

# High Speed, Precision JFET Input Operational Amplifier

## FEATURES

- |  |                                      |
|--|--------------------------------------|
| ■ <b>Guaranteed Slew Rate</b>                        | 23V / $\mu$ s Min.                   |
| ■ <b>Guaranteed Offset Voltage</b><br>–55°C to 125°C | 250 $\mu$ V Max.<br>750 $\mu$ V Max. |
| ■ <b>Guaranteed Drift</b>                            | 5 $\mu$ V / °C Max.                  |
| ■ <b>Guaranteed Bias Current</b><br>70°C<br>125°C    | 180pA Max.<br>4nA Max.               |
| ■ <b>Gain-Bandwidth Product</b>                      | 8.5MHz Typ.                          |
| ■ <b>Settling Time to 0.05% (10V Step)</b>           | 0.9 $\mu$ s Typ.                     |

## APPLICATIONS

- Fast D/A Output Amplifiers (12, 14, 16 Bits)
- High Speed Instrumentation
- Fast, Precision Sample and Hold
- Voltage-to-Frequency Converters
- Logarithmic Amplifiers

## DESCRIPTION

The LT1022 JFET input operational amplifier combines high speed and precision performance.

A 26V /  $\mu$ s slew rate and 8.5MHz gain-bandwidth product are simultaneously achieved with offset voltage of typically 80 $\mu$ V, 1.5 $\mu$ V / °C drift, bias currents of 50pA at 70°C, 500pA at 125°C. The output delivers 20mA of load current without gain degradation.

The 250 $\mu$ V maximum offset voltage specification represents less than 1/2 least significant bit error in a 14-bit, 10V system.

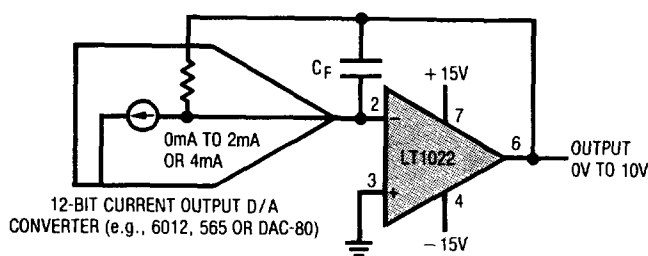
The LT1022A meets or exceeds all OP-16A and OP-16E specifications. It is faster and more accurate without stability problems at cold temperatures.

The LT1022 can be used as the output amplifier for 12-bit current output D/A converters, as shown below.

For a more accurate, lower power dissipation, but slower JFET input op amp, please refer to the LT1055 data sheet.

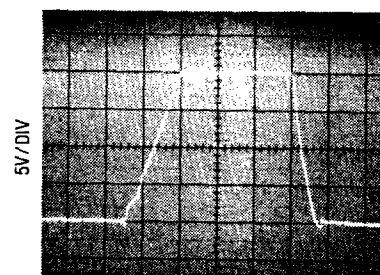
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### 12-Bit Voltage Output D/A Converter



$C_F = 15\text{pF TO } 33\text{pF}$   
 SETTLE TIME TO 2mV (0.8 LSB) = 1.5 $\mu$ s TO 2 $\mu$ s

### Large Signal Response



$A_V = 1$ ,  $C_L = 100\text{pF}$ , 0.5 $\mu$ s / DIV  
 $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage . . . . .	± 20V
Differential Input Voltage . . . . .	± 40V
Input Voltage . . . . .	± 20V
Output Short Circuit Duration . . . . .	Indefinite
Operating Temperature Range	
LT1022AM / 1022M . . . . .	− 55°C to 125°C
LT1022AC / 1022C . . . . .	0°C to 70°C
Storage Temperature Range	
All Devices . . . . .	− 65°C to 150°C
Lead Temperature (Soldering, 10 sec.) . . . . .	300°C

**PACKAGE/ORDER INFORMATION**

<p>TOP VIEW N/C BALANCE 1 7 V+ -IN 2 6 OUT +IN 3 5 BALANCE V- 4 METAL CAN H PACKAGE</p>	ORDER PART NUMBER
	LT1022AMH LT1022MH LT1022ACH LT1022CH
<p>TOP VIEW BAL 1 8 N/C -IN 2 7 V+ +IN 3 6 OUT V- 4 5 BAL PLASTIC DIP N8 PACKAGE</p>	LT1022CN8

