

## FEATURES

- 60 $\mu$ V Maximum Offset Voltage
- 300pA Maximum Input Bias Current
- 135 $\mu$ A Supply Current per Amplifier
- Rail-to-Rail Output Swing
- 120dB Minimum Voltage Gain,  $V_S = \pm 15\text{V}$
- 0.8 $\mu\text{V}/^\circ\text{C}$  Maximum  $V_{OS}$  Drift
- 14nV/ $\sqrt{\text{Hz}}$  Input Noise Voltage
- 2.7V to  $\pm 18\text{V}$  Supply Voltage Operation
- Operating Temperature Range:  $-40^\circ\text{C}$  to  $85^\circ\text{C}$
- Space Saving 3mm  $\times$  3mm DFN Package

## APPLICATIONS

- Thermocouple Amplifiers
- Precision Photo Diode Amplifiers
- Instrumentation Amplifiers
- Battery-Powered Precision Systems
- Low Voltage Precision Systems

## DESCRIPTION

The LT<sup>®</sup>6011/LT6012 op amps combine low noise and high precision input performance with low power consumption and rail-to-rail output swing.

Input offset voltage is trimmed to less than 60 $\mu\text{V}$ . The low drift and excellent long-term stability guarantee a high accuracy over temperature and time. The 300pA maximum input bias current and 120dB minimum voltage gain further maintain this precision over operating conditions.

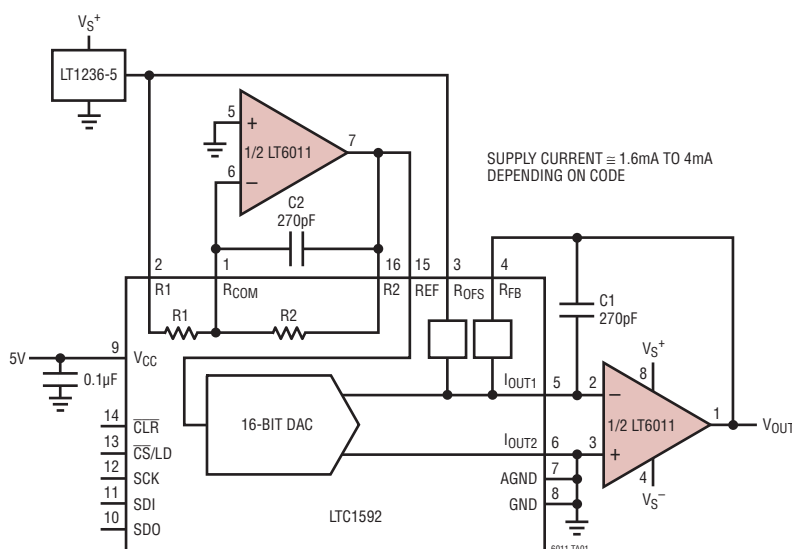
The LT6011/LT6012 work on any power supply voltage from 2.7V to 36V and draw only 135 $\mu\text{A}$  of supply current on a 5V supply. The output swings to within 40mV of either supply rail, making the amplifier a good choice for low voltage single supply applications.

The LT6011/LT6012 are specified at 5V and  $\pm 15\text{V}$  supplies and from  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ . The LT6011 (dual) is available in SO-8, MS8 and space saving 3mm  $\times$  3mm DFN packages. The LT6012 (quad) is available in SO-14 and 16-pin SSOP packages.

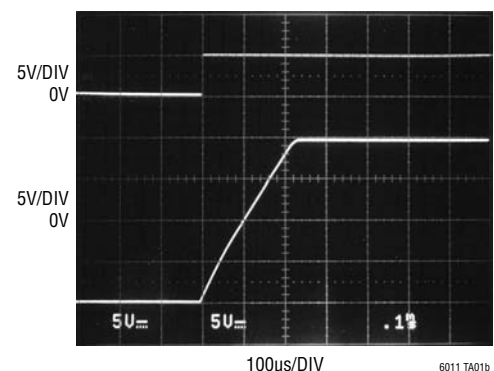
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## TYPICAL APPLICATION

### Low Power Programmable Output Range 16-Bit SoftSpan<sup>™</sup> DAC



### 20V Output Step Response



## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                                               |                   |                                           |                                                |
|-----------------------------------------------|-------------------|-------------------------------------------|------------------------------------------------|
| Total Supply Voltage ( $V^+$ to $V^-$ ) ..... | 40V               | Operating Temperature Range (Note 4)....  | $-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$  |
| Differential Input Voltage (Note 2) .....     | 10V               | Specified Temperature Range (Note 5) .... | $-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$  |
| Input Voltage.....                            | $V^+$ to $V^-$    | Maximum Junction Temperature .....        | $150^{\circ}\text{C}$                          |
| Input Current (Note 2).....                   | $\pm 10\text{mA}$ | Storage Temperature Range .....           | $-65^{\circ}\text{C}$ to $150^{\circ}\text{C}$ |
| Output Short-Circuit Duration (Note 3) .....  | Indefinite        | Lead Temperature (Soldering, 10 sec)..... | $300^{\circ}\text{C}$                          |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                                                          |                                                                                                                                                                 |                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>TOP VIEW</p> <p>DD PACKAGE<br/>8-LEAD (3mm × 3mm) PLASTIC DFN</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 43^{\circ}\text{C/W}</math><br/>UNDERSIDE METAL CONNECTED TO <math>V^-</math><br/>(PCB CONNECTION OPTIONAL)</p> | <p>TOP VIEW</p> <p>S8 PACKAGE<br/>8-LEAD PLASTIC SO</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 190^{\circ}\text{C/W}</math></p>    | <p>TOP VIEW</p> <p>MS8 PACKAGE<br/>8-LEAD PLASTIC MSOP</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 220^{\circ}\text{C/W}</math></p> |
| <p>TOP VIEW</p> <p>S PACKAGE<br/>14-LEAD PLASTIC SO</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 110^{\circ}\text{C/W}</math></p>                                                                                             | <p>TOP VIEW</p> <p>GN PACKAGE<br/>16-LEAD PLASTIC SSOP</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 135^{\circ}\text{C/W}</math></p> |                                                                                                                                                                 |

## ORDER INFORMATION

| LEAD FREE FINISH | TAPE AND REEL    | PART MARKING* | PACKAGE DESCRIPTION            | SPECIFIED TEMPERATURE RANGE |
|------------------|------------------|---------------|--------------------------------|-----------------------------|
| LT6011CDD#PBF    | LT6011CDD#TRPBF  | LACD          | 8-Lead (3mm × 3mm) Plastic DFN | 0°C to 70°C                 |
| LT6011IDD#PBF    | LT6011IDD#TRPBF  | LACD          | 8-Lead (3mm × 3mm) Plastic DFN | −40°C to 85°C               |
| LT6011ACDD#PBF   | LT6011ACDD#TRPBF | LACD          | 8-Lead (3mm × 3mm) Plastic DFN | 0°C to 70°C                 |
| LT6011AIDD#PBF   | LT6011AIDD#TRPBF | LACD          | 8-Lead (3mm × 3mm) Plastic DFN | −40°C to 85°C               |
| LT6011CS8#PBF    | LT6011CS8#TRPBF  | 6011          | 8-Lead Plastic SO              | 0°C to 70°C                 |
| LT6011IS8#PBF    | LT6011IS8#TRPBF  | 6011I         | 8-Lead Plastic SO              | −40°C to 85°C               |
| LT6011ACS8#PBF   | LT6011ACS8#TRPBF | 6011A         | 8-Lead Plastic SO              | 0°C to 70°C                 |
| LT6011AIS8#PBF   | LT6011AIS8#TRPBF | 6011AI        | 8-Lead Plastic SO              | −40°C to 85°C               |
| LT6011CMS8#PBF   | LT6011CMS8#TRPBF | LTCGC         | 8-Lead Plastic MSOP            | 0°C to 70°C                 |
| LT6011IMS8#PBF   | LT6011IMS8#TRPBF | LTCGC         | 8-Lead Plastic MSOP            | −40°C to 85°C               |
| LT6012CS#PBF     | LT6012CS#TRPBF   | LT6012CS      | 14-Lead Plastic SO             | 0°C to 70°C                 |
| LT6012IS#PBF     | LT6012IS#TRPBF   | LT6012IS      | 14-Lead Plastic SO             | −40°C to 85°C               |
| LT6012ACS#PBF    | LT6012ACS#TRPBF  | LT6012ACS     | 14-Lead Plastic SO             | 0°C to 70°C                 |
| LT6012AIS#PBF    | LT6012AIS#TRPBF  | LT6012AIS     | 14-Lead Plastic SO             | −40°C to 85°C               |
| LT6012CGN#PBF    | LT6012CGN#TRPBF  | 6012          | 16-Lead Plastic SSOP           | 0°C to 70°C                 |
| LT6012IGN#PBF    | LT6012IGN#TRPBF  | 6012I         | 16-Lead Plastic SSOP           | −40°C to 85°C               |
| LT6012ACGN#PBF   | LT6012ACGN#TRPBF | 6012A         | 16-Lead Plastic SSOP           | 0°C to 70°C                 |
| LT6012AIGN#PBF   | LT6012AIGN#TRPBF | 6012AI        | 16-Lead Plastic SSOP           | −40°C to 85°C               |

