**



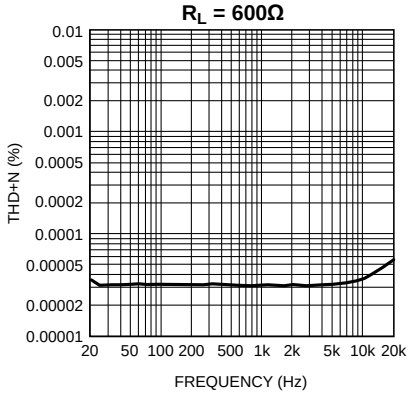

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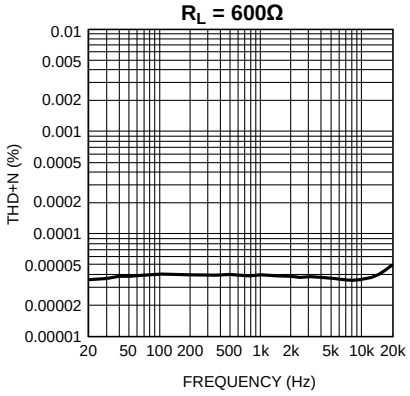

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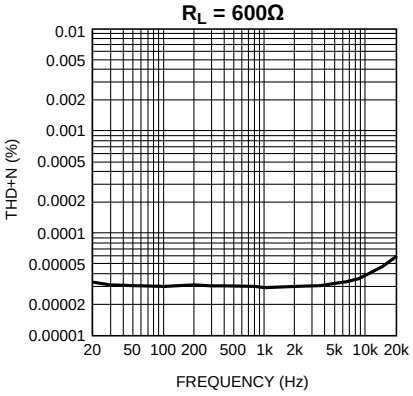

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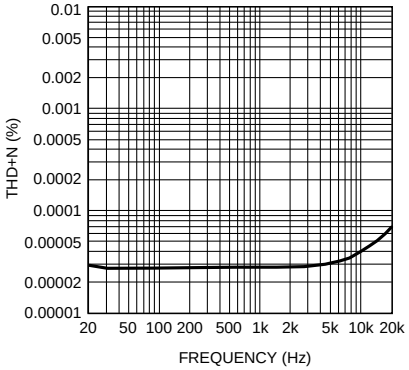




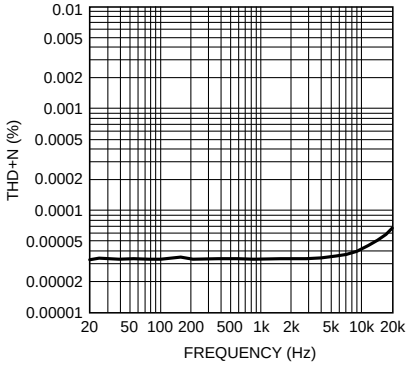
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## Typical Performance Characteristics (continued)

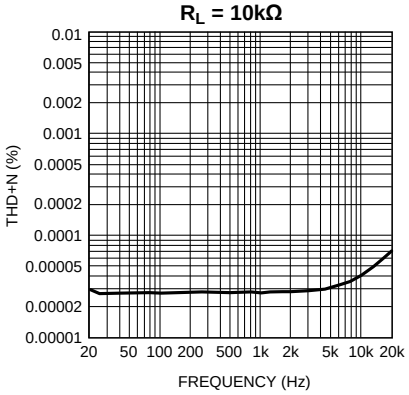
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**$R_L$ = 10kΩ**



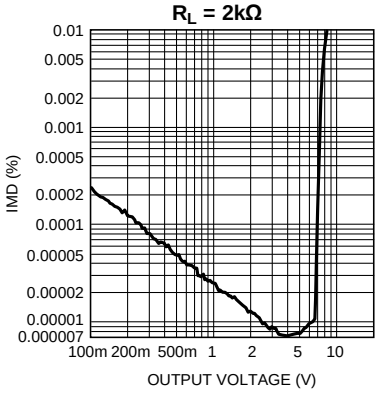

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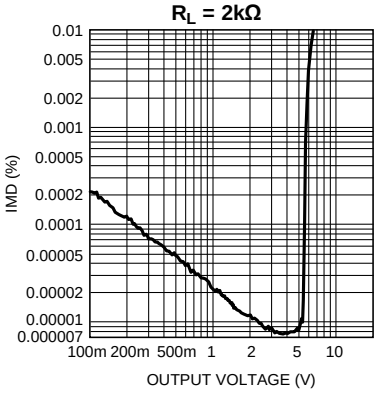

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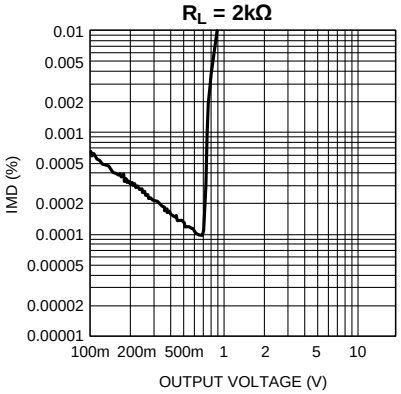

**IMD vs Output Voltage**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 2kΩ**




**IMD vs Output Voltage**
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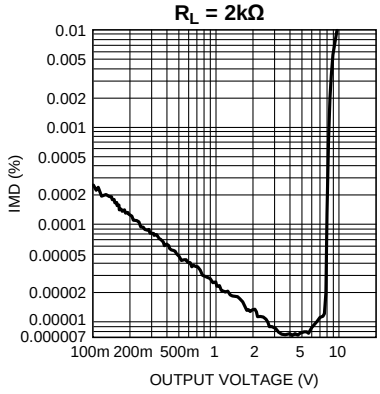

**IMD vs Output Voltage**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 2kΩ**



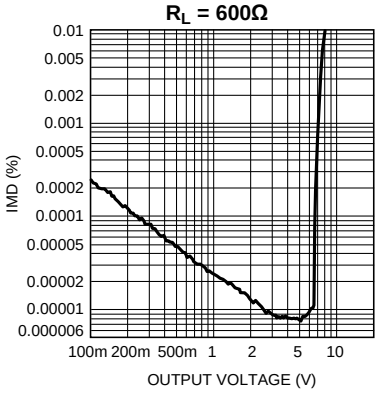

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## Typical Performance Characteristics (continued)

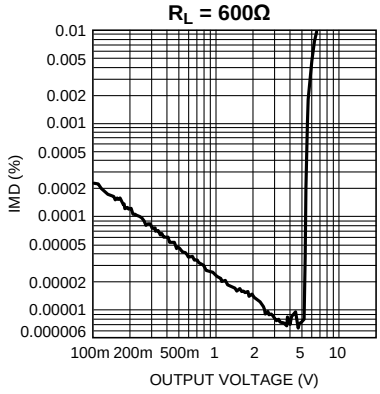
**IMD vs Output Voltage**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 2kΩ**



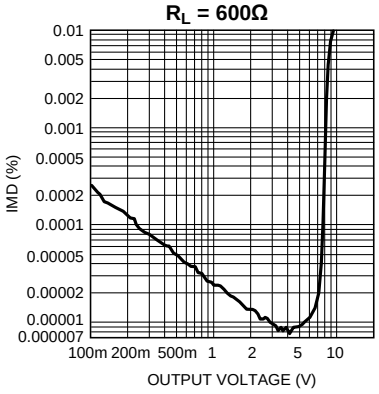

**IMD vs Output Voltage**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 600Ω**



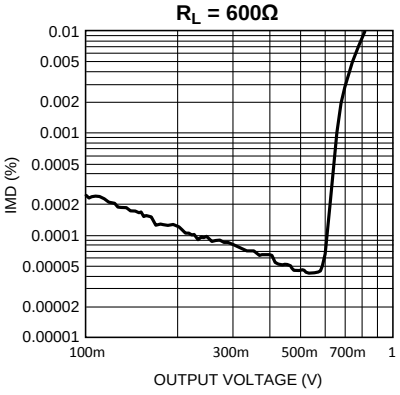

**IMD vs Output Voltage**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 600Ω**



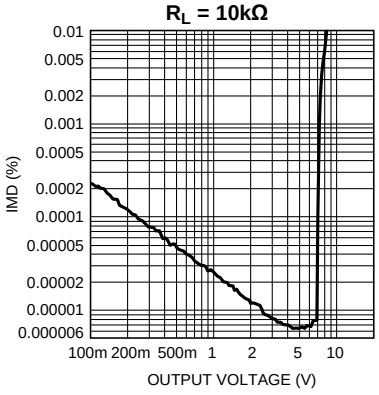

**IMD vs Output Voltage**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 600Ω**




**IMD vs Output Voltage**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 600Ω**




**IMD vs Output Voltage**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 10kΩ**

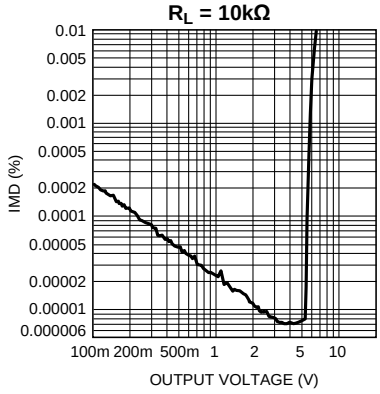




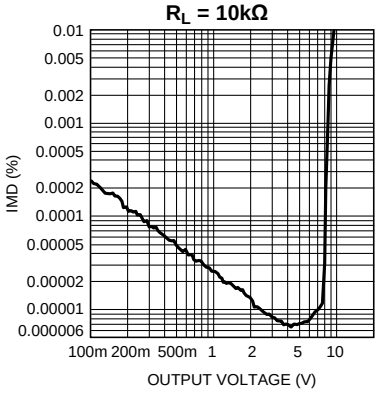
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## Typical Performance Characteristics (continued)

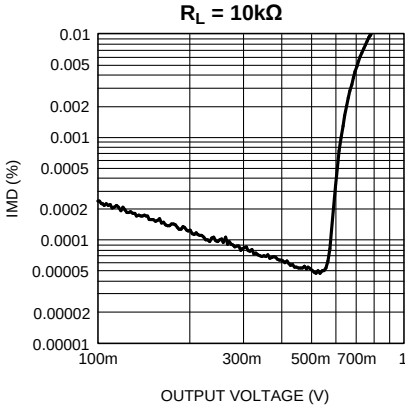
**IMD vs Output Voltage**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 10kΩ**



