Vishay Siliconix

HALOGEN

FREE

20 mΩ, Slew Rate Controlled Load Switch in WCSP6

DESCRIPTION

SiP32458 and SiP32459 are slew rate controlled integrated high side load switches that operate in the input voltage range from 1.5 V to 5.5 V.

SiP32458 and SiP32459 are of p-channel MOSFET switching element with integrated gate pump that provides $20 \text{ m}\Omega$ switch on resistance over a wide input voltage range.

These devices have low voltage logic control threshold that can interface with low voltage control I/O directly without extra level shift or driver. A 2.8 M Ω pulldown resistor is integrated at logic control EN pin.

The slow slew rate of SiP32458 and SiP32459 in the range of 3 ms limits the in-rush current and minimized the switching noise.

The SiP32458 features a reverse current blocking capability while the SiP32459 features an integrated output discharge switch.

Both SiP32458 and SiP32459 are available in compact wafer level WCSP package, WCSP6 1 mm x 1.5 mm with 0.5 mm pitch.

FEATURES

- Low input voltage, 1.5 V to 5.5 V
- Low R_{on}, 20 mΩ typical at 5 V
- · Slew rate control
- Compatible with 1.2 V logic
- Reverse current blocking when disabled (SiP32458, without output discharge switch)
- Integrated output discharge switch (SiP32459 only)
- Integrated pull down resistor at EN pin
- 6 bumps WCSP package
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Battery operated devices
- · Smart phones
- · GPS and PMP
- Computer
- · Medical and healthcare equipment
- · Industrial and instrument
- · Cellular phones and portable media players
- · Game console

TYPICAL APPLICATION CIRCUIT

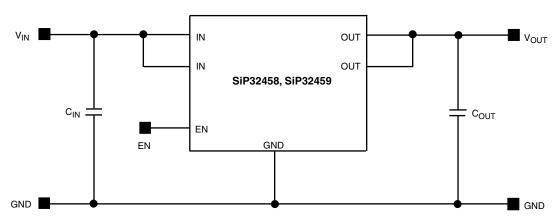


Fig. 1 - SiP32458 and SiP32459 Typical Application Circuit

ORDERING INFORMATION						
TEMPERATURE RANGE	PACKAGE	MARKING	PART NUMBER			
-40 °C to +85 °C	WCSP: 6 bumps (2 x 3, 0.5 mm pitch, 250 µm bump height, 1.5 mm x 1 mm die size)	AA	SiP32458DB-T2-GE1			
		AB	SiP32459DB-T2-GE1			

Note

• -GE1 denotes halogen-free and RoHS-compliant

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ABSOLUTE MAXIMUM RATINGS					
PARAMETER	LIMIT	UNIT			
Supply input voltage (V _{IN})	-0.3 to 6				
Enable input voltage (V _{EN})	-0.3 to 6	V			
Output voltage (V _{OUT})	-0.3 to 6				
Maximum continuous switch current (I _{max})	3	^			
Maximum pulsed current (I _{DM}) V _{IN} (pulsed at 1 ms, 10 % duty cycle)	6	- A			
ESD rating (HBM)	4000	V			
Junction temperature (T _J)	-40 to +150	°C			
Thermal resistance (θ _{JA}) ^a	110	°C/W			
Power dissipation (P _D) ^a	500	mW			

Notes

- a. Device mounted with all bumps soldered to PC board
- b. Derate 9.1 mW/°C above $T_A = 70$ °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.

RECOMMENDED OPERATING RANGE					
PARAMETER	LIMIT	UNIT			
Input voltage range (V _{IN})	1.5 to 5.5	V			
Operating junction temperature range	-40 to +125	°C			

