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

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

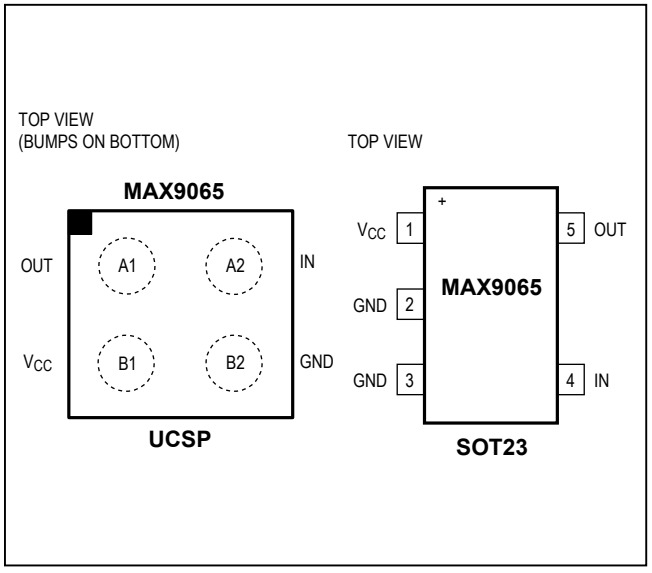
PART	PIN-PACKAGE	TOP MARK
MAX9065EBS+G45	4 UCSP	AGC
MAX9065EUK+	5 SOT23	AFFL
MAX9065AEWS+TCNB	4 WLP	AGO

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

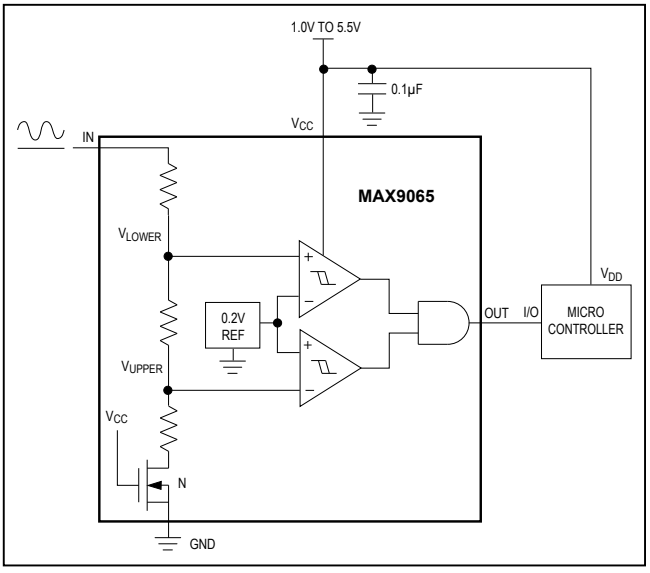
+Denotes a lead-free/RoHS-compliant package.

G45 = Protective die coating.

Pin Configurations



Typical Operating Circuit



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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
4-Bump WLP (derate 3mW/ºC above +70ºC) 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°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	
		MAX9065AEBS+ 4 UCSP	T_A = +25°C	1.152	1.20	1.248	
			-40°C < T_A < +85°C	1.132		1.268	
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	
		MAX9065AEBS+ 4 UCSP	T_A = +25°C	0.576	0.60	0.624	
			-40°C < T_A < +85°C	0.566		0.634	
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

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)

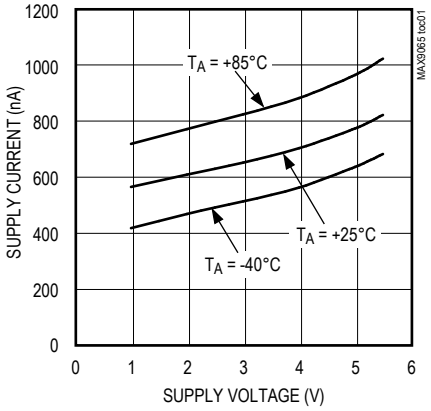
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Supply Voltage	V_{CC}	Guaranteed by V_{OS} tests	1		5.5	V
Supply Current	I_{CC}	V_{CC} = 5.5V		0.7	1.35	µA
		V_{CC} = 1.0V, T_A = +25°C		0.6	1.0	
Power-Supply Rejection Ratio	PSRR	V_{CC} = 0.9V to 5.5V, T_A = +25°C	40	53		dB
Power-Up Time	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.

