

FEATURES

- Single Supply Operation
 - Input Voltage Range Extends to Ground
 - Output Swings to Ground while Sinking Current
- Pin Compatible to 1458 and 324 with Precision Specs
- *Guaranteed* Offset Voltage 150 μ V Max.
- *Guaranteed* Low Drift 2 μ V/ $^{\circ}$ C Max.
- *Guaranteed* Offset Current 0.8nA Max.
- *Guaranteed* High Gain
 - 5mA Load Current 1.5 Million Min.
 - 17mA Load Current 0.8 Million Min.
- *Guaranteed* Low Supply Current 500 μ A Max.
- Low Voltage Noise, 0.1Hz to 10Hz 0.55 μ Vp-p
- Low Current Noise—Better than OP-07, 0.07pA/ $\sqrt{\text{Hz}}$

APPLICATIONS

- Battery-Powered Precision Instrumentation
 - Strain Gauge Signal Conditioners
 - Thermocouple Amplifiers
 - Instrumentation Amplifiers
- 4mA–20mA Current Loop Transmitters
- Multiple Limit Threshold Detection
- Active Filters
- Multiple Gain Blocks

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DESCRIPTION

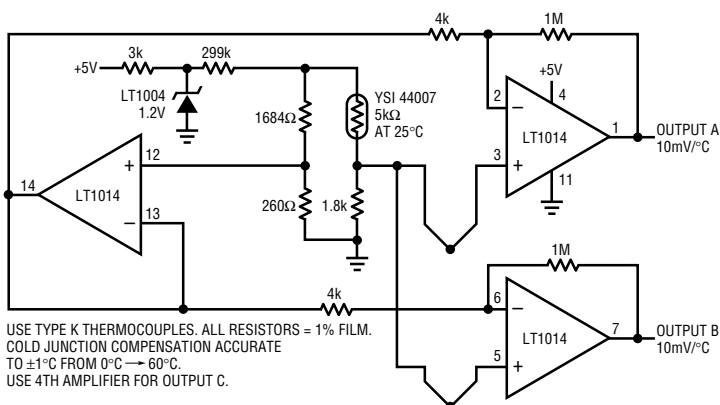
The LT[®]1014 is the first precision quad operational amplifier which directly upgrades designs in the industry standard 14-pin DIP LM324/LM348/OP-11/4156 pin configuration. It is no longer necessary to compromise specifications, while saving board space and cost, as compared to single operational amplifiers.

The LT1014's low offset voltage of 50 μ V, drift of 0.3 μ V/ $^{\circ}$ C, offset current of 0.15nA, gain of 8 million, common-mode rejection of 117dB and power supply rejection of 120dB qualify it as four truly precision operational amplifiers. Particularly important is the low offset voltage, since no offset null terminals are provided in the quad configuration. Although supply current is only 350 μ A per amplifier, a new output stage design sources and sinks in excess of 20mA of load current, while retaining high voltage gain.

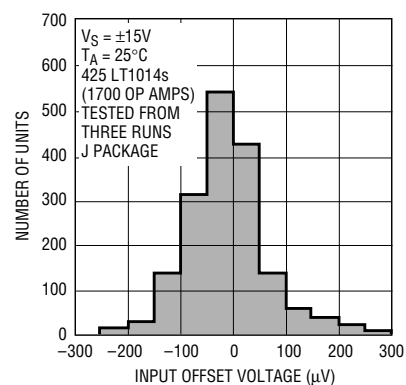
Similarly, the LT1013 is the first precision dual op amp in the 8-pin industry standard configuration, upgrading the performance of such popular devices as the MC1458/1558, LM158 and OP-221. The LT1013's specifications are similar to (even somewhat better than) the LT1014's.

Both the LT1013 and LT1014 can be operated off a single 5V power supply: input common-mode range includes ground; the output can also swing to within a few millivolts of ground. Crossover distortion, so apparent on previous single-supply designs, is eliminated. A full set of specifications is provided with ± 15 V and single 5V supplies.

3 Channel Thermocouple Thermometer



LT1014 Distribution of Offset Voltage



LT1013/LT1014

ABSOLUTE MAXIMUM RATINGS

Supply Voltage $\pm 22V$
 Differential Input Voltage $\pm 30V$
 Input Voltage Equal to Positive Supply Voltage
 5V Below Negative Supply Voltage
 Output Short-Circuit Duration Indefinite
 Storage Temperature Range
 All Grades $-65^{\circ}C$ to $150^{\circ}C$

Lead Temperature (Soldering, 10 sec.) $300^{\circ}C$
 Operating Temperature Range
 LT1013AM/LT1013M/
 LT1014AM/LT1014M $-55^{\circ}C$ to $125^{\circ}C$
 LT1013AC/LT1013C/LT1013D
 LT1014AC/LT1014C/LT1014D $0^{\circ}C$ to $70^{\circ}C$
 LT1013I/ LT1014I $-40^{\circ}C$ to $85^{\circ}C$

PACKAGE/ORDER INFORMATION

TOP VIEW OUTPUT A 1, -IN A 2, +IN A 3, V-(CASE) 4, +IN B 5, -IN B 6, OUTPUT B 7, V+ 8 H PACKAGE 8-LEAD TO-5 METAL CAN	ORDER PART NUMBER LT1013AMH LT1013MH LT1013ACH LT1013CH	TOP VIEW OUTPUT A 1, -IN A 2, +IN A 3, V- 4, +IN B 5, -IN B 6, OUTPUT B 7, V+ 8 J PACKAGE 8-LEAD CERAMIC DIP N PACKAGE 8-LEAD PLASTIC DIP	ORDER PART NUMBER LT1013AMJ8 LT1013MJ8 LT1013ACJ8 LT1013CJ8 LT1013ACN8 LT1013CN8 LT1013DN8 LT1013IN8	TOP VIEW OUTPUT A 1, -IN A 2, +IN A 3, V+ 4, +IN B 5, -IN B 6, OUTPUT B 7, V- 8, -IN C 9, +IN C 10, -IN D 11, +IN D 12, OUTPUT D 13, V+ 14 J PACKAGE 14-LEAD CERAMIC DIP N PACKAGE 14-LEAD PLASTIC DIP	ORDER PART NUMBER LT1014AMJ LT1014MJ LT1014ACJ LT1014CJ LT1014ACN LT1014CN LT1014DN LT1014IN
TOP VIEW +IN A 1, V- 2, +IN B 3, -IN B 4, OUTB 5, V+ 6, OUTA 7, -IN A 8 SO PACKAGE 8-LEAD PLASTIC SOIC NOTE: THIS PIN CONFIGURATION DIFFERS FROM THE STANDARD 8-PIN DUAL-IN-LINE CONFIGURATION	ORDER PART NUMBER LT1013DS8 LT1013IS8 PART MARKING 1013 1013I	TOP VIEW OUTPUT A 1, -IN A 2, +IN A 3, V+ 4, +IN B 5, -IN B 6, OUTPUT B 7, NC 8, NC 9, OUTPUT C 10, -IN C 11, +IN C 12, V- 13, +IN D 14, -IN D 15, OUTPUT D 16 SO PACKAGE 16-LEAD PLASTIC SOIC	ORDER PART NUMBER LT1014DS LT1014IS PART MARKING LT1014DS LT1014IS		

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $T_A = 25^{\circ}C$ unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1013AM/AC LT1014AM/AC			LT1013C/D/I/M LT1014C/D/I/M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1013	—	40	150	—	60	300	μV
		LT1014	—	50	180	—	60	300	μV
		LT1013D/I, LT1014D/I	—	—	—	—	200	800	μV
	Long Term Input Offset Voltage Stability		—	0.4	—	—	0.5	—	$\mu V/Mo.$
I_{SO}	Input Offset Current		—	0.15	0.8	—	0.2	1.5	nA
I_B	Input Bias Current		—	12	20	—	15	30	nA
e_n	Input Noise Voltage	0.1Hz to 10Hz	—	0.55	—	—	0.55	—	$\mu Vp-p$
e_n	Input Noise Voltage Density	$f_0 = 10Hz$	—	24	—	—	24	—	$nV/\sqrt{Hz}$
		$f_0 = 1000Hz$	—	22	—	—	22	—	$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	$f_0 = 10Hz$	—	0.07	—	—	0.07	—	$pA/\sqrt{Hz}$

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $T_A = 25^\circ C$ unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1013AM/AC LT1014AM/AC			LT1013C/D/I/M LT1014C/D/I/M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
	Input Resistance – Differential Common-Mode	(Note 1)	100 —	400 5	— —	70 —	300 4	— —	M Ω G Ω
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 2k$	1.5	8.0	—	1.2	7.0	—	V/ μV
		$V_O = \pm 10V$, $R_L = 600\Omega$	0.8	2.5	—	0.5	2.0	—	V/ μV
	Input Voltage Range		+13.5 –15.0	+13.8 –15.3	— —	+13.5 –15.0	+13.8 –15.3	— —	V V
CMRR	Common-Mode Rejection Ratio	$V_{CM} = +13.5V$, $-15.0V$	100	117	—	97	114	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2V$ to $\pm 18V$	103	120	—	100	117	—	dB
	Channel Separation	$V_O = \pm 10V$, $R_L = 2k$	123	140	—	120	137	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2k$	± 13	± 14	—	± 12.5	± 14	—	V
	Slew Rate		0.2	0.4	—	0.2	0.4	—	V/ μs
I_S	Supply Current	Per Amplifier	—	0.35	0.50	—	0.35	0.55	mA

Note 1: This parameter is guaranteed by design and is not tested. Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers; i.e., out of 100 LT1014s (or 100 LT1013s) typically 240 op amps (or 120) will be better than the indicated specification.

