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 0.55μVp-p
- Low Current Noise—Better than OP-07, 0.07 pA/√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

DESCRIPTION

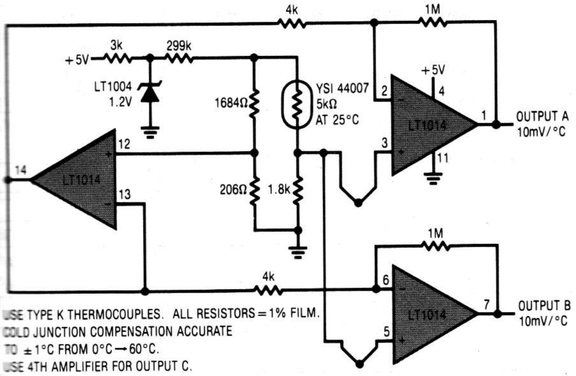
The LT1014 is the first precision quad operational amplifier which directly upgrades designs in the industry standard 14-pin DIP LM324/LM348/OP-11/4156 pin configuration. It is no longer necessary to compromise specifications, while saving board space and cost, as compared to single operational amplifiers.

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.

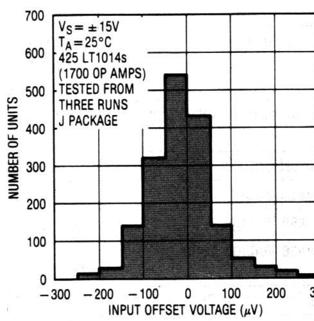
Similarly, the LT1013 is the first precision dual op amp in the 8-pin industry standard configuration, upgrading the performance of such popular devices as the MC1458/1558, LM158 and OP-221. The LT1013's specifications are similar to (even somewhat better than) the LT1014's.

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 ±15V and single 5V supplies.

3 Channel Thermocouple Thermometer



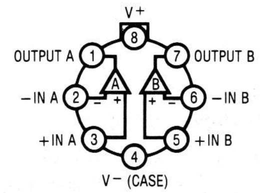
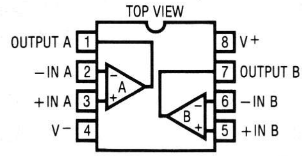
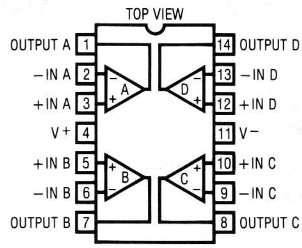
LT1014 Distribution of Offset Voltage



ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . ±22V
Differential Input Voltage . . . . ±30V
Input Voltage . . . . Equal to Positive Supply Voltage
. . . . . . 5V Below Negative Supply Voltage
Output Short Circuit Duration . . . . Indefinite
Operating Temperature Range
LT1013AM/LT1013M/
LT1014AM/LT1014M . . . . −55°C to 125°C
LT1013AC/1013C/1013D
LT1014AC/1014C/1014D . . . . 0°C to 70° C
Storage Temperature Range
All Grades . . . . −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) . . . . 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
 METAL CAN H PACKAGE	LT1013AMH LT1013MH LT1013ACH LT1013CH
 HERMETIC DIP J8 PACKAGE PLASTIC DIP N8 PACKAGE	LT1013AMJ8 LT1013MJ8 LT1013ACJ8 LT1013CJ8 LT1013CN8 LT1013DN8
 HERMETIC DIP J14 PACKAGE PLASTIC DIP N14 PACKAGE	LT1014AMJ LT1014MJ LT1014ACJ LT1014CJ LT1014CN LT1014DN

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	LT1013AM LT1013AC LT1014AM LT1014AC MIN	TYP	MAX	LT1013M/LT1013C LT1013DN8 LT1014M/LT1014C LT1014DN MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1013 LT1014 LT1013DN8/LT1014DN	— — —	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_{OS}	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	—	μVp-p
e_n	Input Noise Voltage Density	$f_0 = 10Hz$ $f_0 = 1000Hz$	— —	24 22	— —	— —	24 22	— —	$nV/\sqrt{Hz}$ $nV/\sqrt{Hz}$
i_n	Input Noise Current Density	$f_0 = 10Hz$	—	0.07	—	—	0.07	—	$pA/\sqrt{Hz}$
	Input Resistance—Differential Common-Mode	(Note 1)	100 —	400 5	— —	70 —	300 4	— —	MΩ GΩ

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	LT1013AM LT1013AC LT1014AM LT1014AC MIN	TYP	MAX	LT1013M/LT1013C LT1013DN8 LT1014M/LT1014C LT1014DN MIN	TYP	MAX	UNITS
A_{VOL}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 2k$ $V_O = \pm 10V$, $R_L = 600\Omega$	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	$V_S = \pm 2V$ 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

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

SYMBOL	PARAMETER	CONDITIONS	LT1013AM LT1013AC LT1014AM LT1014AC MIN	TYP	MAX	LT1013M/LT1013C LT1013DN8 LT1014M/LT1014C LT1014DN MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1013 LT1014 LT1013DN8/LT1014DN	— — —	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 $4V$, $R_L = 500\Omega$	—	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 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 $V_S = \pm15V$, $V_{CM} = 0V$, $-55°C \le T_A \le 125°C$ 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 2)	●	—	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 $V_S = \pm15V$, $V_{CM} = 0V$, $0°C \le T_A \le 70°C$ unless otherwise noted

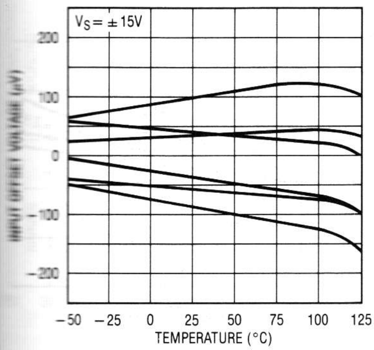
SYMBOL	PARAMETER	CONDITIONS		LT1013AC MIN	LT1013AC TYP	LT1013AC MAX	LT1014AC MIN	LT1014AC TYP	LT1014AC MAX	LT1013C/LT1013DN8 LT1014C/LT1014DN MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●	—	55	240	—	65	270	—	80	400	μV
		LT1013DN8, LT1014DN	●	—	—	—	—	—	—	—	230	1000	μV
		$V_S = +5V, 0V; V_O = 1.4V$	●	—	75	350	—	85	380	—	110	570	μV
		LT1013DN8, LT1014DN	●	—	—	—	—	—	—	—	280	1200	μV
	Average Input Offset Voltage Drift	(Note 2)	●	—	0.3	2.0	—	0.3	2.0	—	0.4	2.5	μV/°C
		LT1013DN, LT1014DN	●	—	—	—	—	—	—	—	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 2: This parameter is not 100% tested.

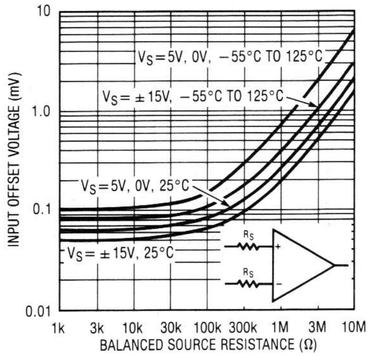
The ● denotes the specifications which apply over the full operating temperature range.

