The AD706 is a dual, low power, bipolar op amp that has the low input bias current of a JFET amplifier, but which offers a significantly lower $I_B$ drift over temperature. It utilizes superbeta bipolar input transistors to achieve picocurrent input bias current levels (similar to FET input amplifiers at room temperature), while its $I_B$ typically only increases by $5\times$ at $125^\circ C$ (unlike a JFET amp, for which $I_B$ doubles every $10^\circ C$ for a $1000\times$ increase at $125^\circ C$). The AD706 also achieves the microvolt offset voltage and low noise characteristics of a precision bipolar input amplifier. Since it has < 200 pA of bias current, the AD706 does not require the commonly used “balancing” resistor. Furthermore, the current noise is only 50 fA/$\sqrt{\text{Hz}}$, which makes this amplifier usable with very high source impedances. At 600 μA max supply current (per amplifier), the AD706 is well suited for today’s high density boards.

The AD706 is an excellent choice for use in low frequency active filters in 12-bit and 14-bit data acquisition systems, in precision instrumentation, and as a high quality integrator. The AD706 is internally compensated for unity gain and is available in five performance grades. The AD706J is rated over the commercial temperature range of 0°C to +70°C. The AD706A is rated for the extended industrial temperature range of −40°C to +85°C.

The AD706 is offered in two varieties of an 8-lead package: PDIP and surface-mount (SOIC).

**Figure 1. Input Bias Current vs. Temperature**

**PRODUCT HIGHLIGHTS**

1. The AD706 is a dual low drift op amp that offers JFET level input bias currents, yet has the low $I_B$ drift of a bipolar amplifier. It may be used in circuits using dual op amps such as the LT1024.

2. The AD706 provides both low drift and high dc precision.

3. The AD706 can be used in applications where a chopper amplifier would normally be required but without the chopper’s inherent noise.
# AD706—SPECIFICATIONS

(@ T<sub>a</sub> = +25°C, V<sub>CM</sub> = 0 V and ±15 V dc, unless otherwise noted.)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
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<tr>
<td><strong>INPUT OFFSET VOLTAGE</strong></td>
<td></td>
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<td>µV</td>
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<tr>
<td>Offset</td>
<td></td>
<td>40</td>
<td>150</td>
<td></td>
<td>µV</td>
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<td>vs. Temperature, Average TC</td>
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<td>µV/°C</td>
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<tr>
<td>vs. Supply (PSRR)</td>
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<td>110</td>
<td>132</td>
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<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
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<td>106</td>
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<td>pA</td>
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<tr>
<td>vs. Temperature, Average TC</td>
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<td></td>
<td>pA</td>
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<tr>
<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>V&lt;sub&gt;CM&lt;/sub&gt; = 0 V</td>
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<td>pA</td>
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<tr>
<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>V&lt;sub&gt;CM&lt;/sub&gt; = ±13.5 V</td>
<td>250</td>
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<td>pA</td>
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<td><strong>INPUT OFFSET CURRENT</strong></td>
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<td></td>
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<tr>
<td>vs. Temperature, Average TC</td>
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<td>pA/°C</td>
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<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
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<td>80</td>
<td>350</td>
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<td>pA</td>
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<tr>
<td>Offset Voltage</td>
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<td>µV</td>
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<td>Input Bias Current&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>Common-Mode Rejection</td>
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<td>pA</td>
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<td>Power Supply Rejection</td>
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<td></td>
<td>pA</td>
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<td>Crosstalk (Figure 2a)</td>
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<td>@ f = 10 Hz</td>
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<td>Slew Rate</td>
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<td>V/µs</td>
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<td></td>
<td>dB</td>
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<td>128</td>
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<td></td>
<td>pA p-p</td>
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<tr>
<td>f = 10 Hz</td>
<td>50</td>
<td></td>
<td></td>
<td>fA/√Hz</td>
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<tr>
<td><strong>INPUT VOLTAGE NOISE</strong></td>
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<td></td>
<td>µV p-p</td>
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<tr>
<td>f = 10 Hz</td>
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<td></td>
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<td>nV/√Hz</td>
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<td>2000</td>
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<td>V/mV</td>
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<td>R&lt;sub&gt;LOAD&lt;/sub&gt; = 10 kΩ</td>
<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
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<td>1500</td>
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<td>V/mV</td>
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<td>V&lt;sub&gt;0&lt;/sub&gt; = ±10 V</td>
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<td></td>
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<tr>
<td>Voltage Swing</td>
<td>R&lt;sub&gt;LOAD&lt;/sub&gt; = 10 kΩ</td>
<td>±13</td>
<td>±14</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Current</td>
<td>T&lt;sub&gt;MIN&lt;/sub&gt; to T&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>±13</td>
<td>±14</td>
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<td>V</td>
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<td>mA</td>
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<td>Capacitive Load Drive Capability</td>
<td>Gain = +1</td>
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## SPECIFICATIONS (continued)

