19-1569; Rev 6; 3/09

MAXIM

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs



## General Description

The MAX9039–MAX9043 and MAX9050–MAX9053 feature combinations of low-power comparators and precision voltage references. Their operating voltage range makes them ideal for both 3V and 5V systems. The MAX9039/MAX9040/MAX9041/MAX9050/MAX9051 have a single comparator and reference consuming only 40µA of supply current. The MAX9042/MAX9043/MAX9052/MAX9053 have dual comparators and one reference, and consume only 55µA of supply current. Low-voltage operation and low supply current make these devices ideal for battery-operated systems.

The comparators feature rail-to-rail inputs and outputs, with a common-mode input voltage range that extends 250mV beyond the supply rails. Input bias current is typically 1.0pA, and input offset voltage is typically 0.5mV. Internal hysteresis ensures clean output switching, even with slow-moving input signals. The output stage features a unique design that limits supply current surges while switching, virtually eliminating supply glitches typical of many other comparators. This design also minimizes overall power consumption under dynamic conditions. The comparator outputs have rail-to-rail, push-pull output stages that sink and source up to 8mA. The propagation delay is 400ns, even with the low-operating supply current.

The reference output voltage is set to 1.23V in the MAX9039, to 2.048V in the MAX9040–MAX9043, and to 2.500V in the MAX9050–MAX9053. The MAX9040–MAX9043 and the MAX9050–MAX9053 are offered in two grades: an A grade with 0.4% initial accuracy and 6ppm/°C tempco, and a B grade with 1% initial accuracy and 100ppm/°C tempco. The voltage references feature a proprietary curvature-correction circuit and laser-trimmed thin-film resistors. These series-mode references can sink or source up to 500µA of load current.

## Applications

Precision Battery Management

Window Comparators

IR Receivers

Level Translators

Digital Line Receivers

***Typical Operating Circuit and Functional Diagrams appear at end of data sheet.***

*UCSP is a trademark of Maxim Integrated Products, Inc.*

## Features

- **Comparator + Precision Reference in UCSP/SOT23**
- **2.5V to 5.5V Single-Supply Operation (MAX9039–MAX9043)**
- **Low Supply Current (MAX9039/MAX9040/MAX9041/MAX9050/MAX9051)**
  - **40µA Quiescent**
  - **50µA with 100kHz Switching**
- **400ns Propagation Delay**
- **Rail-to-Rail Inputs**
- **Rail-to-Rail Output Stage Sinks and Sources 8mA**
- **Internal ±3mV Hysteresis**
- **Voltage Reference Offers**
  - **±0.4% (max) Initial Accuracy (A grade)**
  - **6ppm/°C (typ) Temperature Coefficient (A grade)**
  - **Stable for 0 to 4.7nF Capacitive Loads**

## Ordering Information

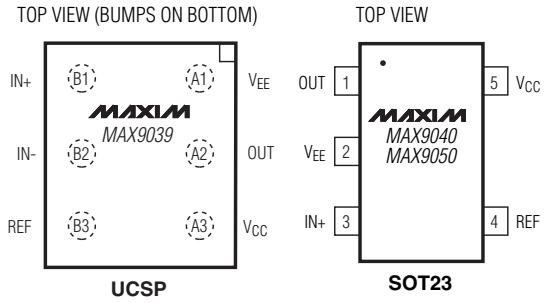
| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX9039**BEBT-T* | -40°C to +85°C | 6 UCSP | AAZ |
| **MAX9040**AEUK-T | -40°C to +85°C | 5 SOT23 | ADNW |
| MAX9040BEUK-T | -40°C to +85°C | 5 SOT23 | ADNX |
| **MAX9041**AEUT-T | -40°C to +85°C | 6 SOT23 | AAHF |
| MAX9041BEUT-T | -40°C to +85°C | 6 SOT23 | AAHH |
| MAX9041AESA | -40°C to +85°C | 8 SO | — |
| MAX9041BESA | -40°C to +85°C | 8 SO | — |

**UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and environment. Refer to the UCSP Reliability section of this data sheet for more information.*

***Ordering Information continued at end of data sheet.***

***Selector Guide appears at end of data sheet.***

## Pin Configurations




*Pin Configurations continued at end of data sheet.*



***For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.***

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ($V_{CC}$ to $V_{EE}$) .....-0.3V to +6V
All Other Pins .....($V_{EE}$ - 0.3V) to ($V_{CC}$ + 0.3V)
Current into Input Pins .....±20mA
Output Short-Circuit Duration
(OUT_, REF) .....Indefinite Short Circuit to Either Supply
Continuous Power Dissipation ($T_A$ = +70°C)
5-Pin SOT23 (derate 7.10mW/°C above +70°C).....571mW
6-Bump UCSP (derate 3.9mW/°C above +70°C) .....308mW
6-Pin SOT23 (derate 8.70mW/°C above +70°C).....696mW
8-Pin SO (derate 5.88mW/°C above +70°C).....471mW
8-Pin µMAX® (derate 4.1mW/°C above +70°C).....330mW
10-Pin µMAX (derate 5.6mW/°C above +70°C).....444mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C
Bump Reflow Temperature (Note 1) .....+235°C

**Note 1:** This device is constructed using a unique set of packaging techniques that impose a limit on the thermal profile the device can be exposed to during board-level solder attach and rework. This limit permits only the use of the solder profiles recommended in the industry-standard specification, JEDEC 020A, paragraph 7.6, Table 3 for IR/VPR and Convection Packaging Reflow. Preheating is required. Hand or wave soldering is not allowed.

*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.*

## ELECTRICAL CHARACTERISTICS—A Grade (0.4% Initial Accuracy)

($V_{CC}$ = +5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Voltage Range (Note 3) | $V_{CC}$ | MAX9040–MAX9043 | | 2.5 | | 5.5 | V |
| | | MAX9050–MAX9053 | | 2.7 | | 5.5 | |
| Supply Current | $I_{CC}$ | MAX9040/MAX9041/ MAX9050/MAX9051 | $V_{CC}$ = 2.7V | | 47 | 67 | µA |
| | | | $V_{CC}$ = 5V | | 52 | 72 | |
| | | MAX9042/MAX9043/ MAX9052/MAX9053 | $V_{CC}$ = 2.7V | | 55 | 80 | |
| | | | $V_{CC}$ = 5V | | 60 | 85 | |
| **COMPARATORS** | | | | | | | |
| Input Offset Voltage (Note 4) | $V_{OS}$ | Over entire common-mode range | $T_A$ = +25°C | | ±0.5 | ±5.0 | mV |
| | | | $T_A$ = -40°C to +85°C | | | ±7.0 | |
| Input Hysteresis | $V_{HYST}$ | | | | ±3.0 | | mV |
| Input Bias Current (Notes 5, 6, 7) | $I_B$ | Specified common-mode range | | | ±0.001 | ±10.0 | nA |
| Input Offset Current (Note 5) | $I_{OS}$ | Specified common-mode range | | | ±0.5 | | pA |
| Common-Mode Voltage Range (Notes 5, 8) | CMVR | $T_A$ = +25°C | | $V_{EE}$ - 0.25 | | $V_{CC}$ + 0.25 | V |
| | | $T_A$ = -40°C to +85°C | | $V_{EE}$ | | $V_{CC}$ | |
| Common-Mode Rejection Ratio (Note 5) | CMRR | Specified common-mode range | | 52 | 80 | | dB |
| Power-Supply Rejection Ratio | PSRR | MAX9040–MAX9043, 2.5V ≤ $V_{CC}$ ≤ 5.5V | | 55 | 80 | | dB |
| | | MAX9050–MAX9053, 2.5V ≤ $V_{CC}$ ≤ 5.5V | | 55 | 80 | | |
| Input Capacitance (Note 5) | $C_{IN}$ | | | | 2.5 | | pF |
| Output Short-Circuit Current | $I_{SC}$ | $V_{OUT}$ = $V_{EE}$ or $V_{CC}$ | $V_{CC}$ = 5V | | 95 | | mA |
| | | | $V_{CC}$ = 2.7V | | 35 | | |
| Output Voltage Low | $V_{OL}$ | $V_{CC}$ = 5V, $I_{SINK}$ = 8mA | | | 0.2 | 0.55 | V |
| | | $V_{CC}$ = 2.7V, $I_{SINK}$ = 3.5mA | | | 0.15 | 0.4 | |

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## ELECTRICAL CHARACTERISTICS—A Grade (0.4% Initial Accuracy) (continued)