TYPICAL PERFORMANCE CHARACTERISTICS

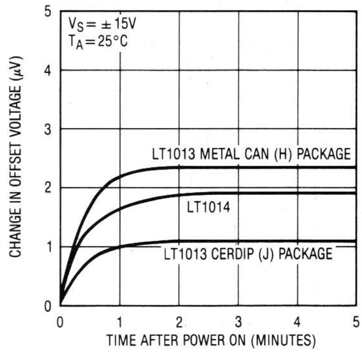
Offset Voltage Drift with Temperature of Representative Units



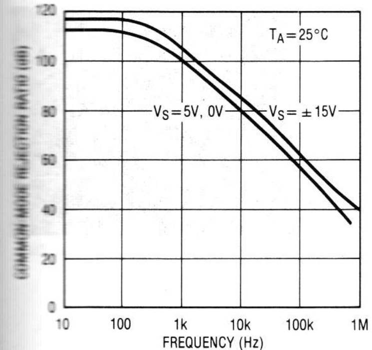
Offset Voltage vs Balanced Source Resistance



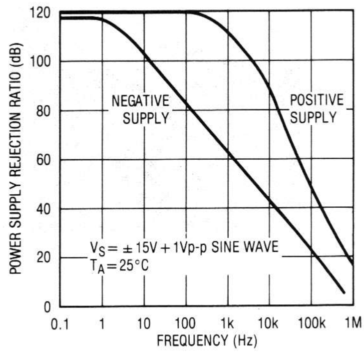
Warm-Up Drift



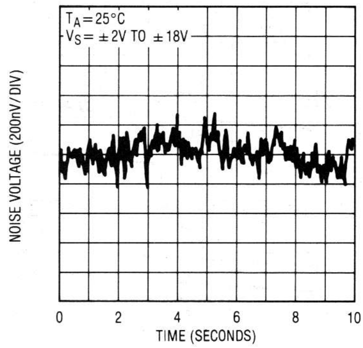
Common-Mode Rejection Ratio vs Frequency



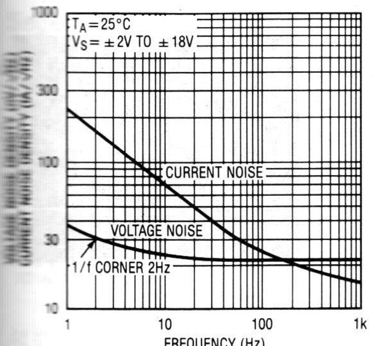
Power Supply Rejection Ratio vs Frequency



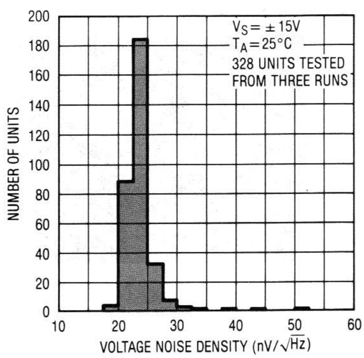
0.1Hz to 10Hz Noise



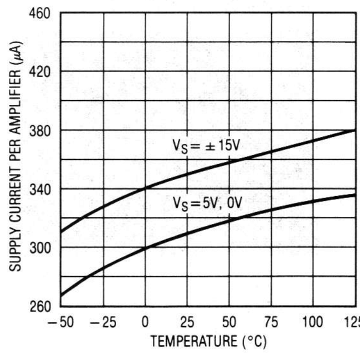
Noise Spectrum



10Hz Voltage Noise Distribution

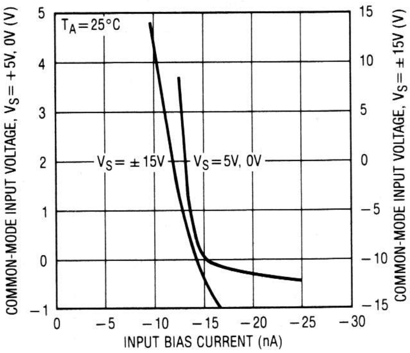


Supply Current vs Temperature

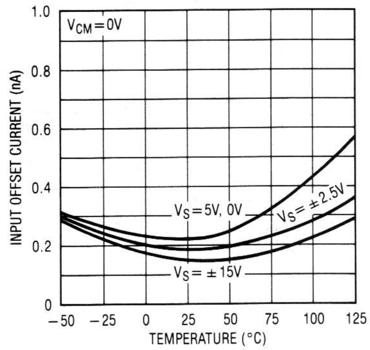


TYPICAL PERFORMANCE CHARACTERISTICS

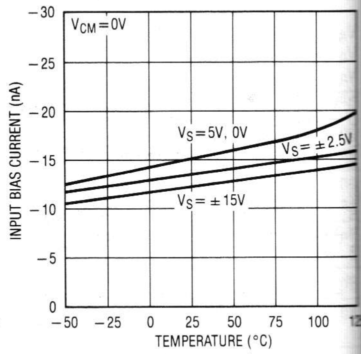
Input Bias Current vs Common-Mode Voltage



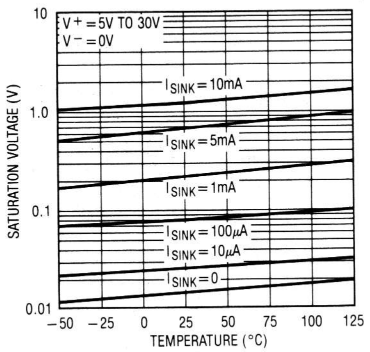
Input Offset Current vs Temperature



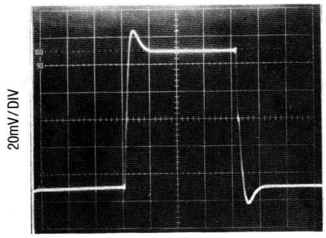
Input Bias Current vs Temperature



Output Saturation vs Sink Current vs Temperature

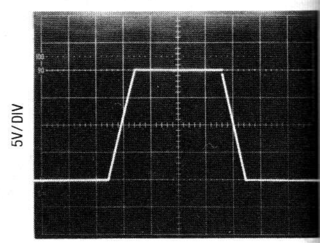


Small Signal Transient Response, $V_S = \pm 15V$



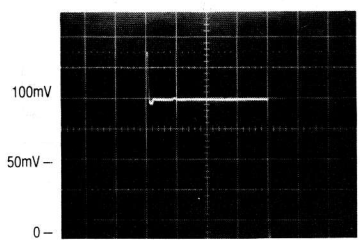
$A_V = +1$ 2µs/DIV

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



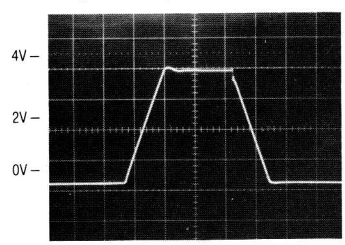
$A_V = +1$ 50µs/DIV

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



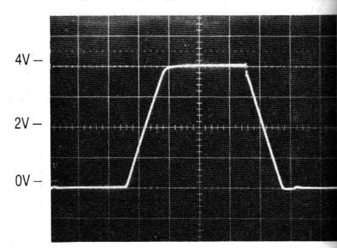
$A_V = +1$ 20µs/DIV
$R_L = 600\Omega$ TO GROUND
INPUT = 0V TO 100mV PULSE

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



$A_V = +1$ 10µs/DIV
$R_L = 4.7k$ to 5V
INPUT = 0V TO 4V PULSE

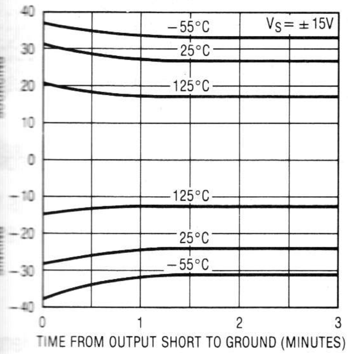
Large Signal Transient Response, $V_S = 5V, 0V$



