High Speed, Precision, JFET Input Instrumentation Amplifier (Fixed Gain = 10 or 100)

FEATURES

■ Slew Rate	30V/µs
■ Gain-Bandwidth Product	35MHz
■ Settling Time (0.01%)	3µs
■ Overdrive Recovery	0.4µs
■ Gain Error	0.05% Max
■ Gain Drift	5ppm/°C
■ Gain Non-Linearity	16ppm Max
■ Offset Voltage (Input + Output)	600µV Max
– Drift with Temperature	2.5µV/°C
■ Input Bias Current	40pA Max
■ Input Offset Current	40pA Max
– Drift with Temperature (to 70°C)	0.5pA/°C

APPLICATIONS

- Fast Settling Analog Signal Processing
- Multiplexed Input Data Acquisition Systems
- High Source Impedance Signal Amplification from High Resistance Bridges, Capacitance Sensors, Photodetector Sensors
- Bridge Amplifier with <1Hz Lowpass Filtering

DESCRIPTION

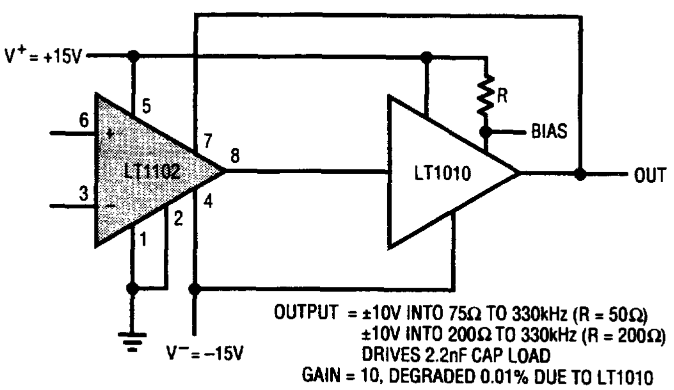
The LT1102 is the first fast FET input instrumentation amplifier offered in the low cost, space saving 8-pin packages. Fixed gains of 10 and 100 are provided with excellent gain accuracy (0.01%) and non-linearity (3ppm). No external gain setting resistor is required.

Slew rate, settling time, gain-bandwidth product, overdrive recovery time are all improved compared to competitive high speed instrumentation amplifiers.

Industry best speed performance is combined with impressive precision specifications: less than 10pA input bias and offset currents, 200µV offset voltage. Unlike other FET input instrumentation amplifiers, on the LT1102 there is no output offset voltage contribution to total error, and input bias currents do not double with every 10°C rise in temperature. Indeed, at 70°C ambient temperature the input bias current is only 50pA.

3

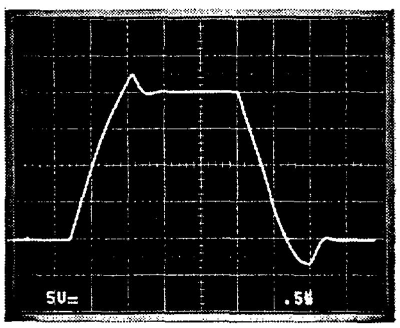
Wideband Instrumentation Amplifier with ±150mA Output Current



OUTPUT = ±10V INTO 75Ω TO 330kHz (R = 50Ω)
±10V INTO 200Ω TO 330kHz (R = 200Ω)
DRIVES 2.2nF CAP LOAD
GAIN = 10, DEGRADED 0.01% DUE TO LT1010

LT1102 • TA01

Slew Rate

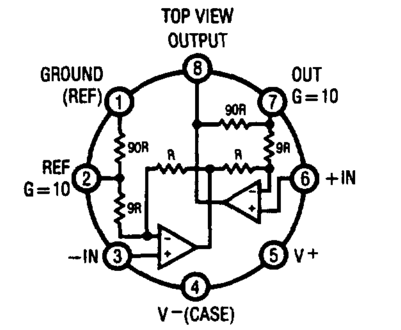
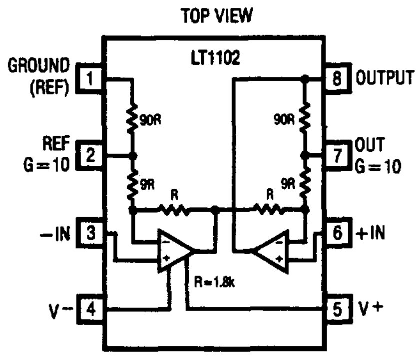