($V_{CC}$ = +5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Output Voltage High | $V_{OH}$ | $V_{CC}$ = 5V, $I_{SOURCE}$ = 8mA | | 4.45 | 4.85 | | V |
| | | $V_{CC}$ = 2.7V, $I_{SOURCE}$ = 3.5mA | | 2.3 | 2.55 | | |
| Output Rise/Fall Times | $t_R/t_F$ | $C_L$ = 15pF | | | 40 | | ns |
| | | $C_L$ = 50pF | | | 50 | | |
| | | $C_L$ = 200pF | | | 80 | | |
| Output Propagation Delay (Note 9) | $t_{PD+}$/ $t_{PD-}$ | $C_L$ = 15pF, $V_{CC}$ = 2.7V | 50mV overdrive | | 450 | | ns |
| | | | 100mV overdrive | | 400 | | |
| Power-Up Time | $t_{PU}$ | Time to $V_{OUT}$ valid logic state | | | 20 | | µs |
| **VOLTAGE REFERENCE** | | | | | | | |
| Output Voltage | $V_{REF}$ | $T_A$ = +25°C | MAX9040–MAX9043 | 2.040 | 2.048 | 2.056 | V |
| | | | MAX9050–MAX9053 | 2.490 | 2.500 | 2.510 | |
| Output Voltage Temperature Coefficient (Note 10) | $TCV_{REF}$ | µMAX/SO | | | 6 | 30 | ppm/°C |
| | | SOT23 | | | 6 | 50 | |
| Line Regulation | $\Delta V_{REF}/\Delta V_{CC}$ | 2.5V ≤ $V_{CC}$ ≤ 5.5V, MAX9040–MAX9043 | | | +50 | +200 | µV/V |
| | | 2.7V ≤ $V_{CC}$ ≤ 5.5V, MAX9050–MAX9053 | | | +50 | +200 | |
| Load Regulation | $\Delta V_{REF}/\Delta I_{REF}$ | Sourcing. 0µA ≤ $I_{REF}$ ≤ 500µA | | | 2 | 4 | µV/µA |
| | | Sinking, -500µA ≤ $I_{REF}$ ≤ 0µA | | | 3.5 | 6 | |
| Output Short-Circuit Current | $I_{SC}$ | $V_{REF}$ = $V_{EE}$ or $V_{CC}$ | | | 4 | | mA |
| Thermal Hysteresis (Note 11) | $T_{HYST}$ | | | | 130 | | ppm |
| Long-Term Stability | | 1000h at $T_A$ = +25°C | | | 50 | | ppm |
| Noise Voltage | $E_{OUT}$ | f = 0.1Hz to 10Hz | | | 40 | | $\mu V_{P-P}$ |
| | | f = 10Hz to 10kHz | | | 105 | | $\mu V_{RMS}$ |
| Ripple Rejection | $\Delta V_{REF}/\Delta V_{CC}$ | $V_{CC}$ = 5V ±100mV, f = 120Hz | | | 84 | | dB |
| Turn-On Settling Time | $t_R(V_{REF})$ | To $V_{REF}$ = 1% of final value | | | 200 | | µs |
| Capacitive-Load Stability Range (Note 7) | $C_L(V_{REF})$ | | | 0 | | 4.7 | nF |

## ELECTRICAL CHARACTERISTICS—B Grade (1% Initial Accuracy)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Voltage Range (Note 3) | $V_{CC}$ | MAX9039–MAX9043 | | 2.5 | | 5.5 | V |
| | | MAX9050–MAX5053 | | 2.7 | | 5.5 | |
| Supply Current | $I_{CC}$ | MAX9039/MAX9040/ MAX9041/MAX9050/ MAX9051 | $V_{CC}$ = 2.7V | | 40 | | µA |
| | | | $V_{CC}$ = 5.0V | | 45 | 100 | |
| | | MAX9042/MAX9043/ MAX9052/MAX5053 | $V_{CC}$ = 2.7V | | 55 | | |
| | | | $V_{CC}$ = 5.0V | | 60 | 130 | |

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## ELECTRICAL CHARACTERISTICS—B Grade (1% Initial Accuracy) (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **COMPARATOR** | | | | | | | |
| Input Offset Voltage (Note 4) | $V_{OS}$ | Over entire common-mode range | | | ±1 | ±9.0 | mV |
| Input Hysteresis | $V_{HYST}$ | | | | ±3.0 | | mV |
| Input Bias Current (Notes 5, 6, 7) | $I_B$ | Specified common-mode range | | | ±0.001 | ±25.0 | nA |
| Input Offset Current (Note 5) | $I_{OS}$ | Specified common-mode range | | | ±0.5 | | pA |
| Common-Mode Voltage Range (Notes 5, 8) | CMVR | | | $V_{EE}$ | | $V_{CC}$ | V |
| Common-Mode Rejection Ratio (Note 5) | CMRR | Specified common-mode range | | 52 | 80 | | dB |
| Power-Supply Rejection Ratio | PSRR | MAX9039–MAX9043, 2.5V ≤ $V_{CC}$ ≤ 5.5V | | 55 | 80 | | dB |
| | | MAX9050–MAX9053, 2.7V ≤ $V_{CC}$ ≤ 5.5V | | 55 | 80 | | |
| Input Capacitance (Note 5) | $C_{IN}$ | | | | 2.5 | | pF |
| Output Short-Circuit Current | $I_{SC}$ | $V_{OUT}$ = $V_{EE}$ or $V_{CC}$ | $V_{CC}$ = 5V | | 95 | | mA |
| | | | $V_{CC}$ = 2.7V | | 35 | | |
| Output Voltage Low | $V_{OL}$ | $V_{CC}$ = 5V, $I_{SINK}$ = 8mA | | | 0.2 | 0.55 | V |
| | | $V_{CC}$ = 2.7V, $I_{SINK}$ = 3.5mA | | | 0.15 | | |
| Output Voltage High | $V_{OH}$ | $V_{CC}$ = 5V, $I_{SOURCE}$ = 8mA | | 4.45 | 4.85 | | V |
| | | $V_{CC}$ = 2.7V, $I_{SOURCE}$ = 3.5mA | | | 2.55 | | |
| Output Rise/Fall Times | $t_R/t_F$ | $C_L$ = 15pF | | | 40 | | ns |
| | | $C_L$ = 50pF | | | 50 | | |
| | | $C_L$ = 200pF | | | 80 | | |
| Output Propagation Delay (Note 9) | $t_{PD+}/t_{PD-}$ | $C_L$ = 15pF, $V_{CC}$ = 2.7V | 50mV overdrive | | 450 | | ns |
| | | | 100mV overdrive | | 400 | | |
| Power-Up Time | $t_{PU}$ | Time to $V_{OUT}$ valid logic state | | | 20 | | µs |
| **VOLTAGE REFERENCE** | | | | | | | |
| Output Voltage | $V_{REF}$ | $T_A$ = +25°C | MAX9039 | 1.218 | 1.230 | 1.242 | V |
| | | | MAX9040–MAX9043 | 2.028 | 2.048 | 2.068 | |
| | | | MAX9050–MAX9053 | 2.475 | 2.500 | 2.525 | |
| Output Voltage Temperature Coefficient (Note 10) | $TCV_{REF}$ | | | | 20 | 100 | ppm/°C |
| Line Regulation | $\Delta V_{REF}/\Delta V_{CC}$ | 2.5V ≤ $V_{CC}$ ≤ 5.5V | MAX9039–MAX9043 | | +50 | +200 | µV/V |
| | | | MAX9050–MAX9053 | | +50 | +200 | |
| Load Regulation | $\Delta V_{REF}/\Delta I_{REF}$ | Sourcing: 0µA ≤ $I_{REF}$ ≤ 500µA | | | 2 | 4 | µV/µA |
| | | Sinking: -500µA ≤ $I_{REF}$ ≤ 0µA | | | 3.5 | 6 | |
| Output Short-Circuit Current | $I_{SC}$ | $V_{REF}$ = $V_{EE}$ or $V_{CC}$ | | | 4 | | mA |
| Thermal Hysteresis (Note 11) | $T_{HYST}$ | | | | 130 | | ppm |
| Long-Term Stability | | 1000h at $T_A$ = +25°C | | | 100 | | ppm |
| Noise Voltage | $E_{OUT}$ | f = 0.1Hz to 10Hz | | | 40 | | $\mu V_{P-P}$ |
| | | f = 10Hz to 10kHz | | | 105 | | $\mu V_{RMS}$ |

## ELECTRICAL CHARACTERISTICS—B Grade (1% Initial Accuracy) (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

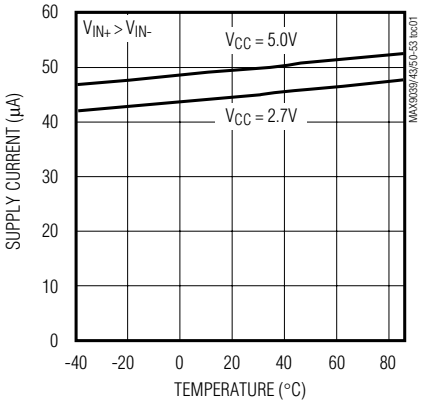
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Ripple Rejection | $\Delta V_{REF}/\Delta V_{CC}$ | $V_{CC}$ = 5V ±100mV, f = 120Hz | | 84 | | dB |
| Turn-On Settling Time | $t_R(V_{REF})$ | To $V_{REF}$ = 1% of final value | | 200 | | µs |
| Capacitive Load Stability Range (Note 7) | $C_L(V_{REF})$ | | 0 | | 4.7 | nF |

**Note 2:** All devices are 100% production tested at $T_A$ = +25°C. Limits over the extended temperature range are guaranteed by design.
**Note 3:** Supply voltage range guaranteed by PSRR test on comparator and line regulation of REF.
**Note 4:** $V_{OS}$ is defined as the center of the input-referred hysteresis band.
**Note 5:** For the comparators with the inverting input (IN-) uncommitted.
**Note 6:** Input bias current is the average of the inverting and noninverting input bias currents.
**Note 7:** Not production tested. Guaranteed by design.
**Note 8:** Guaranteed by CMRR test.
**Note 9:** $V_{OVERDRIVE}$ is beyond the offset and hysteresis determined trip point.
**Note 10:** Temperature coefficient is measured by the box method; i.e., the maximum $\Delta V_{REF}$ is divided by the maximum $\Delta T$.
**Note 11:** Thermal hysteresis is defined as the change in $V_{REF}$ at +25°C before and after cycling the device from $T_{MIN}$ to $T_{MAX}$.

