

## Dual and Quad, JFET Input Precision High Speed Op Amps

### FEATURES

- 14V/ $\mu$ s Slew Rate 10V/ $\mu$ s Min.
- 5MHz Gain-Bandwidth Product
- Fast Settling Time 1.3 $\mu$ s to 0.02%
- 150 $\mu$ V Offset Voltage (LT1057) 450 $\mu$ V Max.
- 180 $\mu$ V Offset Voltage (LT1058) 600 $\mu$ V Max.
- 2 $\mu$ V/ $^{\circ}$ C  $V_{OS}$  Drift 7 $\mu$ V/ $^{\circ}$ C Max.
- 50pA Bias Current at 70 $^{\circ}$ C
- Low Voltage Noise 13nV/ $\sqrt{\text{Hz}}$  @ 1kHz  
26nV/ $\sqrt{\text{Hz}}$  @ 10Hz

### APPLICATIONS

- Precision, High Speed Instrumentation
- Fast, Precision Sample and Hold
- Logarithmic Amplifiers
- D/A Output Amplifiers
- Photodiode Amplifiers
- Voltage to Frequency Converters
- Frequency to Voltage Converters

### DESCRIPTION

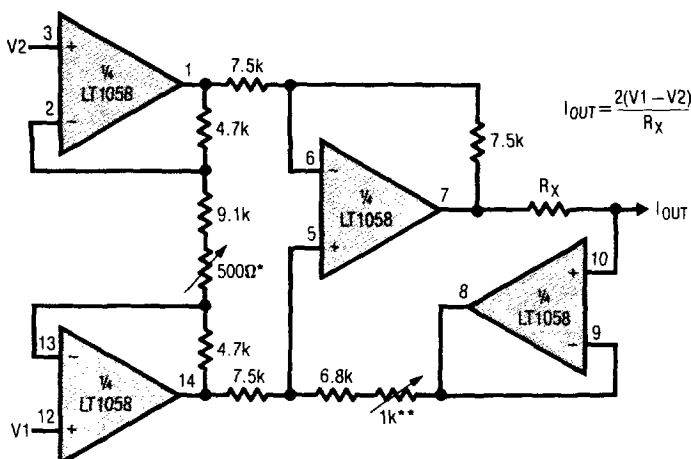
The LT1057 is a matched JFET input dual op amp in the industry standard 8 pin configuration, featuring a combination of outstanding high speed and precision specifications. It replaces all the popular bipolar and JFET input dual op amps. In particular, the LT1057 upgrades the performance of systems using the LF412A and OP-215 JFET input duals.

The LT1058 is the lowest offset quad JFET input operational amplifier in the standard 14 pin configuration. It offers significant accuracy improvement over presently available JFET input quad operational amplifiers. It can replace four single precision JFET input op amps, while saving board space, power dissipation and cost.

Both the LT1057 and LT1058 are available in all standard packages: plastic and hermetic DIP and (LT1057 only) metal can.

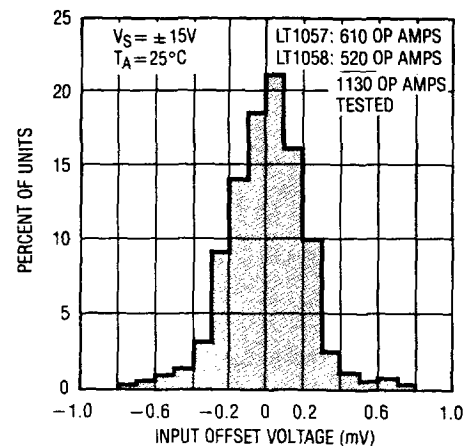
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**Current Output, High Speed, High Input Impedance Instrumentation Amplifier**



\*GAIN ADJUST  
 \*\*COMMON-MODE REJECTION ADJUST  
 BANDWIDTH  $\approx$  2MHz

**Distribution of Offset Voltage (All Packages, LT1057 and LT1058)**



**ABSOLUTE MAXIMUM RATINGS**

|                                       |                 |
|---------------------------------------|-----------------|
| Supply Voltage                        | ± 20V           |
| Differential Input Voltage            | ± 40V           |
| Input Voltage                         | ± 20V           |
| Output Short Circuit Duration         | Indefinite      |
| Operating Temperature Range           |                 |
| LT1057AM/LT1057M/                     |                 |
| LT1058AM/LT1058M                      | - 55°C to 125°C |
| LT1057AC/LT1057C/                     |                 |
| LT1058AC/LT1058C                      | 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**

| TOP VIEW  | ORDER PART NO.  |
|---|---|
| <p>METAL CAN H PACKAGE</p>                                  | LT1057AMH<br>LT1057MH<br>LT1057ACH<br>LT1057CH                                |
| <p>HERMETIC DIP J8 PACKAGE<br/>PLASTIC DIP N8 PACKAGE</p>   | LT1057AMJ8<br>LT1057MJ8<br>LT1057ACJ8<br>LT1057CJ8<br>LT1057ACN8<br>LT1057CN8 |
| <p>HERMETIC DIP J14 PACKAGE<br/>PLASTIC DIP N14 PACKAGE</p> | LT1058AMJ<br>LT1058MJ<br>LT1058ACJ<br>LT1058CJ<br>LT1058ACN<br>LT1058CN       |

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, T_A = 25^\circ C, V_{CM} = 0V$  unless otherwise noted. (Note 1)

| SYMBOL    | PARAMETER                                     | CONDITIONS   | LT1057AM/LT1058AM<br>LT1057AC/LT1058AC |           |     | LT1057M/LT1058M<br>LT1057C/LT1058C |           |     | UNITS          |
|-----------|---|--|--|-----------|-----|------------------------------------|-----------|-----|----------------|
|           |   |  | MIN                                    | TYP       | MAX | MIN                                | TYP       | MAX |                |
| $V_{OS}$  | Input Offset Voltage                          |  |  |           |     |                                    |           |     | $\mu V$        |
|           |   |  |  |           |     |                                    |           |     | $\mu V$        |
| $I_{OS}$  | Input Offset Current                          | Fully Warm Up  |  |           |     |                                    |           |     | pA             |
| $I_b$     | Input Bias Current                            | Fully Warm Up  |  |           |     |                                    |           |     | pA             |
|           | Input Resistance-Differential<br>-Common-Mode | $V_{CM} = -11V$ to $8V$<br>$V_{CM} = 8V$ to $11V$      |  | $10^{12}$ |     |                                    | $10^{12}$ |     | $\Omega$       |
|           |   |  |  | $10^{12}$ |     |                                    | $10^{12}$ |     | $\Omega$       |
|           |   |  |  | $10^{11}$ |     |                                    | $10^{11}$ |     | $\Omega$       |
|           | Input Capacitance                             |  |  | 4         |     |                                    | 4         |     | pF             |
| $e_n$     | Input Noise Voltage                           | 0.1Hz to 10Hz  |  |           |     |                                    |           |     | $\mu V_{p-p}$  |
|           |   |  |  | 2.0       |     |                                    | 2.1       |     | $\mu V_{p-p}$  |
|           |   |  |  | 2.4       |     |                                    | 2.5       |     | $\mu V_{p-p}$  |
| $e_n$     | Input Noise Voltage Density                   | $f_0 = 10Hz$<br>$f_0 = 1kHz$ (Note 2)                  |  |           |     |                                    |           |     | $nV/\sqrt{Hz}$ |
|           |   |  |  | 26        |     |                                    | 28        |     | $nV/\sqrt{Hz}$ |
|           |   |  |  | 13        | 22  |                                    | 14        | 24  | $nV/\sqrt{Hz}$ |
| $i_n$     | Input Noise Current Density                   | $f_0 = 10Hz, 1kHz$ (Note 3)                            |  |           |     |                                    |           |     | $fA/\sqrt{Hz}$ |
|           |   |  |  | 1.5       | 4   |                                    | 1.8       | 6   | $fA/\sqrt{Hz}$ |
| $A_{VOL}$ | Large Signal Voltage Gain                     | $V_O = \pm 10V, R_L = 2k$<br>$V_O = \pm 10V, R_L = 1k$ | 150                                    | 350       |     | 100                                | 300       |     | V/mV           |
|           |   |  | 120                                    | 250       |     | 80                                 | 220       |     | V/mV           |
|           | Input Voltage Range                           |  | $\pm 10.5$                             | 14.3      |     | $\pm 10.5$                         | 14.3      |     | V              |
|           |   |  |  | -11.5     |     |                                    | -11.5     |     | V              |
| CMRR      | Common-Mode Rejection Ratio                   |  |  |           |     |                                    |           |     | dB             |
|           |   |  | 86                                     | 100       |     | 82                                 | 98        |     | dB             |
|           |   |  | 84                                     | 98        |     | 80                                 | 96        |     | dB             |
| PSRR      | Power Supply Rejection Ratio                  | $V_S = \pm 10V$ to $\pm 18V$                           | 88                                     | 103       |     | 86                                 | 102       |     | dB             |
| $V_{OUT}$ | Output Voltage Swing                          | $R_L = 2k$   | $\pm 12$                               | $\pm 13$  |     | $\pm 12$                           | $\pm 13$  |     | V              |

