# 17μA Max, Dual and Quad, Single Supply, Precision Op Amps

## FEATURES

- **SO Package with Standard Pinout**
- **Supply Current per Amplifier: 17μA Max**
- **Offset Voltage: 70μV Max**
- Offset Current: 250pA Max
- Input Bias Current: 5nA Max
- Voltage Noise: 0.9μ$V_{P-P}$, 0.1Hz to 10Hz
- Current Noise: 1.5p$A_{P-P}$, 0.1Hz to 10Hz
- Offset Voltage Drift: 0.5μV/°C
- Gain Bandwidth Product: 85kHz
- Slew Rate: 0.04V/μs
- Single Supply Operation
  - Input Voltage Range Includes Ground
  - Output Swings to Ground while Sinking Current
  - No Pull-Down Resistors Needed
- Output Sources and Sinks 5mA Load Current

## APPLICATIONS

- Battery- or Solar-Powered Systems
  - Portable Instrumentation
  - Remote Sensor Amplifier
  - Satellite Circuitry
- Micropower Sample-and-Hold
- Thermocouple Amplifier
- Micropower Filters



## DESCRIPTION

The LT®2178 is a micropower dual op amp in a surface mount standard 8-pin configuration, the LT2179 is a micropower quad op amp offered in a surface mount 14-pin package. Both devices are optimized for single supply operation at 5V. Specifications are also provided at ±15V supply.

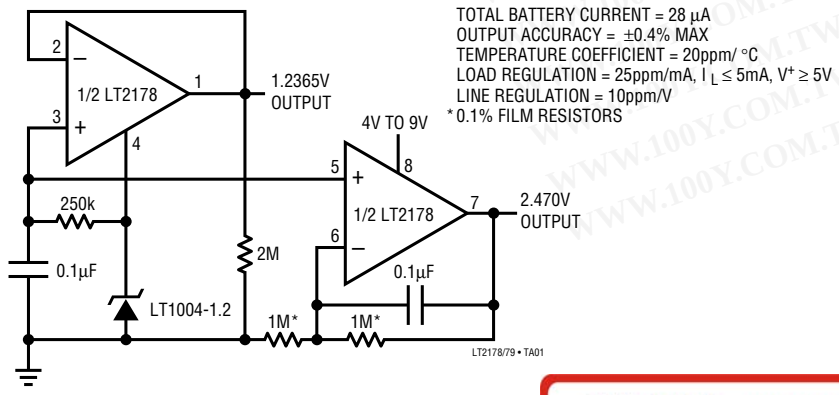
The extremely low supply current is combined with true precision specifications: offset voltage is 30μV and offset current is 50pA. Both offset parameters have low drift with temperature. The 1.5p$A_{P-P}$ current noise and picoampere offset current permit the use the megohm level source resistors without introducing serious errors. Voltage noise, at 0.9μ$V_{P-P}$, is remarkably low considering the low supply current.

The LT2178/LT2179 can be operated from a single supply (as low as one lithium-cell or two NiCd batteries). The input range goes below ground. The all-NPN output stage swings to within a few millivolts of ground while sinking current. No power consuming pull down resistors are needed.

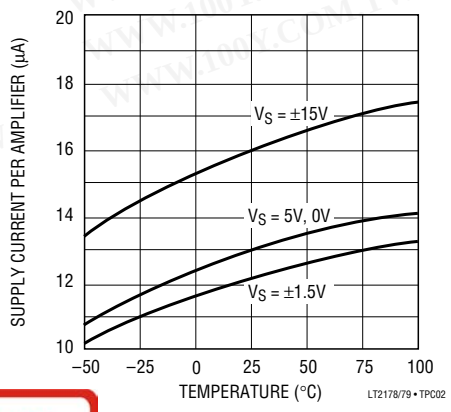
For surface mount applications where three times higher supply current is acceptable, the micropower LT1077 single, LT2078 dual and LT2079 quad are recommended. The LT1077/LT2078/LT2079 have significantly higher bandwidth, slew rate, lower voltage noise and better output drive capability. For applications requiring DIP packages refer to the LT1178/LT1179.

## TYPICAL APPLICATION

**Self-Buffered, Dual Output, Micropower Reference**




**Supply Current vs Temperature**

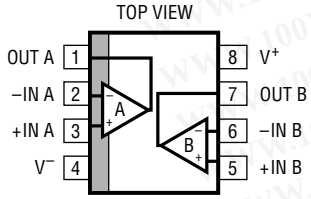


## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
Input Voltage ..... Equal to Positive Supply Voltage
..... 5V Below Negative Supply Voltage
Output Short-Circuit Duration ..... Indefinite

Specified Temperature Range
Commercial ..... 0°C to 70°C
Industrial ..... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

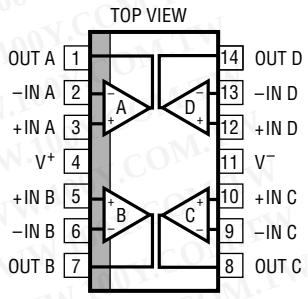
## PACKAGE/ORDER INFORMATION




S8 PACKAGE
8-LEAD PLASTIC SO

$T_{JMAX}$ = 150°C, $\theta_{JA}$ = 190°C/W

| ORDER PART NUMBER |
|---|
| LT2178ACS8<br>LT2178AIS8<br>LT2178CS8<br>LT2178IS8 |
| **PART MARKING** |
| 2178A 2178<br>2178AI 2178I |




S PACKAGE
14-LEAD PLASTIC SO

$T_{JMAX}$ = 150°C, $\theta_{JA}$ = 150°C/W

| ORDER PART NUMBER |
|---|
| LT2179ACS<br>LT2179AIS<br>LT2179CS<br>LT2179IS |

Consult factory for Military grade parts.

