National Semiconductor

April 3, 2008

LME49725
PowerWise® Dual High Performance, High Fidelity Audio Operational Amplifier

General Description

The LME49725 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 LME49725 audio operational amplifiers deliver superior audio signal amplification for outstanding audio performance. The LME49725 combines extremely low voltage noise density ($3.3nV/\sqrt{Hz}$) with vanishingly low THD+N (0.00004%) to easily satisfy the most demanding audio applications. To ensure that the most challenging loads are driven without compromise, the LME49725 has a high slew rate of ±15V/μs and an output current capability of ±22mA. 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.

Part of the PowerWise® family of energy efficient solutions, the LME49725 consumes only 3.0mA of supply current per amplifier while providing superior performance to high performance, high fidelity applications.

The LME49725's outstanding CMRR (120dB), PSRR (120dB), and V_{OS} (0.5mV) give the amplifier excellent operational amplifier DC performance.

The LME49725 has a wide supply range of ±4.5V to ±18V. Over this supply range the LME49725's input circuitry maintains excellent common-mode and power supply rejection, as well as maintaining its low input bias current. The LME49725 is unity gain stable. This audio operational amplifier achieves outstanding AC performance while driving complex loads with values as high as 100pF.

The LME49725 is available in 8–lead narrow body SOIC.

Key Specifications

■ Power Supply Voltage Range	±4.5V to ±18V
■ THD+N ($A_V = 1$, $V_{OUT} = 3V_{RMS}$, $f_{IN} = 1kHz$)	
$R_L = 2k\Omega$	0.00004% (typ)
$R_L = 600\Omega$	0.00004% (typ)
■ Quiescent current per Amplifier	3.0mA (typ)
■ Input Noise Density	$3.3nV/\sqrt{Hz}$ (typ)
■ Slew Rate	±15V/μs (typ)
■ Gain Bandwidth Product	40MHz (typ)
■ Open Loop Gain ($R_L = 600\Omega$)	135dB (typ)
■ Input Bias Current	15nA (typ)
■ Input Offset Voltage	0.5mV (typ)
■ DC Gain Linearity Error	0.000009% (typ)

Features

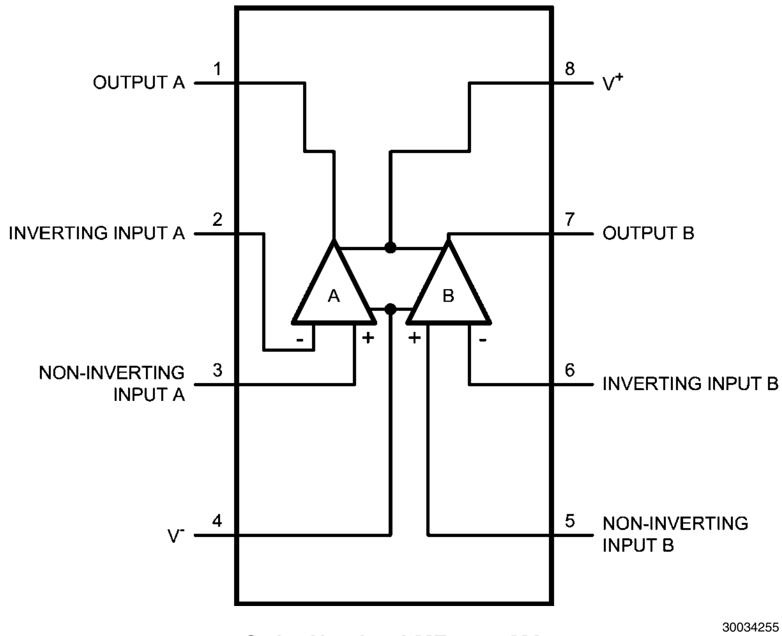
- Optimized for superior audio signal fidelity
- Output short circuit protection
- PSRR and CMRR exceed 120dB (typ)

Applications

- Audio amplification
- Preamplifiers
- Multimedia
- Phono preamplifiers
- Professional audio
- Equalization and crossover networks
- Line drivers
- Line receivers
- Active filters

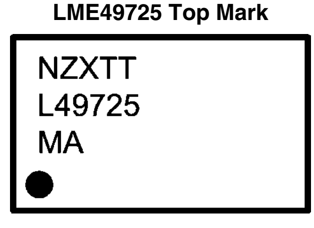
Connection Diagrams

Dual-In-Line Package



Order Number LME49725MA
See NS Package Number — M08A

LME49725 Top Mark



N — National logo
Z — Assembly plant code
X — 1 Digit date code
TT — Die traceability
L49725 — LME49725
MA — Package code

Absolute Maximum Ratings (Note 1)

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

Power Supply Voltage ($V_S = V^+ - V^-$)	38V
Storage Temperature	–65°C to 150°C
Input Voltage	(V-)-0.7V to (V+)+0.7V
Differential Input Voltage	±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
Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40°C \le T_A \le 85°C$
Supply Voltage Range	$\pm4.5V \le V_S \le \pm18V$

Electrical Characteristics for the LME49725 (Note 2)

The specifications apply for $V_S = \pm15V$, $R_L = 2k\Omega$, $f_{IN} = 1kHz$, $T_A = 25°C$, unless otherwise specified.

Symbol	Parameter	Conditions	LME49725 Typical (Note 6)	LME49725 Limit (Note 7)	Units (Limits)
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, $V_{OUT} = 3V_{rms}$ $R_L = 2k\Omega$ $R_L = 600\Omega$	 0.00004 0.00004	 0.0002	 % %
IMD	Intermodulation Distortion	$A_V = 1$, $V_{OUT} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.00005		%
GBWP	Gain Bandwidth Product		40	30	MHz (min)
SR	Slew Rate		±15	±10	V/μs (min)
FPBW	Full Power Bandwidth	$V_{OUT} = 1V_{P-P}$, –3dB referenced to output magnitude at f = 1kHz	7		MHz
t_s	Settling time	$A_V = -1$, 10V step, $C_L = 100pF$ 0.1% error range	1.6		μs
e_n	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.4	0.8	μV_{RMS} (max)
	Equivalent Input Noise Density	f = 1kHz f = 10Hz	3.3 20	5.2	$nV/\sqrt{Hz}$ (max)
i_n	Current Noise Density	f = 1kHz f = 10Hz	1.4 3.5		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
V_{OS}	Offset Voltage		±0.5	±1.0	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.2		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$\Delta V_S = 20V$ (Note 8)	120	100	dB (min)
ISO_{CH-CH}	Channel-to-Channel Isolation	$f_{IN} = 1kHz$ $f_{IN} = 20kHz$	118 112		dB dB
I_B	Input Bias Current	$V_{CM} = 0V$	±15	±90	nA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.1		nA/°C
I_{OS}	Input Offset Current	$V_{CM} = 0V$	11	65	nA (max)
V_{IN-CM}	Common-Mode Input Voltage Range		±13.9	(V+)-2.0 (V-)+2.0	V (min) V (min)
CMRR	Common-Mode Rejection	–10V<Vcm<10V	120	100	dB (min)
Z_{IN}	Differential Input Impedance		30		kΩ
	Common Mode Input Impedance	–10V<Vcm<10V	1000		MΩ

Symbol	Parameter	Conditions	LME49725 Typical (Note 6)	LME49725 Limit (Note 7)	Units (Limits)
A_{VOL}	Open Loop Voltage Gain	–10V<Vout<10V, R_L = 600Ω	135	110	dB (min)
		–10V<Vout<10V, R_L = 2kΩ	135		dB
		–10V<Vout<10V, R_L = 10kΩ	135		dB
V_{OUTMAX}	Maximum Output Voltage Swing	R_L = 600Ω	±13.6	±11.5	V (min)
		R_L = 2kΩ	±13.9		V
		R_L = 10kΩ	±14.0		V
I_{OUT}	Output Current	R_L = 600Ω, V_S = ±17V	±22		mA (min)
$I_{OUT\text{-}CC}$	Instantaneous Short Circuit Current		+45 –35		mA mA
R_{OUT}	Output Impedance	f_{IN} = 10kHz Closed-Loop Open-Loop	 0.01 18		 Ω Ω
C_{LOAD}	Capacitive Load Drive Overshoot	100pF	16		%
I_S	Quiescent Current per Amplifier	I_{OUT} = 0mA	3.0	4.5	mA (max)
f_C	1/f Corner Frequency		120		Hz

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.

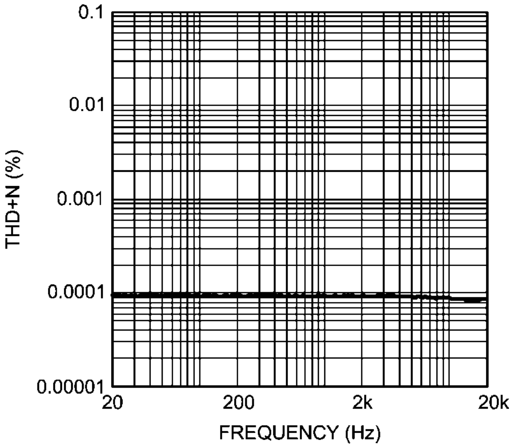
Note 6: Typical values represent most likely parametric norms at T_A = +25ºC, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

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

Note 8: PSRR is measured as follows: V_{OS} is measured at two supply voltages, ±5V and ±15V, PSRR = $|20\log(\Delta V_{OS}/\Delta V_S)|$.

