Dual/Quad Decompensated Low Noise, High Speed Precision Op Amps

FEATURES

- 100% Tested Low Voltage Noise — 2.7nV/√Hz Typ, 4.2nV/√Hz Max
- Slew Rate — 11V/µs Typ
- Gain-Bandwidth Product — 65MHz Typ
- Offset Voltage, Prime Grade — 70µV Max; Low Grade — 100µV Max
- High Voltage Gain — 5 Million Min
- Supply Current Per Amplifier — 3.1mA Max
- Common Mode Rejection — 112dB Min
- Power Supply Rejection — 116dB Min
- Available in 8-Pin SO Package

APPLICATIONS

- Two and Three Op Amp Instrumentation Amplifiers
- Low Noise Signal Processing
- Active Filters
- Microvolt Accuracy Threshold Detection
- Strain Gauge Amplifiers
- Direct Coupled Audio Gain Stages
- Tape Head Preamplifiers
- Microphone Preamplifiers
- Accelerometer Amplifiers
- Infrared Detectors

DESCRIPTION

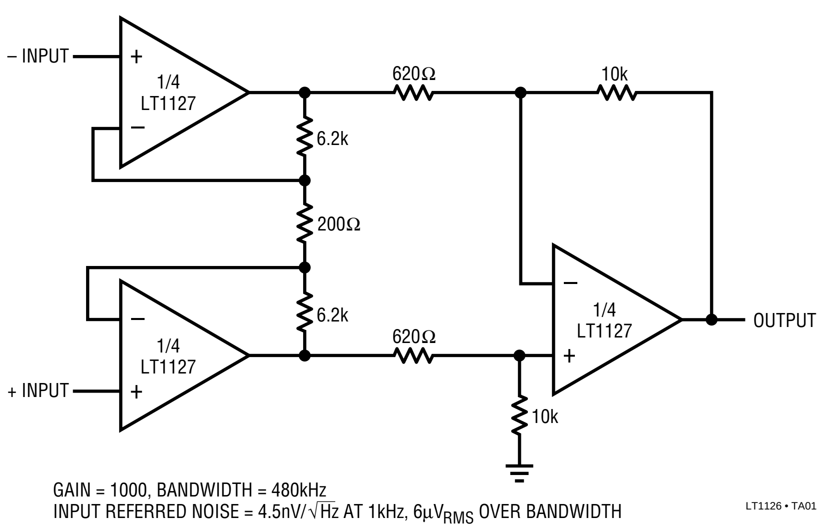
The LT1126 dual and LT1127 quad are high performance, decompensated op amps that offer higher slew rate and bandwidth than the LT1124 dual and the LT1125 quad operational amplifiers. The enhanced AC performance is available without degrading DC specs of the LT1124/LT1125. Both LT1126/LT1127 are stable in a gain of 10 or more.

In the design, processing, and testing of the device, particular attention has been paid to the optimization of the entire distribution of several key parameters. Slew rate, gain-bandwidth, and 1kHz noise are 100% tested for each individual amplifier. Consequently, the specifications of even the lowest cost grades (the LT1126C and the LT1127C) have been enhanced.

Power consumption of the dual LT1126 is less than one half of two OP-37s. Low power and high performance in an 8-pin SO package makes the LT1126 a first choice for surface mounted systems and where board space is restricted.

Protected by U.S. patents 4,775,884 and 4,837,496.

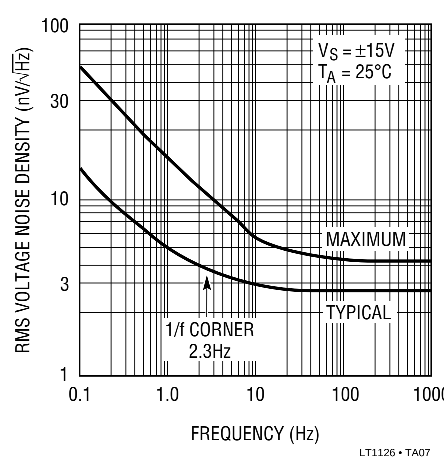
Low Noise, Wide Bandwidth Instrumentation Amplifier



GAIN = 1000, BANDWIDTH = 480kHz
INPUT REFERRED NOISE = 4.5nV/√Hz AT 1kHz, 6µV$_{RMS}$ OVER BANDWIDTH

LT1126 • TA01

Voltage Noise vs Frequency



LT1126 • TA07

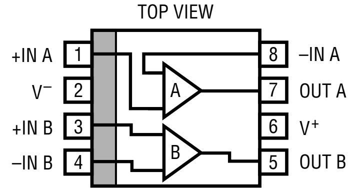
ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... ±22V
Input Voltage .... Equal to Supply Voltage
Output Short Circuit Duration .... Indefinite
Differential Input Current (Note 5) .... ±25mA
Lead Temperature (Soldering, 10 sec.)................. 300°C

