ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V$^+$ to V$^-$) 36V
Differential Input Voltage .... ±6V
Input Voltage .... ±V$_S$
Output Short-Circuit Duration (Note 1) .... Indefinite
Operating Temperature Range
    LT1208C/LT1209C .... −40°C to 85°C

Maximum Junction Temperature
    Plastic Package .... 150°C
Storage Temperature Range .... − 65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW

OUT A [1]   [8] V$^+$
−IN A [2] A [7] OUT B
+IN A [3]   [6] −IN B
V$^-$ [4] B [5] +IN B

N8 PACKAGE
8-LEAD PLASTIC DIP

T$_{JMAX}$ = 150°C, θ$_{JA}$ = 100°C/W

ORDER PART NUMBER

LT1208CN8

CONTACT FACTORY FOR MILITARY/883B PARTS

TOP VIEW

OUT A [1]   [8] V$^+$
−IN A [2] A [7] OUT B
+IN A [3]   [6] −IN B
V$^-$ [4] B [5] +IN B

S8 PACKAGE
8-LEAD PLASTIC SOIC

T$_{JMAX}$ = 150°C, θ$_{JA}$ = 150°C/W

ORDER PART NUMBER

LT1208CS8

S8 PART MARKING

1208

TOP VIEW

OUT A [1]   [14] OUT D
−IN A [2] A D [13] −IN D
+IN A [3]   [12] +IN D
V$^+$ [4]   [11] V$^-$
+IN B [5]   [10] +IN C
−IN B [6] B C [9] −IN C
OUT B [7]   [8] OUT C

N PACKAGE
14-LEAD PLASTIC DIP

T$_{JMAX}$ = 150°C, θ$_{JA}$ = 70°C/W

ORDER PART NUMBER

LT1209CN

TOP VIEW

OUT A [1]   [16] OUT D
−IN A [2] A D [15] −IN D
+IN A [3]   [14] +IN D
V$^+$ [4]   [13] V$^-$
+IN B [5]   [12] +IN C
−IN B [6] B C [11] −IN C
OUT B [7]   [10] OUT C
NC [8]   [9] NC

S PACKAGE
16-LEAD PLASTIC SOIC

T$_{JMAX}$ = 150°C, θ$_{JA}$ = 100°C/W

ORDER PART NUMBER

LT1209CS

ELECTRICAL CHARACTERISTICS

V$_S$ = ±15V, T$_A$ = 25°C, R$_L$ = 1k, V$_{CM}$ = 0V, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V$_{OS}$	Input Offset Voltage	V$_S$ = ±5V (Note 2)			0.5	3.0	mV
		0°C to 70°C	●			4.0	mV
		V$_S$ = ±15V (Note 2)			1.0	5.0	mV
		0°C to 70°C	●			6.0	mV
	Input V$_{OS}$ Drift				25		μV/°C
I$_{OS}$	Input Offset Current	V$_S$ = ±5V and V$_S$ = ±15V			100	400	nA
		0°C to 70°C	●			600	nA
I$_B$	Input Bias Current	V$_S$ = ±5V and V$_S$ = ±15V			4	8	μA
		0°C to 70°C	●			9	μA
e$_n$	Input Noise Voltage	f = 10kHz			22		nV/$\sqrt{Hz}$
i$_n$	Input Noise Current	f = 10kHz			1.1		pA/$\sqrt{Hz}$

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $T_A = 25°C$, $R_L = 1k$, $V_{CM} = 0V$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
R_{IN}	Input Resistance	$V_{CM} = \pm12V$		20	40		$M\Omega$
		Differential			250		$k\Omega$
C_{IN}	Input Capacitance				2		pF
CMRR	Common-Mode Rejection Ratio	$V_S = \pm15V$, $V_{CM} = \pm12V$; $V_S = \pm5V$,		86	98		dB
		$V_{CM} = \pm2.5V$, 0°C to 70°C	●	83			dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm5V$ to $\pm15V$		76	84		dB
		0°C to 70°C	●	75			dB
	Input Voltage Range	$V_S = \pm15V$		±12	±13		V
		$V_S = \pm5V$		±2.5	±3		V
A_{VOL}	Large-Signal Voltage Gain	$V_S = \pm15V$, $V_{OUT} = \pm10V$, $R_L = 500\Omega$		3.3	7		V/mV
		0°C to 70°C	●	2.5			V/mV
		$V_S = \pm5V$, $V_{OUT} = \pm2.5V$, $R_L = 500\Omega$		2.5	7		V/mV
		0°C to 70°C	●	2.0			V/mV
		$V_S = \pm5V$, $V_{OUT} = \pm2.5V$, $R_L = 150\Omega$			3		V/mV
V_{OUT}	Output Swing	$V_S = \pm15V$, $R_L = 500\Omega$, 0°C to 70°C	●	12.0	13.3		$\pm V$
		$V_S = \pm5V$, $R_L = 150\Omega$, 0°C to 70°C	●	3.0	3.3		$\pm V$
I_{OUT}	Output Current	$V_S = \pm15V$, $V_{OUT} = \pm12V$, 0°C to 70°C	●	24	40		mA
		$V_S = \pm5V$, $V_{OUT} = \pm3V$, 0°C to 70°C	●	20	40		mA
SR	Slew Rate	$V_S = \pm15V$, $A_{VCL} = -2$, (Note 3)		250	400		V/μs
		0°C to 70°C	●	200			V/μs
		$V_S = \pm5V$, $A_{VCL} = -2$, (Note 3)		150	250		V/μs
		0°C to 70°C	●	130			V/μs
	Full Power Bandwidth	10V Peak, (Note 4)			6.4		MHz
GBW	Gain-Bandwidth	$V_S = \pm15V$, f = 1MHz			45		MHz
		$V_S = \pm5V$, f = 1MHz			34		MHz
t_r, t_f	Rise Time, Fall Time	$V_S = \pm15V$, $A_{VCL} = 1$, 10% to 90%, 0.1V			5		ns
		$V_S = \pm5V$, $A_{VCL} = 1$, 10% to 90%, 0.1V			7		ns
	Overshoot	$V_S = \pm15V$, $A_{VCL} = 1$, 0.1V			30		%
		$V_S = \pm5V$, $A_{VCL} = 1$, 0.1V			20		%
	Propagation Delay	$V_S = \pm15V$, 50% V_{IN} to 50% V_{OUT}			5		ns
		$V_S = \pm5V$, 50% V_{IN} to 50% V_{OUT}			7		ns
t_S	Settling Time	$V_S = \pm15V$, 10V Step, $V_S = \pm5V$, 5V Step, 0.1%			90		ns
	Differential Gain	f = 3.58MHz, $R_L = 150\Omega$			1.30		%
		f = 3.58MHz, $R_L = 1k$			0.09		%
	Differential Phase	f = 3.58MHz, $R_L = 150\Omega$			1.8		Deg
		f = 3.58MHz, $R_L = 1k$			0.1		Deg
R_O	Output Resistance	$A_{VCL} = 1$, f = 1MHz			2.5		Ω
	Crosstalk	$V_{OUT} = \pm10V$, $R_L = 500\Omega$			-100	-94	dB
I_S	Supply Current	Each Amplifier, $V_S = \pm5V$ and $V_S = \pm15V$			7	9	mA
		0°C to 70°C	●			10.5	mA

