

# MAX9065

## Ultra-Small, nanoPower, 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.

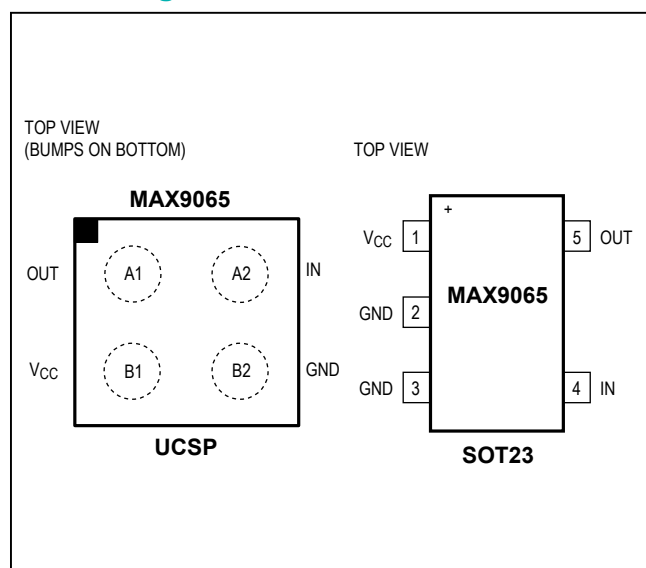
The MAX9065 features a common-mode input range of -0.3V to +5.5V independent of supply voltage. The input current goes to zero when the MAX9065 is powered down ( $V_{CC} = 0$ ). Additionally, the MAX9065 features high RF immunity.

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

### Pin Configurations



UCSP is a trademark of Maxim Integrated Products, Inc.

### 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

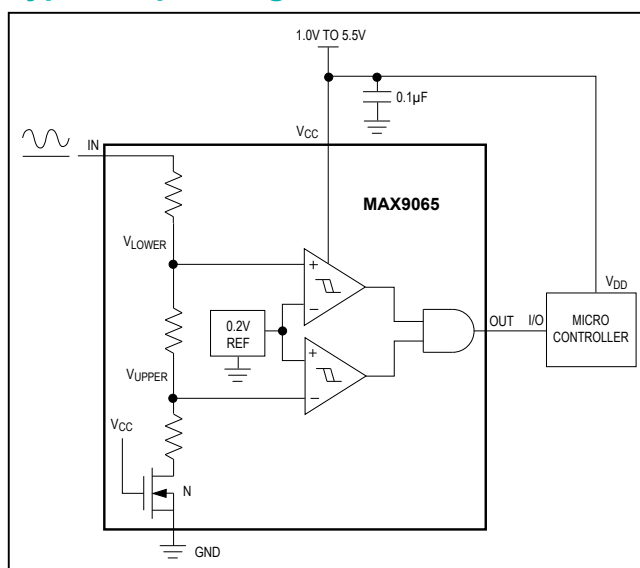
| PART             | PIN-PACKAGE | TOP MARK |
|------------------|-------------|----------|
| MAX9065EBS+G45   | 4 UCSP      | AGC      |
| MAX9065EUK+      | 5 SOT23     | AFFL     |
| MAX9065AEWS+TCNB | 4 WLP       | AGO      |

**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.

### Typical Operating Circuit



## 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 .....  $\pm 20mA$   
 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  
   4-Bump WLP (derate 3mW/°C above +70°C) ..... 915mW

