

LME49870

*LME49870 44V Single High Performance, High Fidelity Audio Operational
Amplifier*



Literature Number: SNAS413B

LME49870

44V Single High Performance, High Fidelity Audio Operational Amplifier

General Description

The LME49870 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 LME49870 audio operational amplifier delivers superior audio signal amplification for outstanding audio performance. The LME49870 combines extremely low voltage noise density ($2.7\text{nV}/\sqrt{\text{Hz}}$) 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 LME49870 has a high slew rate of $\pm 20\text{V}/\mu\text{s}$ and an output current capability of $\pm 26\text{mA}$. Further, dynamic range is maximized by an output stage that drives $2\text{k}\Omega$ loads to within 1V of either power supply voltage and to within 1.4V when driving 600Ω loads.

The LME49870's outstanding CMRR (120dB), PSRR (120dB), and V_{OS} (0.1mV) give the amplifier excellent operational amplifier DC performance.

The LME49870 has a wide supply range of $\pm 2.5\text{V}$ to $\pm 22\text{V}$. Over this supply range the LME49870 maintains excellent common-mode rejection, power supply rejection, and low input bias current. The LME49870 is unity gain stable. This Audio Operational Amplifier achieves outstanding AC performance while driving complex loads with values as high as 100pF.

The LME49870 is available in 8-lead narrow body SOIC. Demonstration boards are available for each package.

Key Specifications

- Power Supply Voltage Range $\pm 2.5\text{V}$ to $\pm 22\text{V}$
- THD+N
($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1\text{kHz}$)

$R_L = 2\text{k}\Omega$	0.00003% (typ)
$R_L = 600\Omega$	0.00003% (typ)
■ Input Noise Density	$2.7\text{nV}/\sqrt{\text{Hz}}$ (typ)
■ Slew Rate	$\pm 20\text{V}/\mu\text{s}$ (typ)
■ Gain Bandwidth Product	55MHz (typ)
■ Open Loop Gain ($R_L = 600\Omega$)	140dB (typ)
■ Input Bias Current	10nA (typ)
■ Input Offset Voltage	0.1mV (typ)
■ DC Gain Linearity Error	0.000009%

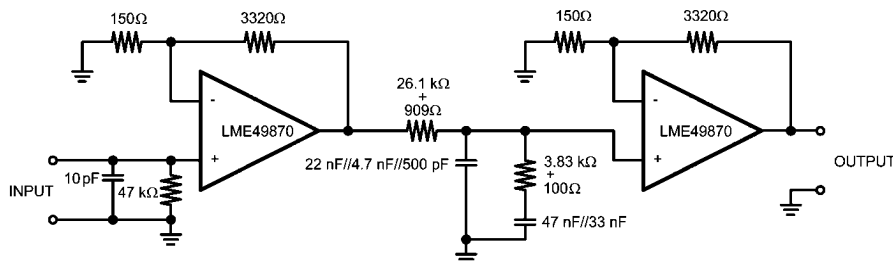
Features

- Easily drives 600Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- PSRR and CMRR exceed 120dB (typ)

Applications

- 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
- Low noise industrial applications including test, measurement, and ultrasound

Typical Application

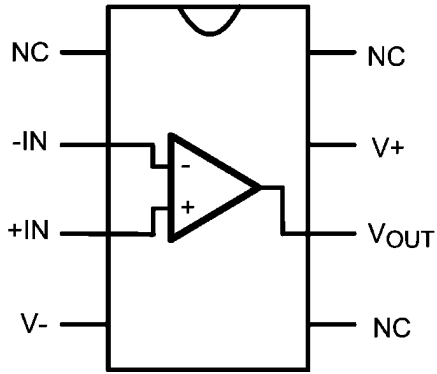


Note: 1% metal film resistors, 5% polypropylene capacitors

Passively Equalized RIAA Phono Preamp

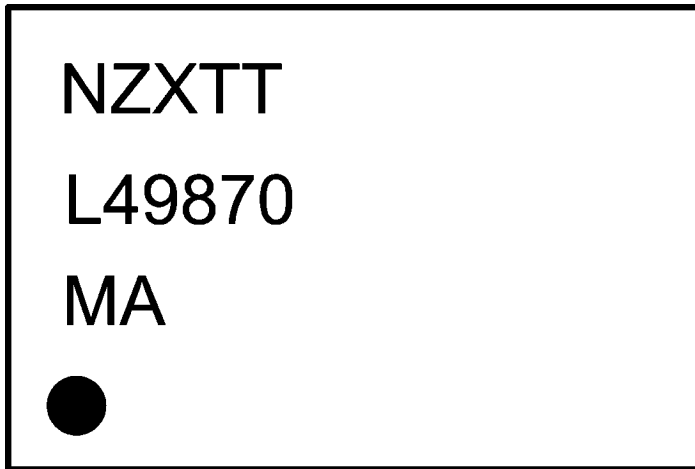
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Connection Diagrams



30019401
Order Number LME49870MA
See NS Package Number — M08A

LME49870 Top Mark



30019402
N — National Logo
Z — Assembly Plant code
X — 1 Digit Date code
TT — Die Traceability
L49870 — LME49870
MA — Package code

Absolute Maximum Ratings (Notes 1, 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Supply Voltage ($V_S = V^+ - V^-$)	46V
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 Rating (Note 4)	2000V
ESD Rating (Note 5)	

Pins 1, 4, 7 and 8	200V
Pins 2, 3, 5 and 6	100V
Junction Temperature	150°C
Thermal Resistance	
θ_{JA} (SO)	145°C/W

Operating Ratings

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

Electrical Characteristics for the LME49870 (Note 1) The following specifications apply for $V_S = \pm 18V$ and $\pm 22V$, $R_L = 2k\Omega$, $R_{SOURCE} = 10\Omega$, $f_{IN} = 1kHz$, $T_A = 25^\circ C$, unless otherwise specified.

Symbol	Parameter	Conditions	LME49870		Units (Limits)
			Typical	Limit	
			(Note 6)	(Note 7)	
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, $V_{OUT} = 3V_{rms}$ $R_L = 2k\Omega$ $R_L = 600\Omega$	0.00003 0.00003	0.00009	% (max)
IMD	Intermodulation Distortion	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.00005		%
GBWP	Gain Bandwidth Product		55	45	MHz (min)
SR	Slew Rate		±20	±15	V/μs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$, -3dB referenced to output magnitude at $f = 1kHz$	10		MHz
t_s	Settling time	$A_V = -1$, 10V step, $C_L = 100pF$ 0.1% error range	1.2		μs
e_n	Equivalent Input Noise Voltage	$f_{BW} = 20Hz$ to 20kHz	0.34	0.65	μV _{RMS} (max)
	Equivalent Input Noise Density	$f = 1kHz$ $f = 10Hz$	2.5 6.4	4.7	nV/√Hz (max)
i_n	Current Noise Density	$f = 1kHz$	1.6		pA/√Hz
		$f = 10Hz$	3.1		
V_{OS}	Offset Voltage	$V_S = \pm 18V$	±0.12		mV (max)
		$V_S = \pm 22V$	±0.14	±0.7	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	-40°C ≤ T_A ≤ 85°C	0.1		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$V_S = \pm 18V$, $\Delta V_S = 24V$ (Note 8)	120		dB (min)
		$V_S = \pm 22V$, $\Delta V_S = 30V$	120	110	
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	0.2		nA/°C
I_{OS}	Input Offset Current	$V_{CM} = 0V$	11	65	nA (max)
V_{IN-CM}	Common-Mode Input Voltage Range	$V_S = \pm 18V$	+17.1 -16.9		V (min) V (min)
		$V_S = \pm 22V$	+21.0 -20.8	(V+) - 2.0 (V-) + 2.0	V (min) V (min)

Symbol	Parameter	Conditions	LME49870		Units (Limits)
			Typical	Limit	
			(Note 6)	(Note 7)	
CMRR	Common-Mode Rejection	$V_S = \pm 18V$ $-12V \leq V_{cm} \leq 12V$	120		dB (min)
		$V_S = \pm 22V$ $-15V \leq V_{cm} \leq 15V$	120	110	dB (min)
Z_{IN}	Differential Input Impedance		30		k Ω
	Common Mode Input Impedance	$-10V < V_{cm} < 10V$	1000		M Ω
A_{VOL}	Open Loop Voltage Gain	$V_S = \pm 18V$ $-12V \leq V_{out} \leq 12V$ $R_L = 600\Omega$	140		dB
		$R_L = 2k\Omega$	140		dB
		$R_L = 10\Omega$	140		dB
		$V_S = \pm 22V$ $-15V \leq V_{out} \leq 15V$ $R_L = 600\Omega$	140	125	dB
		$R_L = 2k\Omega$	140		dB
		$R_L = 10\Omega$	140		dB
V_{OUTMAX}	Maximum Output Voltage Swing	$R_L = 600\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$	± 16.7 ± 20.4	± 19.0	V (min) V (min)
		$R_L = 2k\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$	± 17.0 ± 21.0		V (min) V (min)
		$R_L = 10k\Omega$ $V_S = \pm 18V$ $V_S = \pm 22V$	± 17.1 ± 21.0		V (min) V (min)
I_{OUT}	Output Current	$R_L = 600\Omega$ $V_S = \pm 20V$ $V_S = \pm 22V$	± 31 ± 37	± 30	mA (min) mA (min)
			+53 -42		mA
I_{OUT-CC}	Instantaneous Short Circuit Current				mA
R_{OUT}	Output Impedance	$f_{IN} = 10kHz$ Closed-Loop	0.01		Ω
		Open-Loop	13		
C_{LOAD}	Capacitive Load Drive Overshoot	100pF	16		%
I_S	Total Quiescent Current	$I_{OUT} = 0mA$	5	6.5	mA (max)

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

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

Note 3: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX} , θ_{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.

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

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

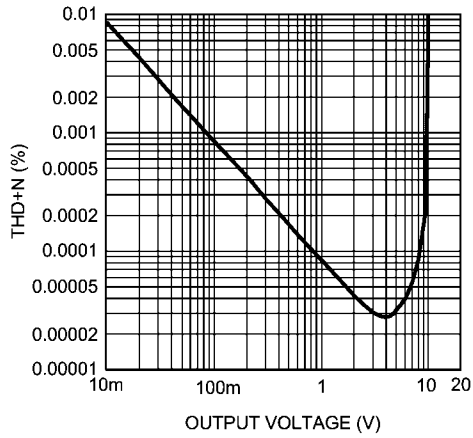
Note 6: Typical values represent most likely parametric norms at $T_A = +25^\circ C$, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

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

Note 8: PSRR is measured as follows: For V_S , V_{OS} is measured at two supply voltages, $\pm 7V$ and $\pm 22V$, $PSRR = 120 \log(\Delta V_{OS} / \Delta V_S)$.

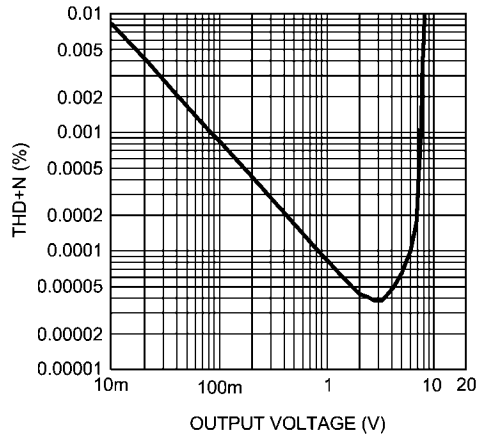
Typical Performance Characteristics

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



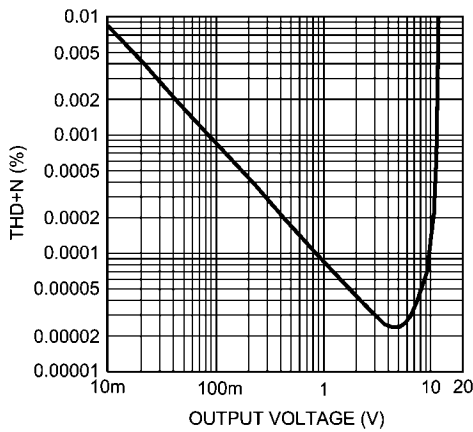
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THD+N vs Output Voltage
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 2k\Omega$



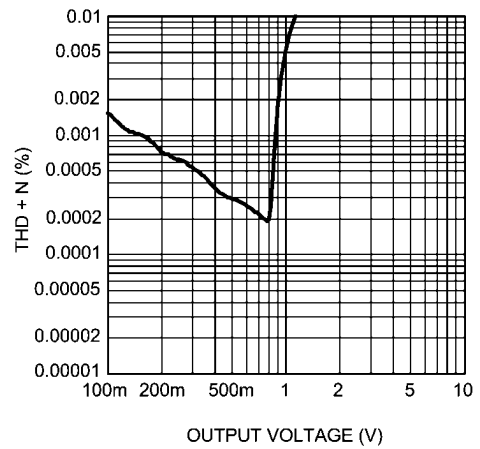
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THD+N vs Output Voltage
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 2k\Omega$



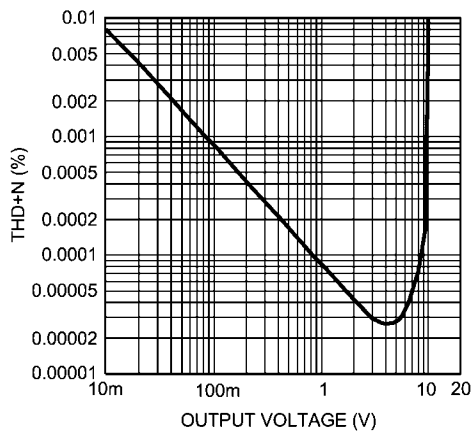
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THD+N vs Output Voltage
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 2k\Omega$