**ELECTRICAL CHARACTERISTICS**

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

SYMBOL	PARAMETER	CONDITIONS	LT1022AM LT1022AC			LT1022M LT1022CH LT1022CN8			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage (Note 1)	H Package N8 Package	—	80	250	—	100	600	$\mu V$ $\mu V$
$I_{OS}$	Input Offset Current	Fully Warm Up	—	2	10	—	2	20	$\mu A$
$I_B$	Input Bias Current	Fully Warm Up $V_{CM} = +10V$	—	± 10	± 50	—	± 10	± 50	$\mu A$ $\mu A$
	Input Resistance—Differential —Common-Mode	$V_{CM} = -11V$ to $+8V$ $V_{CM} = +8V$ to $+11V$	—	$10^{12}$	—	—	$10^{12}$	—	$\Omega$ $\Omega$ $\Omega$
	Input Capacitance		—	4	—	—	4	—	$\mu F$
$e_n$	Input Noise Voltage	0.1Hz to 10Hz	—	2.5	—	—	2.8	—	$\mu V_{p-p}$
$e_n$	Input Noise Voltage Density	$f_0 = 10Hz$ (Note 2) $f_0 = 1kHz$ (Note 3)	—	28	50	—	30	60	$nV/\sqrt{Hz}$ $nV/\sqrt{Hz}$
$i_n$	Input Noise Current Density	$f_0 = 10Hz, 1kHz$ (Note 4)	—	1.8	4	—	1.8	4	$fA/\sqrt{Hz}$
$A_{VOL}$	Large Signal Voltage Gain	$V_0 = \pm 10V$ $R_L = 2k$ $R_L = 1k$	150	400	—	120	400	—	$V/mV$ $V/mV$
	Input Voltage Range		± 10.5	± 12	—	± 10.5	± 12	—	V
CMRR	Common-Mode Rejection Ratio	$V_{CM} = \pm 10.5V$	86	94	—	82	92	—	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 10V$ to $\pm 18V$	88	104	—	86	102	—	dB
$V_{OUT}$	Output Voltage Swing	$R_L = 2k$	± 12	± 13.2	—	± 12	± 13.2	—	V
SR	Slew Rate		23	26	—	18	24	—	$V/\mu s$
GBW	Gain-Bandwidth Product	$f = 1MHz$	—	8.5	—	—	8.0	—	MHz
$I_S$	Supply Current		—	5.2	7.0	—	5.2	7.0	mA
	Settling Time	$A = +1$ or $A = -1$ 10V Step to 0.05% 10V Step to 0.02%	—	0.9	—	—	0.9	—	$\mu s$ $\mu s$
	Offset Voltage Adjustment Range	$R_{POT} = 100k$	—	± 7	—	—	± 7	—	mV

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, V_{CM} = 0V, 0^\circ C \leq T_A \leq 70^\circ C$  unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1022AC			LT1022CH LT1022CN8			UNITS	
			MIN	TYP	MAX	MIN	TYP	MAX		
V <sub>OS</sub>	Input Offset Voltage (Note 1)	H Package	●	—	140	480	—	180	1000	μV
		N8 Package	●	—	—	—	—	300	1700	μV
	Average Temperature Coefficient of Input Offset Voltage	H Package	●	—	1.3	5.0	—	1.8	9.0	μV/°C
		N8 Package (Note 5)	●	—	—	—	—	3.0	15.0	μV/°C
I <sub>OS</sub>	Input Offset Current	Warmed Up, T <sub>A</sub> = 70°C	●	—	15	80	—	18	100	pA
I <sub>B</sub>	Input Bias Current	Warmed Up, T <sub>A</sub> = 70°C	●	—	± 50	± 200	—	± 60	± 250	pA
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = ± 10V, R <sub>L</sub> = 2k	●	80	250	—	60	250	—	V/mV
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = ± 10.4V	●	85	93	—	80	91	—	dB
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = ± 10V to ± 18V	●	86	103	—	84	101	—	dB
V <sub>OUT</sub>	Output Voltage Swing	R <sub>L</sub> = 2k	●	± 12	± 13.1	—	± 12	± 13.1	—	V

