0.8 V to 2.5 V, 28 mΩ, Slew Rate Controlled Load Switch in WCSP4

DESCRIPTION

The SiP32454 and SiP32455 are slew rate controlled integrated high side load switches that operate in the input voltage range from 0.8 V to 2.5 V. The SiP32454 and SiP32455 are of N-channel MOSFET switching elements that provide 28 mΩ switch on resistance. They have a 1 ms at 1.2 V and 1.5 ms at 2.5 V slow slew rate that limits the in-rush current and minimizes the switching noise. These devices' low voltage logic control threshold can interface with low voltage control I/O directly without extra level shift or driver. A 2 MΩ pull-down resistor is integrated at logic control EN pin. SiP32454 integrates a switch OFF output discharge circuit.

Both SiP32454 and SiP32455 are available in compact wafer level CSP package, WCSP4 0.8 mm x 0.8 mm with 0.4 mm pitch.

FEATURES

- Low input voltage, 0.8 V to 2.5 V
- Low R_{ON}, 28 mΩ typical
- Slew rate control
- Low logic control with hysteresis
- Reverse current blocking when disabled
- Integrated output discharge switch for SiP32454
- Integrated pull down resistor at EN pin
- 4 bump WCSP 0.8 mm x 0.8 mm with 0.4 mm pitch package
- Material categorization: For definitions of compliance please see www.vishay.com/doc?9991

Pb-free
RoHS COMPLIANT
HALOGEN FREE Available

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

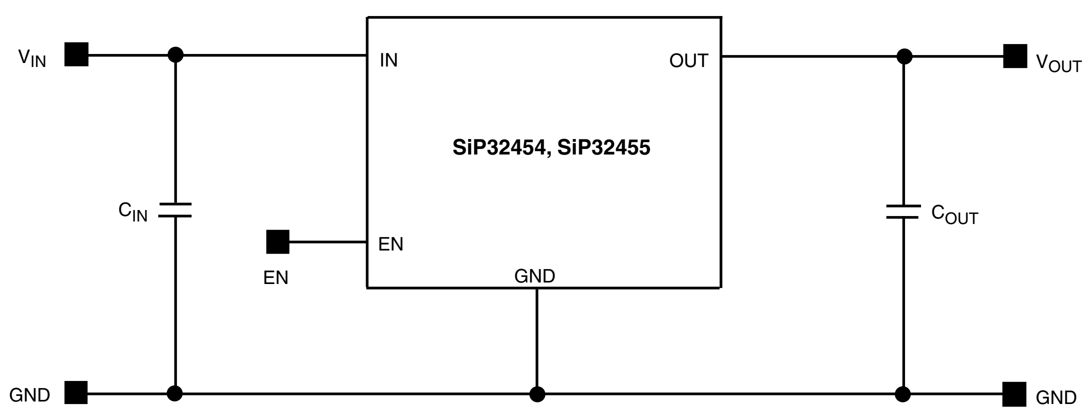

Figure 1 - SiP32454 and SiP32455 Typical Application Circuit

ORDERING INFORMATION

Temperature Range	Package	Marking	Part Number
- 40 °C to 85 °C	WCSP: 4 Bumps (2 x 2, 0.4 mm pitch, 208 µm bump height, 0.8 mm x 0.8 mm die size)	AD	SiP32454DB-T2-GE1
		AE	SiP32455DB-T2-GE1

Note:
GE1 denotes halogen-free and RoHS compliant

ABSOLUTE MAXIMUM RATINGS

Parameter	Limit	Unit
Supply Input Voltage (V_{IN})	- 0.3 to 2.75	V
Enable Input Voltage (V_{EN})	- 0.3 to 2.75	
Output Voltage (V_{OUT})	- 0.3 to 2.75	
Maximum Continuous Switch Current ($I_{max.}$)	1.2	A
Maximum Pulsed Current (I_{DM}) V_{IN} (Pulsed at 1 ms, 10 % Duty Cycle)	2	
ESD Rating (HBM)	4000	V
Junction Temperature (T_J)	- 40 to 150	°C
Thermal Resistance (θ_{JA})[a]	280	°C/W
Power Dissipation (P_D)[a]	196	mW

Notes:
a. Device mounted with all leads and power pad soldered or welded to PC board.
b. Derate 3.6 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})	0.8 to 2.5	V
Operating Junction Temperature Range	- 40 to 125	°C

For technical questions, contact: powerictechsupport@vishay.com
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SPECIFICATIONS

Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 1 V, T_A = - 40 °C to 85 °C (Typical values are at T_A = 25 °C)	Limits Min.[a]	Typ.[b]	Max.[a]	Unit
Operating Voltage[c]	V_{IN}		0.8	-	2.5	V
Quiescent Current	I_Q	V_{IN} = 1.2 V, V_{EN} = V_{IN}, OUT = open	-	10	15	µA
		V_{IN} = 2.5 V, V_{EN} = V_{IN}, OUT = open	-	34	60	
Off Supply Current	$I_{Q(off)}$	SiP32454, EN = GND, OUT = open	-	-	30	
		SiP32455, EN = GND, OUT = open	-	-	1	
Off Switch Current	$I_{DS(off)}$	EN = GND, OUT = 0 V	-	-	30	
Reverse Blocking Current	I_{RB}	V_{OUT} = 2.5 V, V_{IN} = 0.9 V, V_{EN} = 0 V	-	0.001	30	
On-Resistance	$R_{DS(on)}$	V_{IN} = 1 V, I_L = 200 mA, T_A = 25 °C	-	30	35	mΩ
		V_{IN} = 1.2 V, I_L = 200 mA, T_A = 25 °C	-	29	35	
		V_{IN} = 1.8 V, I_L = 200 mA, T_A = 25 °C	-	28	35	
		V_{IN} = 2.5 V, I_L = 200 mA, T_A = 25 °C	-	28	35	
On-Resistance Temp.-Coefficient	TC_{RDS}		-	4100	-	ppm/°C
Output Pulldown Resistance	R_{PD}	V_{EN} = 0 V, T_A = 25 °C (SiP32454 only)	-	417	550	Ω
EN Input Low Voltage[c]	V_{IL}	V_{IN} = 1 V	-	-	0.1	V
EN Input High Voltage[c]	V_{IH}	V_{IN} = 2.5 V	1.5	-	-	
EN Input Leakage	I_{EN}	V_{IN} = 2.5 V, V_{EN} = 0 V	-	-	1	µA
		V_{IN} = 2.5 V, V_{EN} = 2.5 V	-	6.5	12	
Output Turn-On Delay Time	$t_{d(on)}$	V_{IN} = 1.2 V, R_{LOAD} = 10 Ω, C_L = 0.1 µF, T_A = 25 °C	-	0.6	1.2	ms
		V_{IN} = 2.5 V	-	0.6	1.2	
Output Turn-On Rise Time	t_r	V_{IN} = 1.2 V	0.4	1	1.6	
		V_{IN} = 2.5 V	0.5	1.5	2.5	
Output Turn-Off Delay Time	$t_{d(off)}$	V_{IN} = 1.2 V	-	0.3	1	µs
		V_{IN} = 2.5 V	-	0.1	1	

Notes:
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

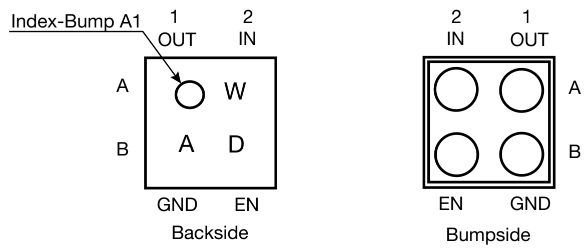


Figure 2 - WCSP 2 x 2 Package

PIN DESCRIPTION		
Pin Number	**Name**	**Function**
A1	OUT	This is the output pin of the switch
A2	IN	This is the input pin of the switch
B1	GND	Ground connection
B2	EN	Enable input

