MAX44280
1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

General Description

The MAX44280 offers a unique combination of high speed, precision, low noise, and low-voltage operation making it ideally suited for a large number of signal processing functions such as filtering and amplification of signals in portable and industrial equipment.

The amplifier features an input offset of less than 50µV and a high-gain bandwidth product of 50MHz while maintaining a low 1.8V supply rail. The device is internally compensated for gains of 5V/V or greater. The device’s rail-to-rail input/outputs and low noise guarantee maximum dynamic range in demanding applications such as 12- to 16-bit SAR ADC drivers. Unlike traditional rail-to-rail input structures, input crossover distortion is absent due to an optimized input stage with an ultra-quiet charge pump.

The MAX44280 includes a fast-power-on shutdown mode for further power savings.

The MAX44280 operates from a supply range of 1.8V to 5.5V over the -40°C to +125°C temperature range and can operate down to a 1.7V over the 0°C to +70°C temperature range. The MAX44280 is available in a small, 6-pin SC70 package and is also available in a 1mm x 1.5mm Thin µDFN (ultra-thin LGA) package.

Ordering Information appears at end of data sheet.

Features

- Low 1.8V Supply Rail Over the -40°C to +125°C Range
- 1.7V Supply Rail Over the 0°C to +70°C Range
- 50MHz Bandwidth
- Low 12.7nV/√Hz Input Voltage-Noise Density
- Low 1.2fA/√Hz Input Current-Noise Density
- Low 50µV (max) Vos at +25°C
- 500fA Low Input Bias Current
- < 1µA Supply Current in Shutdown
- Small, 2mm x 2mm SC70 and 1mm x 1.5mm Thin µDFN Packages
- Low -110dB Total Harmonic Distortion
- 5V/V Minimum Stable Gain

Applications

- Notebooks
- 3G/4G Handsets
- Portable Media Players
- Portable Medical Instruments
- Battery-Operated Devices
- Analog-to-Digital Converter Buffers
- Transimpedance Amplifiers
- General-Purpose Signal Processing

Typical Application Circuit

For related parts and recommended products to use with this part, refer to: www.maximintegrated.com/MAX44280.related

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated’s website at www.maximintegrated.com.
**ABSOLUTE MAXIMUM RATINGS**

IN+, IN-, OUT ................. (Vss - 0.3V) to (Vdd + 0.3V)  
Vdd to Vss ........................................ -0.3V to +6V  
SHDN ........................................ -0.3V to +6V  
Output to Short-Circuit Ground Duration ....................... 10s  
Continuous Input Current into Any Pin ......................... ±20mA  
Continuous Power Dissipation (TA = +70°C) ............... SC70 (derate 3.1mW/°C above +70°C) ... 245mW  
Thin µDFN (Ultra-Thin LGA)  
Operating Temperature Range .................. -40°C to +125°C  
Junction Temperature ......................... +150°C  
Lead Temperature (soldering, 10s) ................. +300°C  
Soldering Temperature (reflow) ................. +260°C

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**PACKAGE THERMAL CHARACTERISTICS (Note 1)**

SC70  
Junction-to-Ambient Thermal Resistance (θJA) .... 326.5°C/W  
Junction-to-Case Thermal Resistance (θJC) .......... 115°C/W

Thin µDFN (Ultra-Thin LGA)  
Junction-to-Ambient Thermal Resistance (θJA) ...... 470°C/W  
Junction-to-Case Thermal Resistance (θJC) .......... 120°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to www.maximintegrated.com/thermal-tutorial.

