

## FEATURES

- Single Supply Operation
  - Input Voltage Range Extends to Ground
  - Output Swings to Ground while Sinking Current
- *Guaranteed* Offset Voltage: 50 $\mu$ V Max
- *Guaranteed* Low Drift: 1.3 $\mu$ V/ $^{\circ}$ C Max
- *Guaranteed* Offset Current: 0.5nA Max
- *Guaranteed* High Gain
  - 5mA Load Current: 1.5 Million Min
  - 17mA Load Current: 0.8 Million Min
- *Guaranteed* Low Supply Current: 520 $\mu$ A Max
- Supply Current can be Reduced by a Factor of 4
- Low Voltage Noise, 0.1Hz to 10Hz: 0.55 $\mu$ V<sub>P-P</sub>
  - Low Current Noise—
  - Better than OP-07: 0.07pA/ $\sqrt{\text{Hz}}$  at 10Hz
- High Input Impedance: 250M $\Omega$  Min
- Minimum Supply Voltage: 2.7V Min

## APPLICATIONS

- Low Power Sample-and-Hold Circuits
- Battery-Powered Precision Instrumentation
  - Strain Gauge Signal Conditioners
  - Thermocouple Amplifiers
- 4mA to 20mA Current Loop Transmitters
- Active Filters

## DESCRIPTION

The LT<sup>®</sup>1006 is the first precision single supply operational amplifier. Its design has been optimized for single supply operation with a full set of specifications at 5V. Specifications at  $\pm 15$ V are also provided.

The LT1006 has a low offset voltage of 20 $\mu$ V, drift of 0.2 $\mu$ V/ $^{\circ}$ C, offset current of 120pA, gain of 2.5 million, common mode rejection of 114dB and power supply rejection of 126dB.

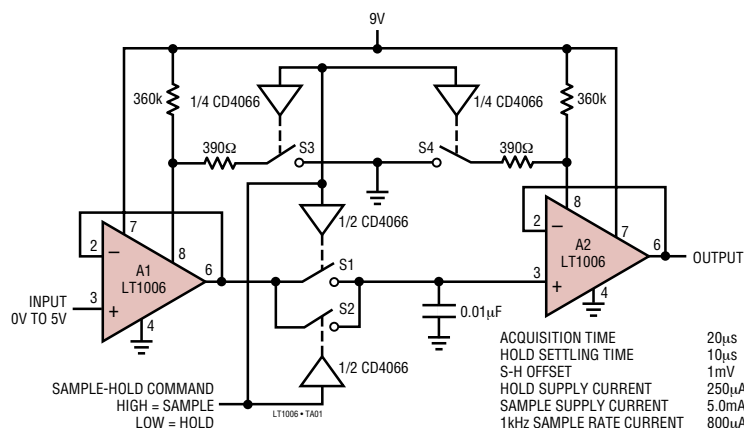
Although supply current is only 340 $\mu$ A, a novel output stage can source or sink in excess of 20mA while retaining high voltage gain. Common mode input range includes ground to accommodate low ground-referenced inputs from strain gauges or thermocouples, and output can swing to within a few millivolts of ground. If a higher slew rate (in excess of 1V/ $\mu$ s) or micropower operation (supply current down to 90 $\mu$ A) is required, the operating currents can be modified by connecting an external optional resistor to Pin 8.

For similar single supply precision dual and quad op amps, please see the LT1013/LT1014 data sheet. For micropower dual and quad op amps, please see the LT1078/LT1079 data sheet.

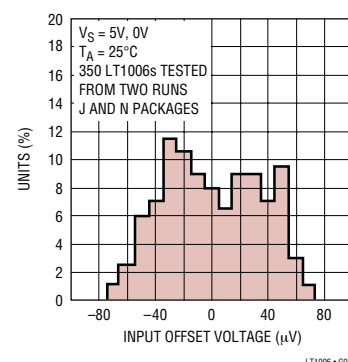
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## TYPICAL APPLICATION

LT1006 Single Supply, Micropower Sample and Hold



Distribution of Input Offset Voltage



## ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage .....  $\pm 22\text{V}$   
 Input Voltage ..... Equal to Positive Supply Voltage  
 Input Voltage ..... 5V Below Negative Supply Voltage  
 Differential Input Voltage ..... 30V  
 Output Short-Circuit Duration ..... Indefinite

Operating Temperature Range

LT1006AM/LT1006M (**OBSOLETE**)....  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$

LT1006AC/LT1006C/LT1006S8 .....  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$

Storage Temperature Range .....  $-65^{\circ}\text{C}$  to  $150^{\circ}\text{C}$

Lead Temperature (Soldering, 10 sec) .....  $300^{\circ}\text{C}$

## PACKAGE/ORDER INFORMATION

| <p>TOP VIEW</p> <p>ISY SET (NOTE 3)</p> <p>VOS TRIM</p> <p>-IN</p> <p>+IN</p> <p>V-</p> <p>V+</p> <p>OUT</p> <p>VOS TRIM (NOTE 4)</p> <p>H PACKAGE</p> <p>8-LEAD TO-5 METAL CAN</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 150^{\circ}\text{C/W}</math>, <math>\theta_{JC} = 45^{\circ}\text{C}</math></p> | ORDER<br>PART NUMBER                           | <p>TOP VIEW</p> <p>VOS TRIM</p> <p>-IN</p> <p>+IN</p> <p>V-</p> <p>ISY SET (NOTE 3)</p> <p>V+</p> <p>OUT</p> <p>VOS TRIM (NOTE 4)</p> <p>N8 PACKAGE</p> <p>8-LEAD PDIP</p> <p>S8 PACKAGE</p> <p>8-LEAD PLASTIC SO</p> <p><math>T_{JMAX} = 100^{\circ}\text{C}</math>, <math>\theta_{JA} = 130^{\circ}\text{C/W}</math> (N8)</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 200^{\circ}\text{C/W}</math> (S8)</p> | ORDER<br>PART NUMBER                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                         | LT1006AMH<br>LT1006MH<br>LT1006ACH<br>LT1006CH |                                                                                                                                                                                                                                                                                                                                                                                                                                           | LT1006CN8<br>LT1006S8                              |
|                                                                                                                                                                                                                                                                                                                                         |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                           | S8 PART MARKING                                    |
|                                                                                                                                                                                                                                                                                                                                         |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1006                                               |
|                                                                                                                                                                                                                                                                                                                                         |                                                | J8 PACKAGE 8-LEAD CERDIP<br>$T_{JMAX} = 100^{\circ}\text{C}$ , $\theta_{JA} = 130^{\circ}\text{C/W}$                                                                                                                                                                                                                                                                                                                                      | LT1006AMJ8<br>LT1006MJ8<br>LT1006ACJ8<br>LT1006CJ8 |
| <b>OBSOLETE PACKAGES</b><br>Consider the N8 or S8 Package for Alternate Source                                                                                                                                                                                                                                                          |                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                    |

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

## ELECTRICAL CHARACTERISTICS $V_S = 5\text{V}$ , $V_{CM} = 0\text{V}$ , $V_{OUT} = 1.4\text{V}$ , $T_A = 25^{\circ}\text{C}$ , unless otherwise noted.

| SYMBOL                                     | PARAMETER                                | CONDITIONS            | LT1006AM/AC |      |     | LT1006M/C |      |     | UNITS                        |
|--------------------------------------------|------------------------------------------|-----------------------|-------------|------|-----|-----------|------|-----|------------------------------|
|                                            |                                          |                       | MIN         | TYP  | MAX | MIN       | TYP  | MAX |                              |
| $V_{OS}$                                   | Input Offset Voltage                     | LT1006S8              |             | 20   | 50  |           | 30   | 80  | $\mu\text{V}$                |
|                                            |                                          |                       |             |      |     |           | 80   | 400 | $\mu\text{V}$                |
| $\frac{\Delta V_{OS}}{\Delta \text{Time}}$ | Long-Term Input Offset Voltage Stability | LT1006S8              |             | 0.4  |     |           | 0.5  |     | $\mu\text{V/Mo}$             |
|                                            |                                          |                       |             |      |     |           | 0.7  |     | $\mu\text{V/Mo}$             |
| $I_{OS}$                                   | Input Offset Current                     |                       |             | 0.12 | 0.5 |           | 0.15 | 0.9 | nA                           |
| $I_B$                                      | Input Bias Current                       |                       |             | 9    | 15  |           | 10   | 25  | nA                           |
| $e_n$                                      | Input Noise Voltage                      | 0.1Hz to 10Hz         |             | 0.55 |     |           | 0.55 |     | $\mu\text{V}_{P-P}$          |
|                                            | Input Noise Voltage Density              | $f_0 = 10\text{Hz}$   |             | 23   | 32  |           | 23   | 32  | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                            |                                          | $f_0 = 1000\text{Hz}$ |             | 22   | 25  |           | 22   | 25  | $\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$                                      | Input Noise Current Density              | $f_0 = 10\text{Hz}$   |             | 0.07 |     |           | 0.08 |     | $\text{pA}/\sqrt{\text{Hz}}$ |
|                                            | Input Resistance                         | (Note 2)              |             |      |     |           |      |     |                              |
|                                            | Differential Mode                        |                       | 180         | 400  |     | 100       | 300  |     | M $\Omega$                   |
|                                            | Common Mode                              |                       |             | 5    |     |           | 4    |     | G $\Omega$                   |

