

# Dual/Quad Low Noise, High Speed Precision Op Amps

## FEATURES

- 100% Tested Low Voltage Noise:  
2.7nV/√Hz Typ  
4.2nV/√Hz Max
- Slew Rate: 4.5V/μs Typ
- Gain-Bandwidth Product: 12.5MHz Typ
- Offset Voltage,  
Prime Grade: 70μV Max  
Low Grade: 100μV Max
- High Voltage Gain: 5 Million Min
- Supply Current Per Amplifier: 2.75mA Max
- Common Mode Rejection: 112dB Min
- Power Supply Rejection: 116dB Min
- Available in 8-Pin SO Package

## APPLICATIONS

- Two and Three Op Amp Instrumentation Amplifiers
- Low Noise Signal Processing
- Active Filters
- Microvolt Accuracy Threshold Detection
- Strain Gauge Amplifiers
- Direct Coupled Audio Gain Stages
- Tape Head Preamplifiers
- Infrared Detectors

## DESCRIPTION

The **LT®1124** dual and LT1125 quad are high performance op amps that offer higher gain, slew rate and bandwidth than the industry standard OP-27 and competing OP-270/OP-470 op amps. In addition, the LT1124/LT1125 have lower  $I_B$  and  $I_{OS}$  than the OP-27; lower  $V_{OS}$  and noise than the OP-270/OP-470.

In the design, processing and testing of the device, particular attention has been paid to the optimization of the entire distribution of several key parameters. Slew rate, gain bandwidth and 1kHz noise are 100% tested for each individual amplifier. Consequently, the specifications of even the lowest cost grades (the LT1124C and the LT1125C) have been spectacularly improved compared to equivalent grades of competing amplifiers.

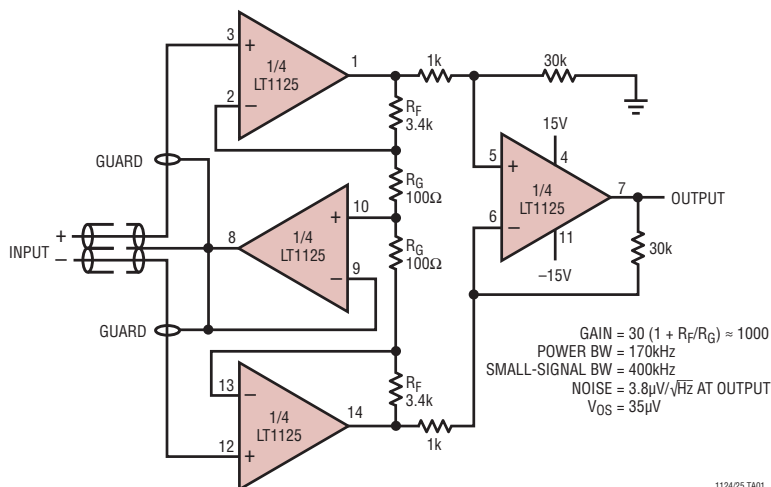
Power consumption of the LT1124 is one-half of two OP-27s. Low power and high performance in an 8-pin SO package make the LT1124 a first choice for surface mounted systems and where board space is restricted.

For a decompensated version of these devices, with three times higher slew rate and bandwidth, please see the LT1126/LT1127 data sheet.

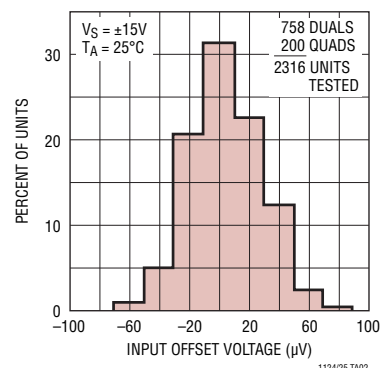
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## TYPICAL APPLICATION

**Instrumentation Amplifier with Shield Driver**



**Input Offset Voltage Distribution  
(All Packages, LT1124 and LT1125)**



1124/25 TA01

11245ff

# LT1124/LT1125

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage .....  $\pm 22\text{V}$   
 Input Voltages ..... Equal to Supply Voltage  
 Output Short-Circuit Duration ..... Indefinite  
 Differential Input Current (Note 6) .....  $\pm 25\text{mA}$   
 Lead Temperature (Soldering, 10 sec) .....  $300^\circ\text{C}$   
 Storage Temperature Range .....  $-65^\circ\text{C}$  to  $150^\circ\text{C}$

Operating Temperature Range

LT1124AC/LT1124C

LT1125AC/LT1125C (Note 10) .....  $-40^\circ\text{C}$  to  $85^\circ\text{C}$

LT1124AI/LT1124I .....  $-40^\circ\text{C}$  to  $85^\circ\text{C}$

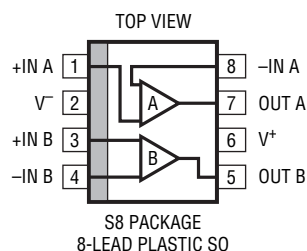
LT1124AMP/LT1125MP .....  $-55^\circ\text{C}$  to  $125^\circ\text{C}$

LT1124AM/LT1124M

LT1125AM/LT1125M

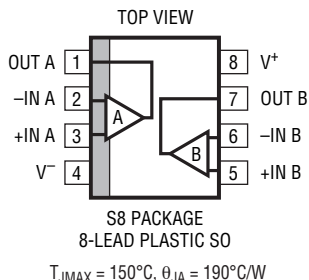
**OBSOLETE** .....  $-55^\circ\text{C}$  to  $125^\circ\text{C}$

## PIN CONFIGURATION



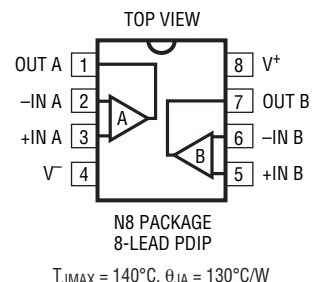
$T_{JMAX} = 140^\circ\text{C}$ ,  $\theta_{JA} = 190^\circ\text{C/W}$

NOTE: THIS PIN CONFIGURATION DIFFERS FROM THE 8-PIN PDIP CONFIGURATION. INSTEAD, IT FOLLOWS THE ROTATED LT1013DS8 SO PACKAGE PIN LOCATIONS



$T_{JMAX} = 150^\circ\text{C}$ ,  $\theta_{JA} = 190^\circ\text{C/W}$

**OBSOLETE PINOUT**



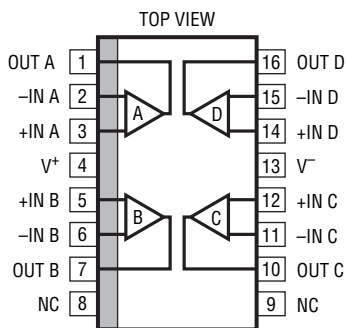
$T_{JMAX} = 140^\circ\text{C}$ ,  $\theta_{JA} = 130^\circ\text{C/W}$

J8 PACKAGE  
8-LEAD CERAMIC DIP

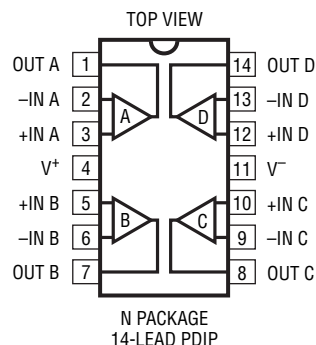
$T_{JMAX} = 160^\circ\text{C}$ ,  $\theta_{JA} = 100^\circ\text{C/W}$

**OBSOLETE PACKAGE**

Consider the N8 for Alternate Source



$T_{JMAX} = 140^\circ\text{C}$ ,  $\theta_{JA} = 130^\circ\text{C/W}$



$T_{JMAX} = 140^\circ\text{C}$ ,  $\theta_{JA} = 110^\circ\text{C/W}$  (N)