Operating Temperature Range
LT1126AM/LT1126M
LT1127AM/LT1127M .... –55°C to 125°C
LT1126AC/LT1126C
LT1127AC/LT1127C .... –40°C to 85°C
Storage Temperature Range
All Grades .... –65°C to 150°C

PACKAGE/ORDER INFORMATION

TOP VIEW



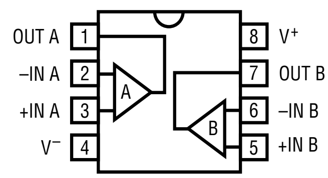
S8 PACKAGE
8-LEAD PLASTIC SOIC

NOTE: THIS PIN CONFIGURATION DIFFERS FROM THE 8-PIN DIP CONFIGURATION. INSTEAD, IT FOLLOWS THE INDUSTRY STANDARD LT1013DS8 SO PACKAGE PIN LOCATIONS

LT1126 • POI01

ORDER PART NUMBER
LT1126CS8
S8 PART MARKING
1126

TOP VIEW



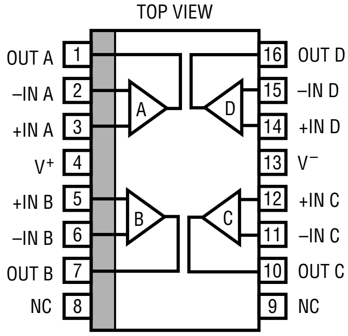
J8 PACKAGE
8-LEAD CERAMIC DIP

N8 PACKAGE
8-LEAD PLASTIC DIP

LT1126 • POI02

ORDER PART NUMBER
LT1126AMJ8 LT1126MJ8 LT1126CJ8 LT1126ACN8 LT1126CN8

TOP VIEW

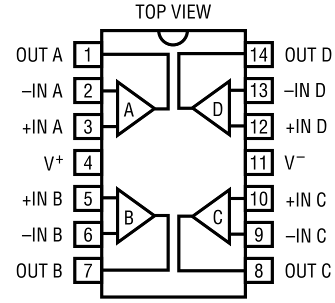


S PACKAGE
16-LEAD PLASTIC SOL

LT1126 • POI03

ORDER PART NUMBER
LT1127CS

TOP VIEW



J PACKAGE
14-LEAD CERAMIC DIP

N PACKAGE
14-LEAD PLASTIC DIP

LT1126 • POI04

ORDER PART NUMBER
LT1127AMJ LT1127MJ LT1127CJ LT1127ACN LT1127CN

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $T_A = 25°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)	LT1126AM/AC LT1127AM/AC MIN	TYP	MAX	LT1126M/C LT1127M/C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1126		20	70		25	100	µV
		LT1127		25	90		30	140	µV
$\frac{\Delta V_{OS}}{\Delta Time}$	Long Term Input Offset Voltage Stability			0.3			0.3		µV/Mo
I_{OS}	Input Offset Current	LT1126		5	15		6	20	nA
		LT1127		6	20		7	30	nA
I_B	Input Bias Current			±7	±20		±8	±30	nA
e_n	Input Noise Voltage	0.1Hz to 10Hz (Notes 7 and 8)		70	200		70		nVp-p

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $T_A = 25°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)	LT1126AM/AC LT1127AM/AC MIN	TYP	MAX	LT1126M/C LT1127M/C MIN	TYP	MAX	UNITS
	Input Noise Voltage Density	f_O = 10Hz (Note 3)		3.0	5.5		3.0	5.5	nV/√Hz
		f_O = 1000Hz (Note 2)		2.7	4.2		2.7	4.2	nV/√Hz
i_n	Input Noise Current Density	f_O = 10Hz		1.3			1.3		pA/√Hz
		f_O = 1000Hz		0.3			0.3		pA/√Hz
V_{CM}	Input Voltage Range		±12.0	±12.8		±12.0	±12.8		V
CMRR	Common Mode Rejection Ratio	V_{CM} = ±12V	112	126		106	124		dB
PSRR	Power Supply Rejection Ratio	V_S = ±4V to ±18V	116	126		110	124		dB
A_{VOL}	Large Signal Voltage Gain	R_L ≥ 10kΩ, V_O = ±10V	5.0	17.0		3.0	15.0		V/µV
		R_L ≥ 2kΩ, V_O = ±10V	2.0	4.0		1.5	3.0		V/µV
V_{OUT}	Maximum Output Voltage Swing	R_L ≥ 2kΩ	±13.0	±13.8		±12.5	±13.8		V
SR	Slew Rate	R_L ≥ 2kΩ (Notes 2 and 6)	8.0	11		8.0	11		V/µs
GBW	Gain-Bandwidth Product	f_O = 10kHz (Note 2)	45	65		45	65		MHz
Z_O	Open Loop Output Resistance	V_O = 0, I_O = 0		75			75		Ω
I_S	Supply Current Per Amplifier			2.6	3.1		2.6	3.1	mA
	Channel Separation	f ≤ 10Hz (Note 8) V_O = ±10V, R_L = 2kΩ	134	150		130	150		dB

