28 V, 56 mΩ, Load Switch
with Programmable Current Limit and Slew Rate Control

OPERATION DESCRIPTION

SiP32419 and SiP32429 are load switches that integrate multiple control features that simplify the design and increase the reliability of the circuitry connected to the switch. Both devices are 56 mΩ switches designed to operate in the 6 V to 28 V range. An internally generated gate drive voltage ensures good R_{ON} linearity over the input voltage operating range.

The SiP32419 and SiP32429 have a slew rate control circuit that controls the switch turn on time to the value set by an external capacitor.

After soft start, an over current protection circuit (OCP) continously monitors the current through the load switch, and controls the switch impedance to limit the current to the level programmed by an external resistor. If the overcurrent condition persists for more than 7 ms, the switch shuts off automatically. The SiP32419 and SiP32429 has an over temperature protection circuit (OTP) which will shut the switch off if the junction temperature exceeds about 135 °C. The OTP circuit will release the switch when the temperature has decreased by about 40 °C of hystersis.

When an OCP or an OTP fault condition is detected the $\overline{FLG}$ pin is pulled low. For the SiP32429, the fault flag will release 150 ms after the fault condition is cleared, and the switch will automatically turn on at the programmed slew rate. For the SiP32419, the switch will remain off and the fault flag will remain on.

These devices feature a low voltage control logic interface which can be controlled without the need for level shifting. These devices also include a power good flag.

SiP32419 and SiP32429 are available in a space efficient DFN10 3 mm x 3 mm package.

FEATURES

- 6 V to 28 V operation
- Programmable soft start
- Programmable current limit
- Over temperature protection
- ON resistance 56 mΩ
- Power good, when V_{OUT} reaches 90 % of V_{IN}
- Fault flag
- Under voltage lockout: 4.8 V/5.4 V (typ./max.)
- Package: DFN10 3 mm x 3 mm
- SiP32429 will turn OFF the switch under fault conditions, and re-try to turn on through the full soft start procedure 150 ms after the switch is off and the fault removed.
- SiP32419 will turn OFF the switch under fault conditions and remain OFF.
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

RoHS
COMPLIANT

HALOGEN
FREE
Available

APPLICATIONS

- Personal Computers
- Lighting
- Flat panel displays
- Game Consoles
- Industrial
- Network communication
- Data storage

TYPICAL APPLICATION CIRCUIT

Figure 1 - SiP32419, SiP32429 Typical Application Circuit

ORDERING INFORMATION

Temperature Range	Package	Marking	Part Number
-40 °C to 85 °C	DFN10 3 mm x 3 mm	2429	SiP32429DN-T1-GE4
		2419	SiP32419DN-T1-GE4

Note:
GE4 denotes halogen-free and RoHS-compliant

ABSOLUTE MAXIMUM RATINGS

Parameter	Limit	Unit
Input Voltage (V_{IN})	-0.3 to 30	V
Output Voltage (V_{OUT})	-0.3 to V_{IN} + 0.3 V	
$\overline{PG}$ Voltage	-0.3 to 30	
$\overline{FLG}$ Voltage	-0.3 to 30	
EN Voltage	-0.3 to 6	
Maximum Continuous Switch Current	4.5	A
ESD Rating (HBM)	4000	V
Maximum Junction Temperature	150	°C
Storage Temperature	-55 to 150	
Thermal Resistance (θ_{JA})[a]	88	°C/W
Power Dissipation (P_D)[a,b]	1.42	W

Notes:
a) Device mounted with all lead and power pad soldered or welded to PCB.
b) Derate 11.4 mW/°C above T_A = 25 °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 (V_{IN})	6 to 28	V
V_{SS}	0 to 6	
V_{OUT}	0 V to 28	
EN	0 to 6	
$\overline{FLG}$. $\overline{PG}$	0 to V_{IN}	
I_{LIM}	0 to 6	
Current Limit	0.75 to 3.5	A
Operating Temperature Range	-40 to 85	°C

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SPECIFICATIONS

Parameter	Symbol	Test Conditions Unless Specified V_{IN} =12 V, V_{EN} = 2.4 V, T_A = 25 °C	Temp.	Min.	Typ.	Max.	Unit
Power Input Voltage	V_{IN}		-	6	-	28	V
Quiescent Current	I_Q	I_{OUT} = 0 A, and device enabled	-	-	170	300	μA
Shutdown Current	I_{SD}	I_{OUT} = 0 A, and device disabled	-	-	12	20	
Switch OFF Leakage	$I_{(OFF)}$	V_{IN} = 28 V, V_{OUT} = 0 V (current measured at output)	-	-	-	1	
Current Limit Accuracy		R_{SET} = 4.1 kΩ	-40 °C to 85 °C	1.2	1.5	1.8	A
Switch On Resistance	$R_{DS(ON)}$	I_{SW} = 500 mA	-	-	56	72	mΩ
Soft Start Charge Current	I_{SS}	Constant current source	-	-	4.5	-	μA
Turn ON Delay Time	T_{ONDLY}	50 % V_{EN} to 50 % V_{OUT} C_{SS} = open, R_L = 10 Ω, C_{OUT} = 10 μF	-	-	550	-	μs
Turn ON Rise Time	T_R	C_{SS} = open, R_L = 10 Ω, C_{OUT} = 10 μF	-	-	400	-	
		C_{SS} = 47 nF, R_L = 10 Ω, C_{OUT} = 10 μF	-	-	7	-	ms
		C_{SS} = 47 nF, no R_L, C_{OUT} = 10 μF	-	-	2	-	
Turn Off Delay	T_{OFFDLY}		-	-	1	-	
Current Limit Response Time			-	-	20	-	μs
Short Circuit Response Time			-	-	1	-	
OC Flag Blanking Time/Switch OFF delay under OC			-40 °C to 85 °C	4	-	-	ms
Auto re-try time (SiP32429 only)			-	-	150	-	
Input Logic High Voltage	V_{ENH}	V_{IN} = 6 V to 28 V	-40 °C to 85 °C	1.5	-	-	V
Input Logic Low Voltage	V_{ENL}		-40 °C to 85 °C	-	-	0.6	
Input Pull Down Resistor	R_{EN}	V_{EN} = 5 V	-	-	2.5	-	MΩ
Power Good Trip Voltage			-	-	90 % x V_{IN}	-	V
Power Good Hysteresis			-	-	3 % x V_{IN}	-	
$\overline{PG}$ and $\overline{FLG}$ Output Logic Low Voltage		I_{SINK} = 1 mA	-	-	< 0.1	-	
$\overline{PG}$ and $\overline{FLG}$ Output High Leakage		V_{PG}, V_{FLG} = 28 V	-	-	-	1	μA
UVLO Threshold			-	-	4.8	5.4	V
UVLO Hysteresis			-	-	0.28	-	
Thermal Shutdown Threshold			-	-	137	-	°C
Thermal Shut down Hysteresis			-	-	39	-	