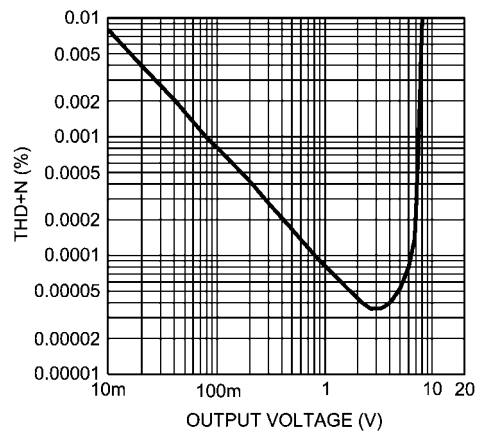
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THD+N vs Output Voltage
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 600\Omega$



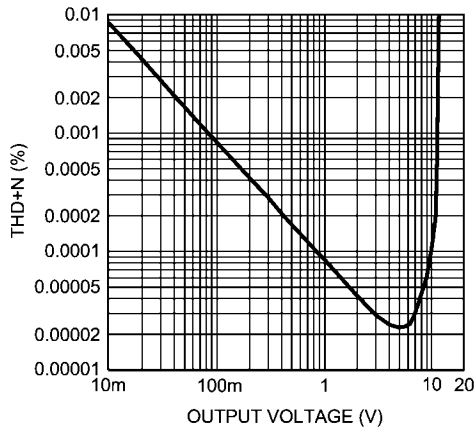
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THD+N vs Output Voltage
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 $R_L = 600\Omega$



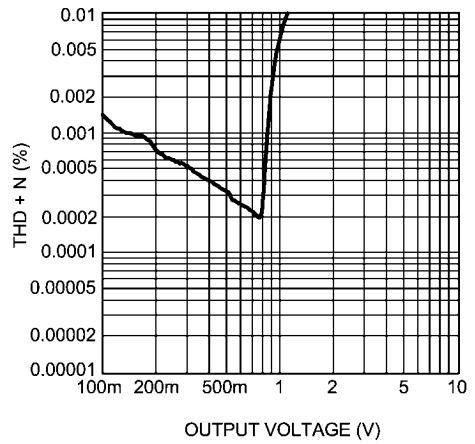
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THD+N vs Output Voltage
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 600\Omega$



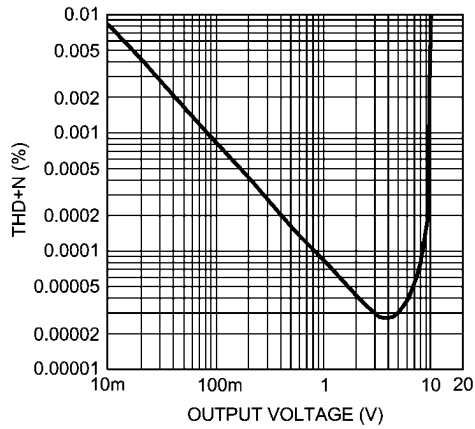
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THD+N vs Output Voltage
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 $R_L = 600\Omega$



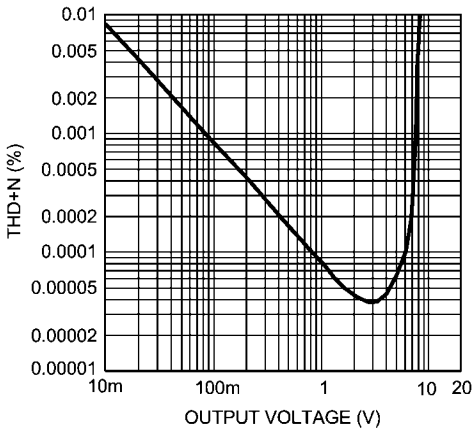
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THD+N vs Output Voltage
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 $R_L = 10k\Omega$



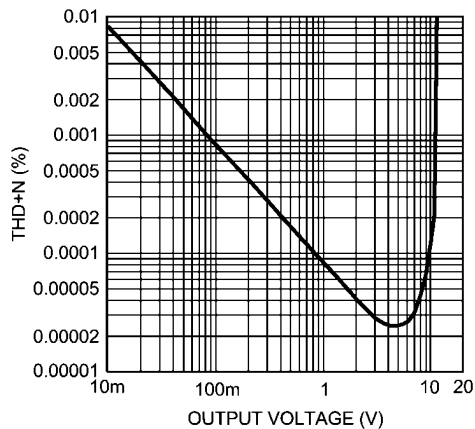
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THD+N vs Output Voltage
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 $R_L = 10k\Omega$



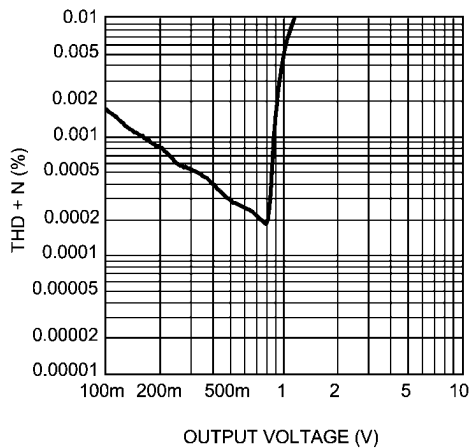
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THD+N vs Output Voltage
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 $R_L = 10k\Omega$



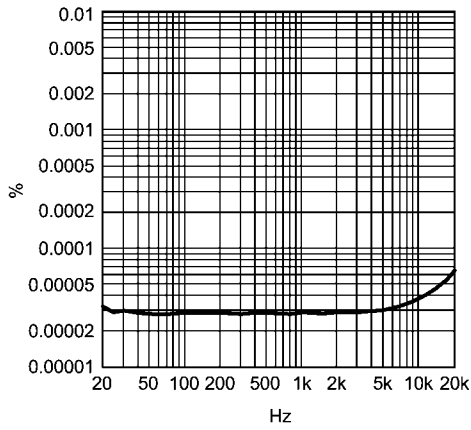
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THD+N vs Output Voltage
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 $R_L = 10k\Omega$



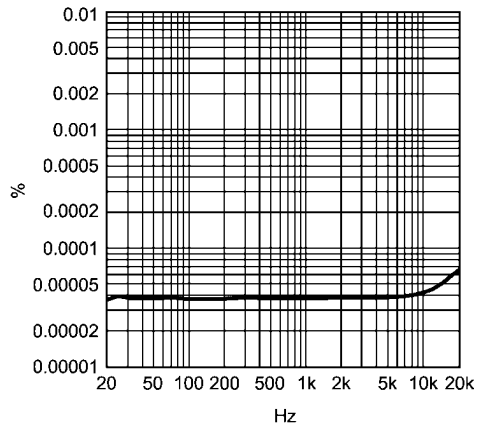
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THD+N vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V, V_{OUT} = 3V_{RMS}$
 $R_L = 2k\Omega$



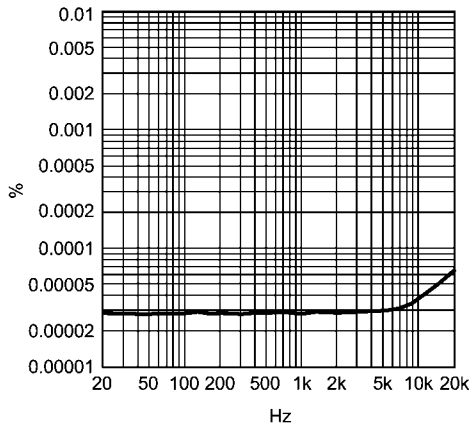
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THD+N vs Frequency
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 $R_L = 2k\Omega$



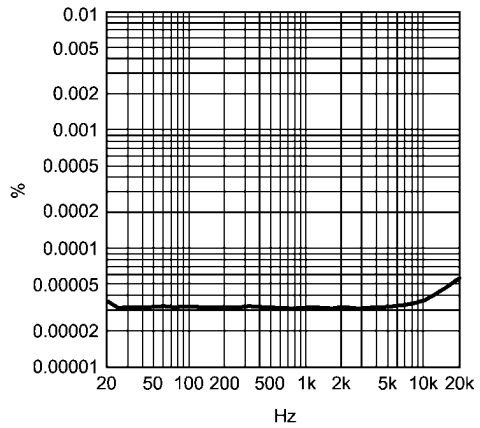
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THD+N vs Frequency
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 $R_L = 2k\Omega$



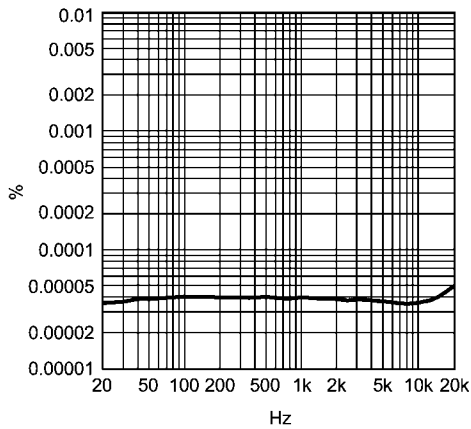
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THD+N vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V, V_{OUT} = 3V_{RMS}$
 $R_L = 600\Omega$



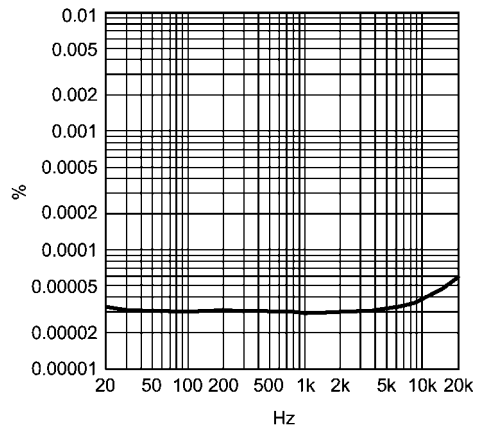
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THD+N vs Frequency
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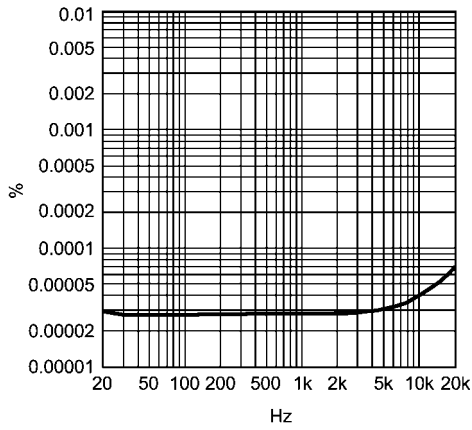
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THD+N vs Frequency
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 $R_L = 600\Omega$



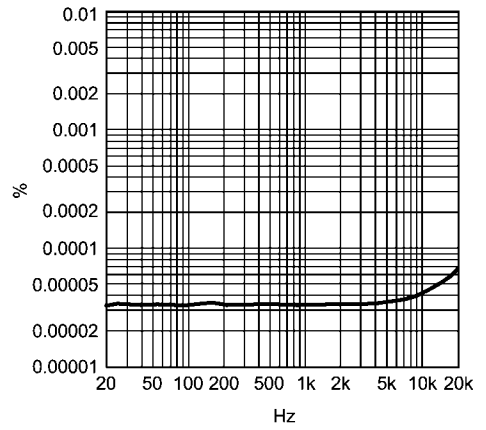
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THD+N vs Frequency
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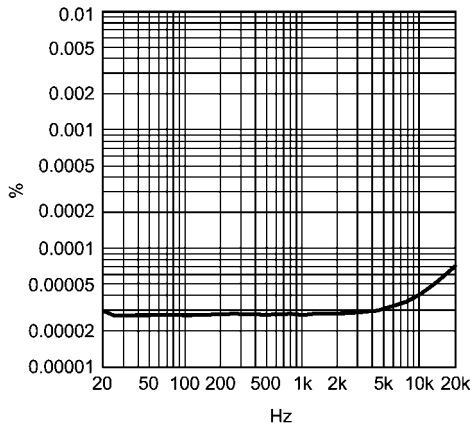
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THD+N vs Frequency
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 $R_L = 10k\Omega$



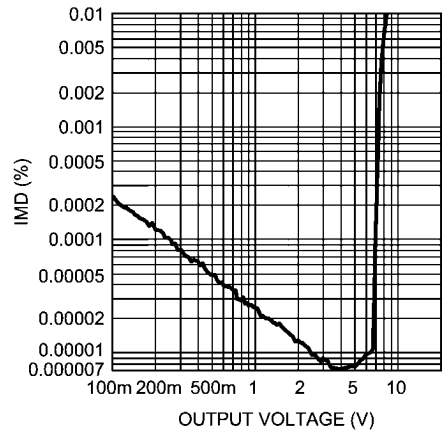
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THD+N vs Frequency
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 $R_L = 10k\Omega$



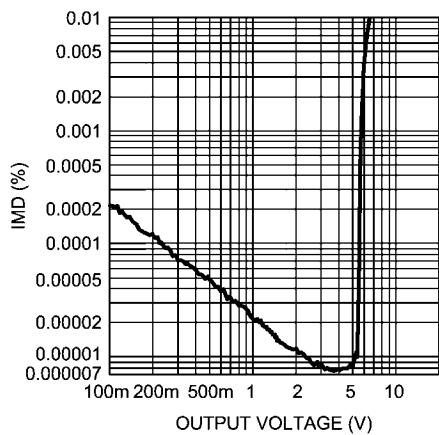
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IMD vs Output Voltage
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 2k\Omega$