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, T_A = 25^\circ C, V_{CM} = 0V$  unless otherwise noted. (Note 1)

| SYMBOL | PARAMETER                    | CONDITIONS                     | LT1057AM/LT1058AM<br>LT1057AC/LT1058AC |     |     | LT1057M/LT1058M<br>LT1057C/LT1058C |     |     | UNITS     |
|--------|------------------------------|--------------------------------|--|-----|-----|------------------------------------|-----|-----|-----------|
|        |                              |                                | MIN                                    | TYP | MAX | MIN                                | TYP | MAX |           |
| SR     | Slew Rate                    |                                | 10                                     | 14  |     | 8                                  | 13  |     | $V/\mu s$ |
| GBW    | Gain-Bandwidth Product       | $f = 1MHz$ (Note 5)            | 3.5                                    | 5   |     | 3                                  | 5   |     | MHz       |
| $I_S$  | Supply Current Per Amplifier |                                |  | 1.6 | 2.5 |                                    | 1.7 | 2.8 | mA        |
|        | Channel Separation           | DC to 5kHz, $V_{IN} = \pm 10V$ |  | 132 |     |                                    | 130 |     | dB        |

**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                    | LT1057AC<br>LT1058AC |          |            | LT1057C<br>LT1058C |          |            | UNITS            |
|-----------|---|-------------------------------|----------------------|----------|------------|--------------------|----------|------------|------------------|
|           |   |                               | MIN                  | TYP      | MAX        | MIN                | TYP      | MAX        |                  |
| $V_{OS}$  | Input Offset Voltage                                    | LT1057                        | ●                    | 250      | 800        |                    | 330      | 1400       | $\mu V$          |
|           |   | LT1058                        | ●                    | 300      | 1200       |                    | 400      | 1800       | $\mu V$          |
|           | Average Temperature Coefficient of Input Offset Voltage | LT1057 H/J8 Package           | ●                    | 1.8      | 7          |                    | 2.3      | 12         | $\mu V/^\circ C$ |
|           |   | N8 Package                    | ●                    | 3        | 10         |                    | 4        | 16         | $\mu V/^\circ C$ |
|           |   | LT1058 J Package (Note 4)     | ●                    | 2.5      | 10         |                    | 3        | 15         | $\mu V/^\circ C$ |
|           |   | N Package (Note 4)            | ●                    | 4        | 15         |                    | 5        | 22         | $\mu V/^\circ C$ |
| $I_{OS}$  | Input Offset Current                                    | Warmed Up, $T_A = 70^\circ C$ |                      | 18       | 150        |                    | 20       | 250        | pA               |
| $I_b$     | Input Bias Current                                      | Warmed Up, $T_A = 70^\circ C$ |                      | $\pm 50$ | $\pm 250$  |                    | $\pm 60$ | $\pm 350$  | pA               |
| $A_{VOL}$ | Large Signal Voltage Gain                               | $V_O = \pm 10V, R_L = 2k$     | ●                    | 70       | 220        |                    | 50       | 200        | V/mV             |
| CMRR      | Common-Mode Rejection Ratio                             | $V_{CM} = \pm 10.4V$          | ●                    | 85       | 98         |                    | 80       | 96         | dB               |
| PSRR      | Power Supply Rejection Ratio                            | $V_S = \pm 10V$ to $\pm 18V$  | ●                    | 87       | 102        |                    | 84       | 100        | dB               |
| $V_{OUT}$ | Output Voltage Swing                                    | $R_L = 2k$                    | ●                    | $\pm 12$ | $\pm 12.8$ |                    | $\pm 12$ | $\pm 12.8$ | V                |
| $I_S$     | Supply Current Per Amplifier                            | $T_A = 70^\circ C$            | ●                    |          | 2.8        |                    |          | 3.2        | mA               |
|           |   |                               |                      | 1.4      |            |                    | 1.5      |            | mA               |

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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                     | LT1057AM<br>LT1058AM |           |            | LT1057M<br>LT1058M |           |            | UNITS            |
|-----------|---|--------------------------------|----------------------|-----------|------------|--------------------|-----------|------------|------------------|
|           |   |                                | MIN                  | TYP       | MAX        | MIN                | TYP       | MAX        |                  |
| $V_{OS}$  | Input Offset Voltage                                    | LT1057                         | ●                    | 300       | 1100       |                    | 400       | 2000       | $\mu V$          |
|           |   | LT1058                         | ●                    | 380       | 1600       |                    | 550       | 2500       | $\mu V$          |
|           | Average Temperature Coefficient of Input Offset Voltage | LT1057                         | ●                    | 2.0       | 7          |                    | 2.5       | 12         | $\mu V/^\circ C$ |
|           |   | LT1058 (Note 4)                | ●                    | 2.5       | 10         |                    | 3         | 15         | $\mu V/^\circ C$ |
| $I_{OS}$  | Input Offset Current                                    | Warmed Up, $T_A = 125^\circ C$ |                      | 0.15      | 2          |                    | 0.2       | 3          | nA               |
| $I_b$     | Input Bias Current                                      | Warmed Up, $T_A = 125^\circ C$ |                      | $\pm 0.6$ | $\pm 4.5$  |                    | $\pm 0.7$ | $\pm 6$    | nA               |
| $A_{VOL}$ | Large Signal Voltage Gain                               | $V_O = \pm 10V, R_L = 2k$      | ●                    | 40        | 120        |                    | 30        | 110        | V/mV             |
| CMRR      | Common-Mode Rejection Ratio                             | $V_{CM} = \pm 10.4V$           | ●                    | 84        | 97         |                    | 80        | 95         | dB               |
| PSRR      | Power Supply Rejection Ratio                            | $V_S = \pm 10V$ to $\pm 17V$   | ●                    | 86        | 100        |                    | 83        | 98         | dB               |
| $V_{OUT}$ | Output Voltage Swing                                    | $R_L = 2k$                     | ●                    | $\pm 12$  | $\pm 12.7$ |                    | $\pm 12$  | $\pm 12.6$ | V                |
| $I_S$     | Supply Current Per Amplifier                            | $T_A = 125^\circ C$            |                      | 1.25      | 1.9        |                    | 1.3       | 2.2        | mA               |

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

**Note 1:** Typical parameters are defined as the 60% yield of distributions of individual amplifiers; i.e., out of 100 LT1058s or (100 LT1057s), typically 240 op amps (or 120 for the LT1057) will be better than the indicated specification.

