

DATA SHEET

SKY84632: 3A Slew-Rate Controlled Load Switch with Reverse Blocking

Applications

• Smartphones, tablet PCs, and portable devices

Features

- 1.5 V to 5.5 V input voltage range
- 3 A Maximum continuous current capability
- Typical Rds(on)
 - $-38 \text{ m}\Omega$ at VIN = 5.5 V
- $-40~\text{m}\Omega$ at VIN =4.5~V
- $-76 \text{ m}\Omega$ at VIN = 1.8 V
- $-97 \text{ m}\Omega$ at Vin = 1.5 V
- · Reverse blocking (RB)
- Input hot plug capability
- Over-temperature protection
- Typical 2.7 ms rise time for slew rate/inrush control
- Low quiescent current (typical 9 μA)
- Less than 1 µA off supply current
- Enable control
 - Logic CMOS IO meets JESD76 standard
 - Active high with internal pull-down resistor
- Ultra small, low-profile WLCSP (6-bump, 0.5 mm pitch, 0.995 x 1.495 mm) package (MSL1, 260 °C per JEDEC-J-STD-020)



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Description

The SKY84632 SmartSwitch is a slew rate controlled P-channel MOSFET power switch designed for high side load switching applications. This switch operates with inputs ranging from 1.5 V to 5.5 V, making it ideal for 1.8 V, 3 V, and 5 V systems. It connects/disconnects up to 3 A continuous loads powered from the DC power rail with stringent off-state current targets and high load capacitances (up to 100 μF) through enable control. The integrated low-impedance PMOSFET switch, together with typical 2.7 ms turn-on slew rate control, prevents large inrush current and excessive voltage drop on power rails.

The SKY84632 has the reverse blocking feature that blocks unexpected reverse current from OUT to IN during the PMOSFET on and off states. The typical 9 μA quiescent current makes it ideal for power saving applications. The exceptional low off-state current drain (maximum 1 μA) facilitates compliance with standby power requirements. The switch enable control is active high with an internal pull-down resistor that eliminates the need for an external pull-down resistor. The SKY84632 also includes over-temperature protection and recovers automatically when the fault is removed.

The SKY84632 is available in a 6-bump, 0.995×1.495 mm, Wafer-Level Chip-Scale Package (WLCSP) with 0.5 mm pin pitch, and is rated over the -40 °C to +85 °C temperature range.

A typical application circuit is shown in Figure 1. The pin configuration is shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.



Figure 1. SKY84632 Typical Application Circuit

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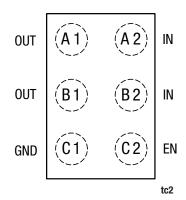


Figure 2. SKY84632 Pinout – 6-Bump WLCSP (Top View)

Table 1. SKY84632 Signal Descriptions

Pin #	Name	Description
A1, B1	OUT	Load switch output. Put at least 0.1 µF output capacitor between OUT and GND.
A2, B2	IN	Supply input. Put at least 1 μF input capacitor between IN and GND.
C1	GND	Ground.
C2	EN	Enable input. Active high with internal pull-down resistor.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY84632 are provided in Table 2. The recommended operating conditions are specified in Table 3, and electrical specifications are provided in Table 4.

Typical performance characteristics of the SKY84632 are illustrated in Figures 5 through 22.

Timing Diagrams

Figure 3 shows the tR and tF of Vout. Figure 4 illustrates the relationship between tD(ON) and tD(OFF).

Table 2. SKY84632 Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Typical	Maximum	Units
IN to GND	VIN	-0.3		+6	V
EN to GND	VEN	-0.3		VIN + 0.3	V
OUT to GND	Vout	-0.3		VIN + 0.3	V
Maximum continuous DC output current (Note 2)	Isw		3		Α
Maximum junction operating temperature	TJ	-40		+150	°C
Maximum soldering temperature (at leads, 10 sec)	TLEAD		300		°C
Thermal resistance, junction to ambient (Note 3)	θја		136		°C/W
Maximum power dissipation	PD		0.9		W

Note 1: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed may result in permanent damage to the device.

CAUTION: Although this device is designed to be as robust as possible, Electrostatic Discharge (ESD) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.

