

Quad Precision Op Amp (LT1014) Dual Precision Op Amp (LT1013)

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.

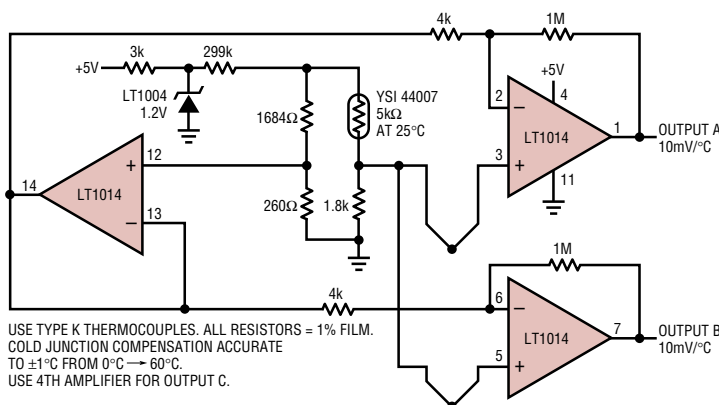
The LT1014's low offset voltage of 50 μ V, drift of 0.3 μ V/ $^{\circ}$ C, offset current of 0.15nA, gain of 8 million, common mode rejection of 117dB and power supply rejection of 120dB qualify it as four truly precision operational amplifiers. Particularly important is the low offset voltage, since 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.

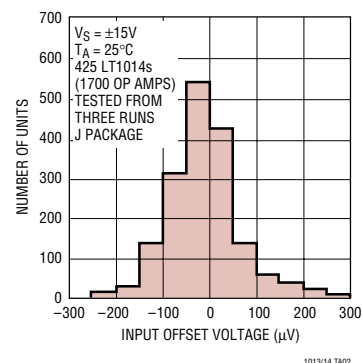
Both the LT1013 and LT1014 can be operated off a single 5V power supply: input common mode range includes ground; the output can also swing to within a few millivolts of ground. Crossover distortion, so apparent on previous single-supply designs, is eliminated. A full set of specifications is provided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

TYPICAL APPLICATION

3 Channel Thermocouple Thermometer



LT1014 Distribution of Offset Voltage



LT1013/LT1014

ABSOLUTE MAXIMUM RATINGS (Note 1)

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

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

LT1013AM/LT1013M/
 LT1014AM/LT1014M -55°C to 125°C
 LT1013AC/LT1013C/LT1013D
 LT1014AC/LT1014C/LT1014D 0°C to 70°C
 LT1013I/ LT1014I -40°C to 85°C

PACKAGE/ORDER INFORMATION

TOP VIEW S8 PACKAGE 8-LEAD PLASTIC SO NOTE: THIS PIN CONFIGURATION DIFFERS FROM THE STANDARD 8-PIN DUAL-IN-LINE CONFIGURATION $T_{JMAX} = 100^{\circ}\text{C}$, $\theta_{JA} = 190^{\circ}\text{C/W}$	ORDER PART NUMBER LT1013DS8 LT1013IS8 PART MARKING 1013 1013I	TOP VIEW SW PACKAGE 16-LEAD PLASTIC SO $T_{JMAX} = 100^{\circ}\text{C}$, $\theta_{JA} = 130^{\circ}\text{C/W}$	ORDER PART NUMBER LT1014DSW LT1014ISW PART MARKING LT1014DSW LT1014ISW
TOP VIEW N8 PACKAGE 8-LEAD PDIP $T_{JMAX} = 100^{\circ}\text{C}$, $\theta_{JA} = 130^{\circ}\text{C/W}$ J8 PACKAGE 8-LEAD CERDIP $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 100^{\circ}\text{C/W}$	ORDER PART NUMBER LT1013ACN8 LT1013CN8 LT1013DN8 LT1013IN8 LT1013AMJ8 LT1013MJ8 LT1013ACJ8 LT1013CJ8	TOP VIEW N PACKAGE 14-LEAD PDIP $T_{JMAX} = 100^{\circ}\text{C}$, $\theta_{JA} = 100^{\circ}\text{C/W}$ J PACKAGE 14-LEAD CERDIP $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 100^{\circ}\text{C/W}$	ORDER PART NUMBER LT1014ACN LT1014CN LT1014DN LT1014IN LT1014AMJ LT1014MJ LT1014ACJ LT1014CJ
OBSOLETE PACKAGE Consider the N or S8 Packages for Alternate Source			
OBSOLETE PACKAGE Consider the N or S8 (not N8) Packages for Alternate Source		ORDER PART NUMBER LT1013AMH LT1013MH LT1013ACH LT1013CH	
TOP VIEW V-(CASE) H PACKAGE 8-LEAD TO-5 METAL CAN $T_{JMAX} = 150^{\circ}\text{C}$, $\theta_{JA} = 150^{\circ}\text{C/W}$, $\theta_{JC} = 45^{\circ}\text{C/W}$			

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

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ELECTRICAL CHARACTERISTICS $T_A = 25^\circ\text{C}$. $V_S = \pm 15\text{V}$, $V_{CM} = 0\text{V}$ 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	—	$\mu\text{V}/\text{Mo.}$
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	—	$\mu\text{Vp-p}$
e_n	Input Noise Voltage Density	$f_0 = 10\text{Hz}$	—	24	—	—	24	—	$\text{nV}/\sqrt{\text{Hz}}$
		$f_0 = 1000\text{Hz}$	—	22	—	—	22	—	$\text{nV}/\sqrt{\text{Hz}}$
i_n	Input Noise Current Density	$f_0 = 10\text{Hz}$	—	0.07	—	—	0.07	—	$\text{pA}/\sqrt{\text{Hz}}$
	Input Resistance – Differential Common Mode	(Note 2)	100	400	—	70	300	—	$\text{M}\Omega$
			—	5	—	—	4	—	$\text{G}\Omega$
A_{VOL}	Large Signal Voltage Gain	$V_0 = \pm 10\text{V}$, $R_L = 2\text{k}$	1.5	8.0	—	1.2	7.0	—	$\text{V}/\mu\text{V}$
		$V_0 = \pm 10\text{V}$, $R_L = 600\Omega$	0.8	2.5	—	0.5	2.0	—	$\text{V}/\mu\text{V}$
	Input Voltage Range		+13.5	+13.8	—	+13.5	+13.8	—	V
			–15.0	–15.3	—	–15.0	–15.3	—	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = +13.5\text{V}$, -15.0V	100	117	—	97	114	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2\text{V}$ to $\pm 18\text{V}$	103	120	—	100	117	—	dB
	Channel Separation	$V_0 = \pm 10\text{V}$, $R_L = 2\text{k}$	123	140	—	120	137	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2\text{k}$	± 13	± 14	—	± 12.5	± 14	—	V
	Slew Rate		0.2	0.4	—	0.2	0.4	—	$\text{V}/\mu\text{s}$
I_S	Supply Current	Per Amplifier	—	0.35	0.50	—	0.35	0.55	mA

 $T_A = 25^\circ\text{C}$. $V_{S^+} = +5\text{V}$, $V_{S^-} = 0\text{V}$, $V_{OUT} = 1.4\text{V}$, $V_{CM} = 0\text{V}$ 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	$V_0 = 5\text{mV}$ to 4V , $R_L = 500\Omega$	—	1.0	—	—	1.0	—	$\text{V}/\mu\text{V}$
			+3.5	+3.8	—	+3.5	+3.8	—	V
V_{OUT}	Output Voltage Swing	Output Low, No Load Output Low, 600Ω to Ground Output Low, $I_{SINK} = 1\text{mA}$ Output High, No Load Output High, 600Ω to Ground	0	–0.3	—	0	–0.3	—	V
			—	15	25	—	15	25	mV
			—	5	10	—	5	10	mV
			—	220	350	—	220	350	mV
			4.0	4.4	—	4.0	4.4	—	V
			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

