LINEAR TECHNOLOGY

LTC1100

Precision, Chopper Stabilized Instrumentation Amplifier

FEATURES

- Offset Voltage 10µV Max
- Offset Voltage Drift 50nV/°C Max
- Bias Current 50pA Max
- Offset Current 50pA Max
- Gain Non-Linearity 8ppm Max
- Gain Error ±0.05% Max
- CMRR 104dB
- 0.1Hz-10Hz Noise 2µVp-p
- Single 5V Supply Operation
- 8-Pin MiniDIP

APPLICATIONS

- Thermocouple Amplifiers
- Strain Gauge Amplifiers
- Differential to Single Ended Converters

DESCRIPTION

The LTC1100 is a high precision instrumentation amplifier using chopper stabilization techniques to achieve outstanding DC performance. The input DC offset is typically 1µV while the DC offset drift is typically 10nV/°C; a very low bias current of 50pA is also achieved.

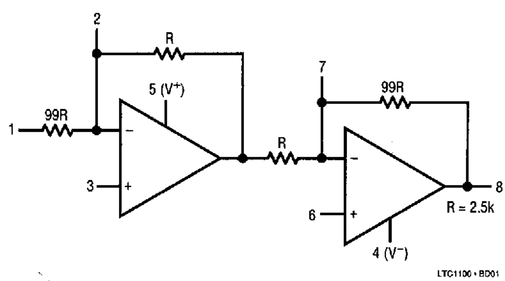
The LTC1100 is self contained; that is, it achieves a differential gain of 100 without any external gain setting resistor or trim pot. The gain linearity is 8ppm and the gain drift is 4ppm/°C. The LTC1100 operates from a single 5V supply up to ±8V. The output typically swings 300mV from its power supply rails with a 10k load.

An optional external capacitor can be added from pin 7 to pin 8 to tailor the device's 18kHz bandwidth and to eliminate any unwanted noise pickup.

The LTC1100 is also offered in a 16-pin surface mount package with selectable gains of 10 or 100.

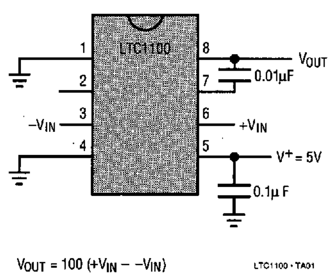
The LTC1100 is manufactured using Linear Technology's enhanced LTCMOS™ silicon gate process.

BLOCK DIAGRAM



TYPICAL APPLICATION

Single 5V Supply, DC Instrumentation Amplifier



LINEAR TECHNOLOGY

ABSOLUTE MAXIMUM RATINGS

T-71-11-01

Operating Temperature Range
- LTC1100M/AM .... −55°C to 125°C
- LTC1100C/AC .... −40°C to 85°C

Storage Temperature Range .... −65°C to 150°C

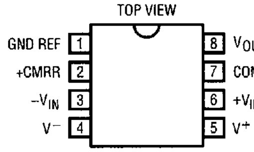
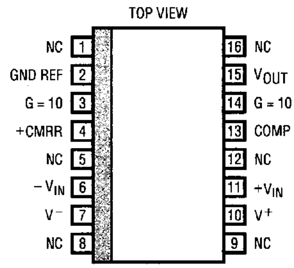
Lead Temperature (Soldering, 10 sec.) .... 300°C

Total Supply Voltage (V^+ to V^-) 18V

Input Voltage .... (V^+ + 0.3V) to (V^- − 0.3V)

Output Short Circuit Duration .... Indefinite

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER		ORDER PART NUMBER
 N8 PACKAGE 8-LEAD PLASTIC DIP; J8 PACKAGE 8-LEAD CERAMIC DIP	LTC1100ACN/ACJ LTC1100CN/CJ LTC1100AMJ LTC1100MJ	 S PACKAGE 16-LEAD PLASTIC SOL	LTC1100ACS LTC1100CS

ELECTRICAL CHARACTERISTICS $V_S = \pm5V$, $R_L = 10k$, $C_C = 1000pF$, unless otherwise specified.