G = 10 0.5µs/DIV

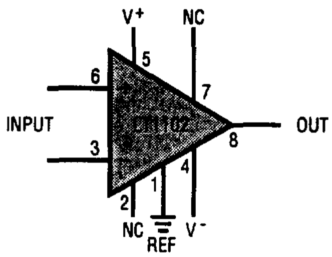
ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... ±20V
Differential Input Voltage .... ±40V
Input Voltage.................................... ±20V
Output Short Circuit Duration .... Indefinite
Operating Temperature Range
  LT1102AM/LT1102M .... –55°C to 125°C
  LT1102I .... –40°C to 85°C
  LT1102AC/LT1102C .... 0°C to 70°C
Storage Temperature Range
  All Grades .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.).............. 300°C

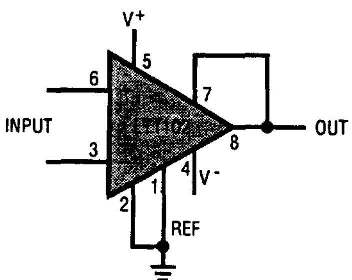
PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
 H PACKAGE 8-LEAD TO-5 METAL CAN	LT1102AMH LT1102MH LT1102ACH LT1102CH
 J PACKAGE 8-LEAD CERAMIC DIP, N PACKAGE 8-LEAD PLASTIC DIP	LT1102IN8 LT1102ACN8 LT1102CN8 LT1102MJ8 LT1102CJ8