**Note 2:** This parameter is tested on a sample basis only.

**Note 3:** Current noise is calculated from the formula:

$$i_n = (2qI_b)^{1/2}$$

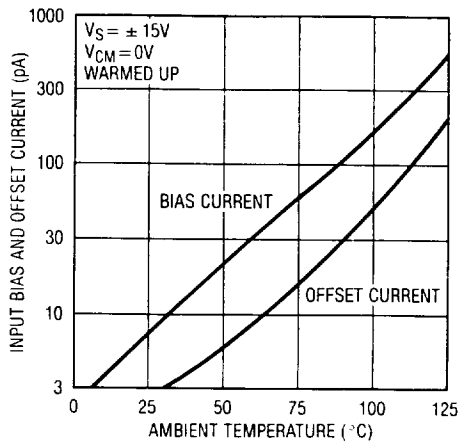
where  $q = 1.6 \times 10^{-19}$  coulomb. The noise of source resistors up to 1GΩ swamps the contribution of current noise.

**Note 4:** This parameter is not 100% tested.

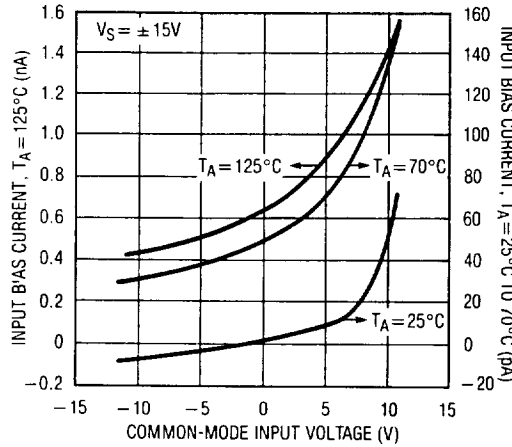
**Note 5:** Gain-bandwidth product is not tested. It is guaranteed by design and by inference from the slew rate measurement.

# TYPICAL PERFORMANCE CHARACTERISTICS

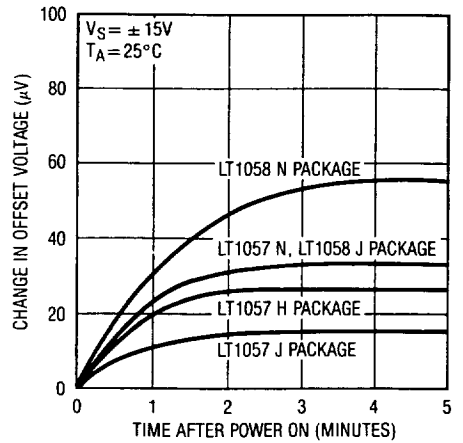
**Input Bias and Offset Currents vs Temperature**



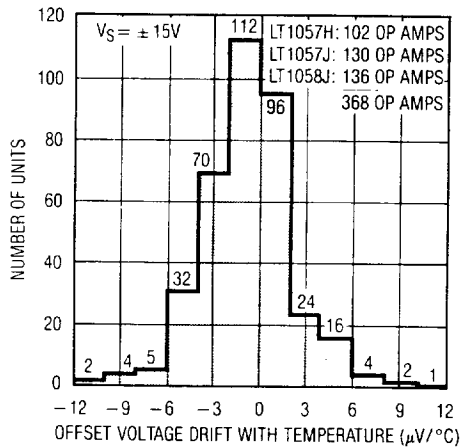
**Input Bias Current Over the Common-Mode Range**



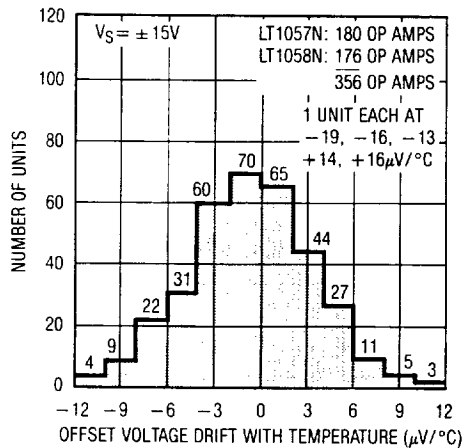
**Warm-Up Drift**



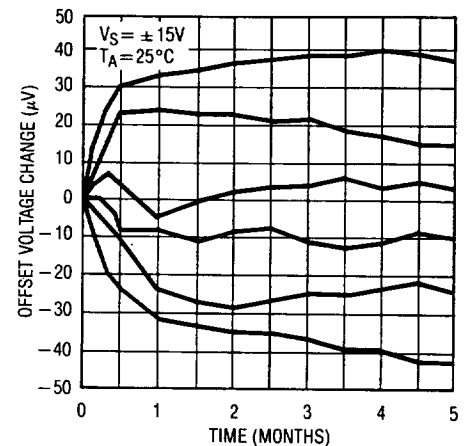
**Distribution of Offset Voltage Drift with Temperature (H and J Package)**



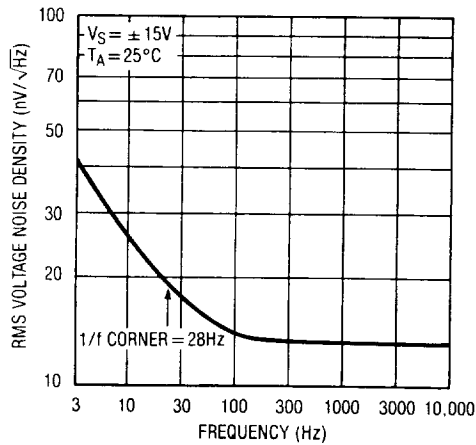
**Distribution of Offset Voltage Drift with Temperature (Plastic N Package)**



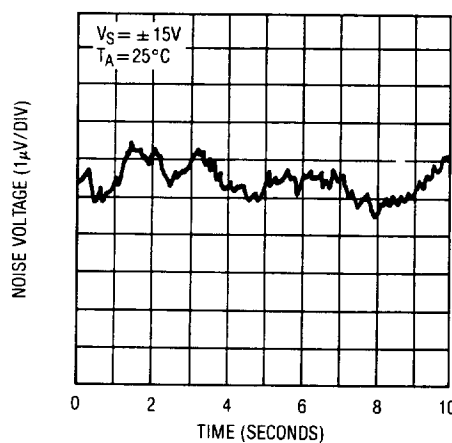
**Long Term Drift of Representative Units**



