LINEAR TECHNOLOGY

LT1220

45MHz, 250V/µs Operational Amplifier

FEATURES

- **Gain-Bandwidth: 45MHz**
- **Unity-Gain Stable**
- **Slew Rate: 250V/µs**
- C-Load™ Op Amp Drives Capacitive Loads
- Maximum Input Offset Voltage: 1mV
- Maximum Input Bias Current: 300nA
- Maximum Input Offset Current: 300nA
- Minimum Output Swing Into 500Ω: ±12V
- Minimum DC Gain: 20V/mV, R_L = 500Ω
- Settling Time to 0.1%: 75ns, 10V Step
- Settling Time to 0.01%: 95ns, 10V Step
- Differential Gain: 0.1%, A_V = 2, R_L = 150Ω
- Differential Phase: 0.2°, A_V = 2, R_L = 150Ω

APPLICATIONS

- Wideband Amplifiers
- Buffers
- Active Filters
- Video and RF Amplification
- Cable Drivers
- 8-, 10-, 12-Bit Data Acquisition Systems

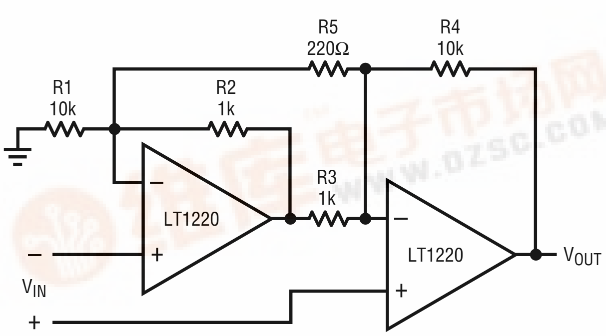
DESCRIPTION

The LT1220 is a high speed operational amplifier with superior DC performance. The LT1220 features reduced input offset voltage, lower input bias currents and higher DC gain than devices with comparable bandwidth and slew rate. The circuit is a single gain stage that includes proprietary DC gain enhancement circuitry to obtain precision with high speed. The high gain and fast settling time make the circuit an ideal choice for data acquisition systems. The circuit is also capable of driving large capacitive loads which makes it useful in buffer or cable driver applications.

The LT1220 is a member of a family of fast, high performance amplifiers that employ Linear Technology Corporation's advanced complementary bipolar processing. For applications with gains of 4 or greater the LT1221 can be used, and for gains of 10 or greater the LT1222 can be used for increased bandwidth.

TYPICAL APPLICATION

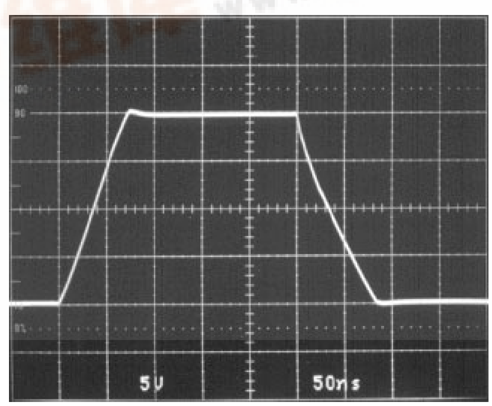
Two Op Amp Instrumentation Amplifier



GAIN = [R4/R3][1 + (1/2)(R2/R1 + R3/R4) + (R2 + R3)/R5] = 102
TRIM R5 FOR GAIN
TRIM R1 FOR COMMON-MODE REJECTION
BW = 450kHz

LT1220 • TA01

Inverter Pulse Response



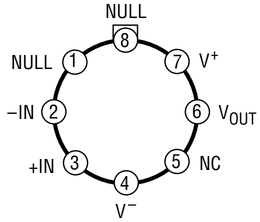
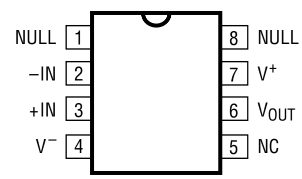
$R_F = R_G$ = 1k V_{IN} = 20V
V_S = ±15V f = 2MHz