**ELECTRICAL CHARACTERISTICS**

(VDD = 3.3V, VSS = 0V, VIN+ = VIN- = VDD/2, RL = 10kΩ to VDD/2, VSHDN = VDD, TA = -40°C to +125°C. Typical values are at TA = +25°C, unless otherwise noted.) (Note 2)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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<td>Input Voltage Range</td>
<td>VIN+ VIN-</td>
<td>Guaranteed by CMRR test</td>
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<td></td>
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<td>V</td>
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<td>Input Offset Voltage</td>
<td>VOSS</td>
<td>TA = +25°C</td>
<td>10</td>
<td>50</td>
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<td>μV</td>
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<td>TA = -40°C to +125°C after calibration</td>
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<td>TA = -40°C to +125°C</td>
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<tr>
<td>Input Offset Voltage Drift</td>
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<td>TA = +25°C</td>
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<td>5</td>
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<td>Input Bias Current (Note 3)</td>
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<td>pA</td>
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<td>Input Capacitance</td>
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<td>Common-Mode Rejection Ratio</td>
<td>CMRR</td>
<td>VCM = -0.1V to (Vdd + 0.1V)</td>
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<td>90</td>
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<td>dB</td>
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<td>Open-Loop Gain</td>
<td>AOL</td>
<td>0.4V ≤ VOUT ≤ VDD - 0.4V, ROUT = 10kΩ</td>
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<td>115</td>
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<td>dB</td>
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<td></td>
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<td>0.4V ≤ VOUT ≤ VDD - 0.4V, ROUT = 600Ω</td>
<td>91</td>
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<td>0.4V ≤ VOUT ≤ VDD - 0.4V, ROUT = 32Ω</td>
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<td>80</td>
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<td>Output Short-Circuit Current</td>
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<td>To VDD or VSS</td>
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<td>85</td>
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<td>mA</td>
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MAX44280
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ELECTRICAL CHARACTERISTICS (continued)

\( V_{DD} = 3.3\text{V}, V_{SS} = 0\text{V}, V_{IN+} = V_{IN-} = V_{DD}/2, R_L = 10k\Omega \text{ to } V_{DD}/2, V_{SHDN} = V_{DD}, T_A = -40^\circ\text{C} \text{ to } +125^\circ\text{C}. \) Typical values are at \( T_A = +25^\circ\text{C} \), unless otherwise noted. \( \) (Note 2)

<table>
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<tr>
<th>PARAMETER</th>
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<th>CONDITIONS</th>
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<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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<tr>
<td>Output Voltage Swing</td>
<td>( V_{OL} - V_{SS} )</td>
<td>( R_{OUT} = 10k\Omega )</td>
<td>20</td>
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<td>mV</td>
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<td>( R_{OUT} = 600\Omega )</td>
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<td>( R_{OUT} = 32\Omega )</td>
<td>400</td>
<td>700</td>
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<td>( R_{OUT} = 10k\Omega )</td>
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<td></td>
<td>( R_{OUT} = 600\Omega )</td>
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<tr>
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<td></td>
<td>( R_{OUT} = 32\Omega )</td>
<td>400</td>
<td>800</td>
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</tbody>
</table>

AC CHARACTERISTICS

- Input Voltage-Noise Density \( e_n \)
  \( f = 10\text{kHz} \)
  Min: 12.7 nV/\( \sqrt{\text{Hz}} \)

- Input Current-Noise Density \( i_n \)
  \( f = 10\text{kHz} \)
  Min: 1.2 fA/\( \sqrt{\text{Hz}} \)

- Gain-Bandwidth Product GBWP
  Min: 50 MHz

- Minimum Stable Gain \( A_{MIN} \)
  Min: 5 V/V

- Slew Rate SR
  Min: 30 V/\( \mu\text{s} \)

- Settling Time
  \( V_{OUT} = 2\text{VP-P}, V_{DD} = 3.3\text{V}, A_{V} = 5\text{V/V}, C_L = 30pF \) (load), settle to 0.01%
  Min: 0.6 \( \mu\text{s} \)

- Capacitive Load \( C_{LOAD} \)
  No sustained oscillation, 5V/V
  Min: 80 pF

- Total Harmonic Distortion THD
  \( f = 10\text{kHz}, V_O = 2\text{VP-P}, A_{V} = 5\text{V/V}, R_{OUT} = 10k\Omega \)
  Min: -110 dB