Typical Performance Characteristics

THD+N vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 600Ω



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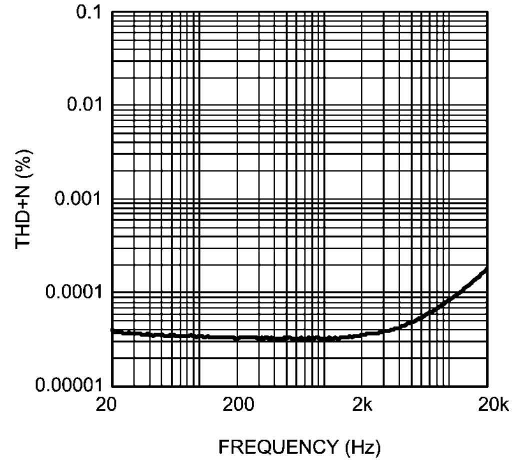
THD+N vs Frequency
V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 600Ω



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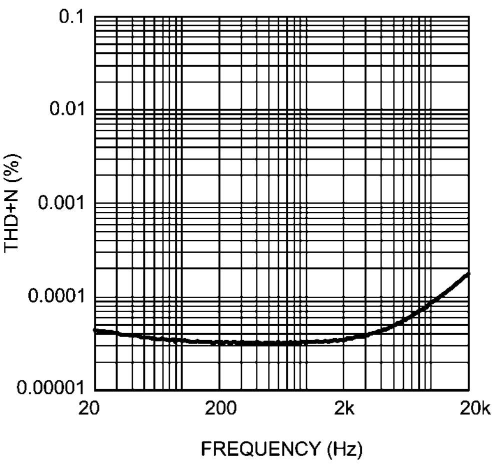
THD+N vs Frequency
V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 600Ω



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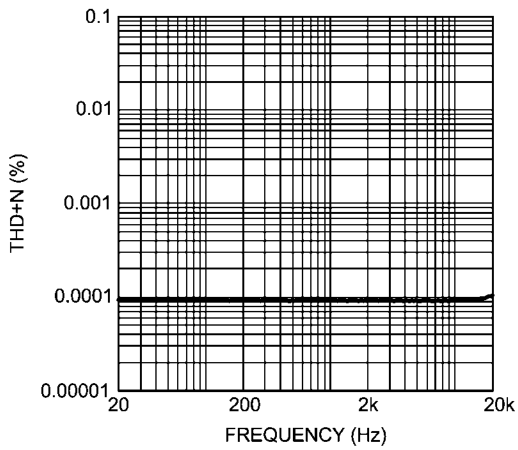
THD+N vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 2kΩ



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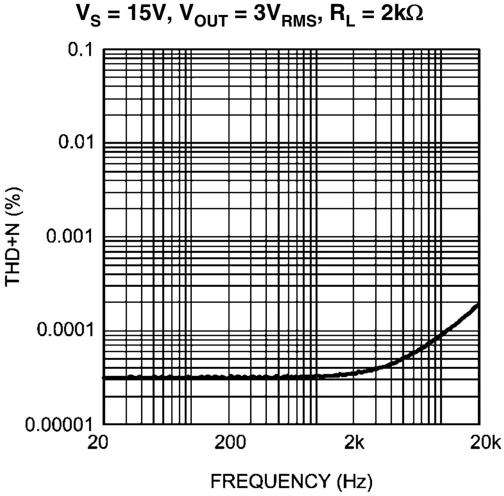
THD+N vs Frequency
V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 2kΩ



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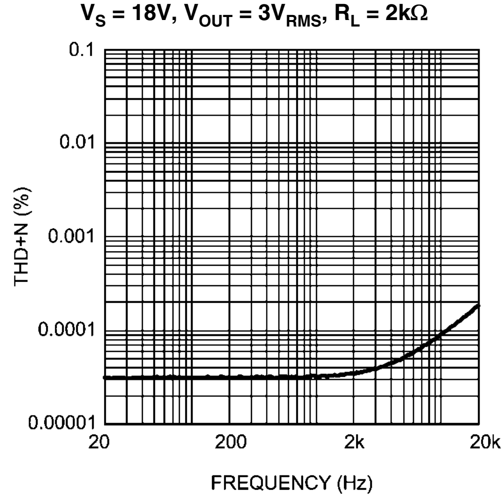
THD+N vs Frequency
V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 2kΩ



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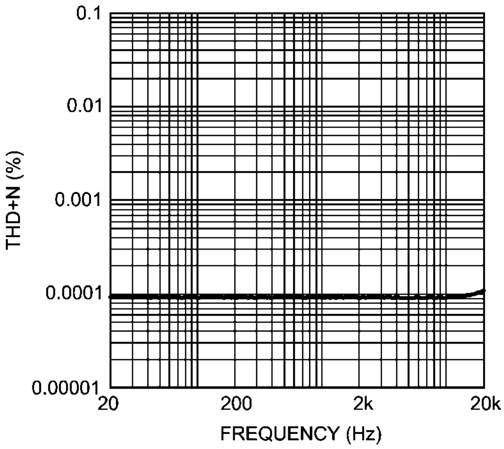
THD+N vs Frequency
$V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 10k\Omega$



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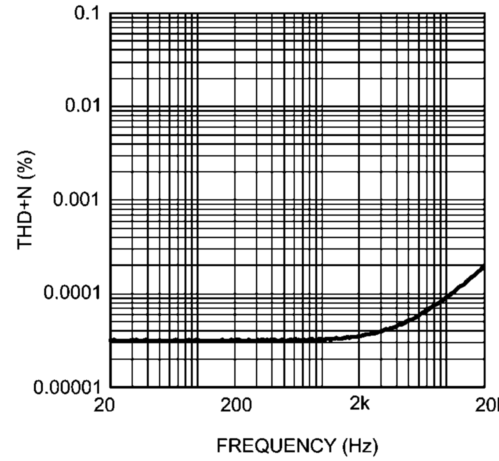
THD+N vs Frequency
$V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 10k\Omega$



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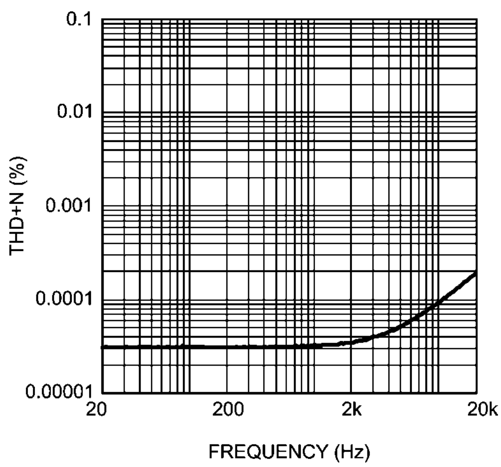
THD+N vs Frequency
$V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 10k\Omega$



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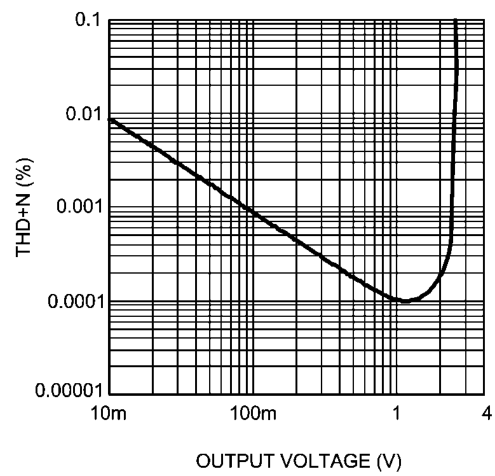
THD+N vs Output Voltage
$V_S = 4.5V, R_L = 600\Omega, f = 1kHz$



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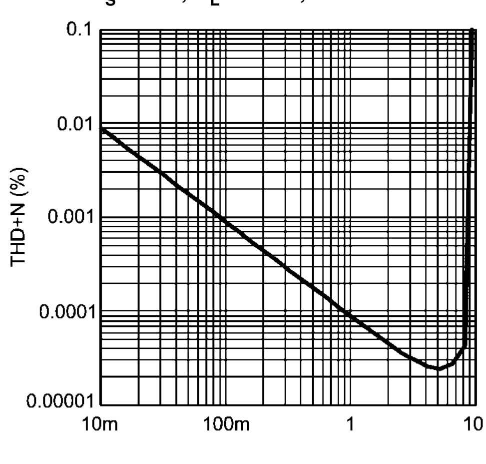
THD+N vs Output Voltage
$V_S = 15V, R_L = 600\Omega, f = 1kHz$



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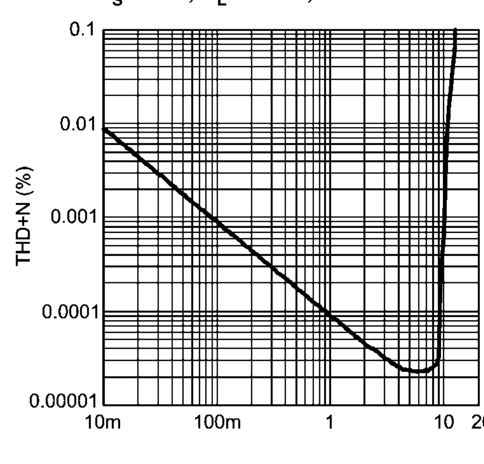
THD+N vs Output Voltage
$V_S = 18V, R_L = 600\Omega, f = 1kHz$



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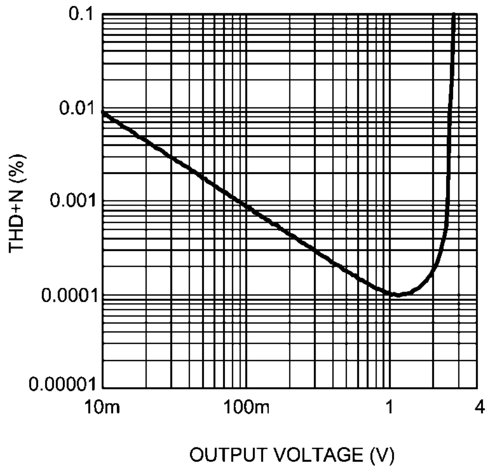
THD+N vs Output Voltage
V_S = 4.5V, R_L = 2kΩ, f = 1kHz



