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

FEATURES

- Gain Error: 0.04% Max
- Gain Nonlinearity: 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 to 20mA Bridge Transmitter

DESCRIPTION

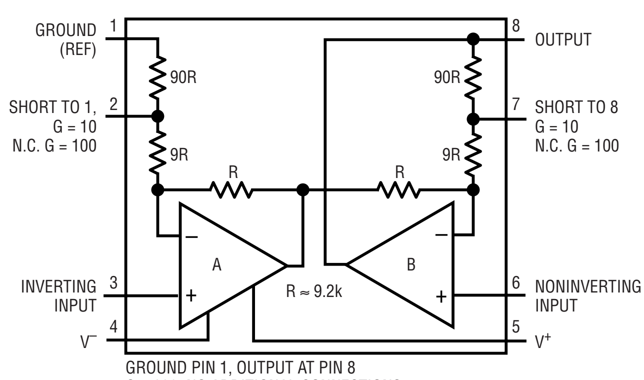
The LT®1101 establishes the following milestones: (1) It is the first micropower instrumentation amplifier, (2) It is the first single supply instrumentation amplifier, (3) It is the first instrumentation amplifier to feature fixed gains of 10 and/or 100 in low cost, space-saving 8-lead packages.

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.

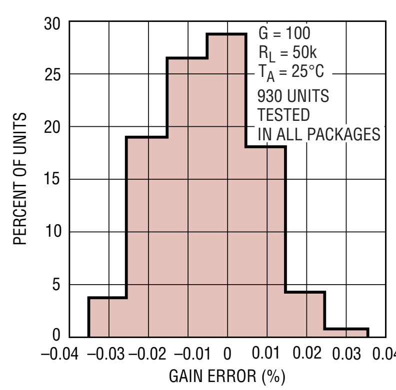
Other precision specifications are also outstanding: 50μV input offset voltage, 130pA input offset current, and low drift (0.4μV/°C and 0.7pA/°C). In addition, unlike other instrumentation amplifiers, there is no output offset voltage contribution to total error.

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.

TYPICAL APPLICATION



Gain Error Distribution

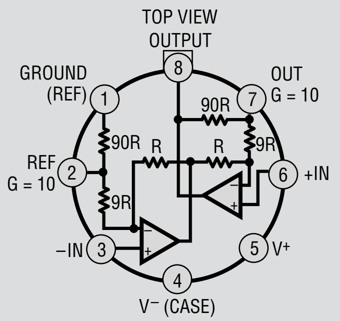


ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage .... ±22V
Differential Input Voltage .... ±36V
Input Voltage .... Equal to Positive Supply Voltage
..........10V Below Negative Supply Voltage
Output Short Circuit Duration .... Indefinite

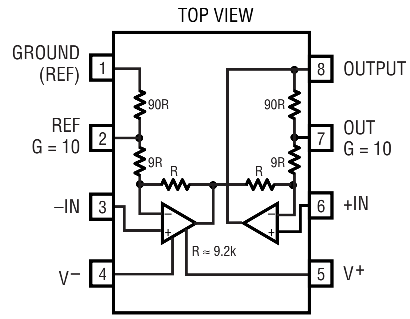
Operating Temperature Range
LT1101AM/LT1101M **(OBSOLETE)** ... −55°C to 125°C
LT1101AI/LT1101I .... −40°C to 85°C
LT1101AC/LT1101C .... 0°C to 70°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION



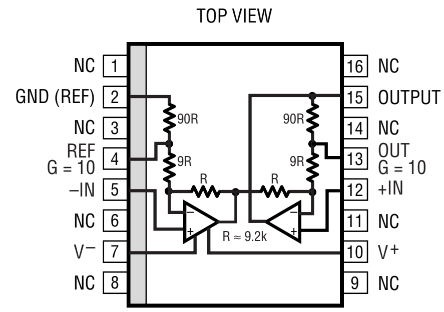
H PACKAGE
8-LEAD TO-5 METAL CAN

T_{JMAX} = 150°C, θ_{JA} = 150°C/W, θ_{JC} = 45°C/W



N PACKAGE 8-LEAD PDIP
T_{JMAX} = 150°C, θ_{JA} = 130°C/W

J PACKAGE 8-LEAD CERDIP
T_{JMAX} = 150°C, θ_{JA} = 100°C/W



SW PACKAGE
16-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 100°C/W

ORDER PART NUMBER	ORDER PART NUMBER		ORDER PART NUMBER
LT1101AMH	LT1101AMJ8	LT1101AIN8	LT1101SW
LT1101MH	LT1101MJ8	LT1101IN8	LT1101ISW
LT1101ACH	LT1101ACJ8	LT1101ACN8	
LT1101CH	LT1101CJ8	LT1101CN8	

OBSOLETE PACKAGES
Consider the N8 as an Alternate Source

Consult LTC Marketing for parts specified with wider operating temperature ranges.

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 4)

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	TYP	MAX	LT1101M/I/C MIN	TYP	MAX	UNITS
G_E	Gain Error	G = 100, V_0 = 0.1V to 3.5V, R_L = 50k		0.010	0.050		0.011	0.075	%
		G = 10, V_0 = 0.1V to 3.5V, R_L = 50k		0009	0.040		0.010	0.060	%
G_{NL}	Gain Nonlinearity	G = 100, R_L = 50k		20	60		20	75	ppm
		G = 10, R_L = 50k (Note 2)		3	7		3	8	ppm
V_{OS}	Input Offset Voltage			50	160		60	220	µV
		LT1101SW					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 4)

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	LT1101AM/AI/AC TYP	LT1101AM/AI/AC MAX	LT1101M/I/C MIN	LT1101M/I/C TYP	LT1101M/I/C 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 5)		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 2)	2.0	3.0		2.0	3.0		kHz
		G = 10 (Note 2)	22	33		22	33		kHz
SR	Slew Rate	(Note 2)	0.04	0.07		0.04	0.07		V/µs

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

SYMBOL	PARAMETER	CONDITIONS	LT1101AM/AI/AC MIN	LT1101AM/AI/AC TYP	LT1101AM/AI/AC MAX	LT1101M/I/C MIN	LT1101M/I/C TYP	LT1101M/I/C 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 = 100, V_O = ±10V, R_L = 50k or 2k		0.008	0.040		0.009	0.060	%
G_{NL}	Gain Nonlinearity	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
		LT1101SW					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 2)	4	7		3	7		GΩ
	Differential Mode	(Note 2)	7	12		5	12		GΩ
e_n	Input Noise Voltage	0.1Hz to 10Hz (Note 3)		0.9	1.8		0.9		µVp-p
	Input Noise Voltage Density	f_O = 10Hz (Note 3)		45	64		45		nV/√Hz
		f_O = 1000Hz (Note 3)		43	54		43		nV/√Hz
i_n	Input Noise Current	0.1Hz to 10Hz (Note 3)		2.3	4.0		2.3		pAp-p
	Input Noise Current Density	f_O =10Hz (Note 3)		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