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

SYMBOL	PARAMETER	CONDITIONS	LT1022AM			LT1022M			UNITS	
			MIN	TYP	MAX	MIN	TYP	MAX		
V <sub>OS</sub>	Input Offset Voltage	(Note 1)	●	—	230	750	—	300	1500	μV
		Average Temperature Coefficient of Input Offset Voltage	(Note 5)	●	—	1.5	5.0	—	2.0	9.0
I <sub>OS</sub>	Input Offset Current	Warmed Up, T <sub>A</sub> = 125°C	●	—	0.3	2.0	—	0.30	3.0	nA
I <sub>B</sub>	Input Bias Current	Warmed Up, T <sub>A</sub> = 125°C	●	—	± 0.5	± 4.0	—	± 0.7	± 6.0	nA
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = ± 10V, R <sub>L</sub> = 2k	●	40	120	—	35	120	—	V/mV
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = ± 10.4V	●	85	92	—	80	90	—	dB
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> = ± 10V to ± 17V	●	86	102	—	84	100	—	dB
V <sub>OUT</sub>	Output Voltage Swing	R <sub>L</sub> = 2k	●	± 12	± 12.9	—	± 12	± 12.9	—	V

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

**Note 1:** Offset voltage is measured under two different conditions:  
 (a) approximately 0.5 seconds after application of power;  
 (b) at T<sub>A</sub> = 25°C, with the chip self-heated to approximately 45°C to account for chip temperature rise when the device is fully warmed up.

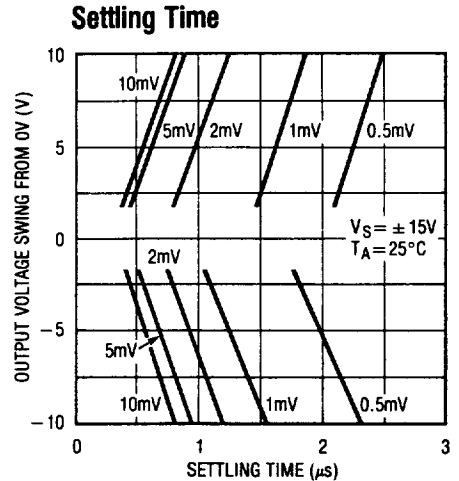
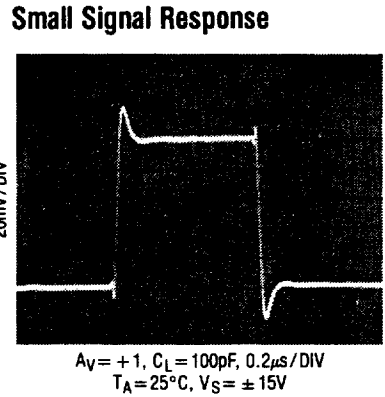
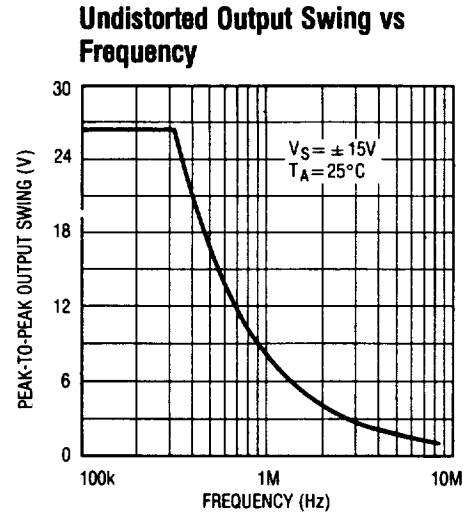
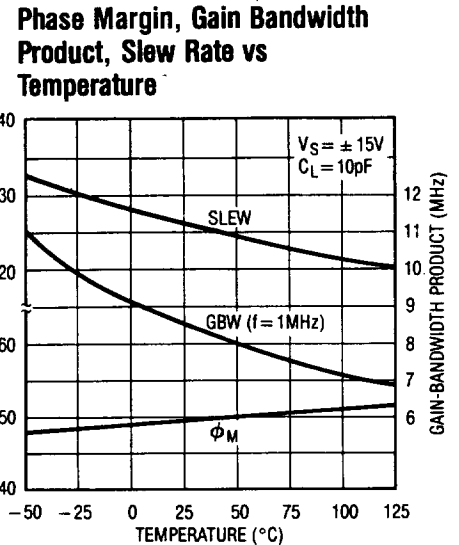
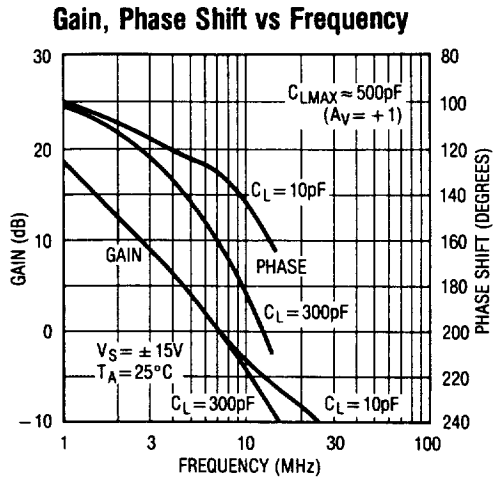
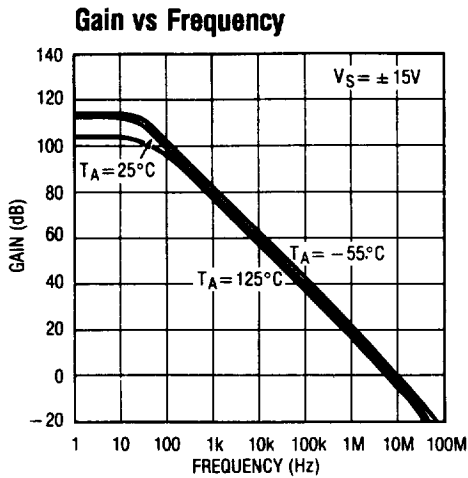
**Note 2:** 10Hz noise voltage density is sample tested on every lot of A grades. Devices 100% tested at 10Hz are available on request.

