

### GENERAL DESCRIPTION

The SGM40659/60/61 over-voltage protection devices feature a low 27m $\Omega$  (TYP) on-resistance high current integrated MOSFET which actively protect low-voltage systems against voltage supply faults up to +28V<sub>DC</sub>.

An input voltage exceeding the over-voltage threshold will cause the internal MOSFET to turn off, preventing excessive voltage from damaging downstream devices. When the OVLO input is connected to GND, the SGM40659/60/61 automatically choose the internal fixed OVLO threshold, preset to be typical 15.61V/ 6.80V/5.94V (SGM40659/60/61). The over-voltage protection threshold can be adjusted with optional external resistors to any voltage between 4V and 20V.

In case the device temperature exceeds the maximum junction temperature, the device switches off.

The SGM40659/60/61 are available in Green WLCSP-1.30×0.94-6B package, and operate over an ambient temperature range of -40°C to +85°C.

### FEATURES

- Wide Input Voltage Range: 2.5V to 28V
- Up to 4A Current Capability
- Integrated 27m $\Omega$  (TYP) N-Channel MOSFET
- Fast OVP Turn-Off Response Time: 80ns
- Flexible Over-Voltage Protection Design
  - Internal Preset OVLO Thresholds:
    - Fixed 15.61V (SGM40659)
    - Fixed 6.80V (SGM40660)
    - Fixed 5.94V (SGM40661)
  - Wide Adjustable OVLO Threshold Range from 4V to 20V
- Surge Immunity up to +40V
- Auto-Enabled Switch with 15ms Debounce Time
- Under-Voltage (UVLO), Short-Circuit and Thermal Shutdown Protection
- -40°C to +85°C Operating Temperature Range
- Available in Green WLCSP-1.30×0.94-6B Package

### APPLICATIONS

Smart Phones  
Mobile Internet Devices  
Tablet Computers  
Peripherals

### TYPICAL APPLICATION

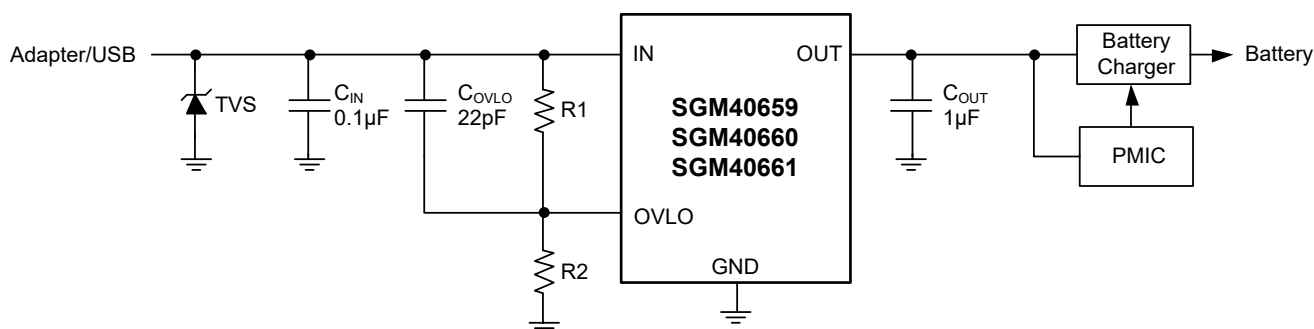


Figure 1. Typical Application Circuit

## SGM40659 SGM40660/SGM40661 Adjustable Over-Voltage Protection Switches

## PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM40659	WLCSP-1.30×0.94-6B	-40°C to +85°C	SGM40659YG/TR	6C XX	Tape and Reel, 3000
SGM40660	WLCSP-1.30×0.94-6B	-40°C to +85°C	SGM40660YG/TR	6E XX	Tape and Reel, 3000
SGM40661	WLCSP-1.30×0.94-6B	-40°C to +85°C	SGM40661YG/TR	4A XX	Tape and Reel, 3000

## MARKING INFORMATION

NOTE: XX = Date Code.