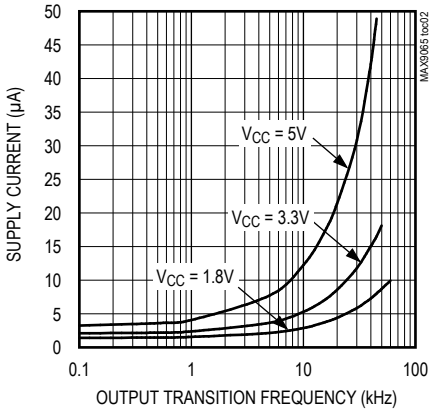
Typical Operating Characteristics

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

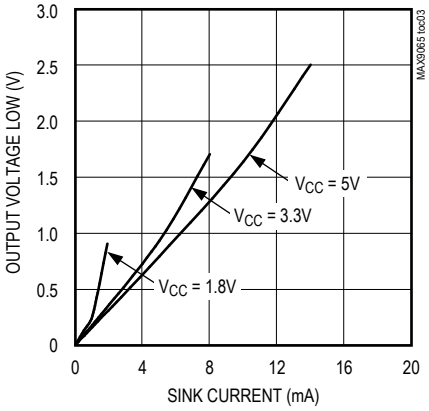
SUPPLY CURRENT vs. SUPPLY VOLTAGE



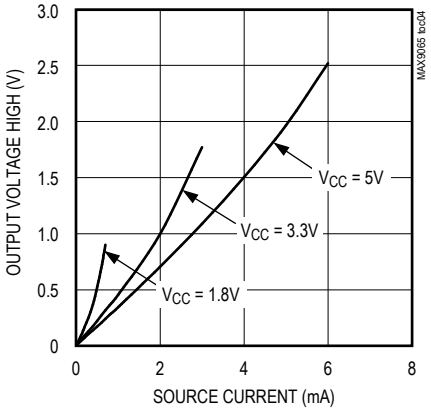
SUPPLY CURRENT vs. OUTPUT TRANSITION FREQUENCY



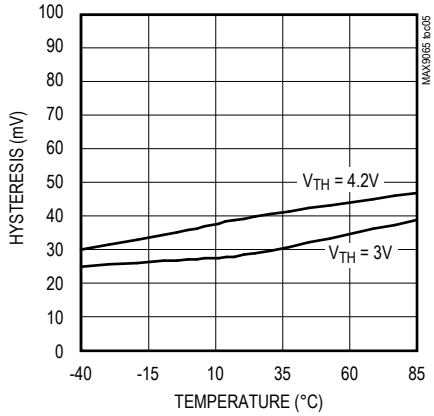
OUTPUT VOLTAGE LOW vs. SINK CURRENT



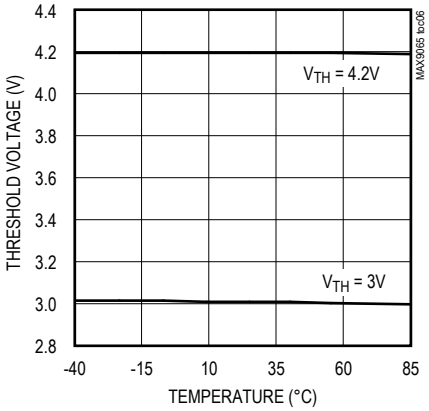
OUTPUT VOLTAGE HIGH vs. SOURCE CURRENT



HYSTERESIS VOLTAGE vs. TEMPERATURE



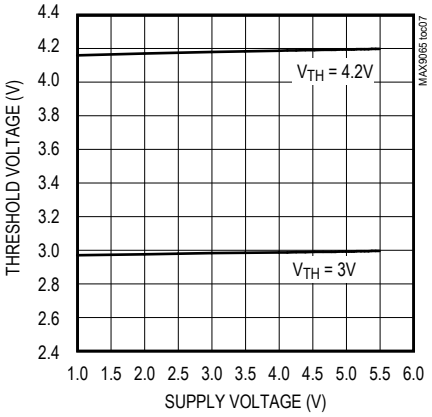
THRESHOLD VOLTAGE vs. TEMPERATURE



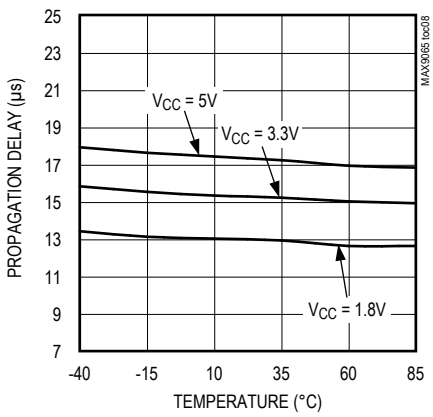
Typical Operating Characteristics (continued)