ELECTRICAL CHARACTERISTICS

$V_S = \pm15V$, $V_{CM} = 0V$, $T_A = 25°C$, Gain = 10 or 100, 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
V_O	Maximum Output Voltage Swing	R_L = 50k R_L = 2k	13.0 11.0	14.2 13.2		13.0 11.0	14.2 13.2		V V
BW	Bandwidth	G = 100 (Note 2) G = 10 (Note 2)	2.3 25	3.5 37		2.3 25	3.5 37		kHz kHz
SR	Slew Rate		0.06	0.10		0.06	0.10		V/μs

ELECTRICAL CHARACTERISTICS

$V_S = \pm15V$, $V_{CM} = 0V$, 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, $V_O = \pm10V$, R_L = 50k G = 100, $V_O = \pm10V$, R_L = 5k G = 10, $V_O = \pm10V$, R_L = 50k or 5k		0.024 0.030 0.015	0.070 0.100 0.070		0.026 0.035 0.018	0.100 0.130 0.100	% % %
TCG_E	Gain Error Drift (Note 2)	G = 100, R_L = 50k G = 100, R_L = 5k G = 10, R_L = 50k or 5k		2 2 1	4 7 4		2 2 1	5 8 5	ppm/°C ppm/°C ppm/°C
G_{NL}	Gain Nonlinearity	G = 100, R_L = 50k G = 100, R_L = 5k G = 10, R_L = 50k G = 10, R_L = 5k		24 70 4 10	70 300 13 40		26 75 5 12	90 500 15 60	ppm ppm ppm ppm
V_{OS}	Input Offset Voltage	 LT1101ISW		90	350		110 110	500 950	μV μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 2) LT1101ISW		0.4	2.0		0.5 0.5	2.8 4.8	μV/°C mV/°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 2)		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 2)		10	25		10	30	pA/°C
CMRR	Common Mode Rejection Ratio	G = 100, V_{CM} = –14.4V to 13V G = 100, V_{CM} = –13V to 11.5V	96 80	111 99		94 78	111 98		dB dB
PSRR	Power Supply Rejection Ratio	V_S = 3.0, –0.1V to ±18V	98	110		94	110		dB
I_S	Supply Current			105	165		108	190	μA
V_O	Maximum Output Voltage Swing	R_L = 50k R_L = 5k	12.5 11.0	14.0 13.5		12.5 11.0	14.0 13.5		V 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 = ±10V, R_L = 50k G = 100, V_O = ±10V, R_L = 2k G = 10, V_O = ±10V, R_L = 50k or 2k		0.012 0.018 0.009	0.055 0.085 0.055		0.014 0.020 0.010	0.080 0.100 0.080	% % %
TCG_E	Gain Error Drift (Note 2)	G = 100, R_L = 50k G = 100, R_L = 2k G = 10, R_L = 50k or 5k		1 2 1	4 7 4		1 2 1	5 9 5	ppm/°C ppm/°C ppm/°C
G_{NL}	Gain Nonlinearity	G = 100, R_L = 50k G = 100, R_L = 2k G = 10, R_L = 50k or 2k		9 33 4	25 75 10		10 36 4	35 100 11	ppm ppm ppm
V_{OS}	Input Offset Voltage	 LT1101SW		70	250		85 300	350 800	µV µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 2) LT1101SW		0.4	2.0		0.5 1.2	2.8 4.5	µV/°C 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 2)		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 2)		10	25		10	30	pA/°C
CMRR	Common Mode Rejection Ratio	G = 100, V_{CM} = –14.4V to 13V G = 100, V_{CM} = –13V to 11.5V	98 82	112 100		96 80	112 99		dB dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5, –0.1V to ±18V	100	112		97	112		dB
I_S	Supply Current			98	148		100	170	µA
V_O	Maximum Output Voltage Swing	R_L = 50k R_L = 2k	±12.5 ±10.5	±14.1 ±13.0		±12.5 ±10.5	±14.1 ±13.0		V V

ELECTRICAL CHARACTERISTICS

V_S = 5V, 0V, V_{CM} = 0.1V, $V_{REF(PIN\ 1)}$ = 0.1V, Gain = 10 or 100, –40°C ≤ T_A ≤ 85°C for AI/I grades, unless otherwise noted (Note 4).

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 G = 10, V_{CM} = 0.15, R_L = 50k		0.026 0.011	0.080 0.070		0.028 0.014	0.120 0.100	% %
TCG_E	Gain Error Drift	R_L = 50k (Note 2)		1	4		1	5	ppm/°C
G_{NL}	Gain Nonlinearity	G = 100, R_L = 50k G = 10, R_L = 50k (Note 2)		45 4	110 13		48 5	140 15	ppm ppm
V_{OS}	Input Offset Voltage	 LT1101ISW		90	350		110 110	500 950	μV μV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 2) LT1101ISW		0.4	2.0		0.5 0.5	2.8 4.8	μV/°C μV/°C
I_{OS}	Input Offset Current			0.16	0.80		0.19	1.30	nA
$\Delta V_{OS}/\Delta T$	Input Offset Current Drift	(Note 2)		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 2)		10	25		10	30	pA/°C
CMRR	Common Mode Rejection Ratio	G = 100, V_{CM} = 0.1V to 3.2V G = 10, V_{CM} = 0.1V to 2.9V, V_{REF} = 0.15V	91 80	105 98		88 77	104 97		dB dB
I_S	Supply Current			88	135		92	160	μA
V_O	Maximum Output Voltage Swing	Output High, 50k to GND Output High, 2k to GND Output Low, V_{REF} = 0, No Load Output Low, V_{REF} = 0, 2k to GND Output Low, V_{REF} = 0, I_{SINK} = 100μA	3.8 3.0	4.1 3.7 4.5 0.7 125	 8 1.5 170	3.8 3.0	4.1 3.7 4.5 0.7 125	 8 1.5 170	V V mV mV mV

ELECTRICAL CHARACTERISTICS

V_S = 5V, 0V, V_{CM} = 0.1V, $V_{REF(PIN 1)}$ = 0.1V, Gain = 10 or 100, 0°C ≤ T_A ≤ 70°C, unless otherwise noted (Note 4).