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<th>Parameter</th>
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<td>Operating Range</td>
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<tr>
<td>TRANSISTOR COUNT</td>
<td>Number of Transistors</td>
<td>90</td>
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</table>

### NOTES

1. Bias current specifications are guaranteed maximum at either input.
2. Input bias current match is the difference between corresponding inputs (I_B of –IN of Amplifier 1 minus I_B of –IN of Amplifier 2).
3. CMRR match is the difference between $\frac{\Delta V_{OS1}}{V_{CM}}$ for Amplifier 1 and $\frac{\Delta V_{OS2}}{V_{CM}}$ for Amplifier 2, expressed in dB.
4. PSRR match is the difference between $\frac{\Delta V_{OS1}}{V_{SUPPLY}}$ for Amplifier 1 and $\frac{\Delta V_{OS2}}{V_{SUPPLY}}$ for Amplifier 2, expressed in dB.

All min and max specifications are guaranteed.
Specifications subject to change without notice.

### ABSOLUTE MAXIMUM RATINGS

1. Supply Voltage.......................... ±18 V
2. Internal Power Dissipation
   (Total: Both Amplifiers)............. 650 mW
3. Input Voltage.......................... ±V_S
4. Differential Input Voltage.......... +0.7 V
5. Output Short Circuit Duration....... Indefinite
6. Storage Temperature Range (N, R) .... −65°C to +125°C
7. Operating Temperature Range
   AD706J .................................. 0°C to +70°C
   AD706A .................................. −40°C to +85°C
8. Lead Temperature (Soldering 10 secs).... 300°C

### NOTES

1. 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.
2. Specification is for device in free air:
   8-Lead PDIP Package: $\theta_{JA} = 100°C/W$
   8-Lead Small Outline Package: $\theta_{JA} = 155°C/W$
3. The input pins of this amplifier are protected by back-to-back diodes. If the differential voltage exceeds ±0.7 V, external series protection resistors should be added to limit the input current to less than 25 mA.

### 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.

### METALIZATION PHOTOGRAPH

Dimensions shown in inches and (mm). Contact factory for latest dimensions.
AD706—Typical Performance Characteristics

(Default Conditions: ±5 V, C₁ = 5 pF, G = 2, R₉ = R₁ = 1 kΩ, R₂ = 2 kΩ, V₀ = 2 V p-p, Frequency = 1 MHz, T_A = 25°C)

TPC 1. Typical Distribution of Input Offset Voltage

TPC 2. Typical Distribution of Input Bias Current

TPC 3. Typical Distribution of Input Offset Current

TPC 4. Input Common-Mode Voltage Range vs. Supply Voltage

TPC 5. Large Signal Frequency Response

TPC 6. Offset Voltage Drift vs. Source Resistance

TPC 7. Typical Distribution of Offset Voltage Drift

TPC 8. Change in Input Offset Voltage vs. Warm-Up Time

TPC 9. Input Bias Current vs. Common-Mode Voltage
TPC 10. Input Noise Voltage Spectral Density