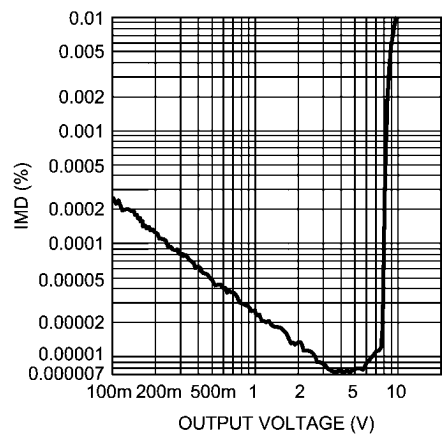
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IMD vs Output Voltage
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 2k\Omega$



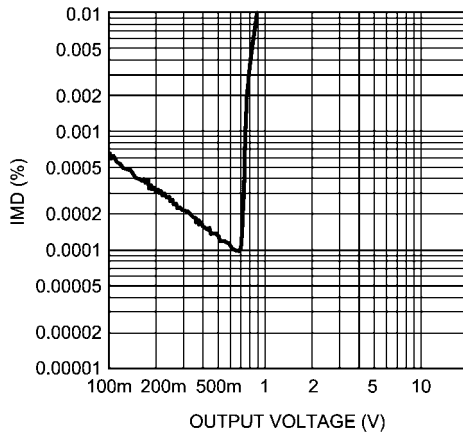
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IMD vs Output Voltage
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 2k\Omega$



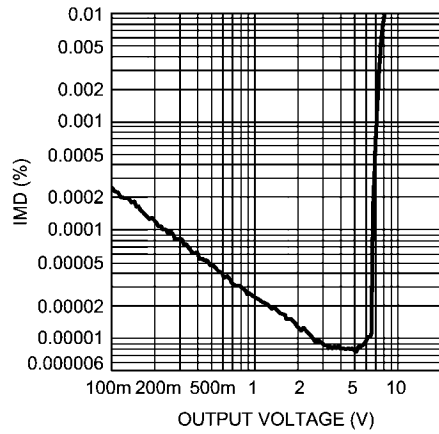
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IMD vs Output Voltage
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 $R_L = 2k\Omega$



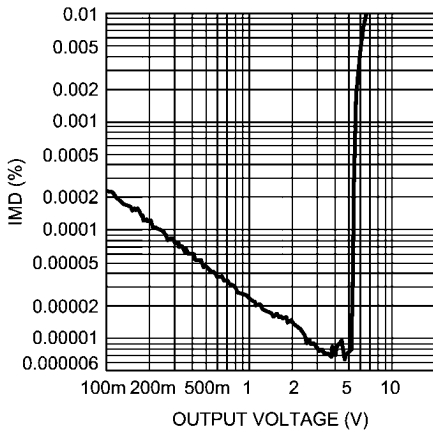
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IMD vs Output Voltage
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 600\Omega$



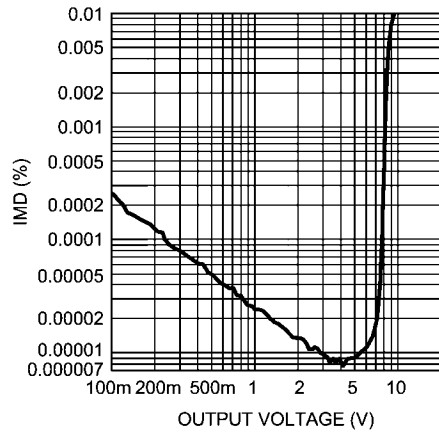
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IMD vs Output Voltage
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 $R_L = 600\Omega$



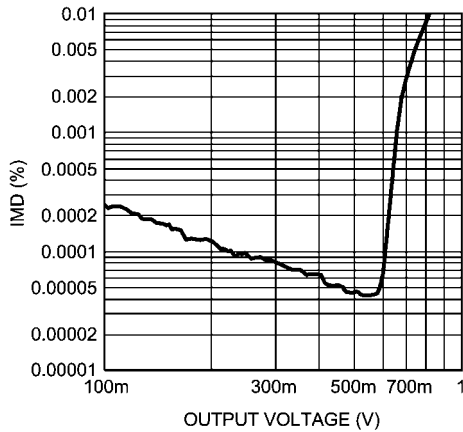
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IMD vs Output Voltage
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 600\Omega$



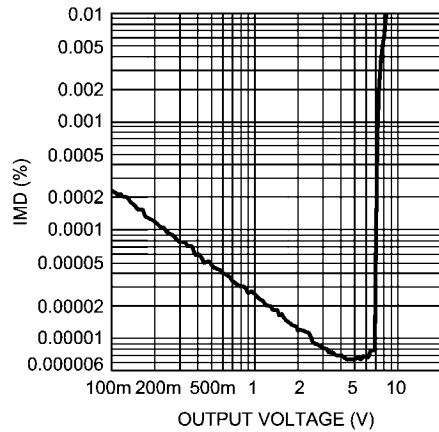
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IMD vs Output Voltage
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 600\Omega$



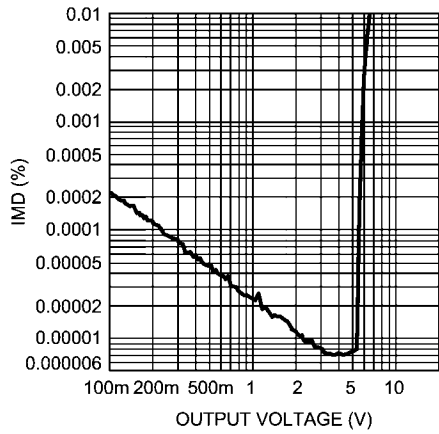
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IMD vs Output Voltage
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 10k\Omega$



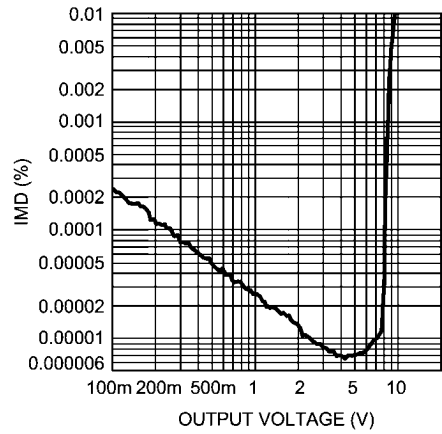
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IMD vs Output Voltage
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 10k\Omega$



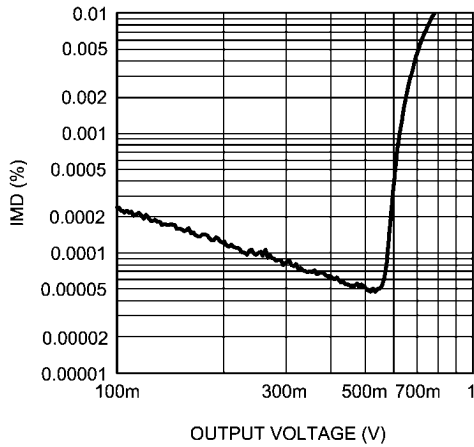
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IMD vs Output Voltage
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 10k\Omega$



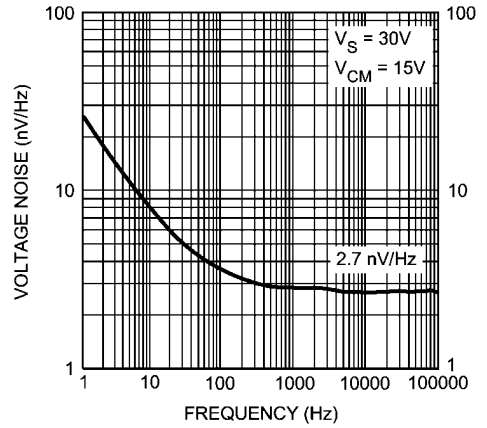
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IMD vs Output Voltage
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 10k\Omega$



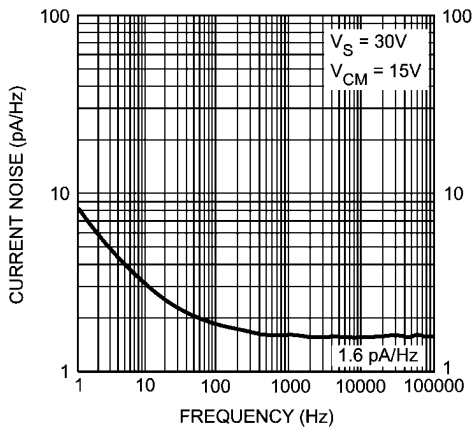
300194i6

Voltage Noise Density vs Frequency



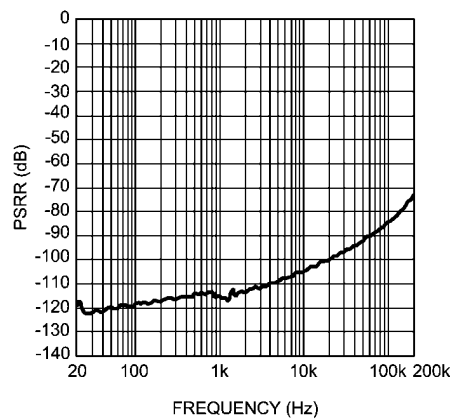
300194h6

Current Noise Density vs Frequency

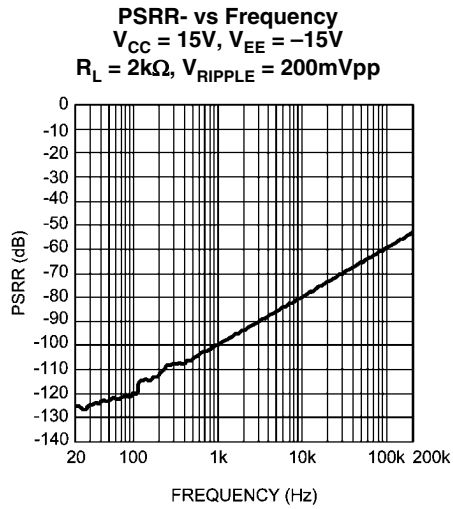


300194h7

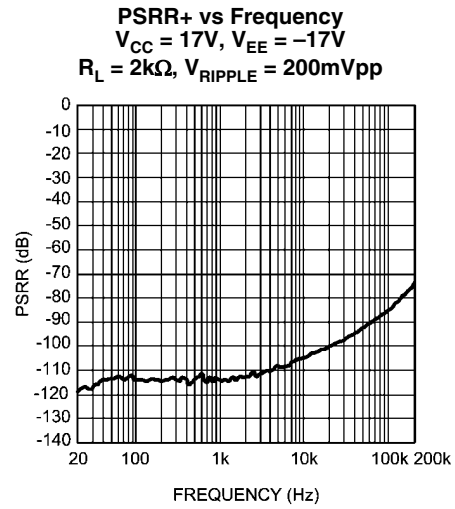
PSRR+ vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 2k\Omega, V_{RIPPLE} = 200mVpp$



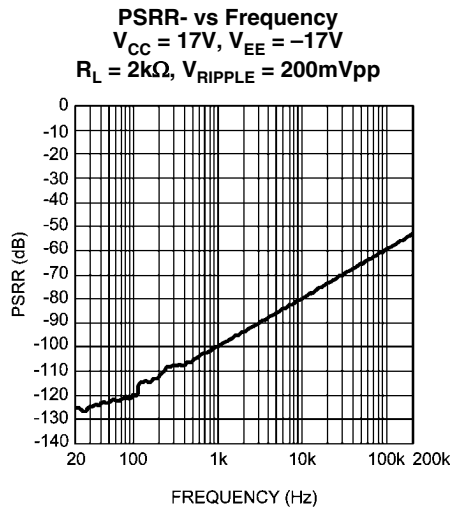
300194p7



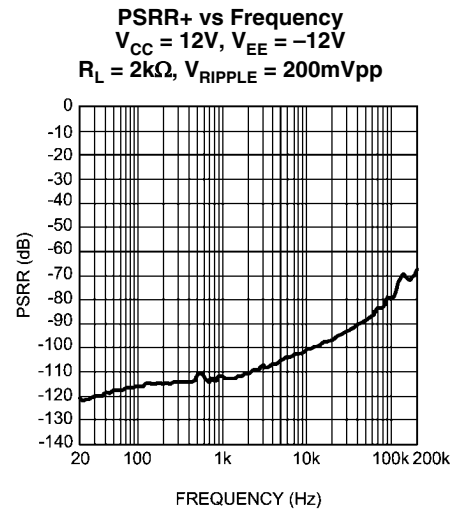
300194r2



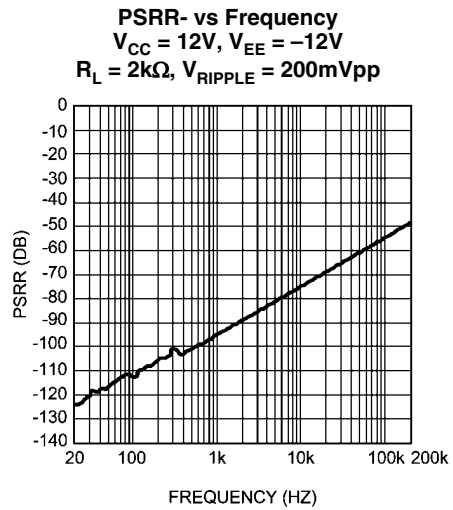
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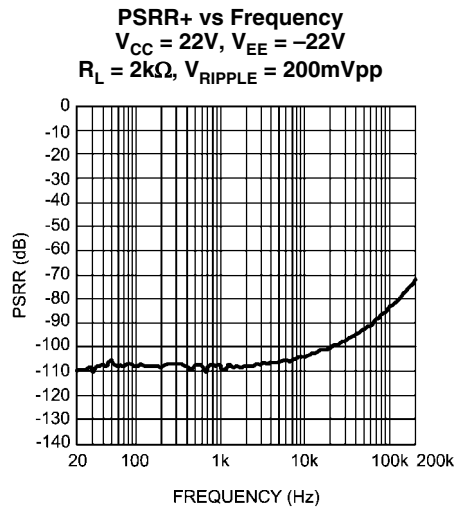
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300194p4