LT1220 • TA02

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V^+ to V^-) 36V
Differential Input Voltage .... ±6V
Input Voltage .... $\pm V_S$
Output Short-Circuit Duration (Note 1) .... Indefinite
Specified Temperature Range
  LT1220C (Note 2) .... 0°C to 70°C
  LT1220M .... −55°C to 125°C
Operating Temperature Range
  LT1220C .... −40°C TO 85°C
  LT1220M .... −55°C to 150°C
Maximum Junction Temperature (See Below)
  Plastic Package .... 150°C
  Ceramic Package .... 175°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER		ORDER PART NUMBER
TOP VIEW  H PACKAGE 8-LEAD TO-5 METAL CAN T_{JMAX} = 175°C, θ_{JA} = 150°C/W	SPECIAL ORDER CONSULT FACTORY	TOP VIEW  J8 PACKAGE 8-LEAD CERAMIC DIP; N8 PACKAGE 8-LEAD PLASTIC DIP; S8 PACKAGE 8-LEAD PLASTIC SOIC; T_{JMAX} = 175°C, θ_{JA} = 100°C/W (J); T_{JMAX} = 150°C, θ_{JA} = 130°C/W (N); T_{JMAX} = 150°C, θ_{JA} = 190°C/W (S)	LT1220CN8 LT1220MJ8 LT1220CS8 — S8 PART MARKING: 1220

Consult factory for Industrial grade parts.

ELECTRICAL CHARACTERISTICS V_S = ±15V, T_A = 25°C, V_{CM} = 0V, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	(Note 3)		0.5	1	mV
I_{OS}	Input Offset Current			100	300	nA
I_B	Input Bias Current			100	300	nA
e_n	Input Noise Voltage	f = 10kHz		17		$nV/\sqrt{Hz}$
i_n	Input Noise Current	f = 10kHz		2		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	V_{CM} = ±12V Differential	20	45 150		MΩ kΩ
C_{IN}	Inut Capacitance			2		pF
	Input Voltage Range (Positive) Input Voltage Range (Negative)		12	14 −13	 −12	V V
CMRR	Common-Mode Rejection Ratio	V_{CM} = ±12V	92	114		dB
PSRR	Power Supply Rejection Ratio	V_S = ±5V to ±15V	90	94		dB
A_{VOL}	Large-Signal Voltage Gain	V_{OUT} = ±10V, R_L = 500Ω	20	50		V/mV
V_{OUT}	Output Swing	R_L = 500Ω	12	13		±V
I_{OUT}	Output Current	V_{OUT} = ±12V	24	26		mA
SR	Slew Rate	(Note 4)	200	250		V/µs
	Full Power Bandwidth	10V Peak (Note 5)		4		MHz
GBW	Gain-Bandwidth	f = 1MHz		45		MHz

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

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
t_r, t_f	Rise Time, Fall Time	$A_V = 1$, 10% to 90%, 0.1V			2.5		ns
	Overshoot	$A_V = 1$, 0.1V			5		%
	Propagation Delay	$A_V = 1$, 50% V_{IN} to 50% V_{OUT}, 0.1V			4.9		ns
t_s	Settling Time	10V Step, 0.1% 10V Step, 0.01%			75 95		ns ns
	Differential Gain	f = 3.58MHz, $R_L = 150\Omega$ (Note 6) f = 3.58MHz, R_L = 1k (Note 6)			0.10 0.02		% %
	Differential Phase	f = 3.58MHz, $R_L = 150\Omega$ (Note 6) f = 3.58MHz, R_L = 1k (Note 6)			0.20 0.03		DEG DEG
R_O	Output Resistance	$A_V = 1$, f = 1MHz			1		Ω
I_S	Supply Current				8	10.5	mA

$V_S = \pm15V$, $0°C \le T_A \le 70°C$, $V_{CM} = 0V$, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	(Note 3)	●		0.5	3.5	mV
	Input V_{OS} Drift				20		μV/°C
I_{OS}	Input Offset Current		●		100	400	nA
I_B	Input Bias Current		●		100	400	nA
CMRR	Common-Mode Rejection Ratio	$V_{CM} = \pm12V$	●	92	114		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm5V$ to $\pm15V$	●	86	94		dB
A_{VOL}	Large-Signal Voltage Gain	$V_{OUT} = \pm10V$, $R_L = 500\Omega$	●	20	50		V/mV
V_{OUT}	Output Swing	$R_L = 500\Omega$	●	12	13		±V
I_{OUT}	Output Current	$V_{OUT} = \pm12V$	●	24	26		mA
SR	Slew Rate	(Note 4)	●	180	250		V/μs
I_S	Supply Current		●		8	11	mA

$V_S = \pm15V$, $-55°C \le T_A \le 125°C$, $V_{CM} = 0V$, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	(Note 3)	●		0.5	4	mV
	Input V_{OS} Drift				20		μV/°C
I_{OS}	Input Offset Current		●		100	800	nA
I_B	Input Bias Current		●		100	1000	nA
CMRR	Common-Mode Rejection Ratio	$V_{CM} = \pm12V$	●	92	114		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm5V$ to $\pm15V$	●	82	94		dB
A_{VOL}	Large-Signal Voltage Gain	$V_{OUT} = \pm10V$, $R_L = 500\Omega$	●	5	50		V/mV
V_{OUT}	Output Swing	$R_L = 500\Omega$ R_L = 1k	● ●	10 12	13 13		±V ±V
I_{OUT}	Output Current	$V_{OUT} = \pm10V$ $V_{OUT} = \pm12V$	● ●	20 12	26 13		mA mA
SR	Slew Rate	(Note 4)	●	130	250		V/μs
I_S	Supply Current		●		8	11	mA

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

Note 1: A heat sink may be required when the output is shorted indefinitely.