**YY** — Serial Number  
**XX**  
└──┬── Date Code - Week  
└──┴── Date Code - Year

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

### ABSOLUTE MAXIMUM RATINGS

Input Voltage Range, IN .....	-0.3V to 28V
Output Voltage Range, OUT .....	-0.3V to $V_{IN} + 0.3V$
OVLO Pin, OVLO.....	-0.3V to 7V
Continuous Current, IN, OUT Current.....	4A
Package Thermal Resistance	
WLCSP-1.30×0.94-6B, $\theta_{JA}$ .....	110°C/W
Junction Temperature.....	+150°C
Storage Temperature Range .....	-65°C to +150°C
Lead Temperature (Soldering, 10s).....	+260°C
ESD Susceptibility	
HBM.....	4000V
MM.....	400V
CDM .....	1000V

## RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... 2.7V to 20V  
Input to Output Continuous Current ..... 3A  
Output Capacitance Range ..... Up to 100µF  
Operating Temperature Range ..... -40°C to +85°C

## OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

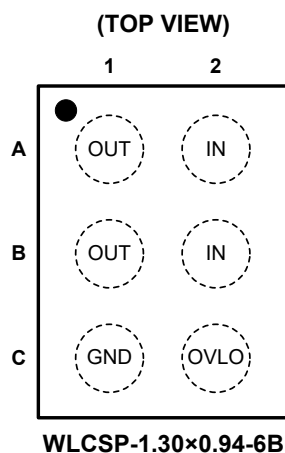
## ESD SENSITIVITY CAUTION

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

## PIN CONFIGURATION



## PIN DESCRIPTION

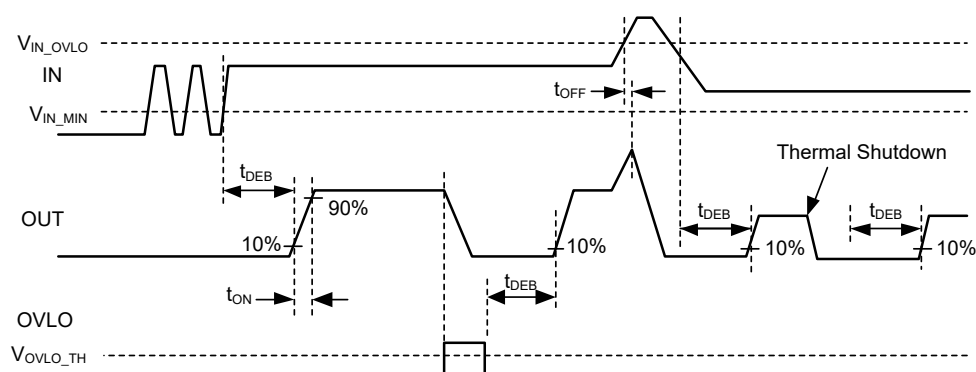
PIN	NAME	FUNCTION
A1, B1	OUT	Output Voltage.
A2, B2	IN	Input Voltage. Bypass IN with a 0.1μF capacitor as close as possible to the device.
C1	GND	Ground.
C2	OVLO	External OVLO Adjustment. Connect OVLO to GND when using the internal threshold. Connect a resistor-divider to OVLO to set a different OVLO threshold.

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = 2.5V$  to  $28V$ ,  $C_{IN} = 0.1\mu F$ , Full =  $-40^{\circ}C$  to  $+85^{\circ}C$ , typical values are at  $V_{IN} = 5V$ ,  $I_{IN} \leq 3A$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
INPUT OPERATION							
Input Voltage Range	V <sub>IN</sub>			2.5		28	V
Input Supply Current	I <sub>IN</sub>	V <sub>IN</sub> = 5V				140	μA
Under-Voltage Lockout Threshold	V <sub>IN_UVLO</sub>	V <sub>IN</sub> rising			2.4		V
Under-Voltage Lockout Hysteresis	V <sub>UVLO_HYS</sub>				0.2		V
OVER-VOLTAGE PROTECTION							
Internal Over-Voltage Trip Level	V <sub>IN_OVLO</sub>	V <sub>IN</sub> rising	SGM40659	15.07	15.61	16.14	V
			SGM40660	6.60	6.80	7.00	
			SGM40661	5.75	5.94	6.12	
		V <sub>IN</sub> falling	SGM40659	14.22	14.76		
			SGM40660	6.24	6.47		
			SGM40661	5.45	5.66		
OVLO Preset Threshold Range	V <sub>OVLO_TH</sub>			1.183	1.213	1.242	V
Adjustable OVLO Threshold Range				4		20	V
External OVLO Select threshold	V <sub>OVLO_SELECT</sub>			0.24	0.27	0.31	V
Switch On-Resistance	R <sub>ON</sub>	V <sub>IN</sub> = 5V, I <sub>OUT</sub> = 0.5A, T <sub>A</sub> = +25°C			27	45	mΩ
OVLO Input Leakage Current	I <sub>OVLO</sub>	V <sub>OVLO</sub> = 1.3V		-100		100	nA
TIMING CHARACTERISTICS							
Debounce Time	t <sub>DEB</sub>	Time from V <sub>IN</sub> > 2.5V to the time V <sub>OUT</sub> starts rising			15		ms
Switch Turn-On Time	t <sub>ON</sub>	V <sub>IN</sub> = 5V, R <sub>L</sub> = 100Ω, C <sub>LOAD</sub> = 100μF, V <sub>OUT</sub> from 10%, V <sub>IN</sub> to 90% V <sub>IN</sub>			2		ms
Switch Turn-Off Time	t <sub>OFF</sub>	V <sub>IN</sub> > V <sub>OVLO</sub> to V <sub>OUT</sub> = 80% of V <sub>IN</sub> , R <sub>L</sub> = 100Ω, V <sub>IN</sub> rising at 2V/μs			80		ns
THERMAL SHUTDOWN							
Thermal Shutdown					150		°C
Thermal Shutdown Hysteresis					60		°C