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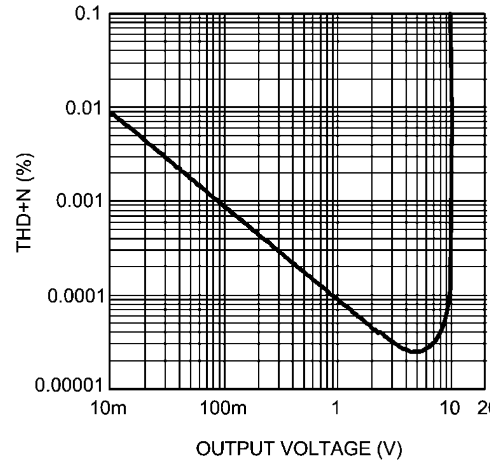
THD+N vs Output Voltage
V_S = 15V, R_L = 2kΩ, f = 1kHz



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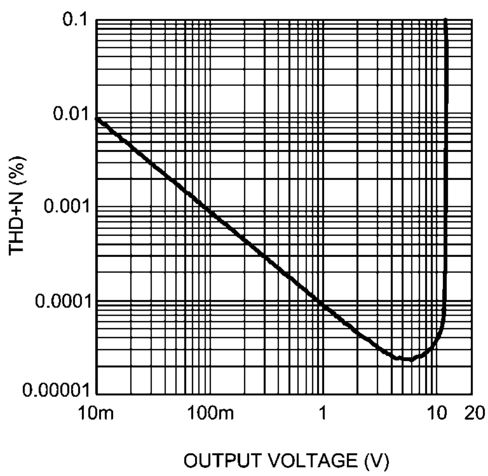
THD+N vs Output Voltage
V_S = 18V, R_L = 2kΩ, f = 1kHz



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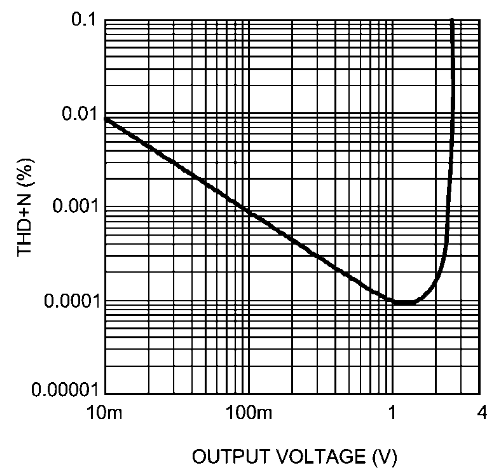
THD+N vs Output Voltage
V_S = 4.5V, R_L = 10kΩ, f = 1kHz



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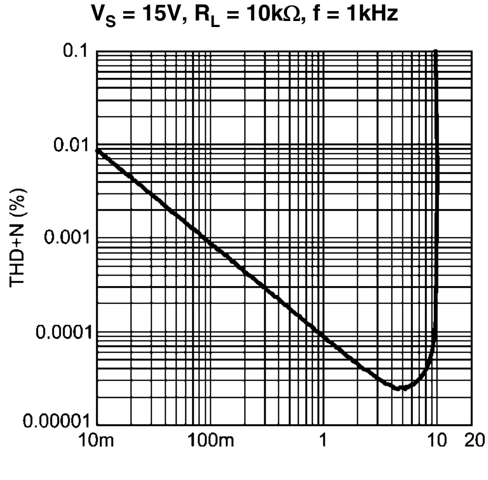
THD+N vs Output Voltage
V_S = 15V, R_L = 10kΩ, f = 1kHz



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THD+N vs Output Voltage
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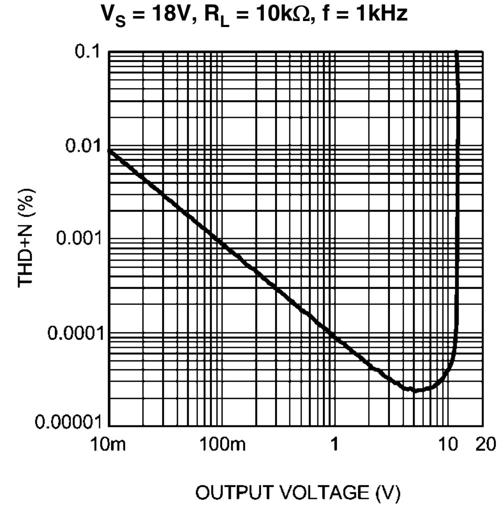

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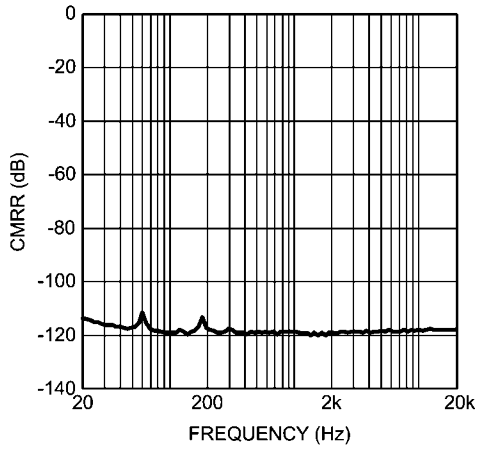
CMRR vs Frequency
V_S = 4.5V, R_L = 600Ω



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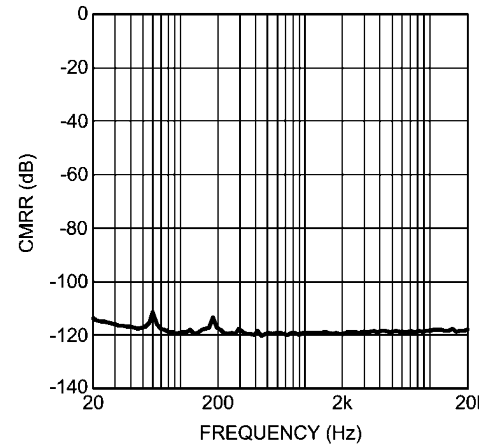
CMRR vs Frequency
V_S = 15V, R_L = 600Ω



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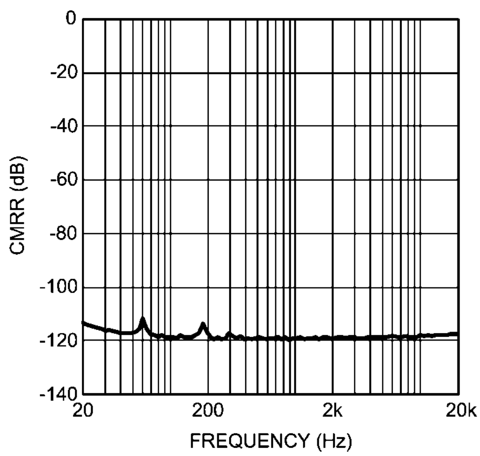
CMRR vs Frequency
V_S = 15V, R_L = 600Ω



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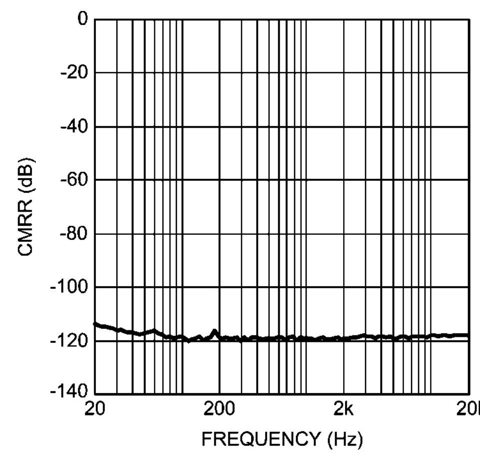
CMRR vs Frequency
V_S = 4.5V, R_L = 2kΩ



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CMRR vs Frequency
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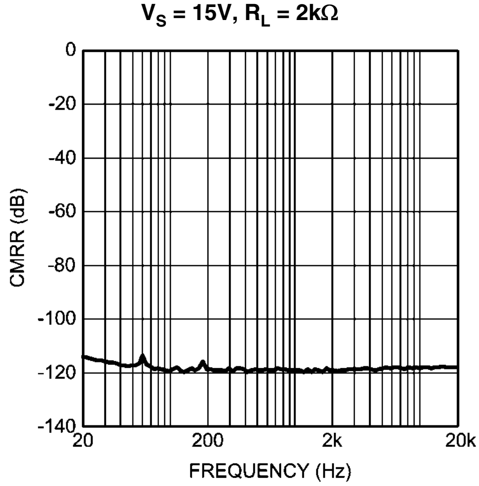

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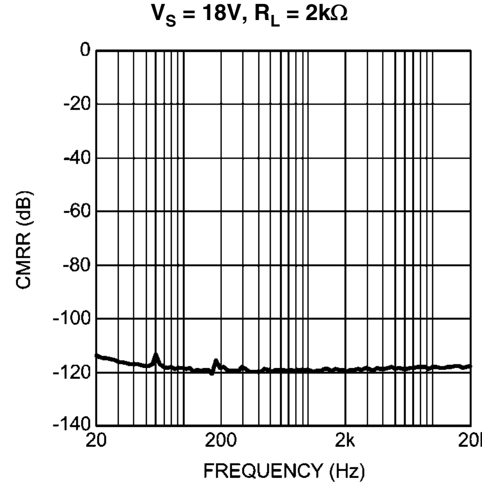
CMRR vs Frequency
V_S = 18V, R_L = 2kΩ