TPC 11. Input Noise Current Spectral Density

TPC 12. 0.1 Hz to 10 Hz Noise Voltage

TPC 13. Quiescent Supply Current vs. Supply Voltage

TPC 14. Common-Mode Rejection Ratio vs. Frequency

TPC 15. Power Supply Rejection Ratio vs. Frequency

TPC 16. Open-Loop Gain vs. Load Resistance vs. Load Resistance

TPC 17. Open-Loop Gain and Phase Shift vs. Frequency

TPC 18. Output Voltage Swing vs. Supply Voltage
AD706

Figure 2a. Crosstalk vs. Frequency

Figure 2b. Crosstalk Test Circuit

Figure 3. Magnitude of Closed-Loop Output Impedance vs. Frequency

Figure 4a. Unity Gain Follower (For large signal applications, resistor $R_F$ limits the current through the input protection diodes.)

Figure 4b. Unity Gain Follower Large Signal Pulse Response, $R_F = 10 \text{ k}\Omega$, $C_L = 1,000 \text{ pF}$

Figure 4c. Unity Gain Follower Small Signal Pulse Response, $R_F = 0 \text{ \Omega}$, $C_L = 100 \text{ pF}$

Figure 4d. Unity Gain Follower Small Signal Pulse Response, $R_F = 0 \text{ \Omega}$, $C_L = 1000 \text{ pF}$
Figure 5a. Unity Gain Inverter Connection

Figure 5b. Unity Gain Inverter Large Signal Pulse Response, \(C_L = 1,000 \text{ pF}\)

Figure 5c. Unity Gain Inverter Small Signal Pulse Response, \(C_L = 100 \text{ pF}\)

Figure 5d. Unity Gain Inverter Small Signal Pulse Response, \(C_L = 1000 \text{ pF}\)

Figure 6 shows an in-amp circuit that has the obvious advantage of requiring only one AD706, rather than three opamps, with subsequent savings in cost and power consumption. The transfer function of this circuit (without \(R_G\)) is

\[ V_{OUT} = (V_{IN1} - V_{IN2}) \left( 1 + \frac{R4}{R3} \right) \]

for \(R1 = R4\) and \(R2 = R3\).

Input resistance is high, thus permitting the signal source to have an unbalanced output impedance.

CMR is still dependent upon the ratio matching of Resistors \(R1\) through \(R4\). Resistor values for this circuit, using the optional gain resistor, \(R_G\), can be calculated using

\[ R1 = R4 = 49.9 \text{ k}\Omega \]
\[ R2 = R3 = \frac{49.9 \text{ k}\Omega}{0.9 G - 1} \]
\[ R_G = \frac{99.8 \text{ k}\Omega}{0.06 G} \]

where \(G = \) The desired circuit gain.

Table I provides practical 1% resistance values. Note that without resistor \(R_G\), \(R2\) and \(R3 = 49.9 \text{ k}\Omega/G-1\).

<table>
<thead>
<tr>
<th>Circuit Gain</th>
<th>Gain of A1</th>
<th>Gain of A2</th>
<th>(R2, R3)</th>
<th>(R1, R4)</th>
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</thead>
<tbody>
<tr>
<td>1.10</td>
<td>11.00</td>
<td>1.10</td>
<td>499 k\Omega</td>
<td>49.9 k\Omega</td>
</tr>
<tr>
<td>1.33</td>
<td>4.01</td>
<td>1.33</td>
<td>150 k\Omega</td>
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<td>1.50</td>
<td>3.00</td>
<td>1.50</td>
<td>100 k\Omega</td>
<td>49.9 k\Omega</td>
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<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>49.9 k\Omega</td>
<td>49.9 k\Omega</td>
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<td>10.10</td>
<td>5.49 k\Omega</td>
<td>49.9 k\Omega</td>
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<td>101.0</td>
<td>1.01</td>
<td>101.0</td>
<td>499 \Omega</td>
<td>49.9 k\Omega</td>
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<tr>
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<td>49.9 \Omega</td>
<td>49.9 k\Omega</td>
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For a much more comprehensive discussion of in-amp applications, refer to the *Instrumentation Amplifier Applications Guide*—available free from Analog Devices, Inc.
AD706

**1 Hz, 4-Pole, Active Filter**

Figure 7 shows the AD706 in an active filter application. An important characteristic of the AD706 is that both the input bias current, input offset current, and their drift remain low over most of the op amp’s rated temperature range. Therefore, for most applications, there is no need to use the normal balancing resistor. Adding the balancing resistor enhances performance at high temperatures, as shown by Figure 8.