## TIMING DIAGRAM



NOTE: Waveforms are not to scale.

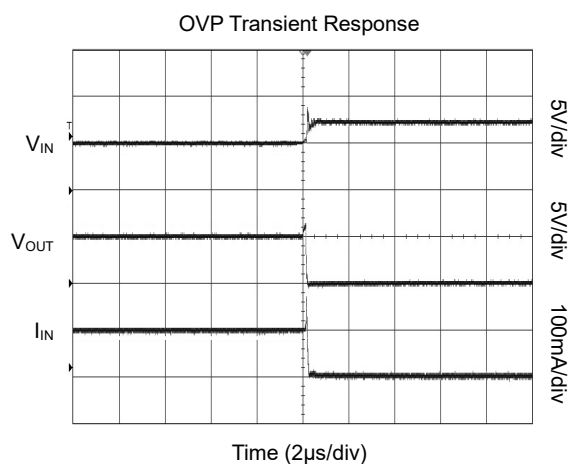
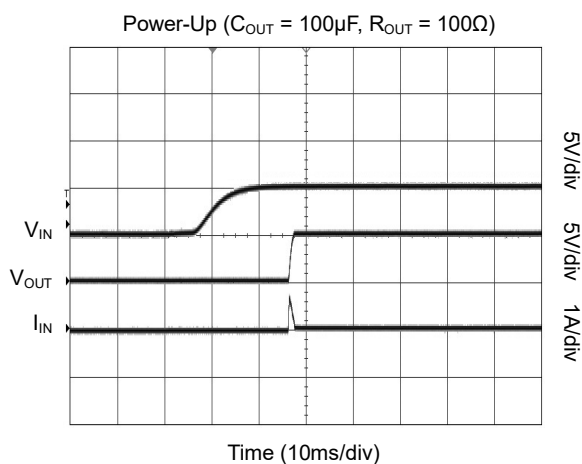
### Figure 2. Timing Diagram

# SGM40659

## SGM40660/SGM40661 Adjustable Over-Voltage Protection Switches

### TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = +25^\circ\text{C}$ ,  $V_{IN} = 5\text{V}$ , OVLO pin = GND,  $C_{IN} = 0.1\mu\text{F}$  and  $C_{OUT} = 1\mu\text{F}$ , unless otherwise specified.



