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: 150μV Max
- *Guaranteed* Low Drift: 2μV/°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: 500μA Max
- Low Voltage Noise, 0.1Hz to 10Hz: $0.55\mu V_{P-P}$

Low Current Noise—Better than OP-07, $0.07pA/\sqrt{Hz}$

APPLICATIONS

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

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.

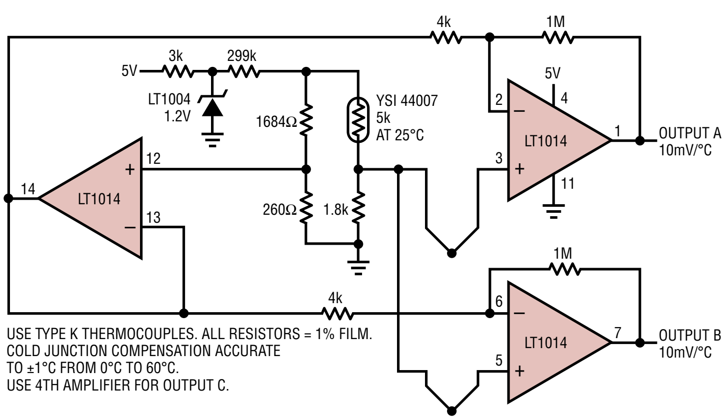
The LT1014's low offset voltage of 50μV, drift of 0.3μV/°C, offset current of 0.15nA, gain of 8 million, common mode rejection of 117dB and power supply rejection of 120dB qualify it as four truly precision operational amplifiers. Particularly important is the low offset voltage, since no offset null terminals are provided in the quad configuration. Although supply current is only 350μA 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/MC1558, 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 ±15V and single 5V supplies.

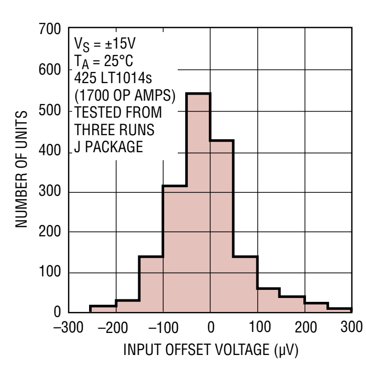
TYPICAL APPLICATION

3-Channel Thermocouple Thermometer



USE TYPE K THERMOCOUPLES. ALL RESISTORS = 1% FILM.
COLD JUNCTION COMPENSATION ACCURATE
TO ±1°C FROM 0°C TO 60°C.
USE 4TH AMPLIFIER FOR OUTPUT C.

LT1014 Distribution of Offset Voltage



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ABSOLUTE MAXIMUM RATINGS (Note 1)

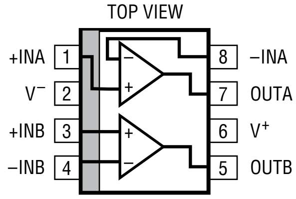
Supply Voltage .... ±22V
Differential Input Voltage.. ±30V
Input Voltage................ Equal to Positive Supply Voltage
.... 5V Below Negative Supply Voltage
Output Short-Circuit Duration .... Indefinite
Storage Temperature Range
All Grades ....–65°C to 150°C

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

PIN CONFIGURATION

LT1013

TOP VIEW



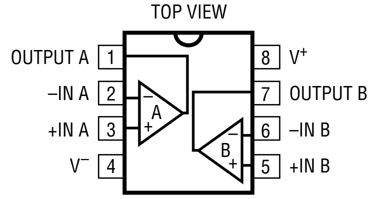
S8 PACKAGE
8-LEAD PLASTIC SO

NOTE: THIS PIN CONFIGURATION DIFFERS FROM THE STANDARD 8-PIN DUAL-IN-LINE CONFIGURATION

T_{JMAX} = 150°C, θ_{JA} = 190°C/W

LT1013

TOP VIEW



N8 PACKAGE
8-LEAD PDIP
T_{JMAX} = 150°C, θ_{JA} = 130°C

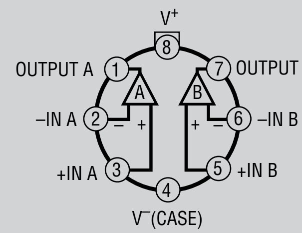
J8 PACKAGE
8-LEAD CERDIP
T_{JMAX} = 150°C, θ_{JA} = 100°C

OBSOLETE PACKAGE

Consider the N or S8 Packages for Alternate Source

LT1013

TOP VIEW



H PACKAGE
8-LEAD TO-5 METAL CAN

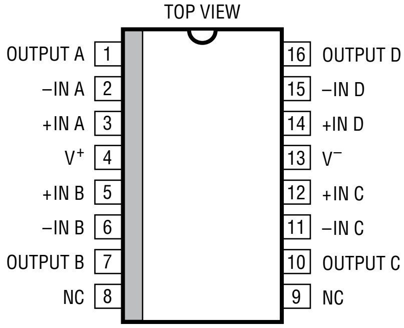
T_{JMAX} = 125°C, θ_{JA} = 55°C/W

OBSOLETE PACKAGE

Consider the N or S8 (Not N8) Packages for Alternate Source

LT1014

TOP VIEW

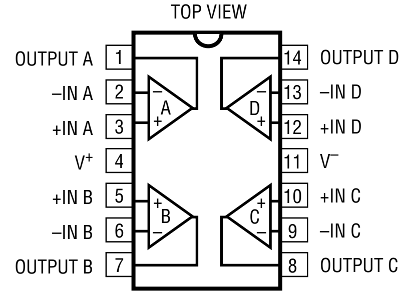


SW PACKAGE
16-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 130°C/W

LT1014

TOP VIEW



N PACKAGE
14-LEAD PDIP
T_{JMAX} = 150°C, θ_{JA} = 100°C

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

OBSOLETE PACKAGE

Consider the N or SW Packages for Alternate Source

ORDER INFORMATION http://www.linear.com/product/LT1013#orderinfo

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LT1013DS8#PBF	LT1013DS8#TRPBF	1013	8-Lead Plastic SO	0°C to 70°C
LT1013IS8#PBF	LT1013IS8#TRPBF	1013I	8-Lead Plastic SO	–40°C to 85°C
LT1013ACN8#PBF	LT1013ACN8#TRPBF	LT1013ACN8	8-Lead PDIP	0°C to 70°C
LT1013CN8#PBF	LT1013CN8#TRPBF	LT1013CN8	8-Lead PDIP	0°C to 70°C
LT1013DN8#PBF	LT1013DN8#TRPBF	LT1013DN8	8-Lead PDIP	0°C to 70°C
LT1013IN8#PBF	LT1013IN8#TRPBF	LT1013IN8	8-Lead PDIP	–40°C to 85°C
LT1014DSW#PBF	LT1014DSW#TRPBF	LT1014DSW	16-Lead Plastic SO	0°C to 70°C
LT1014ISW#PBF	LT1014ISW#TRPBF	LT1014ISW	16-Lead Plastic SO	–40°C to 85°C
LT1014ACN#PBF	LT1014ACN#TRPBF	LT1014ACN	14-Lead PDIP	0°C to 70°C
LT1014CN#PBF	LT1014CN#TRPBF	LT1014CN	14-Lead PDIP	0°C to 70°C
LT1014DN#PBF	LT1014DN#TRPBF	LT1014DN	14-Lead PDIP	0°C to 70°C
LT1014IN#PBF	LT1014IN#TRPBF	LT1014IN	14-Lead PDIP	–40°C to 85°C
LT1013AMJ8#PBF	LT1013AMJ8#TRPBF	LT1013AMJ8	8-Lead CERDIP	–55°C to 125°C **(OBSOLETE)**
LT1013MJ8#PBF	LT1013MJ8#TRPBF	LT1013MJ8	8-Lead CERDIP	–55°C to 125°C **(OBSOLETE)**
LT1013ACJ8#PBF	LT1013ACJ8#TRPBF	LT1013ACJ8	8-Lead CERDIP	0°C to 70°C **(OBSOLETE)**
LT1013CJ8#PBF	LT1013CJ8#TRPBF	LT1013CJ8	8-Lead CERDIP	0°C to 70°C **(OBSOLETE)**
LT1013AMH#PBF	LT1013AMH#TRPBF	LT1013AMH	8-Lead TO-5 Metal Can	–55°C to 125°C **(OBSOLETE)**
LT1013MH#PBF	LT1013MH#TRPBF	LT1013MH	8-Lead TO-5 Metal Can	–55°C to 125°C **(OBSOLETE)**
LT1013ACH#PBF	LT1013ACH#TRPBF	LT1013ACH	8-Lead TO-5 Metal Can	0°C to 70°C **(OBSOLETE)**
LT1013CH#PBF	LT1013CH#TRPBF	LT1013CH	8-Lead TO-5 Metal Can	0°C to 70°C **(OBSOLETE)**
LT1014AMJ#PBF	LT1014AMJ#TRPBF	LT1014AMJ	14-Lead CERDIP	–55°C to 125°C **(OBSOLETE)**
LT1014MJ#PBF	LT1014MJ#TRPBF	LT1014MJ	14-Lead CERDIP	–55°C to 125°C **(OBSOLETE)**
LT1014ACJ#PBF	LT1014ACJ#TRPBF	LT1014ACJ	14-Lead CERDIP	0°C to 70°C **(OBSOLETE)**
LT1014CJ#PBF	LT1014CJ#TRPBF	LT1014CJ	14-Lead CERDIP	0°C to 70°C **(OBSOLETE)**

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

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

ELECTRICAL CHARACTERISTICS

$T_A = 25°C$. $V_S = ±15V$, $V_{CM} = 0V$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1013AM/AC LT1014AM/AC MIN	TYP	MAX	LT1013C/D/I/M LT1014C/D/I/M MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1013 LT1014 LT1013D/I, LT1014D/I		40 50	150 180		60 60 200	300 300 800	μV μV μV
	Long-Term Input Offset Voltage Stability			0.4			0.5		μV/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		$μV_{P-P}$
e_n	Input Noise Voltage Density	$f_O = 10Hz$ $f_O = 1000Hz$		24 22			24 22		$nV/\sqrt{Hz}$ $nV/\sqrt{Hz}$
i_n	Input Noise Current Density	$f_O = 10Hz$		0.07			0.07		$pA/\sqrt{Hz}$
	Input Resistance – Differential Common Mode	(Note 2)	100	400 5		70	300 4		MΩ GΩ
A_{VOL}	Large-Signal Voltage Gain	$V_O = ±10V$, $R_L = 2k$ $V_O = ±10V$, $R_L = 600Ω$	1.5 0.8	8.0 2.5		1.2 0.5	7.0 2.0		V/μV 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	$V_S = ±2V$ to $±18V$	103	120		100	117		dB
	Channel Separation	$V_O = ±10V$, $R_L = 2k$	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

$T_A = 25°C$. $V_S^+ = 5V$, $V_S^- = 0V$, $V_{OUT} = 1.4V$, $V_{CM} = 0V$ unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1013AM/AC LT1014AM/AC MIN	TYP	MAX	LT1013C/D/I/M LT1014C/D/I/M MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1013 LT1014 LT1013D/I, LT1014D/I		60 70	250 280		90 90 250	450 450 950	μV μV 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 $4V$, $R_L = 500Ω$		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 Output Low, 600Ω to Ground Output Low, $I_{SINK} = 1mA$ Output High, No Load Output High, 600Ω to Ground	 4.0 3.4	15 5 220 4.4 4.0	25 10 350	 4.0 3.4	15 5 220 4.4 4.0	25 10 350	mV mV mV V 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 $-55°C \le T_A \le 125°C$. $V_S = \pm15V$, $V_{CM} = 0V$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		LT1013AM MIN	LT1013AM TYP	LT1013AM MAX	LT1014AM MIN	LT1014AM TYP	LT1014AM MAX	LT1013M/LT1014M MIN	LT1013M/LT1014M TYP	LT1013M/LT1014M MAX	UNITS
V_{OS}	Input Offset Voltage		●		80	300		90	350		110	550	µV
		$V_S = 5V, 0V; V_O = 1.4V$											
		$-55°C \le T_A \le 100°C$	●		80	450		90	480		100	750	µV
		$V_{CM} = 0.1V, T_A = 125°C$			120	450		150	480		200	750	µV
		$V_{CM} = 0V, T_A = 125°C$			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	µV/°C
I_{OS}	Input Offset Current		●		0.3	2.5		0.3	2.8		0.4	5.0	nA
		$V_S = 5V, 0V; V_O = 1.4V$	●		0.6	6.0		0.7	7.0		0.9	10.0	nA
I_B	Input Bias Current		●		15	30		15	30		18	45	nA
		$V_S = 5V, 0V; V_O = 1.4V$	●		20	80		25	90		28	120	nA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm10V, R_L = 2k$	●	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	$V_S = \pm2V$ to $\pm18V$	●	100	117		100	117		97	116		dB
V_{OUT}	Output Voltage Swing	$R_L = 2k$	●	±12	±13.8		±12	±13.8		±11.5	±13.8		V
		$V_S = 5V, 0V$											
		$R_L = 600\Omega$ to Ground											
		Output Low	●		6	15		6	15		6	18	mV
		Output High	●	3.2	3.8		3.2	3.8		3.1	3.8		V
I_S	Supply Current Per Amplifier		●		0.38	0.60		0.38	0.60		0.38	0.7	mA
		$V_S = 5V, 0V; V_O = 1.4V$	●		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 $-40°C \le T_A \le 85°C$ for LT1013I, LT1014I, $0°C \le T_A \le 70°C$ for LT1013C, LT1013D, LT1014C, LT1014D. $V_S = \pm15V$, $V_{CM} = 0V$ unless otherwise noted.