The ● denotes the specifications which apply over the temperature range $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$. $V_S = \pm 15\text{V}$, $V_{CM} = 0\text{V}$ 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	$V_S = +5\text{V}$, 0V ; $V_O = +1.4\text{V}$ $-55^{\circ}\text{C} \leq T_A \leq 100^{\circ}\text{C}$ $V_{CM} = 0.1\text{V}$, $T_A = 125^{\circ}\text{C}$ $V_{CM} = 0\text{V}$, $T_A = 125^{\circ}\text{C}$	●	—	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 3)	●	—	0.4	2.0	—	0.4	2.0	—	0.5	2.5	$\mu\text{V}/^{\circ}\text{C}$
I_{OS}	Input Offset Current	$V_S = +5\text{V}$, 0V ; $V_O = +1.4\text{V}$	●	—	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	$V_S = +5\text{V}$, 0V ; $V_O = +1.4\text{V}$	●	—	15	30	—	15	30	—	18	45	nA
			●	—	20	80	—	25	90	—	28	120	nA
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 2\text{k}$	●	0.5	2.0	—	0.4	2.0	—	0.25	2.0	—	$\text{V}/\mu\text{V}$
CMRR	Common Mode Rejection	$V_{CM} = +13.0\text{V}$, -14.9V	●	97	114	—	96	114	—	94	113	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2\text{V}$ to $\pm 18\text{V}$	●	100	117	—	100	117	—	97	116	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2\text{k}$ $V_S = +5\text{V}$, 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	$V_S = +5\text{V}$, 0V ; $V_O = +1.4\text{V}$	●	—	0.38	0.60	—	0.38	0.60	—	0.38	0.7	mA
			●	—	0.34	0.55	—	0.34	0.55	—	0.34	0.65	mA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ for LT1013I, LT1014I, $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ for LT1013C, LT1013D, LT1014C, LT1014D. $V_S = \pm 15\text{V}$, $V_{CM} = 0\text{V}$ 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 $V_S = +5\text{V}$, 0V ; $V_O = 1.4\text{V}$ LT1013D/I, LT1014D/I $V_S = +5\text{V}$, 0V ; $V_O = 1.4\text{V}$	●	—	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 3) LT1013D/I, LT1014D/I	●	—	0.3	2.0	—	0.3	2.0	—	0.4	2.5	$\mu\text{V}/^{\circ}\text{C}$
			●	—	—	—	—	—	—	—	0.7	5.0	$\mu\text{V}/^{\circ}\text{C}$
I_{OS}	Input Offset Current	$V_S = +5\text{V}$, 0V ; $V_O = 1.4\text{V}$	●	—	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	$V_S = +5\text{V}$, 0V ; $V_O = 1.4\text{V}$	●	—	13	25	—	13	25	—	16	38	nA
			●	—	18	55	—	20	60	—	24	90	nA
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 2\text{k}$	●	1.0	5.0	—	1.0	5.0	—	0.7	4.0	—	$\text{V}/\mu\text{V}$
CMRR	Common Mode Rejection Ratio	$V_{CM} = +13.0\text{V}$, -15.0V	●	98	116	—	98	116	—	94	113	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 2\text{V}$ to $\pm 18\text{V}$	●	101	119	—	101	119	—	97	116	—	dB
V_{OUT}	Output Voltage Swing	$R_L = 2\text{k}$ $V_S = +5\text{V}$, 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
I_S	Supply Current per Amplifier	$V_S = +5\text{V}$, 0V ; $V_O = 1.4\text{V}$	●	—	0.36	0.55	—	0.36	0.55	—	0.37	0.60	mA
			●	—	0.32	0.50	—	0.32	0.50	—	0.34	0.55	mA

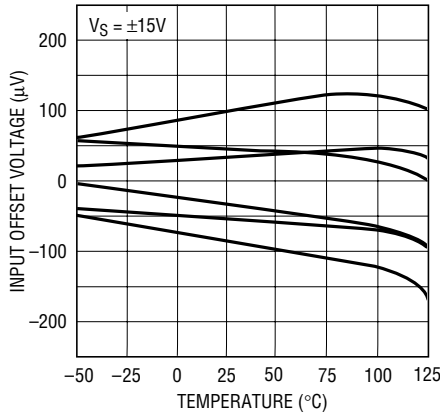
Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: 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.

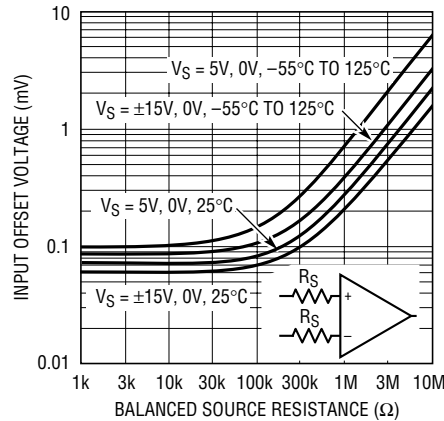
Note 3: This parameter is not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

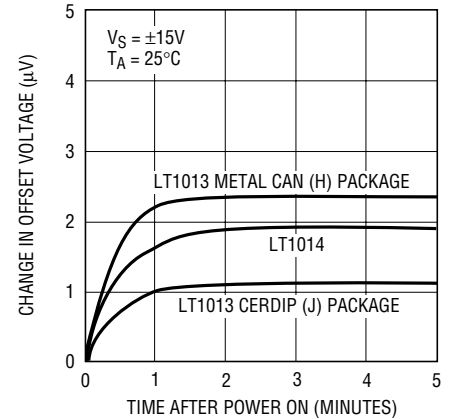
Offset Voltage Drift with Temperature of Representative Units



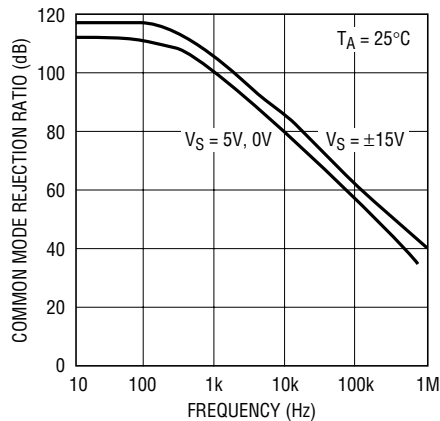
Offset Voltage vs Balanced Source Resistance



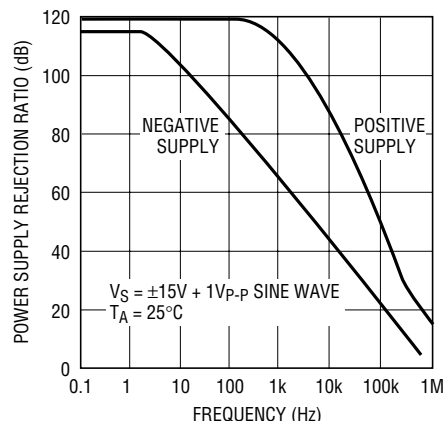
Warm-Up Drift



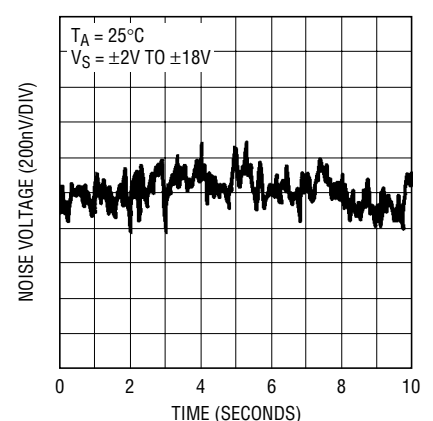
Common Mode Rejection Ratio vs Frequency



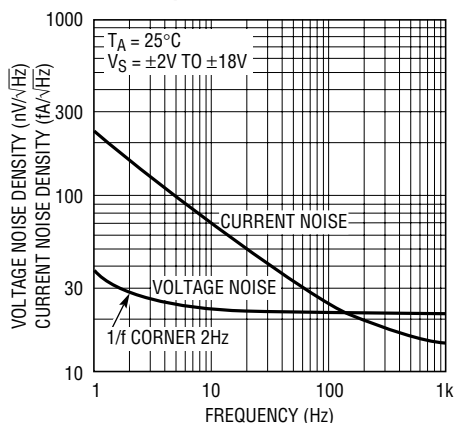
Power Supply Rejection Ratio vs Frequency



