LT1122

Fast Settling, JFET Input Operational Amplifier

FEATURES

- 100% Tested Settling Time   340ns Typ
  to 1mV at Sum Node, 10V Step   540ns Max
  Tested with Fixed Feedback Capacitor
- Slew Rate   60V/μs Min
- Gain Bandwidth Product   14MHz
- Power Bandwidth (20Vp-p)   1.2 MHz
- Unity Gain Stable; Phase Margin   60°
- Input Offset Voltage   600μV Max
- Input Bias Current   25°C   75pA Max
                              70°C   600pA Max
- Input Offset Current   25°C   40pA Max
                              70°C   150pA Max
- Low Distortion

APPLICATIONS

- Fast 12-Bit D/A Output Amplifiers
- High Speed Buffers
- Fast Sample and Hold Amplifiers
- High Speed Integrators
- Voltage to Frequency Converters
- Active Filters
- Log Amplifiers
- Peak Detectors

DESCRIPTION

The LT1122 JFET input operational amplifier combines high speed and precision performance.

A unique poly-gate JFET process minimizes gate series resistance and gate-to-drain capacitance, facilitating wide bandwidth performance, without degrading JFET transistor matching.

It slews at 80V/μs and settles in 340ns. The LT1122 is internally compensated to be unity gain stable, yet it has a bandwidth of 14MHz at a supply current of only 7mA. Its speed makes the LT1122 an ideal choice for fast settling 12-bit data conversion and acquisition systems.

The LT1122 offset voltage of 120μV, and voltage gain of 500,000 also support the 12-bit accurate applications.

The input bias current of 10pA and offset current of 4pA combined with its speed allow the LT1122 to be used in such applications as high speed sample and hold amplifiers, peak detectors, and integrators.
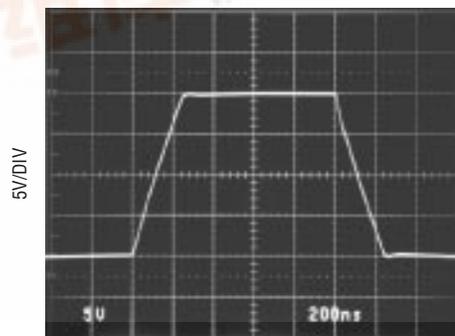
TYPICAL APPLICATION

12-Bit Voltage Output D/A Converter
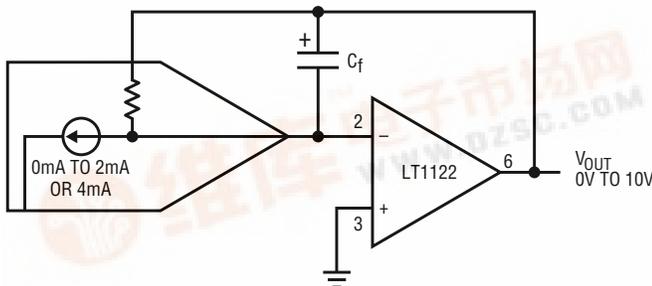
12-BIT CURRENT OUTPUT D/A CONVERTER
C_f = 5pF TO 17pF
(DEPENDING ON D/A CONVERTER USED)

LT1122•TA01

Large-Signal Response
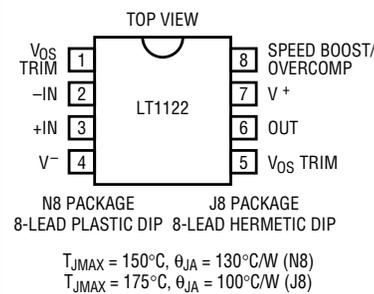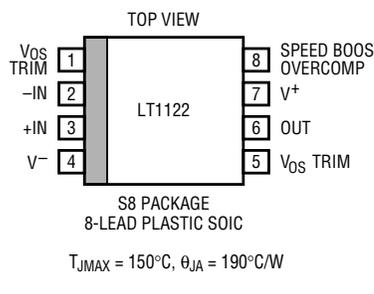

200ns/DIV
AV = −1

1122 TA07

LT1122

ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... ± 20V
Differential Input Voltage .... ± 40V
Input Voltage .... ± 20V
Output Short Circuit Duration .... Indefinite
Lead Temperature (Soldering, 10 sec.) .... 300°C

Operating Temperature Range
   LT1122AM/BM/CM/DM .... – 55°C to 125°C
   LT1122AC/BC/CC/DC/CS/DS .... – 40°C to 85°C
Storage Temperature Range
   All Devices .... – 65°C to 150°C

PACKAGE/ORDER INFORMATION

Consult factory for Industrial grade parts.