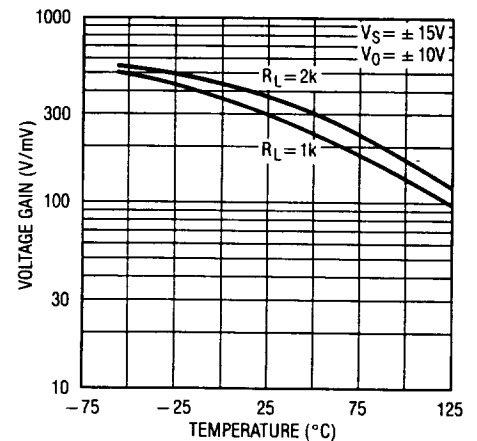
**Voltage Noise vs Frequency**



**0.1Hz to 10Hz Noise**

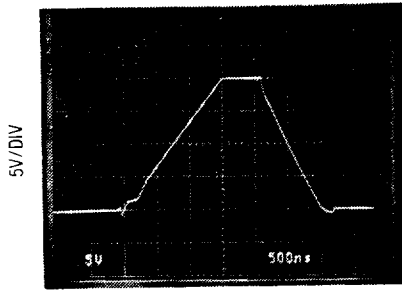


**Voltage Gain vs Temperature**



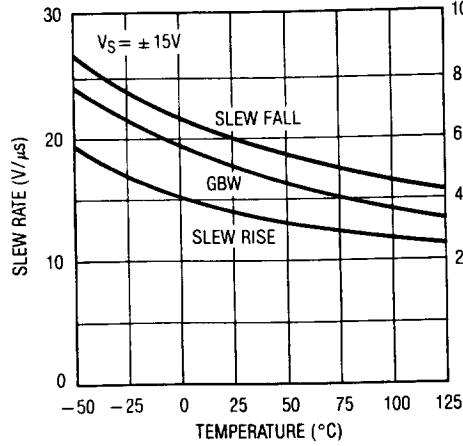
# TYPICAL PERFORMANCE CHARACTERISTICS

Large Signal Response

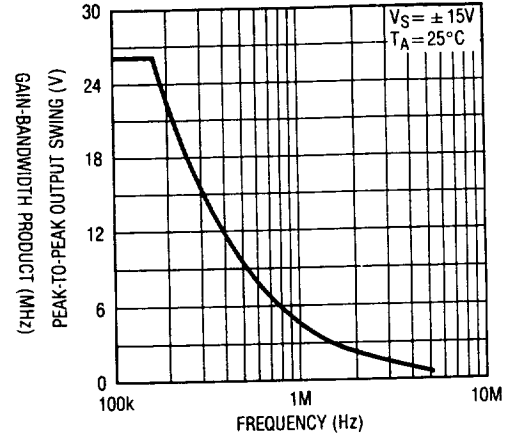


$A_V = +1$ ,  $C_L = 100\text{pF}$ ,  $0.5\mu\text{s}/\text{DIV}$

Slew Rate, Gain-Bandwidth Product vs Temperature

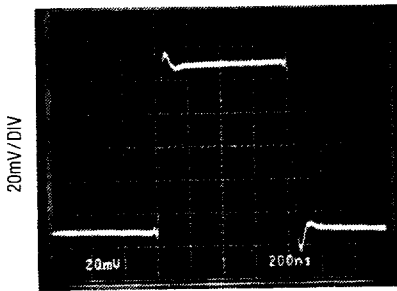


Undistorted Output Swing vs Frequency



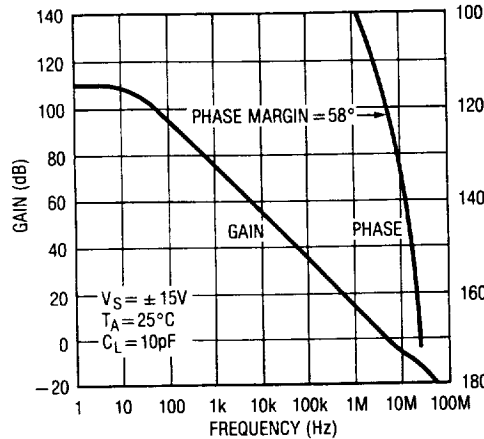
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Small Signal Response

