

### FEATURES

**Micropower at high voltage (18 V): 18  $\mu$ A typical**  
**Single-supply operation: 2.7 V to 18 V**  
**Dual-supply operation:  $\pm 1.35$  V to  $\pm 9$  V**  
**Low input bias current: 20 pA**  
**Gain bandwidth: 200 kHz**  
**Unity-gain stable**  
**Excellent electromagnetic interference immunity**

### APPLICATIONS

**Portable operating systems**  
**Current monitors**  
**4 mA to 20 mA loop drivers**  
**Buffer/level shifting**  
**Multipole filters**  
**Remote/wireless sensors**  
**Low power transimpedance amplifiers**

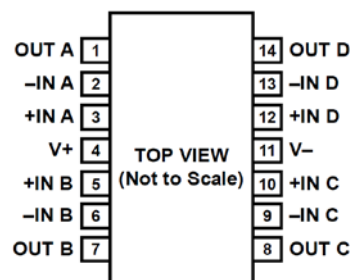
### GENERAL DESCRIPTION

The AD8548 is a Quad, micropower, rail-to-rail input/output amplifier optimized for low power and wide operating supply voltage range applications.

The AD8548 operates from 2.7 V up to 18 V with a typical quiescent supply current of 18  $\mu$ A. The AD8548 also has high immunity to electromagnetic interference.

The combination of low supply current, low offset voltage, very low input bias current, wide supply range, and rail-to-rail input and output make the AD8548 ideal for current monitoring and current loops in process and motor control applications. The combination of precision specifications makes this device ideal for dc gain and buffering of sensor front ends or high impedance input sources in wireless or remote sensors or transmitters.

### PIN CONFIGURATION



14-Lead SOIC\_N (R Suffix)

Table 1. Micropower Op Amps

| Supply Voltage | 5 V                                               | 12 V to 16 V    | 36 V               |
|----------------|---------------------------------------------------|-----------------|--------------------|
| Single         | AD8500<br>ADA4505-1<br>AD8505<br>AD8541<br>AD8603 | AD8663          |                    |
| Dual           | AD8502<br>ADA4505-2<br>AD8506<br>AD8542<br>AD8607 | AD8667<br>OP281 | OP295<br>ADA4062-2 |
| Quad           | AD8504<br>ADA4505-4<br>AD8508<br>AD8544<br>AD8609 | AD8669<br>OP481 | OP495<br>ADA4062-4 |

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## SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS—2.7 V OPERATION

$V_{SY} = 2.7\text{ V}$ ,  $V_{CM} = V_{SY}/2\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

Table 2.