The ● denotes the specifications which apply over the full operating temperature range.

Note 1: A heat sink may be required to keep the junction temperature below absolute maximum when the output is shorted indefinitely.

Note 2: Input offset voltage is tested with automated test equipment and is exclusive of warm-up drift.

Note 3: Slew rate is measured in a gain of −2. For $\pm15V$ supplies measure between $\pm10V$ on the output with $\pm6V$ on the input. For $\pm5V$ supplies measure between $\pm2V$ on the output with $\pm1.75V$ on the input.

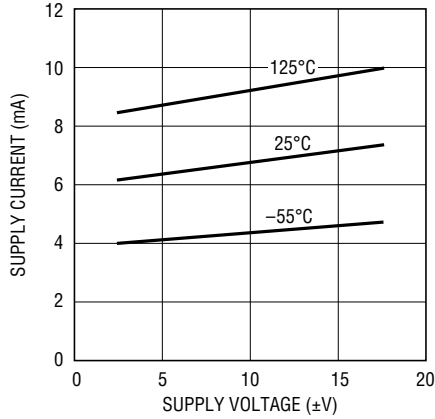**Note 4:** Full power bandwidth is calculated from the slew rate measurement: $FPBW = SR/2\pi V_P$.

3

TYPICAL PERFORMANCE CHARACTERISTICS
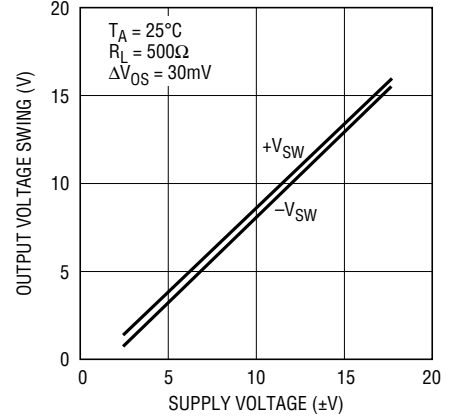
Input Common-Mode Range vs Supply Voltage

$T_A = 25°C$
$\Delta V_{OS} < 1mV$

$+V_{CM}$ $-V_{CM}$

MAGNITUDE OF INPUT VOLTAGE (V)
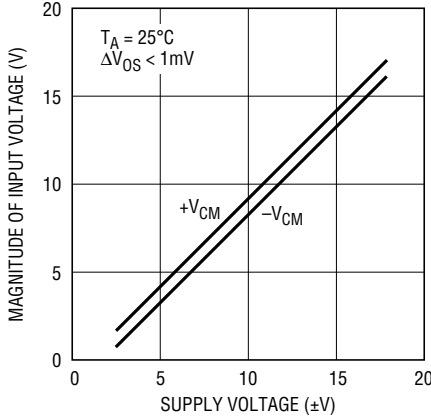
SUPPLY VOLTAGE (±V)

1208/09 G01

Supply Current vs Supply Voltage and Temperature

125°C

25°C

−55°C

SUPPLY CURRENT (mA)

SUPPLY VOLTAGE (±V)

1208/09 G02

Output Voltage Swing vs Supply Voltage

$T_A = 25°C$
$R_L = 500\Omega$
$\Delta V_{OS} = 30mV$

$+V_{SW}$

$-V_{SW}$

OUTPUT VOLTAGE SWING (V)

SUPPLY VOLTAGE (±V)

1208/09 G03

Output Voltage Swing vs Resistive Load

$T_A = 25°C$
$\Delta V_{OS} = 30mV$

$V_S = ±15V$

$V_S = ±5V$

OUTPUT VOLTAGE SWING (V_P-P)

LOAD RESISTANCE (Ω)
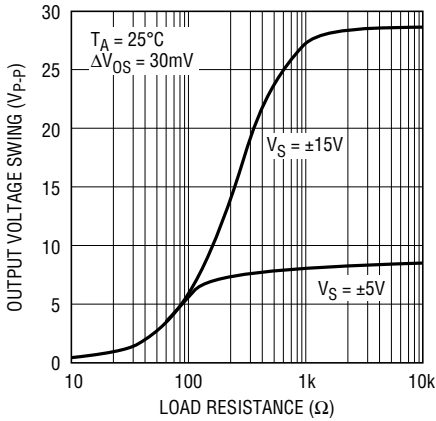
1208/09 G04

Input Bias Current vs Input Common-Mode Voltage

$V_S = ±15V$
$T_A = 25°C$

$I_B = \dfrac{I_B^+ + I_B^-}{2}$

INPUT BIAS CURRENT (μA)