## ELECTRICAL CHARACTERISTICS

**$V_S$ = 5V, 0V, $V_{CM}$ = 0.1V, $V_O$ = 1.4V, $T_A$ = 25°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS (NOTE 1) | LT2178AC/LT2178AI LT2179AC/LT2179AI MIN | TYP | MAX | LT2178C/LT2178I LT2179C/LT2179I MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178<br>LT2179 | | 30<br>35 | 70<br>100 | | 40<br>40 | 120<br>150 | µV<br>µV |
| $\frac{\Delta V_{OS}}{\Delta Time}$ | Long Term Input Offset Voltage Stability | | | 0.5 | | | 0.6 | | µV/Mo |
| $I_{OS}$ | Input Offset Current | | | 0.05 | 0.25 | | 0.05 | 0.35 | nA |
| $I_B$ | Input Bias Current | | | 3 | 5 | | 3 | 6 | nA |
| $e_n$ | Input Noise Voltage | 0.1Hz to 10Hz (Note 2) | | 0.9 | 2.0 | | 0.9 | | $\mu V_{P-P}$ |
| | Input Noise Voltage Density | $f_O$ = 10Hz (Note 2)<br>$f_O$ = 1000Hz (Note 2) | | 50<br>49 | 75<br>65 | | 50<br>49 | | $nV\sqrt{Hz}$<br>$nV\sqrt{Hz}$ |
| $i_n$ | Input Noise Current | 0.1Hz to 10Hz (Note 2) | | 1.5 | 2.5 | | 1.5 | | $pA_{P-P}$ |
| | Input Noise Current Density | $f_O$ = 10Hz (Note 2)<br>$f_O$ = 1000Hz | | 0.03<br>0.01 | 0.07 | | 0.03<br>0.01 | | $pA\sqrt{Hz}$<br>$pA\sqrt{Hz}$ |
| | Input Resistance<br>Differential Mode<br>Common Mode | (Note 3) | 0.8 | 2.0<br>12 | | 0.6 | 2.0<br>12 | | GΩ<br>GΩ |
| | Input Voltage Range | | 3.5<br>0 | 3.9<br>–0.3 | | 3.5<br>0 | 3.9<br>–0.3 | | V<br>V |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 0V to 3.5V | 93 | 103 | | 90 | 102 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 2.2V to 12V | 94 | 104 | | 92 | 104 | | dB |

## ELECTRICAL CHARACTERISTICS

**$V_S$ = 5V, 0V, $V_{CM}$ = 0.1V, $V_O$ = 1.4V, $T_A$ = 25°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS (NOTE 1) | LT2178AC/LT2178AI LT2179AC/LT2179AI MIN | TYP | MAX | LT2178C/LT2178I LT2179C/LT2179I MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = 0.03V to 4V, No Load (Note 3)<br>$V_O$ = 0.03V to 3.5V, $R_L$ = 50k | 140<br>80 | 700<br>200 | | 110<br>70 | 700<br>200 | | V/mV<br>V/mV |
| | Maximum Output Voltage Swing | Output Low, No Load<br>Output Low, 2k to GND<br>Output Low, $I_{SINK}$ = 100µA | | 6.5<br>0.2<br>120 | 9<br>0.6<br>160 | | 6.5<br>0.2<br>120 | 9<br>0.6<br>160 | mV<br>mV<br>mV |
| | | Output High, No Load<br>Output High, 2k to GND | 4.2<br>3.5 | 4.4<br>3.8 | | 4.2<br>3.5 | 4.4<br>3.8 | | V<br>V |
| SR | Slew Rate | $A_V$ = 1, $C_L$ = 10pF (Note 3) | 0.013 | 0.025 | | 0.013 | 0.025 | | V/µs |
| GBW | Gain Bandwidth Product | $f_O \leq$ 5kHz | | 60 | | | 60 | | kHz |
| $I_S$ | Supply Current per Amplifier | <br>$V_S$ = ±1.5V, $V_O$ = 0V | | 13<br>12 | 18<br>17 | | 14<br>13 | 21<br>20 | µA<br>µA |
| | Channel Separation | $\Delta V_{IN}$ = 3V, $R_L$ = 10k | | 110 | | | 110 | | dB |
| | Minimum Supply Voltage | (Note 4) | | 2.0 | 2.2 | | 2.0 | 2.2 | V |

**$V_S$ = 5V, 0V, $V_{CM}$ = 0.1V, $V_O$ = 1.4V, −40°C ≤ $T_A$ ≤ 85°C for I grades, unless otherwise noted. (Note 6)**

| SYMBOL | PARAMETER | CONDITIONS | | LT2178AI/LT2179AI MIN | TYP | MAX | LT2178I/LT2179I MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178<br>LT2179 | ●<br>● | | 70<br>80 | 270<br>300 | | 95<br>100 | 370<br>400 | µV<br>µV |
| $\frac{\Delta V_{OS}}{\Delta T}$ | Input Offset Voltage Drift | LT2178 (Note 5)<br>LT2179 | ● | | 0.4<br>0.5 | 1.8<br>3.0 | | 0.5<br>0.6 | 2.5<br>3.5 | µV/°C<br>µV/°C |
| $I_{OS}$ | Input Offset Current | | ● | | 0.07 | 0.70 | | 0.1 | 1.0 | nA |
| $I_B$ | Input Bias Current | | ● | | 3 | 7 | | 4 | 8 | nA |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 0.05V to 3.2V | ● | 86 | 100 | | 84 | 98 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 3V to 12V | ● | 88 | 100 | | 86 | 100 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = 0.05V to 4V, No Load (Note 3)<br>$V_O$ = 0.05V to 3.5V, $R_L$ = 50k | ●<br>● | 75<br>40 | 350<br>130 | | 50<br>30 | 350<br>130 | | V/mV<br>V/mV |
| | Maximum Output Voltage Swing | Output Low, No Load<br>Output Low, $I_{SINK}$ = 100µA | ●<br>● | | 9<br>160 | 13<br>220 | | 9<br>160 | 13<br>220 | mV<br>mV |
| | | Output High, No Load<br>Output High, 2k to GND | ●<br>● | 3.9<br>3.0 | 4.2<br>3.7 | | 3.9<br>3.0 | 4.2<br>3.7 | | V<br>V |
| $I_S$ | Supply Current per Amplifier | | ● | | 15 | 24 | | 15 | 27 | µA |

**$V_S$ = 5V, 0V, $V_{CM}$ = 0.1V, $V_O$ = 1.4V, 0°C ≤ $T_A$ ≤ 70°C, unless otherwise noted. (Note 7)**

| SYMBOL | PARAMETER | CONDITIONS | | LT2178AC/LT2179AC MIN | TYP | MAX | LT2178C/LT2179C MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178<br>LT2179 | ●<br>● | | 50<br>60 | 170<br>200 | | 65<br>70 | 250<br>290 | µV<br>µV |
| $\frac{\Delta V_{OS}}{\Delta T}$ | Input Offset Voltage Drift | LT2178 (Note 5)<br>LT2179 | ● | | 0.4<br>0.5 | 1.8<br>3.0 | | 0.5<br>0.6 | 2.5<br>3.5 | µV/°C<br>µV/°C |
| $I_{OS}$ | Input Offset Current | | ● | | 0.06 | 0.35 | | 0.06 | 0.50 | nA |
| $I_B$ | Input Bias Current | | ● | | 3 | 6 | | 3 | 7 | nA |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 0V to 3.4V | ● | 90 | 101 | | 86 | 100 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 2.5V to 12V | ● | 90 | 102 | | 88 | 102 | | dB |