				LT1013AC			LT1014AC			LT1013C/D/I LT1014C/D/I			
SYMBOL	**PARAMETER**	**CONDITIONS**		**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**MIN**	**TYP**	**MAX**	**UNITS**
V_{OS}	Input Offset Voltage		●		55	240		65	270		80	400	μV
		LT1013D/I, LT1014D/I	●								230	1000	μV
		$V_S = 5V, 0V; V_O = 1.4V$	●		75	350		85	380		110	570	μV
		LT1013D/I, LT1014D/I $V_S = 5V, 0V; V_O = 1.4V$	●								280	1200	μV
	Average Input Offset Voltage Drift	(Note 3)	●		0.3	2.0		0.3	2.0		0.4	2.5	μV/°C
		LT1013D/I, LT1014D/I	●								0.7	5.0	μV/°C
I_{OS}	Input Offset Current		●		0.2	1.5		0.2	1.7		0.3	2.8	nA
		$V_S = 5V, 0V; V_O = 1.4V$	●		0.4	3.5		0.4	4.0		0.5	6.0	nA
I_B	Input Bias Current		●		13	25		13	25		16	38	nA
		$V_S = 5V, 0V; V_O = 1.4V$	●		18	55		20	60		24	90	nA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm10V, R_L = 2k$	●	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	$V_S = \pm2V$ to $\pm18V$	●	101	119		101	119		97	116		dB
V_{OUT}	Output Voltage Swing	$R_L = 2k$	●	±12.5	±13.9		±12.5	±13.9		±12.0	±13.9		V
		$V_S = 5V, 0V; R_L = 600\Omega$ Output Low	●		6	13		6	13		6	13	mV
		Output High	●	3.3	3.9		3.3	3.9		3.2	3.9		V
I_S	Supply Current per Amplifier		●		0.36	0.55		0.36	0.55		0.37	0.60	mA
		$V_S = 5V, 0V; V_O = 1.4V$	●		0.32	0.50		0.32	0.50		0.34	0.55	mA

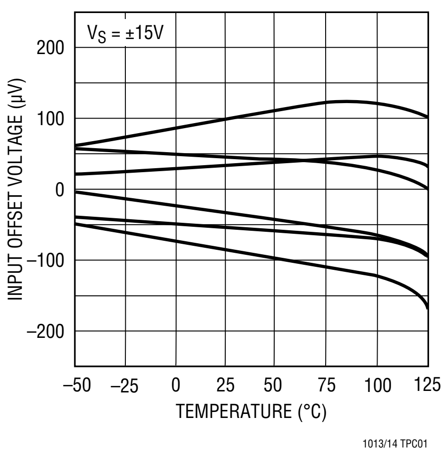
Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Rating condition for extended periods may affect device reliability and lifetime.

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.

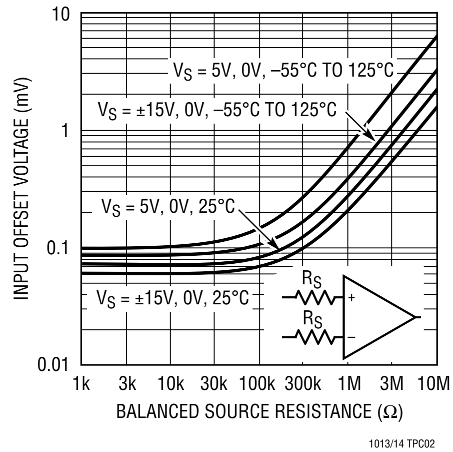
Note 3: This parameter is not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

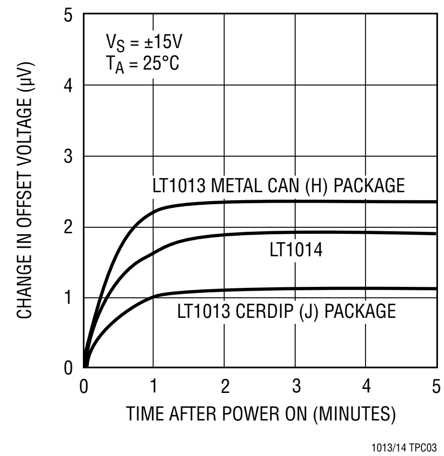
Offset Voltage Drift with Temperature of Representative Units



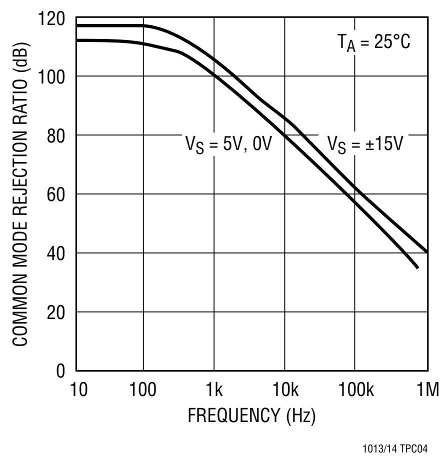
Offset Voltage vs Balanced Source Resistance



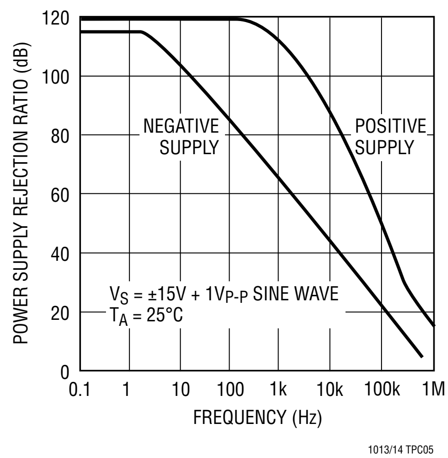
Warm-Up Drift



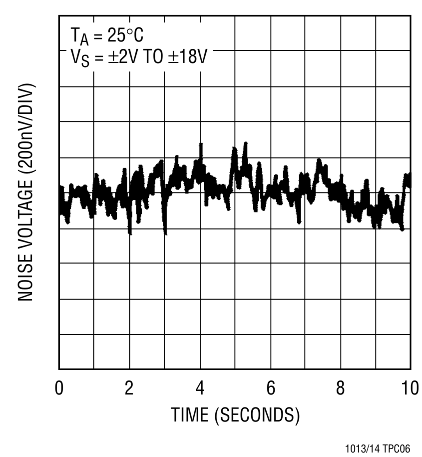
Common Mode Rejection Ratio vs Frequency



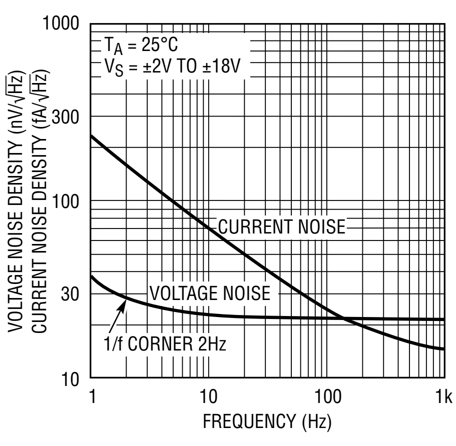
Power Supply Rejection Ratio vs Frequency



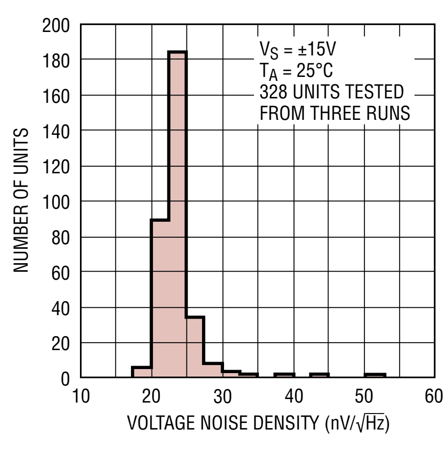
0.1Hz to 10Hz Noise



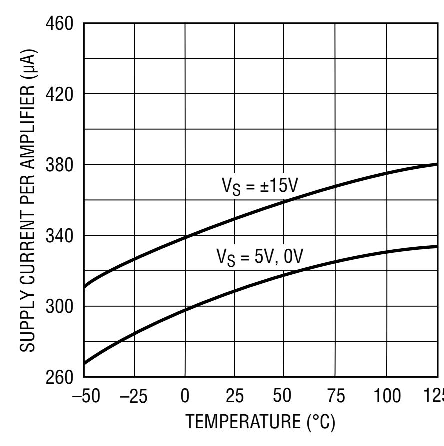
Noise Spectrum



10Hz Voltage Noise Distribution

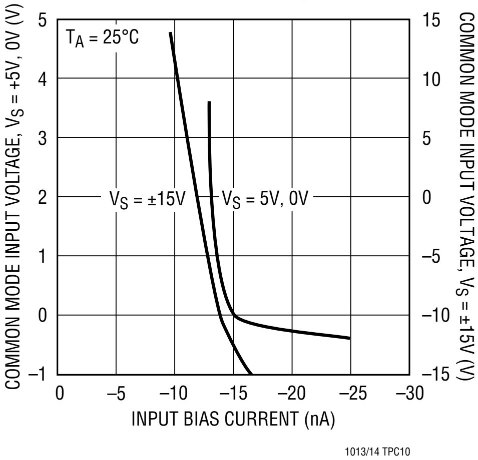


Supply Current vs Temperature

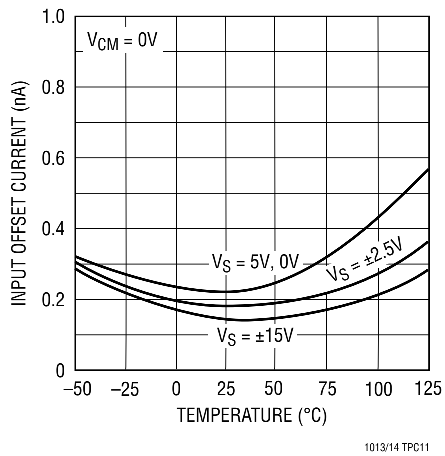


TYPICAL PERFORMANCE CHARACTERISTICS

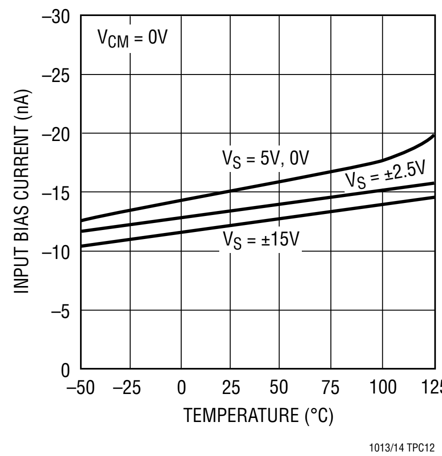
Input Bias Current vs Common Mode Voltage



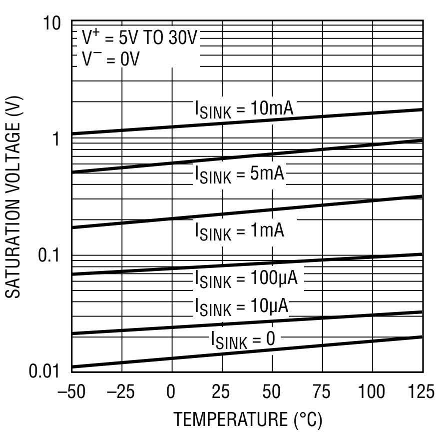
Input Offset Current vs Temperature



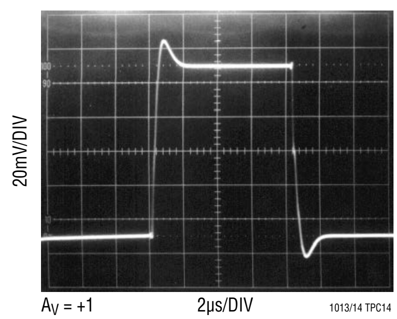
Input Bias Current vs Temperature



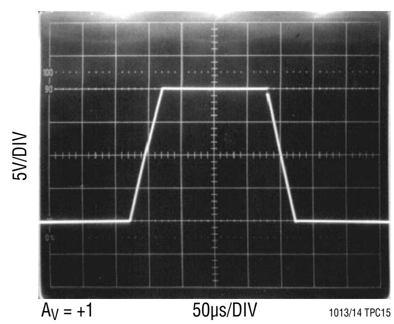
Output Saturation vs Sink Current vs Temperature