BLOCK DIAGRAM

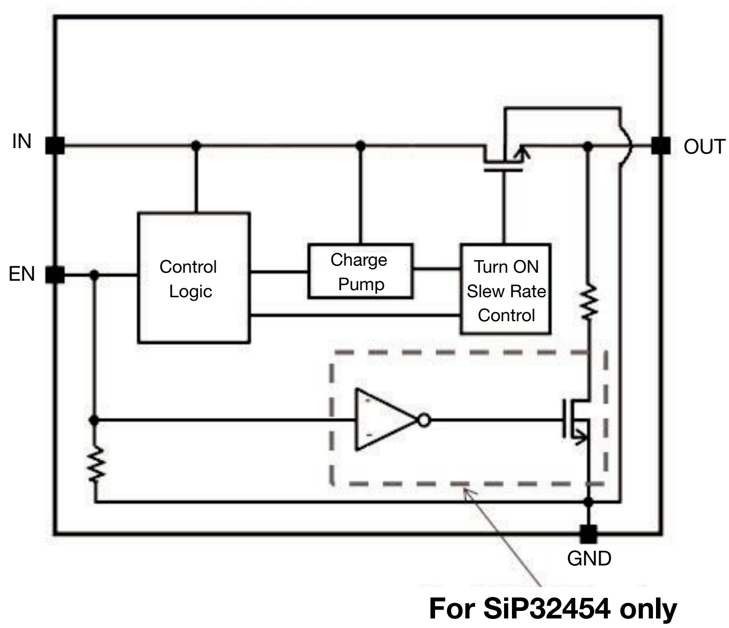
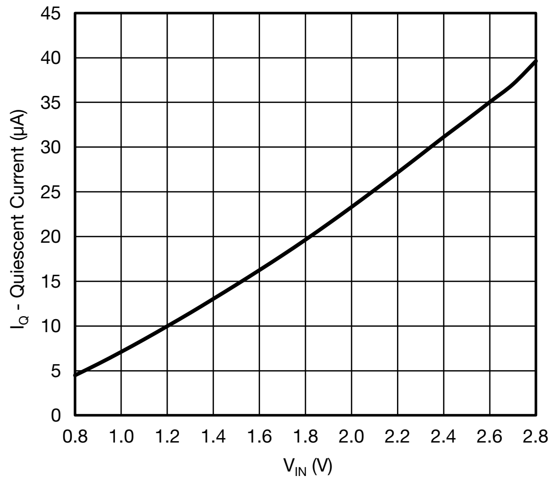
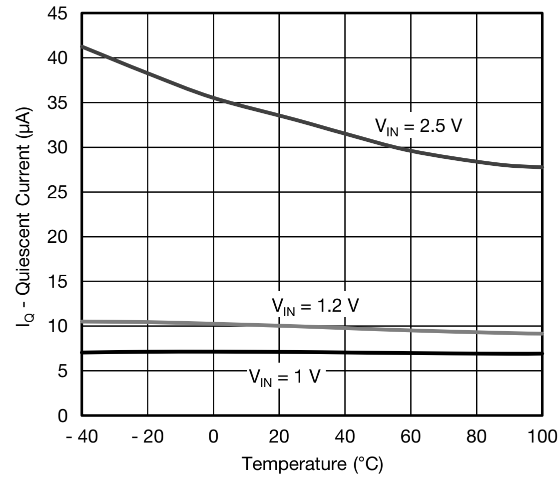


Figure 3 - Functional Block Diagram

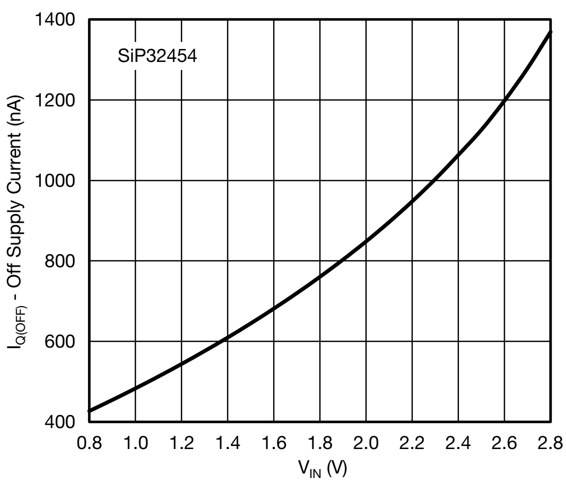
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