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

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

| PARAMETER                        | SYMBOL               | CONDITIONS                                                               |                                | MIN                   | TYP  | MAX   | UNITS |    |
|----------------------------------|----------------------|--------------------------------------------------------------------------|--------------------------------|-----------------------|------|-------|-------|----|
| DC CHARACTERISTICS               |                      |                                                                          |                                |                       |      |       |       |    |
| Upper Threshold Voltage          | UTV                  | MAX9065EBS+<br>4 UCSP                                                    | T <sub>A</sub> = +25°C         | 4.158                 | 4.20 | 4.242 | V     |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 4.10                  |      | 4.30  |       |    |
|                                  |                      | MAX9065EUK+<br>5 SOT23                                                   | T <sub>A</sub> = +25°C         | 4.04                  | 4.20 | 4.36  |       |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 3.98                  |      | 4.42  |       |    |
|                                  |                      | MAX9065AEBS+<br>4 UCSP                                                   | T <sub>A</sub> = +25°C         | 1.152                 | 1.20 | 1.248 |       |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 1.132                 |      | 1.268 |       |    |
| Lower Threshold Voltage          | LTV                  | MAX9065EBS+<br>4 UCSP                                                    | T <sub>A</sub> = +25°C         | 2.94                  | 3.00 | 3.06  | V     |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 2.92                  |      | 3.08  |       |    |
|                                  |                      | MAX9065EUK+<br>5 SOT23                                                   | T <sub>A</sub> = +25°C         | 2.88                  | 3.00 | 3.12  |       |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 2.83                  |      | 3.17  |       |    |
|                                  |                      | MAX9065AEBS+<br>4 UCSP                                                   | T <sub>A</sub> = +25°C         | 0.576                 | 0.60 | 0.624 |       |    |
|                                  |                      |                                                                          | -40°C < T <sub>A</sub> < +85°C | 0.566                 |      | 0.634 |       |    |
| Input Voltage Range              | V <sub>IN</sub>      |                                                                          |                                | -0.3                  |      | +5.5  | V     |    |
| Hysteresis                       | V <sub>HYS</sub>     | (Note 2)                                                                 |                                | ±1.0                  |      |       | %     |    |
| Resistor String Input Resistance | R <sub>IN</sub>      |                                                                          |                                | 5.8                   | 11   | 17.7  | MΩ    |    |
| Input Shutdown Current           | I <sub>IN_SHDN</sub> | V <sub>CC</sub> = 0V, V <sub>IN</sub> = 5.5V                             |                                | 1                     |      |       | 15    | nA |
| Output Voltage Low               | V <sub>OL</sub>      | I <sub>SINK</sub> = 100μA, V <sub>CC</sub> = 1V, T <sub>A</sub> = +25°C  |                                |                       |      |       | 0.2   | V  |
|                                  |                      | I <sub>SINK</sub> = 1.2mA, V <sub>CC</sub> = 3.3V                        |                                |                       |      |       | 0.3   |    |
|                                  |                      | I <sub>SINK</sub> = 1.2mA, V <sub>CC</sub> = 5.5V                        |                                |                       |      |       | 0.5   |    |
| Output Voltage High              | V <sub>OH</sub>      | I <sub>SOURCE</sub> = 25μA, V <sub>CC</sub> = 1V, T <sub>A</sub> = +25°C |                                | V <sub>CC</sub> - 0.2 |      |       | V     |    |
|                                  |                      | I <sub>SOURCE</sub> = 0.3mA, V <sub>CC</sub> = 3.3V                      |                                | V <sub>CC</sub> - 0.3 |      |       |       |    |
|                                  |                      | I <sub>SOURCE</sub> = 0.75mA, V <sub>CC</sub> = 5.5V                     |                                | V <sub>CC</sub> - 0.5 |      |       |       |    |
| AC CHARACTERISTICS               |                      |                                                                          |                                |                       |      |       |       |    |
| Propagation Delay                | t <sub>PD</sub>      | Overdrive = ±100mV (Notes 3, 4)                                          |                                | 25                    |      |       | μs    |    |
| Fall Time                        | t <sub>F</sub>       | C <sub>L</sub> = 10pF                                                    |                                | 14                    |      |       | ns    |    |
| Rise Time                        | t <sub>R</sub>       | C <sub>L</sub> = 10pF                                                    |                                | 30                    |      |       | ns    |    |

