National Semiconductor

April 28, 2008

LME49871
High Performance, High Fidelity Current Feedback Audio Operational Amplifier

General Description

The LME49871 is an ultra-low distortion, low noise, ultra high slew rate current feedback operational amplifier optimized and fully specified for high performance, high fidelity applications. Combining advanced leading-edge process technology with state-of-the-art circuit design, the LME49871 current feedback operational amplifier delivers superior signal amplification for outstanding performance. Operating on a wide supply range of ±5V to ±22V, the LME49871 combines extremely low voltage noise density (1.9nV/$\sqrt{Hz}$) with very low THD+N (0.00012%) to easily satisfy the most demanding applications. To ensure that the most challenging loads are driven without compromise, the LME49871 has a high slew rate of ±1900V/μs and an output current capability of ±100-mA. Further, dynamic range is maximized by an output stage that drives 150Ω loads to within 2.9V of either power supply voltage.

The LME49871 's outstanding CMRR (88dB), PSRR (102dB), and V_{OS} (0.05mV) give the amplifier excellent operational amplifier DC performance.

The LME49871 is available in an 8–lead narrow body SOIC. Demonstration boards are available.

Key Specifications

■ Power Supply Voltage Range	±5V to ±22V
■ THD+N (A_V = 1, R_L = 100Ω, V_{OUT} = 2V_{P-P}, f = 1kHz)	0.00021% (typ)
■ THD+N (A_V = 1, R_L = 600Ω, V_{OUT} = 1.4V_{RMS}, f = 1kHz)	0.00012% (typ)
■ Input Noise Density	1.9nV/$\sqrt{Hz}$ (typ)
■ Slew Rate	±1900V/μs (typ)
■ Bandwidth (A_V = 1, R_L= 2kΩ, R_F = 800Ω)	213MHz (typ)
■ Input Bias Current	1.8μA (typ)
■ Input Offset Voltage	0.05mV (typ)
■ PSRR	102dB (typ)
■ CMRR	90dB (typ)

Features

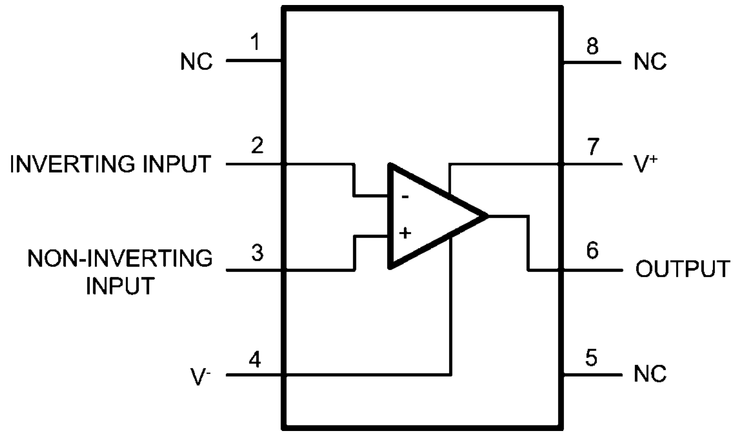
- Easily drives 150Ω loads
- Optimized for superior audio signal fidelity
- Output short circuit protection
- SOIC package

Applications

- Ultra high quality audio amplification
- High fidelity preamplifiers
- High fidelity multimedia
- State of the art phono pre amps
- High performance professional audio
- High fidelity equalization and crossover networks
- High performance line drivers
- High performance line receivers
- High fidelity active filters

Connection Diagrams

SOIC Package



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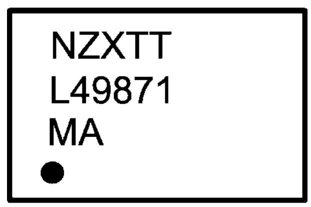
Order Number LME49871MA
See NS Package Number M08A

LME49871MA Top Mark



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N = National Logo
Z = Assembly plant code
X = 1 Digit date code
TT = Die traceability
L49871 = LME49871
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} (MA)	145°C/W
Temperature Range	
$T_{MIN} \le T_A \le T_{MAX}$	$-40°C \le T_A \le 85°C$
Supply Voltage Range	$\pm5.0V \le V_S \le \pm22V$