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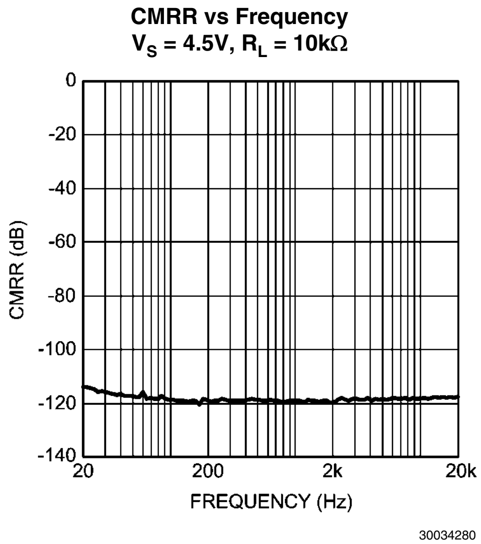
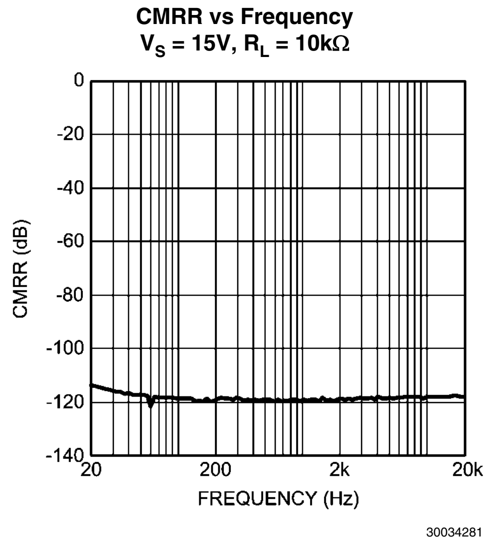
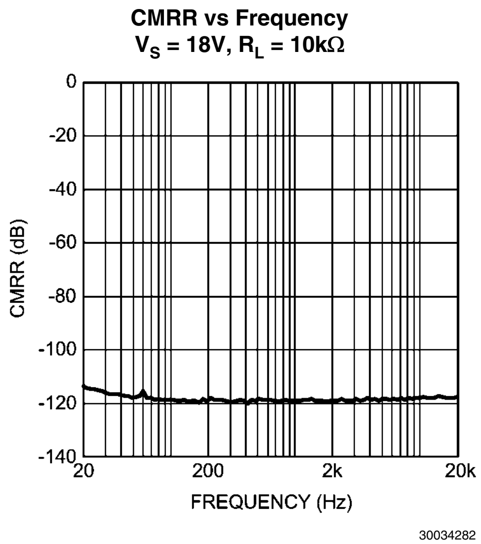
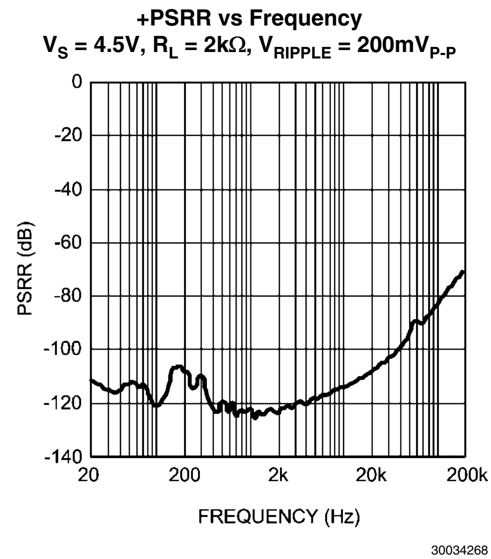
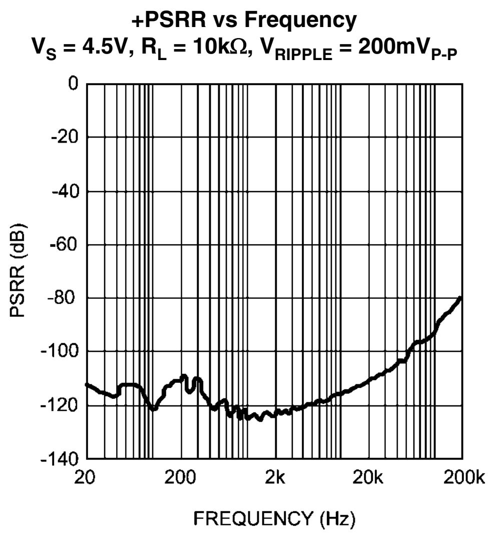
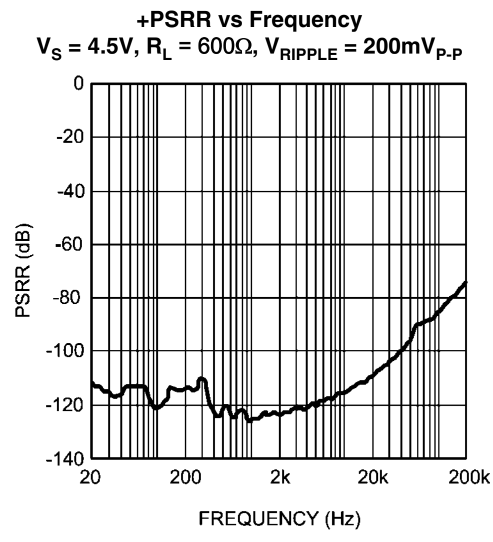

CMRR vs Frequency
V_S = 4.5V, R_L = 10kΩ
CMRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
30034280


CMRR vs Frequency
V_S = 15V, R_L = 10kΩ
CMRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
30034281

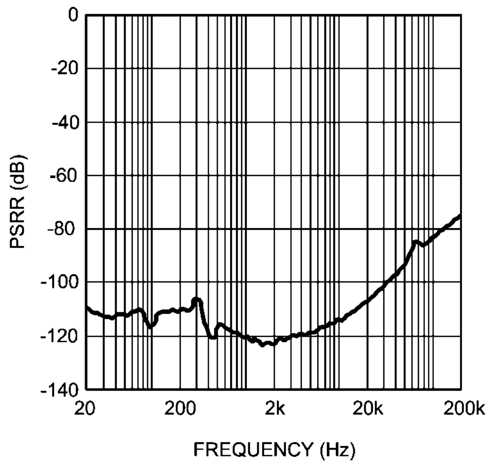

CMRR vs Frequency
V_S = 18V, R_L = 10kΩ
CMRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
30034282


+PSRR vs Frequency
V_S = 4.5V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{P-P}
PSRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
200k
30034268


+PSRR vs Frequency
V_S = 4.5V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{P-P}
PSRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
200k
30034269

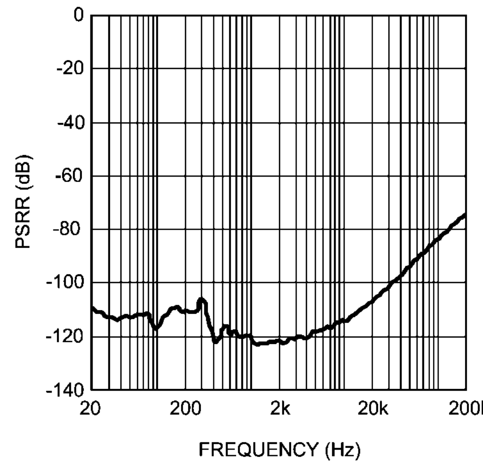

+PSRR vs Frequency
V_S = 4.5V, R_L = 600Ω, V_{RIPPLE} = 200mV_{P-P}
PSRR (dB)
FREQUENCY (Hz)
0
-20
-40
-60
-80
-100
-120
-140
20
200
2k
20k
200k
30034270

+PSRR vs Frequency
V_S = 15V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{P-P}



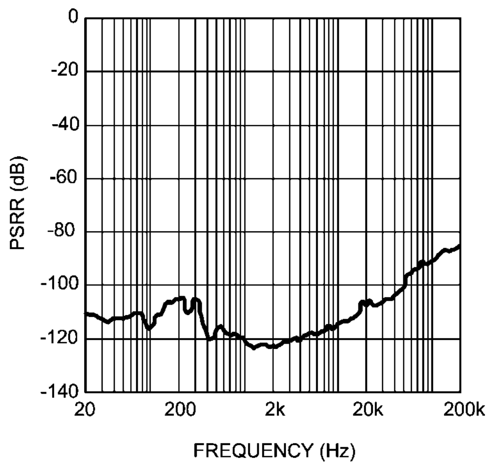
30034271

+PSRR vs Frequency
V_S = 15V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{P-P}



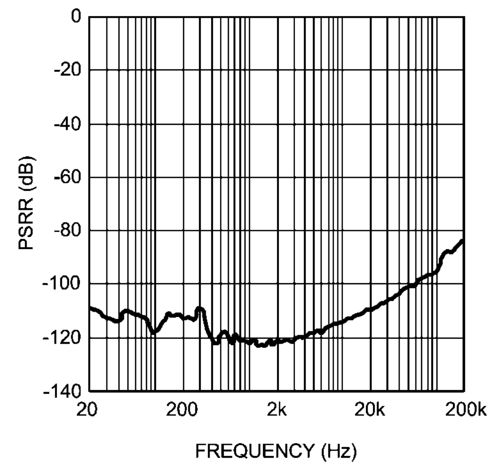
30034272

+PSRR vs Frequency
V_S = 15V, R_L = 600Ω, V_{RIPPLE} = 200mV_{P-P}



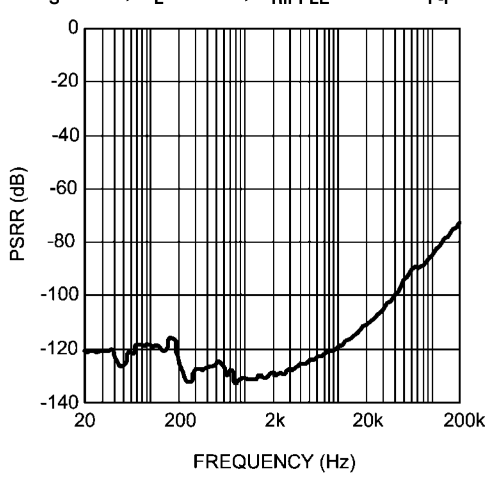
30034273

+PSRR vs Frequency
V_S = 18V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{P-P}