Basic Connections

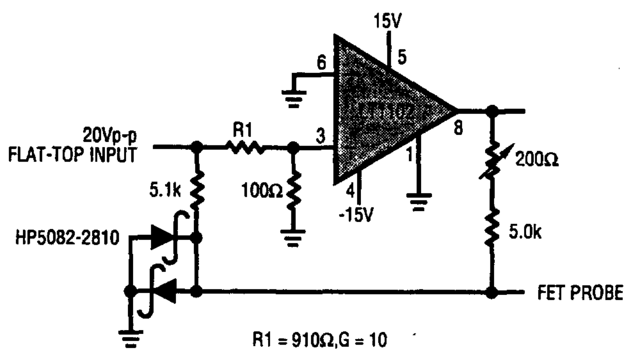


GAIN = 100



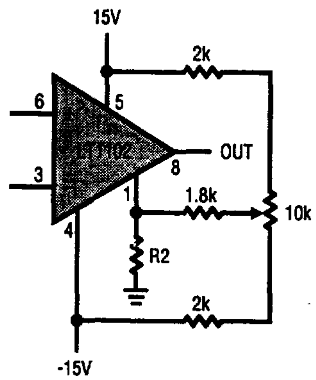
GAIN = 10

Settling Time Test Circuit



R1 = 910Ω, G = 10
R1 = 10k, G = 100

Offset Nulling



R2 = 3.3Ω, G = 10
R2 = 30Ω, G = 100
NULL RANGE = ±1mV
GAIN DEGRADATION ≈ 0.018%

ELECTRICAL CHARACTERISTICS

$V_S = \pm15V$, $V_{CM} = 0V$, $T_A = 25°C$, Gain = 10 or 100, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1102AM/AC MIN	LT1102AM/AC TYP	LT1102AM/AC MAX	LT1102M/I/C MIN	LT1102M/I/C TYP	LT1102M/I/C MAX	UNITS
G_E	Gain Error	$V_O = \pm10V$, $R_L = 50k$ or 2k		0.010	0.050		0.012	0.070	%
G_{NL}	Gain Non-Linearity	G = 100, $R_L = 50k$ G = 100, $R_L = 2k$ G = 10, $R_L = 50k$ or 2k		3 8 7	14 20 16		4 8 7	18 25 30	ppm ppm ppm
V_{OS}	Input Offset Voltage			180	600		200	900	μV
I_{OS}	Input Offset Current			3	40		4	60	pA
I_B	Input Bias Current			±3	±40		±4	±60	pA
	Input Resistance Common-Mode Differential Mode	 $V_{CM} = -11V$ to 8V $V_{CM} = 8V$ to 11V		 10^{12} 10^{11} 10^{12}			 10^{12} 10^{11} 10^{12}		 Ω Ω Ω
e_n	Input Noise Voltage	0.1Hz to 10Hz		2.8			2.8		μVp-p
	Input Noise Voltage Density	$f_o = 10Hz$ $f_o = 1000Hz$ (Note 1)		37 19	 30		37 20		nV/√Hz nV/√Hz
	Input Noise Current Density	$f_o = 1000Hz$, 10Hz (Note 2)		1.5	4		2	5	fA/√Hz
	Input Voltage Range		±10.5	±11.5		±10.5	±11.5		V
CMRR	Common-Mode Rejection Ratio	1k Source Imbalance, $V_{CM} = \pm10.5V$	84	98		82	97		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm9V$ to $\pm18V$	88	102		86	101		dB
I_S	Supply Current			3.3	5.0		3.4	5.6	mA
V_O	Maximum Output Voltage Swing	$R_L = 50k$ $R_L = 2k$	±13.0 ±12.0	±13.5 ±13.0		±13.0 ±12.0	±13.5 ±13.0		V V
BW	Bandwidth	G = 100 (Note 3) G = 10 (Note 3)	120 2.0	220 3.5		100 1.7	220 3.5		kHz MHz
SR	Slew Rate	G = 100, $V_{IN} = \pm0.13V$, $V_O = \pm5V$ G = 10, $V_{IN} = \pm1V$, $V_O = \pm5V$	12 21	17 30		10 18	17 30		V/μs V/μs
	Overdrive Recovery	50% Overdrive (Note 4)		400			400		ns
	Settling Time	$V_O = 20V$ Step (Note 3) G = 10 to 0.05% G = 10 to 0.01% G = 100 to 0.05% G = 100 to 0.01%		 1.8 3.0 7 9	 4.0 6.5 13 18		 1.8 3.0 7 9	 4.0 6.5 13 18	 μs μs μs μs

Note 1: This parameter is tested on a sample basis only.

Note 2: Current noise is calculated from the formula:
$i_n = (2qI_b)^{1/2}$
where $q = 1.6 \times 10^{-19}$ coulomb. The noise of source resistors up to 1GΩ swamps the contribution of current noise.

Note 3: This parameter is not tested. It is guaranteed by design and by inference from the slew rate measurement.

Note 4: Overdrive recovery is defined as the time delay from the removal of an input overdrive to the output's return from saturation to linear operation. 50% overdrive equals $V_{IN} = \pm2V$ (G = 10) or $V_{IN} = \pm200mV$ (G = 100).

Note 5: This parameter is not tested. It is guaranteed by design and by inference from other tests.

ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, Gain = 10 or 100, −55°C ≤ T_A ≤ 125°C for AM/M grades, −40°C ≤ T_A ≤ 85°C for I grades, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1102AM MIN	LT1102AM TYP	LT1102AM MAX	LT1102M/I MIN	LT1102M/I TYP	LT1102M/I MAX	UNITS
G_E	Gain Error	G = 100, V_O = ±10V, R_L = 50k or 2k		0.10	0.25		0.10	0.30	%
		G = 10, V_O = ±10V, R_L = 50k or 2k		0.05	0.12		0.06	0.15	%
TCG_E	Gain Error Drift (Note 5)	G = 100, R_L = 50k or 2k		9	20		10	25	ppm/°C
		G = 10, R_L = 50k or 2k		5	10		6	14	ppm/°C
G_{NL}	Gain Non-Linearity	G = 100, R_L = 50k		20	70		24	90	ppm
		G = 100, R_L = 2k		28	85		32	110	ppm
		G = 10, R_L = 50k or 2k		9	20		9	24	ppm
V_{OS}	Input Offset Voltage			300	1400		400	2000	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 5)		2	8		3	12	µV/°C
I_{OS}	Input Offset Current			0.3	4		0.4	6	nA
I_B	Input Bias Current			±2	±10		±2.5	±15	nA
CMRR	Common-Mode Rejection Ratio	V_{CM} = ±10.3V	82	97		80	96		dB
PSRR	Power Supply Rejection Ratio	V_S = ±10V to ±17V	86	100		84	99		dB
I_S	Supply Current	T_A = 125°C		2.5			2.5		mA
V_O	Maximum Output Voltage Swing	R_L = 50k	±12.5	±13.2		±12.5	±13.2		V
		R_L = 2k	±12.0	±12.6		±12.0	±12.6		V

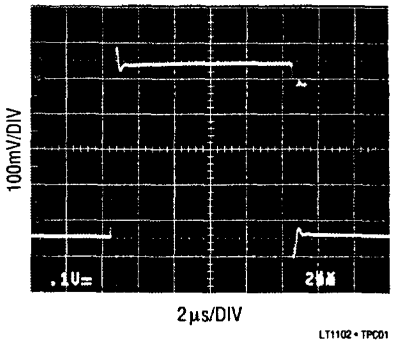
ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, Gain = 10 or 100, 0°C ≤ T_A ≤ 70°C, unless otherwise noted.