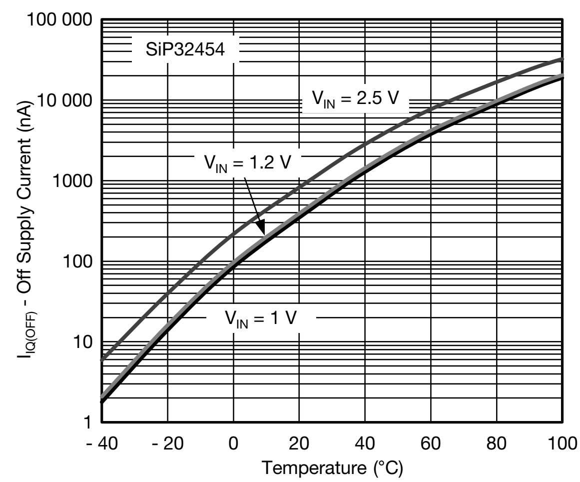
Quiescent vs. Input Voltage



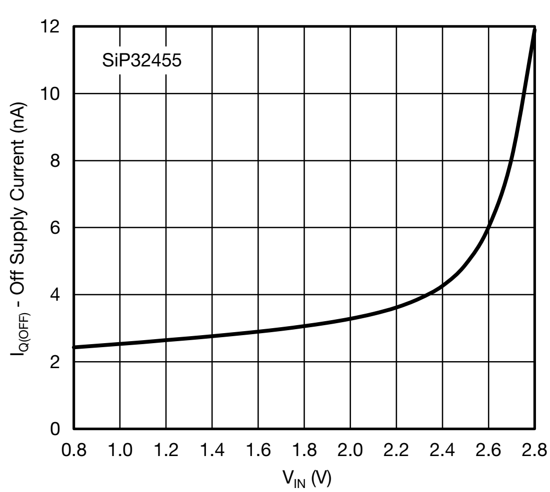
Quiescent vs. Temperature



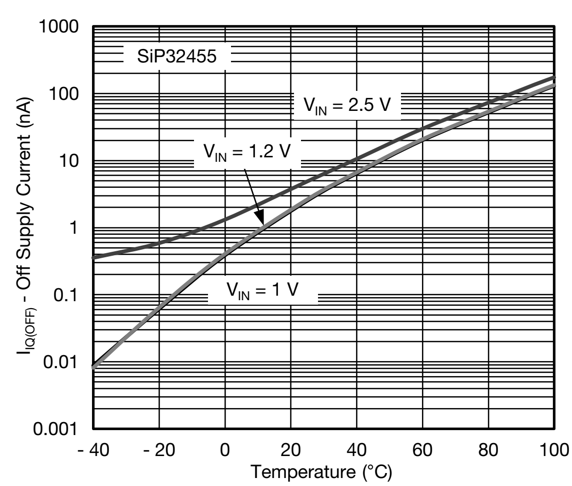
Off Supply Current vs. Input Voltage



Off Supply Current vs. Temperature

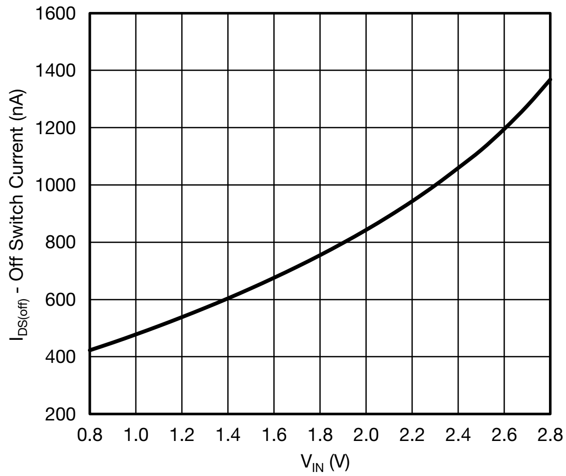


Off Supply Current vs. Input Voltage

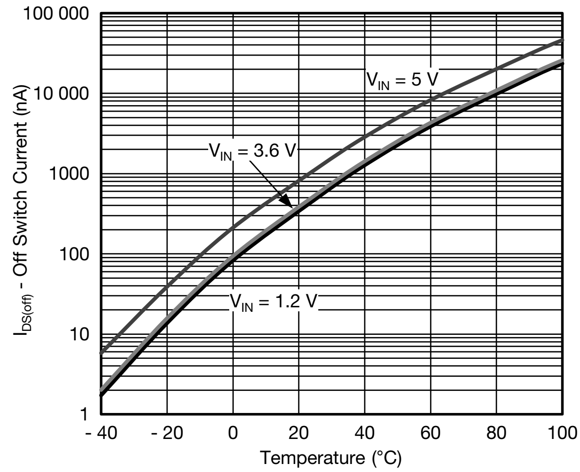


Off Supply Current vs. Temperature

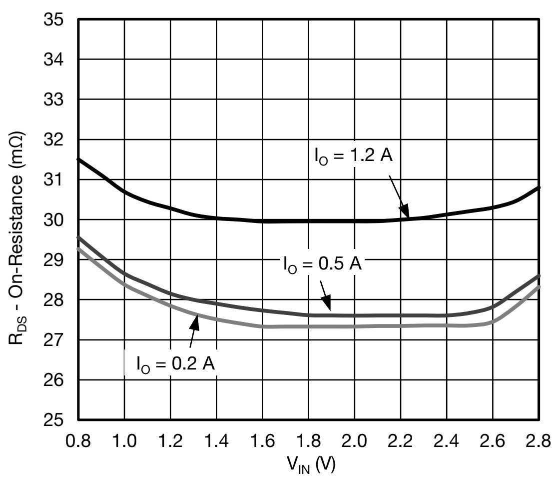
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