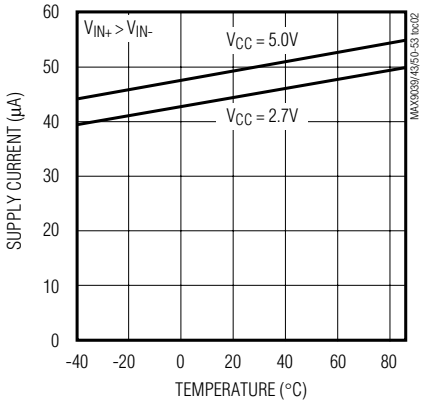
## Typical Operating Characteristics

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = +25°C, unless otherwise noted.)

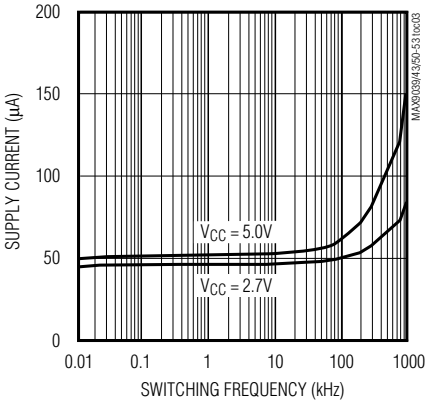
**MAX9039/MAX9040/MAX9041/MAX9050/MAX9051 SUPPLY CURRENT vs. TEMPERATURE**




**MAX9042/MAX9043/MAX9052/MAX9053 SUPPLY CURRENT vs. TEMPERATURE**




**MAX9039/MAX9040/MAX9041/MAX9050/MAX9051 SUPPLY CURRENT vs. SWITCHING FREQUENCY**

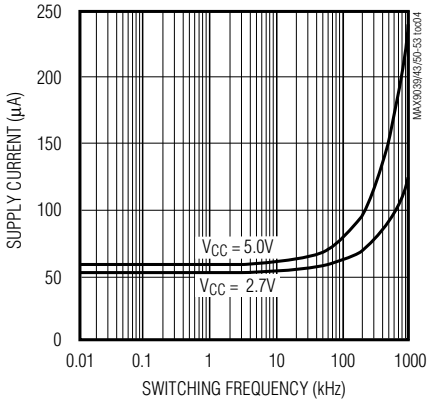


# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

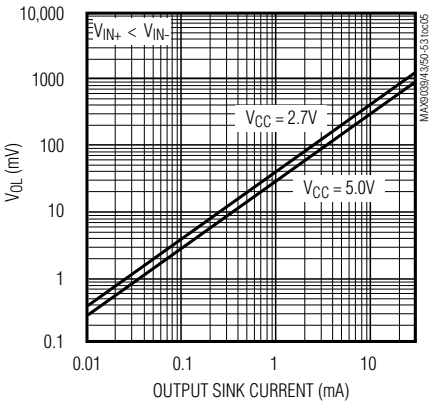
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = +25°C, unless otherwise noted.)

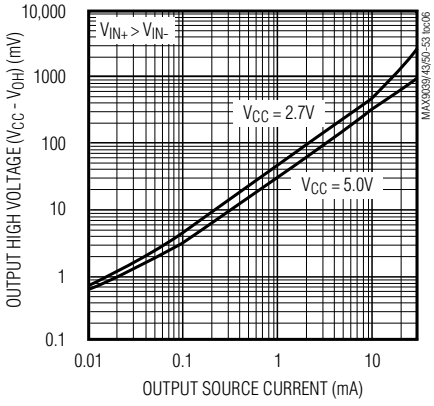
**MAX9042/MAX9043/MAX9052/MAX9053 SUPPLY CURRENT vs. SWITCHING FREQUENCY**



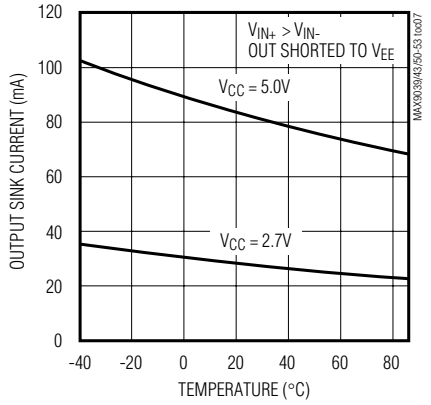

**OUTPUT LOW VOLTAGE vs. OUTPUT SINK CURRENT**



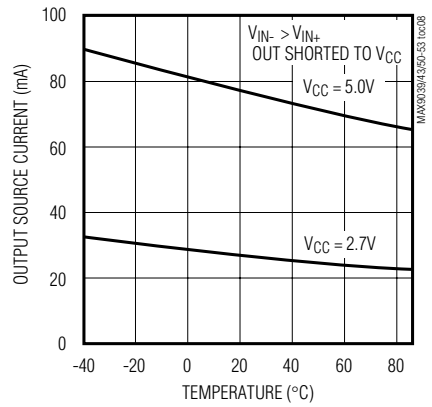

**OUTPUT HIGH VOLTAGE vs. OUTPUT SOURCE CURRENT**



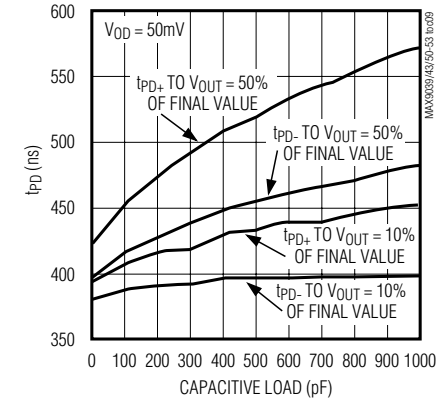

**OUTPUT SHORT-CIRCUIT CURRENT vs. TEMPERATURE**



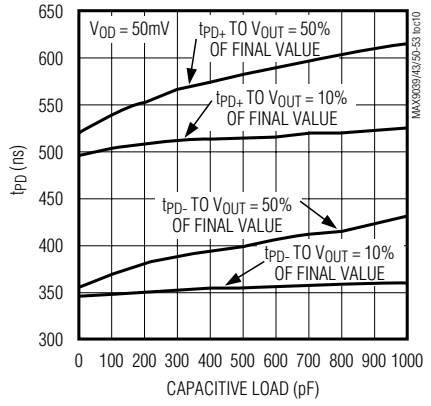

**OUTPUT SHORT-CIRCUIT CURRENT vs. TEMPERATURE**



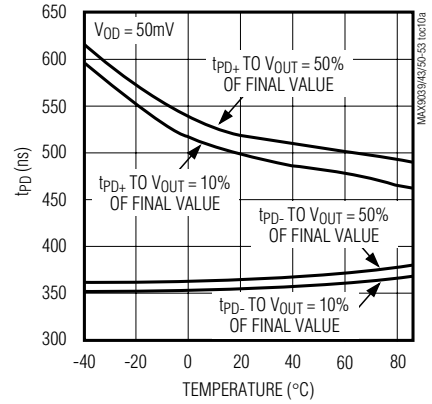

**PROPAGATION DELAY vs. CAPACITIVE LOAD ($V_{CC}$ = 2.7V)**



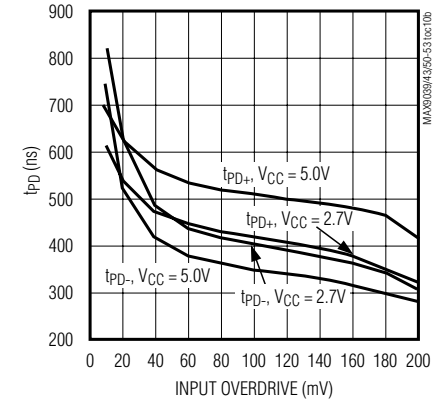

**PROPAGATION DELAY vs. CAPACITIVE LOAD ($V_{CC}$ = 5V)**




**PROPAGATION DELAY vs. TEMPERATURE**



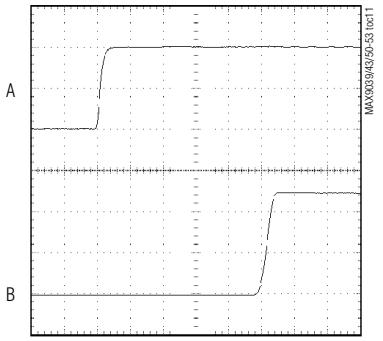

**PROPAGATION DELAY vs. INPUT OVERDRIVE**



## Typical Operating Characteristics (continued)

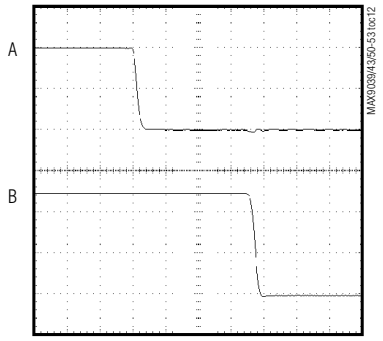
($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = +25°C, unless otherwise noted.)