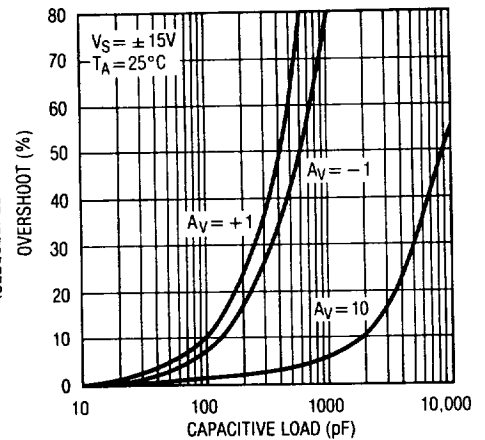


$A_V = +1$ ,  $C_L = 100\text{pF}$ ,  $0.2\mu\text{s}/\text{DIV}$

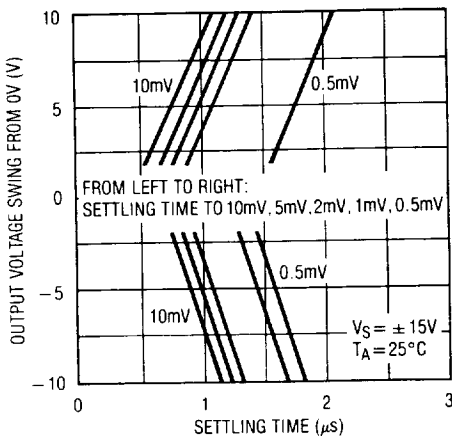
Gain, Phase Shift vs Frequency



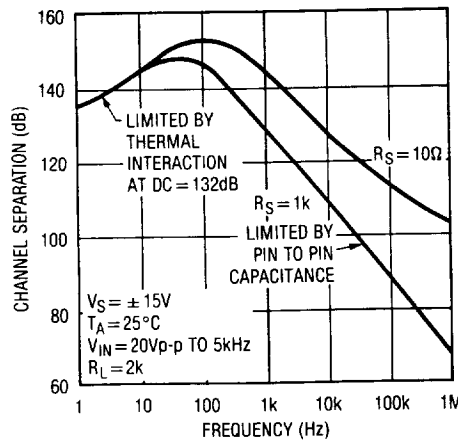
Capacitive Load Handling



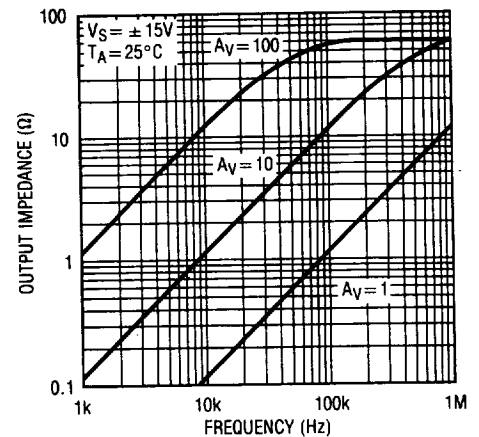
Settling Time



Channel Separation vs Frequency

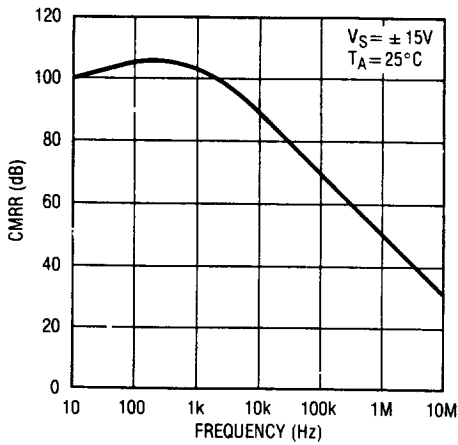


Output Impedance vs Frequency

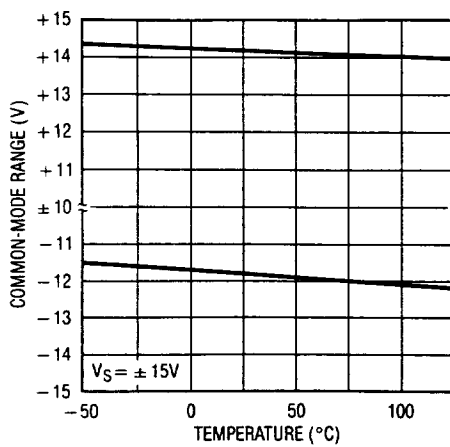


# TYPICAL PERFORMANCE CHARACTERISTICS

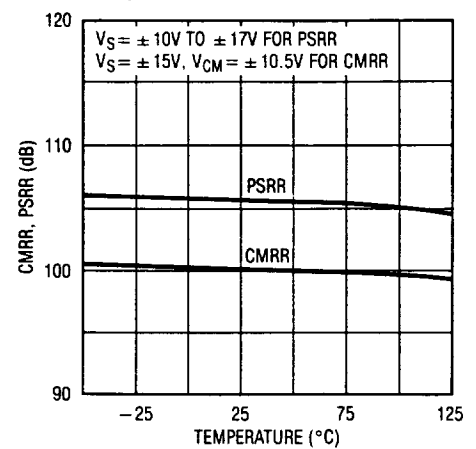
**Common-Mode Rejection Ratio vs Frequency**



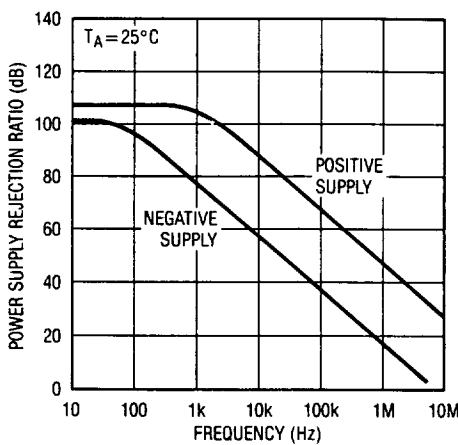
**Common-Mode Range vs Temperature**



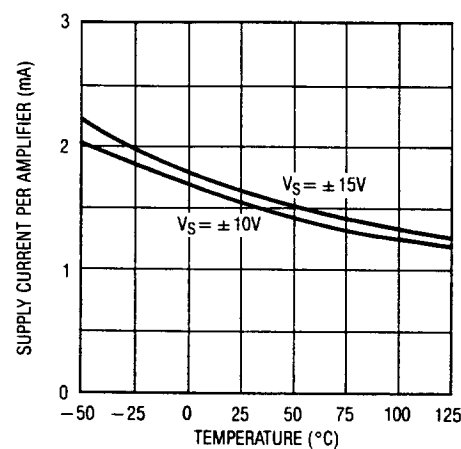
**Common-Mode and Power Supply Rejections vs Temperature**



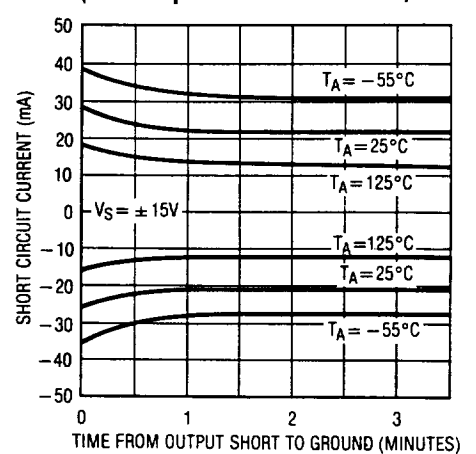
**Power Supply Rejection Ratio vs Frequency**



**Supply Current vs Temperature**



**Short Circuit Current vs Time (One Output Shorted to Ground)**



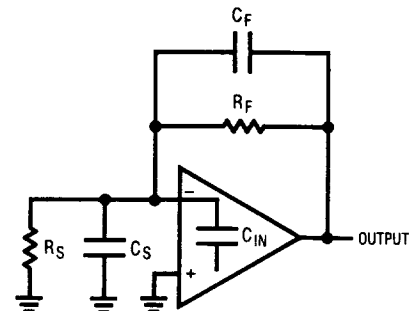
## APPLICATIONS INFORMATION

The LT1057 may be inserted directly into LF353, LF412, LF442, TL072, TL082 and OP-215 sockets. The LT1058 plugs into LF347, LF444, TL074, TL084 sockets. Of course, all standard dual and quad bipolar op amps can also be replaced by these devices.

### High Speed Operation

When the feedback around the op amp is resistive ( $R_F$ ), a pole will be created with  $R_F$ , the source resistance and capacitance ( $R_S, C_S$ ), and the amplifier input capacitance ( $C_{IN} \approx 4\text{pF}$ ). In low closed loop gain configurations and with  $R_S$  and  $R_F$  in the kilohm range, this pole can create excess phase shift and even oscillation. A small capacitor

( $C_F$ ) in parallel with  $R_F$  eliminates this problem. With  $R_S(C_S + C_{IN}) = R_F C_F$ , the effect of the feedback pole is completely removed.



## APPLICATIONS INFORMATION

Settling time is measured in a test circuit which can be found in the LT1055/LT1056 data sheet and in Application Note 10.

### Achieving Picoampere/Microvolt Performance

In order to realize the picoampere/microvolt level accuracy of the LT1057/LT1058, proper care must be exercised. For example, leakage currents in circuitry external to the op amp can significantly degrade performance. High quality insulation should be used (e.g., Teflon™, Kel-F); cleaning of all insulating surfaces to remove fluxes and other residues will probably be required. Surface coating may be necessary to provide a moisture barrier in high humidity environments.

Board leakage can be minimized by encircling the input circuitry with a guard ring operated at a potential close to that of the inputs; in inverting configurations the guard ring should be tied to ground, in non-inverting connections to the inverting input. Guarding both sides of the printed circuit board is required. Bulk leakage reduction depends on the guard ring width.

The LT1057/LT1058 have the lowest offset voltage of any dual and quad JFET input op amps available today. However, the offset voltage and its drift with time and temperature are still not as good as on the best bipolar amplifiers because the transconductance of FETs is considerably lower than that of bipolar transistors. Conversely, this lower transconductance is the main cause of the significantly faster speed performance of FET input op amps.

Teflon™ is a trademark of DuPont.

Offset voltage also changes somewhat with temperature cycling. The AM grades show a typical  $40\mu\text{V}$  hysteresis ( $50\mu\text{V}$  on the M grades) when cycled over the  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  temperature range. Temperature cycling from  $0^\circ\text{C}$  to  $70^\circ\text{C}$  has a negligible (less than  $20\mu\text{V}$ ) hysteresis effect.

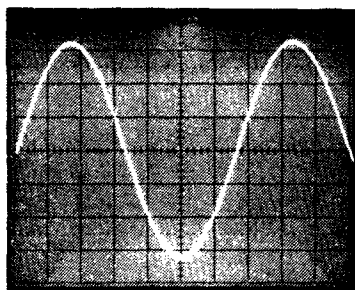
The offset voltage and drift performance are also affected by packaging. In the plastic N package the molding compound is in direct contact with the chip, exerting pressure on the surface. While NPN input transistors are largely unaffected by this pressure, JFET device drift is degraded. Consequently, for best drift performance, as shown in the typical performance distribution plots, the J or H packages are recommended.

