19-4224; Rev 2; 1/11

EVALUATION KIT AVAILABLE

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23



## General Description

The MAX9065 is an ultra-small, low-power, window comparator ideal for a wide variety of portable electronics applications such as cell phones, portable media players, and notebooks that have extremely tight board space and power constraints. It comes in both a 4-bump UCSP™ package with a 1mm x 1mm footprint (as small as two 0402 resistors) and a 5-pin SOT23 package.

The MAX9065 features a common-mode input range of -0.3V to +5.5V independent of supply voltage. The input current goes to zero when the MAX9065 is powered down ($V_{CC}$ = 0). Additionally, the MAX9065 features high RF immunity.

The MAX9065 has a push-pull output and consumes only 1µA (max) supply current. The MAX9065 operates down to 1.0V over the extended -40°C to +85°C temperature range.

## Applications

Cell Phones

Portable Media Players

Electronic Toys

Notebook Computers

Portable Medical Devices

## Features

- **Tiny 1mm x 1mm 4-Bump UCSP**
  **Footprint = Two 0402 Resistors**
  **Also Available in 5-Pin SOT23 Package**
- **Ultra-Low Power Operating Current**
  **1µA (max)**
- **-0.3V to +5.5V Input Voltage Range**
- **1.0V to 5.5V $V_{CC}$ Range**
- **3.0V and 4.2V Trigger Points**
- **-40°C to +85°C Extended Temperature Range**

## Ordering Information

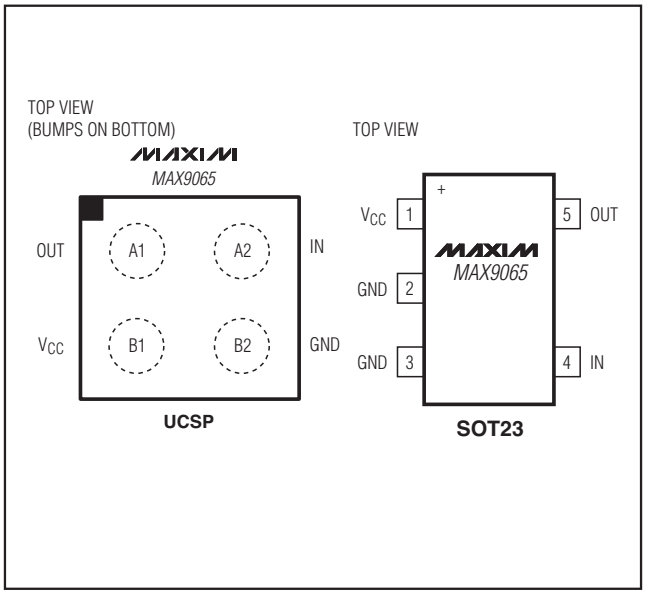
| PART | PIN-PACKAGE | TOP MARK |
|---|---|---|
| MAX9065EBS+G45 | 4 UCSP | AGC |
| MAX9065EUK+ | 5 SOT23 | AFFL |

***Note:*** *All devices are specified over the extended -40°C to +85°C operating temperature range.*

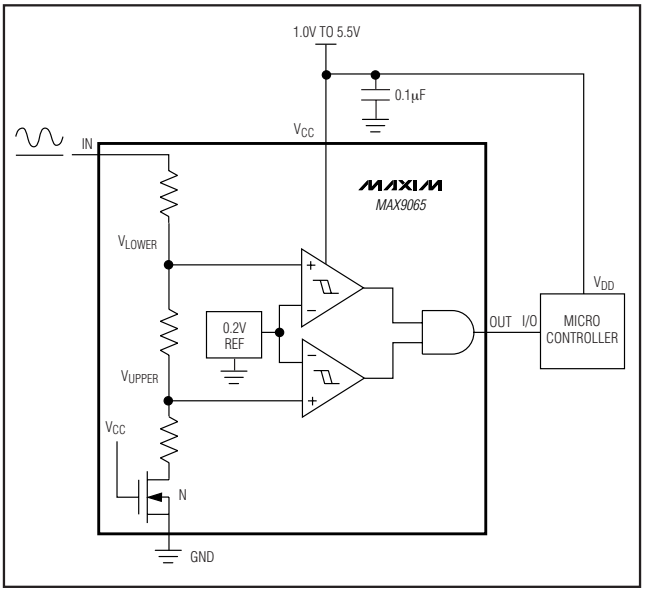
*+Denotes a lead-free/RoHS-compliant package.*

