Precision, Micropower, Single Supply Instrumentation Amplifier (Fixed Gain =10 or 100)

FEATURES

■ Gain Error	0.04% Max
■ Gain Non-Linearity	0.0008% (8ppm) Max
■ Gain Drift	4ppm/°C Max
■ Supply Current	105μA Max
■ Offset Voltage	160μV Max
■ Offset Voltage Drift	0.4μV/°C Typ
■ Offset Current	600pA Max
■ CMRR, G = 100	100dB Min
■ 0.1Hz to 10Hz Noise	0.9μVp-p Typ 2.3pAp-p Typ
■ Gain Bandwidth Product	250kHz Min
■ Single or Dual Supply Operation	
■ Surface Mount Package Available	

APPLICATIONS

- Differential Signal Amplification in Presence of Common-Mode Voltage
- Micropower Bridge Transducer Amplifier
  - Thermocouples
  - Strain Gauges
  - Thermistors
- Differential Voltage to Current Converter
- Transformer Coupled Amplifier
- 4mA-20mA Bridge Transmitter

DESCRIPTION

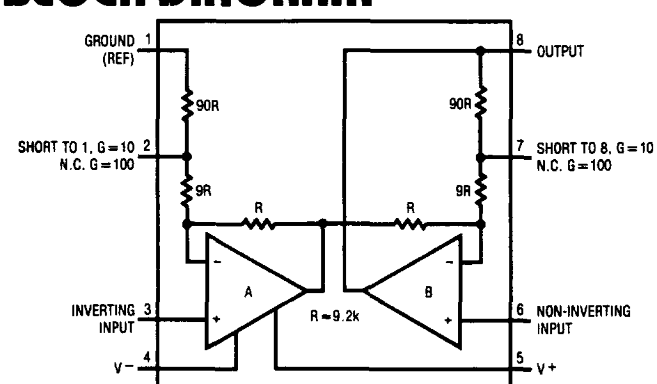
The LT1101 establishes the following milestones:
(1) It is the first micropower instrumentation amplifier,
(2) It is the first single supply instrumentation amplifier,
(3) It is the first instrumentation amplifier to feature fixed gains of 10 and/or 100 in low cost, space-saving 8-lead packages.

The LT1101 is completely self-contained: no external gain setting resistor is required. The LT1101 combines its micropower operation (75μA supply current) with a gain error of 0.008%, gain linearity of 3ppm, gain drift of 1ppm/°C. The output is guaranteed to drive a 2k load to ±10V with excellent gain accuracy.

Other precision specifications are also outstanding: 50μV input offset voltage, 130pA input offset current, and low drift (0.4μV/°C and 0.7pA/°C). In addition, unlike other instrumentation amplifiers, there is no output offset voltage contribution to total error.

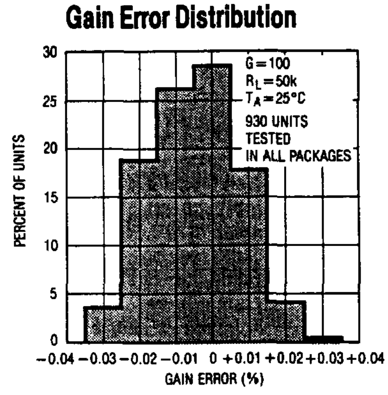
A full set of specifications are provided with ±15V dual supplies and for single 5V supply operation. The LT1101 can be operated from a single lithium cell or two Ni-Cad batteries. Battery voltage can drop as low as 1.8V, yet the LT1101 still maintains its gain accuracy. In single supply applications, both input and output voltages swing to within a few millivolts of ground. The output sinks current while swinging to ground — no external, power consuming pull down resistors are needed.

BLOCK DIAGRAM



GROUND PIN 1, OUTPUT AT PIN 8
G=100: NO ADDITIONAL CONNECTIONS
G=10: SHORT PIN 2 TO PIN 1, SHORT PIN 7 TO PIN 8

Gain Error Distribution

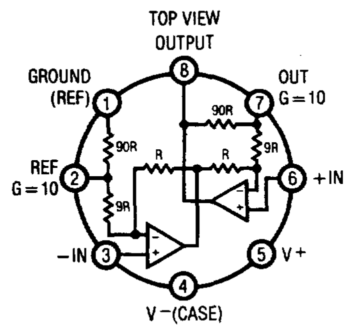


ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... ±22V
Differential Input Voltage .... ±36V
Input Voltage .... Equal to Positive Supply Voltage
.... 10V Below Negative Supply Voltage
Output Short Circuit Duration .... Indefinite
Lead Temperature (Soldering, 10 sec.)............. 300°C

Operating Temperature Range
LT1101AM/LT1101M .... −55°C to 125°C
LT1101AI/LT1101I .... −40°C to 85°C
LT1101AC/LT1101C/LT1101S .... 0°C to 70°C
Storage Temperature Range
All Grades .... −65°C to 150°C

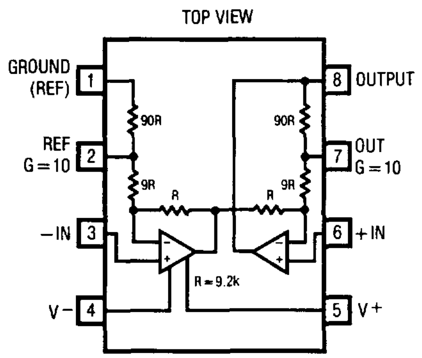
PACKAGE/ORDER INFORMATION



H PACKAGE
8-LEAD TO-5 METAL CAN

ORDER PART NUMBER

LT1101AMH
LT1101MH
LT1101ACH
LT1101CH

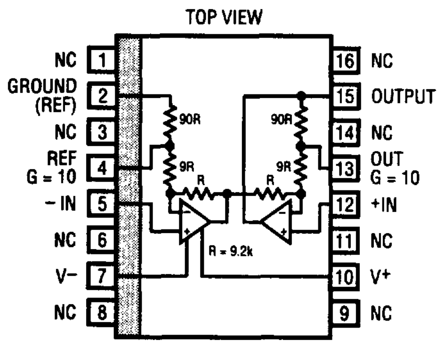


N PACKAGE
8-LEAD PLASTIC DIP

J PACKAGE
8-LEAD CERAMIC DIP

ORDER PART NUMBER

LT1101AIN8
LT1101IN8
LT1101ACN8
LT1101CN8
LT1101AMJ8
LT1101MJ8
LT1101ACJ8
LT1101CJ8



S PACKAGE
16-LEAD PLASTIC SOL

LT1101S

ELECTRICAL CHARACTERISTICS

$V_S = 5V, 0V, V_{CM} = 0.1V, V_{REF(PIN 1)} = 0.1V, G = 10 \text{ or } 100, T_A = 25°C$, unless otherwise noted (Note 3).