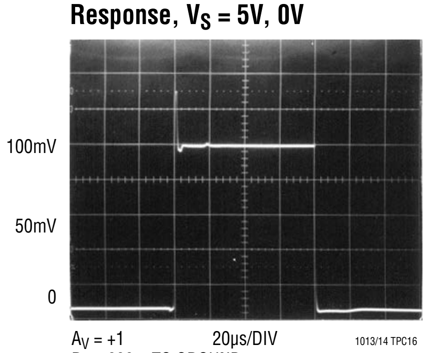
Small-Signal Transient Response, V_S = ±15V



Large-Signal Transient Response, V_S = ±15V

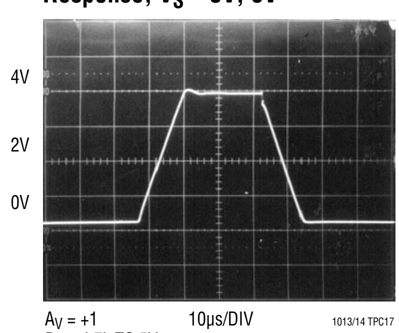


Small-Signal Transient Response, V_S = 5V, 0V



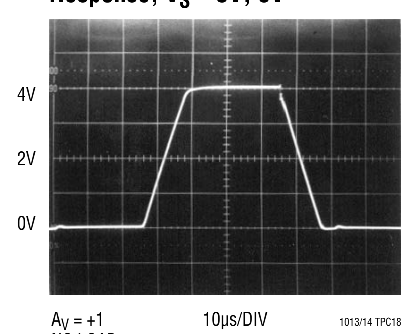
R_L = 600Ω TO GROUND
INPUT = 0V TO 100mV PULSE

Large-Signal Transient Response, V_S = 5V, 0V



R_L = 4.7k TO 5V
INPUT = 0V TO 4V PULSE

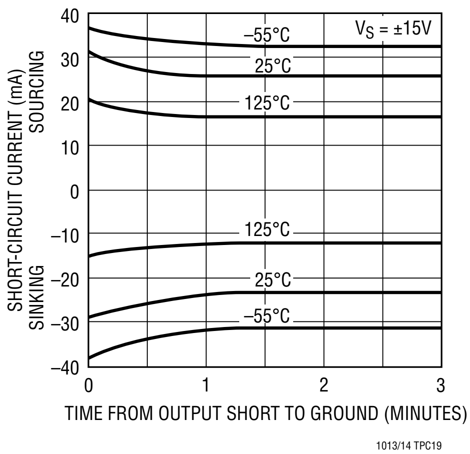
Large-Signal Transient Response, V_S = 5V, 0V



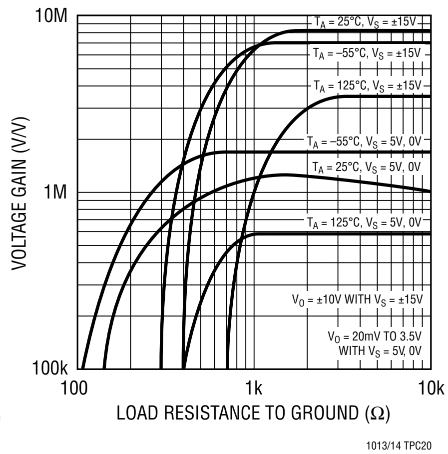
NO LOAD
INPUT = 0V TO 4V PULSE

TYPICAL PERFORMANCE CHARACTERISTICS

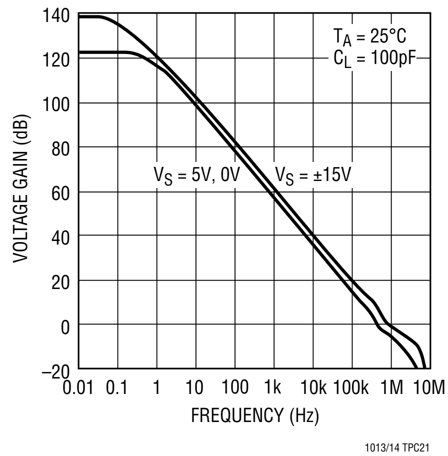
Output Short-Circuit Current vs Time



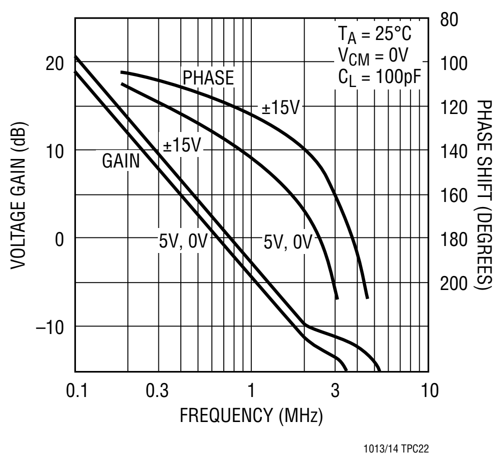
Voltage Gain vs Load Resistance



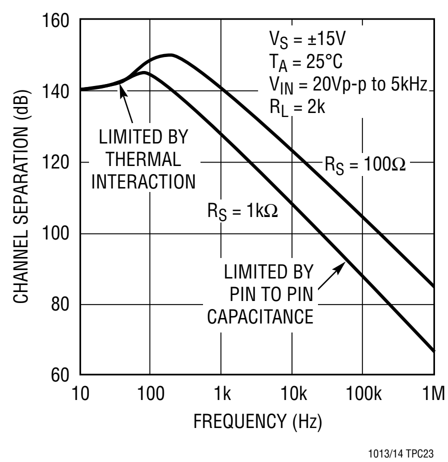
Voltage Gain vs Frequency



Gain, Phase vs Frequency



Channel Separation vs Frequency



APPLICATIONS INFORMATION

Single Supply Operation

The LT1013/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 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/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.

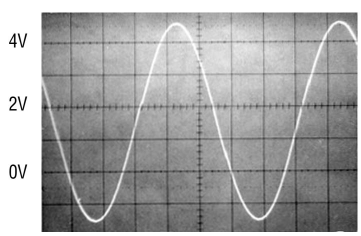
In dual supply operations, the output stage is crossover distortion-free.

Comparator Applications

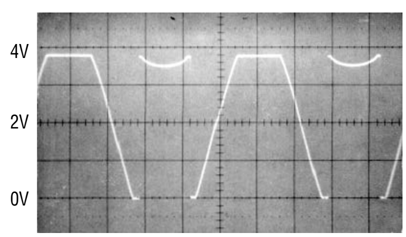
The single supply operation of the LT1013/LT1014 lends itself to its use as a precision comparator with TTL compatible output:

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.

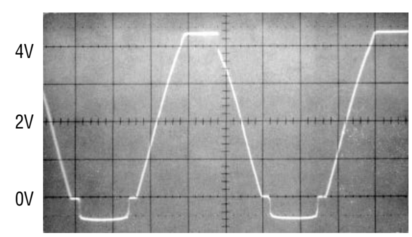
Voltage Follower with Input Exceeding the Negative Common Mode Range



$6V_{P-P}$ INPUT, –1.5V TO 4.5V

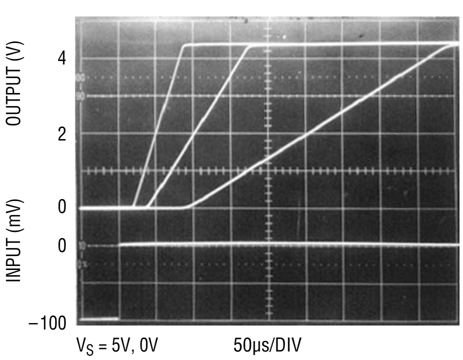


LM324, LM358, OP-20 EXHIBIT OUTPUT PHASE REVERSAL

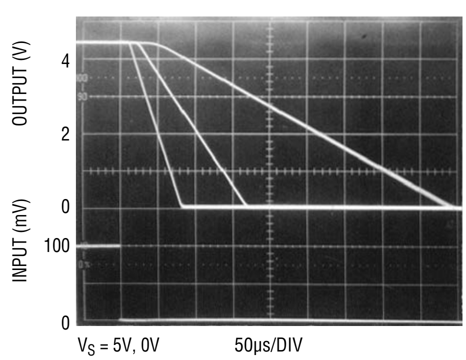


LT1013/LT1014 NO PHASE REVERSAL

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



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



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APPLICATIONS INFORMATION

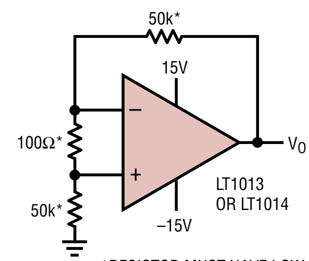
Low Supply Operation

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 290µA, 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

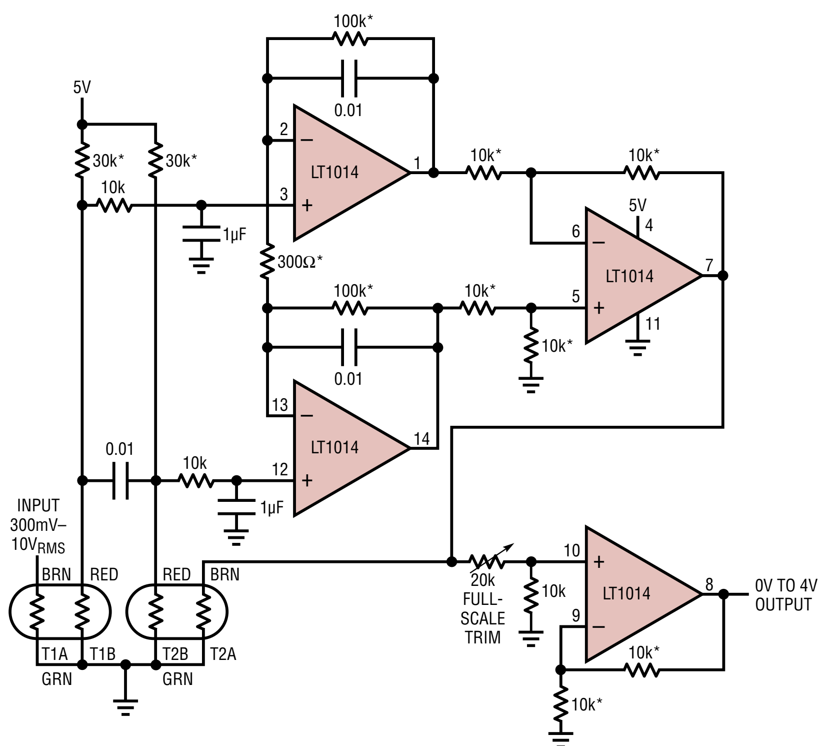


*RESISTOR MUST HAVE LOW THERMOELECTRIC POTENTIAL.
**THIS CIRCUIT IS ALSO USED AS THE BURN-IN CONFIGURATION, WITH SUPPLY VOLTAGES INCREASED TO ±20V.
$V_O = 1000V_{OS}$

LT1013/14 F06

TYPICAL APPLICATIONS

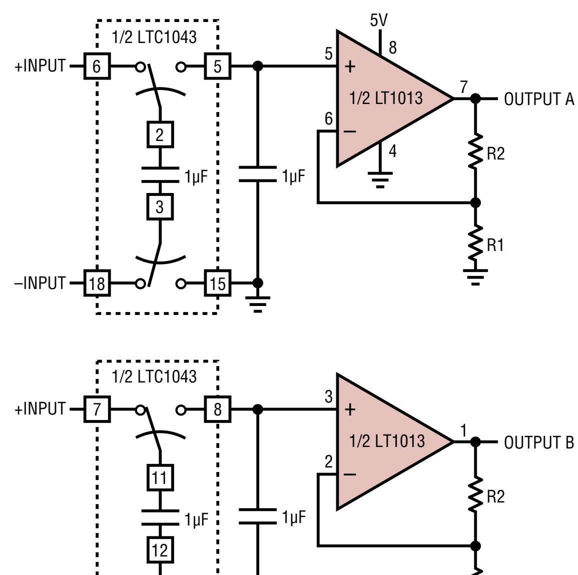
50MHz Thermal RMS-to-DC Converter



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.

