# LHV870 44V Single High Performance, High Voltage Operational Amplifier

Check for Samples: LHV870

## FEATURES

- Easily Drives 600Ω Loads
- Output Short Circuit Protection
- PSRR and CMRR Exceed 120dB (Typ)

## APPLICATIONS

- Low Noise Industrial Applications Including Test, Measurement, and Ultrasound
- High Quality Audio Amplification
- High Fidelity Preamplifiers, Phono Preamps, and Multimedia
- High Performance Professional Audio
- High Fidelity Equalization and Crossover Networks with Active Filters
- High Performance Line Drivers and Receivers

## KEY SPECIFICATIONS

- Power Supply Voltage Range ±2.5V to ±22 V
- Input Noise Density 2.7nV/√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)
- DC Gain Linearity Error 0.000009%
- 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)

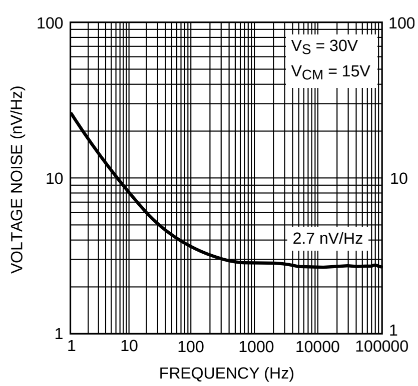
## DESCRIPTION

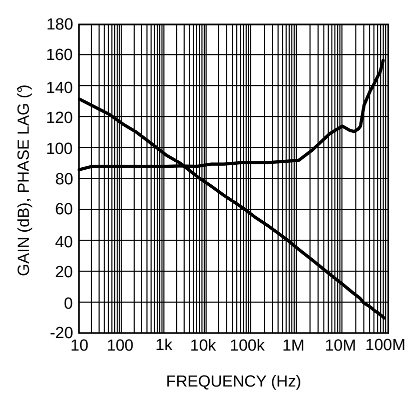
The LHV870 is an ultra-low distortion, low noise, high slew rate operational amplifier optimized and fully specified for high performance, high voltage applications. Combining advanced leading-edge process technology with state-of-the-art circuit design, the LHV870 operational amplifier delivers superior signal amplification for outstanding performance. The LHV870 combines extremely low voltage noise density (2.7nV/√Hz) with vanishingly low DC Gain Linearity Error (0.000009%) to easily satisfy the most demanding applications. To ensure that the most challenging loads are driven without compromise, the LHV870 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 LHV870's outstanding CMRR (120dB), PSRR (120dB), and $V_{OS}$ (0.1mV) give the amplifier excellent DC performance.

The LHV870 operates over a wide supply range of ±2.5V to ±22V and is unity gain stable. This operational amplifier achieves outstanding AC performance while driving complex loads with values as high as 100pF.

The LHV870 is available in 10-lead WQFN package.



## Connection Diagram

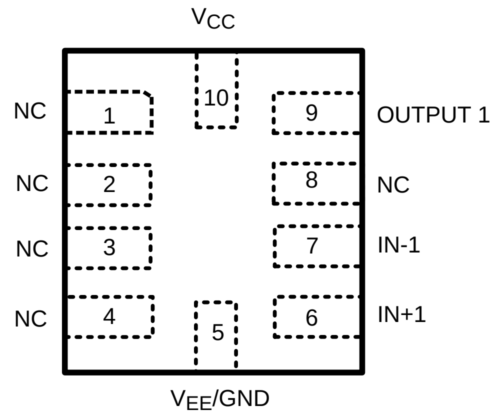



**Figure 1. See Package Number – NKY0010A**

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS[(1)(2)(3)]

| | | |
|---|---|---|
| Power Supply Voltage ($V_S = V^+ - V^-$) | | 46V |
| Storage Temperature | | −65°C to 150°C |
| Input Voltage | | (V-) - 0.7V to (V+) + 0.7V |
| Output Short Circuit[(4)] | | Continuous |
| Power Dissipation | | Internally Limited |
| ESD Rating[(5)] | | 2000V |
| ESD Rating[(6)] | Pins 1, 4, 7 and 8 | 200V |
| | Pins 2, 3, 5 and 6 | 100V |
| Junction Temperature | | 150°C |
| Thermal Resistance | $\theta_{JA}$ (WQFN) | 168°C/W |

(1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) The Electrical Characteristics tables list ensured specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not ensured.
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(4) The maximum power dissipation must be derated at elevated temperatures and is dictated by $T_{JMAX}$, $\theta_{JA}$, and the ambient temperature, $T_A$. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower.
(5) Human body model, applicable std. JESD22-A114C.
(6) Machine model, applicable std. JESD22-A115-A.

## OPERATING RATINGS

| | |
|---|---|
| Temperature Range ($T_{MIN} \le T_A \le T_{MAX}$) | $-40°C \le T_A \le 85°C$ |
| Supply Voltage Range | $\pm2.5V \le V_S \le \pm22V$ |

## ELECTRICAL CHARACTERISTICS FOR THE LHV870 (1)

The following specifications apply for $V_S$ = ±18V and ±22V, $R_L$ = 2kΩ, $R_{SOURCE}$ = 10Ω, $f_{IN}$ = 1kHz, $T_A$ = 25°C, unless otherwise specified.

| Symbol | Parameter | Conditions | LHV870 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typical (2) | Limit (3) | |
| THD+N | Total Harmonic Distortion + Noise | $A_V$ = 1, $V_{OUT}$ = $3V_{RMS}$, $R_L$ = 2kΩ | 0.00003 | | % |
| IMD | Intermodulation Distortion | $A_V$ = 1, $V_{OUT}$ = $3V_{RMS}$<br>Two-tone, 60Hz & 7kHz 4:1 | 0.00005 | | % |
| GBWP | Gain Bandwidth Product | | 55 | 45 | MHz (min) |
| SR | Slew Rate | | ±20 | | V/μs |
| FPBW | Full Power Bandwidth | $V_{OUT}$ = $1V_{P-P}$, –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 | $\mu V_{RMS}$ (max) |
| | Equivalent Input Noise Density | f = 1kHz | 2.5 | 4.7 | $nV/\sqrt{Hz}$ (max) |
| $i_n$ | Current Noise Density | f = 1kHz | 1.6 | | $pA/\sqrt{Hz}$ |
| $V_{OS}$ | Offset Voltage | $V_S$ = ±18V | ±0.12 | | mV |
| | | $V_S$ = ±22V | ±0.14 | ±2 | mV (max) |
| $\Delta V_{OS}/\Delta Temp$ | Average Input Offset Voltage Drift vs Temperature | $-40°C \le T_A \le 85°C$ | 0.1 | | μV/°C |
| PSRR | Average Input Offset Voltage Shift vs Power Supply Voltage | $V_S$ = ±18V, $\Delta V_S$ = 24V (4)<br>$V_S$ = ±22V, $\Delta V_S$ = 30V | 120<br>120 | <br>110 | dB (min) |
| $I_B$ | Input Bias Current | $V_{CM}$ = 0V | 10 | 300 | nA (max) |
| $\Delta I_{OS}/\Delta Temp$ | Input Bias Current Drift vs Temperature | $-40°C \le T_A \le 85°C$ | 0.2 | | nA/°C |
| $I_{OS}$ | Input Offset Current | $V_{CM}$ = 0V | 11 | 100 | nA (max) |
| $V_{IN-CM}$ | Common-Mode Input Voltage Range | $V_S$ = ±18V | +17.1<br>–16.9 | | V<br>V |
| | | $V_S$ = ±22V | +21.0<br>–20.8 | (V+) – 2.0<br>(V-) + 2.0 | V (min)<br>V (min) |
| CMRR | Common-Mode Rejection | $V_S$ = ±18V<br>$-12V \le V_{CM} \le 12V$ | 120 | | dB |
| | | $V_S$ = ±22V<br>$-15V \le V_{CM} \le 15V$ | 120 | 110 | dB (min) |
| $Z_{IN}$ | Differential Input Impedance | | 30 | | kΩ |
| | Common Mode Input Impedance | $-10V < V_{CM} < 10V$ | 1000 | | MΩ |

(1) "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional and the device should not be operated beyond such conditions. All voltages are measured with respect to the ground pin, unless otherwise specified.
(2) Typical values represent most likely parametric norms at $T_A$ = +25ºC, and at the Recommended Operation Conditions at the time of product characterization and are not ensured.
(3) Datasheet min/max specification limits are specified by test or statistical analysis.
(4) PSRR is measured as follows: For $V_S$, $V_{OS}$ is measured at two supply voltages, ±7V and ±22V, PSRR = $|20\log(\Delta V_{OS} / \Delta V_S)|$.

## ELECTRICAL CHARACTERISTICS FOR THE LHV870[1] (continued)

The following specifications apply for $V_S$ = ±18V and ±22V, $R_L$ = 2kΩ, $R_{SOURCE}$ = 10Ω, $f_{IN}$ = 1kHz, $T_A$ = 25°C, unless otherwise specified.

| Symbol | Parameter | Conditions | LHV870 Typical[2] | LHV870 Limit[3] | Units (Limits) |
|---|---|---|---|---|---|
| $A_{VOL}$ | Open Loop Voltage Gain | $V_S$ = ±18V<br>–12V≤$V_{OUT}$≤12V<br>$R_L$ = 2kΩ | 140 | | dB |
| | | $V_S$ = ±22V<br>–15V≤$V_{OUT}$t≤15V<br>$R_L$ = 2kΩ | 140 | | dB |
| $V_{OUTMAX}$ | Maximum Output Voltage Swing | $R_L$ = 600Ω<br>$V_S$ = ±18V<br>$V_S$ = ±22V | ±16.7<br>±20.4 | ±19.0 | V<br>V (min) |
| | | $R_L$ = 2kΩ<br>$V_S$ = ±18V<br>$V_S$ = ±22V | ±17.0<br>±21.0 | | V<br>V |
| $I_{OUT}$ | Output Current | $R_L$ = 600Ω<br>$V_S$ = ±20V<br>$V_S$ = ±22V | ±31<br>±37 | ±30 | mA<br>mA (min) |
| $I_{OUT-CC}$ | Instantaneous Short Circuit Current | | +53<br>–42 | | mA |
| $R_{OUT}$ | Output Impedance | $f_{IN}$ = 10kHz<br>Closed-Loop<br>Open-Loop | 0.01<br>13 | | Ω<br>Ω |
| $I_S$ | Total Quiescent Current | $I_{OUT}$ = 0mA | 5 | 6.5 | mA (max) |