Electrical Characteristics

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

Symbol	Parameter	Conditions	LME49871		Units (Limits)
			Typical (Note 6)	Limit (Note 7)	
THD+N	Total Harmonic Distortion + Noise	$A_V = 1$, f = 1kHz, $R_F = 1.2k\Omega$ $R_L = 100\Omega$, $V_{OUT} = 3V_{RMS}$ $R_L = 600\Omega$, $V_{OUT} = 1.4V_{RMS}$	0.00021 0.00012		% %
IMD	Intermodulation Distortion	$A_V = 1$, $V_{IN} = 3V_{RMS}$ Two-tone, 60Hz & 7kHz 4:1	0.00009		%
BW	Bandwidth	$A_V = -1$, $R_F = 800\Omega$	213		MHz
SR	Slew Rate	$V_{OUT} = 20V_{P-P}$, $A_V = -5$	±1900		V/μs
FPBW	Full Power Bandwidth	$V_{OUT} = 20V_{P-P}$, −3dB referenced to output magnitude at f = 1kHz, $A_V = 1$	30		MHz
t_s	Settling Time	$A_V = -1$, 10V step, 0.1% error range	50		ns
e_n	Equivalent Input Noise Voltage	f_{BW} = 20Hz to 20kHz	0.26	0.6	μV_{RMS} (max)
	Equivalent Input Noise Density	f = 1kHz f = 10Hz	1.9 11.5	4.0	$nV/\sqrt{Hz}$ (max)
i_n	Current Noise Density	f = 1kHz f = 10Hz	16 160		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
V_{OS}	Input Offset Voltage		±0.05	±1.0	mV (max)
$\Delta V_{OS}/\Delta Temp$	Average Input Offset Voltage Drift vs Temperature	$-40°C \le T_A \le 85°C$	0.29		μV/°C
PSRR	Average Input Offset Voltage Shift vs Power Supply Voltage	$V_S = \pm22V$, $\Delta V_S = 30V$ (Note 8)	102	100	dB (min)
I_B	Input Bias Current	$V_{CM} = 0V$	1.8	6	μA (max)
$\Delta I_{OS}/\Delta Temp$	Input Bias Current Drift vs Temperature	$-40°C \le T_A \le 85°C$ Inverting input Non-inverting input	4.5 4.7		nA/°C nA/°C
I_{OS}	Input Offset Current	$V_{CM} = 0V$	1.3	5	μA (max)
V_{IN-CM}	Common-Mode Input Voltage Range	$V_S = \pm22V$	±20.5	(V+) – 1.0 (V-) + 1.0	V (min) V (min)
CMRR	Common-Mode Rejection	$-10V \le V_{CM} \le 10V$	90	86	dB (min)
Z_{IN}	Non-inverting-input Input Impedance	$-10V \le V_{CM} \le 10V$	1.2		MΩ
	Inverting-input Input Impedance	$-10V \le V_{CM} \le 10V$	58		Ω
Z_T	Transimpedance	$V_{OUT} = \pm10V$ $R_L = 200\Omega$ $R_L = \infty$	4.2 4.7	2.0 2.65	MΩ (min) MΩ (min)

Symbol	Parameter	Conditions	LME49871		Units (Limits)
			Typical	Limit	
			(Note 6)	(Note 7)	
V_{OUTMAX}	Maximum Output Voltage Swing	R_L = 150Ω	±18.6	±17.6	V (min)
		R_L = 600Ω	±19.4	±18.4	V (min)
I_{OUT}	Output Current	R_L = 150Ω, V_S = ±22V	±100	±93	mA (min)
I_{OUT-CC}	Instantaneous Short Circuit Current		±140		mA
R_{OUT}	Output Resistance	f_{IN} = 5MHz Open-Loop	10		Ω
I_S	Total Quiescent Current	I_{OUT} = 0mA	8.3	9.5	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: Amplifier output connected to GND, any number of amplifiers within a package.

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

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

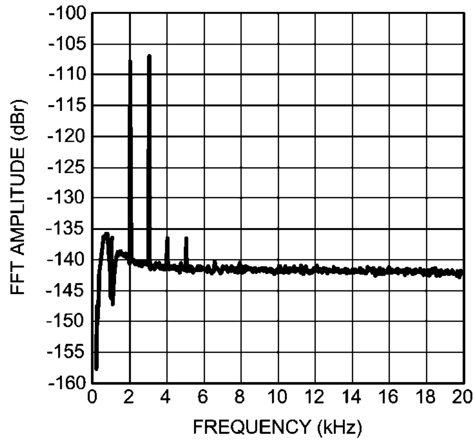
Note 6: Typical values represent most likely parametric norms at T_A = +25ºC, and at the *Recommended Operation Conditions* at the time of product characterization and are not guaranteed.

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, ±7V and ±22V. PSRR = | $20\log(\Delta V_{OS}/\Delta V_S)$ |.

Typical Performance Characteristics

FFT of 1kHz Sinewave, 0dBr Input Magnitude
V_{OUT} = 3V_{RMS}, R_L = 1kΩ, V_S = ±15V, A_V = 1



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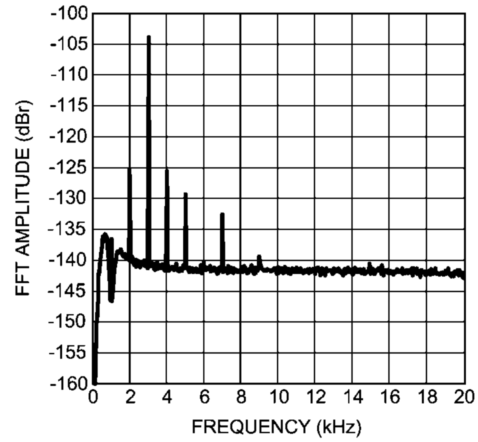
FFT of 1kHz Sinewave, 0dBr Input Magnitude
V_{OUT} = 3V_{RMS}, R_L = 100Ω, V_S = ±15V, A_V = 1