1013/14 TA03

5V Single Supply Dual Instrumentation Amplifier

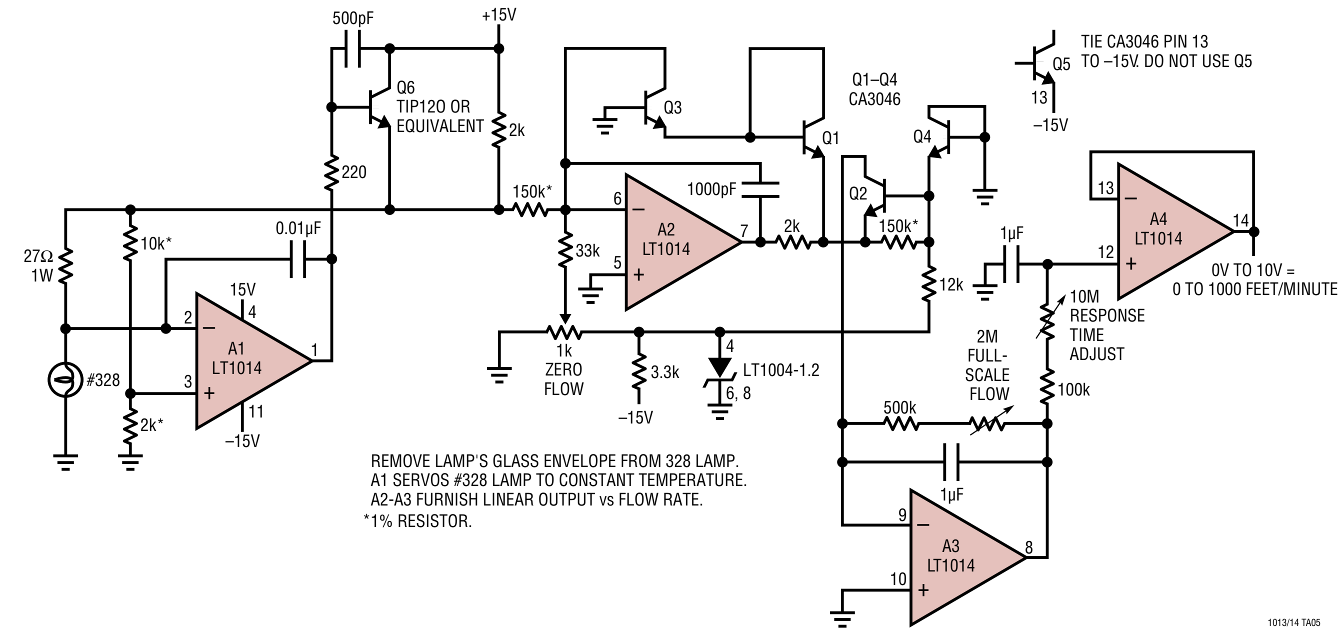


OFFSET = 150mV
GAIN = $\frac{R2}{R1} + 1$.
CMRR = 120dB.
COMMON MODE RANGE IS 0V TO 5V.