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

**Note 4:** Current noise is calculated from the formula:  $i_n = (2qI_B)^{1/2}$ , where  $q = 1.6 \times 10^{-19}$  coulomb. The noise of source resistors up to 1GΩ swamps the contribution of current noise.

**Note 5:** Offset voltage drift with temperature is practically unchanged when the offset voltage is trimmed to zero with a 100k potentiometer between the balance terminals and the wiper tied to V<sup>+</sup>. Devices tested to tighter drift specifications are available on request.

**TYPICAL PERFORMANCE CHARACTERISTICS**



The typical behavior of many LT1022 parameters is identical to the LT1056. Please refer to the LT1055/1056 data sheet for the following typical performance characteristics:

- Input Bias and Offset Currents vs Temperature
- Input Bias Current Over the Common-Mode Range
- Distribution of Input Offset Voltage (H and N8 Package)
- Distribution of Offset Voltage Drift with Temperature
- Warm-Up Drift
- Long Term Drift of Representative Units
- 0.1Hz to 10Hz Noise
- Voltage Noise vs Frequency
- Noise vs Chip Temperature
- Output Impedance vs Frequency
- Common-Mode Range vs Temperature
- Common-Mode and Power Supply Rejections vs Temperature
- Common-Mode Rejection Ratio vs Frequency
- Power Supply Rejection Ratio vs Frequency
- Voltage Gain vs Temperature
- Supply Current vs Supply Voltage
- Output Swing vs Load Resistance
- Short Circuit Current vs Time

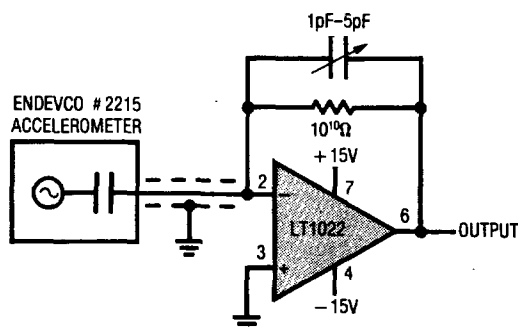
## APPLICATIONS INFORMATION

The LT1056 applications information is directly applicable to the LT1022. Please consult the LT1055/1056 data sheet for details on:

- (1) plug-in compatibility to industry standard devices
- (2) offset nulling
- (3) achieving picoampere/microvolt performance
- (4) phase-reversal protection
- (5) high speed operation (including settling time test circuit)
- (6) noise performance
- (7) simplified circuit schematic.