## TYPICAL PERFORMANCE CHARACTERISTICS

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

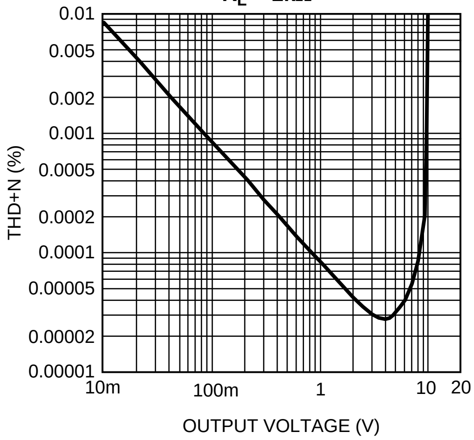



**Figure 2.**

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

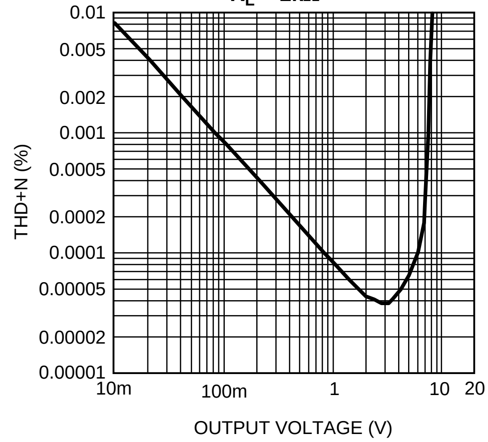



**Figure 3.**

**THD+N vs Output Voltage**
**$V_{CC}$ = 22V, $V_{EE}$ = –22V**
**$R_L$ = 2kΩ**

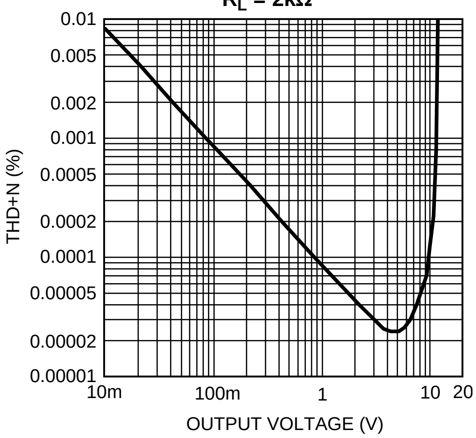



**Figure 4.**

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

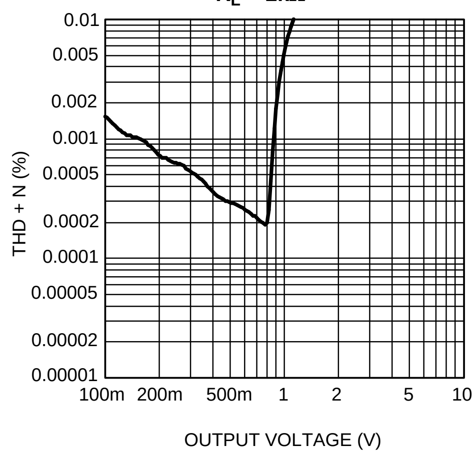



**Figure 5.**

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

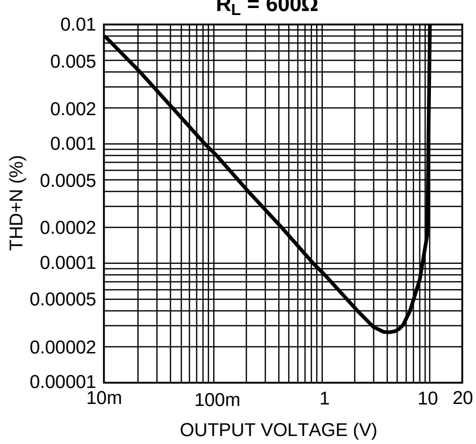



**Figure 6.**

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

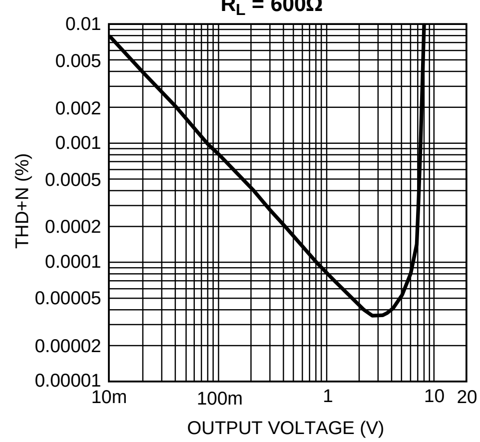



**Figure 7.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

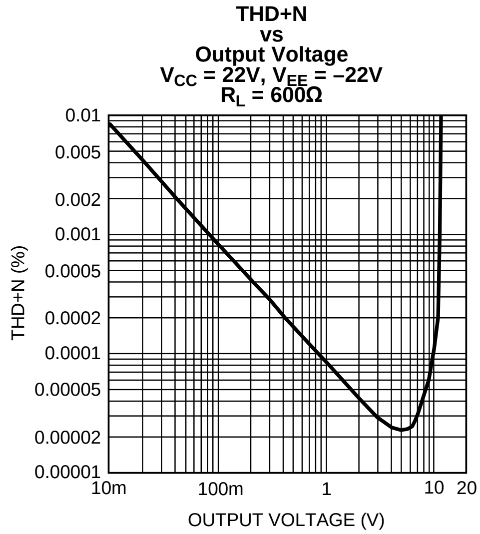



**Figure 8.**

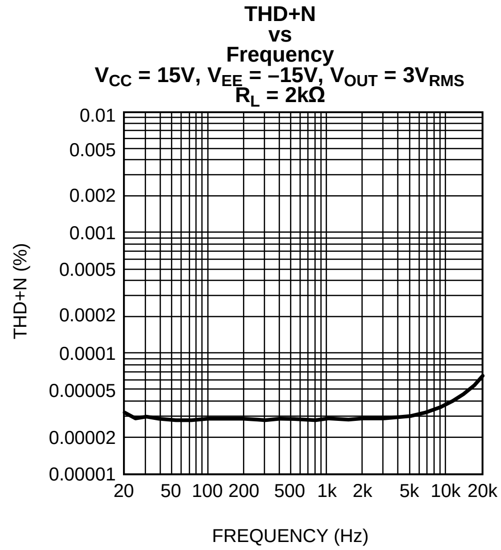



**Figure 9.**

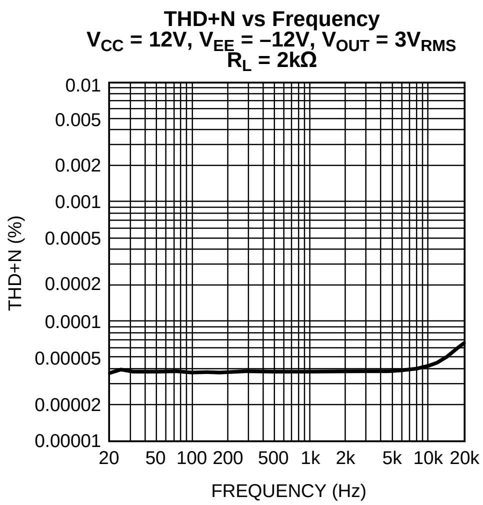



**Figure 10.**

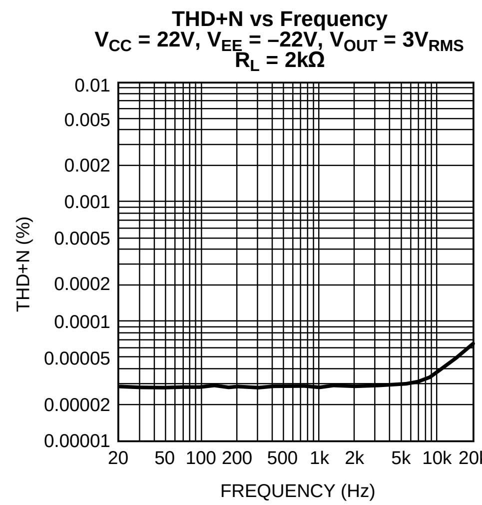
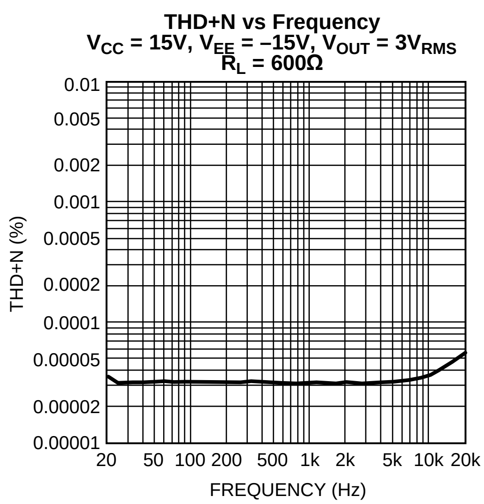



**Figure 11.**

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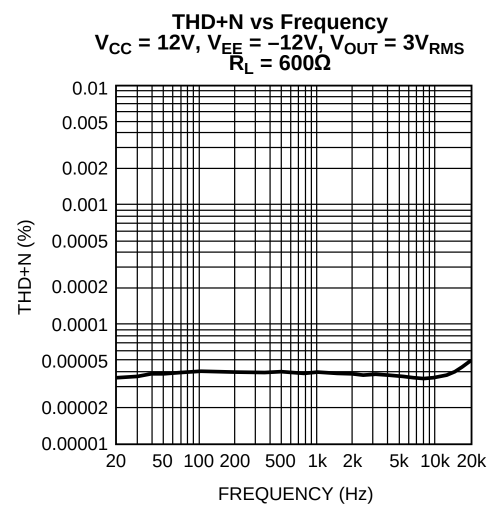