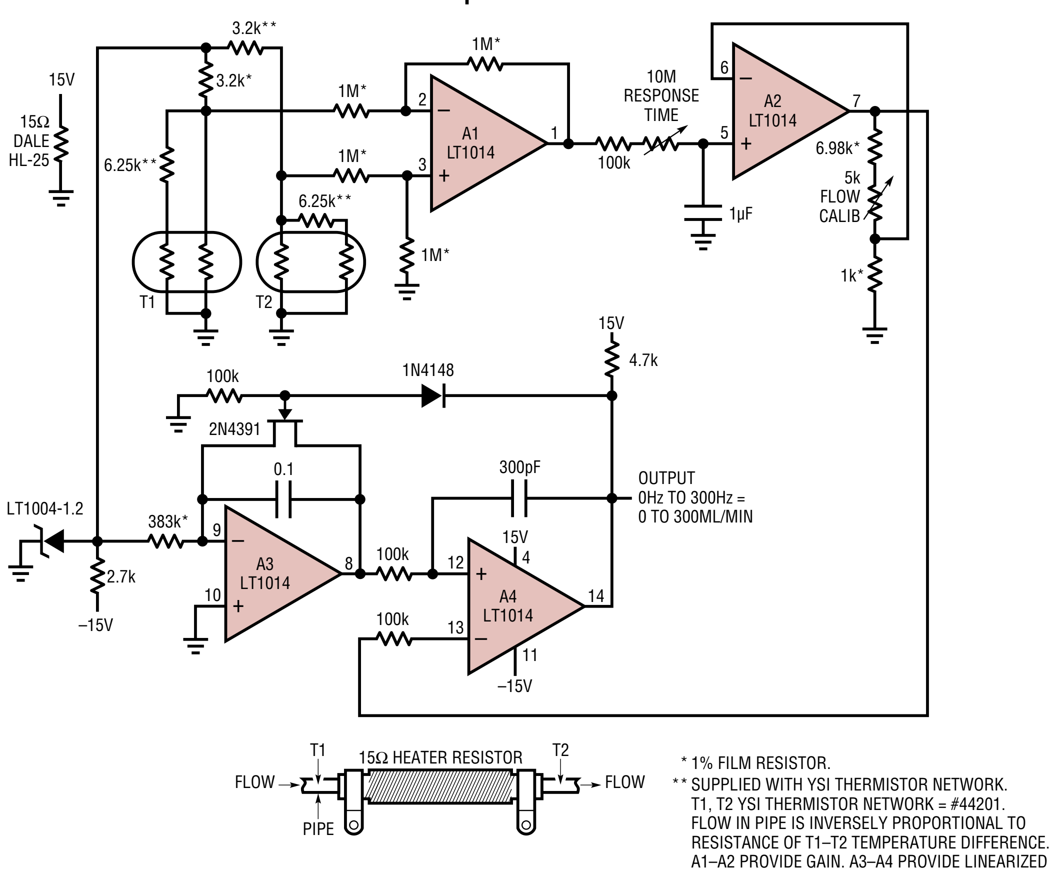
1013/14 TA04

TYPICAL APPLICATIONS

Hot-Wire Anemometer

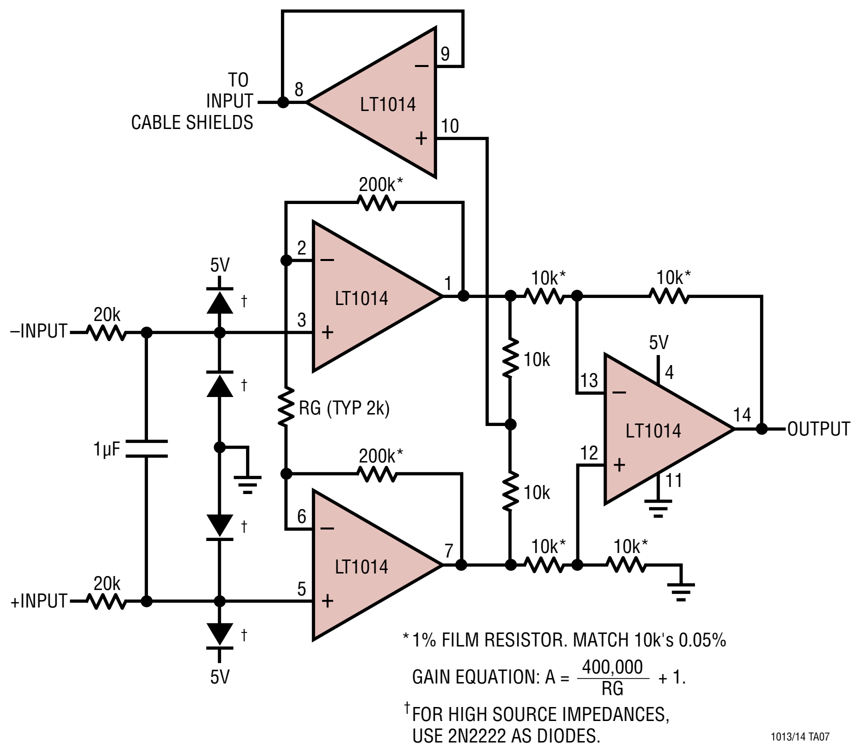


Liquid Flowmeter

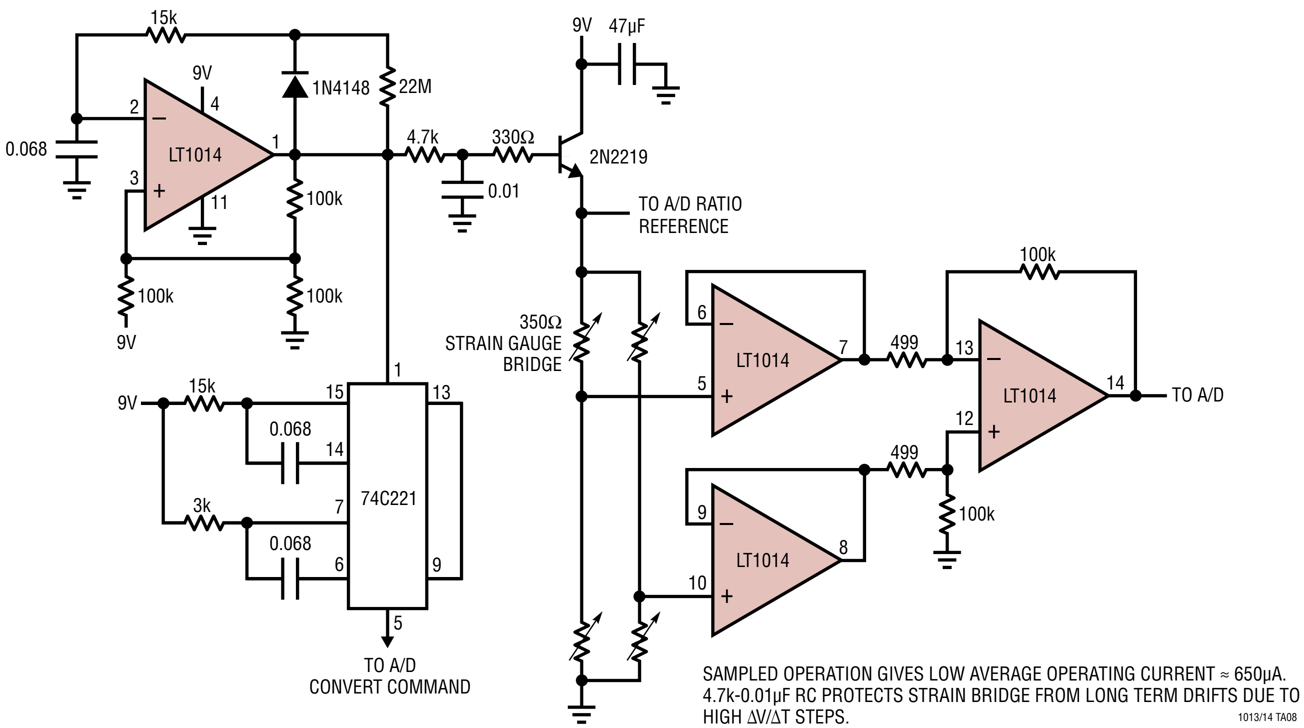


TYPICAL APPLICATIONS

5V Powered Precision Instrumentation Amplifier

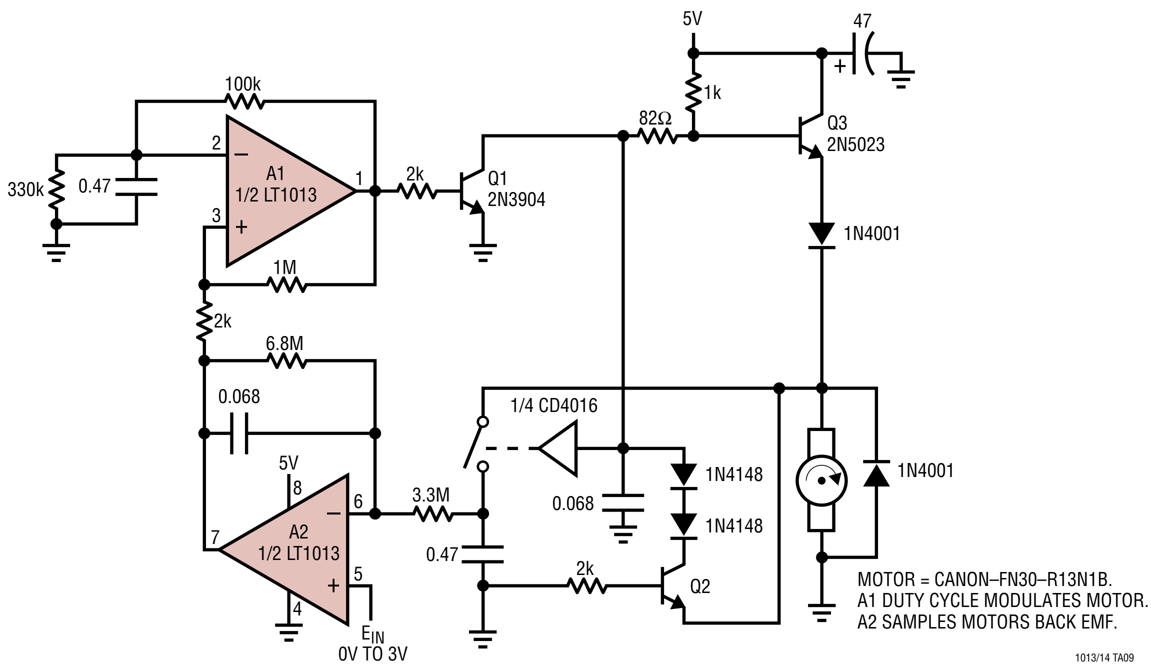


9V Battery Powered Strain Gauge Signal Conditioner

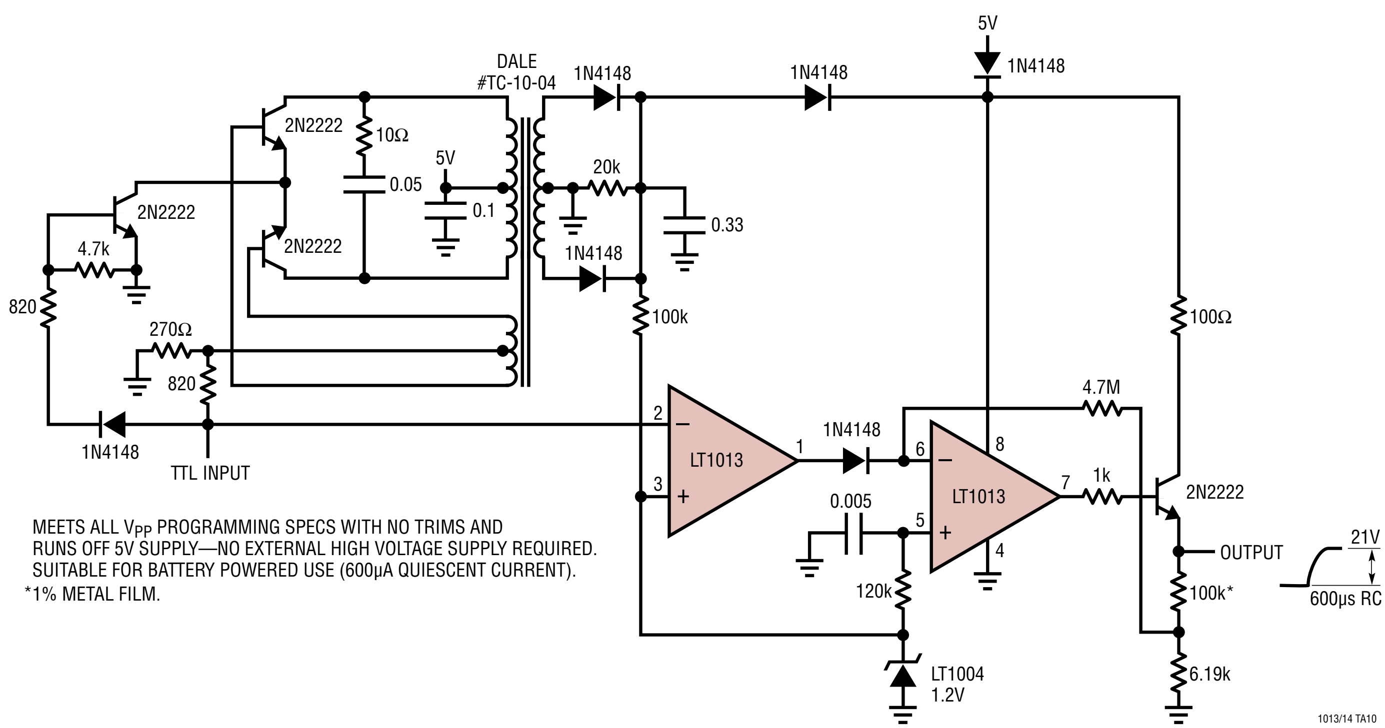


TYPICAL APPLICATIONS

5V Powered Motor Speed Controller No Tachometer Required

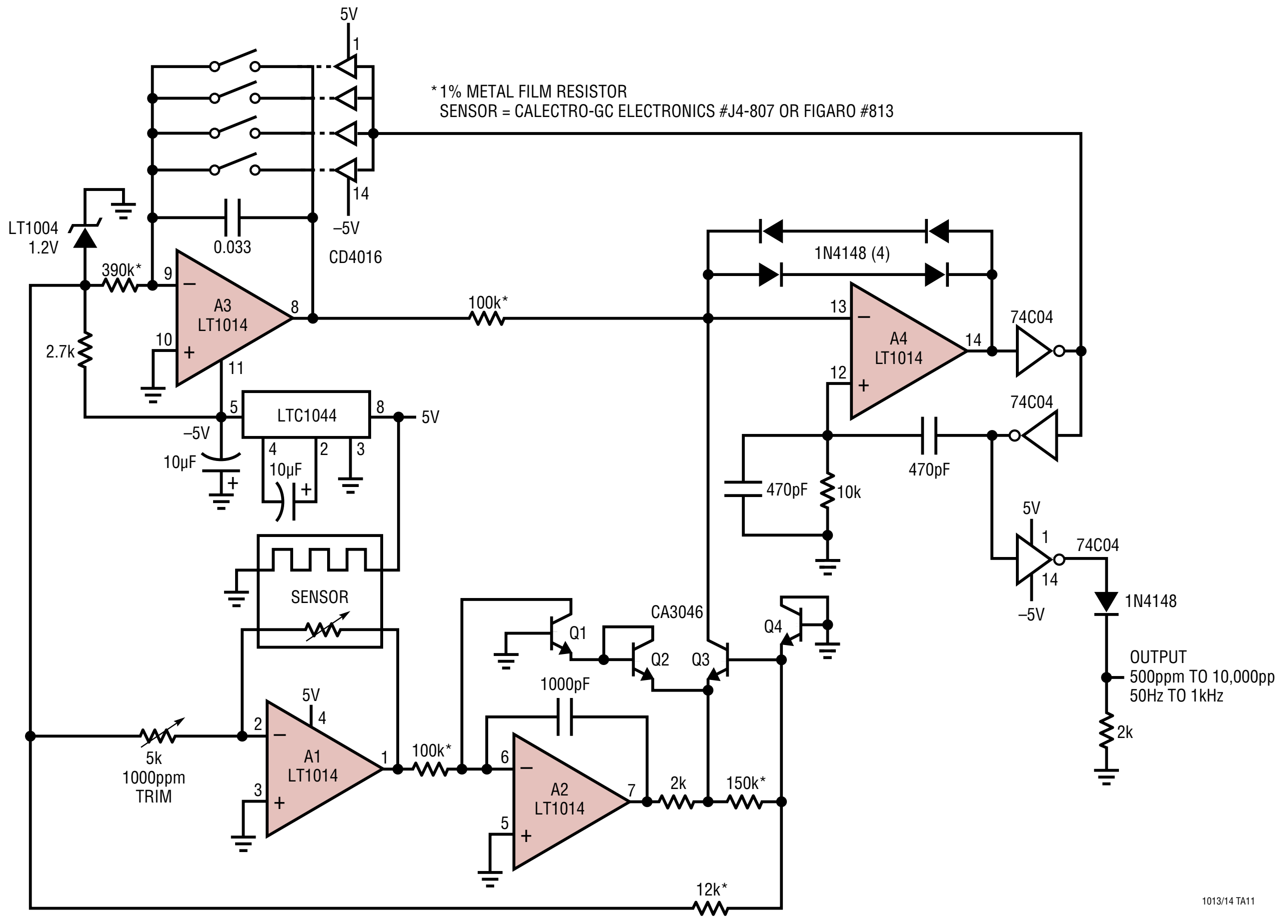


5V Powered EEPROM Pulse Generator

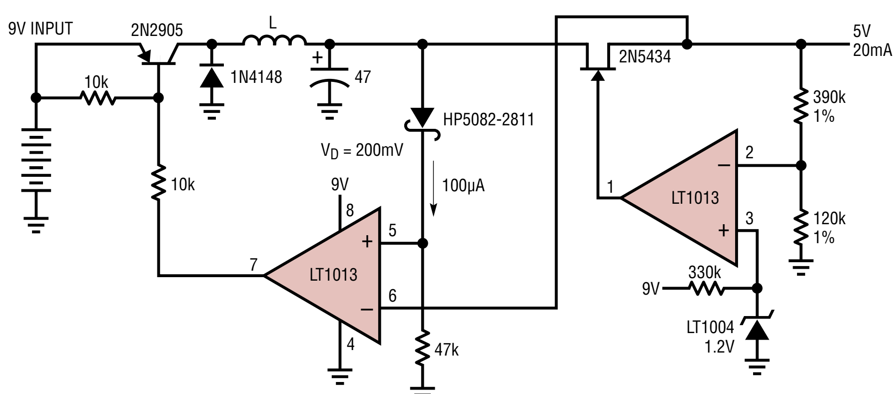


TYPICAL APPLICATIONS

Methane Concentration Detector with Linearized Output



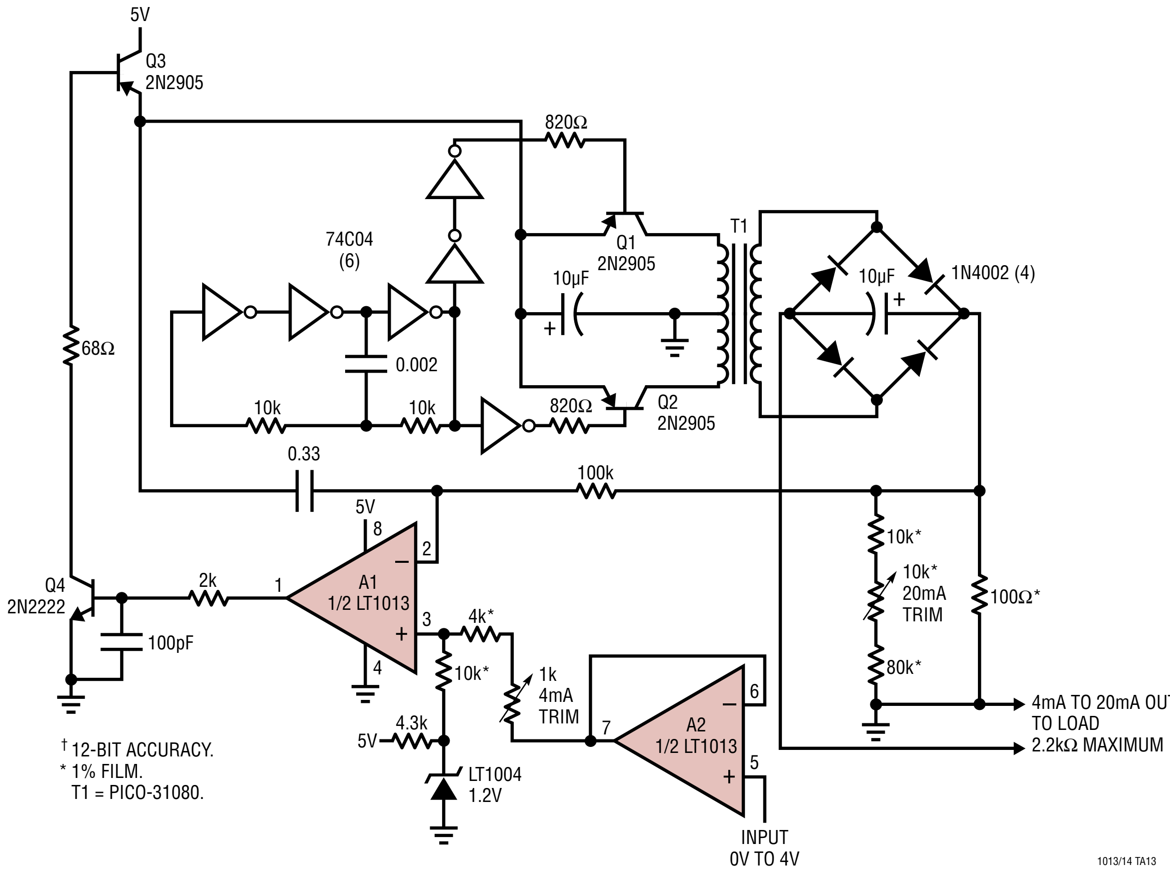
Low Power 9V to 5V Converter



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

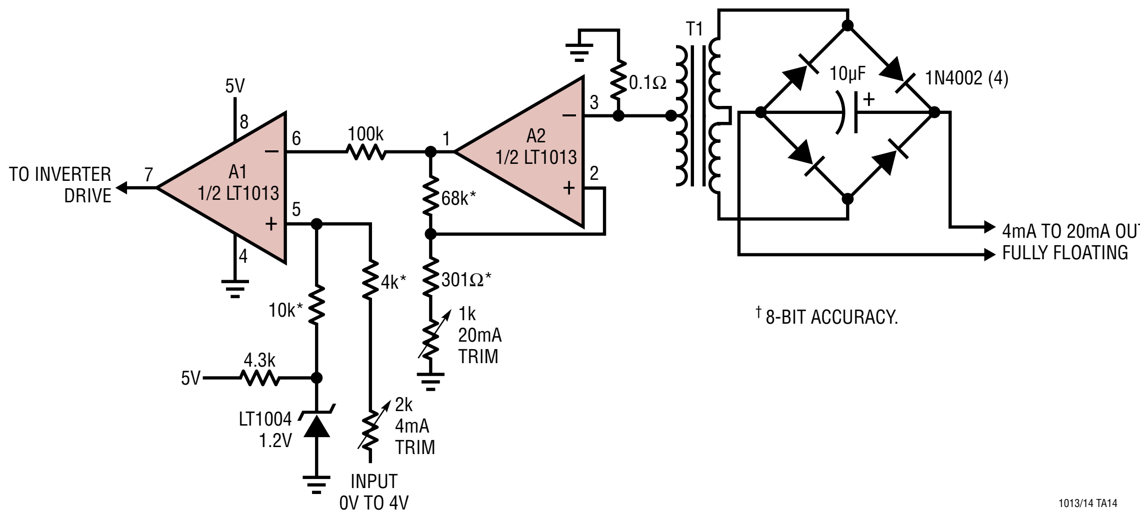
TYPICAL APPLICATIONS

5V Powered 4mA to 20mA Current Loop Transmitter†



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

Fully Floating Modification to 4mA-20mA Current Loop†



† 8-BIT ACCURACY.