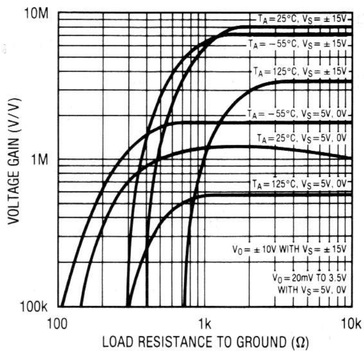
$A_V = +1$ 10µs/DIV
NO LOAD
INPUT = 0V TO 4V PULSE

TYPICAL PERFORMANCE CHARACTERISTICS

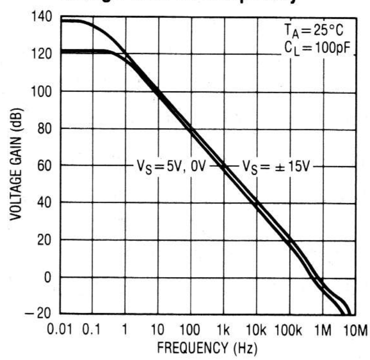
Output Short Circuit Current vs Time



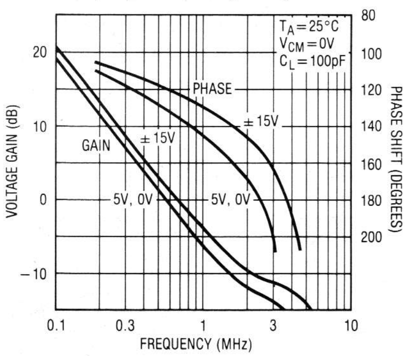
Voltage Gain vs Load Resistance



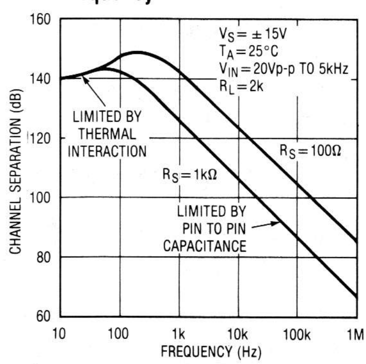
Voltage Gain vs Frequency



Gain, Phase vs Frequency



Channel Separation vs Frequency



APPLICATIONS INFORMATION

Single Supply Operation

The LT1013/1014 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 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 LT1013/1014'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.

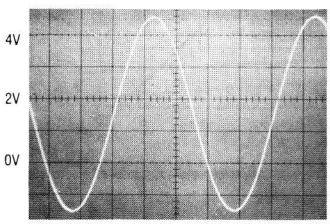
In dual supply operations, the output stage is crossover distortion-free.

Comparator Applications

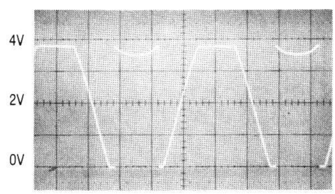
The single supply operation of the LT1013/1014 lends itself to its use as a precision comparator with TTL compatible output:

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

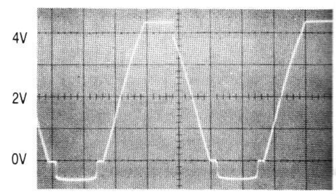
Voltage Follower with Input Exceeding the Negative Common-Mode Range



6Vp-p INPUT, −1.5V TO 4.5V

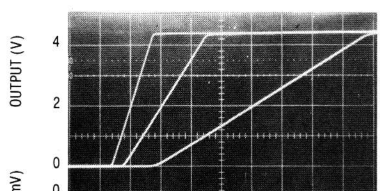


LM324, LM358, OP-20 EXHIBIT OUTPUT PHASE REVERSAL

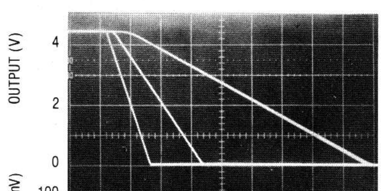


LT1013/LT1014 NO PHASE REVERSAL

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



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



APPLICATIONS INFORMATION

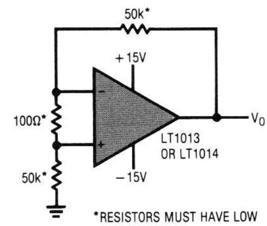
Low Supply Operation

The minimum supply voltage for proper operation of the LT1013/1014 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 application information on noise testing and calculations, please see the LT1007 or LT1008 data sheet.

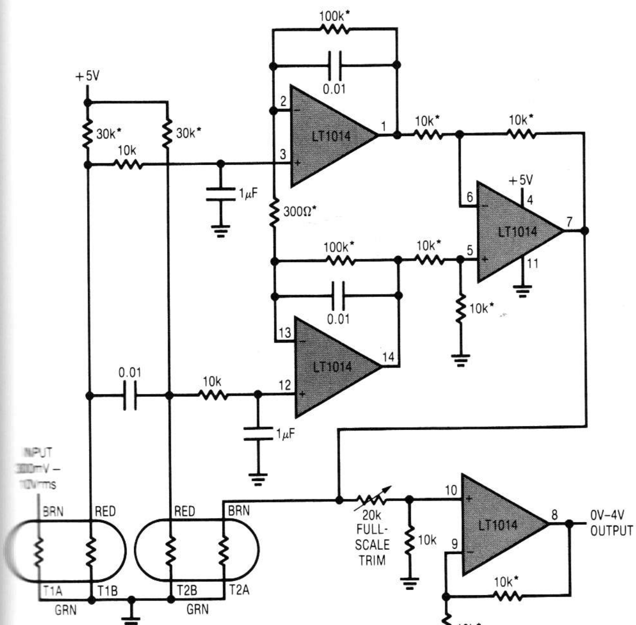
Test Circuit for Offset Voltage and Offset Drift with Temperature



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

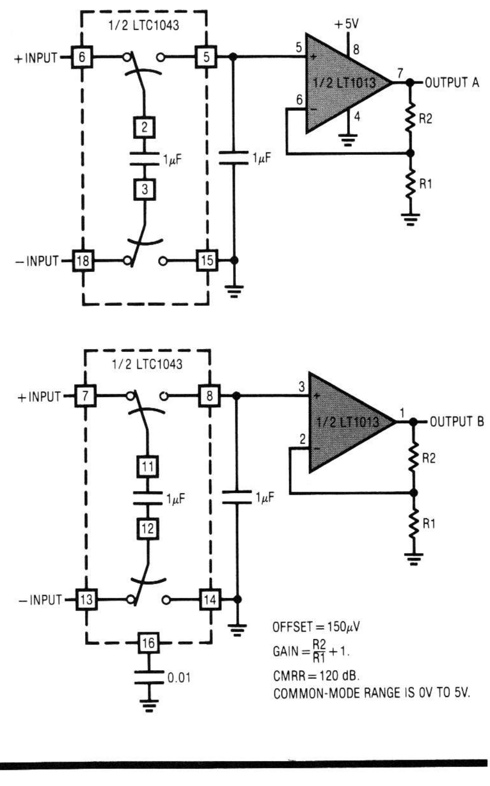
TYPICAL APPLICATIONS

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.