**Figure 13.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

**THD+N vs Frequency**
**$V_{CC}$ = 22V, $V_{EE}$ = –22V, $V_{OUT}$ = 3$V_{RMS}$**
**$R_L$ = 600Ω**

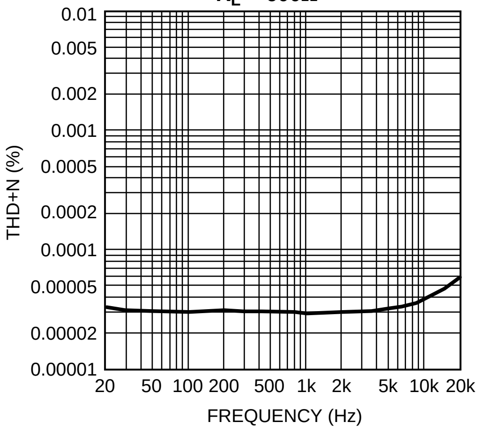



**Figure 14.**

**Voltage Noise Density vs Frequency**

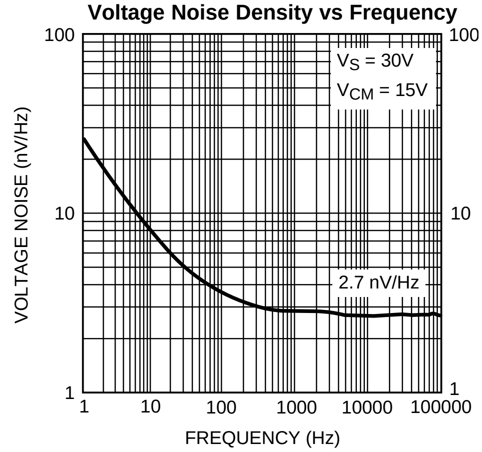



**Figure 15.**

**Current Noise Density vs Frequency**

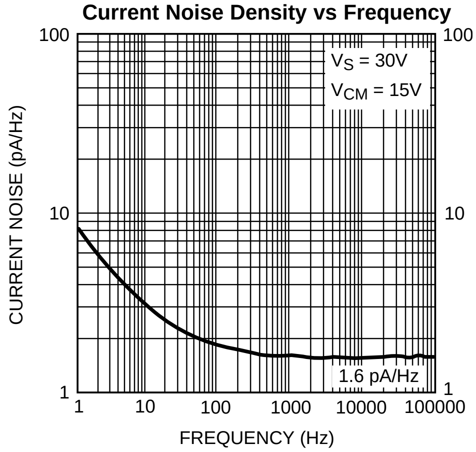



**Figure 16.**

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

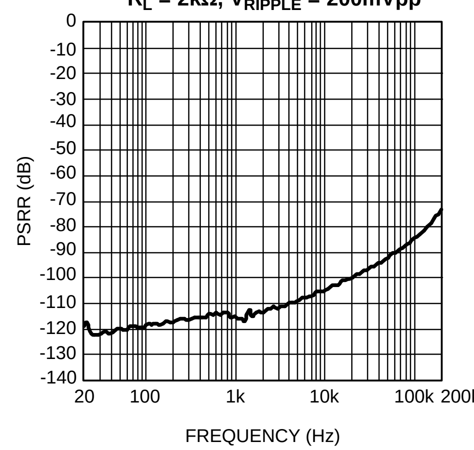



**Figure 17.**

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

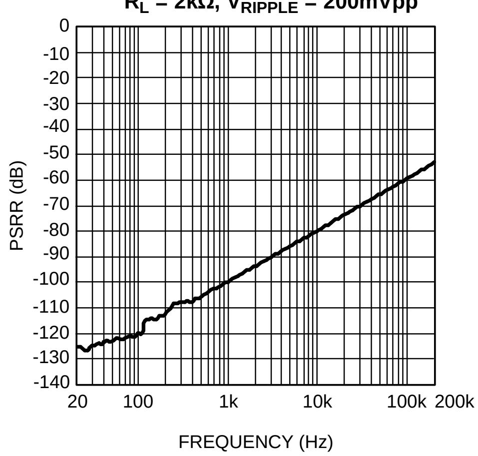



**Figure 18.**

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

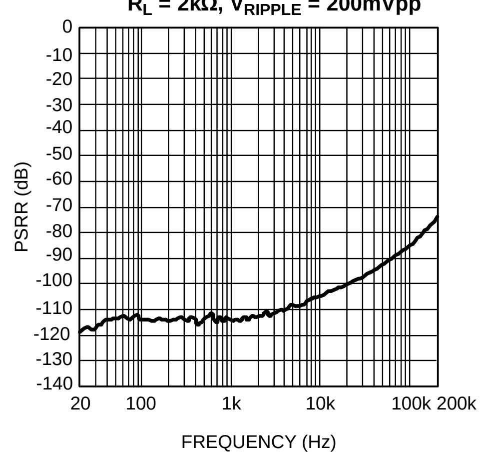



**Figure 19.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

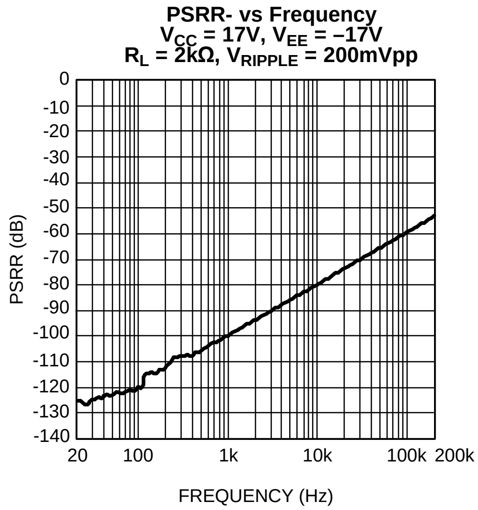



**Figure 20.**

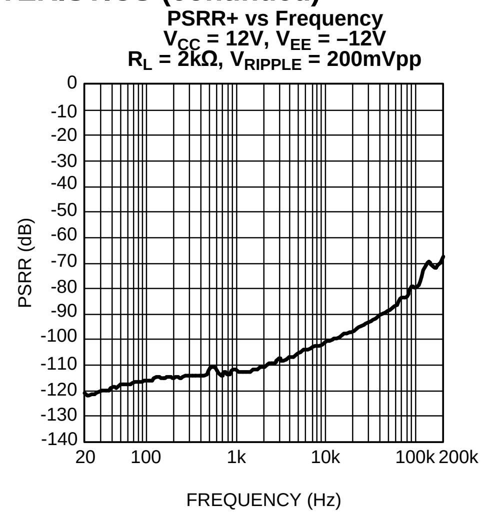



**Figure 21.**

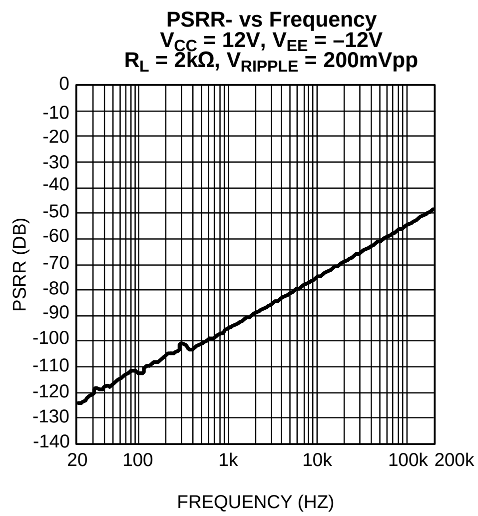



**Figure 22.**

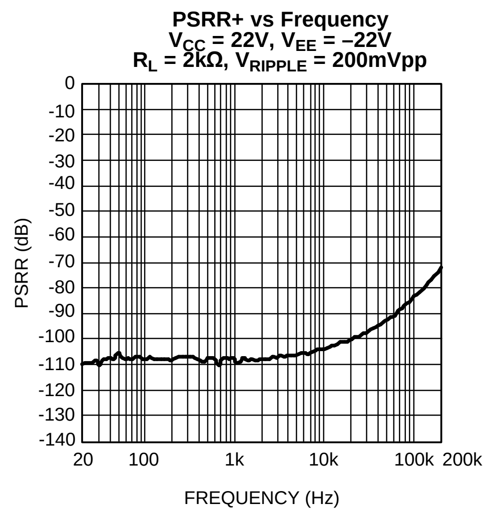



**Figure 23.**

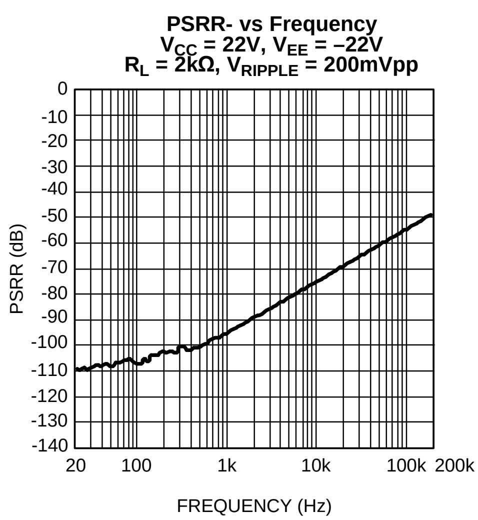



**Figure 24.**

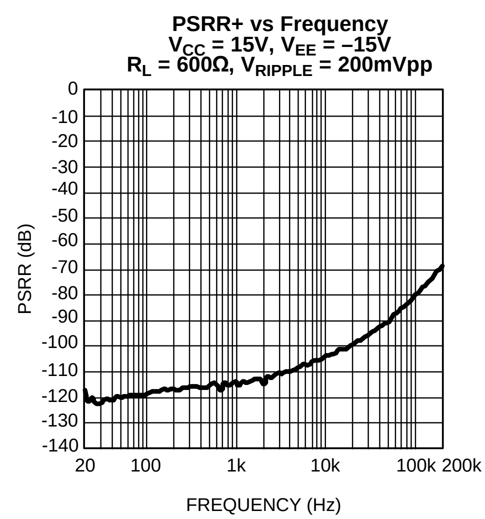



**Figure 25.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

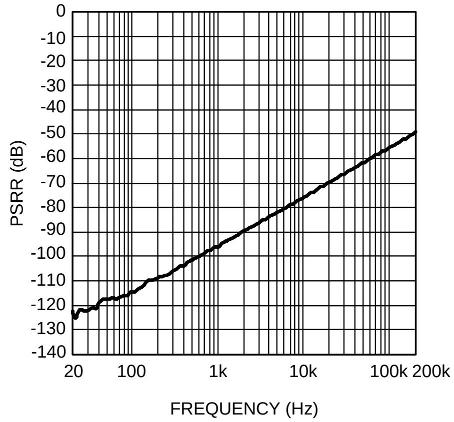



**Figure 26.**

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

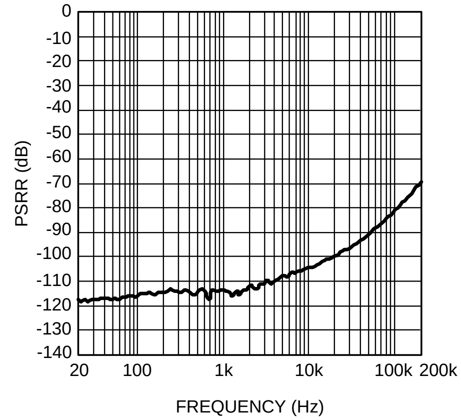



**Figure 27.**

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

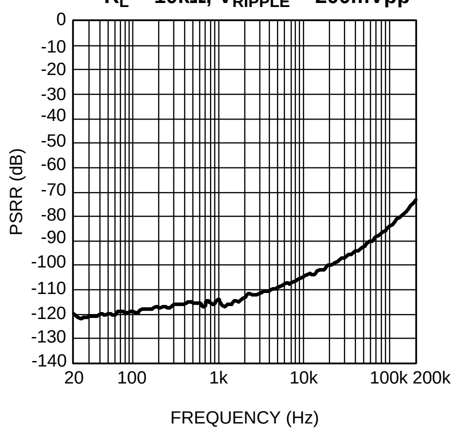



**Figure 28.**

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