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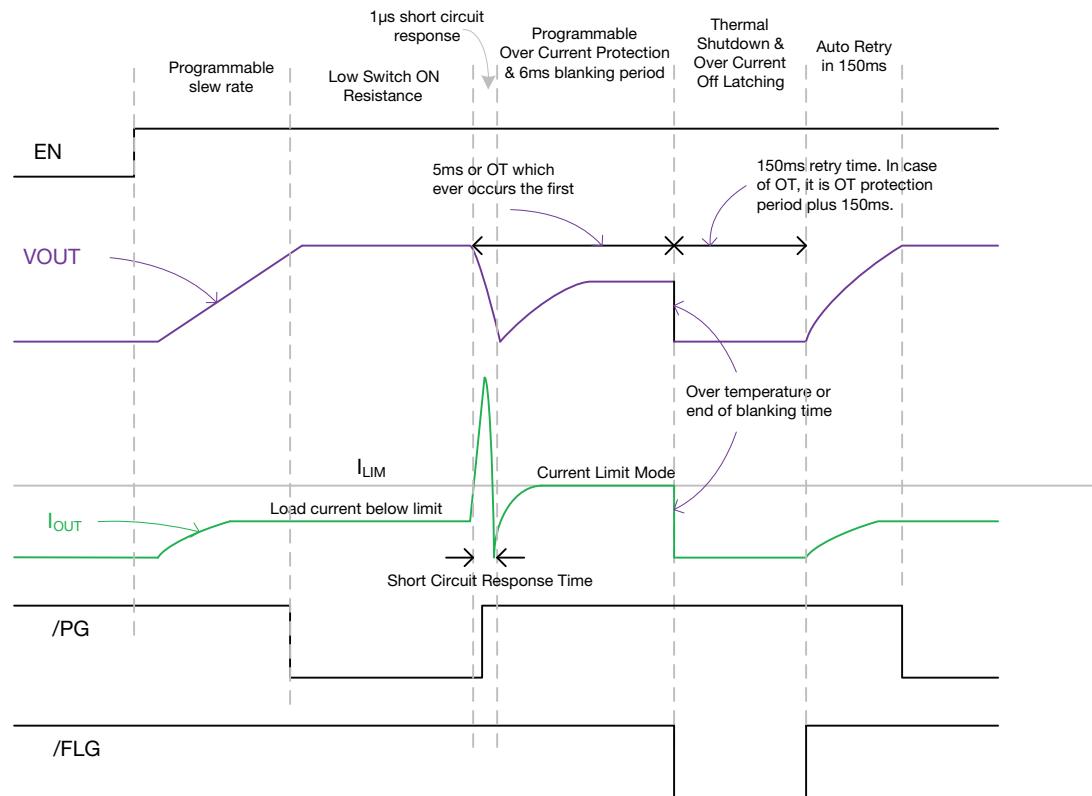
TIMING DIAGRAM

Figure 2 - Timing Diagram

PIN CONFIGURATION
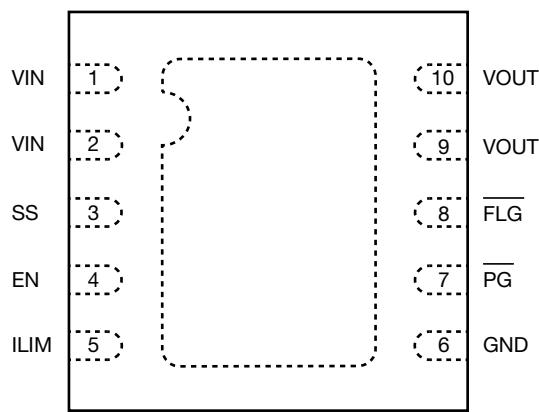
Figure 3 - DFN10 3 mm x 3 mm Package
Top View

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PIN DESCRIPTION

Pin Number	Name	Function
1	V_{IN}	Power Input
2	V_{IN}	Power Input
3	SS	Soft-Start Pin. Connect a Capacitor from SS to GND to Program the Soft-Start Time. Leave SS open to set the Default Soft-Start Time of 400 µs.
4	EN	Enable Input. Logic High Enabled
5	I_{LIM}	Current Limit Setting Pin. Connect R_{SET} Resistor to GND
6	GND	Ground
7	$\overline{PG}$	Power Good
8	$\overline{FLG}$	Fault Condition Flag
9	V_{OUT}	Switch Output
10	V_{OUT}	Switch Output
Central Pad		Connect this Pad to GND or leave it floating