ELECTRICAL CHARACTERISTICS

$V_{S^+} = +5V$, $V_{S^-} = 0V$, $V_{OUT} = 1.4V$, $V_{CM} = 0V$, $T_A = 25^\circ C$ unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1013AM/AC LT1014AM/AC			LT1013C/D/I/M LT1014C/D/I/M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1013	—	60	250	—	90	450	μV
		LT1014	—	70	280	—	90	450	μV
		LT1013D/I, LT1014D/I	—	—	—	—	250	950	μV
I_{OS}	Input Offset Current		—	0.2	1.3	—	0.3	2.0	nA
I_B	Input Bias Current		—	15	35	—	18	50	nA
A_{VOL}	Large Signal Voltage Gain	$V_O = 5mV$ to $4V$, $R_L = 500\Omega$	—	1.0	—	—	1.0	—	V/ μV
	Input Voltage Range		+3.5 0	+3.8 –0.3	— —	+3.5 0	+3.8 –0.3	— —	V V
V_{OUT}	Output Voltage Swing	Output Low, No Load	—	15	25	—	15	25	mV
		Output Low, 600 Ω to Ground	—	5	10	—	5	10	mV
		Output Low, $I_{SINK} = 1mA$	—	220	350	—	220	350	mV
		Output High, No Load	4.0	4.4	—	4.0	4.4	—	V
		Output High, 600 Ω to Ground	3.4	4.0	—	3.4	4.0	—	V
I_S	Supply Current	Per Amplifier	—	0.31	0.45	—	0.32	0.50	mA

ELECTRICAL CHARACTERISTICS $V_S = \pm 15V$, $V_{CM} = 0V$, $-55^\circ C \leq T_A \leq 125^\circ C$ unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS		LT1013AM			LT1014AM			LT1013M/LT1014M			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	$V_S = +5V$, $0V$; $V_O = +1.4V$ $-55^\circ C \leq T_A \leq 100^\circ C$ $V_{CM} = 0.1V$, $T_A = 125^\circ C$ $V_{CM} = 0V$, $T_A = 125^\circ C$	●	—	80	300	—	90	350	—	110	550	μV
			●	—	80	450	—	90	480	—	100	750	μV
			●	—	120	450	—	150	480	—	200	750	μV
			●	—	250	900	—	300	960	—	400	1500	μV
	Input Offset Voltage Drift	(Note 2)	●	—	0.4	2.0	—	0.4	2.0	—	0.5	2.5	$\mu V/^\circ C$
I_{OS}	Input Offset Current	$V_S = +5V$, $0V$; $V_O = +1.4V$	●	—	0.3	2.5	—	0.3	2.8	—	0.4	5.0	nA
			●	—	0.6	6.0	—	0.7	7.0	—	0.9	10.0	nA
I_B	Input Bias Current	$V_S = +5V$, $0V$; $V_O = +1.4V$	●	—	15	30	—	15	30	—	18	45	nA
			●	—	20	80	—	25	90	—	28	120	nA
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 2k$	●	0.5	2.0	—	0.4	2.0	—	0.25	2.0	—	V/ μV
CMRR	Common-Mode Rejection	$V_{CM} = +13.0V$, $-14.9V$	●	97	114	—	96	114	—	94	113	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2V$ to $\pm 18V$	●	100	117	—	100	117	—	97	116	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2k$ $V_S = +5V$, $0V$ $R_L = 600\Omega$ to Ground Output Low Output High	●	± 12	± 13.8	—	± 12	± 13.8	—	± 11.5	± 13.8	—	V
			●	—	6	15	—	6	15	—	6	18	mV
			●	3.2	3.8	—	3.2	3.8	—	3.1	3.8	—	V
			●	—	0.38	0.60	—	0.38	0.60	—	0.38	0.7	mA
I_S	Supply Current Per Amplifier	$V_S = +5V$, $0V$; $V_O = +1.4V$	●	—	0.34	0.55	—	0.34	0.55	—	0.34	0.65	mA
			●	—	0.34	0.55	—	0.34	0.55	—	0.34	0.65	mA

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $-40^\circ C \leq T_A \leq 85^\circ C$ for LT1013I, LT1014I, $0^\circ C \leq T_A \leq 70^\circ C$ for LT1013C, LT1013D, LT1014C, LT1014D unless otherwise noted

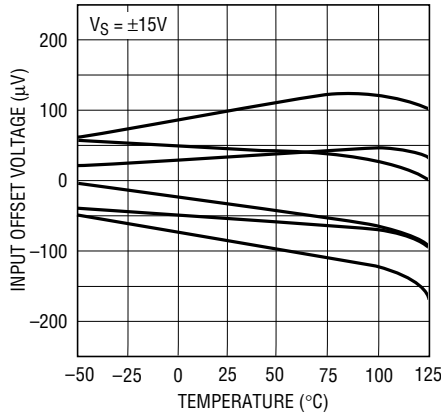
SYMBOL	PARAMETER	CONDITIONS		LT1013AC			LT1014AC			LT1013C/D/I LT1014C/D/I			UNITS
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage	LT1013D/I, LT1014D/I $V_S = +5V$, $0V$; $V_O = 1.4V$ LT1013D/I, LT1014D/I $V_S = +5V$, $0V$; $V_O = 1.4V$	●	—	55	240	—	65	270	—	80	400	μV
			●	—	—	—	—	—	—	—	230	1000	μV
			●	—	75	350	—	85	380	—	110	570	μV
			●	—	—	—	—	—	—	—	280	1200	μV
	Average Input Offset Voltage Drift	(Note 2) LT1013D/I, LT1014D/I	●	—	0.3	2.0	—	0.3	2.0	—	0.4	2.5	$\mu V/^\circ C$
			●	—	—	—	—	—	—	—	0.7	5.0	$\mu V/^\circ C$
I_{OS}	Input Offset Current	$V_S = +5V$, $0V$; $V_O = 1.4V$	●	—	0.2	1.5	—	0.2	1.7	—	0.3	2.8	nA
			●	—	0.4	3.5	—	0.4	4.0	—	0.5	6.0	nA
I_B	Input Bias Current	$V_S = +5V$, $0V$; $V_O = 1.4V$	●	—	13	25	—	13	25	—	16	38	nA
			●	—	18	55	—	20	60	—	24	90	nA
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 2k$	●	1.0	5.0	—	1.0	5.0	—	0.7	4.0	—	V/ μV
CMRR	Common-Mode Rejection Ratio	$V_{CM} = +13.0V$, $-15.0V$	●	98	116	—	98	116	—	94	113	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2V$ to $\pm 18V$	●	101	119	—	101	119	—	97	116	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2k$ $V_S = +5V$, $0V$; $R_L = 600\Omega$ Output Low Output High	●	± 12.5	± 13.9	—	± 12.5	± 13.9	—	± 12.0	± 13.9	—	V
			●	—	6	13	—	6	13	—	6	13	mV
			●	3.3	3.9	—	3.3	3.9	—	3.2	3.9	—	V
			●	—	0.36	0.55	—	0.36	0.55	—	0.37	0.60	mA
I_S	Supply Current per Amplifier	$V_S = +5V$, $0V$; $V_O = 1.4V$	●	—	0.32	0.50	—	0.32	0.50	—	0.34	0.55	mA
			●	—	0.32	0.50	—	0.32	0.50	—	0.34	0.55	mA

Note 2: This parameter is not 100% tested.

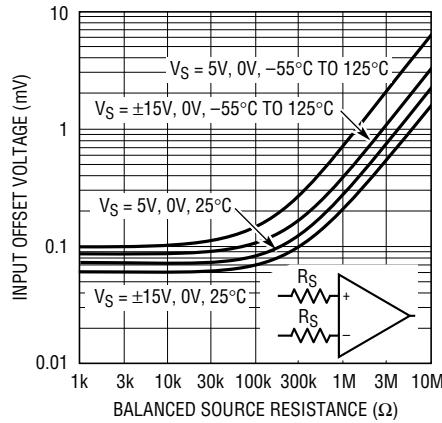
The ● denotes specifications which apply over the full operating temperature range.