Note 2: Commercial parts are designed to operate over −40°C to 85°C, but are not tested nor guaranteed beyond 0°C to 70°C. Industrial grade parts specified and tested over −40°C to 85°C are available on special request. Consut factory.

Note 3: Input offset voltage is pulse tested and is exclusive of warm-up drift.

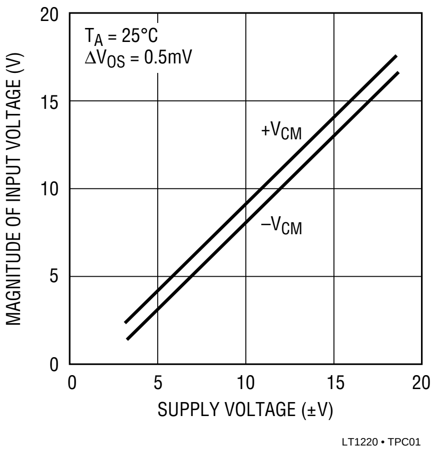
Note 4: Slew rate is measured between ±10V on an output swing of ±12V.

Note 5: FPBW = $SR/2\pi V_P$.

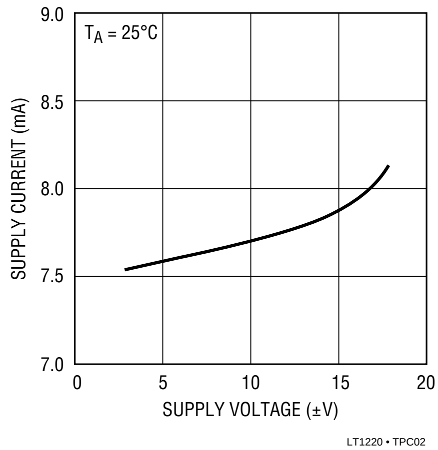
Note 6: Differential Gain and Phase are tested in $A_V = 2$ with five amps in series. Attenuators of 1/2 are used as loads (75Ω, 75Ω and 499Ω, 499Ω).

TYPICAL PERFORMANCE CHARACTERISTICS

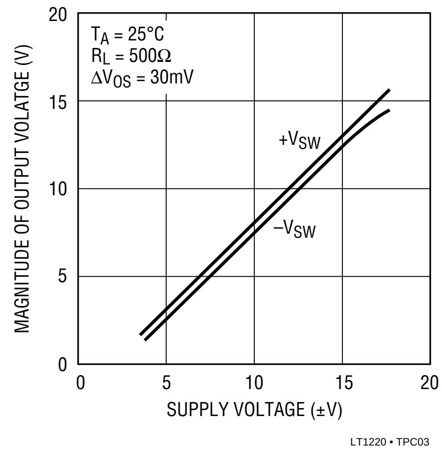
Input Common-Mode Range vs Supply Voltage



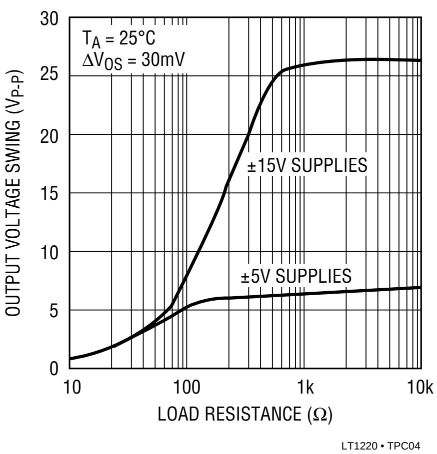
Supply Current vs Supply Voltage and Temperature