*G45 = Protective die coating.*

## Pin Configurations




## Typical Operating Circuit




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



***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.***

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$, IN to GND .....-0.3V to +6V
OUT to GND .....-0.3V to ($V_{CC}$ + 0.3V)
Output Short-Circuit Current Duration .....10s
Input Current into Any Terminal .....±20mA
Continuous Power Dissipation
4-Bump UCSP (derate 3.0mW/°C above +70°C).....238mW
5-Pin SOT23 (derate 3.9mW/°C above +70°C).....312mW

Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (SOT23 only, 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.*

## ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 3.3V, $T_A$ = -40°C to +85°C. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **DC CHARACTERISTICS** | | | | | | | |
| Upper Threshold Voltage | UTV | MAX9065EBS+ 4 UCSP | $T_A$ = +25°C | 4.158 | 4.20 | 4.242 | V |
| | | | -40°C < $T_A$ < +85°C | 4.10 | | 4.30 | |
| | | MAX9065EUK+ 5 SOT23 | $T_A$ = +25°C | 4.04 | 4.20 | 4.36 | |
| | | | -40°C < $T_A$ < +85°C | 3.98 | | 4.42 | |
| Lower Threshold Voltage | LTV | MAX9065EBS+ 4 UCSP | $T_A$ = +25°C | 2.94 | 3.00 | 3.06 | V |
| | | | -40°C < $T_A$ < +85°C | 2.92 | | 3.08 | |
| | | MAX9065EUK+ 5 SOT23 | $T_A$ = +25°C | 2.88 | 3.00 | 3.12 | |
| | | | -40°C < $T_A$ < +85°C | 2.83 | | 3.17 | |
| Input Voltage Range | $V_{IN}$ | | | -0.3 | | +5.5 | V |
| Hysteresis | $V_{HYS}$ | (Note 2) | | | ±1.0 | | % |
| Resistor String Input Resistance | $R_{IN}$ | | | 5.8 | 11 | 17.7 | MΩ |
| Input Shutdown Current | $I_{IN\_SHDN}$ | $V_{CC}$ = 0V, $V_{IN}$ = 5.5V | | | 1 | 15 | nA |
| Output Voltage Low | $V_{OL}$ | $I_{SINK}$ = 100µA, $V_{CC}$ = 1V, $T_A$ = +25°C | | | | 0.2 | V |
| | | $I_{SINK}$ = 1.2mA, $V_{CC}$ = 3.3V | | | | 0.3 | |
| | | $I_{SINK}$ = 1.2mA, $V_{CC}$ = 5.5V | | | | 0.5 | |
| Output Voltage High | $V_{OH}$ | $I_{SOURCE}$ = 25µA, $V_{CC}$ = 1V, $T_A$ = +25°C | | | | $V_{CC}$ - 0.2 | V |
| | | $I_{SOURCE}$ = 0.3mA, $V_{CC}$ = 3.3V | | | | $V_{CC}$ - 0.3 | |
| | | $I_{SOURCE}$ = 0.75mA, $V_{CC}$ = 5.5V | | | | $V_{CC}$ - 0.5 | |
| **AC CHARACTERISTICS** | | | | | | | |
| Propagation Delay | $t_{PD}$ | Overdrive = ±100mV (Notes 3, 4) | | | 25 | | µs |
| Fall Time | $t_F$ | $C_L$ = 10pF | | | 14 | | ns |
| Rise Time | $t_R$ | $C_L$ = 10pF | | | 30 | | ns |
| **POWER SUPPLY** | | | | | | | |
| Supply Voltage | $V_{CC}$ | Guaranteed by $V_{OS}$ tests | | 1 | | 5.5 | V |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 3.3V, $T_A$ = -40°C to +85°C. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

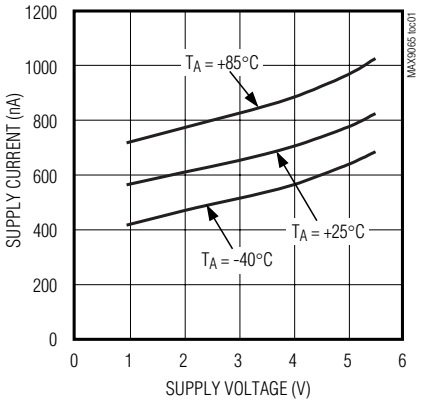
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Current | $I_{CC}$ | $V_{CC}$ = 5.5V | | 0.7 | 1.35 | µA |
| | | $V_{CC}$ = 1.0V, $T_A$ = +25°C | | 0.6 | 1.0 | |
| Power-Supply Rejection Ratio | PSRR | $V_{CC}$ = 0.9V to 5.5V, $T_A$ = +25°C | 40 | 53 | | dB |
| Power-Up Time | $t_{ON}$ | | | 3 | | ms |