Table 3. SKY84632 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Input voltage	Vin	1.5		5.5	V
Enable threshold	Venh	1.15			V
Disable threshold	VENL			0.6	V
Continuous switch output current	Isw			3	Α
Operating ambient temperature range	Та	-40		+85	°C

Note 2: Support IN high voltage pulse up to 7 V lasting 8 μ s.

Note 3: Mounted on FR4 circuit board.

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Table 4. SKY84632 Electrical Specifications (1 of 2) (Note 1) (VIN = 1.5 V to 5.5 V, TA = -40 °C to 85 °C, Typical Values are at VIN = 4.5 V to 5.5 V, VIN = 4.5 V to

Symbol	Test Condition	Min	Typical	Max	Units
VIN		1.5		5.5	٧
IQ(OFF)	VEN = GND, Vout = Open			1	μΑ
ISD	Ven = GND, Vout = GND, Ta = -40 °C to $+85$ °C		0.2	4	μΑ
IQ	VEN = High, IOUT = 0 A		9	12	μΑ
	VIN = 5.5 V, IOUT = 3 A		40		
	VIN = 5.5 V, IOUT = 2 A		39		mΩ
	VIN = 5.5 V, IOUT = 1 A, TA = 25°C		38	53	
	VIN = 4.5 V, IOUT = 3 A		42		
Proc(on)	VIN = 4.5 V, IOUT = 2 A		41		
หมอ(บท)	Vin = 4.5 V, lout = 1 A, Ta = 25°C		40	54	
	$VIN = 3.3 \text{ V}, IOUT = 500 \text{ mA}, TA = 25 ^{\circ}\text{C}$		47		
	VIN = 2.5 V, IOUT = 500 mA, TA = 25°C		56		
	VIN = 1.8 V, IOUT = 250 mA, TA = 25°C		76		
	VIN = 1.5 V, IOUT = 250 mA, TA = 25°C		97	122	
VIH	VIN = 1.5 V to 5.5 V	1.15			٧
Vu	VIN = 1.8 V to 5.5 V			0.55	V
VIL	VIN = 1.5 V to 1.8 V			0.5	\ \ \
IEN	VEN = VIN or GND			1	μΑ
REN_PD	VEN = VIN = 1.5 V to 5.5 V, TA = -40 °C to +85 °C	6	9	12	mΩ
VT_RB	Vout — Vin		45		mV
VR_RB	VIN — VOUT		25		mV
			70		mV
ISD_OUT	VEN = 0 V, VOUT = 5.5 V, VIN = GND (Note 2)			2	μА
trb_on	Vout – Vin = 100 mV, EN = High		4		μS
trb_off	Vout – Vin = 100 mV, EN = Low		2.5		μS
	VIN IQ(OFF) ISD IQ RDS(ON) VIH VIL IEN REN_PD VT_RB VR_RB ISD_OUT tRB_ON	Vin Io(off) Ven = GND, Vout = Open IsD Ven = GND, Vout = GND, Ta = -40 °C to +85 °C Io Ven = High, Iout = 0 A Vin = 5.5 V, Iout = 3 A Vin = 5.5 V, Iout = 1 A, Ta = 25°C Vin = 4.5 V, Iout = 2 A Vin = 4.5 V, Iout = 2 A Vin = 4.5 V, Iout = 1 A, Ta = 25°C Vin = 2.5 V, Iout = 500 mA, Ta = 25°C Vin = 2.5 V, Iout = 500 mA, Ta = 25°C Vin = 1.8 V, Iout = 250 mA, Ta = 25°C Vin = 1.5 V, Iout = 250 mA, Ta = 25°C Vin = 1.8 V, Iout = 250 mA, Ta = 25°C Vin = 1.5 V, Iout = 250 mA, Ta = 25°C Vin = 1.5 V, Iout = 1.5 V to 5.5 V Vin = 1.5 V to 1.8 V Ien Ven = Vin or GND Ven = 0 V, Vout = 5.5 V, Vin = GND (Note 2) Irb_Out Ven = 0 V, Vout = 5.5 V, Vin = High Vout - Vin = 100 mV, EN = High Vout - Vin = 100 mV, EN = High Ven = 0 V, Vout = 100 mV, EN = High Ven = 0 V,	Vin	Vin	Vin