PARAMETER	CONDITIONS		LTC1100ACN/ACJ MIN	TYP	MAX	LTC1100CN/CJ MIN	TYP	MAX	UNITS
Gain Error	T_A = 25°C			0.01	0.05		0.01	0.075	±%
		●			0.1			0.15	
Gain Non-Linearity	T_A = 25°C			3	8		3	20	ppm
		●		12	30		12	60	
Input Offset Voltage	(Note 1)			±1	±10		±1	±10	µV
Input Offset Voltage Drift	(Note 1)	●		±5	±100		±5	±100	nV/°C
Input Noise Voltage	DC to 10Hz, T_A = 25°C			1.9			1.9		µVp-p
Input Bias Current	T_A = 25°C			2.5	50		2.5	65	pA
		●			120			135	
Input Offset Current		●		10	50		10	65	pA
Common Mode Rejection Ratio	V_{CM} = +2.3V to −4.7V (Note 2)	●	104	115		90	110		dB
Power Supply Rejection Ratio	V_S = ±2.375V to ±8V	●	120			105			dB
Output Voltage Swing	R_L = 2kΩ, V_S = ±8V	●	−7.2		6.2	−7.2		6.2	V
	R_L = 10kΩ, V_S = ±8V	●	−7.7		7.5	−7.7		7.5	
Supply Current	T_A = 25°C			2.4	2.8		2.4	3.3	mA
		●		3.4	4		3.4	4.5	
Internal Sampling Frequency	T_A = 25°C			2.8			2.8		kHz
Bandwidth	T_A = 25°C			18			18		kHz

ELECTRICAL CHARACTERISTICS

T-71-11-01

$V_S = \pm5V$, $R_L = 10k$, $C_C = 1000pF$, unless otherwise specified.

PARAMETER	CONDITIONS		LTC1100AMJ MIN	LTC1100AMJ TYP	LTC1100AMJ MAX	LTC1100MJ MIN	LTC1100MJ TYP	LTC1100MJ MAX	UNITS
Gain Error	$T_A = 25°C$			0.01	0.05		0.01	0.075	±%
		●			0.11			0.15	
Gain Non-Linearity	$T_A = 25°C$			3	8		3	20	ppm
		●			40			65	
Input Offset Voltage	(Note 1)			±1	±10		±1	±10	µV
Input Offset Voltage Drift	(Note 1)	●		±5	±100		±5	±100	nV/°C
Input Noise Voltage	DC to 10Hz, $T_A = 25°C$			1.9			1.9		µVp-p
Input Bias Current	$T_A = 25°C$			5	50		5	65	pA
		●			300			450	
Input Offset Current		●			80			120	pA
Common Mode Rejection Ratio	$V_{CM} = -4.7V$ to $+2.3V$	●	100			90			dB
Power Supply Rejection Ratio	$V_S = \pm2.375V$ to $\pm8V$	●	115			95			dB
Output Voltage Swing	$R_L = 10k\Omega$, $V_S = \pm8V$	●	−7.4		7.4	−7.4		7.4	V
	$R_L = 2k\Omega$, $V_S = \pm8V$	●	−7.0		6.0	−7.0		6.0	
Supply Current	$T_A = 25°C$			2.4			2.4	3.3	mA
		●			4.2			4.6	
Internal Sampling Frequency	$T_A = 25°C$			2.8			2.8		kHz
Bandwidth	$T_A = 25°C$			18			18		kHz

ELECTRICAL CHARACTERISTICS

$V_S = \pm5V$, $R_L = 10k$, $C_C = 1000pF$, unless otherwise specified.