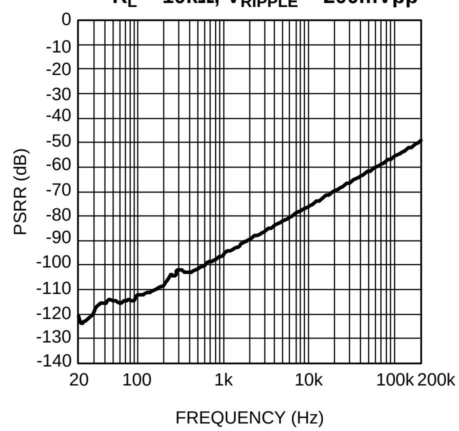



**Figure 29.**

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

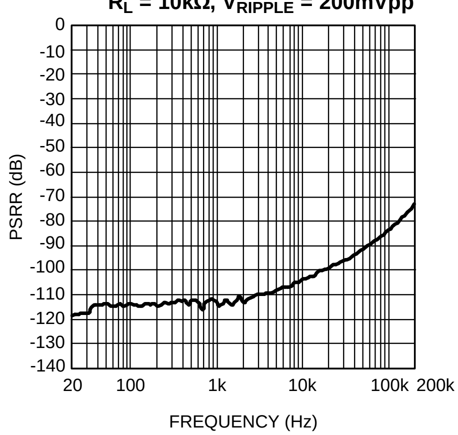



**Figure 30.**

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

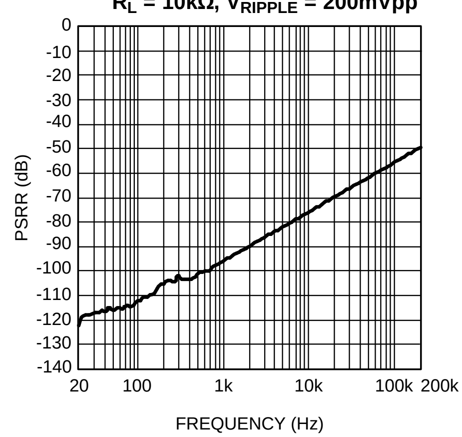



**Figure 31.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

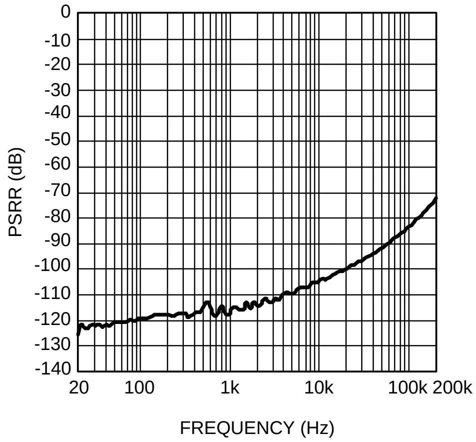



**Figure 32.**

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

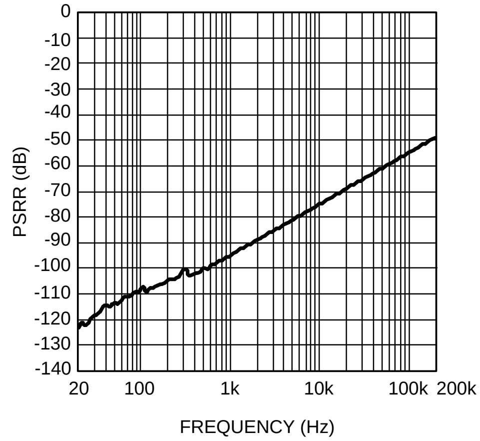



**Figure 33.**

**PSRR+ vs Frequency**
**$V_{CC}$ = 22V, $V_{EE}$ = –22V**
**$R_L$ = 10kΩ, $V_{RIPPLE}$ = 200mVpp**

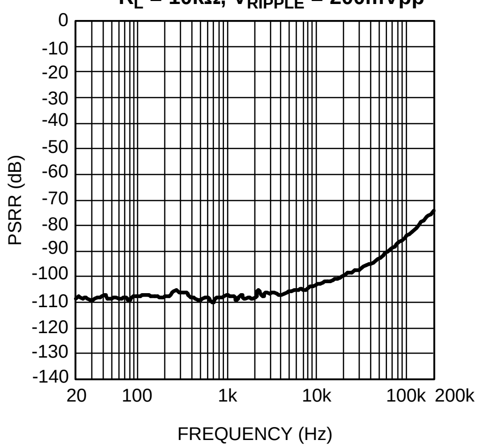



**Figure 34.**

**PSRR- vs Frequency**
**$V_{CC}$ = 22V, $V_{EE}$ = –22V**
**$R_L$ = 10kΩ, $V_{RIPPLE}$ = 200mVpp**

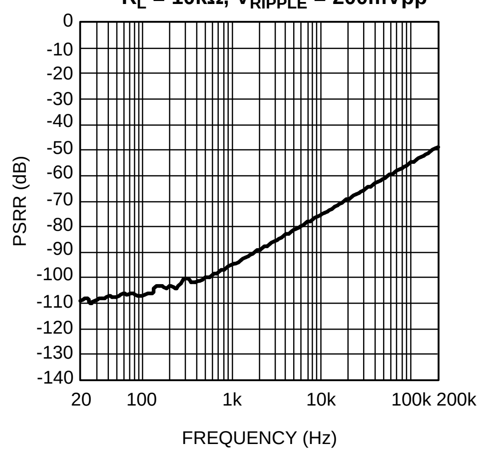



**Figure 35.**

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

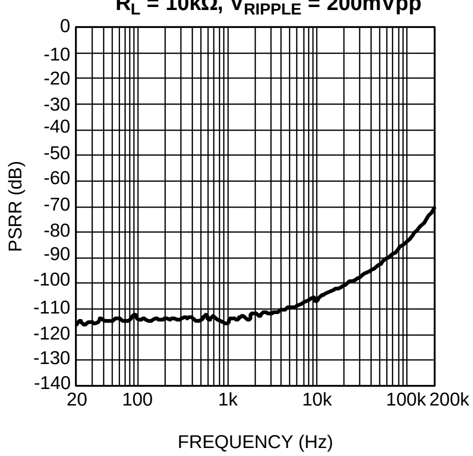



**Figure 36.**

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

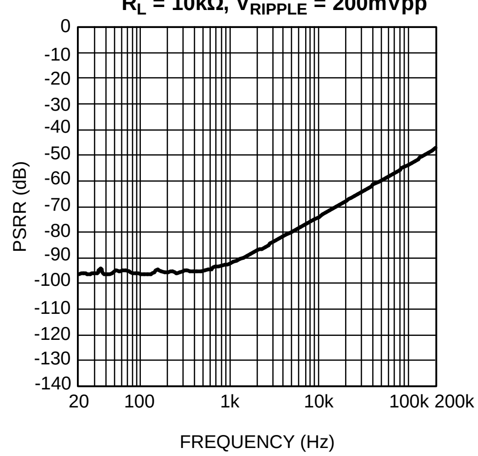



**Figure 37.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

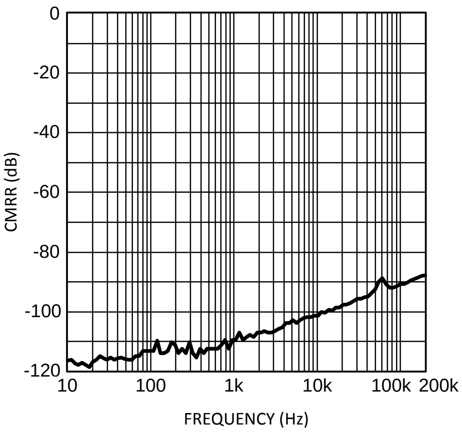



**Figure 38.**

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

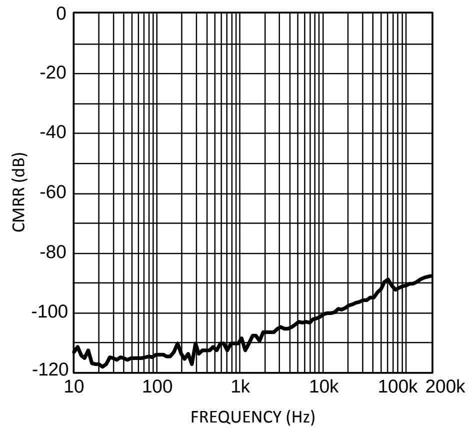



**Figure 39.**

**CMRR vs Frequency**
**$V_{CC}$ = 22V, $V_{EE}$ = –22V**
**$R_L$ = 2kΩ**

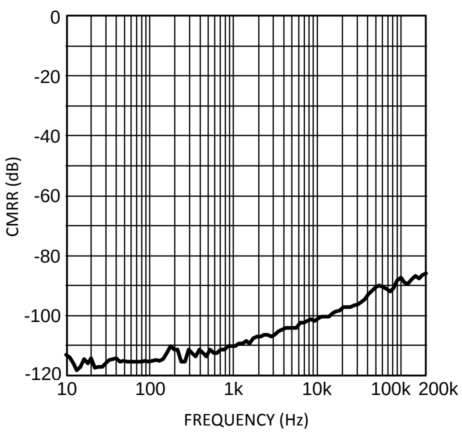



**Figure 40.**

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

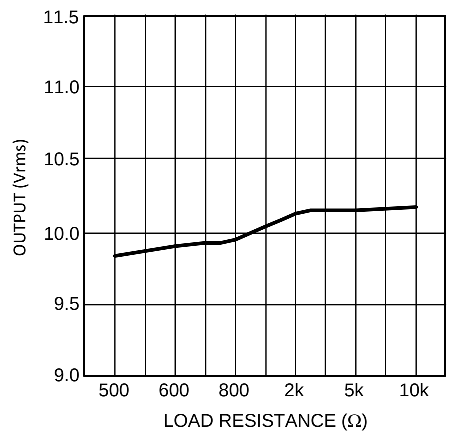