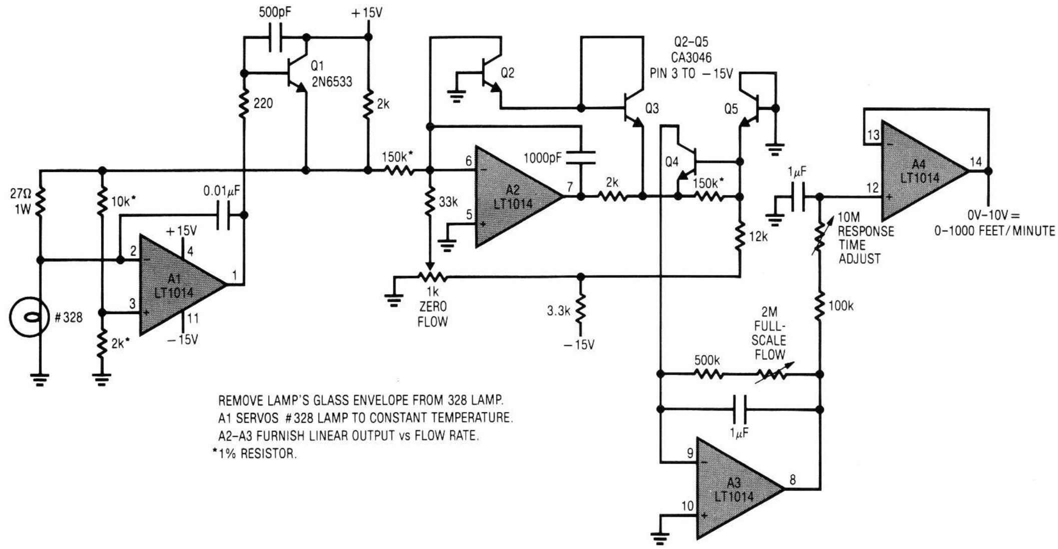
5V Single Supply Dual Instrumentation Amplifier



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

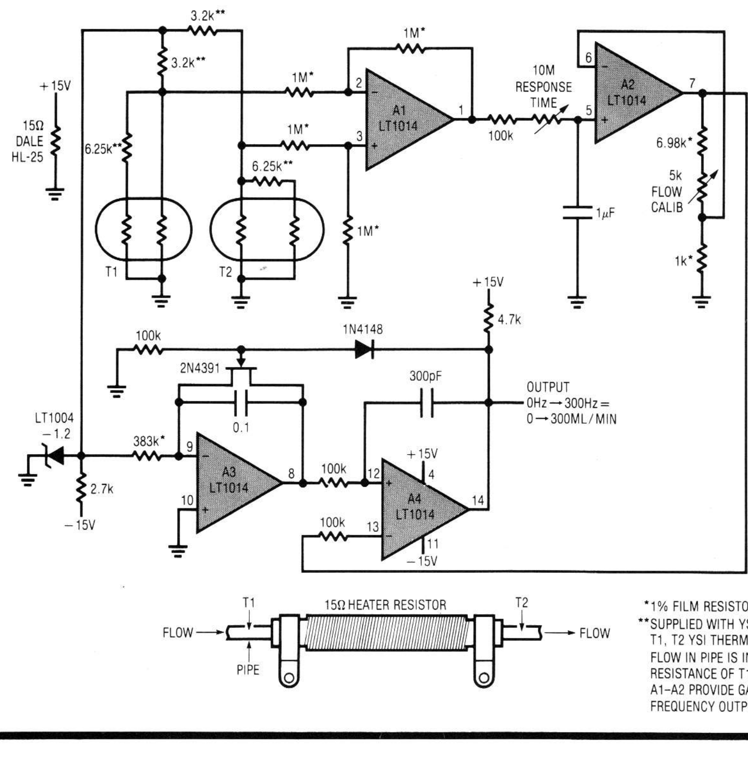
TYPICAL APPLICATIONS

Hot Wire Anemometer



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

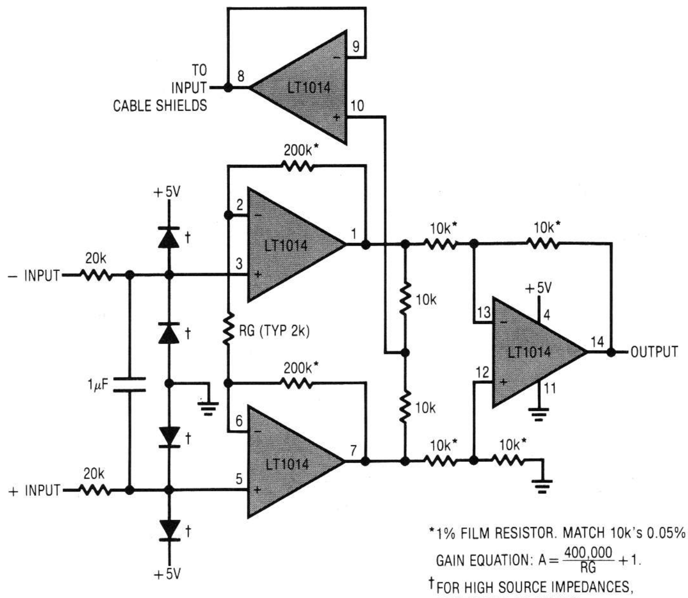
Liquid Flowmeter



*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.

TYPICAL APPLICATIONS

5V Powered Precision Instrumentation Amplifier

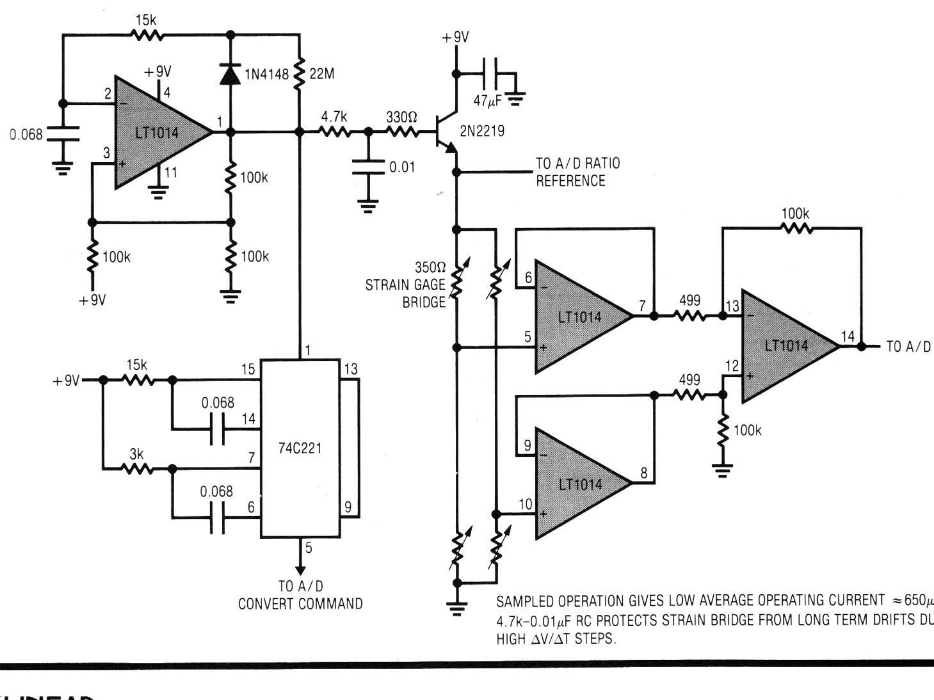


*1% FILM RESISTOR. MATCH 10k's 0.05%

GAIN EQUATION: $A = \frac{400{,}000}{RG} + 1.$

†FOR HIGH SOURCE IMPEDANCES, USE 2N2222 AS DIODES.