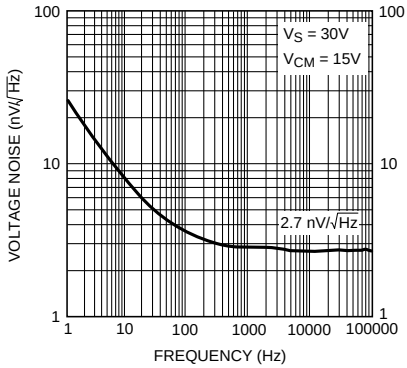

**IMD vs Output Voltage**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 10kΩ**




**IMD vs Output Voltage**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 10kΩ**

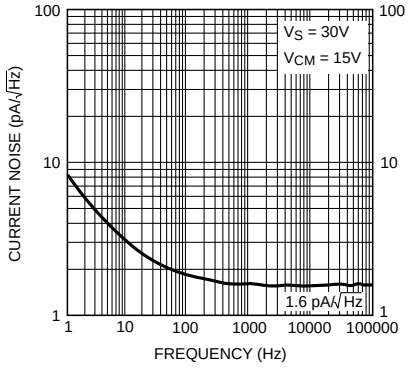



**Voltage Noise Density vs Frequency**

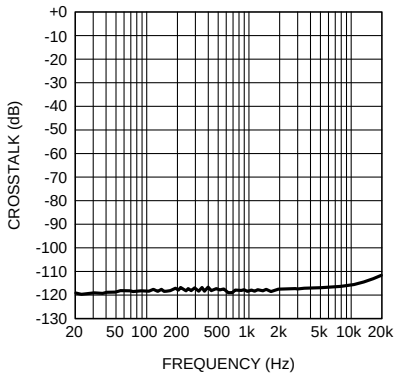


## Typical Performance Characteristics (continued)

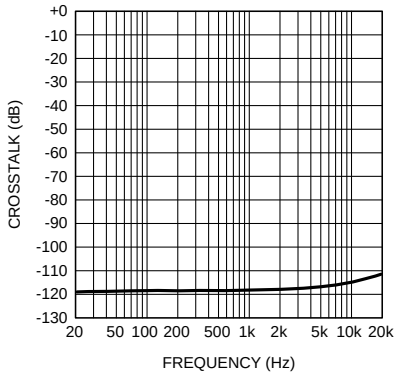
**Current Noise Density vs Frequency**



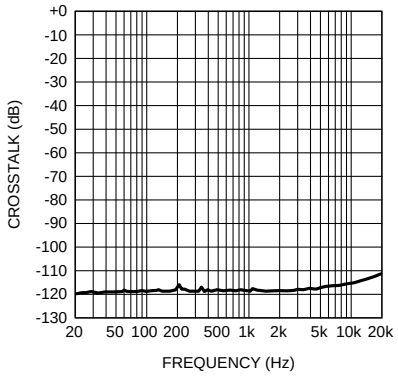

**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**




**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**




**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**

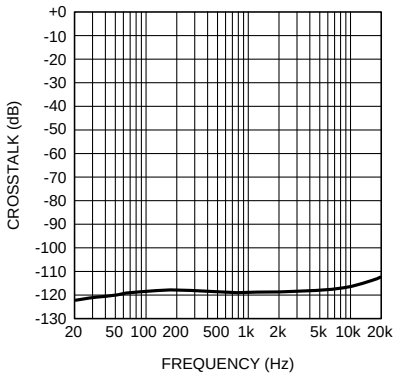




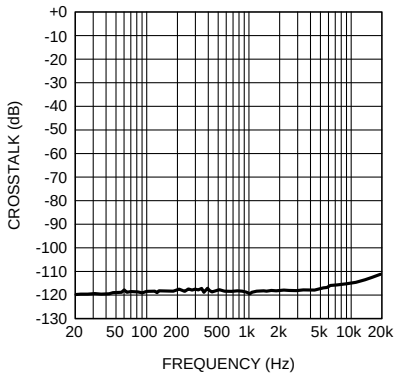
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## Typical Performance Characteristics (continued)

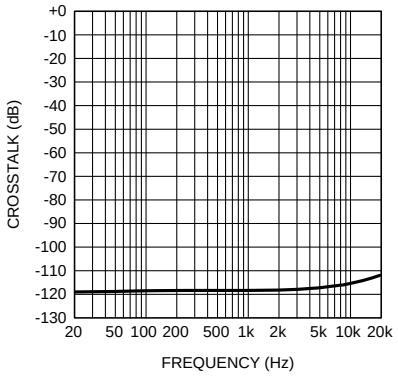
**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**



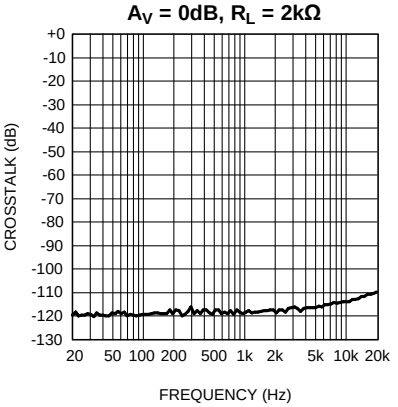

**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**




**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**



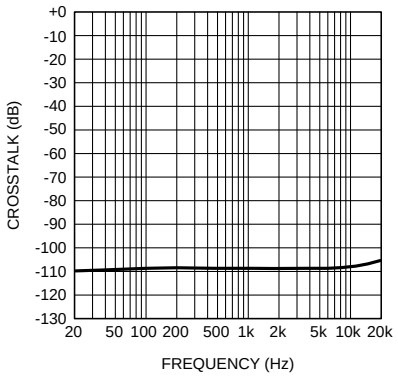

**Crosstalk vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V, $V_{OUT}$ = 1$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 2kΩ**



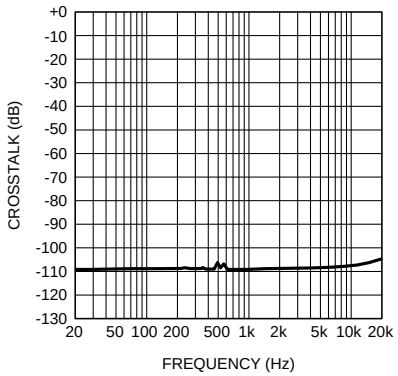

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## Typical Performance Characteristics (continued)

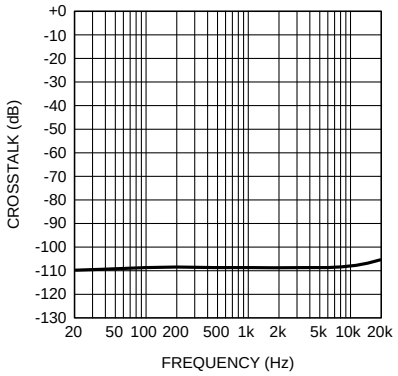
**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**



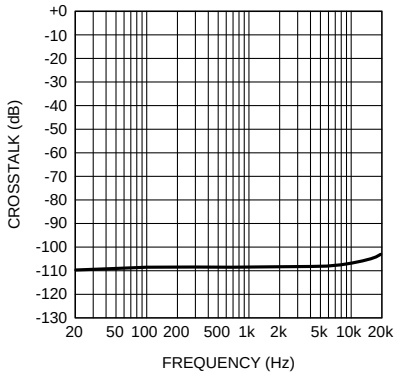

**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**




**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**




**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**

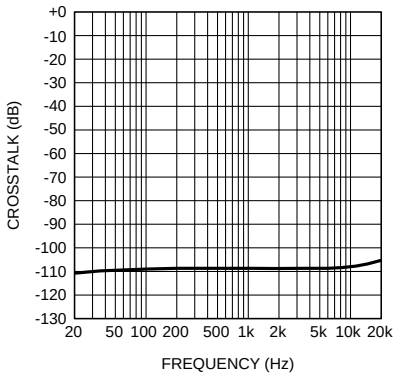




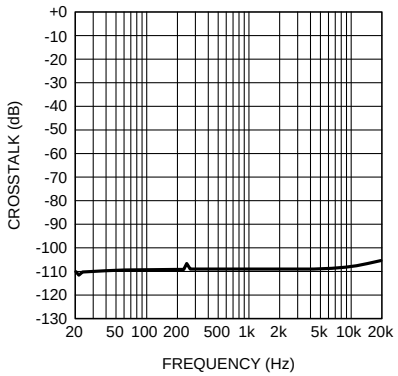
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## Typical Performance Characteristics (continued)

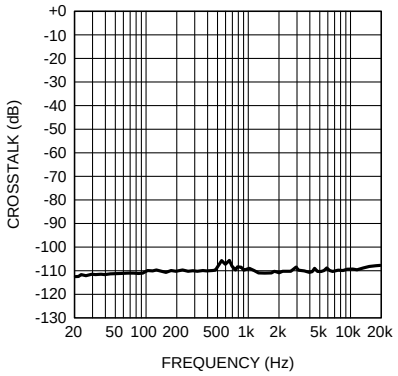
**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**



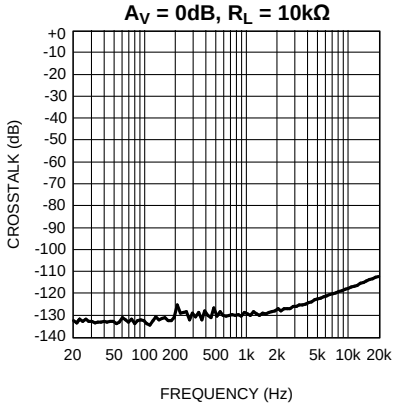

**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**




**Crosstalk vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V, $V_{OUT}$ = 1$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 600Ω**



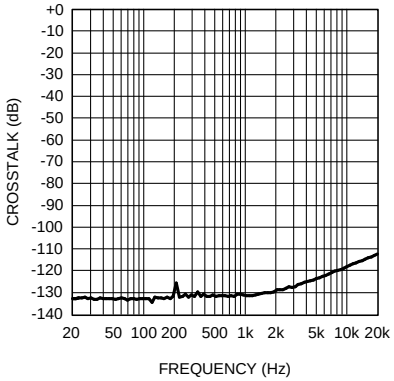

**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**



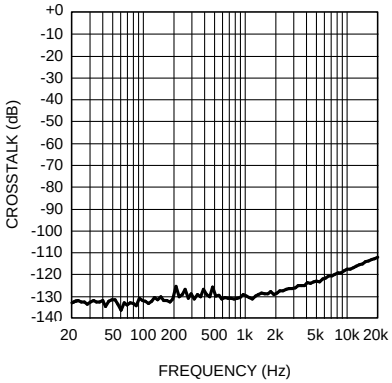

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## Typical Performance Characteristics (continued)

