# High Speed, Precision JFET Input Operational Amplifier

## FEATURES

- *Guaranteed* Slew Rate: 23V/μs Min
- *Guaranteed* Offset Voltage: 250μV Max
  –55°C to 125°C: 750μV Max
- *Guaranteed* Drift: 5μV/°C Max
- *Guaranteed* Bias Current:
  70°C, 180pA Max
  125°C, 4nA Max
- Gain-Bandwidth Product: 8.5MHz Typ
- Settling Time to 0.05% (10V Step): 0.9μs 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 LT®1022 JFET input operational amplifier combines high speed and precision performance.

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

The 250μV 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.

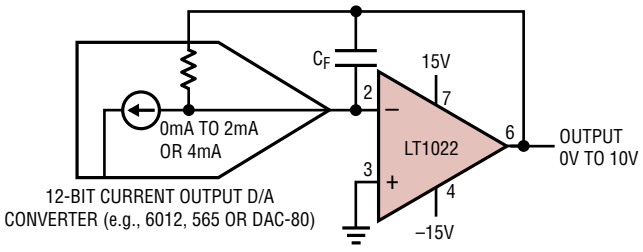
The LT1022 can be used as the output amplifier for 12-bit current output D/A converters, as shown below.

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

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## TYPICAL APPLICATION

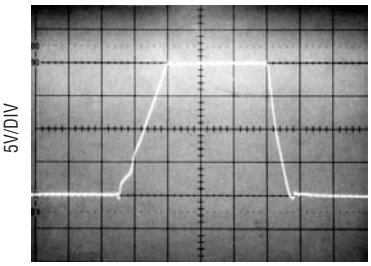
**12-Bit Voltage Output D/A Converter**




$C_F$ = 15pF TO 33pF
SETTLING TIME TO 2mV (0.8 LSB) = 1.5μs TO 2μs

LT1022 • TA01

**Large-Signal Response**




$A_V$ = 1 0.5μs/DIV
$C_L$ = 100pF
$T_A$ = 25°C
$V_S$ = ±15V

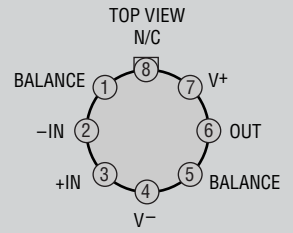
## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

Supply Voltage ..... ±20V
Differential Input Voltage ..... ±40V
Input Voltage ..... ±20V
Output Short Circuit Duration ..... Indefinite

Operating Temperature Range
LT1022AM/1022M **(OBSOLETE)**.....–55°C to 125°C
LT1022AC/1022C ..... 0°C to 70°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec.)..... 300°C

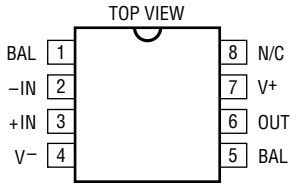
## PACKAGE/ORDER INFORMATION




METAL CAN H PACKAGE
$T_{JMAX}$ = 150° C, $\theta_{JA}$ = 150°C/W, $\theta_{JC}$ = 45° C/W