TYPICAL PERFORMANCE CHARACTERISTICS

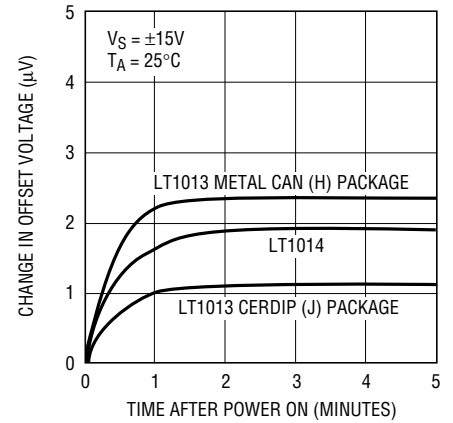
Offset Voltage Drift with Temperature of Representative Units



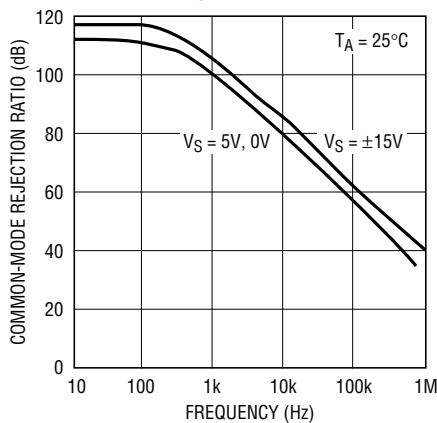
Offset Voltage vs Balanced Source Resistance



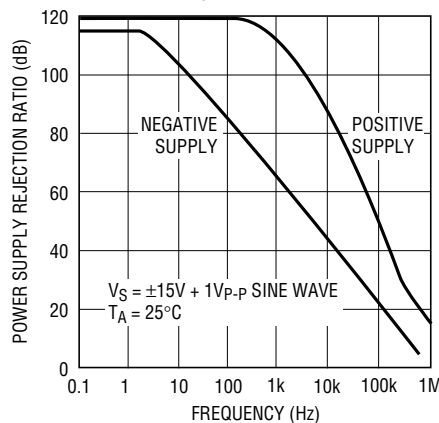
Warm-Up Drift



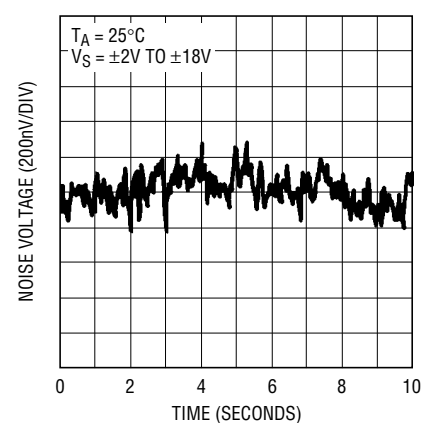
Common-Mode Rejection Ratio vs Frequency



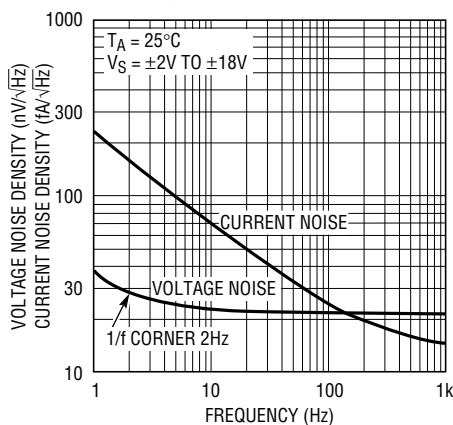
Power Supply Rejection Ratio vs Frequency



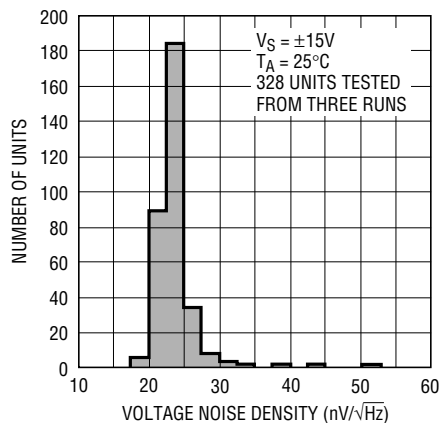
0.1Hz to 10Hz Noise



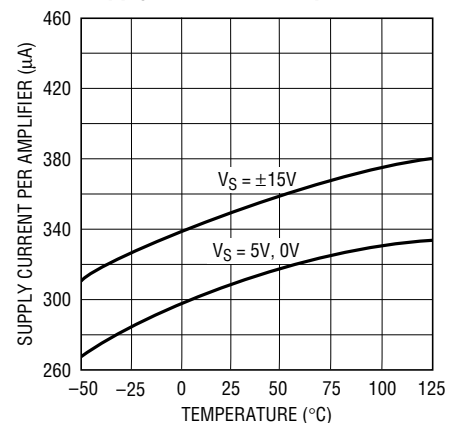
Noise Spectrum



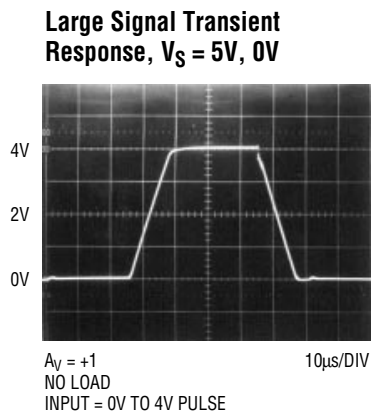
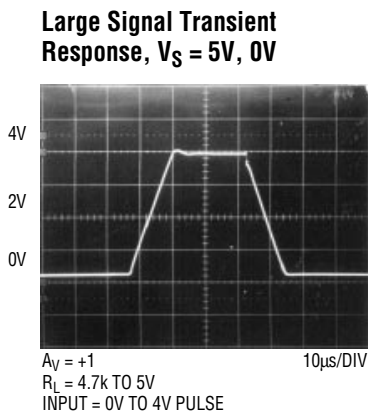
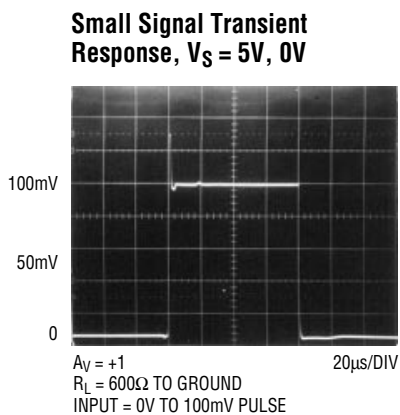
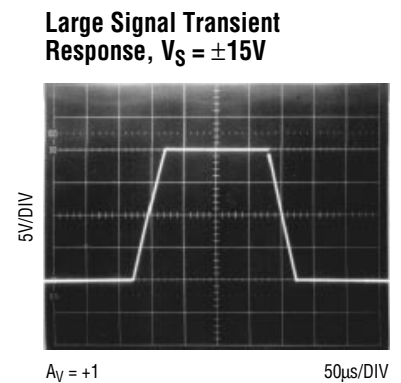
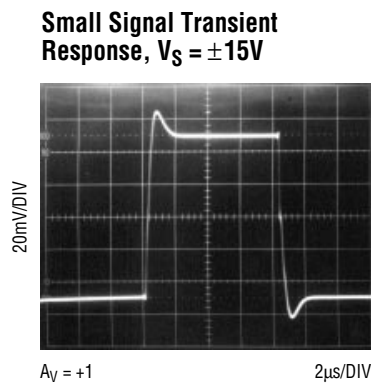
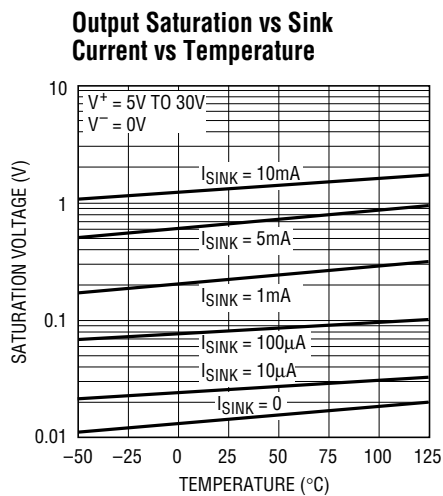
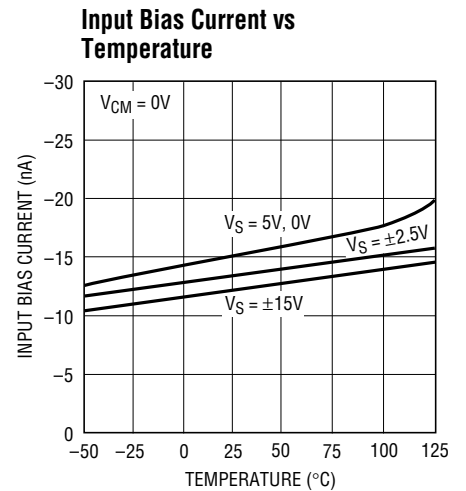
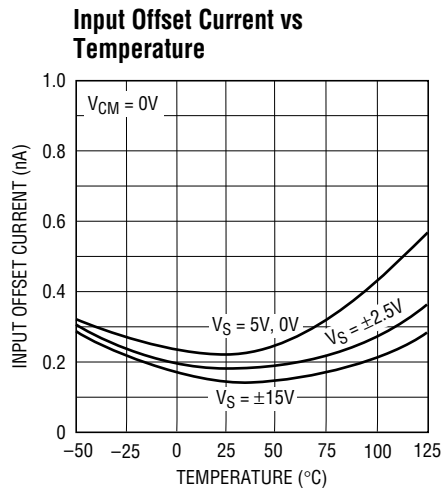
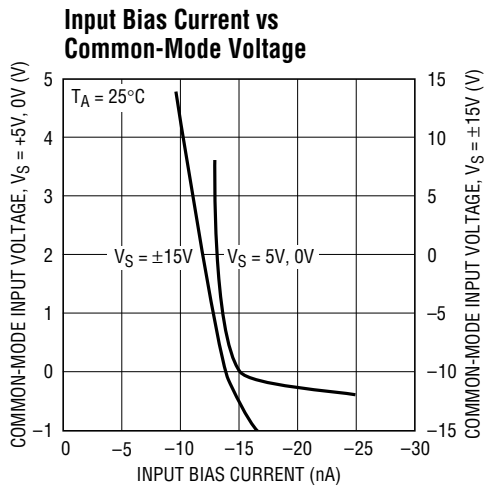
10Hz Voltage Noise Distribution