**PROPAGATION DELAY ($t_{PD+}$)**



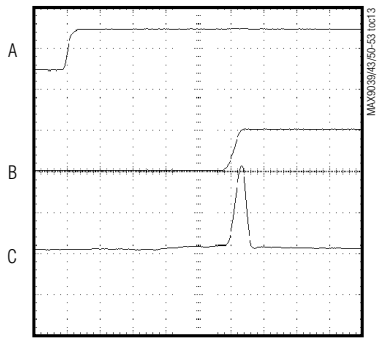

A = IN+, 50mV/div
B = OUT, 2V/div

**PROPAGATION DELAY ($t_{PD-}$)**



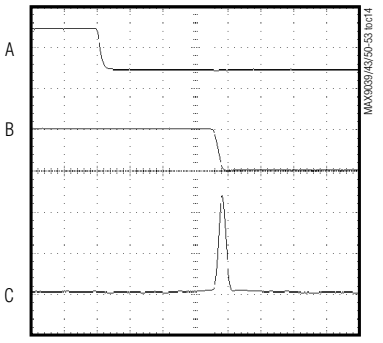

A = IN+, 50mV/div
B = OUT, 2V/div

**SWITCHING CURRENT (OUT RISING EDGE)**



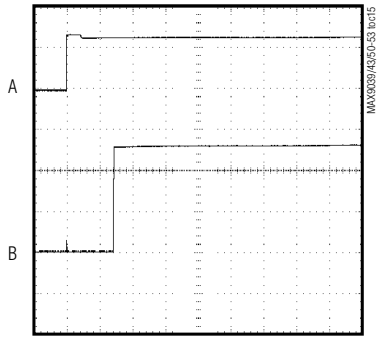

A = IN+, 100mV/div
B = OUT, 5V/div
C = $I_{CC}$, 1mA/div

**SWITCHING CURRENT (OUT FALLING EDGE)**



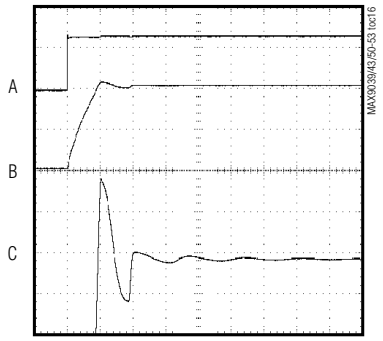

A = IN+, 100mV/div
B = OUT, 5V/div
C = $I_{CC}$, 1mA/div

**POWER-UP DELAY (OUT)**



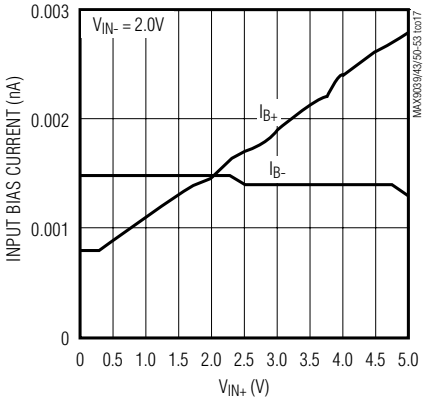

A = $V_{CC}$, 2V/div
B = OUT, 1V/div

**POWER-UP DELAY (REF)**

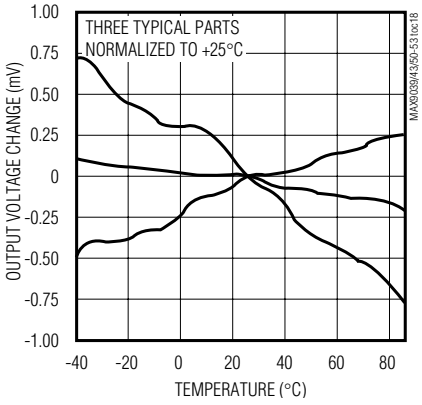



A = $V_{CC}$, 2V/div
B = REF, 1V/div
C = REF, 50mV/div, 2.048V OFFSET

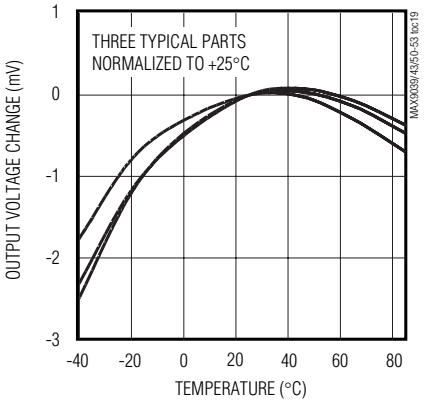
**INPUT BIAS CURRENT vs. INPUT VOLTAGE**




**MAX904_/MAX905_ REFERENCE OUTPUT VOLTAGE TEMPERATURE DRIFT**




**MAX9039 REFERENCE OUTPUT VOLTAGE TEMPERATURE DRIFT**

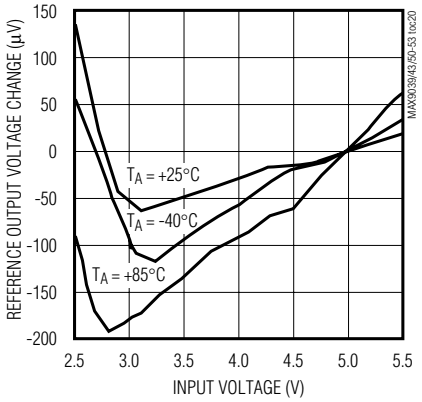


# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

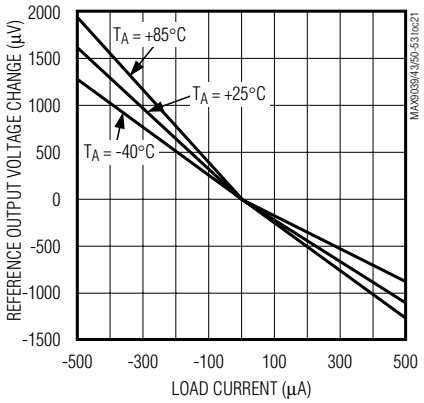
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 0V, $I_{OUT}$ = 0A, $I_{REF}$ = 0A, $T_A$ = +25°C, unless otherwise noted.)

**LINE REGULATION**




**LOAD REGULATION**




## Pin Description

| PIN | | | | | | NAME | FUNCTION |
|---|---|---|---|---|---|---|---|
| MAX9039 | MAX9040 MAX9050 | MAX9041 MAX9051 | | MAX9042 MAX9052 | MAX9043 MAX9053 | | |
| UCSP | SOT23 | SOT23 | SO | SO/µMAX | µMAX | | |
| A2 | 1 | 1 | 6 | — | — | OUT | Comparator Output |
| A1 | 2 | 2 | 4 | 4 | 5 | $V_{EE}$ | Negative Supply Voltage |
| B1 | 3 | 3 | 3 | — | — | IN+ | Comparator Noninverting Input |
| B3 | 4 | 5 | 1 | 2 | 2 | REF | Reference Voltage Output |
| A3 | 5 | 6 | 7 | 8 | 10 | $V_{CC}$ | Positive Supply Voltage |
| B2 | — | 4 | 2 | — | — | IN- | Comparator Inverting Input |
| — | — | — | 5, 8 | — | 9 | N.C. | No Connection. Not internally connected. |
| — | — | — | — | 1 | 1 | OUTA | Comparator A Output |
| — | — | — | — | 3 | 4 | INA+ | Comparator A Noninverting Input |
| — | — | — | — | 5 | 6 | INB+ | Comparator B Noninverting Input |
| — | — | — | — | 6 | 7 | INB- | Comparator B Inverting Input |
| — | — | — | — | 7 | 8 | OUTB | Comparator B Output |
| — | — | — | — | — | 3 | INA- | Comparator A Inverting Input |

## Detailed Description

The MAX9039–MAX9043 and MAX9050–MAX9053 feature single/dual, low-power, low-voltage comparators and a precision voltage reference. They operate from a single 2.5V to 5.5V (MAX9039/MAX904_) or 2.7V to 5.5V (MAX905_) supply. The single comparators with reference, (MAX9039/MAX9040/MAX9041/MAX9050/MAX9051 consume only 40µA of supply current, while the dual comparators with reference (MAX9042/MAX9043/MAX9052/MAX9053) consume only 55µA of supply current. Their common-mode input range extends 0.25V beyond each rail. Internal hysteresis ensures clean output switching, even with slow-moving input signals.

The output stage employs a unique design that minimizes supply current surges while switching, virtually eliminating the supply glitches typical of many other comparators. Large internal output drivers allow rail-to-rail output swing that can sink and source up to 8mA of current.

The precision reference uses a proprietary curvature-correction circuit and laser-trimmed thin-film resistors, resulting in a temperature coefficient of less than 30ppm/°C over the extended temperature range and initial accuracy of 0.4% (A grade). The reference output voltage is set to 1.23V in the MAX9039, 2.048V in the MAX9040–MAX9043, and to 2.500V in the MAX9050–MAX9053.