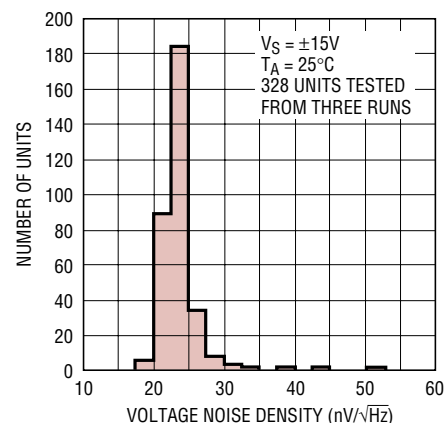
0.1Hz to 10Hz Noise



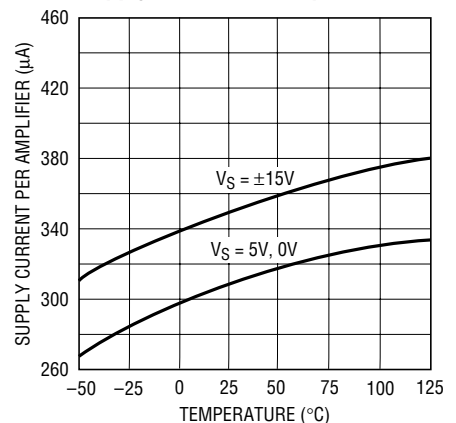
Noise Spectrum



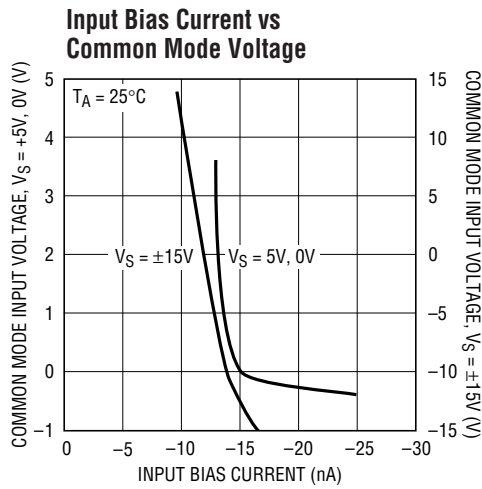
10Hz Voltage Noise Distribution



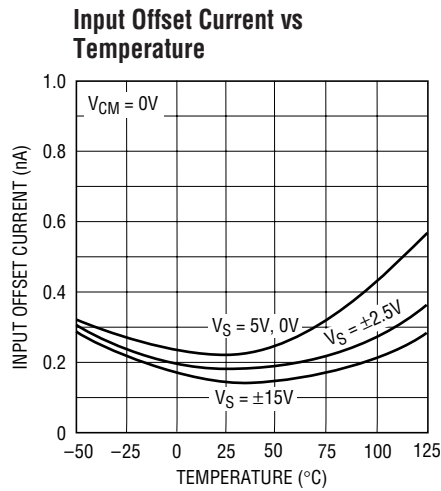
Supply Current vs Temperature



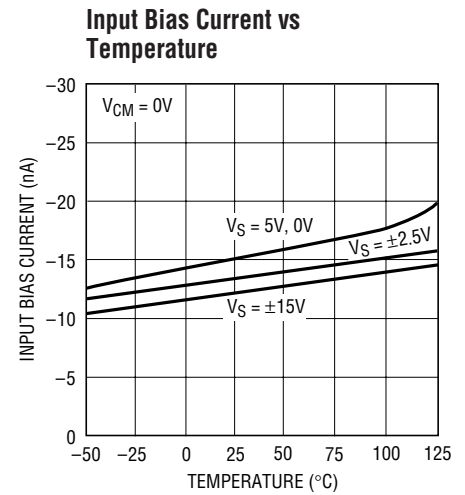
TYPICAL PERFORMANCE CHARACTERISTICS



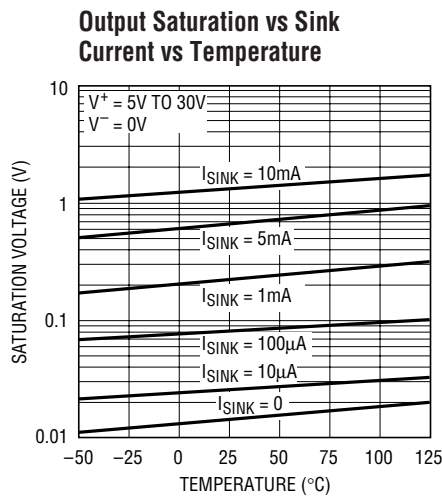
1013/14 TPC10



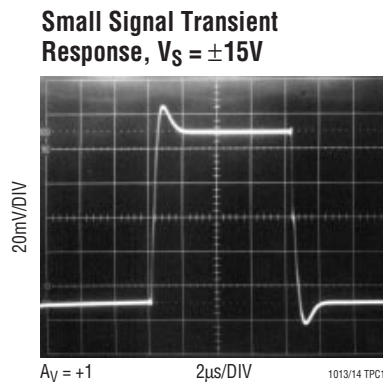
1013/14 TPC11



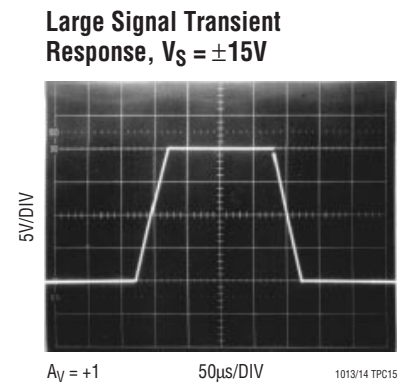
1013/14 TPC12



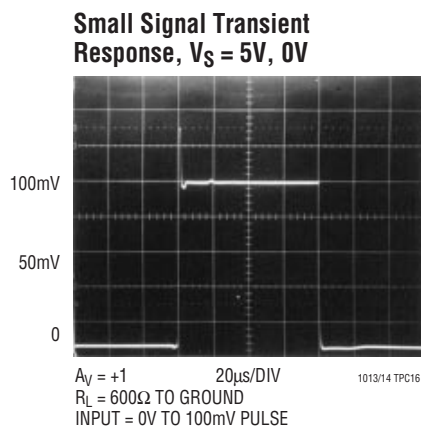
1013/14 TPC13



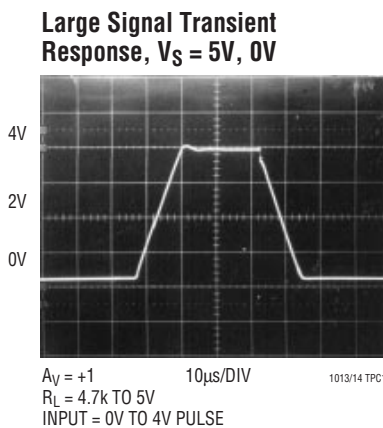
1013/14 TPC14



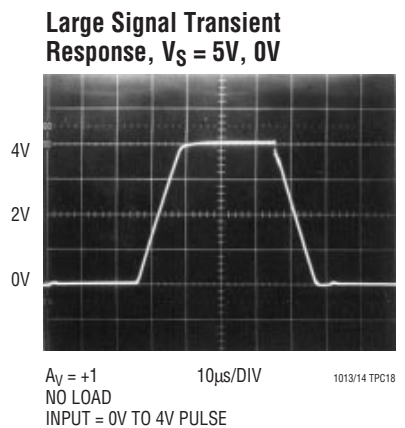
1013/14 TPC15



1013/14 TPC16



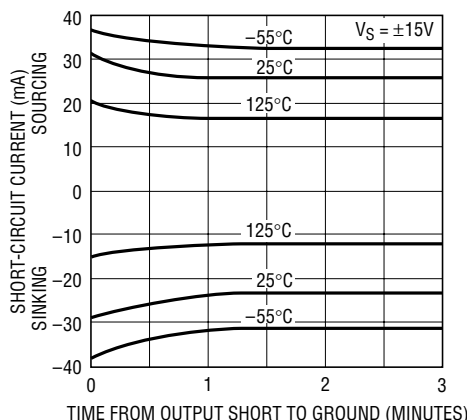
1013/14 TPC17



1013/14 TPC18

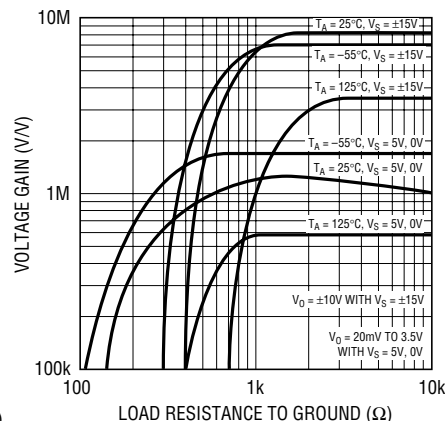
TYPICAL PERFORMANCE CHARACTERISTICS

Output Short-Circuit Current vs Time



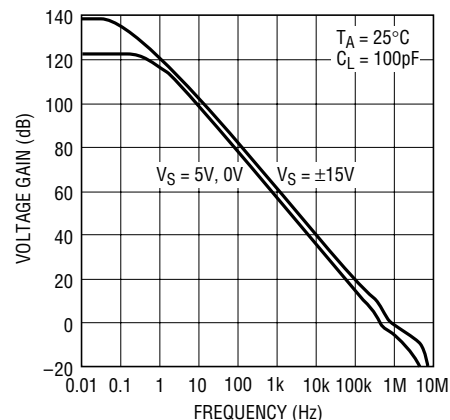
1013/14 TPC19

Voltage Gain vs Load Resistance



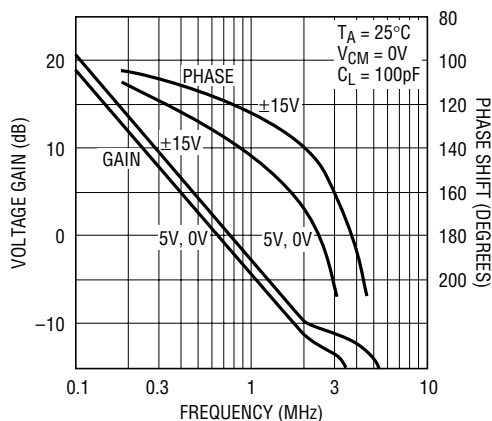
1013/14 TPC20

Voltage Gain vs Frequency



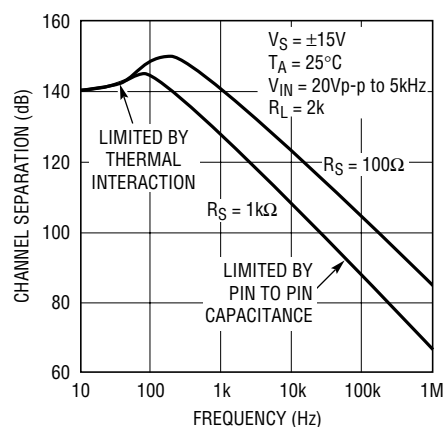
1013/14 TPC21

Gain, Phase vs Frequency



1013/14 TPC22

Channel Separation vs Frequency



1013/14 TPC23

APPLICATIONS INFORMATION

Single Supply Operation

The LT1013/LT1014 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 prob-

lems 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/LT1014, the 400Ω 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/LT1014'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 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/LT1014's all-NPN output stage maintains its low output resistance and high gain characteristics until the output is saturated.