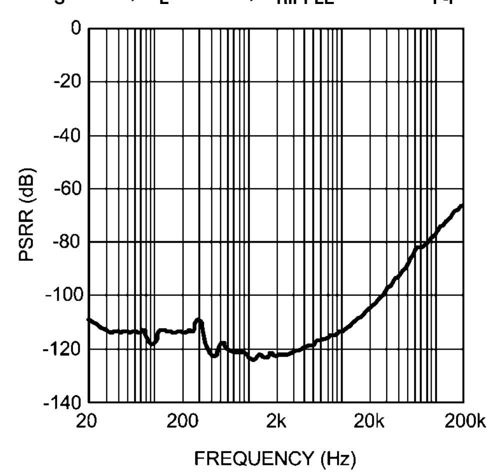
300342a7

+PSRR vs Frequency
V_S = 18V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{P-P}



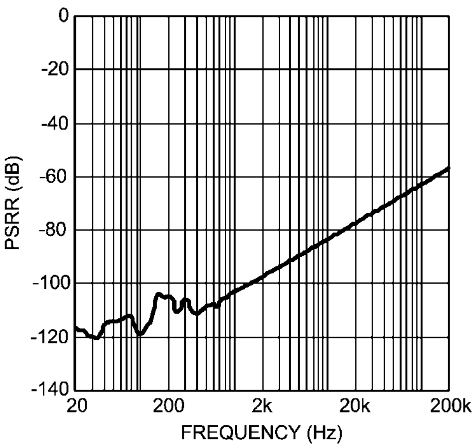
30034275

+PSRR vs Frequency
V_S = 18V, R_L = 600Ω, V_{RIPPLE} = 200mV_{P-P}



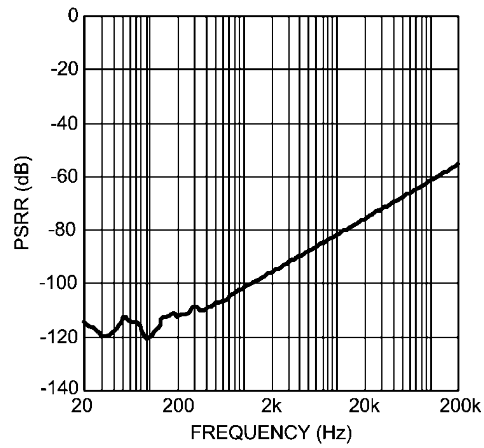
30034276

-PSRR vs Frequency
V_S = 4.5V, R_L = 2kΩ, V_{RIPPLE} = 200mV$_{P-P}$



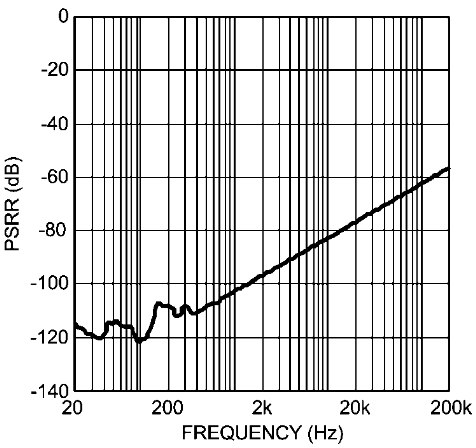
30034295

-PSRR vs Frequency
V_S = 4.5V, R_L = 10kΩ, V_{RIPPLE} = 200mV$_{P-P}$



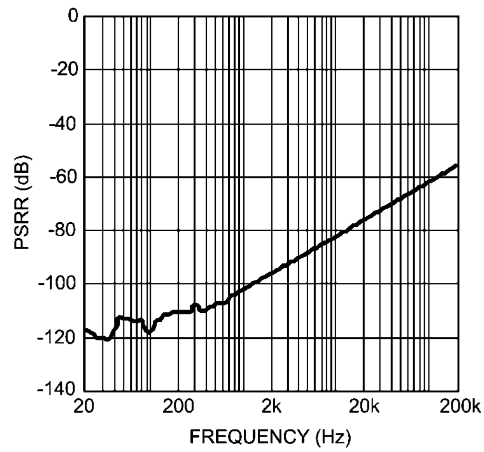
30034296

-PSRR vs Frequency
V_S = 4.5V, R_L = 600Ω, V_{RIPPLE} = 200mV$_{P-P}$



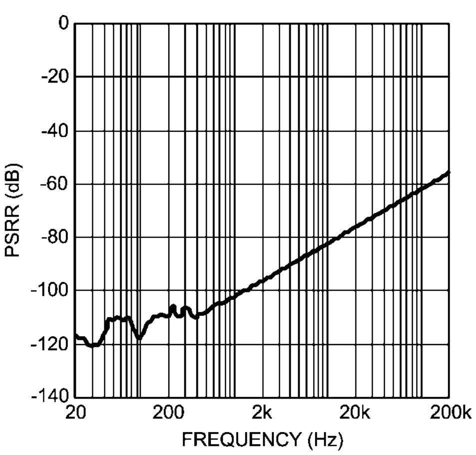
30034297

-PSRR vs Frequency
V_S = 15V, R_L = 2kΩ, V_{RIPPLE} = 200mV$_{P-P}$



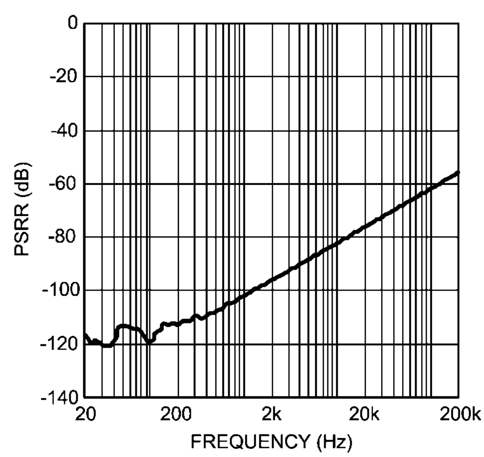
30034298

-PSRR vs Frequency
V_S = 15V, R_L = 10kΩ, V_{RIPPLE} = 200mV$_{P-P}$



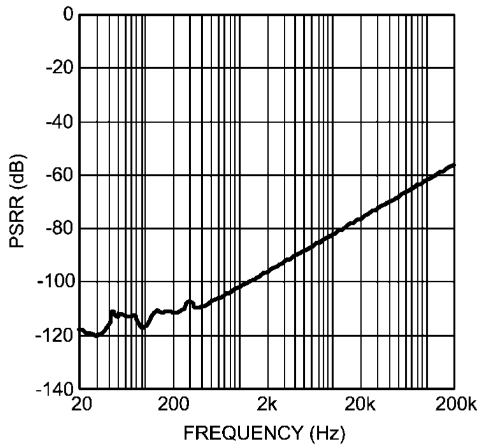
30034299

-PSRR vs Frequency
V_S = 15V, R_L = 600Ω, V_{RIPPLE} = 200mV$_{P-P}$



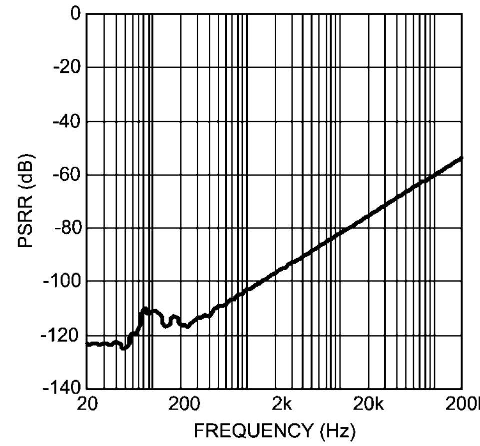
300342a0

-PSRR vs Frequency
V_S = 18V, R_L = 2kΩ, V_{RIPPLE} = 200mV_{P-P}



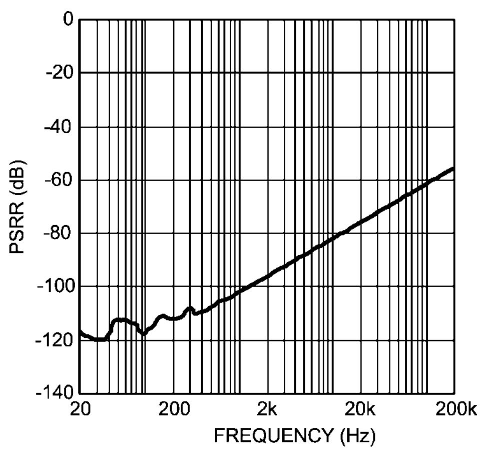
300342a1

-PSRR vs Frequency
V_S = 18V, R_L = 10kΩ, V_{RIPPLE} = 200mV_{P-P}



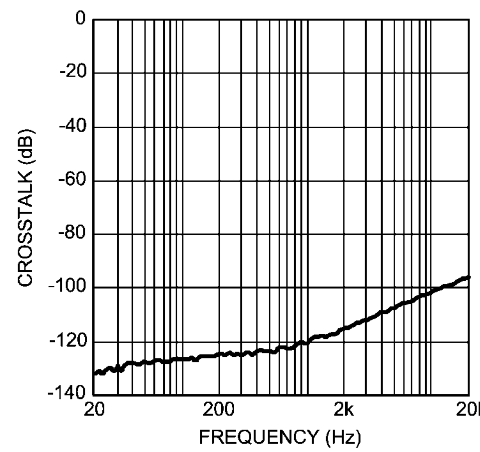
300342a2

-PSRR vs Frequency
V_S = 18V, R_L = 600Ω, V_{RIPPLE} = 200mV_{P-P}



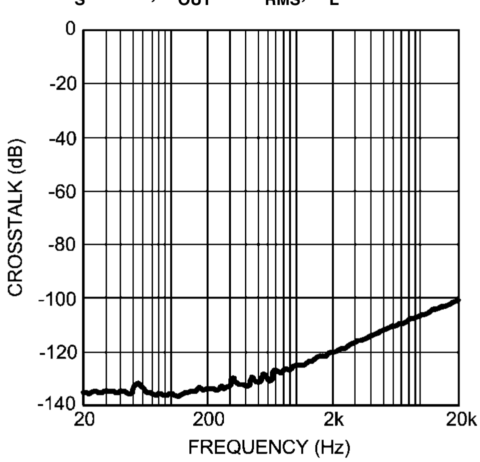
300342a3

Crosstalk vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 600Ω