### Comparator Input Stage Circuitry

The devices' input common-mode range extends from ($V_{EE}$ - 0.25V) to ($V_{CC}$ + 0.25V). These comparators may operate at any differential input voltage within these limits. Input bias current is typically 1.0pA if the input voltage is between the supply rails. Comparator inputs are protected from overvoltage by internal body diodes connected to the supply rails. As the input voltage exceeds the supply rails, these body diodes become forward biased and begin to conduct. Consequently, bias currents increase exponentially as the input voltage exceeds the supply rails.

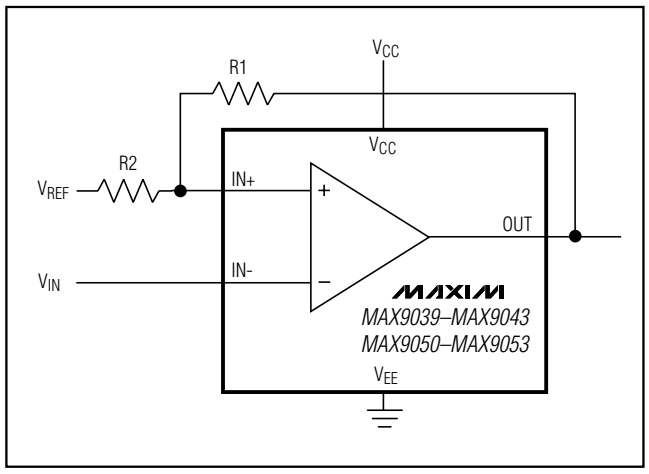



*Figure 1. Additional Hysteresis*

### Comparator Output Stage Circuitry

The comparators in these devices contain a unique output stage capable of rail-to-rail operation with loads up to 8mA. Many comparators consume orders-of-magnitude more current during switching than during steady-state operation. However, with this family of comparators, the supply current change during an output transition is extremely small. The *Typical Operating Characteristics* graph Supply Current vs. Switching Frequency shows the minimal supply current increase as the output switching frequency approaches 1MHz. This characteristic reduces the need for power-supply filter capacitors to reduce glitches created by comparator switching currents. Another advantage realized in high-speed, battery-powered applications is a substantial increase in battery life.

## Applications Information

### Additional Hysteresis

These comparators have ±3mV internal hysteresis. Additional hysteresis can be generated with two resistors using positive feedback (Figure 1). Use the following procedure to calculate resistor values:

1) Calculate the trip points of the comparator using these formulas:

$$V_{TH} = V_{REF} + \left( \frac{(V_{CC} - V_{REF})R2}{R1 + R2} \right)$$

$$V_{TL} = V_{REF} \left( 1 - \frac{R2}{R1 + R2} \right)$$

$V_{TH}$ is the threshold voltage at which the comparator switches its output from high to low as $V_{IN}$ rises above the trip point. $V_{TL}$ is the threshold voltage at which the comparator switches its output from low to high as $V_{IN}$ drops below the trip point.

2) The hysteresis band will be:

$$V_{HYS} = V_{TH} - V_{TL} = V_{CC} \left( \frac{R2}{R1 + R2} \right)$$

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

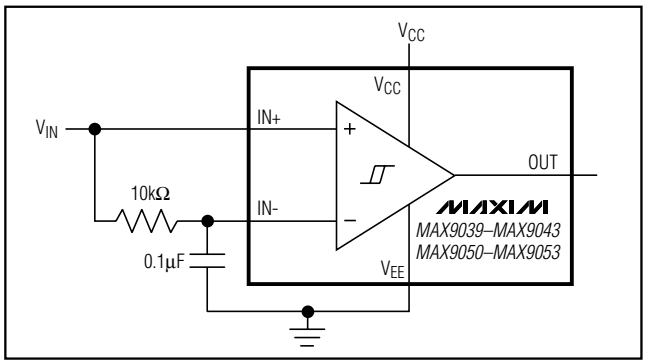



*Figure 2. Time Averaging of the Input Signal for Data Recovery*

3) In this example, let $V_{CC}$ = 5V and $V_{REF}$ = 2.5V:

$$V_{TH} = 2.5 + 2.5\left(\frac{R2}{R1+R2}\right)$$

and

$$V_{TL} = 2.5\left(1-\frac{R2}{R1+R2}\right)$$

4) Select R2. In this example, we will choose 1kΩ.

5) Select $V_{HYS}$. In this example, we will choose 50mV.

6) Solve for R1:

$$V_{HYS} = V_{CC}\left(\frac{R2}{R1+R2}\right)$$

$$0.050 = 5\left(\frac{1000}{R1+1000}\right)$$

where R1 ≈ 100kΩ, $V_{TH}$ = 2.525V, and $V_{TL}$ = 2.475V.

### Board Layout and Bypassing

Power-supply bypass capacitors are not typically needed, but would be called for in cases where supply impedance is high, supply leads are long, or excessive noise is expected on the supply lines. Use 100nF bypass capacitors under these conditions. Minimize signal trace lengths to reduce stray capacitance.

### Reference Output/Load Capacitance

The MAX9039/MAX904_/MAX905_ do not require an output capacitor on REF for frequency stability. They are stable for capacitive loads up to 4.7nF. However, in applications where the load or the supply can experience step changes, an output capacitor will reduce the amount of overshoot (or undershoot) and assist the circuit's transient response. When an application is not subject to transient conditions, the REF capacitor can be omitted.

### Biasing for Data Recovery

Digital data is often embedded into a bandwidth- and amplitude-limited analog path. Recovering the data can be difficult. Figure 2 compares the input signal to a time-averaged version of itself. This self-biases the threshold to the average input voltage for optimal noise margin.

Even severe phase distortion is eliminated from the digital output signal. Be sure to choose R1 and C1 so that:

$$f_{CAR} >> \frac{1}{2\pi R1C1}$$

where $f_{CAR}$ is the fundamental carrier frequency of the digital data stream.

### UCSP Package Consideration

For general UCSP package information and PC layout considerations, please refer to Maxim Application Note,"*Wafer-Level Chip-Scale Package.*"

## UCSP Reliability

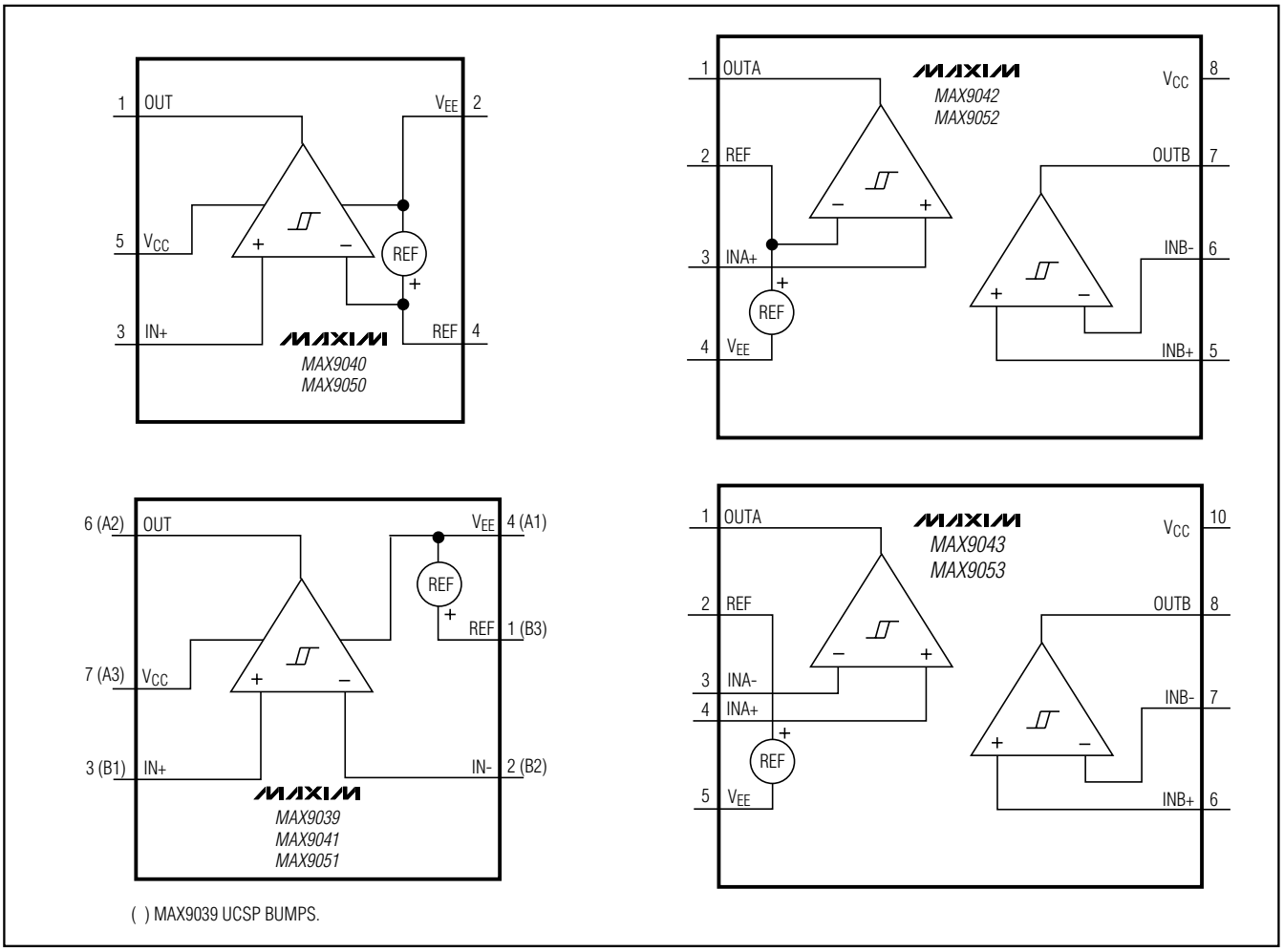
The chip-scale package (UCSP) represents a unique packaging form factor that may not perform equally to a packaged product through traditional mechanical reliability tests. UCSP reliability is integrally linked to the user's assembly methods, circuit board material, and usage environment. The user should closely review these areas when considering use of a UCSP. Performance through Operating Life Test and Moisture Resistance remains uncompromised as it is primarily determined by the wafer-fabrication process.