| ORDER PART NUMBER |
|---|
| LT1022AMH |
| LT1022MH |
| LT1022ACH |
| LT1022CH |

**OBSOLETE PACKAGE**
Consider the N8 Package as an Alternate Source




N8 PACKAGE 8-LEAD PDIP
$T_{JMAX}$ = 100°C, $\theta_{JA}$ = 130°C/W

| ORDER PART NUMBER |
|---|
| LT1022CN8 |

LT1022 • POI01

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

## ELECTRICAL CHARACTERISTICS

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

| SYMBOL | PARAMETER | CONDITIONS | LT1022AM LT1022AC MIN | LT1022AM LT1022AC TYP | LT1022AM LT1022AC MAX | LT1022M, LT1022CH LT1022CN8 MIN | LT1022M, LT1022CH LT1022CN8 TYP | LT1022M, LT1022CH LT1022CN8 MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage (Note 2) | H Package<br>N8 Package | | 80 | 250 | | 100<br>160 | 600<br>1000 | µV<br>µV |
| $I_{OS}$ | Input Offset Current | Fully Warmed Up | | 2 | 10 | | 2 | 20 | pA |
| $I_B$ | Input Bias Current | Fully Warmed Up<br>$V_{CM}$ = +10V | | ±10<br>30 | ±50<br>100 | | ±10<br>30 | ±50<br>150 | pA<br>pA |
| | Input Resistance—Differential<br>—Common Mode | <br>$V_{CM}$ = –11V to 8V<br>$V_{CM}$ = 8V to 11V | | $10^{12}$<br>$10^{12}$<br>$10^{11}$ | | | $10^{12}$<br>$10^{12}$<br>$10^{11}$ | | Ω<br>Ω<br>Ω |
| | Input Capacitance | | | 4 | | | 4 | | pF |
| $e_n$ | Input Noise Voltage | 0.1Hz to 10Hz | | 2.5 | | | 2.8 | | $\mu V_{P-P}$ |
| $e_n$ | Input Noise Voltage Density | $f_O$ = 10Hz (Note 3)<br>$f_O$ = 1kHz (Note 4) | | 28<br>14 | 50<br>20 | | 30<br>15 | 60<br>22 | nV/√Hz<br>nV/√Hz |
| $i_n$ | Input Noise Current Density | $f_O$ = 10Hz, 1kHz (Note 5) | | 1.8 | 4 | | 1.8 | 4 | fA√Hz |
| $A_{VOL}$ | Large Signal Voltage Gain | $V_O$ = ±10V $R_L$ = 2k<br>$R_L$ = 1k | 150<br>130 | 400<br>300 | | 120<br>100 | 400<br>300 | | V/mV<br>V/mV |
| | Input Voltage Range | | ±10.5 | ±12 | | ±10.5 | ±12 | | V |
| CMRR | Common-Mode Rejection Ratio | $V_{CM}$ = ±10.5V | 86 | 94 | | 82 | 92 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = ±10V to ±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/µs |

## ELECTRICAL CHARACTERISTICS

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

| SYMBOL | PARAMETER | CONDITIONS | LT1022AM LT1022AC MIN | LT1022AM LT1022AC TYP | LT1022AM LT1022AC MAX | LT1022M, LT1022CH LT1022CN8 MIN | LT1022M, LT1022CH LT1022CN8 TYP | LT1022M, LT1022CH LT1022CN8 MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| 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% | | 0.9 | | | 0.9 | | µs |
| | | 10V Step to 0.02% | | 1.3 | | | 1.3 | | µs |
| | Offset Voltage Adjustment Range | $R_{POT}$ = 100k | | ±7 | | | ±7 | | mV |

**The ● denotes the specifications which apply over the full operating temperature range of $V_{CM}$ = 0V, 0°C ≤ $T_A$ ≤ 70°C. $V_S = \pm 15V$, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | LT1022AC MIN | LT1022AC TYP | LT1022AC MAX | LT1022CH LT1022CN8 MIN | LT1022CH LT1022CN8 TYP | LT1022CH LT1022CN8 MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | H Package | ● | | 140 | 480 | | 180 | 1000 | µV |
| | (Note 2) | N8 Package | ● | | | | | 300 | 1700 | µV |
| | Average Temperature | H Package | ● | | 1.3 | 5.0 | | 1.8 | 9.0 | µV/°C |
| | Coefficient of Input Offset Voltage | N8 Package (Note 6) | ● | | | | | 3.0 | 15.0 | µV/°C |
| $I_{OS}$ | Input Offset Current | Warmed Up, $T_A$ = 70°C | ● | | 15 | 80 | | 18 | 100 | pA |
| $I_B$ | Input Bias Current | Warmed Up, $T_A$ = 70°C | ● | | ±50 | ±200 | | ±60 | ±250 | pA |
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O = \pm 10V$, $R_L$ = 2k | ● | 80 | 250 | | 60 | 250 | | V/mV |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = \pm 10.4V$ | ● | 85 | 93 | | 80 | 91 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S = \pm 10V$ to ±18V | ● | 86 | 103 | | 84 | 101 | | dB |
| $V_{OUT}$ | Output Voltage Swing | $R_L$ = 2k | ● | ±12 | ±13.1 | | ±12 | ±13.1 | | V |