**Note 1:** All devices are 100% production tested at $T_A$ = +25°C. Temperature limits are guaranteed by design.
**Note 2:** Hysteresis is the input voltage difference between the two switching points.
**Note 3:** Overdrive is defined as the voltage above or below the average of the switching points.
**Note 4:** Guaranteed by ATE and/or bench characterization over temperature.

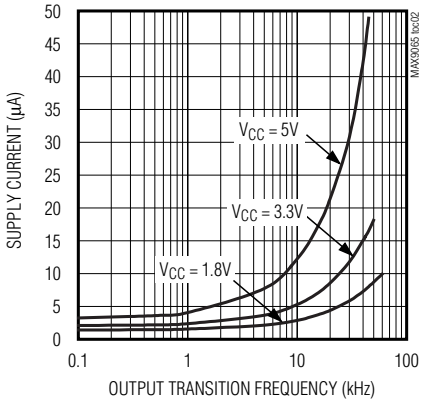
## Typical Operating Characteristics

($V_{CC}$ = 3.3V, $T_A$ = -40°C to +85°C. Typical values are at $T_A$ = +25°C, unless otherwise noted.)

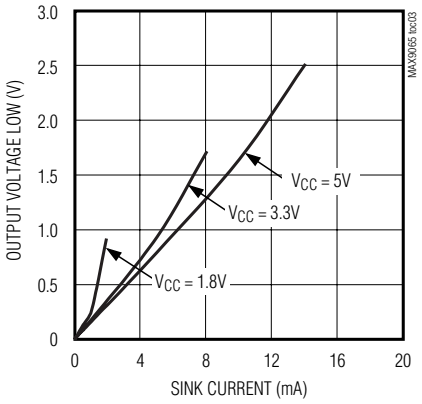
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