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/tapeandreeel/>

# LT6011/LT6012

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_S = 5\text{V}$ ,  $0\text{V}$ ;  $V_{CM} = 2.5\text{V}$ ;  $R_L$  to  $0\text{V}$ ; unless otherwise specified. (Note 5)

| SYMBOL                   | PARAMETER                           | CONDITIONS                                                                                                                                              | MIN | TYP | MAX                                   | UNITS                                           |
|--------------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|---------------------------------------|-------------------------------------------------|
| $V_{OS}$                 | Input Offset Voltage (Note 8)       | LT6011AS8, LT6012AS<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                 | ●   | 20  | 60<br>85<br>110                       | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                     | LT6011ADD, LT6012AGN<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                | ●   | 25  | 85<br>135<br>170                      | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                     | LT6011S8, LT6012S<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                   | ●   | 25  | 75<br>100<br>125                      | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                     | LT6011DD, LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                       | ●   | 30  | 125<br>175<br>210                     | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
| $\Delta V_{OS}/\Delta T$ | Input Offset Voltage Drift (Note 6) | LT6011AS8, LT6011S8, LT6012AS, LT6012S<br>LT6011ADD, LT6011DD, LT6012AGN,<br>LT6012GN, LT6011MS8                                                        | ●   | 0.2 | 0.8                                   | $\mu\text{V}/^\circ\text{C}$                    |
|                          |                                     |                                                                                                                                                         | ●   | 0.2 | 1.2                                   | $\mu\text{V}/^\circ\text{C}$                    |
| $I_{OS}$                 | Input Offset Current (Note 8)       | LT6011AS8, LT6011ADD, LT6012AS,<br>LT6012AGN<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$        | ●   | 20  | 300<br>450<br>600                     | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                     | LT6011S8, LT6011DD, LT6012S,<br>LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ | ●   | 150 | 900<br>1200<br>1500                   | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
| $I_B$                    | Input Bias Current (Note 8)         | LT6011AS8, LT6011ADD, LT6012AS,<br>LT6012AGN<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$        | ●   | 20  | $\pm 300$<br>$\pm 450$<br>$\pm 600$   | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                     | LT6011S8, LT6011DD, LT6012S,<br>LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ | ●   | 150 | $\pm 900$<br>$\pm 1200$<br>$\pm 1500$ | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          | Input Noise Voltage                 | 0.1Hz to 10Hz                                                                                                                                           |     | 400 |                                       | $\text{nV}_{P-P}$                               |
| $e_n$                    | Input Noise Voltage Density         | $f = 1\text{kHz}$                                                                                                                                       |     | 14  |                                       | $\text{nV}/\sqrt{\text{Hz}}$                    |
| $i_n$                    | Input Noise Current Density         | $f = 1\text{kHz}$ , Unbalanced Source Resistance                                                                                                        |     | 0.1 |                                       | $\text{pA}/\sqrt{\text{Hz}}$                    |
| $R_{IN}$                 | Input Resistance                    | Common Mode, $V_{CM} = 1\text{V}$ to $3.8\text{V}$                                                                                                      |     | 10  | 120                                   | $\text{G}\Omega$                                |
|                          |                                     | Differential                                                                                                                                            |     |     | 20                                    | $\text{M}\Omega$                                |
| $C_{IN}$                 | Input Capacitance                   |                                                                                                                                                         |     | 4   |                                       | $\text{pF}$                                     |
| $V_{CM}$                 | Input Voltage Range (Positive)      | Guaranteed by CMRR                                                                                                                                      | ●   | 3.8 | 4                                     | $\text{V}$                                      |
|                          | Input Voltage Range (Negative)      | Guaranteed by CMRR                                                                                                                                      | ●   |     | 0.7                                   | $\text{V}$                                      |
| CMRR                     | Common Mode Rejection Ratio         | $V_{CM} = 1\text{V}$ to $3.8\text{V}$                                                                                                                   | ●   | 107 | 135                                   | $\text{dB}$                                     |
|                          | Minimum Supply Voltage              | Guaranteed by PSRR                                                                                                                                      | ●   | 2.4 | 2.7                                   | $\text{V}$                                      |
| PSRR                     | Power Supply Rejection Ratio        | $V_S = 2.7\text{V}$ to $36\text{V}$ , $V_{CM} = 1/2V_S$                                                                                                 | ●   | 112 | 135                                   | $\text{dB}$                                     |
| $A_{VOL}$                | Large-Signal Voltage Gain           | $R_L = 10\text{k}$ , $V_{OUT} = 1\text{V}$ to $4\text{V}$                                                                                               | ●   | 300 | 2000                                  | $\text{V}/\text{mV}$                            |
|                          |                                     | $R_L = 2\text{k}$ , $V_{OUT} = 1\text{V}$ to $4\text{V}$                                                                                                | ●   | 250 | 2000                                  | $\text{V}/\text{mV}$                            |
|                          | Channel Separation                  | $V_{OUT} = 1\text{V}$ to $4\text{V}$                                                                                                                    | ●   | 110 | 140                                   | $\text{dB}$                                     |

**ELECTRICAL CHARACTERISTICS** The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_S = 5\text{V}$ ,  $0\text{V}$ ;  $V_{CM} = 2.5\text{V}$ ;  $R_L$  to  $0\text{V}$ ; unless otherwise specified. (Note 5)

| SYMBOL              | PARAMETER                                                 | CONDITIONS                                                                                                                                               | MIN         | TYP                  | MAX                  | UNITS                                                    |
|---------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------------|----------------------------------------------------------|
| $V_{OUT}$           | Maximum Output Swing (Positive, Referred to $V^+$ )       | No Load, 50mV Overdrive                                                                                                                                  | ●           | 35                   | 55<br>65             | mV<br>mV                                                 |
|                     |                                                           | $I_{SOURCE} = 1\text{mA}$ , 50mV Overdrive                                                                                                               | ●           | 120                  | 170<br>220           | mV<br>mV                                                 |
|                     | Maximum Output Swing (Negative, Referred to $0\text{V}$ ) | No Load, 50mV Overdrive                                                                                                                                  | ●           | 40                   | 55<br>65             | mV<br>mV                                                 |
|                     |                                                           | $I_{SINK} = 1\text{mA}$ , 50mV Overdrive                                                                                                                 | ●           | 150                  | 225<br>275           | mV<br>mV                                                 |
| $I_{SC}$            | Output Short-Circuit Current (Note 3)                     | $V_{OUT} = 0\text{V}$ , 1V Overdrive, Source                                                                                                             | ●           | 10<br>4              | 14                   | mA<br>mA                                                 |
|                     |                                                           | $V_{OUT} = 5\text{V}$ , -1V Overdrive, Sink                                                                                                              | ●           | 10<br>4              | 21                   | mA<br>mA                                                 |
| SR                  | Slew Rate                                                 | $A_V = -10$ , $R_F = 50\text{k}$ , $R_G = 5\text{k}$<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ | ●<br>●<br>● | 0.06<br>0.05<br>0.04 | 0.09                 | V/ $\mu\text{s}$<br>V/ $\mu\text{s}$<br>V/ $\mu\text{s}$ |
| GBW                 | Gain Bandwidth Product                                    | $f = 10\text{kHz}$                                                                                                                                       | ●           | 250<br>225           | 330                  | kHz<br>kHz                                               |
| $t_s$               | Settling Time                                             | $A_V = -1$ , 0.01%, $V_{OUT} = 1.5\text{V}$ to $3.5\text{V}$                                                                                             |             | 45                   |                      | $\mu\text{s}$                                            |
| $t_r$ , $t_f$       | Rise Time, Fall Time                                      | $A_V = 1$ , 10% to 90%, 0.1V Step                                                                                                                        |             | 1                    |                      | $\mu\text{s}$                                            |
| $\Delta V_{OS}$     | Offset Voltage Match (Note 7)                             | LT6011AS8, LT6012AS<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                  | ●<br>●      | 50                   | 120<br>170<br>220    | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$          |
|                     |                                                           | LT6011ADD, LT6012AGN<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                 | ●<br>●      | 50                   | 170<br>270<br>340    | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$          |
|                     |                                                           | LT6011S8, LT6012S<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                    | ●<br>●      | 50                   | 150<br>200<br>250    | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$          |
|                     |                                                           | LT6011DD, LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                        | ●<br>●      | 60                   | 250<br>350<br>420    | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$          |
|                     |                                                           | LT6011AS8, LT6011ADD, LT6012AS,<br>LT6012AGN<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$         | ●<br>●      | 50                   | 600<br>900<br>1200   | pA<br>pA<br>pA                                           |
|                     |                                                           | LT6011S8, LT6011DD, LT6012S,<br>LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$<br>$T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$  | ●<br>●      |                      | 1800<br>2400<br>3000 | pA<br>pA<br>pA                                           |
| $\Delta\text{CMRR}$ | Common Mode Rejection Ratio Match (Note 7)                |                                                                                                                                                          | ●           | 101                  | 135                  | dB                                                       |
| $\Delta\text{PSRR}$ | Power Supply Rejection Ratio Match (Note 7)               |                                                                                                                                                          | ●           | 106                  | 135                  | dB                                                       |
| $I_S$               | Supply Current                                            | per Amplifier<br>$T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$                                                                                           | ●           | 135                  | 150                  | $\mu\text{A}$                                            |
|                     |                                                           | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                                                          | ●           |                      | 190                  | $\mu\text{A}$                                            |
|                     |                                                           |                                                                                                                                                          | ●           |                      | 210                  | $\mu\text{A}$                                            |