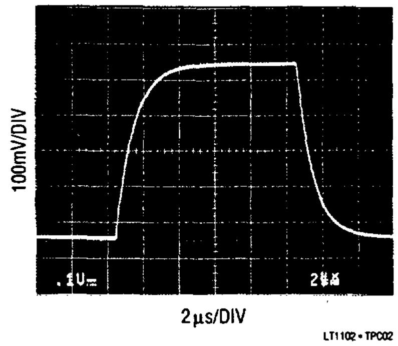
SYMBOL	PARAMETER	CONDITIONS	LT1102AC MIN	LT1102AC TYP	LT1102AC MAX	LT1102C MIN	LT1102C TYP	LT1102C MAX	UNITS
G_E	Gain Error	G = 100, V_O = ±10V, R_L = 50k or 2k		0.04	0.11		0.05	0.14	%
		G = 10, V_O = ±10V, R_L = 50k or 2k		0.03	0.09		0.04	0.12	%
TCG_E	Gain Error Drift (Note 5)	G = 100, R_L = 50k or 2k		8	18		9	22	ppm/°C
		G = 10, R_L = 50k or 2k		5	10		6	14	ppm/°C
G_{NL}	Gain Non-Linearity	G = 100, R_L = 50k		8	30		9	40	ppm
		G = 100, R_L = 2k		11	36		12	48	ppm
		G = 10, R_L = 50k or 2k		8	18		8	22	ppm
V_{OS}	Input Offset Voltage			230	1000		280	1400	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 5)		2	8		3	12	µV/°C
I_{OS}	Input Offset Current			10	150		15	220	pA
$\Delta I_{OS}/\Delta T$	Input Offset Current Drift	(Note 5)		0.5	3		0.5	4	pA/°C
I_B	Input Bias Current			±40	±300		±50	±400	pA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 5)		1	4		1	6	pA/°C
CMRR	Common-Mode Rejection Ratio	V_{CM} = ±10.3V	83	98		81	97		dB
PSRR	Power Supply Rejection Ratio	V_S = ±10V to ±17V	87	101		85	100		dB
I_S	Supply Current	T_A = 70°C		2.8			2.9		mA
V_O	Maximum Output Voltage Swing	R_L = 50k	±12.8	±13.4		±12.8	±13.4		V
		R_L = 2k	±12.0	±12.8		±12.0	±12.8		V

TYPICAL PERFORMANCE CHARACTERISTICS

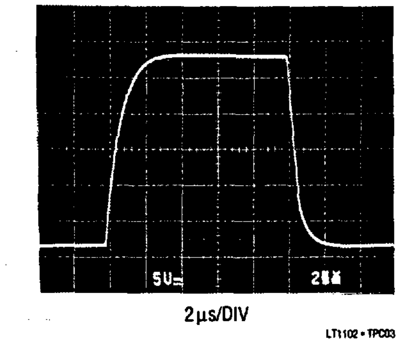
Small Signal Response, G = 10 (Input = 50mV Pulse)



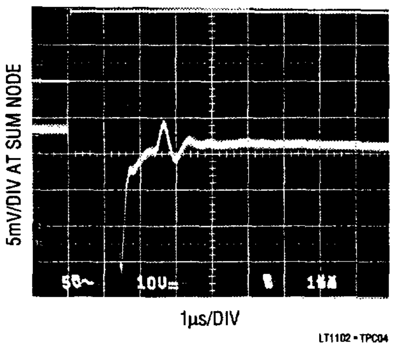
Small Signal Response, G = 100 (Input = 5mV Pulse)



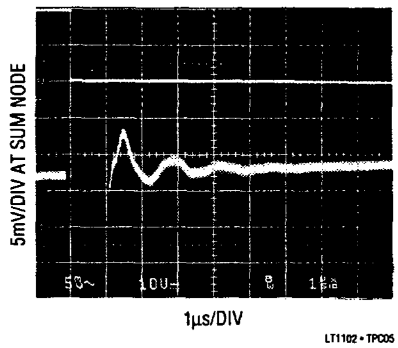
Slew Rate, G = 100 (Input = ±130mV Pulse)