Table 4. SKY84632 Electrical Specifications (2 of 2) (Note 1) (VIN = 1.5 V to 5.5 V, TA = -40 °C to 85 °C, Typical Values are at VIN = 4.5 V and TA = 25 °C, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Dynamic Characteristics						
Turn-on delay (Note 3)	tD(ON)			1.7		ms
Vout rise time (Note 3)	tR	Vin = 4.5 V, RL = 5 Ω , CL = 100 μ F, TA = 25°C		2.7		
Turn-on time (Note 4)	ton			4.4		
Turn-on delay (Note 3)	tD(ON)	VIN = 4.5 V, RL = 150 Ω , CL = 100 μ F, TA = 25°C		1.8		
Vout rise time (Note 3)	tR			2		ms
Turn-on time (Note 4)	ton			3.8		
Turn-off delay (Note 3)	tD(0FF)			3		
Vout fall time (Note 3)	tF	VIN = 4.5 V, RL = 150 Ω , CL = 100 μ F, TA = 25°C		35		ms
Turn-off time (Note 5)	toff	17 - 20 0		38		7
Over-Temperature Protection						
Over-temperature shutdown threshold	TSD	Temperature increases		150		°C
Over-temperature shutdown hysteresis	TSD_HYS			20		°C

Note 1: Performance is guaranteed only under the conditions listed in this Table.

Note 2: This parameter's performance is only guaranteed in a completely dark environment. Exposing the WLCSP device to direct sunlight causes the parameter to slightly exceed the maximum value.

Note 3: Turn-on/turn-off delay, and rise/fall times are defined in Figures 3 and 4.

Note 4: ton = td(on) + tR

Note 5: toff = td(off) + tf.

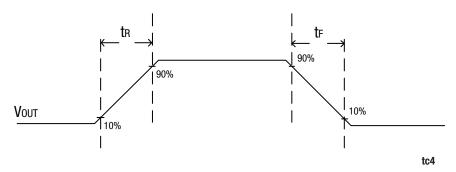


Figure 3. Timing Diagram of tr/tr

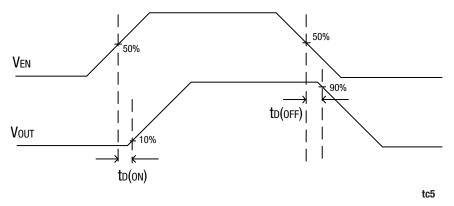


Figure 4. Timing Diagram of tD(ON)/tD(OFF)