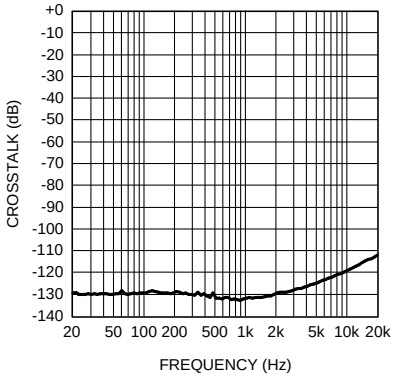
**Crosstalk vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**



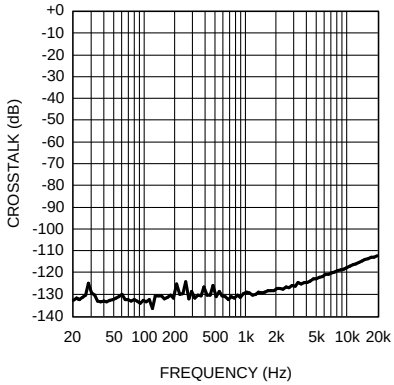

**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**



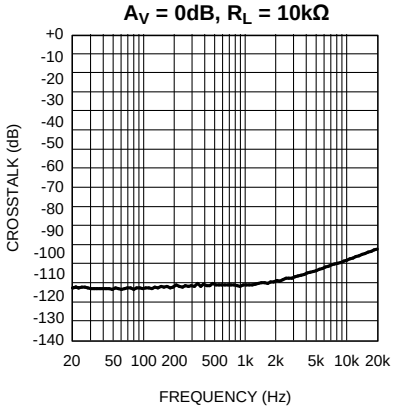

**Crosstalk vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**



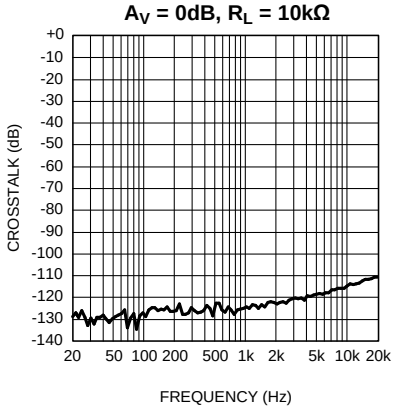

**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 3$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**




**Crosstalk vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V, $V_{OUT}$ = 10$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**




**Crosstalk vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V, $V_{OUT}$ = 1$V_{RMS}$**
**$A_V$ = 0dB, $R_L$ = 10kΩ**

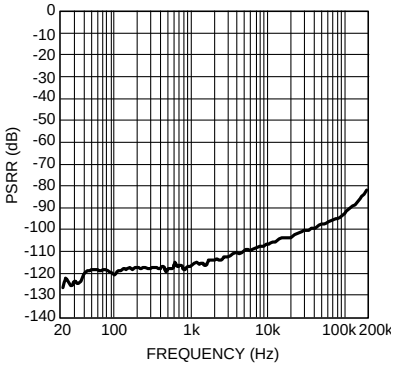




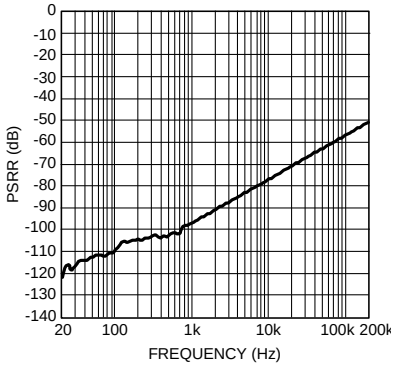
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## Typical Performance Characteristics (continued)

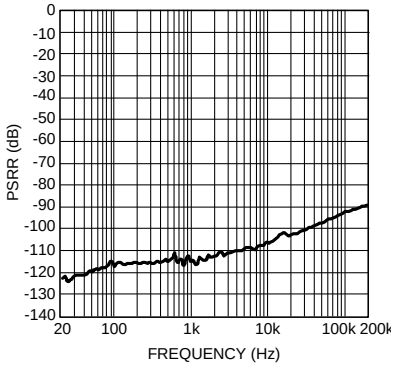
**PSRR+ vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



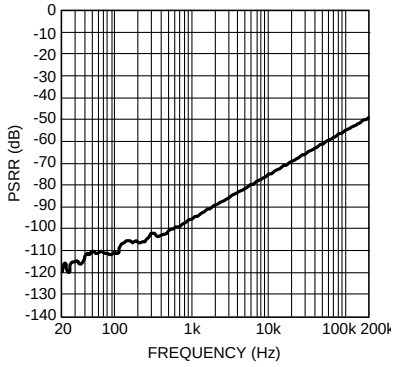

**PSRR- vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



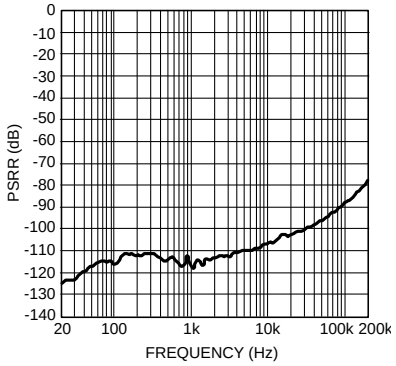

**PSRR+ vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



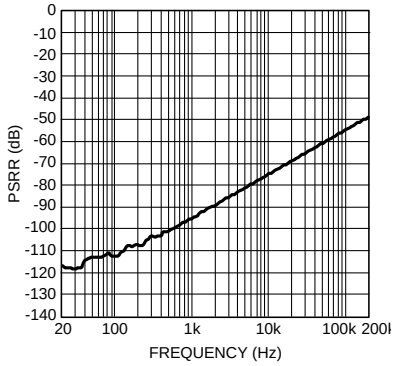

**PSRR- vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR+ vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



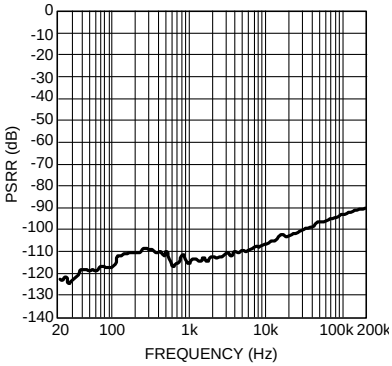

**PSRR- vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



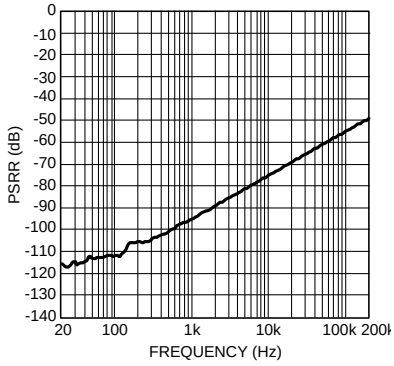

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## Typical Performance Characteristics (continued)

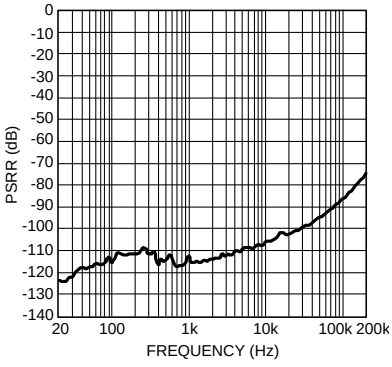
**PSRR+ vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



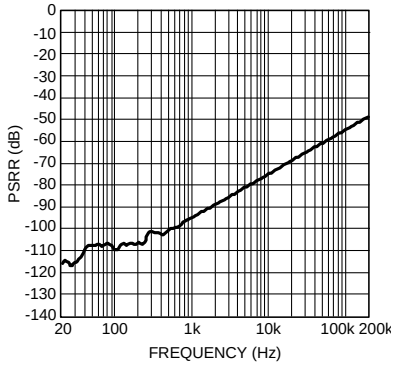

**PSRR– vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



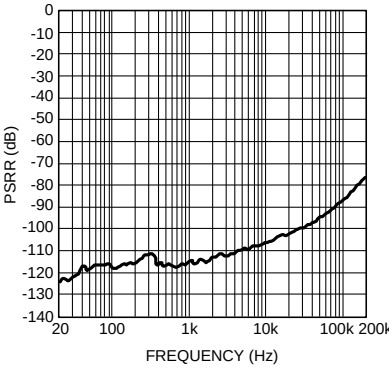

**PSRR+ vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



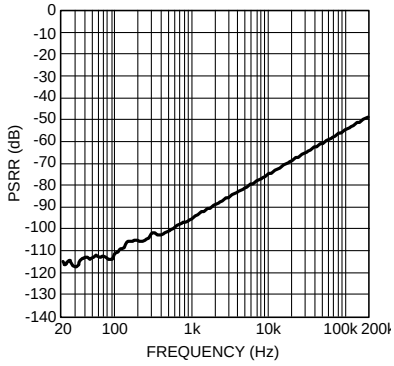

**PSRR– vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR+ vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR– vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**

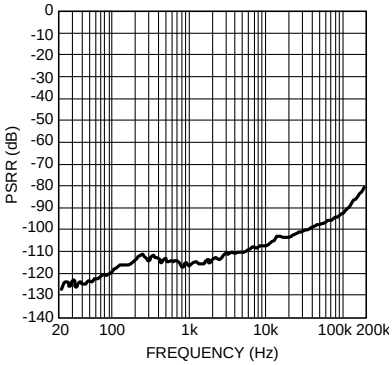




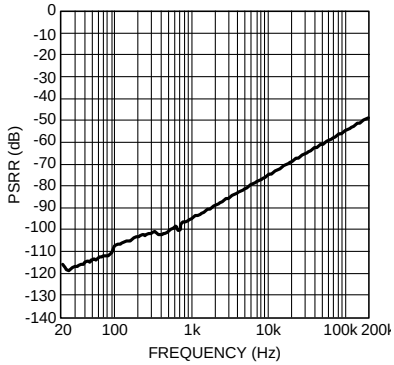
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## Typical Performance Characteristics (continued)