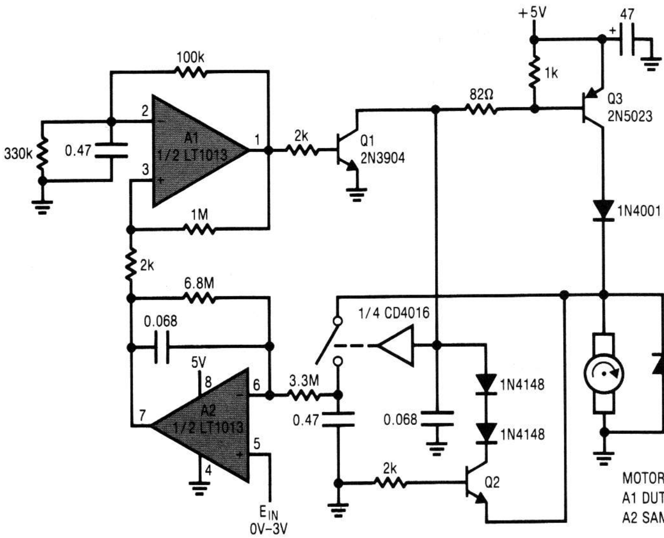
9V Battery Powered Strain Gage Signal Conditioner



SAMPLED OPERATION GIVES LOW AVERAGE OPERATING CURRENT ≈ 650µA.
4.7k–0.01µF RC PROTECTS STRAIN BRIDGE FROM LONG TERM DRIFTS DUE TO HIGH ΔV/ΔT STEPS.

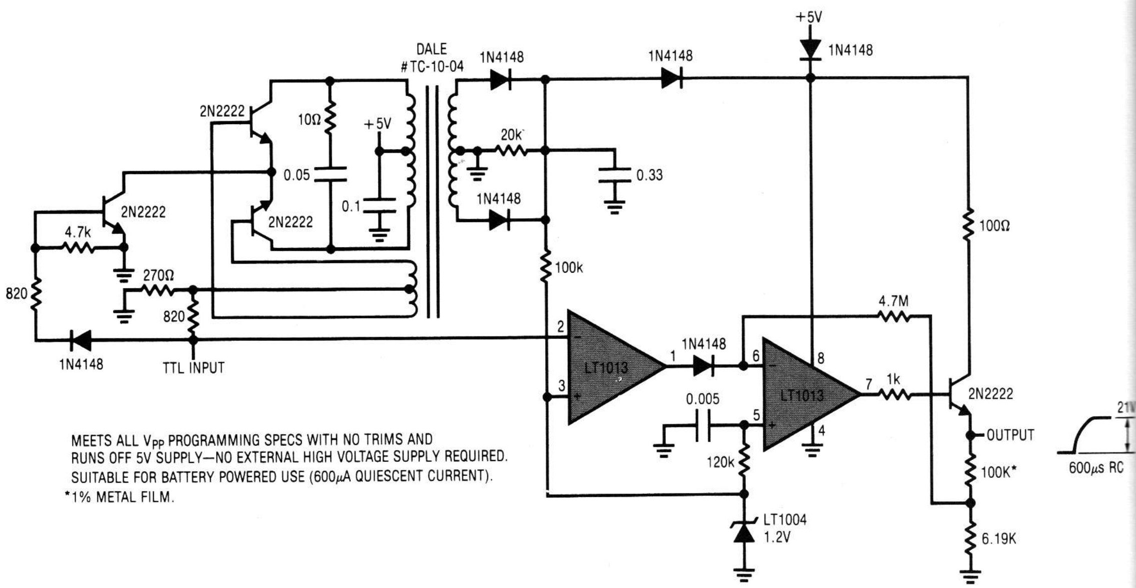
TYPICAL APPLICATIONS

5V Powered Motor Speed Controller
No Tachometer Required



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

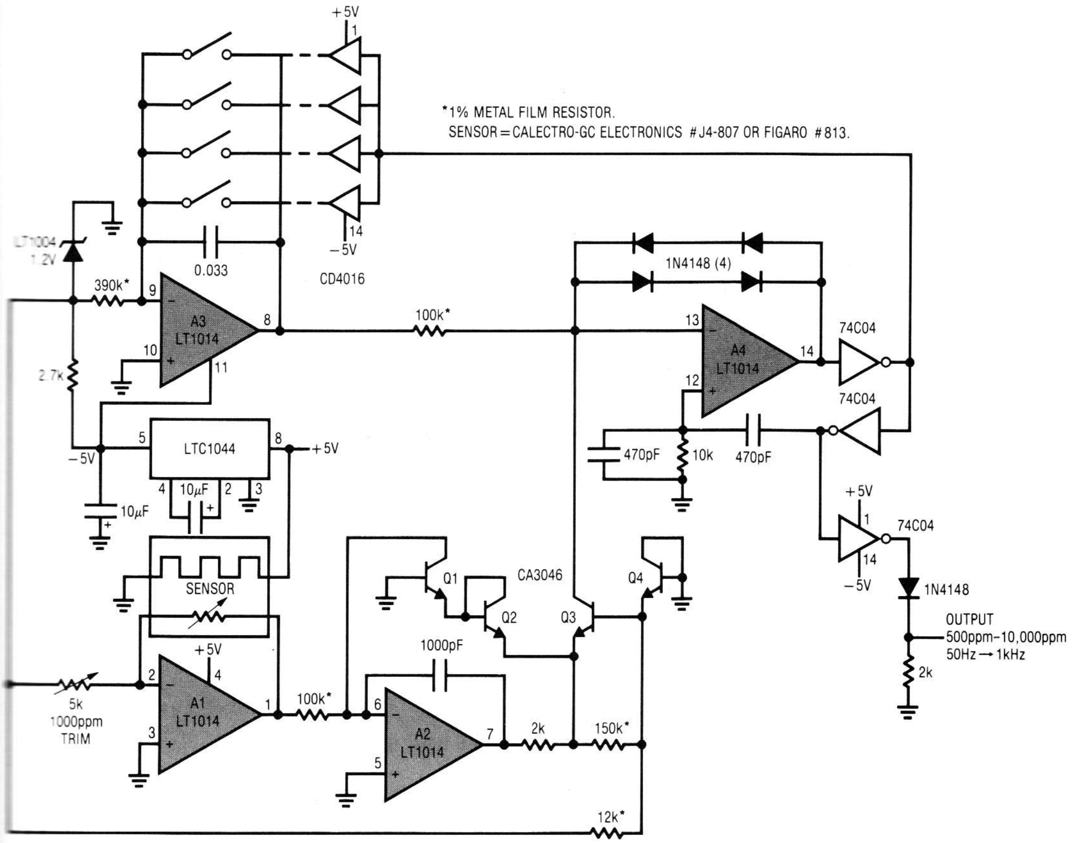
5V Powered EEPROM Pulse Generator



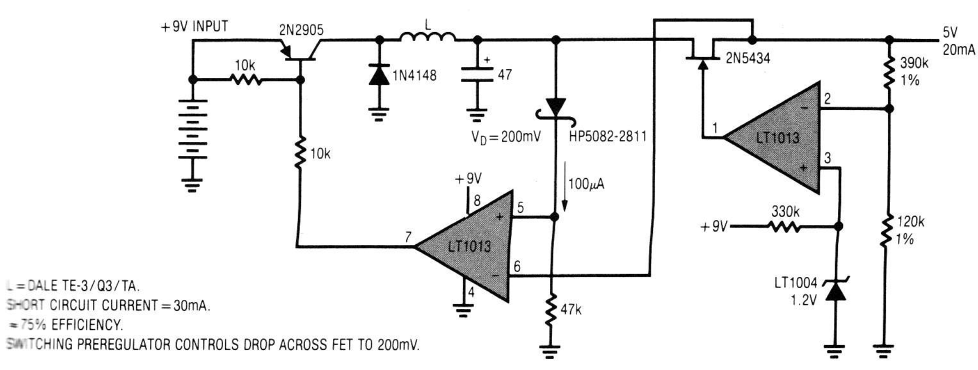
MEETS ALL V_{PP} PROGRAMMING SPECS WITH NO TRIMS AND RUNS OFF 5V SUPPLY—NO EXTERNAL HIGH VOLTAGE SUPPLY REQUIRED. SUITABLE FOR BATTERY POWERED USE (600μA QUIESCENT CURRENT).
*1% METAL FILM.