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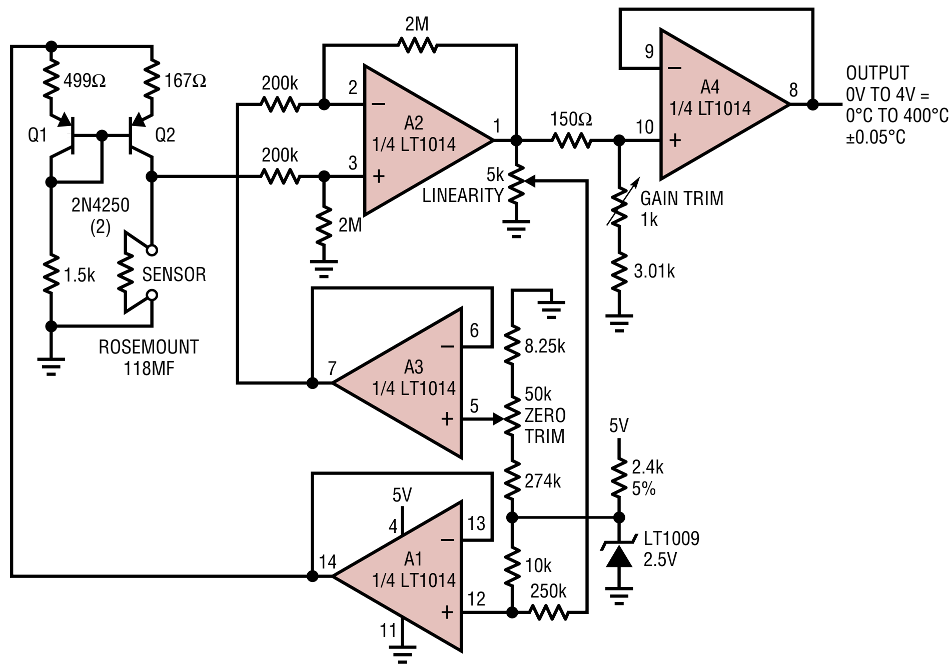
TYPICAL APPLICATIONS

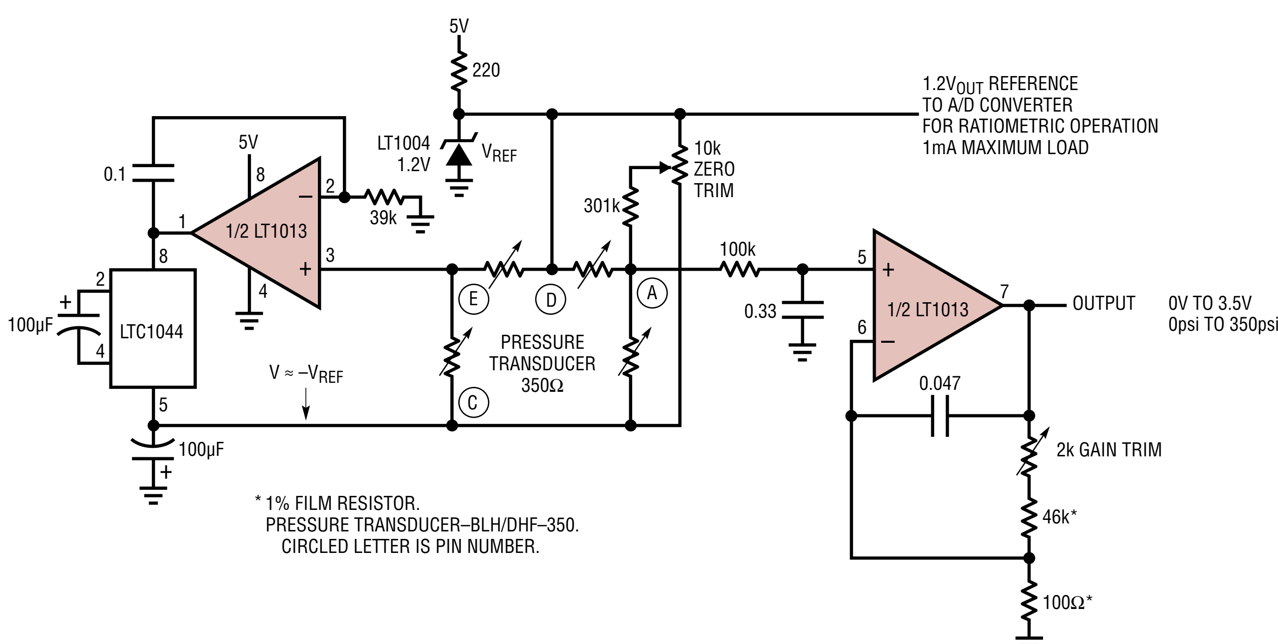
5V Powered, Linearized Platinum RTD Signal Conditioner



ALL RESISTORS ARE TRW-MAR-6 METAL FILM.
RATIO MATCH 2M–200K ± 0.01%.
TRIM SEQUENCE:
SET SENSOR TO 0° VALUE.
ADJUST ZERO FOR 0V OUT.
SET SENSOR TO 100°C VALUE.
ADJUST GAIN FOR 1.000V OUT.
SET SENSOR TO 400°C.
ADJUST LINEARITY FOR 4.000V OUT, REPEAT AS REQUIRED.

1013/14 TA15

Strain Gauge Bridge Signal Conditioner



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

1013/14 TA16

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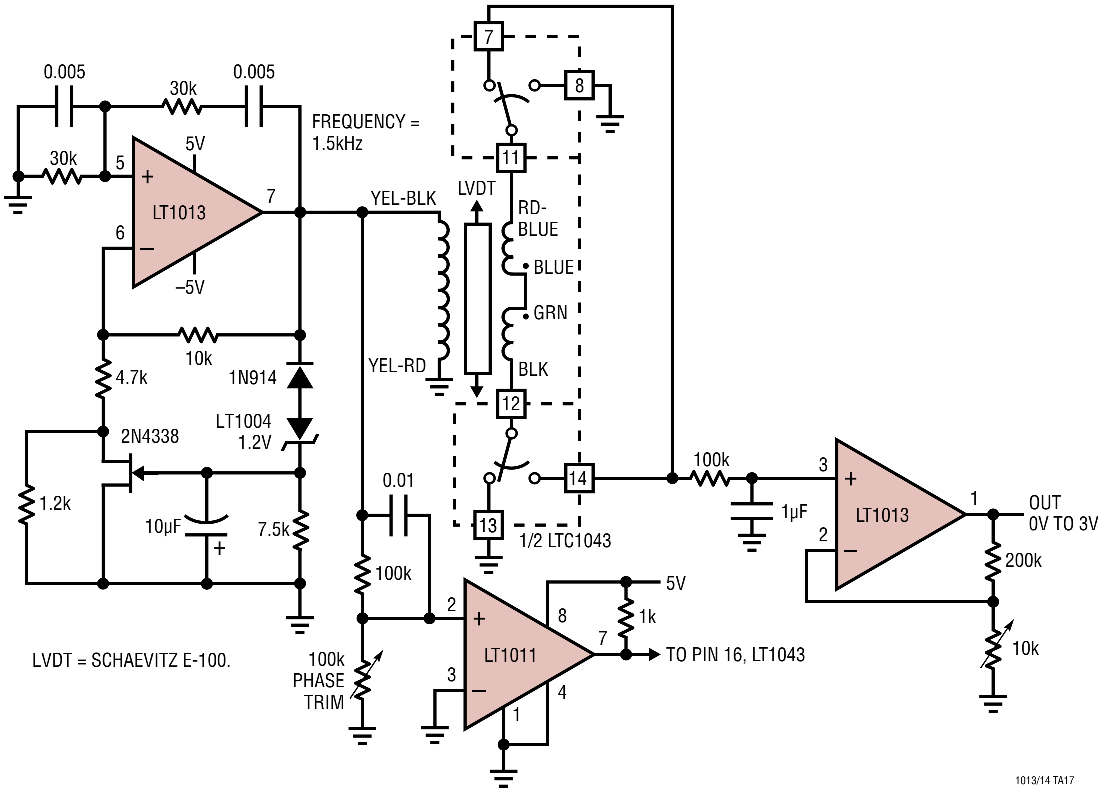
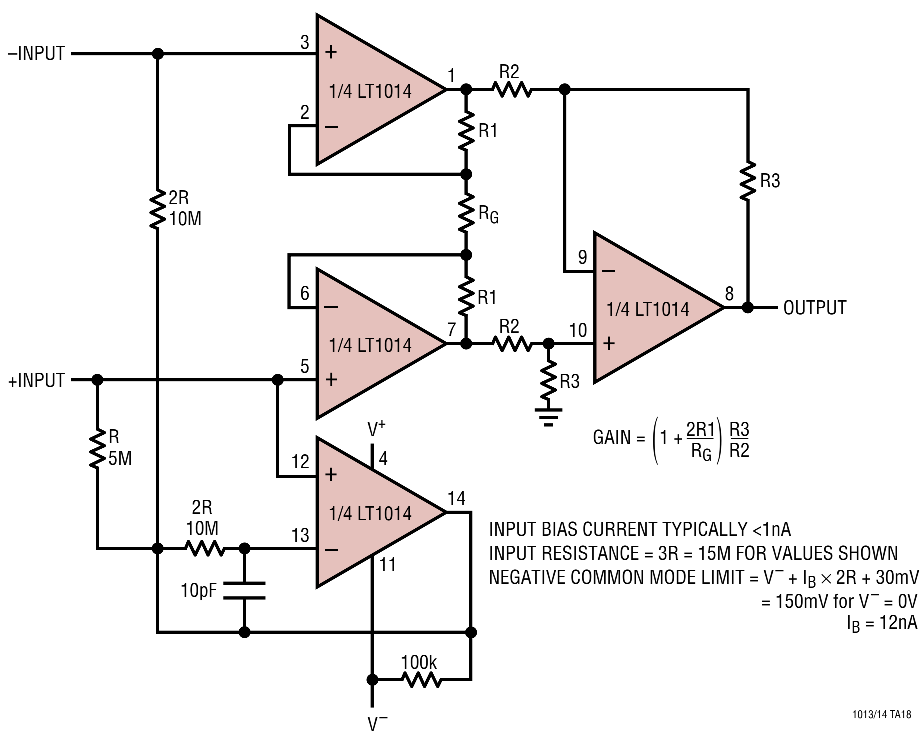
TYPICAL APPLICATIONS

LVDT Signal Conditioner



Triple Op Amp Instrumentation Amplifier with Bias Current Cancellation

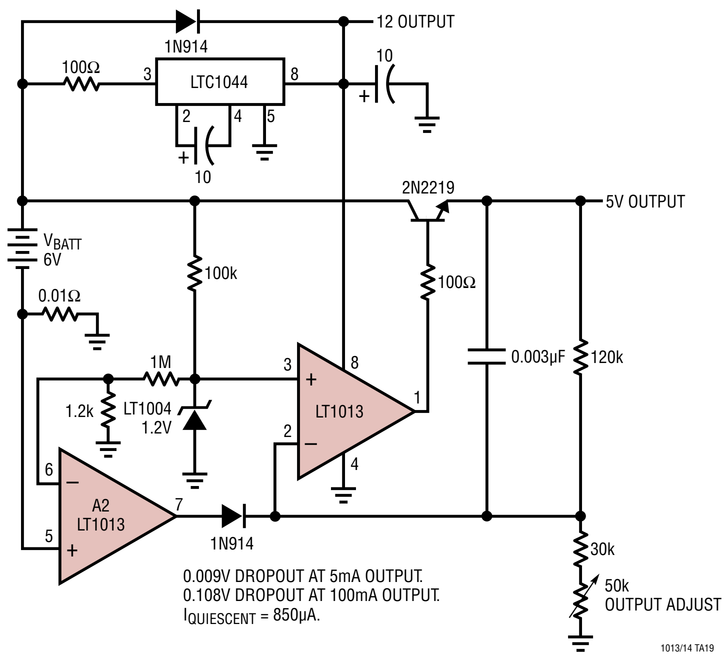


$$\text{GAIN} = \left(1 + \frac{2R1}{R_G}\right)\frac{R3}{R2}$$

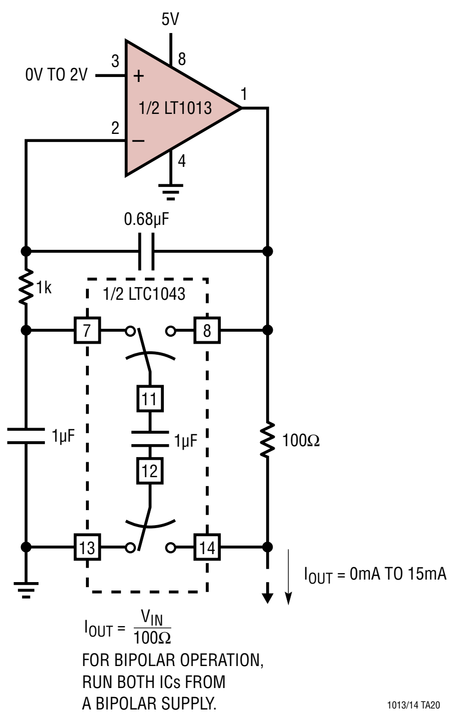
INPUT BIAS CURRENT TYPICALLY <1nA
INPUT RESISTANCE = 3R = 15M FOR VALUES SHOWN
NEGATIVE COMMON MODE LIMIT = $V^- + I_B \times 2R + 30mV$
$= 150mV$ for $V^- = 0V$
$I_B = 12nA$