**Figure 41.**

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

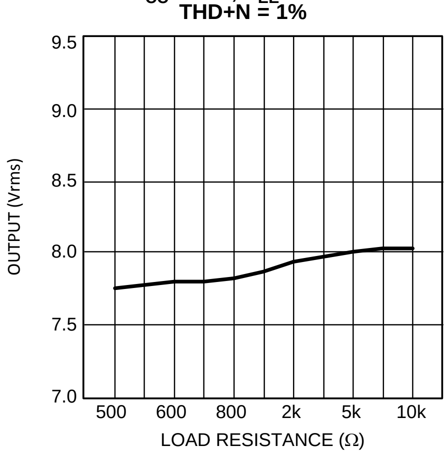



**Figure 42.**

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

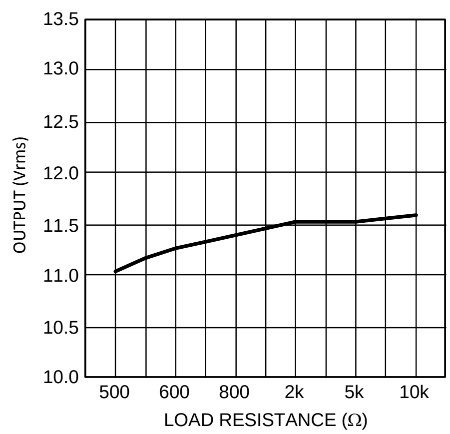



**Figure 43.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

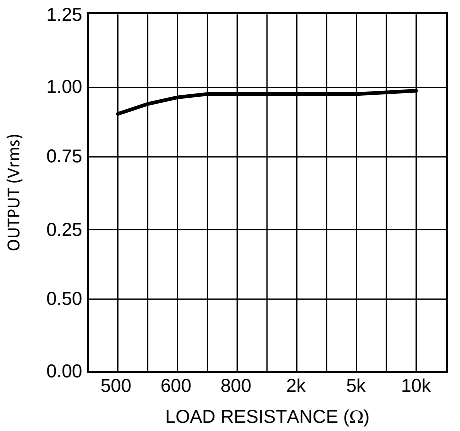



**Figure 44.**

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

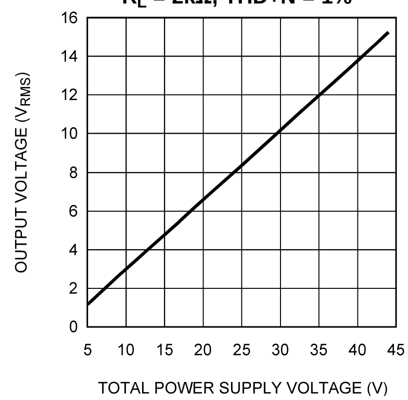



**Figure 45.**

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

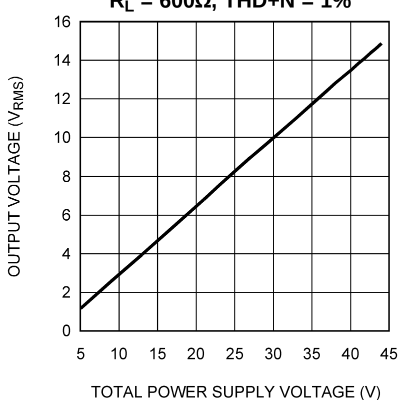



**Figure 46.**

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

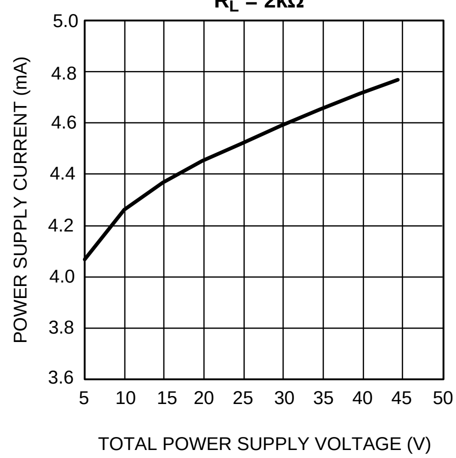



**Figure 47.**

**Full Power Bandwidth vs Frequency**
**$V_S$ = ±18V, $R_L$ = 2kΩ**

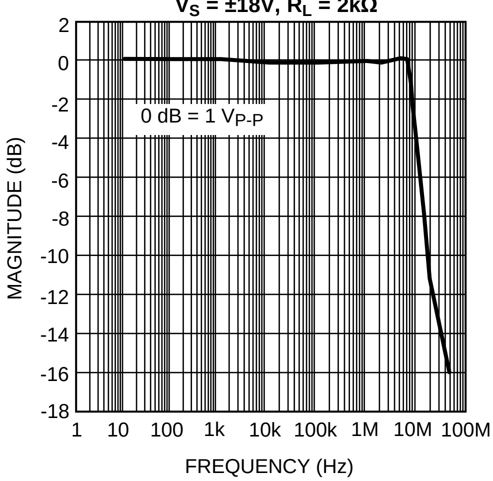



**Figure 48.**

**Gain Phase vs Frequency**
**$V_S$ = ±18V, $R_L$ = 2kΩ**

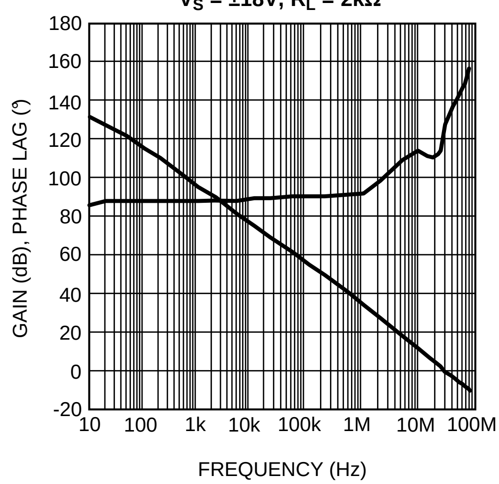



**Figure 49.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

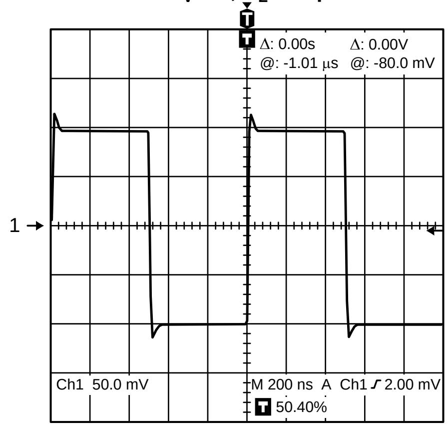



**Figure 50.**

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

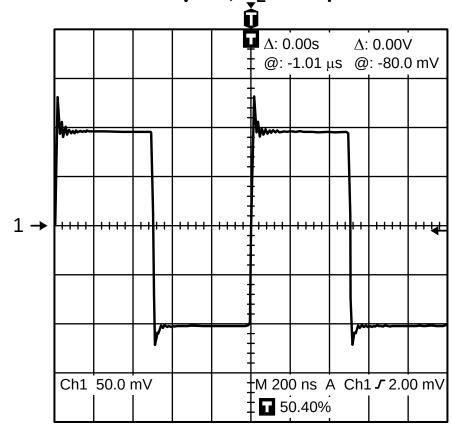



**Figure 51.**

## APPLICATION INFORMATION

### DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LHV870 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 LHV870's low residual distortion is an input referred internal error. As shown in Figure 52, 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 52.

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.