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $-55°C \le T_A \le 125°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1126AM LT1127AM MIN	TYP	MAX	LT1126M LT1127M MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1126	●		50	170		60	250	µV
		LT1127	●		55	190		70	290	µV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Voltage Drift	(Note 4)	●		0.3	1.0		0.4	1.5	µV/°C
I_{OS}	Input Offset Current	LT1126	●		18	45		20	60	nA
		LT1127	●		18	55		20	70	nA
I_B	Input Bias Current		●		±18	±55		±20	±70	nA
V_{CM}	Input Voltage Range		●	±11.3	±12		±11.3	±12		V
CMRR	Common Mode Rejection Ratio	V_{CM} = ±11.3V	●	106	122		100	120		dB
PSRR	Power Supply Rejection Ratio	V_S = ±4V to ±18V	●	110	122		104	120		dB
A_{VOL}	Large Signal Voltage Gain	R_L ≥ 10kΩ, V_O = ±10V	●	3.0	10.0		2.0	10.0		V/µV
		R_L ≥ 2kΩ, V_O = ±10V	●	1.0	3.0		0.7	2.0		V/µV
V_{OUT}	Maximum Output Voltage Swing	R_L ≥ 2kΩ	●	±12.5	±13.6		±12.0	±13.6		V
SR	Slew Rate	R_L ≥ 2kΩ (Notes 2 and 6)	●	7.2	10		7.0	10		V/µs
I_S	Supply Current Per Amplifier		●		2.8	3.5		2.8	3.5	mA

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

Note 1: Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers; i.e., out of 100 LT1127s (or 100 LT1126s) typically 240 op amps (or 120) will be better than the indicated specification.

Note 2: This parameter is 100% tested for each individual amplifier.

Note 3: This parameter is sample tested only.

Note 4: This parameter is not 100% tested.

Note 5: The inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise. If differential input voltage exceeds ±1.4V, the input current should be limited to 25mA.

Note 6: Slew rate is measured in A_V = –10; input signal is ±1V, output measured at ±5V.

Note 7: 0.1Hz to 10Hz noise can be inferred from the 10Hz noise voltage density test. See the test circuit and frequency response curve for 0.1Hz to 10Hz tester in the Applications Information section of the LT1007 or LT1028 datasheets.

Note 8: This parameter is guaranteed but not tested.

Note 9: The LT1126 and LT1127 are not tested and are 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.

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1126AC LT1127AC MIN	TYP	MAX	LT1126C LT1127C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1126	●		35	120		45	170	µV
		LT1127	●		40	140		50	210	µV
$\Delta V_{OS}/\Delta T$	Average Input Offset Voltage Drift	(Note 4)	●		0.3	1.0		0.4	1.5	µV/°C
I_{OS}	Input Offset Current	LT1126	●		6	25		7	35	nA
		LT1127	●		7	35		8	45	nA
I_B	Input Bias Current		●		± 8	± 35		± 9	± 45	nA
V_{CM}	Input Voltage Range		●	± 11.5	± 12.4		± 11.5	± 12.4		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm11.5V$	●	109	125		102	122		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm4V$ to $\pm18V$	●	112	125		107	122		dB
A_{VOL}	Large Signal Voltage Gain	$R_L \ge 10k\Omega$, $V_O = \pm10V$	●	4.0	15.0		2.5	14.0		V/µV
		$R_L \ge 2k\Omega$, $V_O = \pm10V$	●	1.5	3.5		1.0	2.5		V/µV
V_{OUT}	Maximum Output Voltage Swing	$R_L \ge 2k\Omega$	●	± 12.5	± 13.7		± 12.0	± 13.7		V
SR	Slew Rate	$R_L \ge 2k\Omega$ (Notes 2 and 6)	●	7.5	10.5		7.3	10.5		V/µs
I_S	Supply Current Per Amplifier		●		2.7	3.3		2.7	3.3	mA

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $-40°C \le T_A \le 85°C$, unless otherwise noted. (Note 9)