PARAMETER	CONDITIONS		LTC1100ACS MIN	LTC1100ACS TYP	LTC1100ACS MAX	LTC1100CS MIN	LTC1100CS TYP	LTC1100CS MAX	UNITS
Gain Error	$T_A = 25°C$, $A_V = 100$			0.01	0.05		0.01	0.075	±%
	$A_V = 100$	●			0.1			0.15	
	$A_V = 10$			0.01	0.04		0.01	0.06	
	$A_V = 10$	●			0.1			0.15	
Gain Non-Linearity	$T_A = 25°C$, $A_V = 100$			3	8		3	20	ppm
	$A_V = 100$	●		12	30		12	60	
	$A_V = 10$			1	8		1	10	
	$A_V = 10$	●			25			40	
Input Offset Voltage	(Note 1)			±1	±10		±1	±10	µV
Input Offset Voltage Drift	(Note 1)	●		±5	±100		±5	±100	nV/°C
Input Noise Voltage	DC to 10Hz, $T_A = 25°C$			1.9			1.9		µVp-p
Input Bias Current	$T_A = 25°C$			2.5	50		2.5	65	pA
		●			120			135	
Input Offset Current		●		10	50		10	65	pA
Common Mode Rejection Ratio	$V_{CM} = -4.7V$ to $+2.3V$,								
	$A_V = 100$	●	104	115		90	110		dB
	$A_V = 10$	●	95			85			
Power Supply Rejection Ratio	$V_S = \pm2.375V$ to $\pm8V$	●	120			105			dB

ELECTRICAL CHARACTERISTICS

T-71-11-01

$V_S = \pm 5V$, $R_L = 10k$, $C_C = 1000pF$, unless otherwise specified.

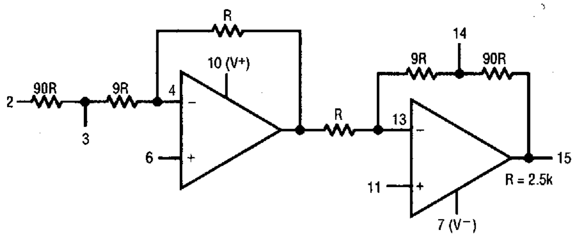
PARAMETER		CONDITIONS		LTC1100ACS MIN	LTC1100ACS TYP	LTC1100ACS MAX	LTC1100CS MIN	LTC1100CS TYP	LTC1100CS MAX	UNITS
Output Voltage Swing		$R_L = 10k\Omega$, $V_S = \pm 8V$	●	−7.2		6.2	−7.2		6.2	V
		$R_L = 2k\Omega$, $V_S = \pm 8V$	●	−7.7		7.5	−7.7		7.5	
Supply Current		$T_A = 25°C$			2.4	2.8		2.4	3.3	mA
			●		3.4	4		3.4	4.5	
Internal Sampling Frequency		$T_A = 25°C$			2.8			2.8		kHz
Bandwidth	G = 100	$T_A = 25°C$			18			18		kHz
	G = 10				180			180		

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

Note 1: These parameters are guaranteed by design. Thermocouple effects preclude measurement of these voltage levels in high speed automatic test systems. V_{OS} is measured to a limit determined by test equipment capability.

Note 2: See Applications Information, Single Supply Operation.

LTC1100CS BLOCK DIAGRAM

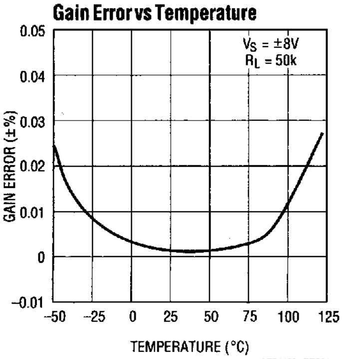


NOTE: FOR A VOLTAGE GAIN OF 10V/V SHORT PIN 2 TO 3, AND PIN 14 TO 15.