- Output Transient Recovery Time
  \( \Delta V_{OUT} = 0.2\text{V}, V_{DD} = 3.3\text{V}, A_{V} = 5\text{V/V}; R_S = 20\Omega, C_L = 1\text{nF} \) (load)
  Min: 1 \( \mu\text{s} \)

POWER-SUPPLY CHARACTERISTICS

- Power-Supply Range \( V_{DD} \)
  Guaranteed by PSRR
  Min: 1.8 V

- Power-Supply Rejection Ratio PSRR
  \( V_{CM} = V_{DD}/2 \)
  Min: 82 dB

- Quiescent Current \( I_{DD} \)
  Min: 750 \( \mu\text{A} \)

- Shutdown Supply Current \( I_{SHDN} \)
  Min: 1 \( \mu\text{A} \)

- Shutdown Input Low \( V_{IL} \)
  Min: 0.7 V

- Shutdown Input High \( V_{IH} \)
  Min: 1.3 V

- Output Leakage Current in Shutdown \( I_{SHDN} \)
  Min: 100 pA

- Shutdown Input Bias Current \( I_{IL}/I_{IH} \)
  Min: 1 \( \mu\text{A} \)

- Shutdown Turn-On Time \( t_{ON} \)
  Min: 15 \( \mu\text{s} \)

- Turn-On Time \( t_{ON} \)
  Min: 10 ms

Note 2: All devices are 100% production tested at \( T_A = +25^\circ\text{C} \). Temperature limits are guaranteed by design.

Note 3: Guaranteed by design.
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Typical Operating Characteristics

\( (V_{DD} = 3.3\, \text{V}, V_{SS} = 0\, \text{V}, V_{IN+} = V_{IN-} = V_{DD}/2, R_L = 10k\, \Omega \text{ to } V_{DD}/2, V_{SHDN} = V_{DD}, T_A = -40^\circ\text{C} \text{ to } +125^\circ\text{C}. \text{ Typical values are at } T_A = +25^\circ\text{C}, \text{ unless otherwise noted. All devices are 100% production tested at } T_A = +25^\circ\text{C}. \text{ Temperature limits are guaranteed by design.} ) \)
**MAX44280**

1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

**Typical Operating Characteristics (continued)**

(V\(_\text{DD} = 3.3\)V, V\(_\text{SS} = 0\)V, V\(_\text{IN+} = V_{\text{IN-}} = V_{\text{DD}}/2\), R\(_L = 10k\Omega\) to \(V_{\text{DD}}/2\), V\(_{\text{SHDN}} = V_{\text{DD}}\), T\(_A = -40^\circ\)C to +125°C. Typical values are at T\(_A = +25^\circ\)C, unless otherwise noted. All devices are 100% production tested at T\(_A = +25^\circ\)C. Temperature limits are guaranteed by design.)
MAX44280
1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

Typical Operating Characteristics (continued)

(V_{DD} = 3.3V, V_{SS} = 0V, V_{IN+} = V_{IN-} = V_{DD}/2, R_L = 10kΩ to V_{DD}/2, V_{SHDN} = V_{DD}, T_A = -40°C to +125°C. Typical values are at T_A = +25°C, unless otherwise noted. All devices are 100% production tested at T_A = +25°C. Temperature limits are guaranteed by design.)
MAX44280
1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

**Typical Operating Characteristics (continued)**

(V_{DD} = 3.3V, V_{SS} = 0V, V_{IN+} = V_{IN-} = V_{DD}/2, R_L = 10kΩ to V_{DD}/2, V_{SHDN} = V_{DD}, T_A = -40°C to +125°C. Typical values are at T_A = +25°C, unless otherwise noted. All devices are 100% production tested at T_A = +25°C. Temperature limits are guaranteed by design.)
MAX44280

1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

Typical Operating Characteristics (continued)

(VDD = 3.3V, VSS = 0V, VIN+ = VIN-, = VDD/2, RL = 10kΩ to VDD/2, VSHDN = VDD, TA = -40°C to +125°C. Typical values are at TA = +25°C, unless otherwise noted. All devices are 100% production tested at TA = +25°C. Temperature limits are guaranteed by design.)
MAX44280
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Pin Configurations