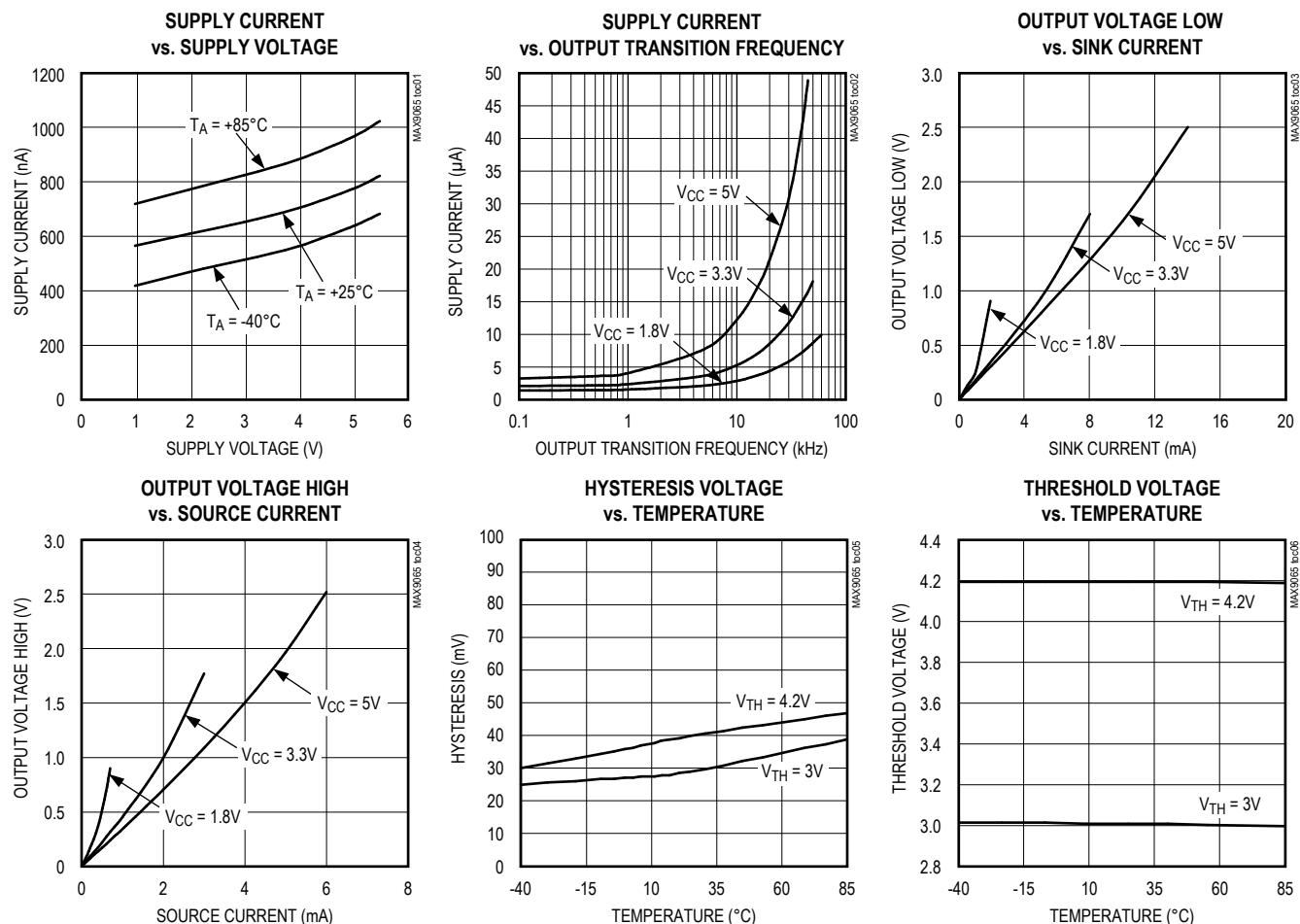
## Electrical Characteristics (continued)

(V<sub>CC</sub> = 3.3V, T<sub>A</sub> = -40°C to +85°C. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