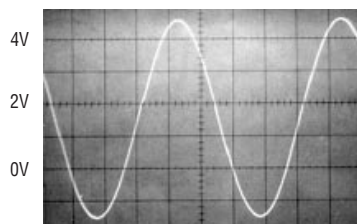
In dual supply operations, the output stage is crossover distortion-free.

Comparator Applications

The single supply operation of the LT1013/LT1014 lends itself to its use as a precision comparator with TTL compatible output:

In systems using both op amps and comparators, the LT1013/LT1014 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.

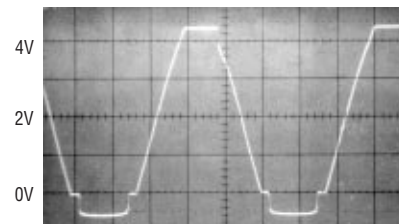
Voltage Follower with Input Exceeding the Negative Common Mode Range



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

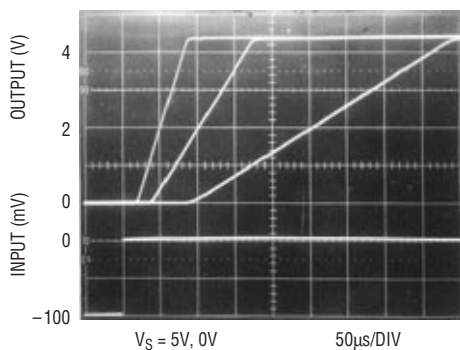


LM324, LM358, OP-20
EXHIBIT OUTPUT PHASE
REVERSAL

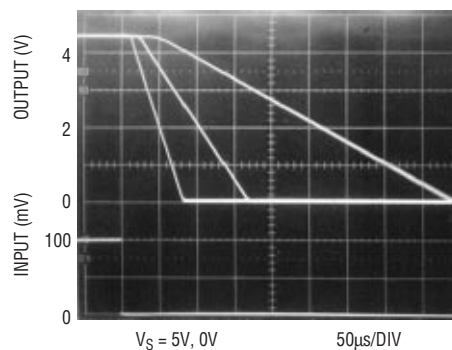


LT1013/LT1014
NO PHASE REVERSAL

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



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



APPLICATIONS INFORMATION

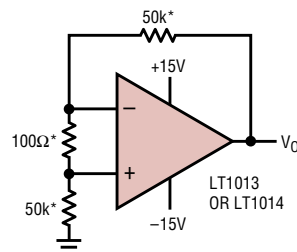
Low Supply Operation

The minimum supply voltage for proper operation of the LT1013/LT1014 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

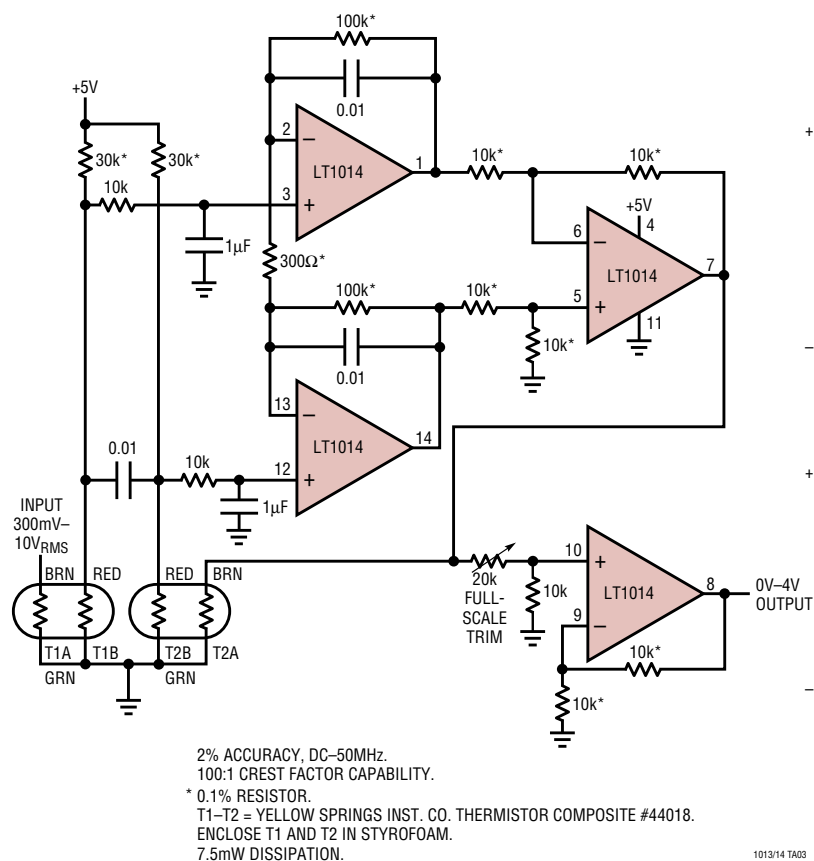


*RESISTOR MUST HAVE LOW THERMOELECTRIC POTENTIAL.
 **THIS CIRCUIT IS ALSO USED AS THE BURN-IN CONFIGURATION, WITH SUPPLY VOLTAGES INCREASED TO ± 20 V.
 $V_O = 1000V_{OS}$

LT1013/14 F06

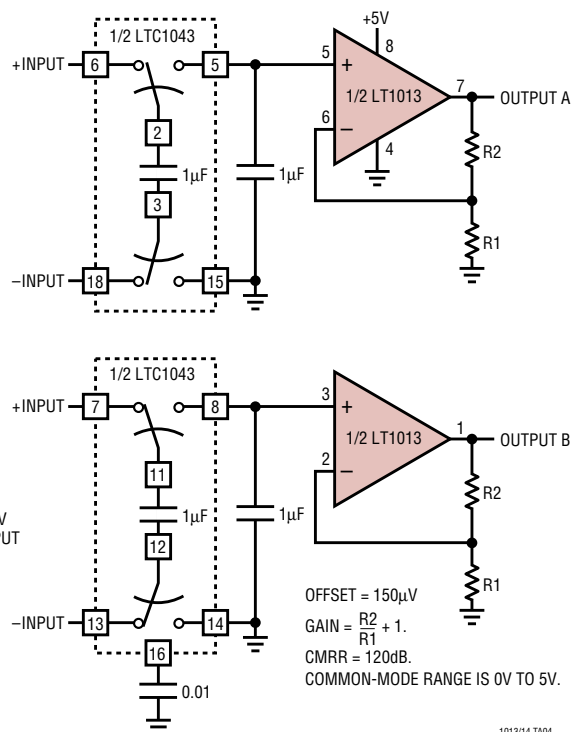
TYPICAL APPLICATIONS

50MHz Thermal rms to DC Converter



1013/14 TA03

5V Single Supply Dual Instrumentation Amplifier



1013/14 TA04

[illegible]

The circuit diagram illustrates a precision instrumentation amplifier designed for a strain gauge bridge. Key components and their connections include:

- 74C221 Timer:** Configured with a 15k resistor and 0.068 capacitors on its timing network. Its output (pin 13) is labeled "TO A/D CONVERT COMMAND".
- LT1014 Op-Amps:** Two op-amp buffers (pins 6 and 9) are used to buffer the bridge output. Their non-inverting inputs (pins 5 and 10) are connected to the bridge, and their outputs (pins 7 and 8) are connected to the inverting inputs of a second LT1014 (pin 14), which provides the final "TO A/D" output.
- 2N2219 Transistor:** A common-emitter amplifier stage that provides high gain. Its base is biased via a 4.7k resistor and a 0.01μF capacitor. The emitter is grounded, and the collector is connected to a +9V supply through a 330Ω resistor.
- 1N4148 Diode:** Connected in parallel with the 330Ω collector resistor to protect the transistor from overvoltage.
- Strain Gauge Bridge:** A 350Ω bridge is connected to the +9V supply and ground. The output is connected to the op-amp buffers.
- RC Protection:** A 4.7k resistor and 0.01μF capacitor network is used to protect the strain bridge from long-term drift.
- Power Supply:** The circuit is powered by a +9V supply, with a 47μF capacitor used for decoupling.

SAMPLED OPERATION GIVES LOW AVERAGE OPERATING CURRENT. 4.7k-0.01μF RC PROTECTS STRAIN BRIDGE FROM LONG TERM DRIFT. HIGH ΔV/ΔT STEPS.