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 G = 10, V_{CM} = 0.15V, R_L = 50k		0.017 0.010	0.065 0.060		0.018 0.012	0.095 0.080	% %
TCG_E	Gain Error Drift	R_L = 50k (Note 2)		1	4		1	5	ppm/°C
G_{NL}	Gain Nonlinearity	G = 100, R_L = 50k G = 10, R_L = 50k (Note 2)		25 4	80 10		25 4	100 11	ppm ppm
V_{OS}	Input Offset Voltage	 LT1101SW		70	250		85 300	350 800	µV µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift	(Note 2) LT1101SW		0.4	2.0		0.5 1.2	2.8 4.5	µV/°C 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 2)		0.5	4.0		0.8	7	pA/°C
I_B	Input Bias Current			6	9		6	11	nA
$\Delta I_B/\Delta T$	Input Bias Current Drift	(Note 2)		10	25		10	30	pA/°C
CMRR	Common Mode Rejection Ratio	G = 100, V_{CM} = 0.07V to 3.3V G = 10, V_{CM} = 0.07V to 3V, V_{REF} = 0.15V	93 82	105 99		90 80	104 98		dB dB
I_S	Supply Current			80	120		85	145	µA
V_O	Maximum Output Voltage Swing	Output High, 50k to GND Output High, 2k to GND Output Low, V_{REF} = 0, No Load Output Low, V_{REF} = 0, 2k to GND Output Low, V_{REF} = 0, I_{SINK} = 100µA	4.0 3.3 	4.2 3.8 4 0.6 100	 7 1.2 150	4.0 3.3 	4.2 3.8 4 0.6 100	 7 1.2 150	V V mV mV mV

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: This parameter is not tested. It is guaranteed by design and by inference from other tests.

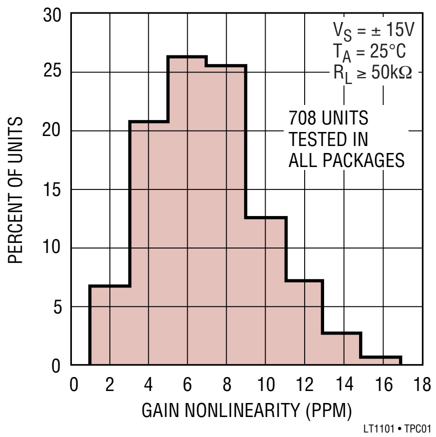
Note 3: This parameter is tested on a sample basis only.

Note 4: These test conditions are equivalent to V_S = 4.9V, –0.1V, V_{CM} = 0V, $V_{REF(PIN1)}$ = 0V.

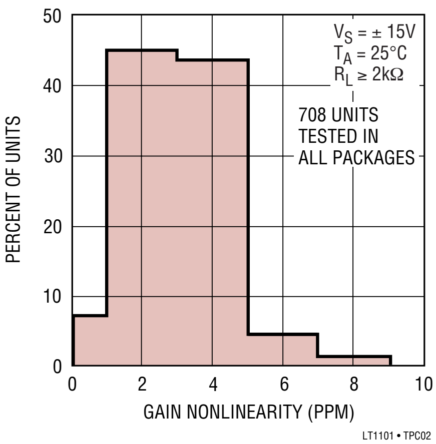
Note 5: Minimum supply voltage is guaranteed by the power supply rejection test. The LT1101 actually works at 1.8V supply with minimal degradation in performance.