BLOCK DIAGRAM
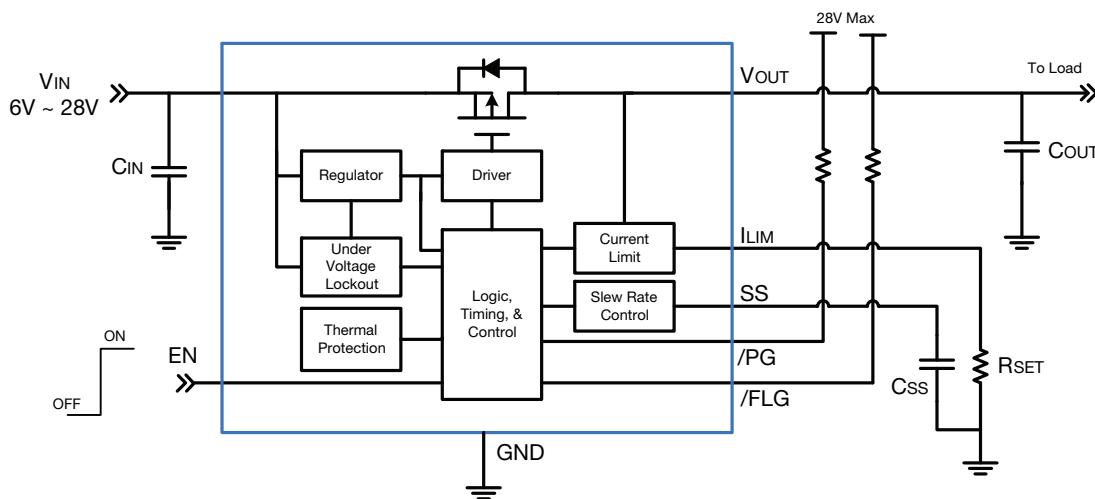
Figure 4 - Block Diagram

TYPICAL CHARACTERISTICS (internally regulated, 25 °C, unless otherwise noted)
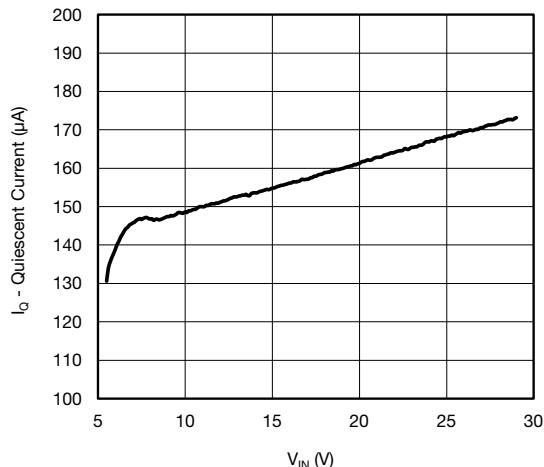
Figure 5 - Quiescent Current vs. Input Voltage
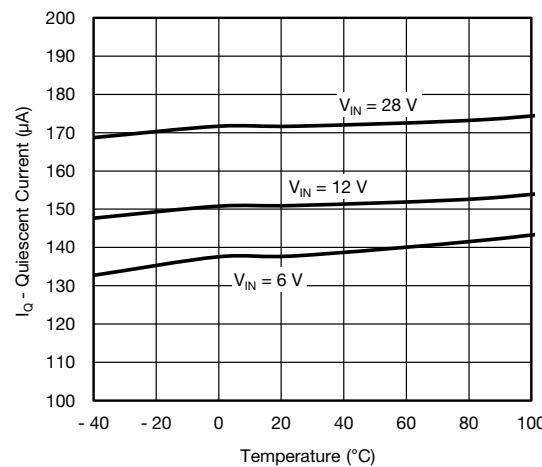
Figure 6 - Quiescent Current vs. Temperature

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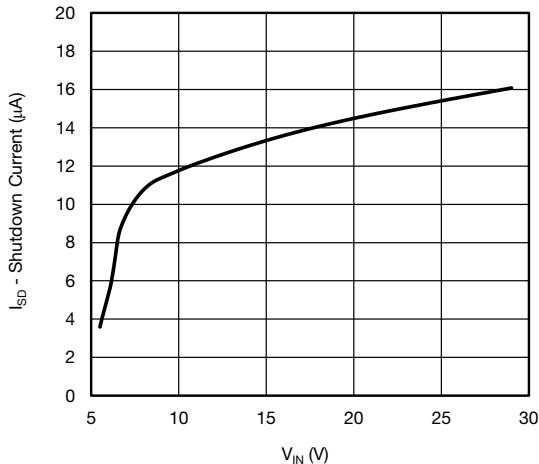
Figure 7 - Shutdown Current vs. Input Voltage
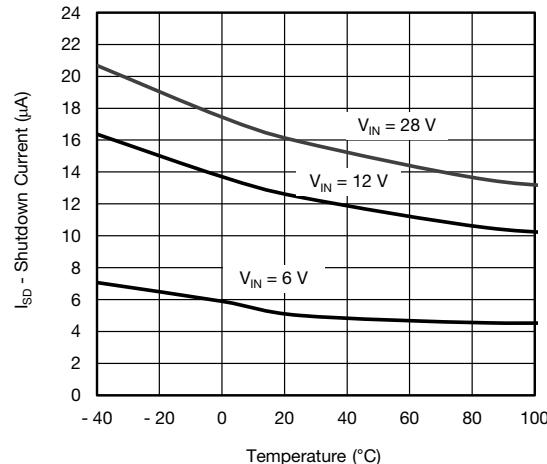
Figure 10 - Shutdown Current vs. Temperature
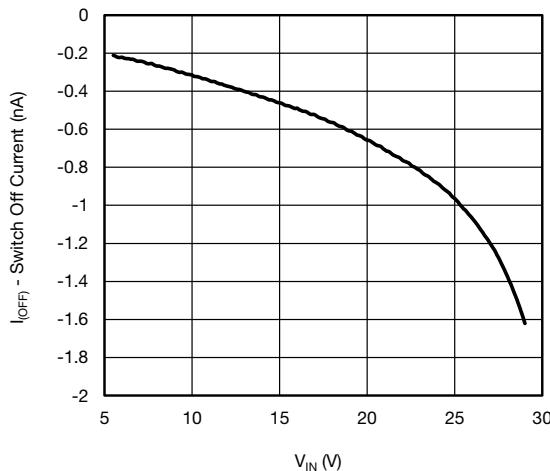
Figure 8 - Shutdown Current vs. Input Voltage
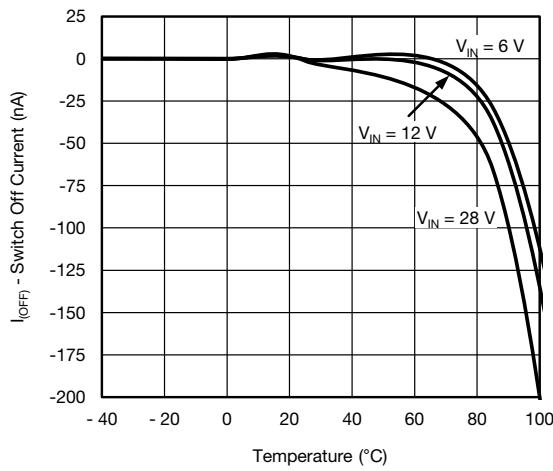
Figure 11 - Switch Off Current vs. Temperature
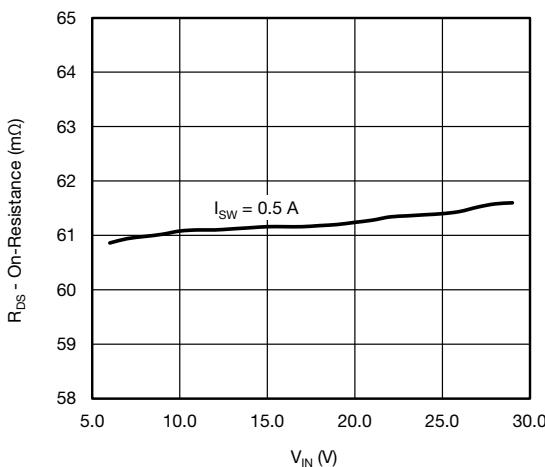
Figure 9 - On Resistance vs. Input Voltage
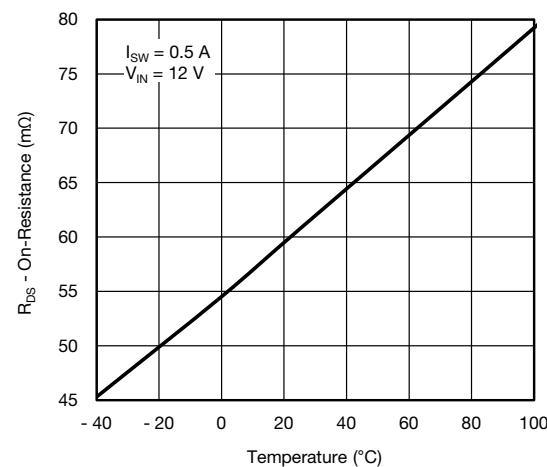
Figure 12 - On Resistance vs. Temperature