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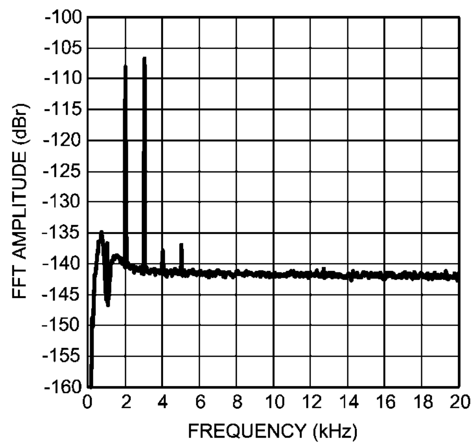
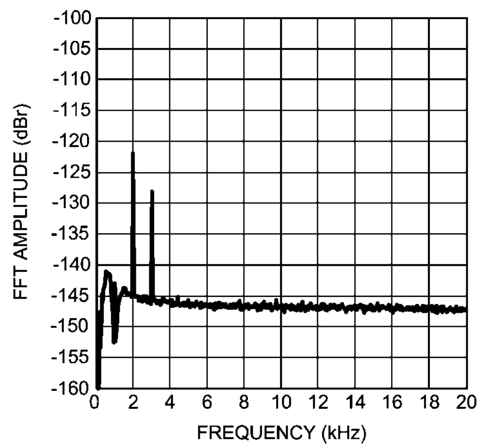
FFT of 1kHz Sinewave, 0dBr Input Magnitude
V_{OUT} = 3V_{RMS}, R_L = 600Ω, V_S = ±15V, A_V = 1



30042621

FFT of 1kHz Sinewave, 0dBr Input Magnitude
V_{OUT} = 1.4V_{RMS}, R_L = 1kΩ, V_S = ±15V, A_V = 1



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FFT of 1kHz Sinewave, 0dBr Input Magnitude
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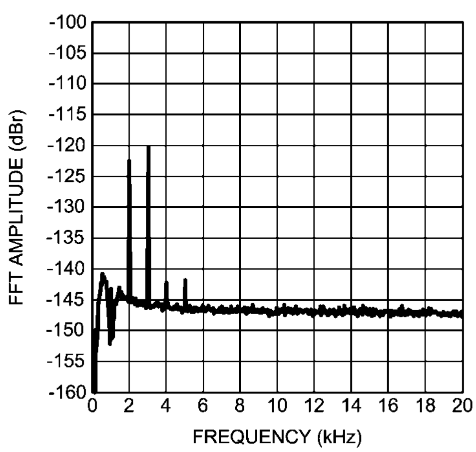

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FFT of 1kHz Sinewave, 0dBr Input Magnitude
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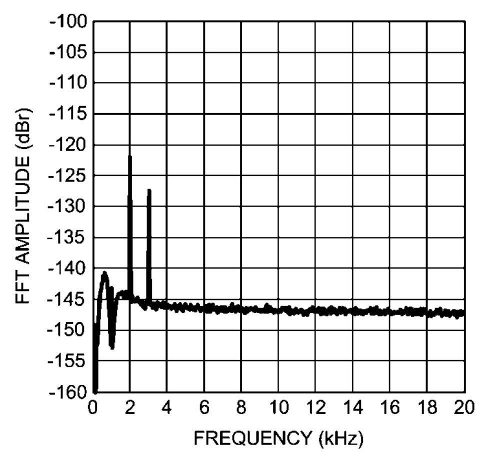

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FFT of 1kHz Sinewave, 0dBr Input Magnitude
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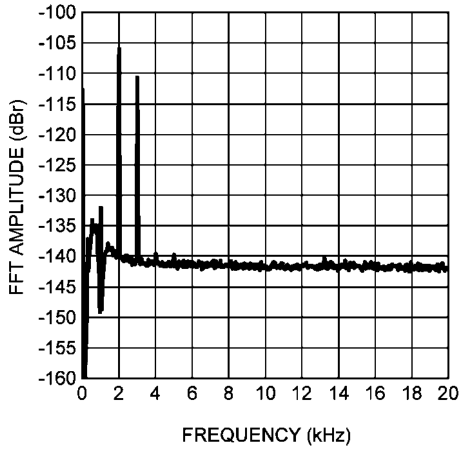

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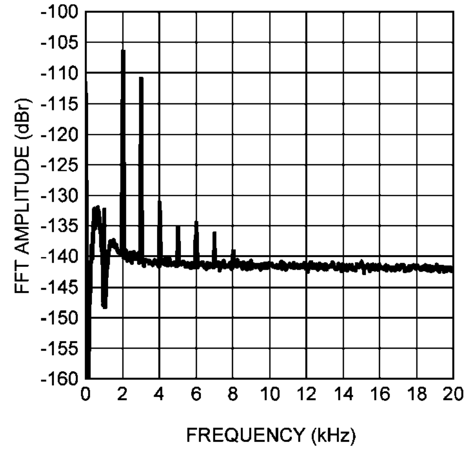