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	TYP	MAX	LT1101M/I/C/S MIN	TYP	MAX	UNITS
G_E	Gain Error	$G = 100, V_O = 0.1V$ to $3.5V, R_L = 50k$		0.010	0.050		0.011	0.075	%
		$G = 10, V_O = 0.1V$ to $3.5V, R_L = 50k$		0.009	0.040		0.010	0.060	%
G_{NL}	Gain Non-Linearity	$G = 100, R_L = 50k$		20	60		20	75	ppm
		$G = 10, R_L = 50k$ (Note 1)		3	7		3	8	ppm
V_{OS}	Input Offset Voltage			50	160		60	220	µV
		LT1101S					250	600	µV
I_{OS}	Input Offset Current			0.13	0.60		0.15	0.90	nA
I_B	Input Bias Current			6	8		6	10	nA
I_S	Supply Current			75	105		78	120	µA

ELECTRICAL CHARACTERISTICS

V_S = 5V, 0V, V_{CM} = 0.1V, $V_{REF(PIN\ 1)}$ = 0.1V, G = 10 or 100, T_A = 25°C, unless otherwise noted (Note 3).

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	TYP	MAX	LT1101M/I/C/S MIN	TYP	MAX	UNITS
CMRR	Common-Mode Rejection Ratio	1k Source Imbalance							
		G = 100, V_{CM} = 0.07V to 3.4V	95	106		92	105		dB
		G = 10, V_{CM} = 0.07V to 3.1V	84	100		82	99		dB
	Minimum Supply Voltage	(Note 4)		1.8	2.3		1.8	2.3	V
V_O	Maximum Output Voltage Swing	Output High, 50k to GND	4.1	4.3		4.1	4.3		V
		Output High, 2k to GND	3.5	3.9		3.5	3.9		V
		Output Low, V_{REF} = 0, No Load		3.3	6		3.3	6	mV
		Output Low, V_{REF} = 0, 2k to GND		0.5	1		0.5	1	mV
		Output Low, V_{REF} = 0, I_{SINK} = 100μA		90	130		90	130	mV
BW	Bandwidth	G = 100 (Note 1)	2.0	3.0		2.0	3.0		kHz
		G = 10 (Note 1)	22	33		22	33		kHz
SR	Slew Rate	(Note 1)	0.04	0.07		0.04	0.07		V/μs

ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, T_A = 25°C, Gain = 10 or 100, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	TYP	MAX	LT1101M/I/C/S MIN	TYP	MAX	UNITS
G_E	Gain Error	G = 100, V_O = ±10V, R_L = 50k		0.008	0.040		0.009	0.060	%
		G = 100, V_O = ±10V, R_L = 2k		0.011	0.055		0.012	0.070	%
		G = 10, V_O = ±10V, R_L = 50k or 2k		0.008	0.040		0.009	0.060	%
G_{NL}	Gain Non-Linearity	G = 100, R_L = 50k		7	16		8	20	ppm
		G = 100, R_L = 2k		24	45		25	60	ppm
		G = 10, R_L = 50k or 2k		3	8		3	9	ppm
V_{OS}	Input Offset Voltage			50	160		60	220	μV
		LT1101S					250	600	μV
I_{OS}	Input Offset Current			0.13	0.60		0.15	0.90	nA
I_B	Input Bias Current			6	8		6	10	nA
	Input Resistance								
	Common-Mode	(Note 1)	4	7		3	7		GΩ
	Differential Mode	(Note 1)	7	12		5	12		GΩ
e_n	Input Noise Voltage	0.1Hz to 10Hz (Note 2)		0.9	1.8		0.9		μVp-p
	Input Noise Voltage Density	f_o = 10Hz (Note 2)		45	64		45		nV/√Hz
		f_o = 1000Hz (Note 2)		43	54		43		nV/√Hz
i_n	Input Noise Current	0.1Hz to 10Hz (Note 2)		2.3	4.0		2.3		pAp-p
	Input Noise Current Density	f_o = 10Hz (Note 2)		0.06	0.10		0.06		pA/√Hz
		f_o = 1000Hz		0.02			0.02		pA/√Hz
	Input Voltage Range	G = 100	+13.0	+13.8		+13.0	+13.8		V
			−14.4	−14.7		−14.4	−14.7		V
		G = 10	+11.5	+12.5		+11.5	+12.5		V
			−13.0	−13.3		−13.0	−13.3		V
CMRR	Common-Mode Rejection Ratio	1k Source Imbalance							
		G = 100, Over CM Range	100	112		98	112		dB
		G = 10, Over CM Range	84	100		82	99		dB
PSRR	Power Supply Rejection Ratio	V_S = +2.2V, −0.1V to ±18V	102	114		100	114		dB
I_S	Supply Current			92	130		94	150	μA
V_O	Maximum Output Voltage Swing	R_L = 50k	±13.0	±14.2		±13.0	±14.2		V
		R_L = 2k	±11.0	±13.2		±11.0	±13.2		V
BW	Bandwidth	G = 100 (Note 1)	2.3	3.5		2.3	3.5		kHz
		G = 10 (Note 1)	25	37		25	37		kHz
SR	Slew Rate		0.06	0.10		0.06	0.10		V/μs

Note 1: This parameter is not tested. It is guaranteed by design and by inference from other tests.

Note 2: This parameter is tested on a sample basis only.

Note 3: These test conditions are equivalent to V_S = 4.9V, −0.1V, V_{CM} = 0V, $V_{REF(PIN\ 1)}$ = 0V.

Note 4: Minimum supply voltage is guaranteed by the power supply rejection test. The LT1101 actually works at 1.8V supply with minimal degradation in performance.