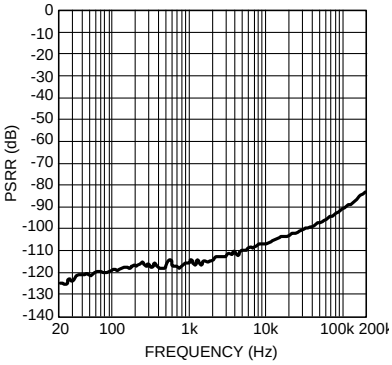
**PSRR+ vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



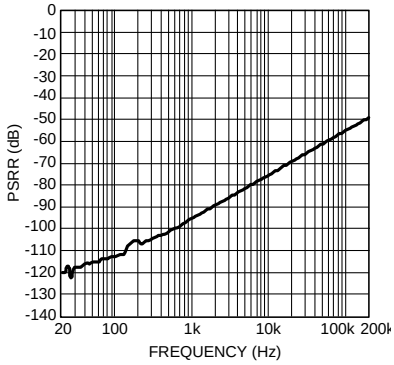

**PSRR– vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



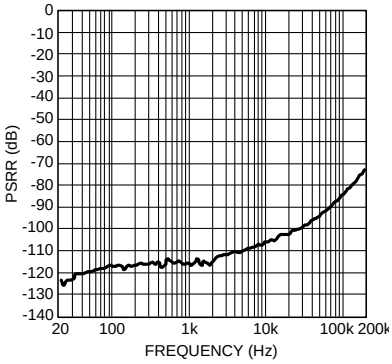

**PSRR+ vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



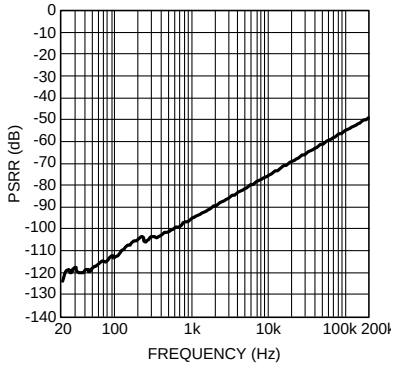

**PSRR– vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR+ vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



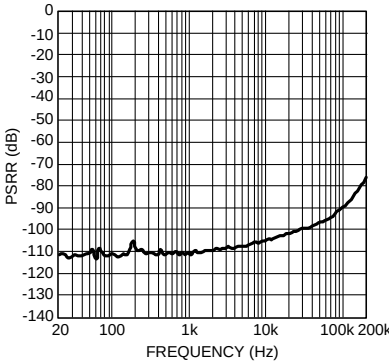

**PSRR– vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



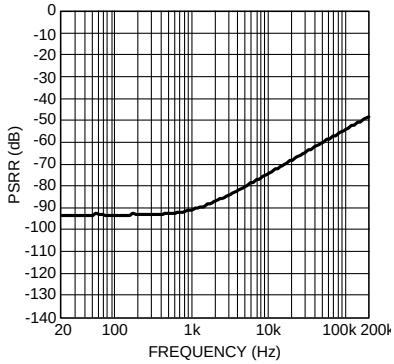

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## Typical Performance Characteristics (continued)

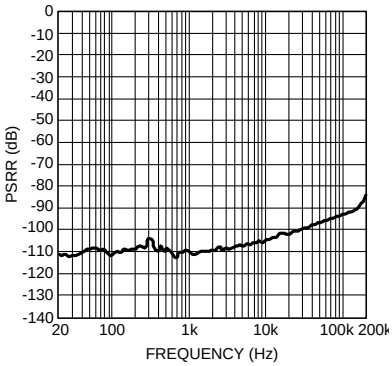
**PSRR+ vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



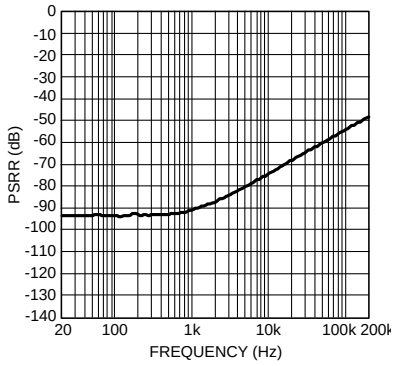

**PSRR– vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 10kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



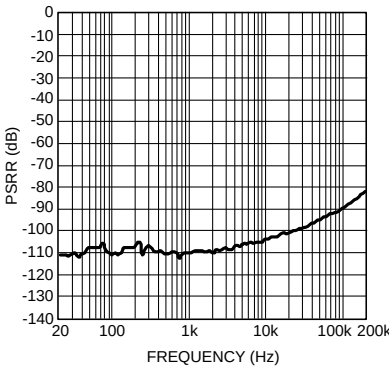

**PSRR+ vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**



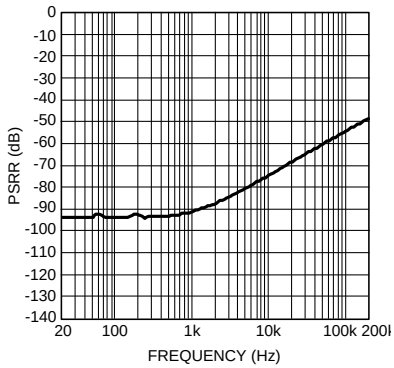

**PSRR– vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 2kΩ, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR+ vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**




**PSRR– vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 600Ω, f = 200kHz, $V_{RIPPLE}$ = 200mVpp**

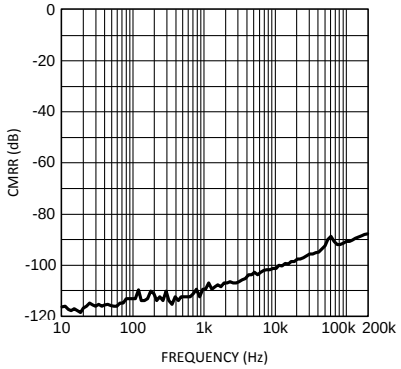




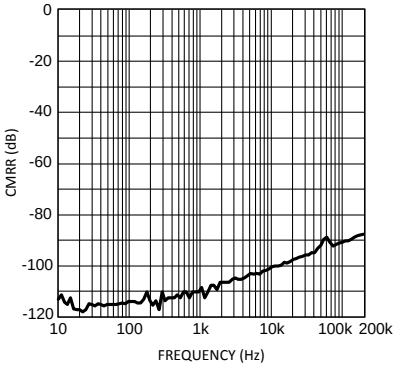
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## Typical Performance Characteristics (continued)

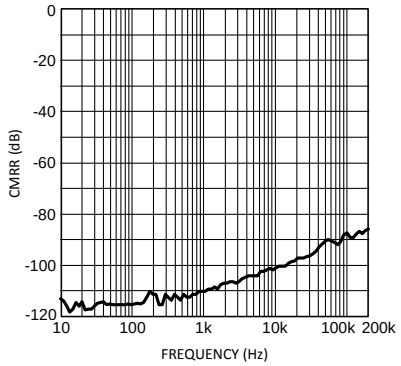
**CMRR vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 2kΩ**



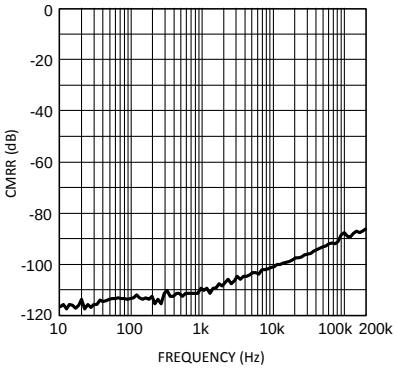

**CMRR vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 2kΩ**



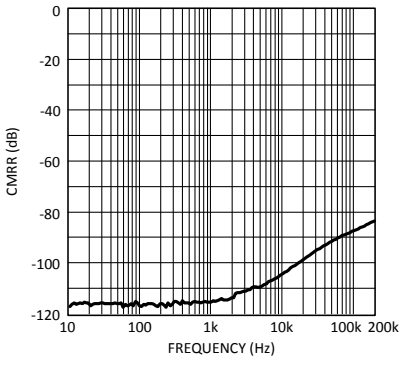

**CMRR vs Frequency**
**$V_{CC}$ = 17V, $V_{EE}$ = –17V**
**$R_L$ = 2kΩ**



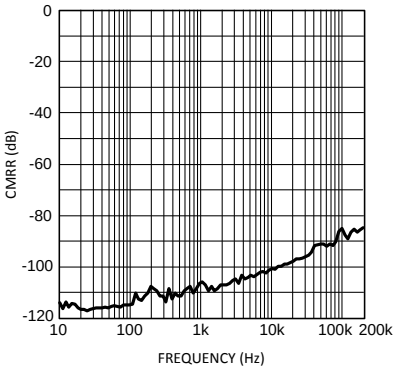

**CMRR vs Frequency**
**$V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V**
**$R_L$ = 2kΩ**




**CMRR vs Frequency**
**$V_{CC}$ = 15V, $V_{EE}$ = –15V**
**$R_L$ = 600Ω**



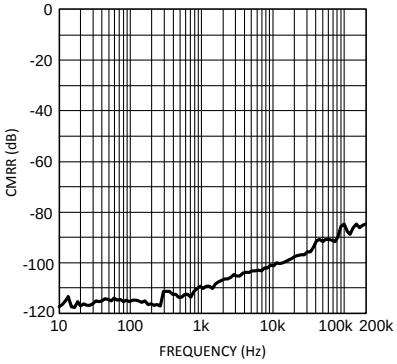

**CMRR vs Frequency**
**$V_{CC}$ = 12V, $V_{EE}$ = –12V**
**$R_L$ = 600Ω**



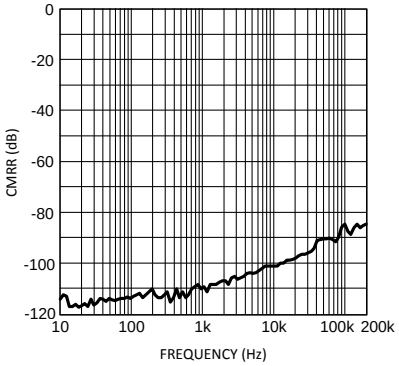

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## Typical Performance Characteristics (continued)