LTC1100 • BD02

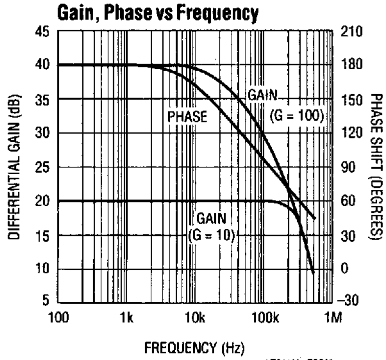
TYPICAL PERFORMANCE CHARACTERISTICS

Gain Error vs Temperature



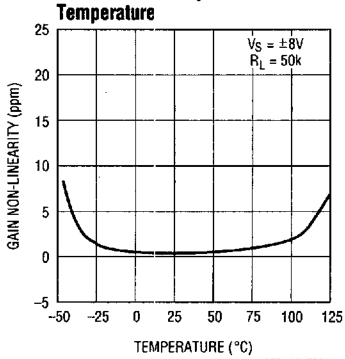
LTC1100 • TPC01

Gain, Phase vs Frequency



LTC1100 • TPC03

Gain Non-Linearity vs Temperature

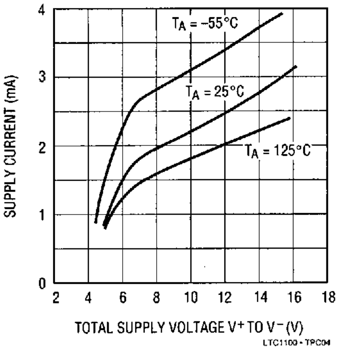


LTC1100 • TPC02

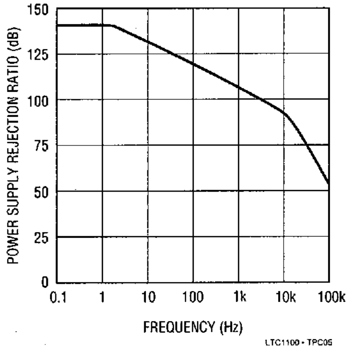
TYPICAL PERFORMANCE CHARACTERISTICS

T-71-11-01

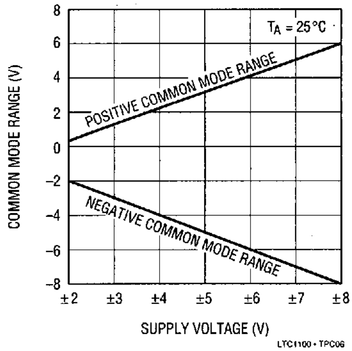
Supply Current vs Supply Voltage



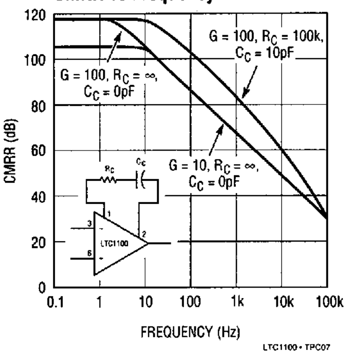
Power Supply Rejection Ratio vs Frequency