Supply Current vs Temperature

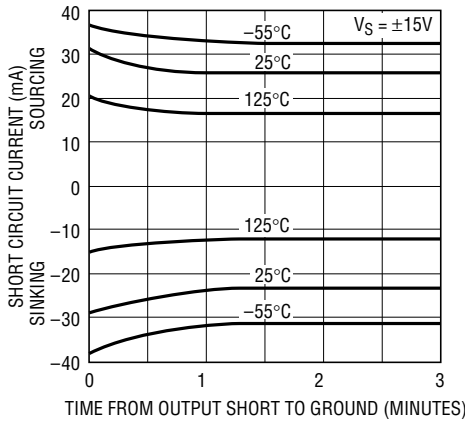


TYPICAL PERFORMANCE CHARACTERISTICS

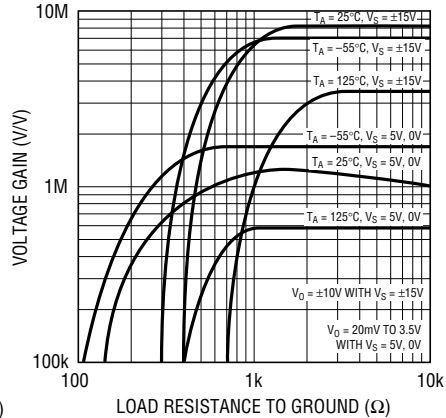


TYPICAL PERFORMANCE CHARACTERISTICS

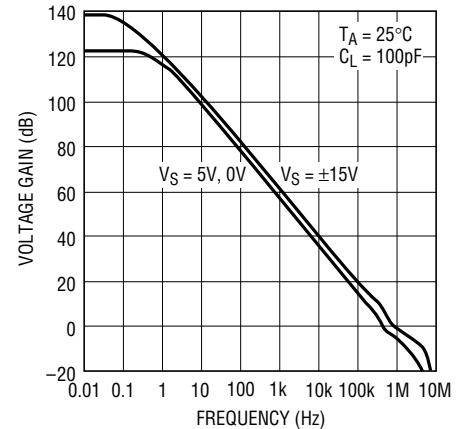
Output Short Circuit Current vs Time



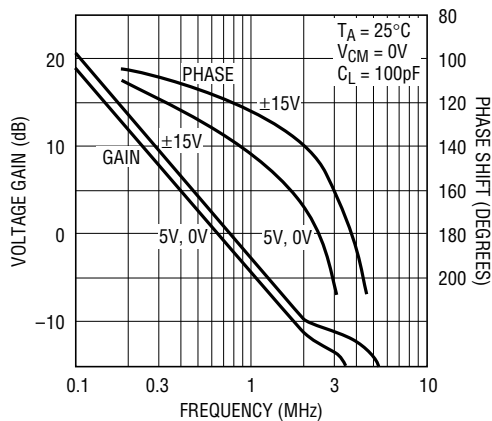
Voltage Gain vs Load Resistance



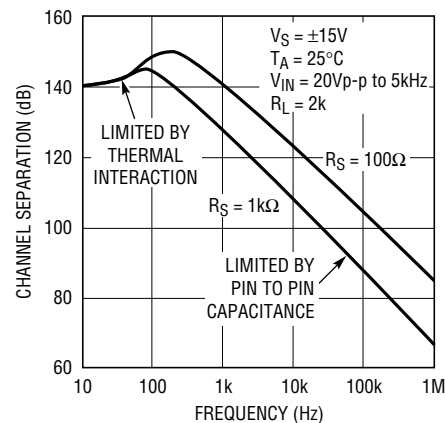
Voltage Gain vs Frequency



Gain, Phase vs Frequency



Channel Separation vs Frequency



APPLICATIONS INFORMATION

Single Supply Operation

The LT1013/1014 are fully specified for single supply operation, i.e., when the negative supply is 0V. Input common-mode range includes ground; the output swings within a few millivolts of ground. Single supply operation, however, can create special difficulties, both at the input and at the output. The LT1013/LT1014 have specific circuitry which addresses these problems.

At the input, the driving signal can fall below 0V—inadvertently or on a transient basis. If the input is more than

a few hundred millivolts below ground, two distinct problems can occur on previous single supply designs, such as the LM124, LM158, OP-20, OP-21, OP-220, OP-221, OP-420:

a) When the input is more than a diode drop below ground, unlimited current will flow from the substrate (V^- terminal) to the input. This can destroy the unit. On the LT1013/1014, the 400 Ω resistors, in series with the input (see schematic diagram), protect the devices even when the input is 5V below ground.

APPLICATIONS INFORMATION

(b) When the input is more than 400mV below ground (at 25°C), the input stage saturates (transistors Q3 and Q4) and phase reversal occurs at the output. This can cause lock-up in servo systems. Due to a unique phase reversal protection circuitry (Q21, Q22, Q27, Q28), the LT1013/1014's outputs do not reverse, as illustrated below, even when the inputs are at -1.5V.

There is one circumstance, however, under which the phase reversal protection circuitry does not function: when the other op amp on the LT1013, or one specific amplifier of the other three on the LT1014, is driven hard into negative saturation at the output.

Phase reversal protection does not work on amplifier:

A when D's output is in negative saturation. B's and C's outputs have no effect.

B when C's output is in negative saturation. A's and D's outputs have no effect.

C when B's output is in negative saturation. A's and D's outputs have no effect.

D when A's output is in negative saturation. B's and C's outputs have no effect.

At the output, the aforementioned single supply designs either cannot swing to within 600mV of ground (OP-20) or cannot sink more than a few microamperes while swinging to ground (LM124, LM158). The LT1013/1014's all-NPN output stage maintains its low output resistance and high gain characteristics until the output is saturated.

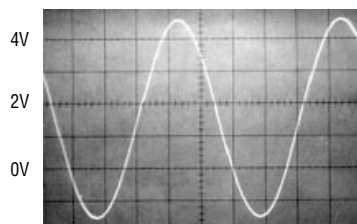
In dual supply operations, the output stage is crossover distortion-free.

Comparator Applications

The single supply operation of the LT1013/1014 lends itself to its use as a precision comparator with TTL compatible output:

In systems using both op amps and comparators, the LT1013/1014 can perform multiple duties; for example, on the LT1014, two of the devices can be used as op amps and the other two as comparators.

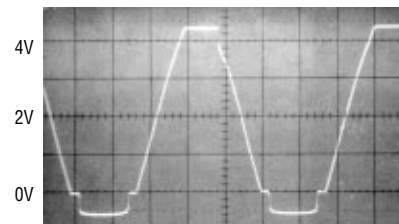
Voltage Follower with Input Exceeding the Negative Common-Mode Range



6Vp-p INPUT, -1.5V TO 4.5V

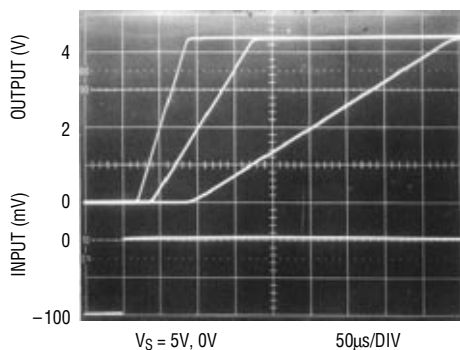


LM324, LM358, OP-20
EXHIBIT OUTPUT PHASE
REVERSAL



LT1013/LT1014
NO PHASE REVERSAL

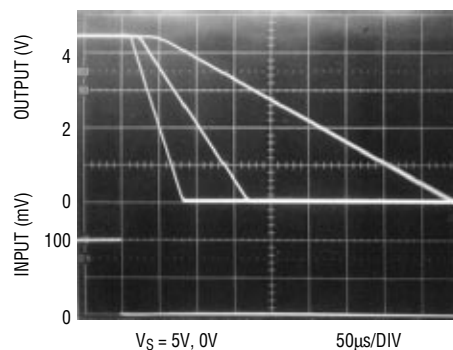
Comparator Rise Response Time 10mV, 5mV, 2mV Overdrives



$V_S = 5V, 0V$

50 μ s/DIV

Comparator Fall Response Time to 10mV, 5mV, 2mV Overdrives



$V_S = 5V, 0V$

50 μ s/DIV

APPLICATIONS INFORMATION

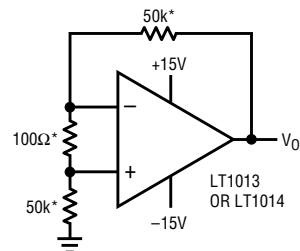
Low Supply Operation

The minimum supply voltage for proper operation of the LT1013/1014 is 3.4V (three Ni-Cad batteries). Typical supply current at this voltage is 290 μ A, therefore power dissipation is only one milliwatt per amplifier.