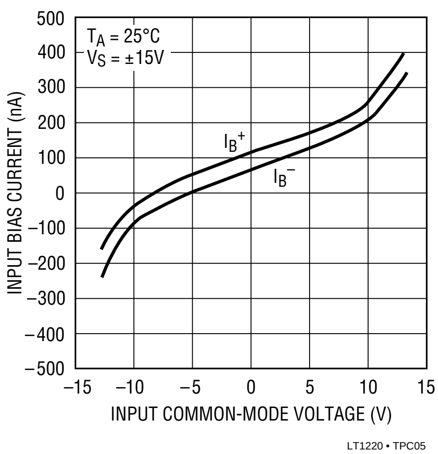
Output Voltage Swing vs Supply Voltage



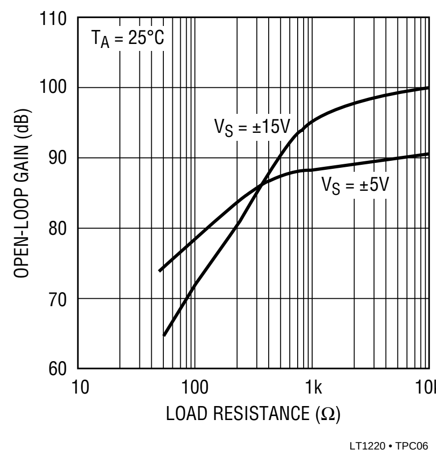
Output Voltage Swing vs Resistive Load



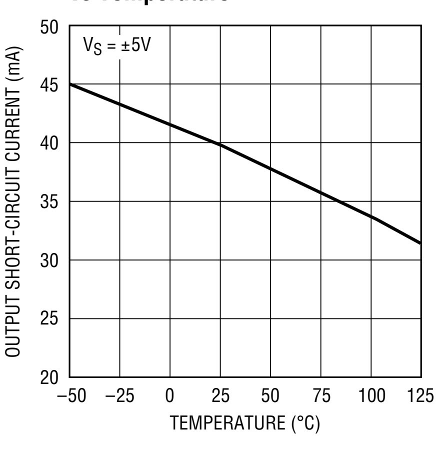
Input Bias Current vs Input Common-Mode Voltage



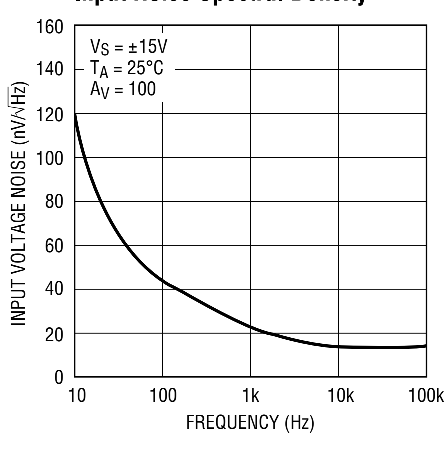
Open-Loop Gain vs Resistive Load



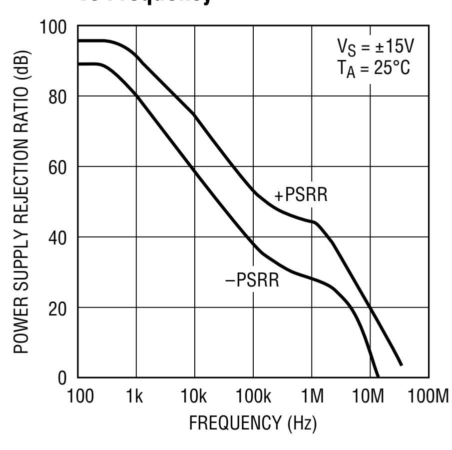
Output Short-Circuit Current vs Temperature