| Parameter                            | Symbol               | Test Conditions/Comments                                                            | Min  | Typ | Max | Unit    |
|--------------------------------------|----------------------|-------------------------------------------------------------------------------------|------|-----|-----|---------|
| INPUT CHARACTERISTICS                |                      |                                                                                     |      |     |     |         |
| Offset Voltage                       | V <sub>OS</sub>      | V <sub>CM</sub> = 0 V to 2.7 V                                                      |      |     | 4   | mV      |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 2.4 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                    |      |     | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0 V to 2.7 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                      |      |     | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 2.4 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                   |      |     | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0 V to 2.7 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                     |      |     | tbd | mV      |
| Input Bias Current                   | I <sub>B</sub>       | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |      | 1   | 10  | pA      |
| Input Offset Current                 | I <sub>OS</sub>      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |      |     | 2.6 | nA      |
|                                      |                      |                                                                                     |      |     | 20  | pA      |
| Input Voltage Range                  |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |      |     | 500 | pA      |
|                                      |                      |                                                                                     |      |     | 2.7 | V       |
| Common-Mode Rejection Ratio          | CMRR                 | V <sub>CM</sub> = 0 V to 2.7 V                                                      | 0    |     |     |         |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 2.4 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                    | 79   | 95  |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0 V to 2.7 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                      | 70   |     |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 2.4 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                   | 64   |     |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0 V to 2.7 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                     | 63   |     |     | dB      |
| Large Signal Voltage Gain            | A <sub>VO</sub>      | V <sub>CM</sub> = 0 V to 2.7 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                     | 60   |     |     | dB      |
|                                      |                      | R <sub>L</sub> = 100 kΩ, V <sub>O</sub> = 0.5 V to 2.2 V                            | 94   | 105 |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +85°C                                                      | 75   |     |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     | 65   |     |     | dB      |
| Offset Voltage Drift                 | ΔV <sub>OS</sub> /ΔT |                                                                                     |      | 2   |     | μV/°C   |
| Input Resistance                     | R <sub>IN</sub>      |                                                                                     |      | 10  |     | GΩ      |
| Input Capacitance, Differential Mode | C <sub>INDM</sub>    |                                                                                     |      | 3.5 |     | pF      |
| Input Capacitance, Common Mode       | C <sub>INCM</sub>    |                                                                                     |      | 3.5 |     | pF      |
| OUTPUT CHARACTERISTICS               |                      |                                                                                     |      |     |     |         |
| Output Voltage High                  | V <sub>OH</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C        | 2.69 |     |     | V       |
| Output Voltage Low                   | V <sub>OL</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C        |      |     | 10  | mV      |
| Short-Circuit Current                | I <sub>SC</sub>      |                                                                                     |      | ±4  |     | mA      |
| Closed-Loop Output Impedance         | Z <sub>OUT</sub>     | f = 1 kHz, A <sub>v</sub> = 1                                                       |      | 20  |     | Ω       |
| POWER SUPPLY                         |                      |                                                                                     |      |     |     |         |
| Power Supply Rejection Ratio         | PSRR                 | V <sub>SY</sub> = 2.7 V to 18 V                                                     | 105  | 125 |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     | 70   |     |     | dB      |
| Supply Current per Amplifier         | I <sub>SY</sub>      | I <sub>O</sub> = 0 mA                                                               |      | 18  | 22  | μA      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |      |     | 33  | μA      |
| DYNAMIC PERFORMANCE                  |                      |                                                                                     |      |     |     |         |
| Slew Rate                            | SR                   | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>v</sub> = 1                   |      | 38  |     | V/ms    |
| Settling Time to 0.1%                | t <sub>s</sub>       | V <sub>IN</sub> = 1 V step, R <sub>L</sub> = 100 kΩ, C <sub>L</sub> = 10 pF         |      | 14  |     | μs      |
| Gain Bandwidth Product               | GBP                  | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>v</sub> = 1                   |      | 170 |     | kHz     |
| Phase Margin                         | Φ <sub>M</sub>       | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>v</sub> = 1                   |      | 69  |     | Degrees |
| Channel Separation                   | CS                   | f = 10 kHz, R <sub>L</sub> = 1 MΩ                                                   |      | 105 |     | dB      |
| EMI Rejection Ratio of IN+           | EMIRR                | V <sub>IN</sub> = 100 mV <sub>PEAK</sub> ; f = 400 MHz, 900 MHz, 1800 MHz, 2400 MHz |      | 90  |     | dB      |
| NOISE PERFORMANCE                    |                      |                                                                                     |      |     |     |         |
| Voltage Noise                        | e <sub>n</sub> p-p   | f = 0.1 Hz to 10 Hz                                                                 |      | 6   |     | μV p-p  |
| Voltage Noise Density                | e <sub>n</sub>       | f = 1 kHz                                                                           |      | 60  |     | nV/√Hz  |
|                                      |                      | f = 10 kHz                                                                          |      | 56  |     | nV/√Hz  |

| Parameter             | Symbol | Test Conditions/Comments | Min | Typ | Max | Unit                         |
|-----------------------|--------|--------------------------|-----|-----|-----|------------------------------|
| Current Noise Density | $i_n$  | $f = 1 \text{ kHz}$      |     | 0.1 |     | $\text{pA}/\sqrt{\text{Hz}}$ |

**ELECTRICAL CHARACTERISTICS—10 V OPERATION**

$V_{SY} = 10 \text{ V}$ ,  $V_{CM} = V_{SY}/2 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