TYPICAL PERFORMANCE CHARACTERISTICS

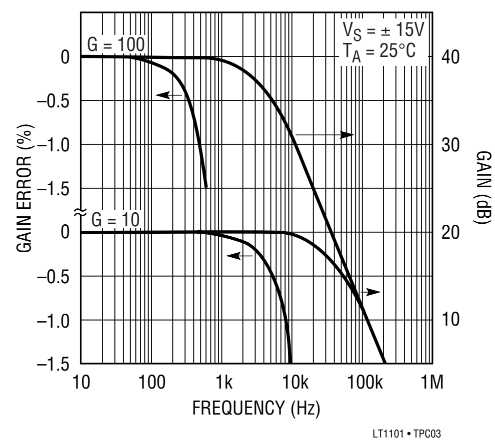
Gain = 100 Nonlinearity Distribution



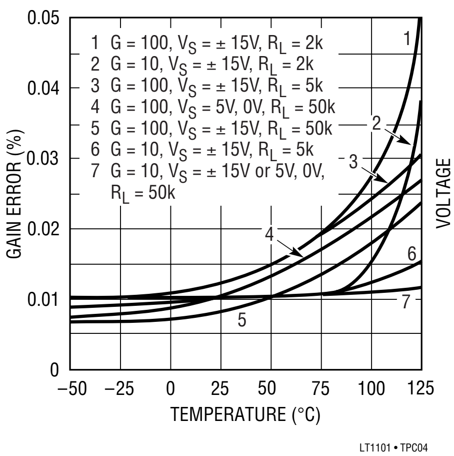
Gain = 10 Nonlinearity Distribution



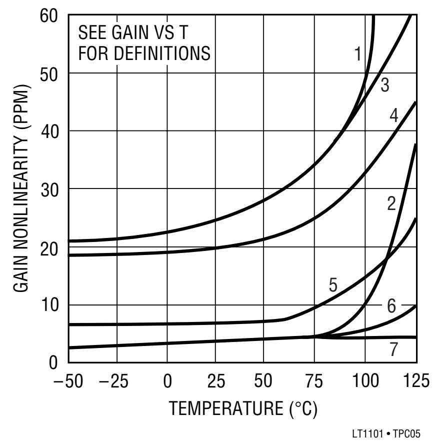
Gain vs Frequency



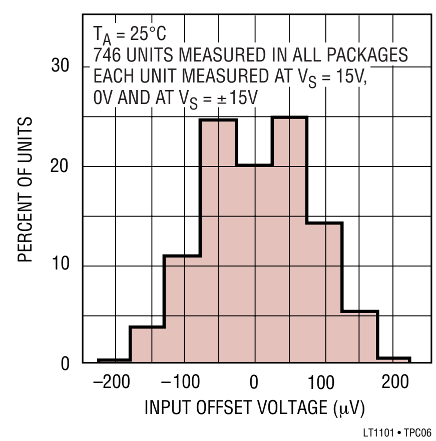
Gain Error Over Temperature



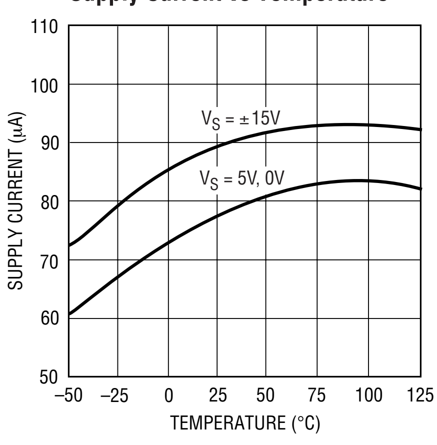
Gain Nonlinearity Temperature



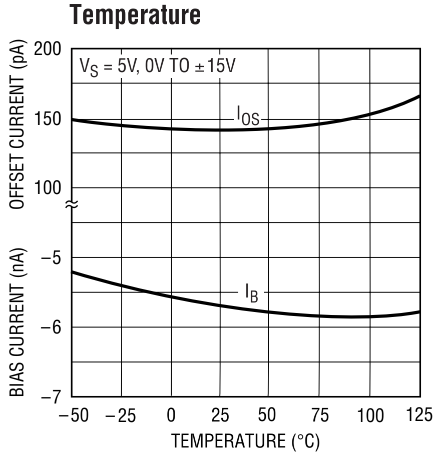
Input Offset Voltage Distribution



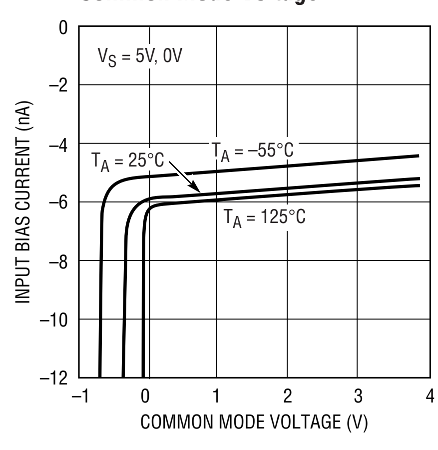
Supply Current vs Temperature



Input Bias and Offset Currents vs Temperature

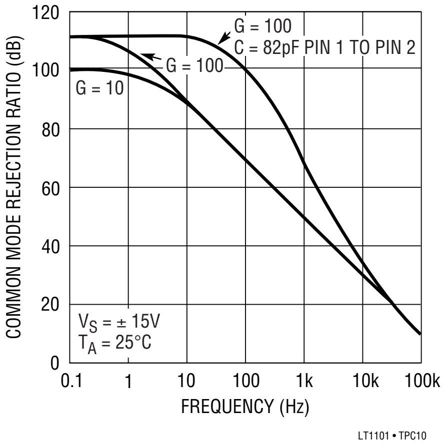


Input Bias Current vs Common Mode Voltage

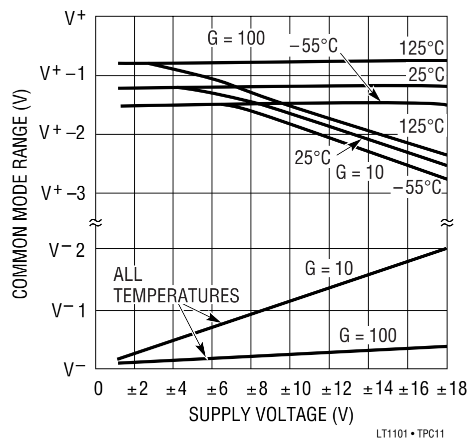


TYPICAL PERFORMANCE CHARACTERISTICS

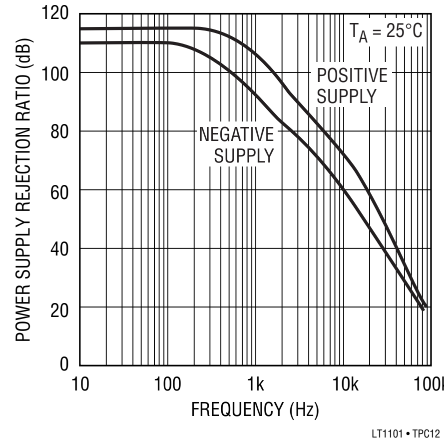
Common Mode Rejection Ratio vs Frequency



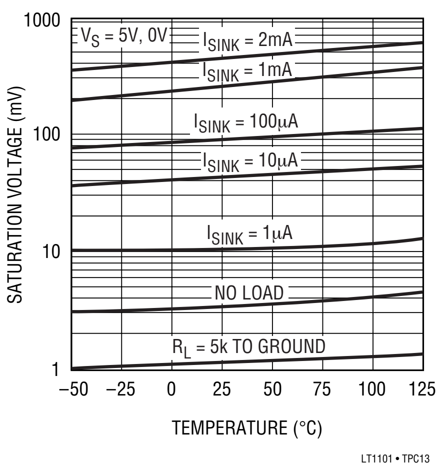
Common Mode Range vs Supply Voltage



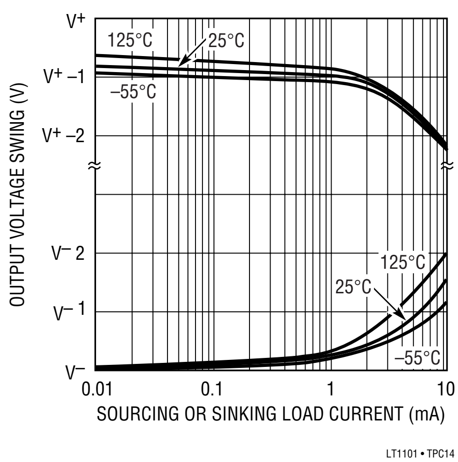
Power Supply Rejection Ratio vs Frequency



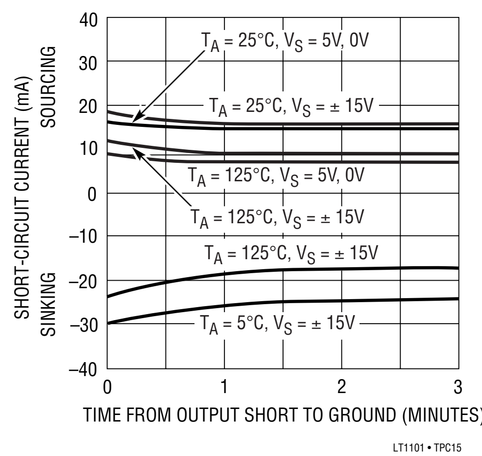
Output Saturation vs Temperature vs Sink Current