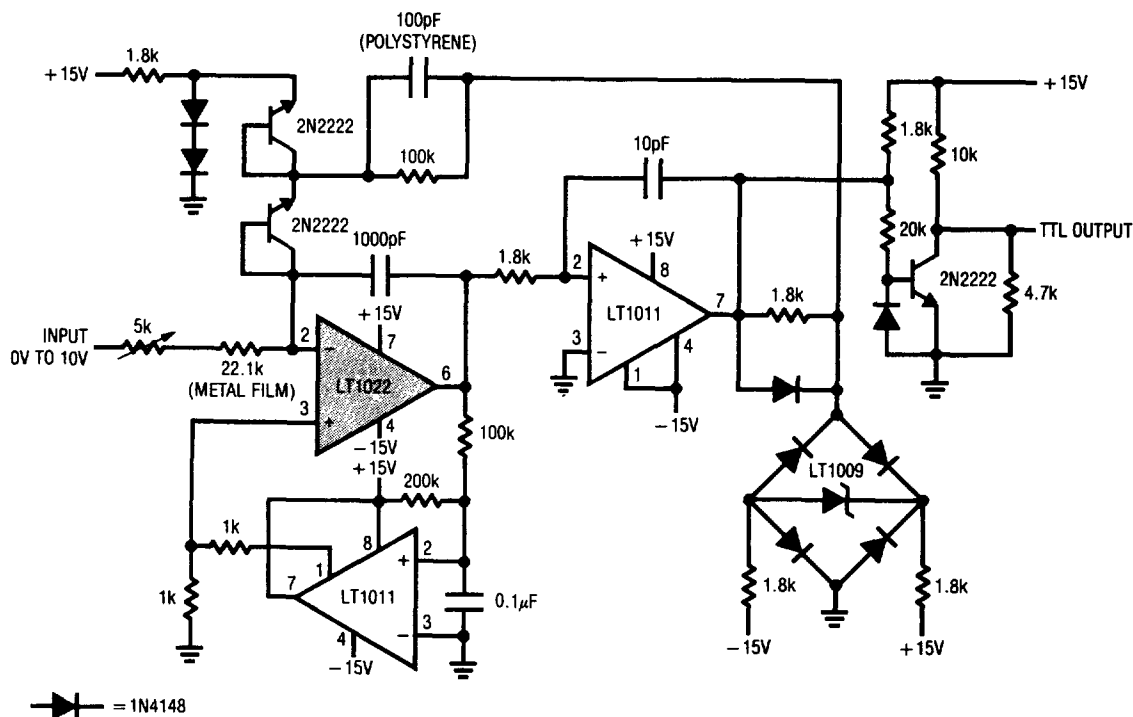
## TYPICAL APPLICATIONS

Fast Piezoelectric Accelerometer



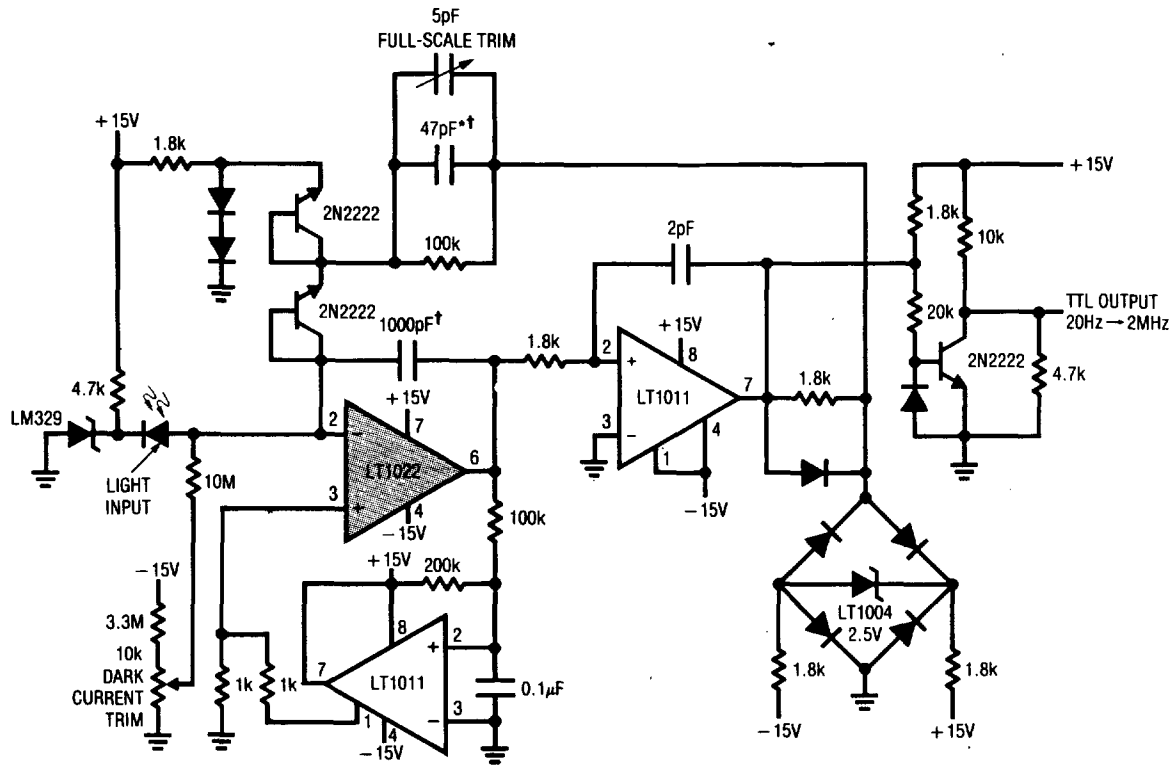
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10Hz to 1MHz Voltage-to-Frequency Converter