# LT6011/LT6012

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_S = \pm 15\text{V}$ ,  $V_{CM} = 0\text{V}$ ;  $R_L$  to  $0\text{V}$ ; unless otherwise specified. (Note 5)

| SYMBOL                   | PARAMETER                                           | CONDITIONS                                                                                                                                         | MIN | TYP             | MAX                                   | UNITS                                           |
|--------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----------------|---------------------------------------|-------------------------------------------------|
| $V_{OS}$                 | Input Offset Voltage (Note 8)                       | LT6011AS8, LT6012AS<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$                              | ●   | 30              | 135<br>160<br>185                     | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                                     | LT6011ADD, LT6012AGN<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$                             | ●   | 35              | 160<br>210<br>225                     | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                                     | LT6011S8, LT6012S<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$                                | ●   | 35              | 150<br>175<br>200                     | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                                     | LT6011DD, LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$                    | ●   | 40              | 200<br>250<br>275                     | $\mu\text{V}$<br>$\mu\text{V}$<br>$\mu\text{V}$ |
|                          |                                                     |                                                                                                                                                    | ●   |                 |                                       |                                                 |
| $\Delta V_{OS}/\Delta T$ | Input Offset Voltage Drift (Note 6)                 | LT6011AS8, LT6011S8, LT6012AS, LT6012S<br>LT6011ADD, LT6011DD, LT6012AGN, LT6012GN, LT6011MS8                                                      | ●   | 0.2             | 0.8                                   | $\mu\text{V}/^\circ\text{C}$                    |
|                          |                                                     |                                                                                                                                                    | ●   | 0.2             | 1.3                                   | $\mu\text{V}/^\circ\text{C}$                    |
| $I_{OS}$                 | Input Offset Current (Note 8)                       | LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$        | ●   | 20              | 300<br>450<br>600                     | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                                     | LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | ●   | 150             | 900<br>1200<br>1500                   | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                                     |                                                                                                                                                    | ●   |                 |                                       |                                                 |
| $I_B$                    | Input Bias Current (Note 8)                         | LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$        | ●   | 20              | $\pm 300$<br>$\pm 450$<br>$\pm 600$   | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                                     | LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8<br>$T_A = 0^\circ\text{C to } 70^\circ\text{C}$<br>$T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | ●   | 150             | $\pm 900$<br>$\pm 1200$<br>$\pm 1500$ | $\text{pA}$<br>$\text{pA}$<br>$\text{pA}$       |
|                          |                                                     |                                                                                                                                                    | ●   |                 |                                       |                                                 |
|                          | Input Noise Voltage                                 | 0.1Hz to 10Hz                                                                                                                                      |     | 400             |                                       | $\text{nV}_{P-P}$                               |
| $e_n$                    | Input Noise Voltage Density                         | $f = 1\text{kHz}$                                                                                                                                  |     | 13              |                                       | $\text{nV}/\sqrt{\text{Hz}}$                    |
| $i_n$                    | Input Noise Current Density                         | $f = 1\text{kHz}$ , Unbalanced Source Resistance                                                                                                   |     | 0.1             |                                       | $\text{pA}/\sqrt{\text{Hz}}$                    |
| $R_{IN}$                 | Input Resistance                                    | Common Mode, $V_{CM} = \pm 13.5\text{V}$<br>Differential                                                                                           |     | 50<br>400<br>20 |                                       | $\text{G}\Omega$<br>$\text{M}\Omega$            |
| $C_{IN}$                 | Input Capacitance                                   |                                                                                                                                                    |     | 4               |                                       | $\text{pF}$                                     |
| $V_{CM}$                 | Input Voltage Range                                 | Guaranteed by CMRR                                                                                                                                 | ●   | $\pm 13.5$      | $\pm 14$                              | V                                               |
| CMRR                     | Common Mode Rejection Ratio                         | $V_{CM} = -13.5\text{V to } 13.5\text{V}$                                                                                                          | ●   | 115<br>112      | 135<br>135                            | $\text{dB}$<br>$\text{dB}$                      |
|                          |                                                     |                                                                                                                                                    | ●   |                 |                                       |                                                 |
|                          | Minimum Supply Voltage                              | Guaranteed by PSRR                                                                                                                                 | ●   | $\pm 1.2$       | $\pm 1.35$                            | V                                               |
| PSRR                     | Power Supply Rejection Ratio                        | $V_S = \pm 1.35\text{V to } \pm 18\text{V}$                                                                                                        | ●   | 112             | 135                                   | $\text{dB}$                                     |
| $A_{VOL}$                | Large-Signal Voltage Gain                           | $R_L = 10\text{k}$ , $V_{OUT} = -13.5\text{V to } 13.5\text{V}$                                                                                    | ●   | 1000<br>600     | 2000                                  | $\text{V/mV}$<br>$\text{V/mV}$                  |
|                          |                                                     | $R_L = 5\text{k}$ , $V_{OUT} = -13.5\text{V to } 13.5\text{V}$                                                                                     | ●   | 500<br>300      | 1500                                  | $\text{V/mV}$<br>$\text{V/mV}$                  |
|                          |                                                     |                                                                                                                                                    | ●   |                 |                                       |                                                 |
|                          | Channel Separation                                  | $V_{OUT} = -13.5\text{V to } 13.5\text{V}$                                                                                                         | ●   | 120             | 140                                   | $\text{dB}$                                     |
| $V_{OUT}$                | Maximum Output Swing (Positive, Referred to $V^+$ ) | No Load, 50mV Overdrive                                                                                                                            | ●   | 45              | 80<br>100                             | $\text{mV}$<br>$\text{mV}$                      |
|                          |                                                     | $I_{SOURCE} = 1\text{mA}$ , 50mV Overdrive                                                                                                         | ●   | 140             | 195<br>240                            | $\text{mV}$<br>$\text{mV}$                      |
|                          | Maximum Output Swing (Negative, Referred to $V^-$ ) | No Load, 50mV Overdrive                                                                                                                            | ●   | 45              | 80<br>100                             | $\text{mV}$<br>$\text{mV}$                      |
|                          |                                                     | $I_{SINK} = 1\text{mA}$ , 50mV Overdrive                                                                                                           | ●   | 150             | 250<br>300                            | $\text{mV}$<br>$\text{mV}$                      |

60112fc

# ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_S = \pm 15\text{V}$ ,  $V_{CM} = 0\text{V}$ ;  $R_L$  to  $0\text{V}$ ; unless otherwise specified. (Note 5)

| SYMBOL              | PARAMETER                                   | CONDITIONS                                                | MIN        | TYP  | MAX  | UNITS            |
|---------------------|---------------------------------------------|-----------------------------------------------------------|------------|------|------|------------------|
| $I_{SC}$            | Output Short-Circuit Current (Note 3)       | $V_{OUT} = 0\text{V}$ , 1V Overdrive (Source)             | 10<br>5    | 15   |      | mA<br>mA         |
|                     |                                             | $V_{OUT} = 0\text{V}$ , -1V Overdrive (Sink)              | 10<br>5    | 20   |      | mA<br>mA         |
| SR                  | Slew Rate                                   | $A_V = -10$ , $R_F = 50\text{k}$ , $R_G = 5\text{k}$      | 0.08       | 0.11 |      | V/ $\mu\text{s}$ |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             | 0.07       |      |      | V/ $\mu\text{s}$ |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           | 0.05       |      |      | V/ $\mu\text{s}$ |
| GBW                 | Gain Bandwidth Product                      | $f = 10\text{kHz}$                                        | 275<br>250 | 350  |      | kHz<br>kHz       |
| $t_s$               | Settling Time                               | $A_V = -1$ , 0.01%, $V_{OUT} = 0\text{V}$ to $10\text{V}$ |            | 85   |      | $\mu\text{s}$    |
| $t_r$ , $t_f$       | Rise Time, Fall Time                        | $A_V = 1$ , 10% to 90%, 0.1V Step                         |            | 1    |      | $\mu\text{s}$    |
| $\Delta V_{OS}$     | Offset Voltage Match (Note 7)               | LT6011AS8, LT6012AS                                       |            | 50   | 270  | $\mu\text{V}$    |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 320  | $\mu\text{V}$    |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 370  | $\mu\text{V}$    |
|                     |                                             | LT6011ADD, LT6012AGN                                      |            | 50   | 320  | $\mu\text{V}$    |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 420  | $\mu\text{V}$    |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 450  | $\mu\text{V}$    |
| $\Delta I_B$        | Input Bias Current Match (Note 7)           | LT6011S8, LT6012S                                         |            | 70   | 300  | $\mu\text{V}$    |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 350  | $\mu\text{V}$    |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 400  | $\mu\text{V}$    |
|                     |                                             | LT6011DD, LT6012GN, LT6011MS8                             |            | 80   | 400  | $\mu\text{V}$    |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 500  | $\mu\text{V}$    |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 550  | $\mu\text{V}$    |
| $\Delta I_B$        | Input Bias Current Match (Note 7)           | LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN                 |            | 50   | 600  | pA               |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 900  | pA               |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 1200 | pA               |
| $\Delta I_B$        | Input Bias Current Match (Note 7)           | LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8          |            |      | 1800 | pA               |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 2400 | pA               |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 3000 | pA               |
| $\Delta\text{CMRR}$ | Common Mode Rejection Ratio Match (Note 7)  |                                                           | 109        | 135  |      | dB               |
| $\Delta\text{PSRR}$ | Power Supply Rejection Ratio Match (Note 7) |                                                           | 106        | 135  |      | dB               |
| $I_S$               | Supply Current                              | per Amplifier                                             |            | 260  | 330  | $\mu\text{A}$    |
|                     |                                             | $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$             |            |      | 380  | $\mu\text{A}$    |
|                     |                                             | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$           |            |      | 400  | $\mu\text{A}$    |

**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:** The inputs are protected by back-to-back diodes and internal series resistors. If the differential input voltage exceeds 10V, the input current must be limited to less than 10mA.