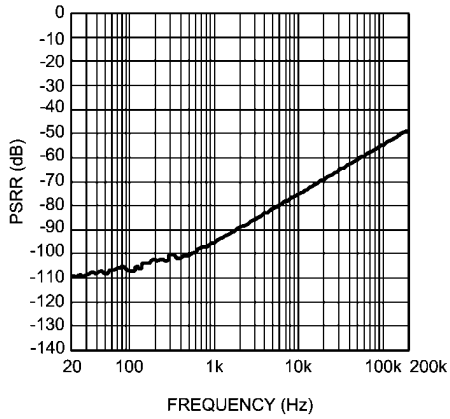


300194q9



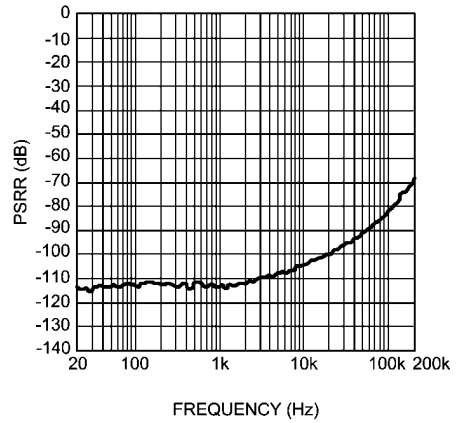
300194q3

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



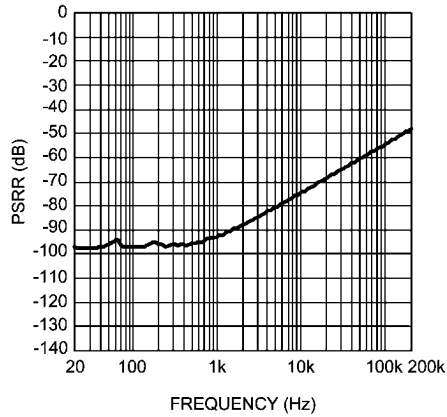
300194r8

PSRR+ vs Frequency
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 2k\Omega, V_{RIPPLE} = 200mV_{pp}$



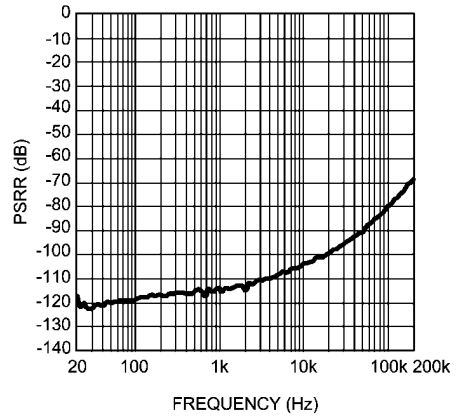
300194p1

PSRR- vs Frequency
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 2k\Omega, V_{RIPPLE} = 200mV_{pp}$



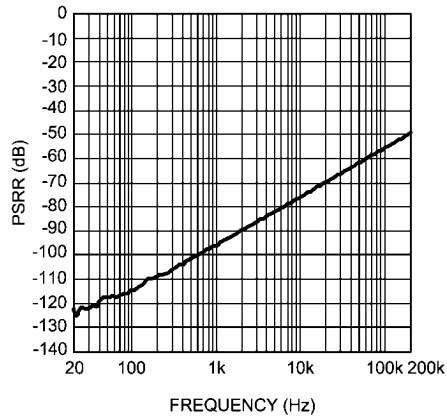
300194q6

PSRR+ vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 600\Omega, V_{RIPPLE} = 200mV_{pp}$



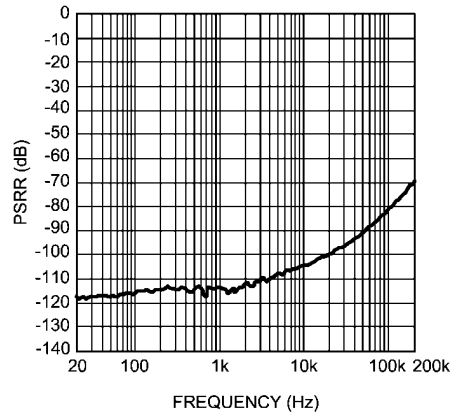
300194p9

PSRR- vs Frequency
 $V_{CC} = 15V, V_{EE} = -15V$
 $R_L = 600\Omega, V_{RIPPLE} = 200mV_{pp}$

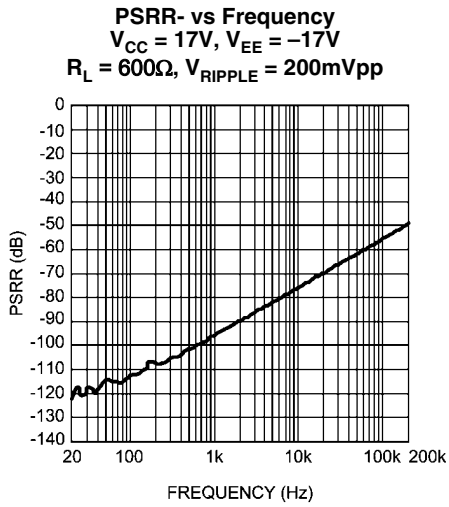


300194r4

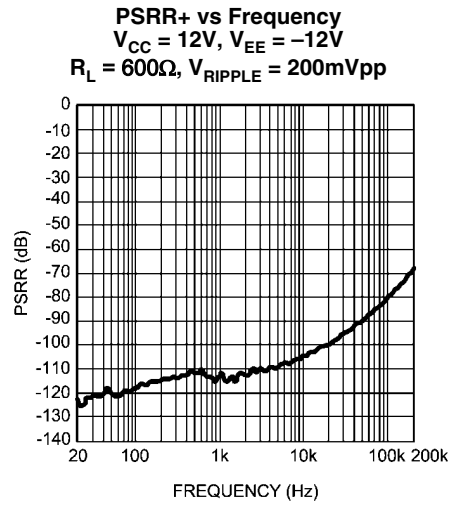
PSRR+ vs Frequency
 $V_{CC} = 17V, V_{EE} = -17V$
 $R_L = 600\Omega, V_{RIPPLE} = 200mV_{pp}$



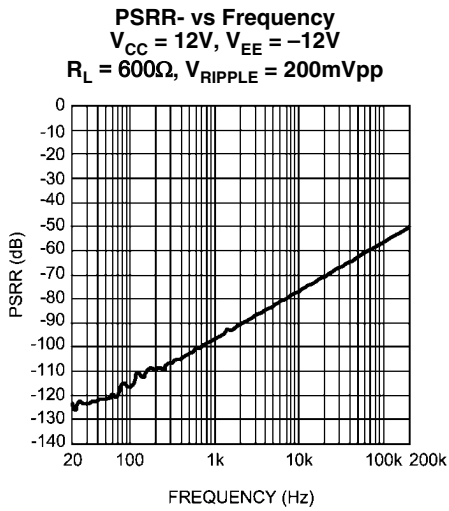
300194q2



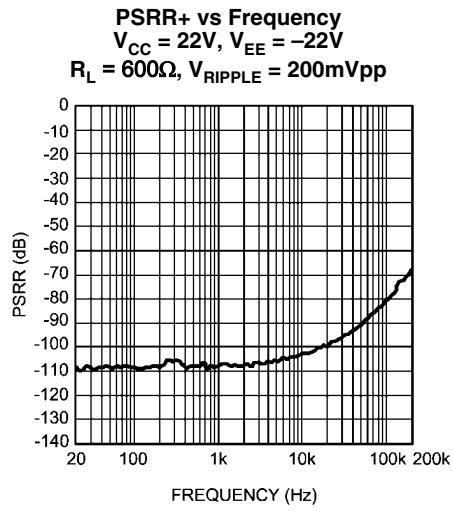
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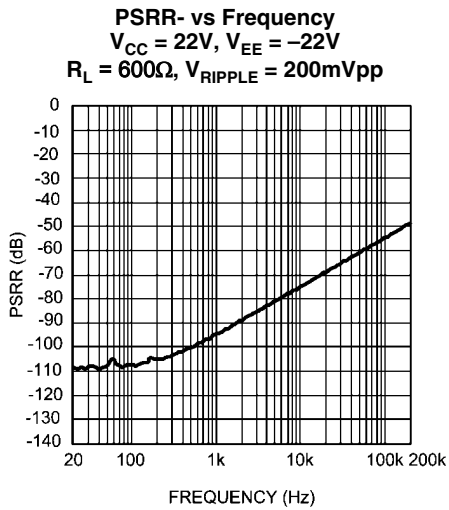
300194p6



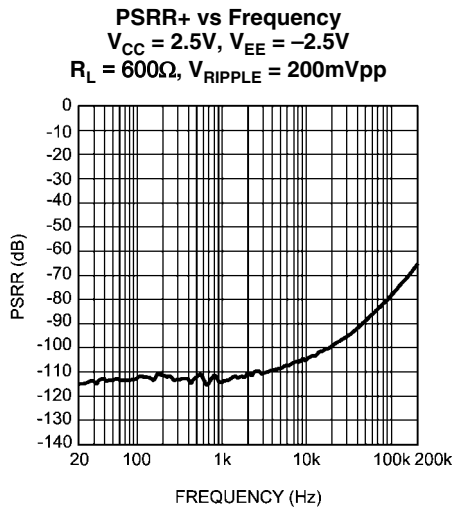
300194r1



300194q5

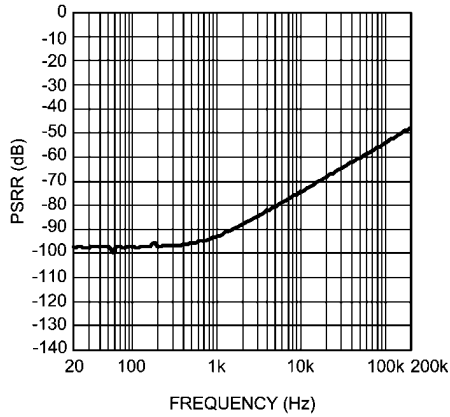


300194s0



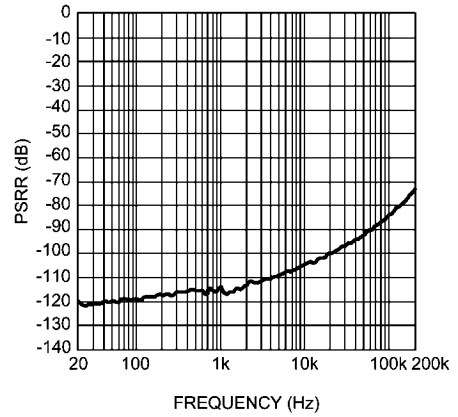
300194p3

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



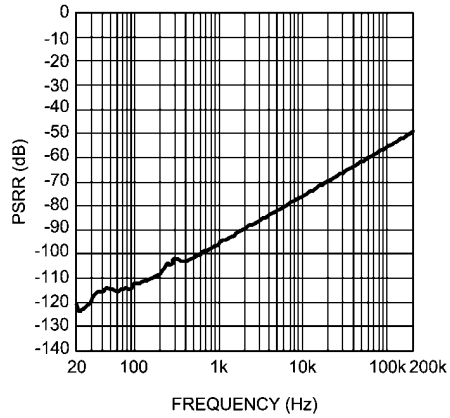
300194q8

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



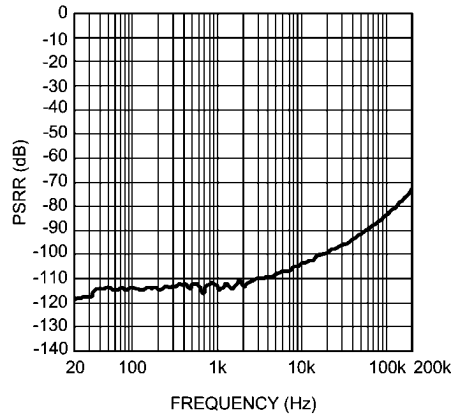
300194p8

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



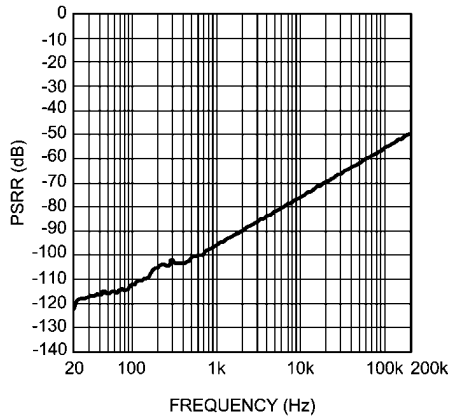
300194r3

PSRR+ vs Frequency
 $V_{CC} = 17V, V_{EE} = -17V$
 $R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$