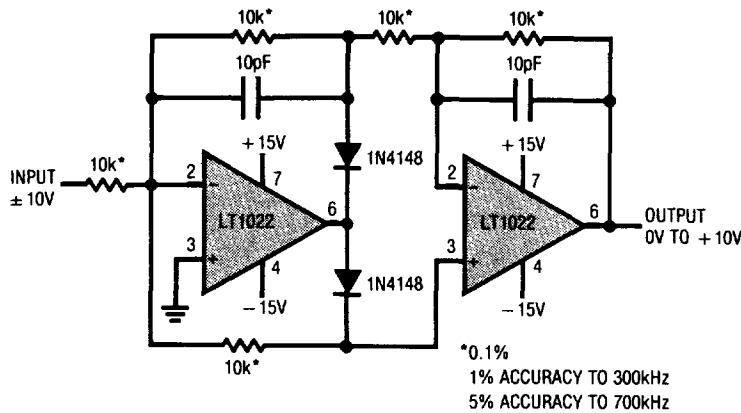
TYPICAL APPLICATIONS

Photodiode-to-Frequency Converter



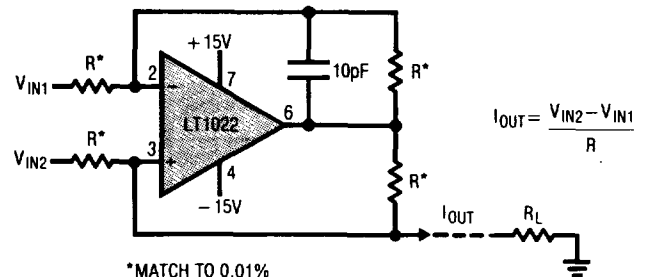
SCALE FACTOR =  
 1nW/Hz AT 900 NANOMETERS FROM 20nW TO 2mW  
 $\nabla$  = HEWLETT PACKARD PHOTODIODE HP5082-4204  
 $\rightarrow$  = 1N4148  
 $\dagger$  POLYSTYRENE  
 \*SELECT VALUE FOR 2mW IN = 2MHz OUT.