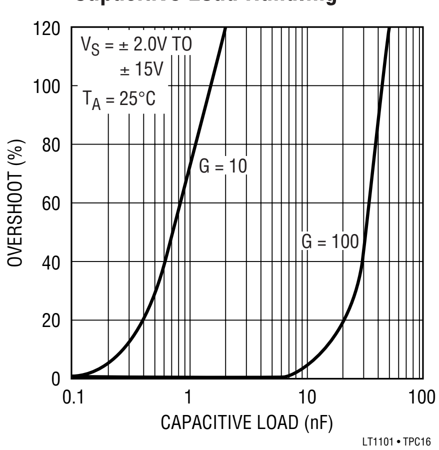
Output Voltage Swing vs Load Current



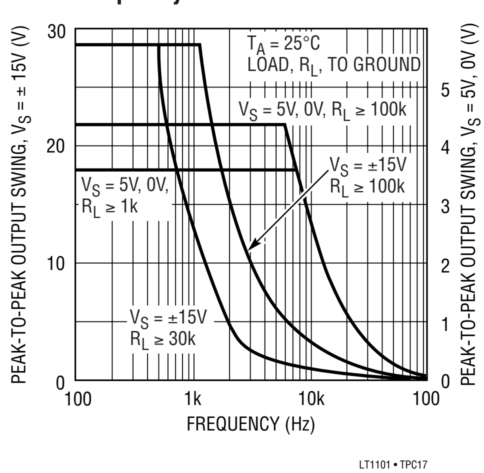
Short-Circuit Current vs Time



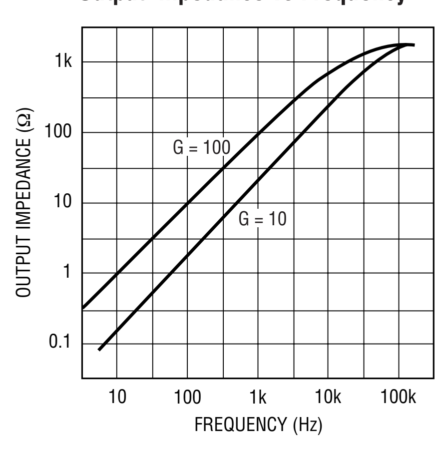
Capacitive Load Handling



Undistorted Output Swing vs Frequency

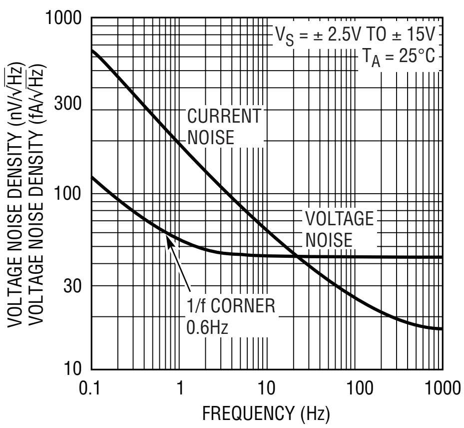


Output Impedance vs Frequency



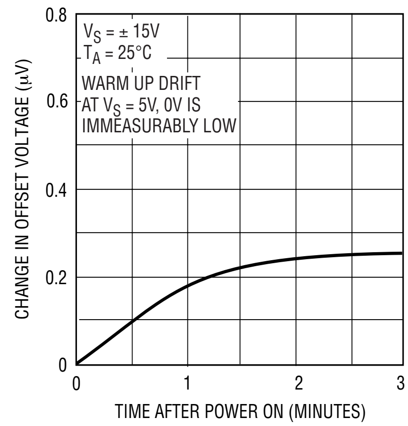
TYPICAL PERFORMANCE CHARACTERISTICS

Noise Spectrum



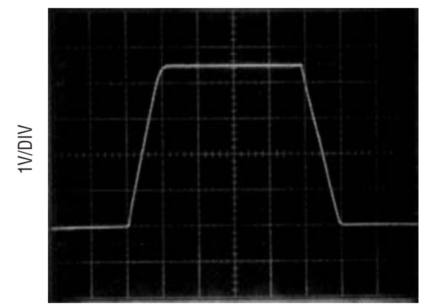
LT1101 • TPC19

Warm-Up Drift



LT1101 • TPC20

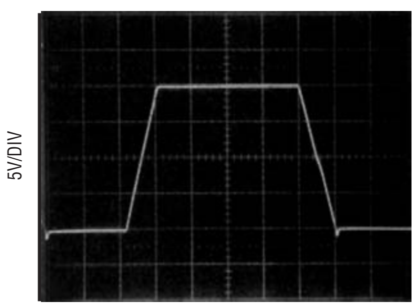
Large Signal Transient Response G = 10, V_S = 5V, 0V



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

LT1101 • TPC20.1

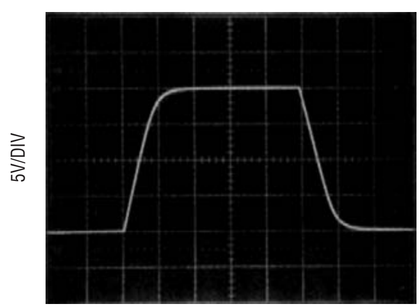
Large Signal Transient Response G = 10, V_S = 15V



200μs/DIV
NO LOAD

LT1101 • TPC20.2

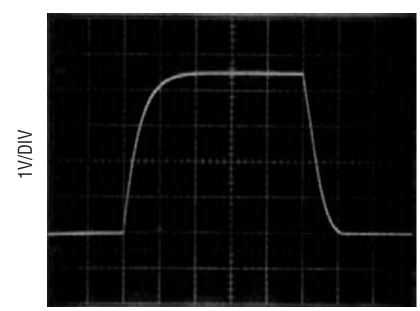
Large Signal Transient Response G = 100, V_S = ±15V



200μs/DIV
NO LOAD

LT1101 • TPC20.3

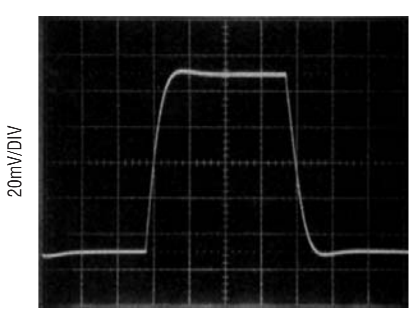
Large Signal Transient Response G = 100, V_S = 5V, 0V



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

LT1101 • TPC20.4

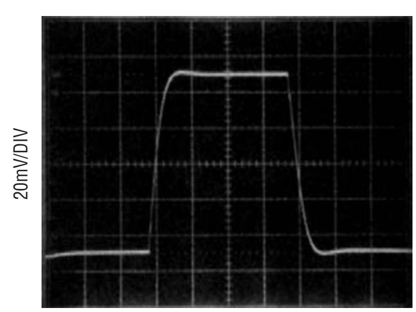
Small Signal Transient Response G = 10, V_S = 5V, 0V