**The ● denotes the specifications which apply over the full operating temperature range of –55°C ≤ $T_A$ ≤ 125°C. $V_S = \pm 15V$, $V_{CM} = 0V$, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | LT1022AM MIN | LT1022AM TYP | LT1022AM MAX | LT1022M MIN | LT1022M TYP | LT1022M MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | (Note 2) | ● | | 230 | 750 | | 300 | 1500 | µV |
| | Average Temperature Coefficient of Input Offset Voltage | (Note 6) | ● | | 1.5 | 5.0 | | 2.0 | 9.0 | µV/°C |
| $I_{OS}$ | Input Offset Current | Warmed Up, $T_A$ = 125°C | ● | | 0.3 | 2.0 | | 0.30 | 3.0 | nA |
| $I_B$ | Input Bias Current | Warmed Up, $T_A$ = 125°C | ● | | ± 0.5 | ± 4.0 | | ± 0.7 | ± 6.0 | nA |
| $A_{VOL}$ | Large Signal Voltage Gain | $V_O = \pm 10V$, $R_L$ = 2k | ● | 40 | 120 | | 35 | 120 | | V/mV |
| CMRR | Common-Mode Rejection Ratio | $V_{CM} = \pm 10.4V$ | ● | 85 | 92 | | 80 | 90 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S = \pm 10V$ to ±17V | ● | 86 | 102 | | 84 | 100 | | dB |
| $V_{OUT}$ | Output Voltage Swing | $R_L$ = 2k | ● | ±12 | ±12.9 | | ±12 | ±12.9 | | V |

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

**Note 2:** Offset voltage is measured under two different conditions:
(a) approximately 0.5 seconds after application of power;
(b) at $T_A$ = 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 3:** 10Hz noise voltage density is sample tested on every lot of A grades. Devices 100% tested at 10Hz are available on request.

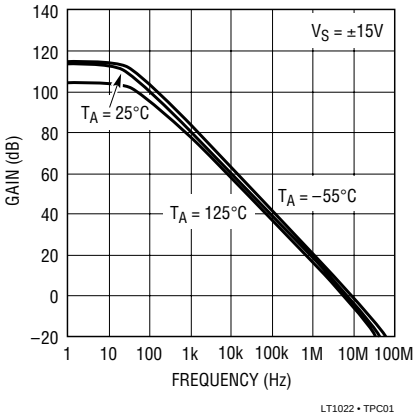
**Note 4:** This parameter is tested on a sample basis only.

**Note 5:** Current noise is calculated from the formula: $i_n = (2qI_B)^{1/2}$, where $q = 1.6 \cdot 10^{-19}$ coulomb. The noise of source resistors up to 1GΩ swamps the contribution of current noise.

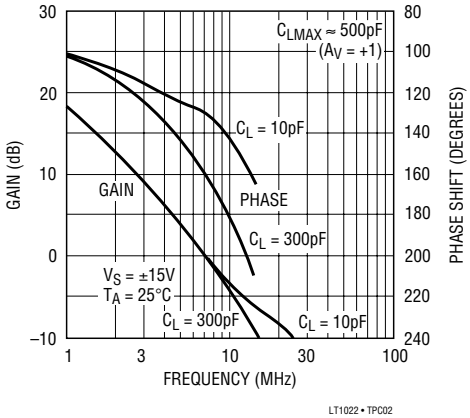
**Note 6:** Offset voltage drift with temperature is practically unchanged when the offset voltage is trimmed to zero with a 100k potentiometer between the balance terminals and the wiper tied to $V^+$. Devices tested to tighter drift specifications are available on request.