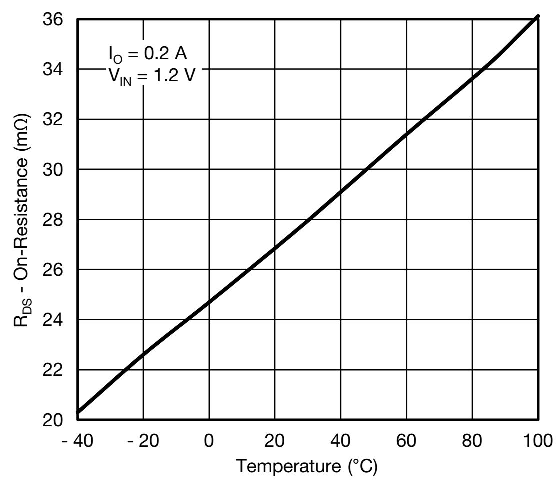
Off Switch Current vs. Input Voltage



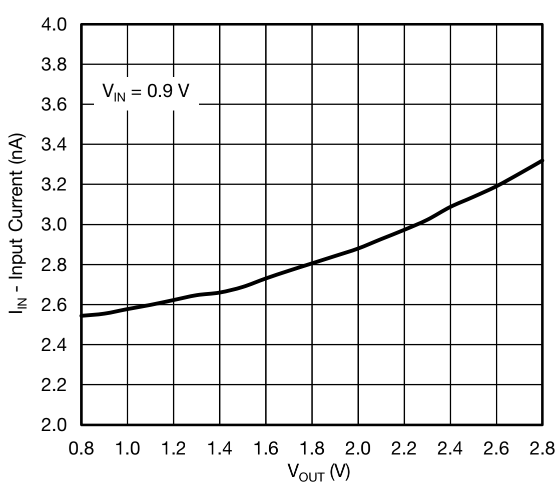
Off Switch Current vs. Temperature



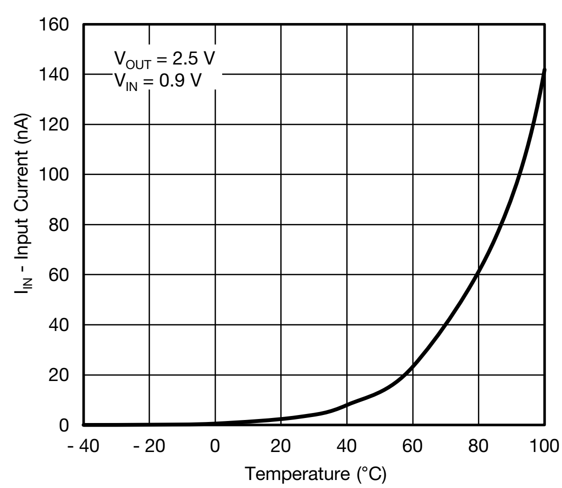
On Resistance vs. Input Voltage



On Resistance vs. Temperature

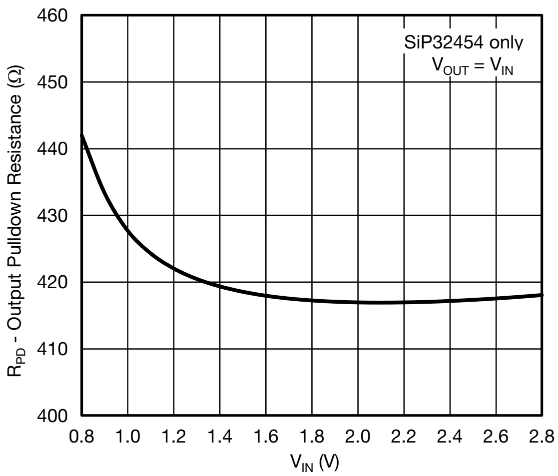


Reverse Blocking Current vs. Output Voltage

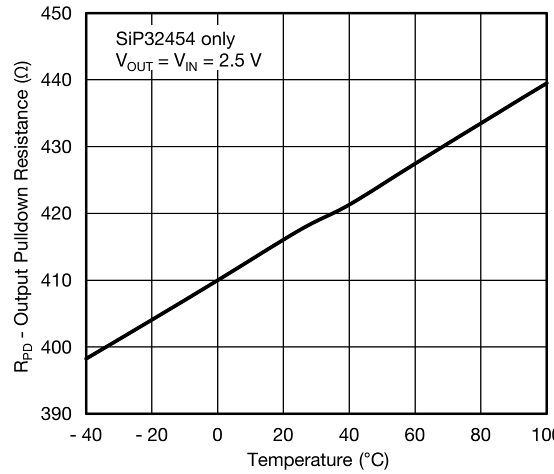


Reverse Blocking Current vs. Temperature

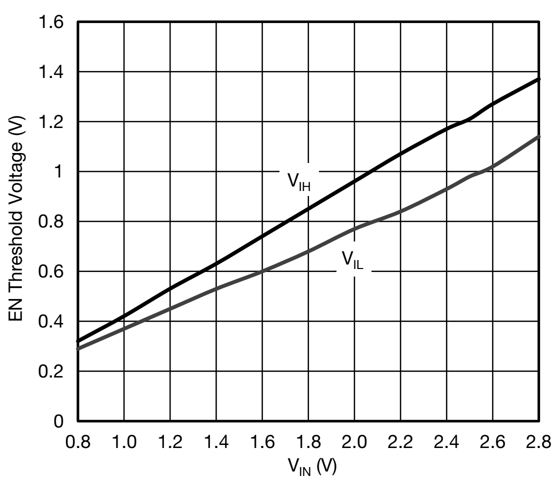
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