## ELECTRICAL CHARACTERISTICS

**$V_S$ = 5V, 0V, $V_{CM}$ = 0.1V, $V_O$ = 1.4V, 0°C ≤ $T_A$ ≤ 70°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | LT2178AC/LT2179AC MIN | LT2178AC/LT2179AC TYP | LT2178AC/LT2179AC MAX | LT2178C/LT2179C MIN | LT2178C/LT2179C TYP | LT2178C/LT2179C MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = 0.05V to 4V, No Load (Note 3)<br>$V_O$ = 0.05V to 3.5V, $R_L$ = 50k | ●<br>● | 150<br>55 | 500<br>160 | | 80<br>45 | 500<br>160 | | V/mV<br>V/mV |
| | Maximum Output Voltage Swing | Output Low, No Load<br>Output Low, $I_{SINK}$ = 100µA | ●<br>● | | 8<br>140 | 11<br>190 | | 8<br>140 | 11<br>190 | mV<br>mV |
| | | Output High, No Load<br>Output High, 2k to GND | ●<br>● | 4.1<br>3.3 | 4.3<br>3.8 | | 4.1<br>3.3 | 4.3<br>3.8 | | V<br>V |
| $I_S$ | Supply Current per Amplifier | | ● | | 14 | 21 | | 15 | 24 | µA |

**$V_S$ = ±15V, $T_A$ = 25°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | LT2178AC/LT2178AI LT2179AC/LT2179AI MIN | TYP | MAX | LT2178C/LT2178I LT2179C/LT2179I MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178<br>LT2179 | | 70<br>80 | 300<br>350 | | 90<br>100 | 400<br>450 | µV<br>µV |
| $I_{OS}$ | Input Offset Current | | | 0.05 | 0.25 | | 0.05 | 0.35 | nA |
| $I_B$ | Input Bias Current | | | 3 | 5 | | 3 | 6 | nA |
| | Input Voltage Range | | 13.5<br>–15.0 | 13.9<br>–15.3 | | 13.5<br>–15.0 | 13.9<br>–15.3 | | V<br>V |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 13.5V to –15V | 96 | 106 | | 93 | 106 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 5V, 0V to ±18V | 96 | 112 | | 94 | 112 | | dB |
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = ±10V, $R_L$ = 50k<br>$V_O$ = ±10V, No Load | 300<br>600 | 1200<br>2500 | | 250<br>400 | 1000<br>2500 | | V/mV<br>V/mV |
| $V_{OUT}$ | Maximum Output Voltage Swing | $R_L$ = 50k<br>$R_L$ = 2k | ±13.0<br>±11.0 | ±14.2<br>±12.7 | | ±13.0<br>±11.0 | ±14.2<br>±12.7 | | V<br>V |
| SR | Slew Rate | $A_V$ = 1 | 0.02 | 0.04 | | 0.02 | 0.04 | | V/µs |
| GBW | Gain Bandwidth Product | $f_O$ ≤ 5kHz | | 85 | | | 85 | | kHz |
| $I_S$ | Supply Current per Amplifier | | | 16 | 21 | | 17 | 25 | µA |

**$V_S$ = ±15V, –40°C ≤ $T_A$ ≤ 85°C for I grades, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | LT2178AI/LT2179AI MIN | LT2178AI/LT2179AI TYP | LT2178AI/LT2179AI MAX | LT2178I/LT2179I MIN | LT2178I/LT2179I TYP | LT2178I/LT2179I MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178<br>LT2179 | ●<br>● | | 100<br>100 | 650<br>650 | | 130<br>130 | 740<br>740 | µV<br>µV |
| $\frac{\Delta V_{OS}}{\Delta T}$ | Input Offset Voltage Drift | LT2178 (Note 5)<br>LT2179 | ● | | 0.6<br>0.7 | 1.8<br>3.0 | | 0.7<br>0.9 | 2.5<br>4.0 | µV/°C<br>µV/°C |
| $I_{OS}$ | Input Offset Current | | ● | | 0.07 | 0.70 | | 0.1 | 1.0 | nA |
| $I_B$ | Input Bias Current | | ● | | 3 | 7 | | 4 | 8 | nA |
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = ±10V, $R_L$ = 50k | ● | 150 | 500 | | 100 | 500 | | V/mV |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 13V, –14.9V | ● | 90 | 105 | | 88 | 103 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 0V, 5V to ±18V | ● | 92 | 110 | | 88 | 109 | | dB |
| | Maximum Output Voltage Swing | $R_L$ = 5k | ● | ±11.0 | ±13.5 | | ±11.0 | ±13.5 | | V |
| $I_S$ | Supply Current per Amplifier | | ● | | 18 | 28 | | 19 | 30 | µA |

## ELECTRICAL CHARACTERISTICS

**$V_S$ = ±15V, 0°C ≤ $T_A$ ≤ 70°C, unless otherwise noted.**

| SYMBOL | PARAMETER | CONDITIONS | | LT2178AC/LT2179AC MIN | LT2178AC/LT2179AC TYP | LT2178AC/LT2179AC MAX | LT2178C/LT2179C MIN | LT2178C/LT2179C TYP | LT2178C/LT2179C MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | LT2178 | ● | | 100 | 480 | | 130 | 660 | µV |
| | | LT2179 | ● | | 120 | 550 | | 150 | 750 | µV |
| $\frac{\Delta V_{OS}}{\Delta T}$ | Input Offset Voltage Drift | LT2178 (Note 5) | ● | | 0.6 | 1.8 | | 0.7 | 2.5 | µV/°C |
| | | LT2179 | | | 0.7 | 3.0 | | 0.9 | 4.0 | µV/°C |
| $I_{OS}$ | Input Offset Current | | ● | | 0.06 | 0.35 | | 0.06 | 0.35 | nA |
| $I_B$ | Input Bias Current | | ● | | 3 | 6 | | 3 | 7 | nA |
| $A_{VOL}$ | Large-Signal Voltage Gain | $V_O$ = ±10V, $R_L$ = 50k | ● | 200 | 800 | | 150 | 750 | | V/mV |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 13V, –15V | ● | 94 | 104 | | 91 | 104 | | dB |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 5V, 0V to ±18V | ● | 93 | 110 | | 91 | 110 | | dB |
| | Maximum Output Voltage Swing | $R_L$ = 5k | ● | ±11.0 | ±13.6 | | ±11.0 | ±13.6 | | V |
| $I_S$ | Supply Current per Amplifier | | ● | | 17 | 24 | | 18 | 28 | µA |

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

**Note 1:** Typical parameters are defined as the 60% yield of parameter distributions of individual amplifiers, i.e., out of 100 LT2179s (or 100 LT2178s) typically 240 op amps (or 120) will be better than the indicated specification.