Noise Testing

For applications information on noise testing and calculations, please see the LT1007 or LT1008 data sheet.

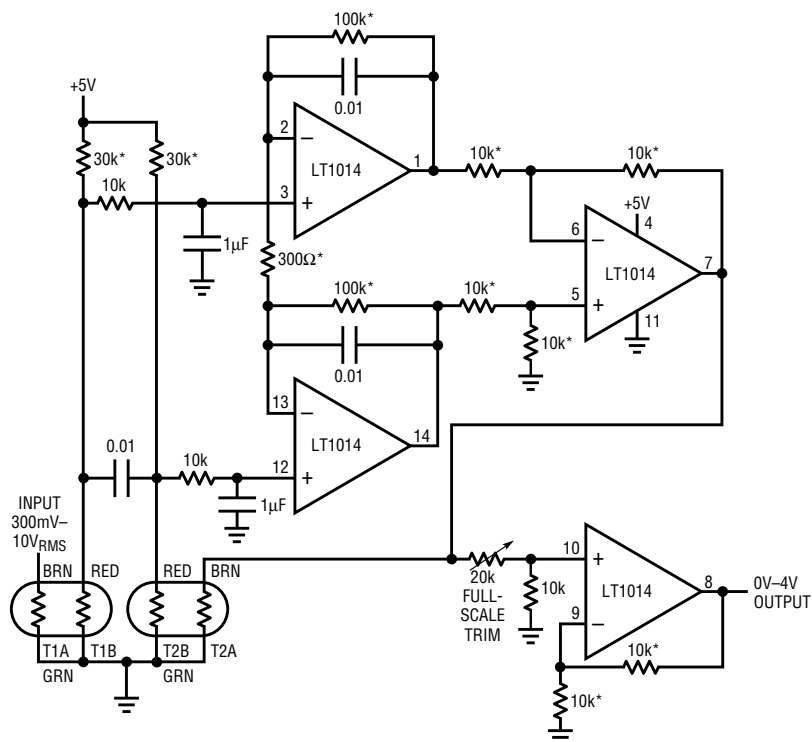
Test Circuit for Offset Voltage and Offset Drift with Temperature



*RESISTOR MUST HAVE LOW THERMOELECTRIC POTENTIAL.
 **THIS CIRCUIT IS ALSO USED AS THE BURN-IN CONFIGURATION, WITH SUPPLY VOLTAGES INCREASED TO ± 20 V.
 $V_O = 1000V_{OS}$

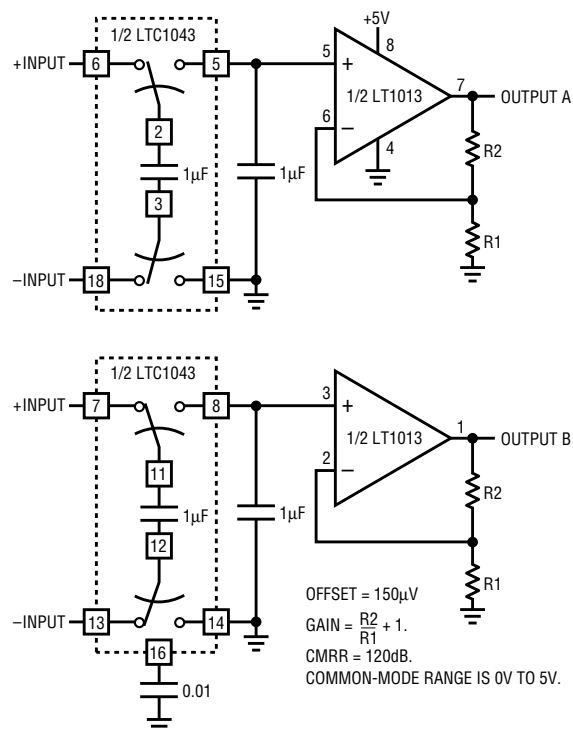
TYPICAL APPLICATIONS

50MHz Thermal rms to DC Converter



2% ACCURACY, DC-50MHz.
 100:1 CREST FACTOR CAPABILITY.
 * 0.1% RESISTOR.
 T1-T2 = YELLOW SPRINGS INST. CO. THERMISTOR COMPOSITE #44018.
 ENCLOSE T1 AND T2 IN STYROFOAM.
 7.5mW DISSIPATION.

5V Single Supply Dual Instrumentation Amplifier



OFFSET = 150 μ V
 GAIN = $\frac{R_2}{R_1} + 1$.
 CMRR = 120dB.
 COMMON-MODE RANGE IS 0V TO 5V.

27Ω
1W

10k*

0.01μF

A1
LT1014

+15V

-15V

2k*

500pF

Q1
2N6533

220

15k

150k*

33k

1k

ZERO
FLOW

A2
LT1014

1000pF

2k

3.3k

-15V

Q2

Q3

Q4

Q5

Q2-Q5
CA3046
PIN 3 TO -15V

12k

150k*

1μF

10M
RESPONSE
TIME
ADJUST

2M
FULL-
SCALE
FLOW

500k

1μF

A3
LT1014

A4
LT1014

0V-10V =
0-1000 FEET/MINUTE

REMOVE LAMP'S GLASS ENVELOPE FROM 328 LAMP.
A1 SERVO'S #328 LAMP TO CONSTANT TEMPERATURE.
A2-A3 FURNISH LINEAR OUTPUT vs FLOW RATE.
*1% RESISTOR.



* 1% FILM RESISTOR.
 ** SUPPLIED WITH YSI THERMISTOR NETWORK.
 T1, T2 YSI THERMISTOR NETWORK = #44201.
 FLOW IN PIPE IS INVERSELY PROPORTIONAL TO
 RESISTANCE OF T1-T2 TEMPERATURE DIFFERENCE.
 A1-A2 PROVIDE GAIN. A3-A4 PROVIDE LINEARIZED
 FREQUENCY OUTPUT.

[illegible][illegible]

The circuit diagram illustrates a motor speed control system. It features two LT1013 op-amps, A1 and A2. Op-amp A1 is configured as a duty cycle modulator, with its non-inverting input connected to a +5V supply through a 1kΩ resistor and its inverting input connected to a feedback network of a 100kΩ resistor and a 1MΩ resistor. The output of A1 drives the base of a 2N3904 transistor (Q1). Op-amp A2 is configured as a motor back EMF sampler, with its non-inverting input connected to the motor's back EMF through a 2kΩ resistor and its inverting input connected to a feedback network of a 6.8MΩ resistor and a 0.068μF capacitor. The output of A2 drives the base of a 2N5023 transistor (Q2). The motor is connected to a +5V supply through a 1kΩ resistor and to ground through a 1N4001 diode. The motor's speed is controlled by the duty cycle modulator (A1) and the back EMF sampler (A2).

COMPONENTS:

- Op-amps: A1, A2 (1/2 LT1013)
- Transistors: Q1 (2N3904), Q2 (2N5023)
- Diodes: 1N4001 (x2), 1N4148 (x2)
- Resistors: 330k, 100k, 1M, 2k, 82Ω, 1k, 6.8M, 3.3M, 2k, 0.47, 0.068
- Capacitors: 0.47, 0.068
- Motor: CANON-FN30-R13N1B

FUNCTIONS:

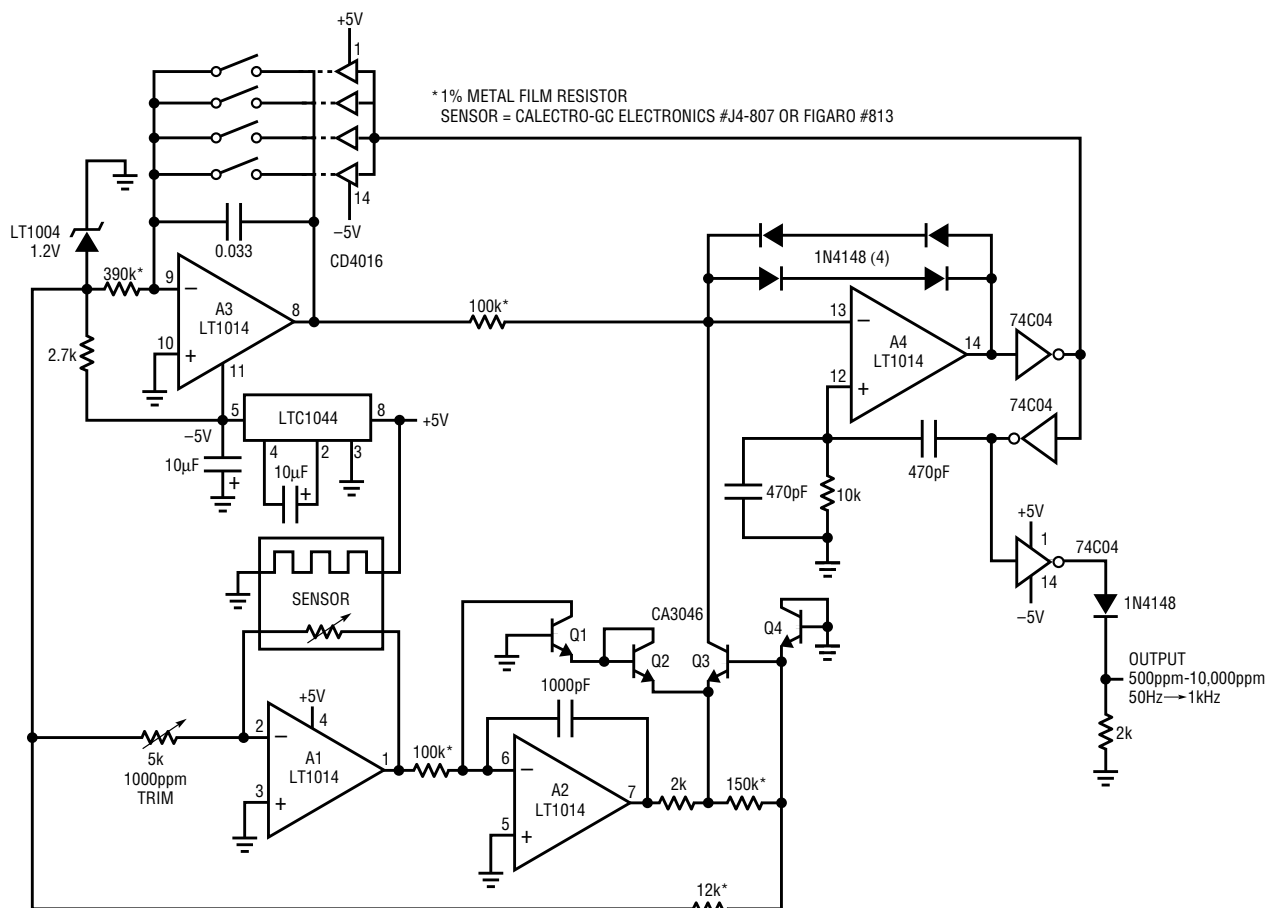
- A1 DUTY CYCLE MODULATES MOTOR.
- A2 SAMPLES MOTORS BACK EMF.

The circuit diagram shows a 1-wire digital-to-analog converter (DALE) using two LT1013 comparators and a transformer. The input is a TTL signal, which is connected to the non-inverting input of the first LT1013 comparator. The inverting input of the first comparator is connected to the secondary winding of a transformer (DALE #TC-10-04). The transformer's primary winding is connected to a +5V supply and a 100k resistor. The secondary winding is also connected to a 100k resistor and a 0.33μF capacitor. The output of the first comparator is connected to the non-inverting input of the second LT1013 comparator. The inverting input of the second comparator is connected to a 120k resistor and a 0.005μF capacitor. The output of the second comparator is connected to a 100k resistor and a 6.19k resistor. The output of the circuit is a 21V signal with a 600μs RC time constant. The circuit is powered by a +5V supply and a 1.2V supply (LT1004).

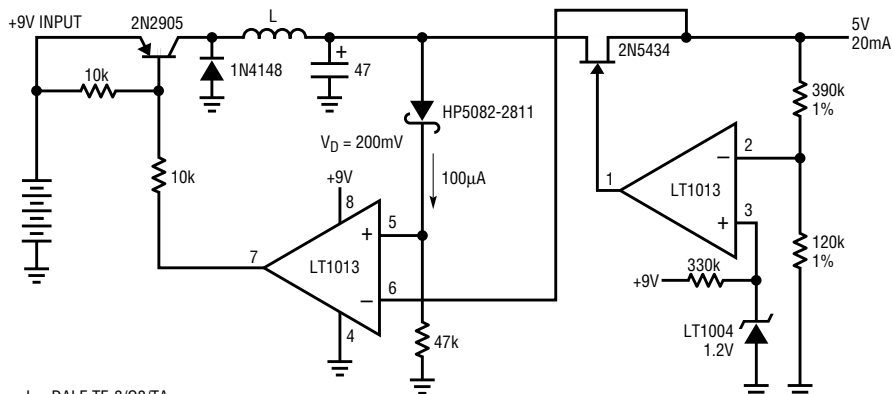
MEETS ALL V_{pp} PROGRAMMING SPECS WITH NO TRIMS AND RUNS OFF 5V SUPPLY—NO EXTERNAL HIGH VOLTAGE SUPPLY REQUIRED. SUITABLE FOR BATTERY POWERED USE (600μA QUIESCENT CURRENT). *1% METAL FILM.