Input Noise Spectral Density

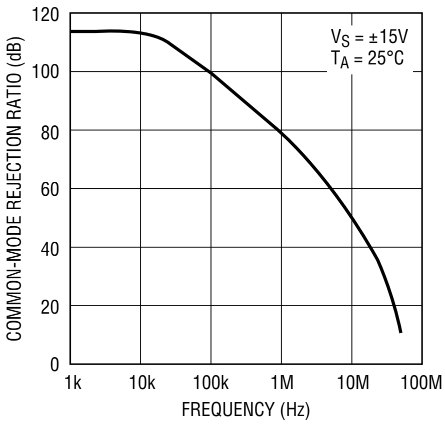


Power Supply Rejection Ratio vs Frequency



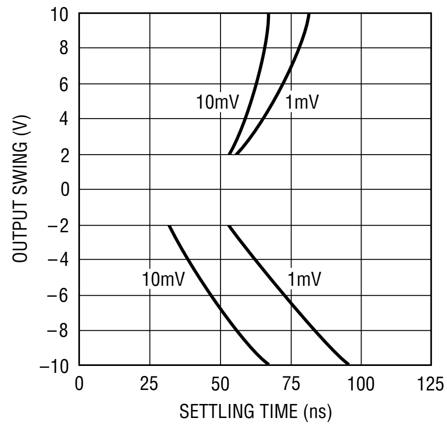
TYPICAL PERFORMANCE CHARACTERISTICS

Common-Mode Rejection Ratio vs Frequency



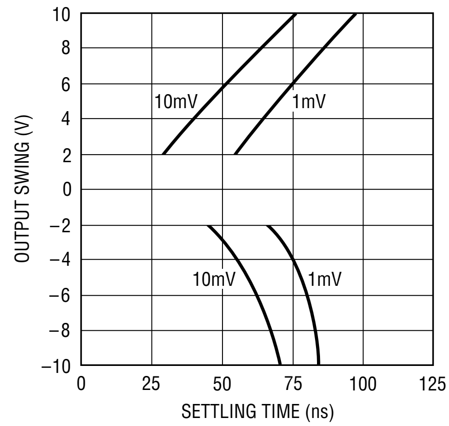
LT1220 • TPC10

Output Swing and Error vs Settling Time (Noninverting)



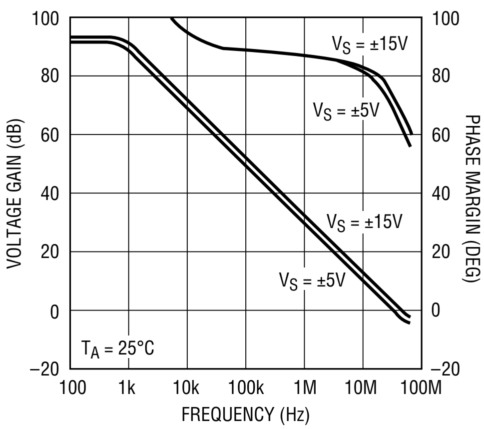
LT1220 • TPC11

Output Swing and Error vs Settling Time (Inverting)