**Note 2:** This parameter is tested on a sample basis only. All noise parameters are tested with $V_S$ = ±2.5V, $V_O$ = 0V.

**Note 3:** This parameter is guaranteed by design and is not tested.

**Note 4:** Power supply rejection ratio is measured at the minimum supply voltage. The op amps actually work at 1.7V supply but with a typical offset skew of –300µV.

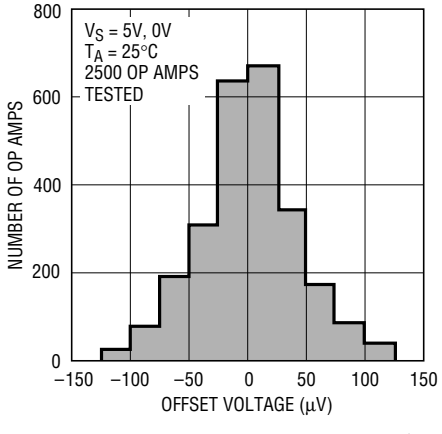
**Note 5:** This parameter is not 100% tested.

**Note 6:** During testing at –40°C, the 5V power supply turn-on time is less than 0.5s.

**Note 7:** The LT2178C/LT2179C are designed, characterized and expected to meet the industrial temperature limits, but are not tested at –40°C and 85°C. I-grade parts are guaranteed.

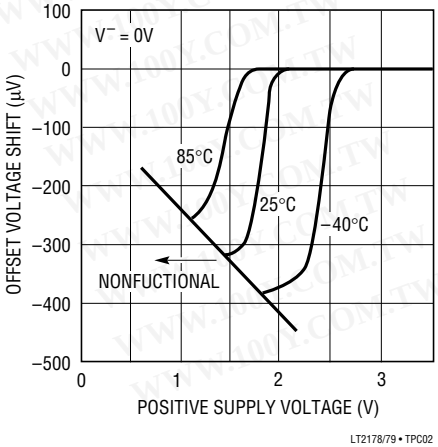
## TYPICAL PERFORMANCE CHARACTERISTICS

**Distribution of Input Offset Voltage**



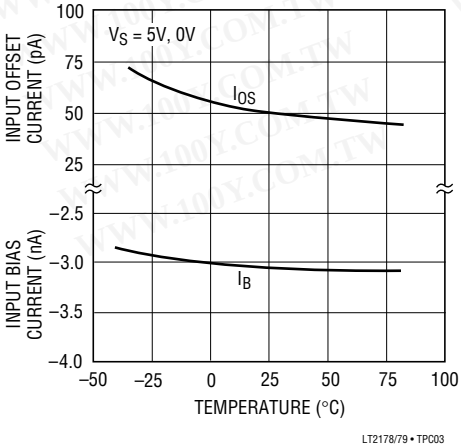

LT2178/79 • TPC01

**Minimum Supply Voltage**




LT2178/79 • TPC02

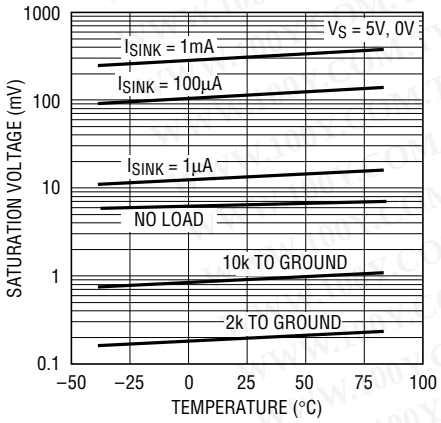
**Input Bias and Offset Currents vs Temperature**