# TYPICAL PERFORMANCE CHARACTERISTICS

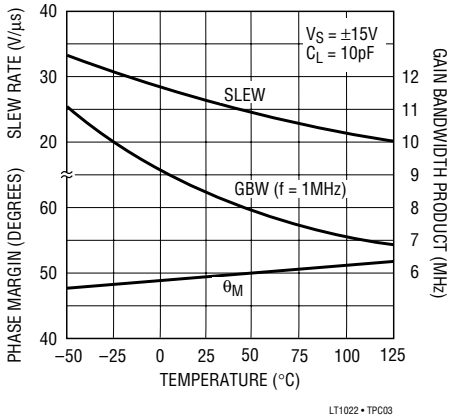
**Gain vs Frequency**



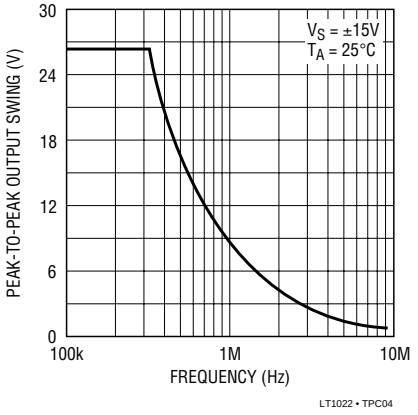

**Gain, Phase Shift vs Frequency**



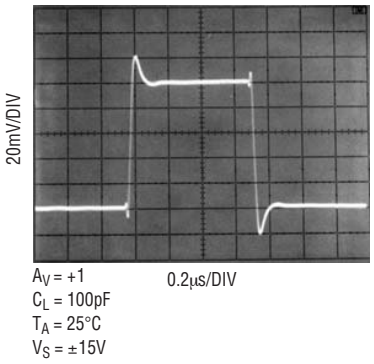

**Phase Margin, Gain Bandwidth Product, Slew Rate vs Temperature**



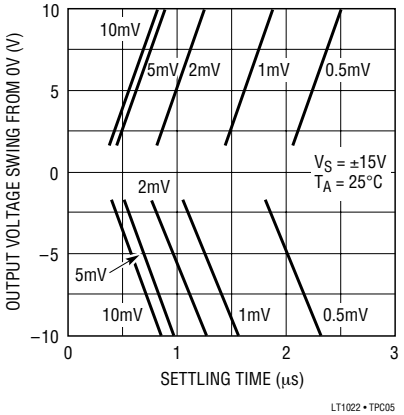

**Undistorted Output Swing vs Frequency**




**Small-Signal Response**




**Settling Time**




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**
**Short Circuit Current vs Time**
**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**

## 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

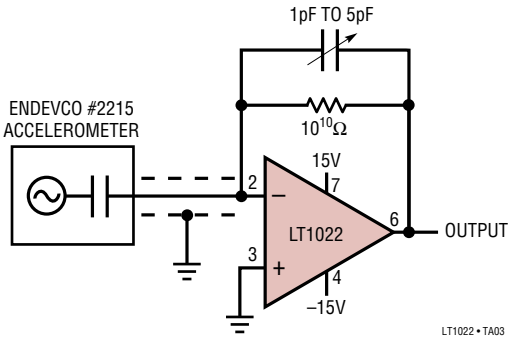
(5) high speed operation (including settling time test circuit)