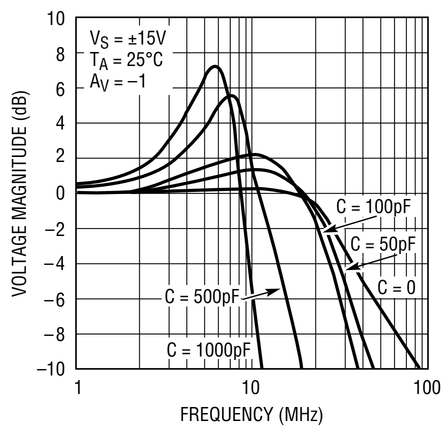
LT1220 • TPC12

Voltage Gain and Phase vs Frequency



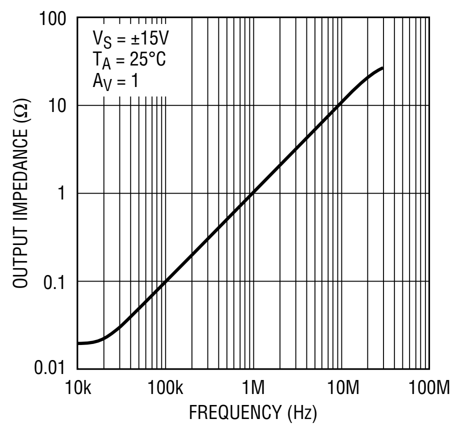
LT1220 • TPC13

Frequency Response vs Capacitive Load



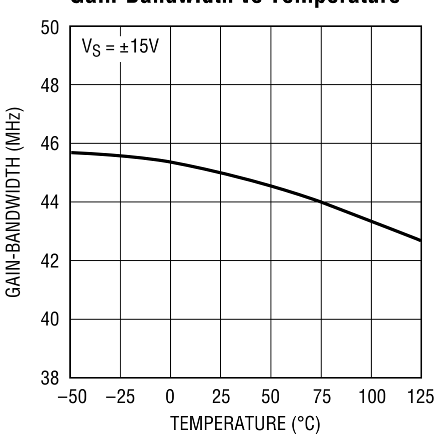
LT1220 • TPC14

Closed-Loop Output Impedance vs Frequency



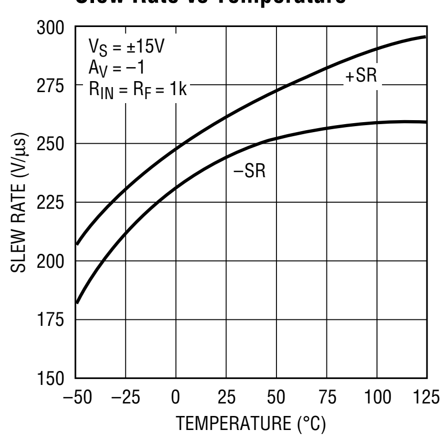
LT1220 • TPC15

Gain-Bandwidth vs Temperature



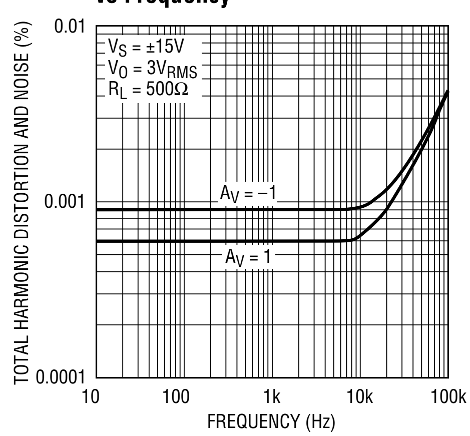
LT1220 • TPC16

Slew Rate vs Temperature



LT1220 • TPC24

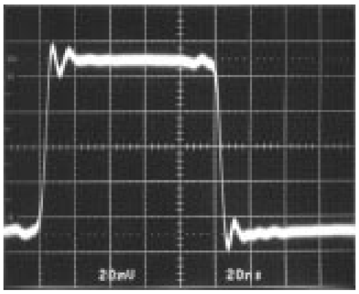
Total Harmonic Distortion vs Frequency



LT1220 • TPC18

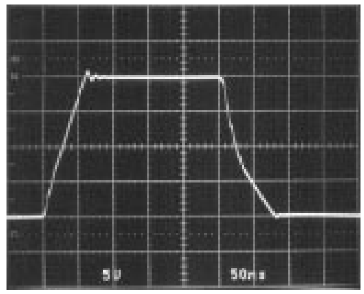
TYPICAL PERFORMANCE CHARACTERISTICS

Small Signal, $A_V = 1$



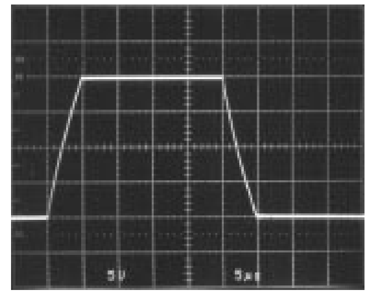
$R_G = 0$ $V_{IN} = 100mV$
$V_S = \pm15V$ f = 5MHz
LT1220 • TPC19

Large Signal, $A_V = 1$



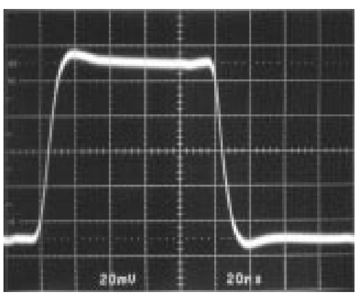
$R_G = 0$ $V_{IN} = 20V$
$V_S = \pm15V$ f = 2MHz
LT1220 • TPC20

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



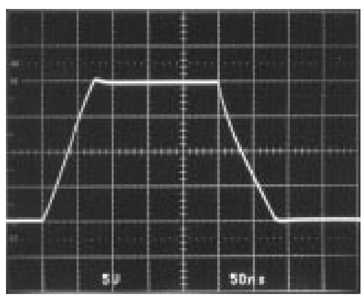
$R_G = 0$ $V_{IN} = 10V$
$V_S = \pm15V$ f = 20kHz
LT1220 • TPC21

Small Signal, $A_V = -1$



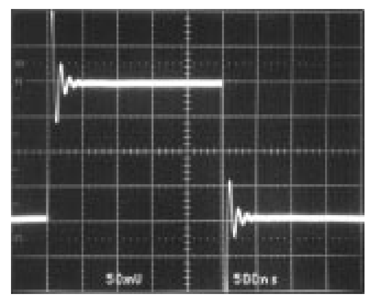
$R_F = R_G = 1k$ $V_{IN} = 100mV$
$V_S = \pm15V$ f = 5MHz
LT1220 • TPC22

Large Signal, $A_V = -1$



$R_F = R_G = 1k$ $V_{IN} = 20V$
$V_S = \pm15V$ f = 2MHz
LT1220 • TPC23

Small Signal, $A_V = -1$, $C_L = 1,000pF$

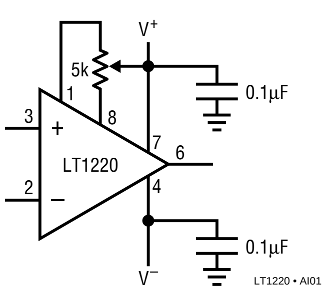


$R_F = R_G = 1k$ $V_{IN} = 200mV$
$V_S = \pm15V$ f = 200kHz
LT1220 • TPC24

APPLICATIONS INFORMATION

The LT1220 may be inserted directly into HA2505/15/25, HA2541/2/4, AD817, AD847, EL2020, EL2044 and LM6361 applications, provided that the nulling circuitry is removed. The suggested nulling circuit for the LT1220 is shown in the following figure.