LT2178/79 • TPC03

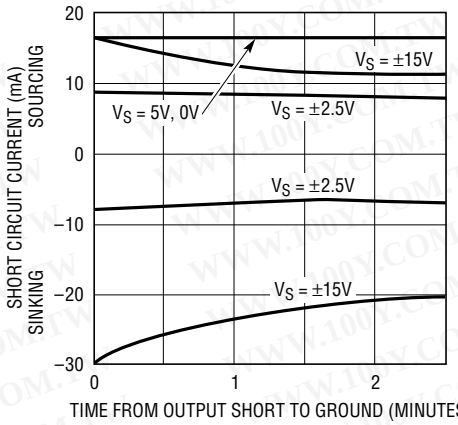
## TYPICAL PERFORMANCE CHARACTERISTICS

### Output Saturation vs Temperature vs Sink Current



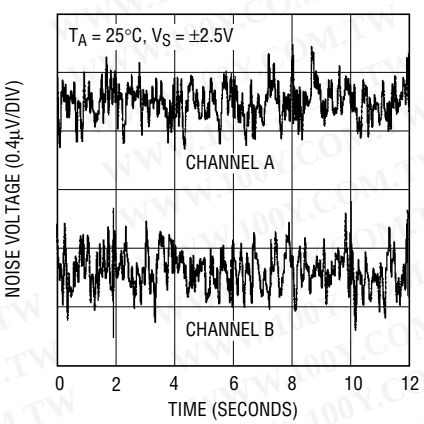

LT2178/79 • TPC04

### Short-Circuit Current



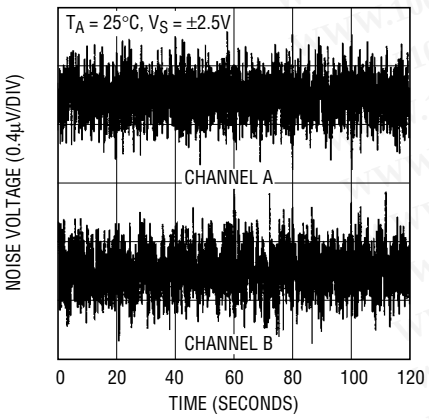

LT2178/79 • TPC05

### 0.1Hz to 10Hz Noise



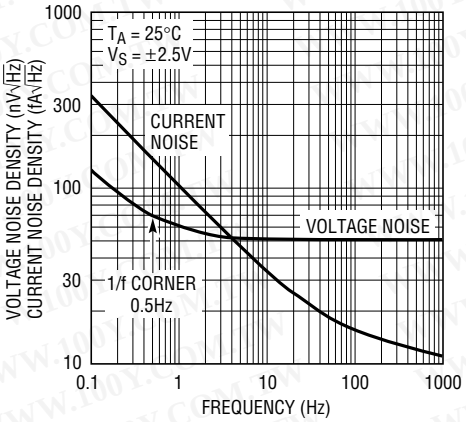

LTC2178/79 • TPC06

### 0.01Hz to 10Hz Noise



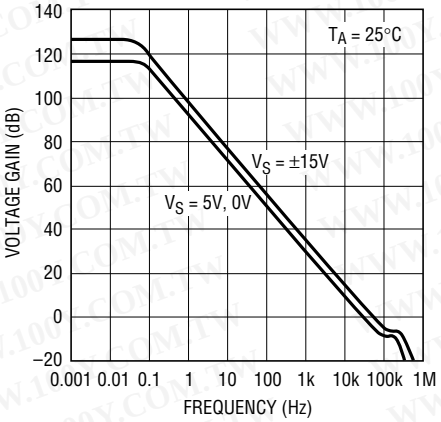

LTC2178/79 • TPC07

### Noise Spectrum



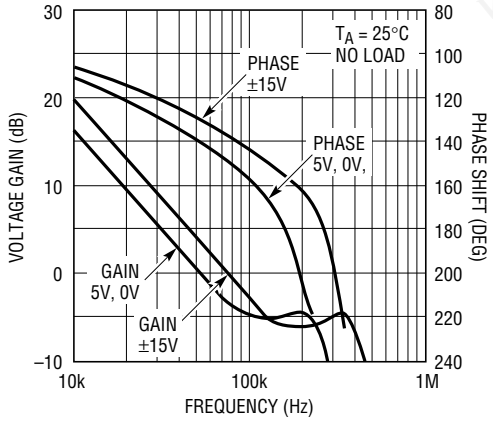

LT2178/79 • TPC08

### Voltage Gain vs Frequency



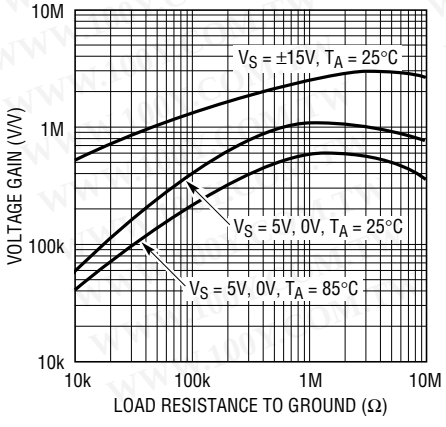

LT2178/79 • TPC09

### Gain, Phase vs Frequency



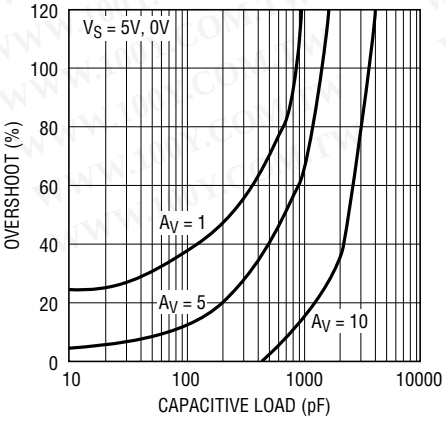

LT2178/79 • TPC10

### Voltage Gain vs Load Resistance




LT2178/79 • TPC11

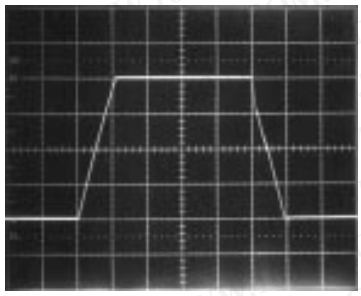