ELECTRICAL CHARACTERISTICS

V_S = ± 15V, T_A = 25°C, V_{CM} = 0V unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS	LT1122AM/BM LT1122AC/BC			LT1122CM/DM LT1122CC/DC LT1122CS/DS			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			120	600		130	900	μV
I_{OS}	Input Offset Current			4	40		5	50	pA
I_B	Input Bias Current			10	75		12	100	pA
	Input Resistance Differential			10^{12}			10^{12}		Ω
	Common Mode	V_{CM} = – 10V to + 8V		10^{12}			10^{12}		Ω
		V_{CM} = + 8V to + 11V		10^{11}			10^{11}		Ω
	Input Capacitance			4			4		pF
S_R	Slew Rate	A_V = – 1	60	80		50	75		V/μs
	Settling Time (Note 2)	+ 10V to 0V, – 10V to 0V							
		100% Tested: A and C Grades to 1mV at Sum Node		340	540		350	590	ns
		B and D Grades to 1mV at Sum Node		350			360		ns
		All Grades to 0.5mV at Sum Node		450			470		ns
GBW	Gain Bandwidth Product			14			13		MHz
	Power Bandwidth	V_{OUT} = 20Vp-p		1.2			1.1		MHz
A_{VOL}	Large Signal Voltage Gain	V_{OUT} = ±10V, R_L = 2kΩ	180	500		150	450		V/mV
		V_{OUT} = ±10V, R_L = 600Ω	130	250		110	220		V/mV
CMRR	Common Mode Rejection Ratio	V_{CM} = ±10V	83	99		80	98		dB
	Input Voltage Range	(Note 3)	±10.5	±11		±10.5	±11		V
PSRR	Power Supply Rejection Ratio	V_S = ±10V to +18V	86	103		82	101		dB
	Input Noise Voltage	0.1Hz to 10Hz		3.0			3.3		μV_{P-P}
	Input Noise Voltage Density	f_O = 100Hz		25			27		nV/$\sqrt{Hz}$
		f_O = 10kHz		14			15		nV/$\sqrt{Hz}$
	Input Noise Current Density	f_O = 100Hz, f_O = 10kHz		2			2		fA/$\sqrt{Hz}$

ELECTRICAL CHARACTERISTICS $V_S = \pm 15V$, $T_A = 25°C$, $V_{CM} = 0V$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1122AM/BM LT1122AC/BC			LT1122CM/DM LT1122CC/DC LT1122CS/DS			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OUT}	Output Voltage Swing	$R_L = 2k\Omega$	± 12	± 12.5		± 12	± 12.5		V
		$R_L = 600\Omega$	± 11.5	± 12		± 11.5	± 12		V
I_S	Supply Current			7.5	10		7.8	11	mA
	Minimum Supply voltage	(Note 4)	± 5			± 5			V
	Offset Adjustment Range	$R_{POT} \geq 10k$, Wiper to V+	± 4	± 10		± 4	± 10		mV

$V_S = \pm 15V$, $V_{CM} = 0V$, $0°C \leq T_A \leq 70°C$, unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS		LT1122AC/BC			LT1122CC/DC LT1122CS/DS			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage		●		350	1400		400	2000	μV
	Average Temperature Coefficient of Input Offset Voltage		●		5	18		6	25	μV/°C
I_{OS}	Input Offset Current		●		12	150		15	200	pA
I_B	Input Bias Current		●		80	600		90	800	pA
A_{VOL}	Large Signal Voltage Gain	$V_{OUT} = \pm 10V$, $R_L \geq 2k\Omega$	●	120	380		100	340		V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	●	82	98		78	96		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 10V$ to $\pm 17V$	●	84	101		80	99		dB
	Input Voltage Range		●	± 10	± 10.8		± 10	± 10.8		V
V_{OUT}	Output Voltage Swing	$R_L = 2k\Omega$	●	± 11.5	± 12.4		± 11.5	± 12.4		V
S_R	Slew Rate	$A_V = -1$	●	50	70		40	65		V/μs