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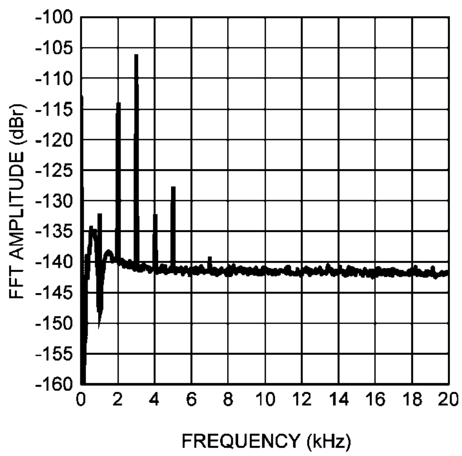

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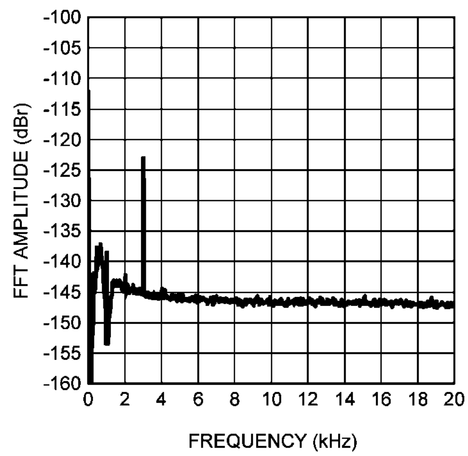

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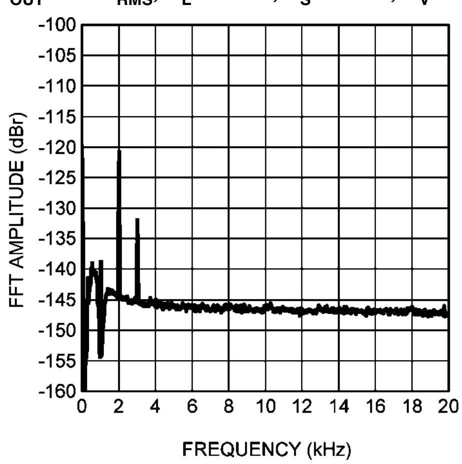

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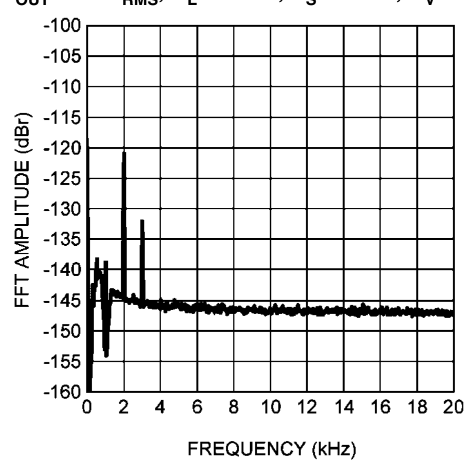

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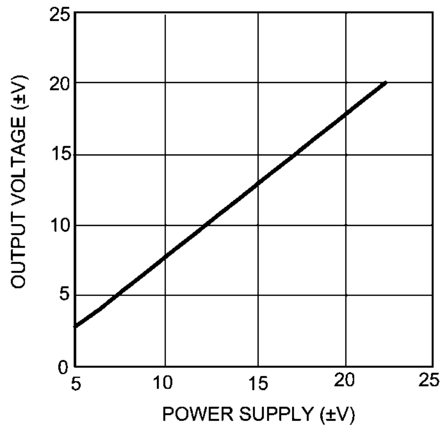
Output Voltage vs Supply Voltage
A_V = 1, R_L = 600Ω, 1% THD+N



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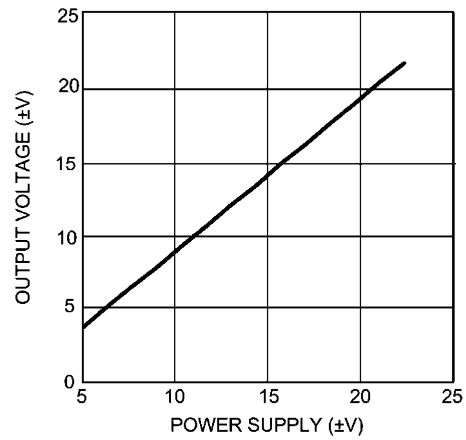
Output Voltage vs Supply Voltage
A_V = 1, R_L = open, 1% THD+N



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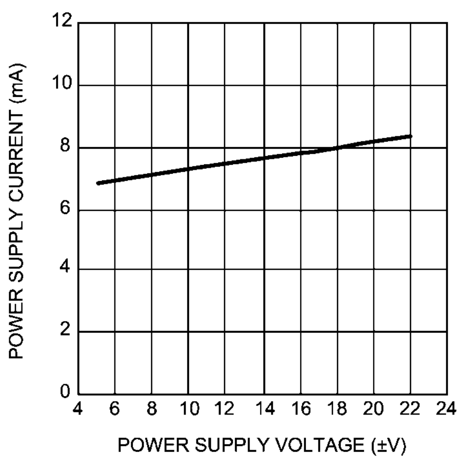
Supply Current (I_{CC}) vs Power Supply
R_L = open