**Note 3:** A heat sink may be required to keep the junction temperature below absolute maximum ratings.

**Note 4:** Both the LT6011C/LT6012C and LT6011I/LT6012I are guaranteed functional over the operating temperature range of  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

**Note 5:** The LT6011C/LT6012C are guaranteed to meet the specified performance from  $0^\circ\text{C}$  to  $70^\circ\text{C}$  and is designed, characterized and expected to meet specified performance from  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  but is not tested or QA sampled at these temperatures. The LT6011I/LT6012I are guaranteed to meet specified performance from  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

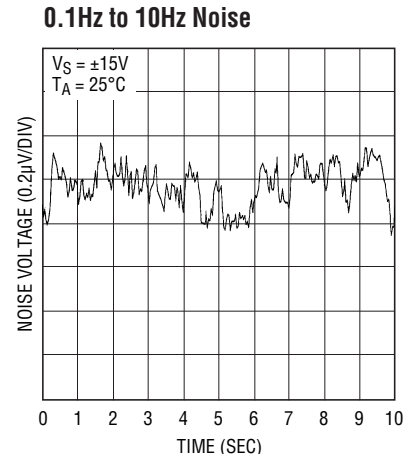
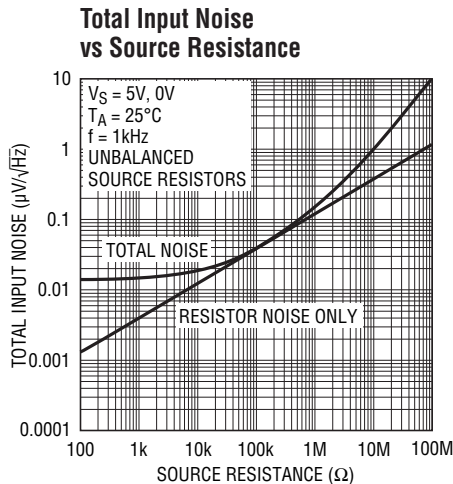
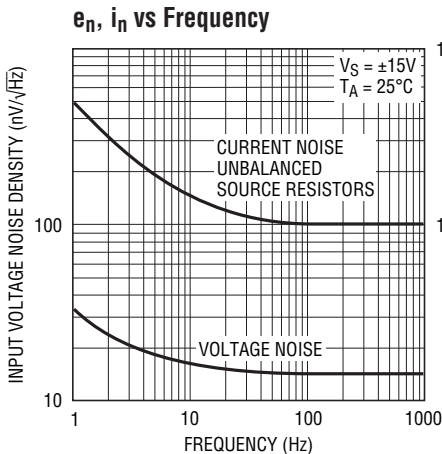
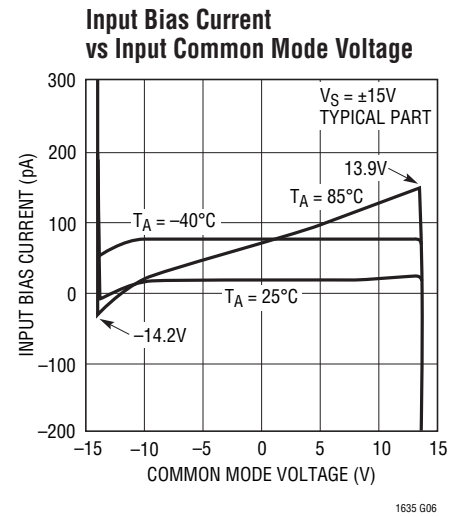
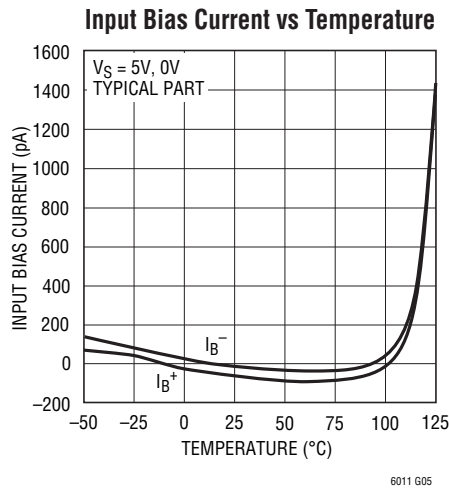
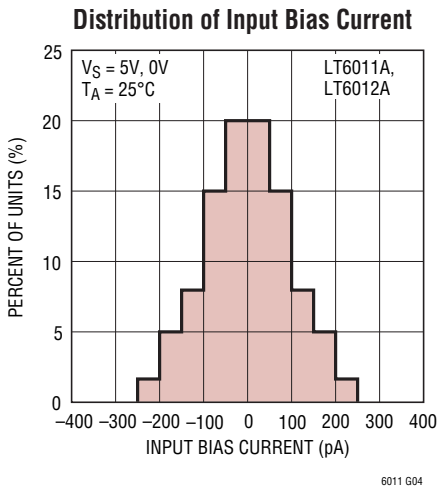
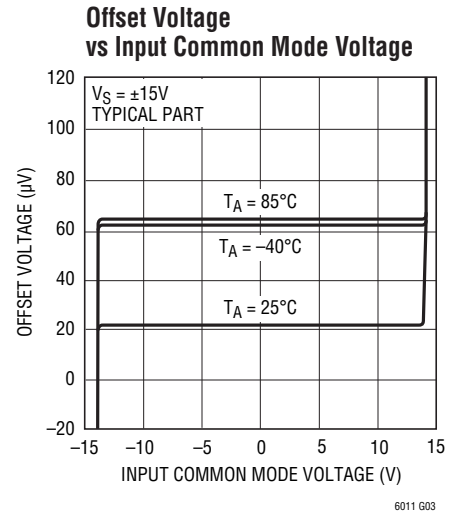
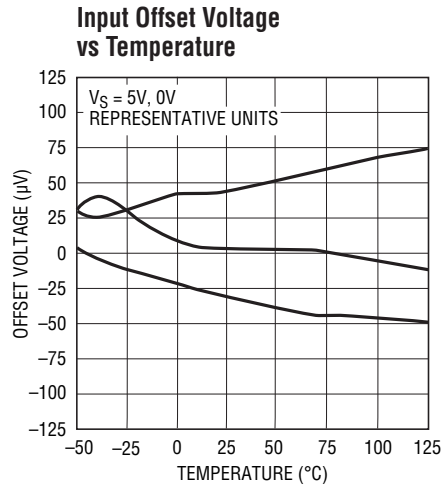
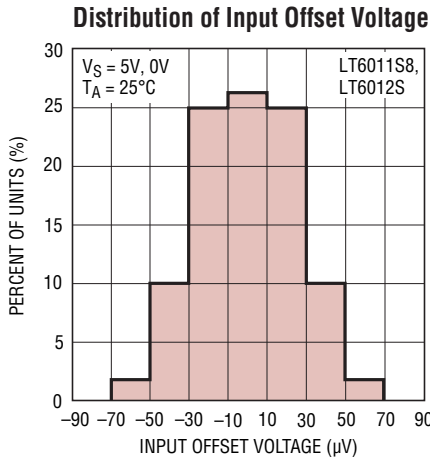
**Note 6:** This parameter is not 100% tested.

**Note 7:** Matching parameters are the difference between any two amplifiers.  $\Delta\text{CMRR}$  and  $\Delta\text{PSRR}$  are defined as follows: (1) CMRR and PSRR are measured in  $\mu\text{V/V}$  for the individual amplifiers. (2) The difference between matching amplifiers is calculated in  $\mu\text{V/V}$ . (3) The result is converted to dB.

**Note 8:** The specifications for  $V_{OS}$ ,  $I_B$ , and  $I_{OS}$  depend on the grade and on the package. The following table clarifies the notations.

|              | STANDARD GRADE | A GRADE   |
|--------------|----------------|-----------|
| S8 Package   | LT6011S8       | LT6011AS8 |
| DFN Package  | LT6011DD       | LT6011ADD |
| S14 Package  | LT6012S        | LT6012AS  |
| GN16 Package | LT6012GN       | LT6012AGN |
| MS8 Package  | LT6011MS8      | N/A       |