# ELECTRICAL CHARACTERISTICS

$V_S = 5V$ ,  $V_{CM} = 0V$ ,  $V_{OUT} = 1.4V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

| SYMBOL    | PARAMETER                    | CONDITIONS                                                                                                                                       | LT1006AM/AC |                              |                 | LT1006M/C  |                              |                 | UNITS                    |
|-----------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------------------------|-----------------|------------|------------------------------|-----------------|--------------------------|
|           |                              |                                                                                                                                                  | MIN         | TYP                          | MAX             | MIN        | TYP                          | MAX             |                          |
|           | Input Voltage Range          |                                                                                                                                                  | 3.5<br>0    | 3.8<br>−0.3                  |                 | 3.5<br>0   | 3.8<br>−0.3                  |                 | V<br>V                   |
| CMRR      | Common Mode Rejection Ratio  | $V_{CM} = 0V$ to $3.5V$                                                                                                                          | 100         | 114                          |                 | 97         | 112                          |                 | dB                       |
| PSRR      | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$                                                                                                         | 106         | 126                          |                 | 103        | 124                          |                 | dB                       |
| $A_{VOL}$ | Large-Signal Voltage Gain    | $V_O = 0.03V$ to $4V$ , $R_L = 10k$<br>$V_O = 0.03V$ to $3.5V$ , $R_L = 2k$                                                                      | 1.0<br>0.5  | 2.5<br>2.0                   |                 | 0.7<br>0.3 | 2.0<br>1.8                   |                 | V/ $\mu V$<br>V/ $\mu V$ |
|           | Maximum Output Voltage Swing | Output Low, No Load<br>Output Low, $600\Omega$ to GND<br>Output Low, $I_{SINK} = 1mA$<br>Output High, No Load<br>Output High, $600\Omega$ to GND |             | 15<br>5<br>220<br>4.0<br>3.4 | 25<br>10<br>350 |            | 15<br>5<br>220<br>4.4<br>4.0 | 25<br>10<br>350 | mV<br>mV<br>mV<br>V<br>V |
| SR        | Slew Rate                    |                                                                                                                                                  | 0.25        | 0.4                          |                 | 0.25       | 0.4                          |                 | V/ $\mu s$               |
| $I_S$     | Supply Current               | $R_{SET} = \infty$<br>$R_{SET} = 180k$ Pin 8 to Pin 7 (Note 3)                                                                                   |             | 340<br>90                    | 520             |            | 350<br>90                    | 570             | $\mu A$<br>$\mu A$       |
|           | Minimum Supply Voltage       |                                                                                                                                                  | 2.7         |                              |                 | 2.7        |                              |                 | V                        |

The ● denotes the specifications which apply over the full operating temperature range.  $V_S = 5V$ ,  $0V$ ;  $V_{CM} = 0.1V$ ;  $V_O = 1.4V$ ;  $-55^\circ C \leq T_A \leq 125^\circ C$ , unless otherwise noted.

| SYMBOL                              | PARAMETER                    | CONDITIONS                                                        |        | LT1006AM |          |     | LT1006M |          |     | UNITS            |
|-------------------------------------|------------------------------|-------------------------------------------------------------------|--------|----------|----------|-----|---------|----------|-----|------------------|
|                                     |                              |                                                                   |        | MIN      | TYP      | MAX | MIN     | TYP      | MAX |                  |
| $V_{OS}$                            | Input Offset Voltage         |                                                                   | ●      |          | 40       | 180 |         | 60       | 250 | $\mu V$          |
| $\frac{\Delta V_{OS}}{\Delta Temp}$ | Input Offset Voltage Drift   |                                                                   | ●      |          | 0.2      | 1.3 |         | 0.3      | 1.8 | $\mu V/^\circ C$ |
| $I_{OS}$                            | Input Offset Current         |                                                                   | ●      |          | 0.4      | 2.0 |         | 0.5      | 4.0 | nA               |
| $I_B$                               | Input Bias Current           |                                                                   | ●      |          | 13       | 25  |         | 16       | 40  | nA               |
| $A_{VOL}$                           | Large-Signal Voltage Gain    | $V_O = 0.05V$ to $3.5V$ , $R_L = 2k$                              | ●      | 0.25     | 0.8      |     | 0.15    | 0.7      |     | V/ $\mu V$       |
| CMRR                                | Common Mode Rejection Ratio  | $V_{CM} = 0.1V$ to $3.2V$                                         | ●      | 90       | 103      |     | 87      | 102      |     | dB               |
| PSRR                                | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$                          | ●      | 100      | 117      |     | 97      | 116      |     | dB               |
|                                     | Maximum Output Voltage Swing | Output Low, $600\Omega$ to GND<br>Output High, $600\Omega$ to GND | ●<br>● | 3.2      | 6<br>3.8 | 15  | 3.1     | 6<br>3.8 | 18  | mV<br>V          |
| $I_S$                               | Supply Current               |                                                                   | ●      |          | 380      | 630 |         | 400      | 680 | $\mu A$          |

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range.  $V_S = 5V$ ,  $0V$ ;  $V_{CM} = 0V$ ;  $V_O = 1.4V$ ;  $0^\circ C \leq T_A \leq 70^\circ C$ , unless otherwise noted.

| SYMBOL                              | PARAMETER                    | CONDITIONS                               |   | LT1006AC |      |     | LT1006C |     |     | UNITS            |
|-------------------------------------|------------------------------|------------------------------------------|---|----------|------|-----|---------|-----|-----|------------------|
|                                     |                              |                                          |   | MIN      | TYP  | MAX | MIN     | TYP | MAX |                  |
| $V_{OS}$                            | Input Offset Voltage         | J8/H Package                             | ● |          | 30   | 110 |         | 45  | 160 | $\mu V$          |
|                                     |                              | N8 Package                               | ● |          |      |     |         | 50  | 190 | $\mu V$          |
|                                     |                              | S8 Package                               | ● |          |      |     |         | 110 | 560 | $\mu V$          |
| $\frac{\Delta V_{OS}}{\Delta Temp}$ | Input Offset Voltage Drift   | J8/H Package                             | ● |          | 0.2  | 1.3 |         | 0.3 | 1.8 | $\mu V/^\circ C$ |
|                                     |                              | N8 Package                               | ● |          |      |     |         | 0.5 | 2.5 | $\mu V/^\circ C$ |
|                                     |                              | S8 Package                               | ● |          |      |     |         | 0.7 | 3.5 | $\mu V/^\circ C$ |
| $I_{OS}$                            | Input Offset Current         |                                          | ● |          | 0.25 | 1.2 |         | 0.3 | 2.5 | nA               |
| $I_B$                               | Input Bias Current           |                                          | ● |          | 11   | 20  |         | 12  | 30  | nA               |
| $A_{VOL}$                           | Large-Signal Voltage Gain    | $V_O = 0.04V$ to $3.5V$ , $R_L = 2k$     | ● | 0.35     | 1.3  |     | 0.25    | 1.2 |     | $V/\mu V$        |
| CMRR                                | Common Mode Rejection Ratio  | $V_{CM} = 0V$ to $3.4V$                  | ● | 96       | 109  |     | 92      | 108 |     | dB               |
| PSRR                                | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$ | ● | 101      | 120  |     | 97      | 118 |     | dB               |
|                                     | Maximum Output Voltage Swing | Output Low, $600\Omega$ to GND           | ● |          | 6    | 13  |         | 6   | 13  | mV               |
|                                     |                              | Output High, $600\Omega$ to GND          | ● | 3.3      | 3.9  |     | 3.2     | 3.9 |     | V                |
| $I_S$                               | Supply Current               |                                          | ● |          | 350  | 570 |         | 360 | 620 | $\mu A$          |