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ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, Gain = 10 or 100, $-55°C \le T_A \le 125°C$ for AM/M grades, $-40°C \le T_A \le 85°C$ for AI/I grades, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI MIN	LT1101AM/AI TYP	LT1101AM/AI MAX	LT1101M/I MIN	LT1101M/I TYP	LT1101M/I MAX	UNITS
G_E	Gain Error	$G = 100, V_O = \pm 10V, R_L = 50k$		0.024	0.070		0.026	0.100	%
		$G = 100, V_O = \pm 10V, R_L = 5k$		0.030	0.100		0.035	0.130	%
		$G = 10, V_O = \pm 10V, R_L = 50k$ or $5k$		0.015	0.070		0.018	0.100	%
TCG_E	Gain Error Drift (Note 1)	$G = 100, R_L = 50k$		2	4		2	5	ppm/°C
		$G = 100, R_L = 5k$		2	7		2	8	ppm/°C
		$G = 10, R_L = 50k$ or $5k$		1	4		1	5	ppm/°C
G_{NL}	Gain Non-Linearity	$G = 100, R_L = 50k$		24	70		26	90	ppm
		$G = 100, R_L = 5k$		70	300		75	500	ppm
		$G = 10, R_L = 50k$		4	13		5	15	ppm
		$G = 10, R_L = 5k$		10	40		12	60	ppm
V_{OS}	Input Offset Voltage			90	350		110	500	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 1)		0.4	2.0		0.5	2.8	µV/°C
I_{OS}	Input Offset Current			0.16	0.80		0.19	1.30	nA
$\Delta I_{OS}/\Delta T$	Input Offset Current Drift	(Note 1)		0.5	4.0		0.8	7.0	pA/°C
I_B	Input Bias Current			7	10		7	12	nA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 1)		10	25		10	30	pA/°C
CMRR	Common-Mode Rejection Ratio	$G = 100, V_{CM} = -14.4V$ to $13V$	96	111		94	111		dB
		$G = 10, V_{CM} = -13V$ to $11.5V$	80	99		78	98		dB
PSRR	Power Supply Rejection Ratio	$V_S = +3.0, -0.1V$ to $\pm 18V$	98	110		94	110		dB
I_S	Supply Current			105	165		108	190	µA
V_O	Maximum Output Voltage Swing	$R_L = 50k$	±12.5	±14.0		±12.5	±14.0		V
		$R_L = 5k$	±11.0	±13.5		±11.0	±13.5		V

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, Gain = 10 or 100, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1101AC MIN	LT1101AC TYP	LT1101AC MAX	LT1101C/S MIN	LT1101C/S TYP	LT1101C/S MAX	UNITS
G_E	Gain Error	$G = 100, V_O = \pm 10V, R_L = 50k$		0.012	0.055		0.014	0.080	%
		$G = 100, V_O = \pm 10V, R_L = 2k$		0.018	0.085		0.020	0.100	%
		$G = 10, V_O = \pm 10V, R_L = 50k$ or $2k$		0.009	0.055		0.010	0.080	%
TCG_E	Gain Error Drift (Note 1)	$G = 100, R_L = 50k$		1	4		1	5	ppm/°C
		$G = 100, R_L = 2k$		2	7		2	9	ppm/°C
		$G = 10, R_L = 50k$ or $2k$		1	4		1	5	ppm/°C
G_{NL}	Gain Non-Linearity	$G = 100, R_L = 50k$		9	25		10	35	ppm
		$G = 100, R_L = 2k$		33	75		36	100	ppm
		$G = 10, R_L = 50k$ or $2k$		4	10		4	11	ppm
V_{OS}	Input Offset Voltage			70	250		85	350	µV
		LT1101S					300	800	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 1)		0.4	2.0		0.5	2.8	µV/°C
		LT1101S					1.2	4.5	µV/°C
I_{OS}	Input Offset Current			0.14	0.70		0.17	1.10	nA
$\Delta I_{OS}/\Delta T$	Input Offset Current Drift	(Note 1)		0.5	4.0		0.8	7.0	pA/°C
I_B	Input Bias Current			6	9		6	11	nA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 1)		10	25		10	30	pA/°C
CMRR	Common-Mode Rejection Ratio	$G = 100, V_{CM} = -14.4V$ to $13V$	98	112		96	112		dB
		$G = 10, V_{CM} = -13V$ to $11.5V$	82	100		80	99		dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.5, -0.1V$ to $\pm 18V$	100	112		97	112		dB
I_S	Supply Current			98	148		100	170	µA
V_O	Maximum Output Voltage Swing	$R_L = 50k$	±12.5	±14.1		±12.5	±14.1		V
		$R_L = 2k$	±10.5	±13.0		±10.5	±13.0		V

ELECTRICAL CHARACTERISTICS

$V_S = 5V, 0V, V_{CM} = 0.1V, V_{REF(PIN\ 1)} = 0.1V$, Gain = 10 or 100, $-55°C \le T_A \le 125°C$ for AM/M grades, $-40°C \le T_A \le 85°C$ for AI/I grades, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI MIN	LT1101AM/AI TYP	LT1101AM/AI MAX	LT1101M/I MIN	LT1101M/I TYP	LT1101M/I MAX	UNITS
G_E	Gain Error	$G = 100, V_O = 0.1V$ to $3.5V; R_L = 50k$		0.026	0.080		0.028	0.120	%
		$G = 10, V_{CM} = 0.15, R_L = 50k$		0.011	0.070		0.014	0.100	%
TCG_E	Gain Error Drift	$R_L = 50k$ (Note 1)		1	4		1	5	ppm/°C
G_{NL}	Gain Non-Linearity	$G = 100, R_L = 50k$		45	110		48	140	ppm
		$G = 10, R_L = 50k$ (Note 1)		4	13		5	15	ppm
V_{OS}	Input Offset Voltage			90	350		110	500	μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 1)		0.4	2.0		0.5	2.8	μV/°C
I_{OS}	Input Offset Current			0.16	0.80		0.19	1.30	nA
$\Delta I_{OS}/\Delta T$	Input Offset Current Drift	(Note 1)		0.5	4.0		0.8	7.0	pA/°C
I_B	Input Bias Current			7	10		7	12	nA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 1)		10	25		10	30	pA/°C
CMRR	Common-Mode Rejection Ratio	$G = 100, V_{CM} = 0.1V$ to $3.2V$	91	105		88	104		dB
		$G = 10, V_{CM} = 0.1V$ to $2.9V, V_{REF} = 0.15V$	80	98		77	97		dB
I_S	Supply Current			88	135		92	160	μA
V_O	Maximum Output Voltage Swing	Output High, 50k to GND	3.8	4.1		3.8	4.1		V
		Output High, 2k to GND	3.0	3.7		3.0	3.7		V
		Output Low, $V_{REF} = 0$, No Load		4.5	8		4.5	8	mV
		Output Low, $V_{REF} = 0$, 2k to GND		0.7	1.5		0.7	1.5	mV
		Output Low, $V_{REF} = 0, I_{SINK} = 100\mu A$		125	170		125	170	mV