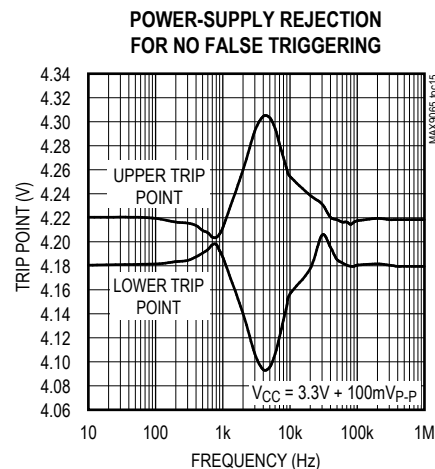
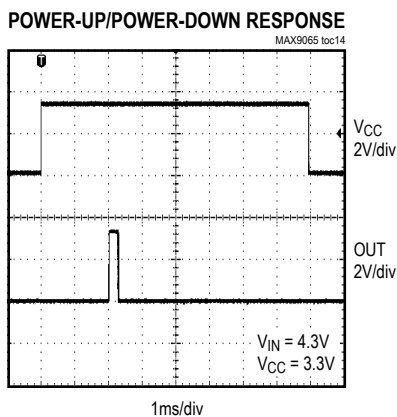
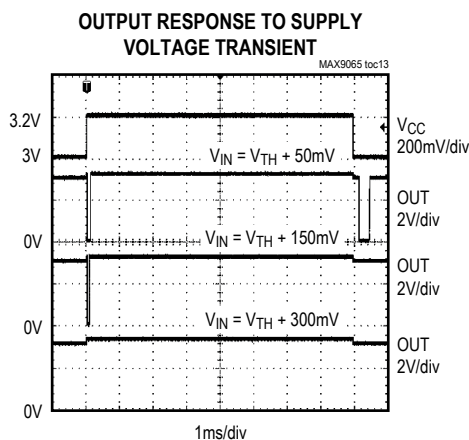
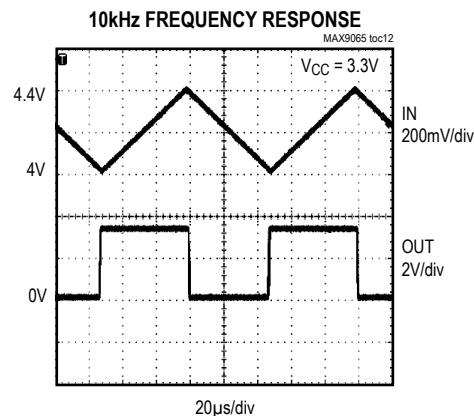
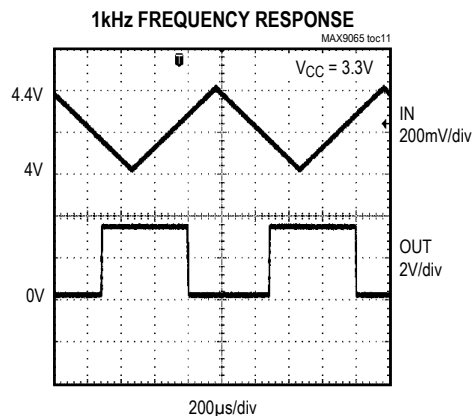
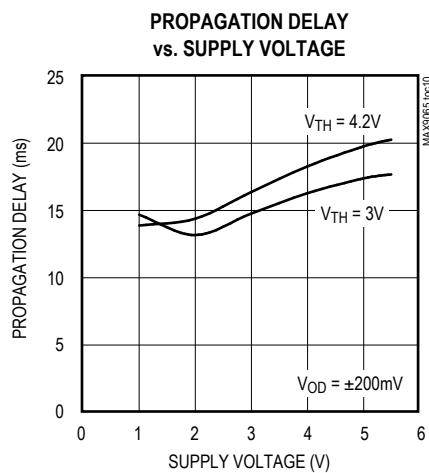
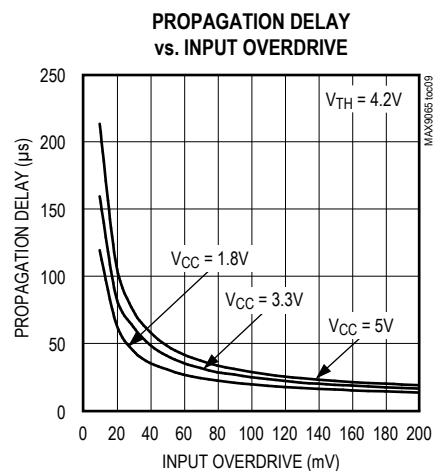
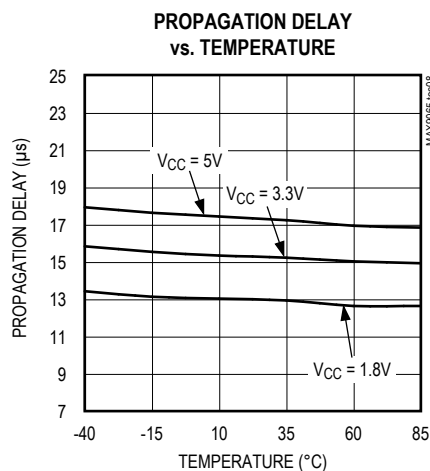
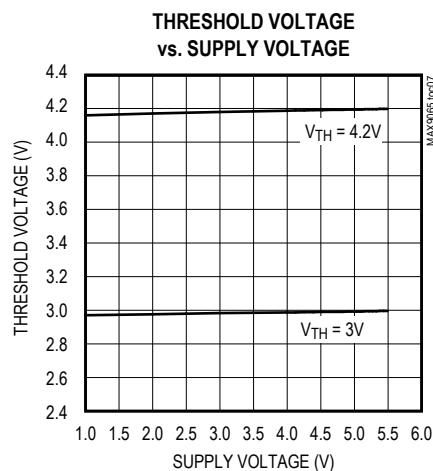
| PARAMETER                    | SYMBOL          | CONDITIONS                                             | MIN | TYP | MAX  | UNITS |
|------------------------------|-----------------|--------------------------------------------------------|-----|-----|------|-------|
| <b>POWER SUPPLY</b>          |                 |                                                        |     |     |      |       |
| Supply Voltage               | V <sub>CC</sub> | Guaranteed by V <sub>OS</sub> tests                    | 1   |     | 5.5  | V     |
| Supply Current               | I <sub>CC</sub> | V <sub>CC</sub> = 5.5V                                 |     | 0.7 | 1.35 | μA    |
|                              |                 | V <sub>CC</sub> = 1.0V, T <sub>A</sub> = +25°C         |     | 0.6 | 1.0  |       |
| Power-Supply Rejection Ratio | PSRR            | V <sub>CC</sub> = 0.9V to 5.5V, T <sub>A</sub> = +25°C | 40  | 53  |      | dB    |
| Power-Up Time                | t <sub>ON</sub> |                                                        |     | 3   |      | ms    |