$V_S = \pm 15V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

| SYMBOL    | PARAMETER                    | CONDITIONS                               |  | LT1006AM/AC |          |      | LT1006M/C  |          |     | UNITS     |
|-----------|------------------------------|------------------------------------------|--|-------------|----------|------|------------|----------|-----|-----------|
|           |                              |                                          |  | MIN         | TYP      | MAX  | MIN        | TYP      | MAX |           |
| $V_{OS}$  | Input Offset Voltage         | LT1006S8                                 |  |             | 30       | 100  |            | 50       | 180 | $\mu V$   |
|           |                              |                                          |  |             |          |      |            | 100      | 525 | $\mu V$   |
| $I_{OS}$  | Input Offset Current         |                                          |  |             | 0.1      | 0.5  |            | 0.15     | 0.9 | nA        |
| $I_B$     | Input Bias Current           |                                          |  |             | 7.5      | 12.0 |            | 8        | 20  | nA        |
|           | Input Voltage Range          |                                          |  | 13.5        | 13.8     |      | 13.5       | 13.8     |     | V         |
|           |                              |                                          |  | -15.0       | -15.3    |      | -15.0      | -15.3    |     | V         |
| CMRR      | Common Mode Rejection Ratio  | $V_{CM} = +13.5V$ , $-15V$               |  | 100         | 117      |      | 97         | 116      |     | dB        |
| PSRR      | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$ |  | 106         | 126      |      | 103        | 124      |     | dB        |
| $A_{VOL}$ | Large Signal Voltage Gain    | $V_O = \pm 10V$ , $R_L = 2k$             |  | 1.5         | 5.0      |      | 1.2        | 4.0      |     | $V/\mu V$ |
|           |                              | $V_O = \pm 10V$ , $R_L = 600\Omega$      |  | 0.8         | 1.5      |      | 0.5        | 1.0      |     | $V/\mu V$ |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L = 2k$                               |  | $\pm 13$    | $\pm 14$ |      | $\pm 12.5$ | $\pm 14$ |     | V         |
| SR        | Slew Rate                    | $R_{SET} = \infty$                       |  | 0.25        | 0.4      |      | 0.25       | 0.4      |     | $V/\mu s$ |
|           |                              | $R_{SET} = 390\Omega$ Pin 8 to Pin 4     |  | 1.0         | 1.2      |      | 1.0        | 1.2      |     | $V/\mu s$ |
| $I_S$     | Supply Current               |                                          |  |             | 360      | 540  |            | 360      | 600 | $\mu A$   |

## ELECTRICAL CHARACTERISTICS

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

| SYMBOL                              | PARAMETER                    | CONDITIONS                               |   | LT1006AM |            |     | LT1006M    |            |     | UNITS            |
|-------------------------------------|------------------------------|------------------------------------------|---|----------|------------|-----|------------|------------|-----|------------------|
|                                     |                              |                                          |   | MIN      | TYP        | MAX | MIN        | TYP        | MAX |                  |
| $V_{OS}$                            | Input Offset Voltage         |                                          | ● |          | 80         | 320 |            | 110        | 460 | $\mu V$          |
| $\frac{\Delta V_{OS}}{\Delta Temp}$ | Input Offset Voltage Drift   |                                          | ● |          | 0.5        | 2.2 |            | 0.6        | 2.8 | $\mu V/^\circ C$ |
| $I_{OS}$                            | Input Offset Current         |                                          | ● |          | 0.2        | 2.0 |            | 0.3        | 3.0 | nA               |
| $I_B$                               | Input Bias Current           |                                          | ● |          | 9          | 18  |            | 11         | 27  | nA               |
| $A_{VOL}$                           | Large-Signal Voltage Gain    | $V_O = \pm 10V$ , $R_L = 2k$             | ● | 0.5      | 1.5        |     | 0.25       | 1.0        |     | V/ $\mu V$       |
| CMRR                                | Common Mode Rejection Ratio  | $V_{CM} = +13V$ , $-14.9V$               | ● | 97       | 114        |     | 94         | 113        |     | dB               |
| PSRR                                | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$ | ● | 100      | 117        |     | 97         | 116        |     | dB               |
|                                     | Maximum Output Voltage Swing | $R_L = 2k$                               | ● | $\pm 12$ | $\pm 13.8$ |     | $\pm 11.5$ | $\pm 13.8$ |     | V                |
| $I_S$                               | Supply Current               |                                          | ● |          | 400        | 650 |            | 400        | 750 | $\mu A$          |

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

| SYMBOL                              | PARAMETER                    | CONDITIONS                               |   | LT1006AC   |            |     | LT1006C    |            |     | UNITS            |
|-------------------------------------|------------------------------|------------------------------------------|---|------------|------------|-----|------------|------------|-----|------------------|
|                                     |                              |                                          |   | MIN        | TYP        | MAX | MIN        | TYP        | MAX |                  |
| $V_{OS}$                            | Input Offset Voltage         | J8/H Package                             | ● |            | 50         | 200 |            | 75         | 300 | $\mu V$          |
|                                     |                              | N8 Package                               | ● |            |            |     |            | 80         | 330 | $\mu V$          |
|                                     |                              | S8 Package                               | ● |            |            |     |            | 150        | 730 | $\mu V$          |
| $\frac{\Delta V_{OS}}{\Delta Temp}$ | Input Offset Voltage Drift   | J8/H Package                             | ● |            | 0.5        | 2.2 |            | 0.6        | 2.8 | $\mu V/^\circ C$ |
|                                     |                              | N8 Package                               | ● |            |            |     |            | 0.7        | 3.5 | $\mu V/^\circ C$ |
|                                     |                              | S8 Package                               | ● |            |            |     |            | 1.0        | 4.5 | $\mu V/^\circ C$ |
| $I_{OS}$                            | Input Offset Current         |                                          | ● |            | 0.15       | 1   |            | 0.25       | 2   | nA               |
| $I_B$                               | Input Bias Current           |                                          | ● |            | 8          | 15  |            | 10         | 23  | nA               |
| $A_{VOL}$                           | Large-Signal Voltage Gain    | $V_O = \pm 10V$ , $R_L = 2k$             | ● | 1          | 3          |     | 0.7        | 2.5        |     | V/ $\mu V$       |
| CMRR                                | Common Mode Rejection Ratio  | $V_{CM} = 13V$ , $-15V$                  | ● | 98         | 116        |     | 94         | 114        |     | dB               |
| PSRR                                | Power Supply Rejection Ratio | $V_S = \pm 2V$ to $\pm 18V$ , $V_O = 0V$ | ● | 101        | 120        |     | 97         | 118        |     | dB               |
|                                     | Maximum Output Voltage Swing | $R_L = 2k$                               | ● | $\pm 12.5$ | $\pm 13.9$ |     | $\pm 11.5$ | $\pm 13.8$ |     | V                |
| $I_S$                               | Supply Current               |                                          | ● |            | 370        | 600 |            | 380        | 660 | $\mu A$          |

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

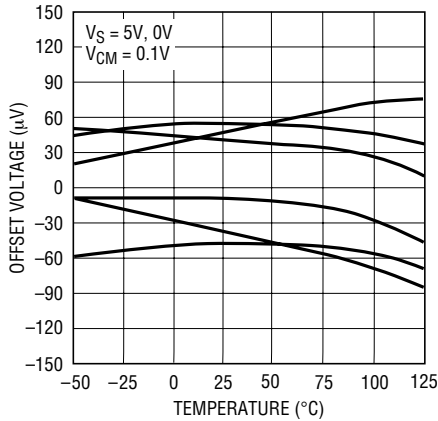
**Note 2:** This parameter is guaranteed by design and is not tested.

**Note 3:** Regular operation does not require an external resistor. In order to program the supply current for low power or high speed operation, connect an external resistor from Pin 8 to Pin 7 or from Pin 8 to Pin 4, respectively. Supply current specifications (for  $R_{SET} = 180k$ ) do not include current in  $R_{SET}$ .

**Note 4:** Optional offset nulling is accomplished with a potentiometer connected between the trim terminals and the wiper to  $V^-$ . A 10k pot (providing a null range of  $\pm 6mV$ ) is recommended for minimum drift of nulled offset voltage with temperature. For increased trim resolution and accuracy, two fixed resistors can be used in conjunction with a smaller potentiometer. For example, two 4.7k resistors tied to Pins 1 and 5, with a 500 $\Omega$  pot in the middle, will have a null range of  $\pm 150\mu V$ .