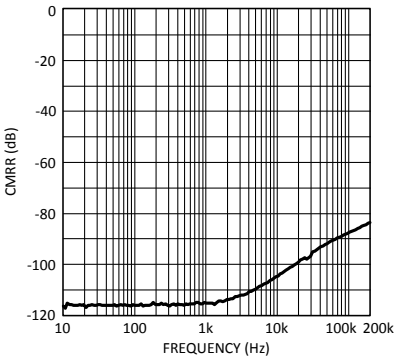
**CMRR vs Frequency $V_{CC}$ = 17V, $V_{EE}$ = –17V $R_L$ = 600Ω**



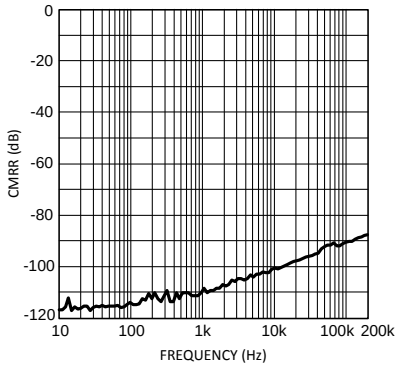

**CMRR vs Frequency $V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V $R_L$ = 600Ω**



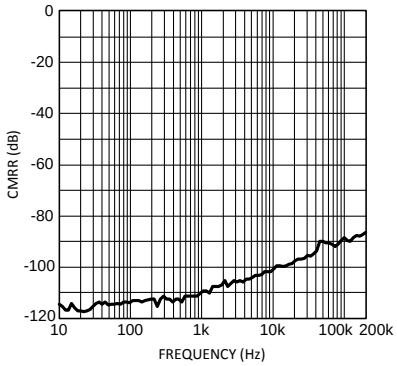

**CMRR vs Frequency $V_{CC}$ = 15V, $V_{EE}$ = –15V $R_L$ = 10kΩ**



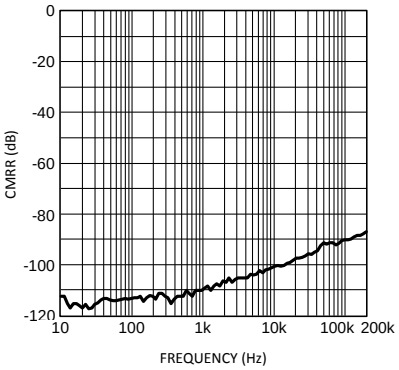

**CMRR vs Frequency $V_{CC}$ = 12V, $V_{EE}$ = –12V $R_L$ = 10kΩ**




**CMRR vs Frequency $V_{CC}$ = 17V, $V_{EE}$ = –17V $R_L$ = 10kΩ**




**CMRR vs Frequency $V_{CC}$ = 2.5V, $V_{EE}$ = –2.5V $R_L$ = 10kΩ**

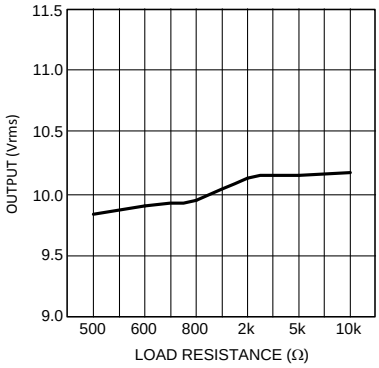




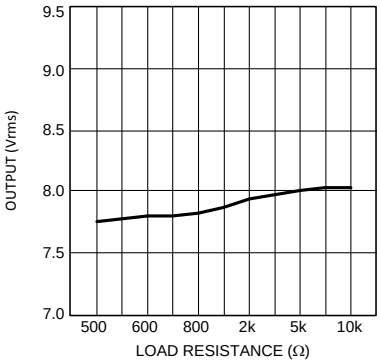
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## Typical Performance Characteristics (continued)

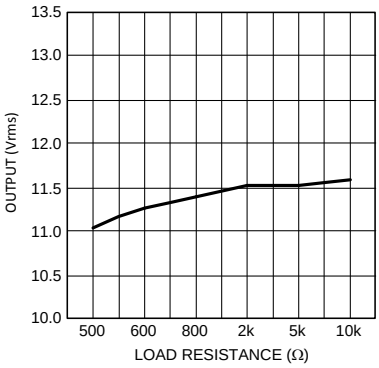
**Output Voltage vs Load Resistance**
**$V_{DD}$ = 15V, $V_{EE}$ = –15V**
**THD+N = 1%**



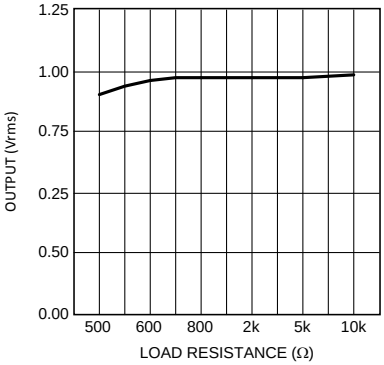

**Output Voltage vs Load Resistance**
**$V_{DD}$ = 12V, $V_{EE}$ = –12V**
**THD+N = 1%**



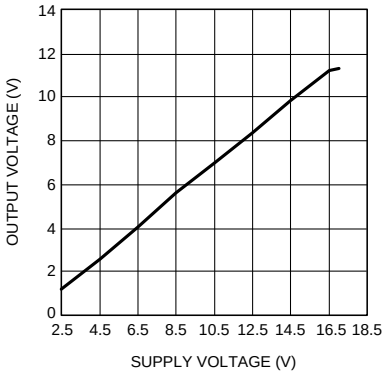

**Output Voltage vs Load Resistance**
**$V_{DD}$ = 17V, $V_{EE}$ = –17V**
**THD+N = 1%**



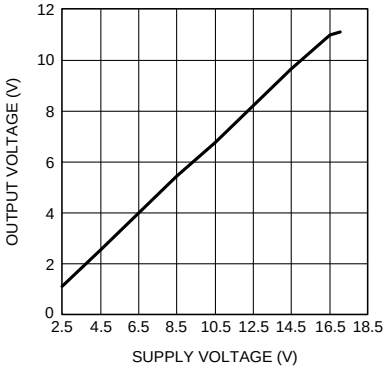

**Output Voltage vs Load Resistance**
**$V_{DD}$ = 2.5V, $V_{EE}$ = –2.5V**
**THD+N = 1%**




**Output Voltage vs Supply Voltage**
**$R_L$ = 2kΩ, THD+N = 1%**



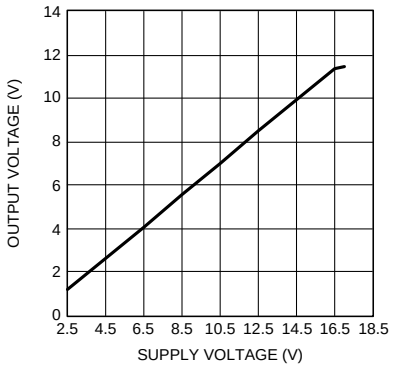

**Output Voltage vs Supply Voltage**
**$R_L$ = 600Ω, THD+N = 1%**



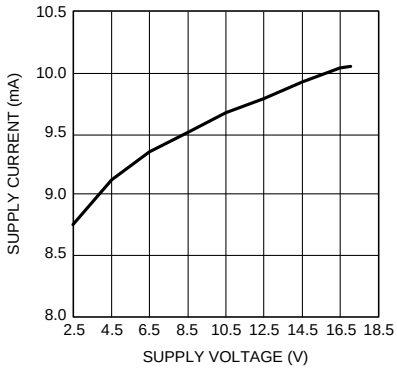

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## Typical Performance Characteristics (continued)

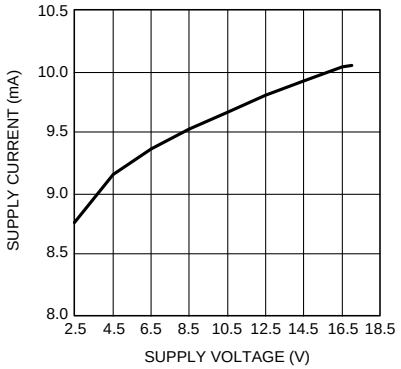
**Output Voltage vs Supply Voltage $R_L$ = 10kΩ, THD+N = 1%**



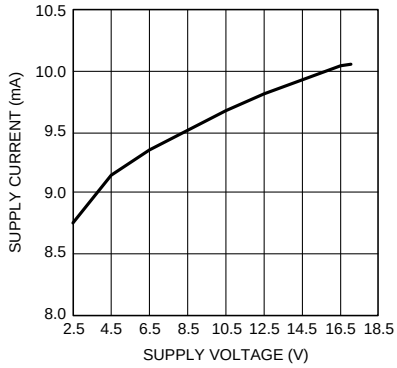

**Supply Current vs Supply Voltage $R_L$ = 2kΩ**



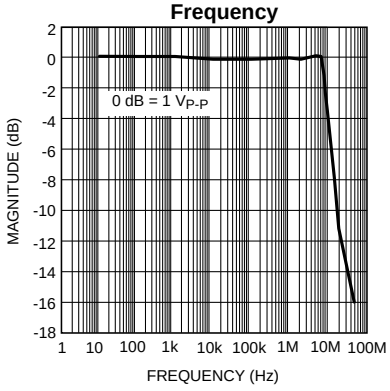

**Supply Current vs Supply Voltage $R_L$ = 600Ω**



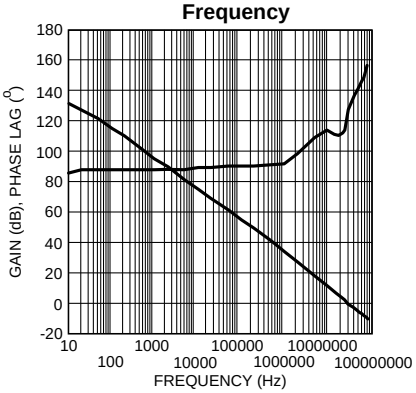

**Supply Current vs Supply Voltage $R_L$ = 10kΩ**




**Full Power Bandwidth vs Frequency**




**Gain Phase vs Frequency**

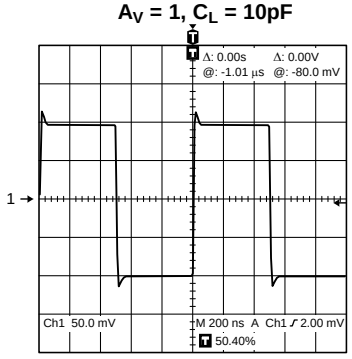




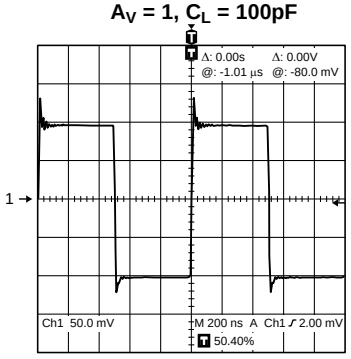
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## Typical Performance Characteristics (continued)

**Small-Signal Transient Response**
**$A_V$ = 1, $C_L$ = 10pF**




**Small-Signal Transient Response**
**$A_V$ = 1, $C_L$ = 100pF**




## Application Information

### DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49720 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 LME49720's low residual distortion is an input referred internal error. As shown in Figure 1, adding the 10Ω resistor connected between the amplifier's inverting and non-inverting inputs changes the amplifier's noise gain. The result is that the error signal (distortion) is amplified by a factor of 101. Although the amplifier's closed-loop gain is unaltered, the feedback available to correct distortion errors is reduced by 101, which means that measurement resolution increases by 101. To ensure minimum effects on distortion measurements, keep the value of R1 low as shown in Figure 1.