J PACKAGE  
14-LEAD CERAMIC DIP

$T_{JMAX} = 160^\circ\text{C}$ ,  $\theta_{JA} = 80^\circ\text{C/W}$

**OBSOLETE PACKAGE**

Consider the N for Alternate Source

## ORDER INFORMATION

| LEAD FREE FINISH        | TAPE AND REEL       | PART MARKING* | PACKAGE DESCRIPTION                | SPECIFIED TEMPERATURE RANGE |
|-------------------------|---------------------|---------------|------------------------------------|-----------------------------|
| LT1124CS8#PBF           | LT1124CS8#TRPBF     | 1124          | 8-Lead Plastic SO, Rotated Pinout  | 0°C to 70°C                 |
| LT1124AIS8#PBF          | LT1124AIS8#TRPBF    | 1124AI        | 8-Lead Plastic SO, Rotated Pinout  | -40°C to 85°C               |
| LT1124IS8#PBF           | LT1124IS8#TRPBF     | 1124I         | 8-Lead Plastic SO, Rotated Pinout  | -40°C to 85°C               |
| LT1124AMPS8#PBF         | LT1124AMPS8#TRPBF   | 124AMP        | 8-Lead Plastic SO, Rotated Pinout  | -55°C to 125°C              |
| LT1124CS8-1#PBF         | LT1124CS8-1#TRPBF   | 11241         | 8-Lead Plastic SO, Standard Pinout | 0°C to 70°C                 |
| LT1124AIS8-1#PBF        | LT1124AIS8-1#TRPBF  | 11241         | 8-Lead Plastic SO, Standard Pinout | -40°C to 85°C               |
| LT1124IS8-1#PBF         | LT1124IS8-1#TRPBF   | 11241         | 8-Lead Plastic SO, Standard Pinout | -40°C to 85°C               |
| LT1124AMPS8-1#PBF       | LT1124AMPS8-1#TRPBF | 11241         | 8-Lead Plastic SO, Standard Pinout | -55°C to 125°C              |
| <b>OBSOLETE PINOUT</b>  |                     |               |                                    |                             |
| LT1125CSW#PBF           | LT1125CSW#TRPBF     | LT1125CSW     | 16-Lead Plastic SO Wide            | 0°C to 70°C                 |
| LT1125MPSW              | LT1125MPSW#TR       | LT1125MPSW    | 16-Lead Plastic SO Wide            | -55°C to 125°C              |
| LT1124ACN8#PBF          | LT1124ACN8#TRPBF    | LT1124ACN8    | 8-Lead PDIP                        | 0°C to 70°C                 |
| LT1124CN8#PBF           | LT1124CN8#TRPBF     | LT1124CN8     | 8-Lead PDIP                        | 0°C to 70°C                 |
| LT1125ACN#PBF           | LT1125ACN#TRPBF     | LT1125ACN     | 14-Lead PDIP                       | 0°C to 70°C                 |
| LT1125CN#PBF            | LT1125CN#TRPBF      | LT1125CN      | 14-Lead PDIP                       | 0°C to 70°C                 |
| LEAD BASED FINISH       | TAPE AND REEL       | PART MARKING* | PACKAGE DESCRIPTION                | SPECIFIED TEMPERATURE RANGE |
| LT1124CS8               | LT1124CS8#TR        | 1124          | 8-Lead Plastic SO, Rotated Pinout  | 0°C to 70°C                 |
| LT1124AIS8              | LT1124AIS8#TR       | 1124AI        | 8-Lead Plastic SO, Rotated Pinout  | -40°C to 85°C               |
| LT1124IS8               | LT1124IS8#TR        | 1124I         | 8-Lead Plastic SO, Rotated Pinout  | -40°C to 85°C               |
| LT1125CSW               | LT1125CSW#TR        | LT1125CSW     | 16-Lead Plastic SO Wide            | 0°C to 70°C                 |
| LT1124ACN8              | LT1124ACN8#TR       | LT1124ACN8    | 8-Lead PDIP                        | 0°C to 70°C                 |
| LT1124CN8               | LT1124CN8#TR        | LT1124CN8     | 8-Lead PDIP                        | 0°C to 70°C                 |
| LT1125ACN               | LT1125ACN#TR        | LT1125ACN     | 14-Lead PDIP                       | 0°C to 70°C                 |
| LT1125CN                | LT1125CN#TR         | LT1125CN      | 14-Lead PDIP                       | 0°C to 70°C                 |
| LT1124CJ8               | LT1124CJ8#TR        | LT1124CJ8     | 8-Lead CERAMIC DIP                 | 0°C to 70°C                 |
| LT1124AMJ8              | LT1124AMJ8#TR       | LT1124AMJ8    | 8-Lead CERAMIC DIP                 | -55°C to 125°C              |
| LT1124MJ8               | LT1124MJ8#TR        | LT1124MJ8     | 8-Lead CERAMIC DIP                 | -55°C to 125°C              |
| LT1125CJ                | LT1125CJ#TR         | LT1125CJ      | 14-Lead CERAMIC DIP                | 0°C to 70°C                 |
| LT1125AMJ               | LT1125AMJ#TR        | LT1125AMJ     | 14-Lead CERAMIC DIP                | -55°C to 125°C              |
| LT1125MJ                | LT1125MJ#TR         | LT1125MJ      | 14-Lead CERAMIC DIP                | -55°C to 125°C              |
| <b>OBSOLETE PACKAGE</b> |                     |               |                                    |                             |

Consult LTC Marketing for parts specified with wider operating temperature ranges. \*The temperature grade is identified by a label on the shipping container.

For more information on lead free part marking, go to: <http://www.linear.com/leadfree/>

For more information on tape and reel specifications, go to: <http://www.linear.com/tapeand reel/>

# LT1124/LT1125

## ELECTRICAL CHARACTERISTICS $T_A = 25^\circ\text{C}$ , $V_S = \pm 15\text{V}$ , unless otherwise noted.

| SYMBOL                                     | PARAMETER                                | CONDITIONS (Note 2)                                                                                     | LT1124AC/AI/AM<br>LT1125AC/AM |            |            | LT1124C/I/M<br>LT1125C/M |            |            | UNITS                                                        |
|--------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------|------------|------------|--------------------------|------------|------------|--------------------------------------------------------------|
|                                            |                                          |                                                                                                         | MIN                           | TYP        | MAX        | MIN                      | TYP        | MAX        |                                                              |
| $V_{OS}$                                   | Input Offset Voltage                     | LT1124<br>LT1125                                                                                        |                               | 20<br>25   | 70<br>90   |                          | 25<br>30   | 100<br>140 | $\mu\text{V}$<br>$\mu\text{V}$                               |
| $\frac{\Delta V_{OS}}{\Delta \text{Time}}$ | Long-Term Input Offset Voltage Stability |                                                                                                         |                               | 0.3        |            |                          | 0.3        |            | $\mu\text{V}/\text{Mo}$                                      |
| $I_{OS}$                                   | Input Offset Current                     | LT1124<br>LT1125                                                                                        |                               | 5<br>6     | 15<br>20   |                          | 6<br>7     | 20<br>30   | nA<br>nA                                                     |
| $I_B$                                      | Input Bias Current                       |                                                                                                         |                               | $\pm 7$    | $\pm 20$   |                          | $\pm 8$    | $\pm 30$   | nA                                                           |
| $e_n$                                      | Input Noise Voltage                      | 0.1Hz to 10Hz (Notes 8, 9)                                                                              |                               | 70         | 200        |                          | 70         |            | $\text{nV}_{\text{P-P}}$                                     |
|                                            | Input Noise Voltage Density              | $f_0 = 10\text{Hz}$ (Note 5)<br>$f_0 = 1000\text{Hz}$ (Note 3)                                          |                               | 3.0<br>2.7 | 5.5<br>4.2 |                          | 3.0<br>2.7 | 5.5<br>4.2 | $\text{nV}/\sqrt{\text{Hz}}$<br>$\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$                                      | Input Noise Current Density              | $f_0 = 10\text{Hz}$<br>$f_0 = 1000\text{Hz}$                                                            |                               | 1.3<br>0.3 |            |                          | 1.3<br>0.3 |            | $\text{pA}/\sqrt{\text{Hz}}$<br>$\text{pA}/\sqrt{\text{Hz}}$ |
| $V_{CM}$                                   | Input Voltage Range                      |                                                                                                         | $\pm 12$                      | $\pm 12.8$ |            | $\pm 12$                 | $\pm 12.8$ |            | V                                                            |
| CMRR                                       | Common Mode Rejection Ratio              | $V_{CM} = \pm 12\text{V}$                                                                               | 112                           | 126        |            | 106                      | 124        |            | dB                                                           |
| PSRR                                       | Power Supply Rejection Ratio             | $V_S = \pm 4\text{V}$ to $\pm 18\text{V}$                                                               | 116                           | 126        |            | 110                      | 124        |            | dB                                                           |
| $A_{VOL}$                                  | Large-Signal Voltage Gain                | $R_L \geq 10\text{k}$ , $V_{OUT} = \pm 10\text{V}$<br>$R_L \geq 2\text{k}$ , $V_{OUT} = \pm 10\text{V}$ | 5<br>2                        | 17<br>4    |            | 3.0<br>1.5               | 15<br>3    |            | $\text{V}/\mu\text{V}$<br>$\text{V}/\mu\text{V}$             |
| $V_{OUT}$                                  | Maximum Output Voltage Swing             | $R_L \geq 2\text{k}$                                                                                    | $\pm 13$                      | $\pm 13.8$ |            | $\pm 12.5$               | $\pm 13.8$ |            | V                                                            |
| SR                                         | Slew Rate                                | $R_L \geq 2\text{k}$ (Notes 3, 7)                                                                       | 3                             | 4.5        |            | 2.7                      | 4.5        |            | $\text{V}/\mu\text{s}$                                       |
| GBW                                        | Gain-Bandwidth Product                   | $f_0 = 100\text{kHz}$ (Note 3)                                                                          | 9                             | 12.5       |            | 8                        | 12.5       |            | MHz                                                          |
| $Z_O$                                      | Open-Loop Output Resistance              | $V_{OUT} = 0$ , $I_{OUT} = 0$                                                                           |                               | 75         |            |                          | 75         |            | $\Omega$                                                     |
| $I_S$                                      | Supply Current per Amplifier             |                                                                                                         |                               | 2.3        | 2.75       |                          | 2.3        | 2.75       | mA                                                           |
|                                            | Channel Separation                       | $f \leq 10\text{Hz}$ (Note 9)<br>$V_{OUT} = \pm 10\text{V}$ , $R_L = 2\text{k}$                         | 134                           | 150        |            | 130                      | 150        |            | dB                                                           |

The ● denotes the specifications which apply over the  $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$  temperature range,  $V_S = \pm 15\text{V}$ , unless otherwise noted.

| SYMBOL                                     | PARAMETER                          | CONDITIONS (Note 2)                                                                                     |        | LT1124AM<br>LT1125AM |            |            | LT1124M<br>LT1125M |            |            | UNITS                                            |
|--------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|--------|----------------------|------------|------------|--------------------|------------|------------|--------------------------------------------------|
|                                            |                                    |                                                                                                         |        | MIN                  | TYP        | MAX        | MIN                | TYP        | MAX        |                                                  |
| $V_{OS}$                                   | Input Offset Voltage               | LT1124<br>LT1125                                                                                        | ●<br>● |                      | 50<br>55   | 170<br>190 |                    | 60<br>70   | 250<br>290 | $\mu\text{V}$<br>$\mu\text{V}$                   |
| $\frac{\Delta V_{OS}}{\Delta \text{Temp}}$ | Average Input Offset Voltage Drift | (Note 5)                                                                                                | ●      |                      | 0.3        | 1.0        |                    | 0.4        | 1.5        | $\mu\text{V}/^\circ\text{C}$                     |
| $I_{OS}$                                   | Input Offset Current               | LT1124<br>LT1125                                                                                        | ●<br>● |                      | 18<br>18   | 45<br>55   |                    | 20<br>20   | 60<br>70   | nA<br>nA                                         |
| $I_B$                                      | Input Bias Current                 |                                                                                                         | ●      |                      | $\pm 18$   | $\pm 55$   |                    | $\pm 20$   | $\pm 70$   | nA                                               |
| $V_{CM}$                                   | Input Voltage Range                |                                                                                                         | ●      | $\pm 11.3$           | $\pm 12$   |            | $\pm 11.3$         | $\pm 12$   |            | V                                                |
| CMRR                                       | Common Mode Rejection Ratio        | $V_{CM} = \pm 11.3\text{V}$                                                                             | ●      | 106                  | 122        |            | 100                | 120        |            | dB                                               |
| PSRR                                       | Power Supply Rejection Ratio       | $V_S = \pm 4\text{V}$ to $\pm 18\text{V}$                                                               | ●      | 110                  | 122        |            | 104                | 120        |            | dB                                               |
| $A_{VOL}$                                  | Large-Signal Voltage Gain          | $R_L \geq 10\text{k}$ , $V_{OUT} = \pm 10\text{V}$<br>$R_L \geq 2\text{k}$ , $V_{OUT} = \pm 10\text{V}$ | ●<br>● | 3<br>1               | 10<br>3    |            | 2.0<br>0.7         | 10<br>2    |            | $\text{V}/\mu\text{V}$<br>$\text{V}/\mu\text{V}$ |
| $V_{OUT}$                                  | Maximum Output Voltage Swing       | $R_L \geq 2\text{k}$                                                                                    | ●      | $\pm 12.5$           | $\pm 13.6$ |            | $\pm 12$           | $\pm 13.6$ |            | V                                                |
| SR                                         | Slew Rate                          | $R_L \geq 2\text{k}$ (Notes 3, 7)                                                                       | ●      | 2.3                  | 3.8        |            | 2                  | 3.8        |            | $\text{V}/\mu\text{s}$                           |
| $I_S$                                      | Supply Current per Amplifier       |                                                                                                         | ●      |                      | 2.5        | 3.25       |                    | 2.5        | 3.25       | mA                                               |