ELECTRICAL CHARACTERISTICS

$V_S = 5V, 0V, V_{CM} = 0.1V, V_{REF(PIN\ 1)} = 0.1V$, Gain = 10 or 100, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1101AC MIN	LT1101AC TYP	LT1101AC MAX	LT1101C/S MIN	LT1101C/S TYP	LT1101C/S MAX	UNITS
G_E	Gain Error	$G = 100, V_O = 0.1V$ to $3.5V, R_L = 50k$		0.017	0.065		0.018	0.095	%
		$G = 10, V_{CM} = 0.15V, R_L = 50k$		0.010	0.060		0.012	0.080	%
TCG_E	Gain Error Drift	$R_L = 50k$ (Note 1)		1	4		1	5	ppm/°C
G_{NL}	Gain Non-Linearity	$G = 100, R_L = 50k$		25	80		25	100	ppm
		$G = 10, R_L = 50k$ (Note 1)		4	10		4	11	ppm
V_{OS}	Input Offset Voltage			70	250		85	350	μV
		LT1101S					300	800	μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 1)		0.4	2.0		0.5	2.8	μV/°C
		LT1101S					1.2	4.5	μV/°C
I_{OS}	Input Offset Current			0.14	0.70		0.17	1.10	nA
$\Delta I_{OS}/\Delta T$	Input Offset Current Drift	(Note 1)		0.5	4.0		0.8	7.0	pA/°C
I_B	Input Bias Current			6	9		6	11	nA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 1)		10	25		10	30	pA/°C
CMRR	Common-Mode Rejection Ratio	$G = 100, V_{CM} = 0.07V$ to $3.3V$	93	105		90	104		dB
		$G = 10, V_{CM} = 0.07V$ to $3.0V, V_{REF} = 0.15V$	82	99		80	98		dB
I_S	Supply Current			80	120		85	145	μA
V_O	Maximum Output Voltage Swing	Output High, 50k to GND	4.0	4.2		4.0	4.2		V
		Output High, 2k to GND	3.3	3.8		3.3	3.8		V
		Output Low, $V_{REF} = 0$, No Load		4	7		4	7	mV
		Output Low, $V_{REF} = 0$, 2k to GND		0.6	1.2		0.6	1.2	mV
		Output Low, $V_{REF} = 0, I_{SINK} = 100\mu A$		100	150		100	150	mV

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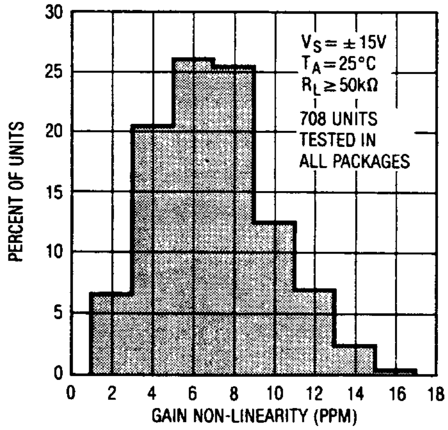
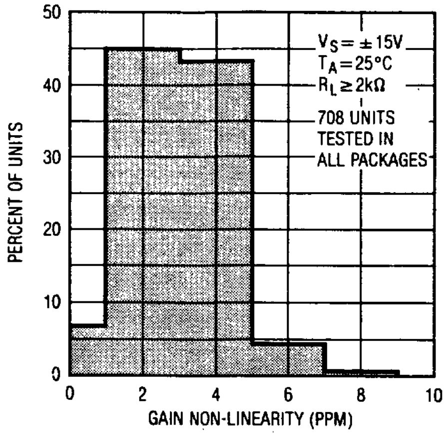
TYPICAL PERFORMANCE CHARACTERISTICS