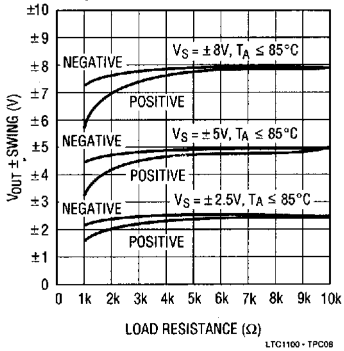
Common Mode Range vs Supply Voltage



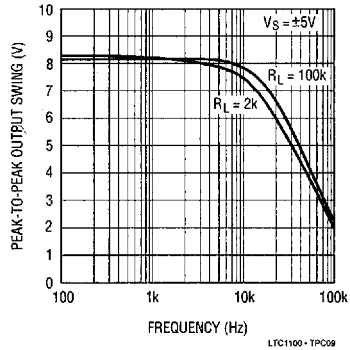
CMRR vs Frequency



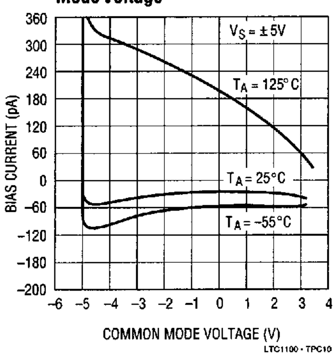
Output Voltage Swing vs Load



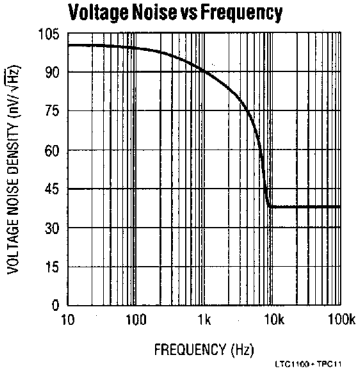
Undistorted Output Swing vs Frequency



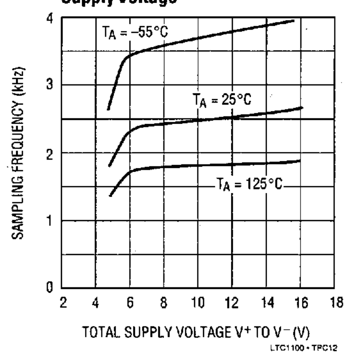
Bias Current vs Common Mode Voltage



Voltage Noise vs Frequency



Internal Sampling Frequency vs Supply Voltage

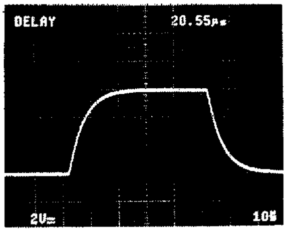


T-71-11-01

TYPICAL PERFORMANCE CHARACTERISTICS

Large Signal Transient Response
G=100, V_S=±5V

2V/DIV

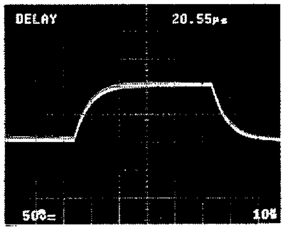


10μs/DIV

LTC1100 • TPC13

Small Signal Transient Response
G=100, V_S=±5V

50mV/DIV



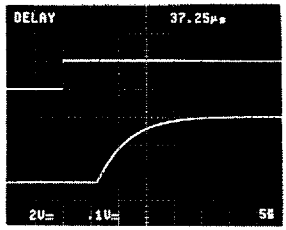
10μs/DIV

LTC1100 • TPC14

Overload Recovery
G=100, V_S=±5V

1V/DIV

2V/DIV

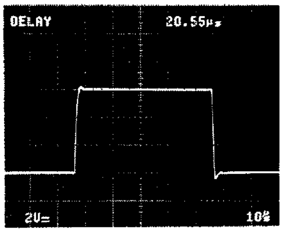


5μs/DIV

LTC1100 • TPC15

Large Signal Transient Response
G=10 (LTC1100CS Only), V_S=±5V

2V/DIV

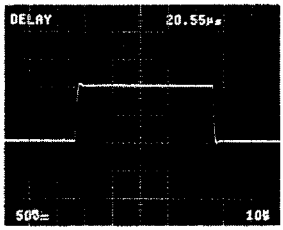


10μs/DIV

LTC1100 • TPC16

Small Signal Transient Response
G=10 (LTC1100CS Only), V_S=±5V

50ms/DIV



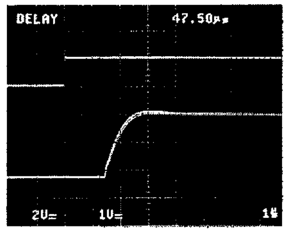
10μs/DIV

LTC1100 • TPC17

Overload Recovery
G=10 (LTC1100CS Only), V_S=±5V

1V/DIV

2V/DIV



1μs/DIV

LTC1100 • TPC18

PIN DESCRIPTION

8-Pin DIP (16-Pin SO)

Pin 1 (2) GND REF – Connect to system ground. This sets the zero reference for the internal op amps.

Pin 2 (4) +CMRR – This pin tailors the gain of the internal amplifiers to maximize AC CMRR. For applications which emphasize CMRR requirements, connect a 100k resistor and a 10pF capacitor in series from +CMRR to ground. See the Applications section.

Pin 3 (6) $-V_{IN}$ – Inverting Input.

Pin 4 (7) V^- – Negative Supply.

Pin 5 (10) V^+ – Positive Supply.

Pin 6 (11) $+V_{IN}$ – Non-Inverting Input.