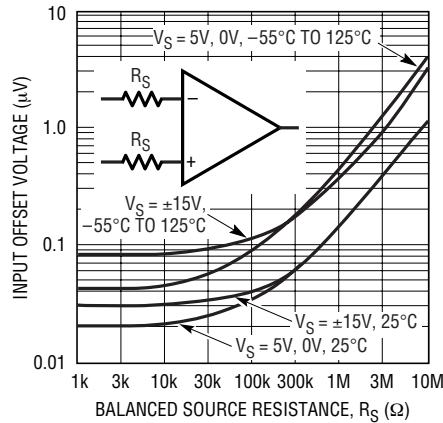
# TYPICAL PERFORMANCE CHARACTERISTICS

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



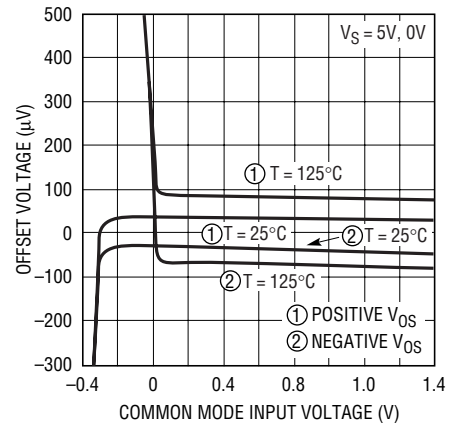
LT1006 • G02

**Offset Voltage vs Balanced Source Resistor**



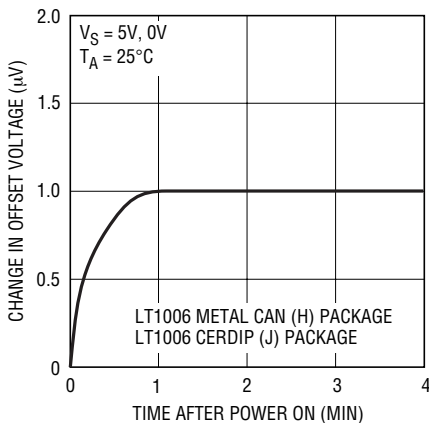
LT1006 • G03

**$V_{OS}$  vs Common Mode Voltage vs Temperature**



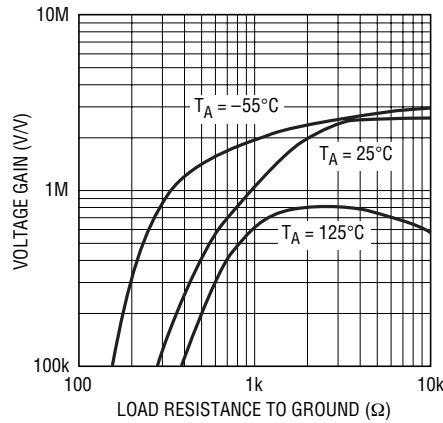
LT1006 • G04

**Warm-Up Drift**



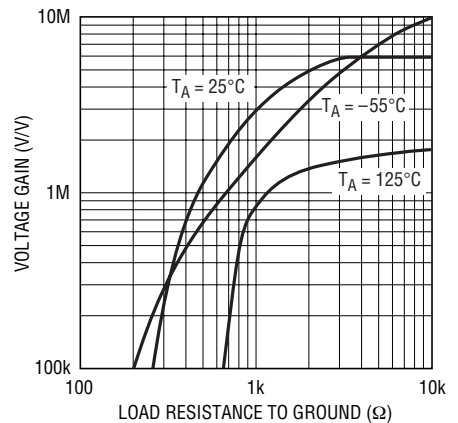
LT1006 • G05

**Voltage Gain vs Load Resistance,  $V_S = 5\text{V}, 0\text{V}$**



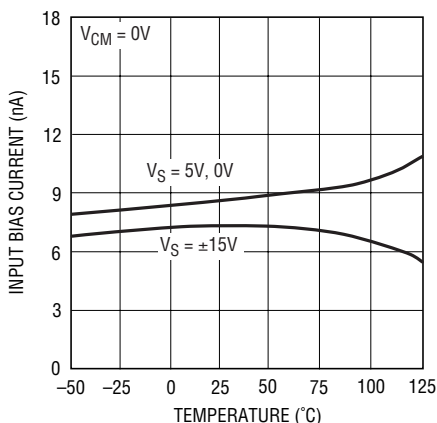
LT1006 • G06

**Voltage Gain vs Load Resistance with  $V_S = \pm 15\text{V}$**



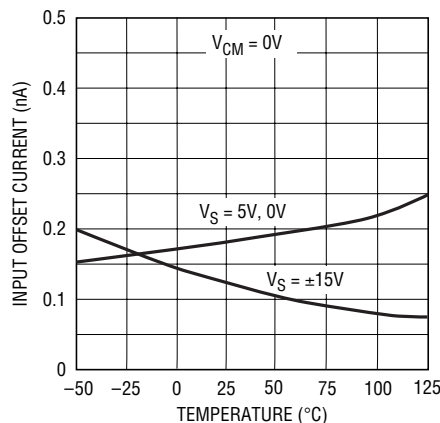
LT1006 • G07

**Input Bias Current vs Temperature**



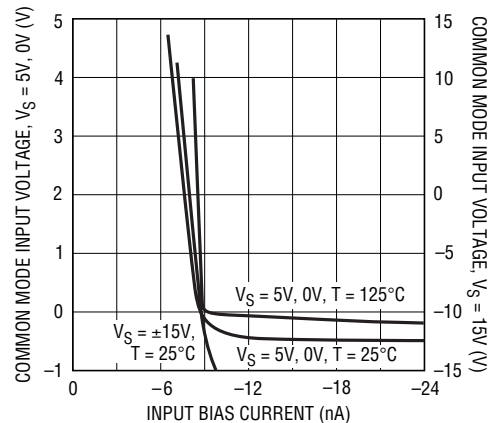
LT1006 • G08

**Input Offset Current vs Temperature**



LT1006 • G09

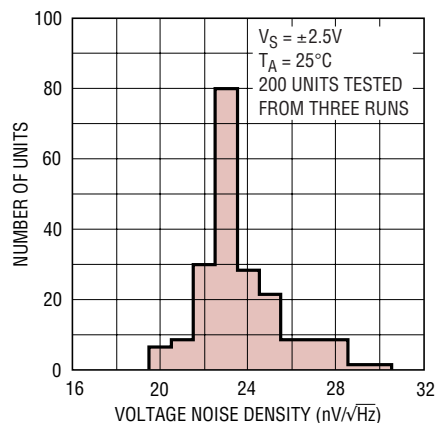
**Input Bias Current vs Common Mode Voltage**



LT1006 • G10

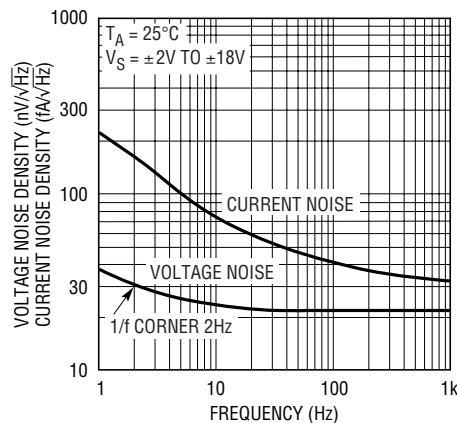
# TYPICAL PERFORMANCE CHARACTERISTICS

10Hz Voltage Noise Distribution



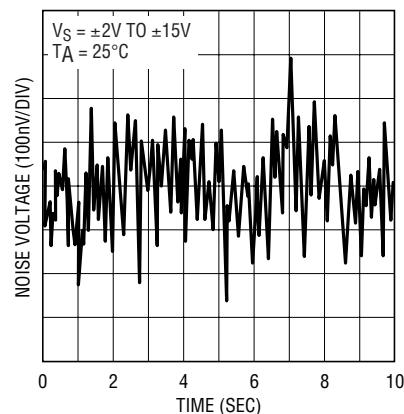
LT1006 • G11

Noise Spectrum



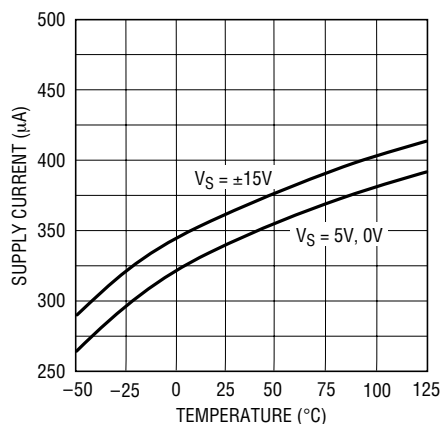
LT1006 • G12

0.1Hz to 10Hz Noise



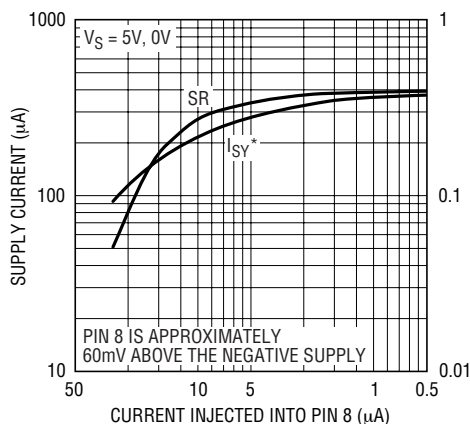
LT1006 • G13

Supply Current vs Temperature



LT1006 • G14

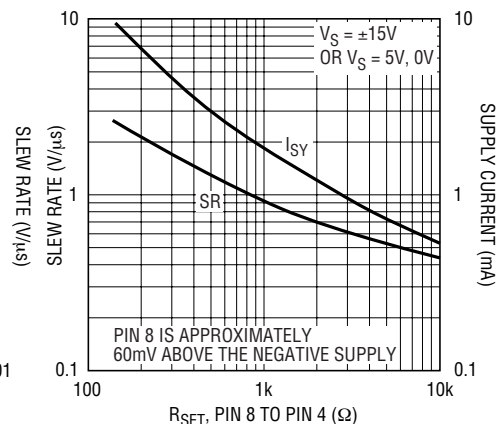
Reducing Power Dissipation



\*ISY DOES NOT INCLUDE CURRENT THROUGH RSET

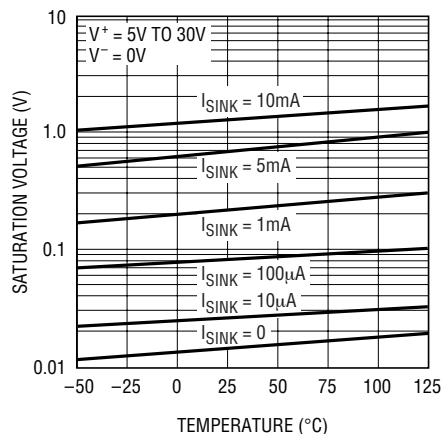
LT1006 • G15

Increasing Slew Rate (RSET to V-)