In applications where speed and picoampere bias currents are not necessary, Linear Technology offers the bipolar input, pin compatible LT1013 and LT1014 dual and quad op amps. These devices have significantly better DC specifications than any JFET input device.

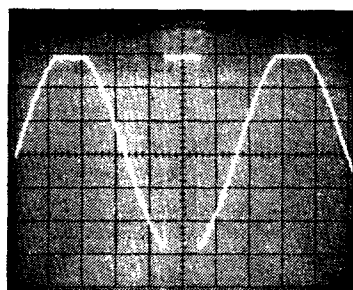
### Phase Reversal Protection

Most industry standard JFET input single, dual and quad op amps (e.g., LF156, LF351, LF353, LF411, LF412, OP-15, OP-16, OP-215, TL084) exhibit phase reversal at the output when the negative common-mode limit at the input is exceeded (i.e., below  $-12\text{V}$  with  $\pm 15\text{V}$  supplies). The photos show a  $\pm 16\text{V}$  sine wave input (A), the response of an LF412A in the unity gain follower mode (B), and the response of the LT1057/LT1058 (C).

The phase reversal of photo (B) can cause lock-up in servo systems. The LT1057/LT1058 does not phase-reverse due to a unique phase reversal protection circuit.

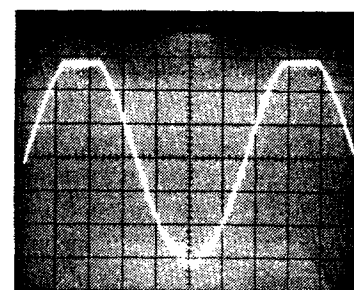


A

(A)  $\pm 16\text{V}$  Sine Wave Input

B

(B) LF412A Output



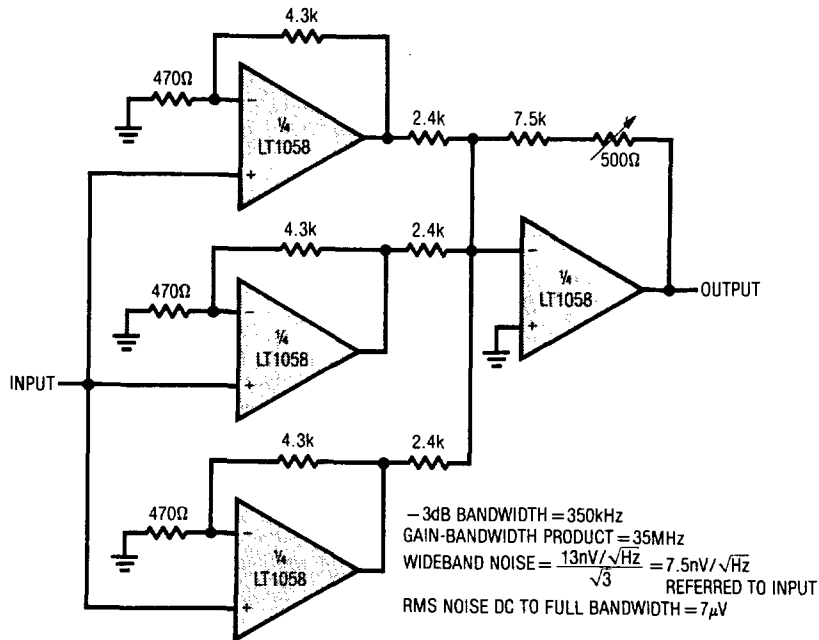
C

(C) LT1057/LT1058 Output

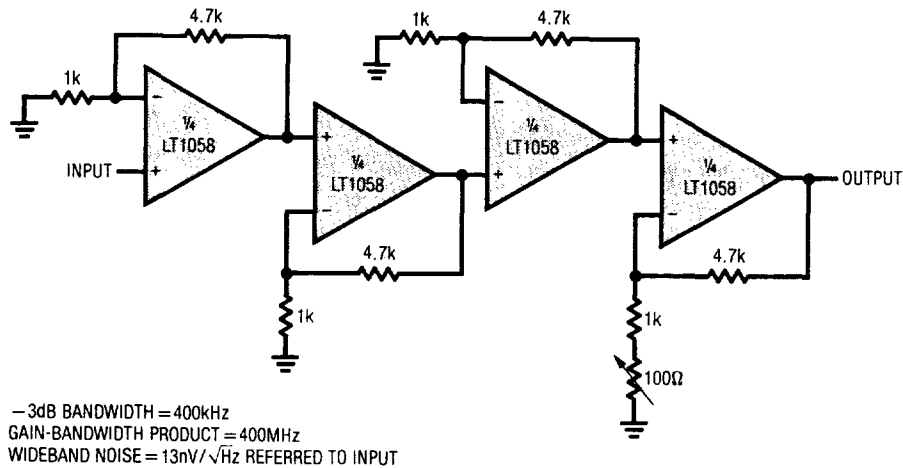
All Photos 5V/Div Vertical Scale,  $50\mu\text{s}/\text{Div}$  Horizontal Scale

**APPLICATIONS**

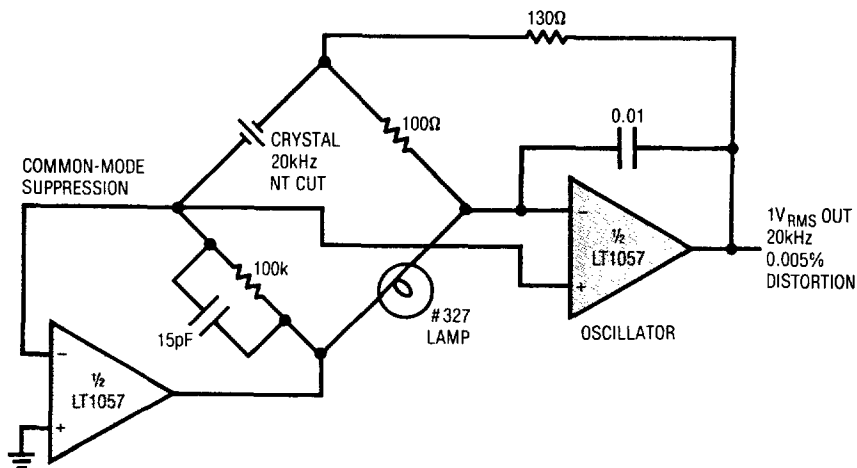
**Low Noise, Wideband, Gain = 100 Amplifier with High Input Impedance**



**Wideband, High Input Impedance, Gain = 1000 Amplifier**



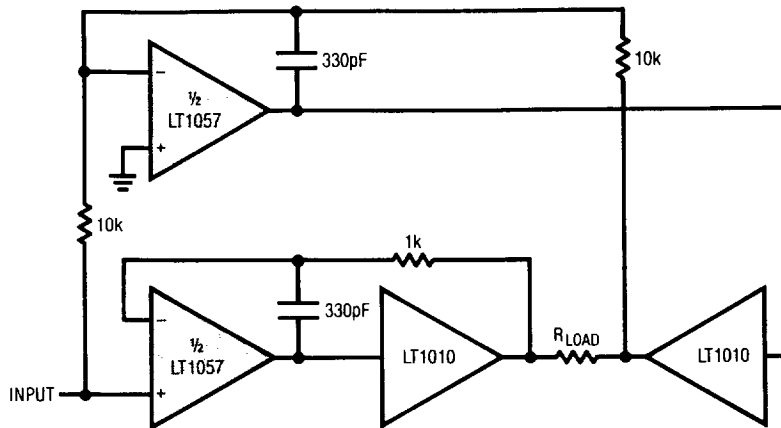
**Low Distortion, Crystal Stabilized Oscillator**