SPECIFICATIONS								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS SPECIFIED $V_{IN}=1.5~V$ to $5.5~V$, $T_A=-40~^{\circ}C$ to $+85~^{\circ}C$ (typical values are at $V_{IN}=4.5~V$, $T_A=25~^{\circ}C$)		LIMITS			UNIT	
				MIN. a	TYP. b	MAX. a		
Operating voltage ^c	V _{IN}			1.5	-	5.5	V	
Quiescent current	IQ	$V_{EN} = V_{IN}$, OUT = open	-	4.2	9.5		
Off supply current	1	SiP32458	EN = GND, OUT = open	1	-	1		
On supply current	I _{Q(off)}	SiP32459	EN = GND, OUT = open	1	-	10	μA	
Off switch current	I _{DS(off)}	EN = GN	ID, OUT = 0 V	1	-	10	J	
Reverse blocking current	I _{RB}		_N = 0.75 V, V _{EN} = 0 V 2458 only)	-	-	10		
		V _{IN} = 1.5 V, I _L = 500 mA, T _A = 25 °C		=	30	36	mΩ	
On-resistance	R _{DS(on)}	V_{IN} = 1.8 V, I_L = 500 mA, T_A = 25 °C		-	26	32		
On-resistance		$V_{IN} = 3.3 \text{ V}, I_L = 500 \text{ mA}, T_A = 25 ^{\circ}\text{C}$		=	20	26		
		V _{IN} = 5 V, I _L = 1 A, T _A = 25 °C		1	20	26		
On-resistance temp. coefficient	TC _{RDS}			1	2820	-	ppm/°C	
Output pulldown resistance	R _{PD}	$V_{IN} = 3.3 \text{ V, } I_{OUT} = 5 \text{ mA, } V_{EN} = 0 \text{ V}$ (SiP32459 only)		-	70	-	W	
EN input low voltage ^c	V_{IL}	V _{IN} = 1.5 V		=	-	0.4	V	
EN input high voltage ^c	V_{IH}	V _{IN} = 5.5 V		1	-	-] v	
EN input leakage	I _{EN}	V _{IN} = 5.5 V, V _{EN} = 0 V		1	-	1	μΑ	
Liv iriput leakage		V _{IN} = 5.5 V, V _{EN} = 1.2 V		ı	0.44	1		
EN pulldown resistor	R _{EN}	V _{IN} = 5.5 V, V _{EN} = 1.2 V		1	2.8	-	MΩ	
Output turn-on delay time	t _{d(on)}	$V_{IN} = 4.5 \text{ V}, R_{LOAD} = 5 \Omega,$ $C_{I} = 100 \text{ uF}, T_{\Delta} = 25 \text{ °C}$		-	0.5	-	ms	
Output turn-on rise time	t _r			-	3	-	1115	
Output turn-off delay time	t _{d(off)}	-L .00	r / A == =	-	18	-	μs	

Notes

S20-0528-Rev. C, 06-Jul-2020

- a. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum
- b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing
- c. For V_{IN} outside this range consult typical EN threshold curve

PIN CONFIGURATION

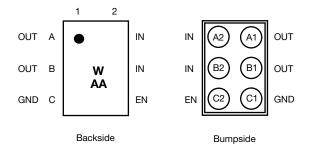


Fig. 2 - WCSP 2 x 3 Package

PIN DESCRIPTION				
PIN NUMBER	NAME	FUNCTION		
A1, B1	OUT	These are the output pins of the switch		
C1	GND	Ground connection		
A2, B2	IN	These are input pins of the switch		
C2	EN	Enable input		

BLOCK DIAGRAM

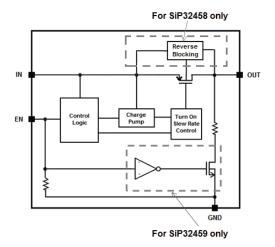


Fig. 3 - Functional Block Diagram



TYPICAL CHARACTERISTICS (internally regulated, 25 °C, unless otherwise noted)