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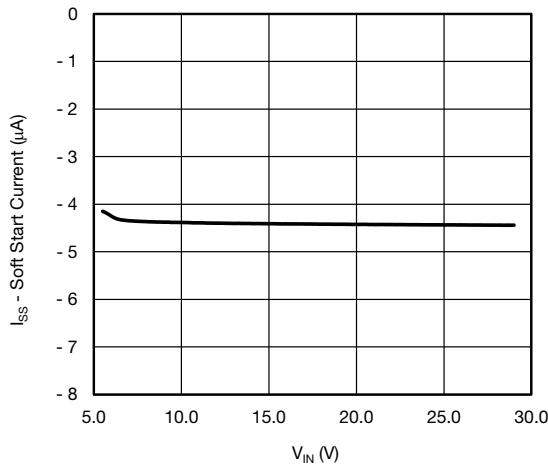
Figure 13 - Soft Start Current vs. Input Voltage
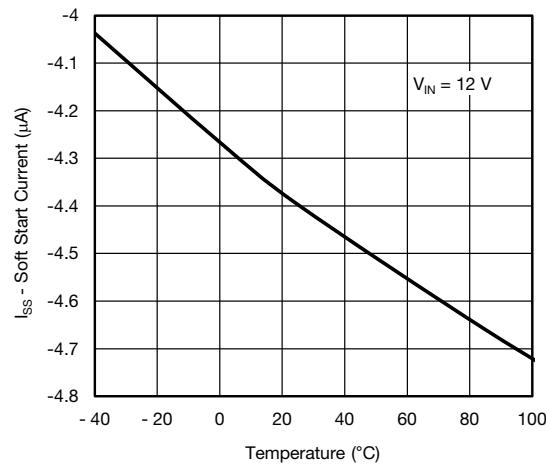
Figure 15 - Soft Start Current vs. Temperature
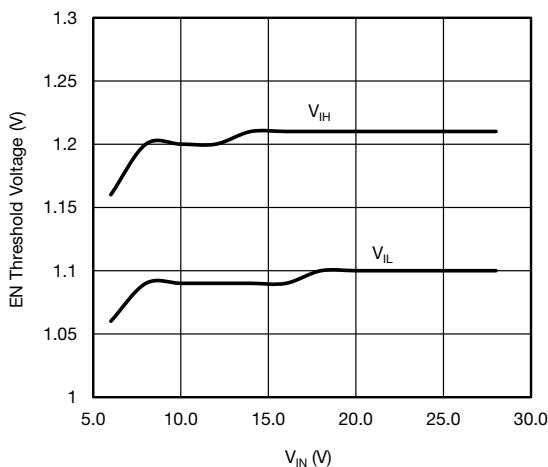

Figure 14 - Threshold Voltage vs. Input Voltage
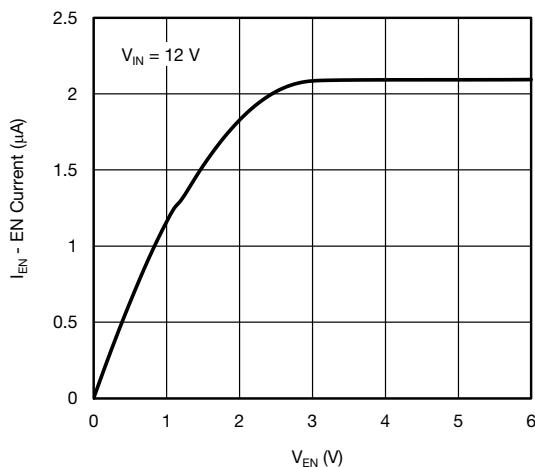
Figure 16 - EN Current vs. V_{EN}