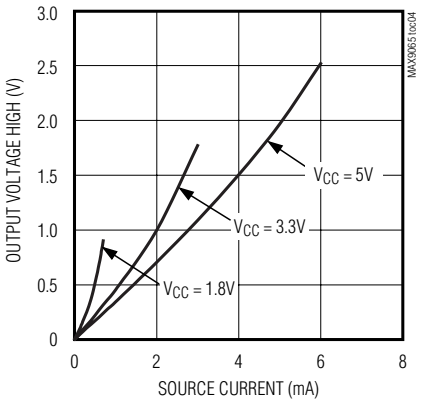

**SUPPLY CURRENT vs. OUTPUT TRANSITION FREQUENCY**



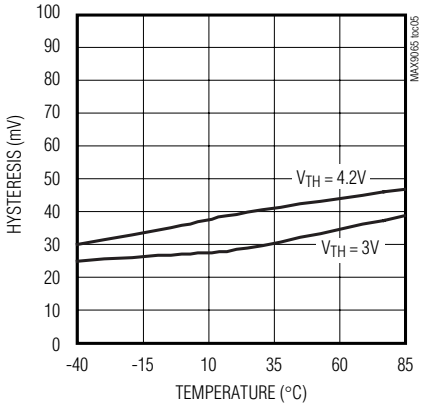

**OUTPUT VOLTAGE LOW vs. SINK CURRENT**



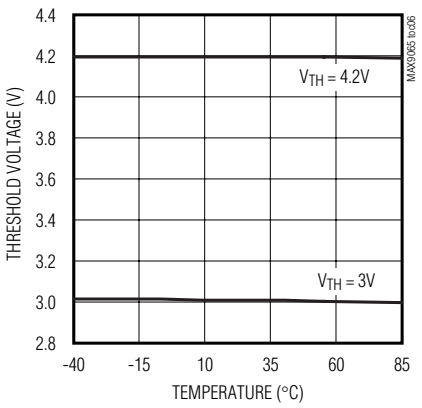

**OUTPUT VOLTAGE HIGH vs. SOURCE CURRENT**




**HYSTERESIS VOLTAGE vs. TEMPERATURE**




**THRESHOLD VOLTAGE vs. TEMPERATURE**

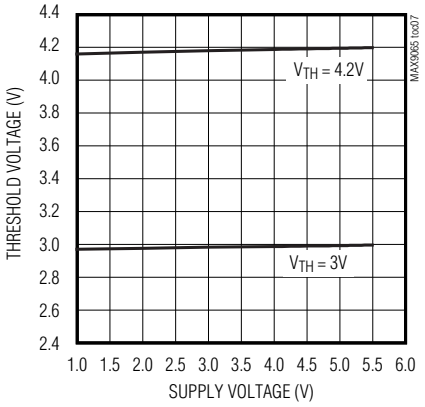


# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

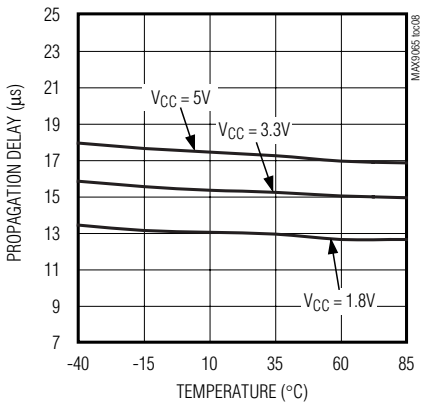
## Typical Operating Characteristics (continued)

($V_{CC}$ = 3.3V, $T_A$ = -40°C to +85°C. Typical values are at $T_A$ = +25°C, unless otherwise noted.)

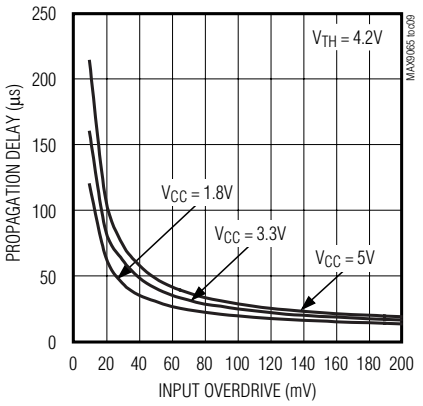
**THRESHOLD VOLTAGE vs. SUPPLY VOLTAGE**