**Table 3.**

| Parameter                            | Symbol               | Test Conditions/Comments                                                                                                                                         | Min             | Typ      | Max              | Unit             |
|--------------------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------|------------------|------------------|
| INPUT CHARACTERISTICS                |                      |                                                                                                                                                                  |                 |          |                  |                  |
| Offset Voltage                       | V <sub>OS</sub>      | V <sub>CM</sub> = 0 V to 10 V<br>V <sub>CM</sub> = 0 V to 10 V; −40°C ≤ T <sub>A</sub> ≤ +85°C<br>V <sub>CM</sub> = 0 V to 10 V; −40°C ≤ T <sub>A</sub> ≤ +125°C |                 |          | 4<br>tbd<br>tbd  | mV<br>mV<br>mV   |
| Input Bias Current                   | I <sub>B</sub>       | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                                                                  |                 | 2        | 15               | pA               |
| Input Offset Current                 | I <sub>OS</sub>      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                                                                  |                 |          | 2.6<br>30<br>500 | nA<br>pA<br>pA   |
| Input Voltage Range                  |                      |                                                                                                                                                                  | 0               |          | 10               | V                |
| Common-Mode Rejection Ratio          | CMRR                 | V <sub>CM</sub> = 0 V to 10 V<br>V <sub>CM</sub> = 0 V to 10 V; −40°C ≤ T <sub>A</sub> ≤ +85°C<br>V <sub>CM</sub> = 0 V to 10 V; −40°C ≤ T <sub>A</sub> ≤ +125°C | 90<br>72<br>64  | 105      |                  | dB<br>dB<br>dB   |
| Large Signal Voltage Gain            | A <sub>VO</sub>      | R <sub>L</sub> = 100 kΩ, V <sub>O</sub> = 0.5 V to 9.5 V<br>−40°C ≤ T <sub>A</sub> ≤ +85°C<br>−40°C ≤ T <sub>A</sub> ≤ +125°C                                    | 105<br>95<br>67 | 120      |                  | dB<br>dB<br>dB   |
| Offset Voltage Drift                 | ΔV <sub>OS</sub> /ΔT |                                                                                                                                                                  |                 | 2        |                  | μV/°C            |
| Input Resistance                     | R <sub>IN</sub>      |                                                                                                                                                                  |                 | 10       |                  | GΩ               |
| Input Capacitance, Differential Mode | C <sub>INDM</sub>    |                                                                                                                                                                  |                 | 3.5      |                  | pF               |
| Input Capacitance, Common Mode       | C <sub>INCM</sub>    |                                                                                                                                                                  |                 | 3.5      |                  | pF               |
| OUTPUT CHARACTERISTICS               |                      |                                                                                                                                                                  |                 |          |                  |                  |
| Output Voltage High                  | V <sub>OH</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                     | 9.98            |          |                  | V                |
| Output Voltage Low                   | V <sub>OL</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                     |                 |          | 20               | mV               |
| Short-Circuit Current                | I <sub>SC</sub>      |                                                                                                                                                                  |                 | ±11      |                  | mA               |
| Closed-Loop Output Impedance         | Z <sub>OUT</sub>     | f = 1 kHz, A <sub>V</sub> = 1                                                                                                                                    |                 | 15       |                  | Ω                |
| POWER SUPPLY                         |                      |                                                                                                                                                                  |                 |          |                  |                  |
| Power Supply Rejection Ratio         | PSRR                 | V <sub>SY</sub> = 2.7 V to 18 V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                               | 105<br>70       | 125      |                  | dB<br>dB         |
| Supply Current per Amplifier         | I <sub>SY</sub>      | I <sub>O</sub> = 0 mA<br>−40°C ≤ T <sub>A</sub> ≤ +125°C                                                                                                         |                 | 18<br>33 | 22               | μA<br>μA         |
| DYNAMIC PERFORMANCE                  |                      |                                                                                                                                                                  |                 |          |                  |                  |
| Slew Rate                            | SR                   | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                                                                                                |                 | 60       |                  | V/ms             |
| Settling Time to 0.1%                | t <sub>s</sub>       | V <sub>IN</sub> = 1 V step, R <sub>L</sub> = 100 kΩ, C <sub>L</sub> = 10 pF                                                                                      |                 | 13       |                  | μs               |
| Gain Bandwidth Product               | GBP                  | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                                                                                                |                 | 200      |                  | kHz              |
| Phase Margin                         | Φ <sub>M</sub>       | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                                                                                                |                 | 60       |                  | Degrees          |
| Channel Separation                   | CS                   | f = 10 kHz, R <sub>L</sub> = 1 MΩ                                                                                                                                |                 | 105      |                  | dB               |
| EMI Rejection Ratio of IN+           | EMIRR                | V <sub>IN</sub> = 100 mV <sub>PEAK</sub> ; f = 400 MHz, 900 MHz, 1800 MHz, 2400 MHz                                                                              |                 | 90       |                  | dB               |
| NOISE PERFORMANCE                    |                      |                                                                                                                                                                  |                 |          |                  |                  |
| Voltage Noise                        | e <sub>n</sub> p-p   | f = 0.1 Hz to 10 Hz                                                                                                                                              |                 | 5        |                  | μV p-p           |
| Voltage Noise Density                | e <sub>n</sub>       | f = 1 kHz<br>f = 10 kHz                                                                                                                                          |                 | 50<br>45 |                  | nV/√Hz<br>nV/√Hz |
| Current Noise Density                | i <sub>n</sub>       | f = 1 kHz                                                                                                                                                        |                 | 0.1      |                  | pA/√Hz           |