### Capacitive Load Handling




LT2078/79 • TPC12

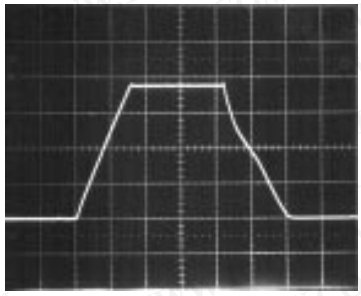
# TYPICAL PERFORMANCE CHARACTERISTICS

**Large-Signal Transient Response**
**$V_S = \pm 15V$**



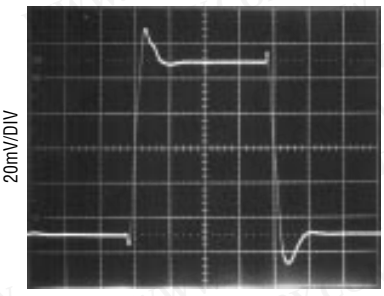

$A_V = 1$ 500µs/DIV
$C_L = 12pF$
LT2178/79 • TPC13

**Large-Signal Transient Response**
**$V_S = 5V, 0V$**



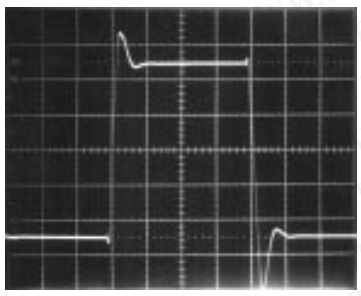

$A_V = 1$ 100µs/DIV
$C_L = 12pF$
INPUT PULSE = 0V TO 3.8V
LT2178/79 • TPC14

**Small-Signal Transient Response**
**$V_S = \pm 2.5V$**



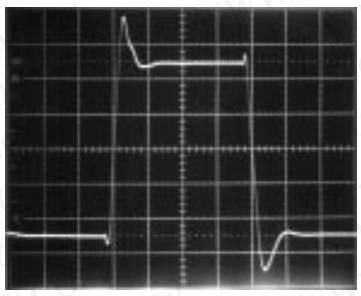

$A_V = 1$ 20µs/DIV
$C_L = 12pF$
LT2178/79 • TPC15

**Small-Signal Transient Response**
**$V_S = \pm 15V$**



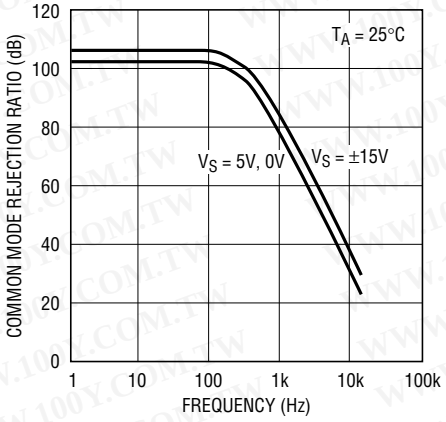

$A_V = 1$ 20µs/DIV
$C_L = 12pF$
LT2178/79 • TPC16

**Small-Signal Transient Response**
**$V_S = 5V, 0V$**



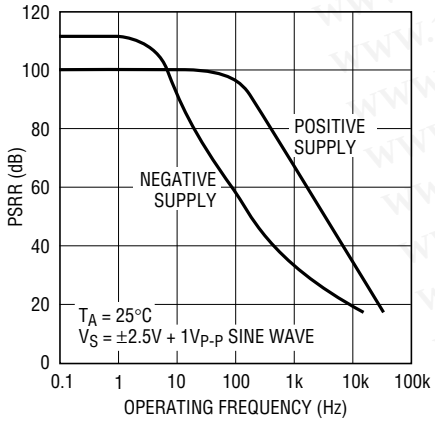