Typical Performance Characteristics

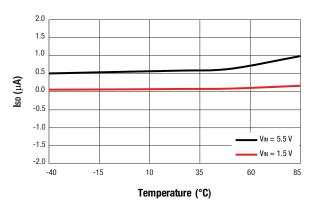


Figure 5. Shutdown Current vs Temperature

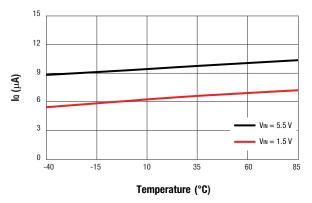


Figure 7. Quiescent Current vs Temperature

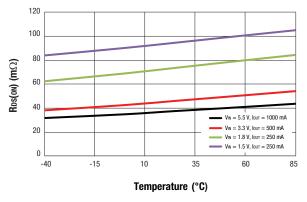


Figure 9. RDS(ON) vs Temperature

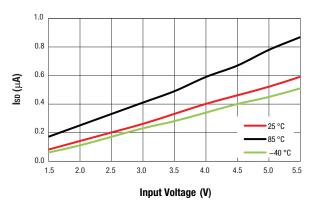


Figure 6. Shutdown Current vs Input Voltage

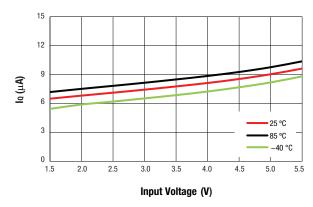


Figure 8. Quiescent Current vs Input Voltage

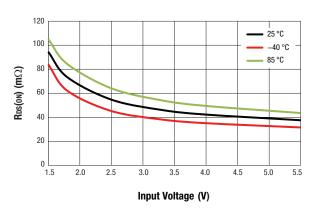


Figure 10. RDS(ON) vs Input Voltage

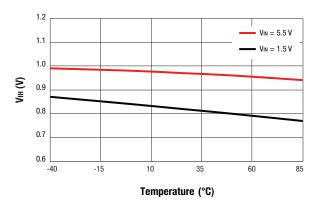


Figure 11. EN Input Logic High Voltage vs Temperature

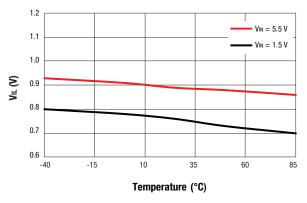


Figure 13. EN Input Logic Low Voltage vs Temperature

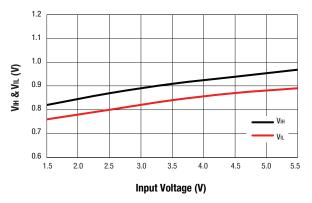


Figure 15. EN Input Logic High/Low Voltage vs Input Voltage

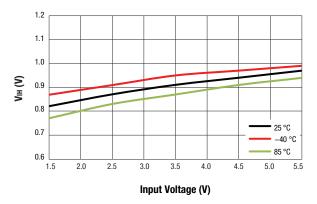


Figure 12. EN Input Logic High Voltage vs Input Voltage

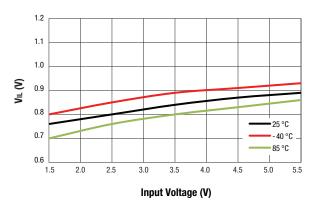


Figure 14. EN Input Logic Low Voltage vs Input Voltage

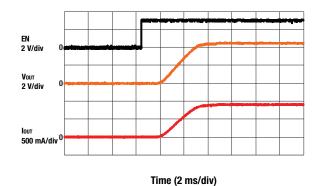
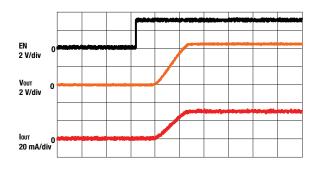


Figure 16. Output Turn-On Time (Vin = 4.5 V, Cin = 10 μF , CovT = 100 μF , RL = 5 Ω)



Time (2 ms/div)

Figure 17. Output Turn-On Time (Vin = 4.5 V, Cin = 10 μ F, Cout = 100 μ F, RL = 150 Ω)

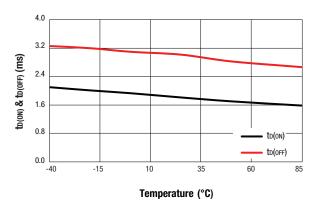
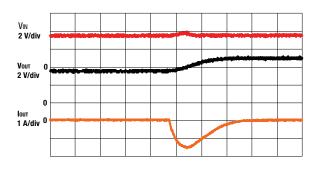
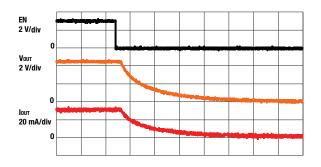


Figure 19. Turn On/Off Delay Time vs Temperature



Time (20 µs/div)

Figure 21. RB Response Time During On (Vin = Ven = 3.6 V, Vout = 5.5 V, Cin = 10 $\mu\text{F},$ Cout = 100 $\mu\text{F})$



Time (10 ms/div)

Figure 18. Output Turn-Off Time (Vin = 4.5 V, Cin = 10 μF , Cout = 100 μF , RL = 150 Ω)

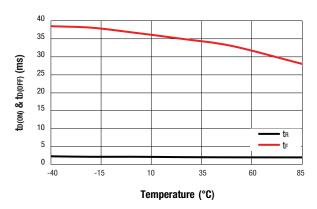
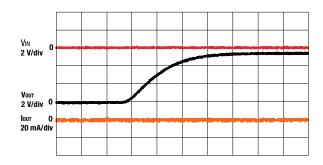


Figure 20. Turn On Rising & Trun-Off Falling Time vs Temperature



Time (40 µs/div)

Figure 22. RB Response Time During Off (Vin = Ven = 0 V, Vout = 5.5 V, Cin = 10 μ F, Cout = 100 μ F)