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1126AC LT1127AC MIN	TYP	MAX	LT1126C LT1127C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1126	●		40	140		50	200	µV
		LT1127	●		45	160		55	240	µV
$\Delta V_{OS}/\Delta T$	Average Input Offset Voltage Drift		●		0.3	1.0		0.4	1.5	µV/°C
I_{OS}	Input Offset Current	LT1126	●		15	40		17	55	nA
		LT1127	●		15	50		17	65	nA
I_B	Input Bias Current		●		± 15	± 50		± 17	± 65	nA
V_{CM}	Input Voltage Range		●	± 11.4	± 12.2		± 11.4	± 12.2		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm11.4V$	●	107	124		101	121		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm4V$ to $\pm18V$	●	111	124		106	121		dB
A_{VOL}	Large Signal Voltage Gain	$R_L \ge 10k\Omega$, $V_O = \pm10V$	●	3.5	12.0		2.2	12.0		V/µV
		$R_L \ge 2k\Omega$, $V_O = \pm10V$	●	1.2	3.2		0.8	2.3		V/µV
V_{OUT}	Maximum Output Voltage Swing	$R_L \ge 2k\Omega$	●	± 12.5	± 13.6		± 12.0	± 13.6		V
SR	Slew Rate	$R_L \ge 2k\Omega$ (Note 6)	●	7.3	10.2		7.1	10.2		V/µs
I_S	Supply Current Per Amplifier		●		2.8	3.4		2.8	3.4	mA

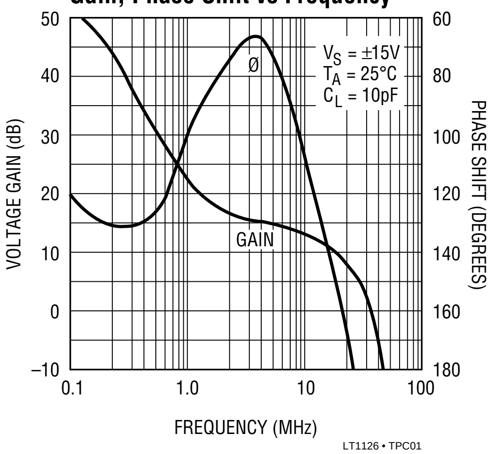
TYPICAL PERFORMANCE CHARACTERISTICS

The typical behavior of many LT1126/LT1127 parameters is identical to the LT1124/LT1125. Please refer to the LT1124/LT1125 data sheet for the following performance characteristics:

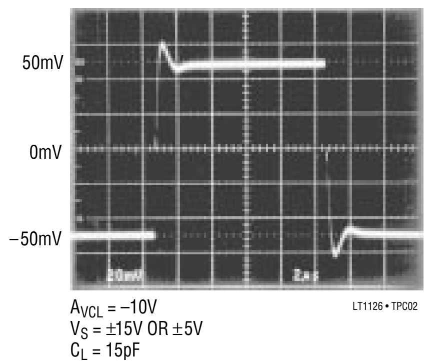
0.1Hz to 10Hz Voltage Noise
0.01Hz to 1Hz Voltage Noise
Current Noise vs Frequency
Input Bias or Offset Current vs Temperature
Output Short Circuit Current vs Time
Input Bias Current Over the Common Mode Range
Voltage Gain vs Temperature
Input Offset Voltage Drift Distribution
Offset Voltage Drift with Temperature of Representative Units
Output Voltage Swing vs Load Current
Common Mode Limit vs Temperature
Channel Separation vs Frequency
Warm-Up Drift
Power Supply Rejection Ratio vs Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