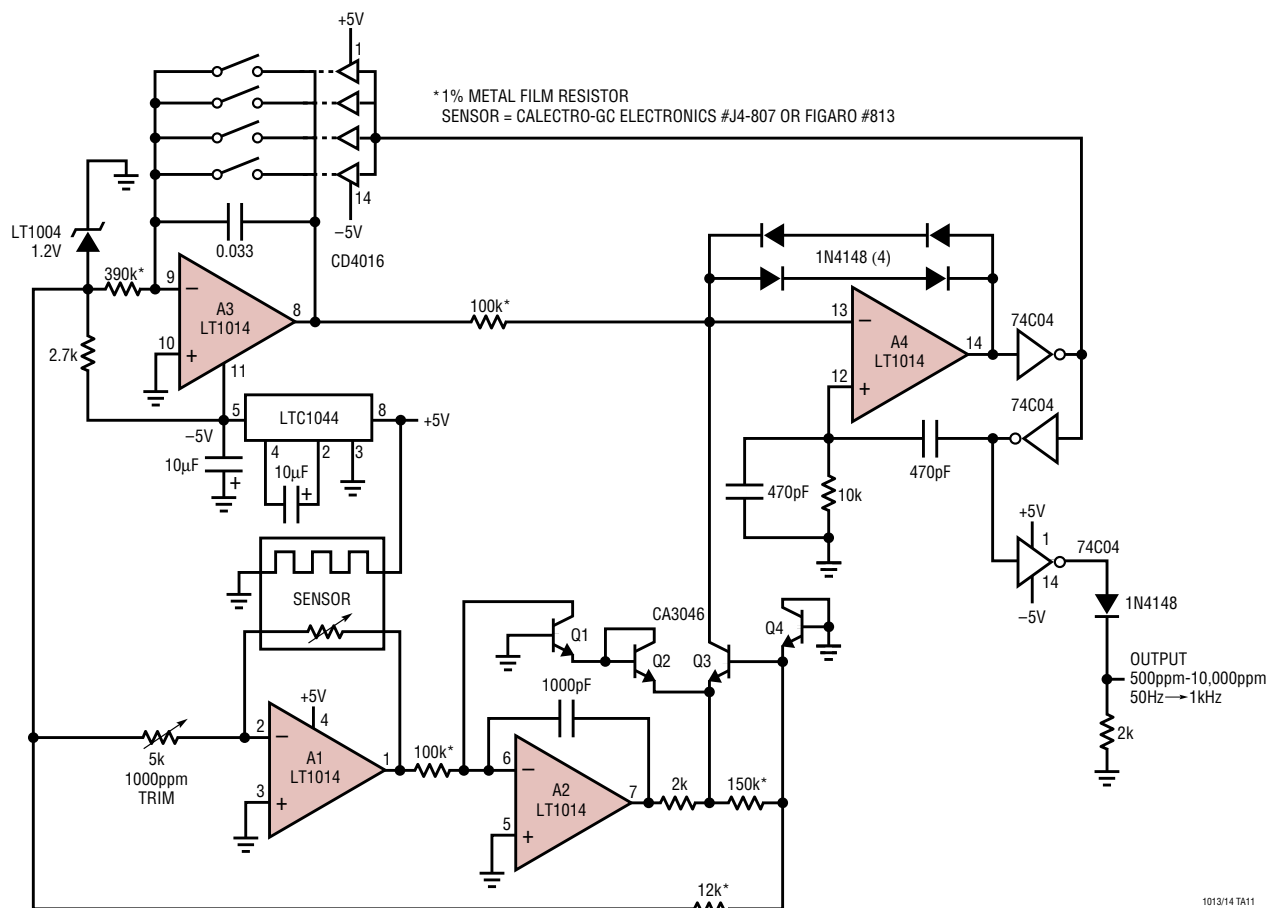
The circuit diagram illustrates a motor speed control system. It features two LT1013 op-amps (A1 and A2) and a CD4016 monostable multivibrator. A 5V supply is connected to the positive inputs of both op-amps. A 330k resistor and a 0.47μF capacitor are connected to the non-inverting input of A1. A 100k resistor connects the output of A1 to its inverting input. A 1M resistor connects the inverting input of A1 to the non-inverting input of A2. A 2k resistor connects the output of A1 to the base of a 2N3904 transistor (Q1). The emitter of Q1 is grounded, and its collector is connected to the base of a 2N5023 transistor (Q3) through an 82Ω resistor. The emitter of Q3 is grounded, and its collector is connected to a +5V supply through a 1k resistor. A 47μF capacitor is connected between the +5V supply and ground. A 1N4001 diode is connected in series with the motor. The motor is represented by a circle with a curved arrow. A 1N4001 diode is connected in parallel with the motor, with its cathode to the motor's positive terminal. A 1N4148 diode is connected in series with the motor. A 1N4148 diode is connected in parallel with the motor, with its cathode to the motor's positive terminal. A 0.068μF capacitor is connected between the base of Q3 and the collector of Q2. A 3.3M resistor connects the base of Q3 to the output of the CD4016. A 0.47μF capacitor is connected between the base of Q2 and ground. A 2k resistor connects the base of Q2 to the output of the CD4016. The output of the CD4016 is connected to the base of Q2. The emitter of Q2 is grounded, and its collector is connected to the motor's positive terminal. The motor's negative terminal is grounded. The circuit is powered by a 5V supply and a 0V-3V supply (E_{IN}).

MOTOR = CANON-FN30-R13N1B.
A1 DUTY CYCLE MODULATES MOTOR.
A2 SAMPLES MOTORS BACK EMF.

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 (600 μ A QUIESCENT CURRENT). *1% METAL FILM.

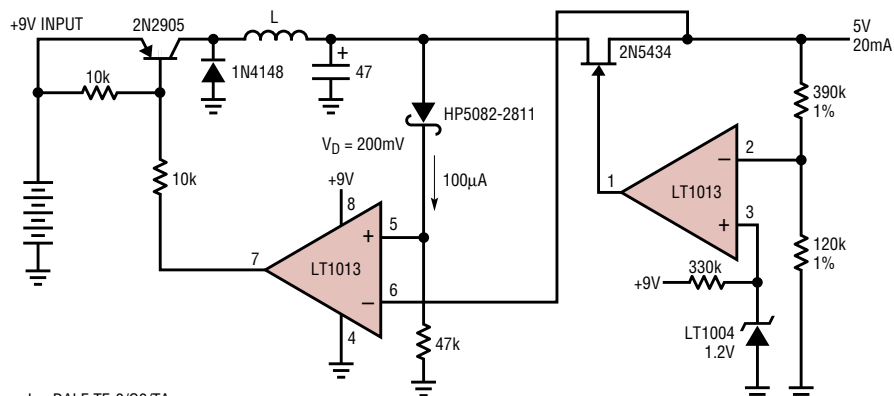
TYPICAL APPLICATIONS

Methane Concentration Detector with Linearized Output



1013/14 TA11

Low Power 9V to 5V Converter



L = DALE TE-3/Q3/TA.
SHORT CIRCUIT CURRENT = 30mA.
≈ 75% EFFICIENCY.
SWITCHING PREREGULATOR CONTROLS DROP ACROSS FET TO 200mV.

1013/14 TA12

The circuit diagram illustrates a precision temperature measurement system. It features four LT1014 op-amp chips (A1, A2, A3, A4) and a 2N4250 (2) transistor. The input stage uses a 2N4250 (2) transistor and a 1.5k resistor to interface with a ROSEMOUNT 118MF sensor. The signal is then processed by op-amp A2, which is configured as a differential amplifier with 200k resistors and a 2M feedback resistor. The output of A2 is connected to op-amp A4, which is configured as a buffer with a 150Ω resistor and a 5k feedback resistor. The output of A4 is connected to a 3.01k resistor and a 1k gain trimmer. The output voltage is labeled as OUTPUT 0V-4V = 0°C-400°C ±0.05°C. The circuit also includes a 5V supply, a 2.4k 5% resistor, and an LT1009 2.5V diode. Other components include a 499Ω resistor, a 167Ω resistor, a 2M resistor, a 200k resistor, a 2M resistor, a 150Ω resistor, a 5k resistor, a 3.01k resistor, a 1k resistor, a 8.25k resistor, a 50k ZERO TRIM resistor, a 274k resistor, a 10k resistor, a 250k resistor, and a 1.5k resistor.