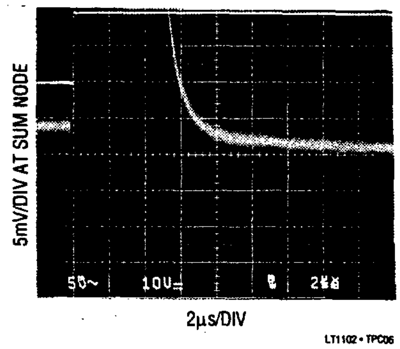
Settling Time, G = 10 (Input From −10V to +10V)



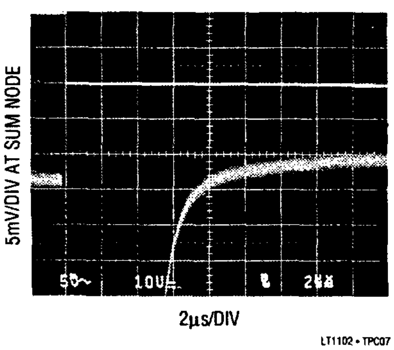
Settling Time, G = 10 (Input From +10V to −10V)



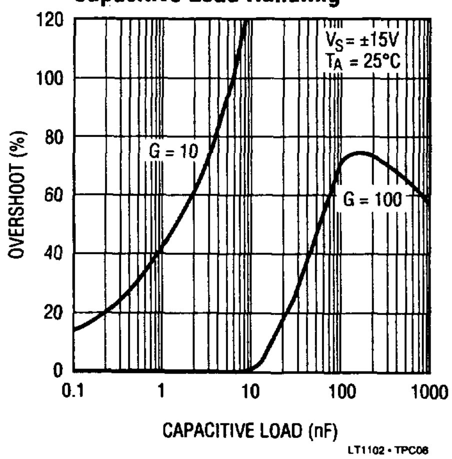
Settling Time, G = 100 (Input From −10V to +10V)



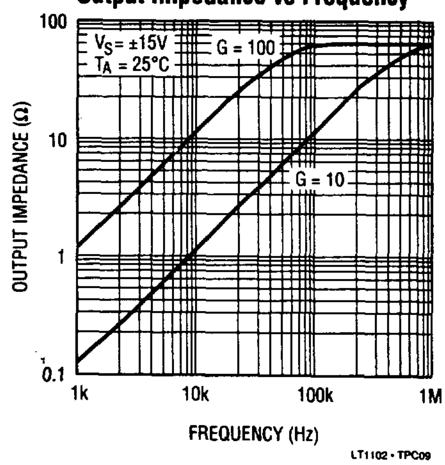
Settling Time, G = 100 (Input From +10V to −10V)