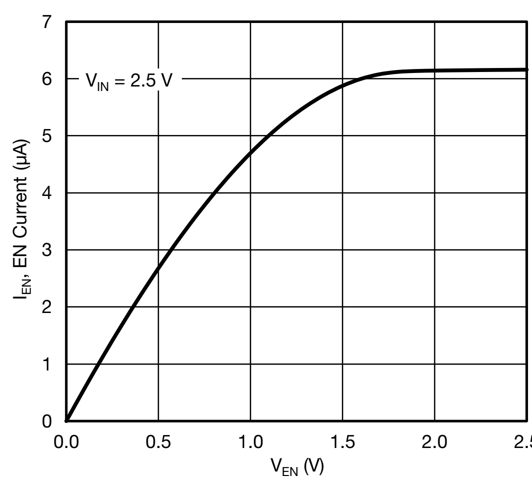
Output Pulldown Resistance vs. Input Voltage



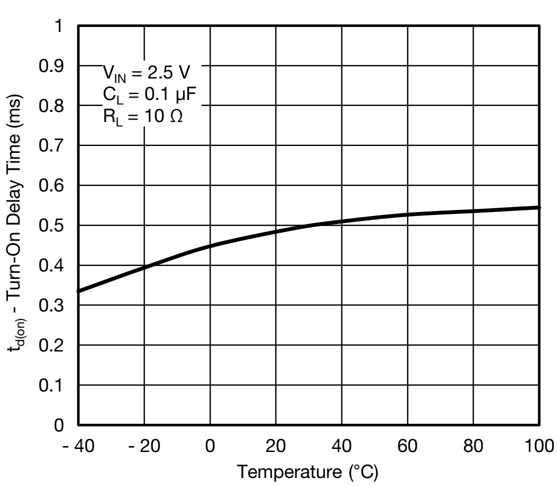
Output Pulldown Resistance vs. Temperature