Pin 7 (13) COMP – This pin reduces the bandwidth of the internal amplifiers for applications at or near DC. Clock feedthru from the internal sampling clock can also be suppressed by using the COMP pin. The standard compensation circuit is a capacitor from COMP to V_{OUT}, sized to provide an RC pole with the internal 247k resistor (22.5k for LTC1100CS in gain-of-10 mode). See the Applications section.

Pin 8 (15) V_{OUT} – Signal Output.

16-Pin SO Package Only

(3) G=10 – Short to pin (2) for gain of 10. Leave disconnected for gain of 100.

(14) G=10 – Short to pin (15) for gain of 10. Leave disconnected for gain of 100.

NOTE: *Both* pins must be shorted or open to provide correct gain.

(1),(5),(8),(9),(12),(16) NC – No internal connection.

APPLICATIONS INFORMATION

T-71-11-01

Common Mode Rejection

Due to very precise matching of the internal resistors, no trims are required to obtain a DC CMRR of better than 100dB. However, things change as frequency rises. The inverting amplifier is in a gain of 1.01 (1.1 for gain of 10), while the non-inverting amplifier is in a gain of 99 (9 for gain of 10). As frequency rises, the higher gain amplifier hits its gain-bandwidth limit long before the low gain amplifier, degrading CMRR. The solution is straightforward — slow down the inverting amplifier to match the non-inverting amp. Figure 1 shows the recommended circuit. The problem is less pronounced in the LTC1100CS in gain-of-10 mode; no CMRR trims are necessary.

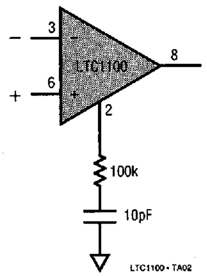


Figure 1. Improving AC CMRR

Overcompensation

Many instrumentation amplifier applications process DC or low frequency signals only; consequently the 18kHz (180kHz for G=10) bandwidth of the LTC1100 can be reduced to minimize system errors or reduce transmitted clock noise by using the COMP pin. A feedback cap from COMP to V_{OUT} will react with the 247k internal resistor (22.5k for G=10) to limit the bandwidth, as in Figure 2.

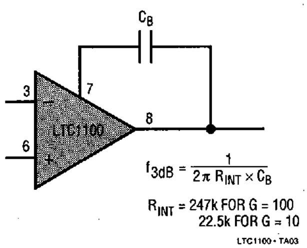


Figure 2. Overcompensation to Reduce System Bandwidth

Aliasing

The LTC1100 is a chopper stabilized instrumentation amplifier; like all sampled systems it exhibits aliasing behavior for input frequencies at or near the internal sampling frequency. The LTC1100 incorporates specialized anti-aliasing circuitry which typically attenuates aliasing products by ≥60dB; however, extremely sensitive systems may still have to take precautions to avoid aliasing errors. For more information, see the LTC1051/1053 data sheet.

Single Supply Operation

The LTC1100 will operate on a single 5V supply, and the common mode range of the internal op amps includes ground; single supply operation is limited only by the output swing of the op amps. The internal inverting amplifier has a negative saturation limit of 5mV typically, setting the minimum common mode limit at 5mV/1.01 (or 1.1 for gain of 10). The inputs can be biased above ground as shown in Figure 3. Low cost biasing components can be used since any errors appear as a common mode term and are rejected.

The minimum differential input voltage is limited by the swing of the output op amp. Lightly loaded, it will swing down to 5mV, allowing differential input voltages as low as 50µV (450µV for gain of 10). Single supply operation limits the LTC1100 to positive differential inputs only; negative inputs will give a saturated zero output.

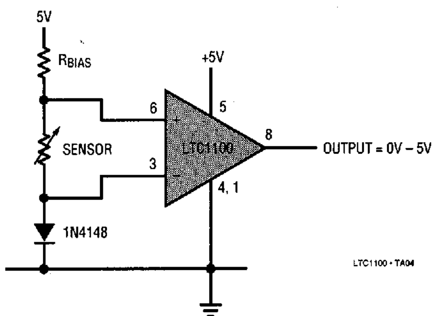


Figure 3.