$V_S = \pm 15V$, $V_{CM} = 0V$, $-55°C \leq T_A \leq 125°C$, unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS		LT1122AM/BM			LT1122CM/DM			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage		●		650	2400		800	3400	μV
	Average Temperature Coefficient of Input Offset Voltage		●		6	18		7	25	μV/°C
I_{OS}	Input Offset Current		●		0.5	6		0.6	9	nA
I_B	Input Bias Current		●		6	25		7	35	nA
A_{VOL}	Large Signal Voltage Gain	$V_{OUT} = \pm 10V$, $R_L \geq 2k\Omega$	●	70	230		60	200		V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	●	80	97		76	94		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 10V$ to $\pm 17V$	●	83	100		78	98		dB
	Input Voltage Range		●	± 10	± 10.5		± 10	± 10.5		V
V_{OUT}	Output Voltage Swing	$R_L = 2k\Omega$	●	± 11.3	± 12.1		± 11.3	± 12.1		V
S_R	Slew Rate	$A_V = -1$	●	45	60		35	55		V/μs

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

Note 1: The LT1122 is measured in an automated tester in less than one second after application of power. Depending on the package used, power dissipation, heat sinking, and air flow conditions, the fully warmed up chip temperature can be 10°C to 50°C higher than the ambient temperature.

Note 2: Settling time is 100% tested for A and C grades using the settling time test circuit shown. This test is not included in quality assurance sample testing.

Note 3: Input voltage range functionality is assured by testing offset voltage at the input voltage range limits to a maximum of 4mV (A, B grades), to 5.7mV (C, D grades).

Note 4: Minimum supply voltage is tested by measuring offset voltage to 7mV maximum at $\pm 5V$ supplies.

Note 5: The LT1122 is not tested and not quality-assurance-sampled at $-40°C$ and at 85°C. These specifications are guaranteed by design, correlation and/or inference from $-55°C$, 0°C, 25°C, 70°C and/or 125°C tests.
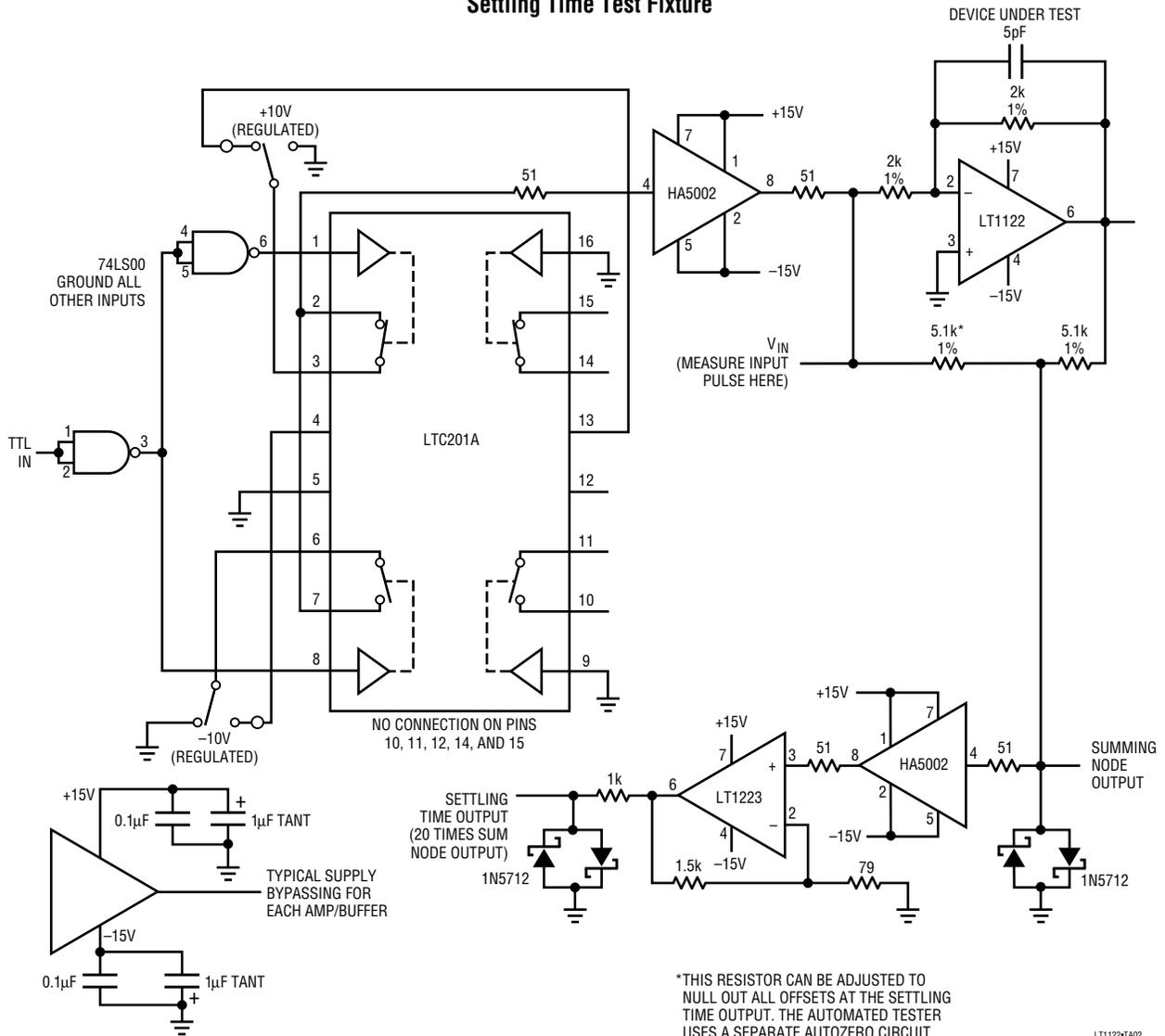
LT1122