This technique is verified by duplicating the measurements with high closed loop gain and/or making the measurements at high frequencies. Doing so produces distortion components that are within the measurement equipment's capabilities. This datasheet's THD+N and IMD values were generated using the above described circuit connected to an Audio Precision System Two Cascade.

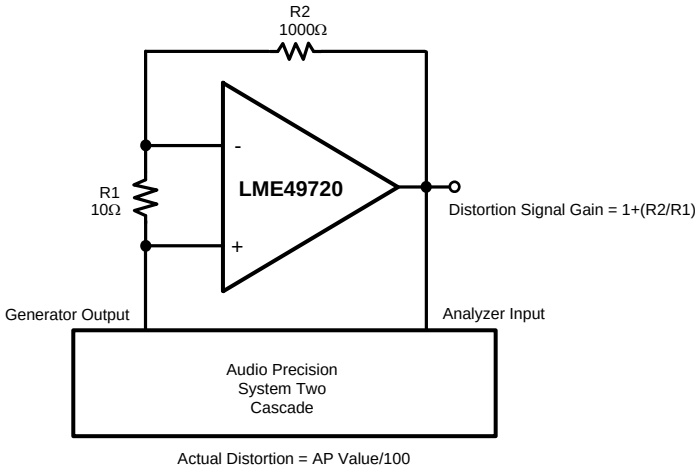
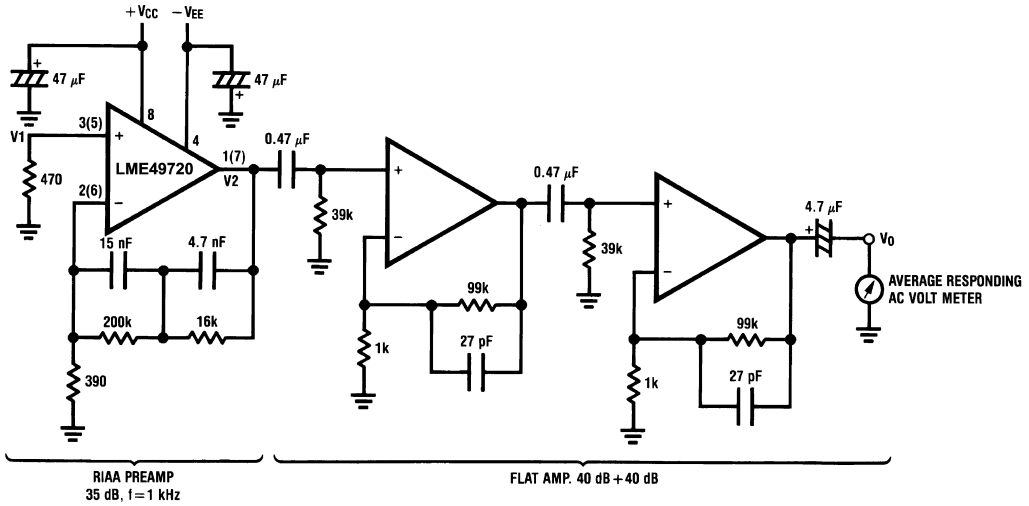



**Figure 4. THD+N and IMD Distortion Test Circuit**

The LME49720 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.

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

**Figure 5. Noise Measurement Circuit**
**Total Gain: 115 dB @f = 1 kHz**
**Input Referred Noise Voltage: $e_n$ = V0/560,000 (V)**

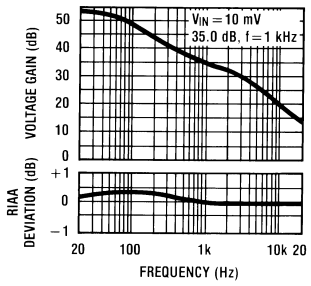



**Figure 6. RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency**

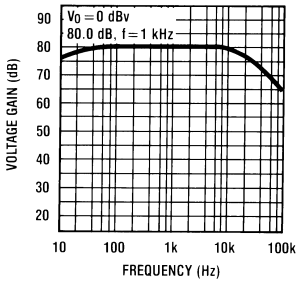
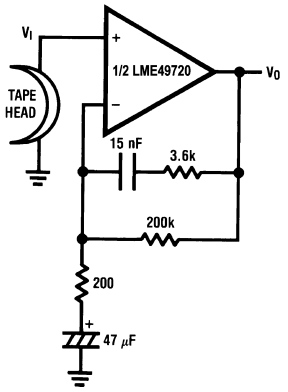



**Figure 7. Flat Amp Voltage Gain vs Frequency**


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## TYPICAL APPLICATIONS




$A_V$ = 34.5
F = 1 kHz
$E_n$ = 0.38 µV
A Weighted

**Figure 8. NAB Preamp**

**Figure 9.**

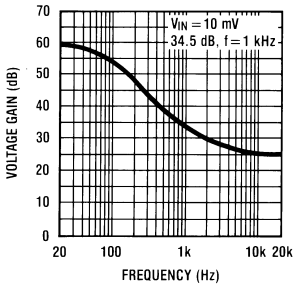
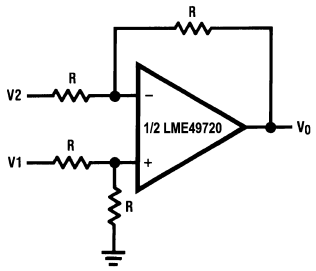
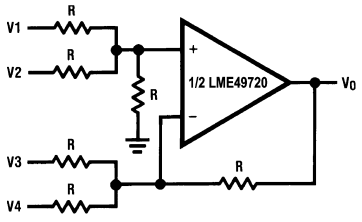



**Figure 10. NAB Preamp Voltage Gain vs Frequency**




$V_O$ = V1–V2

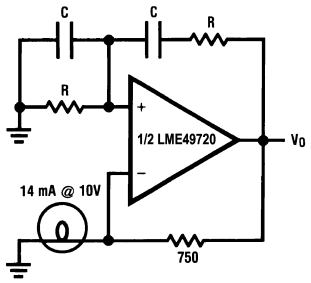
**Figure 11. Balanced to Single Ended Converter**