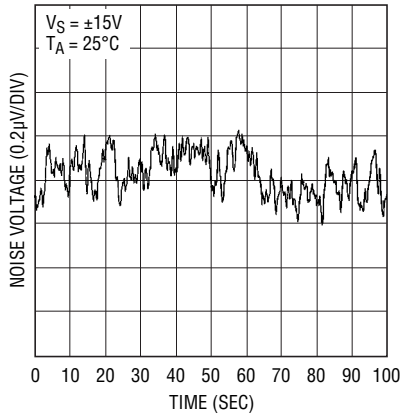
## TYPICAL PERFORMANCE CHARACTERISTICS





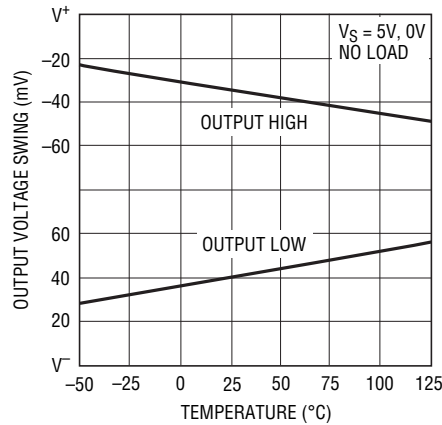
# TYPICAL PERFORMANCE CHARACTERISTICS

0.01Hz to 1Hz Noise



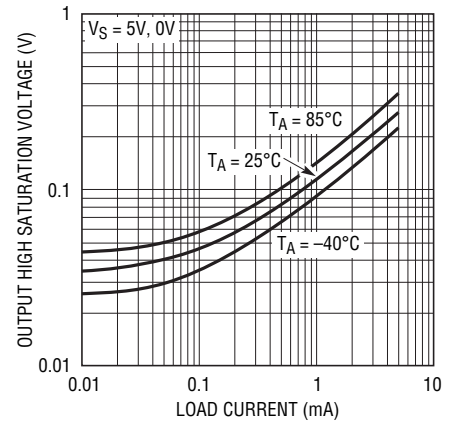
6011 G10

Output Voltage Swing vs Temperature



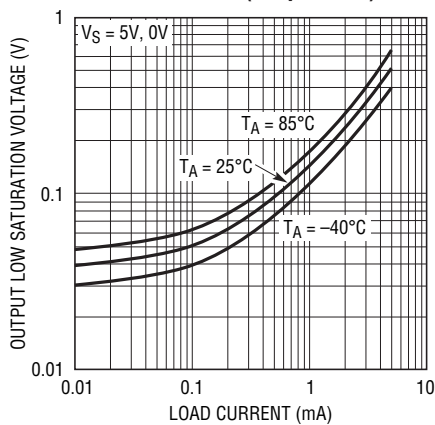
6011 G11

Output Saturation Voltage vs Load Current (Output High)



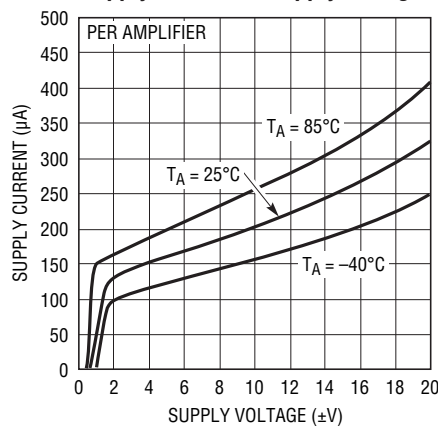
6011 G12

Output Saturation Voltage vs Load Current (Output Low)