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $-40°C \leq T_A \leq 85°C$, unless otherwise noted. (Note 5)

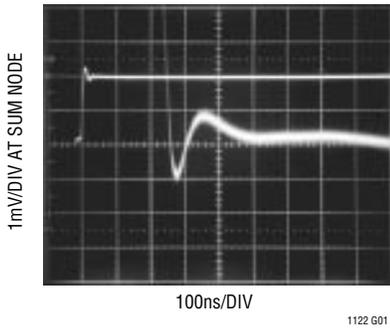| SYMBOL	PARAMETER	CONDITIONS		LT1122AC/BC MIN	TYP	MAX	LT1122CC/DC LT1122CS/DS MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●		450	1900		500	2700	μV
	Average Temperature Coefficient of Input Offset Voltage		●		6	20		7	28	μV/°C
I_{OS}	Input Offset Current		●		30	600		40	900	pA
I_B	Input Bias Current		●		230	2000		260	2700	pA
A_{VOL}	Large Signal Voltage Gain	$V_{OUT} = \pm 10V$, $R_L \geq 2k\Omega$	●	95	340		80	300		V/mV
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	●	80	98		76	96		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 10V$ to $\pm 17V$	●	83	100		78	98		dB
	Input Voltage Range		●	± 10	± 10.6		± 10	± 10.6		V
V_{OUT}	Output Voltage Swing	$R_L = 2k\Omega$	●	± 11.3	± 12.2		± 11.3	± 12.2		V
S_R	Slew Rate	$A_V = -1$	●	45	65		35	60		V/μs

Settling Time Test Fixture

*THIS RESISTOR CAN BE ADJUSTED TO NULL OUT ALL OFFSETS AT THE SETTLING TIME OUTPUT. THE AUTOMATED TESTER USES A SEPARATE AUTOZERO CIRCUIT.