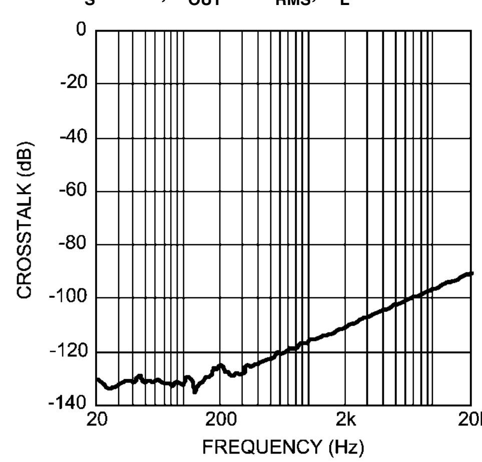
30034292

Crosstalk vs Frequency
V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 600Ω



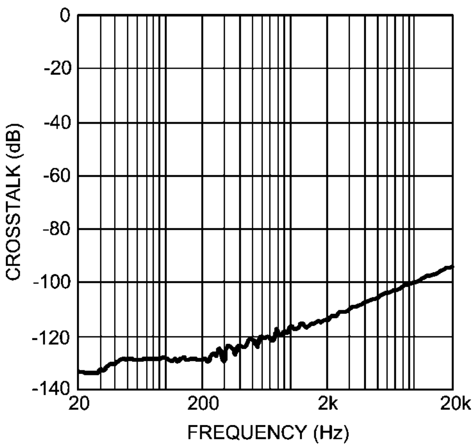
30034293

Crosstalk vs Frequency
V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 600Ω



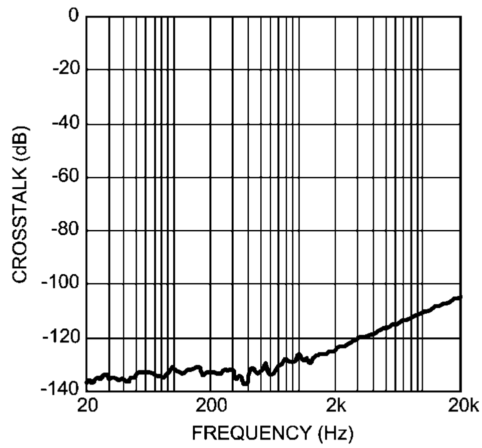
30034294

Crosstalk vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 2kΩ



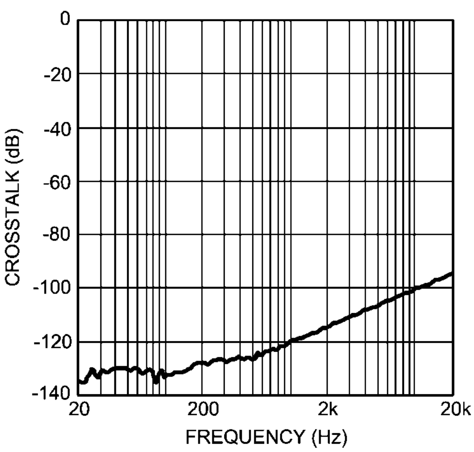
30034286

CrosstalkR vs Frequency
V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 2kΩ



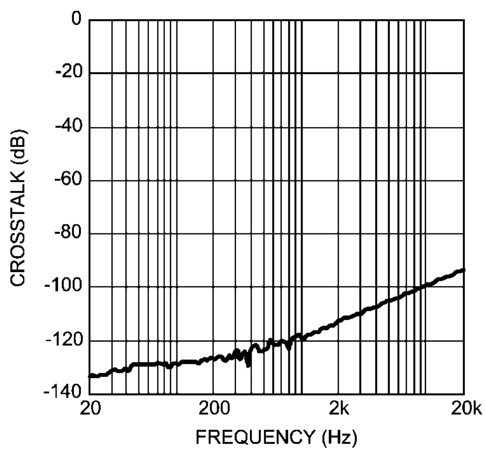
30034287

Crosstalk vs Frequency
V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 2kΩ



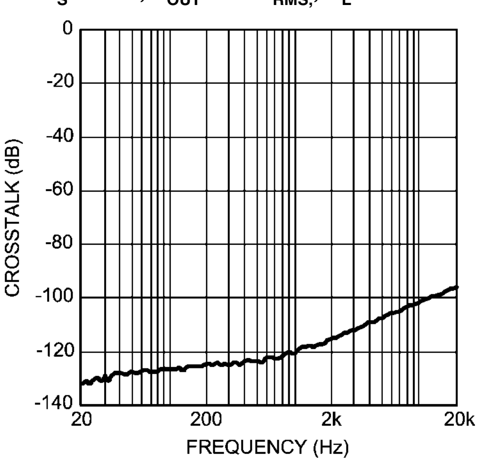
30034288

Crosstalk vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 10kΩ



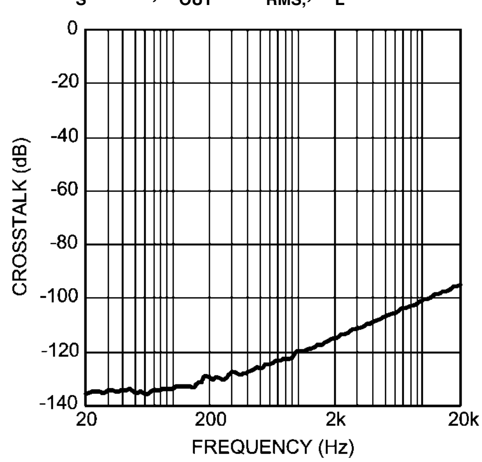
30034289

Crosstalk vs Frequency
V_S = 4.5V, V_{OUT} = 1.2V_{RMS}, R_L = 600Ω



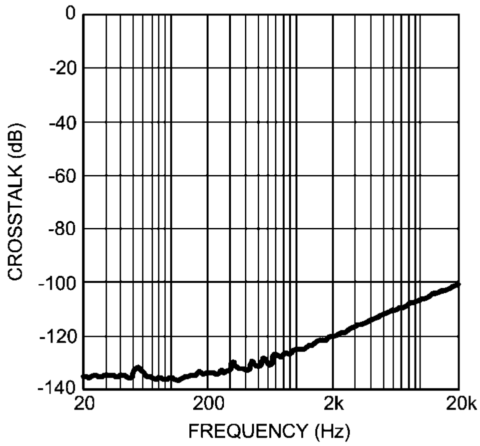
30034292

Crosstalk vs Frequency
V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 10kΩ



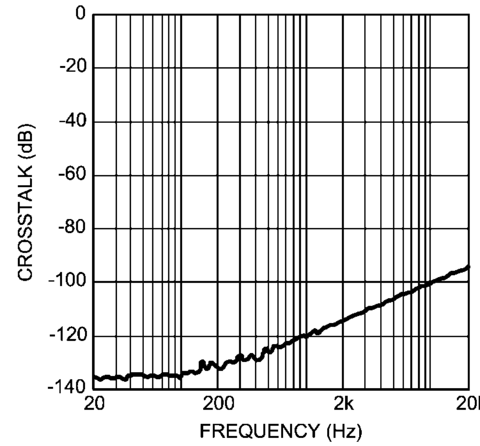
30034290

Crosstalk vs Frequency
$V_S = 15V, V_{OUT} = 3V_{RMS}, R_L = 600\Omega$



30034293

Crosstalk vs Frequency
$V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 10k\Omega$



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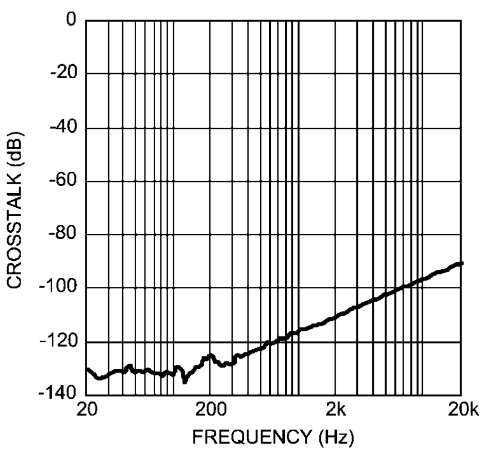
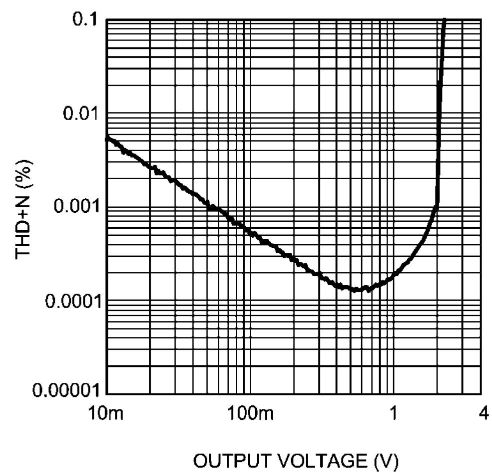
Crosstalk vs Frequency
$V_S = 18V, V_{OUT} = 3V_{RMS}, R_L = 600\Omega$