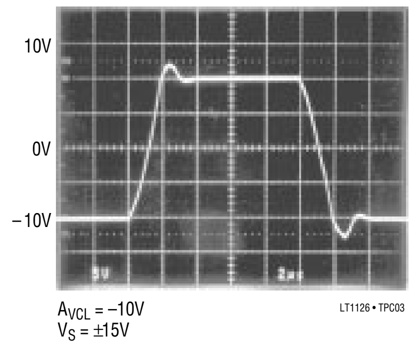
Gain, Phase Shift vs Frequency



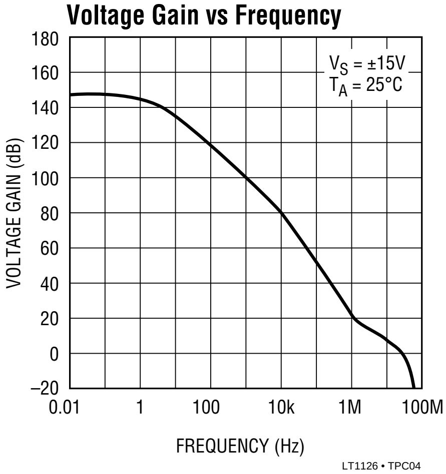
Small-Signal Transient Response



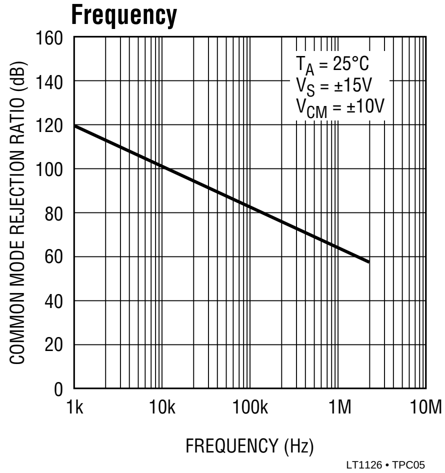
Large-Signal Transient Response



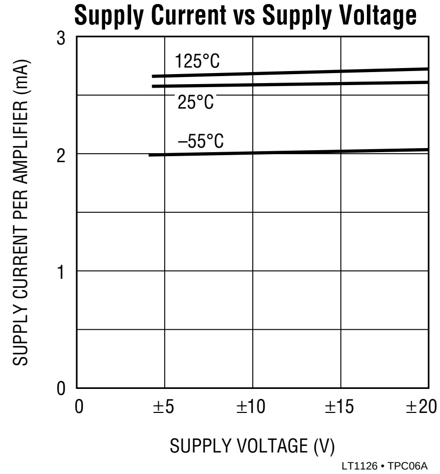
Voltage Gain vs Frequency



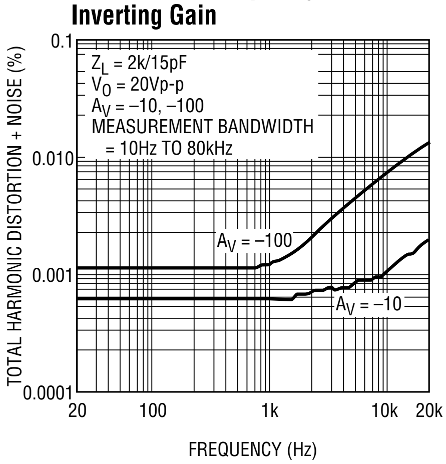
Common Mode Rejection Ratio vs Frequency



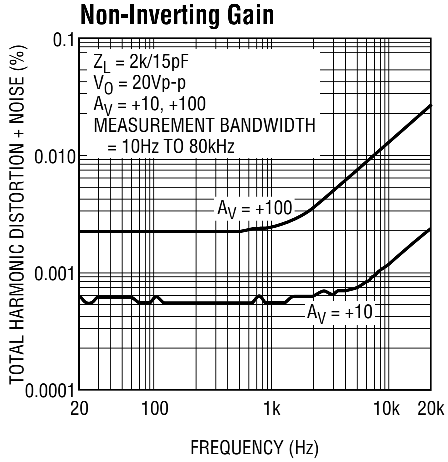
Supply Current vs Supply Voltage



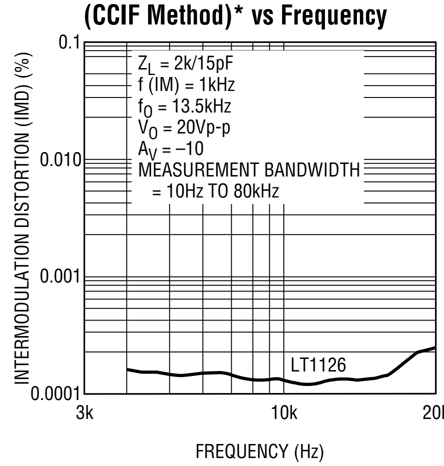
Total Harmonic Distortion and Noise vs Frequency for Inverting Gain



Total Harmonic Distortion and Noise vs Frequency for Non-Inverting Gain



Intermodulation Distortion (CCIF Method)* vs Frequency



*See LT1115 data sheet for definition of CCIF testing

APPLICATIONS INFORMATION

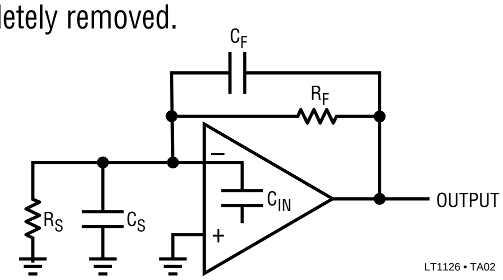
Matching Specifications

In many applications the performance of a system depends on the matching between two op amps, rather than the individual characteristics of the two devices. The three op amp instrumentation amplifier configuration shown in this data sheet is an example. Matching characteristics are not 100% tested on the LT1126/LT1127.

Some specifications are guaranteed by definition. For example, 70μV maximum offset voltage implies that mismatch cannot be more than 140μV. 112dB (= 2.5μV/V) CMRR means that worst case CMRR match is 106dB (5μV/V). However, the following table can be used to estimate the expected matching performance between the two sides of the LT1126, and between amplifiers A and D, and between amplifiers B and C of the LT1127.

High Speed Operation

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 ($C_{IN} \approx 2pF$). 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.