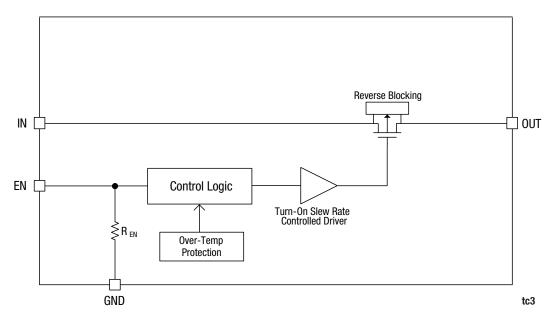


Figure 23. SKY84632 Functional Block Diagram

Functional Description

The SKY84632 is an integrated low-RDS(ON) P-channel load switch with enable activity and reverse blocking. A wide input voltage range from 1.5 V to 5.5 V allows the SKY84632 to be compatible with GPIO/CMOS input. Logic high at the EN bump activates the device. The reverse blocking feature prevents current flow from output to input at the load switch for both on/off states. The SKY84632 typically consumes 9 μA when operating. When switched off, the device draws less than 1 μA .

The SKY84632 also integrates over-temperature protection for high ambient temperature or junction temperature caused by excess current.

A functional block diagram of the SKY84632 is provided in Figure 23.

Application Information

Slew Rate and Inrush Current Control

To avoid large inrush current when the load switch is turned on, the slew rate controller feature allows the output voltage to rise slowly. The inrush current is dependent on slew rate control capability and output capacitance as expressed by:

$$I_{INRUSH} = I_{LOAD} + \frac{C_{OUT} \times (V_{IN} - V_{OUT})}{t_{R}}$$

Where:

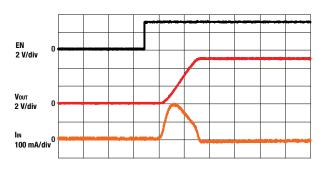
Cout = Output capacitance in μ F

VIN = Input voltage in V

tr: = Rise time at Vout in ms
VINITIAL = Initial voltage at Cout in V

ILOAD = Load current in mA

For example, the SKY84632 has a 2.7 ms of slew rate capability under 4.5 V at 100 μF of CouT and no load, so inrush current can be minimized under 200 mA as Figure 24 shows.



Time (2 ms/div)

Figure 24: Inrush Current Waveform (Vin = 5.0 V, Cin = 10 $\mu\text{F},$ Cout = 100 $\mu\text{F},$ No Load)

High inrush current makes the input voltage drop. The voltage drop value depends on the inrush current, power line equivalent parasitic resistance, and input capacitor. A large input voltage drop can cause system application problems.

Reverse Blocking

The reverse blocking feature protects the input source against current flow from output to input regardless of whether the load switch is on or off.

Thermal Protection

The SKY84632 includes thermal protection that disables the load switch when the die temperature reaches 140 $^{\circ}$ C. It automatically restarts when the temperature drops by 15 $^{\circ}$ C or more.

When an overload or output short to GND occurs, the power dissipation on device increases rapidly, triggering the thermal protection to prevent damage to the part.

Input Capacitor

Select a low Equivalent Series Resistance (ESR) ceramic capacitor with a value of at least 1 μF as the input capacitor. The input capacitor should be placed as close to the IN and GND bumps as possible to minimize the stray resistance from the device to the input power source.

Output Capacitor

Select a low ESR ceramic capacitor with a value of at least 0.1 μ F as the output capacitor. The output capacitor should be placed as close to the OUT and GND bumps as possible to minimize the parasitic board inductance against forcing VouT below GND when the switch is on.

Layout Guidance

For best performance of the SKY84632, the following guidelines should be followed when designing the PCB layout:

- Make the power trace as short and wide as possible, including the input/output power lines
- Connect the input/output capacitor to GND as close as possible to decrease the effect of parasitic inductance and to get a better noise filtering effect.

Evaluation Board Description

The SKY84632 Evaluation Board is used to test the performance of the SKY84632. An Evaluation Board schematic diagram is provided in Figure 25. The PCB layout is shown in Figures 26 and 27. Component values for the SKY84632 Evaluation Board are listed in Table 5.

Package Information

Typical case markings for the 6-bump WLCSP are shown in Figure 28. Package dimensions are shown in Figure 29, and the tape and reel dimensions are provided in Figure 30.