INPUT COMMON-MODE VOLTAGE (V)
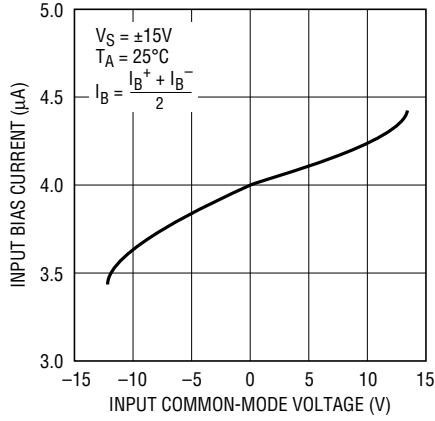
1208/09 G05

Open-Loop Gain vs Resistive Load

$T_A = 25°C$

$V_S = ±15V$

$V_S = ±5V$

OPEN-LOOP GAIN (dB)

LOAD RESISTANCE (Ω)
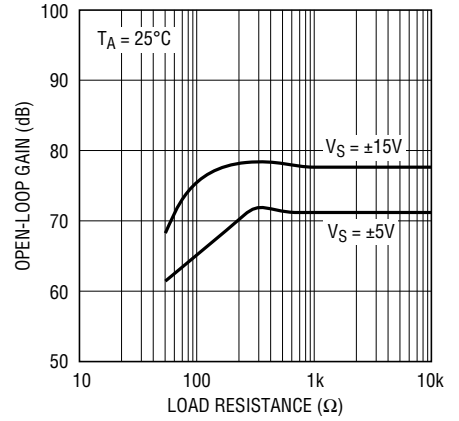
1208/09 G06

Input Bias Current vs Temperature

$V_S = ±15V$

$I_B = \dfrac{I_B^+ + I_B^-}{2}$

INPUT BIAS CURRENT (μA)
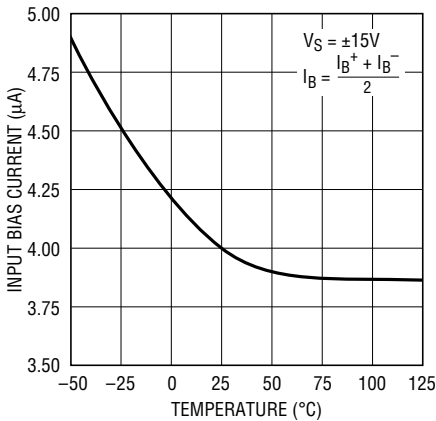
TEMPERATURE (°C)

1208/09 G07

Output Short-Circuit Current vs Temperature

$V_S = ±5V$

SOURCE SINK

OUTPUT SHORT-CIRCUIT CURRENT (mA)

TEMPERATURE (°C)
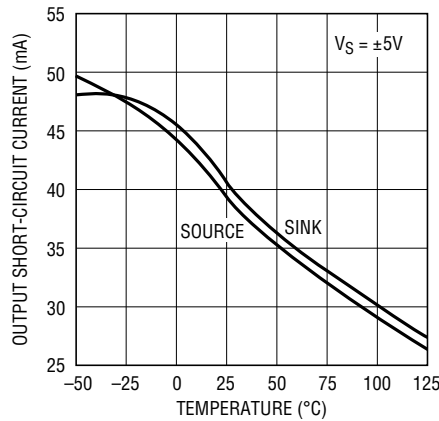
1208/09 G08

Input Noise Spectral Density

$V_S = ±15V$
$T_A = 25°C$
$A_V = 101$
$R_S = 100k$

i_n

e_n

INPUT VOLTAGE NOISE (nV/√Hz)

INPUT CURRENT NOISE (pA/√Hz)
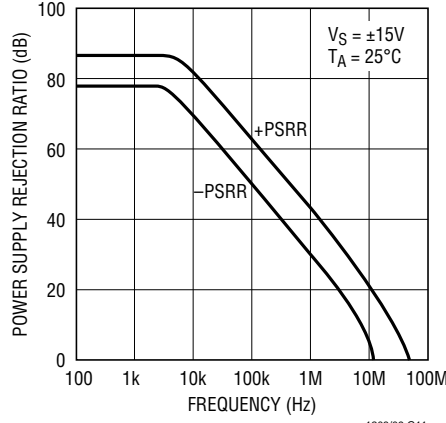
FREQUENCY (Hz)

1208/09 G09

4
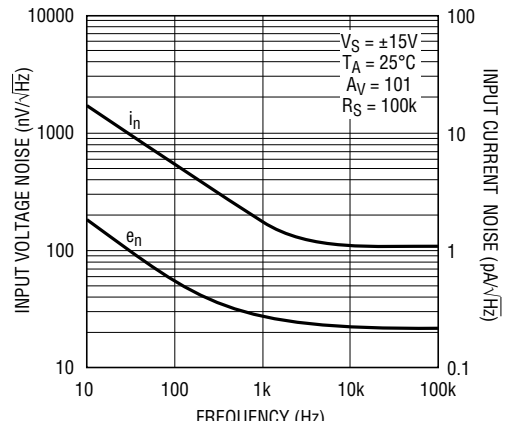
TYPICAL PERFORMANCE CHARACTERISTICS

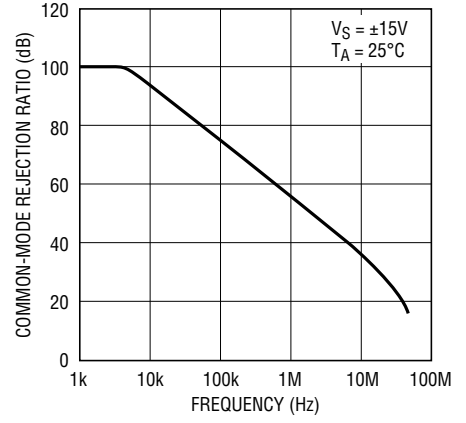**Crosstalk vs Frequency**
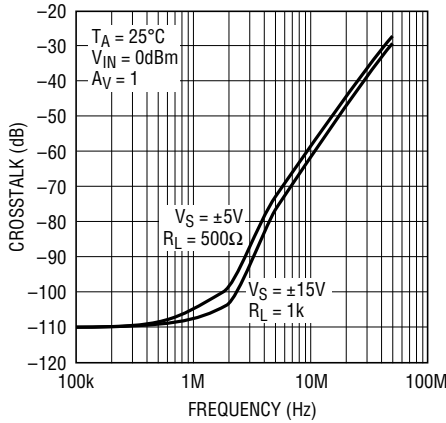
1208/09 G10