Wide Bandwidth Absolute Value Circuit



\*0.1%  
 1% ACCURACY TO 300kHz  
 5% ACCURACY TO 700kHz

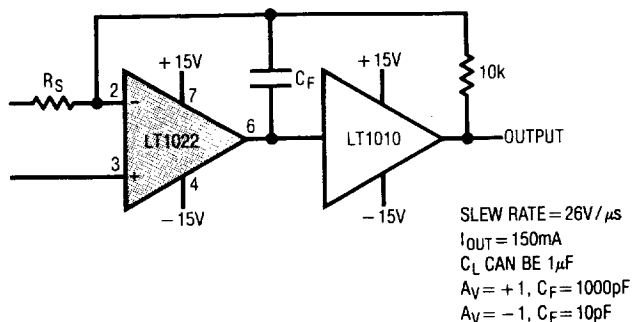
Fast, Differential Input Current Source



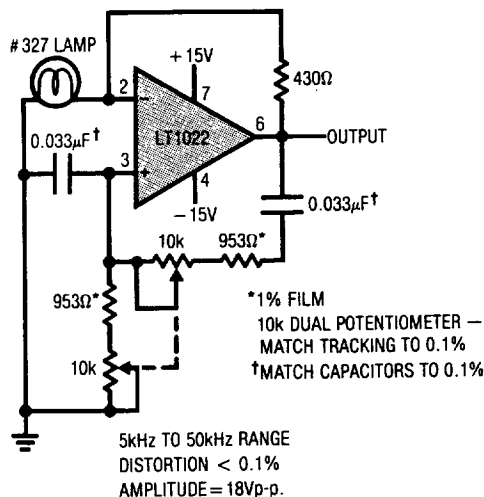
\*MATCH TO 0.01%  
 FULL-SCALE POWER BANDWIDTH  
 = 1MHz FOR  $I_{OUT}R = 8V_{p-p}$   
 = 400kHz FOR  $I_{OUT}R = 20V_{p-p}$   
 MAXIMUM  $I_{OUT} = 10mA_{p-p}$   
 COMMON-MODE VOLTAGE AT LT1022 INPUT =  $\frac{I_{OUT}R_{p-p} \times R_L}{2}$