11245ff

# ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$  temperature range,  $V_S = \pm 15\text{V}$ , unless otherwise noted.

| SYMBOL                                     | PARAMETER                          | CONDITIONS (Note 2)                                                                                     |        | LT1124AC<br>LT1125AC |            |            | LT1124C<br>LT1125C |            |            | UNITS                                            |
|--------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|--------|----------------------|------------|------------|--------------------|------------|------------|--------------------------------------------------|
|                                            |                                    |                                                                                                         |        | MIN                  | TYP        | MAX        | MIN                | TYP        | MAX        |                                                  |
| $V_{OS}$                                   | Input Offset Voltage               | LT1124<br>LT1125                                                                                        | ●<br>● |                      | 35<br>40   | 120<br>140 |                    | 45<br>50   | 170<br>210 | $\mu\text{V}$<br>$\mu\text{V}$                   |
| $\frac{\Delta V_{OS}}{\Delta \text{Temp}}$ | Average Input Offset Voltage Drift | (Note 5)                                                                                                | ●      |                      | 0.3        | 1          |                    | 0.4        | 1.5        | $\mu\text{V}/^{\circ}\text{C}$                   |
| $I_{OS}$                                   | Input Offset Current               | LT1124<br>LT1125                                                                                        | ●<br>● |                      | 6<br>7     | 25<br>35   |                    | 7<br>8     | 35<br>45   | nA<br>nA                                         |
| $I_B$                                      | Input Bias Current                 |                                                                                                         | ●      |                      | $\pm 8$    | $\pm 35$   |                    | $\pm 9$    | $\pm 45$   | nA                                               |
| $V_{CM}$                                   | Input Voltage Range                |                                                                                                         | ●      | $\pm 11.5$           | $\pm 12.4$ |            | $\pm 11.5$         | $\pm 12.4$ |            | V                                                |
| CMRR                                       | Common Mode Rejection Ratio        | $V_{CM} = \pm 11.5\text{V}$                                                                             | ●      | 109                  | 125        |            | 102                | 122        |            | dB                                               |
| PSRR                                       | Power Supply Rejection Ratio       | $V_S = \pm 4\text{V}$ to $\pm 18\text{V}$                                                               | ●      | 112                  | 125        |            | 107                | 122        |            | dB                                               |
| $A_{VOL}$                                  | Large-Signal Voltage Gain          | $R_L \geq 10\text{k}$ , $V_{OUT} = \pm 10\text{V}$<br>$R_L \geq 2\text{k}$ , $V_{OUT} = \pm 10\text{V}$ | ●<br>● | 4.0<br>1.5           | 15<br>3.5  |            | 2.5<br>1.0         | 14<br>2.5  |            | $\text{V}/\mu\text{V}$<br>$\text{V}/\mu\text{V}$ |
| $V_{OUT}$                                  | Maximum Output Voltage Swing       | $R_L \geq 2\text{k}$                                                                                    | ●      | $\pm 12.5$           | $\pm 13.7$ |            | $\pm 12$           | $\pm 13.7$ |            | V                                                |
| SR                                         | Slew Rate                          | $R_L \geq 2\text{k}$ (Notes 3, 7)                                                                       | ●      | 2.6                  | 4          |            | 2.4                | 4          |            | $\text{V}/\mu\text{s}$                           |
| $I_S$                                      | Supply Current per Amplifier       |                                                                                                         | ●      |                      | 2.4        | 3          |                    | 2.4        | 3          | mA                                               |

The ● denotes the specifications which apply over the  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$  temperature range,  $V_S = \pm 15\text{V}$ , unless otherwise noted. (Note 10)

| SYMBOL                                     | PARAMETER                          | CONDITIONS (Note 2)                                                                                     |        | LT1124AC/AI<br>LT1125AC |            |            | LT1124C/I<br>LT1125C |            |            | UNITS                                            |
|--------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------|--------|-------------------------|------------|------------|----------------------|------------|------------|--------------------------------------------------|
|                                            |                                    |                                                                                                         |        | MIN                     | TYP        | MAX        | MIN                  | TYP        | MAX        |                                                  |
| $V_{OS}$                                   | Input Offset Voltage               | LT1124<br>LT1125                                                                                        | ●<br>● |                         | 40<br>45   | 140<br>160 |                      | 50<br>55   | 200<br>240 | $\mu\text{V}$<br>$\mu\text{V}$                   |
| $\frac{\Delta V_{OS}}{\Delta \text{Temp}}$ | Average Input Offset Voltage Drift | (Note 5)                                                                                                | ●      |                         | 0.3        | 1          |                      | 0.4        | 1.5        | $\mu\text{V}/^{\circ}\text{C}$                   |
| $I_{OS}$                                   | Input Offset Current               | LT1124<br>LT1125                                                                                        | ●<br>● |                         | 15<br>15   | 40<br>50   |                      | 17<br>17   | 55<br>65   | nA<br>nA                                         |
| $I_B$                                      | Input Bias Current                 |                                                                                                         | ●      |                         | $\pm 15$   | $\pm 50$   |                      | $\pm 17$   | $\pm 65$   | nA                                               |
| $V_{CM}$                                   | Input Voltage Range                |                                                                                                         | ●      | $\pm 11.4$              | $\pm 12.2$ |            | $\pm 11.4$           | $\pm 12.2$ |            | V                                                |
| CMRR                                       | Common Mode Rejection Ratio        | $V_{CM} = \pm 11.4\text{V}$                                                                             | ●      | 107                     | 124        |            | 101                  | 121        |            | dB                                               |
| PSRR                                       | Power Supply Rejection Ratio       | $V_S = \pm 4\text{V}$ to $\pm 18\text{V}$                                                               | ●      | 111                     | 124        |            | 106                  | 121        |            | dB                                               |
| $A_{VOL}$                                  | Large-Signal Voltage Gain          | $R_L \geq 10\text{k}$ , $V_{OUT} = \pm 10\text{V}$<br>$R_L \geq 2\text{k}$ , $V_{OUT} = \pm 10\text{V}$ | ●<br>● | 3.5<br>1.2              | 12<br>3.2  |            | 2.2<br>0.8           | 12<br>2.3  |            | $\text{V}/\mu\text{V}$<br>$\text{V}/\mu\text{V}$ |
| $V_{OUT}$                                  | Maximum Output Voltage Swing       | $R_L \geq 2\text{k}$                                                                                    | ●      | $\pm 12.5$              | $\pm 13.6$ |            | $\pm 12$             | $\pm 13.6$ |            | V                                                |
| SR                                         | Slew Rate                          | $R_L \geq 2\text{k}$ (Notes 3, 7)                                                                       | ●      | 2.4                     | 3.9        |            | 2.1                  | 3.9        |            | $\text{V}/\mu\text{s}$                           |
| $I_S$                                      | Supply Current per Amplifier       |                                                                                                         | ●      |                         | 2.4        | 3.25       |                      | 2.4        | 3.25       | mA                                               |

## ELECTRICAL CHARACTERISTICS

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

**Note 2:** Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers; i.e., out of 100 LT1125s (or 100 LT1124s) typically 240 op amps (or 120) will be better than the indicated specification.

**Note 3:** This parameter is 100% tested for each individual amplifier.

**Note 4:** This parameter is sample tested only.

**Note 5:** This parameter is not 100% tested.

**Note 6:** The inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise. If differential input

voltage exceeds  $\pm 1.4V$ , the input current should be limited to 25mA.

**Note 7:** Slew rate is measured in  $A_V = -1$ ; input signal is  $\pm 7.5V$ , output measured at  $\pm 2.5V$ .

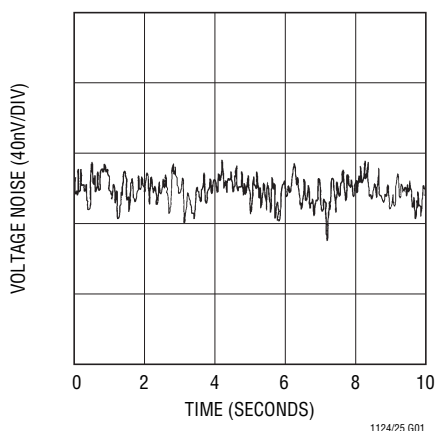
**Note 8:** 0.1Hz to 10Hz noise can be inferred from the 10Hz noise voltage density test. See the test circuit and frequency response curve for 0.1Hz to 10Hz tester in the Applications Information section of the LT1007 or LT1028 data sheets.