(6) noise performance

(7) simplified circuit schematic

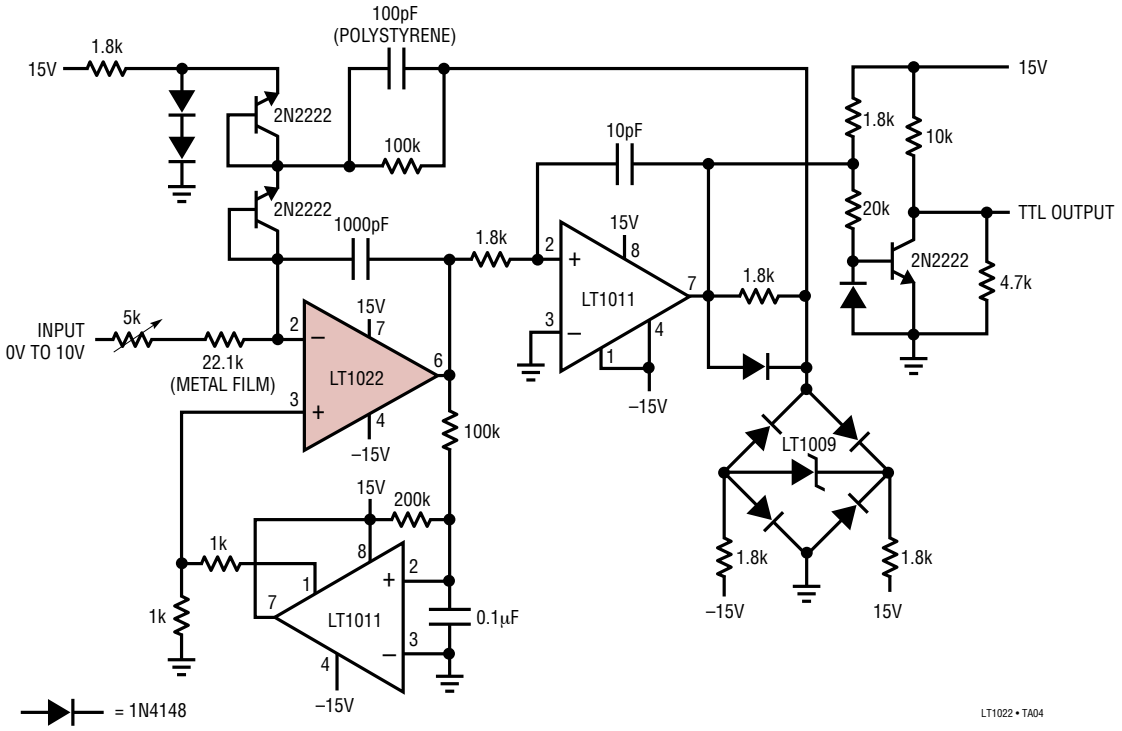
## TYPICAL APPLICATIONS

**Fast Piezoelectric Accelerometer**



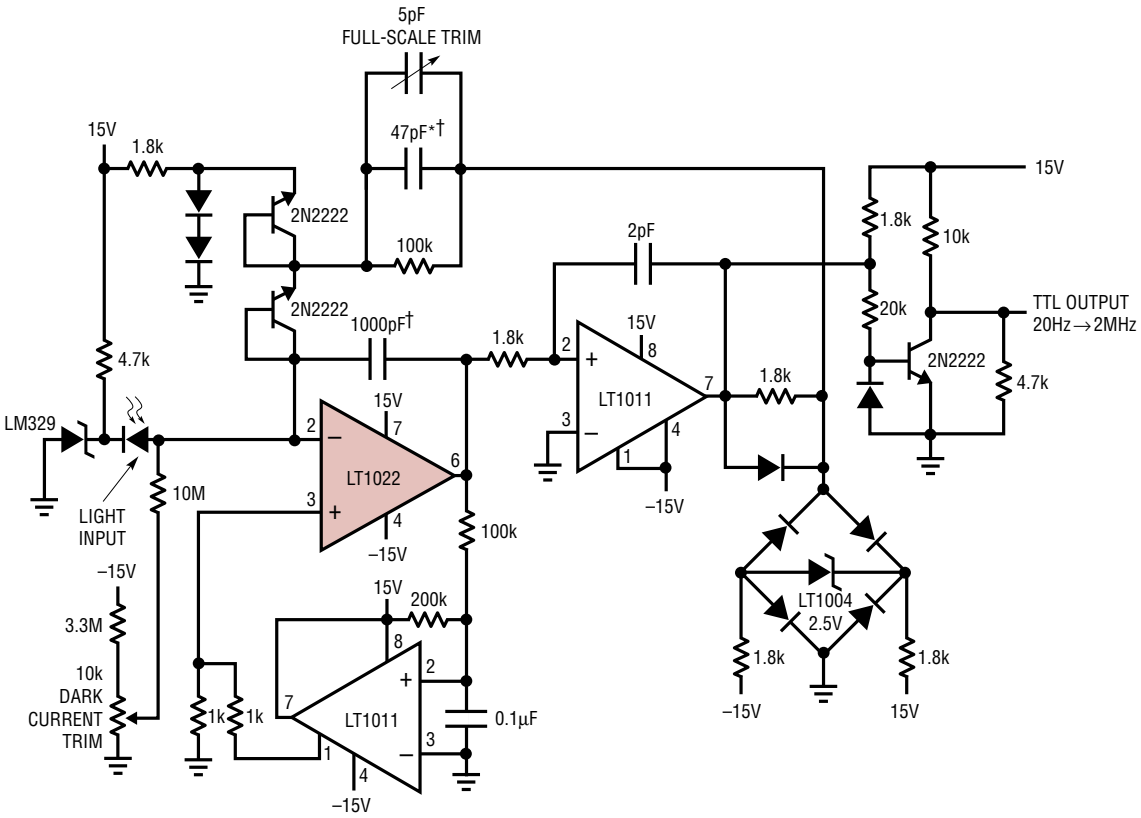
## TYPICAL APPLICATIONS

**10Hz to 1MHz Voltage-to-Frequency Converter**



# TYPICAL APPLICATIONS

**PIN Photodiode-to-Frequency Converter**




SCALE FACTOR =
1nW/Hz AT 900 NANOMETERS FROM 20nW TO 2mW

= HEWLETT PACKARD PHOTODIODE HP5082-4204

= 1N4148

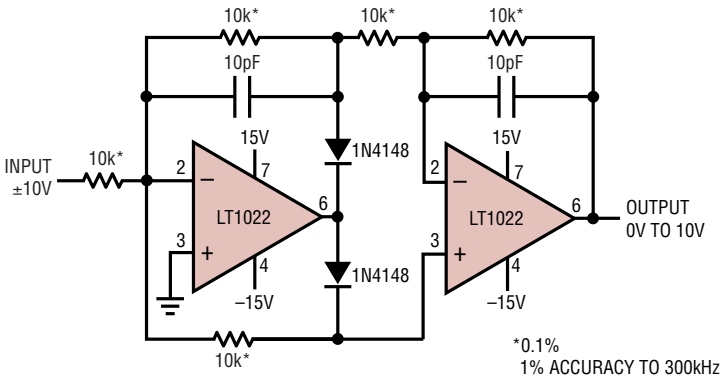
†POLYSTYRENE