## FUNCTIONAL BLOCK DIAGRAM

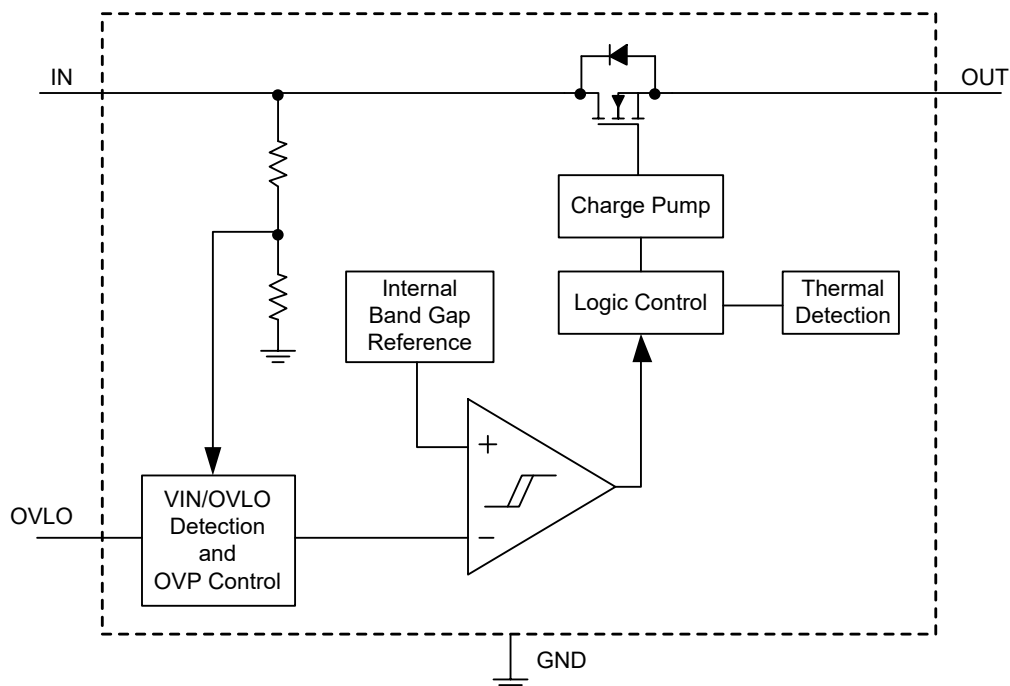


Figure 3. Block Diagram

## DETAILED DESCRIPTION

The SGM40659/60/61 are inserted between the power supply or charger source and the load to be protected. The SGM40659/60/61 consist of a slew-rate controlled, low resistance OVP switch, under-voltage lockout protection (UVLO), and over-voltage monitor and protection (OVLO).

The SGM40659/60/61 over-voltage protection devices feature a low on-resistance ( $R_{ON}$ ) internal FET and protect low voltage systems against voltage faults up to +28V<sub>DC</sub>. If the input voltage exceeds the over-voltage threshold, the internal FET is turned off to prevent damage to downstream components. A 15ms (TYP) debounce time built into the device prevents false turn-on of the internal FET during startup.

In normal operation the OVP switch acts as a slew-rate controlled load switch, connecting and disconnecting the power supply from IN to OUT. A low resistance N-channel MOSFET is used to minimize the voltage drop between the voltage source and the load and to reduce power dissipation.

When the voltage at the input exceeds the programmed over-voltage trip point, the device immediately turns off the internal switch disconnecting the load from the abnormal voltage, preventing damage to downstream components.

In the event that the power dissipation causes the chip temperature to exceed its maximum temperature setting, the SGM40659/60/61 will switch off protecting the device. Once the chip temperature has cooled to below the hysteresis temperature, SGM40659/60/61 will re-initiate. Should the over-temperature condition persist, then SGM40659/60/61 will continue to thermally cycle on and off, until the input power is removed.

### USB On-The-Go (OTG) Operation

When used in an OTG application the SGM40659/60/61 can provide power from OUT to IN. Initially, the OTG voltage applied at OUT will forward-bias the power switch bulk diode and present a voltage drop of approximately 0.7V between OUT and IN. The maximum current in this mode is limited by the thermal performance of the device and at an ambient temperature of +25°C.

$$I_{MAX} = 1.17W/0.7V = 1.67A$$

This is purely a transitional condition as once the voltage at IN exceeds the UVLO voltage of 2.4V (TYP) and the debounce time of 15ms has elapsed, the main power switch will turn fully on, significantly reducing the voltage drop from OUT to IN.

### UVLO (Under-Voltage Lockout)

The device has a built-in under-voltage lockout (UVLO) circuit. When  $V_{IN}$  is rising, the output remains disconnected from the input until  $V_{IN}$  voltage is above 2.4V (TYP). This circuit has a 200mV hysteresis to provide noise immunity to transient conditions.

### OVLO (Over-Voltage Lockout)

The SGM40659/60/61 adjustable version has a 1.213V (TYP) over-voltage trip threshold on the OVP pin. With a resistor-divider on OVLO pin from IN to GND, the over-voltage protection point of IN can be adjusted between 4V and 20V. Fixed OVP products are available with an internal resistor-divider providing 15.61V/6.80V/5.94V (SGM40659/60/61 TYP) OVLO threshold trip voltage. To activate the internal fixed OVP, the OVLO pin should be connected to GND.