**Note 9:** This parameter is guaranteed but not tested.

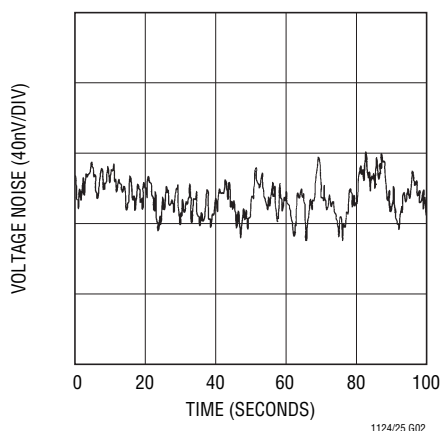
**Note 10:** The LT1124C/LT1125C and LT1124AC/LT1125AC are guaranteed to meet specified performance from  $0^\circ C$  to  $70^\circ C$  and are designed, characterized and expected to meet these extended temperature limits, but are not tested at  $-40^\circ C$  and  $85^\circ C$ . The LT1124AI and LT1124I are guaranteed to meet the extended temperature limits.

## TYPICAL PERFORMANCE CHARACTERISTICS

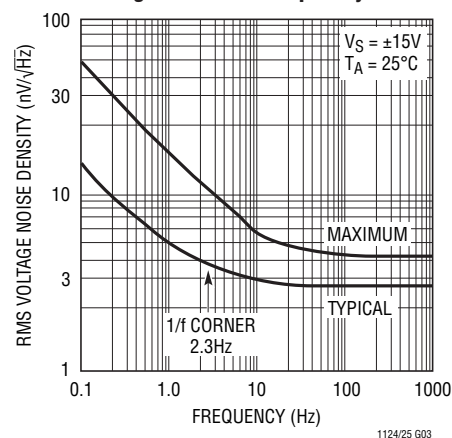
0.1Hz to 10Hz Voltage Noise



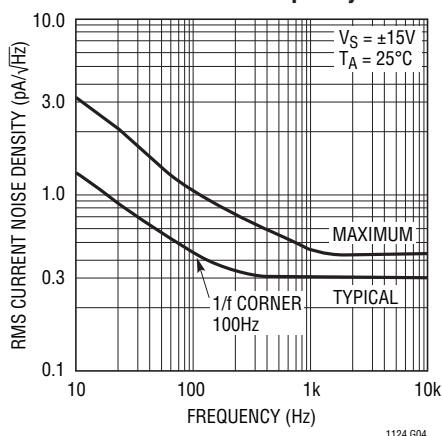
0.01Hz to 1Hz Voltage Noise



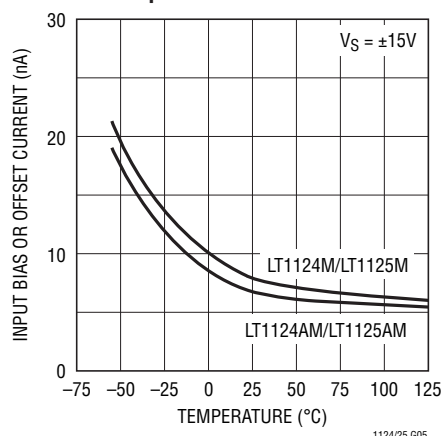
Voltage Noise vs Frequency



Current Noise vs Frequency

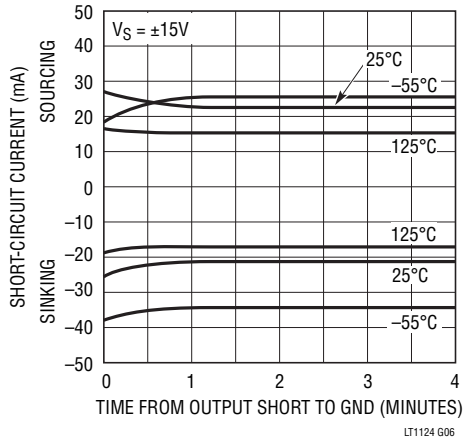


Input Bias or Offset Current vs Temperature

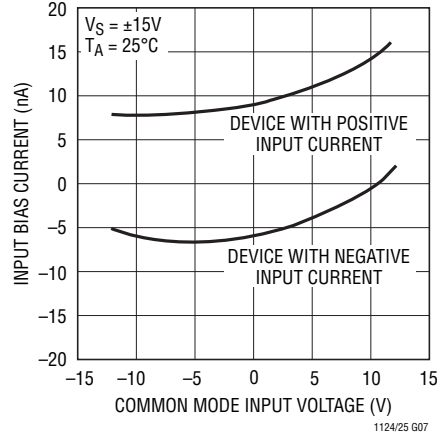


# TYPICAL PERFORMANCE CHARACTERISTICS

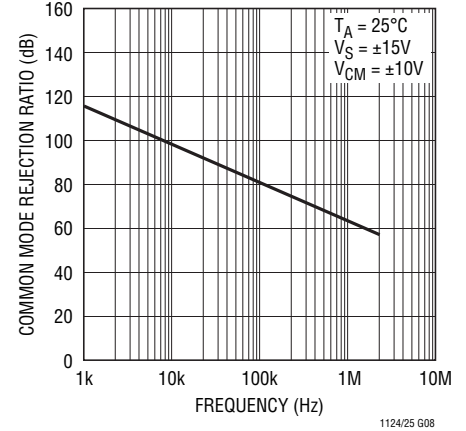
**Output Short-Circuit Current vs Time**



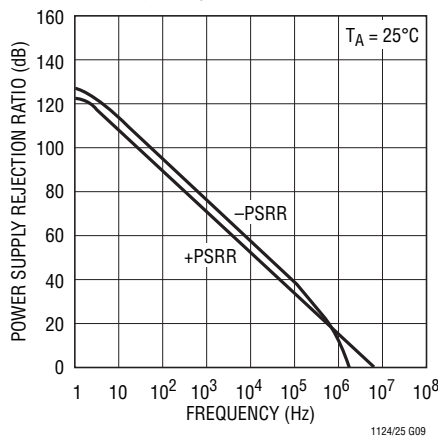
**Input Bias Current Over the Common Mode Range**



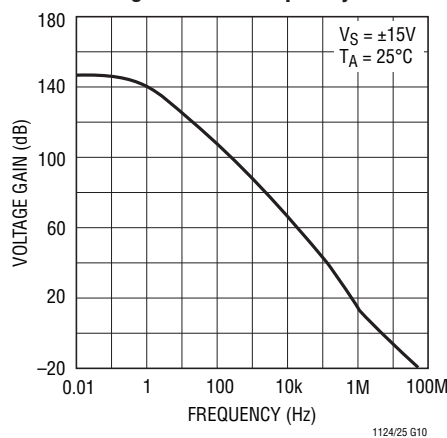
**Common Mode Rejection Ratio vs Frequency**



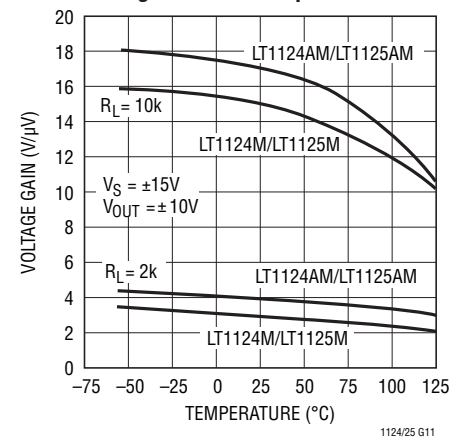
**Power Supply Rejection Ratio vs Frequency**



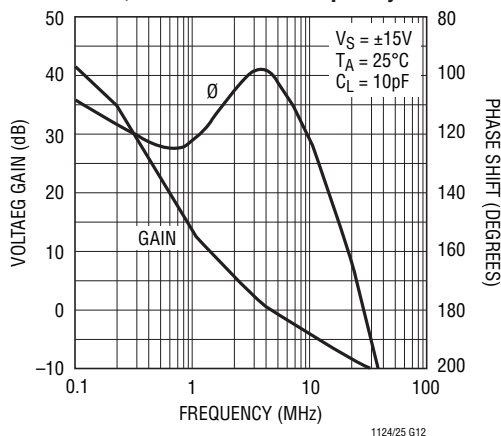
**Voltage Gain vs Frequency**



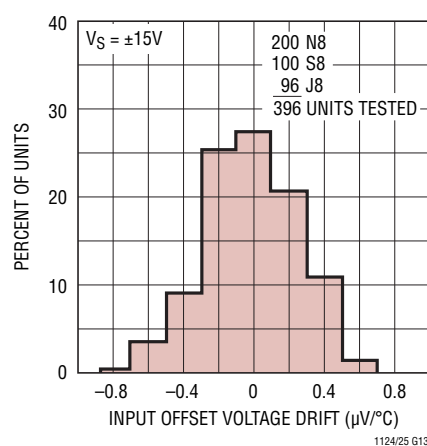
**Voltage Gain vs Temperature**



**Gain, Phase Shift vs Frequency**

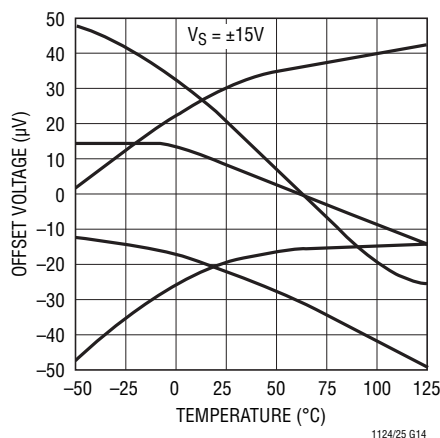


**Input Offset Voltage Drift Distribution**

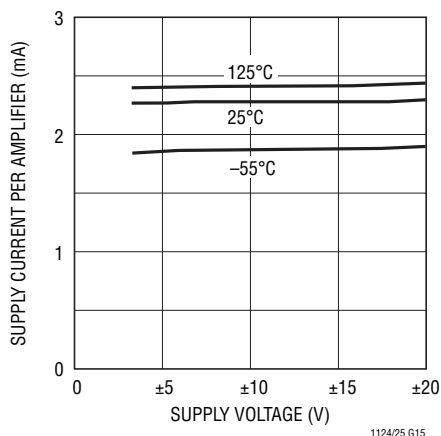


## TYPICAL PERFORMANCE CHARACTERISTICS

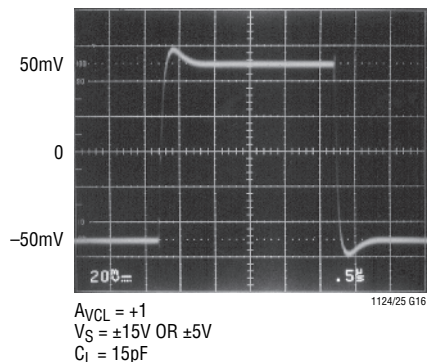
**Offset Voltage Drift with Temperature of Representative Units**