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

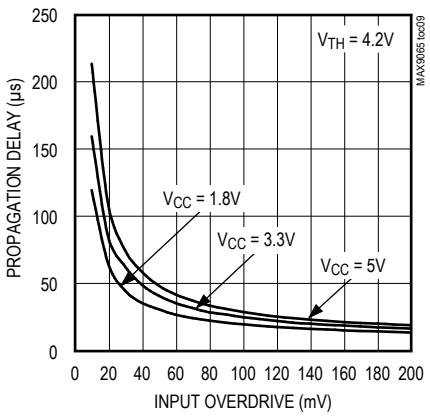
THRESHOLD VOLTAGE vs. SUPPLY VOLTAGE



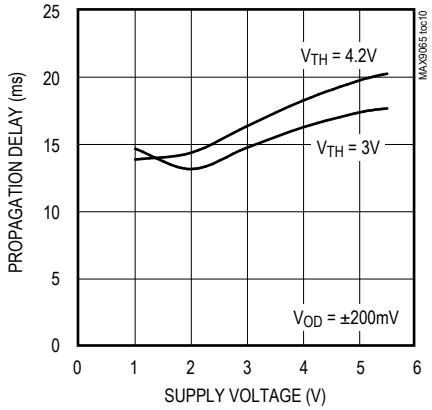
PROPAGATION DELAY vs. TEMPERATURE



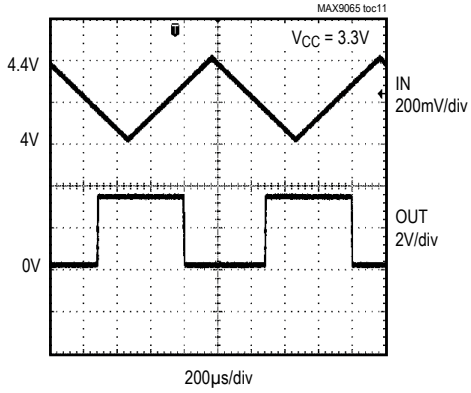
PROPAGATION DELAY vs. INPUT OVERDRIVE



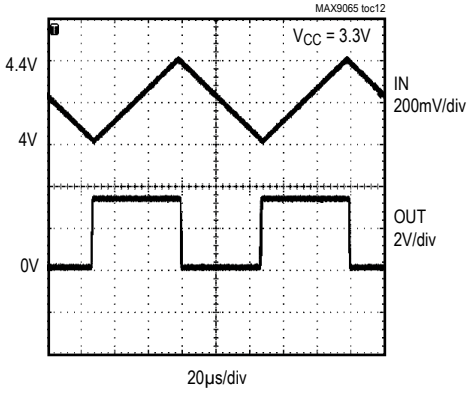
PROPAGATION DELAY vs. SUPPLY VOLTAGE



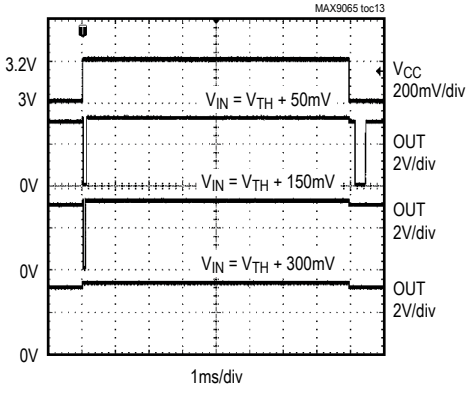
1kHz FREQUENCY RESPONSE



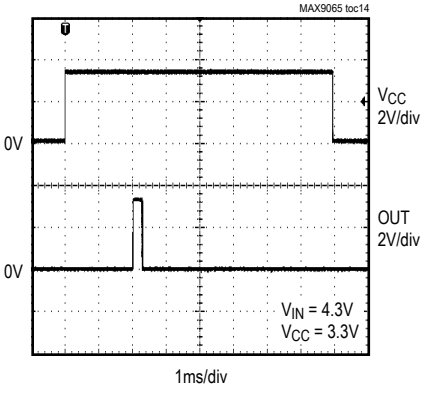
10kHz FREQUENCY RESPONSE



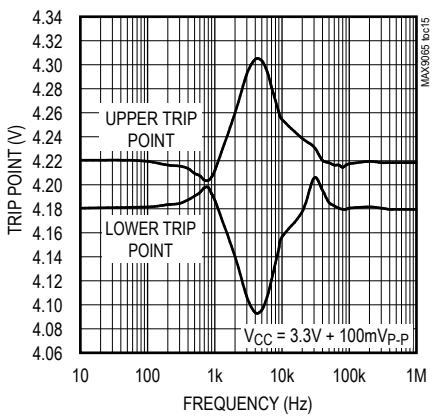
OUTPUT RESPONSE TO SUPPLY VOLTAGE TRANSIENT



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).

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_{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.

When V_{CC} 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_{IN} > 4.2V	Low
3.0V < V_{IN} < 4.2V	High
V_{IN} < 3.0V	Low

Table 2. MAX9065A Operation

INPUT VOLTAGE	OUTPUT
V_{IN} > 1.2V	Low
0.6V < V_{IN} < 1.2V	High
V_{IN} < 0.6V	Low

MAX9065A Operation

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 1.2V, V_{UPPER} is greater than 0.2V, causing the output to assert low.

When the input voltage falls below 0.6V, V_{LOWER} 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_{CC} with a 0.1µF capacitor to ground.