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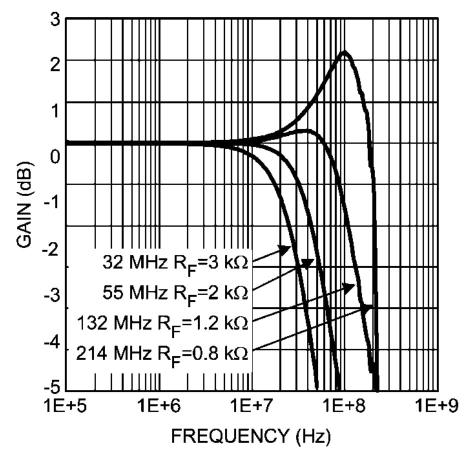
Gain vs Frequency
V_S = ±15V, G = –1



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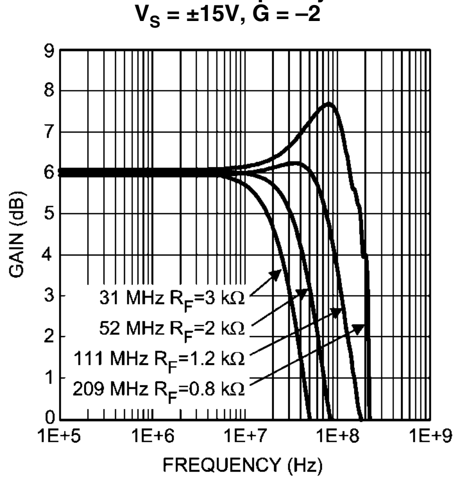
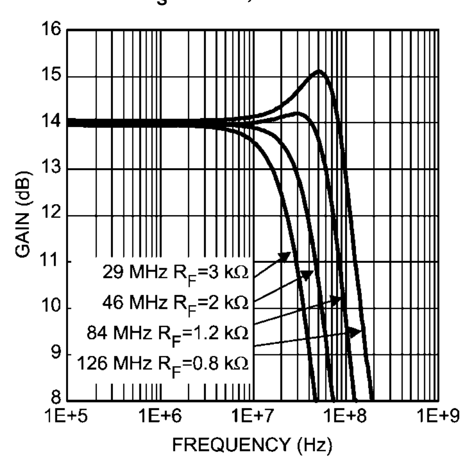
Gain vs Frequency
V_S = ±15V, G = –2



30042605

Gain vs Frequency
V_S = ±15V, G = –5



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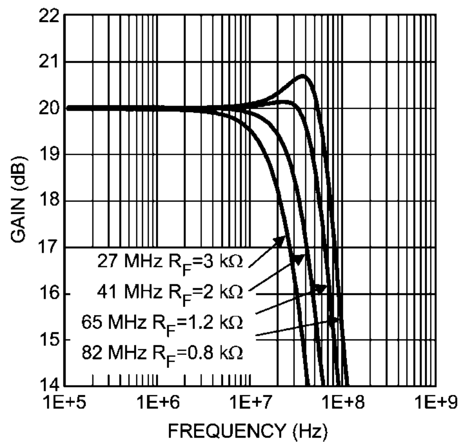
Gain vs Frequency
V_S = ±15V, G = –10



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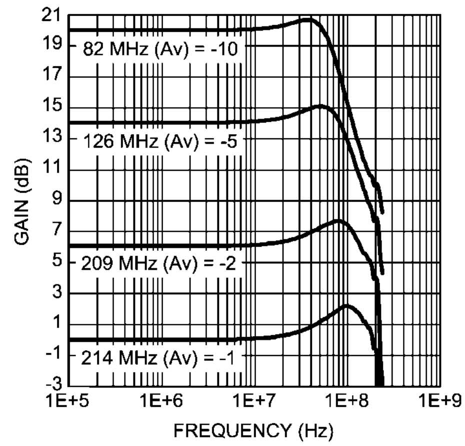
Gain vs Frequency
V_S = ±15V, R_F = 800Ω



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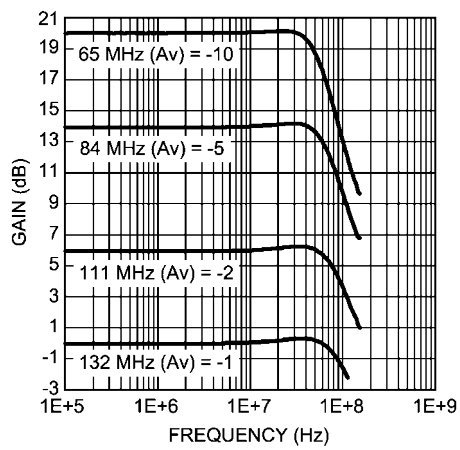
Gain vs Frequency
V_S = ±15V, R_F = 1.2kΩ