* SELECT VALUE FOR 2mW IN = 2MHz OUT

LT1022 • TA05

# TYPICAL APPLICATIONS

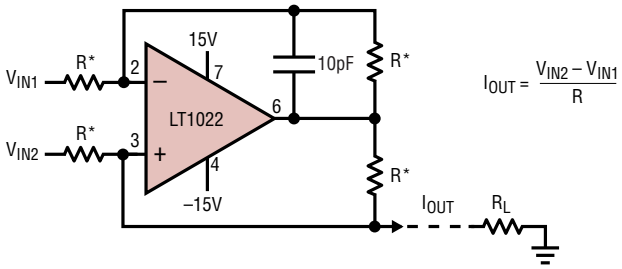
### Wide Bandwidth Absolute Value Circuit




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

LT1022 • TA06

### Fast, Differential Input Current Source

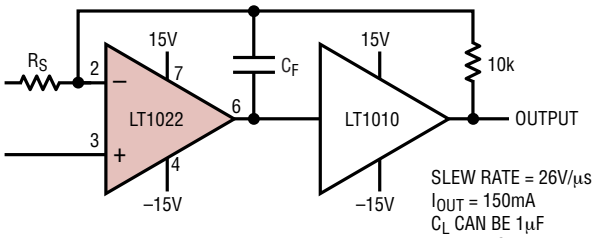



*MATCH TO 0.01%
FULL-SCALE POWER BANDWIDTH
= 1MHz FOR $I_{OUT}R = 8V_{P-P}$
= 400kHz FOR $I_{OUT}R = 20V_{P-P}$
MAXIMUM $I_{OUT} = 10mA_{P-P}$
COMMON-MODE VOLTAGE AT LT1022 INPUT = $\frac{I_{OUTP-P} \bullet R_L}{2}$