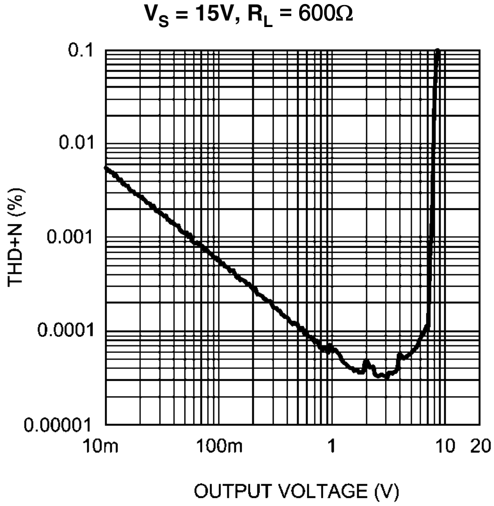
30034294

IMD vs Output Voltage
$V_S = 4.5V, R_L = 600\Omega$



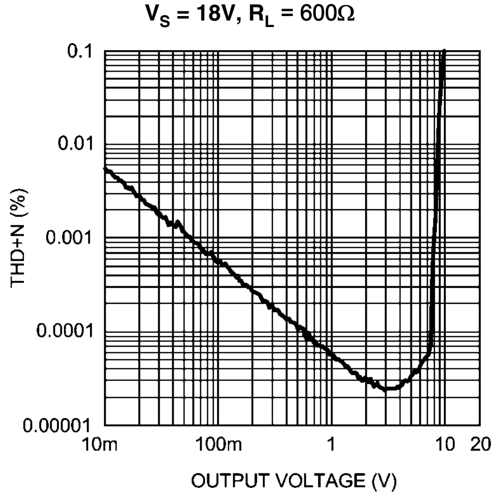
30034216

IMD vs Output Voltage
$V_S = 15V, R_L = 600\Omega$



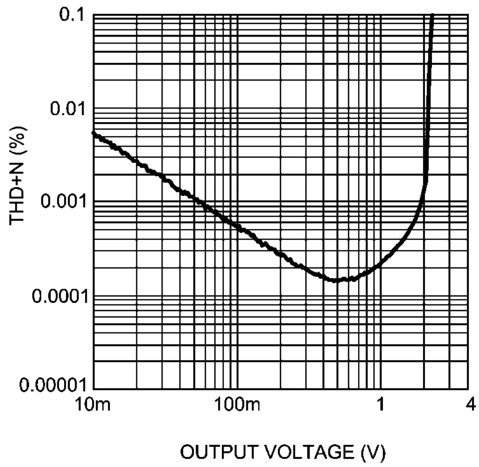
30034266

IMD vs Output Voltage
$V_S = 18V, R_L = 600\Omega$



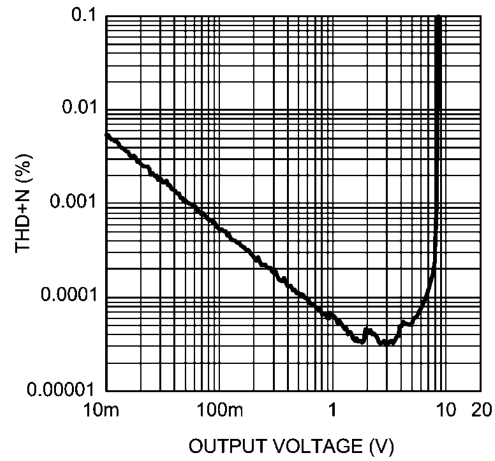
30034267

IMD vs Output Voltage
V_S = 4.5V, R_L = 2kΩ



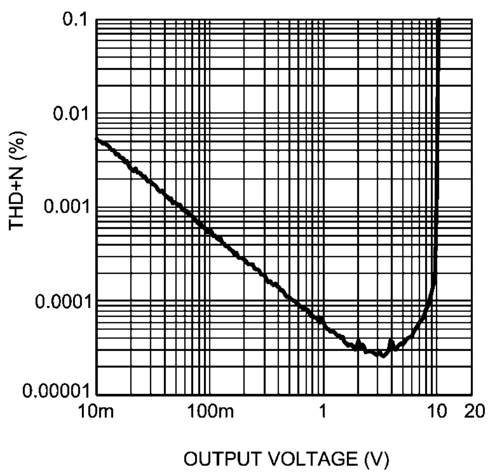
30034210

IMD vs Output Voltage
V_S = 15V, R_L = 2kΩ



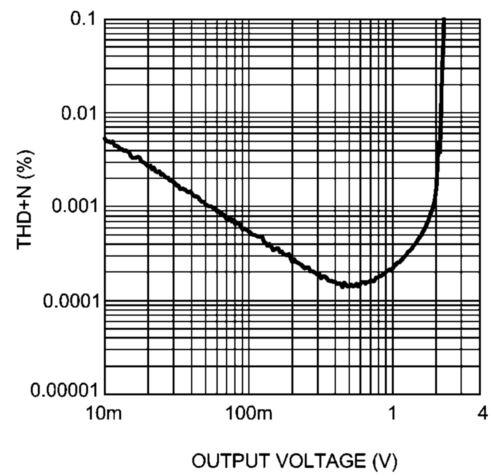
30034264

IMD vs Output Voltage
V_S = 18V, R_L = 2kΩ



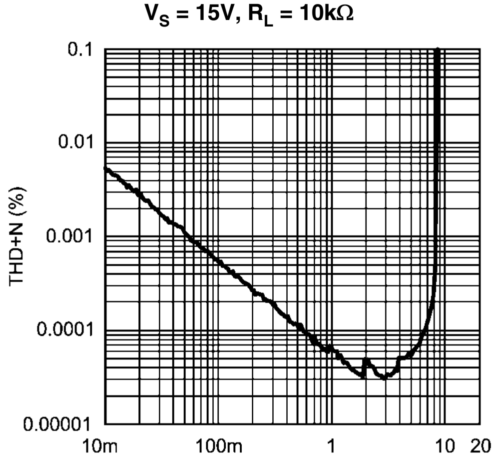
30034212

IMD vs Output Voltage
V_S = 4.5V, R_L = 10kΩ



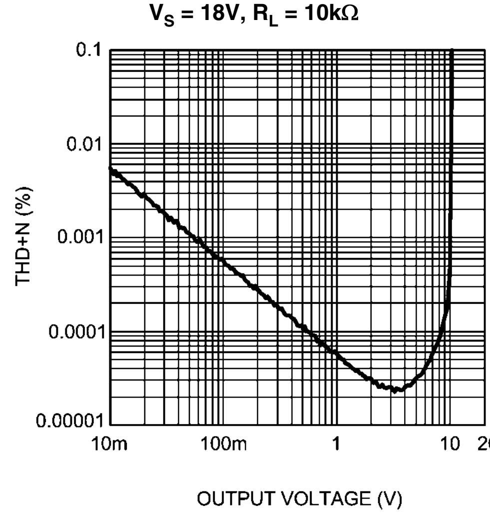
30034213

IMD vs Output Voltage
V_S = 15V, R_L = 10kΩ

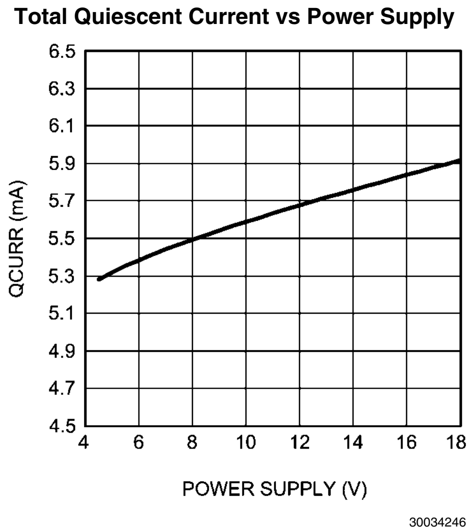


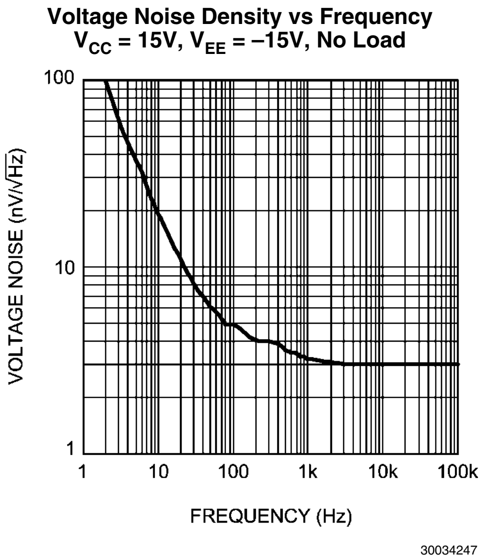
30034265

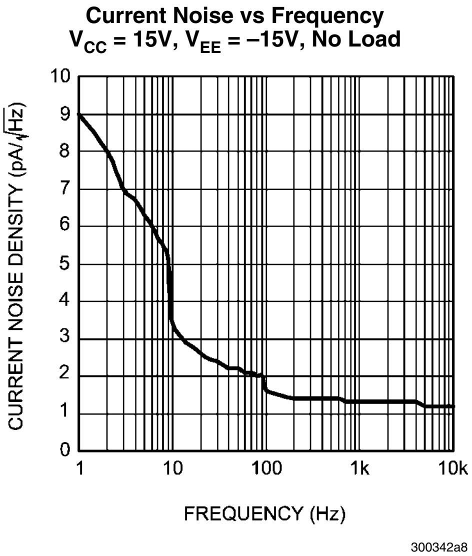
IMD vs Output Voltage
V_S = 18V, R_L = 10kΩ