### Internal MOSFET Switch

The SGM40659/60/61 incorporate an internal MOSFET with a 27mΩ (TYP)  $R_{ON}$ . The MOSFET gate is driven by an integrated charge pump which generates the necessary voltage above IN.

### Thermal Protection

The internal FET turns off when the junction temperature exceeds +150°C (TYP). The device exits thermal shutdown after the junction temperature cools down by 60°C (TYP).

## APPLICATION INFORMATION

### Input Capacitor

A 0.1μF or larger capacitor is typically recommended for C<sub>IN</sub>. C<sub>IN</sub> should be located close to the device IN pin. Ceramic capacitors are recommended for C<sub>IN</sub>. Select capacitors with a voltage rating at least 5V higher than the maximum possible voltage during surge. 50V rated capacitors are ideal for most applications.

### Output Capacitor

In order to ensure stability while the current limit is active, a small output capacitance of approximately 1μF is required at the output. The output capacitor has no specific capacitor ESR requirement. If desired, C<sub>OUT</sub> may be increased to accommodate any load transient condition.

### External OVLO Adjustment

If OVLO is connected to ground, the internal OVLO comparator uses the internally set OVLO value. The adjustable threshold uses a 1.213V (TYP) over-voltage trip threshold on the OVLO pin. With a resistor-divider on the OVLO pin from IN to GND, the over-voltage protection point of IN can be adjusted between 4V and 20V. Once the OVLO pin voltage exceeds the OVLO select voltage, V<sub>OVLO\_SELECT</sub> (0.27V TYP), the comparator reads the OVLO pin voltage (a fraction of IN) set by the external resistor-divider (R1, R2).

R1 = 1MΩ is a good starting value for minimum current consumption. Since V<sub>IN\_OVLO</sub>, V<sub>OVLO\_TH</sub>, and R1 are known, R2 can be calculated from the following formula:

$$V_{IN\_OVLO} = V_{OVLO\_TH} \times (1 + R1/R2) = 1.213V \times (1 + R1/R2)$$

This external resistor-divider is completely independent from the internal resistor-divider.

## REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

### Changes from Original (SEPTEMBER 2018) to REV.A

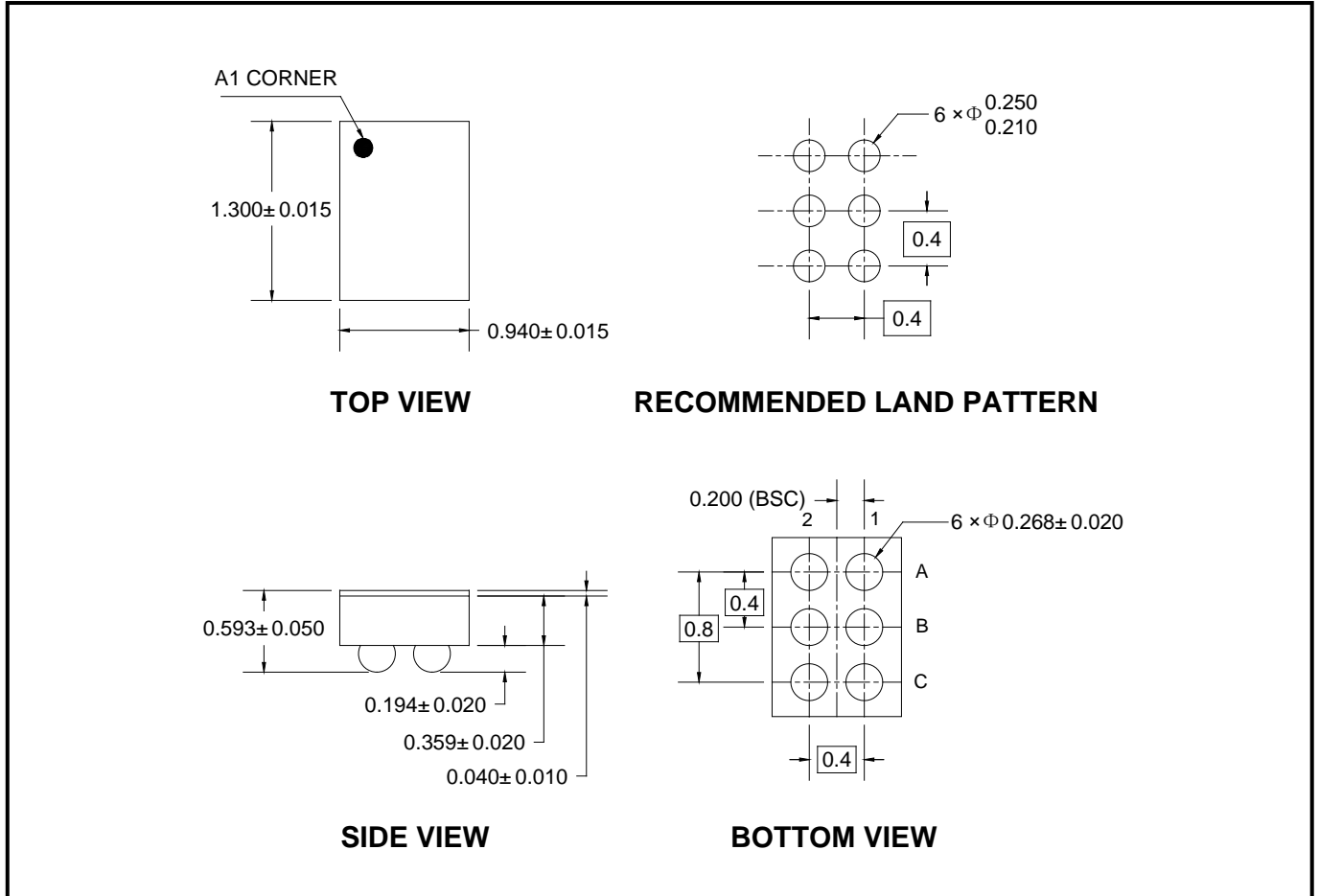
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## PACKAGE OUTLINE DIMENSIONS