1013/14 TA15

100µF

0.1

1

8

2

3

4

5

6

7

8

100µF

10k

301k

100k

0.33

0.047

2k

46k*

100k*

1.2V

39k

220

1.2V_{OUT} REFERENCE
TO A/D CONVERTER
FOR RATIO-METRIC OPERATION
1mA MAXIMUM LOAD

10k ZERO TRIM

2k GAIN TRIM

0V-3.5V
0psi-350psi

OUTPUT

1/2 LT1013

1/2 LT1013

LT1004

LTC1044

PRESSURE TRANSDUCER
350Ω

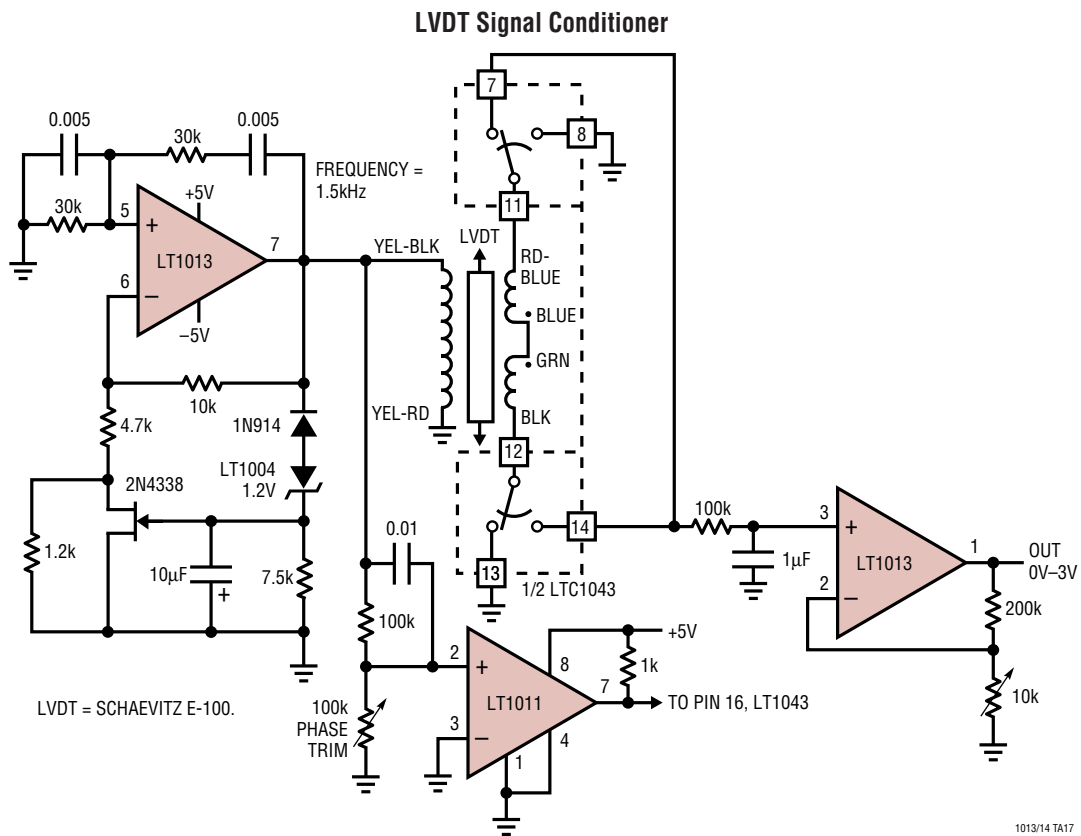
V = -V_{REF}

* 1% FILM RESISTOR.
PRESSURE TRANSDUCER-BLH/DHF-350.
CIRCLED LETTER IS PIN NUMBER.