**Note 1:** All devices are 100% production tested at T<sub>A</sub> = +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 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<sub>CC</sub> = 3.3V, T<sub>A</sub> = -40°C to +85°C. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.)

## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = 3.3V, T<sub>A</sub> = -40°C to +85°C. Typical values are at T<sub>A</sub> = +25°C, unless otherwise noted.)

## Pin Description

| PIN   |      | NAME            | FUNCTION                                                                  |
|-------|------|-----------------|---------------------------------------------------------------------------|
| SOT23 | UCSP |                 |                                                                           |
| 1     | B1   | V <sub>CC</sub> | External Supply Input.<br>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).

### MAX9065 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<sub>CC</sub>, the n-channel FET at the bottom of the resistor-divider is turned on. The resistor-divider provides two voltages, V<sub>UPPER</sub> and V<sub>LOWER</sub>, for comparison with an internal 0.2V reference voltage. When the input voltage exceeds 4.2V, V<sub>UPPER</sub> is greater than 0.2V, causing the output to assert low. When the input voltage falls below 3.0V, V<sub>LOWER</sub> 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.

When V<sub>CC</sub> goes to 0V, the n-channel FET is turned off, eliminating the resistor-divider as a leakage path for current.

**Table 1. MAX9065 Operation**

| INPUT VOLTAGE                 | OUTPUT |
|-------------------------------|--------|
| V <sub>IN</sub> > 4.2V        | Low    |
| 3.0V < V <sub>IN</sub> < 4.2V | High   |
| V <sub>IN</sub> < 3.0V        | Low    |

**Table 2. MAX9065A Operation**

| INPUT VOLTAGE                 | OUTPUT |
|-------------------------------|--------|
| V <sub>IN</sub> > 1.2V        | Low    |
| 0.6V < V <sub>IN</sub> < 1.2V | High   |
| V <sub>IN</sub> < 0.6V        | Low    |

### MAX9065A Operation

The resistor-divider provides two voltages, V<sub>UPPER</sub> and V<sub>LOWER</sub>, for comparison with an internal 0.2V reference voltage. When the input voltage exceeds 1.2V, V<sub>UPPER</sub> is greater than 0.2V, causing the output to assert low.

When the input voltage falls below 0.6V, V<sub>LOWER</sub> is less than 0.2V, causing the output also to assert low. With the input voltage between 0.6V and 1.2V, the output asserts high, indicating that the input voltage is within the desired range. [Table 2](#) summarizes the operation of the MAX9065A.