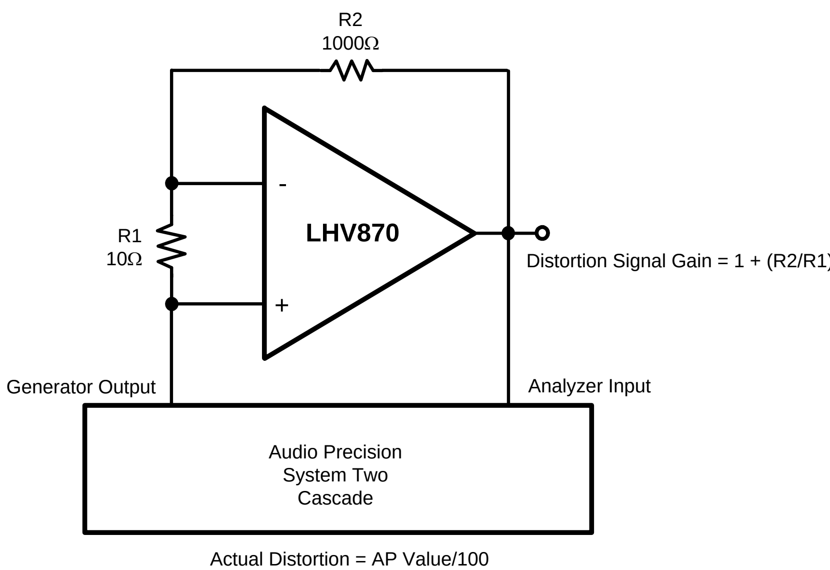
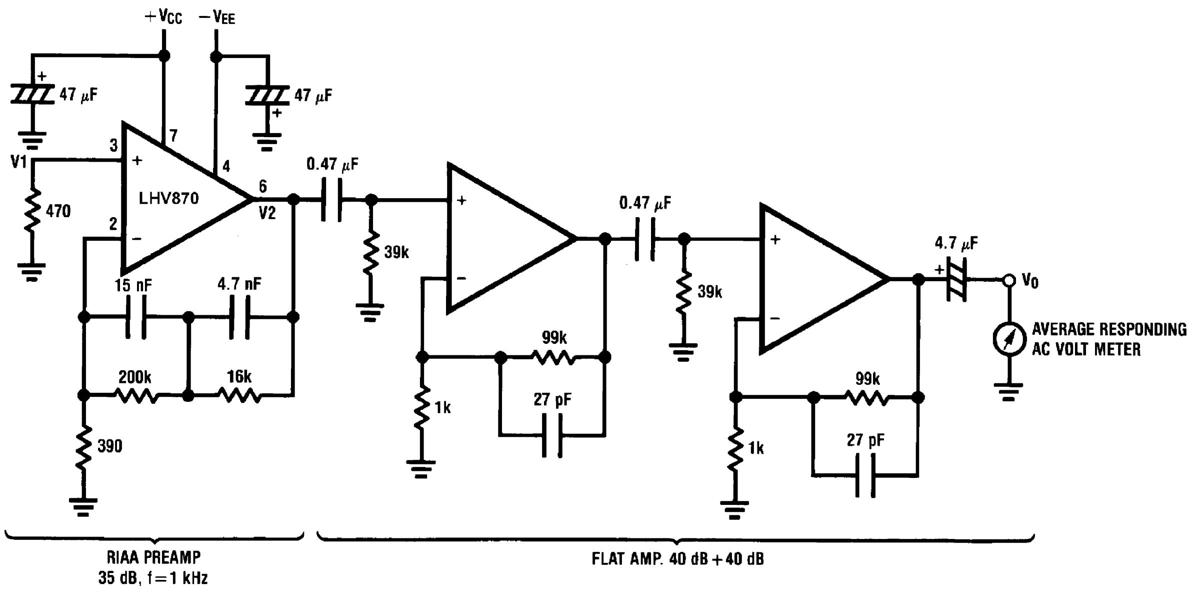



**Figure 52. THD+N and IMD Distortion Test Circuit**

The LHV870 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.

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

**Figure 53. Noise Measurement Circuit**

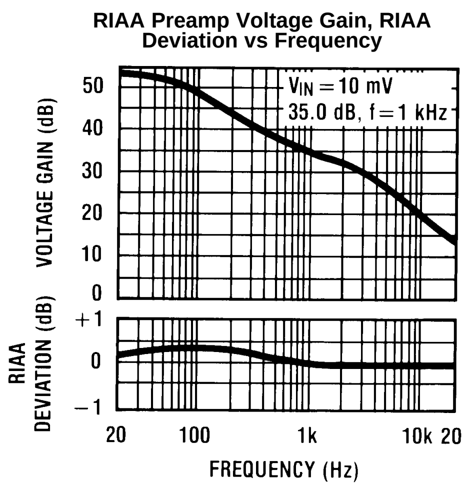



**Figure 54.**

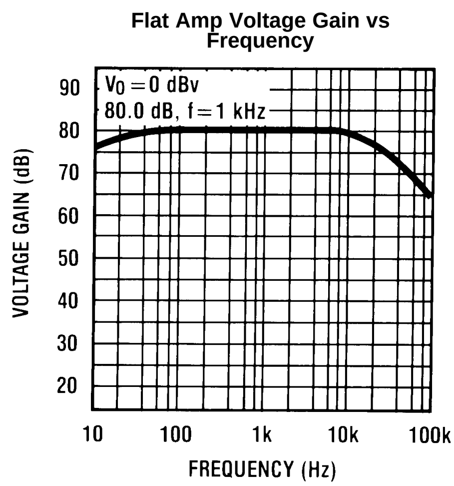
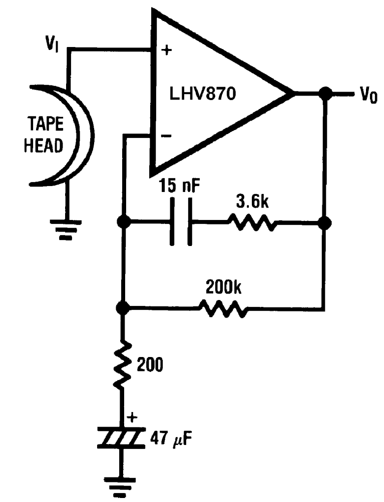



**Figure 55.**

## TYPICAL APPLICATIONS




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

**Figure 56. NAB Preamp**

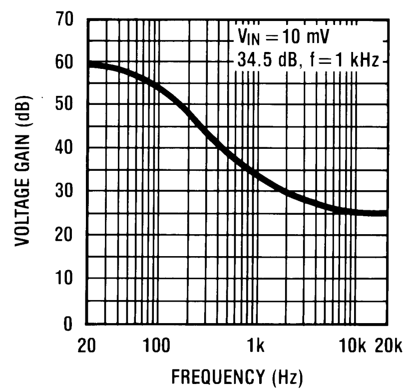
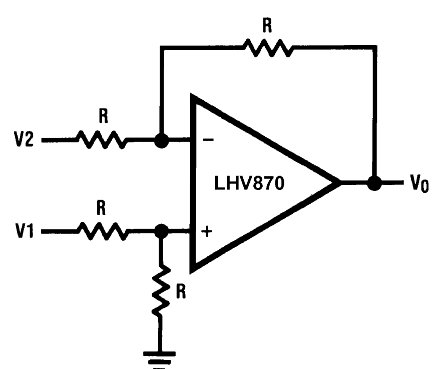
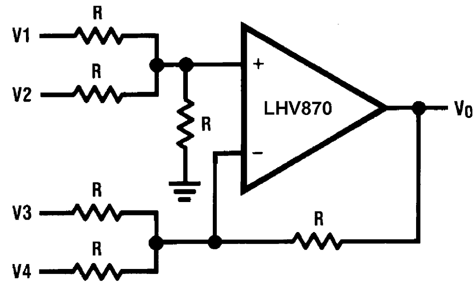