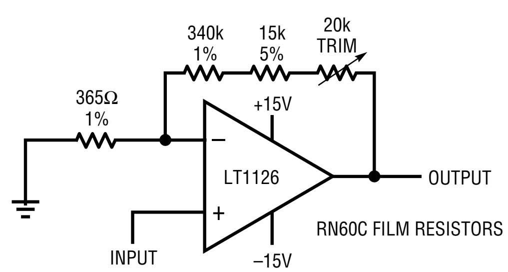


Expected Match

PARAMETER		LT1126AM/AC LT1127AM/AC 50% YIELD	98% YIELD	LT1126M/C LT1127M/C 50% YIELD	98% YIELD	UNITS
V_{OS} Match, ΔV_{OS}	LT1126	20	110	30	130	μV
	LT1127	30	150	50	180	μV
Temperature Coefficient Match		0.35	1.0	0.5	1.5	μV/°C
Average Non-Inverting I_B		6	18	7	25	nA
Match of Non-Inverting I_B		7	22	8	30	nA
CMRR Match		126	115	123	112	dB
PSRR Match		127	118	127	114	dB

TYPICAL APPLICATIONS

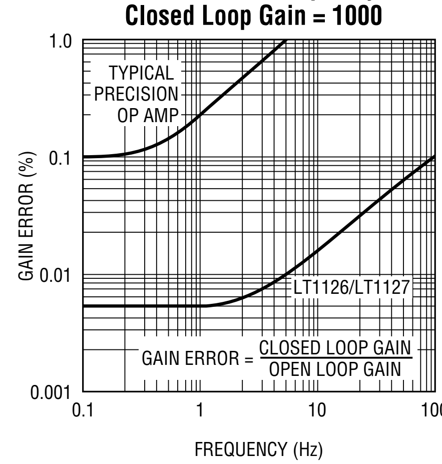
Gain 1000 Amplifier with 0.01% Accuracy, DC to 5Hz



THE HIGH GAIN AND WIDE BANDWIDTH OF THE LT1126/LT1127 IS USEFUL IN LOW FREQUENCY HIGH CLOSED LOOP GAIN AMPLIFIER APPLICATIONS. A TYPICAL PRECISION OP AMP MAY HAVE AN OPEN LOOP GAIN OF ONE MILLION WITH 500kHz BANDWIDTH. AS THE GAIN ERROR PLOT SHOWS, THIS DEVICE IS CAPABLE OF 0.1% AMPLIFYING ACCURACY UP TO 0.3Hz ONLY. EVEN INSTRUMENTATION RANGE SIGNALS CAN VARY AT A FASTER RATE. THE LT1126/LT1127 "GAIN PRECISION — BANDWIDTH PRODUCT" IS 330 TIMES HIGHER, AS SHOWN.

LT1126 • TA03

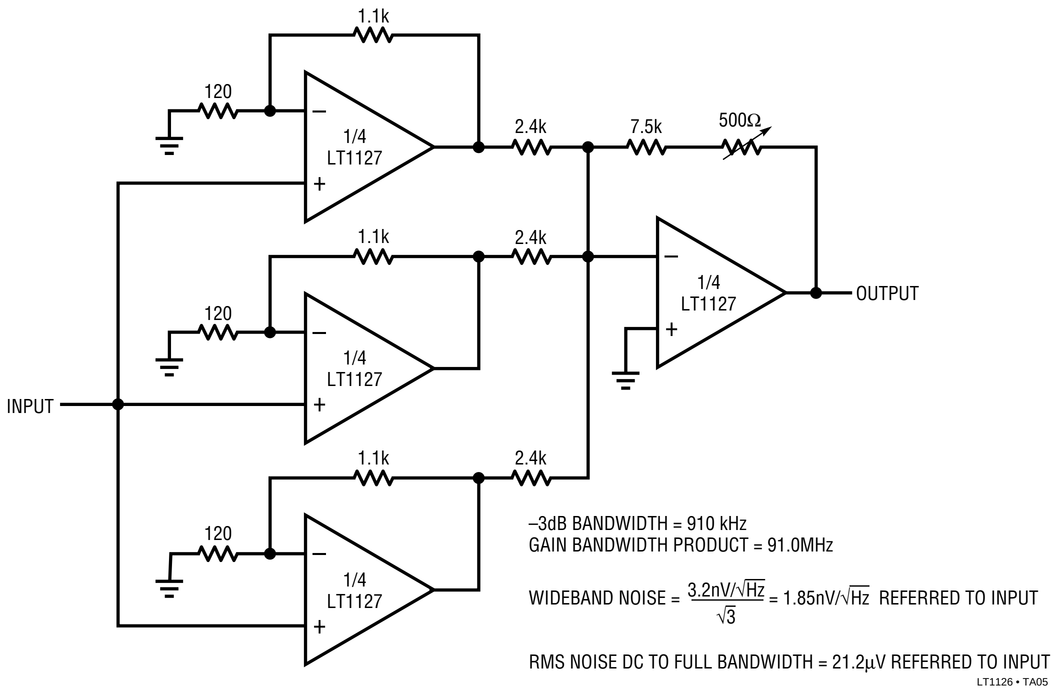
Gain Error vs Frequency Closed Loop Gain = 1000