Chip Information

PROCESS: BiCMOS

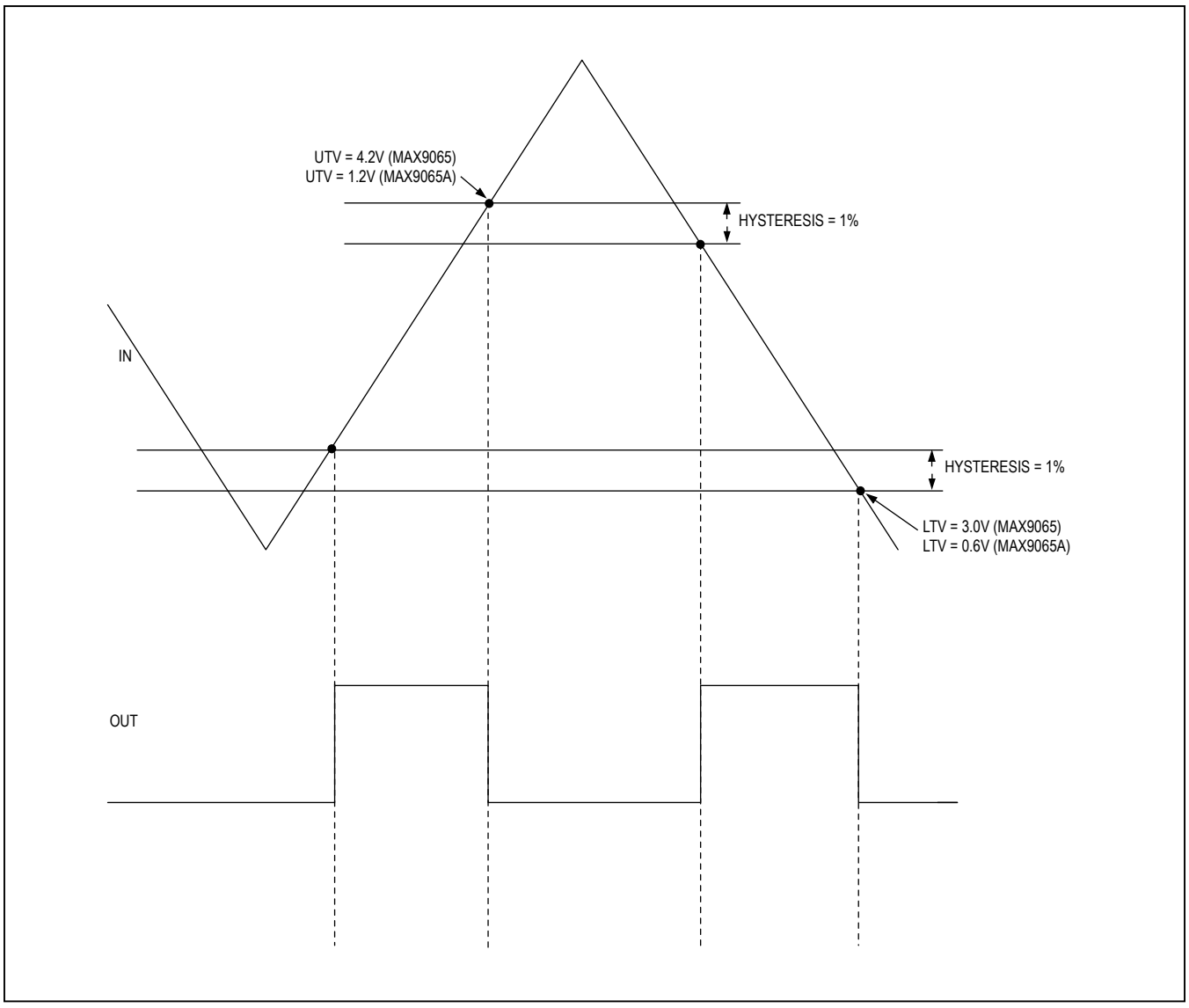