Power Supply Rejection Ratio vs Frequency
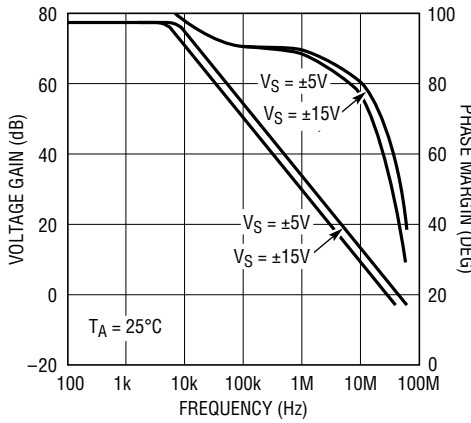

1208/09 G11
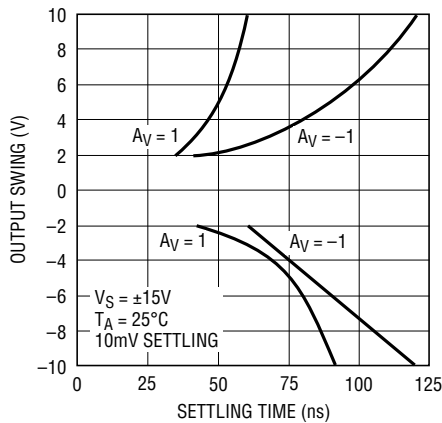
Common-Mode Rejection Ratio vs Frequency

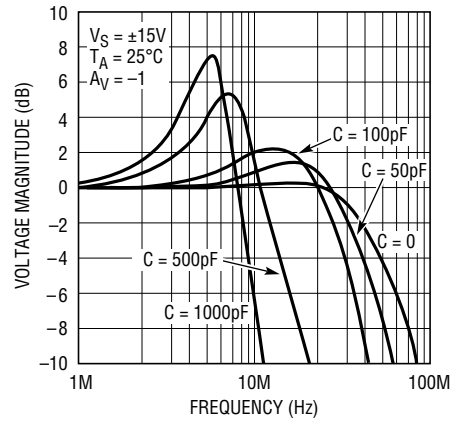1208/09 G12

Voltage Gain and Phase vs Frequency

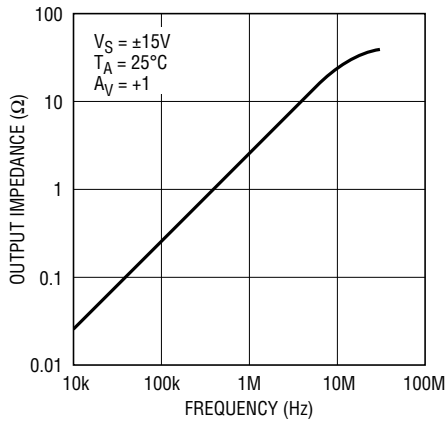1208/09 B13

Output Swing vs Settling Time

1208/09 G14

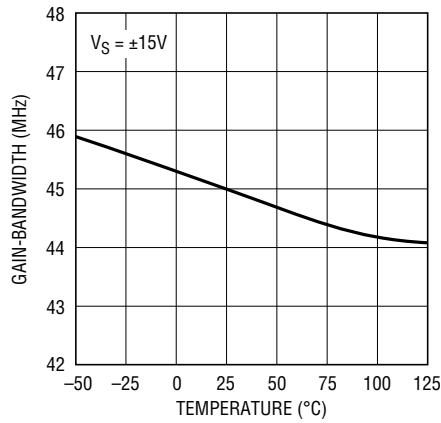**Frequency Response vs Capacitive Load**
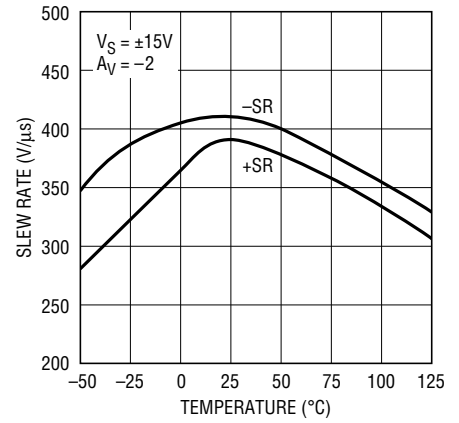