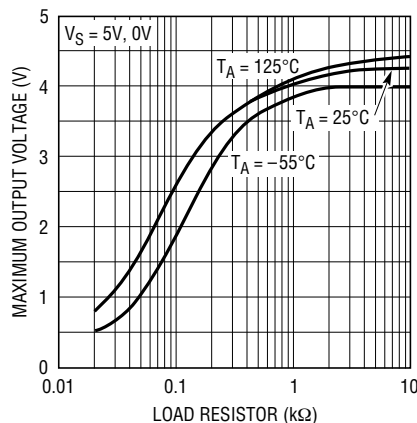
LT1006 • G16

Output Saturation vs Sink Current vs Temperature



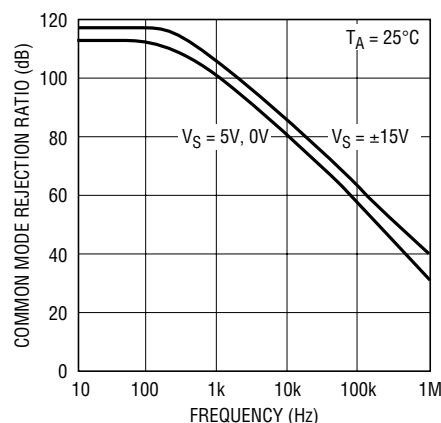
LT1006 • G17

Maximum Output Swing vs Load Resistor



LT1006 • G18

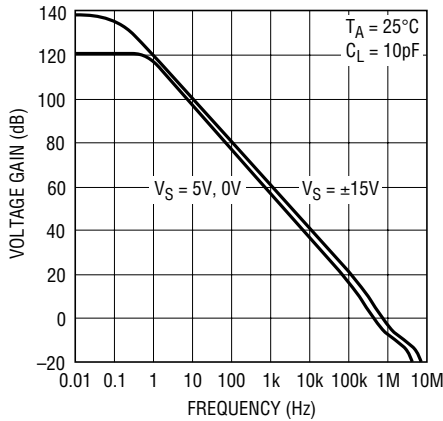
Common Mode Rejection Ratio vs Frequency



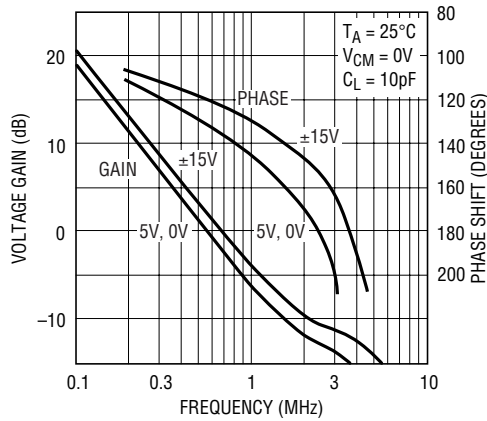
LT1006 • G19

# TYPICAL PERFORMANCE CHARACTERISTICS

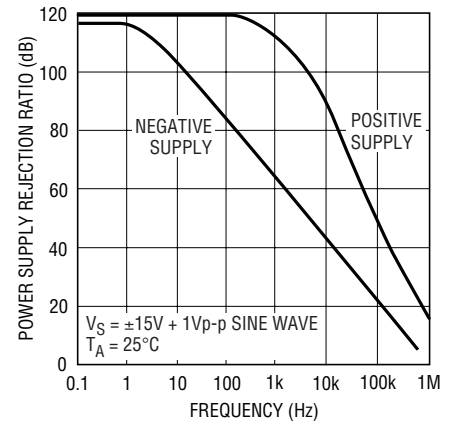
**Voltage Gain vs Frequency**



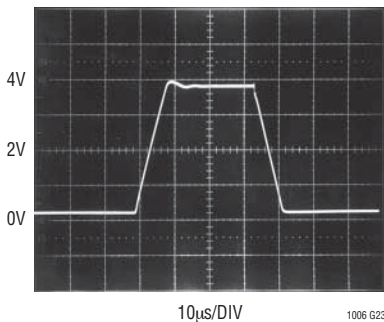
**Gain, Phase vs Frequency**



**Power Supply Rejection Ratio vs Frequency**

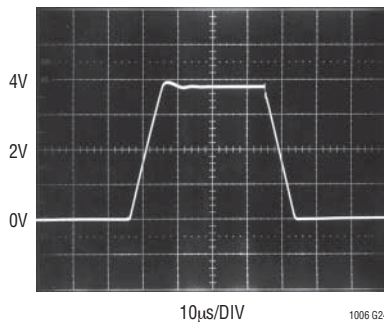


**Large Transient Response, VS = 5V, 0V**



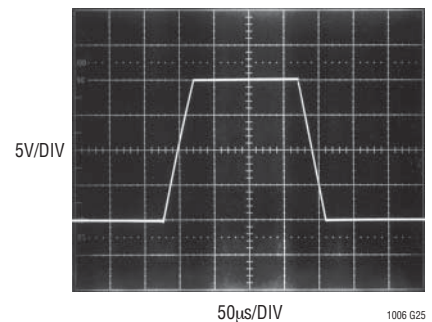
$A_V = 1$   
 $R_L = 4.7k \text{ TO } 5V$   
 INPUT = 0V TO 3.8V

**Large-Signal Transient Response, VS = 5V, 0V**



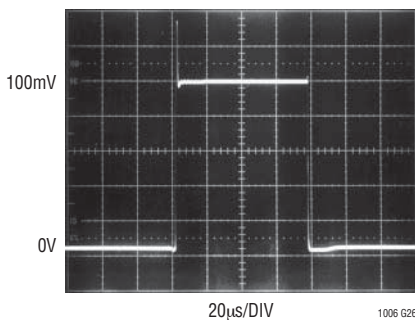
$A_V = 1$   
 $R_L = 4.7k \text{ TO GROUND}$   
 INPUT = 0V TO 3.8V

**Large-Signal Transient Response, VS = ±15V**



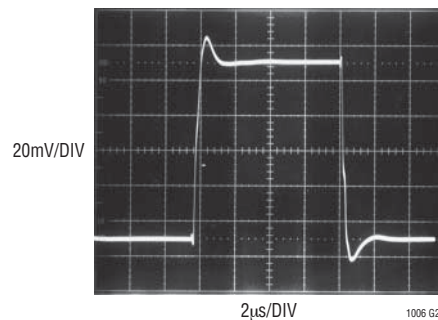
$A_V = 1$

**Small-Signal Transient Response, VS = 5V, 0V**



$A_V = 1$   
 $C_L = 10pF$   
 $R_L = 600\Omega \text{ TO GND}$   
 INPUT = 0V TO 100mV PULSE

**Small-Signal Transient Response, VCC = ±2.5V to ±15V**



$A_V = 1$   
 $C_L = 10pF$

# APPLICATIONS INFORMATION

The LT1006 is fully specified for single supply operation, (i.e., when the negative supply is 0V). Input common mode range includes ground; the output swings within a few millivolts of ground. Single supply operation, however, can create special difficulties, both at the input and at the output. The LT1006 has specific circuitry which addresses these problems.

At the input, the driving signal can fall below 0V—inadvertently or on a transient basis. If the input is more than a few hundred millivolts below ground, two distinct problems can occur on previous single supply designs, such as the LM124, LM158, OP-20, OP-21, OP-220, OP-221, OP-420:

- When the input is more than a diode drop below ground, unlimited current will flow from the substrate ( $V^-$  terminal) to the input. This can destroy the unit. On the LT1006, the 400 $\Omega$  resistors, in series with the input (see Schematic Diagram), protect the devices even when the input is 5V below ground.
- When the input is more than 400mV below ground (at 25°C), the input stage saturates (transistors Q3 and

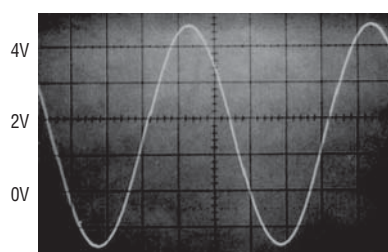
Q4) and phase reversal occurs at the output. This can cause lock-up in servo systems. Due to a unique phase reversal protection circuitry (Q21, Q22, Q27, Q28), the LT1006's output does not reverse, as illustrated below, even when the inputs are at  $-1.5V$ .