TYPICAL APPLICATIONS

Methane Concentration Detector with Linearized Output

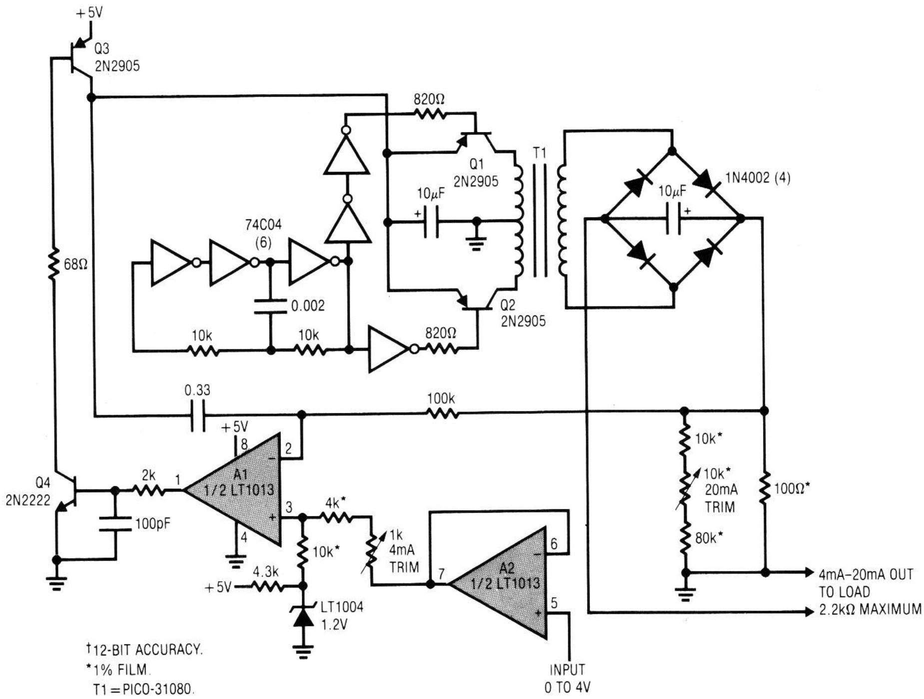


Low Power 9V to 5V Converter



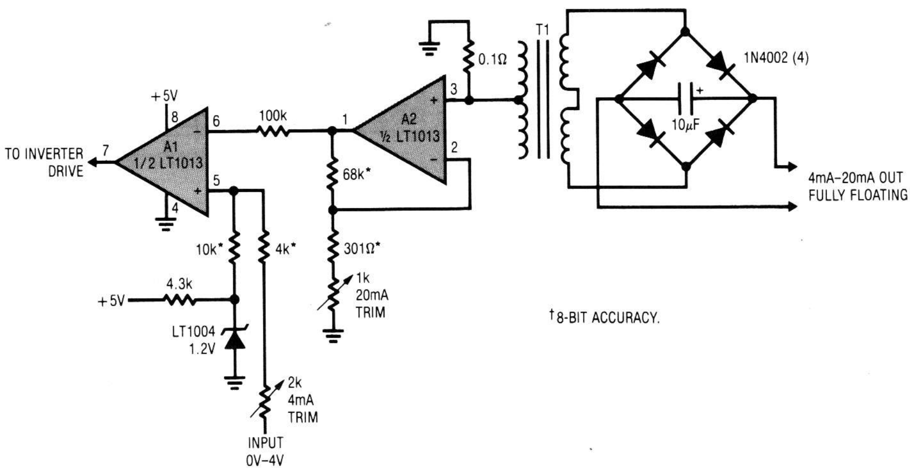
TYPICAL APPLICATIONS

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



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

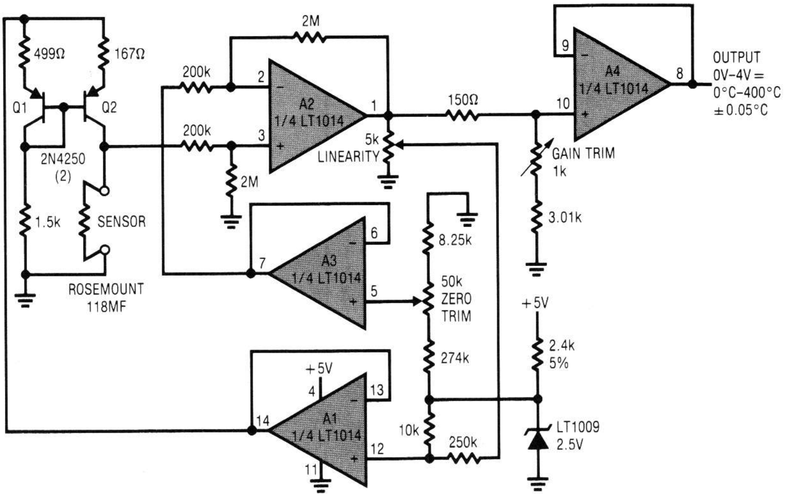
Fully Floating Modification to 4mA-20mA Current Loop †



†8-BIT ACCURACY.

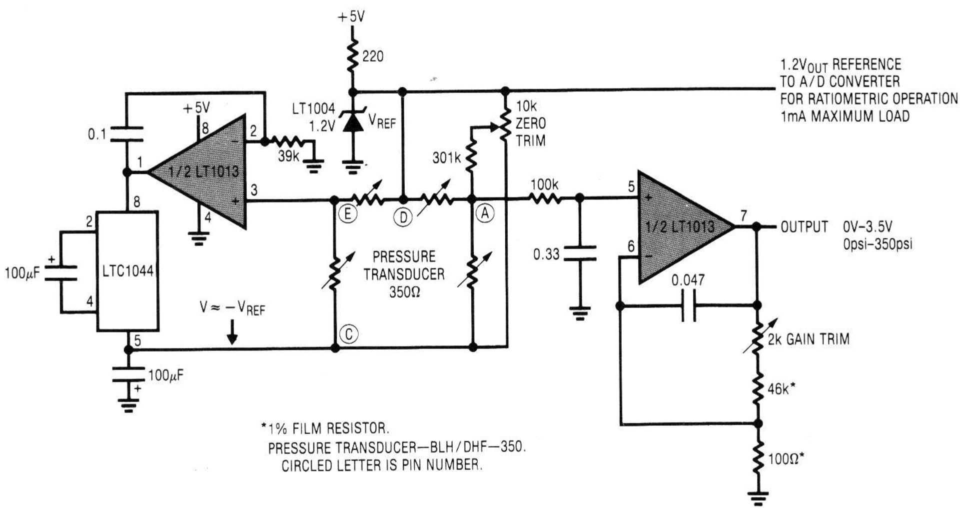
TYPICAL APPLICATIONS

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.