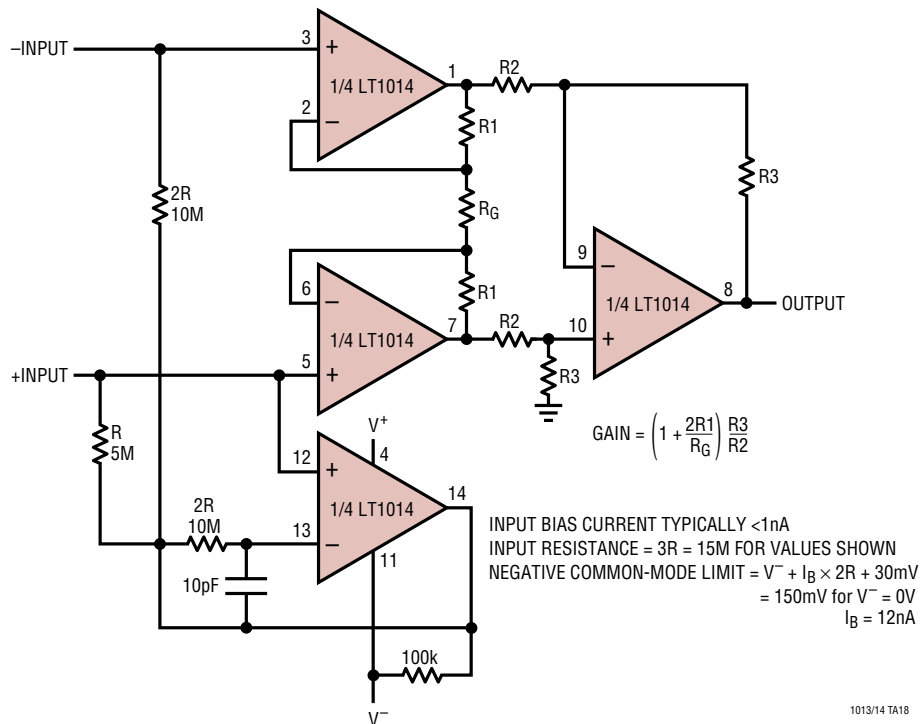
1013/14 TA16

10134fb

TYPICAL APPLICATIONS

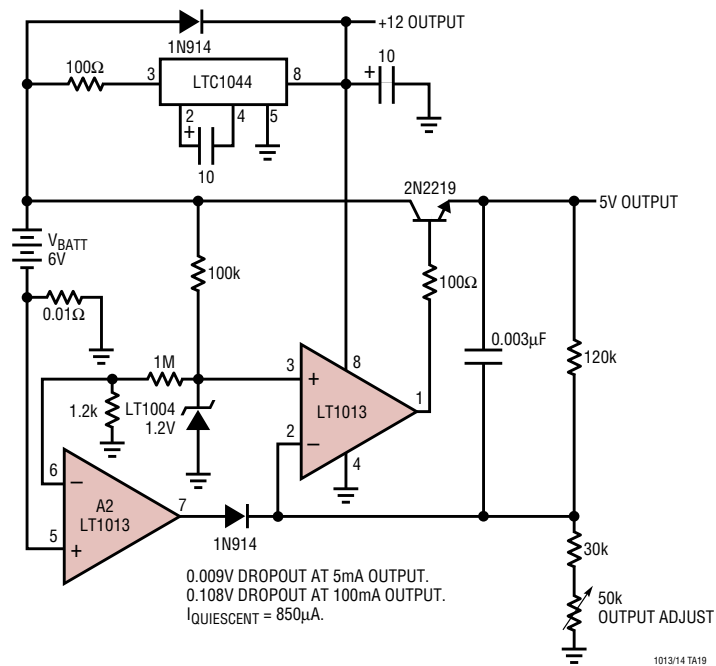


Triple Op Amp Instrumentation Amplifier with Bias Current Cancellation

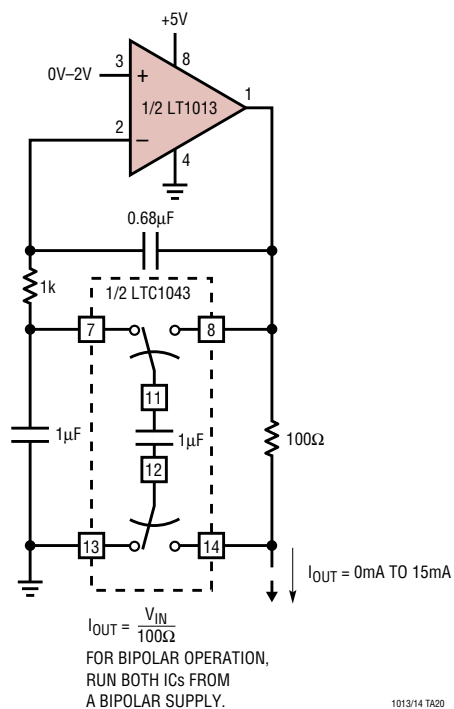


TYPICAL APPLICATIONS

Low Dropout Regulator for 6V Battery

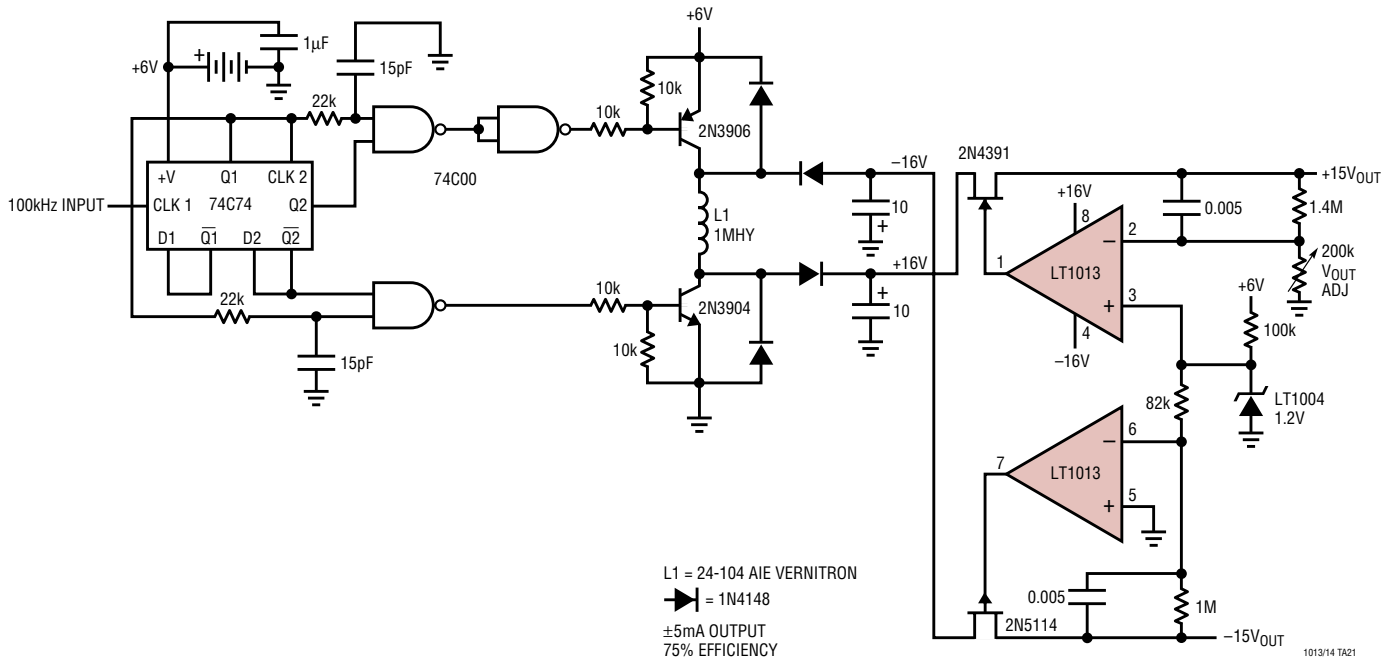


Voltage Controlled Current Source with Ground Referred Input and Output

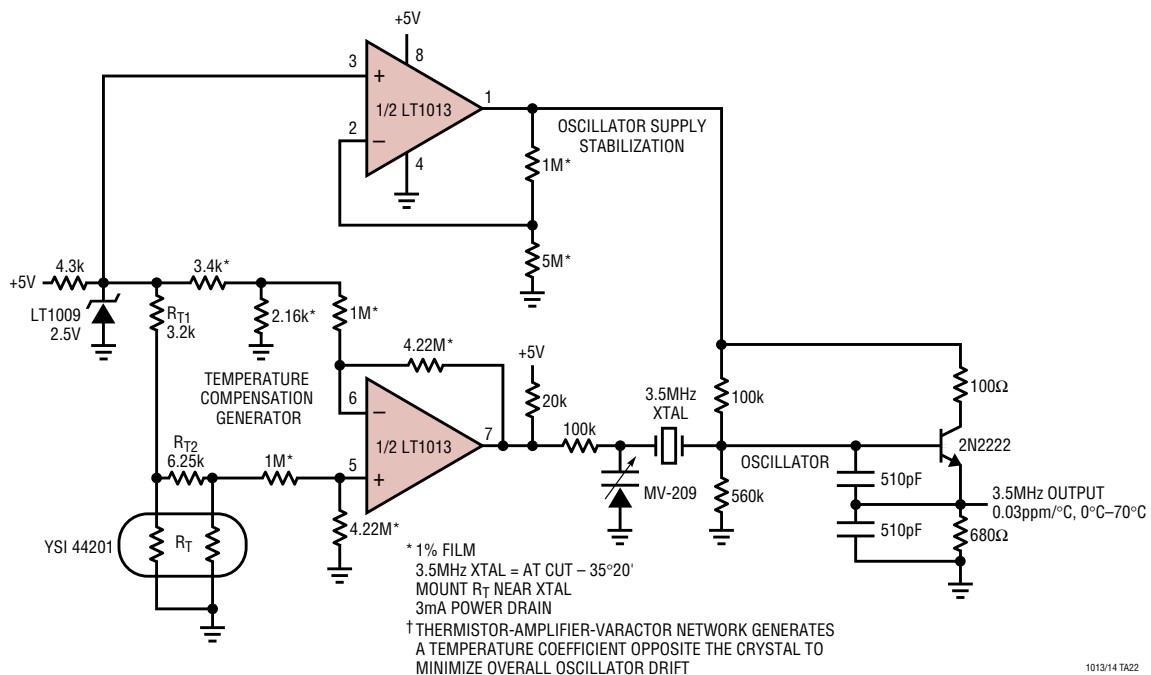


TYPICAL APPLICATIONS

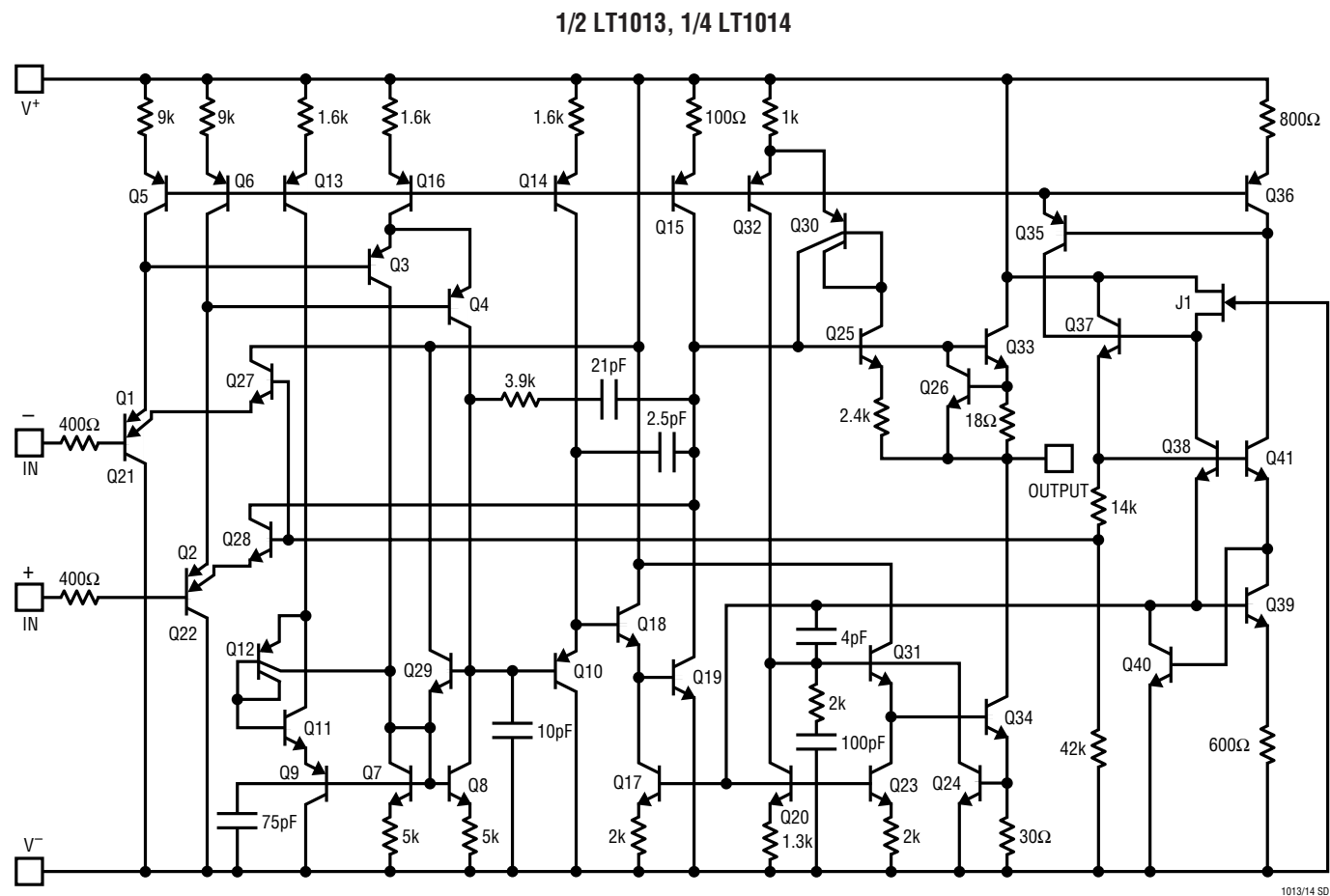
6V to $\pm 15V$ Regulating Converter



Low Power, 5V Driven, Temperature Compensated Crystal Oscillator (TXCO)[†]