LT1122•TA02

TYPICAL PERFORMANCE CHARACTERISTICS

**Settling Time
(Input From –10V to 0V)**
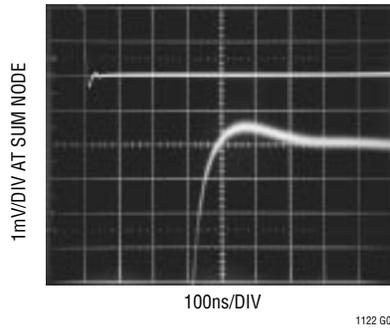
1mV/DIV AT SUM NODE

100ns/DIV

1122 G01

**Settling Time
(Input From +10V to 0V)**

1mV/DIV AT SUM NODE

100ns/DIV

1122 G02

**Settling Time
(Input From 0V to +10V)**

1mV/DIV AT SUM NODE

100ns/DIV

1122 G03

**Settling Time
(Input From 0V to –10V)**

1mV/DIV AT SUM NODE

100ns/DIV

1122 G04

Large Signal Response

5V/DIV

5V   200ns

200ns/DIV
$A_V = +1$

1122 G05
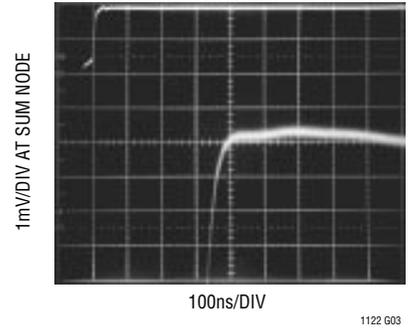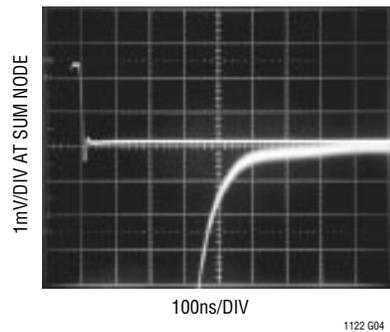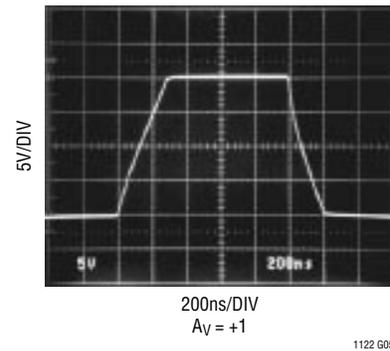
**Undistorted Output Swing vs
Frequency**

PEAK TO PEAK OUTPUT SWING (V)

$V_S = \pm15V$
$T_A = 25°C$

FREQUENCY (Hz)
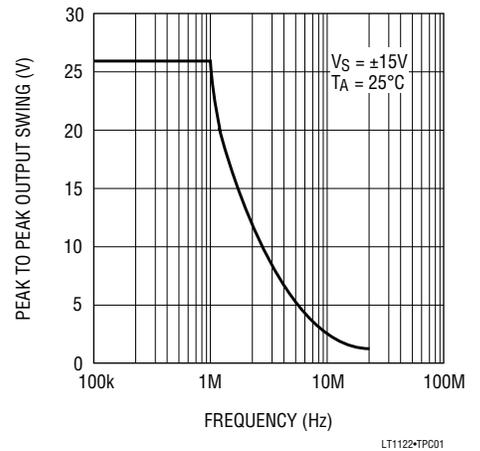
LT1122•TPC01

Voltage Gain vs Frequency

GAIN (dB)

$V_S = \pm15V$
$T_A = 25°C$

FREQUENCY (Hz)

LT1122•TPC02

Gain, Phase vs Frequency

GAIN (dB)

PHASE SHIFT (DEGREES)

$V_S = \pm15V$
$T_A = 25°C$
$C_L = 15pF$

FREQUENCY (Hz)
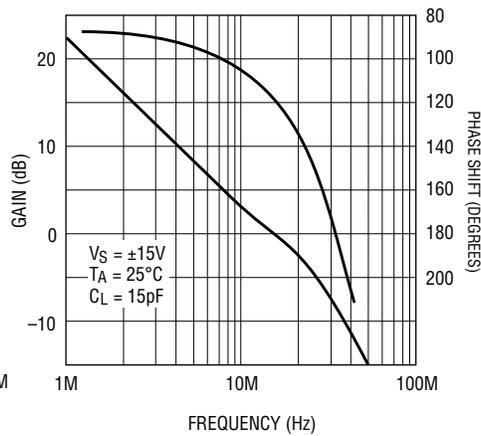
LT1122•TPC03

**Common Mode Rejection vs
Frequency**

COMMON-MODE REJECTION RATIO (dB)