Capacitive Load Handling

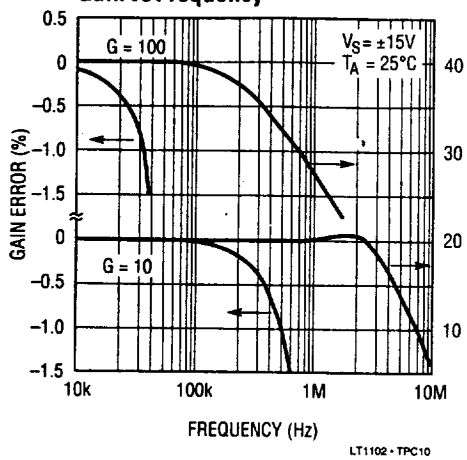


Output Impedance vs Frequency

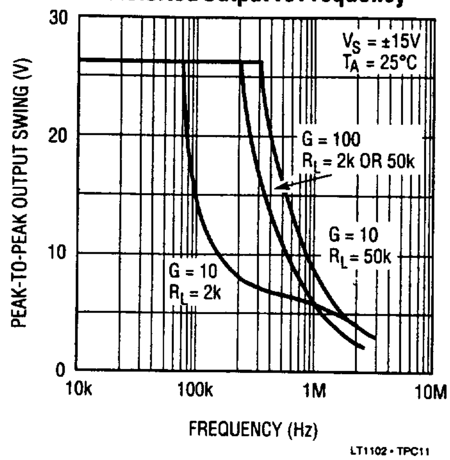


TYPICAL PERFORMANCE CHARACTERISTICS

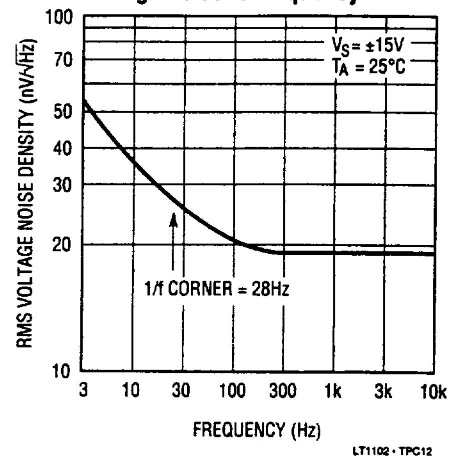
Gain vs Frequency



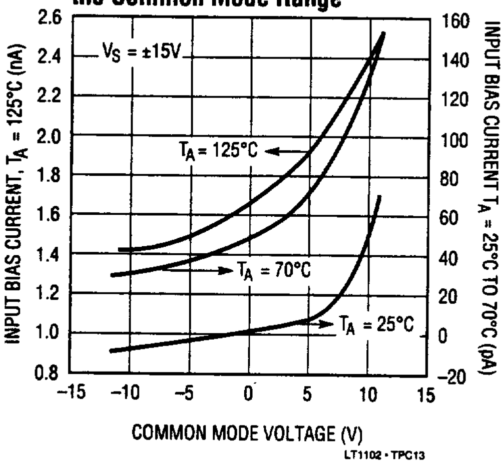
Undistorted Output vs Frequency



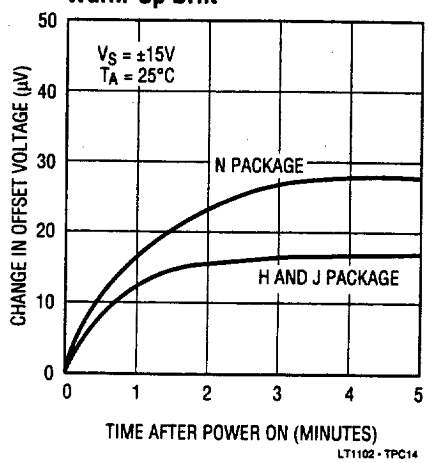
Voltage Noise vs Frequency



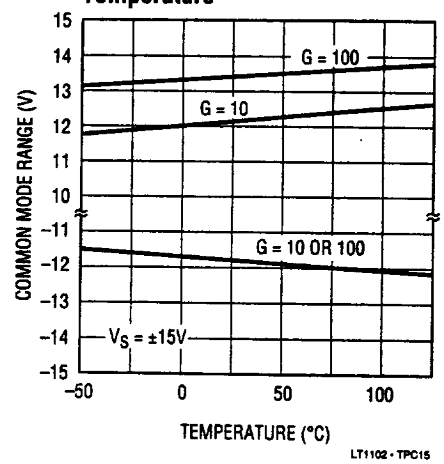
Input Bias Current Over the Common Mode Range