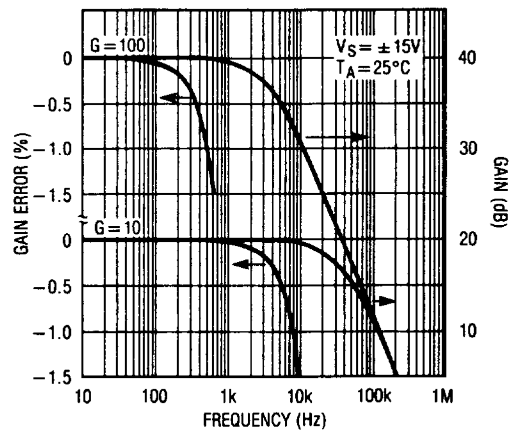
Gain = 100 Non-Linearity Distribution



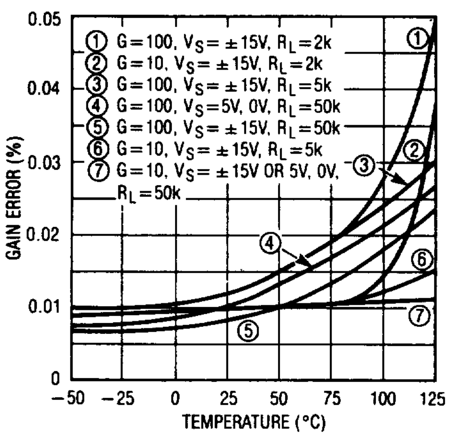
Gain = 10 Non-Linearity Distribution



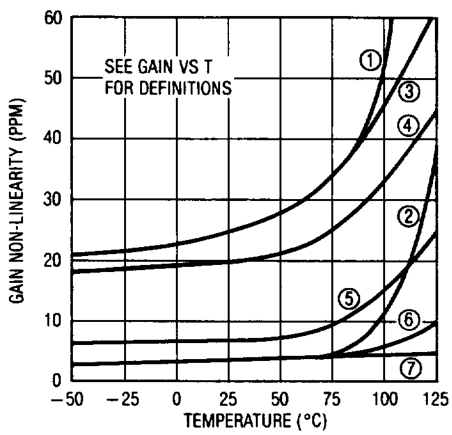
Gain vs Frequency



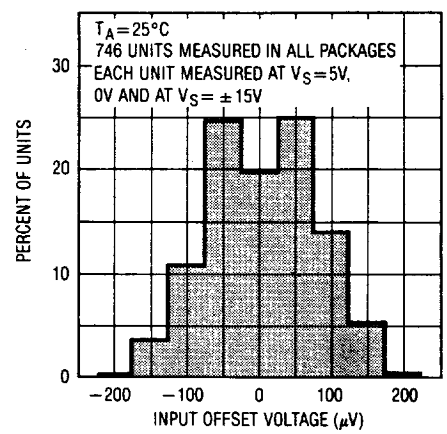
Gain Error Over Temperature



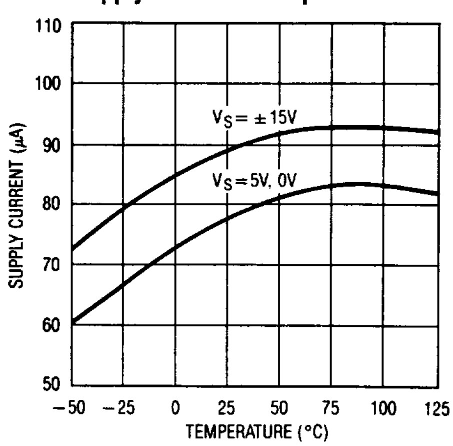
Gain Non-Linearity Over Temperature



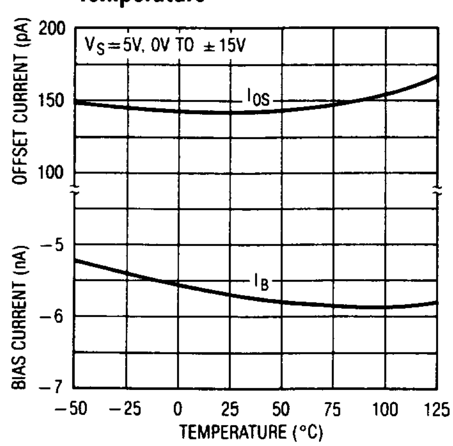
Input Offset Voltage Distribution



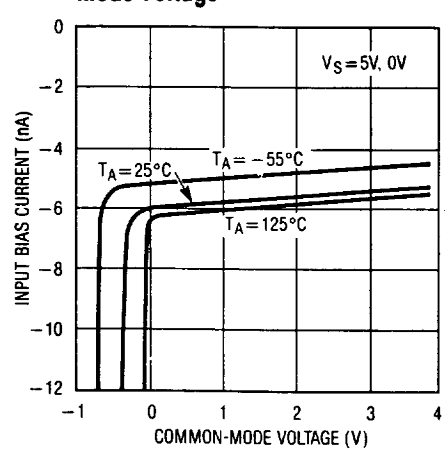
Supply Current vs Temperature



Input Bias and Offset Currents vs Temperature

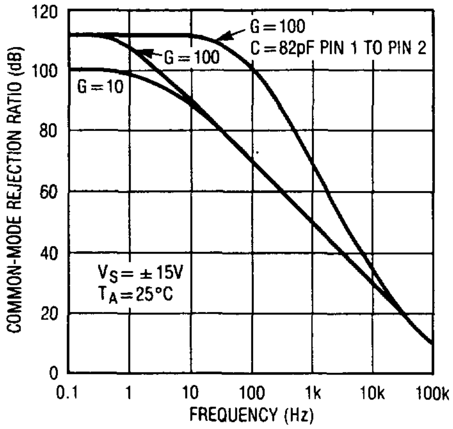


Input Bias Current vs Common-Mode Voltage

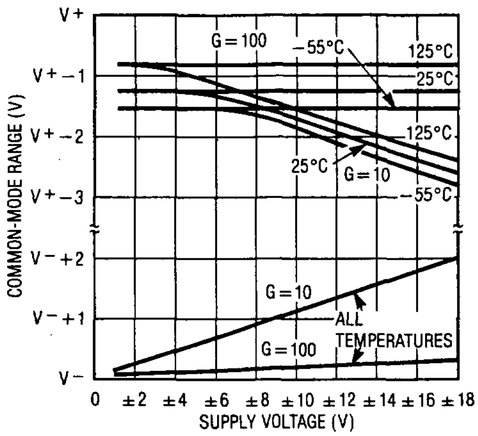


TYPICAL PERFORMANCE CHARACTERISTICS

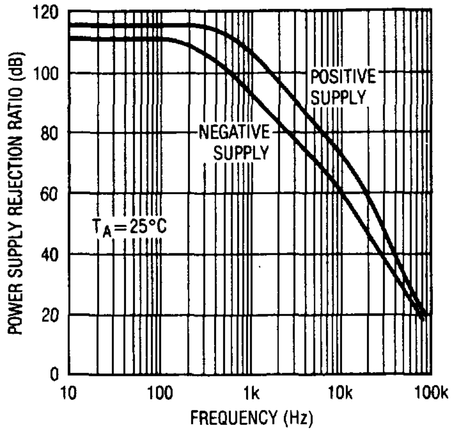
Common-Mode Rejection Ratio vs Frequency



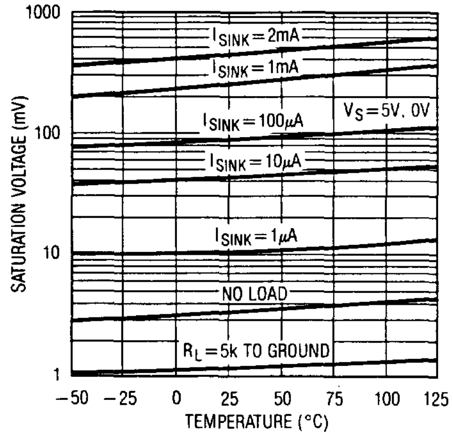
Common-Mode Range vs Supply Voltage



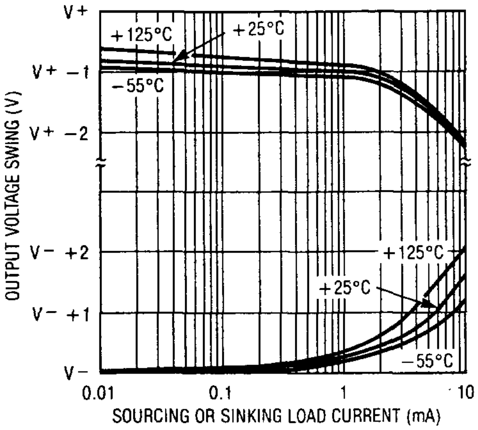
Power Supply Rejection Ratio vs Frequency



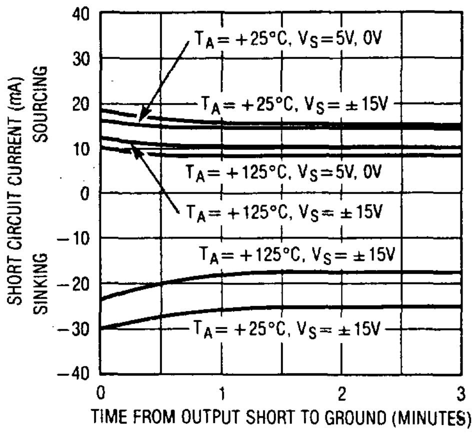
Output Saturation vs Temperature vs Sink Current