Mechanical stress performance is a greater consideration for a UCSP. UCSPs are attached through direct solder contact to the user's PC board, foregoing the inherent stress relief of a packaged product lead frame. Solder joint contact integrity must be considered. Information on Maxim's qualification plan, test data, and recommendations are detailed in the UCSP application note, which can be found on Maxim's website at www.maxim-ic.com.

## Chip Information

PROCESS: BiPOLAR

## Functional Diagrams



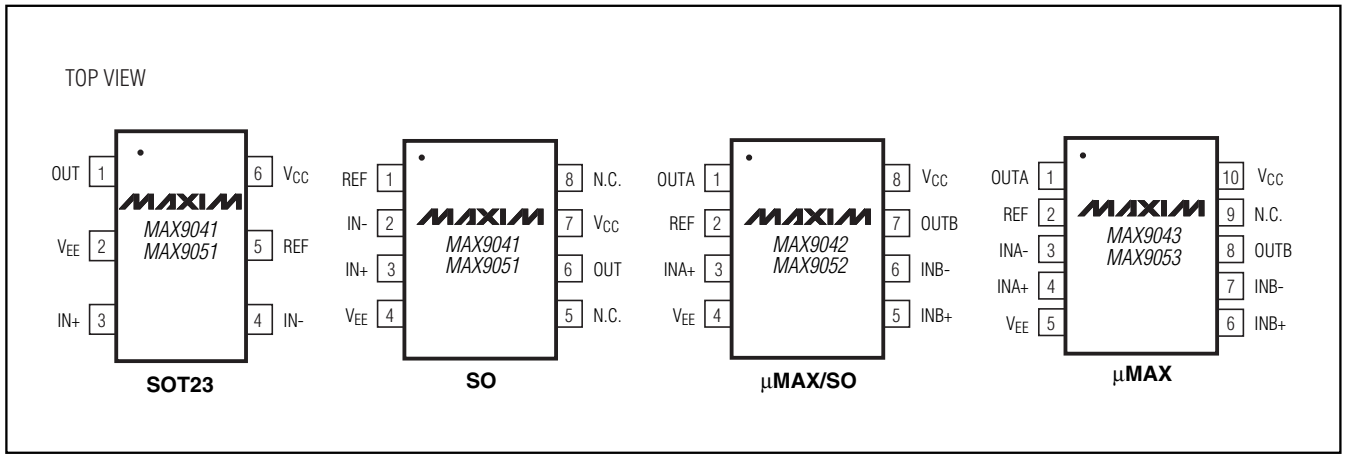

( ) MAX9039 UCSP BUMPS.

## Selector Guide

| PART | COMPARATORS PER PACKAGE | $V_{REF}$ (V) | IN- CONNECTIONS |
|---|---|---|---|
| MAX9039 | 1 | 1.230 | Uncommitted |
| MAX9040 | 1 | 2.048 | REF |
| MAX9041 | 1 | 2.048 | Uncommitted |
| MAX9050 | 1 | 2.500 | REF |
| MAX9051 | 1 | 2.500 | Uncommitted |
| MAX9042 | 2 | 2.048 | REF/Uncommitted |
| MAX9043 | 2 | 2.048 | Uncommitted/Uncommitted |
| MAX9052 | 2 | 2.500 | REF/Uncommitted |
| MAX9053 | 2 | 2.500 | Uncommitted/Uncommitted |

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

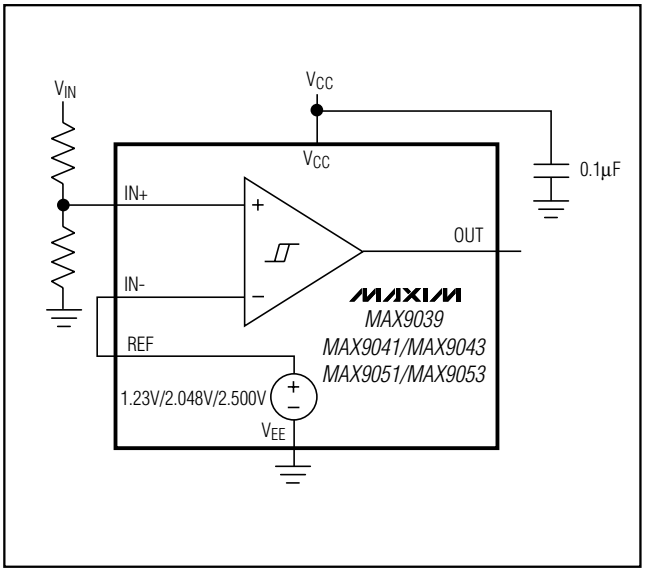
## Pin Configurations (continued)




## Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX9042**AEUA | -40°C to +85°C | 8 µMAX | — |
| MAX9042BEUA | -40°C to +85°C | 8 µMAX | — |
| MAX9042AESA | -40°C to +85°C | 8 SO | — |
| MAX9042BESA | -40°C to +85°C | 8 SO | — |
| **MAX9043**AEUB | -40°C to +85°C | 10 µMAX | — |
| MAX9043BEUB | -40°C to +85°C | 10 µMAX | — |
| **MAX9050**AEUK-T | -40°C to +85°C | 5 SOT23 | ADNW |
| MAX9050BEUK-T | -40°C to +85°C | 5 SOT23 | ADNY |
| **MAX9051**AEUT-T | -40°C to +85°C | 6 SOT23 | AAHG |
| MAX9051BEUT-T | -40°C to +85°C | 6 SOT23 | AAHI |
| MAX9051AESA | -40°C to +85°C | 8 SO | — |
| MAX9051BESA | -40°C to +85°C | 8 SO | — |
| **MAX9052**AEUA | -40°C to +85°C | 8 µMAX | AAHG |
| MAX9052BEUA | -40°C to +85°C | 8 µMAX | AAHI |
| MAX9052AESA | -40°C to +85°C | 8 SO | — |
| MAX9052BESA | -40°C to +85°C | 8 SO | — |
| **MAX9053**AEUB | -40°C to +85°C | 10 µMAX | — |
| MAX9053BEUB | -40°C to +85°C | 10 µMAX | — |

## Typical Operating Circuit



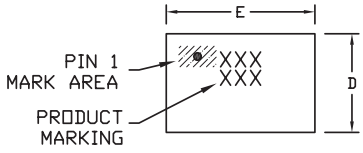
# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|---|---|---|
| 6 UCSP | B6-3 | 21-0097 |
| 5 SOT23 | — | 21-0057 |
| 6 SOT23 | — | 21-0058 |
| 8 SO | — | 21-0041 |
| 8 µMAX | — | 21-0036 |
| 10 µMAX | — | 21-0061 |

6L, UCSP.EPS

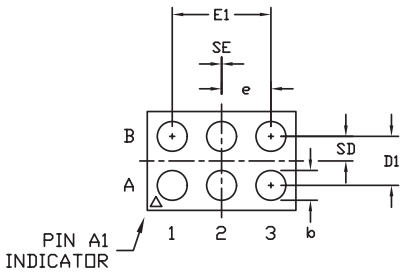



TOP VIEW

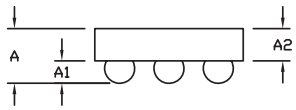
| COMMON DIMENSIONS | |
|---|---|
| A | 0.62±0.05–0.08 |
| A1 | 0.29±0.02 |
| A2 | 0.33 REF. |
| b | ø0.35±0.03 |
| D1 | 0.50 BASIC |
| E1 | 1.00 BASIC |
| e | 0.50 BASIC |
| SD | 0.25 BASIC |
| SE | 0.00 BASIC |

| PKG. CODE | VARIABLE DIMENSIONS | | DEPOPULATED SOLDER BALLS |
|---|---|---|---|
| | D | E | |
| B6-1 | 1.00±0.05 | 1.52±0.05 | NONE |
| B6-2 | 1.00±0.05 | 1.52±0.05 | B2 |
| B6-3 | 1.05±0.05 | 1.57±0.05 | NONE |
| B6-4 | 1.05±0.05 | 1.57±0.05 | B2 |
| B6-5 | 0.97±0.05 | 1.46±0.05 | NONE |
| B6-6 | 1.16±0.05 | 1.57±0.05 | NONE |

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. PRODUCT MARKING: NUMBER OF CHARACTERS AND LINES VARY PER PRODUCT.