### WLCSP-1.30x0.94-6B

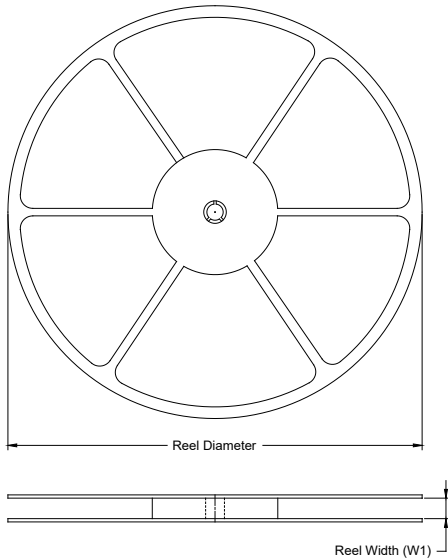


NOTE: All linear dimensions are in millimeters.

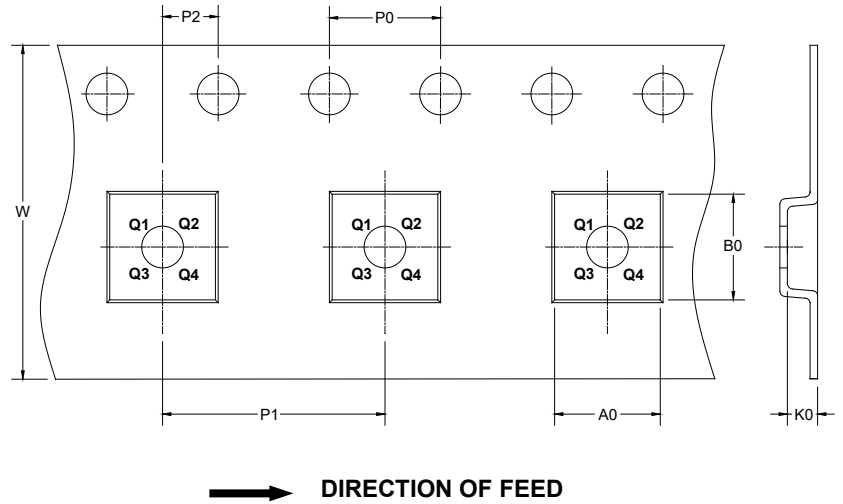
# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
WLCSP-1.30×0.94-6B	7"	9.0	1.07	1.52	0.72	4.0	4.0	2.0	8.0	Q1

DD00001

## PACKAGE INFORMATION

### CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18

DD0002