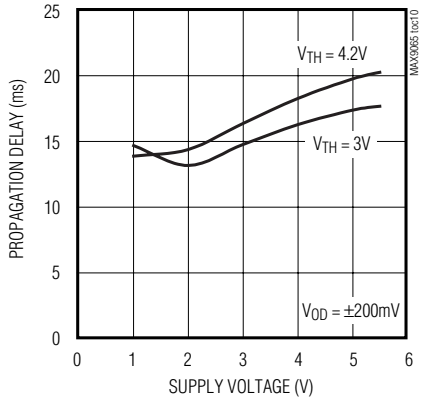

**PROPAGATION DELAY vs. TEMPERATURE**



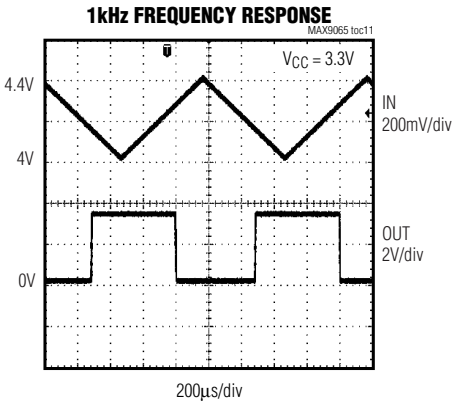

**PROPAGATION DELAY vs. INPUT OVERDRIVE**



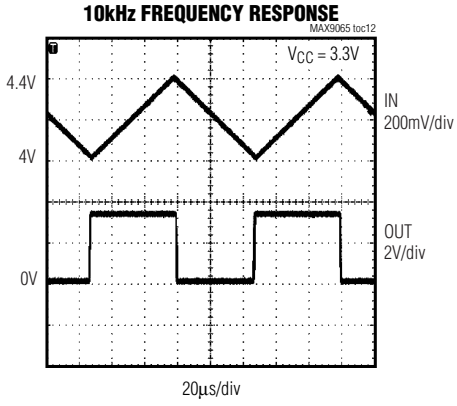

**PROPAGATION DELAY vs. SUPPLY VOLTAGE**



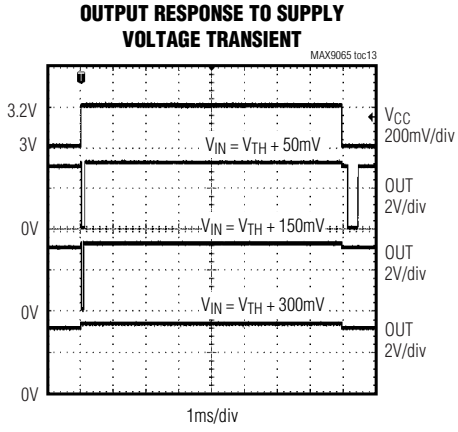

**1kHz FREQUENCY RESPONSE**



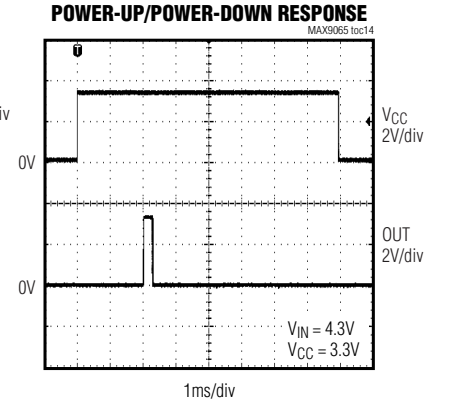

**10kHz FREQUENCY RESPONSE**



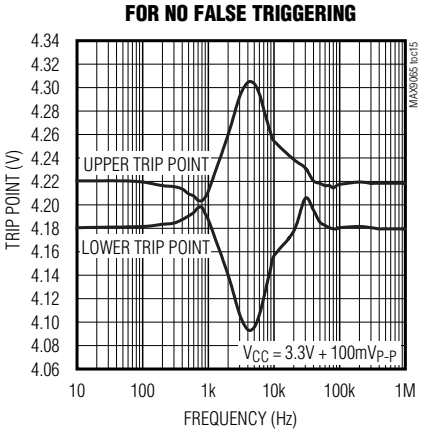

**OUTPUT RESPONSE TO SUPPLY VOLTAGE TRANSIENT**




**POWER-UP/POWER-DOWN RESPONSE**




**POWER-SUPPLY REJECTION FOR NO FALSE TRIGGERING**



## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| SOT23 | UCSP | | |
| 1 | B1 | $V_{CC}$ | External Supply Input. Bypass to ground with a 0.1µF bypass capacitor. |
| 2, 3 | B2 | GND | Ground |
| 4 | A2 | IN | Window Comparator Input |
| 5 | A1 | OUT | Push-Pull Output |

## Detailed Description

The MAX9065 is an extremely small window comparator designed for compact, low-current applications, featuring a supply current of less than 1µA (max).

### Operation

At the heart of the MAX9065 are two comparators, a resistor-divider with a disconnect switch, a 200mV reference, digital logic circuitry, and an output stage (see the *Typical Operating Circuit*).

The digital logic circuitry and the output stage together behave like an AND gate. The gate's inputs are the outputs of the two comparators. When either comparator's output is low, the output asserts low. When both comparator's outputs are high, the output asserts high.

When power is applied to $V_{CC}$, the n-channel FET at the bottom of the resistor-divider is turned on. The resistor-divider provides two voltages, $V_{UPPER}$ and $V_{LOWER}$, for comparison with an internal 0.2V reference voltage. When the input voltage exceeds 4.2V, $V_{UPPER}$ is greater than 0.2V, causing the output to assert low. When the input voltage falls below 3.0V, $V_{LOWER}$ is less than 0.2V, causing the output also to assert low. With the input voltage between 3.0V and 4.2V, the output asserts high, indicating that the input voltage is within the desired range. Table 1 summarizes the operation of the MAX9065.

**Table 1. MAX9065 Operation**

| INPUT VOLTAGE | OUTPUT |
|---|---|
| $V_{IN}$ > 4.2V | Low |
| 3.0V < $V_{IN}$ < 4.2V | High |
| $V_{IN}$ < 3.0V | Low |

When $V_{CC}$ goes to 0V, the n-channel FET is turned off, eliminating the resistor-divider as a leakage path for current.

## Applications

The MAX9065 is designed specifically to monitor the voltage on a single lithium battery. Keeping the voltage on a lithium battery within a tight range is important to prevent damage to the battery. Specifically, ensuring that the battery's voltage neither exceeds 4.2V nor falls below 3.0V lengthens the lifetime of the battery and avoids any hazardous battery conditions.

### Hysteresis

There are four trip points for hysteresis. See Figure 1.

### Power-Supply Considerations

Bypass $V_{CC}$ with a 0.1µF capacitor to ground.