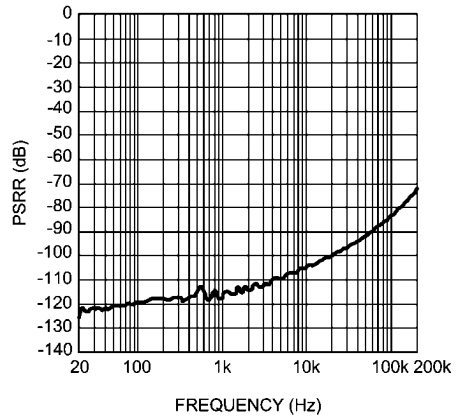
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PSRR- vs Frequency
 $V_{CC} = 17V, V_{EE} = -17V$
 $R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$

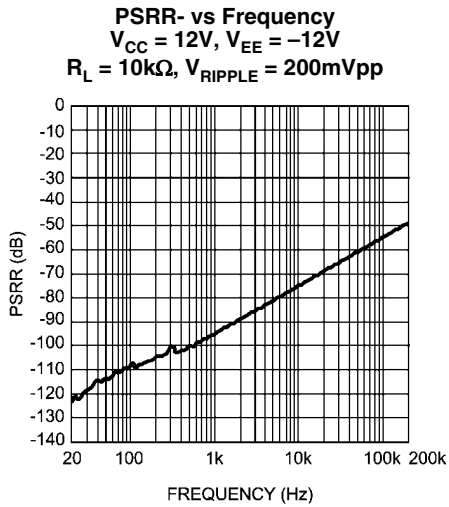


300194r6

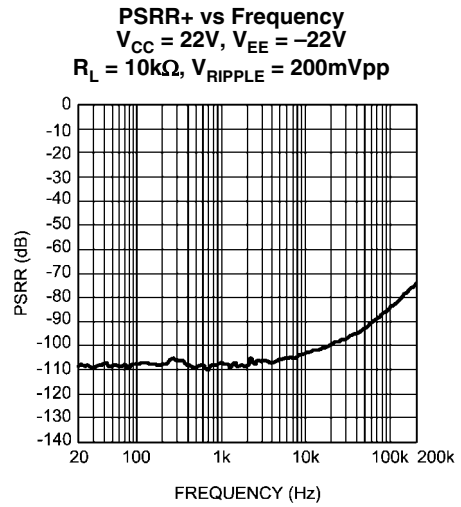
PSRR+ vs Frequency
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 10k\Omega, V_{RIPPLE} = 200mVpp$



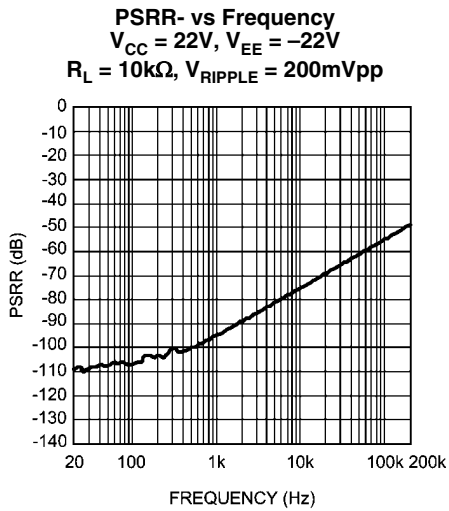
300194p5



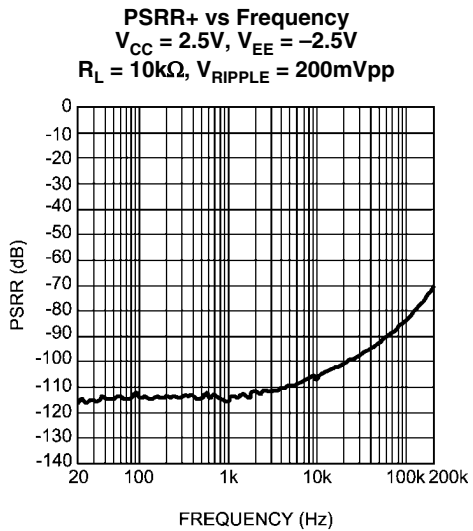
300194r0



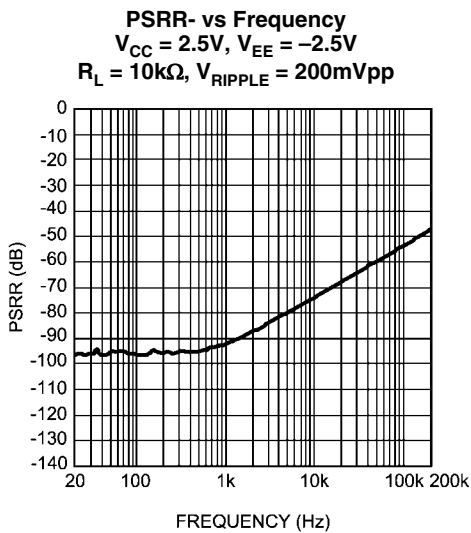
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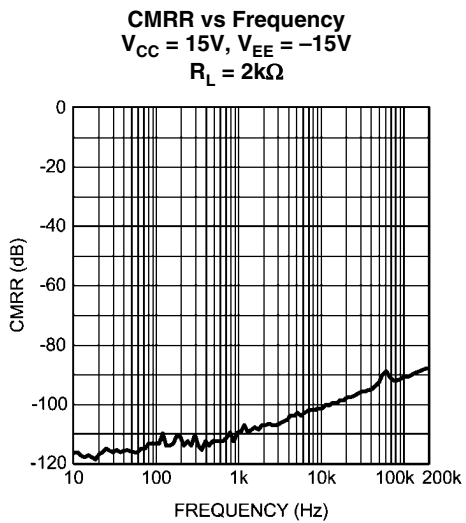
300194r9



300194p2

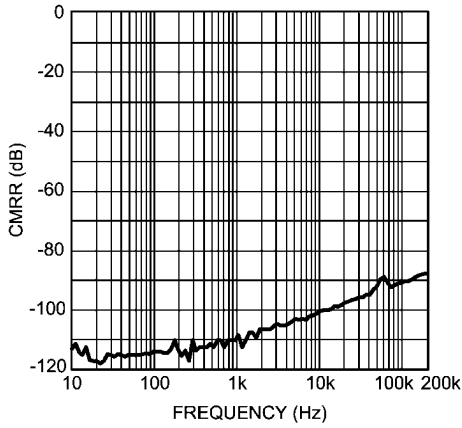


300194q7



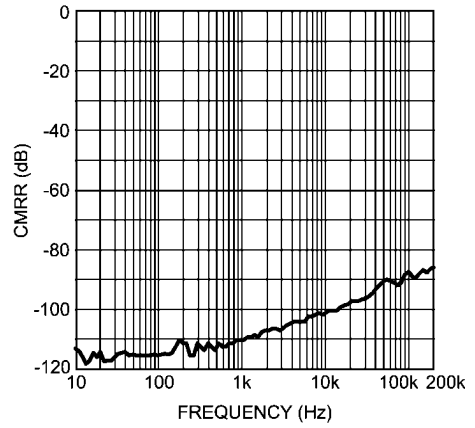
300194g0

CMRR vs Frequency
 $V_{CC} = 12V, V_{EE} = -12V$
 $R_L = 2k\Omega$



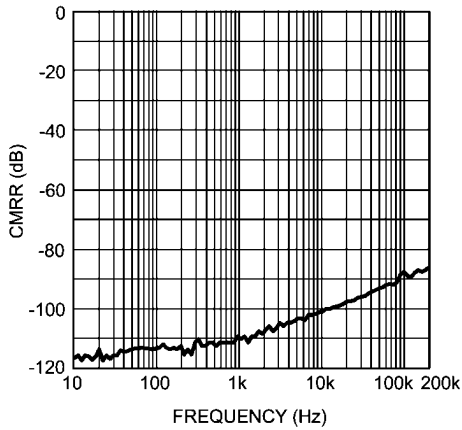
3001947

CMRR vs Frequency
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 2k\Omega$



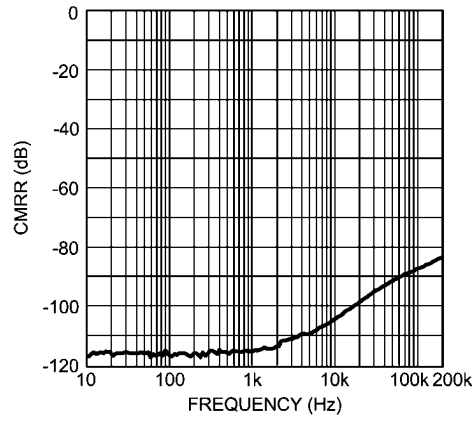
300194g3

CMRR vs Frequency
 $V_{CC} = 2.5V, V_{EE} = -2.5V$
 $R_L = 2k\Omega$



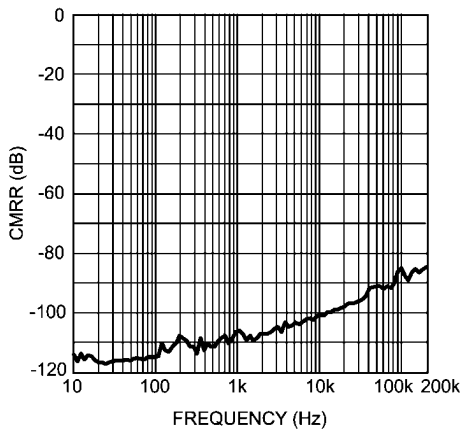
3001944

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



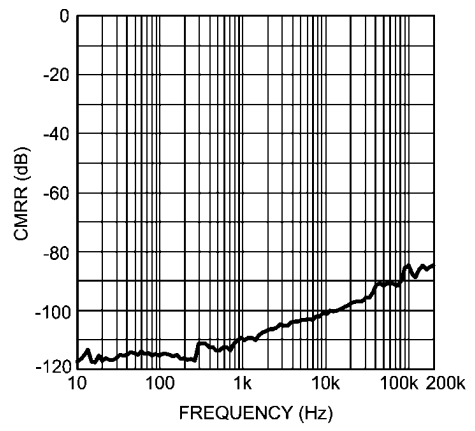
30019409

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



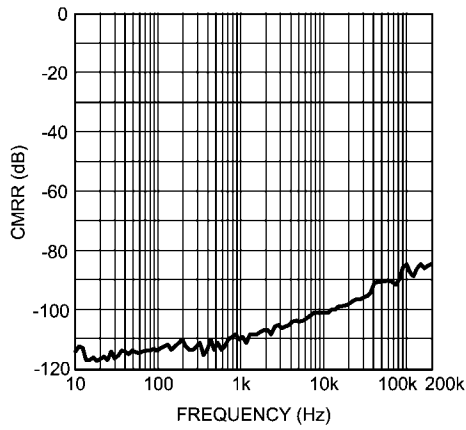
30019419

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



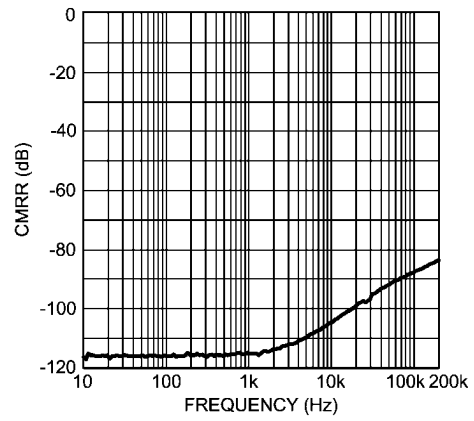
300194g5

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



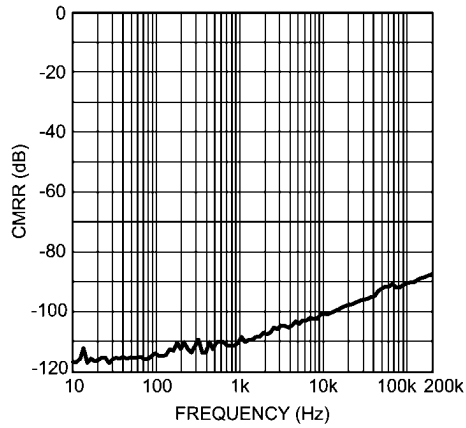
300194f6

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



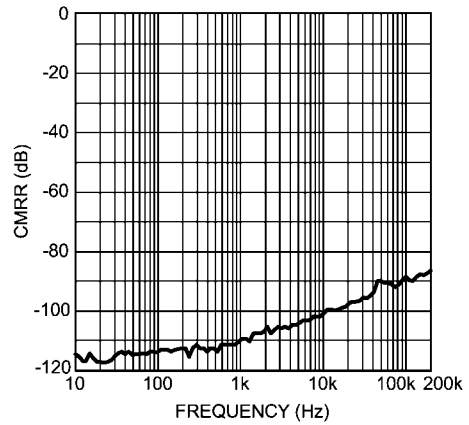
300194o8

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



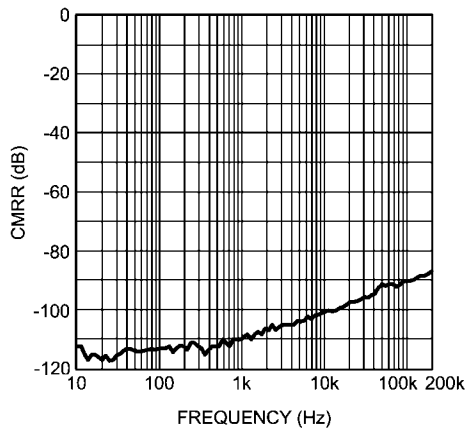
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CMRR vs Frequency
 $V_{CC} = 22V, V_{EE} = -22V$
 $R_L = 10k\Omega$