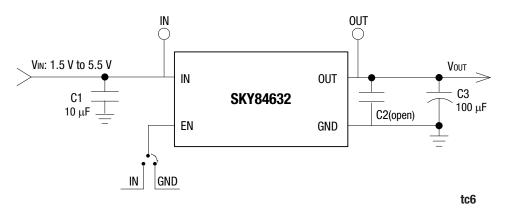
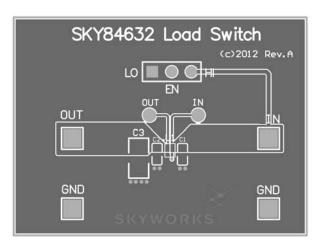


Figure 25. SKY84632 Evaluation Board Schematic





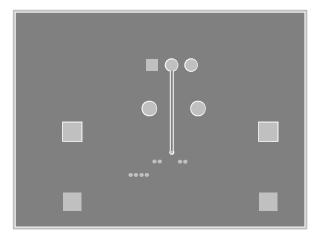


Figure 27. SKY84632 Evaluation Board PCB Bottom Side

Table 5. SKY84632 Evaluation Board Bill of Materials

Component	Part Number	Description	Manufacturer
U1	SKY84632	3A Slew-Rate Controlled Load Switch with Reverse Blocking	Skyworks
C1	GRM188R60J106ME47D	Cap Ceramic, 10 μF, 0603 X5R, 6.3 V, 20%	Murata
C2	GRM188R61E104KA01D	Cap Ceramic, 0.1 μF, 0603 X5R, 25 V, 10%	Murata
C3	GRM31CR60J107ME39L	Cap Ceramic, 100 μF, 1206 X5R, 6.3 V, 20%	Murata

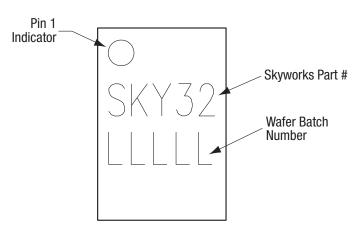
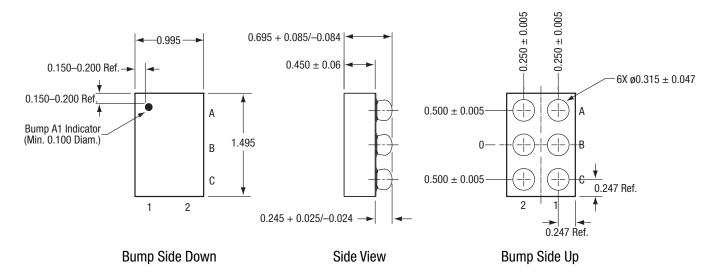


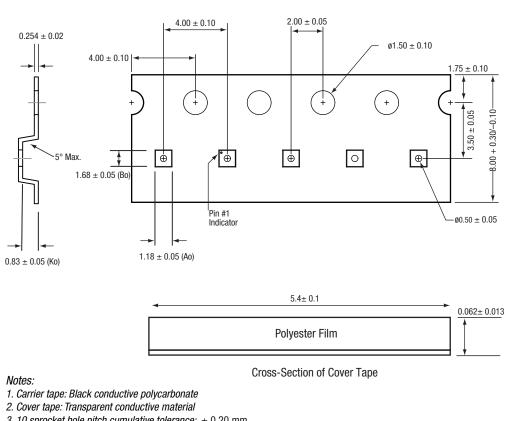
Figure 28. Typical Case Markings (Top View)

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S3486 All measurements are in millimeters

Figure 29. SKY84632 6-Bump WLCSP Package Dimensions



- 3. 10 sprocket hole pitch cumulative tolerance: \pm 0.20 mm
- 4. Pocket position relative to sprocket hole measured as true position of pocket

5. All dimensions are in millimeters

Figure 30. SKY84632 Tape and Reel Dimensions

Y0019

Ordering Information

Model Name	Manufacturing Part Number (Note 1)	Evaluation Board Part Number	
SKY84632 Load Switch with Reverse Blocking	SKY84632-11-001	SKY84632-11-001-EVB	

Note 1: Sample stock is generally held on part numbers listed in BOLD.

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