**Figure 57. NAB Preamp Voltage Gain vs Frequency**



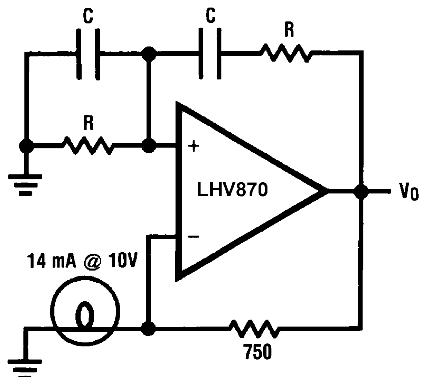

$V_O$ = V1–V2

**Figure 58. Balanced to Single Ended Converter**



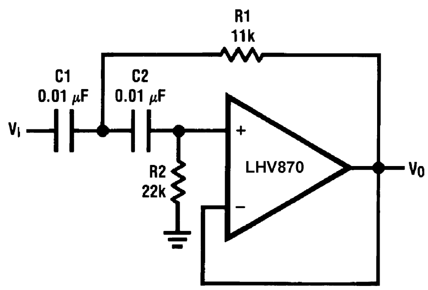

$V_O = V1 + V2 - V3 - V4$

**Figure 59. Adder/Subtracter**




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

**Figure 60. Sine Wave Oscillator**



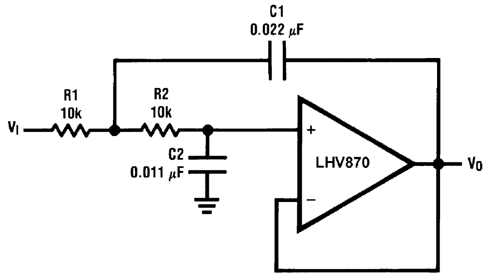

if $C1 = C2 = C$

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

$$R2 = 2 \bullet R1$$

Illustration is $f_0 = 1$ kHz

**Figure 61. Second Order High Pass Filter (Butterworth)**



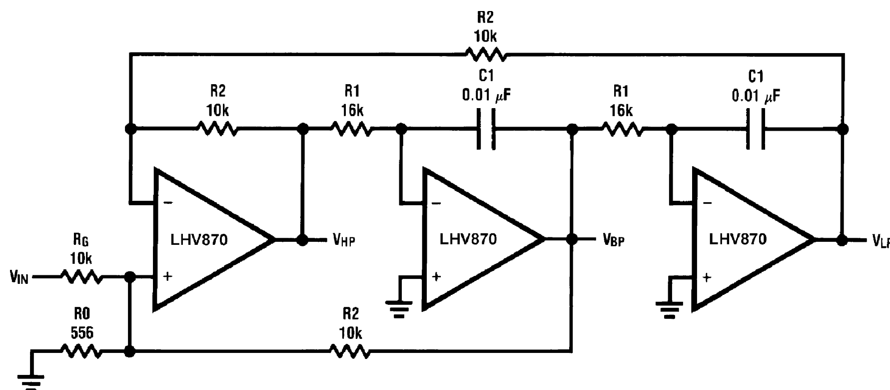

if R1 = R2 = R

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

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

Illustration is $f_0$ = 1 kHz

**Figure 62. Second Order Low Pass Filter (Butterworth)**




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

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

**Figure 63. State Variable Filter**

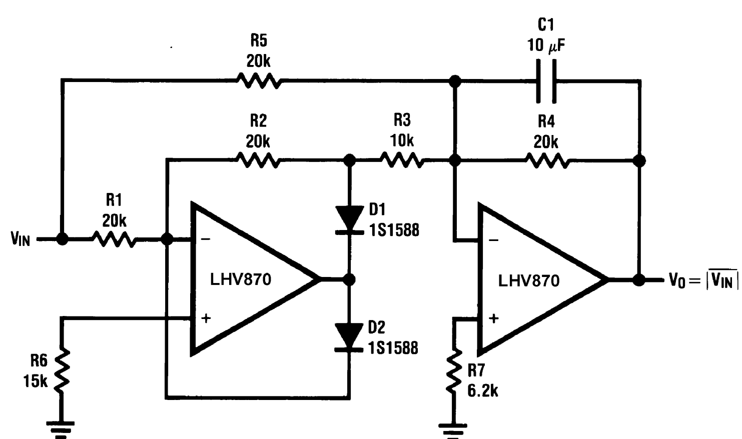



**Figure 64. AC/DC Converter**

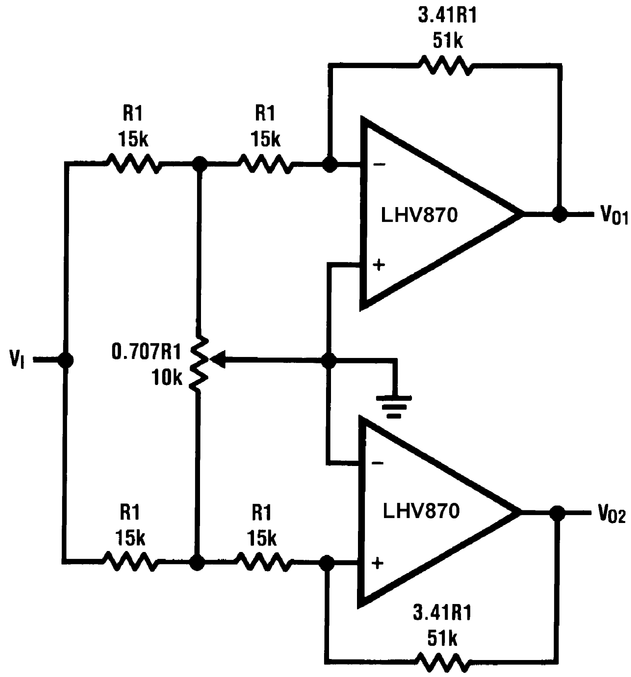



**Figure 65. 2 Channel Panning Circuit (Pan Pot)**

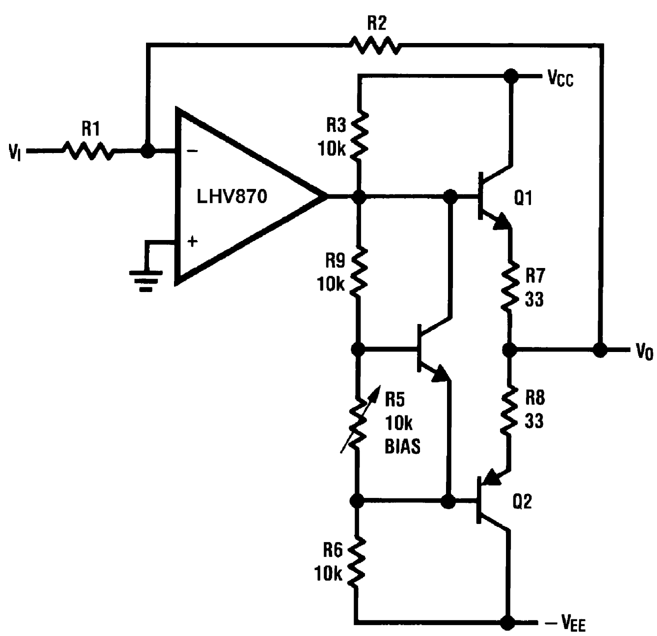
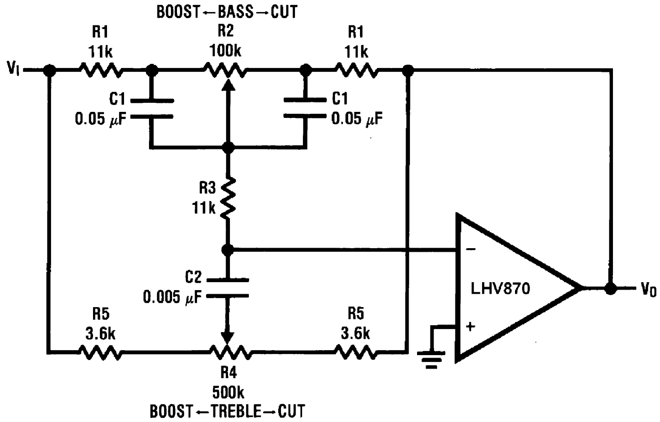



**Figure 66. Line Driver**




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

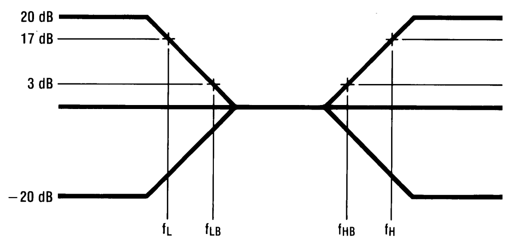
$f_H = \frac{1}{2\pi R5C2}$, $f_{HB} = \frac{1}{2\pi (R1 + R5 + 2R3)C2}$

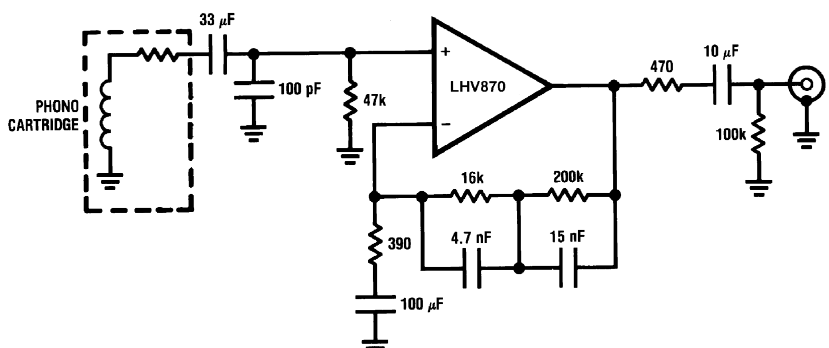
Illustration is:

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

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

**Figure 67. Tone Control**




$A_v$ = 35 dB

$E_n$ = 0.33 µV

S/N = 90 dB

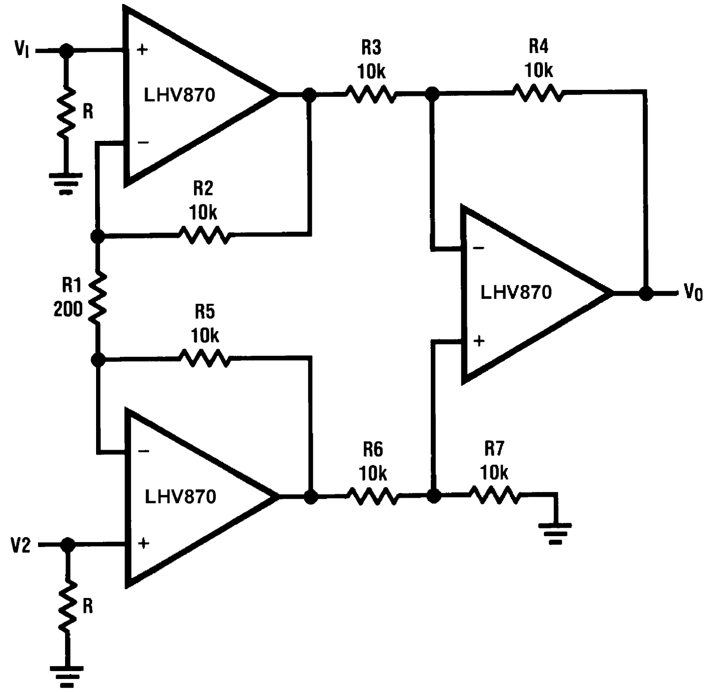
f = 1 kHz

A Weighted

A Weighted, $V_{IN}$ = 10 mV

@f = 1 kHz

**Figure 68. RIAA Preamp**




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 69. Balanced Input Mic Amp**