$A_V = 1$ 20µs/DIV
$C_L = 12pF$
INPUT PULSE = 50mV TO 150mV
LT2178/79 • TPC17

**Common Mode Rejection Ratio vs Frequency**



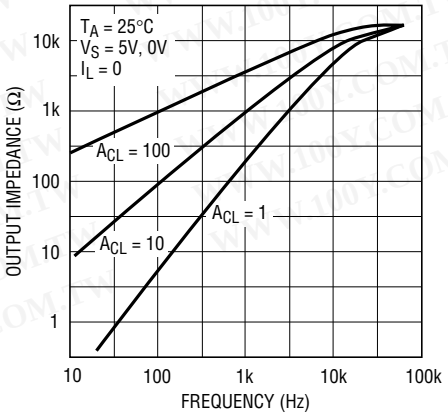

LT2178/79 • TPC18

**Power Supply Rejection Ratio vs Frequency**




LT2178/79 • TPC19

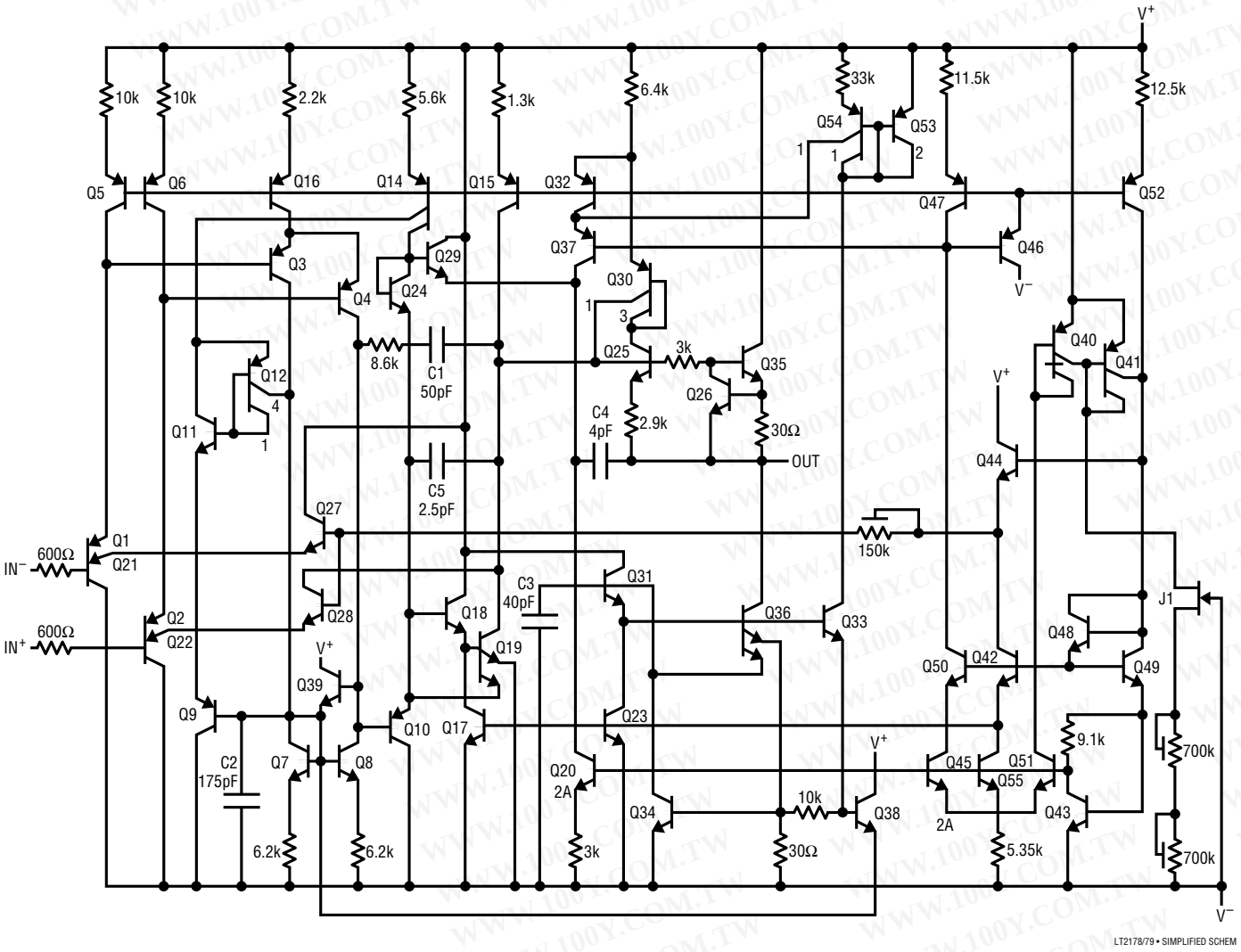
**Closed Loop Output Impedance**




LT2178/79 • TPC20

## SIMPLIFIED SCHEMATIC

**1/2 LT2178**
**1/4 LT2179**

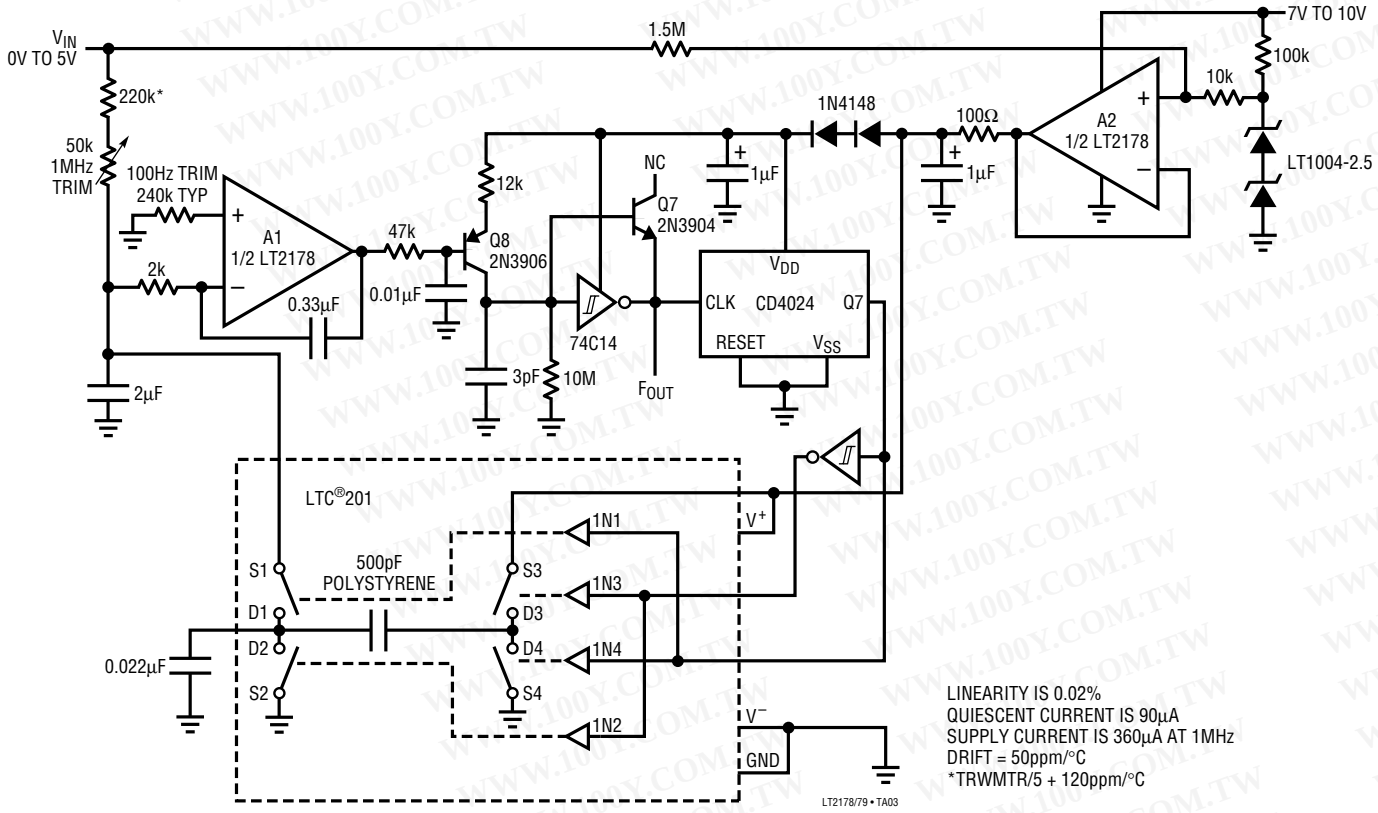



LT2178/79 • SIMPLIFIED SCHEM

## APPLICATIONS INFORMATION

Please see the LT2078/LT2079 data sheet for applications information. All comments relating to specifications, single supply operation and phase reversal protection are directly applicable to the LT2178/LT2179.

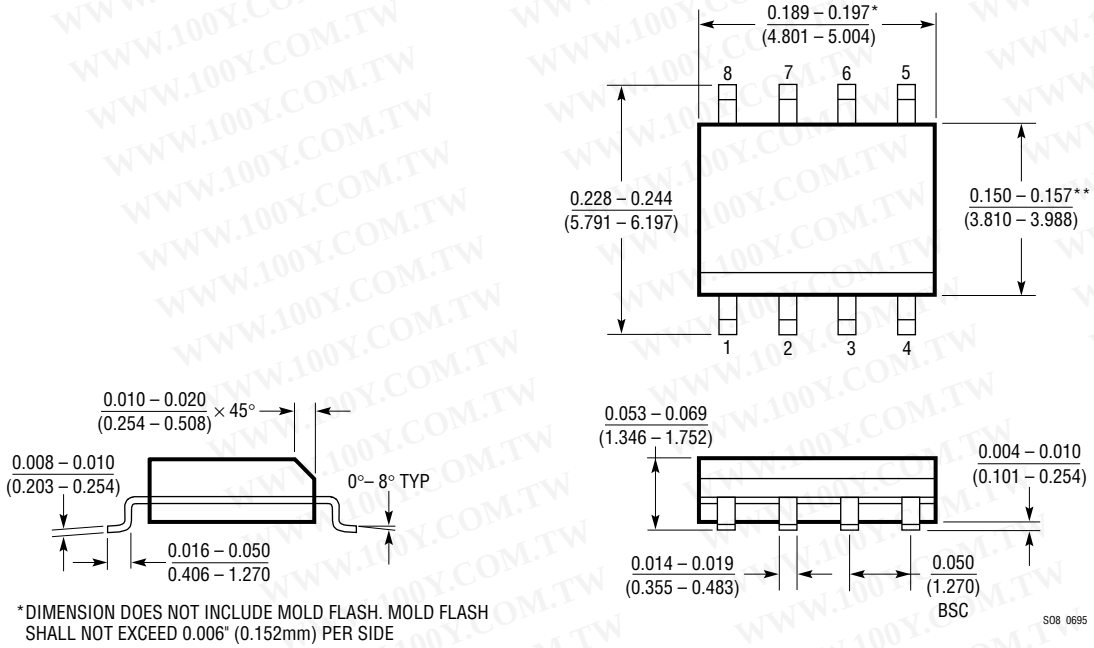
**Micropower 100Hz to 1MHz V-to-F Converter**