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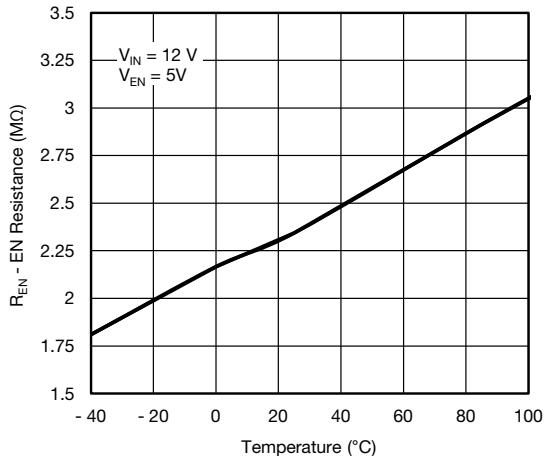
**Figure 17 - EN Resistance vs. Temperature**
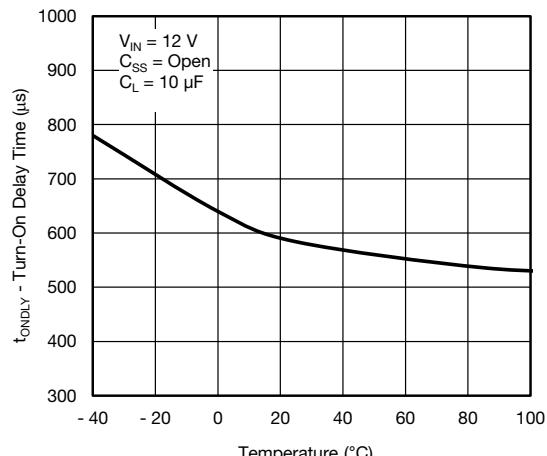
Figure 19 - Turn-On Delay Time vs. Temperature
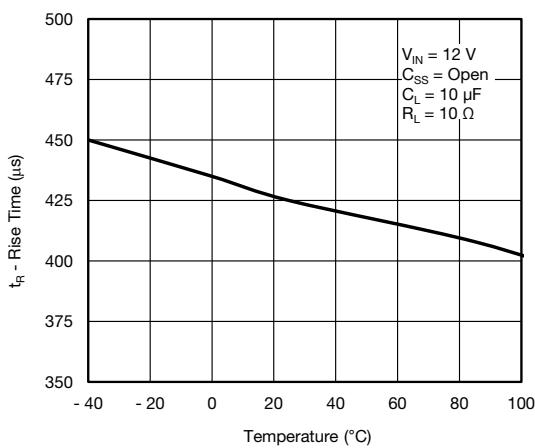
Figure 18 - Rise Time vs. Temperature
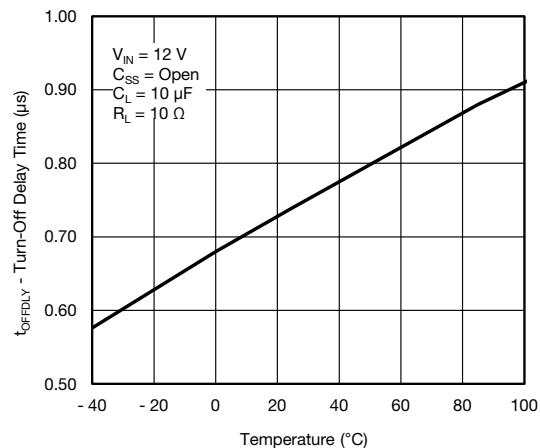
Figure 20 - Turn-Off Delay Time vs. Temperature
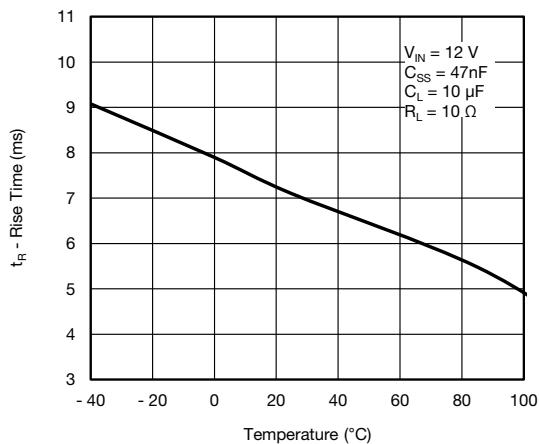
Figure 21 - Rise Time vs. Temperature