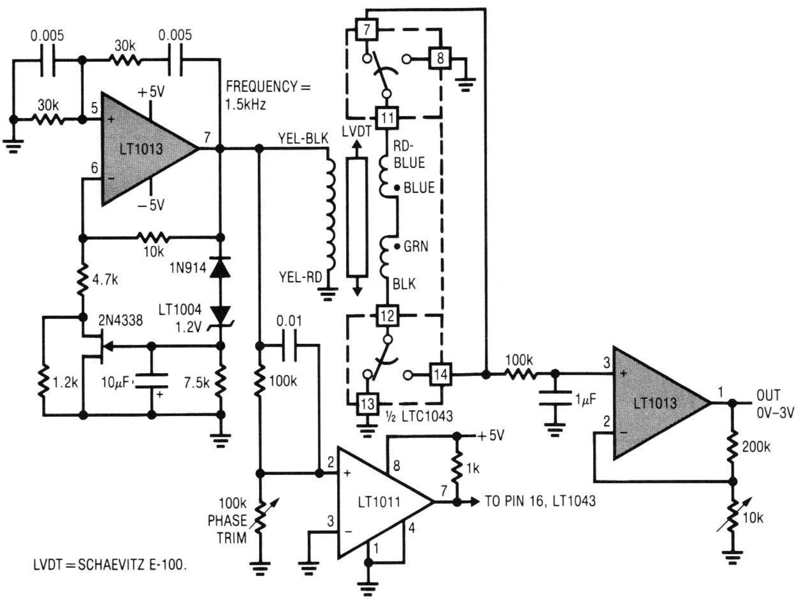
Strain Gage Bridge Signal Conditioner



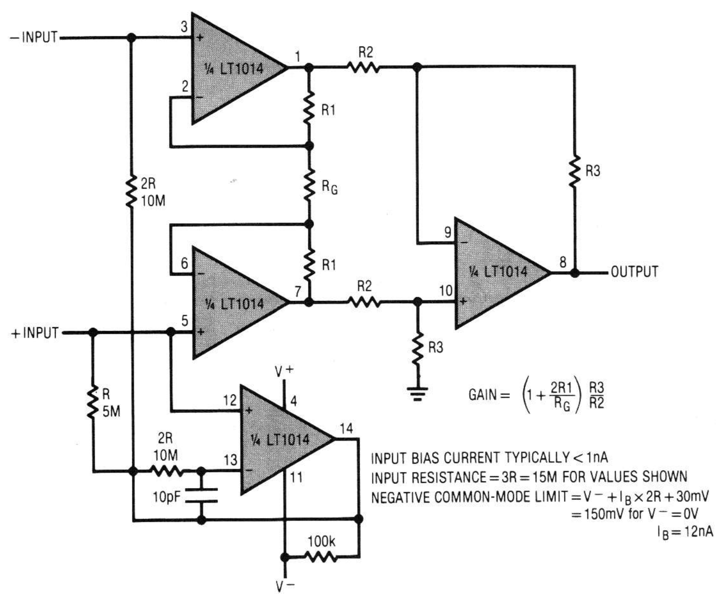
*1% FILM RESISTOR.
PRESSURE TRANSDUCER—BLH/DHF—350.
CIRCLED LETTER IS PIN NUMBER.