$V_O$ = V1 + V2 − V3 − V4

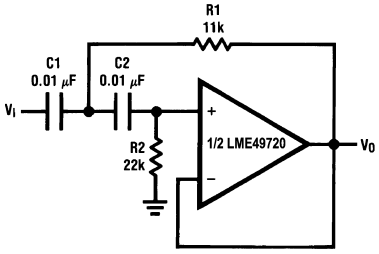
**Figure 12. Adder/Subtracter**

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

**Figure 13. Sine Wave Oscillator**



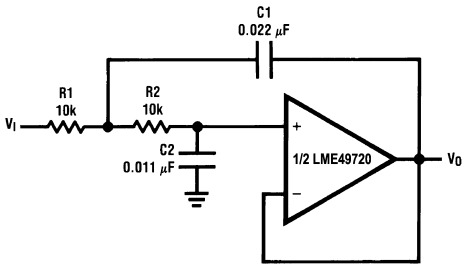

if C1 = C2 = C

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

R2 = 2•R1

Illustration is $f_0$ = 1 kHz

**Figure 14. Second Order High Pass Filter (Butterworth)**




if R1 = R2 = R

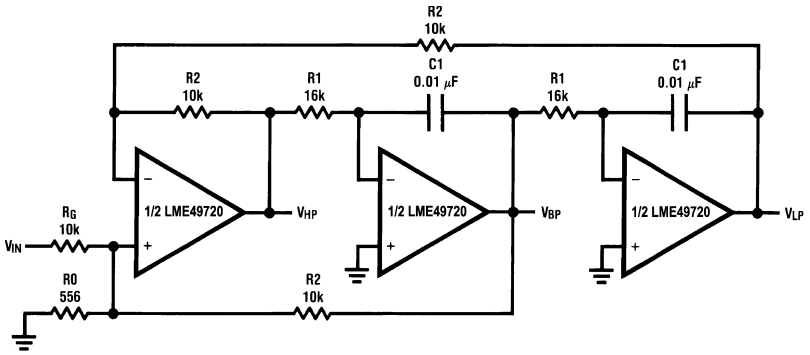
$$C1 = \frac{\sqrt{2}}{\omega_o R}$$

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

Illustration is $f_0$ = 1 kHz

**Figure 15. Second Order Low Pass Filter (Butterworth)**


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

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

**Figure 16. State Variable Filter**

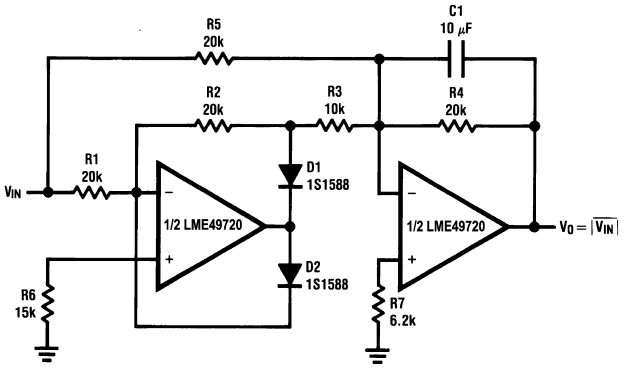



**Figure 17. AC/DC Converter**

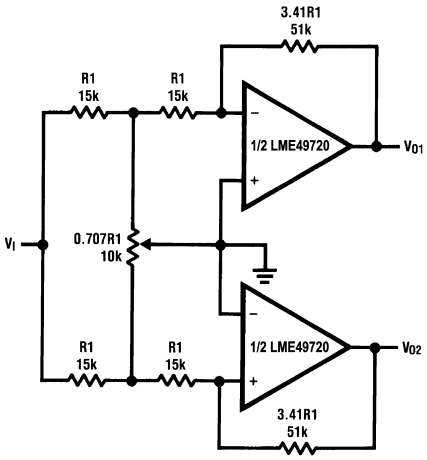



**Figure 18. 2 Channel Panning Circuit (Pan Pot)**

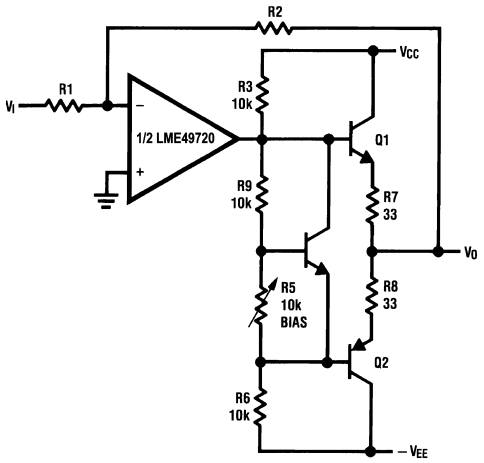
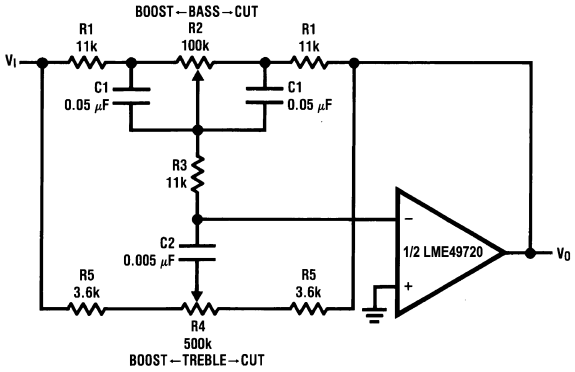



**Figure 19. Line Driver**




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

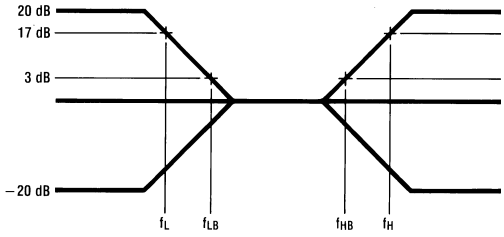
$$f_H = \frac{1}{2\pi R5C2}, f_{HB} = \frac{1}{2\pi(R1 + R5 + 2R3)C2}$$

Illustration is:

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

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

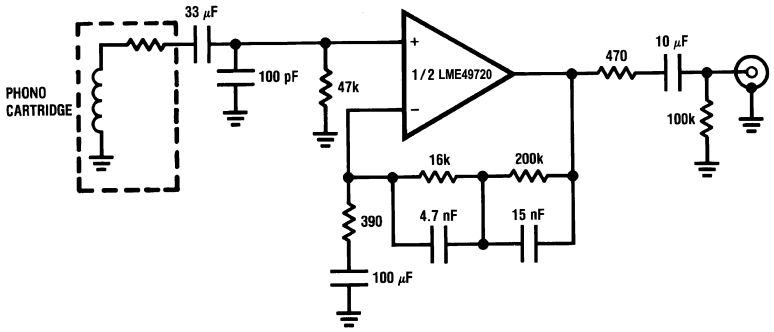
**Figure 20. Tone Control**





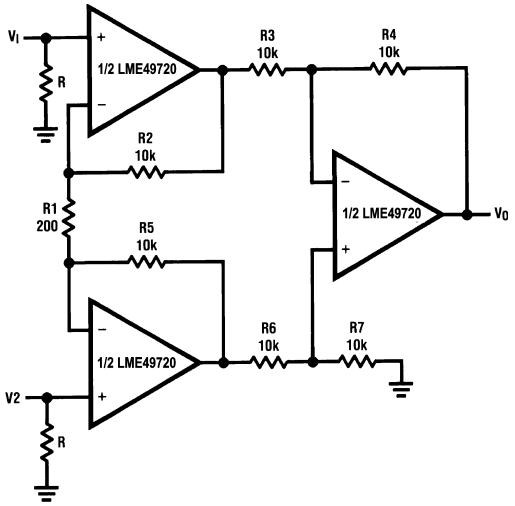
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**Figure 21. RIAA Preamp**




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

**Figure 22. Balanced Input Mic Amp**




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

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

Illustration is:

V0 = 101(V2 − V1)

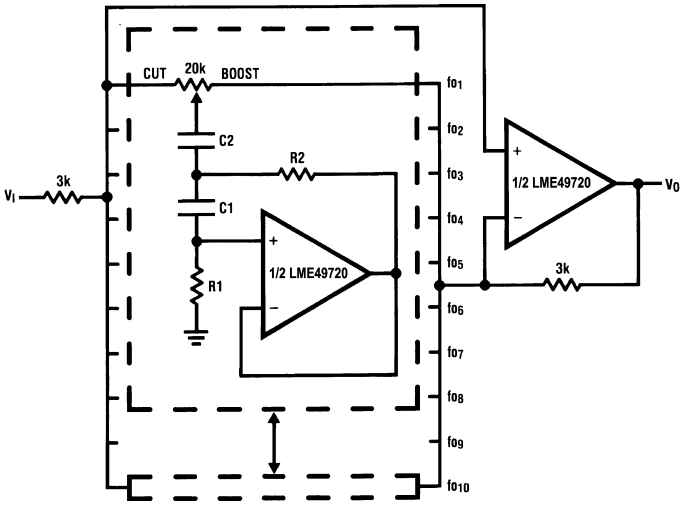



**Figure 23. 10 Band Graphic Equalizer**

| 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 | 03/30/07 | Initial release. |
| 1.1 | 05/03/07 | Put the “general note” under the EC table. |
| 1.2 | 10/22/07 | Replaced all the PSRR curves. |


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## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Samples (Requires Login) |
|---|---|---|---|---|---|---|---|---|---|
| LME49720HA/NOPB | ACTIVE | TO-99 | LMC | 8 | 20 | Green (RoHS & no Sb/Br) | POST-PLATE | Level-1-NA-UNLIM | |
| LME49720MA/NOPB | ACTIVE | SOIC | D | 8 | 95 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | |
| LME49720MAX/NOPB | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | |
| LME49720NA/NOPB | ACTIVE | PDIP | P | 8 | 40 | Green (RoHS & no Sb/Br) | Call TI | Level-1-NA-UNLIM | |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

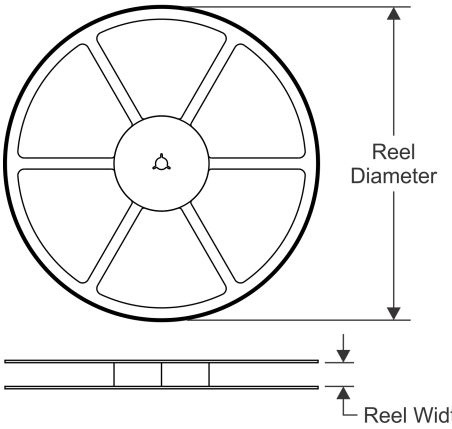
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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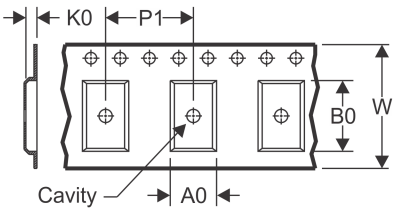
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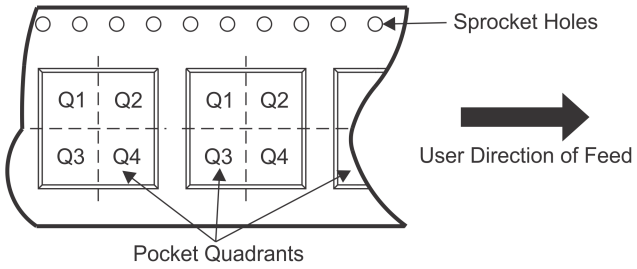



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

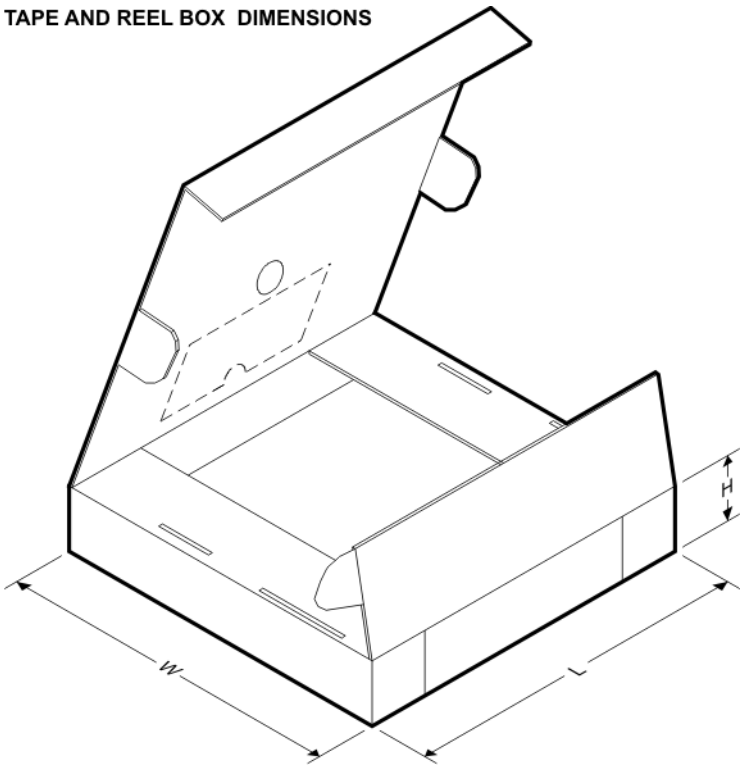
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LME49720MAX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