Offset Nulling



Layout and Passive Components

The LT1220 amplifier is easy to apply and tolerant of less than ideal layouts. For maximum performance (for example, fast settling time) use a ground plane, short lead lengths and RF-quality bypass capacitors (0.01µF to 0.1µF). For high driver current applications use low ESR bypass capacitors (1µF to 10µF 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. Feedback resistors greater than 5k are not recommended because a pole is formed with the input capacitance which can cause peaking or oscillations.

APPLICATIONS INFORMATION

Input Considerations

Bias current cancellation circuitry is employed on the inputs of the LT1220 so the input bias current and input offset current have identical specifications. For this reason, matching the impedance on the inputs to reduce bias current errors is not necessary.

Capacitive Loading

The LT1220 is 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. There will be peaking in the frequency domain as shown in the curve of Frequency Response vs Capacitive Load. The small-signal transient response will have more overshoot as shown in the photo of the small-signal response with 1000pF load. The large-signal response with a 10,000pF load shows the output slew rate being limited to 4V/μs by the short-circuit current. The LT1220 can drive coaxial cable directly, but for best pulse fidelity a resistor of value equal to the characteristic impedance of the cable (i.e., 75Ω) should be placed in series with the output. The other end of the cable should be terminated with the same value resistor to ground.

DAC Current-to-Voltage Amplifier

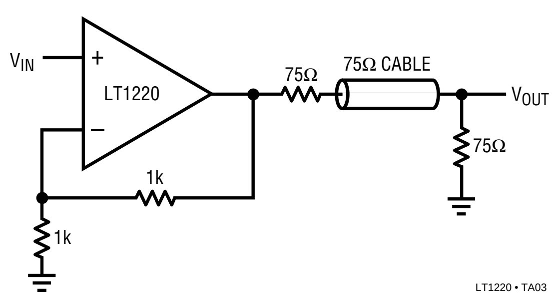
The high gain, low offset voltage, low input bias current, and fast settling of the LT1220 make it particularly useful as an I/V converter for current output DACs. A typical application is shown with a 565A type, 12-bit, 2mA full-scale output current DAC. The 5k resistor around the LT1220 is internal to the DAC and gives a 10V full-scale output voltage. A 5pF capacitor in parallel with the feedback resistor compensates for the DAC output capacitance and improves settling. The output of the LT1220 settles to 1/2LSB (1.2mV) in less than 300ns. The accuracy of this circuit is equal to:

$$V_{ERROR} = V_{OS} + (I_{OS} \times 5k\Omega) + (V_{OUT}/A_{VOL})$$

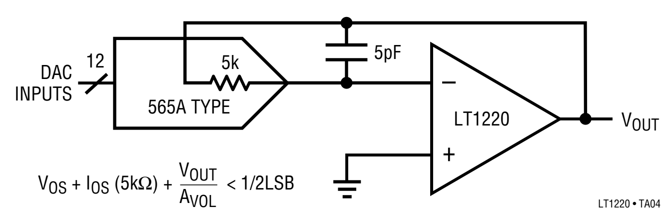
At room temperature the worst-case error is 3mV (1.2LSB). Typically the error is 1.2mV (1/2LSB). Over the commercial temperature range the worse-case error is 6mV (2.5LSB).