TYPICAL APPLICATIONS

Methane Concentration Detector with Linearized Output



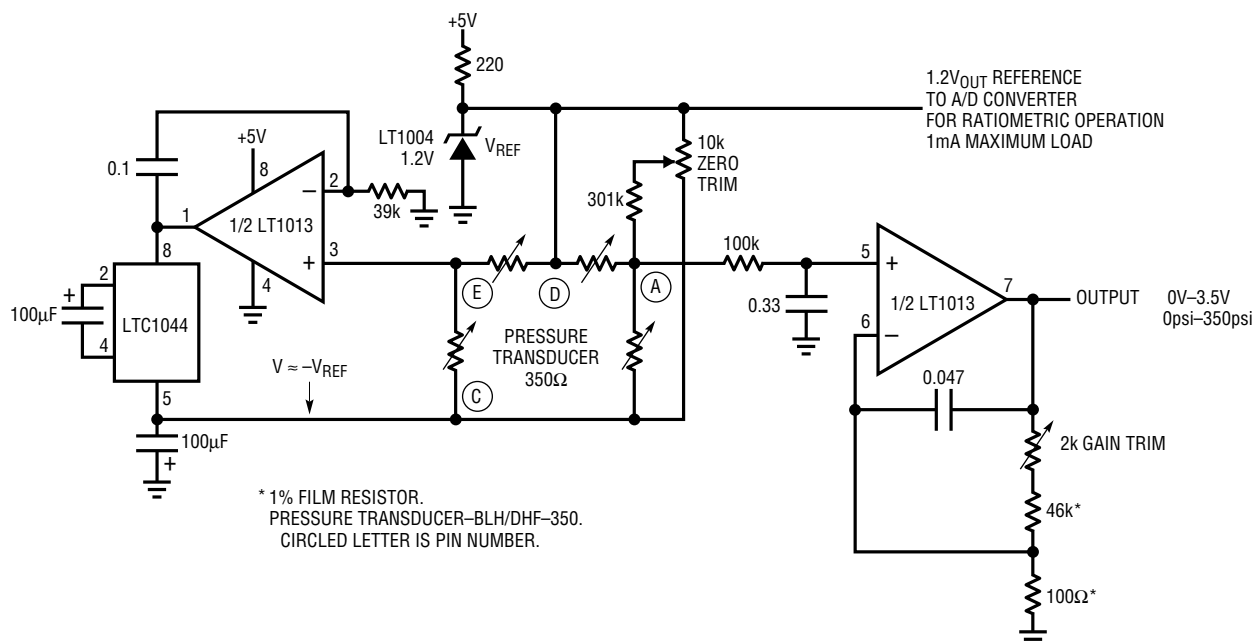
Low Power 9V to 5V Converter



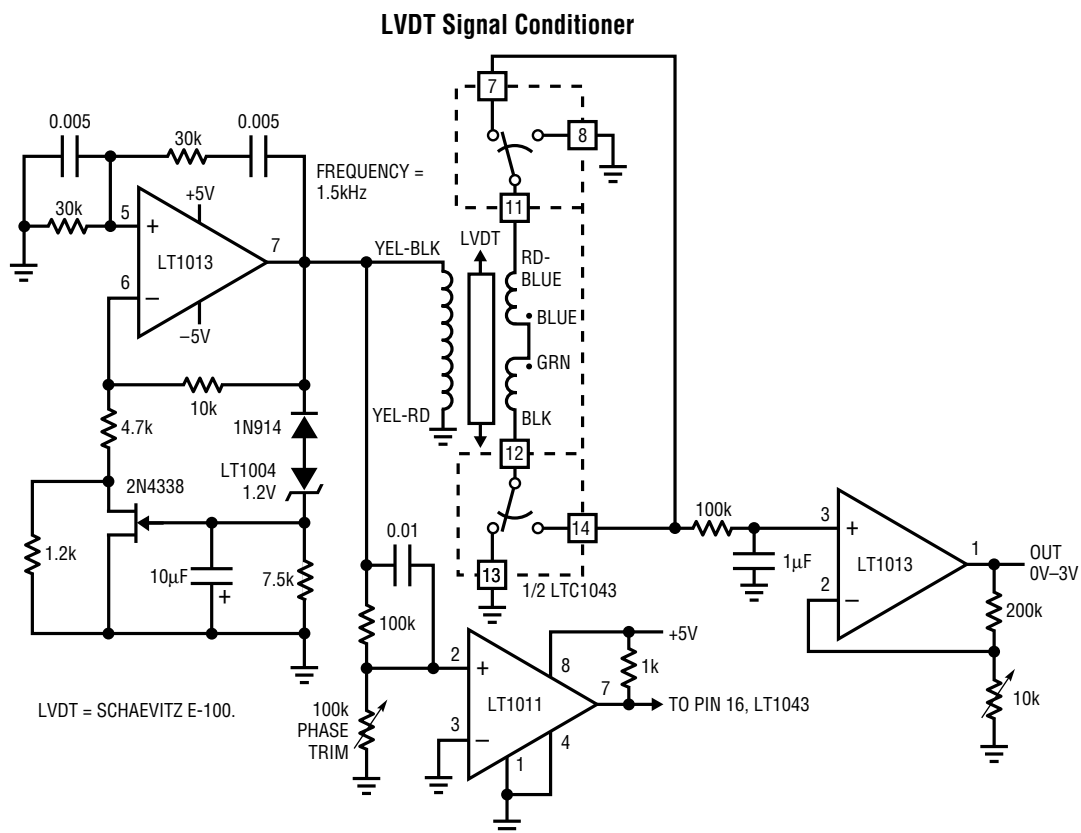
† 12-BIT ACCURACY.
 * 1% FILM.
 T1 = PICO-31080.

The circuit diagram shows a precision 0V to 4V output module. It consists of four 1/4 LT1014 op-amp chips (A1, A2, A3, A4). A1 is a voltage follower for a 5V supply. A2 is a differential amplifier for the sensor signal. A3 is a precision zero trimmer. A4 is the output stage with a gain trimmer. The output is 0V to 4V, corresponding to 0°C to 400°C.

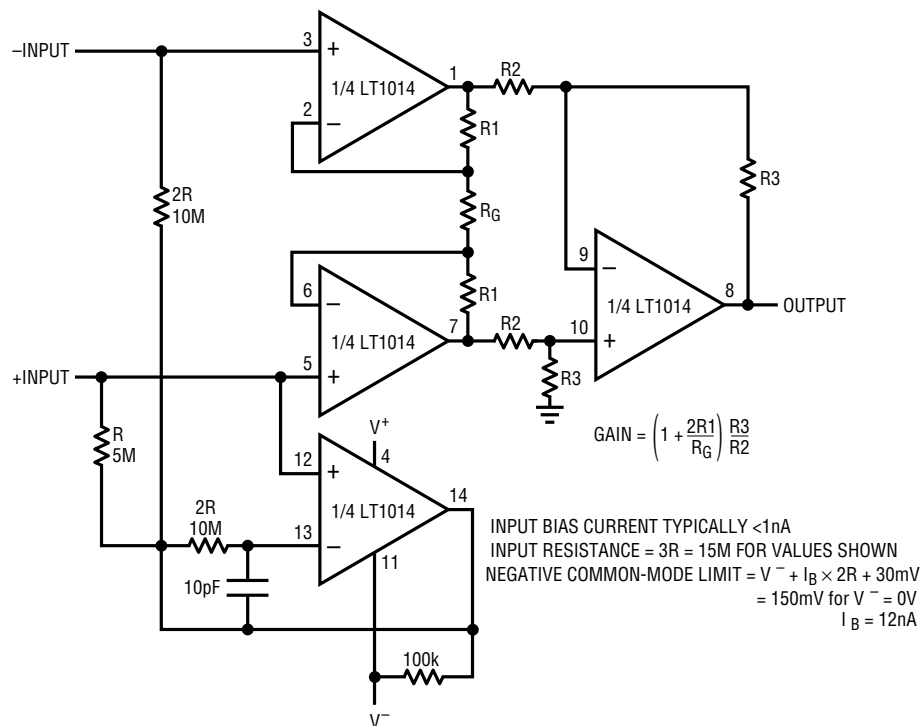
Strain Gauge Bridge Signal Conditioner



TYPICAL APPLICATIONS



Triple Op Amp Instrumentation Amplifier with Bias Current Cancellation



0.009V DROPOUT AT 5mA OUTPUT.
0.108V DROPOUT AT 100mA OUTPUT.
 $I_{\text{QUIESCENT}} = 850\mu\text{A}$.

$I_{OUT} = \frac{V_{IN}}{100\Omega}$
 FOR BIPOLAR OPERATION,
 RUN BOTH ICs FROM
 A BIPOLAR SUPPLY.

[illegible]

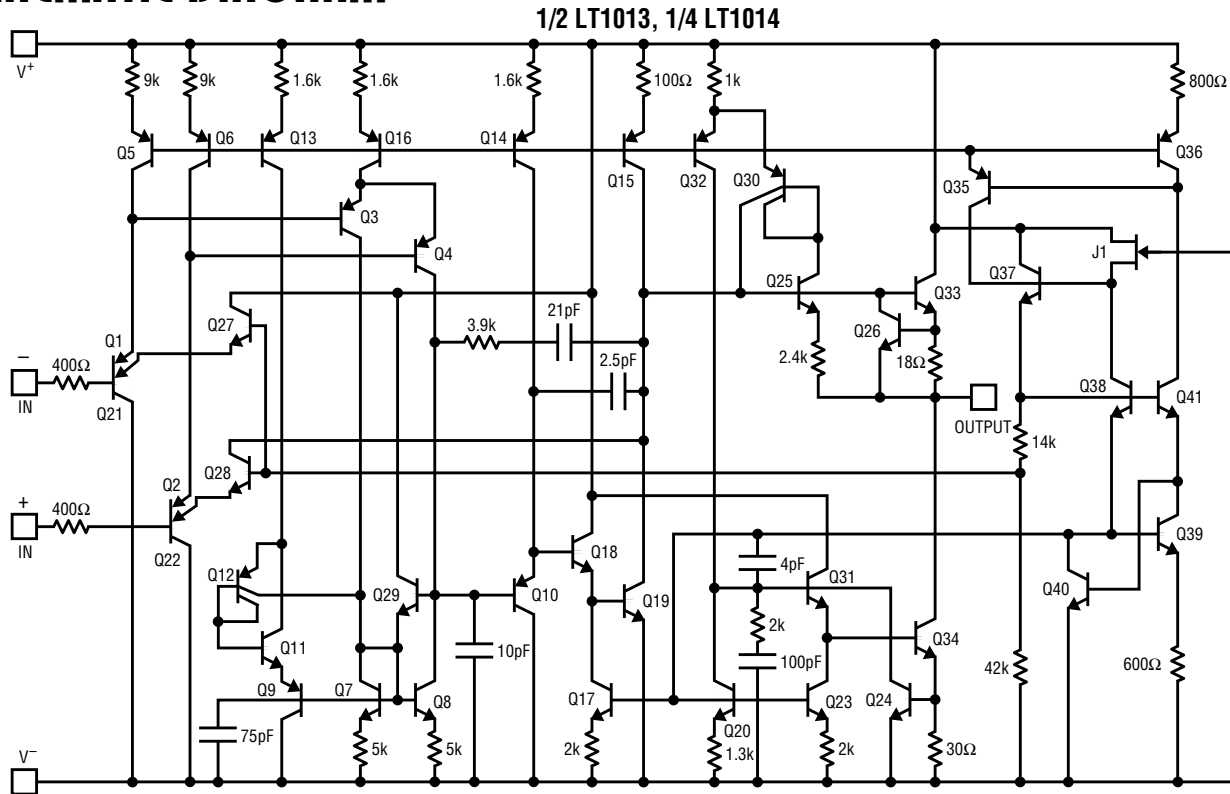
+5V
 4.3k
 LT1009
 2.5V
 R_{T1}
 3.2k
 3.4k*
 2.16k*
 1M*
 TEMPERATURE
 COMPENSATION
 GENERATOR
 R_{T2}
 6.25k
 1M*
 YSI 44201
 R_T
 4.22M*
 1/2 LT1013
 4.22M*
 +5V
 20k
 100k
 3.5MHz
 XTAL
 MV-209
 100k
 560k
 OSCILLATOR
 510pF
 510pF
 2N2222
 100kΩ
 680Ω
 3.5MHz OUTPUT
 0.03ppm/°C, 0°C–70°C

* 1% FILM
 3.5MHz XTAL = AT CUT – 35°20'
 MOUNT R_T NEAR XTAL
 3mA POWER DRAIN
 † THERMISTOR-AMPLIFIER-VARACTOR NETWORK GENERATES
 A TEMPERATURE COEFFICIENT OPPOSITE THE CRYSTAL TO
 MINIMIZE OVERALL OSCILLATOR DRIFT