At the output, the aforementioned single supply designs either cannot swing to within 600mV of ground (OP-20) or cannot sink more than a few microamperes while swinging to ground (LM124, LM158). The LT1006's all-NPN output stage maintains its low output resistance and high gain characteristics until the output is saturated.

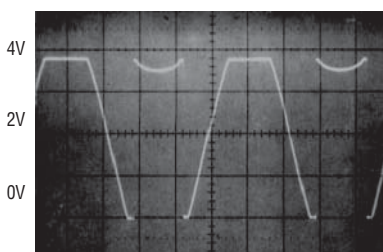
In dual supply operations, the output stage is crossover distortion free.

Since the output cannot go exactly to ground, but can only approach ground to within a few millivolts, care should be exercised to ensure that the output is not saturated. For example, a 1mV input signal will cause the amplifier to set up in its linear region in the gain 100 configuration shown below, but is not enough to make the amplifier function properly in the voltage follower mode.

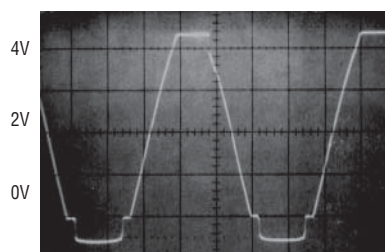
## Voltage Follower with Input Exceeding the Negative Common Mode Range ( $V_S = 5V, 0V$ )



6V<sub>p-p</sub> INPUT,  $-1.5V$  TO  $4.5V$  1006 TA11a

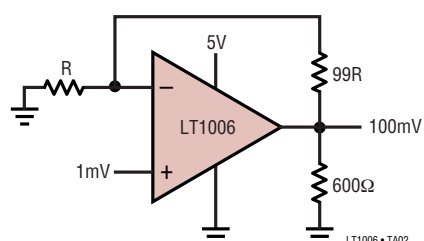


LM324, LM358, OP-20, OP-21  
EXHIBIT OUTPUT PHASE  
REVERSAL 1006 TA11b



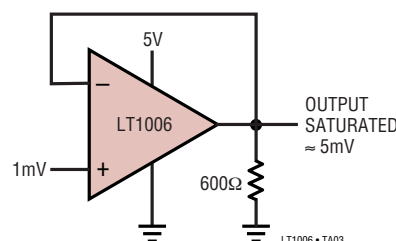
LT1006  
NO PHASE REVERSAL 1006 TA11c

## Gain 100 Amplifier



LT1006 • TA02

## Voltage Follower

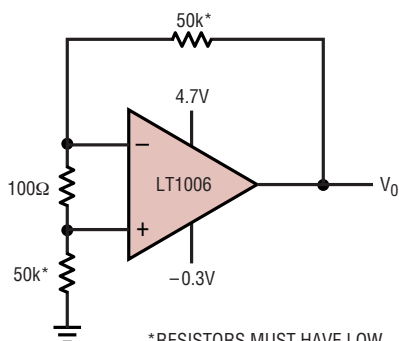


LT1006 • TA03

## APPLICATIONS INFORMATION

In automated production testing the output is forced to 1.4V by the test loop; offset voltage is measured with a common mode voltage of zero and the negative supply at zero (Pin 4). Without the test loop, these exact conditions cannot be achieved. The test circuit shown ensures that the output will never saturate even with worst-case offset voltages ( $-250\mu\text{V}$  over the  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  range). The effective common mode input is 0.3V with respect to the negative supply. As indicated by the common mode rejection specifications the difference is only a few microvolts between the two methods of offset voltage measurement.

**Test Circuit for Offset Voltage and Offset Drift with Temperature**



\*RESISTORS MUST HAVE LOW THERMOELECTRIC POTENTIAL.  
 \*\*THIS CIRCUIT IS ALSO USED AS THE BURN-IN CONFIGURATION, WITH SUPPLY VOLTAGES INCREASED TO  $\pm 20\text{V}$   
 $V_O = 1000V_{OS}$

LT1006 • TA04

### Low Supply Operation

The minimum guaranteed supply voltage for proper operation of the LT1006 is 2.7V. Typical supply current at this voltage is  $320\mu\text{A}$ ; therefore, power dissipation is only  $860\mu\text{W}$ .

### Noise Testing

For application information on noise testing and calculations, please see the LT1007 or LT1028 data sheet.

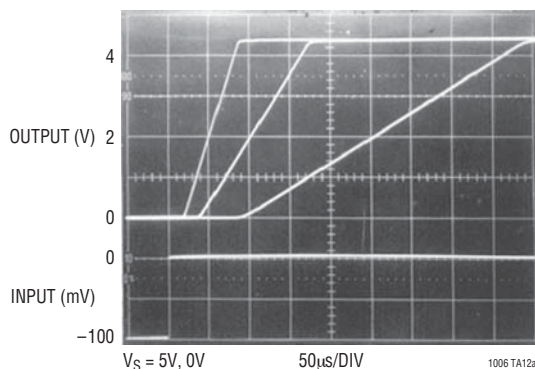
### Supply Current Programming

Connecting an optional external resistor to Pin 8 changes the biasing of the LT1006 in order to increase its speed or to decrease its power consumption. If a higher slew rate is required, connect the external resistor for Pin 8 to Pin 4 [see performance curves for Increasing Slew Rate ( $R_{SET}$  to  $V^-$ )]. For lower power consumption, inject a current into Pin 8 (which is approximately 60mV above  $V^-$ ) as shown on the Reducing Power Dissipation plot. This can be accomplished by connecting  $R_{SET}$  to the positive supply, or to save additional power, by obtaining the injected current from a low voltage battery.

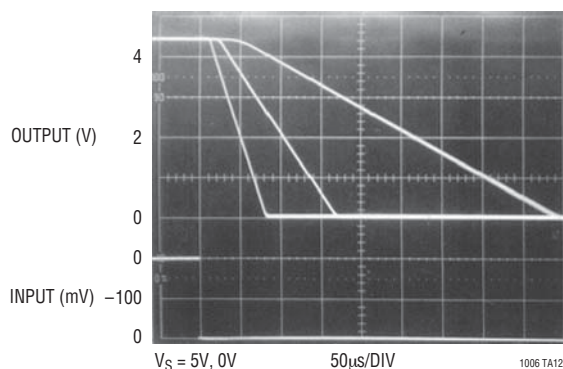
### Comparator Applications

The single supply operation of the LT1006 and its ability to swing close to ground while sinking current lends itself to use as a precision comparator with TTL compatible output.