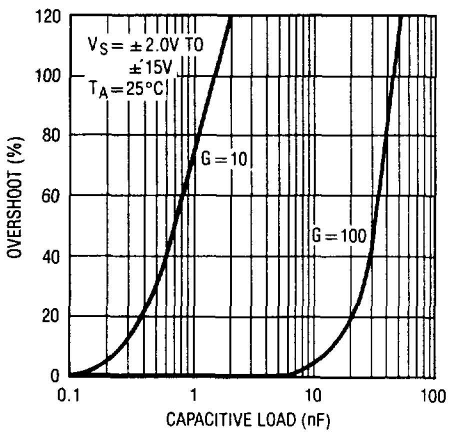
Output Voltage Swing vs Load Current



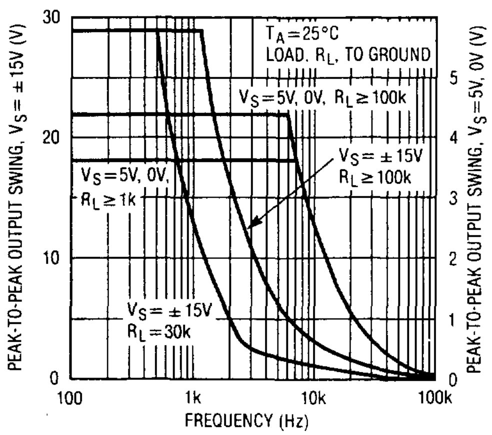
Short Circuit Current vs Time



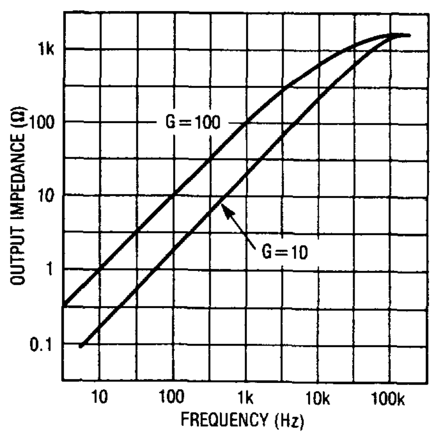
Capacitive Load Handling



Undistorted Output Swing vs Frequency

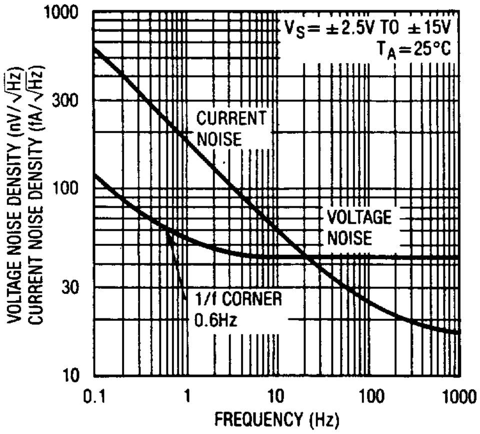


Output Impedance vs Frequency

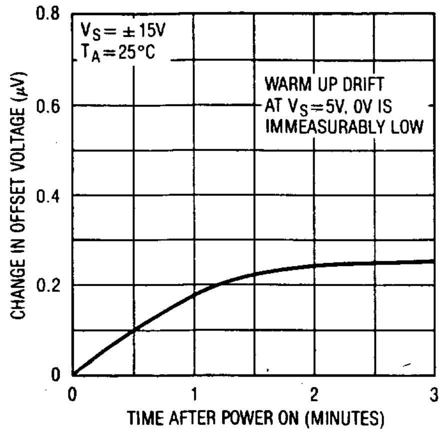


TYPICAL PERFORMANCE CHARACTERISTICS

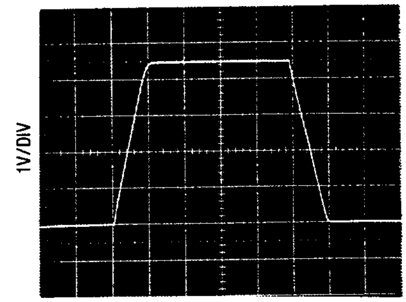
Noise Spectrum



Warm-Up Drift

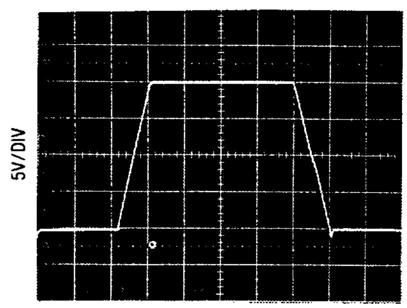


Large Signal Transient Response $G = 10, V_S = 5V, 0V$



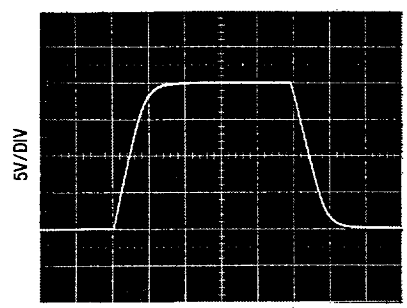
50μs/DIV
OUTPUT FROM 0V TO 4.5V, NO LOAD

Large Signal Transient Response $G = 10, V_S = \pm 15V$



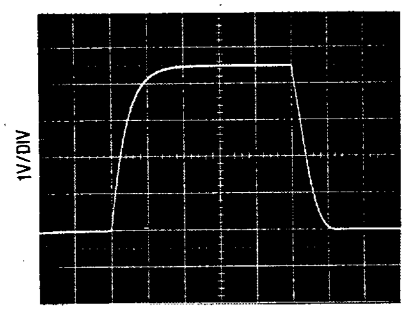
200μs/DIV
NO LOAD

Large Signal Transient Response $G = 100, V_S = \pm 15V$



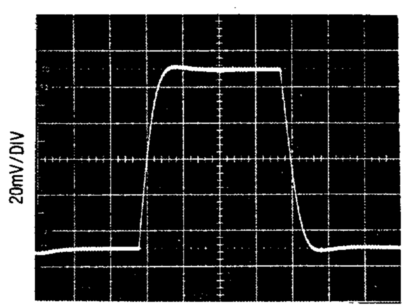
200μs/DIV
NO LOAD

Large Signal Transient Response $G = 100, V_S = 5V, 0V$



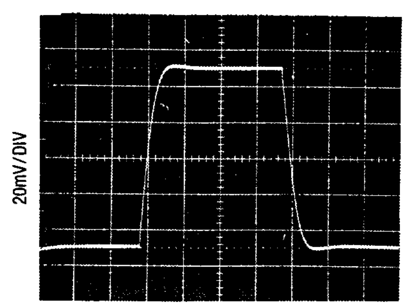
100μs/DIV
OUTPUT FROM 0V TO 4.5V, NO LOAD

Small Signal Transient Response $G = 10, V_S = 5V, 0V$



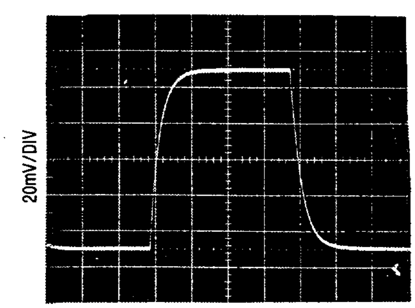
20μs/DIV
OUTPUT FROM 0.05V TO 0.15V, NO LOAD