BOTTOM VIEW




SIDE VIEW

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 3x2 UCSP

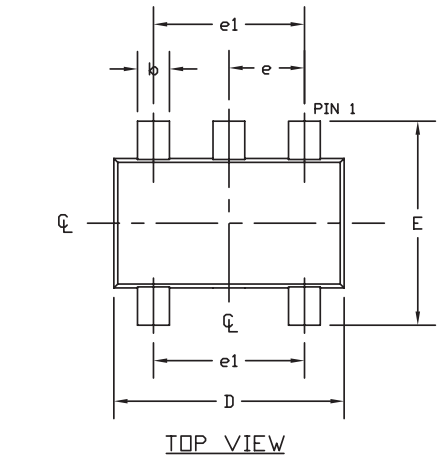
| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0097 | G | 1/1 |

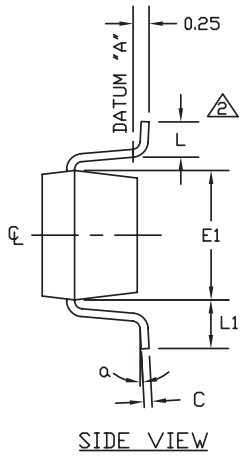
# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## Package Information (continued)

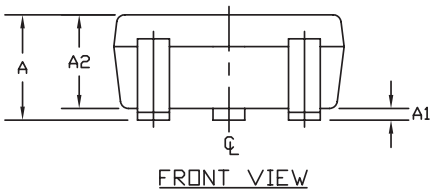
For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

SOT-23 5L .EPS




| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 0.60 REF | | |
| e | 0.95 BSC. | | |
| e1 | 1.90 BSC. | | |
| α | 0° | 2.5° | 8° |
| PKG CODES: U5-1, U5-2 | | | |




NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. MEETS JEDEC MO178, VARIATION AA.
6. LEADS TO BE COPLANAR WITHIN 0.10 mm.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

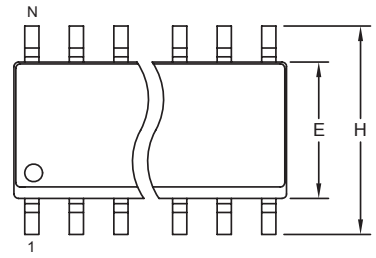
TITLE: PACKAGE OUTLINE, SOT-23, 5L

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0057 | F | 1/1 |

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

SOICN .EPS

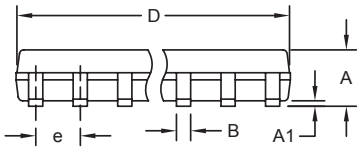



TOP VIEW

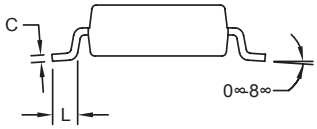
| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| e | 0.050 BSC | | 1.27 BSC | |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
| H | 0.228 | 0.244 | 5.80 | 6.20 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |

VARIATIONS:

| | INCHES | | MILLIMETERS | | | |
|---|---|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX | N | MS012 |
| D | 0.189 | 0.197 | 4.80 | 5.00 | 8 | AA |
| D | 0.337 | 0.344 | 8.55 | 8.75 | 14 | AB |
| D | 0.386 | 0.394 | 9.80 | 10.00 | 16 | AC |




FRONT VIEW




SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

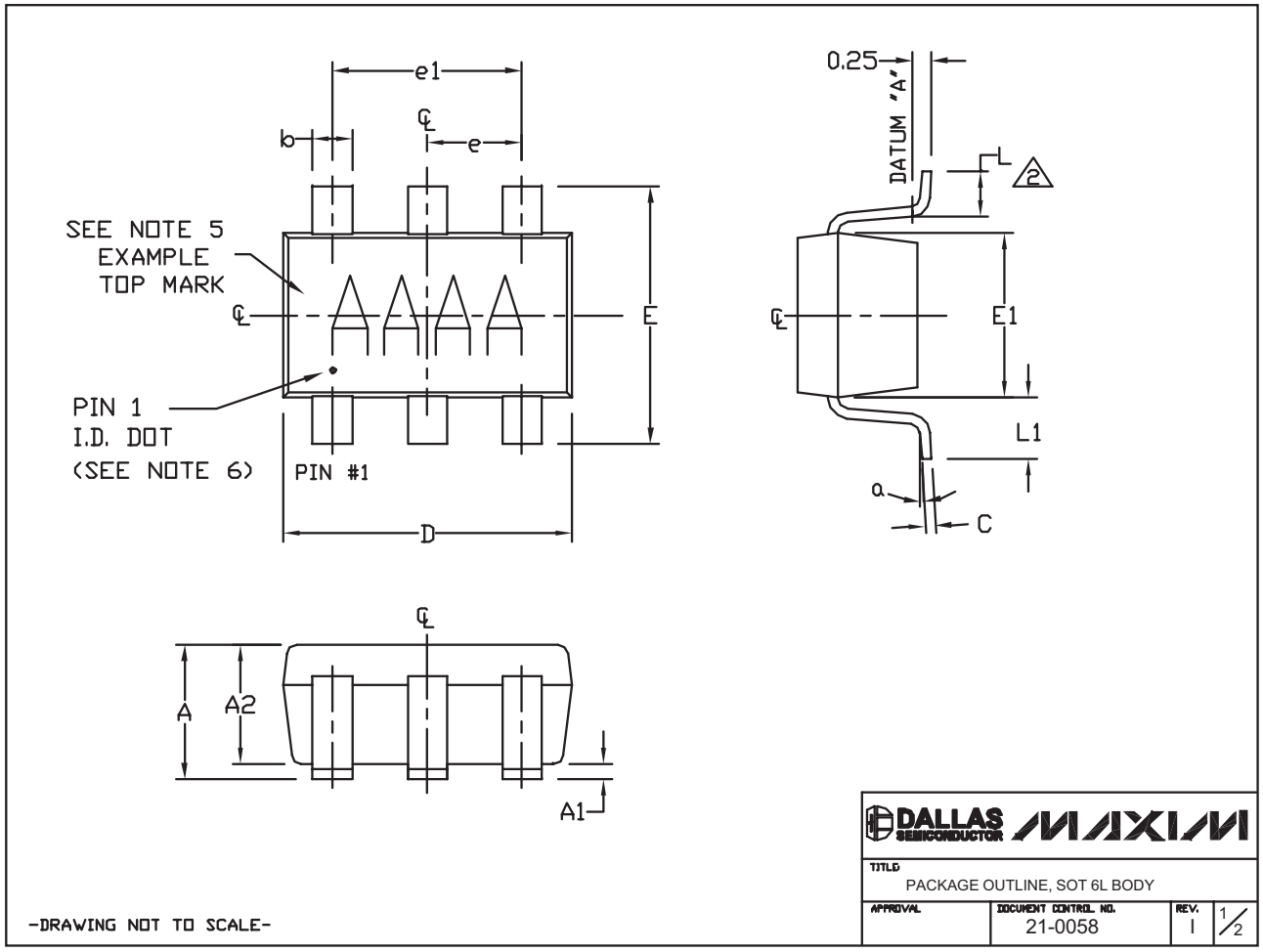
TITLE: PACKAGE OUTLINE, .150" SOIC

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0041 | B | 1/1 |

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.



## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25mm.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3mm ø MIN. LOCATED ABOVE PIN 1.
7. MEETS JEDEC MO178, VARIATION AB.
8. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEADTIP.
9. LEAD TO BE COPLANAR WITHIN 0.1mm.
10. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

| SYMBOL | MIN | NOMINAL | MAX |
|---|---|---|---|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 0.60 REF. | | |
| e1 | 1.90 BSC. | | |
| e | 0.95 BSC. | | |
| α | 0° | 2.5° | 10° |