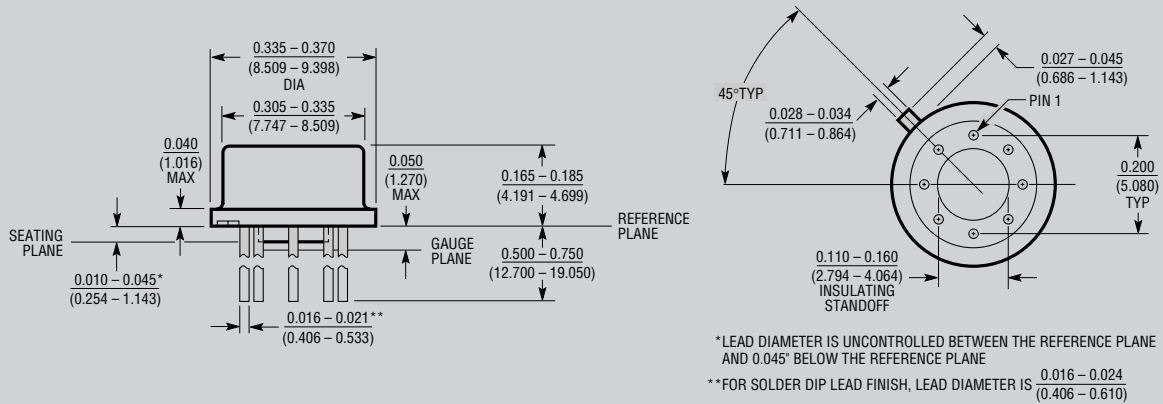
SCHEMATIC DIAGRAM



1013/14 SD

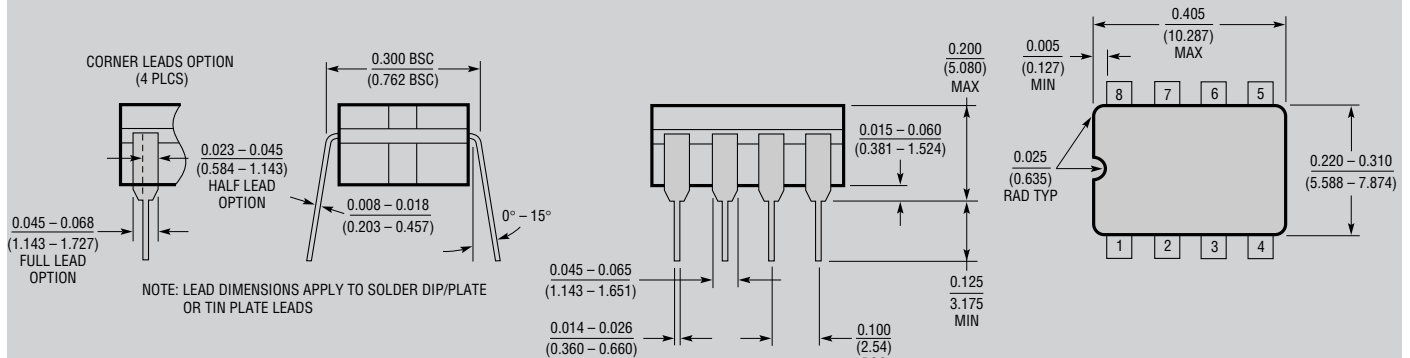
PACKAGE DESCRIPTION

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



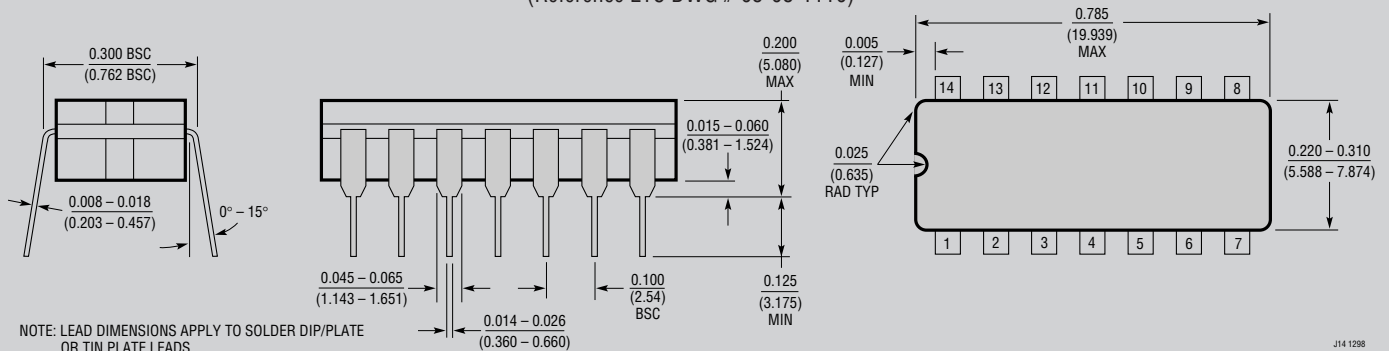
H8(TO-5) 0.200 PCD 1197

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



J8 1298

J Package 14-Lead Cerdip (Narrow .300 Inch, Hermetic) (Reference LTC DWG # 05-08-1110)



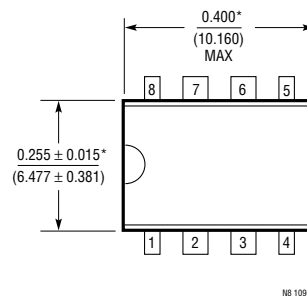
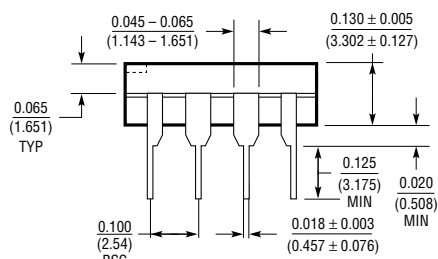
J14 1298

OBSOLETE PACKAGES

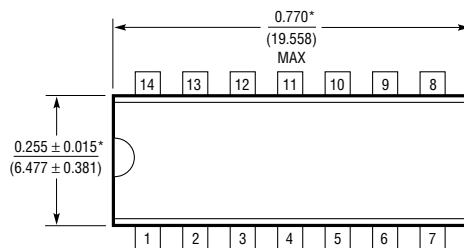
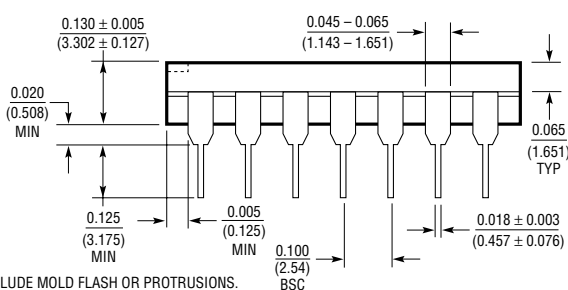
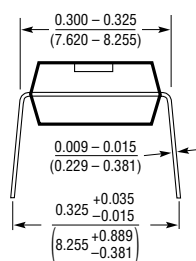
10134fb

Figure 10 shows a technical drawing of a trapezoidal part. The dimensions and tolerances are as follows:

- Top width: $0.300 - 0.325$ ($7.620 - 8.255$)
- Bottom width: $0.325 \begin{smallmatrix} +0.035 \\ -0.015 \end{smallmatrix}$ ($8.255 \begin{smallmatrix} +0.889 \\ -0.381 \end{smallmatrix}$)
- Height: $0.009 - 0.015$ ($0.229 - 0.381$)



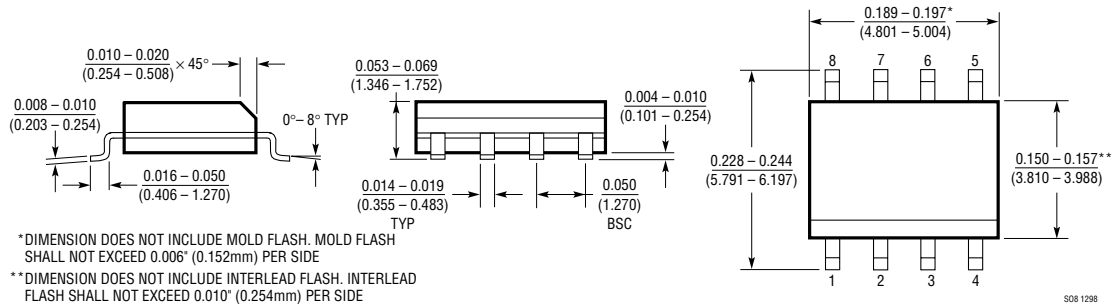
N Package
14-Lead PDIP (Narrow .300 Inch)
 (Reference LTC DWG # 05-08-1510)



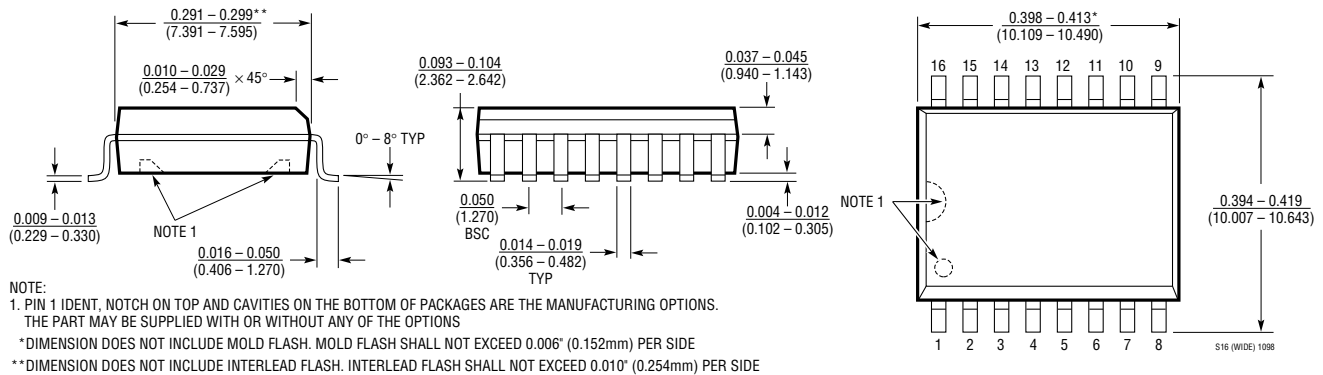
N14 1098

PACKAGE DESCRIPTION

S8 Package 8-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610)



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



1013/14 TA23

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT2078/LT2079	Dual/Quad 50μA Single Supply Precision Amplifier	50μA Max I _S , 70μV Max V _{OS}
LT2178/LT2179	Dual/Quad 17μA Single Supply Precision Amplifier	17μA Max I _S , 70μV Max V _{OS}