**ELECTRICAL CHARACTERISTICS—18 V OPERATION**

$V_{SY} = 18\text{ V}$ ,  $V_{CM} = V_{SY}/2\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

**Table 4.**

| Parameter                            | Symbol               | Test Conditions/Comments                                                            | Min   | Typ  | Max | Unit    |
|--------------------------------------|----------------------|-------------------------------------------------------------------------------------|-------|------|-----|---------|
| INPUT CHARACTERISTICS                |                      |                                                                                     |       |      |     |         |
| Offset Voltage                       | V <sub>OS</sub>      | V <sub>CM</sub> = 0 V to 18 V                                                       |       |      | 4   | V       |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 17.7 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                   |       |      | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0 V to 18 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                       |       |      | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 17.7 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                  |       |      | tbd | mV      |
|                                      |                      | V <sub>CM</sub> = 0 V to 18 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                      |       |      | tbd | mV      |
| Input Bias Current                   | I <sub>B</sub>       | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |       | 5    | 20  | pA      |
| Input Offset Current                 | I <sub>OS</sub>      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |       |      | 2.9 | nA      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |       |      | 40  | pA      |
| Input Voltage Range                  |                      |                                                                                     | 0     |      | 500 | pA      |
| Common-Mode Rejection Ratio          | CMRR                 | V <sub>CM</sub> = 0 V to 18 V                                                       | 95    | 110  | 18  | V       |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 17.7 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                   | 83    |      |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0 V to 18 V; −40°C ≤ T <sub>A</sub> ≤ +85°C                       | 74    |      |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0.3 V to 17.7 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                  | 80    |      |     | dB      |
|                                      |                      | V <sub>CM</sub> = 0 V to 18 V; −40°C ≤ T <sub>A</sub> ≤ +125°C                      | 67    |      |     | dB      |
| Large Signal Voltage Gain            | A <sub>VO</sub>      | R <sub>L</sub> = 100 kΩ, V <sub>O</sub> = 0.5 V to 17.5 V                           | 110   | 120  |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +85°C                                                      | 105   |      |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     | 73    |      |     | dB      |
| Offset Voltage Drift                 | ΔV <sub>OS</sub> /ΔT |                                                                                     |       | 2    |     | μV/°C   |
| Input Resistance                     | R <sub>IN</sub>      |                                                                                     |       | 10   |     | GΩ      |
| Input Capacitance, Differential Mode | C <sub>INDM</sub>    |                                                                                     |       | 3.5  |     | pF      |
| Input Capacitance, Common Mode       | C <sub>INCM</sub>    |                                                                                     |       | 10.5 |     | pF      |
| OUTPUT CHARACTERISTICS               |                      |                                                                                     |       |      |     |         |
| Output Voltage High                  | V <sub>OH</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C        | 17.97 |      |     | V       |
| Output Voltage Low                   | V <sub>OL</sub>      | R <sub>L</sub> = 100 kΩ to V <sub>CM</sub> ; −40°C ≤ T <sub>A</sub> ≤ +125°C        |       |      | 30  | mV      |
| Short-Circuit Current                | I <sub>SC</sub>      |                                                                                     |       | ±12  |     | mA      |
| Closed-Loop Output Impedance         | Z <sub>OUT</sub>     | f = 1 kHz, A <sub>V</sub> = 1                                                       |       | 15   |     | Ω       |