TYPICAL APPLICATIONS

Low Dropout Regulator for 6V Battery

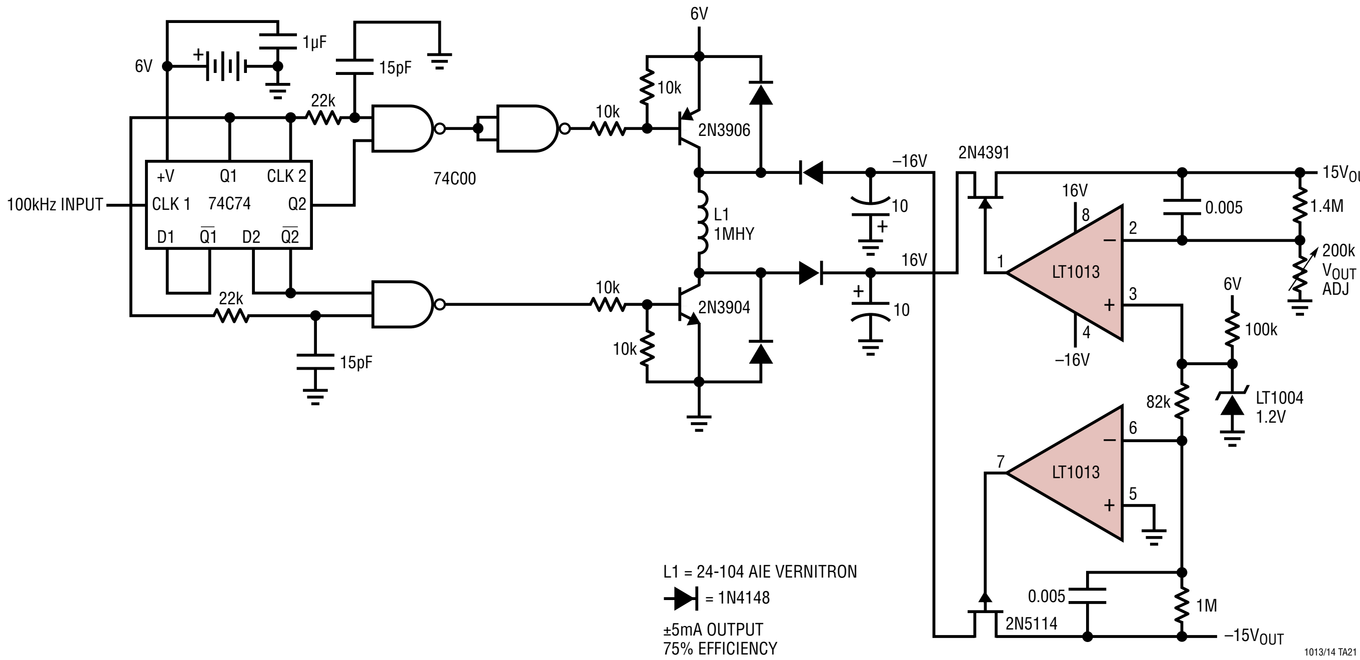


Voltage Controlled Current Source with Ground Referred Input and Output

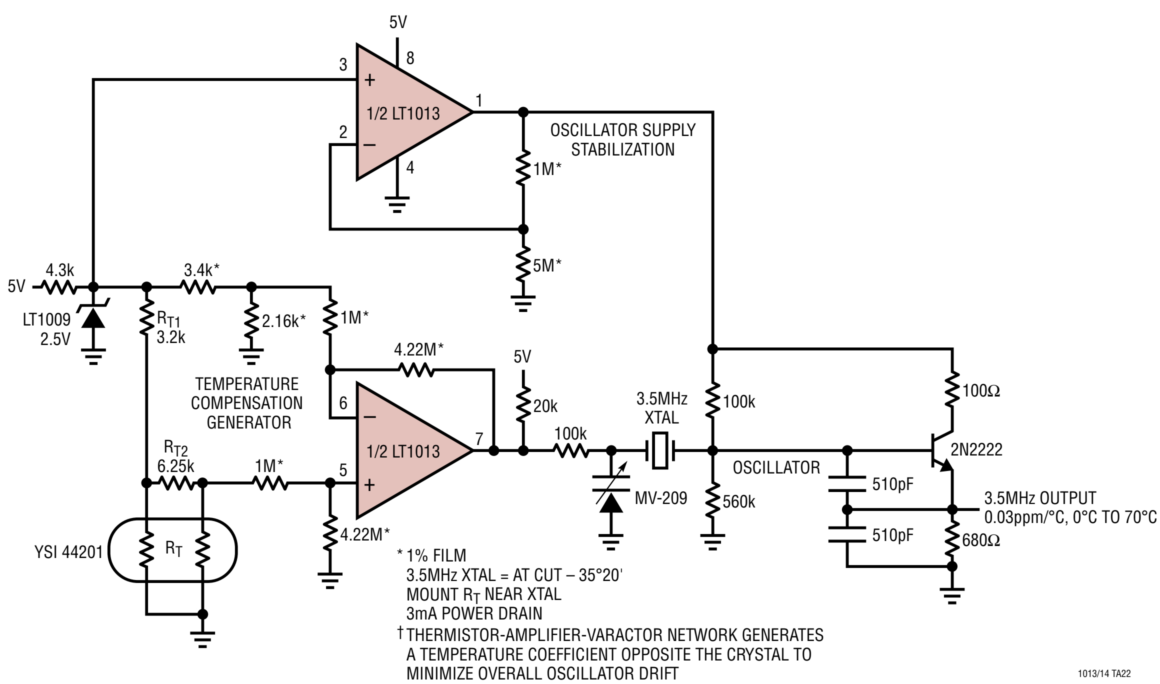


TYPICAL APPLICATIONS

6V to ±15V Regulating Converter

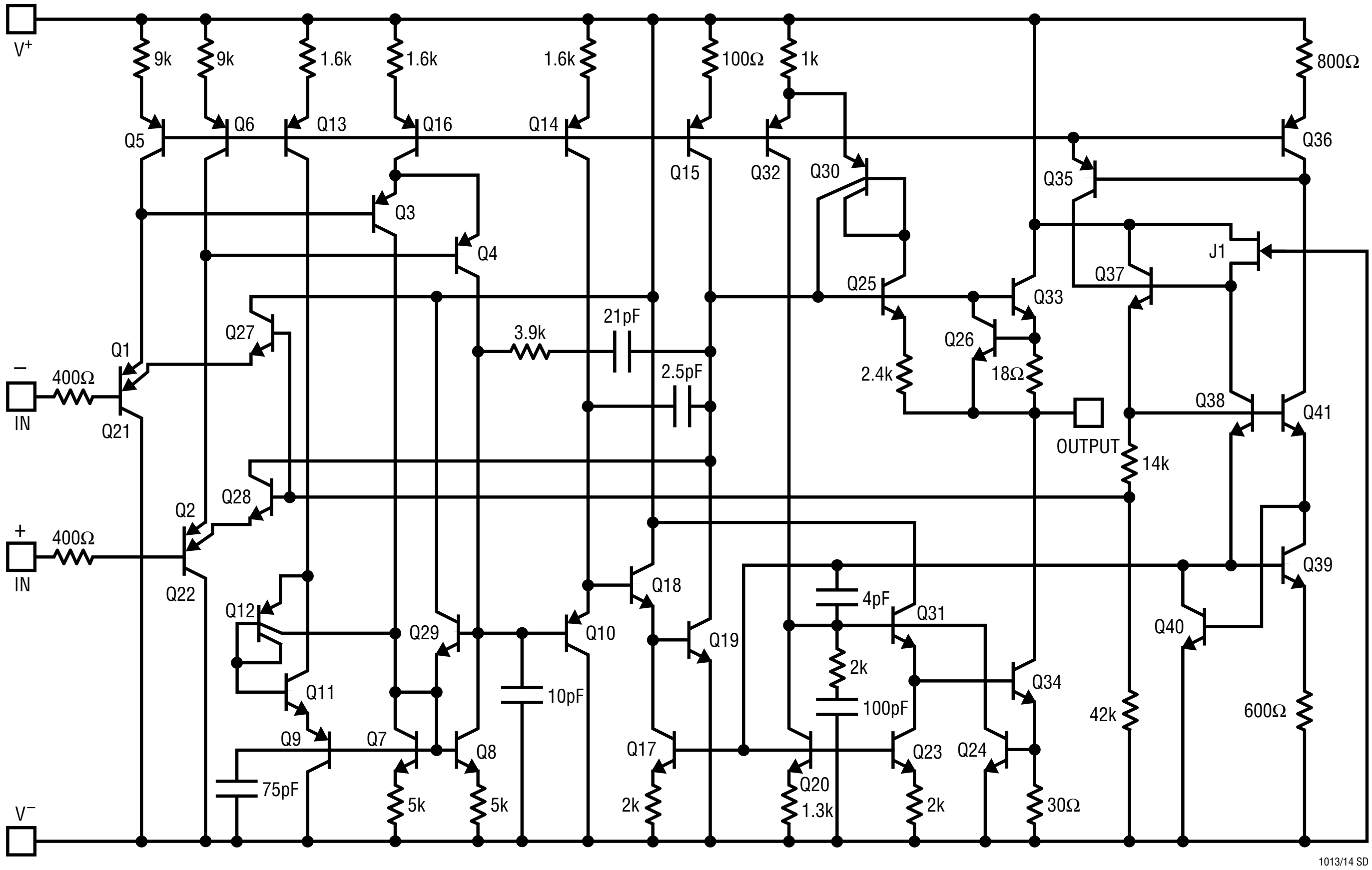


Low Power, 5V Driven, Temperature Compensated Crystal Oscillator (TXCO)†



SCHEMATIC DIAGRAM

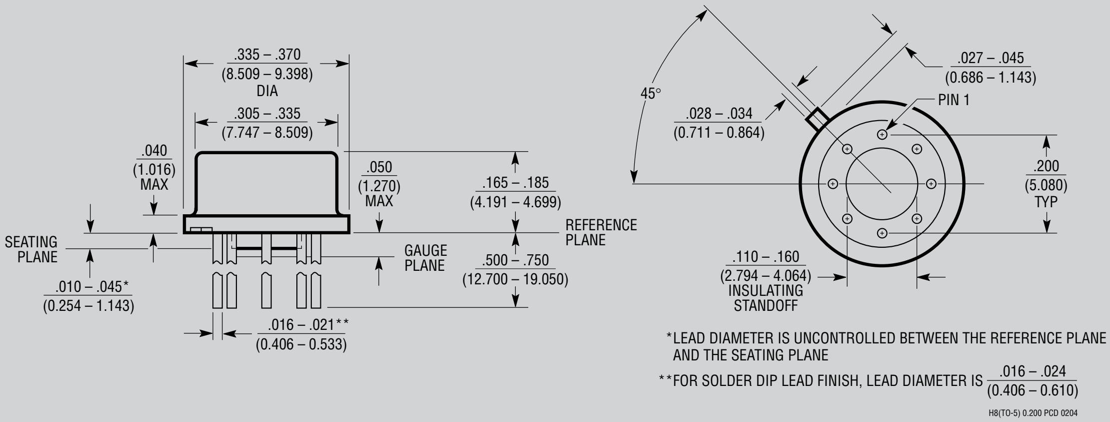
1/2 LT1013, 1/4 LT1014



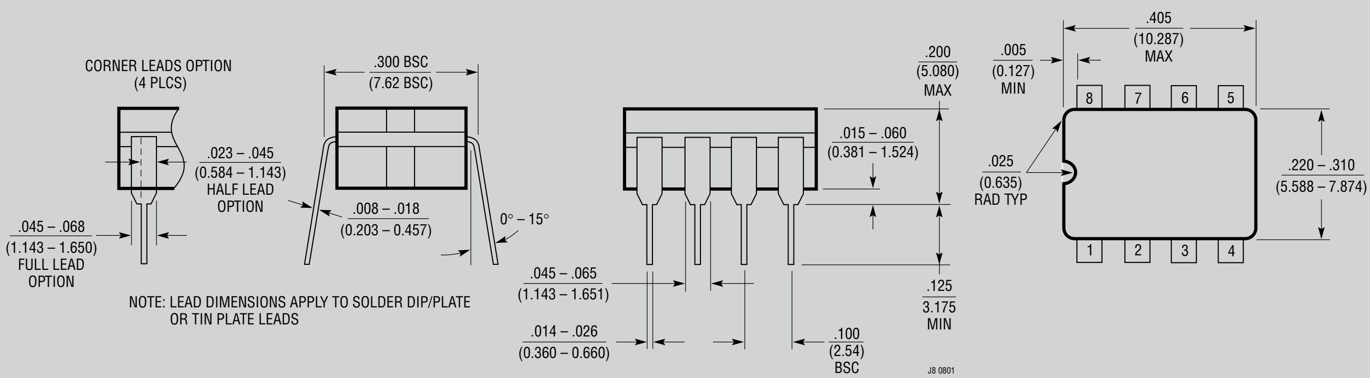
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/product/LT1013#packaging for the most recent package drawings.