## 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<sub>CC</sub> with a 0.1µF capacitor to ground.

## Chip Information

PROCESS: BiCMOS

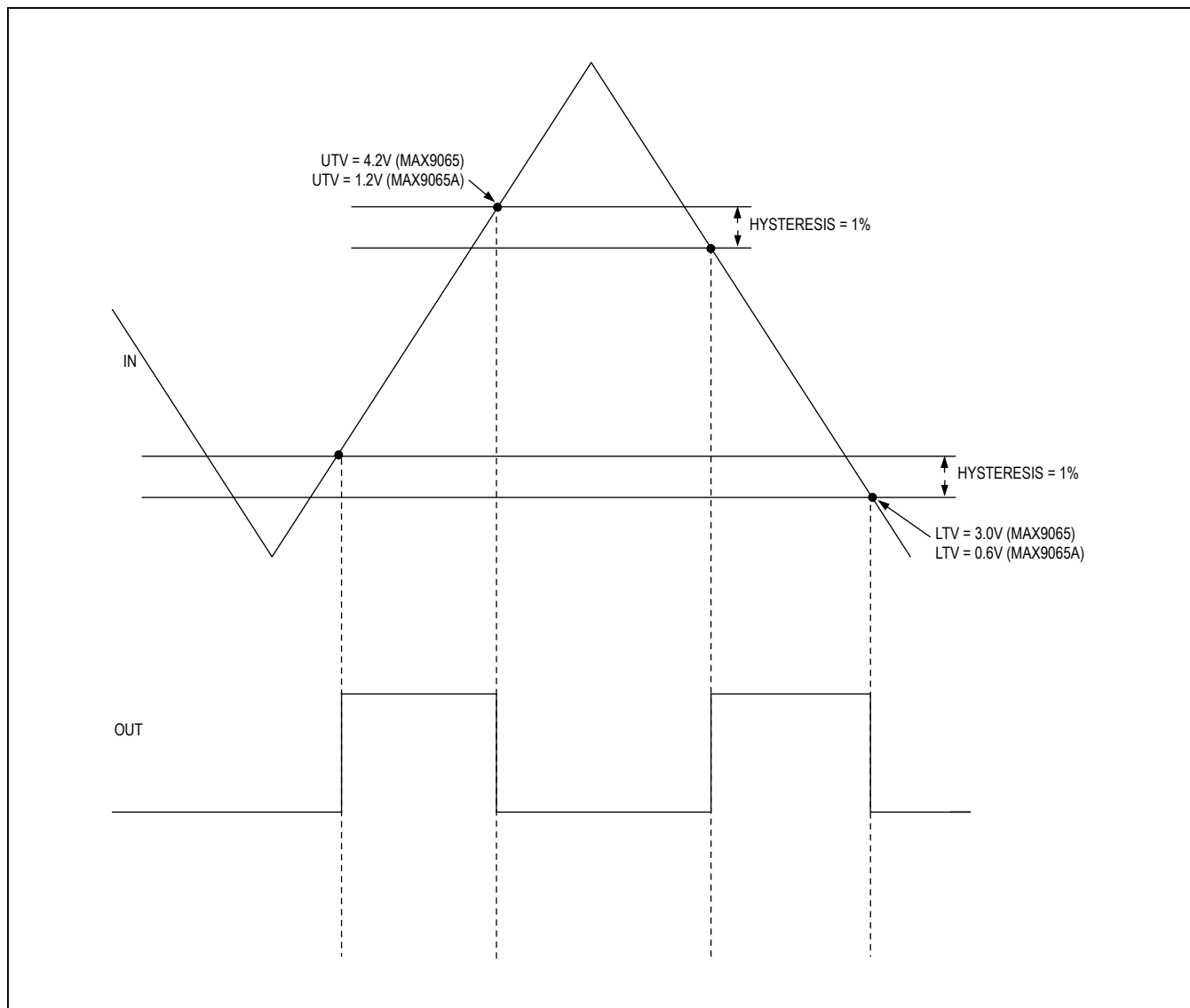
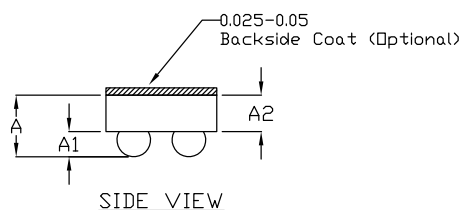
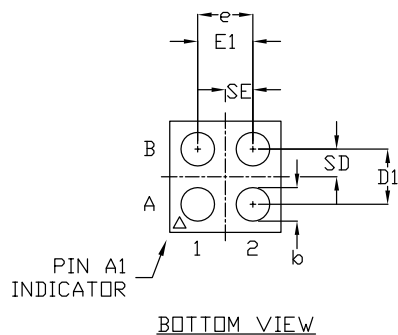
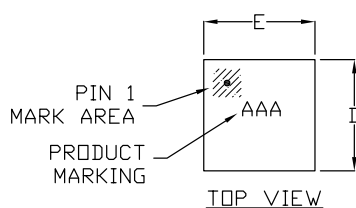