Pin Description

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<tr>
<th>PIN</th>
<th>NAME</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IN+</td>
<td>Positive Input</td>
</tr>
<tr>
<td>2</td>
<td>VSS</td>
<td>Negative Power Supply. Bypass with a 0.1μF capacitor to ground.</td>
</tr>
<tr>
<td>3</td>
<td>IN-</td>
<td>Negative Input</td>
</tr>
<tr>
<td>4</td>
<td>OUT</td>
<td>Output</td>
</tr>
<tr>
<td>5</td>
<td>SHDN</td>
<td>Active-Low Shutdown</td>
</tr>
<tr>
<td>6</td>
<td>VDD</td>
<td>Positive Power Supply. Bypass with a 0.1μF capacitor to ground.</td>
</tr>
</tbody>
</table>
Detailed Description

The MAX44280 is a high-speed low-power op amp ideal for signal processing applications due to the device’s high precision and low-noise CMOS inputs. The device self-calibrates on power-up to eliminate effects of temperature and power-supply variation.

The MAX44280 also features a low-power shutdown mode that greatly reduces quiescent current while the device is not operational and recovers in 30µs.

Crossover Distortion

This op amp features a low-noise integrated charge pump that creates an internal voltage rail 1V above VDD, which is used to power the input differential pair of pMOS transistors as shown in Figure 1. Such a unique architecture eliminates crossover distortion common in traditional CMOS input architecture (Figure 2), especially when used in a noninverting configuration, such as for Sallen-Key filters.

The charge pump’s operating frequency lies well above the unity-gain frequency of the amplifier. Thanks to its high-frequency operation and ultra-quiet circuitry, the charge pump generates little noise, does not require external components, and is entirely transparent to the user.

Figure 1. Comparing the Input Structure of the MAX44280 to Standard Op-Amp Inputs

Figure 2. Crossover Distortion of Typical Amplifiers
Applications Information

Power-Up Autotrim
The IC features an automatic trim that self-calibrates the V_{OS} of this device to less than 50µV of input offset voltage on power-up. This self-calibration feature allows the device to eliminate input offset voltage effects due to power supply and operating temperature variation simply by cycling its power. The autotrim sequence takes approximately 10ms to complete and is triggered by an internal power-on-reset (POR) circuitry. During this time, the inputs and outputs are put into high impedance and left unconnected.

Shutdown Operation
The MAX44280 features an active-low shutdown mode that puts both inputs and outputs into high impedance and substantially lowers the quiescent current to less than 1µA. Putting the output into high impedance allows multiple outputs to be multiplexed onto a single output line without the additional external buffers. The device does not self-calibrate when exiting shutdown mode and retains its power-up trim settings. The device also recovers from shutdown in under 30µs.

The shutdown logic levels of the device is independent of supply, allowing the shutdown feature of the device to operate off of a 1.8V or 3.3V microcontroller, regardless of supply voltage.

Rail-to-Rail Input/Output
The input voltage range of the IC extends 100mV above V_{DD} and below V_{SS}. The wide input common-mode voltage range allows the op amp to be used as a buffer and as a differential amplifier in a wide-variety of signal processing applications. Output voltage high/low is designed to be only 50mV above V_{SS} and below V_{DD} allowing maximum dynamic range in single-supply applications. The high output current and capacitance drive capability of the device make it ideal as an ADC driver and a line driver.

Input Bias Current
The IC features a high-impedance CMOS input stage and a specialized ESD structure that allows low-input bias current operation at low-input, common-mode voltages. Low-input bias current is useful when interfacing with high-ohmic sensors. It is also beneficial for designing transimpedance amplifiers for photodiode sensors. This makes the device ideal for ground-referenced medical and industrial sensor applications.

Active Filters
The MAX44280 is ideal for a wide variety of active filter circuits that makes use of the wide bandwidth, rail-to-rail input/output stages and high-impedance CMOS inputs.