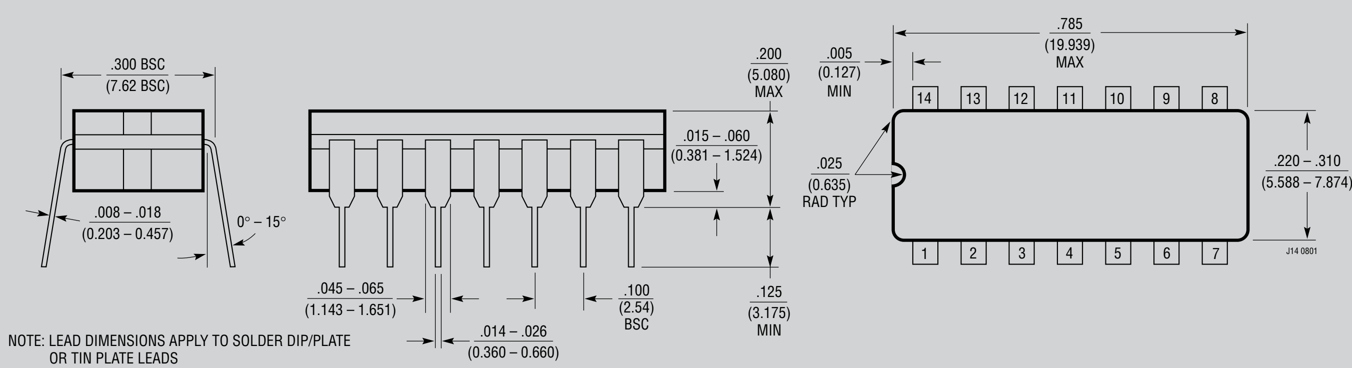
H Package
8-Lead TO-5 Metal Can (.200 Inch PCD)
(Reference LTC DWG # 05-08-1320)



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



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



OBSOLETE PACKAGES

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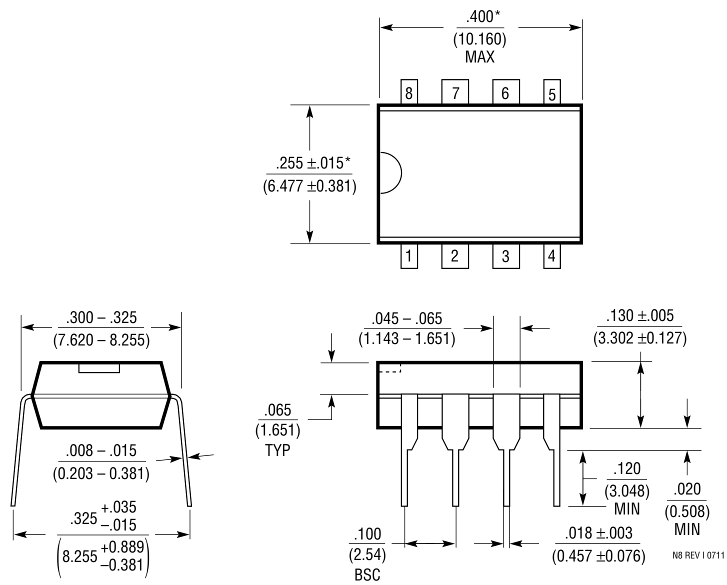
PACKAGE DESCRIPTION

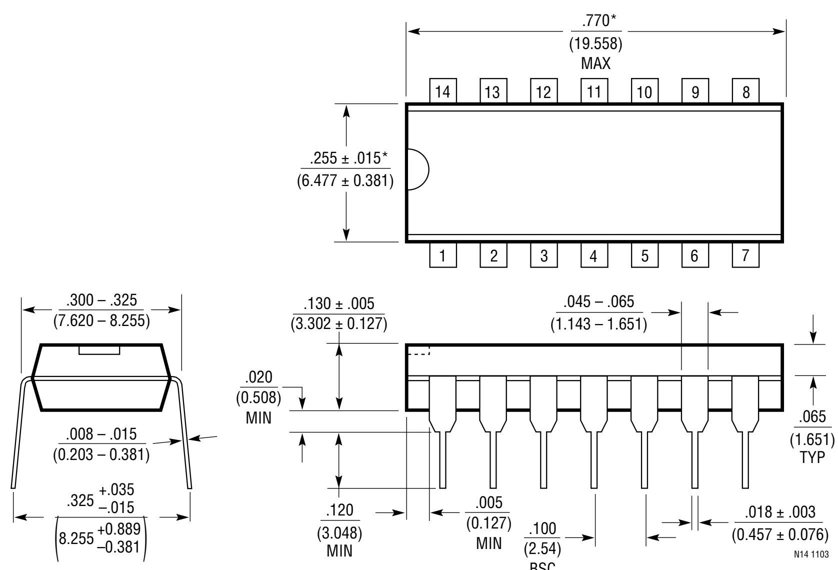
Please refer to http://www.linear.com/product/LT1013#packaging for the most recent package drawings.

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



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)

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

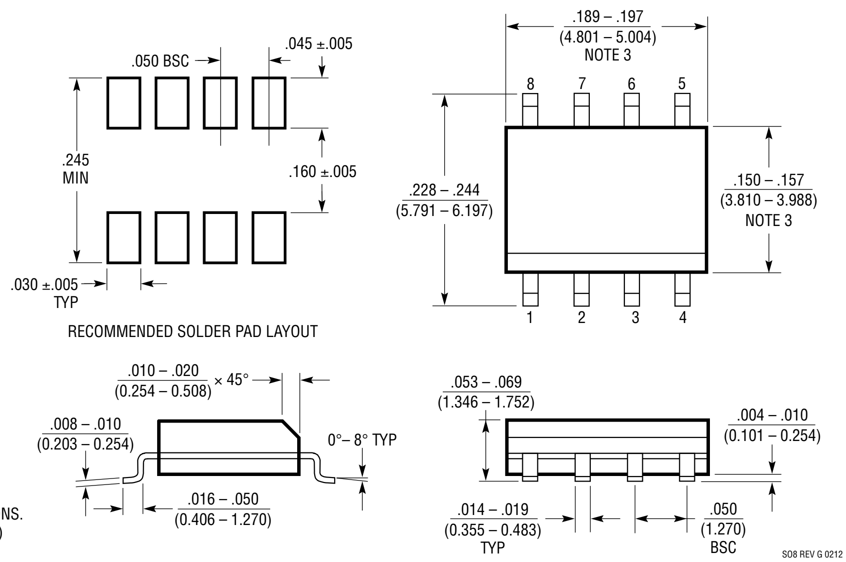


NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

PACKAGE DESCRIPTION

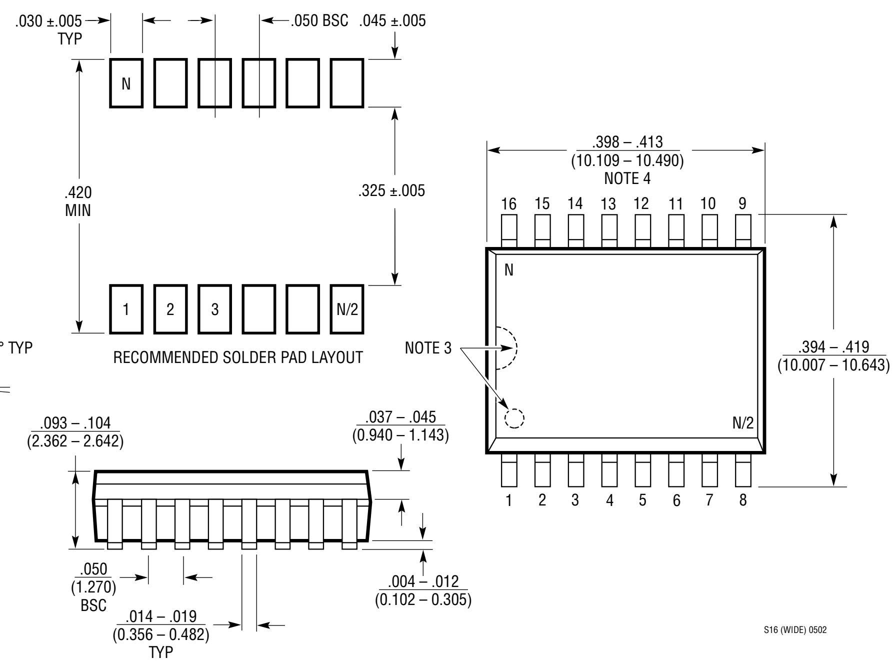
Please refer to http://www.linear.com/product/LT1013#packaging for the most recent package drawings.

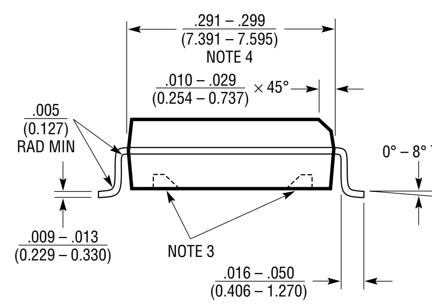
S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610 Rev G)



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

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





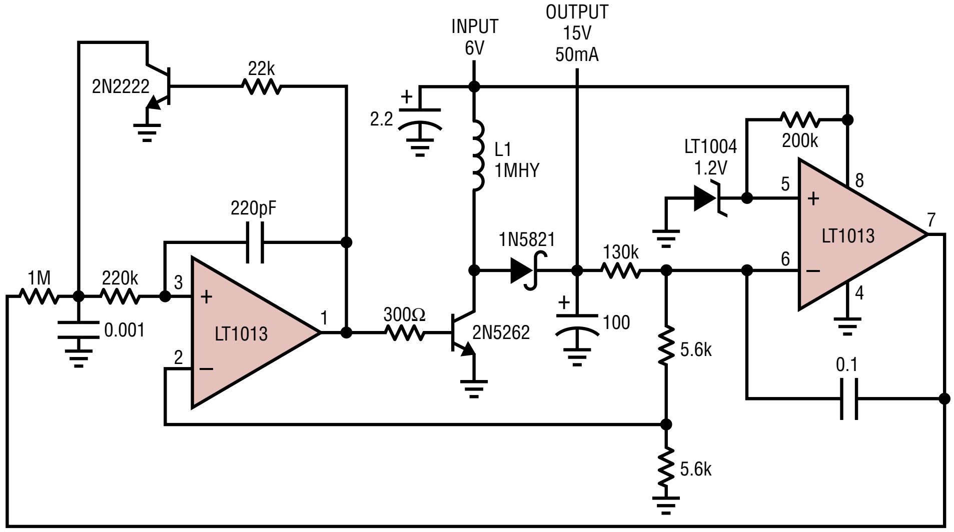
NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS
4. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

REVISION HISTORY (Revision history begins at Rev D)

REV	DATE	DESCRIPTION	PAGE NUMBER
D	05/10	Updates to Typical Application "Hot-Wire Anemometer"	12
		Updated Related Parts	26
E	05/16	Corrected Package Drawing	24

TYPICAL APPLICATION

Step-Up Switching Regulator for 6V Battery



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}
LTC6081/LTC6082	Dual/Quad 400µA Precision Rail-to-Rail Amplifier	V_S = 2.7V to 6V, 400µA Max I_S, 70µV V_{OS} 0.8µV/°C TCV_{OS}
LTC6078/LTC6079	Dual/Quad 72µA Precision Rail-to-Rail Amplifier	V_S = 2.7V to 6V, 72µA Max I_S, 25µV V_{OS} 0.7µV/°C TCV_{OS}

Linear Technology Corporation
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