TYPICAL APPLICATIONS

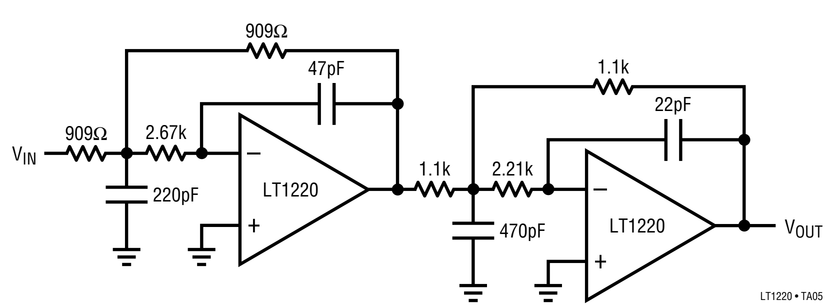
Cable Driver



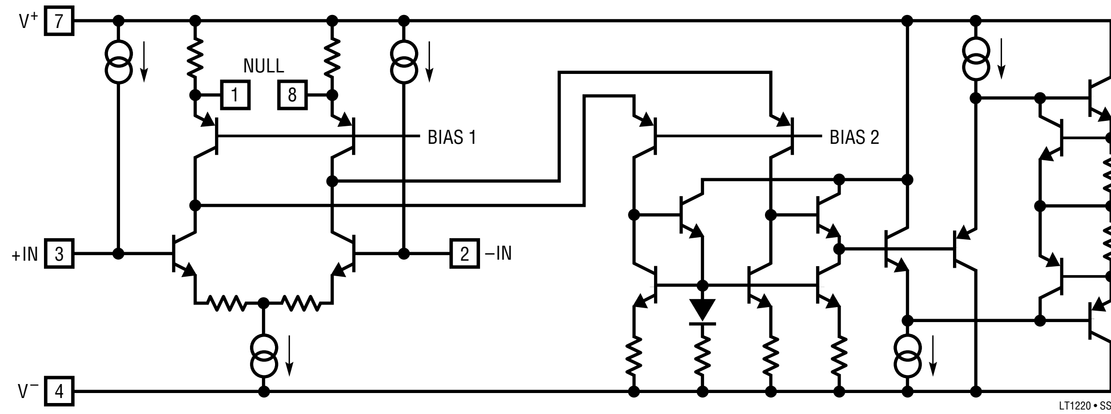
DAC Current-to-Voltage Converter



1MHz, 4th Order Butterworth Filter



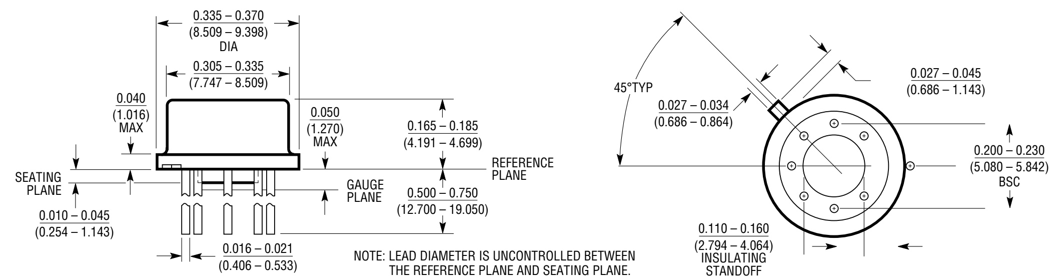
SIMPLIFIED SCHEMATIC



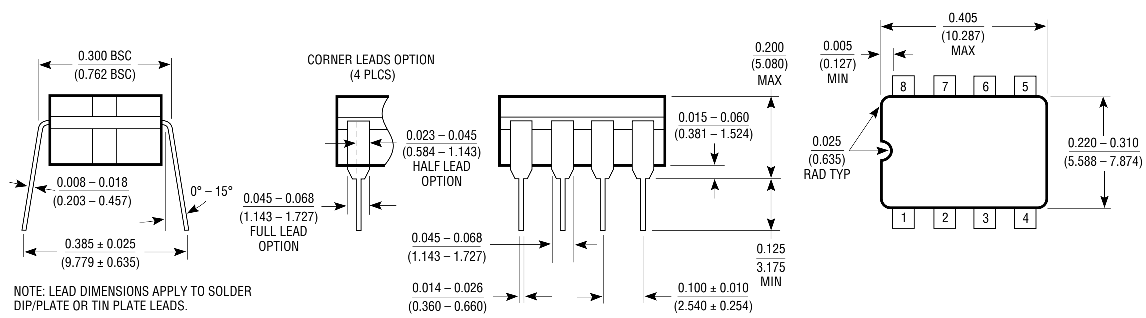
PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

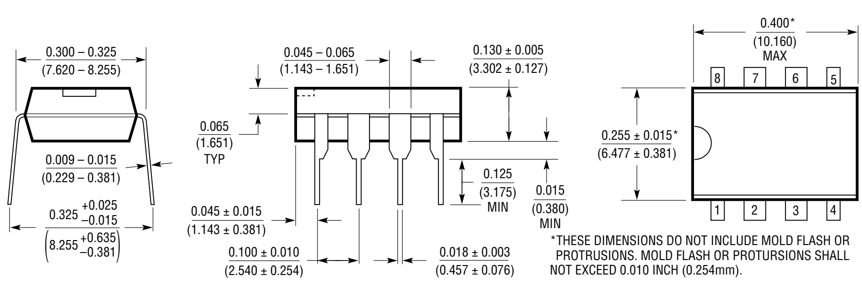
H8 Package
8-Lead TO-5 Metal Can



J8 Package
8-Lead Ceramic Dip



N8 Package
8-Lead Plastic Dip



S8 Package
8-Lead Plastic SOIC