TYPICAL APPLICATIONS

LVDT Signal Conditioner

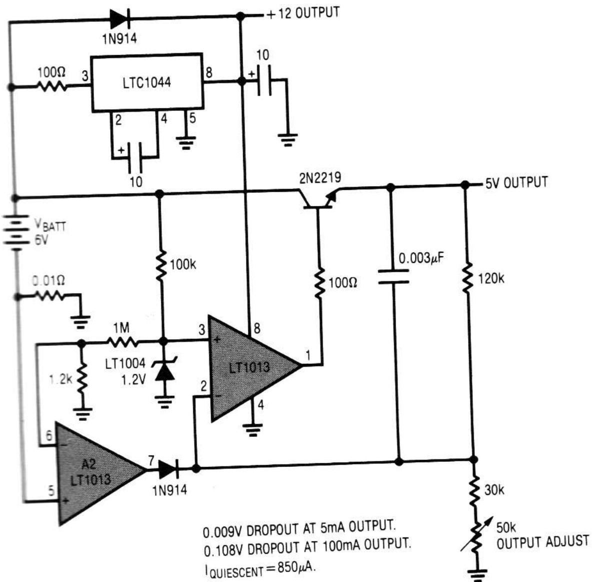


Triple Op Amp Instrumentation Amplifier with Bias Current Cancellation

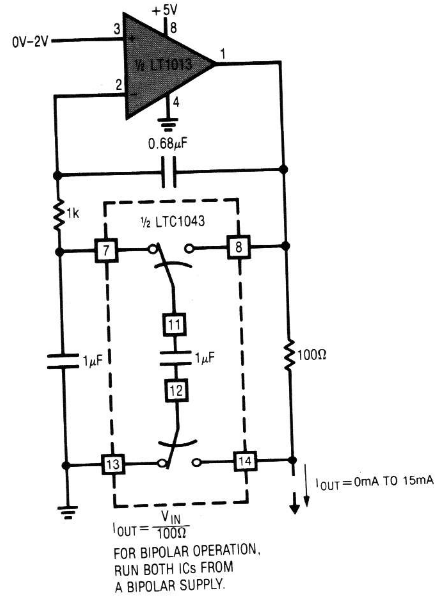


TYPICAL APPLICATIONS

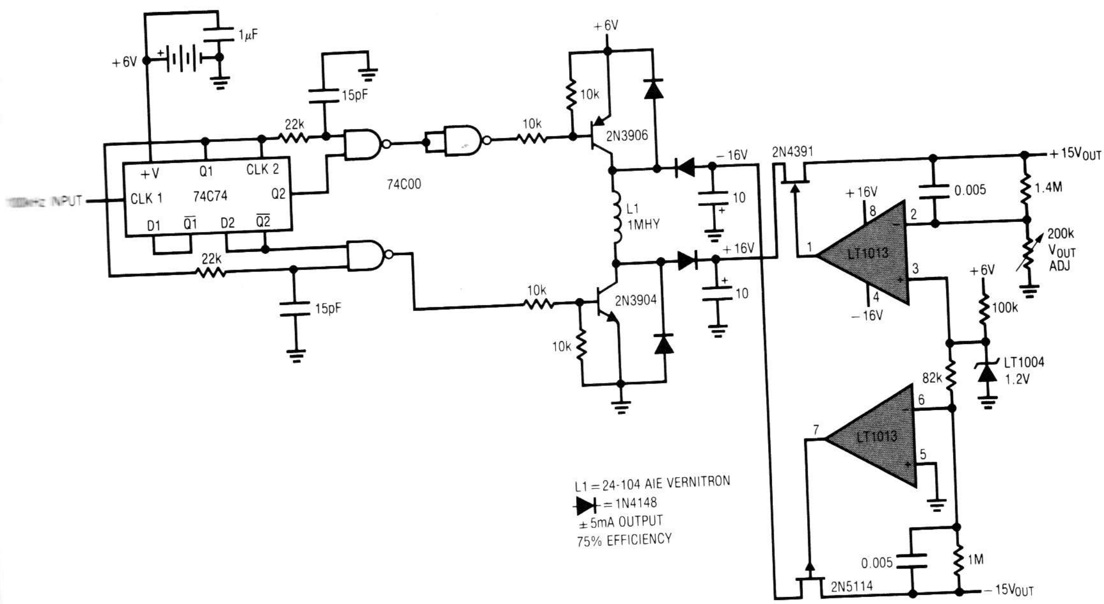
Low Dropout Regulator for 6V Battery



Voltage Controlled Current Source with Ground Referred Input and Output

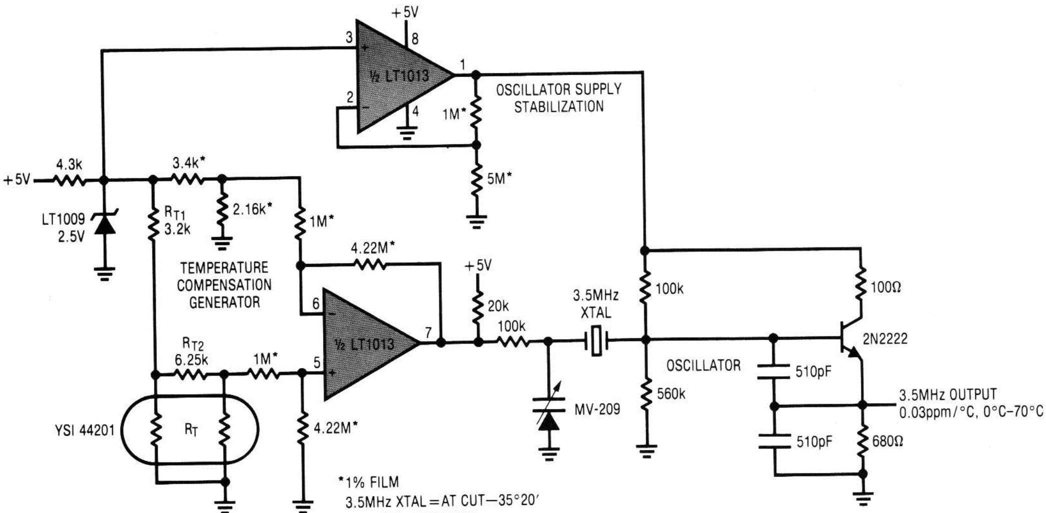


6V to ±15V Regulating Converter



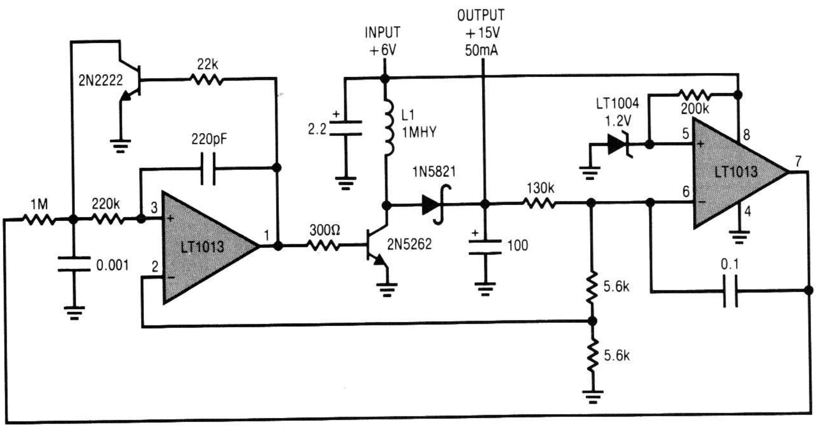
TYPICAL APPLICATIONS

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



*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

Step-Up Switching Regulator for 6V Battery

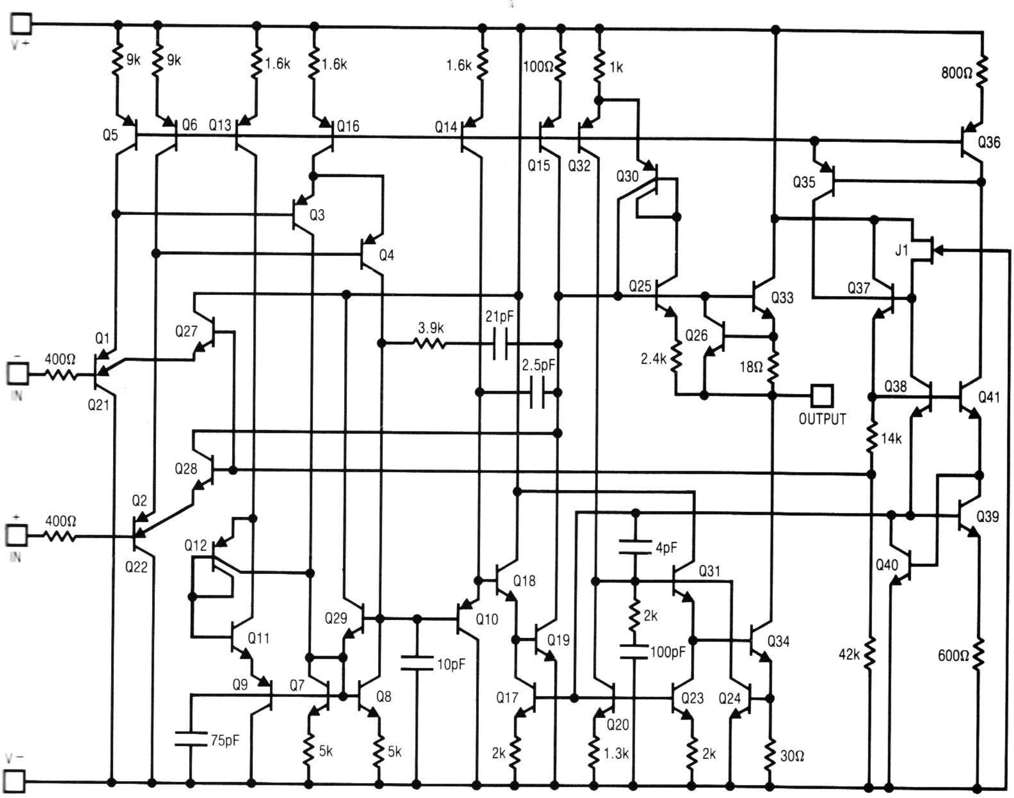


L1 = AIE—VERNITRON 24-104
78% EFFICIENCY

LM158 MC1558 | LM148 (124)

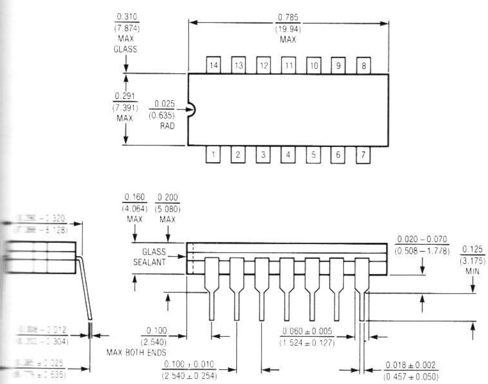
SCHEMATIC DIAGRAM

½ LT1013, ¼ LT1014



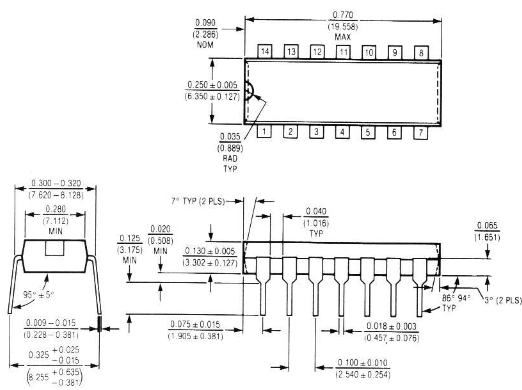
PACKAGE DESCRIPTION

J Package 14 Lead Cavity DIP



$T_j$max	Θ_{jA}
150°C	100°C/W

N Package 14 Lead Molded DIP



$T_j$max	Θ_{jA}
100°C	100°C/W