## Chip Information

PROCESS: BiCMOS

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

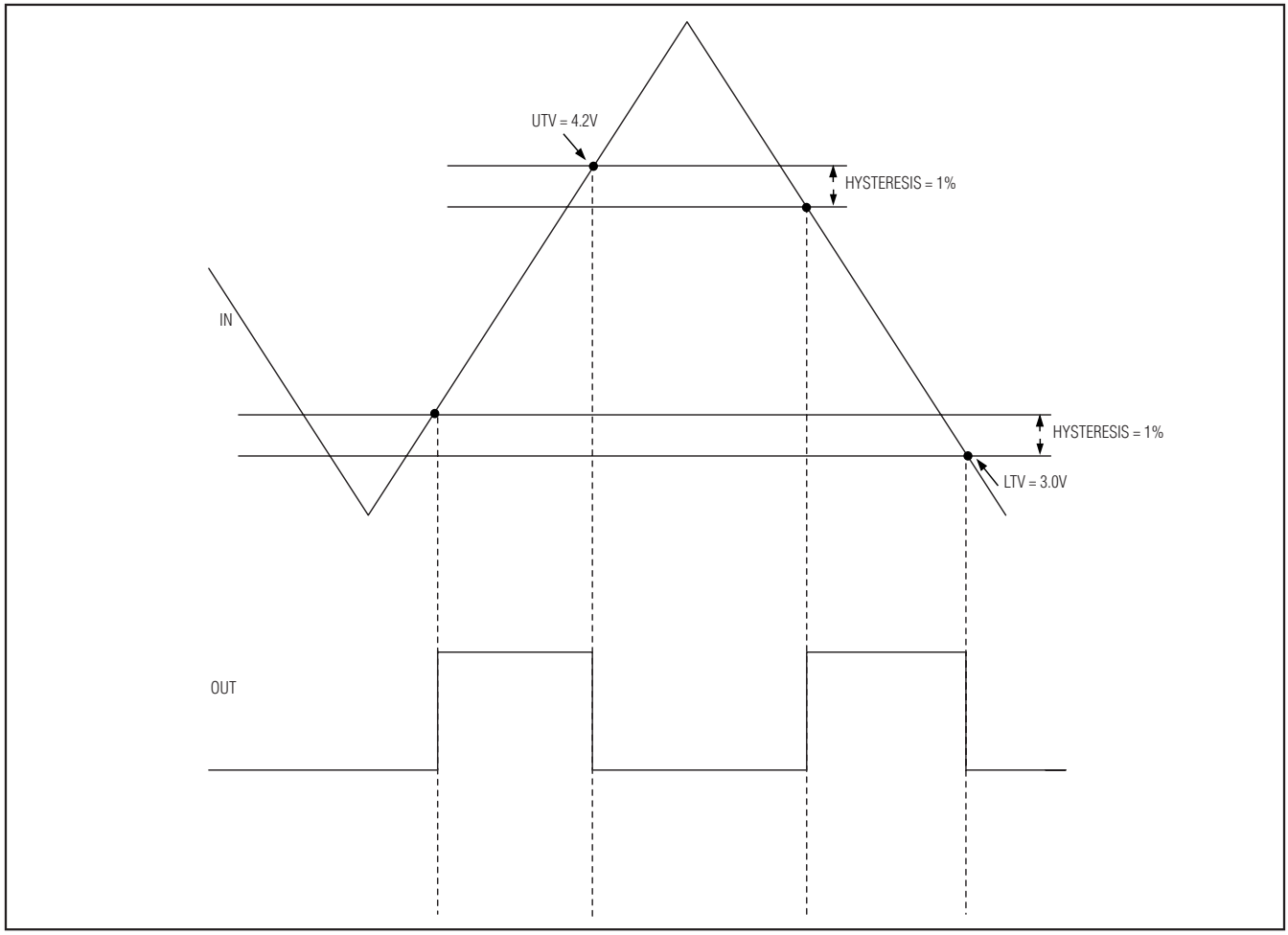


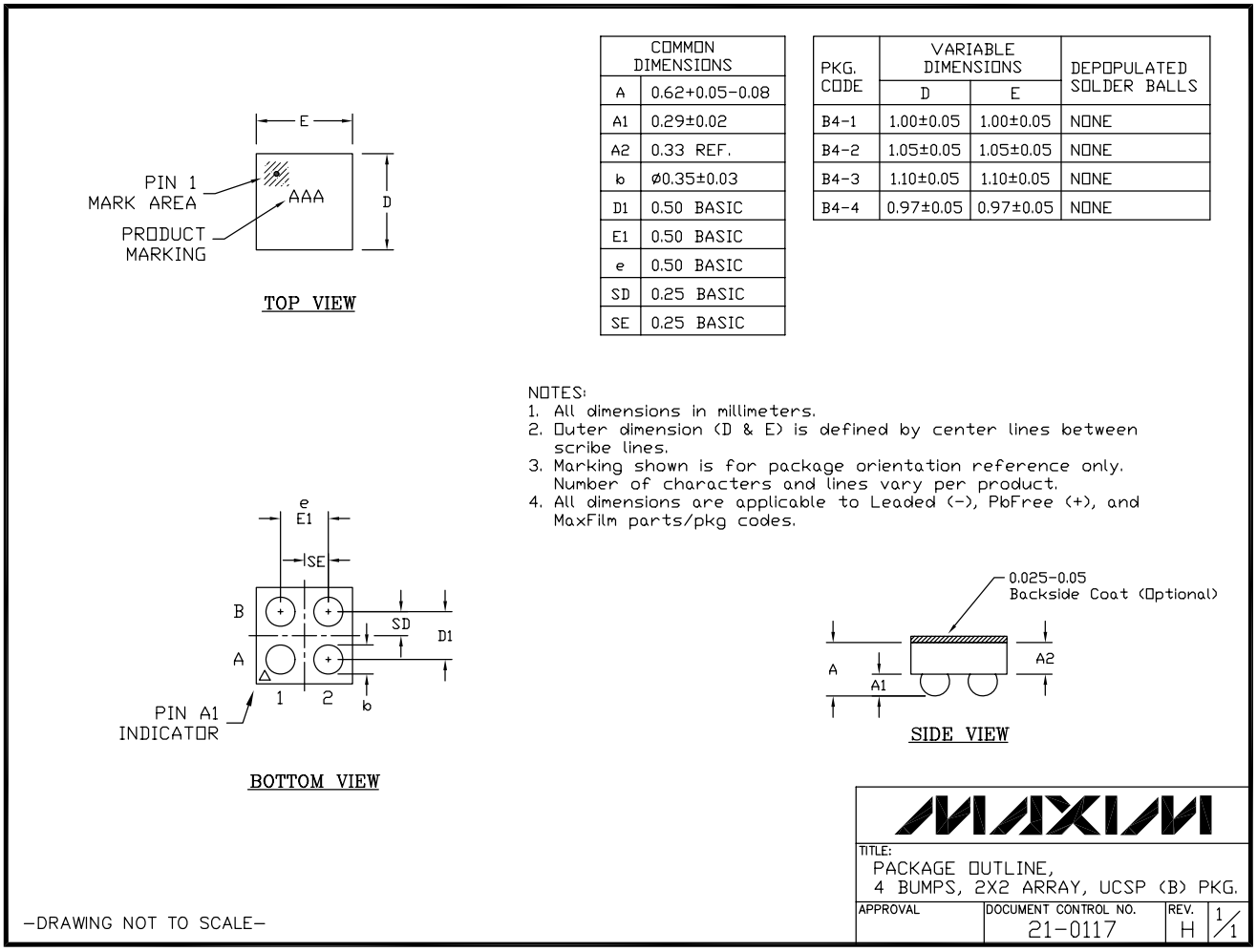

*Figure 1. Hysteresis Trip Points*

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

## Package Information

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

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|---|---|---|---|
| 5 SOT23 | U5+2 | 21-0057 | 90-0174 |
| 4 UCSP | B4+1 | 21-0117 | Refer to Application Note 1891 |




| 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 | 0.50 BASIC |
| e | 0.50 BASIC |
| SD | 0.25 BASIC |
| SE | 0.25 BASIC |

| PKG. CODE | VARIABLE DIMENSIONS | | DEPOPULATED SOLDER BALLS |
|---|---|---|---|
| | D | E | |
| B4-1 | 1.00±0.05 | 1.00±0.05 | NONE |
| B4-2 | 1.05±0.05 | 1.05±0.05 | NONE |
| B4-3 | 1.10±0.05 | 1.10±0.05 | NONE |
| B4-4 | 0.97±0.05 | 0.97±0.05 | NONE |

NOTES:
1. All dimensions in millimeters.
2. Outer dimension (D & E) is defined by center lines between scribe lines.
3. Marking shown is for package orientation reference only. Number of characters and lines vary per product.
4. All dimensions are applicable to Leaded (-), PbFree (+), and MaxFilm parts/pkg codes.