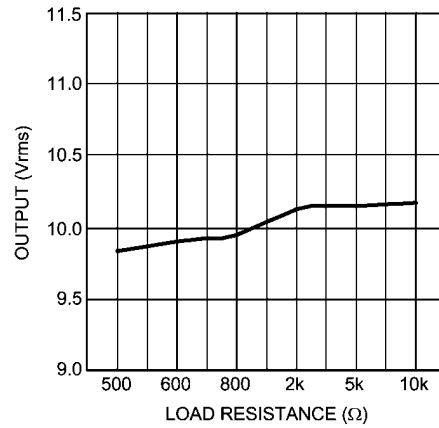
300194g4

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



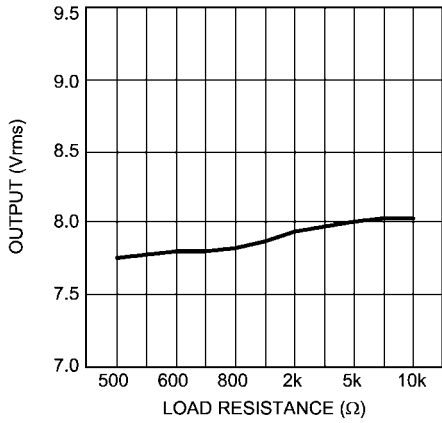
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Output Voltage vs Load Resistance
 $V_{CC} = 15V, V_{EE} = -15V$
 $THD+N = 1\%$



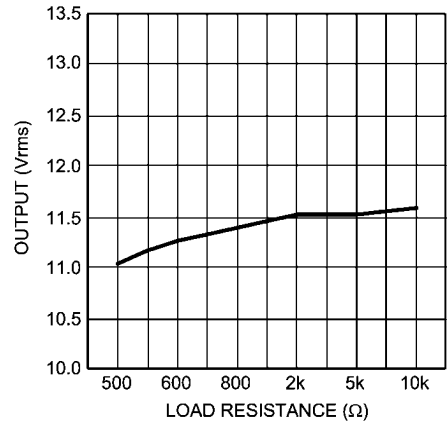
300194h1

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



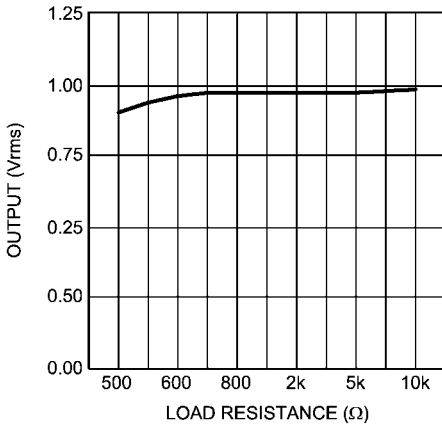
300194h0

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



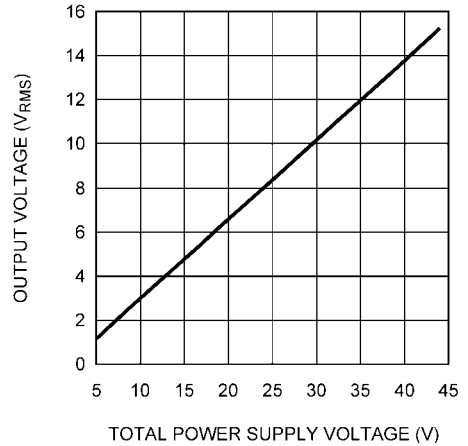
300194h2

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



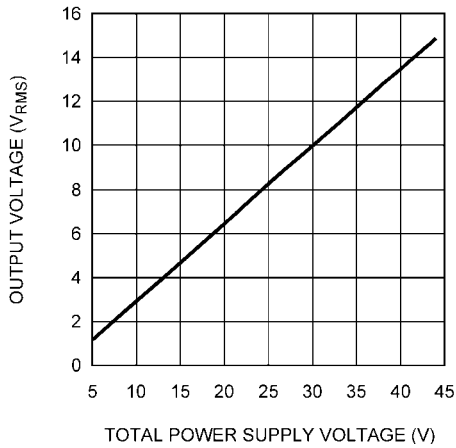
300194g9

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



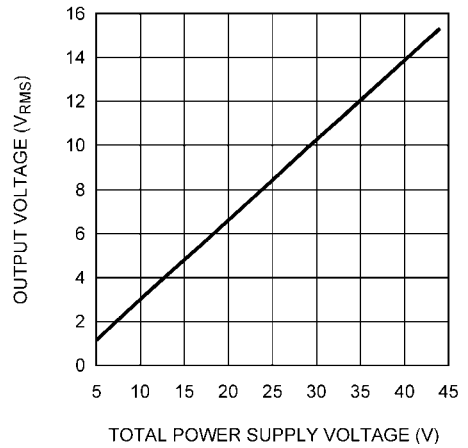
30019407

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



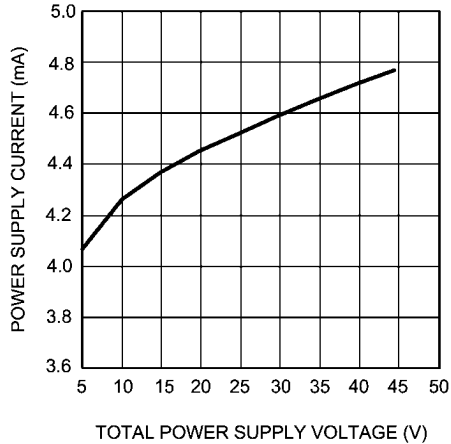
30019409

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



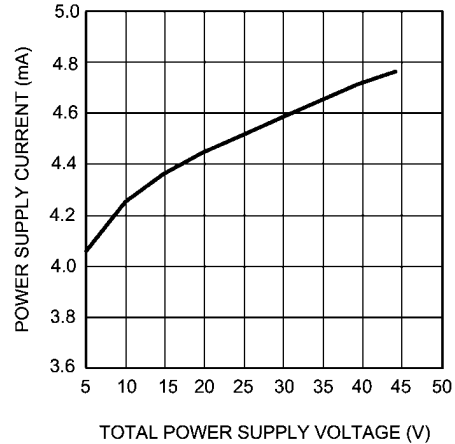
30019408

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



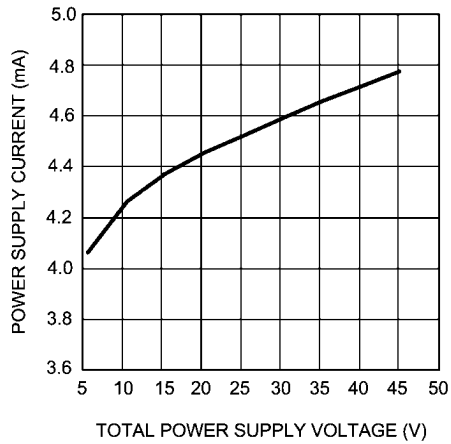
30019413

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



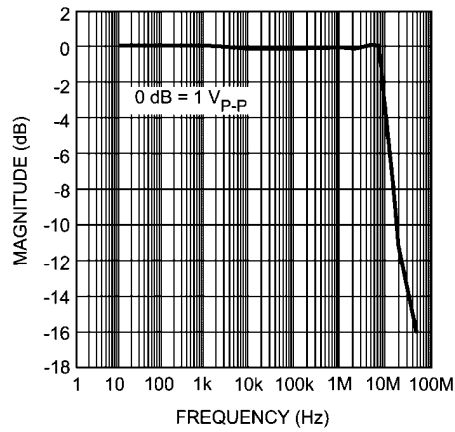
30019415

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



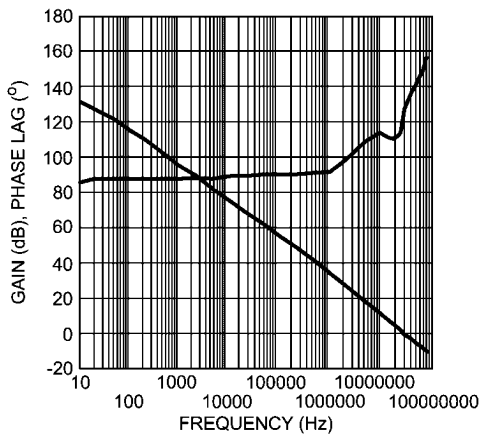
30019414

Full Power Bandwidth vs Frequency
 $V_S = \pm 18V, R_L = 2k\Omega$



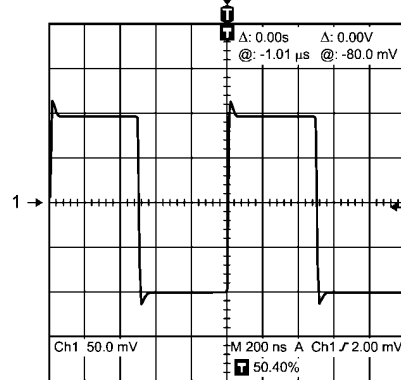
300194j0

Gain Phase vs Frequency
 $V_S = \pm 18V, R_L = 2k\Omega$



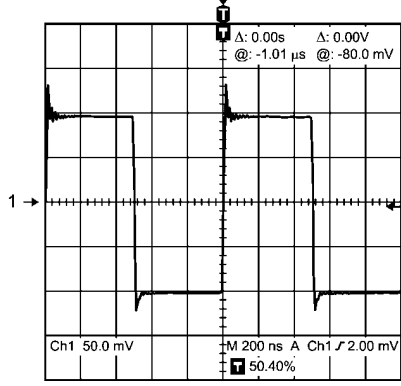
300194j1

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



300194j7

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



300194i8

Application Information

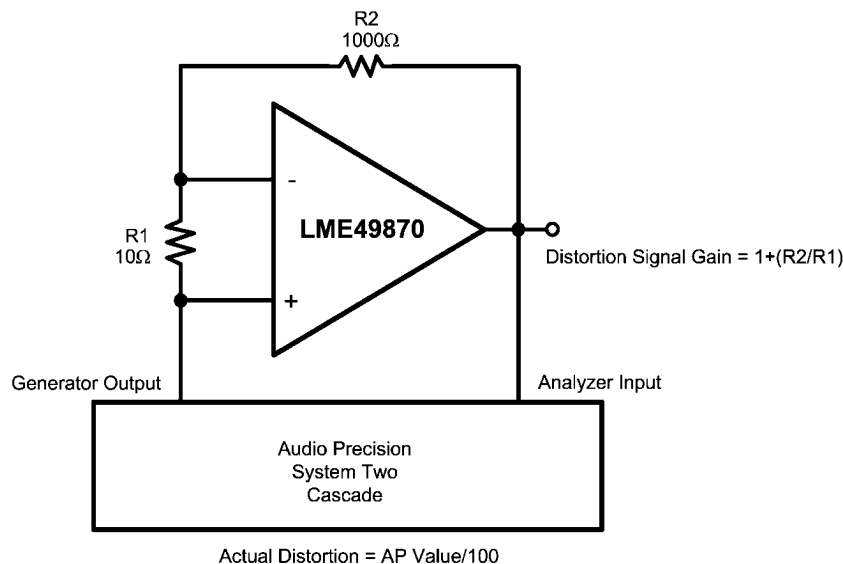
DISTORTION MEASUREMENTS

The vanishingly low residual distortion produced by LME49870 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 LME49870'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.



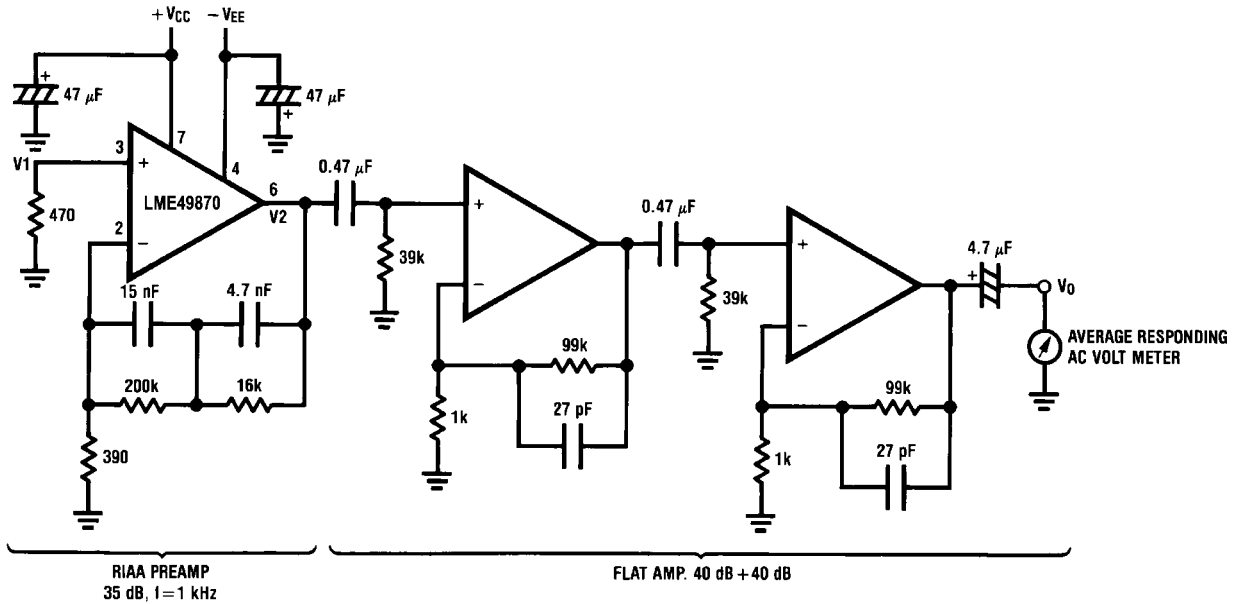
300194k4

FIGURE 1. THD+N and IMD Distortion Test Circuit

The LME49870 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.