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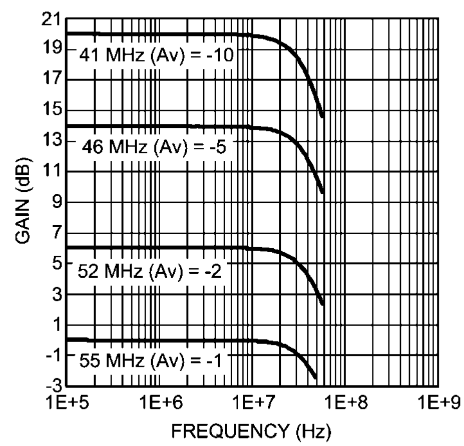
Gain vs Frequency
V_S = ±15V, R_F = 2kΩ



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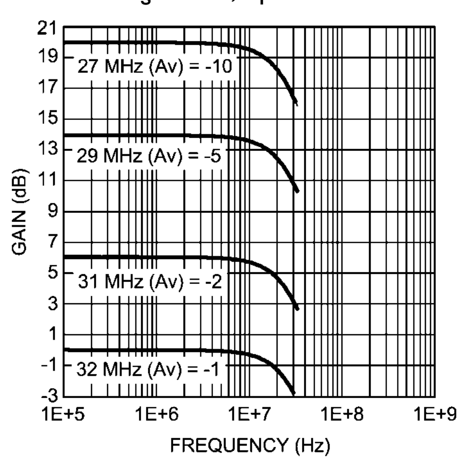
Gain vs Frequency
V_S = ±15V, R_F = 3kΩ



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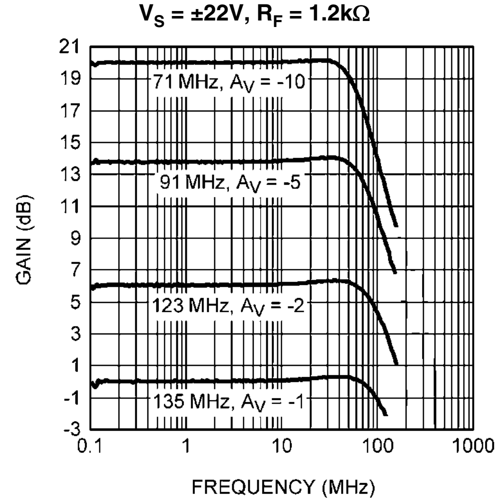
Gain vs Frequency
V_S = ±22V, R_F = 1.2kΩ



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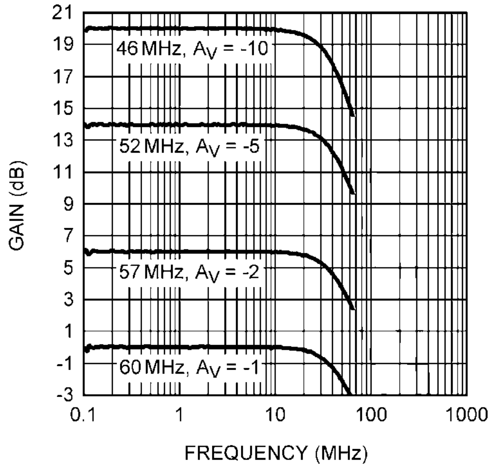
Gain vs Frequency
V_S = ±22V, R_F = 2kΩ



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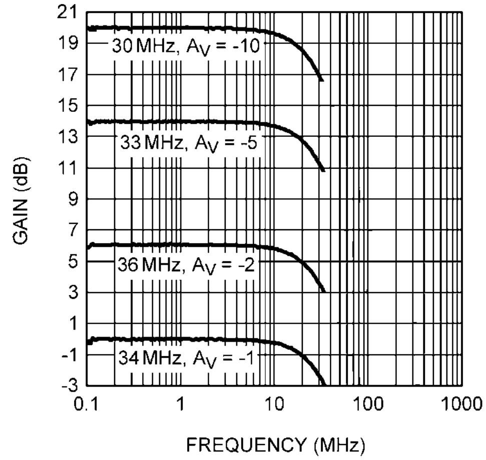
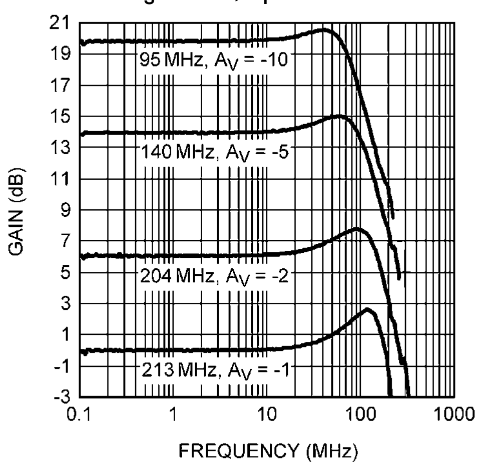
Gain vs Frequency
V_S = ±22V, R_F = 3kΩ