LT1022 • TA07

# TYPICAL APPLICATIONS

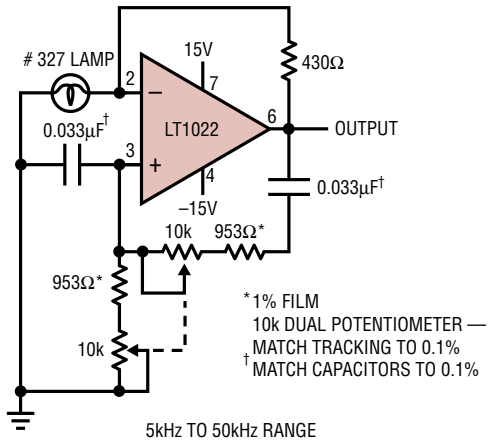
### High Output Current Op Amp




SLEW RATE = 26V/µs
$I_{OUT}$ = 150mA
$C_L$ CAN BE 1µF
$A_V$ = +1, $C_F$ = 1000pF
$A_V$ = –1, $C_F$ = 10pF

LT1022 • TA08

### Low Distortion Sine Wave Oscillator



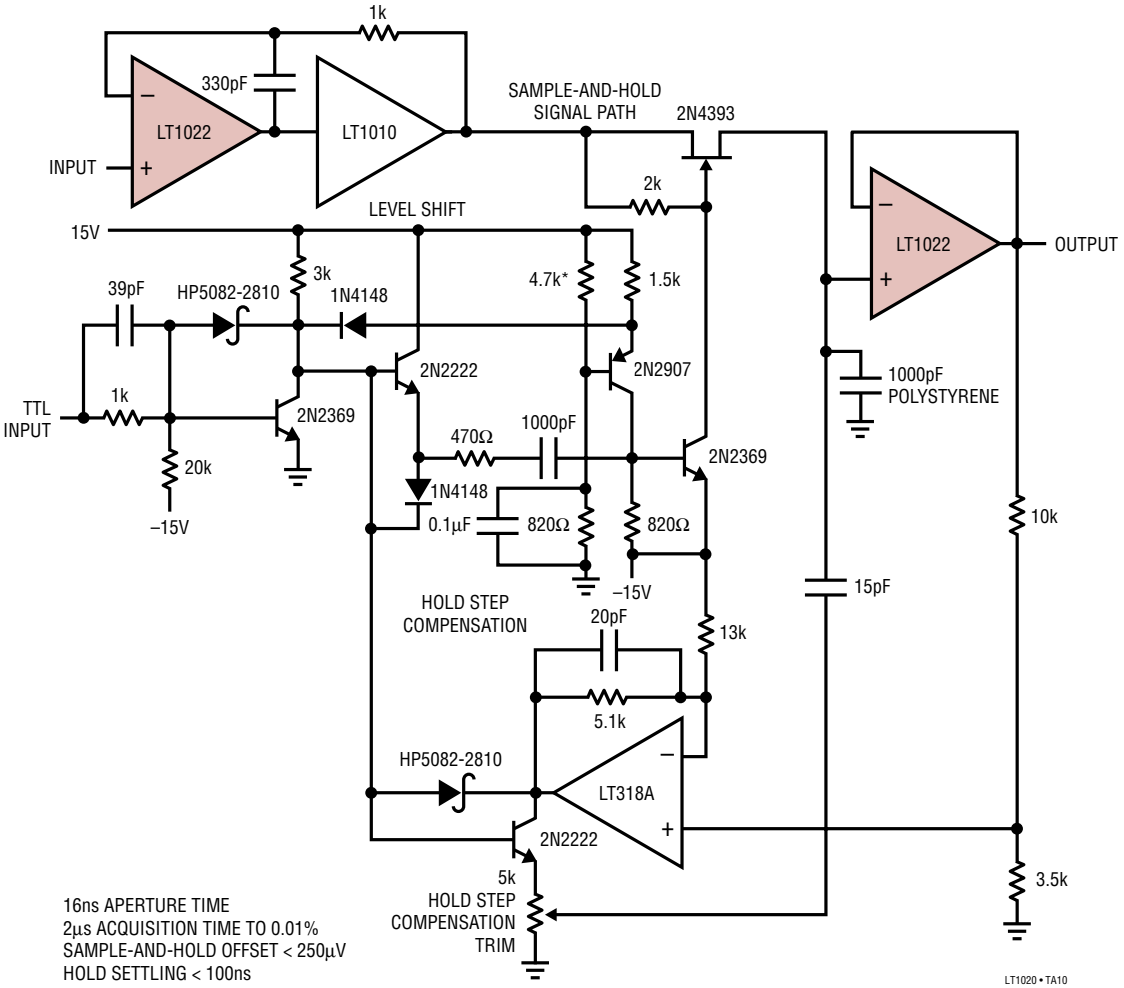

*1% FILM
10k DUAL POTENTIOMETER —
†MATCH TRACKING TO 0.1%
†MATCH CAPACITORS TO 0.1%

5kHz TO 50kHz RANGE
DISTORTION < 0.1%
AMPLITUDE = $18V_{P-P}$

LT1022 • TA09

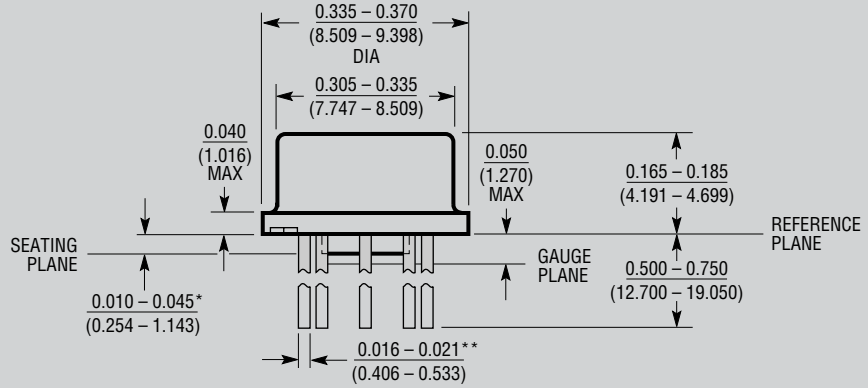
## TYPICAL APPLICATIONS

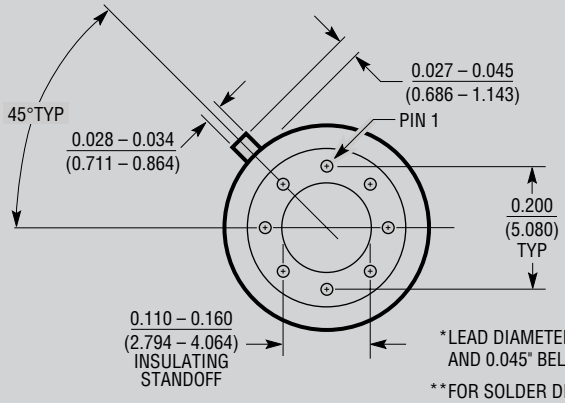