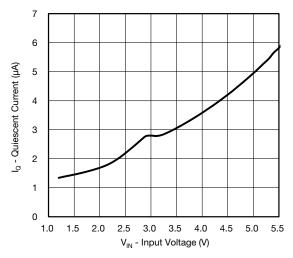


Fig. 4 - Quiescent Current vs. Input Voltage

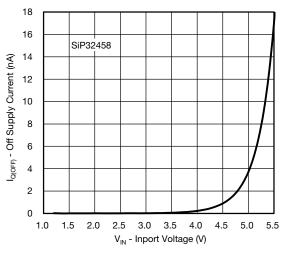


Fig. 5 - Off Supply Current vs. Input Voltage

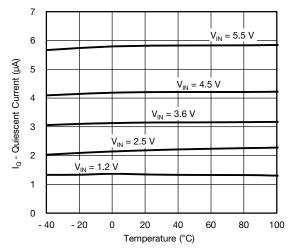


Fig. 6 - Quiescent Current vs. Temperature

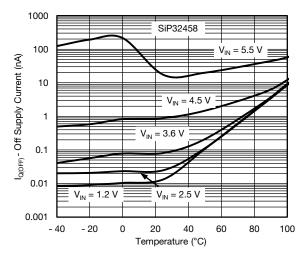


Fig. 7 - Off Supply Current vs. Temperature

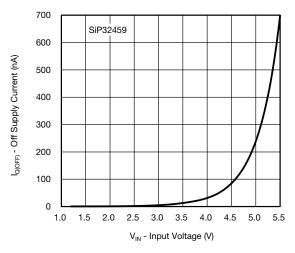


Fig. 8 - Off Supply Current vs. Input Voltage

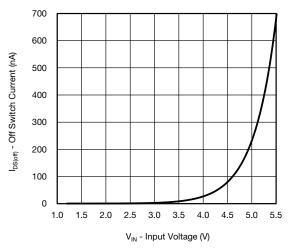


Fig. 9 - Off Switch Current vs. Input Voltage



TYPICAL CHARACTERISTICS (internally regulated, 25 °C, unless otherwise noted)

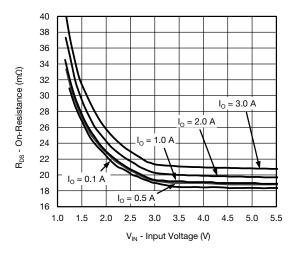


Fig. 10 - R_{DS(on)} vs. Input Voltage

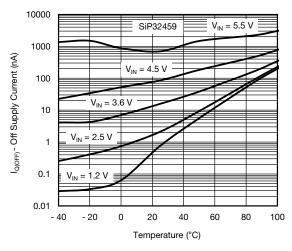


Fig. 11 - Off Supply Current vs. Temperature

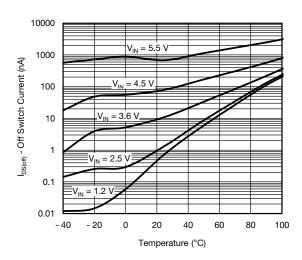


Fig. 12 - Off Switch Current vs. Temperature

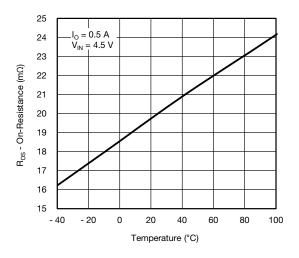


Fig. 13 - R_{DS(on)} vs. Temperature

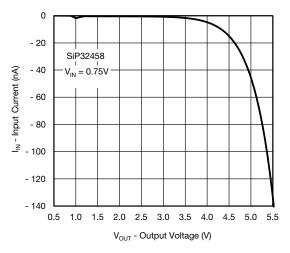


Fig. 14 - Reverse Blocking Current vs. Output Voltage

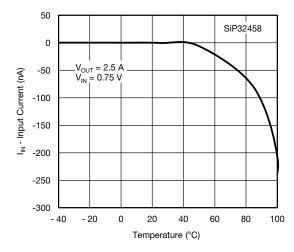


Fig. 15 - Reverse Blocking Current vs. Temperature



TYPICAL CHARACTERISTICS (internally regulated, 25 °C, unless otherwise noted)