30042685

Gain vs Frequency
V_S = ±22V, R_F = 800Ω



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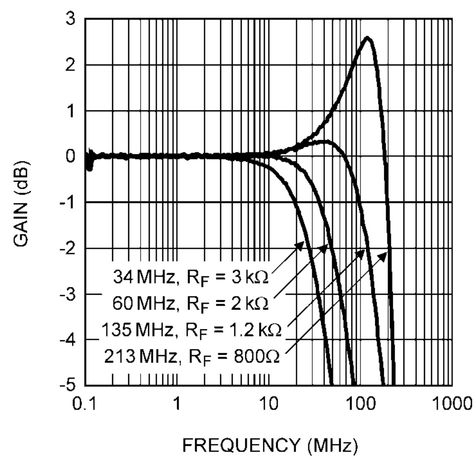
Gain vs Frequency
V_S = ±22V, A_V = –1



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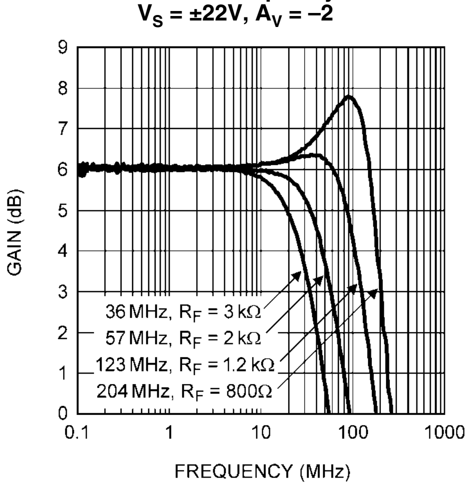
Gain vs Frequency
V_S = ±22V, A_V = –2



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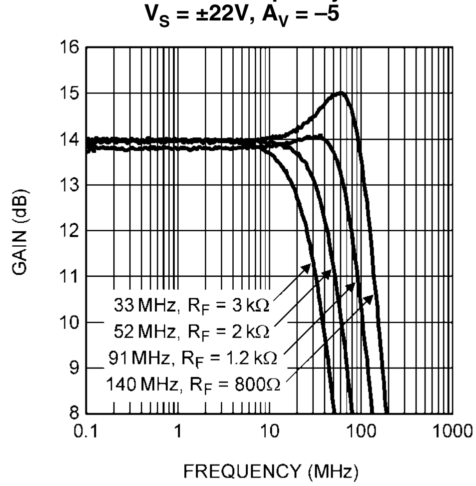
Gain vs Frequency
V_S = ±22V, A_V = –5



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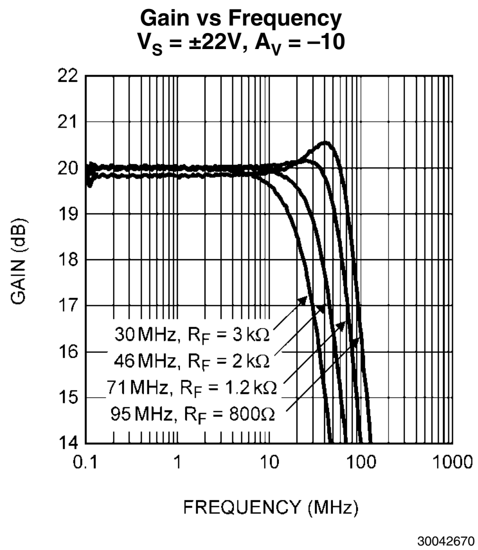

Gain vs Frequency
V_S = ±22V, A_V = –10
GAIN (dB)
FREQUENCY (MHz)
30 MHz, R_F = 3 kΩ
46 MHz, R_F = 2 kΩ
71 MHz, R_F = 1.2 kΩ
95 MHz, R_F = 800Ω
22
21
20
19
18
17
16
15
14
0.1
1
10
100
1000
30042670

Application Information

GENERAL AMPLIFIER FUNCTION

oltage feedback amplifiers have a small-signal bandwidth that is a function of the closed-loop gain. Conversely, the LME49871 current feedback amplifier features a small-signal bandwidth that is relatively independent of the closed-loop gain. This is shown in *Figure 1* where the LME49871's gain is –1,–2, –5 and –10. Like all current feedback amplifiers, the LME49871's closed-loop bandwidth is a function of the feedback resistance value. Therefore, R_s must be varied to select the desired closed-loop gain.

POWER SUPPLY BYPASSING AND LAYOUT CONSIDERATIONS

Properly placed and correctly valued supply bypassing is essential for optimized high-speed amplifier operation. The supply bypassing must maintain a wideband, low-impedance capacitive connection between the amplifier's supply pin and ground. This helps preserve high speed signal and fast transient fidelity. The bypassing is easily accomplished using a parallel combination of a 10μF tantalum and a 0.1μF ceramic capacitors for each power supply pin. The bypass capacitors should be placed as close to the amplifier power supply pins as possible.

FEEDBACK RESISTOR SELECTION (R_f)

The value of the R_f, is also a dominant factor in compensating the LME49871. For general applications, the LME49871 will maintain specified performance with an 1.2kΩ feedback resistor. Although this value will provide good results for most applications, it may be advantageous to adjust this value slightly for best pulse response optimized for the desired bandwidth. In addition to reducing bandwidth, increasing the feedback resistor value also reduces overshoot in the time domain response.