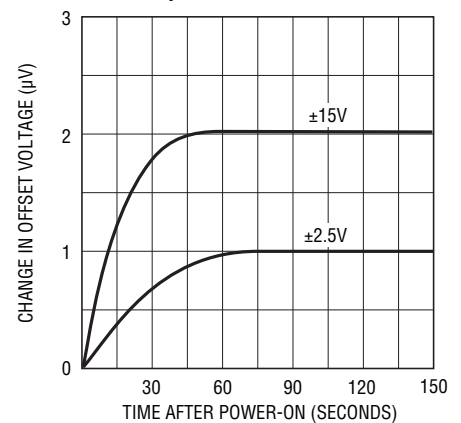
6011 G13

Supply Current vs Supply Voltage



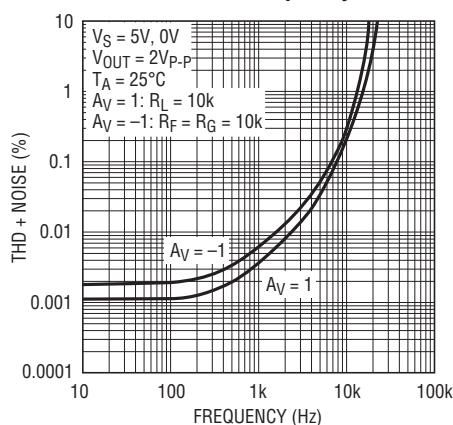
6011 G14

Warm-Up Drift



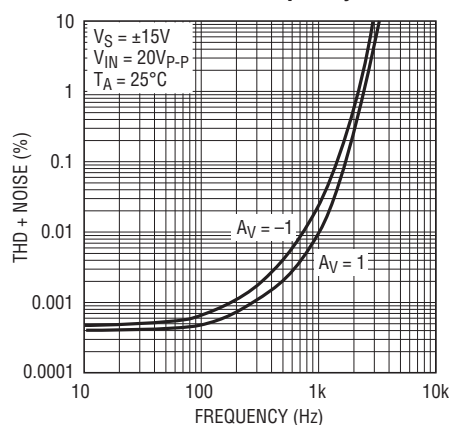
6011 G15

THD + Noise vs Frequency



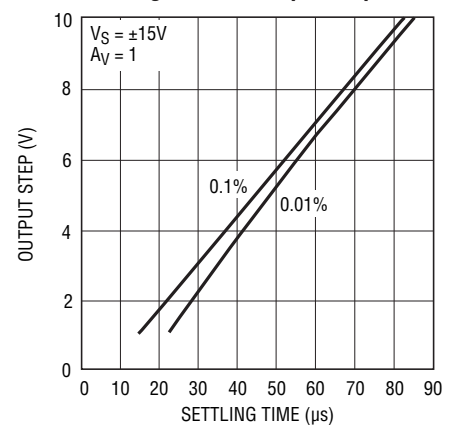
6011 G16

THD + Noise vs Frequency



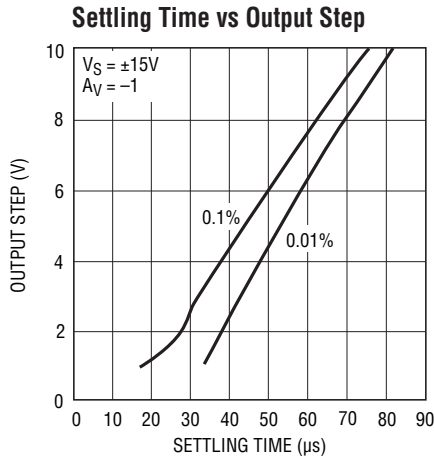
6011 G17

Settling Time vs Output Step

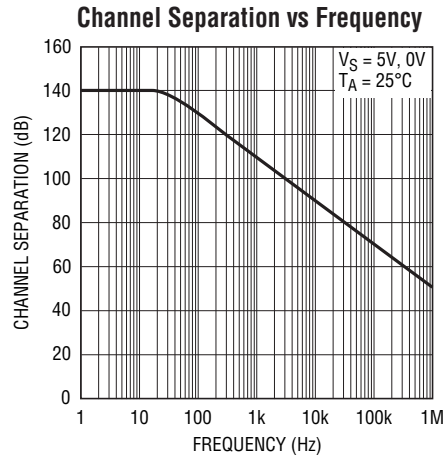


6011 G18

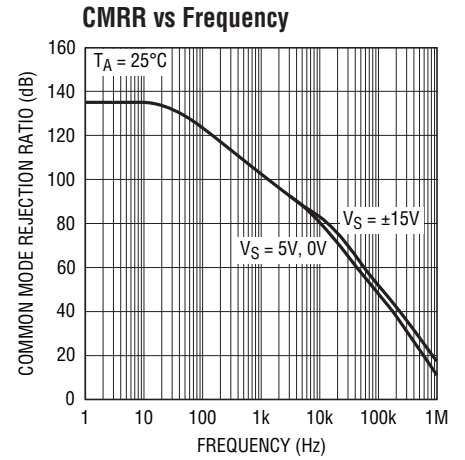
## TYPICAL PERFORMANCE CHARACTERISTICS



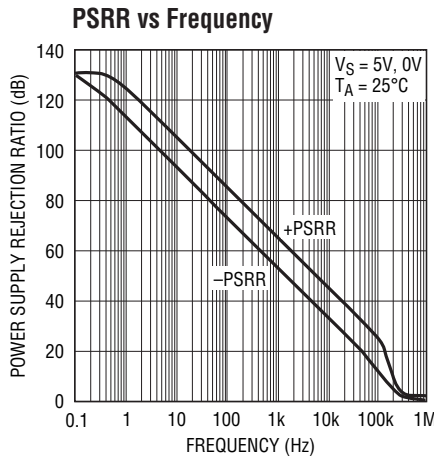
6011 G19



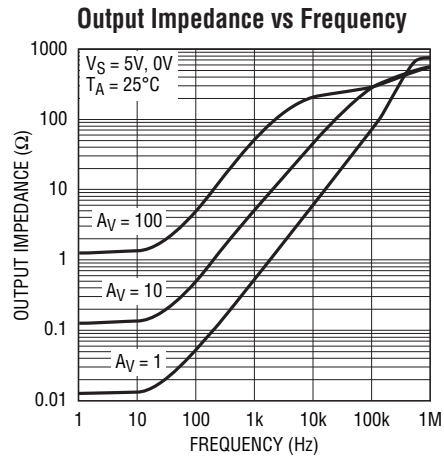
6011 G20



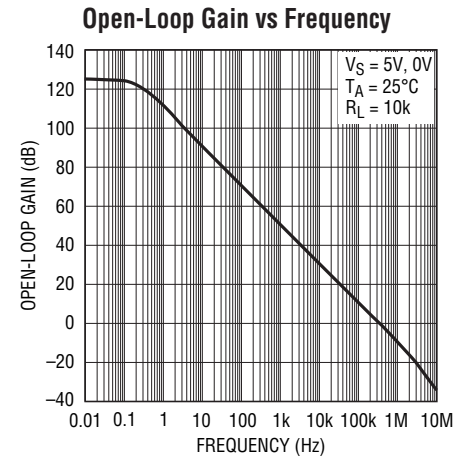
6011 G21



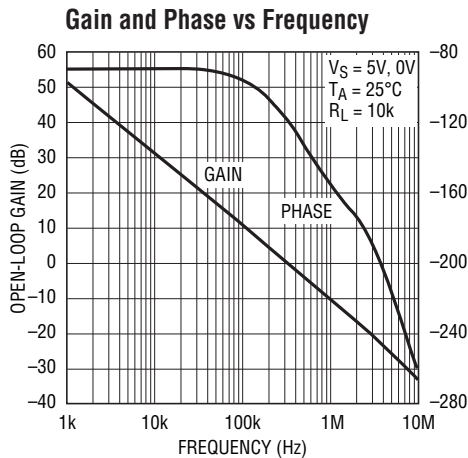
6011 G22



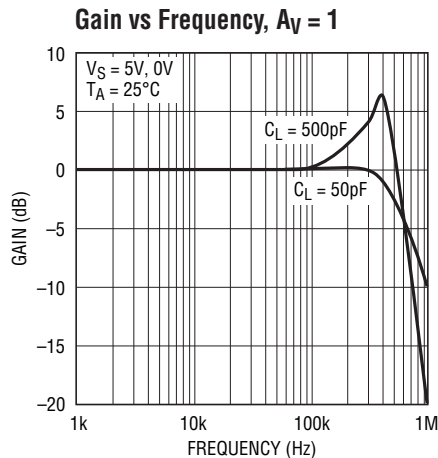
6011 G23



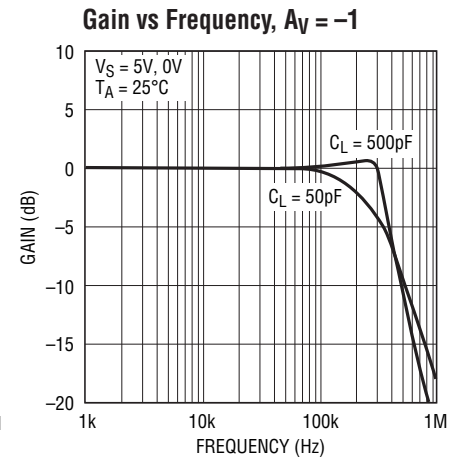
6011 G24



6011 G25



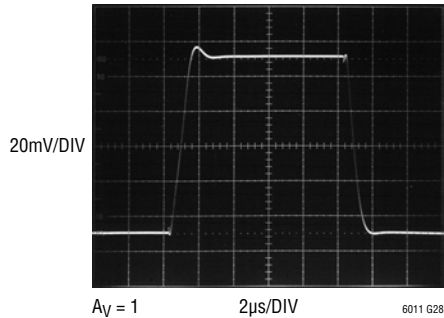
6011 G26



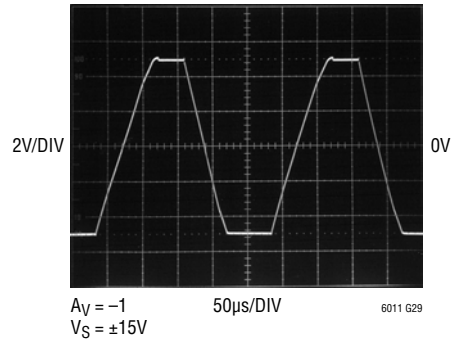
6011 G27

## TYPICAL PERFORMANCE CHARACTERISTICS

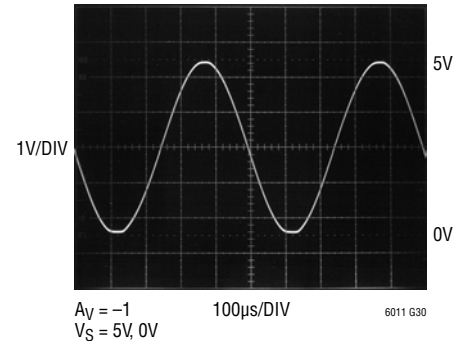
Small-Signal Transient Response



Large-Signal Transient Response



Rail-to-Rail Output Swing



## APPLICATIONS INFORMATION

### Preserving Input Precision

Preserving the input accuracy of the LT6011/LT6012 requires that the applications circuit and PC board layout do not introduce errors comparable to or greater than the 25µV typical offset of the amplifiers. Temperature differentials across the input connections can generate thermocouple voltages of 10's of microvolts so the connections to the input leads should be short, close together and away from heat dissipating components. Air currents across the board can also generate temperature differentials.

The extremely low input bias currents (20pA typical) allow high accuracy to be maintained with high impedance sources and feedback resistors. The LT6011/LT6012 low input bias currents are obtained by a cancellation circuit on-chip. This causes the resulting  $I_B^+$  and  $I_B^-$  to be uncorrelated, as implied by the  $I_{OS}$  specification being comparable to  $I_B$ . Do not try to balance the input resistances in each input lead; instead keep the resistance at either input as low as possible for maximum accuracy.

Leakage currents on the PC board can be higher than the input bias current. For example, 10GΩ of leakage between a 15V supply lead and an input lead will generate 1.5nA! Surround the input leads with a guard ring driven to the same potential as the input common mode to avoid excessive leakage in high impedance applications.

### Input Protection

The LT6011/LT6012 feature on-chip back-to-back diodes between the input devices, along with 500Ω resistors in series with either input. This internal protection limits the input current to approximately 10mA (the maximum allowed) for a 10V differential input voltage. Use additional external series resistors to limit the input current to 10mA in applications where differential inputs of more than 10V are expected. For example, a 1k resistor in series with each input provides protection against 30V differential voltage.

### Input Common Mode Range

The LT6011/LT6012 output is able to swing close to each power supply rail (rail-to-rail out), but the input stage is limited to operating between  $V^- + 1V$  and  $V^+ - 1.2V$ . Exceeding this common mode range will cause the gain to drop to zero, however, no phase reversal will occur.

### Total Input Noise

The LT6011/LT6012 amplifier contributes negligible noise to the system when driven by sensors (sources) with impedance between 20kΩ and 1MΩ. Throughout this range, total input noise is dominated by the  $4kTR_S$  noise of the source. If the source impedance is less than 20kΩ, the input voltage noise of the amplifier starts to contribute

## APPLICATIONS INFORMATION

with a minimum noise of  $14\text{nV}/\sqrt{\text{Hz}}$  for very low source impedance. If the source impedance is more than  $1\text{M}\Omega$ , the input current noise of the amplifier, multiplied by this high impedance, starts to contribute and eventually dominate. Total input noise spectral density can be calculated as:

$$V_{n(\text{TOTAL})} = \sqrt{e_n^2 + 4kTR_S + (i_n R_S)^2}$$

where  $e_n = 14\text{nV}/\sqrt{\text{Hz}}$ ,  $i_n = 0.1\text{pA}/\sqrt{\text{Hz}}$  and  $R_S$  is the total impedance at the input, including the source impedance.

### Capacitive Loads

The LT6011/LT6012 can drive capacitive loads up to  $500\text{pF}$  in unity gain. The capacitive load driving capability increases as the amplifier is used in higher gain configurations.

A small series resistance between the output and the load further increases the amount of capacitance that the amplifier can drive.

### Rail-to-Rail Operation

The LT6011/LT6012 outputs can swing to within millivolts of either supply rail, but the inputs can not. However, for most op amp configurations, the inputs need to swing less than the outputs. Figure 1 shows the basic op amp configurations, lists what happens to the op amp inputs and specifies whether or not the op amp must have rail-to-rail inputs. Select a rail-to-rail input op amp only when really necessary, because the input precision specifications are usually inferior.