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

LT1101 • TPC20.5

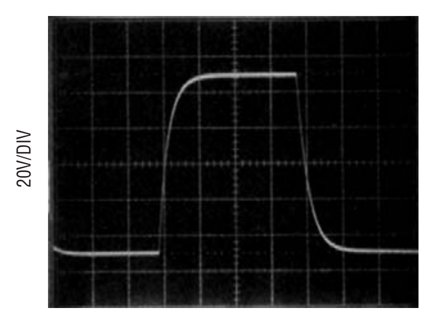
Small Signal Transient Response G = 10, V_S = ±15V



20μs/DIV

LT1101 • TPC20.6

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

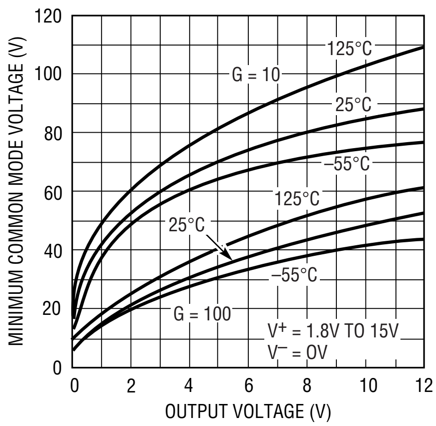


200μs/DIV
OUTPUT FROM 0.05V TO 0.15V, NO LOAD
(RESPONSE WITH V_S = ±15V, G = 100 IS IDENTICAL)

LT1101 • TPC20.7

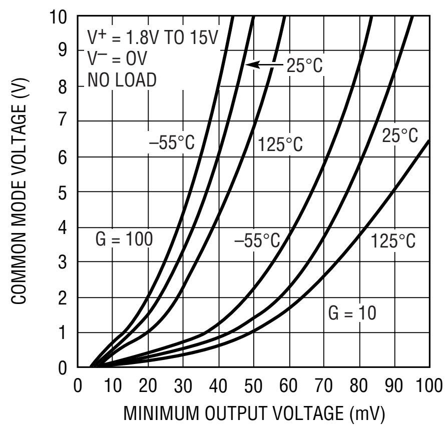
TYPICAL PERFORMANCE CHARACTERISTICS

Single Supply: Minimum Common Mode Voltage vs Output Voltage



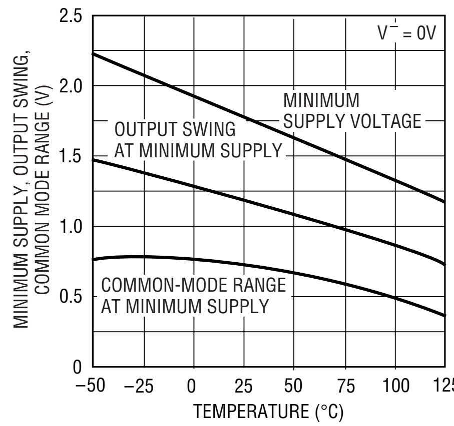
LT1101 • TPC21

Single Supply: Minimum Output Voltage vs Common Mode Voltage



LT1101 • TPC22

Minimum Supply Voltage vs Temperature



LT1101 • TPC23

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 Single Supply 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

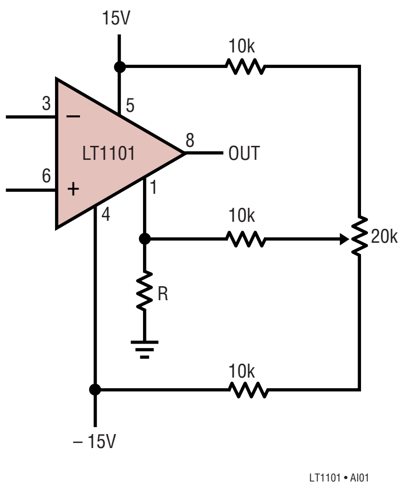
The common mode rejection ratio (CMRR) of the LT1101 starts to roll off at a relatively low frequency. However, as shown on the Common Mode Rejection Ratio vs Frequency plot, CMRR can be enhanced significantly by connecting an 82pF capacitor between pins 1 and 2. This improvement is only available in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

Offset Nulling

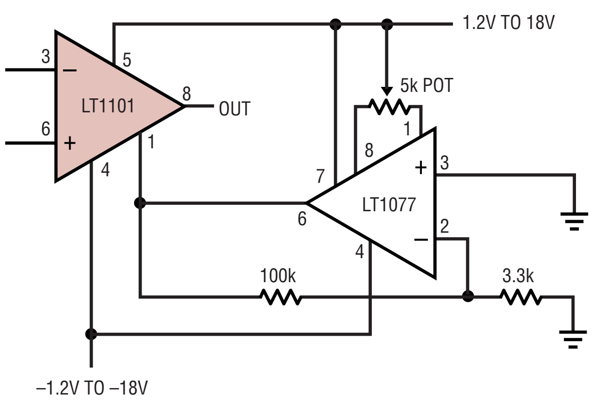
The LT1101 is not equipped with dedicated offset null terminals. In many bridge transducer or sensor applications, calibrating the bridge simultaneously eliminates the instrumentation amplifier's offset as a source of error. For example, in the Micropower Remote Temperature Sensor Application shown,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

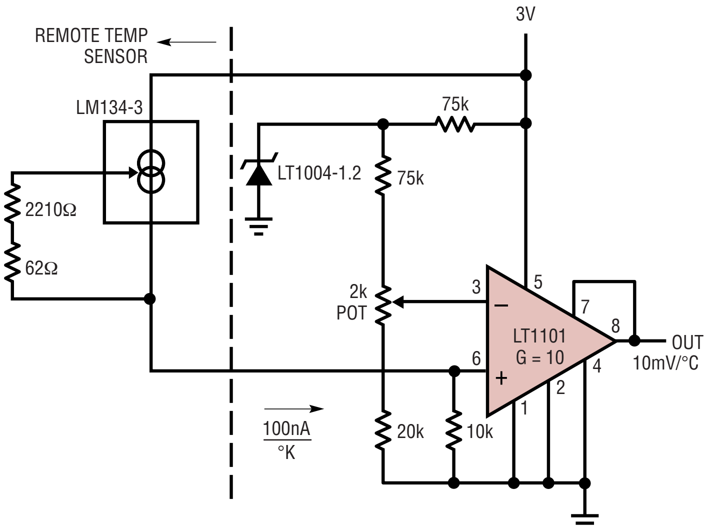
Instrumentation amplifiers are often used in harsh environments where overload conditions can occur. The LT1101 employs PNP input transistors, consequently the differential input voltage can be ±30V (with ±15V supplies, ±36V with ±18V supplies) without an increase in input bias current. Competitive instrumentation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