Driver for Interfacing with the MAX11645 ADC
The IC’s tiny size and low noise make it a good fit for driving 12- to 16-bit resolution ADCs in space-constrained applications. The Typical Application Circuit shows the MAX44280 amplifier output connected to a lowpass filter driving the MAX11645 ADC. The MAX11645 is part of a family of 3V and 5V, 12-bit and 10-bit, 2-channel ADCs. The MAX11645 offers sample rates up to 94ksps and measures two single-ended inputs or one differential input. These ADCs dissipate 670µA at the maximum sampling rate, but just 6µA at 1ksps and 0.5µA in shutdown. Offered in the ultra-tiny, 1.9mm x 2.2mm WLP and µMAX-8 packages, the MAX11645 ADCs are an ideal fit to pair with the MAX44280 amplifier in portable applications.

Where higher resolution is required, refer to the MAX1069 (14-bit) and MAX1169 (16-bit) ADC families.
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**Chip Information**

PROCESS: BiCMOS

**Ordering Information**

<table>
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<tr>
<th>PART</th>
<th>TEMP RANGE</th>
<th>PIN-PACKAGE</th>
<th>TOP MARK</th>
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<tr>
<td>MAX44280AXT+</td>
<td>-40°C to +125°C</td>
<td>6 SC70</td>
<td>+AED</td>
</tr>
<tr>
<td>MAX44280AYT+</td>
<td>-40°C to +125°C</td>
<td>6 Thin μDFN (Ultra-Thin LGA)</td>
<td>+AZ</td>
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</table>

+Denotes a lead(Pb)-free/RoHS-compliant package.
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Package Information

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

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<td>6 Thin µDFN</td>
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COMMON DIMENSIONS

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<td>0.80</td>
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NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COPLANARITY ± Mils, MAX.
5. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.
8. ALL DIMENSIONS COMPLY TO JEDEC MO-203.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (--) AND LEAD FREE (++) PACKAGES.

Maxim Integrated
MAX44280
1.8V, 50MHz, Low-Offset, Low-Power, Rail-to-Rail I/O Op Amp

Package Information (continued)

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Notes:
1. Dimensions are in millimeters unless otherwise specified.
2. Marking shown is for package orientation reference only. Package uses 2-character product code.
3. Lead centerlines to be at true position as defined by basic dimension "a", ±0.05.
4. Calendar year binary date code (refer to pg. 2 table 1 for translation).
5. Weekly date binary code (refer to pg. 2 table 2 for translation).
6. Meets JEDEC MO-252 variation WAAD.
7. Material must comply with banned and restricted substances specification (BRS) 10-0131.
8. All dimensions apply to both leaded (-) and Pb-free (+) pkg. codes.

-Drawing not to scale-
For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. Note that a “+”, “#”, or “-” in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

**TABLE 1** Translation Table for Calendar Year Code

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
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<tbody>
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<td></td>
</tr>
</tbody>
</table>

Legend: □ Marked with bar □ Blank space - no bar required

**TABLE 2** Translation Table for Payweek Binary Coding

<table>
<thead>
<tr>
<th>Payweek</th>
<th>06-11</th>
<th>12-17</th>
<th>18-23</th>
<th>24-29</th>
<th>30-35</th>
<th>36-41</th>
<th>42-47</th>
<th>48-51</th>
<th>52-05</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Legend: □ Marked with bar □ Blank space - no bar required
**Revision History**

<table>
<thead>
<tr>
<th>REVISION NUMBER</th>
<th>REVISION DATE</th>
<th>DESCRIPTION</th>
<th>PAGES CHANGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12/11</td>
<td>Initial release</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>4/12</td>
<td>Updated Package Thermal Characteristics, Electrical Characteristics, and Ordering Information.</td>
<td>2, 3, 12</td>
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<tr>
<td>2</td>
<td>8/12</td>
<td>Added Note 3 to Electrical Characteristics.</td>
<td>2, 3</td>
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