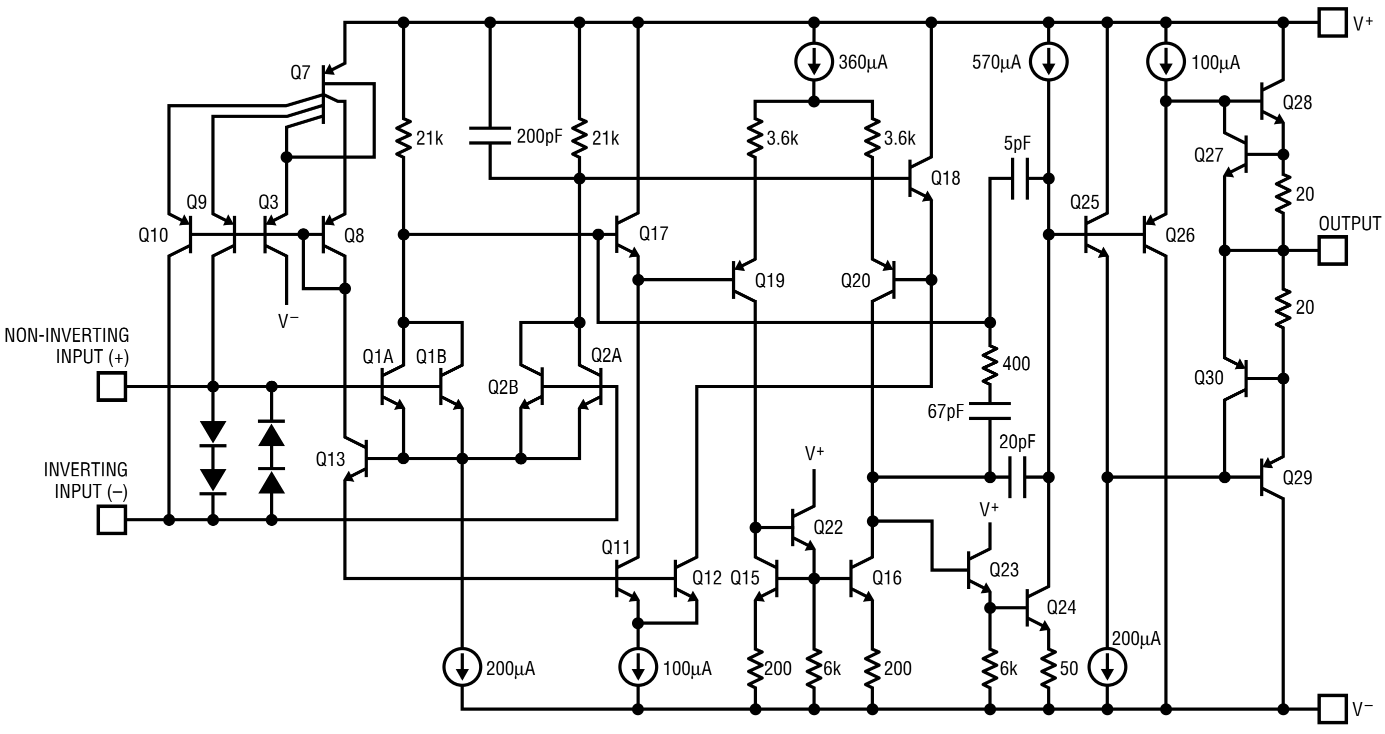
LINEAR TECHNOLOGY

TYPICAL APPLICATIONS

Low Noise, Wideband, Gain = 100 Amplifier with High Input Impedance



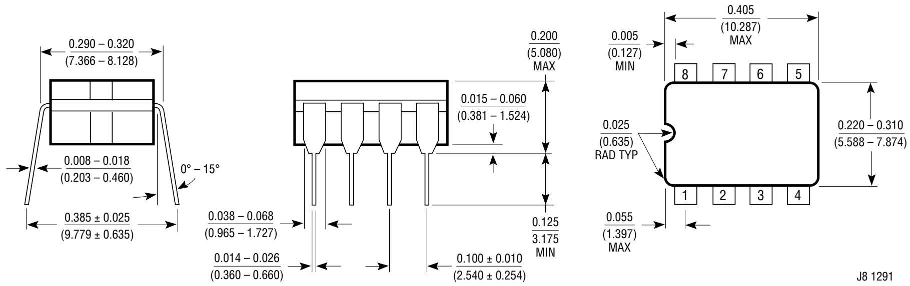
SCHEMATIC DIAGRAM (1/2 LT1126, 1/4 LT1127)