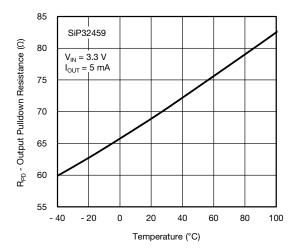


Fig. 16 - Output Pulldown Resistance vs. Temperature

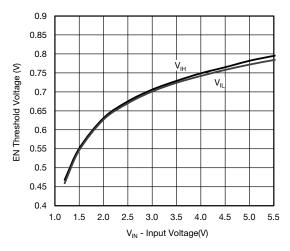


Fig. 17 - EN Threshold Voltage vs. Input Voltage

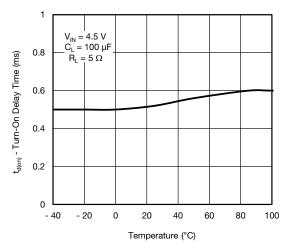


Fig. 18 - Turn-On Delay Time vs. Temperature

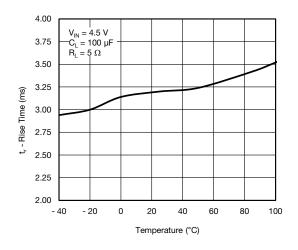


Fig. 19 - Rise Time vs. Temperature

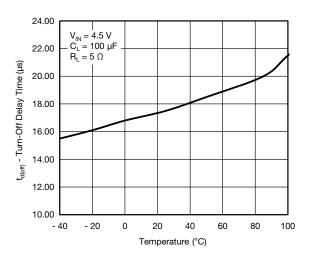


Fig. 20 - Turn-Off Delay Time vs. Temperature

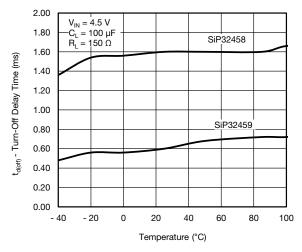


Fig. 21 - Turn-Off Delay Time vs. Temperature



TYPICAL WAVEFORMS

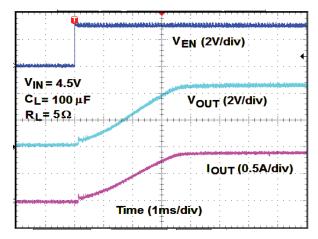


Fig. 22 - Turn-On Time

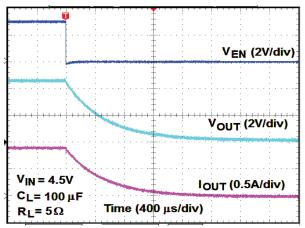
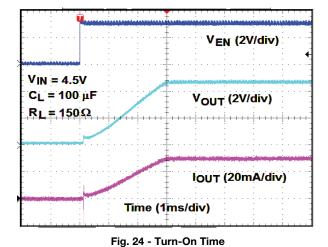


Fig. 23 - Turn-Off Time



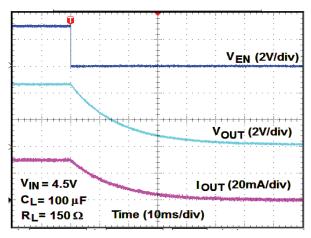


Fig. 25 - Turn-Off Time, SiP32458

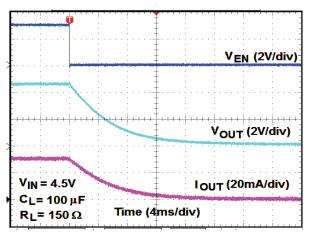


Fig. 26 - Turn-Off Time, SiP32459



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DETAILED DESCRIPTION

SiP32458 and SiP32459 are p-channel power MOSFET designed as high side load switches. They incorporate a negative charge pump at the gate to keep the gate to source voltage high when turned on therefore keep the on resistance low at lower input voltage range. SiP32458 and SiP32459 are designed with slow slew rate to minimize the inrush current during turn on. The SiP32458 has a reverse blocking circuit to prevent the current from going back to the input in case the output voltage is higher than the input voltage. The SiP32459 has an output pulldown resistor to discharge the output capacitance when the device is off.

APPLICATION INFORMATION

Input Capacitor

While a bypass capacitor on the input is not required, a $4.7 \,\mu\text{F}$ or larger capacitor for C_{IN} is recommended in almost all applications. The bypass capacitor should be placed as physically close as possible to the input pin to be effective in minimizing transients on the input. Ceramic capacitors are recommended over tantalum because of their ability to withstand input current surges from low impedance sources such as batteries in portable devices.