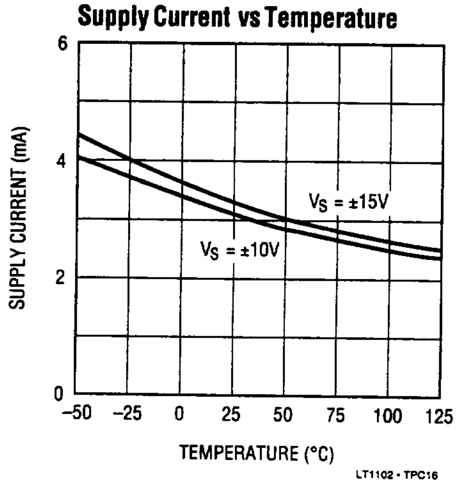
Warm-Up Drift



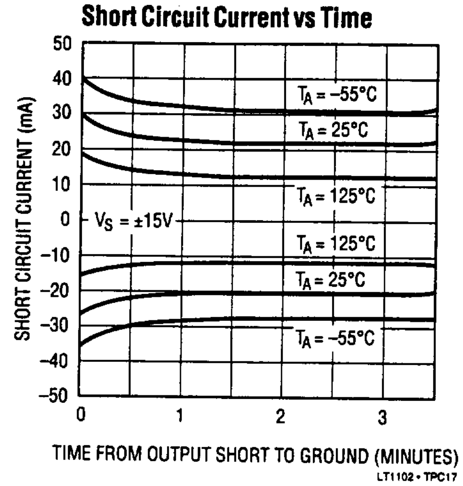
Common Mode Range vs Temperature



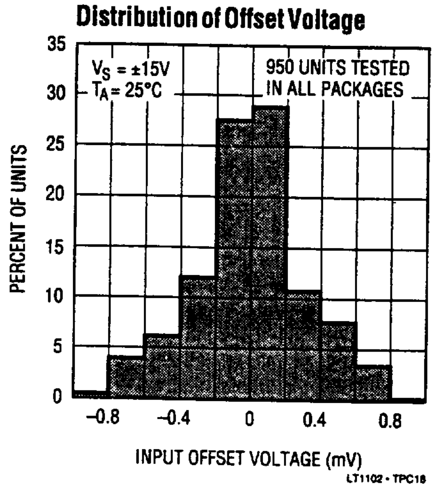
Supply Current vs Temperature



Short Circuit Current vs Time

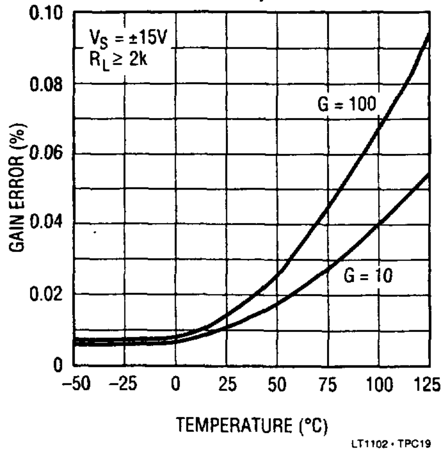


Distribution of Offset Voltage

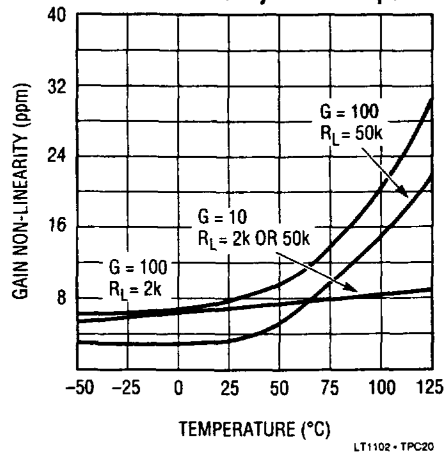


TYPICAL PERFORMANCE CHARACTERISTICS

Gain Error vs Temperature



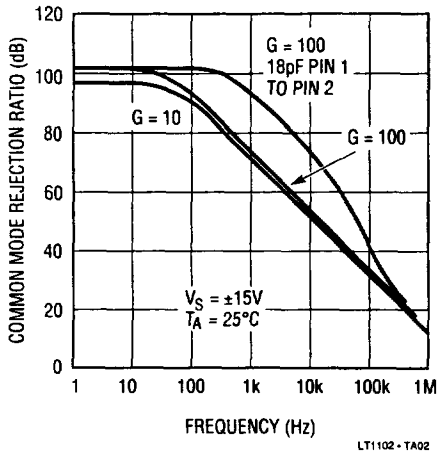
Gain Non-Linearity Over Temperature



APPLICATIONS INFORMATION

In the two op amp instrumentation amplifier configuration, the first amplifier is basically in unity gain, and the second amplifier provides all the voltage gain. In the LT1102 the second amplifier is decompensated for gain of 10 stability, therefore high slew rate and bandwidth are achieved. Common mode rejection versus frequency is also optimized in the G = 10 mode, because the bandwidths of the two op amps are similar. When G = 100 this statement is no longer true. However, by connecting an 18pF capacitor between pins 1 and 2, a common mode AC gain is created to cancel the inherent roll-off. From 200Hz to 30kHz CMRR versus frequency is improved by an order of magnitude.

Common Mode Rejection Ratio vs Frequency



Input Protection

Instrumentation amplifiers are often used in harsh environments where overload conditions can occur. The LT1102 employs FET input transistors, consequently the differential input voltage can be ±30V (with ±15V supplies, ±36V with ±18V supplies) Some competitive instrumentation amplifiers have NPN inputs which are protected by back to back diodes. When the differential input voltage exceeds ±1.3V on these competitive devices, input current increases to milliampere level; more than ±10V differential voltage can cause permanent damage.

When the LT1102 inputs are pulled below the negative supply or above the positive supply, the inputs will clamp a diode voltage below or above the supplies. No damage will occur if the input current is limited to 20mA.

Gains Between 10 and 100

Gains between 10 and 100 can be achieved by connecting two equal resistors (=R_X) between pins 1 and 2 and pins 7 and 8.