$V_S = \pm15V$
$T_A = 25°C$

FREQUENCY (Hz)
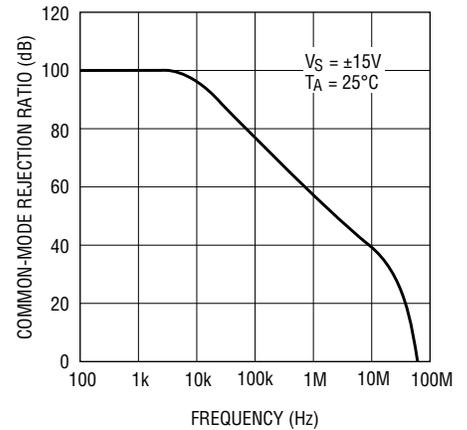
LT1122•TPC04
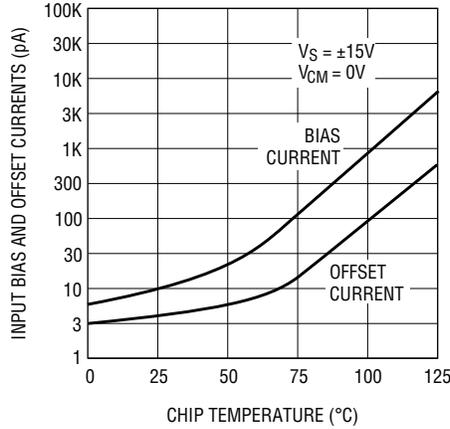
TYPICAL PERFORMANCE CHARACTERISTICS
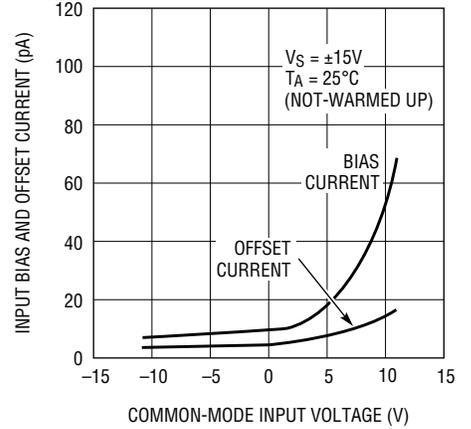
Distribution of Input Offset Voltage
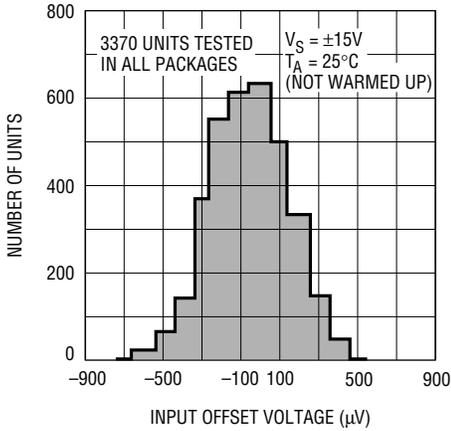
LT1122•TPC05

Input Bias and Offset Currents Over Temperature
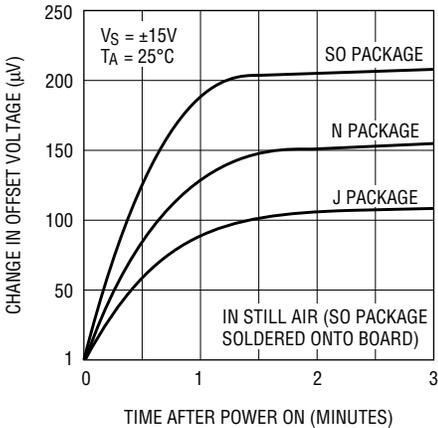