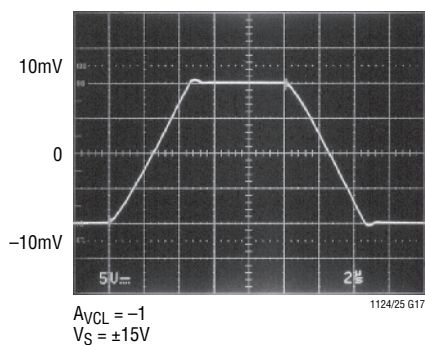
**Supply Current vs Supply Voltage**



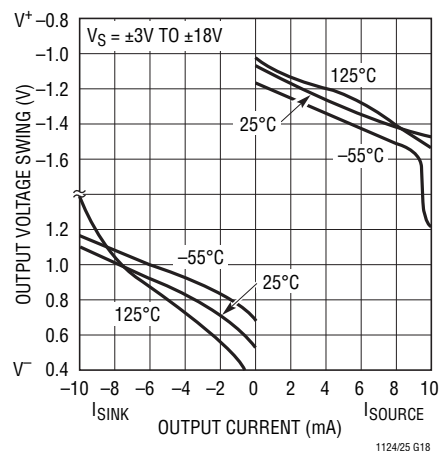
**Small-Signal Transient Response**



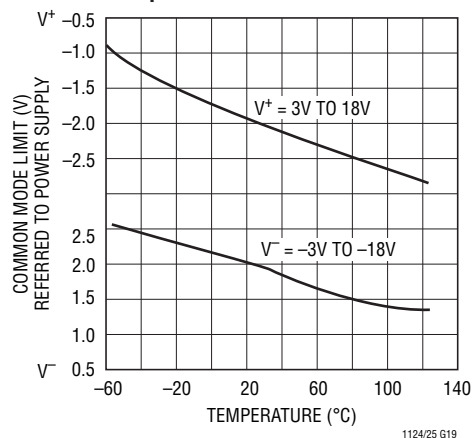
**Large-Signal Transient Response**



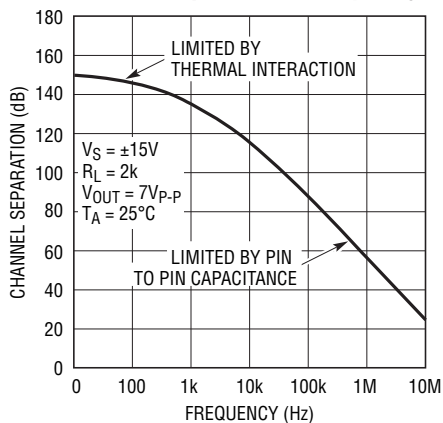
**Output Voltage Swing vs Load Current**



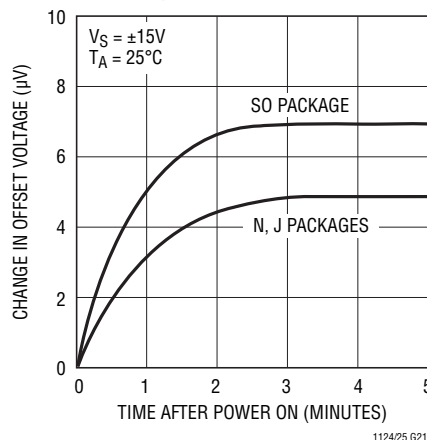
**Common Mode Limit vs Temperature**



**Channel Separation vs Frequency**

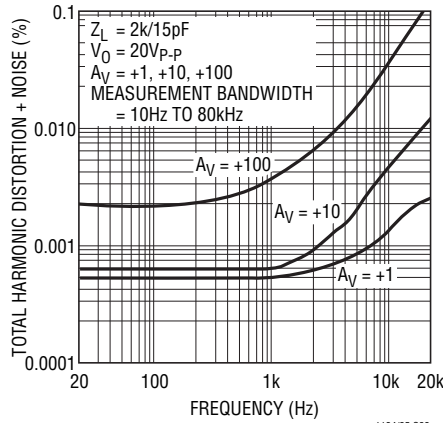


**Warm-Up Drift**

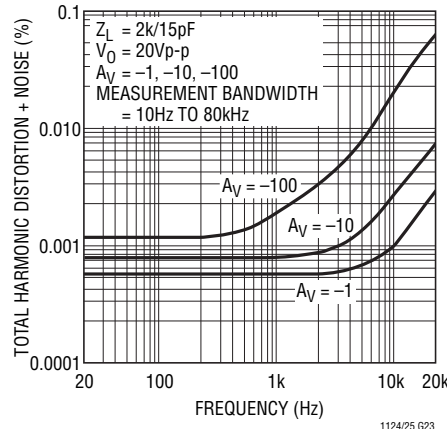


# TYPICAL PERFORMANCE CHARACTERISTICS

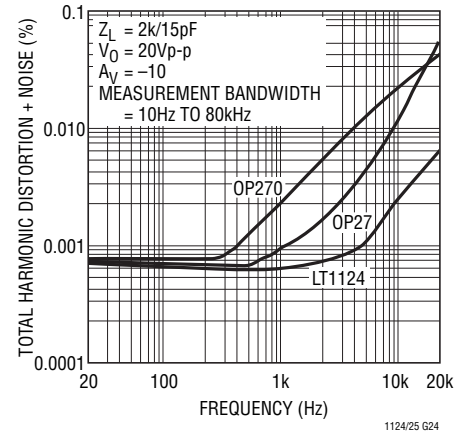
**Total Harmonic Distortion and Noise vs Frequency for Noninverting Gain**



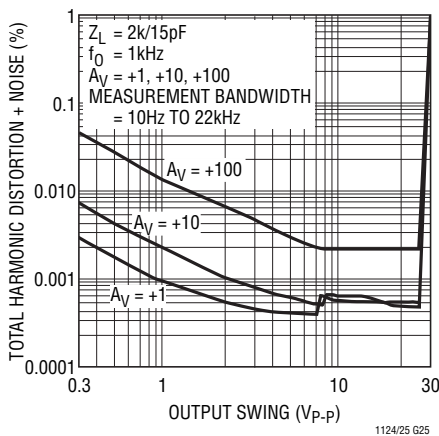
**Total Harmonic Distortion and Noise vs Frequency for Inverting Gain**



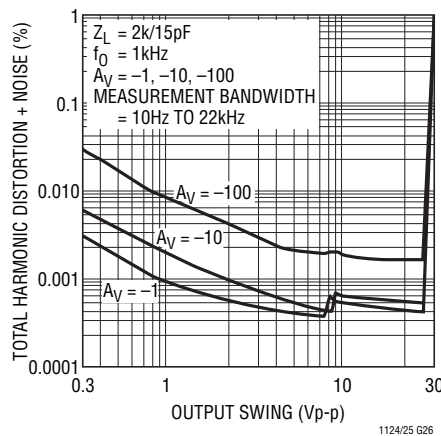
**Total Harmonic Distortion and Noise vs Frequency for Competitive Devices**



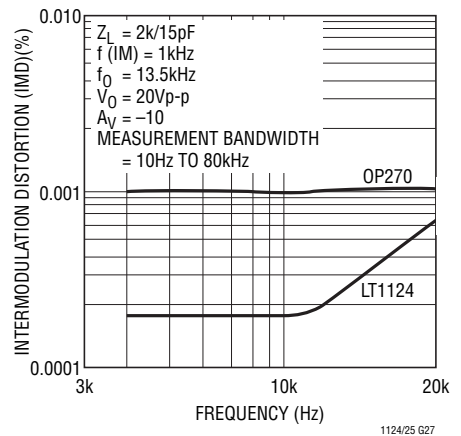
**Total Harmonic Distortion and Noise vs Output Amplitude for Noninverting Gain**



**Total Harmonic Distortion and Noise vs Output Amplitude for Inverting Gain**



**Intermodulation Distortion (CCIF Method)\* vs Frequency LT1124 and OP270**



## APPLICATIONS INFORMATION

The LT1124 may be inserted directly into OP-270 sockets. The LT1125 plugs into OP-470 sockets. Of course, all standard dual and quad bipolar op amps can also be replaced by these devices.

### Matching Specifications

In many applications the performance of a system depends on the matching between two op amps, rather than the individual characteristics of the two devices. The three op amp instrumentation amplifier configuration shown in this data sheet is an example. Matching characteristics are not 100% tested on the LT1124/LT1125.

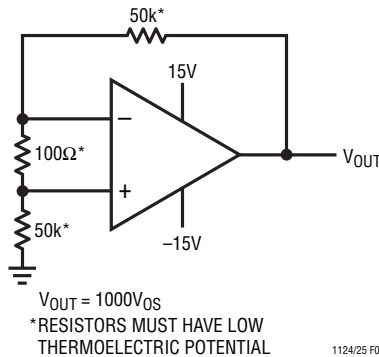
Some specifications are guaranteed by definition. For example, 70 $\mu$ V maximum offset voltage implies that mismatch cannot be more than 140 $\mu$ V. 112dB (= 2.5 $\mu$ V/V) CMRR means that worst-case CMRR match is 106dB

(5 $\mu$ V/V). However, Table 1 can be used to estimate the expected matching performance between the two sides of the LT1124, and between amplifiers A and D, and between amplifiers B and C of the LT1125.

### Offset Voltage and Drift

Thermocouple effects, caused by temperature gradients across dissimilar metals at the contacts to the input terminals, can exceed the inherent drift of the amplifier unless proper care is exercised. Air currents should be minimized, package leads should be short, the two input leads should be close together and maintained at the same temperature.

The circuit shown in Figure 1 to measure offset voltage is also used as the burn-in configuration for the LT1124/LT1125, with the supply voltages increased to  $\pm 16$ V.