30034215


Total Quiescent Current vs Power Supply
QCURR (mA)
6.5
6.3
6.1
5.9
5.7
5.5
5.3
5.1
4.9
4.7
4.5
4
6
8
10
12
14
16
18
POWER SUPPLY (V)
30034246


Voltage Noise Density vs Frequency
VCC = 15V, VEE = –15V, No Load
VOLTAGE NOISE (nV/√Hz)
100
10
1
1
10
100
1k
10k
100k
FREQUENCY (Hz)
30034247


Current Noise vs Frequency
VCC = 15V, VEE = –15V, No Load
CURRENT NOISE DENSITY (pA/√Hz)
10
9
8
7
6
5
4
3
2
1
0
1
10
100
1k
10k
FREQUENCY (Hz)
300342a8

Application Information

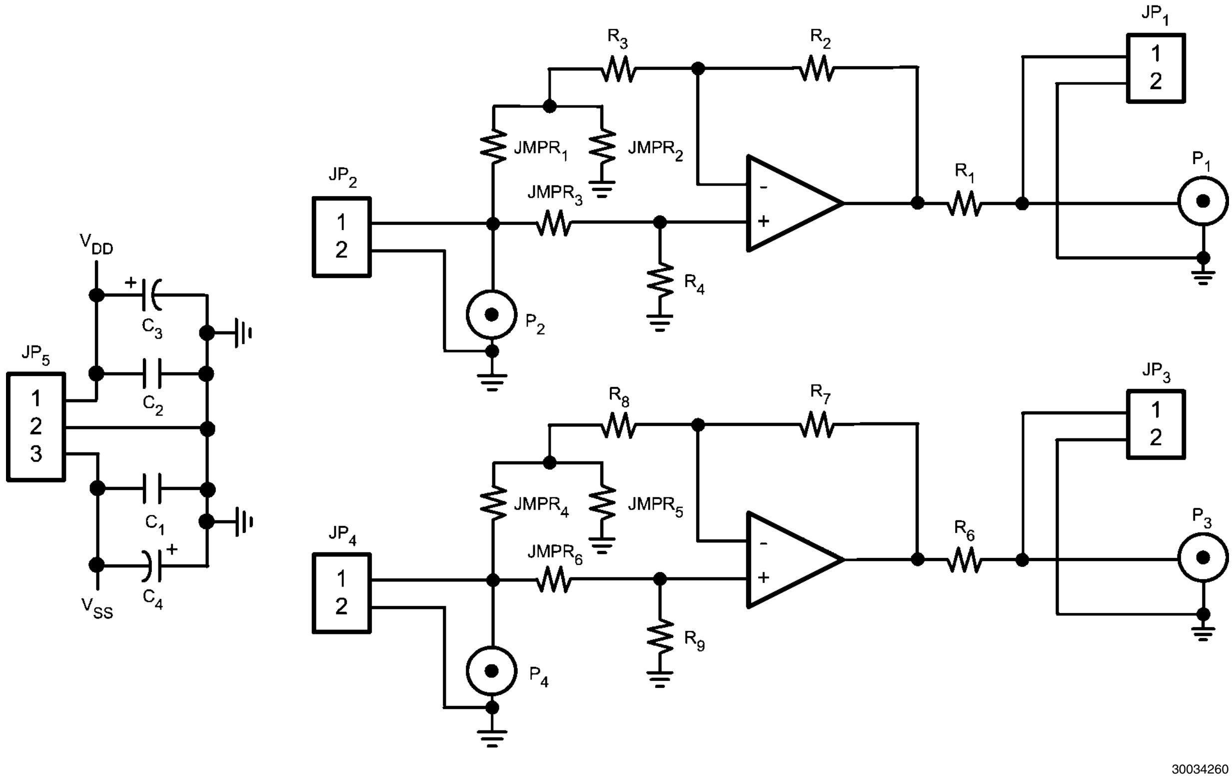
OPERATING RATINGS AND BASIC DESIGN GUIDELINES

The LME49725 has a supply voltage range from +9V to +36V single supply or ±4.5V to ±18V dual supply.

Bypass capacitors for the supplies should be placed as close to the amplifier as possible. This will help minimize any inductance between the power supply and the supply pins. In addition to a 10μF capacitor, a 0.1μF capacitor is also recommended.

The amplifier's inputs lead lengths should also be as short as possible. If the op amp does not have a bypass capacitor, it may oscillate.

Demonstration Board Schematic

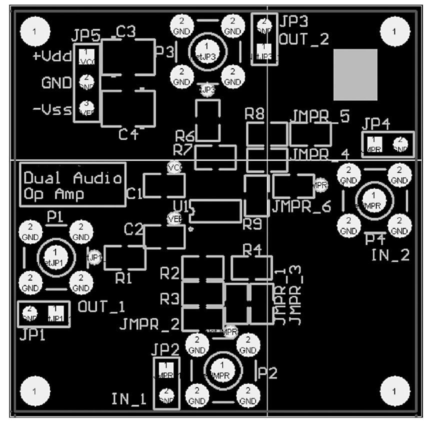


Bill Of Materials For Demonstration Board (Inverting Configuration)

Description	Designator	Part Number	Mfg
Ceramic Capacitor 0.1µF, 10% 50V 0805 SMD	C1, C2	C0805C104K3RAC7533	Kemet
Tantalum Capacitor 10µF, 10% 20V, B-size	C3, C4	T491B106K025AT	Kemet
Resistor 0Ω, 1/8W, 1% 0805 SMD	JMPR1, JMPR4, R1, R4, R6, R9	CRCW0805000020EA	Vishay
Resistor 10kΩ, 1/8W, 1% 0805 SMD	R2, R3, R8, R7	CRCW080510K0FKEA	Vishay
Header, 2-Pin	JP1, JP2, JP3, JP4		
Header, 3-Pin	JP5		
SMA stand-up connectors	P1-P4 (Optional)	132134	Amphenol COnnex

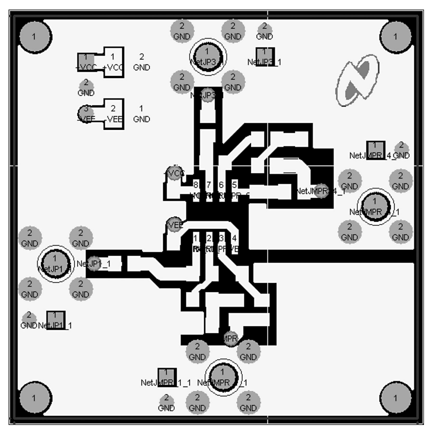
Note: Do not stuff Jmpr2, Jmpr3, Jmpr5, and Jmpr6.

Demonstration Board Layout



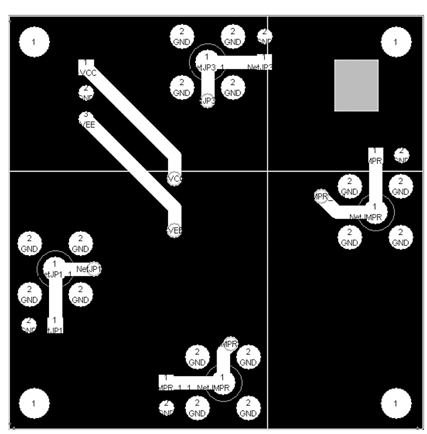
30034262

Silkscreen Layer



30034263

Top Layer



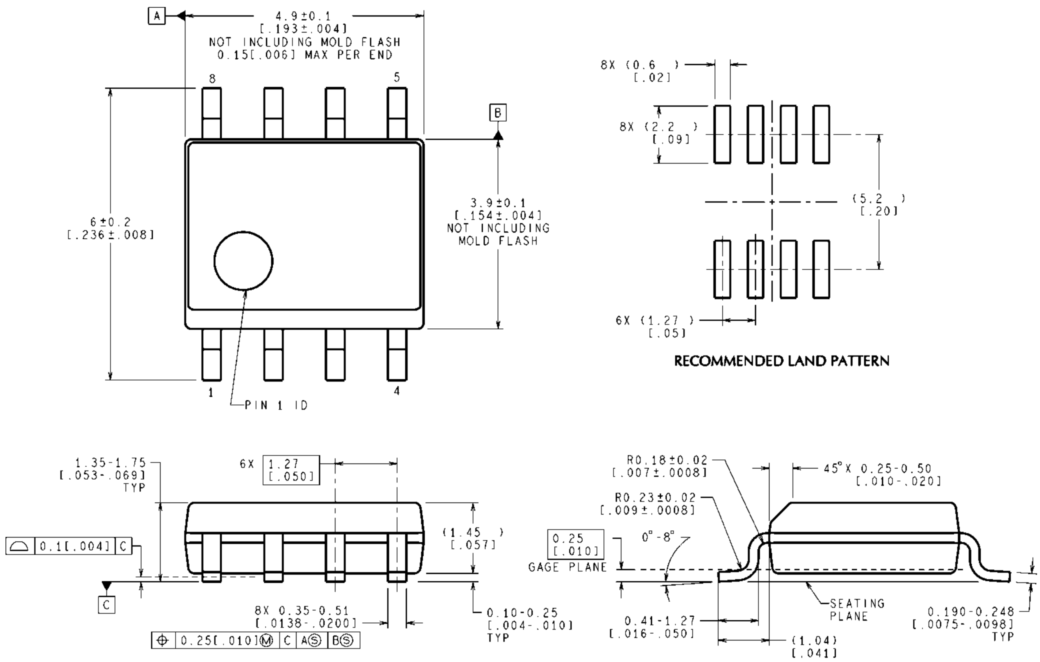
30034261

Bottom Layer

Revision History

Rev	Date	Description
1.0	04/03/08	Initial release.

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 LME49725MA
NS Package Number M08A

Notes

Notes

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