Output Capacitor

A 0.1 μ F capacitor across V_{OUT} and GND is recommended to insure proper slew operation. There is inrush current through the output MOSFET and the magnitude of the inrush current depends on the output capacitor, the bigger the C_{OUT} the higher the inrush current. There are no ESR or capacitor type requirement.

Enable

The EN pin is compatible with CMOS logic voltage levels. It requires at least 0.4 V or below to fully shut down the device and 1 V or above to fully turn on the device. There is a 2.8 $M\Omega$ resistor connected between EN pin and GND pin.

Protection Against Reverse Voltage Condition

The SiP32458 contains the reverse blocking circuit to keep the output current from flowing back to the input in case the output voltage is higher than the input voltage.

Thermal Considerations

These devices are designed to maintain a constant output load current. Due to physical limitations of the layout and assembly of the device the maximum switch current is 3 A as stated in the Absolute Maximum Ratings table. However,

another limiting characteristic for the safe operating load current is the thermal power dissipation of the package. To obtain the highest power dissipation (and a thermal resistance of 110 °C/W) the device should be connected to a heat sink on the printed circuit board.

The maximum power dissipation in any application is dependent on the maximum junction temperature, T_J (max.) = 125 °C, the junction-to-ambient thermal resistance, θ_{J-A} = 110 °C/W, and the ambient temperature, T_A , which may be formulaically expressed as:

$$P (max.) = \frac{T_{J(max.)} - T_A}{\theta_{JA}} = \frac{125 - T_A}{280}$$

It then follows that, assuming an ambient temperature of 70 $^{\circ}$ C, the maximum power dissipation will be limited to about 500 mW.

So long as the load current is below the 3 A limit, the maximum continuous switch current becomes a function two things: the package power dissipation and the $R_{DS(on)}$ at the ambient temperature.

As an example let us calculate the worst case maximum load current at $T_A = 70~^{\circ}\text{C}$. The worst case $R_{DS(on)}$ at 25 $^{\circ}\text{C}$ is 36 m Ω at $V_{IN} = 1.5~\text{V}$. The $R_{DS(on)}$ at 70 $^{\circ}\text{C}$ can be extrapolated from this data using the following formula:

$$R_{DS(on)}$$
 (at 70 °C) = $R_{DS(on)}$ (at 25 °C) x (1 + T_C x ΔT)

Where T_C is 2820 ppm/°C. Continuing with the calculation we have

 $R_{DS(on)}$ (at 70 °C) = 36 m Ω x (1 + 0.00282 x (70 °C - 25 °C)) = 40.5 m Ω

The maximum current limit is then determined by

$$I_{LOAD(max.)} < \sqrt{\frac{P (max.)}{R_{DS(on)}}}$$

which in this case is 3.5 A. Under the stated input voltage condition, if the 3.5 A current limit is exceeded the internal die temperature will rise and eventually, possibly damage the davice

To avoid possible permanent damage to the device and keep a reasonable design margin, it is recommended to operate the device maximum up to 3 A only as listed in the Absolute Maximum Ratings table.



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PRODUCT SUMMARY						
Part number	SiP32458	SiP32459				
Description	1.5 V to 5.5 V, 20 m Ω , bidirectional off isolation	1.5 V to 5.5 V, 20 mΩ, output discharge				
Configuration	Single	Single				
Slew rate time (µs)	3000	3000				
On delay time (µs)	500	500				
Input voltage min. (V)	1.5	1.5				
Input voltage max. (V)	5.5	5.5				
On-resistance at input voltage min. (m Ω)	30	30				
On-resistance at input voltage max. (mΩ)	20	20				
Quiescent current at input voltage min. (µA)	1.5	1.5				
Quiescent current at input voltage max. (μA)	5.8	5.8				
Output discharge (yes / no)	No	Yes				
Reverse blocking (yes / no)	Yes	No				
Continuous current (A)	3	3				
Package type	WCSP6	WCSP6				
Package size (W, L, H) (mm)	1.0 x 1.5 x 0.5	1.0 x 1.5 x 0.5				
Status code	2	2				
Product type	Slew rate	Slew rate				
Applications	Computers, consumer, industrial, healthcare, networking, portable	Computers, consumer, industrial, healthcare, networking, portable				