**Figure 1. Test Circuit for Offset Voltage and Offset Voltage Drift with Temperature**

**Table 1. Expected Match**

|                                 |        | LT1124AC/AM<br>LT1125AC/AM |           | LT1124C/M<br>LT1125C/M |           | UNITS                 |
|---------------------------------|--------|----------------------------|-----------|------------------------|-----------|-----------------------|
| PARAMETER                       |        | 50% YIELD                  | 98% YIELD | 50% YIELD              | 98% YIELD |                       |
| $V_{OS}$ Match, $\Delta V_{OS}$ | LT1124 | 20                         | 110       | 30                     | 130       | $\mu$ V               |
|                                 | LT1125 | 30                         | 150       | 50                     | 180       | $\mu$ V               |
| Temperature Coefficient Match   |        | 0.35                       | 1.0       | 0.5                    | 1.5       | $\mu$ V/ $^{\circ}$ C |
| Average Noninverting $I_B$      |        | 6                          | 18        | 7                      | 25        | nA                    |
| Match of Noninverting $I_B$     |        | 7                          | 22        | 8                      | 30        | nA                    |
| CMRR Match                      |        | 126                        | 115       | 123                    | 112       | dB                    |
| PSRR Match                      |        | 127                        | 118       | 127                    | 114       | dB                    |

## APPLICATIONS INFORMATION

### 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 ( $C_{IN} \approx 2\text{pF}$ ). 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 (see Figure 2). With  $R_S(C_S + C_{IN}) = R_F C_F$ , the effect of the feedback pole is completely removed.

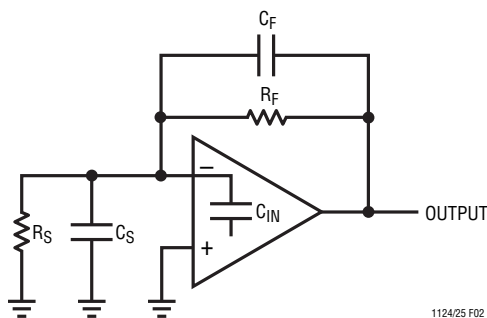


Figure 2. High Speed Operation

### Unity Gain Buffer Applications

When  $R_F \leq 100\Omega$  and the input is driven with a fast, large signal pulse ( $>1\text{V}$ ), the output waveform will look as shown in Figure 3.

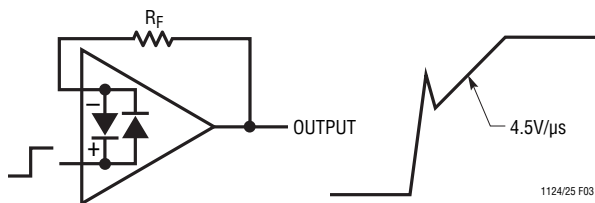


Figure 3. Unity-Gain Buffer Applications

During the fast feedthrough-like portion of the output, the input protection diodes effectively short the output to the input and a current, limited only by the output short circuit protection, will be drawn by the signal generator. With  $R_F \geq 500\Omega$ , the output is capable of handling the current requirements ( $I_L \leq 20\text{mA}$  at  $10\text{V}$ ) and the amplifier stays in its active mode and a smooth transition will occur.

### Noise Testing

Each individual amplifier is tested to  $4.2\text{nV}/\sqrt{\text{Hz}}$  voltage noise; i.e., for the LT1124 two tests, for the LT1125 four tests are performed. Noise testing for competing multiple op amps, if done at all, may be sample tested or tested using the circuit shown in Figure 4.

$$e_{n\text{ OUT}} = \sqrt{(e_{nA})^2 + (e_{nB})^2 + (e_{nC})^2 + (e_{nD})^2}$$

If the LT1125 were tested this way, the noise limit would be  $\sqrt{4 \cdot (4.2\text{nV}/\sqrt{\text{Hz}})^2} = 8.4\text{nV}/\sqrt{\text{Hz}}$ . But is this an effective screen? What if three of the four amplifiers are at a typical  $2.7\text{nV}/\sqrt{\text{Hz}}$ , and the fourth one was contaminated and has  $6.9\text{nV}/\sqrt{\text{Hz}}$  noise?

$$\text{RMS Sum} = \sqrt{(2.7)^2 + (2.7)^2 + (2.7)^2 + (6.9)^2} = 8.33\text{nV}/\sqrt{\text{Hz}}$$

This passes an  $8.4\text{nV}/\sqrt{\text{Hz}}$  spec, yet one of the amplifiers is 64% over the LT1125 spec limit. Clearly, for proper noise measurement, the op amps have to be tested individually.

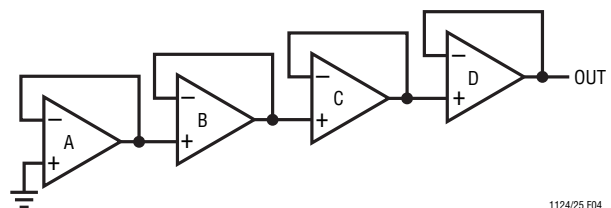


Figure 4. Competing Quad Op Amp Noise Test Method

# LT1124/LT1125

## PERFORMANCE COMPARISON

Table 2 summarizes the performance of the LT1124/LT1125 compared to the low cost grades of alternate approaches. performance is degraded when compared to singles, for the LT1124/LT1125 this is not the case.

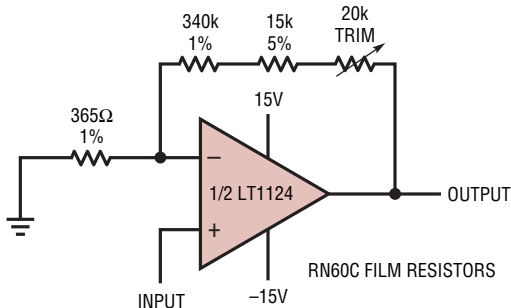
The comparison shows how the specs of the LT1124/LT1125 not only stand up to the industry standard OP-27, but in most cases are superior. Normally dual and quad

Table 2. Guaranteed Performance,  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$ , Low Cost Devices

| PARAMETER/UNITS              |        | LT1124CN8<br>LT1125CN | OP-27 GP             | OP-270 GP     | OP-470 GP            | UNITS           |
|------------------------------|--------|-----------------------|----------------------|---------------|----------------------|-----------------|
| Voltage Noise, 1kHz          |        | 4.2<br>100% Tested    | 4.5<br>Sample Tested | —<br>No Limit | 5.0<br>Sample Tested | nV/ $\sqrt{Hz}$ |
| Slew Rate                    |        | 2.7<br>100% Tested    | 1.7<br>Not Tested    | 1.7           | 1.4                  | V/ $\mu s$      |
| Gain-Bandwidth Product       |        | 8.0<br>100% Tested    | 5.0<br>Not Tested    | —<br>No Limit | —<br>No Limit        | MHz             |
| Offset Voltage               | LT1124 | 100                   | 100                  | 250           | —                    | $\mu V$         |
|                              | LT1125 | 140                   | —                    | —             | 1000                 | $\mu V$         |
| Offset Current               | LT1124 | 20                    | 75                   | 20            | —                    | nA              |
|                              | LT1125 | 30                    | —                    | —             | 30                   | nA              |
| Bias Current                 |        | 30                    | 80                   | 60            | 60                   | nA              |
| Supply Current/Amp           |        | 2.75                  | 5.67                 | 3.25          | 2.75                 | mA              |
| Voltage Gain, $R_L = 2k$     |        | 1.5                   | 0.7                  | 0.35          | 0.4                  | V/ $\mu V$      |
| Common Mode Rejection Ratio  |        | 106                   | 100                  | 90            | 100                  | dB              |
| Power Supply Rejection Ratio |        | 110                   | 94                   | 104           | 105                  | dB              |
| SO-8 Package                 |        | Yes — LT1124          | Yes                  | No            | —                    |                 |

## TYPICAL APPLICATIONS

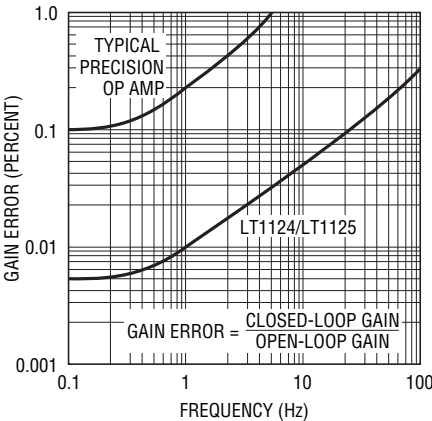
Gain 1000 Amplifier with 0.01% Accuracy, DC to 1Hz



THE HIGH GAIN AND WIDE BANDWIDTH OF THE LT1124/LT1125, IS USEFUL IN LOW FREQUENCY HIGH CLOSED-LOOP GAIN AMPLIFIER APPLICATIONS. A TYPICAL PRECISION OP AMP MAY HAVE AN OPEN-LOOP GAIN OF ONE MILLION WITH 500kHz BANDWIDTH. AS THE GAIN ERROR PLOT SHOWS, THIS DEVICE IS CAPABLE OF 0.1% AMPLIFYING ACCURACY UP TO 0.3Hz ONLY. EVEN INSTRUMENTATION RANGE SIGNALS CAN VARY AT A FASTER RATE. THE LT1124/LT1125 "GAIN PRECISION — BANDWIDTH PRODUCT" IS 75 TIMES HIGHER, AS SHOWN.