| POWER SUPPLY                         |                      |                                                                                     |       |      |     |         |
| Power Supply Rejection Ratio         | PSRR                 | V <sub>SY</sub> = 2.7 V to 18 V                                                     | 105   | 125  |     | dB      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     | 70    |      |     | dB      |
| Supply Current per Amplifier         | I <sub>SY</sub>      | I <sub>O</sub> = 0 mA                                                               |       | 18   | 22  | μA      |
|                                      |                      | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                     |       |      | 33  | μA      |
| DYNAMIC PERFORMANCE                  |                      |                                                                                     |       |      |     |         |
| Slew Rate                            | SR                   | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                   |       | 70   |     | V/ms    |
| Settling Time to 0.1%                | t <sub>s</sub>       | V <sub>IN</sub> = 1 V step, R <sub>L</sub> = 100 kΩ, C <sub>L</sub> = 10 pF         |       | 12   |     | μs      |
| Gain Bandwidth Product               | GBP                  | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                   |       | 200  |     | kHz     |
| Phase Margin                         | Φ <sub>M</sub>       | R <sub>L</sub> = 1 MΩ, C <sub>L</sub> = 10 pF, A <sub>V</sub> = 1                   |       | 60   |     | Degrees |
| Channel Separation                   | CS                   | f = 10 kHz, R <sub>L</sub> = 1 MΩ                                                   |       | 105  |     | dB      |
| EMI Rejection Ratio of IN+           | EMIRR                | V <sub>IN</sub> = 100 mV <sub>PEAK</sub> ; f = 400 MHz, 900 MHz, 1800 MHz, 2400 MHz |       | 90   |     | dB      |
| NOISE PERFORMANCE                    |                      |                                                                                     |       |      |     |         |
| Voltage Noise                        | e <sub>n</sub> p-p   | f = 0.1 Hz to 10 Hz                                                                 |       | 5    |     | μV p-p  |
| Voltage Noise Density                | e <sub>n</sub>       | f = 1 kHz                                                                           |       | 50   |     | nV/√Hz  |
|                                      |                      | f = 10 kHz                                                                          |       | 45   |     | nV/√Hz  |
| Current Noise Density                | i <sub>n</sub>       | f = 1 kHz                                                                           |       | 0.1  |     | pA/√Hz  |

## ABSOLUTE MAXIMUM RATINGS

Table 4.

| Parameter                               | Rating                                                   |
|-----------------------------------------|----------------------------------------------------------|
| Supply Voltage                          | 20.5 V                                                   |
| Input Voltage                           | (V <sub>-</sub> ) – 300 mV to (V <sub>+</sub> ) + 300 mV |
| Input Current <sup>1</sup>              | ±10 mA                                                   |
| Differential Input Voltage              | ±V <sub>SY</sub>                                         |
| Output Short-Circuit<br>Duration to GND | Indefinite                                               |
| Temperature Range                       |                                                          |
| Storage                                 | –65°C to +150°C                                          |
| Operating                               | –40°C to +125°C                                          |
| Junction                                | –65°C to +150°C                                          |
| Lead Temperature<br>(Soldering, 60 sec) | 300°C                                                    |

<sup>1</sup>The input pins have clamp diodes to the power supply pins. Limit the input current to 10 mA or less whenever input signals exceed the power supply rail by 0.3 V.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## THERMAL RESISTANCE

$\theta_{JA}$  is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages using a standard 4-layer board.

Table 5. Thermal Resistance

| Package Type        | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---------------------|---------------|---------------|------|
| 14-Lead SOIC (R-14) | 142           | 45            | °C/W |

## ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