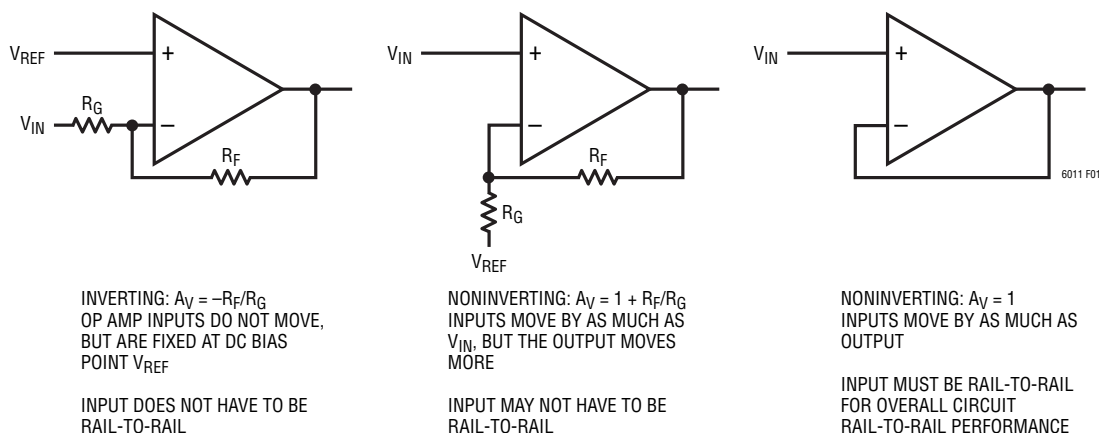
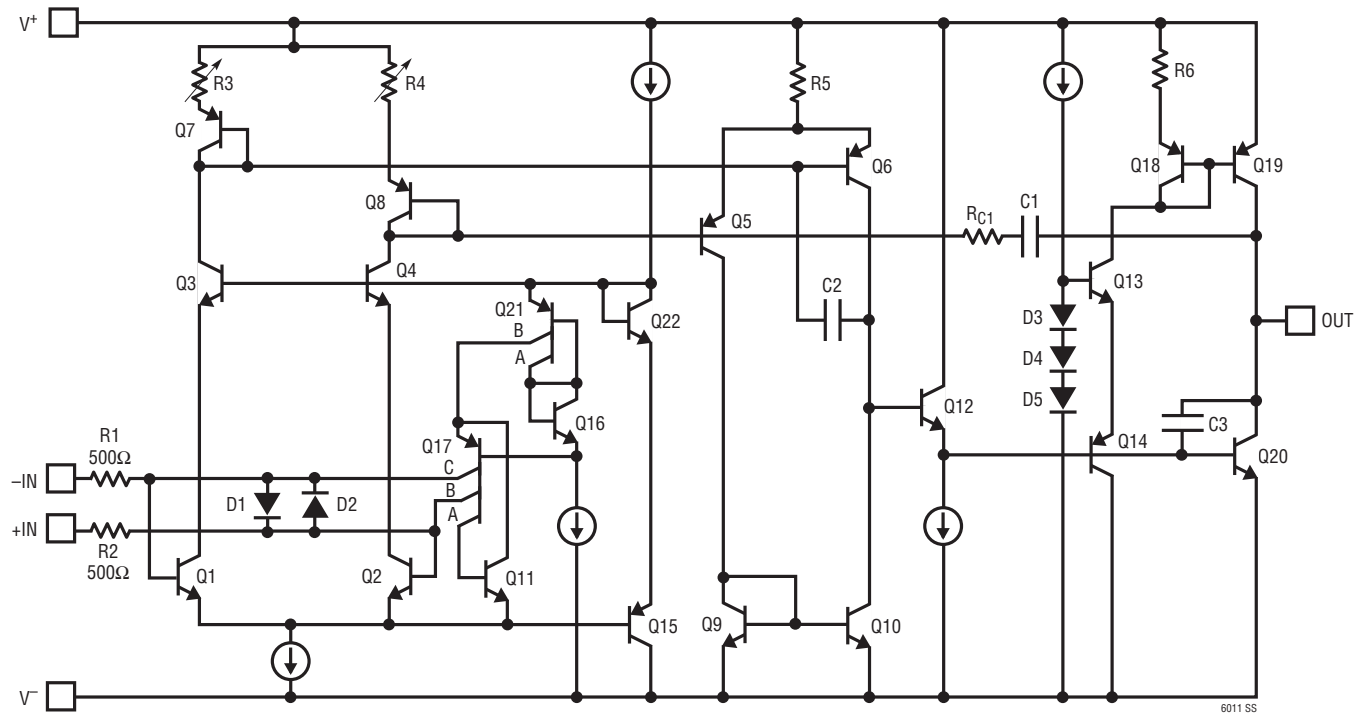


Figure 1. Some Op Amp Configurations Do Not Require Rail-to-Rail Inputs to Achieve Rail-to-Rail Outputs

# SIMPLIFIED SCHEMATIC (One Amplifier)

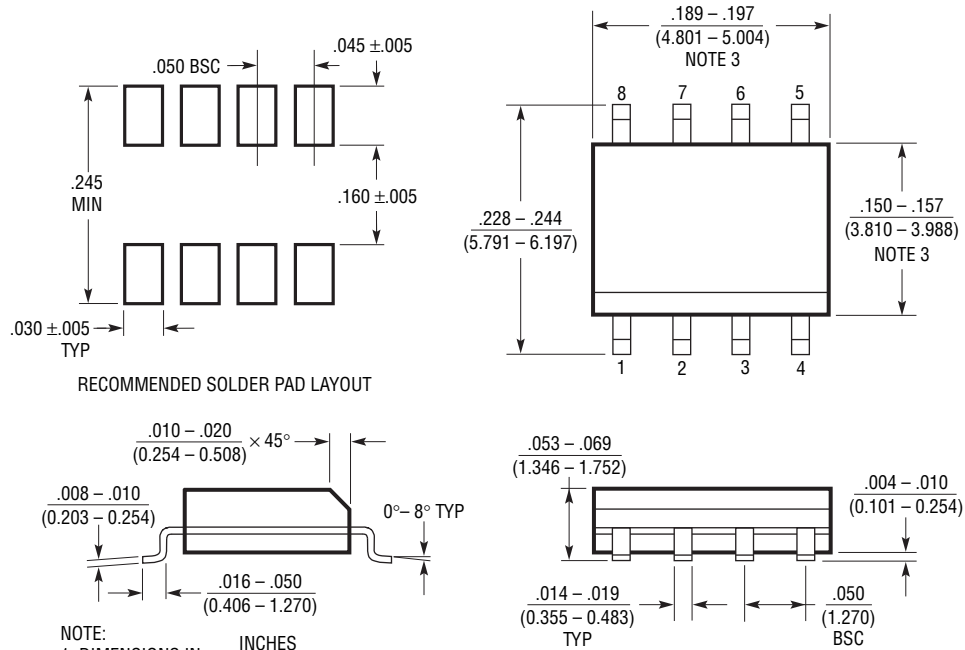




# PACKAGE DESCRIPTION

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

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



- 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)

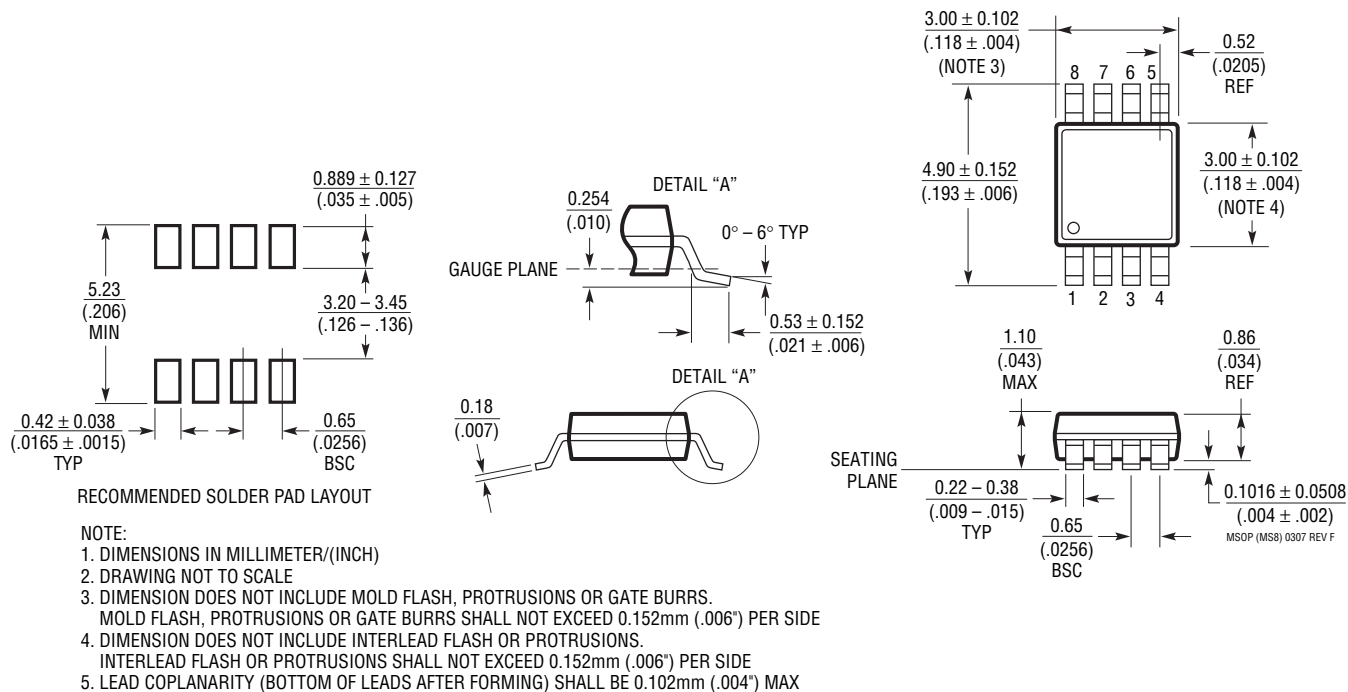
S08 0303

## PACKAGE DESCRIPTION

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

### MS8 Package 8-Lead Plastic MSOP

(Reference LTC DWG # 05-08-1660 Rev F)