LT1122•TPC06

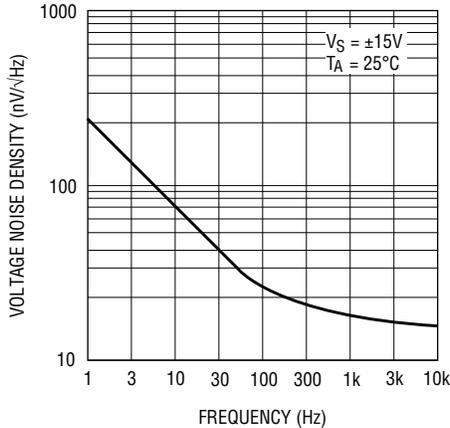**Bias and Offset Currents Over The Common-Mode Range**
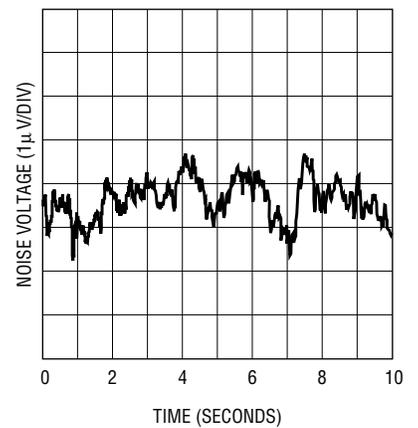

LT1122•TPC07

Warm-up Drift

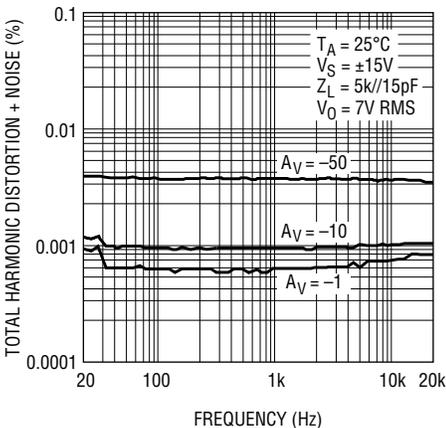LT1122•TPC08

Noise Spectrum

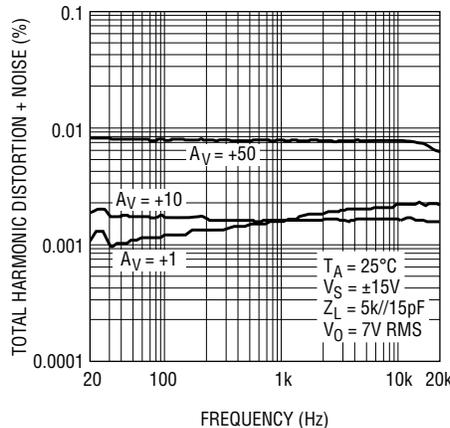LT1122•TPC09

0.1Hz to 10Hz Noise

LT1122•TPC10

Total Harmonic Distortion + Noise vs Frequency Inverting Gain
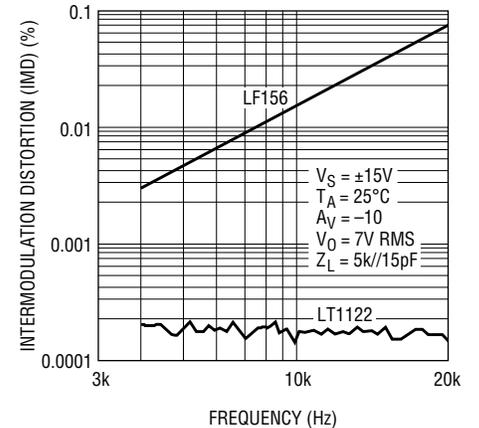

LT1122•TPC11

Total Harmonic Distortion + Noise vs Frequency Non-Inverting Gain

LT1122•TPC12

Intermodulation Distortion (CCIF Method) vs Frequency LT1122 and LF156*

*SEE LT1115 DATA SHEET FOR DEFINITION OF CCIF TESTING

LT1122•TPC13

APPLICATIONS INFORMATION

Settling Time Measurements

Settling time test circuits shown on some competitive devices' data sheets require:

1. A "flat top" pulse generator. Unfortunately, flat top pulse generators are not commercially available.

2. A variable feedback capacitor around the device under test. This capacitor varies over a four to one range. Presumably, as each op amp is measured for settling time, the capacitor is fine tuned to optimize settling time for that particular device.