Figure 1. Hysteresis Trip Points

## Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://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.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.                               |
|--------------|--------------|-------------------------|------------------------------------------------|
| 5 SOT23      | U5+2         | <a href="#">21-0057</a> | <a href="#">90-0174</a>                        |
| 4 UCSP       | B4+1         | <a href="#">21-0117</a> | Refer to <a href="#">Application Note 1891</a> |
| 4 WLP        | W41E1+1      | <a href="#">21-0885</a> | <a href="#">90-0366</a>                        |



| COMMON DIMENSIONS |                |
|-------------------|----------------|
| A                 | 0.62±0.05-0.08 |
| A1                | 0.29±0.02      |
| A2                | 0.33 REF.      |
| b                 | ∅0.35±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         |                          |
| B4-2      | 1.05±0.05           | 1.05±0.05 | NONE                     |
| B4-3      | 1.10±0.05           | 1.10±0.05 | NONE                     |

### NOTES:

- ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
- MATERIAL MUST COMPLY WITH BANNED AND RESTRICTED SUBSTANCES SPEC #10-0131.
- OUTER DIMENSION (D & E) IS DEFINED BY CENTER LINES BETWEEN SCRIBE LINES.
- MARKING SHOWN IS FOR PACKAGE ORIENTATION REFERENCE ONLY. NUMBER OF CHARACTERS AND LINES VARY PER PRODUCT.
- ALL DIMENSIONS APPLY BOTH TO LEAD FREE (+) & LEADED (-) PKG. CODES.
- PACKAGE CODE: B4-2, B4-3



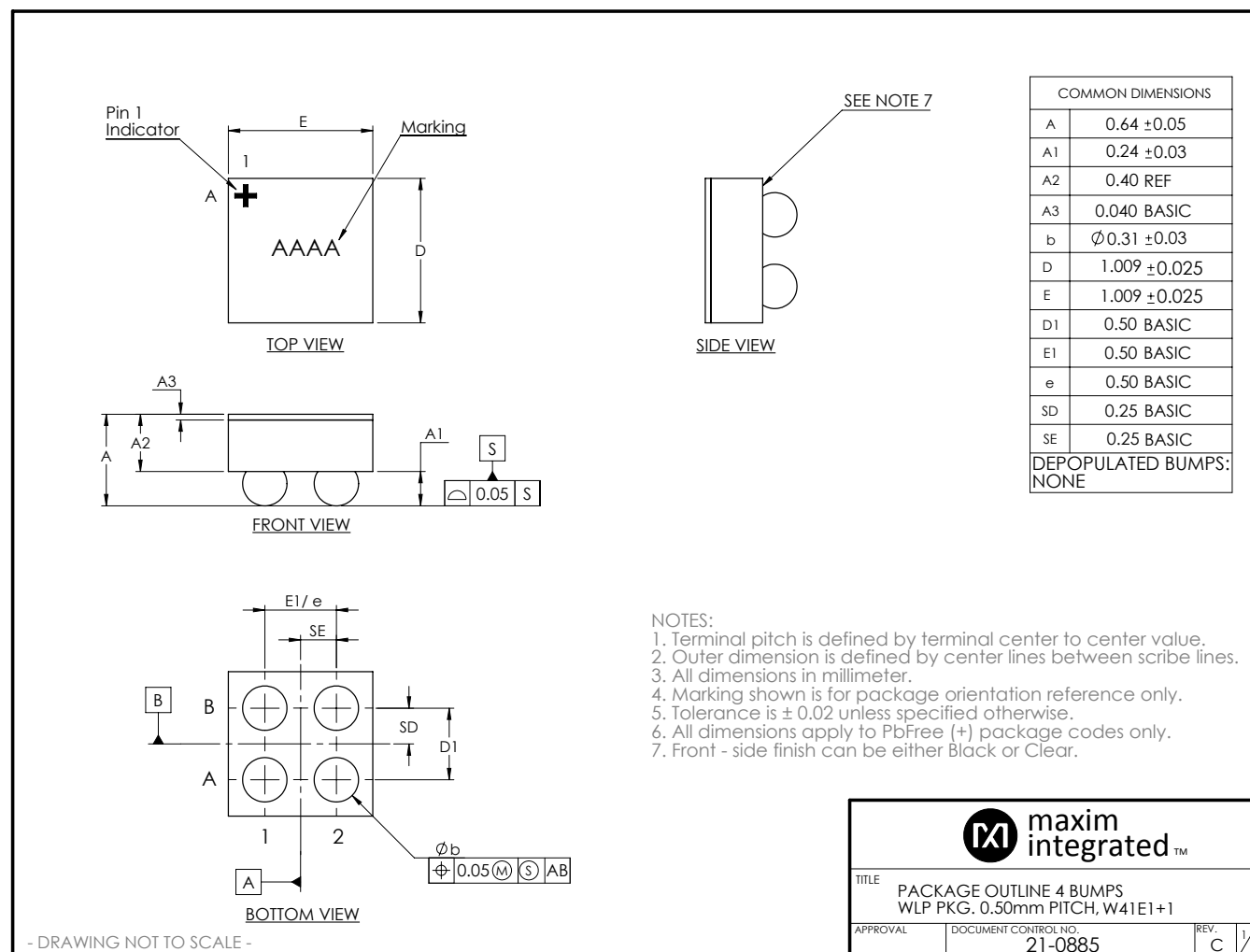
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PACKAGE OUTLINE, 4 BUMPS UCSP (B),  
2X2 ARRAY