**Comparator Rise Response Time to 10mV, 5mV, 2mV Overdrives**

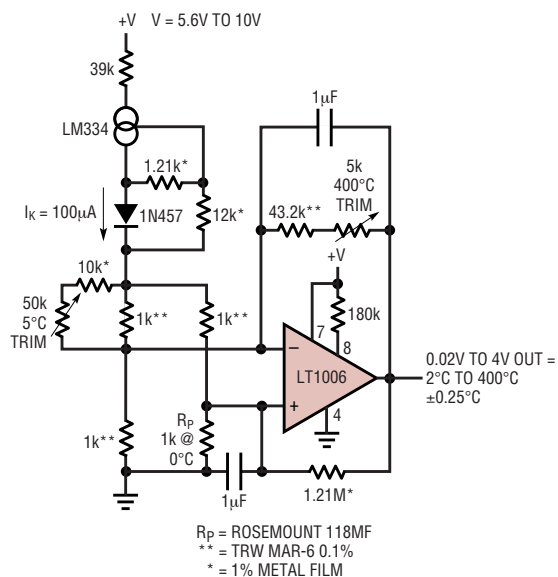


**Comparator Fall Response Time to 10mV, 5mV, 2mV Overdrives**



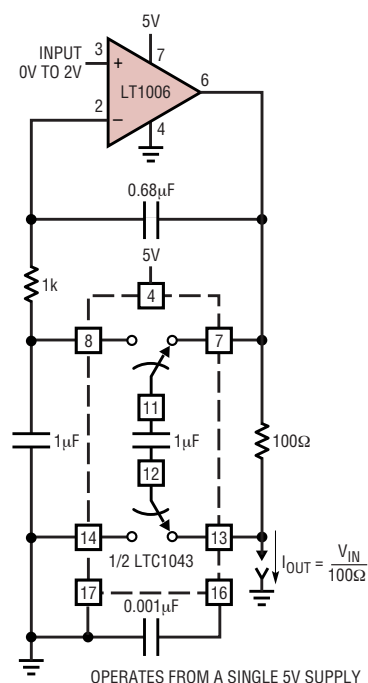
# TYPICAL APPLICATIONS

**Platinum RTD Signal Conditioner  
with Curvature Correction**



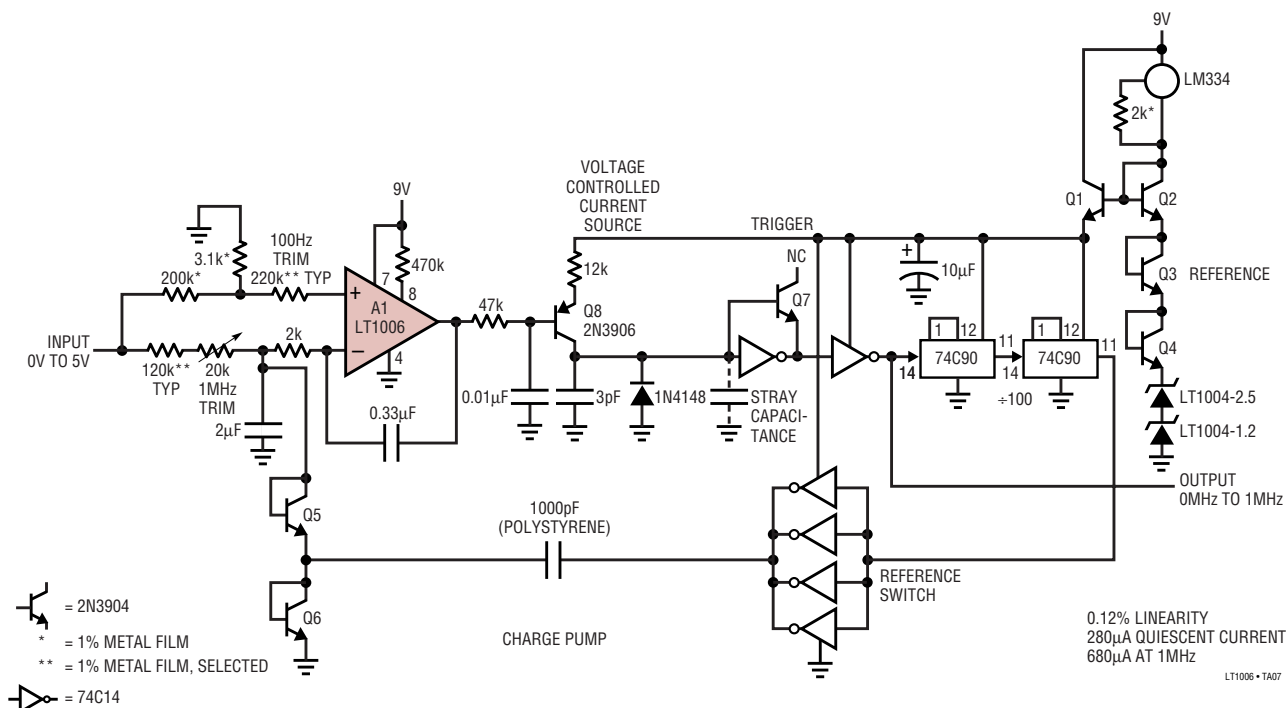
LT1006 • TA05

**Voltage Controlled Current Source  
with Ground Referred Input and Output**



LT1006 • TA06

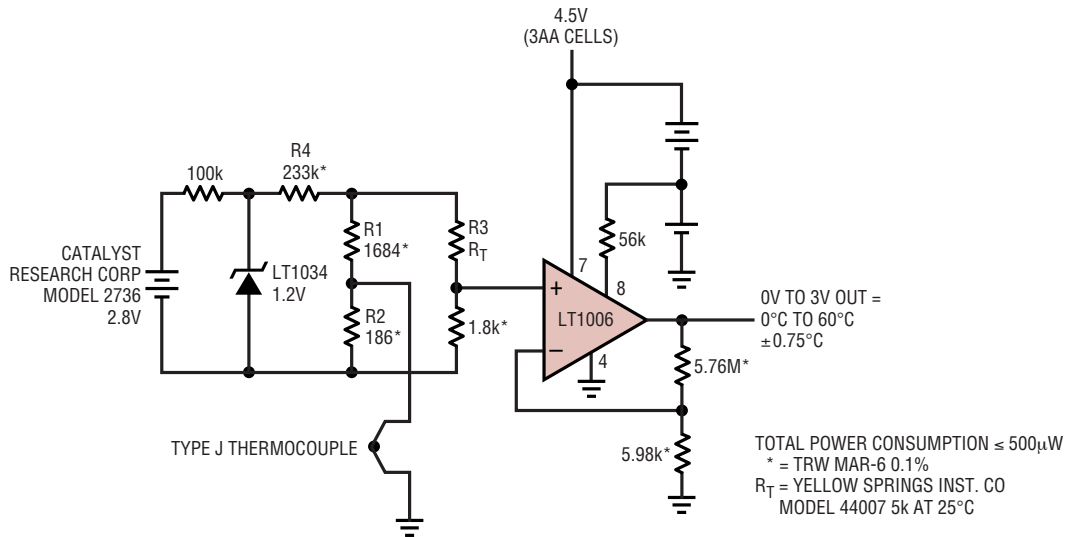
**Micropower 1MHz V/F Converter**



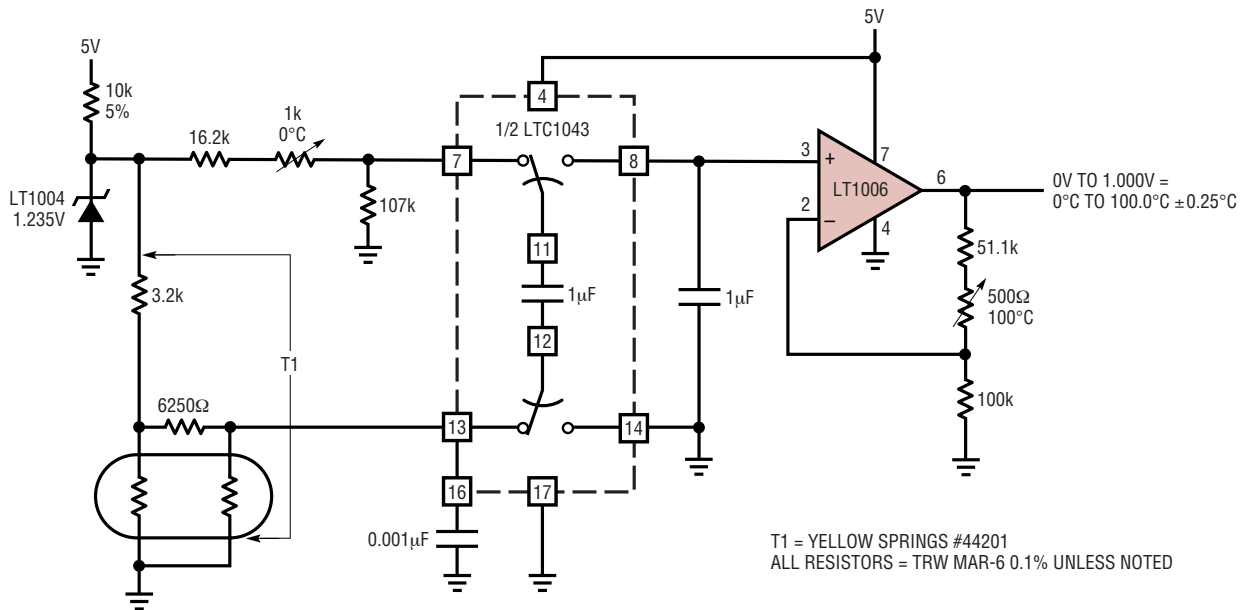
1006fa

## TYPICAL APPLICATIONS

### Micropower Thermocouple Signal Conditioner with Cold Junction Compensation

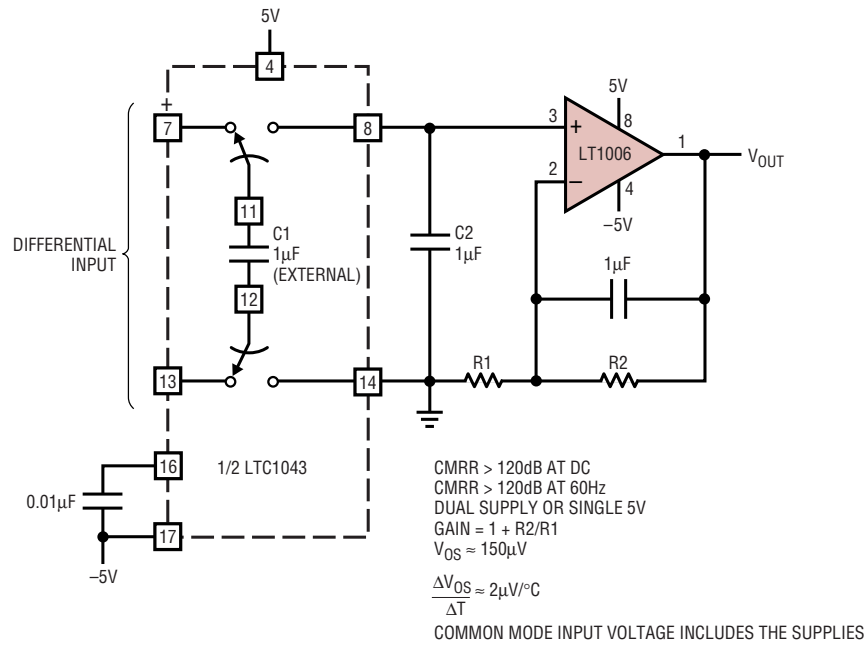


### Linear Thermometer



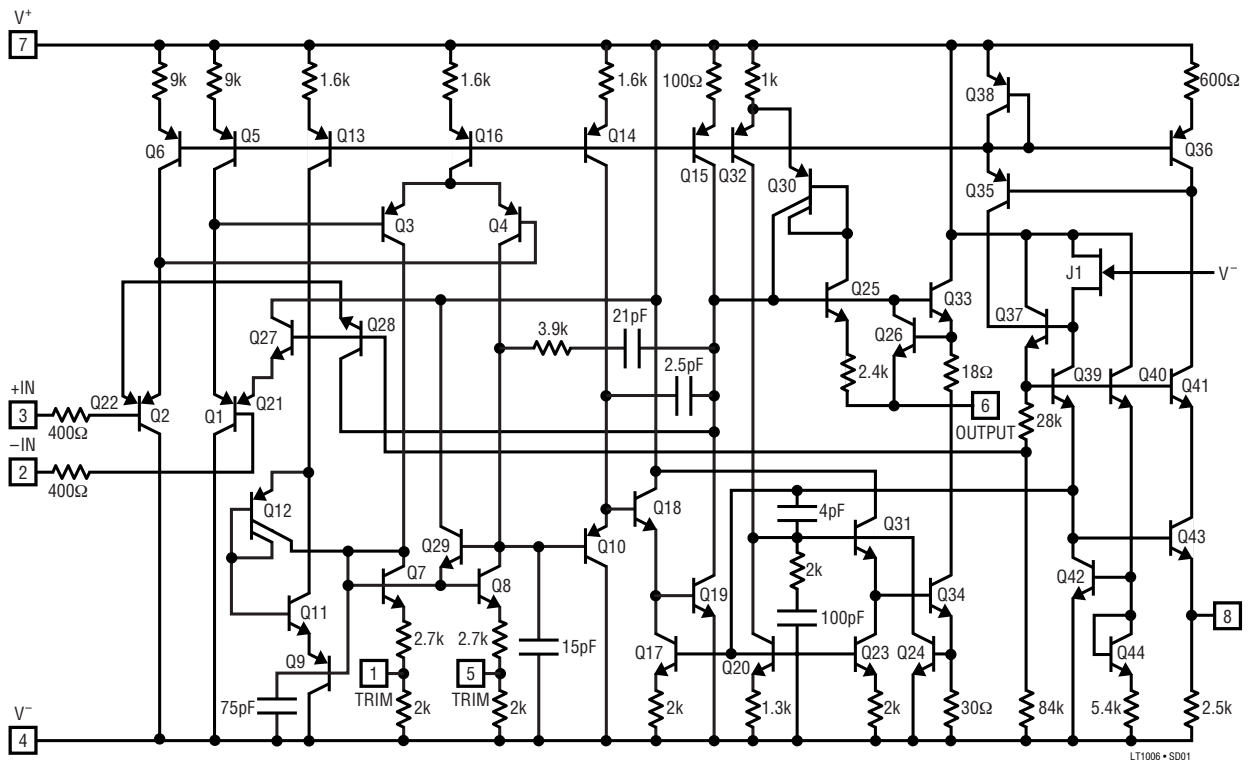
# TYPICAL APPLICATIONS

$\pm 5V$  Precision Instrumentation Amplifier