3. A small inductor load to optimize settling.

The LT1122's settling time is 100% tested in the test circuit shown. No "flat top" pulse generator is required. The test circuit can be readily constructed, using commercially available ICs. Of course, standard high frequency board construction techniques should be followed. All LT1122s are measured with a constant feedback capacitor. No fine tuning is required.

### Speed Boost/Overcompensation Terminal

Pin 8 of the LT1122 can be used to change the input stage operating current of the device. Shorting pin 8 to the positive supply (Pin 7) increases slew rate and bandwidth by about 25%, but at the expense of a reduction in phase margin by approximately 18 degrees. Unity gain capacitive load handling decreases from typically 500pF to 100pF.

Conversely, connecting a 15k resistor from pin 8 to ground pulls 1mA out of pin 8 (with V^+ = 15V). This reduces slew rate and bandwidth by 25%. Phase margin and capacitive load handling improve; the latter typically increasing to 800pF.
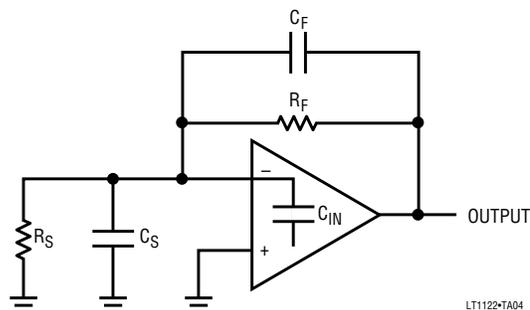
High Speed Operation

As with most high speed amplifiers, care should be taken with supply decoupling, lead dress and component placement.

The power supply connections to the LT1122 must maintain a low impedance to ground over a bandwidth of 20MHz. This is especially important when driving a significant resistive or capacitive load, since all current delivered to the load comes from the power supplies. Multiple high quality bypass capacitors are recommended for each power supply line in any critical application. A 0.1μF ceramic and a 1μF electrolytic capacitor, as shown, placed as close as possible to the amplifier (with short lead lengths to power supply common) will assure adequate high frequency bypassing, in most applications.
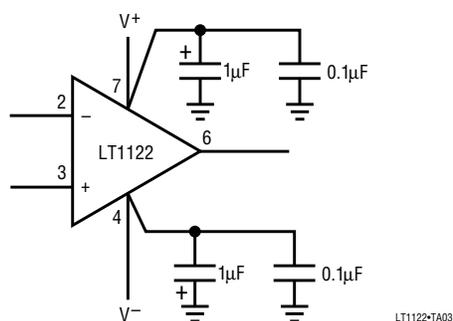
When the feedback around the op amp is resistive (R_F), a pole will be created with R_F, the source resistance and capacitance (R_S, C_S), and the amplifier input capacitance ($C_{IN} \approx 4pF$). In low closed loop gain configurations and with R_S and R_F in the kilohm range, this pole can create excess phase shift and even oscillation. A small capacitor (C_F) in parallel with R_F eliminates this problem. With $R_S (C_S + C_{IN}) = R_F C_F$, the effect of the feedback pole is completely removed.

TYPICAL APPLICATIONS

Quartz Stabilized Oscillator With 9ppm Distortion

OUTPUT

−15V

4.7k

LT1004
2.5V

OUTPUT
AMPLITUDE
TRIM

4.7k   5k   10μF

4kHz
J CUT

47k

LT1122

LT1010

+15V

LT1006

4.7k

MOUNT IN CLOSE
PROXIMITY

430pF

DISTORTION
TRIM

50k

560k

470Ω

GROUND CRYSTAL CASE

2k

+15V

+15V

1M   560k

= VACTEC VTL5C10 OR
CLAIREX CLM410

LT1122

−15V

1/4 LTC201

Q1
2N3904

100k

= 1N4148

LT1122•TA05

Wide-Band, Filtered, Full Wave Rectifier

200k
1%

1μF

200k
1%

50k

20k
1%

100k
1%

1k

20k
1%

LT1122

LT1122

E OUT DC

V IN

OUTPUT DC = RMS VALUE OF INPUT
BANDWIDTH WITH 10Vp-p INPUT = 2MHz

LT1122•TA06

PACKAGE DESCRIPTION

Please see the *1994 Linear Databook Volume III* for package descriptions.