Small Signal Transient Response $G = 10, V_S = \pm 15V$



20μs/DIV

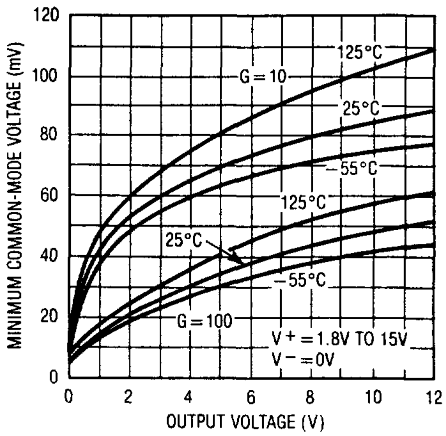
Small Signal Transient Response $G = 100, V_S = 5V, 0V$



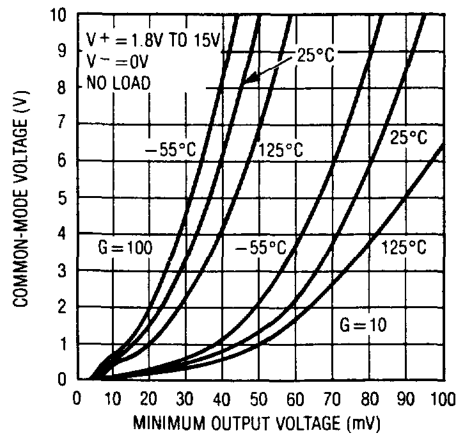
200μs/DIV
OUTPUT FROM 0.05V TO 0.15V, NO LOAD
(RESPONSE WITH $V_S = \pm 15V$, $G = 100$ IS IDENTICAL)

TYPICAL PERFORMANCE CHARACTERISTICS

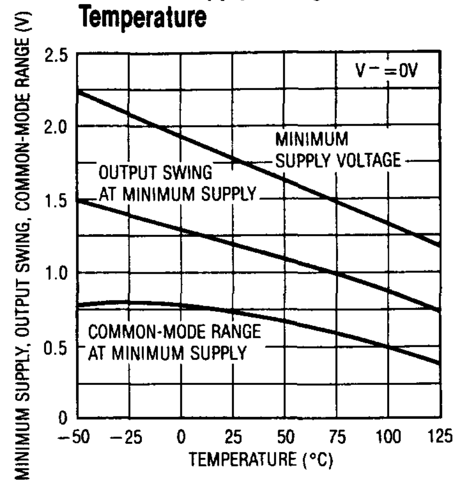
Single Supply: Minimum Common-Mode Voltage vs Output Voltage



Single Supply: Minimum Output Voltage vs Common-Mode Voltage



Minimum Supply Voltage vs Temperature



3

APPLICATIONS INFORMATION

Single Supply Applications

The LT1101 is the first instrumentation amplifier which is fully specified for single supply operation, i.e. when the negative supply is 0V. Both the input common-mode range and the output swing are within a few millivolts of ground.

Probably the most common application for instrumentation amplifiers is amplifying a differential signal from a transducer or sensor resistance bridge. All competitive instrumentation amplifiers have a minimum required common-mode voltage which is 3V to 5V above the negative supply. This means that the voltage across the bridge has to be 6V to 10V or dual supplies have to be used, i.e. micropower, single battery usage is not attainable on competitive devices.

The minimum output voltage obtainable on the LT1101 is a function of the input common-mode voltage. When the common-mode voltage is high and the output is low, current will flow from the output of amplifier A into the output of amplifier B. See the Minimum Output Voltage vs Common-Mode Voltage plot.

Similarly, the Minimum Common-Mode Voltage vs Output Voltage plot specifies the expected common-mode range. When the output is high and input common-mode is low, the output of amplifier A has to sink current coming from the output of amplifier B. Since amplifier A is effectively in unity gain, its input is limited by its output.

Common-Mode Rejection vs Frequency

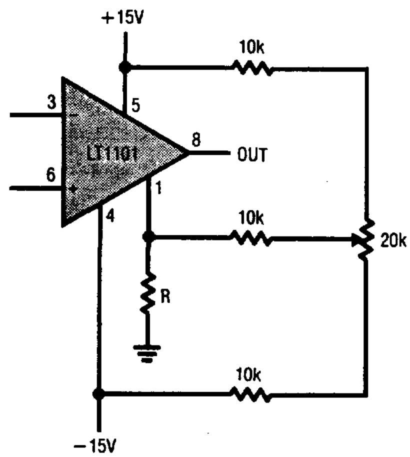
The common-mode rejection ratio (CMRR) of the LT1101 starts to roll off at a relatively low frequency. However, as shown on the CMRR vs Frequency plot, CMRR can be enhanced significantly by connecting an 82pF capacitor between pins 1 and 2. This improvement is only available in the gain 100 configuration, and it is in excess of 30dB at 60Hz.

Offset Nulling

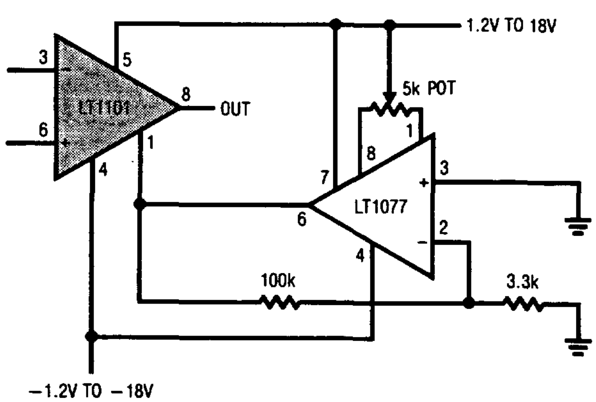
The LT1101 is not equipped with dedicated offset null terminals. In many bridge transducer or sensor applications, calibrating the bridge simultaneously eliminates the instrumentation amplifier's offset as a source of error. For example, in the Micropower Remote Temperature Sensor Application shown, one adjustment removes the offset errors due to the temperature sensor, voltage reference and the LT1101.

APPLICATIONS INFORMATION

A simple resistive offset adjust procedure is shown below. If R = 5Ω for G = 10, and R = 50Ω for G = 100 then the effect of R on gain error is approximately 0.006%. Unfortunately, about 450μA has to flow through R to bias the reference terminal (pin 1) and to null out the worst-case offset voltage. The total current through the resistor network can exceed 1mA, and the micropower advantage of the LT1101 is lost.



Another offset adjust scheme uses the LT1077 micropower op amp to drive the reference pin 1. Gain error and common-mode rejection are unaffected, the total current increase is 45μA. The offset of the LT1077 is trimmed and amplified to match and cancel the offset voltage of the LT1101. Output offset null range is ±25mV.



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 9.2kΩ. The usefulness of this method is limited by the fact that R is not controlled to better than ±10% absolute accuracy in production. However, on any specific unit 90R can be measured between pins 1 and 2.