APPLICATIONS

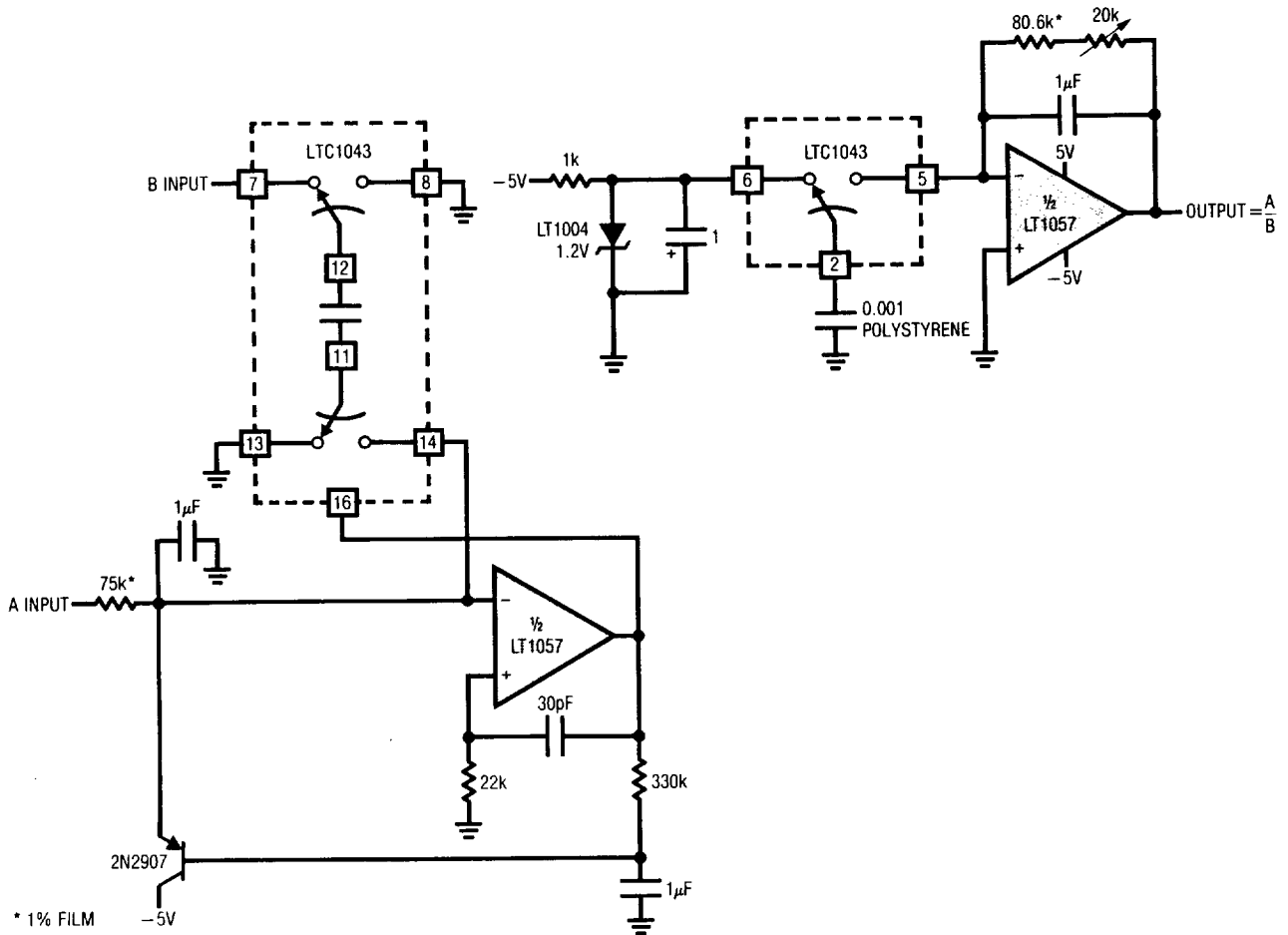
Fast, Precision Bridge Amplifier



SLEW RATE = 14V/ $\mu$ s  
 OUTPUT CURRENT TO LOAD = 150mA  
 LOAD CAPACITANCE: UP TO 1 $\mu$ F

2

Analog Divider

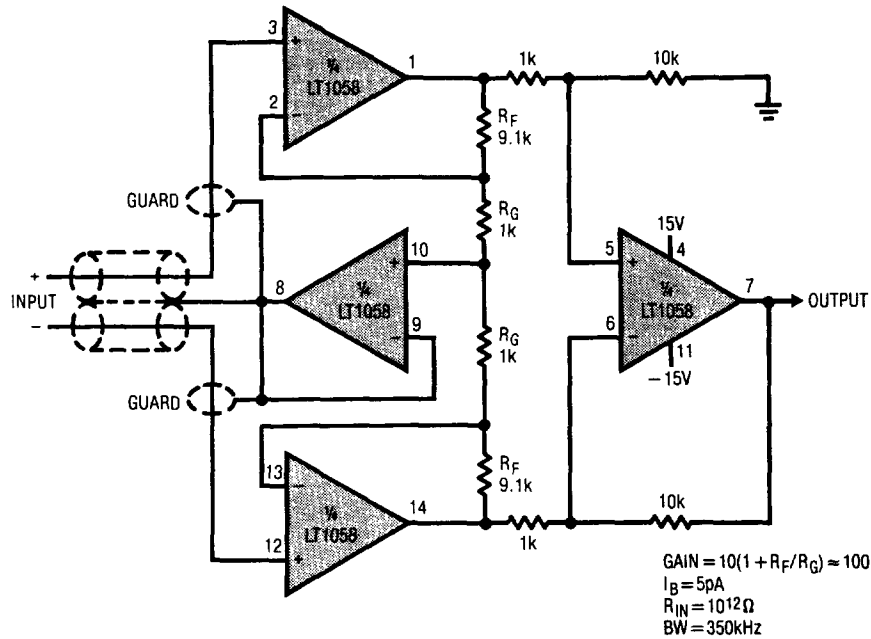


\* 1% FILM



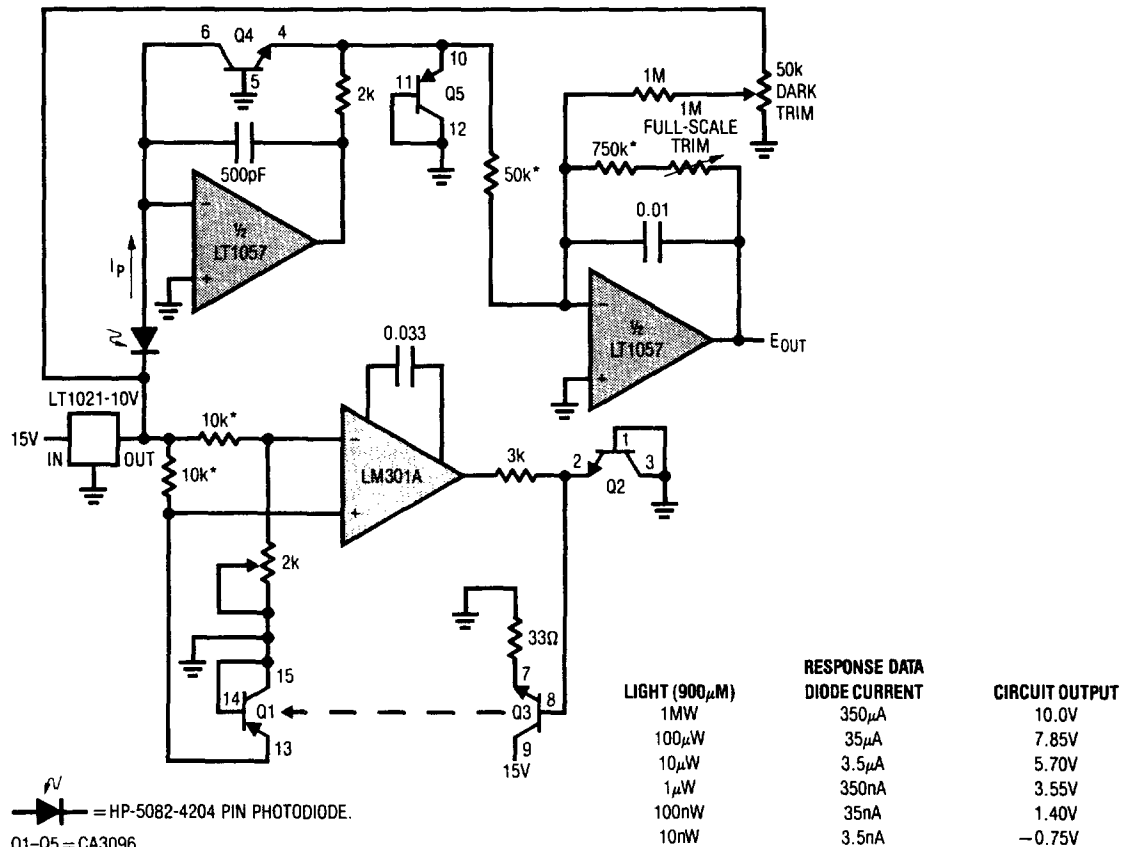
APPLICATIONS

Instrumentation Amplifier with Shield Driver



2

100dB Range Logarithmic Photodiode Amplifier



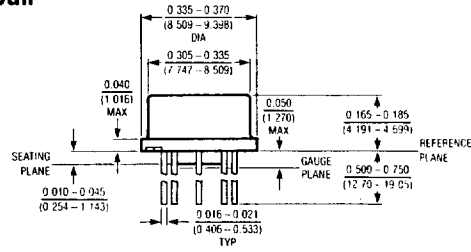
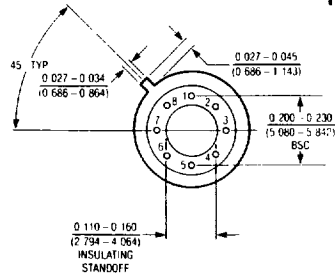
HP-5082-4204 PIN PHOTODIODE.

Q1-Q5 = CA3096.  
CONNECT SUBSTRATE OF CA3096  
ARRAY TO Q4'S EMITTER.

\*1% RESISTOR  
100dB RANGE LOGARITHMIC PHOTODIODE AMPLIFIER

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

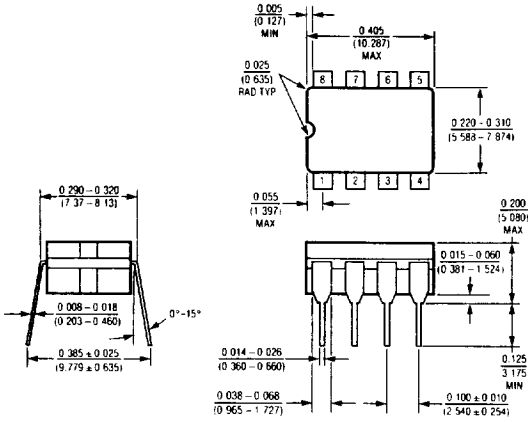
**H Package  
Metal Can**



NOTE LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND SEATING PLANE

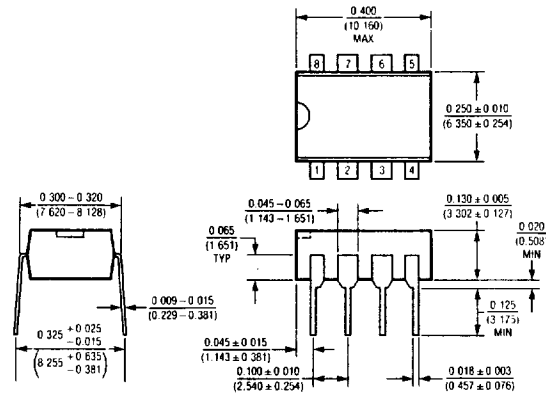