MAXIM

TITLE:
PACKAGE OUTLINE,
4 BUMPS, 2X2 ARRAY, UCSP (B) PKG.

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0117 | H | 1/1 |

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

## Package Information (continued)

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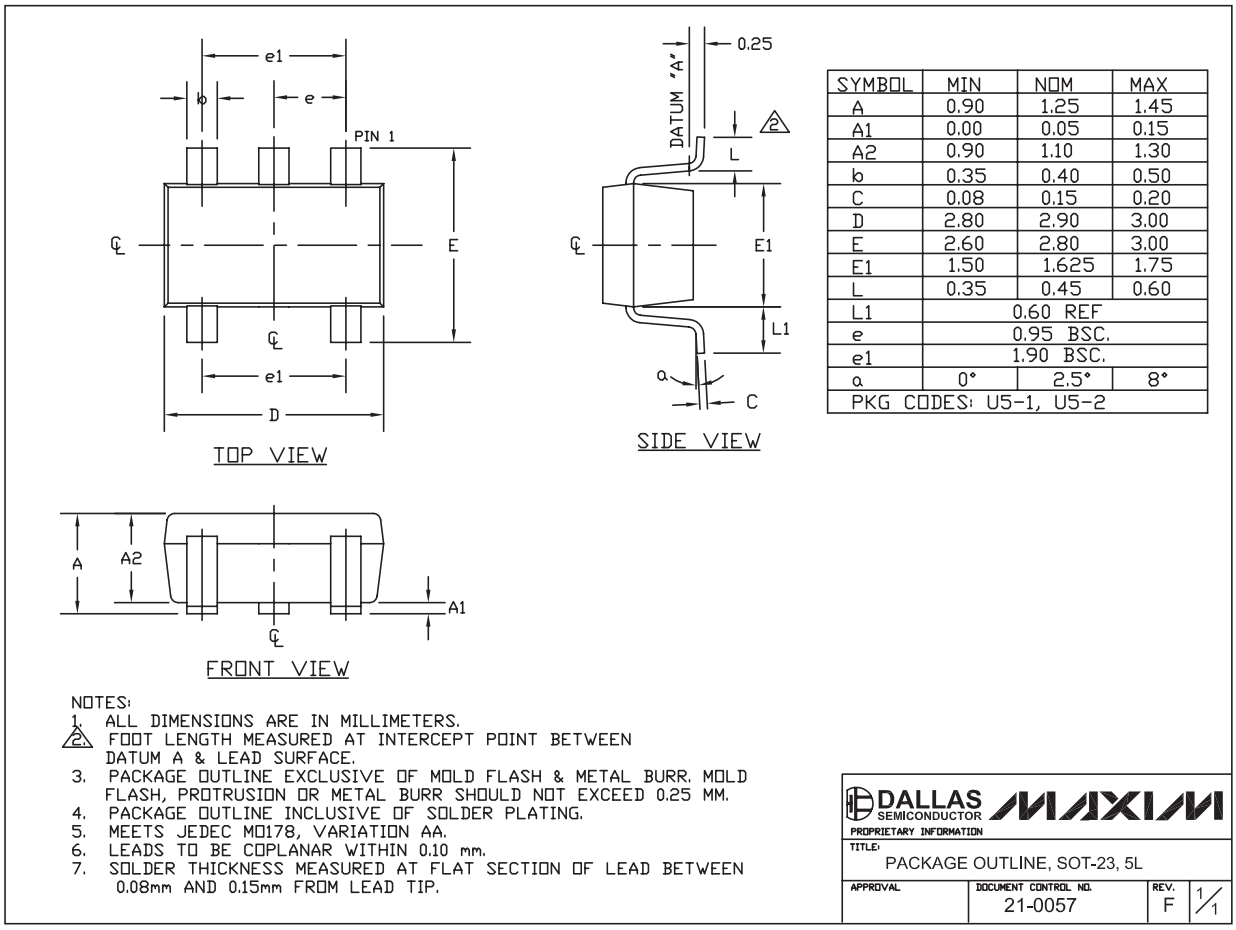


| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 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 |

# Ultra-Small, Low-Power, Window Comparator in 4 UCSP and 5 SOT23

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 7/08 | Initial release | — |
| 1 | 10/08 | Removed future part reference from 5 SOT23 package | 1 |
| 2 | 1/11 | Added G45 designation | 1 |