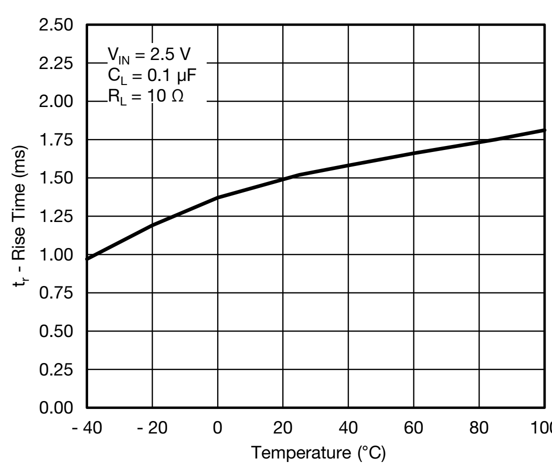
EN Threshold Voltage vs. Input Voltage



EN Input Leakage vs. V_{EN}

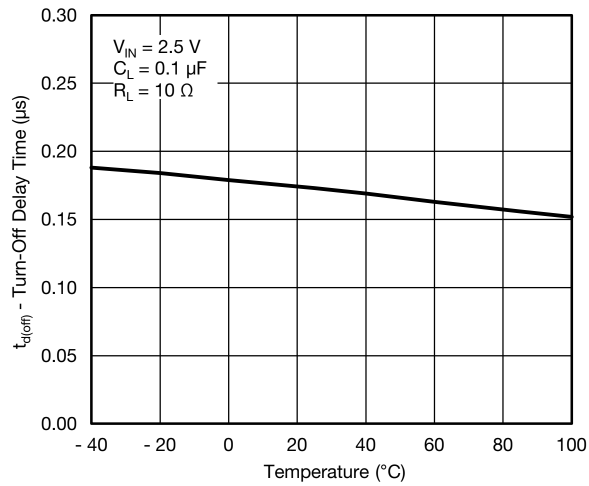


Turn-On Delay Time vs. Temperature



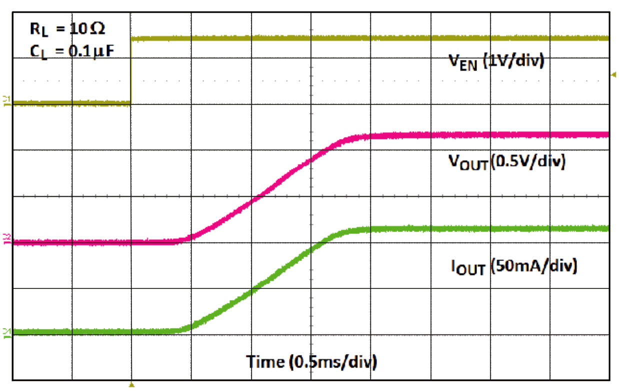
Rise Time vs. Temperature

ELECTRICAL CHARACTERISTICS

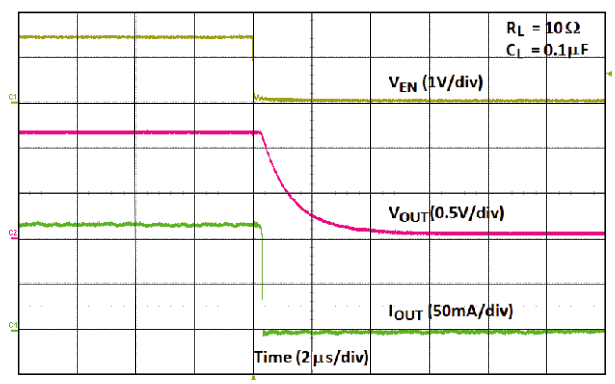


Turn-Off Delay Time vs. Temperature

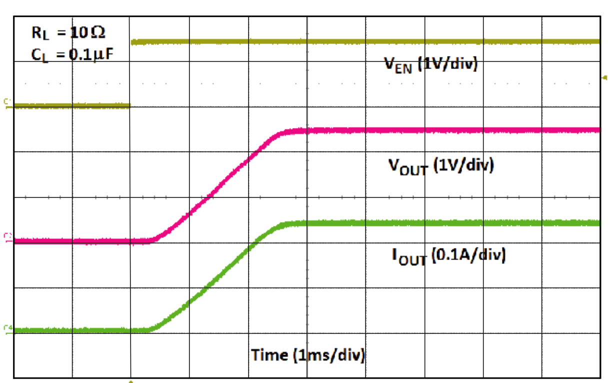
TYPICAL WAVEFORMS



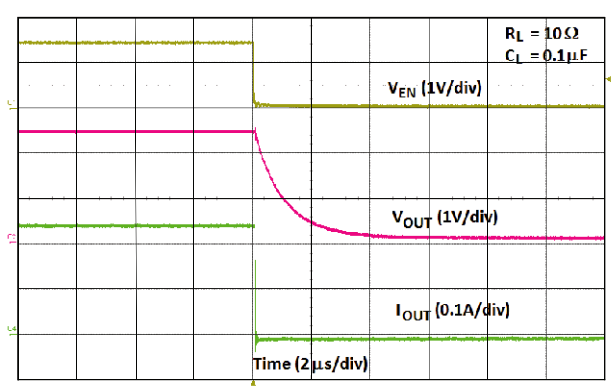
Turn-On Time (V_{IN} = 1.2 V)



Turn-Off Time (V_{IN} = 1.2 V)



Turn-On Time (V_{IN} = 2.5 V)



Turn-Off Time (V_{IN} = 2.5 V)

DETAILED DESCRIPTION

SiP32454 and SiP32455 are n-channel power MOSFET designed as high side load switch. Once enable the device charge pumps the gate of the power MOSFET to a constant gate to source voltage for fast turn on time. The mostly constant gate to source voltage keeps the on resistance low through out the input voltage range. SiP32454 and SiP32455 are designed with slow slew rate to minimize the inrush current during turn on. Because the body of the output n-channel is always connected to GND, it prevents the current from going back to the input in case the output voltage is higher than the output. The SiP32454 especially incorporates an active output pulldown resistor to discharge output capacitance when the device is off.

APPLICATION INFORMATION

Input Capacitor

While a bypass capacitor on the input is not required, a 4.7 µF 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 µF 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 0.1 V or below to fully shut down the device and 1.5 V or above to fully turn on the device.

Protection Against Reverse Voltage Condition

Both the SiP32454 and SiP32455 can block the output current from going to the input in case where the output voltage is higher than the input voltage when the main switch is off.

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 1.2 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 280 °C/W) the device should be connected to a heat sink on the printed circuit board.

The maximum power dissipation in any application is dependant on the maximum junction temperature, $T_{J(max.)}$ = 125 °C, the junction-to-ambient thermal resistance, θ_{J-A} = 280 °C/W, and the ambient temperature, T_A, which may be formulaically expressed as:

$$P\,(\text{max.}) = \frac{T_J\,(\text{max.}) - T_A}{\theta_{J-A}} = \frac{125 - T_A}{280}$$

It then follows that, assuming an ambient temperature of 70 °C, the maximum power dissipation will be limited to about 196 mW.