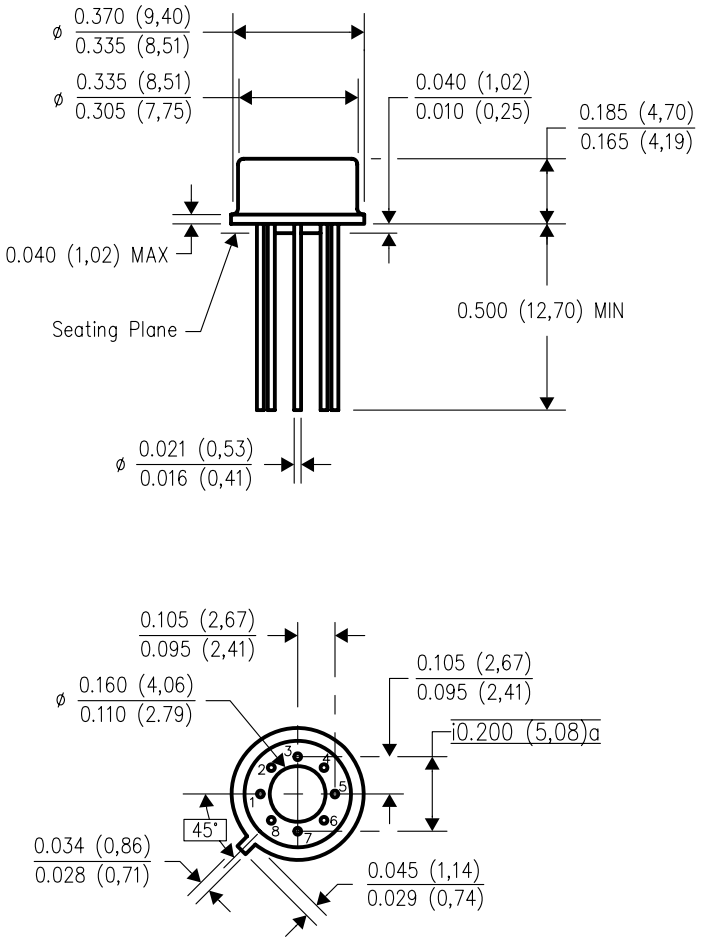
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LME49720MAX/NOPB | SOIC | D | 8 | 2500 | 349.0 | 337.0 | 45.0 |

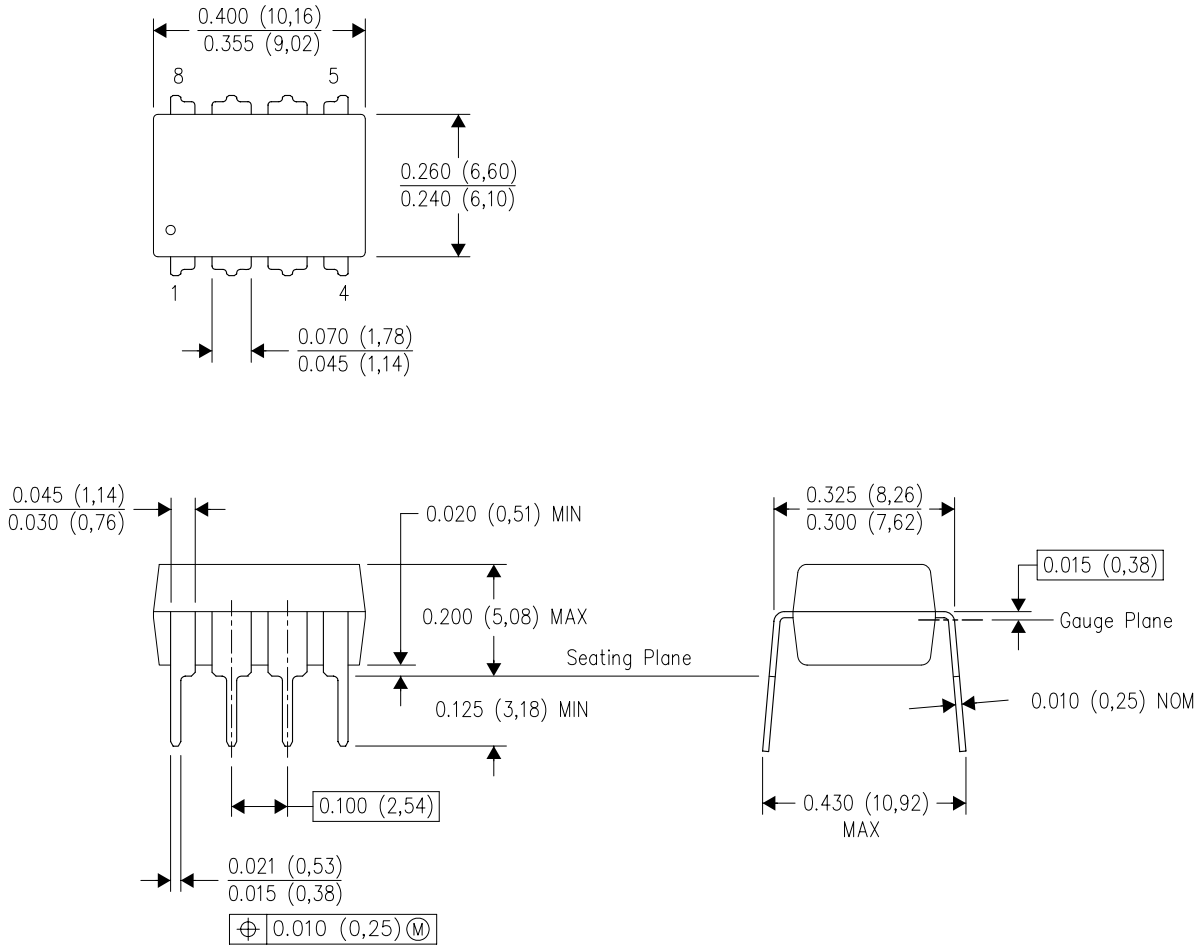
## LMC (O–MBCY–W8) METAL CYLINDRICAL PACKAGE




4202483/B 09/07

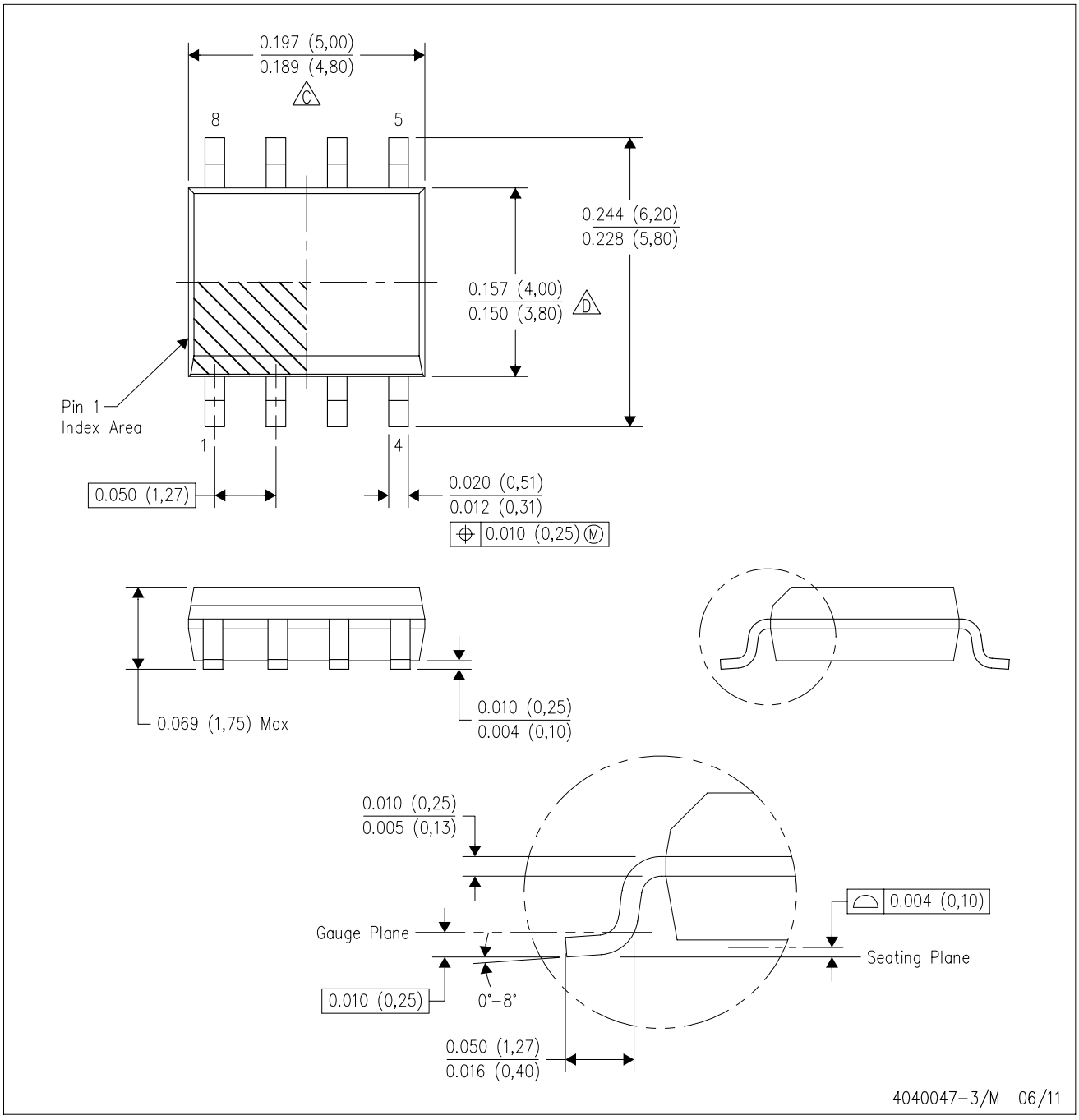
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
D. Pin numbers shown for reference only. Numbers may not be marked on package.
E. Falls within JEDEC MO–002/TO–99.

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE




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

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