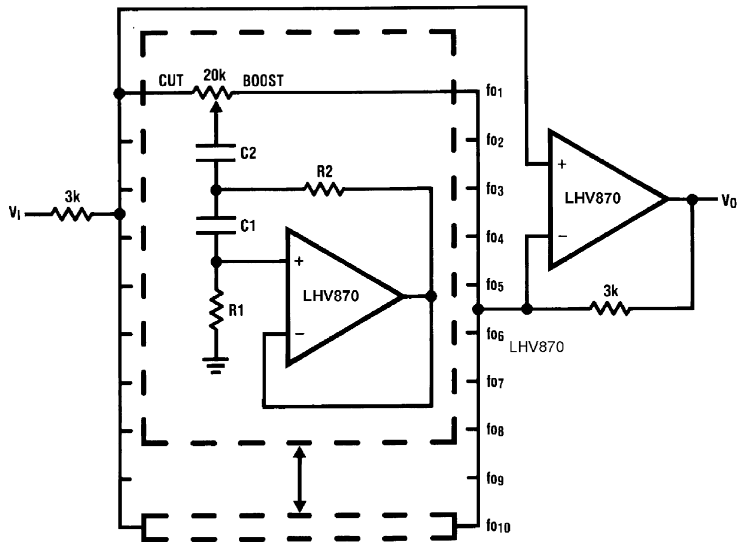



**Figure 70. 10 Band Graphic Equalizer**

| 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 |

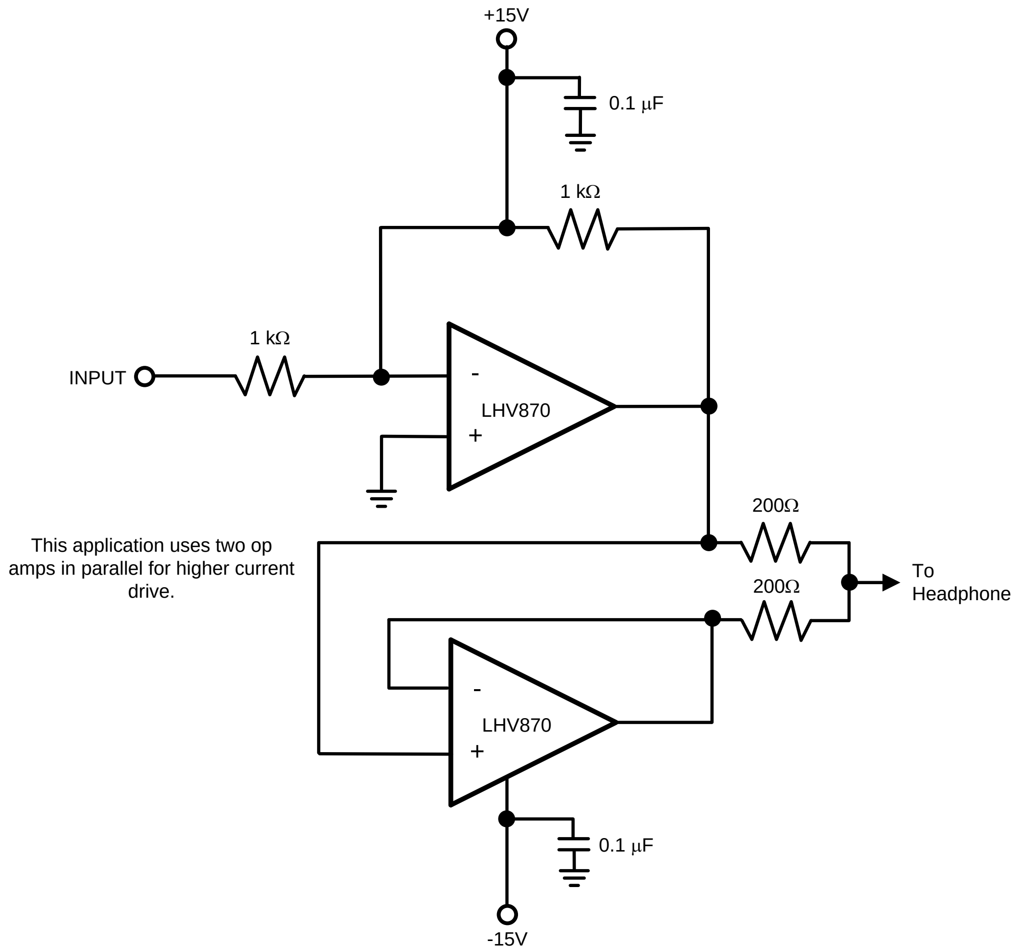



**Figure 71. Headphone Amplifier**

## REVISION HISTORY

| Rev | Date | Description |
|---|---|---|
| 1.0 | 05/25/11 | Initial WEB released. |
| 1.01 | 12/16/11 | Changed the package from LCE10A to LCB10A. |
| 1.02 | 01/04/12 | Re-composed the document to reveal the LCB10A (revB) package. |
| 2.0 | 05/02/13 | layout of National Data Sheet to TI format |

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LHV870LC/NOPB | ACTIVE | UQFN | NKY | 10 | 1000 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | | ZD1 | Samples |
| LHV870LCX/NOPB | ACTIVE | UQFN | NKY | 10 | 4500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | | ZD1 | Samples |

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

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

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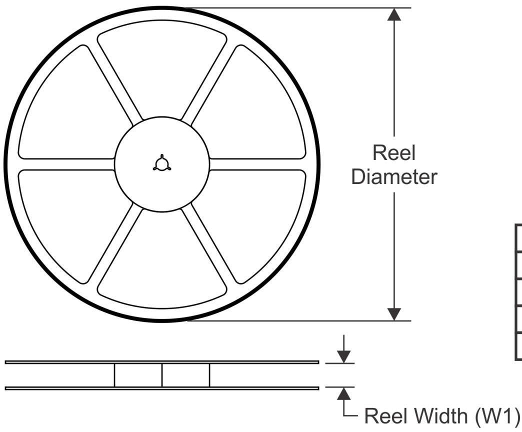
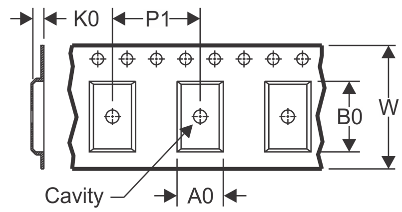
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

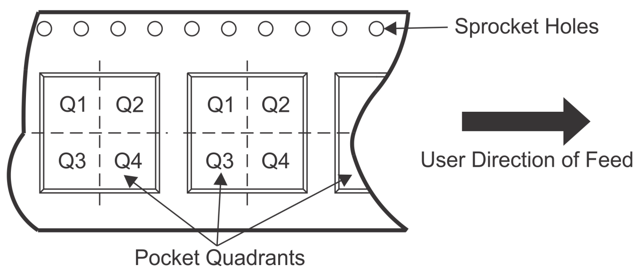



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

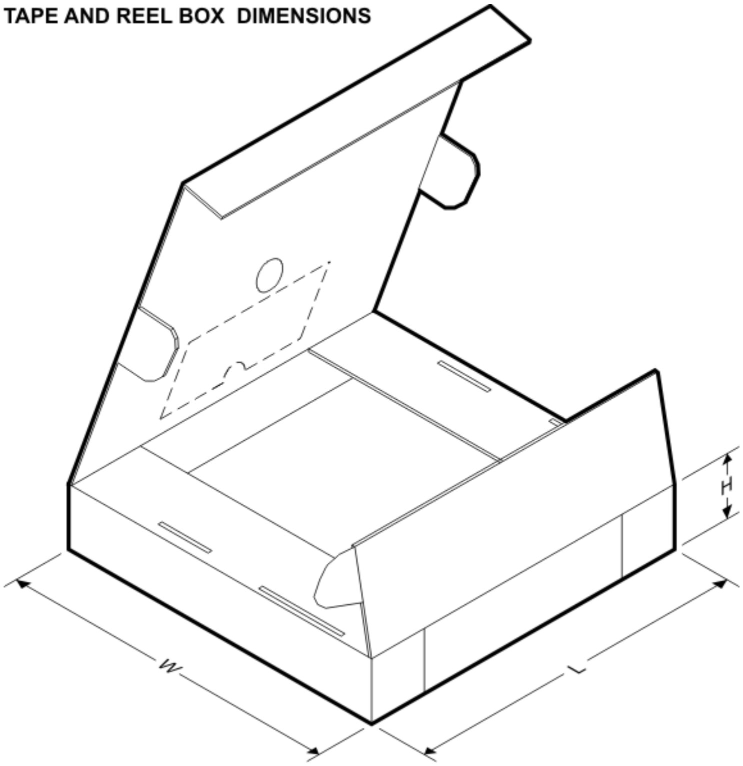
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LHV870LC/NOPB | UQFN | NKY | 10 | 1000 | 178.0 | 12.4 | 2.9 | 2.9 | 1.0 | 8.0 | 12.0 | Q1 |
| LHV870LCX/NOPB | UQFN | NKY | 10 | 4500 | 330.0 | 12.4 | 2.9 | 2.9 | 1.0 | 8.0 | 12.0 | Q1 |

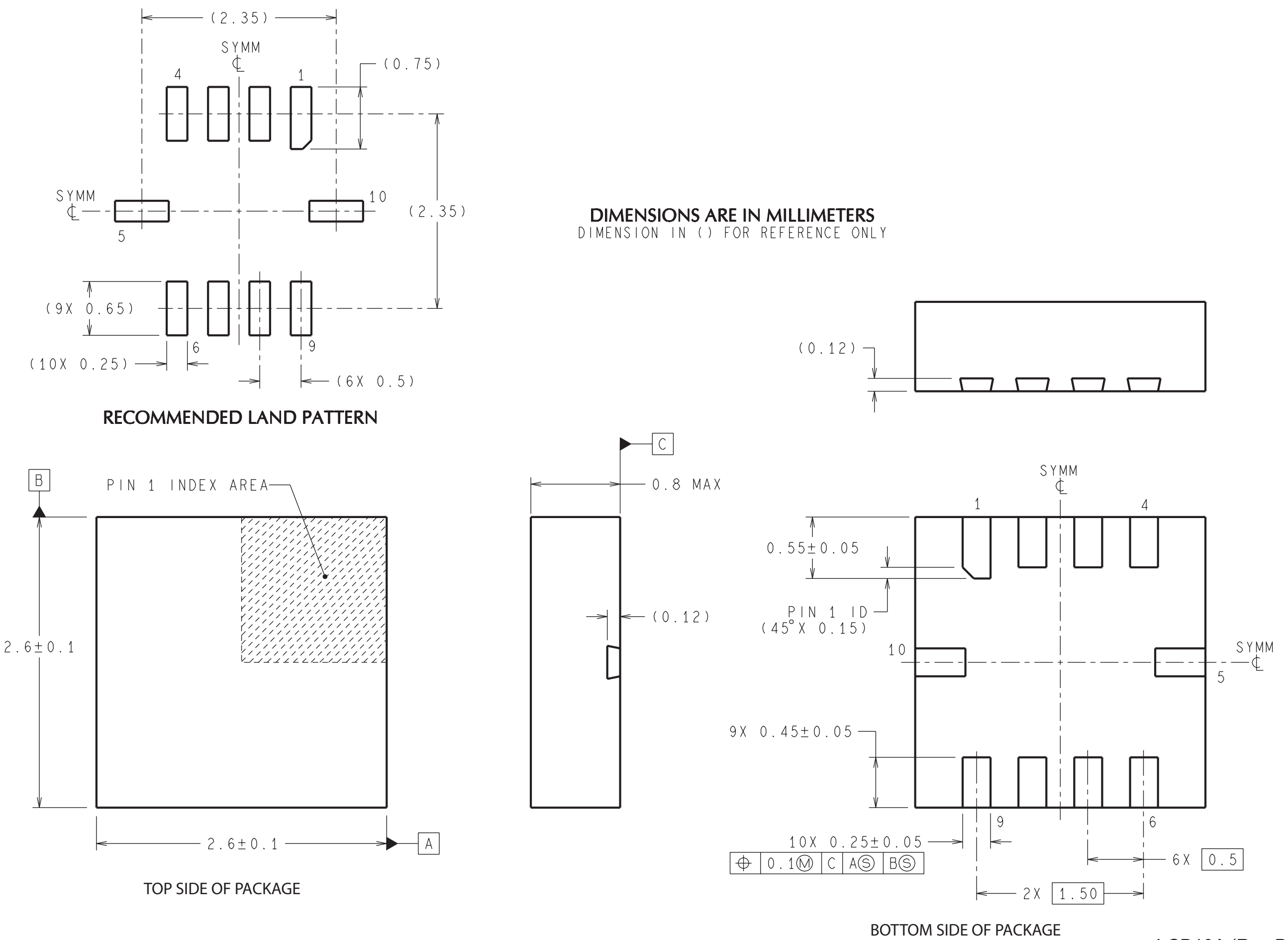
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LHV870LC/NOPB | UQFN | NKY | 10 | 1000 | 210.0 | 185.0 | 35.0 |
| LHV870LCX/NOPB | UQFN | NKY | 10 | 4500 | 367.0 | 367.0 | 35.0 |

# NKY0010A




LCB10A (Rev B)

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