The circuit diagram shows a square wave generator using two LT1013 comparators. The input stage consists of a 1MΩ resistor and a 0.001μF capacitor connected to the non-inverting input (pin 3) of the first LT1013. The inverting input (pin 2) of the first LT1013 is connected to its output (pin 1) via a 220pF capacitor. The output of the first LT1013 (pin 1) is connected to the base of a 2N5262 transistor through a 300Ω resistor. The emitter of the 2N5262 transistor is grounded, and its collector is connected to the non-inverting input (pin 5) of the second LT1013. The inverting input (pin 6) of the second LT1013 is connected to its output (pin 7) via a 200kΩ resistor. The output of the second LT1013 (pin 7) is connected to the base of a 1N5821 diode. The cathode of the diode is grounded, and its anode is connected to the non-inverting input (pin 3) of the first LT1013 via a 130kΩ resistor. The circuit is powered by a +6V input supply and a +15V output supply (50mA). A 2.2μF capacitor is connected between the +6V and +15V supplies. A 1MΩ resistor is connected between the +6V supply and the non-inverting input (pin 3) of the first LT1013. A 22kΩ resistor is connected between the +6V supply and the base of the 2N5262 transistor. A 5.6kΩ resistor is connected between the +6V supply and the non-inverting input (pin 5) of the second LT1013. A 5.6kΩ resistor is connected between the +6V supply and the inverting input (pin 6) of the second LT1013. A 100μF capacitor is connected between the +6V supply and the non-inverting input (pin 5) of the second LT1013. A 0.1μF capacitor is connected between the +6V supply and the inverting input (pin 6) of the second LT1013. A 1μH inductor (L1) is connected between the +6V supply and the non-inverting input (pin 5) of the second LT1013. A 1.2V diode (LT1004) is connected between the +6V supply and the non-inverting input (pin 5) of the second LT1013.

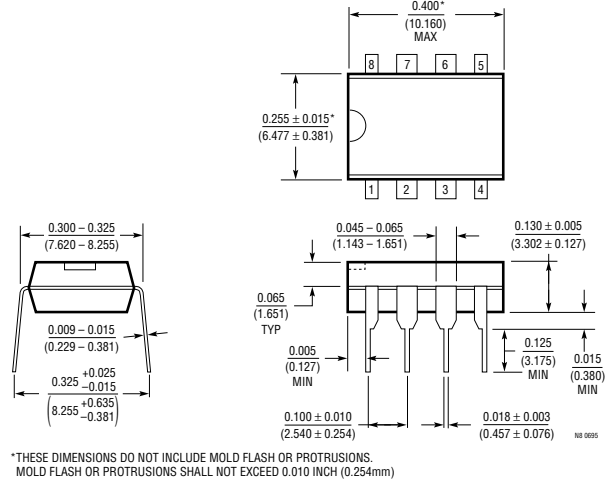
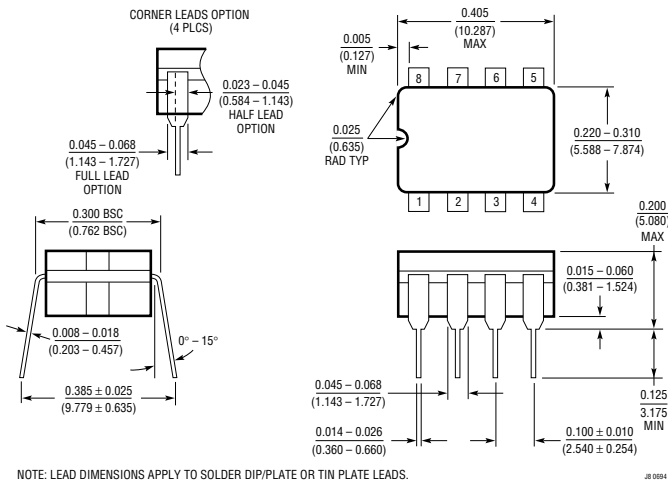
18

SCHEMATIC DIAGRAM



J8 Package
8-Lead Cerdip (Narrow 0.300, Hermetic)
 (LTC DWG # 05-08-1110)

N8 Package
8-Lead PDIP (Narrow 0.300)
 (LTC DWG # 05-08-1510)

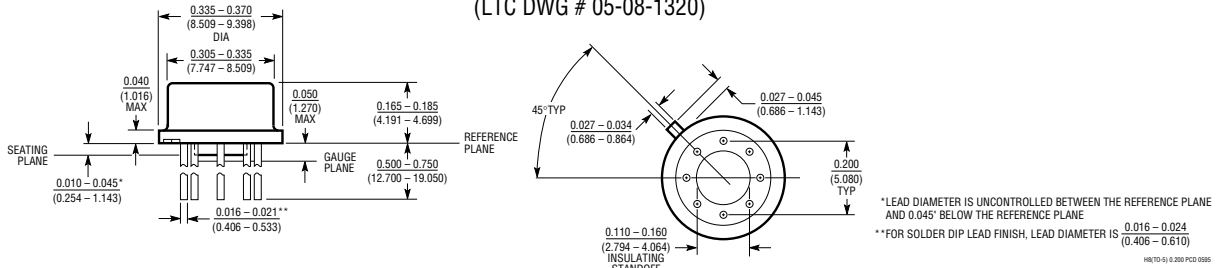


T_{jmax}	θ_{ja}
150°C	100°C/W

T_{jmax}	θ_{ja}
100°C	130°C/W

PACKAGE DESCRIPTION

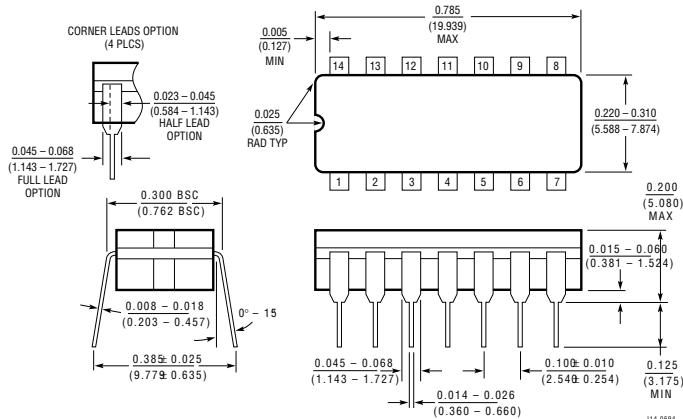
H Package 8-Lead TO-5 Metal Can (0.200 PCD) (LTC DWG # 05-08-1320)



NOTE: DIMENSIONS IN INCHES (MILLIMETERS)

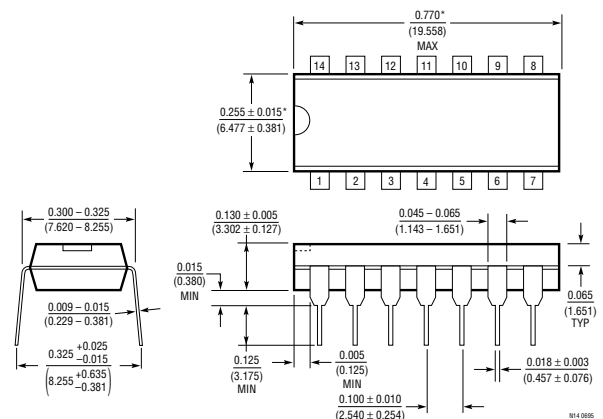
T_{jmax} 150°C	θ_{ja} 150°C/W	θ_{jc} 45°C/W
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J Package 14-Lead CERPDP (Narrow 0.300, Hermetic) (LTC DWG # 05-08-1110)



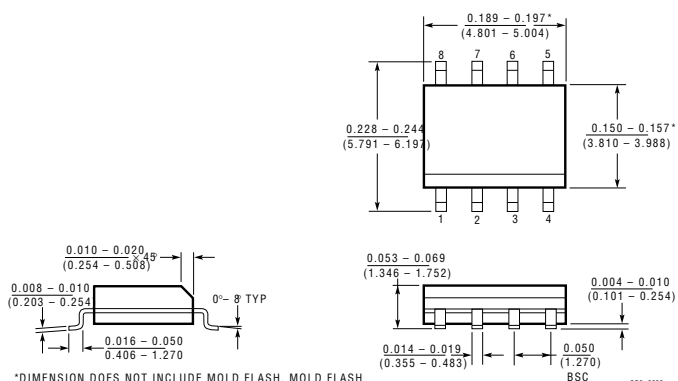
T_{jmax} 150°C	θ_{ja} 100°C/W
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N Package 14-Lead PDIP (Narrow 0.300) (LTC DWG # 05-08-1510)



T_{jmax} 100°C	θ_{ja} 100°C/W
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S8 Package 8-Lead Plastic Small Outline (Narrow 0.150) (LTC DWG # 05-08-1610)



SW Package 16-Lead Plastic Small Outline (Wide 0.300) (LTC DWG # 05-08-1620)