1124/25 TA03

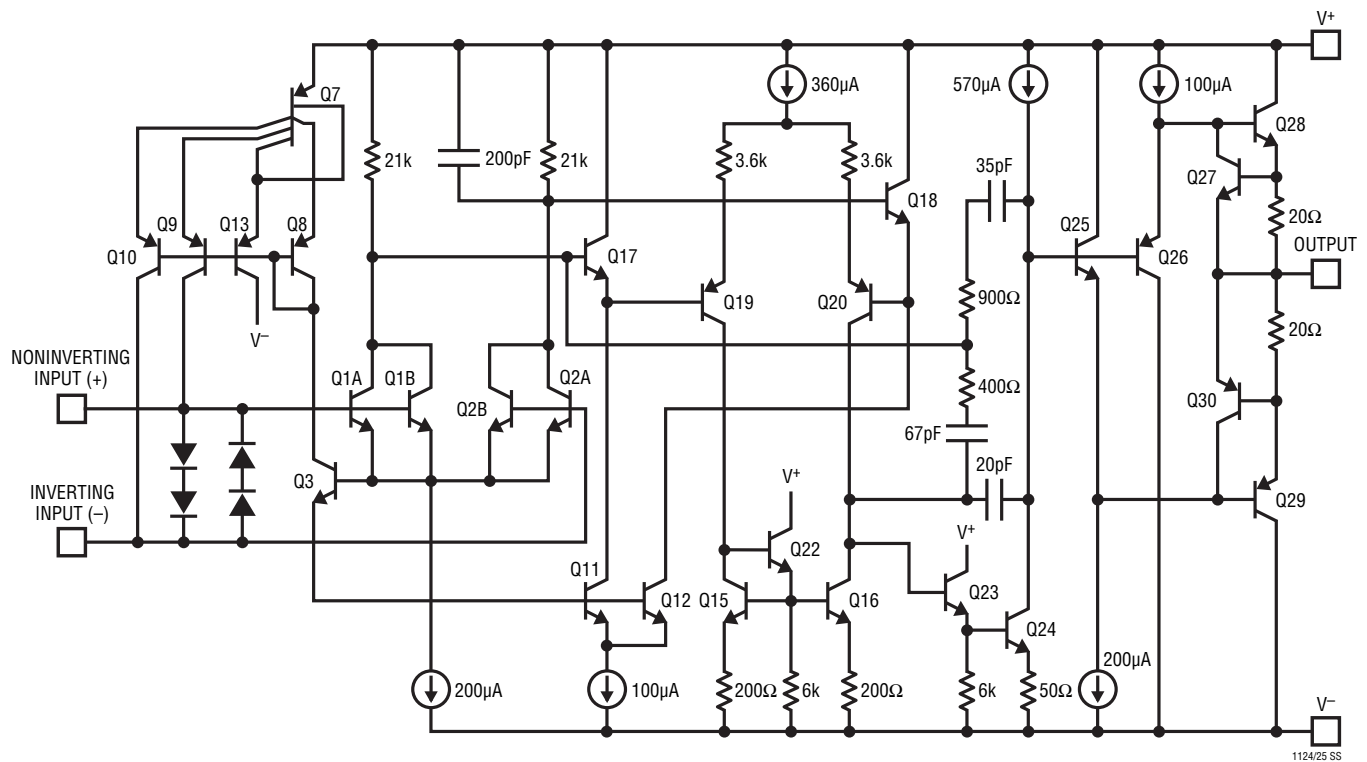
Gain Error vs Frequency Closed-Loop Gain = 1000



1124/25 TA04

11245ff

# SCHEMATIC DIAGRAM (1/2 LT1124, 1/4 LT1125)

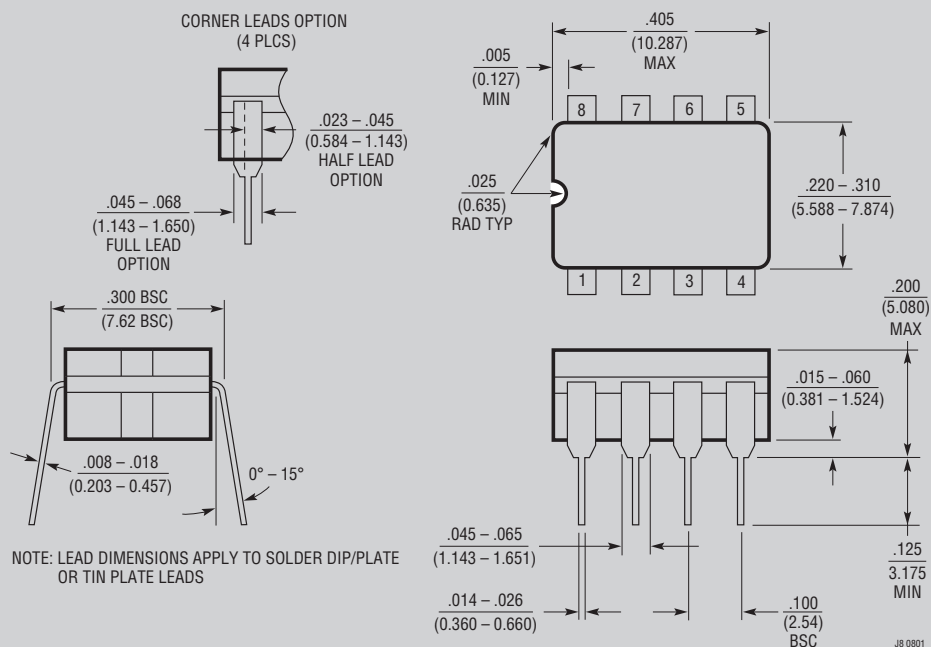


1124/25 SS

## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/designtools/packaging/> for the most recent package drawings.

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

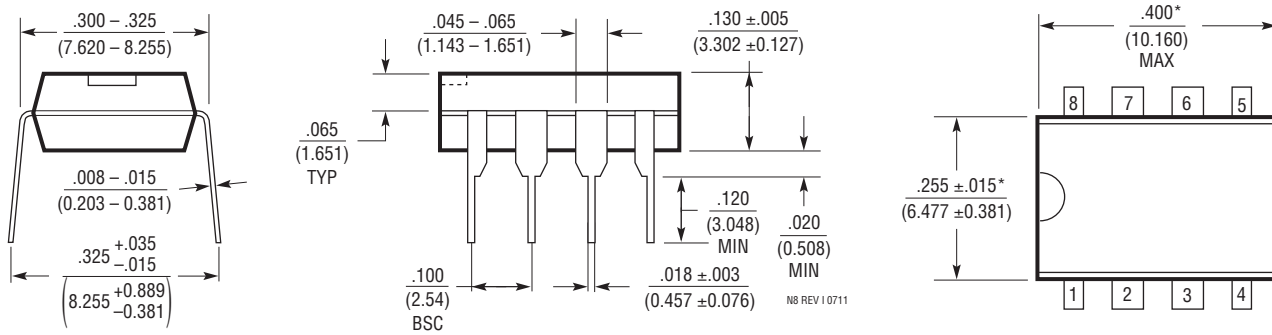


**OBSOLETE PACKAGE**

# PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/designtools/packaging/> for the most recent package drawings.

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

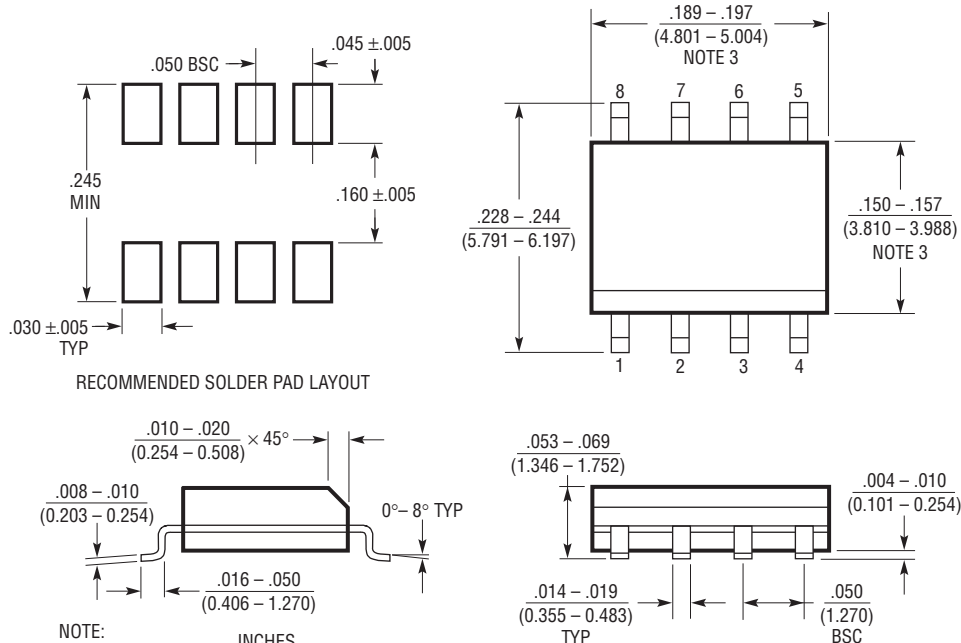


NOTE:

1. DIMENSIONS ARE  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

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



NOTE:

1. DIMENSIONS IN  $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

2. DRAWING NOT TO SCALE

3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

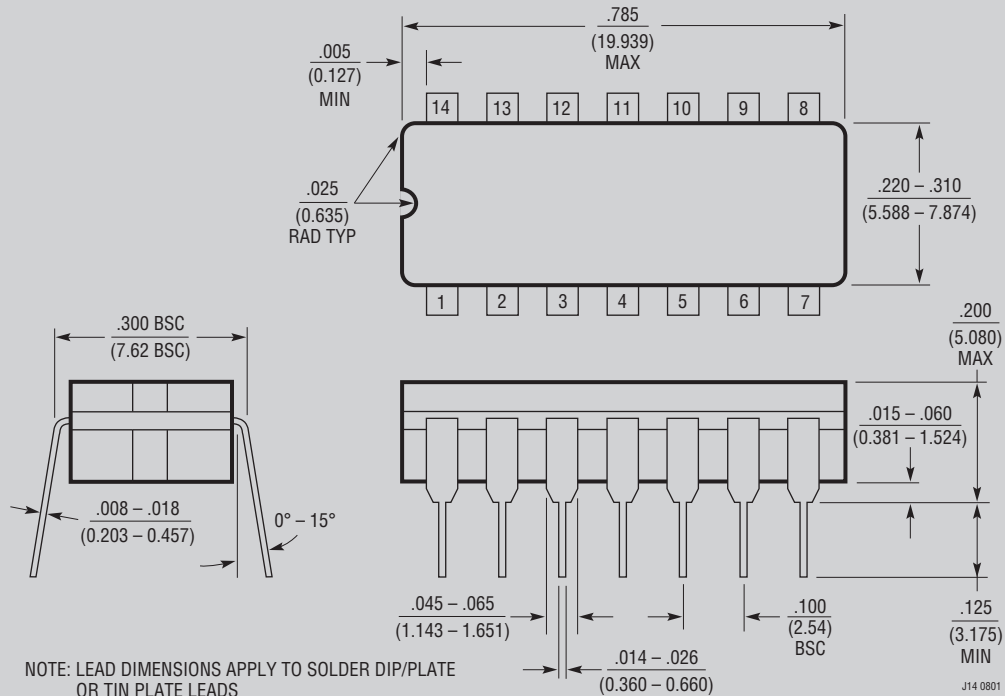
4. PIN 1 CAN BE BEVEL EDGE OR A DIMPLE

S08 REV G 0212

## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/designtools/packaging/> for the most recent package drawings.