LT1006 • TA10

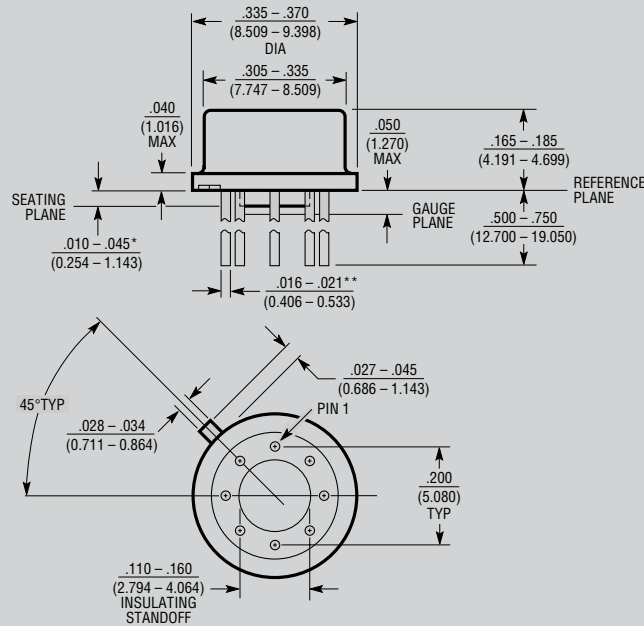
# SCHEMATIC DIAGRAM



1006fa

## PACKAGE DESCRIPTION

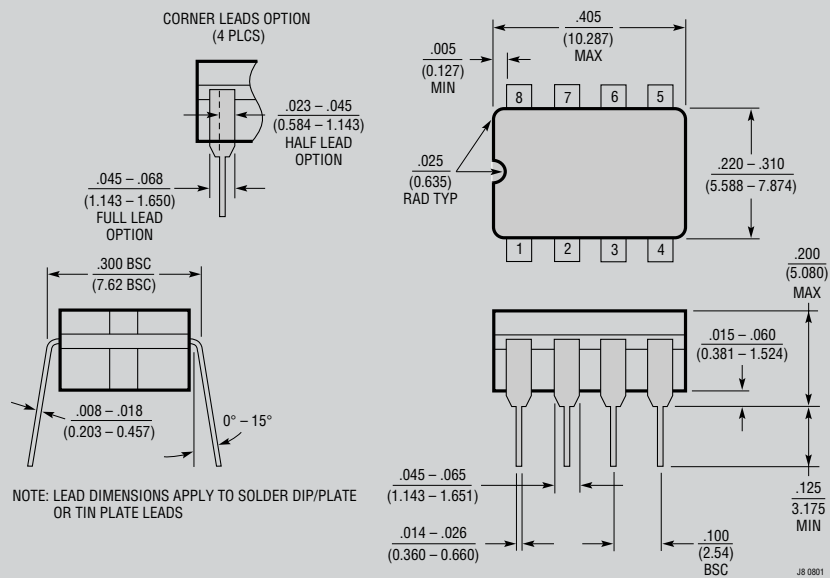
### H Package 8-Lead TO-5 Metal Can (.200 Inch PCD) (Reference LTC DWG # 05-08-1320)



\* LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND THE SEATING PLANE

\*\* FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS  $\frac{.016-.024}{(0.406-0.610)}$  H8(TO-5) 0.200 PCD 0801

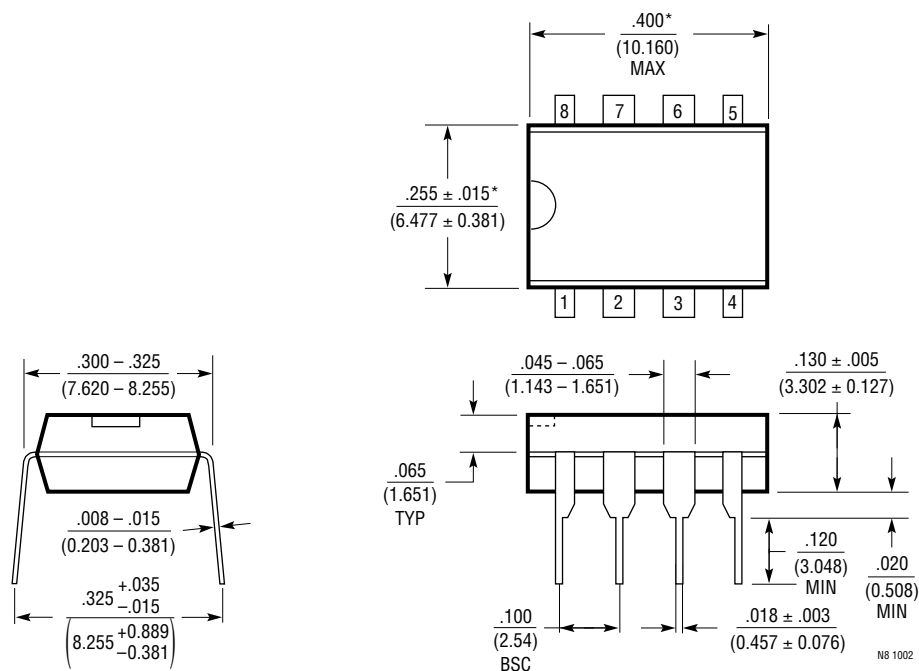
### J8 Package 8-Lead Cerdip (Narrow .300 Inch, Hermetic) (Reference LTC DWG # 05-08-1110)



## OBSOLETE PACKAGES

## PACKAGE DESCRIPTION

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



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)

# PACKAGE DESCRIPTION

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