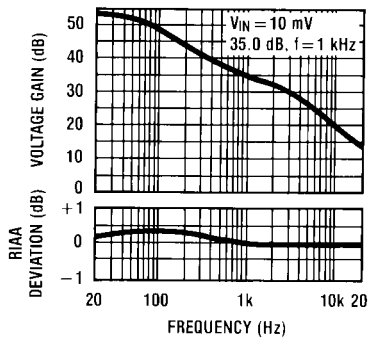


Complete shielding is required to prevent induced pick up from external sources. Always check with oscilloscope for power line noise.

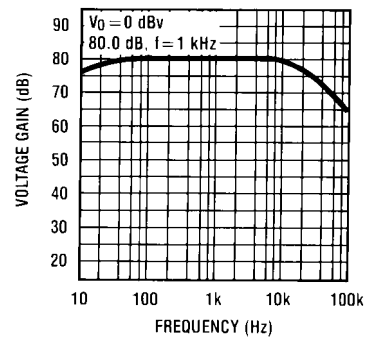
30019427

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

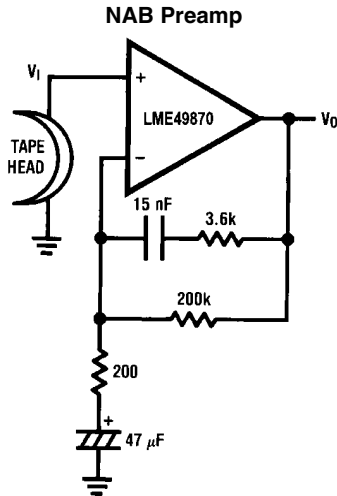
RIAA Preamp Voltage Gain, RIAA Deviation vs Frequency



Flat Amp Voltage Gain vs Frequency



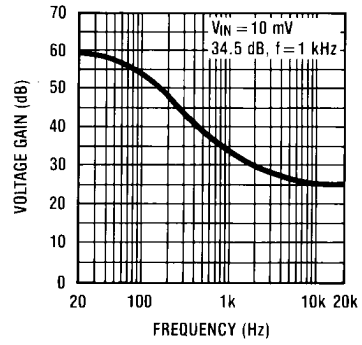
TYPICAL APPLICATIONS



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

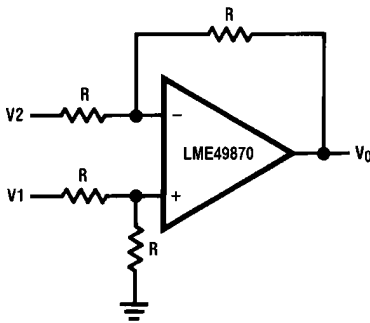
30019430

NAB Preamp Voltage Gain vs Frequency



30019431

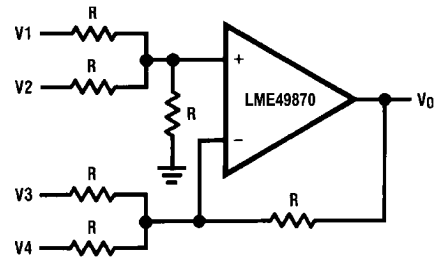
Balanced to Single Ended Converter



$V_o = V1 - V2$

30019432

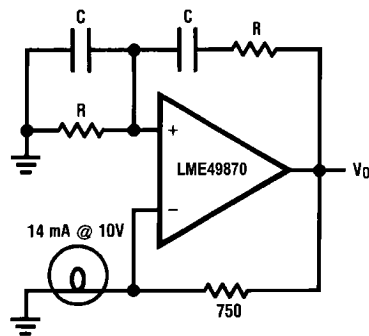
Adder/Subtractor



$V_o = V1 + V2 - V3 - V4$

30019433

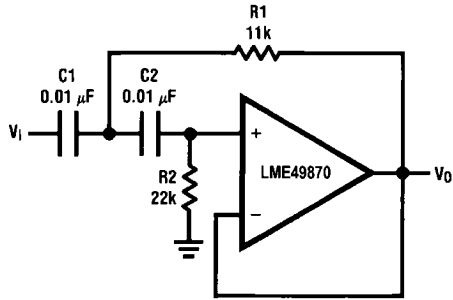
Sine Wave Oscillator



30019434

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

Second Order High Pass Filter (Butterworth)



30019435

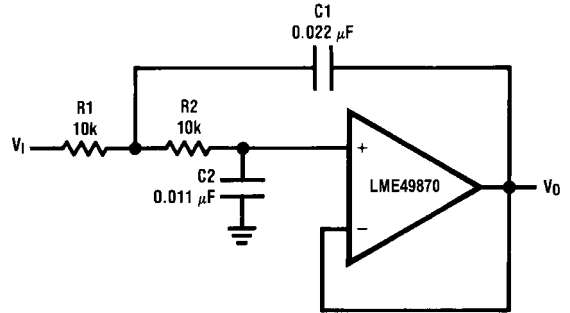
if $C1 = C2 = C$

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

$$R2 = 2 \cdot R1$$

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

Second Order Low Pass Filter (Butterworth)



30019436

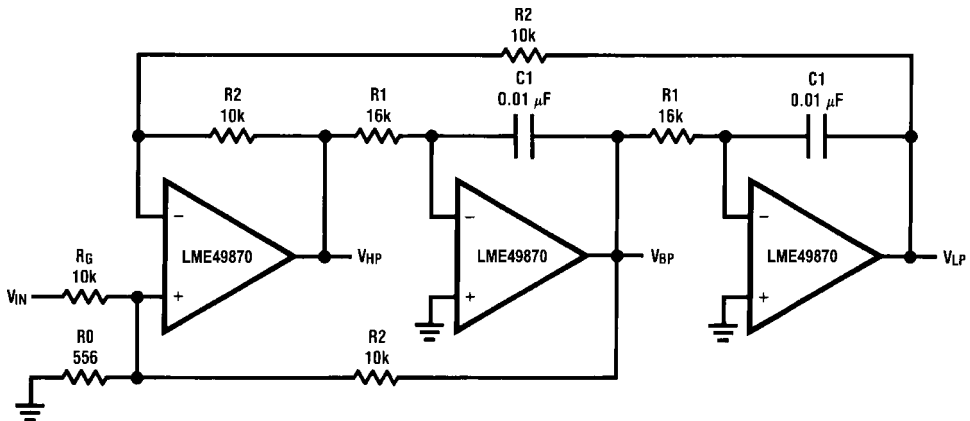
if $R1 = R2 = R$

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

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

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

State Variable Filter

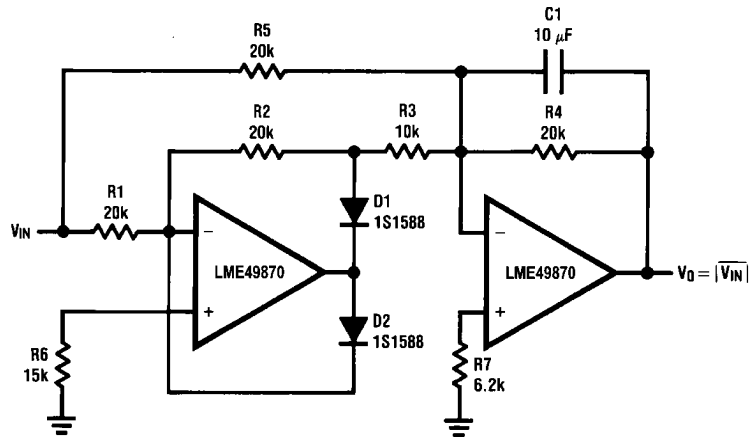


30019437

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

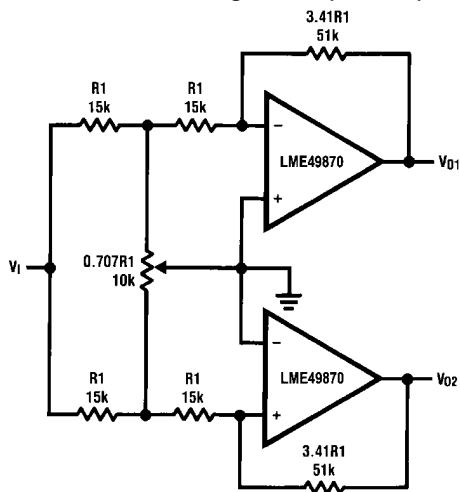
Illustration is $f_0 = 1 \text{ kHz}, Q = 10, A_{BP} = 1$

AC/DC Converter



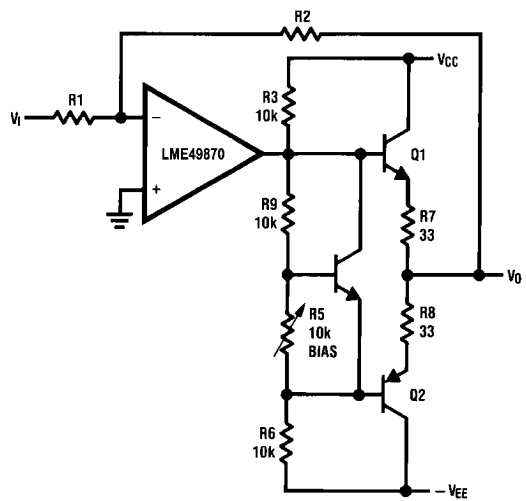
30019438

2 Channel Panning Circuit (Pan Pot)



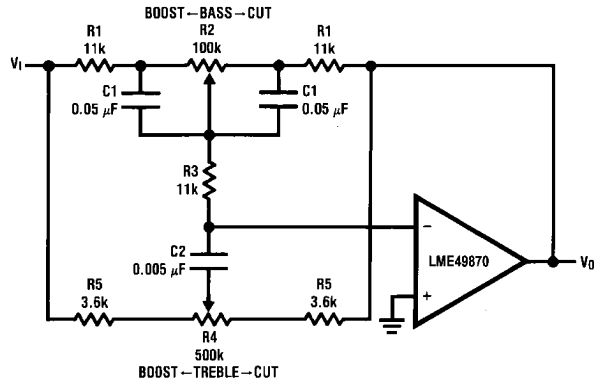
30019439

Line Driver



30019440

Tone Control



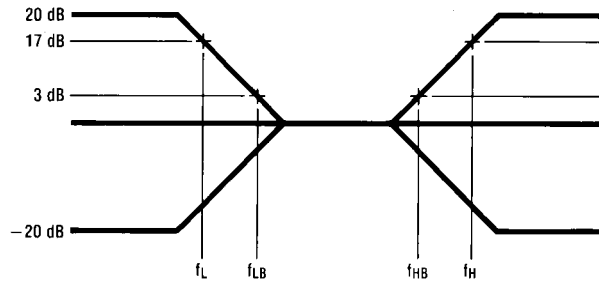
30019441

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

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

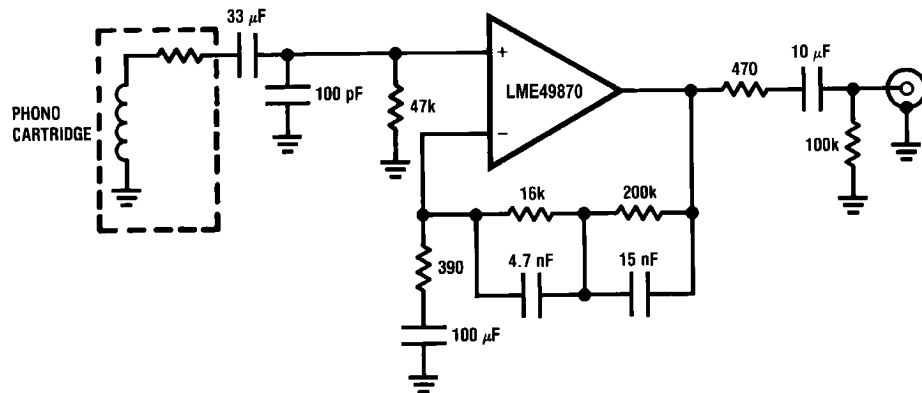
Illustration is:

$f_L = 32 \text{ Hz}, f_{LB} = 320 \text{ Hz}$
 $f_H = 11 \text{ kHz}, f_{HB} = 1.1 \text{ kHz}$