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

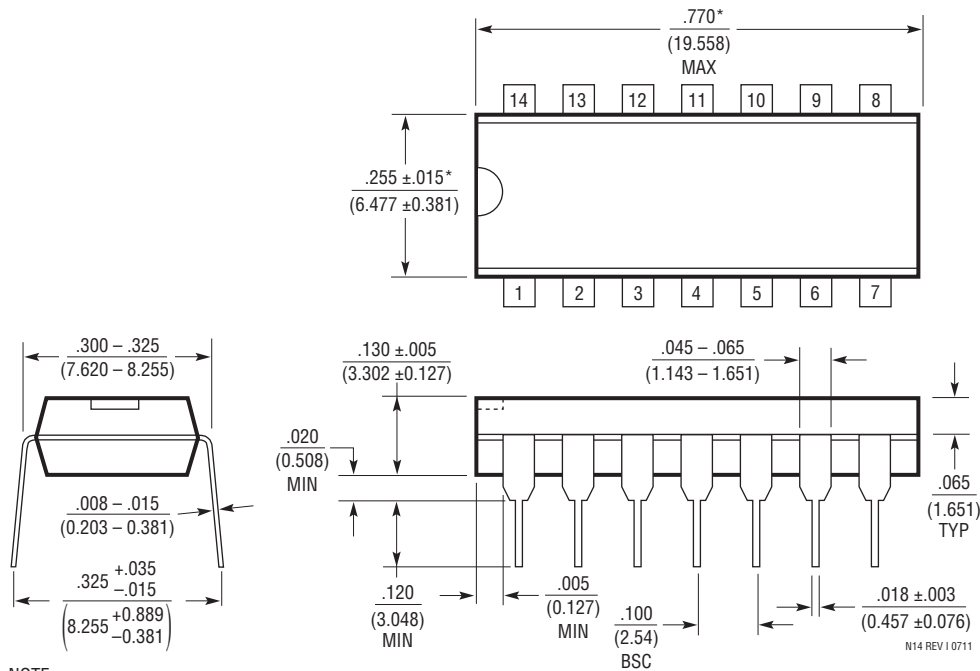


**OBSOLETE PACKAGE**

# PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/designtools/packaging/> for the most recent package drawings.

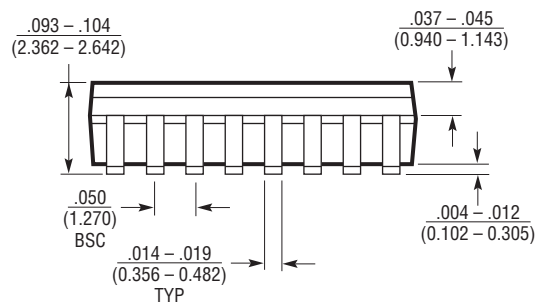
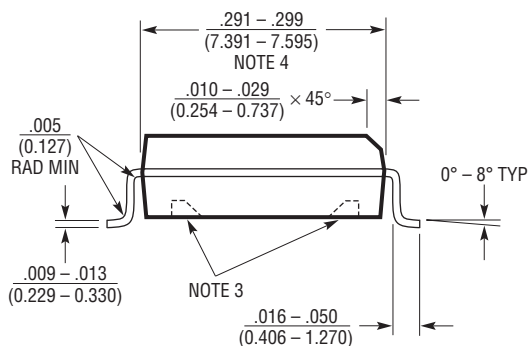
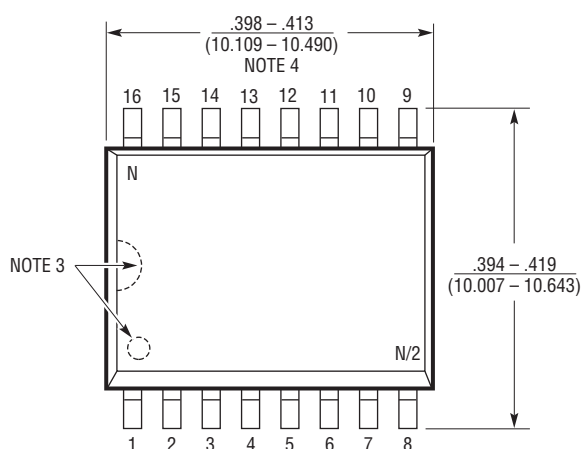
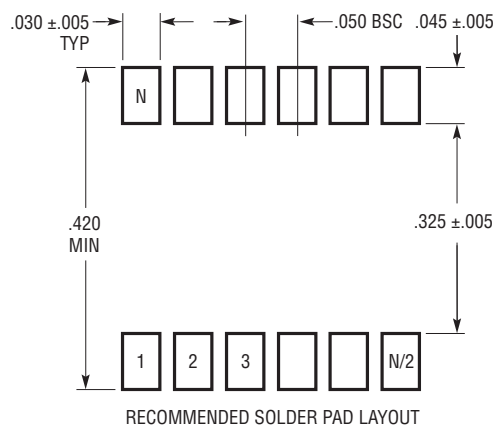
## N Package 14-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510 Rev I)



## PACKAGE DESCRIPTION

Please refer to <http://www.linear.com/designtools/packaging/> for the most recent package drawings.

### SW Package 16-Lead Plastic Small Outline (Wide .300 Inch) (Reference LTC DWG # 05-08-1620)



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

S16 (WIDE) 0502

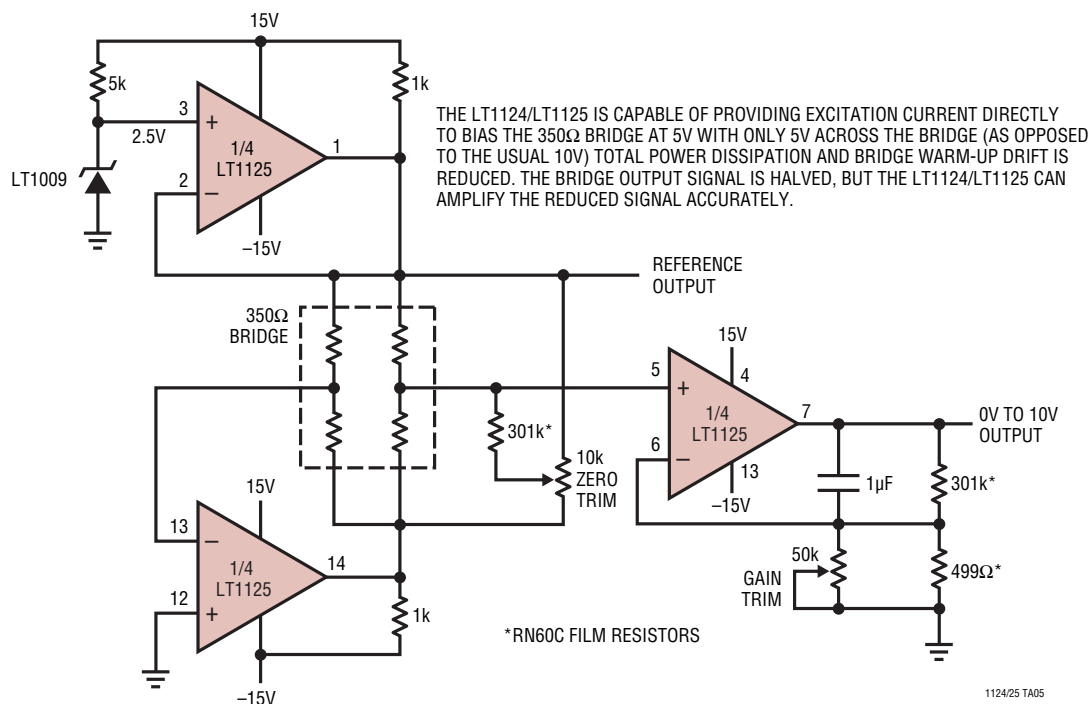
REVISION HISTORY (Revision history begins at Rev D)

| REV | DATE  | DESCRIPTION                                                          | PAGE NUMBER |
|-----|-------|----------------------------------------------------------------------|-------------|
| D   | 09/10 | LT1124-1 added. Reflected throughout the data sheet.                 | 1 to 18     |
| E   | 10/10 | Revised part marking for LT1124AMPS8-1 in Order Information section. | 3           |
| F   | 01/14 | LT1124-1 removed.                                                    | 1 to 3      |

# LT1124/LT1125

## TYPICAL APPLICATION

### Strain Gauge Signal Conditioner with Bridge Excitation



## RELATED PARTS

| PART NUMBER                   | DESCRIPTION                         | COMMENTS                                                              |
|-------------------------------|-------------------------------------|-----------------------------------------------------------------------|
| <a href="#">LT1007</a>        | Single Low Noise, Precision Op Amp  | 2.5nV/√Hz 1kHz Voltage Noise                                          |
| <a href="#">LT1028/LT1128</a> | Single Low Noise, Precision Op Amps | 0.85nV/√Hz Voltage Noise                                              |
| <a href="#">LT1112/LT1114</a> | Dual/Quad Precision Picoamp Input   | 250pA Max I <sub>B</sub>                                              |
| <a href="#">LT1113</a>        | Dual Low Noise JFET Op Amp          | 4.5nV/√Hz Voltage Noise, 10fA/√Hz Current Noise                       |
| <a href="#">LT1126/LT1127</a> | Decompensated LT1124/LT1125         | 11V/μs Slew Rate                                                      |
| <a href="#">LT1169</a>        | Dual Low Noise JFET Op Amp          | 6nV/√Hz Voltage Noise, 1fA/√Hz Current Noise, 10pA Max I <sub>B</sub> |
| <a href="#">LT1792</a>        | Single LT1113                       | 4.2nV/√Hz Voltage Noise, 10fA/√Hz Current Noise                       |
| <a href="#">LT1793</a>        | Single LT1169                       | 6nV/√Hz Voltage Noise, 1fA/√Hz Current Noise, 10pA Max I <sub>B</sub> |