# TYPICAL APPLICATIONS

### High Output Current Op Amp

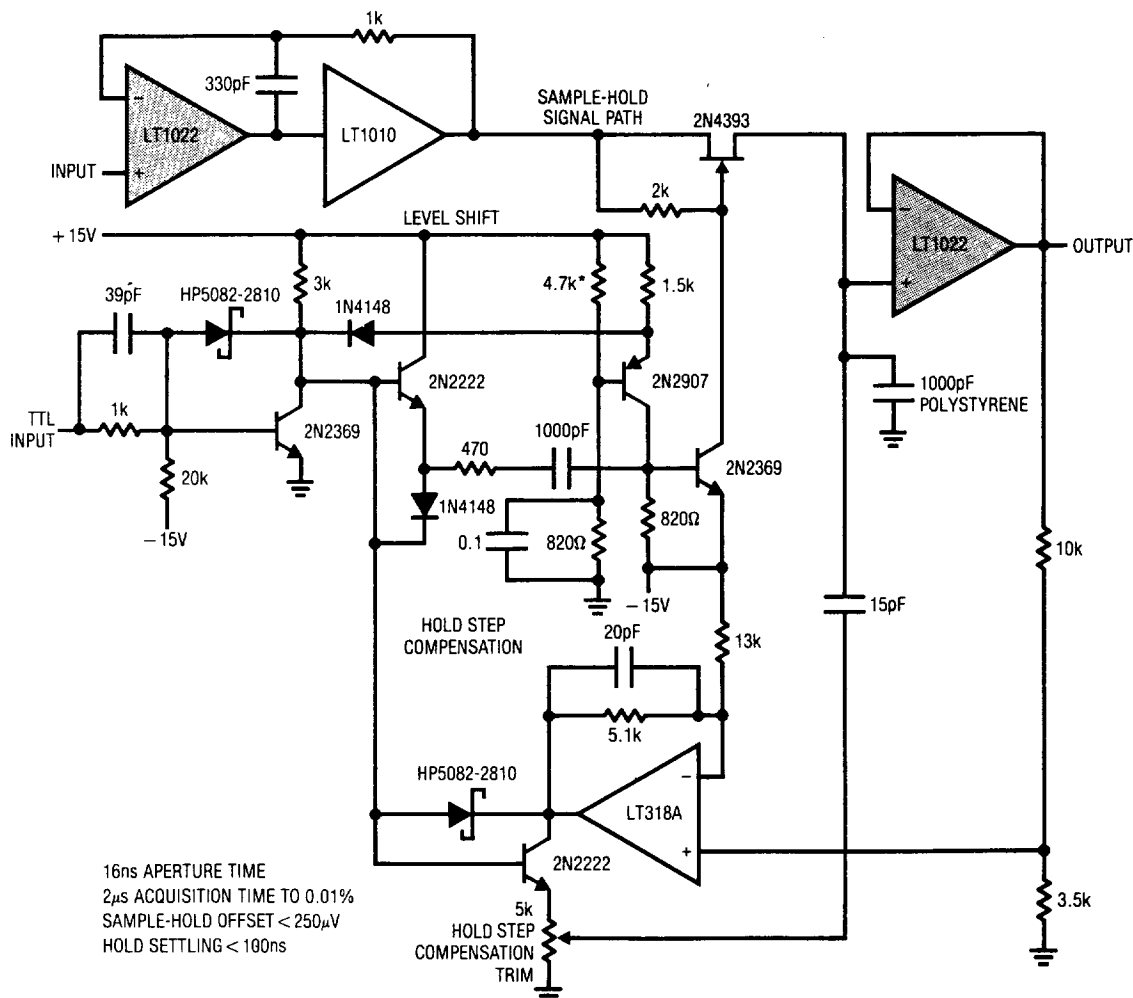


### Low Distortion Sine Wave Oscillator



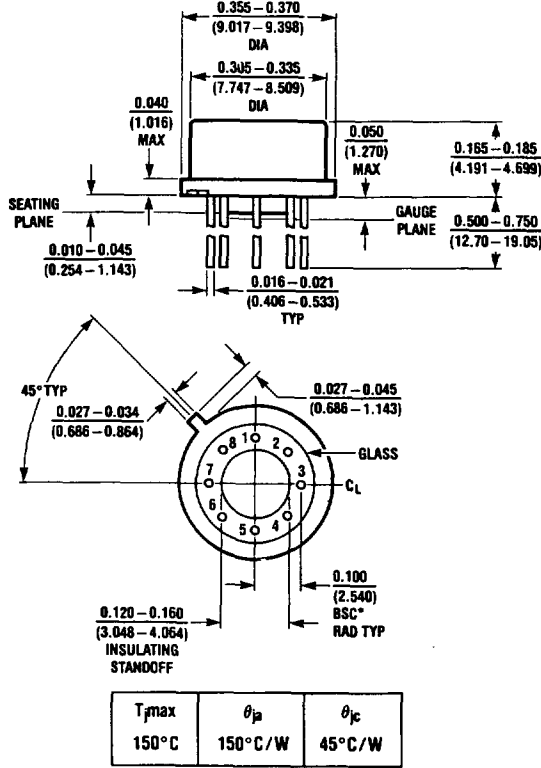
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### Fast, Precision Sample-Hold

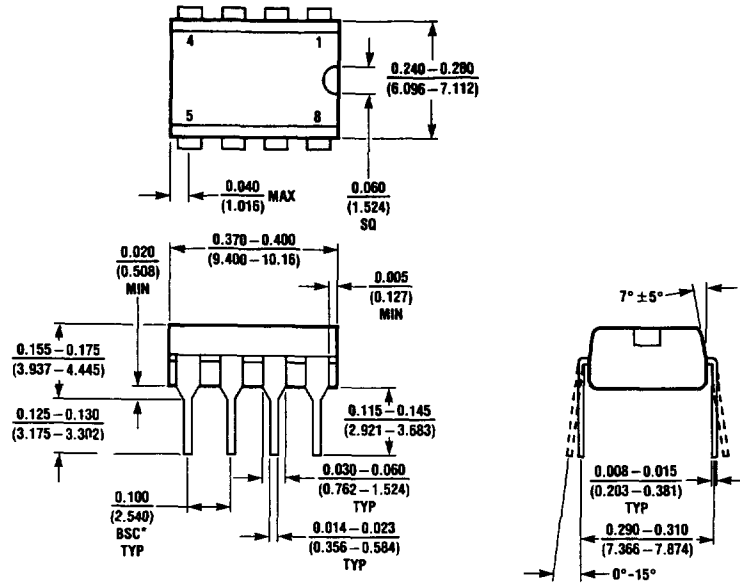


**PACKAGE DESCRIPTION** Dimensions in inches (millimeters) unless otherwise noted.

**H Package  
Metal Can**



**N8 Package  
8 Lead Plastic**



\*LEADS WITHIN 0.007 OF TRUE POSITION (TP) AT GAUGE PLANE

T <sub>p</sub> max	θ <sub>ja</sub>
100°C	130°C/W