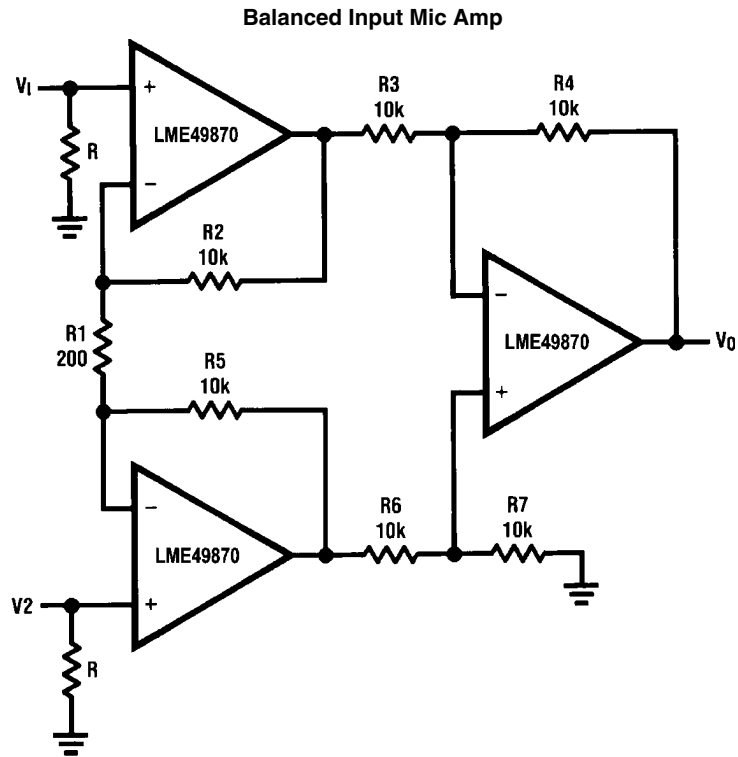
30019442

RIAA Preamp



30019403

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



30019443

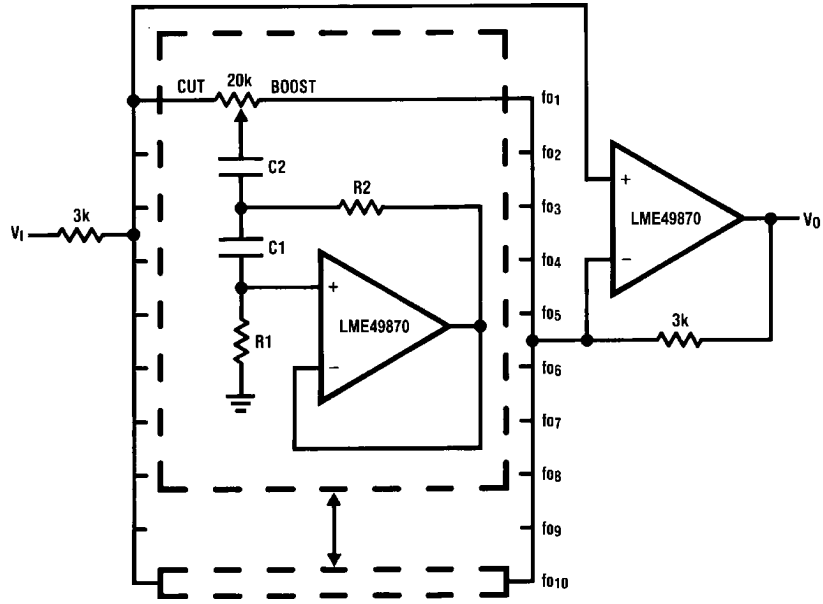
If $R_2 = R_5$, $R_3 = R_6$, $R_4 = R_7$

$$V_0 = \left(1 + \frac{2R_2}{R_1}\right) \frac{R_4}{R_3} (V_2 - V_1)$$

Illustration is:

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

10 Band Graphic Equalizer



30019444

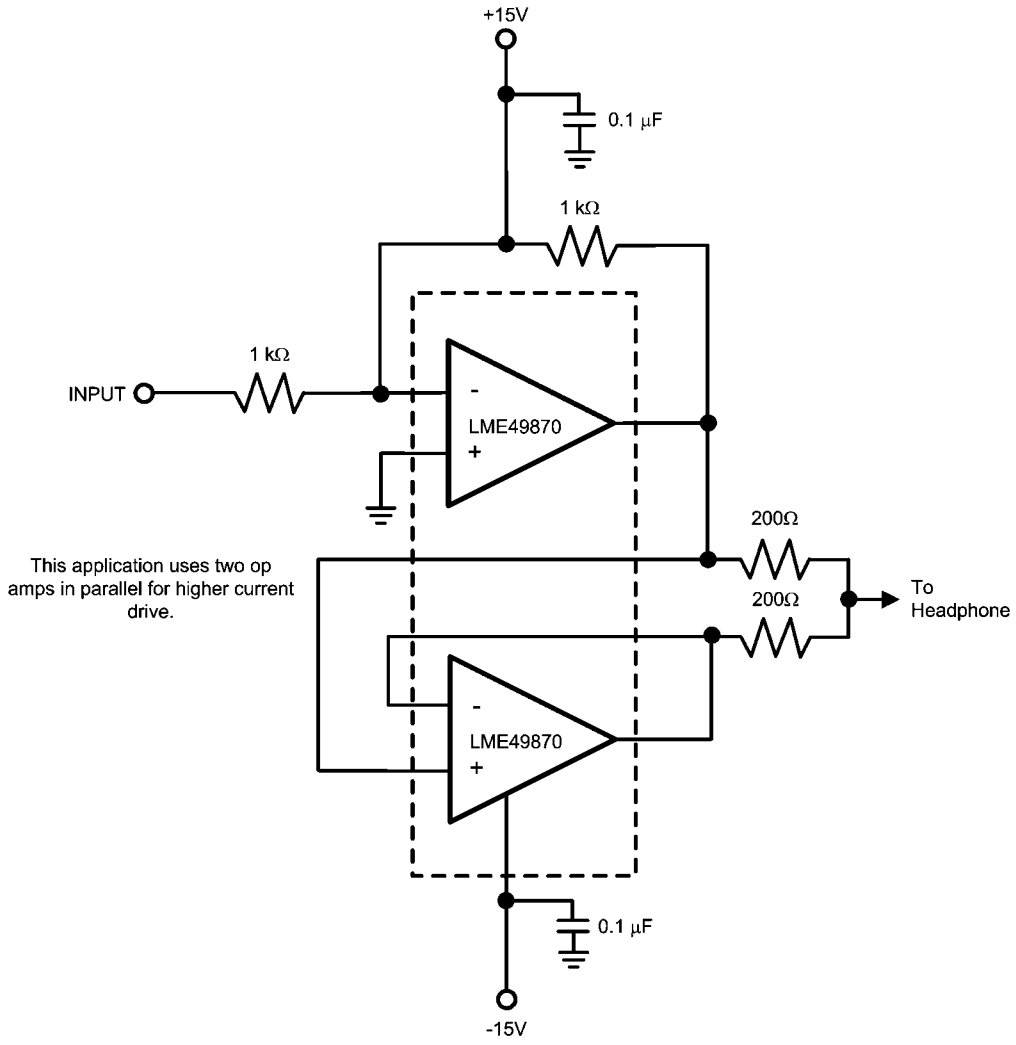
fo (Hz)	C ₁	C ₂	R ₁	R ₂
32	0.12μF	4.7μF	75kΩ	500Ω
64	0.056μF	3.3μF	68kΩ	510Ω
125	0.033μF	1.5μF	62kΩ	510Ω
250	0.015μF	0.82μF	68kΩ	470Ω
500	8200pF	0.39μF	62kΩ	470Ω
1k	3900pF	0.22μF	68kΩ	470Ω
2k	2000pF	0.1μF	68kΩ	470Ω
4k	1100pF	0.056μF	62kΩ	470Ω
8k	510pF	0.022μF	68kΩ	510Ω
16k	330pF	0.012μF	51kΩ	510Ω

Note 9: At volume of change = ±12 dB

Q = 1.7

Reference: "AUDIO/RADIO HANDBOOK", National Semiconductor, 1980, Page 2-61

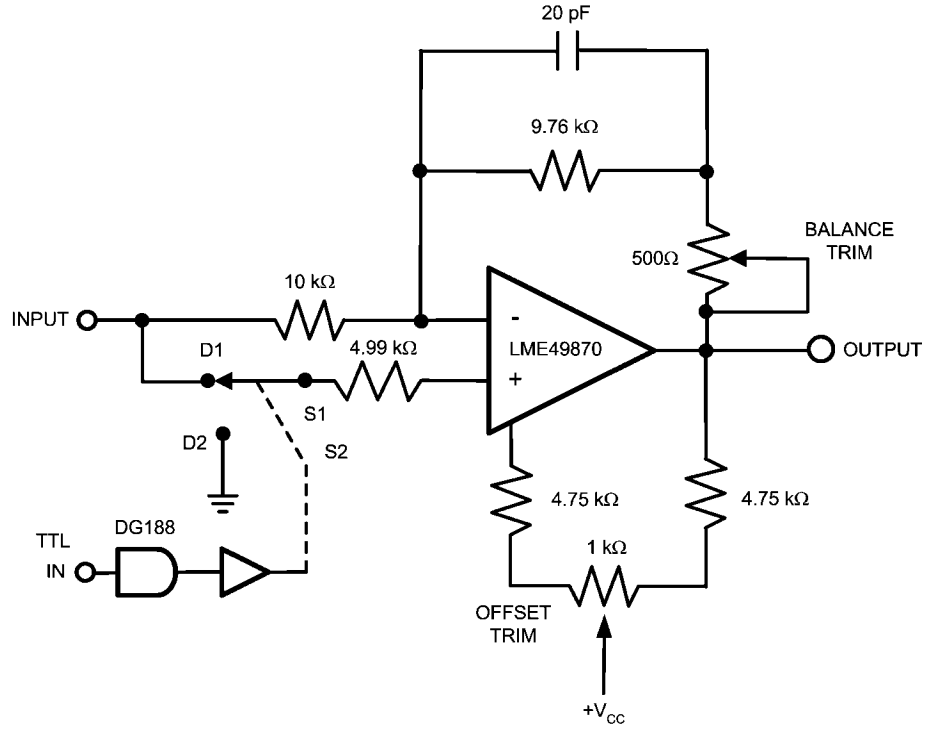
Headphone Amplifier



This application uses two op amps in parallel for higher current drive.

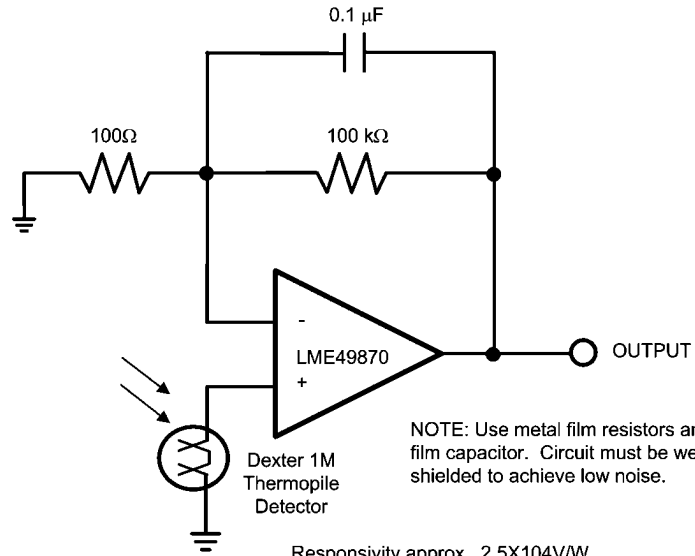
30019410

High Performance Synchronous Demodulator



30019411

Long-Wavelength Infrared Detector Amplifier



NOTE: Use metal film resistors and plastic film capacitor. Circuit must be well shielded to achieve low noise.

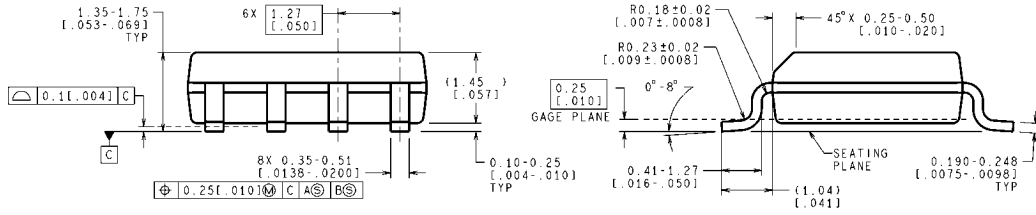
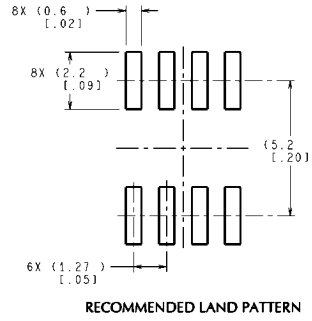
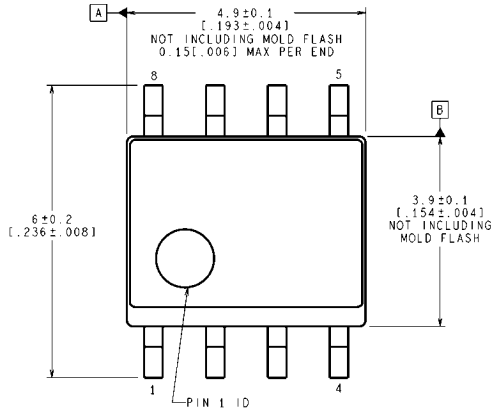
Responsivity approx. $2.5 \times 10^4 \text{ V/W}$
Output Noise approx. $30 \mu\text{Vrms}$, 0.1 Hz to 10 Hz

30019412

Revision History

Rev	Date	Description
1.0	09/20/07	Initial release.
1.1	09/27/07	Updated Notes 1–7 (per National standard).
1.2	12/20/07	Deleted all Crosstalk vs Frequency curves.
1.3	01/14/08	Edited some graphics.

Physical Dimensions inches (millimeters) unless otherwise noted



CONTROLLING DIMENSION IS MILLIMETER
 VALUES IN [] ARE INCHES
 DIMENSIONS IN () FOR REFERENCE ONLY

M08A (Rev L)

Narrow SOIC Package
Order Number LME49870MA
NS Package Number M08A

Notes

LME49870

Notes

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