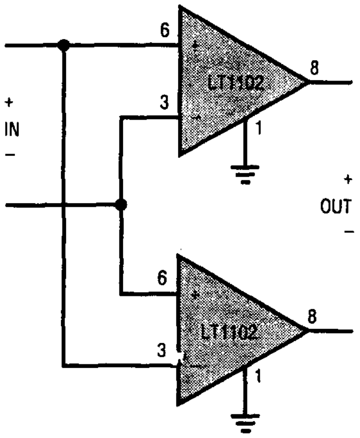
$$\text{Gain} = 10 + \frac{R_X}{R + R_X/90}$$

The nominal value of R is 1.84kΩ. The usefulness of this method is limited by the fact that R is not controlled to better than ±10% absolute accuracy is production. However, on any specific unit 90R can be measured between pins 1 and 2.

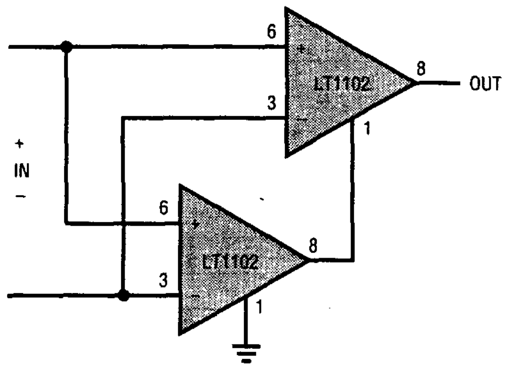
APPLICATIONS INFORMATION

Gain = 20, 110, or 200 Instrumentation Amplifiers

Differential Output



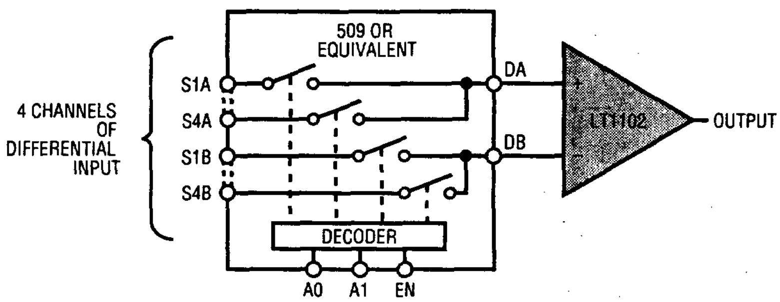
Single Ended Output



GAIN = 200, AS SHOWN
GAIN = 20, SHORT PIN 1 TO PIN 2, PIN 7 TO PIN 8 ON BOTH DEVICES
GAIN = 110, SHORT PIN 1 TO PIN 2, PIN 7 TO PIN 8 ON ONE DEVICE, NOT ON THE OTHER
INPUT REFERRED NOISE IS REDUCED BY $\sqrt{2}$ (G = 200 OR 20)

LT1102 • TA03

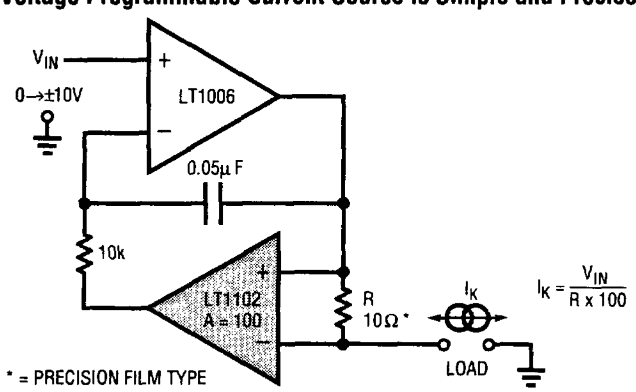
Multiplexed Input Data Acquisition



800kHz SIGNALS CAN BE MULTIPLEXED WITH LT1102 IN G = 10

LT1102 • TA04

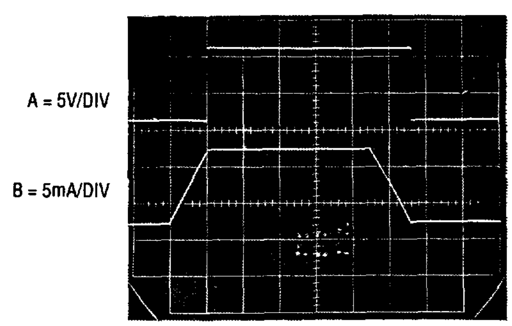
Voltage Programmable Current Source is Simple and Precise



* = PRECISION FILM TYPE

LT1102 • TA05

Dynamic Response of the Current Source



HORIZ. = 20µs/DIV

LT1102 • TA06

LINEAR TECHNOLOGY