|            |               |               |
|------------|---------------|---------------|
| $T_{jmax}$ | $\theta_{ja}$ | $\theta_{jc}$ |
| 150°C      | 150°C/W       | 45°C/W        |

**J8 Package  
8 Lead Hermetic Dip**



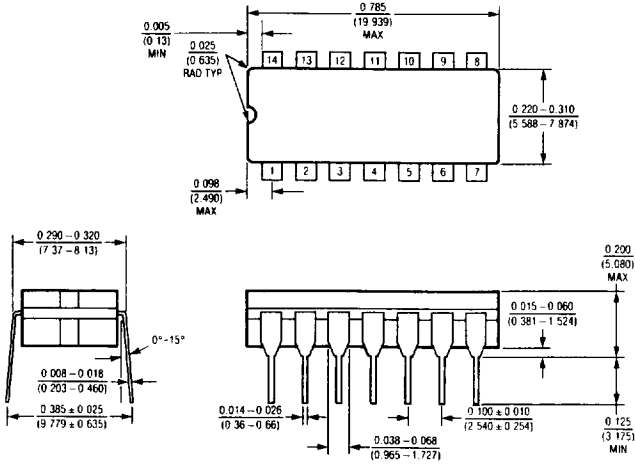
|            |               |
|------------|---------------|
| $T_{jmax}$ | $\theta_{ja}$ |
| 150°C      | 100°C/W       |

**N8 Package  
8 Lead Plastic**



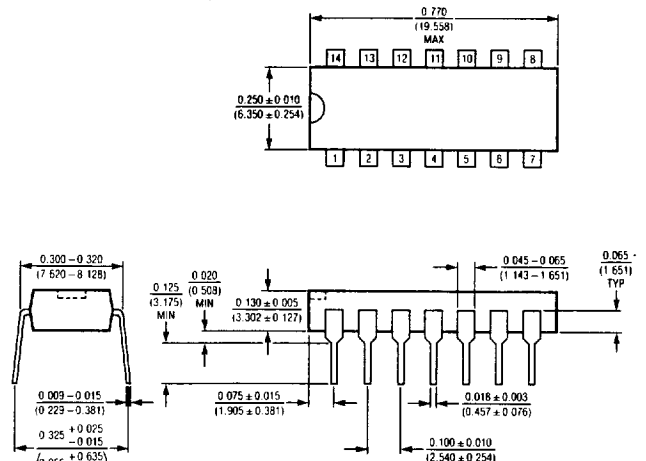
|            |               |
|------------|---------------|
| $T_{jmax}$ | $\theta_{ja}$ |
| 100°C      | 130°C/W       |

**J Package  
14-Lead Hermetic DIP**



|            |               |
|------------|---------------|
| $T_{jmax}$ | $\theta_{ja}$ |
| 150°C      | 100°C/W       |

**N Package  
14-Lead Plastic**



|            |               |
|------------|---------------|
| $T_{jmax}$ | $\theta_{ja}$ |
| 110°C      | 130°C/W       |