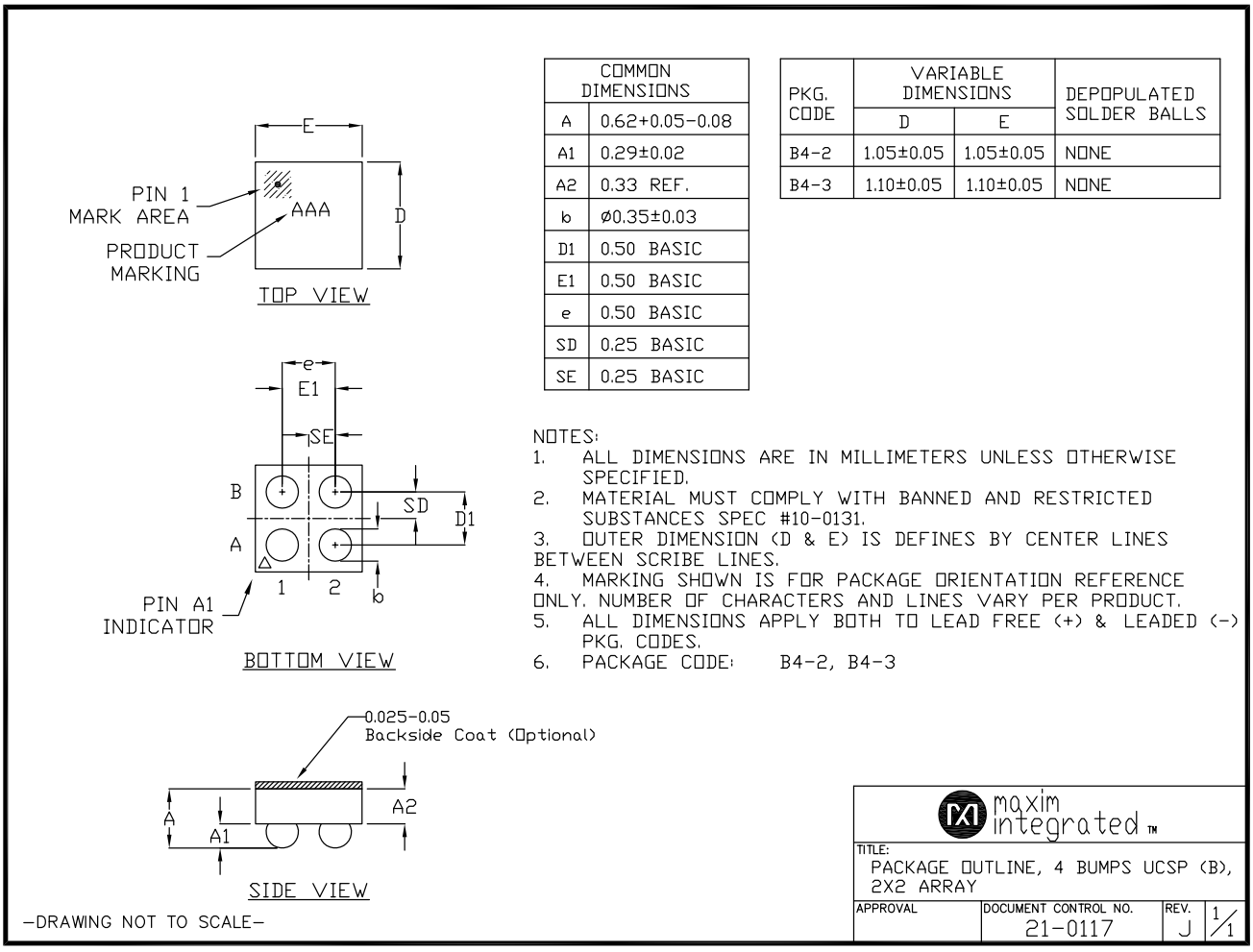