So long as the load current is below the 1.2 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 °C. The worst case $R_{DS(ON)}$ at 25 °C is 35 mΩ. The $R_{DS(ON)}$ at 70 °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 4100 ppm/°C. Continuing with the calculation we have

$R_{DS(ON)}$ (at 70 °C) = 35 mΩ x (1 + 0.0041 x (70 °C - 25 °C)) = 42.2 mΩ

The maximum current limit is then determined by

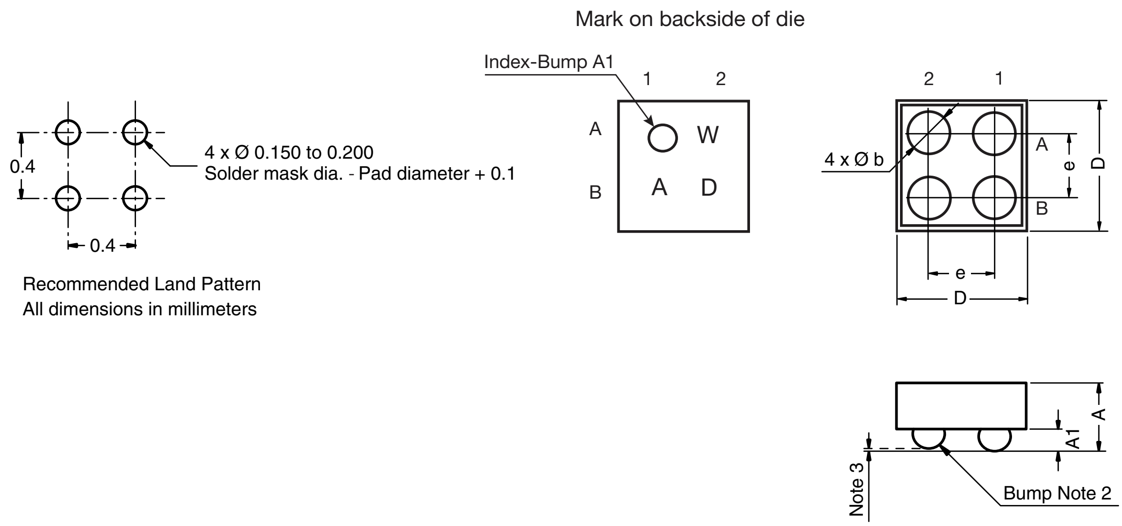
$$I_{LOAD}\,(\text{max.}) < \sqrt{\frac{P\,(\text{max.})}{R_{DS(ON)}}}$$

which in this case is 2.1 A. Under the stated input voltage condition, if the 2.1 A current limit is exceeded the internal die temperature will rise and eventually, possibly damage the device.

To avoid possible permanent damage to the device and keep a reasonable design margin, it is recommended to operate the device maximum up to 1.2 A only as listed in the Absolute Maximum Ratings table.

PACKAGE OUTLINE

WCSP: 4 Bumps (2 x 2, 0.4 mm Pitch, 208 µm Bump Height, 0.8 mm x 0.8 mm Die Size)



Dimension	MILLIMETERS			INCHES		
	Min.	**Nom.**	**MAX.**	**Min.**	**Nom.**	**MAX.**
A	0.515	0.530	0.545	0.0202	0.0208	0.0214
A1		0.208			0.0081	
b	0.250	0.260	0.270	0.0098	0.0102	0.0106
e		0.400			0.0157	
D	0.720	0.760	0.800	0.0182	0.0193	0.0203

Notes:
1. Laser mark on the backside surface of die.
2. Bumps are SAC396.
3. 0.050 max. coplanarity.

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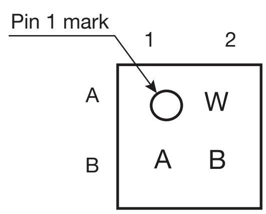
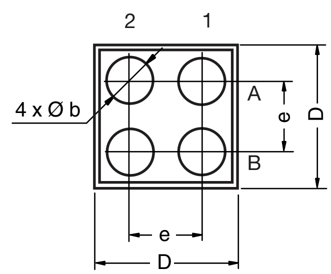
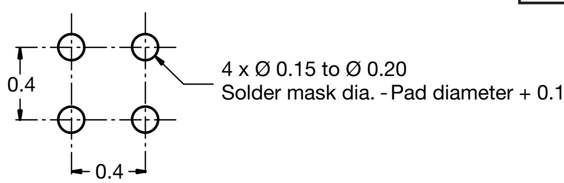
WCSP4: 4 Bumps

(2 x 2, 0.4 mm pitch, 208 µm bump height, 0.8 mm x 0.8 mm die size)

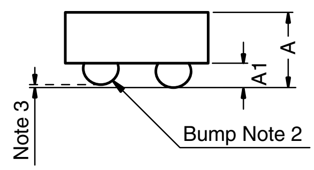
Mark on backside of die







Recommended Land Pattern
All dimensions in millimeters



DWG-No: 6004

Notes

(1) Laser mark on the backside surface of die

(2) Bumps are SAC396

(3) 0.05 max. coplanarity

DIM.	MILLIMETERS [a]			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.515	0.530	0.545	0.0202	0.0208	0.0214
A1		0.208			0.0081	
b	0.250	0.260	0.270	0.0098	0.0102	0.0106
e		0.400			0.0157	
D	0.720	0.760	0.800	0.0182	0.0193	0.0203

Note

a. Use millimeters as the primary measurement.

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