1208/09 G15

Closed-Loop Output Impedance vs Frequency

1208/09 G16

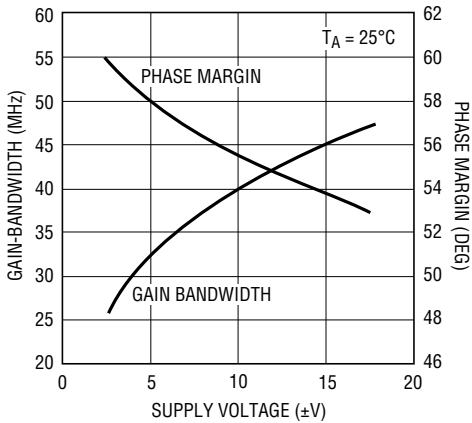**Gain-Bandwidth vs Temperature**

1208/09 G17

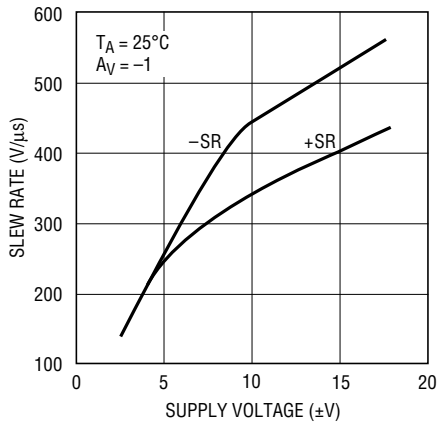**Slew Rate vs Temperature**

1208/09 G18

TYPICAL PERFORMANCE CHARACTERISTICS
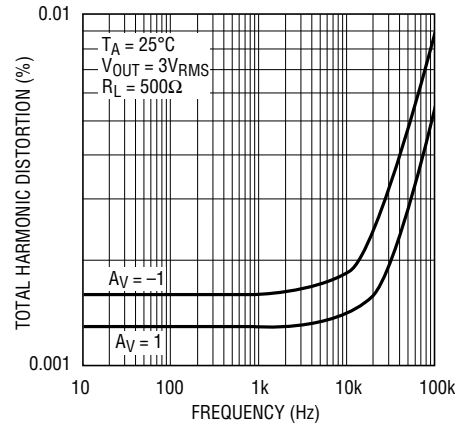
**Gain-Bandwidth and Phase Margin
vs Supply Voltage**

1208/09 G19

Slew Rate vs Supply Voltage

1208/09 G20

**Total Harmonic Distortion
vs Frequency**

1208/09 G21

APPLICATIONS INFORMATION

Layout and Passive Components

As with any high speed operational amplifier, care must be taken in board layout in order to obtain maximum performance. Key layout issues include: use of a ground plane, minimization of stray capacitance at the input pins, short lead lengths, RF-quality bypass capacitors located close to the device (typically $0.01\mu F$ to $0.1\mu F$), and use of low ESR bypass capacitors for high drive current applications (typically $1\mu F$ to $10\mu F$ tantalum). Sockets should be avoided when maximum frequency performance is required, although low profile sockets can provide reasonable performance up to 50MHz. For more details see Design Note 50. The parallel combination of the feedback resistor and gain setting resistor on the inverting input combine with the input capacitance to form a pole which can cause peaking. If feedback resistors greater than 5k are used, a parallel capacitor of value
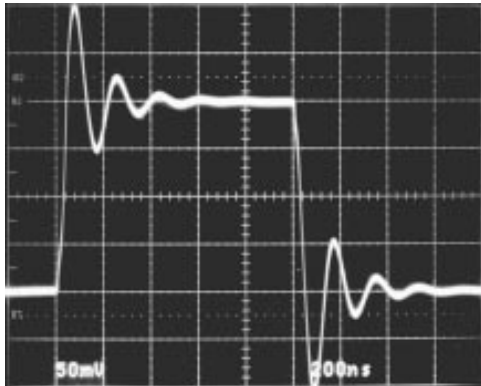
$$C_F \geq R_G \times C_{IN}/R_F$$

should be used to cancel the input pole and optimize dynamic performance. For unity-gain applications where a large feedback resistor is used, C_F should be greater than or equal to C_{IN}.

Capacitive Loading

The LT1208/LT1209 amplifiers are stable with capacitive loads. This is accomplished by sensing the load induced output pole and adding compensation at the amplifier gain node. As the capacitive load increases, both the bandwidth and phase margin decrease so there will be peaking in the frequency domain and in the transient response. The photo of the small-signal response with 1000pF load shows 50% peaking. The large-signal response with a 10,000pF load shows the output slew rate being limited by the short-circuit current. To reduce peaking with capacitive loads, insert a small decoupling resistor between the output and the load, and add a capacitor between the output and inverting input to provide an AC feedback path. Coaxial cable can be driven directly, but for best pulse fidelity the cable should be doubly terminated with a resistor in series with the output.

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APPLICATIONS INFORMATION
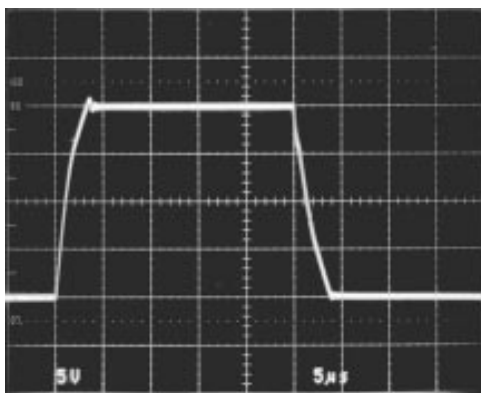
Small-Signal Capacitive Loading

$A_V = -1$
$C_L = 1000pF$

1208/09 AI01

Large-Signal Capacitive Loading

$A_V = 1$
$C_L = 10,000pF$

1208/09 AI02

Input Considerations

Resistors in series with the inputs are recommended for the LT1208/LT1209 in applications where the differential input voltage exceeds ±6V continuously or on a transient basis. An example would be in noninverting configurations with high input slew rates or when driving heavy capacitive loads. The use of balanced source resistance at each input is recommended for applications where DC accuracy must be maximized.

Transient Response

The LT1208/LT1209 gain-bandwidth is 45MHz when measured at 100kHz. The actual frequency response in unity-gain is considerably higher than 45MHz due to peaking

caused by a second pole beyond the unity-gain crossover. This is reflected in the 50° phase margin and shows up as overshoot in the unity-gain small-signal transient response. Higher noise gain configurations exhibit less overshoot as seen in the inverting gain of one response.

The large-signal response in both inverting and noninverting gain show symmetrical slewing characteristics. Normally the noninverting response has a much faster rising edge due to the rapid change in input common-mode voltage which affects the tail current of the input differential pair. Slew enhancement circuitry has been added to the LT1208/LT1209 so that the falling edge slew rate is balanced.
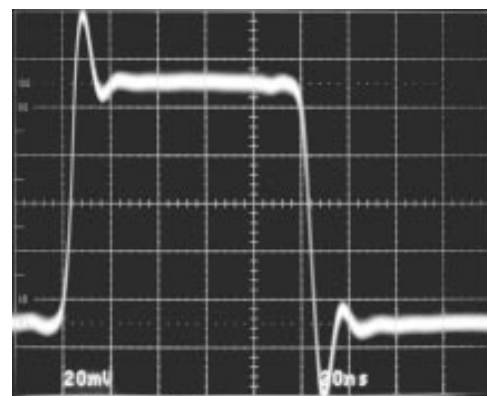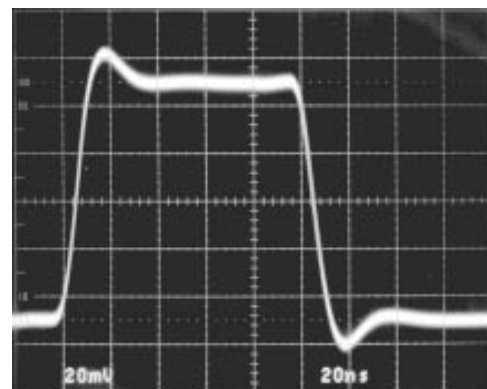
Small-Signal Transient Response