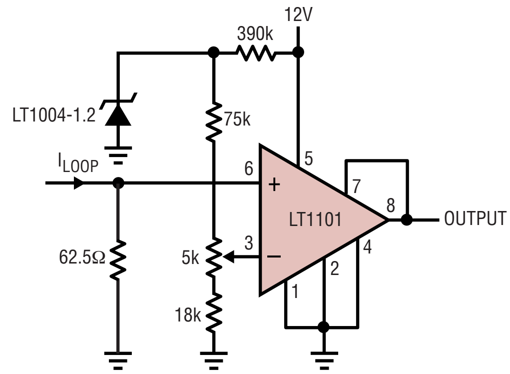
Micropower, Battery Operated Remote Temperature Sensor



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

LT1101 • AI03

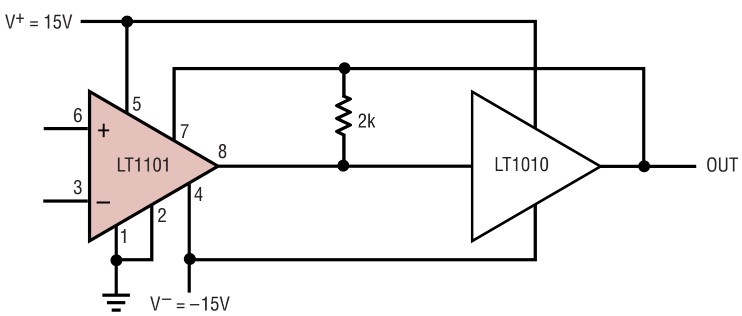
4mA to 20mA Loop Receiver



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

LT1101 • AI04

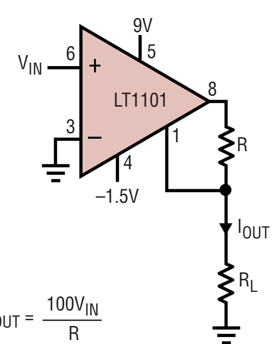
Instrumentation Amplifier with ±150mA Output Current



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

LT1101 • AI05

Voltage Controlled Current Source



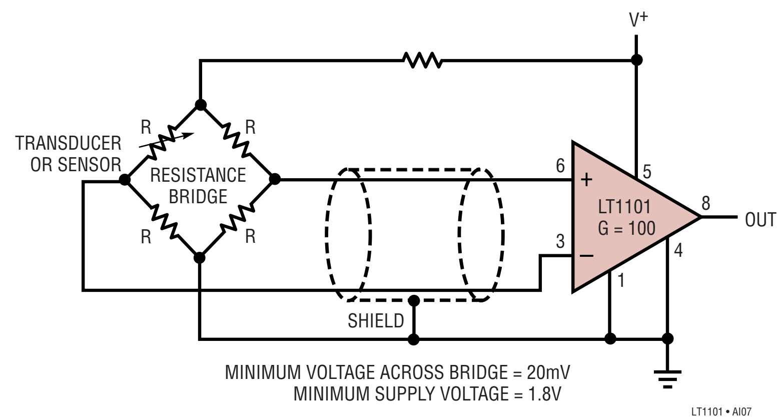
$$I_{OUT} = \frac{100V_{IN}}{R}$$

I_{OUT} = 0mA TO 5mA
VOLTAGE COMPLIANCE = 6.4V
(R ≤ 200Ω)

LT1101 • AI06

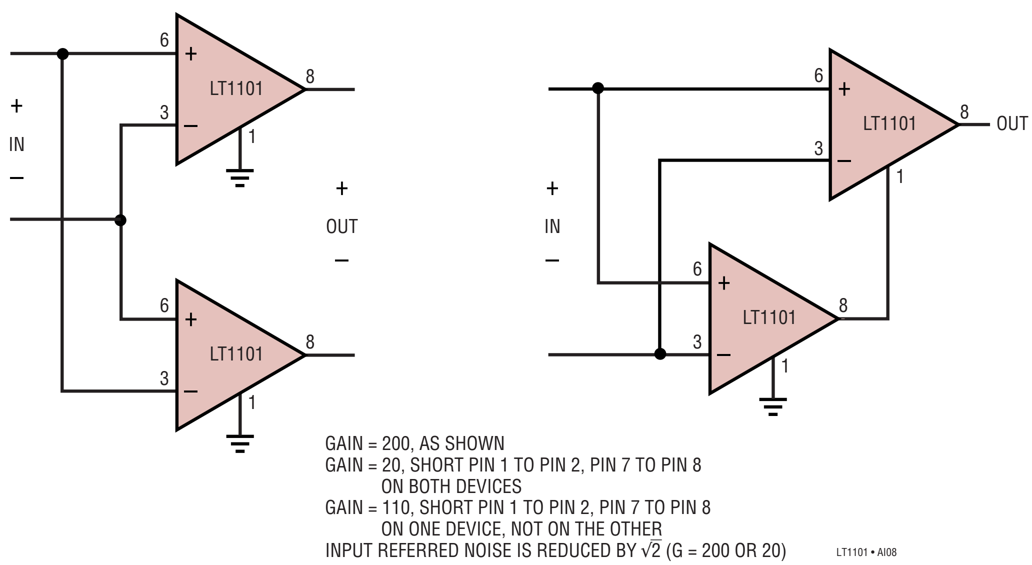
APPLICATIONS INFORMATION

Differential Voltage Amplification from a Resistance Bridge



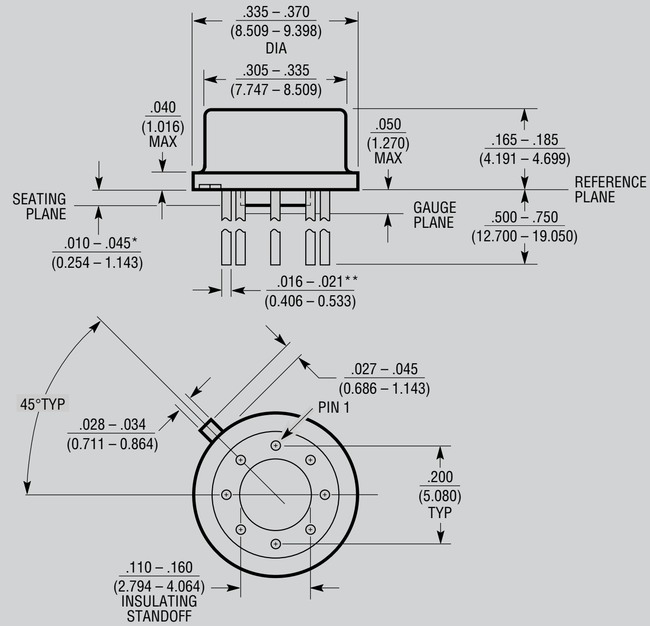
Gain = 20, 110 or 200 Instrumentation Amplifier