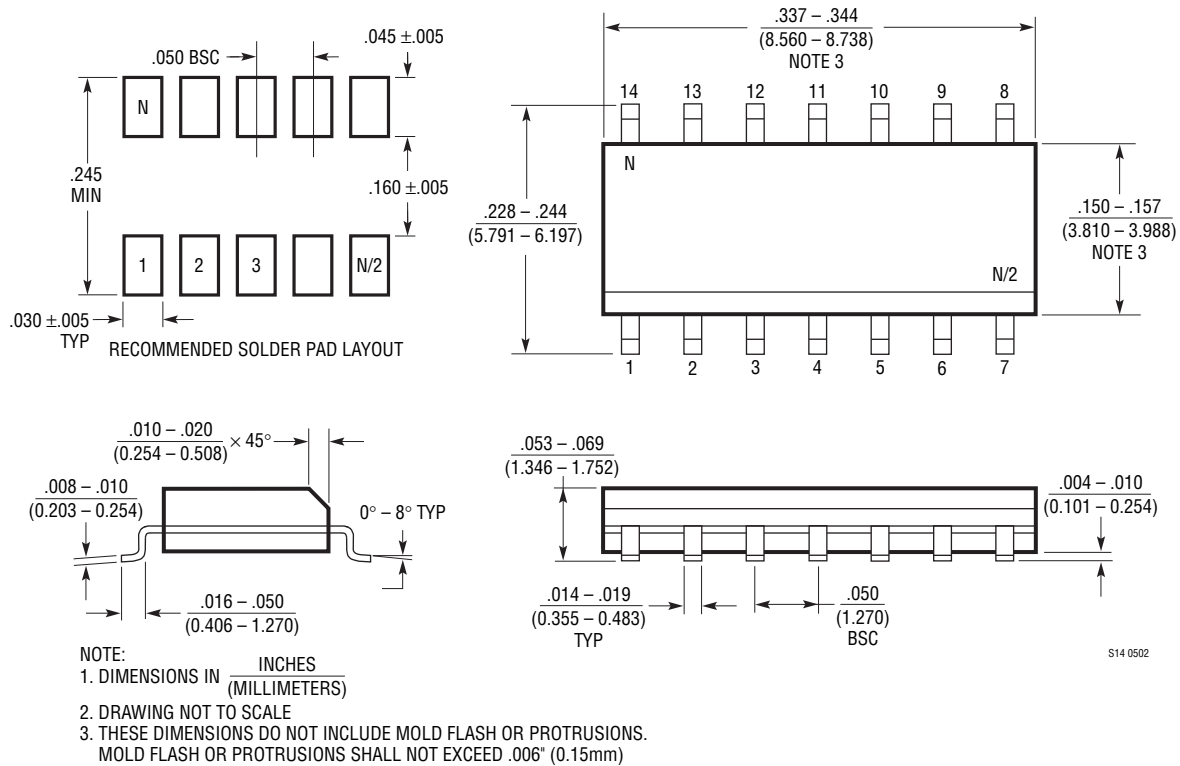




# PACKAGE DESCRIPTION

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

## S14 Package 14-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610)

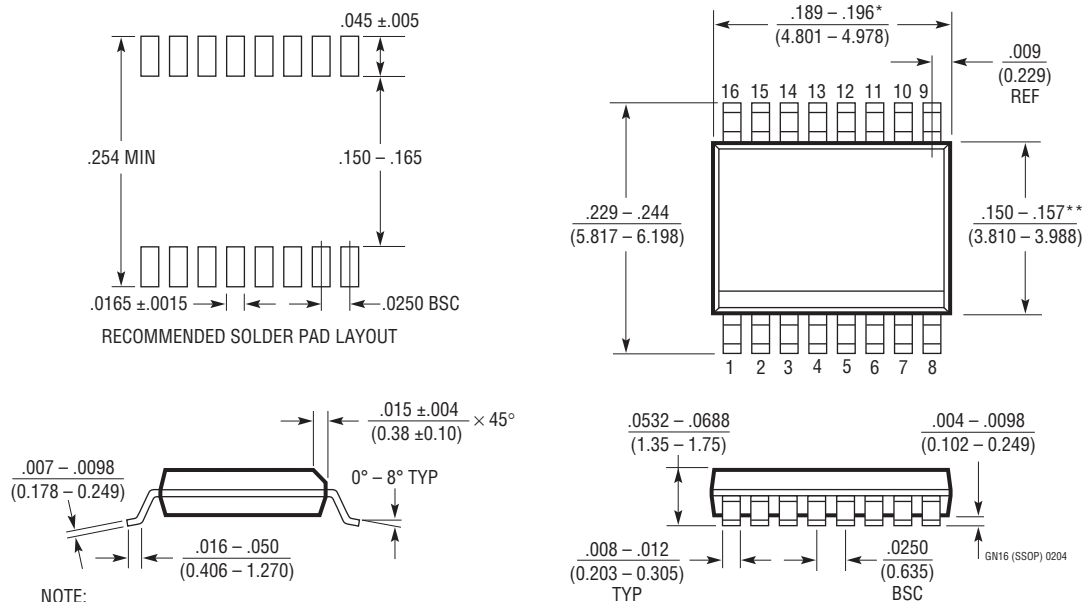


S14 0502

## PACKAGE DESCRIPTION

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

### GN Package 16-Lead Plastic SSOP (Narrow .150 Inch) (Reference LTC DWG # 05-08-1641)

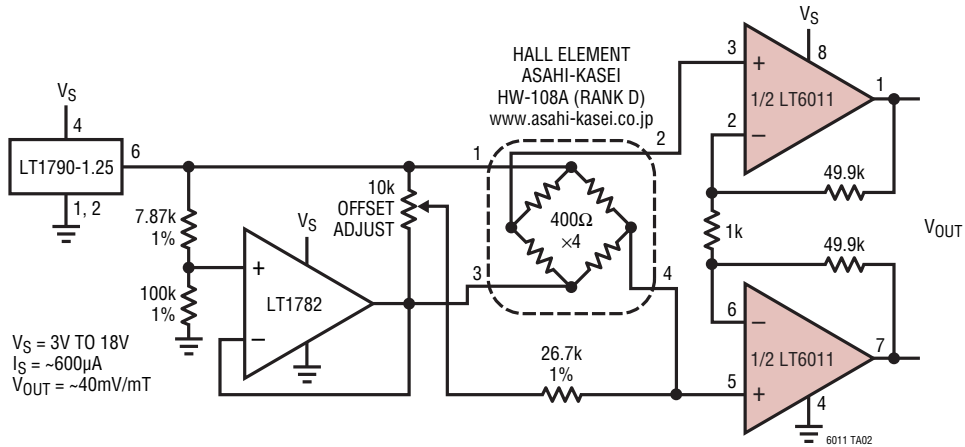


**REVISION HISTORY** (Revision history begins at Rev C)

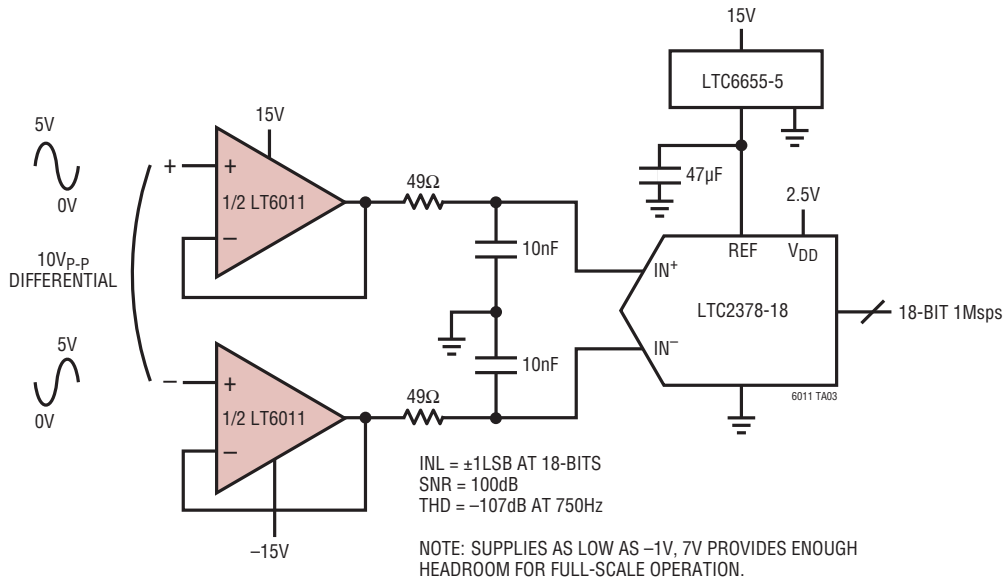
| REV | DATE  | DESCRIPTION                                                                                                                 | PAGE NUMBER |
|-----|-------|-----------------------------------------------------------------------------------------------------------------------------|-------------|
| C   | 01/12 | Removed specific package information from the Absolute Maximum Ratings section.<br>Added a new Typical Application drawing. | 2<br>20     |

## TYPICAL APPLICATION

### Low Power Hall Sensor Amplifier



### Buffering an 18-Bit 1Msps SAR ADC



## RELATED PARTS

| PART NUMBER   | DESCRIPTION                                                        | COMMENTS                                                               |
|---------------|--------------------------------------------------------------------|------------------------------------------------------------------------|
| LT1112/LT1114 | Dual/Quad Low Power, Picoamp Input Precision Op Amp                | 250pA Input Bias Current                                               |
| LT1880        | Rail-to-Rail Output, Picoamp Input Precision Op Amp                | SOT-23                                                                 |
| LT1881/LT1882 | Dual/Quad Rail-to-Rail Output, Picoamp Input Precision Op Amp      | C <sub>LOAD</sub> Up to 1000pF                                         |
| LT1884/LT1885 | Dual/Quad Rail-to-Rail Output, Picoamp Input Precision Op Amp      | 9.5nV/√Hz Input Noise                                                  |
| LT1991/LT1996 | Precision, 100μA Gain-Selectable Amplifier                         | LT6011-Like Op Amp with 0.04% Matched Resistors                        |
| LT6010        | Single 135μA, 14nV/√Hz Rail-to-Rail Output Precision Op Amp        | 35μV Maximum V <sub>OS</sub> ; 100pA Maximum I <sub>B</sub> ; Shutdown |
| LT6013/LT6014 | Single/Dual 145μA, 9.5nV/√Hz, Rail-to-Rail Output Precision Op Amp | A <sub>V</sub> ≥ 5 Stable; 1.4MHz GBW                                  |