$A_V = 1$

1208/09 AI03
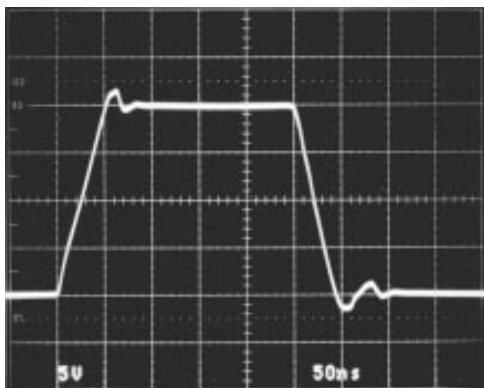
Small-Signal Transient Response

$A_V = -1$

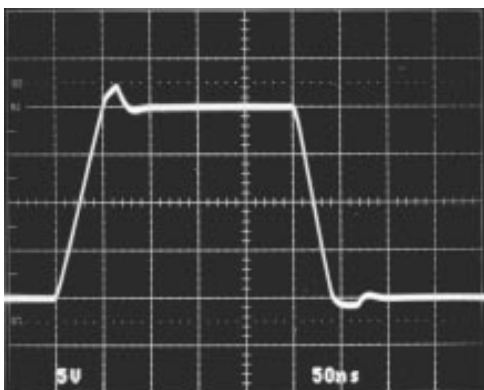1208/09 AI04

APPLICATIONS INFORMATION

Large-Signal Transient Response

$A_V = 1$

1208/09 AI04

Large-Signal Transient Response

$A_V = -1$

1208/09 AI06

Low Voltage Operation

The LT1208/LT1209 are functional at room temperature with only 3V of total supply voltage. Under this condition, however, the undistorted output swing is only $0.8V_{P-P}$. A more realistic condition is operation at ±2.5V supplies (or 5V and ground). Under these conditions, at room temperature, the typical input common-mode range is 1.9V to –1.3V (for a V_{OS} change of 1mV), and a 5MHz, $2V_{P-P}$ sine wave can be faithfully reproduced. With 5V total supply voltage the gain-bandwidth is reduced to 26MHz and the slew rate is reduced to 135V/μs.

Power Dissipation

The LT1208/LT1209 combine high speed and large output current drive in small packages. Because of the wide supply voltage range, it is possible to exceed the maximum junction temperature under certain conditions.

Maximum junction temperature (T_J) is calculated from the ambient temperature (T_A) and power dissipation (P_D) as follows:

LT1208CN8: $T_J = T_A + (P_D \times 100°C/W)$
LT1208CS8: $T_J = T_A + (P_D \times 150°C/W)$
LT1209CN: $T_J = T_A + (P_D \times 70°C/W)$
LT1209CS: $T_J = T_A + (P_D \times 100°C/W)$

Maximum power dissipation occurs at the maximum supply current and when the output voltage is at 1/2 of either supply voltage (or the maximum swing if less than 1/2 supply voltage).

For each amplifier P_{DMAX} is as follows:

$$P_{DMAX} = (V^+ - V^-)(I_{SMAX}) + \frac{(0.5V^+)^2}{R_L}$$

Example: LT1208 in S8 at 70°C, $V_S = \pm10V$, $R_L = 500\Omega$

$$P_{DMAX} = (20V)(10.5mA) + \frac{(5V)^2}{500\Omega} = 260mW$$

$$T_J = 70°C + (2 \times 260mW)(150°C/W) = 148°C$$

DAC Current-to-Voltage Converter

The wide bandwidth, high slew rate and fast settling time of the LT1208/LT1209 make them well-suited for current-to-voltage conversion after current output D/A converters. A typical application with a DAC-08 type converter (full-scale output of 2mA) uses a 5k feedback resistor. A 7pF compensation capacitor across the feedback resistor is used to null the pole at the inverting input caused by the DAC output capacitance. The combination of the LT1208/LT1209 and DAC settles to less than 40mV (1LSB) in 140ns for a 10V step.

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TYPICAL APPLICATIONS

DAC Current-to-Voltage Converter

1 LSB SETTLING = 140ns

1208/09 TA04

Cable Driving

1208/09 TA06
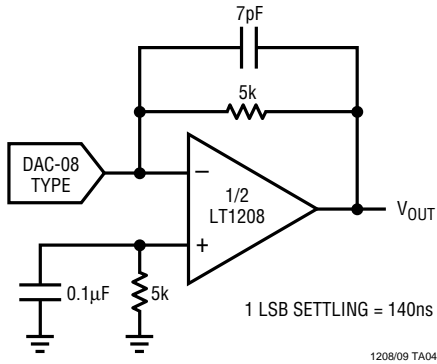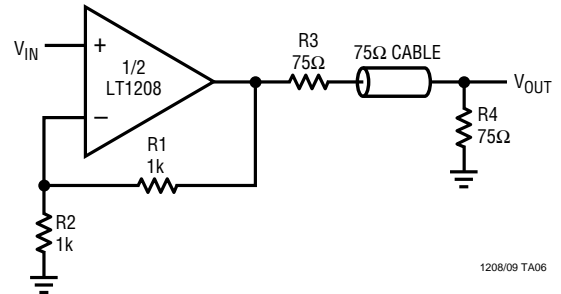
Instrumentation Amplifier

$$A_V = \frac{R4}{R3} \left[1 + \frac{1}{2} \left(\frac{R2}{R1} + \frac{R3}{R4} \right) + \frac{R2 + R3}{R5} \right] = 102$$