|          |                                 |           |     |
|----------|---------------------------------|-----------|-----|
| APPROVAL | DOCUMENT CONTROL NO.<br>21-0117 | REV.<br>J | 1/1 |
|----------|---------------------------------|-----------|-----|

—DRAWING NOT TO SCALE—

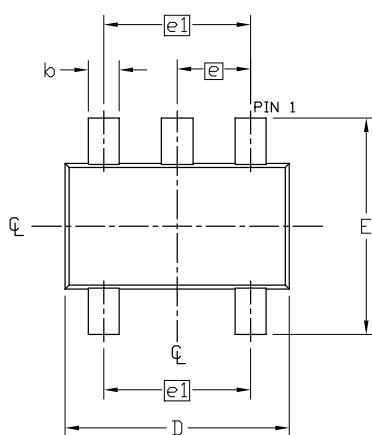
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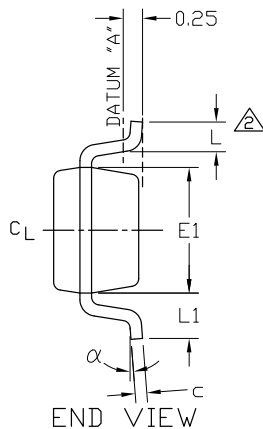


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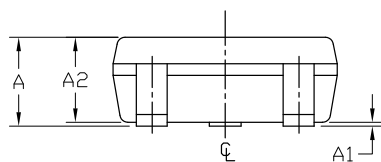


TOP VIEW



END VIEW

| 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. |       |      |
| $\alpha$ | 0°        | 2.5°  | 8°   |



SIDE VIEW

## NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
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. MEETS JEDEC MO178, VARIATION AA.
5. LEADS TO BE COPLANAR WITHIN 0.10 mm.
6. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
7. MATERIAL MUST BE COMPLIANT WITH MAXIM SPECIFICATION 10-0131 FOR SUBSTANCE CONTENT, MUST BE  $E_6$  ROHS COMPLIANT WITHOUT EXEMPTION AND PB-FREE.
8. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.
9. PKG CODES: U5-1/U5+1, U5-2/U5+2

-DRAWING NOT TO SCALE-



TITLE:  
PACKAGE OUTLINE,  
5L SOT23

|          |                                 |           |     |
|----------|---------------------------------|-----------|-----|
| APPROVAL | DOCUMENT CONTROL NO.<br>21-0057 | REV.<br>I | 1/1 |
|----------|---------------------------------|-----------|-----|

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                                               | PAGES<br>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                |
| 3                  | 8/15             | Corrected error in <i>Typical Operating Circuit</i>                       | 1                |
| 4                  | 3/17             | Updated title to include “nanoPower” and updated package outline drawings | 1–10             |

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](http://www.maximintegrated.com).

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В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

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