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

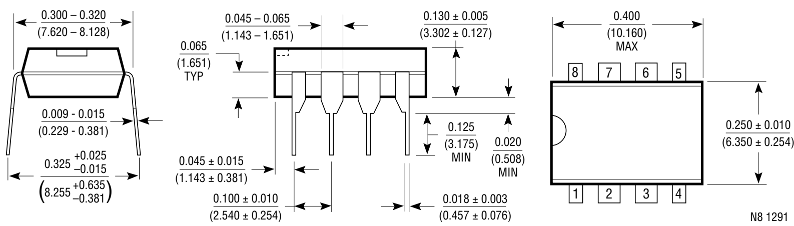
J8 Package
8-Lead Ceramic DIP

$T_{J\ MAX}$	θ_{JA}
160°C	100°C/W



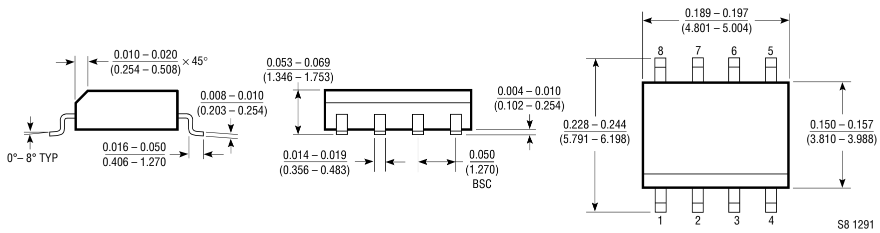
N8 Package
8-Lead Plastic DIP

$T_{J\ MAX}$	θ_{JA}
140°C	130°C/W



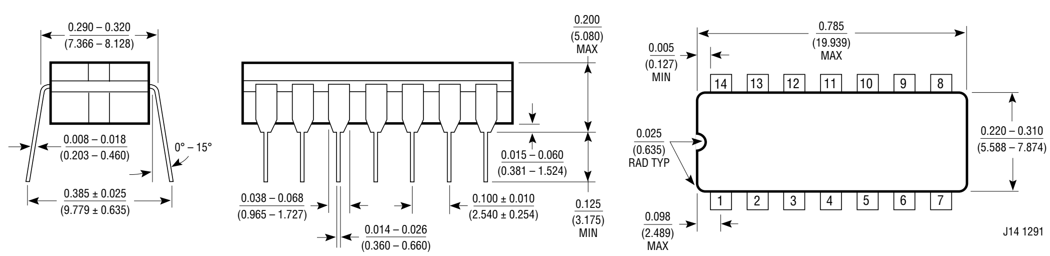
S8 Package
8-Lead Plastic SOIC

$T_{J\ MAX}$	θ_{JA}
140°C	190°C/W



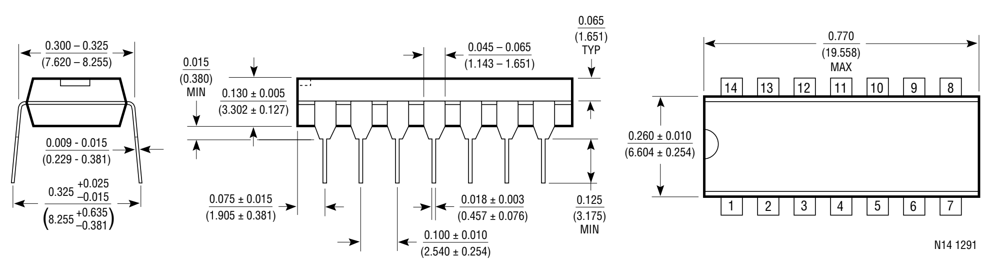
J Package
14-Lead Ceramic DIP

$T_{J\ MAX}$	θ_{JA}
160°C	80°C/W



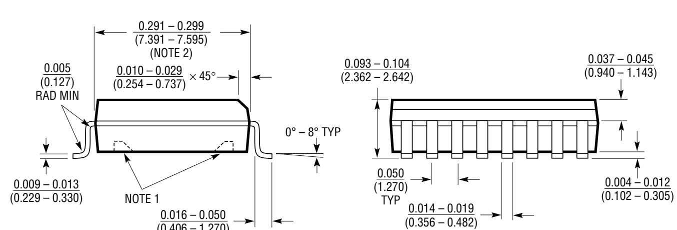
N Package
14-Lead Plastic DIP

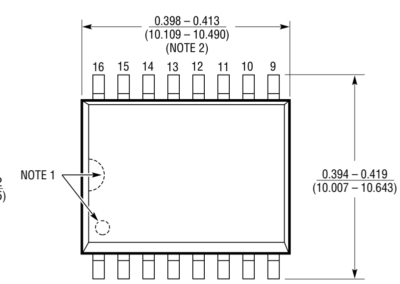
$T_{J\ MAX}$	θ_{JA}
140°C	110°C/W



SOL Package
16-Lead Plastic SOL

$T_{J\ MAX}$	θ_{JA}
140°C	130°C/W





NOTE:
1. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.
2. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

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