TRIM R5 FOR GAIN
TRIM R1 FOR COMMON-MODE REJECTION
BW = 430kHz

1208/09 TA03
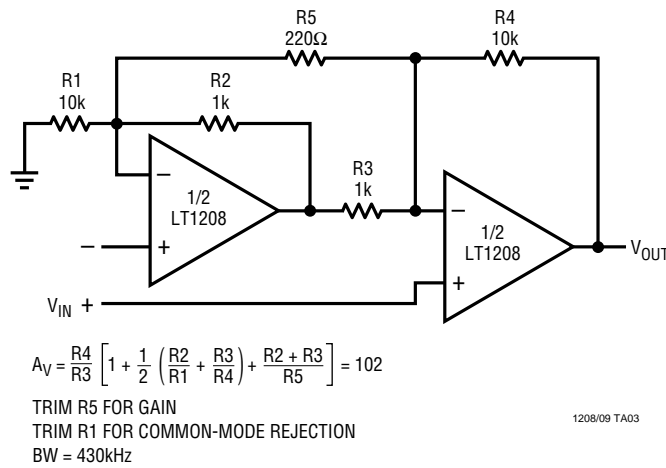
Full-Wave Rectifier

1208/09 TA05
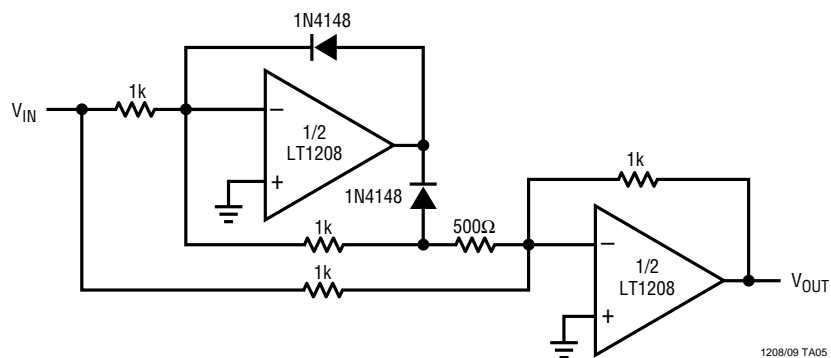
SIMPLIFIED SCHEMATIC

1208/09 SS
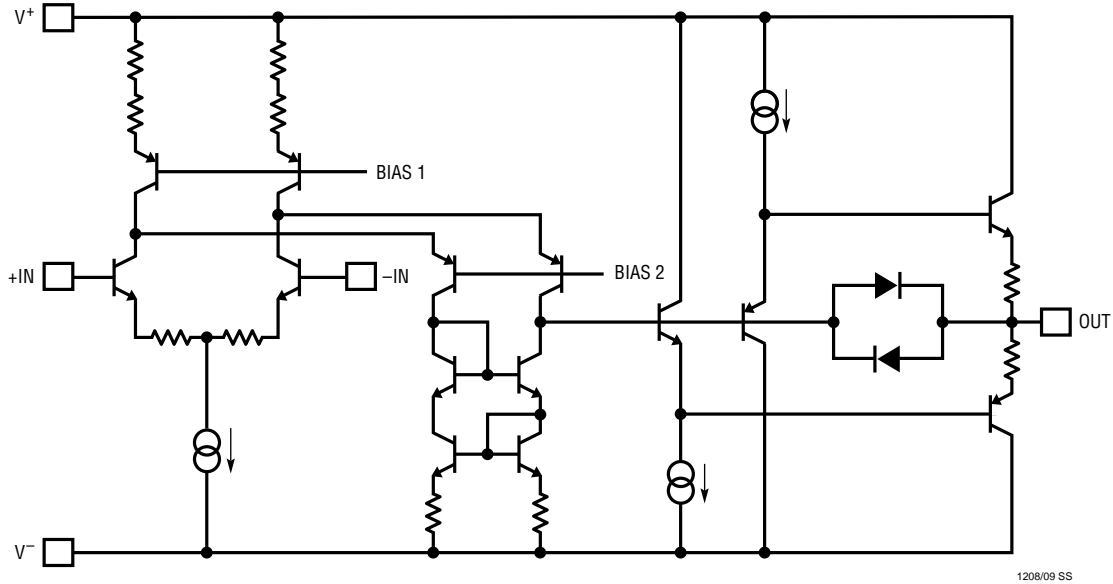
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead Plastic DIP
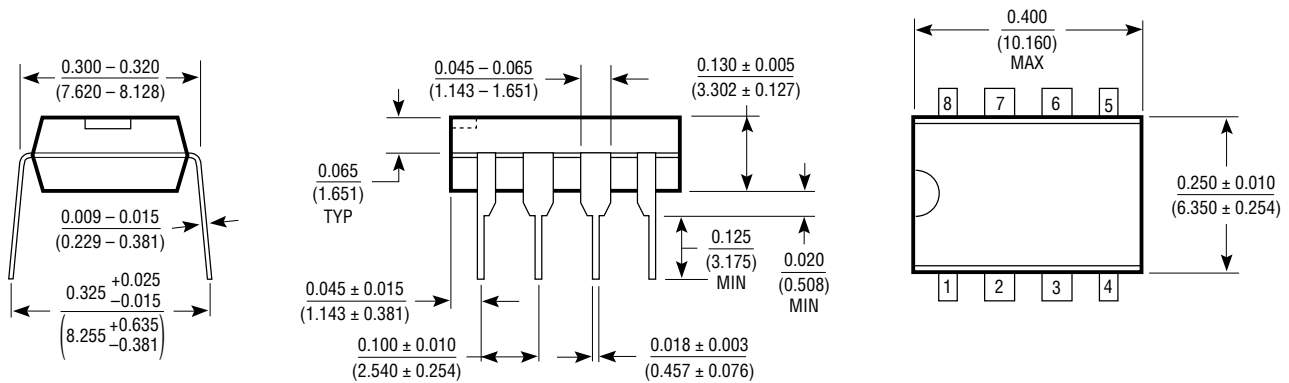
N8 0392