PKG CODES:
U6-1, U6-2, U6-4, U6C-8, U6SN-1, U6CN-2, U6S-3, U6F-5, U6F-6, U6FH-5, U6FH-6

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, SOT 6L BODY

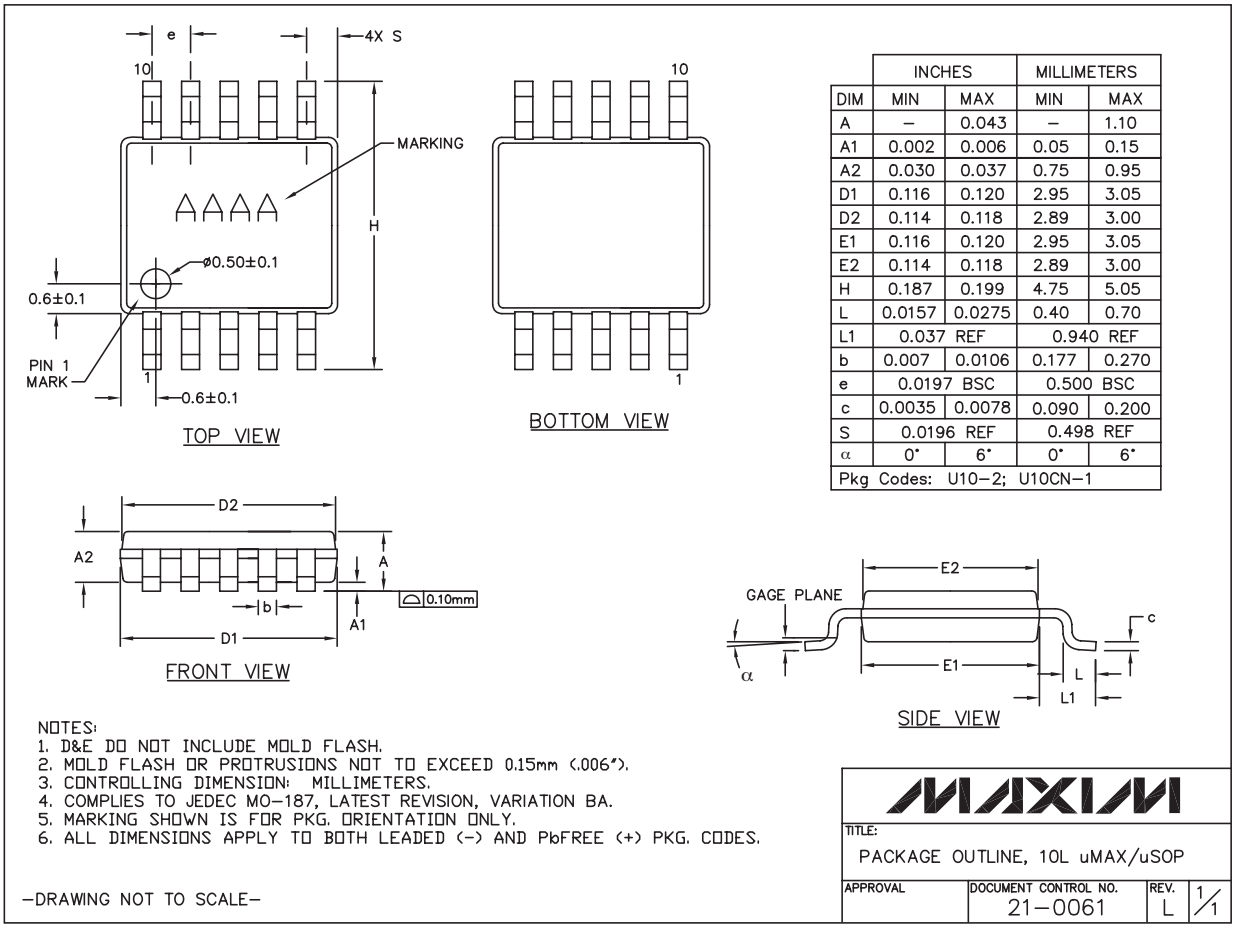
| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0058 | I | 2/2 |

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.

10LUMAX.EPS




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | – | 0.043 | – | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 |
| A2 | 0.030 | 0.037 | 0.75 | 0.95 |
| D1 | 0.116 | 0.120 | 2.95 | 3.05 |
| D2 | 0.114 | 0.118 | 2.89 | 3.00 |
| E1 | 0.116 | 0.120 | 2.95 | 3.05 |
| E2 | 0.114 | 0.118 | 2.89 | 3.00 |
| H | 0.187 | 0.199 | 4.75 | 5.05 |
| L | 0.0157 | 0.0275 | 0.40 | 0.70 |
| L1 | 0.037 REF | | 0.940 REF | |
| b | 0.007 | 0.0106 | 0.177 | 0.270 |
| e | 0.0197 BSC | | 0.500 BSC | |
| c | 0.0035 | 0.0078 | 0.090 | 0.200 |
| S | 0.0196 REF | | 0.498 REF | |
| α | 0° | 6° | 0° | 6° |
| Pkg Codes: U10–2; U10CN–1 | | | | |

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. COMPLIES TO JEDEC MO–187, LATEST REVISION, VARIATION BA.
5. MARKING SHOWN IS FOR PKG. ORIENTATION ONLY.
6. ALL DIMENSIONS APPLY TO BOTH LEADED (–) AND PbFREE (+) PKG. CODES.

–DRAWING NOT TO SCALE–

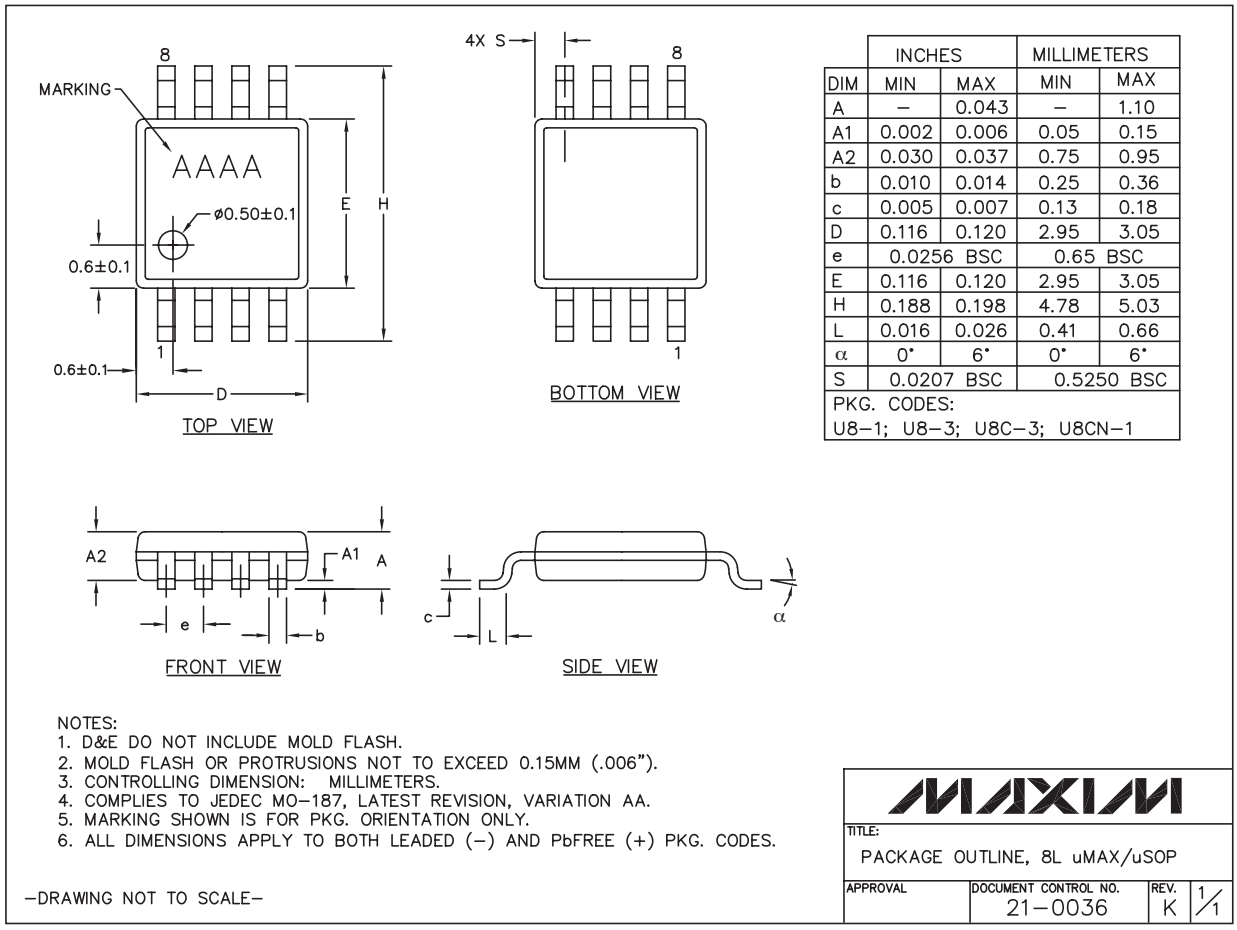
MAXIM

TITLE: PACKAGE OUTLINE, 10L uMAX/uSOP

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21–0061 | L | 1/1 |

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**.




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | – | 0.043 | – | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 |
| A2 | 0.030 | 0.037 | 0.75 | 0.95 |
| b | 0.010 | 0.014 | 0.25 | 0.36 |
| c | 0.005 | 0.007 | 0.13 | 0.18 |
| D | 0.116 | 0.120 | 2.95 | 3.05 |
| e | 0.0256 BSC | | 0.65 BSC | |
| E | 0.116 | 0.120 | 2.95 | 3.05 |
| H | 0.188 | 0.198 | 4.78 | 5.03 |
| L | 0.016 | 0.026 | 0.41 | 0.66 |
| α | 0° | 6° | 0° | 6° |
| S | 0.0207 BSC | | 0.5250 BSC | |
| PKG. CODES: U8-1; U8-3; U8C-3; U8CN-1 | | | | |

# Micropower, Single-Supply, UCSP/SOT23 Comparator + Precision Reference ICs

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 10/99 | Initial release | — |
| 1 | 1/00 | Corrections to initial release | — |
| 2 | 4/00 | Adding new part | — |
| 3 | 4/00 | Increase in Max Supply Current specs | — |
| 4 | 10/02 | Adding UCSP package for MAX9039 | — |
| 5 | 10/07 | Adding input current ratings in Abs Max, style changes | — |
| 6 | 3/09 | Update Chip Information, Package Info, correct MAX9053 part number, style changes | 1, 2, 10, 12–19 |

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