![Figure 7. 1 Hz, 4-Pole Active Filter](image)

---

**Table II. 1 Hz, 4-Pole, Low Pass Filter Recommended Component Values**

<table>
<thead>
<tr>
<th>Desired Low Pass Response</th>
<th>Section 1 Frequency (Hz)</th>
<th>Q</th>
<th>Section 2 Frequency (Hz)</th>
<th>Q</th>
<th>C1 (µF)</th>
<th>C2 (µF)</th>
<th>C3 (µF)</th>
<th>C4 (µF)</th>
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<tr>
<td>Bessel</td>
<td>1.43</td>
<td>0.522</td>
<td>1.60</td>
<td>0.806</td>
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<td>Butterworth</td>
<td>1.00</td>
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<td>1.00</td>
<td>1.31</td>
<td>0.172</td>
<td>0.147</td>
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<td>0.0609</td>
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<td>0.1 dB Chebychev</td>
<td>0.648</td>
<td>0.619</td>
<td>0.948</td>
<td>2.18</td>
<td>0.304</td>
<td>0.198</td>
<td>0.733</td>
<td>0.0385</td>
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<tr>
<td>0.2 dB Chebychev</td>
<td>0.603</td>
<td>0.646</td>
<td>0.941</td>
<td>2.44</td>
<td>0.341</td>
<td>0.204</td>
<td>0.823</td>
<td>0.0347</td>
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<td>0.5 dB Chebychev</td>
<td>0.540</td>
<td>0.705</td>
<td>0.932</td>
<td>2.94</td>
<td>0.416</td>
<td>0.209</td>
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<td>1.0 dB Chebychev</td>
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<td>0.508</td>
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**NOTE**

Specified Values are for a –3 dB point of 1.0 Hz. For other frequencies simply scale capacitors C1 through C4 directly, i.e. for 3 Hz Bessel response, C1 = 0.0387 µF, C2 = 0.0357 µF, C3 = 0.0533 µF, C4 = 0.0205 µF.
OUTLINE DIMENSIONS

COMPLIANT TO JEDEC STANDARDS MS-001
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN. CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

Figure 9. 8-Lead Plastic Dual-in-line Package [PDIP]
Narrow Body
(N-8)
Dimensions shown in inches and (millimeters)

COMPLIANT TO JEDEC STANDARDS MS-012-AA
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 10. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-8)
Dimensions shown in millimeters and (inches)

ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Temperature Range</th>
<th>Package Description</th>
<th>Package Option</th>
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<td>−40°C to +85°C</td>
<td>8-Lead SOIC_N</td>
<td>R-8</td>
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REVISION HISTORY

7/2018—Rev. F to Rev. G
Changed Plastic Mini-DIP to PDIP................................. Universal
Updated Outline Dimensions.............................................10

8/2017—Rev. E to Rev. F
Changes to Figure 6...............................................................6
Updated Outline Dimensions.............................................10
Changes to Ordering Guide.................................................10

10/2003—Rev. D to Rev. E
Removed K Version ............................................................... Universal
Changes to Features and Product Description......................1
Renumbered TPC’s ..............................................................4
Renumbered Figured .........................................................6
Updated Outline Dimensions.............................................10

10/2002—Rev. C to Rev. D
Deleted 8-Lead CERDIP (Q-8) Package ......................... Universal
Changes to Features and Product Description......................1
Changes to Specifications Section.................................2
Changes to Absolute Maximum Ratings Section..............3
Changes to Ordering Guide.................................................3
Updated Outline Dimensions...........................................15

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