S8 Package
8-Lead Plastic SOIC

SO8 0392

PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

N Package
14-Lead Plastic DIP

0.770
(19.558)
MAX

| 14 | 13 | 12 | 11 | 10 | 9 | 8 |

0.260 ± 0.010
(6.604 ± 0.254)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

0.300 – 0.325
(7.620 – 8.255)

0.009 – 0.015
(0.229 – 0.381)

$0.325 \begin{smallmatrix} +0.025 \\ -0.015 \end{smallmatrix}$

$\left(8.255 \begin{smallmatrix} +0.635 \\ -0.381 \end{smallmatrix}\right)$

0.130 ± 0.005
(3.302 ± 0.127)

0.015
(0.380)
MIN

0.125
(3.175)
MIN

0.045 – 0.065
(1.143 – 1.651)

0.075 ± 0.015
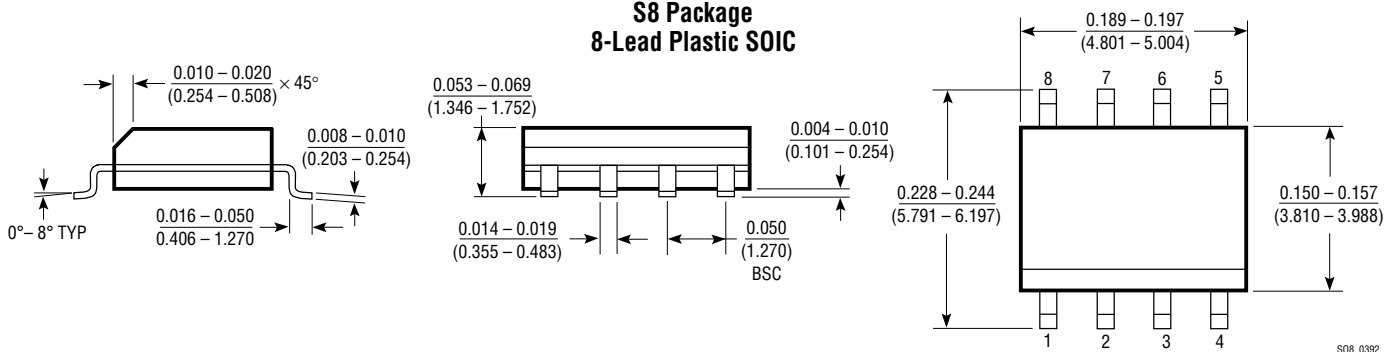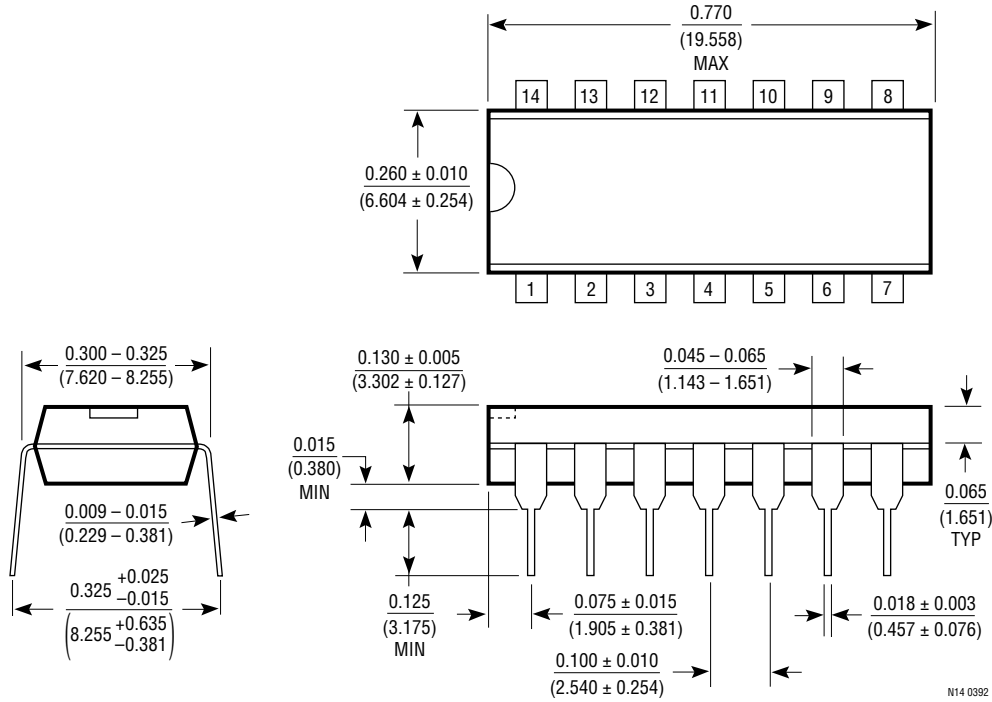(1.905 ± 0.381)

0.100 ± 0.010
(2.540 ± 0.254)

0.018 ± 0.003
(0.457 ± 0.076)

0.065
(1.651)
TYP

N14 0392

S Package
16-Lead Plastic SOIC

0.386 – 0.394*
(9.804 – 10.008)

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 |

0.228 – 0.244
(5.791 – 6.197)

0.150 – 0.157*
(3.810 – 3.988)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

0.010 – 0.020
(0.254 – 0.508) × 45°

0.008 – 0.010
(0.203 – 0.254)

0° – 8° TYP

0.016 – 0.050
0.406 – 1.270

0.053 – 0.069
(1.346 – 1.752)

0.014 – 0.019
(0.355 – 0.483)

0.050
(1.270)
TYP

0.004 – 0.010
(0.101 – 0.254)

SO16 0392

*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

Information furnished by Linear Technology Corporation is believed to be accurate and reliable.
However, no responsibility is assumed for its use. Linear Technology Corporation makes no represen-
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03/10/93

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