Differential Output **Single Ended Output**



PACKAGE DESCRIPTION

H Package
8-Lead TO-5 Metal Can (.200 Inch PCD)
(Reference LTC DWG # 05-08-1320)

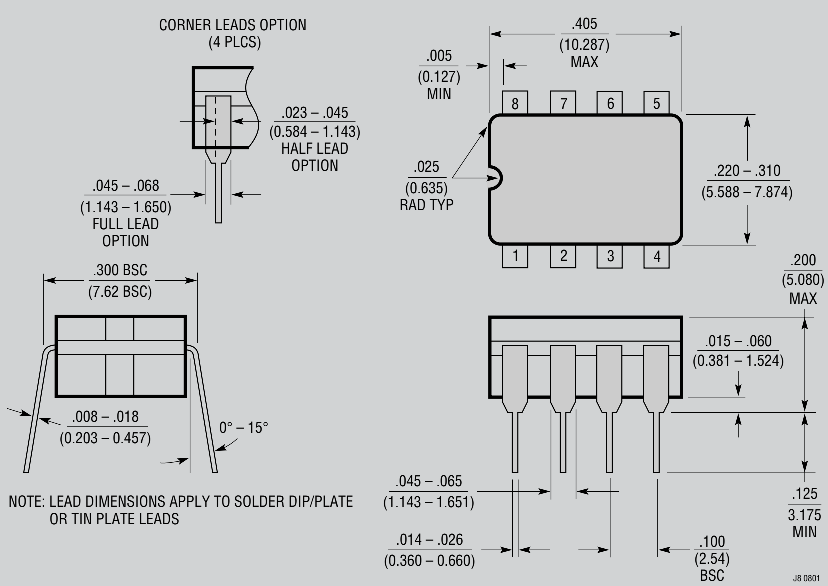


*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND THE SEATING PLANE

**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS .016 – .024 (0.406 – 0.610)

H8(TO-5) 0.200 PCD 0801

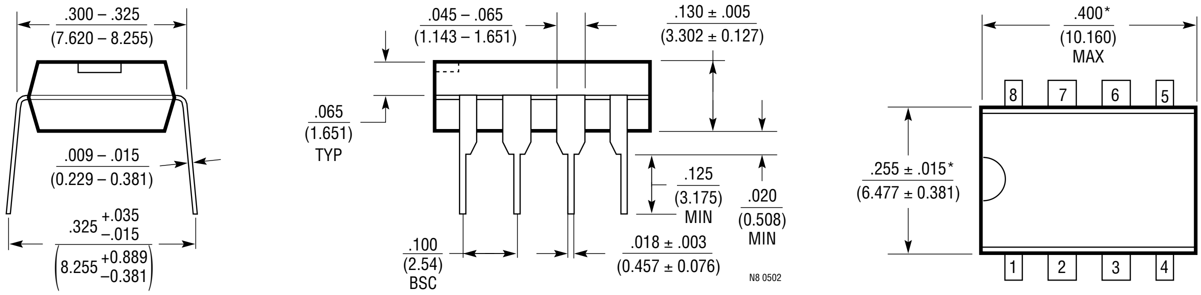
J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)



OBSOLETE PACKAGES

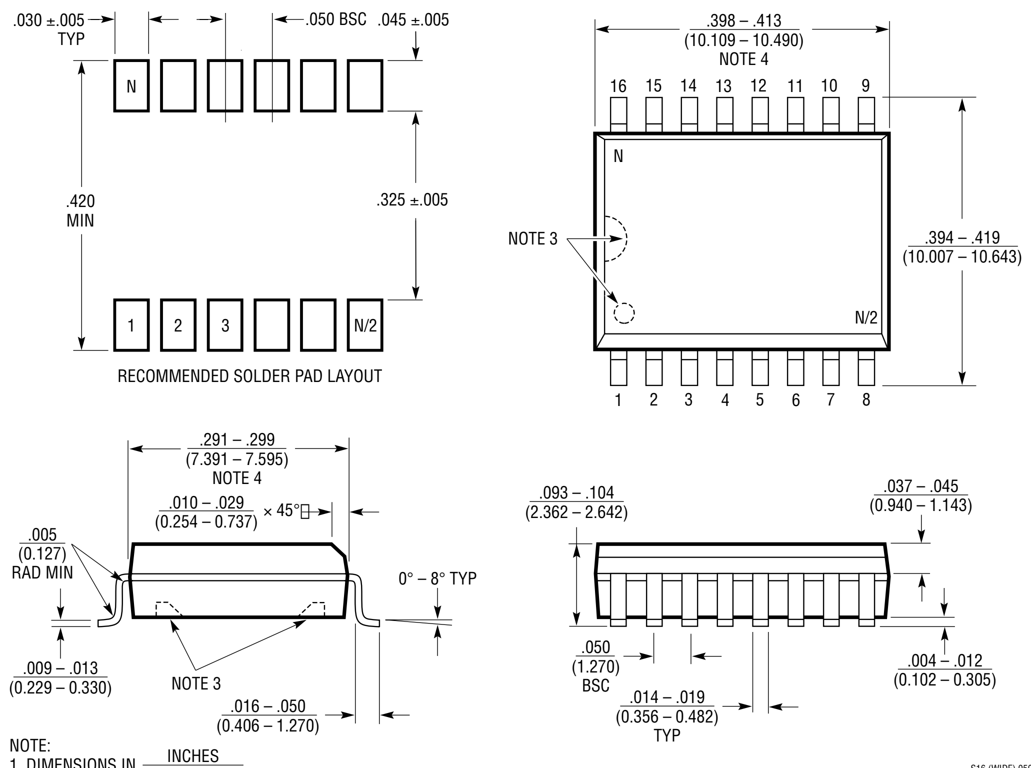
PACKAGE DESCRIPTION

N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)



NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

SW Package
16-Lead Plastic Small Outline (Wide .300 Inch)
(Reference LTC DWG # 05-08-1620)



NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. 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
4. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

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