**Fast, Precision Sample-And-Hold**



# PACKAGE DESCRIPTION

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




*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND 0.045" BELOW THE REFERENCE PLANE

**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS 0.016 – 0.024 (0.406 – 0.610)

H8(TO-5) 0.200 PCD 1197

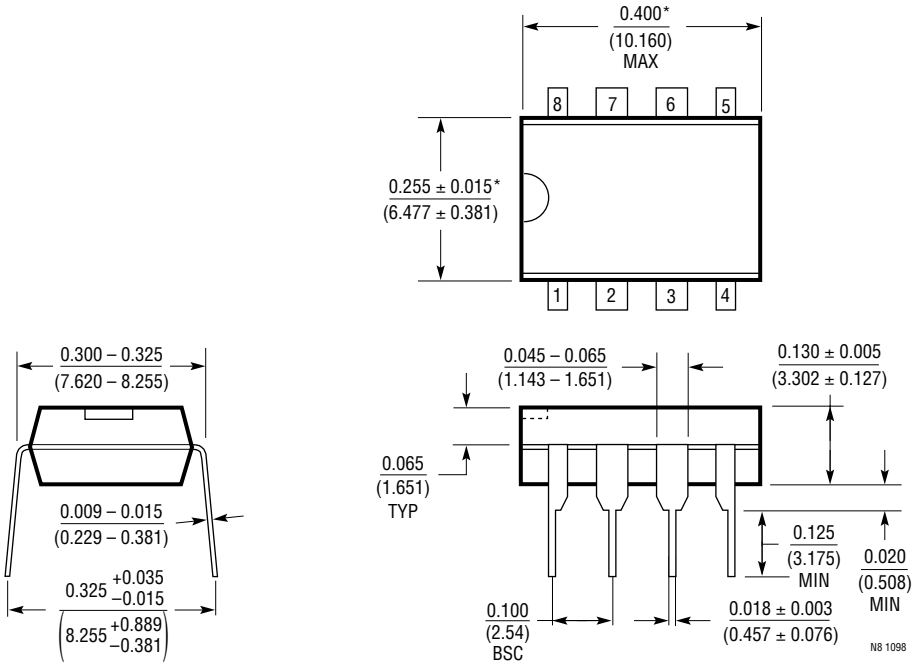
**OBSOLETE PACKAGE**



Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

# PACKAGE DESCRIPTION

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




*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)


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