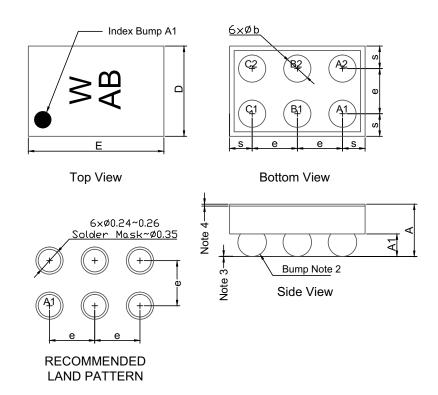
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WCSP6: 6 Bumps

(2 x 3, 0.5 mm pitch, 250 µm bump height, 1 mm x 1.5 mm die size)



	MILLIMETERS ⁽⁵⁾			INCHES		
DIMENSION	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
Α	0.540	0.572	0.620	0.0212	0.0225	0.0244
A1	0.214	0.250	0.286	0.0084	0.0098	0.0113
b	0.279	0.310	0.372	0.0109	0.0122	0.0146
е	0.500				0.0197	
s	0.230	0.250	0.270	0.0090	0.0098	0.0106
D	0.920	0.960	1.000	0.0362	0.0378	0.0394
Е	1.420	1.460	1.500	0.0559	0.0575	0.0591

Notes (unless otherwise specified)

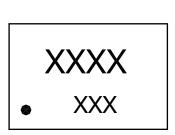
- (1) Laser mark on the silicon die back coated with an epoxy film.
- (2) Bumps are SAC396.
- $^{(3)}$ 0.050 max. co-planarity.
- (4) Laminate tape thickness is 0.022 mm.
- (5) Use millimeters as the primary measurement.

ECN: S13-1424-Rev. B, 01-Jul-13

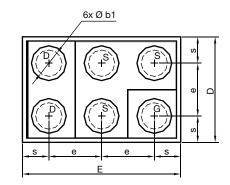
DWG: 6011

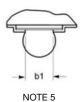


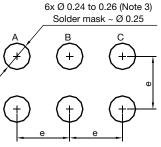
MICRO FOOT®: 6-Bump (1.5 mm x 1 mm, 0.5 mm Pitch, 0.250 mm Bump Height)



Mark on Backside of Die







Bump (Note 2)

Recommended Land Pattern

Notes

(unless otherwise specified)

- 1. Six (6) solder bumps are 95.5/3.8/0.7 Sn/Ag/Cu.
- 2. Backside surface is coated with a Ti/Ni/Ag layer.
- 3. Non-solder mask defined copper landing pad.
- 4. Laser marks on the silicon die back.
- 5. "b1" is the diameter of the solderable substrate surface, defined by an opening in the solder resist layer solder mask defined.
- 6. is the location of pin 1

DIM.		MILLIMETERS			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
Α	0.510	0.575	0.590	0.0201	0.0226	0.0232	
A ₁	0.220	0.250	0.280	0.0087	0.0098	0.0110	
A ₂	0.290	0.300	0.310	0.0114	0.0118	0.0122	
b	0.297	0.330	0.363	0.0116	0.0129	0.0143	
b1	0.250 0.0098						
е		0.500 0.0197					
s	0.210	0.230	0.250	0.0082	0.0090	0.0098	
D	0.920	0.960	1.000	0.0362	0.0378	0.0394	
E	1.420	1.460	1.500	0.0559	0.0575	0.0591	
K	0.028	0.065	0.102	0.0011	0.0025	0.0040	

Note

Use millimeters as the primary measurement.

ECN: T15-0140-Rev. A, 20-Apr-15

DWG: 6035

Revison: 20-Apr-15 Document Number: 69426



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