Input Protection

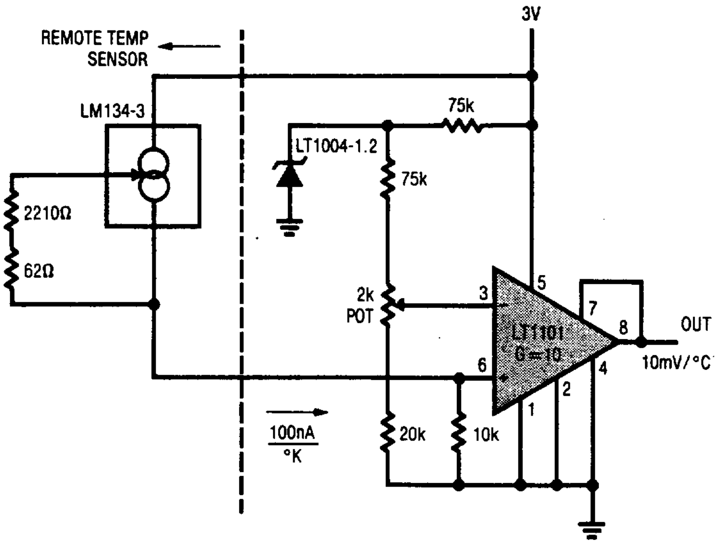
Instrumentation amplifiers are often used in harsh environments where overload conditions can occur. The LT1101 employs PNP input transistors, consequently the differential input voltage can be ±30V (with ±15V supplies, ±36V with ±18V supplies) without an increase in input bias current. Competitive instrumentation 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 the milliampere level; more than ±10V differential voltage can cause permanent damage.

When the LT1101's inputs are pulled above the positive supply, the inputs will clamp a diode voltage above the positive supply. No damage will occur if the input current is limited to 20mA.

500Ω resistors in series with the inputs protect the LT1101 when the inputs are pulled as much as 10V below the negative supply.

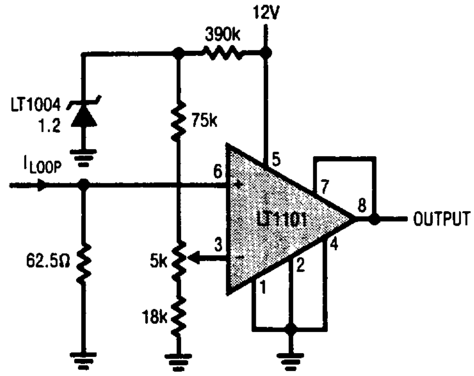
APPLICATIONS INFORMATION

Micropower, Battery Operated, Remote Temperature Sensor



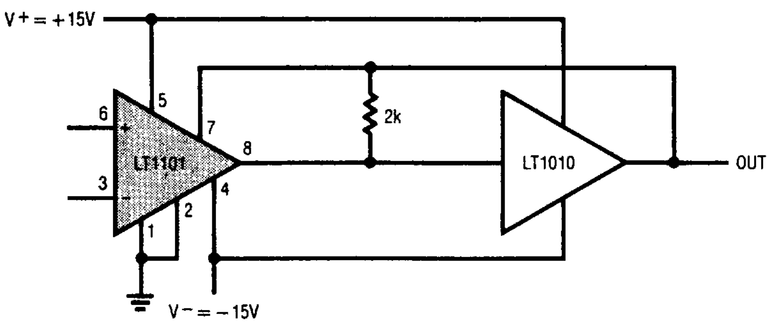
TRIM OUTPUT TO 250mV AT 25°C
TEMPERATURE RANGE = 2.5°C TO 150°C
ACCURACY = ±0.5°C

4mA to 20mA Loop Receiver



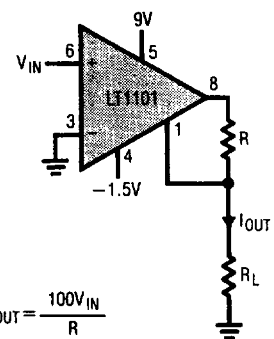
4mA TO 20mA IN → 0V TO 10V OUT
TRIM OUTPUT TO 5V AT 12mA IN

Instrumentation Amplifier with ±150mA Output Current



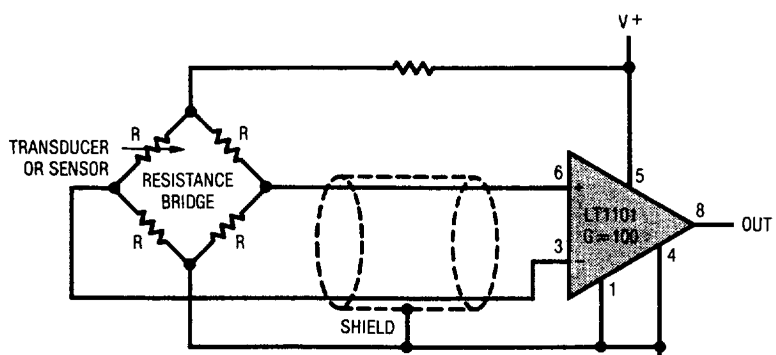
GAIN = 10, DEGRADED BY 0.01% DUE TO LT1010
OUTPUT = ±10V INTO 75Ω (TO 1.5kHz)
DRIVES ANY CAPACITIVE LOAD
SINGLE SUPPLY APPLICATION (V+ = 5V, V− = 0V):
$V_{OUT\ MIN} = 120mV$, $V_{OUT\ MAX} = 3.4V$

Voltage Controlled Current Source



$I_{OUT} = \frac{100V_{IN}}{R}$
I_{OUT} = 0mA TO 5mA
VOLTAGE COMPLIANCE = 6.4V
(R ≤ 200Ω)

Differential Voltage Amplification from a Resistance Bridge

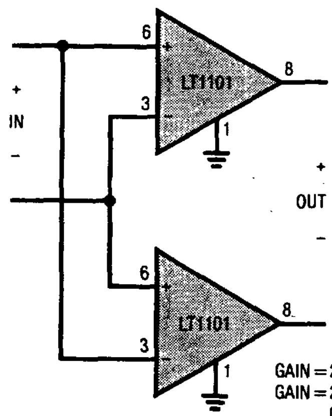


MINIMUM VOLTAGE ACROSS BRIDGE = 20mV
MINIMUM SUPPLY VOLTAGE = 1.8V

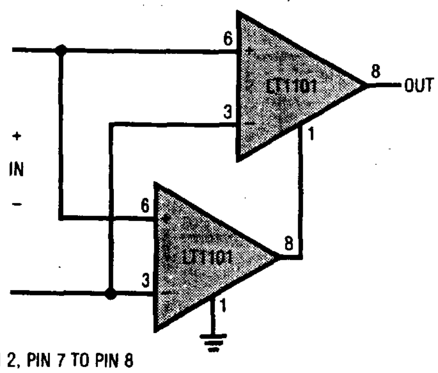
APPLICATIONS INFORMATION

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)