## PACKAGE DESCRIPTION

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

**S8 Package**
**8-Lead Plastic Small Outline (Narrow 0.150)**
(LTC DWG # 05-08-1610)



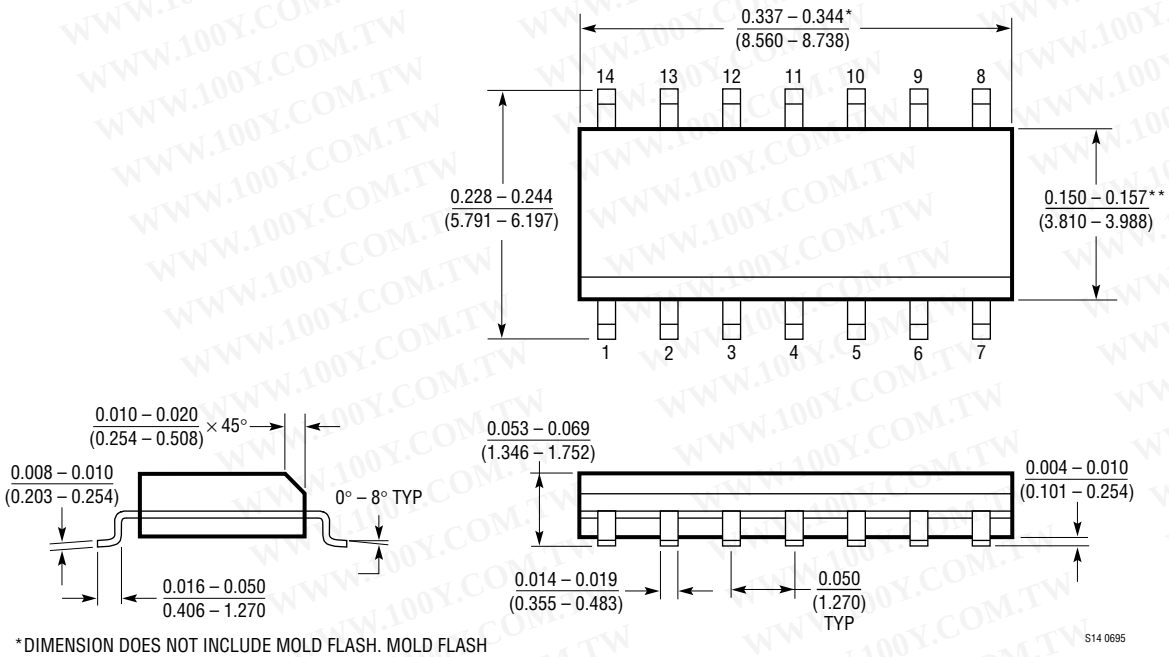

*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

## PACKAGE DESCRIPTION

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

**S Package**
**14-Lead Plastic Small Outline (Narrow 0.150)**
(LTC DWG # 05-08-1610)

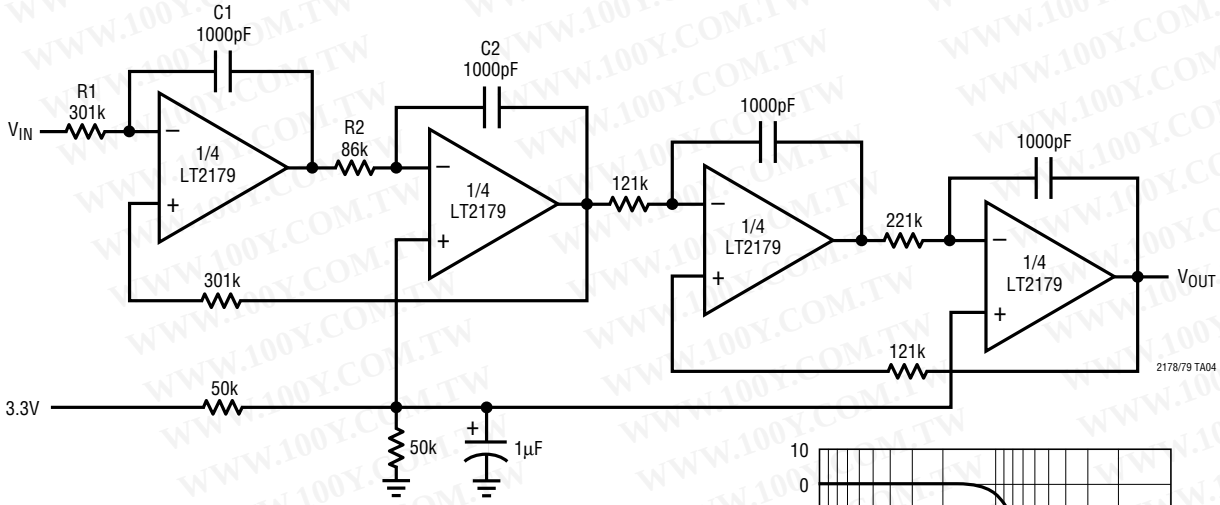



*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

## TYPICAL APPLICATION

**Single Supply, 1kHz, 4th Order Butterworth Lowpass Filter**



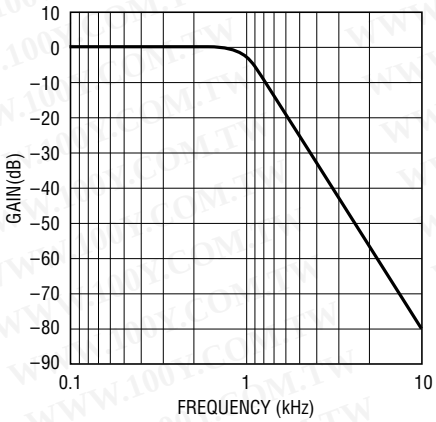

12-BIT ACCURATE SIGNAL RANGE FROM 6mV TO 1.8V ON 3.3V SINGLE SUPPLY.
MAXIMUM OUTPUT OFFSET ERROR IS 448µV.

FOR EACH 2ND ORDER SECTION:

$$W_0^2 = \frac{1}{C1C2R1R2}$$

$$R1 = \frac{1}{W_0QC1}$$

$$R2 = \frac{Q}{W_0C2}$$




## RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| LT1078/LT1079 | Dual/Quad 55µA Max, Single Supply Precision Op Amps | 70µV $V_{OS}$ Max and 2.5µV/°C Drift Max, 200kHz BBW, 0.07V/µs Slew Rate, Input/Output Common Mode Includes Ground |
| LT1211/LT1212 | 14MHz, 7V/µs Single Supply Dual and Quad Precision Op Amps | 275µV $V_{OS}$ Max, 6µV/°C Drift Max Input Voltage Range Includes Ground |
| LT1490/LT1491 | Dual/ Quad Micropower Rail-to-Rail Input and Output Op Amps | Single Supply Input Range: –0.4V to 44V, Micropower 50µA Amplifier, Rail-to-Rail Input and Output, 200kHz GBW |
| LT2078/LT2079 | Dual/Quad 55µA Max, Single Supply Precision Op Amps | 70µV $V_{OS}$ Max and 2.5µV/°C Drift Max, 200kHz BBW, 0.07V/µs Slew Rate, Input/Output Common Mode Includes Ground Surface Mount Standard Pinout |




Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • TELEX: 499-3977
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