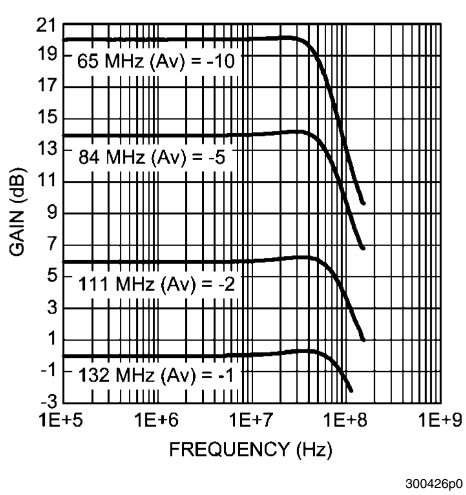


FIGURE 1. Bandwidth as a function of gain

SLEW RATE CONSIDERATIONS

A current feedback amplifier's slew rate characteristics are different than that of voltage feedback amplifiers. A voltage feedback amplifier's slew rate limiting or non-linear amplifier behavior is dominated by the finite availability of the first stage tail current charging the second stage voltage amplifier's compensation capacitor. Conversely, a current feedback amplifier's slew rate is not constant. Transient current at the inverting input determines slew rate for both inverting and non-inverting gains. The non-inverting configuration slew rate is also determined by input stage limitations. Accordingly, variations of slew rates occur for different circuit topologies.

DRIVING CAPACITIVE LOADS

The LME49871 can drive significantly higher capacitive loads than many current feedback amplifiers. Although the LME49871 can directly drive as much as 100pF without oscillating, the resulting response will be a function of the feedback resistor value.

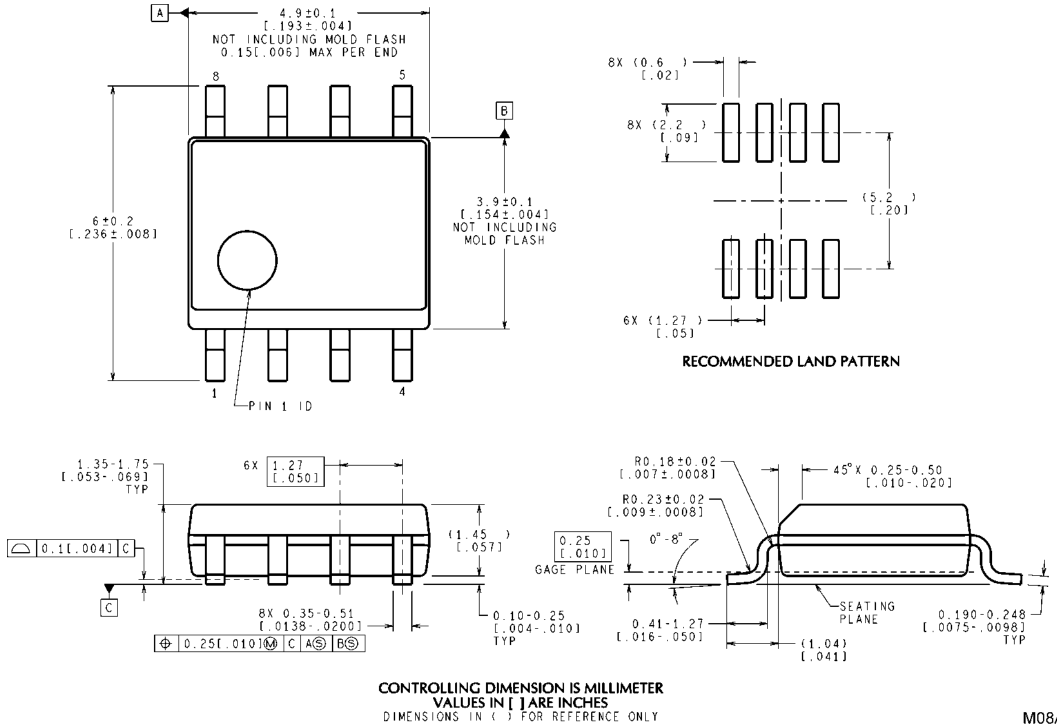
CAPACITIVE FEEDBACK

It is quite common to place a small lead-compensation capacitor in parallel with a voltage feedback amplifier's feedback resistance, R_f. This compensation reduces the amplifier's peaking in the frequency domain and damps the transient response. Whereas this yields the expected results when used with voltage feedback amplifiers, this technique must not be used with current feedback amplifiers. The dynamic impedance of capacitors in the feedback loop reduces the amplifier's stability. Instead, reduced peaking in the frequency response and bandwidth limiting can be accomplished by adding an RC circuit to the amplifier's input.

Revision History

Rev	Date	Description
1.0	04/24/08	Initial release.
1.01	04/28/08	Changed the Limit values on V_{IN-CM} from –2.0 and +2.0 to –1.0 and +1.0.

Physical Dimensions inches (millimeters) unless otherwise noted



M08A (Rev L)

SOIC Package
Order Number LME49871MA
NS Package Number M08A

Notes

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