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TYPICAL WAVEFORMS
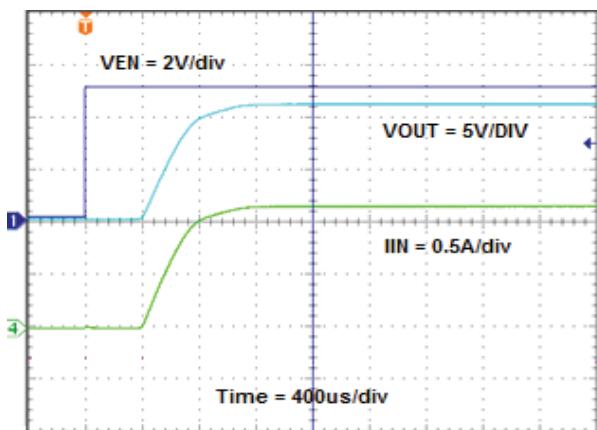
Figure 22 - Turn On Time,
V_{IN} = 12 V, C_{SS} = open, R_L = 10 Ω, C_L = 10 µF
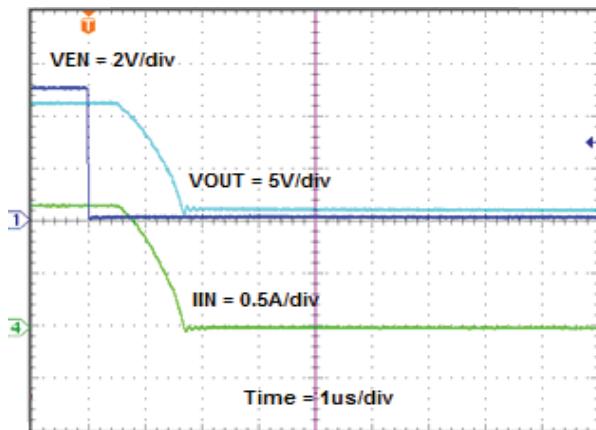
Figure 25 - Turn Off Time,
V_{IN} = 12 V, C_{SS} = open, R_L = 10 Ω, C_L = 10 µF
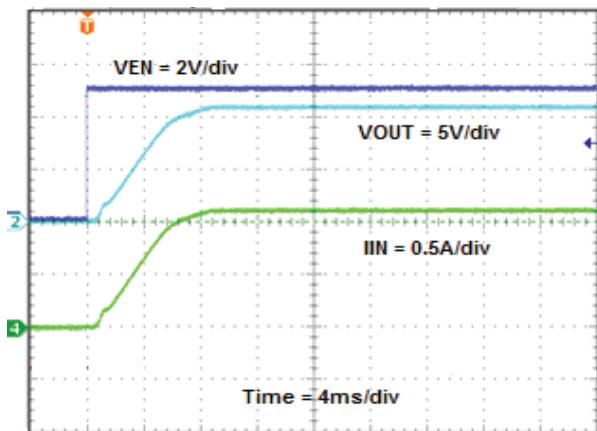
Figure 23 - Turn On Time,
V_{IN} = 12 V, C_{SS} = 47 nF, R_L = 10 Ω, C_L = 10 µF
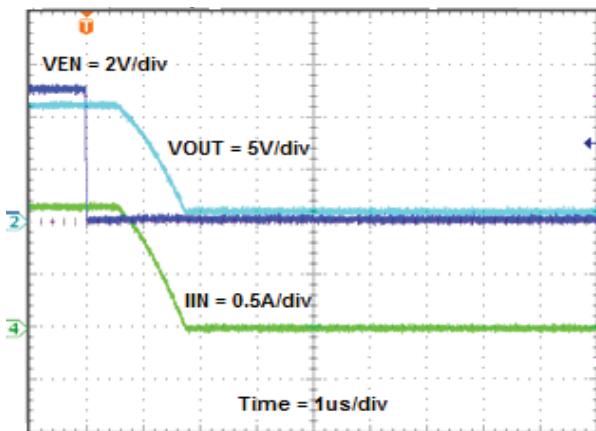
Figure 26 - Turn Off Time,
V_{IN} = 12 V, C_{SS} = 47 nF, R_L = 10 Ω, C_L = 10 µF
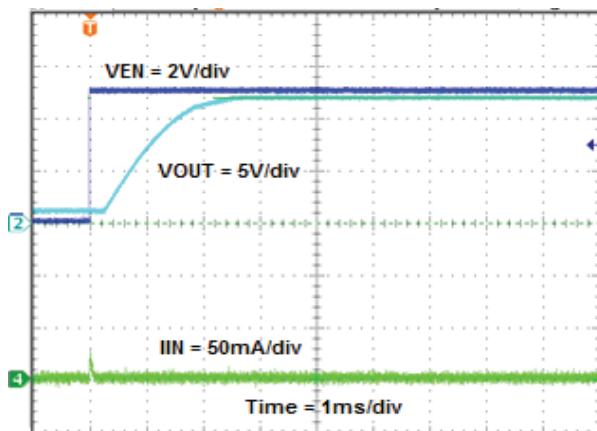
Figure 24 - Turn On Time,
V_{IN} = 12 V, C_{SS} = 47 nF, R_L = open, C_L = 10 µF
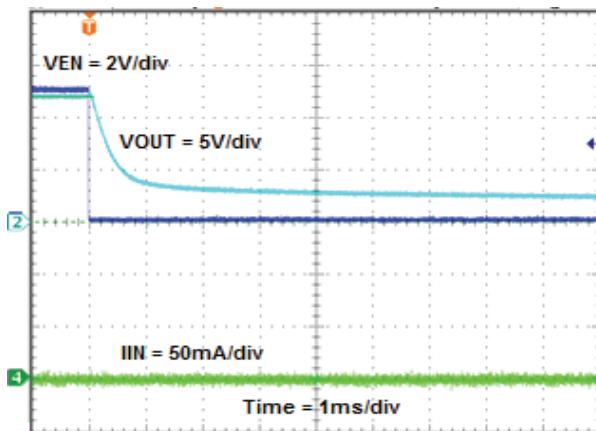
Figure 27 - Turn Off Time,
V_{IN} = 12 V, C_{SS} = 47 nF, R_L = open, C_L = 10 µF

TYPICAL WAVEFORMS
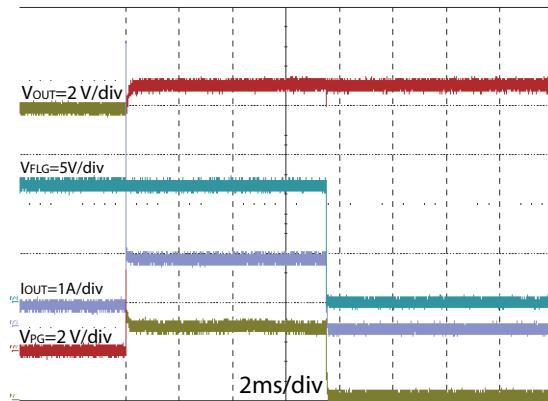
Figure 28 - Current Limit
from 25 Ω to 2 Ω Load, V$_{IN}$ = 12 V
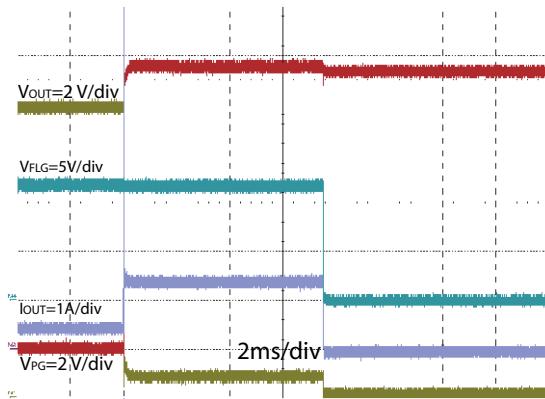
Figure 30 - Current Limit
from 25 Ω to 0.5 Ω Load, V$_{IN}$ = 12 V
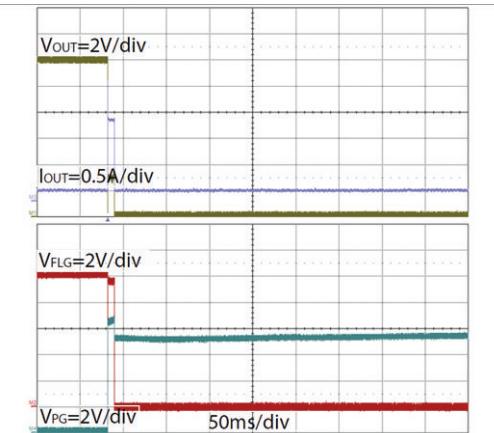
Figure 29 - SiP32419
remains off after seeing Fault Condition
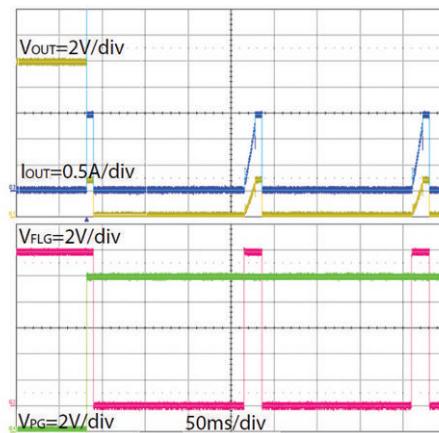
Figure 31 - SiP32429
Re-Starts after ~ 150ms during Fault Condition