Figure 1. Hysteresis Trip Points

Package Information

For the latest package outline information and land patterns (footprints), go to www.maximintegrated.com/packages. 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
4 WLP	W41E1+1	21-0885	90-0366



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	
B4-2	1.05±0.05	1.05±0.05	NONE
B4-3	1.10±0.05	1.10±0.05	NONE

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

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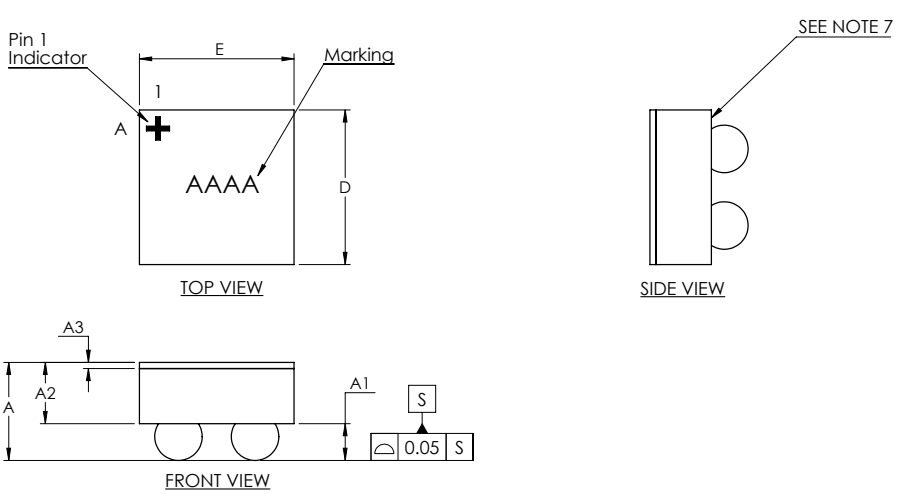
TITLE: PACKAGE OUTLINE, 4 BUMPS UCSP (B), 2X2 ARRAY

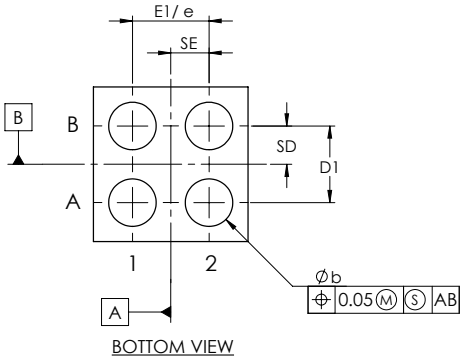
APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0117	J	1/1

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.



COMMON DIMENSIONS	
A	0.64 ±0.05
A1	0.24 ±0.03
A2	0.40 REF
A3	0.040 BASIC
b	∅0.31 ±0.03
D	1.009 ±0.025
E	1.009 ±0.025
D1	0.50 BASIC
E1	0.50 BASIC
e	0.50 BASIC
SD	0.25 BASIC
SE	0.25 BASIC
DEPOPULATED BUMPS: NONE	



NOTES:
1. Terminal pitch is defined by terminal center to center value.
2. Outer dimension is defined by center lines between scribe lines.
3. All dimensions in millimeter.
4. Marking shown is for package orientation reference only.
5. Tolerance is ± 0.02 unless specified otherwise.
6. All dimensions apply to PbFree (+) package codes only.
7. Front - side finish can be either Black or Clear.