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DETAILED DESCRIPTION

OVER CURRENT LIMIT

When an over-current event occurs, the SiP32419 and SiP32429 will current limit immediately. If the event exceeds 7 ms the switch is turned OFF and the $\overline{FLG}$ pin is pulled low. The SiP32429 remains off for 150 ms and after this time if the signal on EN pin is in a high state, the switch will enable. The SiP32419 will remain off and will not try to re-start.

The current limit is set by connecting a resistor between the I_{LIM} pin and GND. R_{SET} can be calculated by the following formula:

$$I_{lim} = \frac{1.24 \text{ V}}{R_{SET}} \text{ x } 5000$$

Where:

I_{LIM} = is the target current limit setting.

R_{SET} SELECTION TABLE

| R_{SET} (kΩ)	Current Limit (A)			Tol. (%)
	Min.	Typ.	Max.	
1.74	2.85	3.56	4.28	20
1.78	2.78	3.48	4.18	20
1.82	2.73	3.41	4.09	20
2.21	2.25	2.81	3.37	20
2.80	1.77	2.21	2.66	20
3.57	1.39	1.74	2.08	20
4.12	1.20	1.50	1.81	20
4.53	1.03	1.37	1.71	25
5.76	0.81	1.08	1.35	25
7.32	0.64	0.85	1.06	25
8.25	0.56	0.75	0.94	25
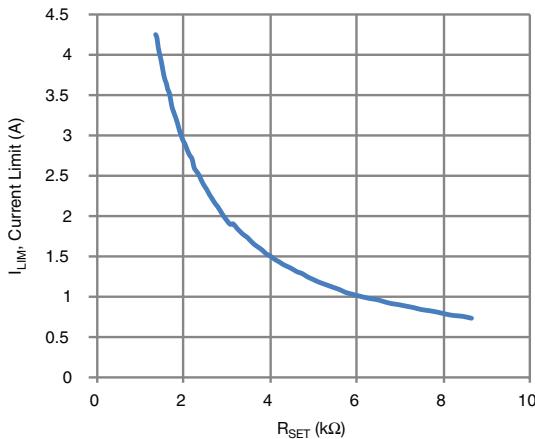
Figure 32 - Current Limit vs. R_{SET}

SOFT START

The soft start time can be calculated by the following formula:

$$\frac{\Delta V_{OUT}}{\Delta T} = \frac{I_{SS}}{C_{SS}} \text{ x } \frac{R_{OUT} \text{ x } 5000}{R_{SET}}$$

Where:

ΔT is the soft start time

ΔV_{OUT} is the output voltage range

I_{SS} is the built-in current source charging the soft start capacitor C_{SS}. I_{ss} value is 5 µA typical.

C_{SS} is the soft start time setting capacitor.

R_{SET} is the current limit setting resistor.

R_{OUT} is the output load.

ENABLE

The enable pin needs to be high for the device to become active. This can be accomplished by applying a logic high signal to the EN pin. Alternatively this pin can be hardwired through a resistor divider to the V_{IN}, thus keeping the switch permanently ON as long as the supply is present.

$\overline{FLG}$

The $\overline{FLG}$ is an open drain output and will be pulled low in fault condition. This pin can be pulled up through a 100K resistor.

$\overline{PG}$

The $\overline{PG}$ is an open drain output that will be pulled low when output voltage passes 90 % of the V_{IN} . This pin can be pulled up through a 100K resistor.

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SiP32419, SiP32429

Vishay Siliconix

APPLICATION INFORMATION

INPUT CAPACITOR

While bypass capacitors at the inputs pins are not required, a 2.2 µF or larger capacitors for C_{IN} is recommended in almost all applications. The bypass capacitors should be placed as physically close to the device's input pins to be effective to minimize 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.

OUTPUT CAPACITOR

The device does not require an output capacitor for proper operation. A proper value C_{OUT} is recommended to accommodate load transient per circuit design requirements. There are no ESR or capacitor type requirements.

OVER TEMPERATURE SHUTDOWN

In case an over temperature event happens, the SiP32419 and SiP32429 will turn the switch off immediately. The SiP32429 will then retry to start 150 ms after the temperature is back to normal; during this period, $\overline{FLG}$ will be pulled low. The SiP32429 $\overline{FLG}$ will be pulled high 150 ms after the OT event has finished. The SiP32419 will remain off and not retry to start, $\overline{FLG}$ will remain to be pulled low.

THERMAL CONSIDERATION

SiP32419 and SiP23429 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 should be kept at reasonably safe level. However, another limiting characteristic of the safe operating load current is the thermal power dissipation.