- DRAWING NOT TO SCALE -

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TITLE
PACKAGE OUTLINE 4 BUMPS
WLP PKG. 0.50mm PITCH, W41E1+1

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0885	C	1/1

Package Information (continued)

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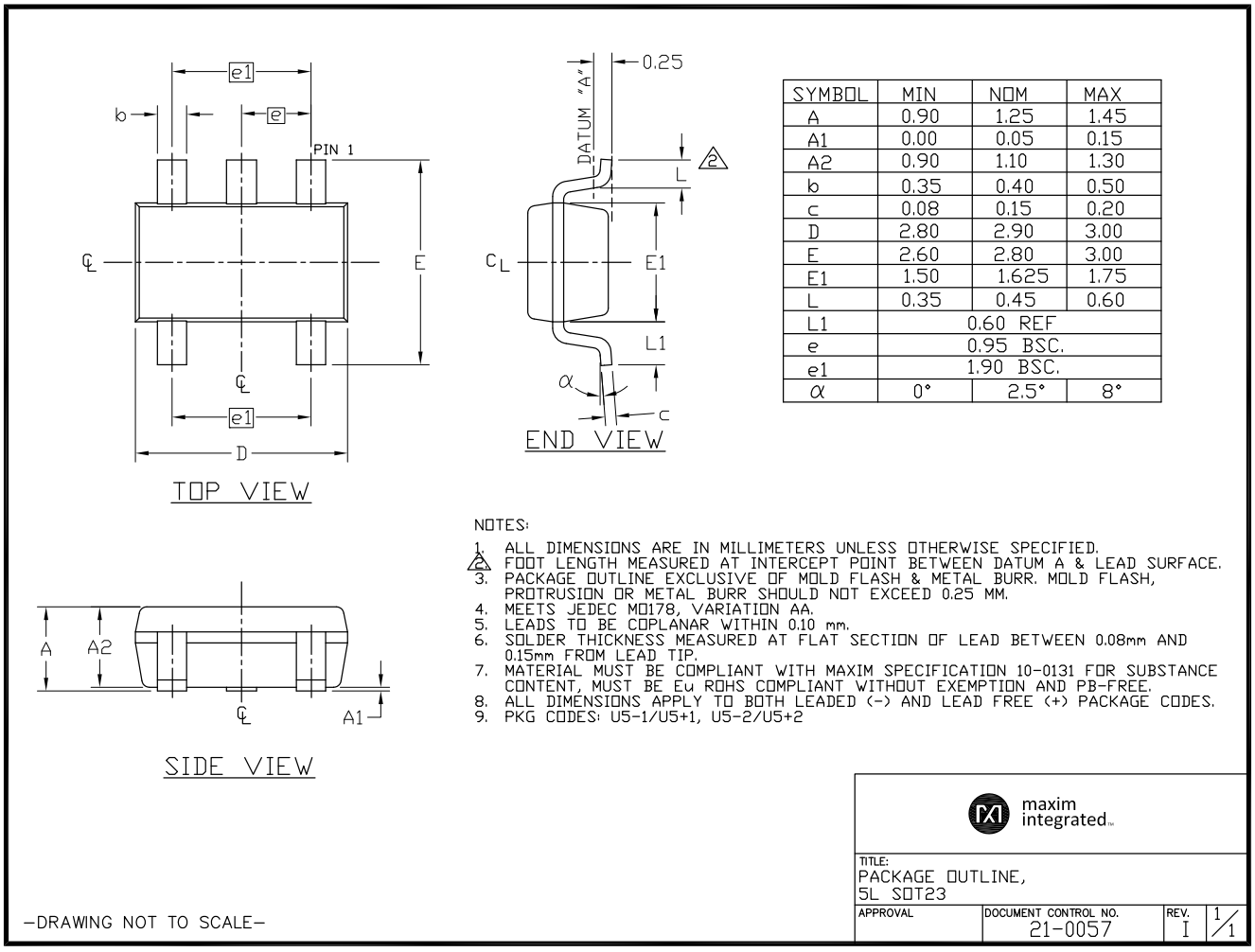

SYMBOL	MIN	NOM	MAX
A	0.90	1.25	1.45
A1	0.00	0.05	0.15
A2	0.90	1.10	1.30
b	0.35	0.40	0.50
c	0.08	0.15	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.625	1.75
L	0.35	0.45	0.60
L1	0.60 REF		
e	0.95 BSC.		
e1	1.90 BSC.		
α	0°	2.5°	8°

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
3	8/15	Corrected error in *Typical Operating Circuit*	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.

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