SOA
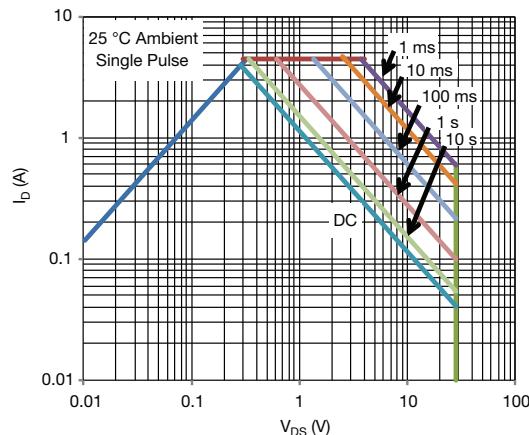
Figure 33 - SOA on Application Board
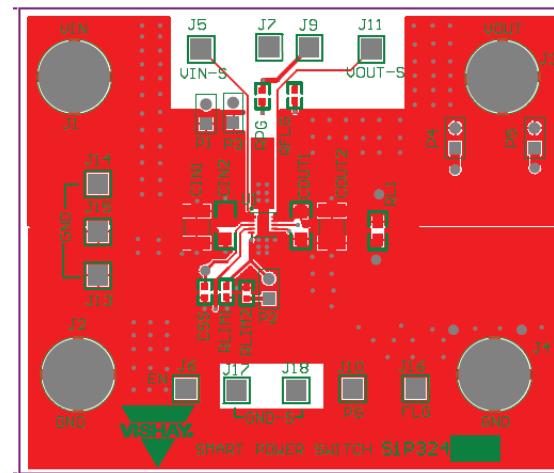
Figure 34 - Application Board Layout

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VISHAY

DFN-10 LEAD (3 X 3)

BOTTOM VIEW

TOP VIEW

SIDE VIEW
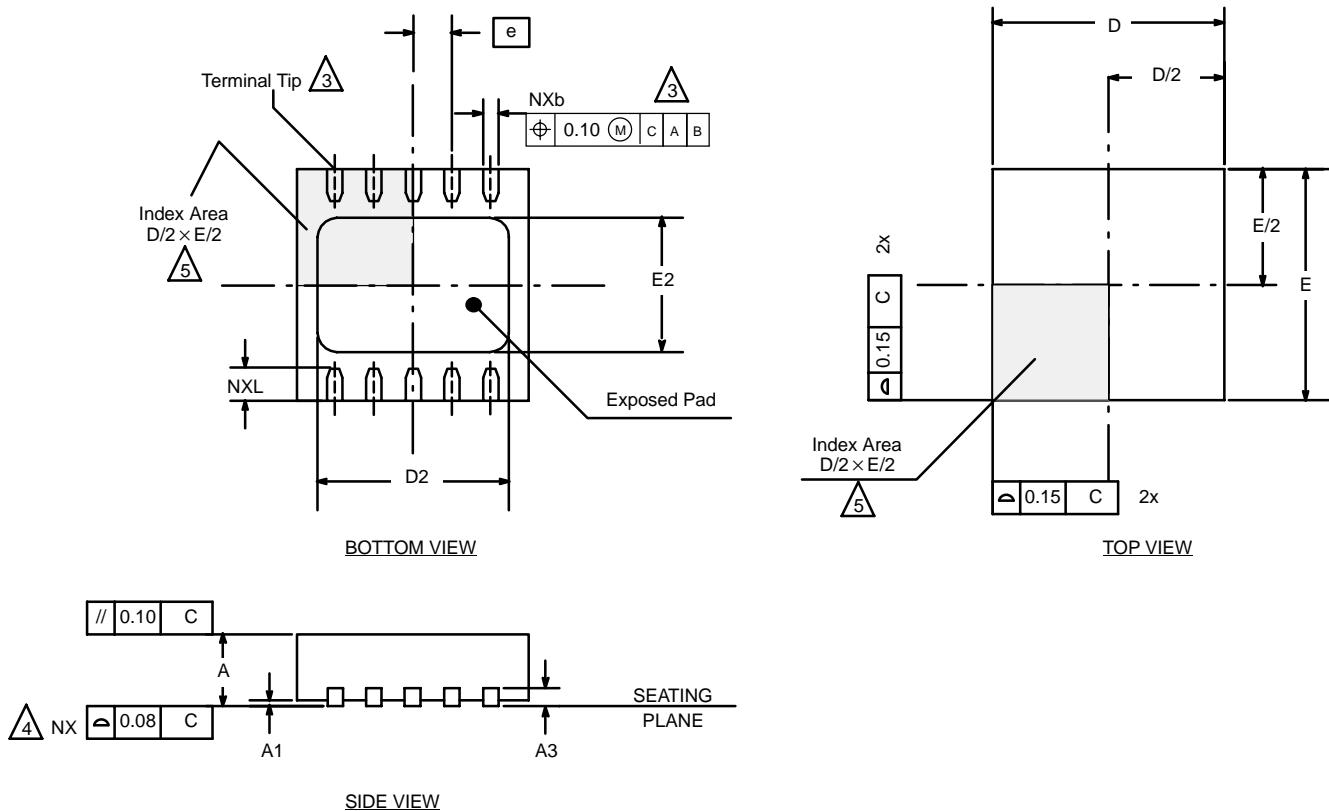
NOTES:

1. All dimensions are in millimeters and inches.

2. N is the total number of terminals.

3. Dimension b applies to metallized terminal and is measured between 0.15 and 0.30 mm from terminal tip.

4. Coplanarity applies to the exposed heat sink slug as well as the terminal.

5. The pin #1 identifier may be either a mold or marked feature, it must be located within the zone iindicated.

Dim	MILLIMETERS			INCHES		
	Min	Nom	Max	Min	Nom	Max
A	0.80	0.90	1.00	0.031	0.035	0.039
A1	0.00	0.02	0.05	0.000	0.001	0.002
A3	0.20 BSC			0.008 BSC		
b	0.18	0.23	0.30	0.007	0.009	0.012
D	3.00 BSC			0.118 BSC		
D2	2.20	2.38	2.48	0.087	0.094	0.098
E	3.00 BSC			0.118 BSC		
E2	1.49	1.64	1.74	0.059	0.065	0.069
e	0.50 BSC			0.020 BSC		
L	0.30	0.40	0.50	0.012	0.016	0.020

*Use millimeters as the primary measurement.

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