Protected 1-A High-Side Load Switch

DESCRIPTION

SiP4613A, SiP4613B is a protected highside power switch. It is designed to operate from voltages ranging from 2.4 V to 5.5 V and handle a continuous current of 1 A. The user settable current limit protects the input supply voltage from excessive load currents that might cause a system failure.

SiP4613A, SiP4613B has a low shutdown supply current, which is reduced to less than 1 µA. A flag output $\overline{C_L}$ is available to indicate fault conditions such as output short and thermal protection.

In addition to current limit, the SiP4613A, SiP4613B is protected by undervoltage lockout and thermal shutdown.

The SiP4613A, SiP4613B is available in a lead (Pb)-free 6-pin PowerPAK® TSC75-6 for operation over the industrial temperature range of - 40 °C to 85 °C.

FEATURES

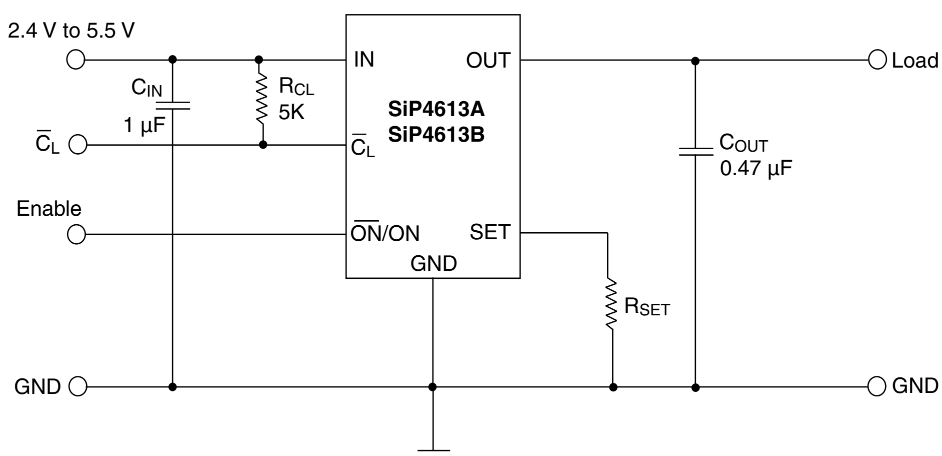
- 1 A continuous output current
- 2.4 V to 5.5 V supply voltage range
- User settable current limit level
- Low quiescent current
- Undervoltage lockout
- Thermal shutdown protection
- 4 kV ESD rating-HBM

Pb-free
RoHS
COMPLIANT

APPLICATIONS

- Peripheral ports
- Hot swap
- Notebook computers
- PDAs

TYPICAL APPLICATION CIRCUIT



ABSOLUTE MAXIMUM RATINGS all voltages referenced to GND = 0 V		
Parameter	**Limit**	**Unit**
V_{IN}, $V_{\overline{ON}}$, V_{ON}	- 0.3 to 6	V
I_{MAX}	2	A
Storage Temperature	- 65 to 150	°C
Operating Junction Temperature	- 40 to 150	°C
Power Dissipation[a], PowerPAK TSC75-6	420	mW
Thermal Impedance (Θ_{JA})[b], PowerPAK TSC75-6	131	°C/W

Notes:
a. Derate 7.6 mW/°C above T_A = 70 °C.
b. Device mounted with all leads soldered or welded to PC board.

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.

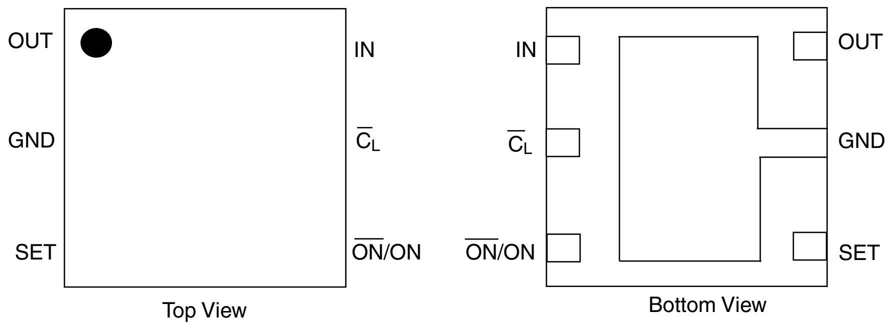
RECOMMENDED OPERATING RANGE all voltages referenced to GND = 0 V		
Parameter	**Limit**	**Unit**
IN	2.4 to 5.5	V
Operating Temperature Range	- 40 to 85	°C

SPECIFICATIONS[a]

Parameter	Symbol	Test Conditions Unless Specified IN = 5 V, T_A = - 40 °C to 85 °C	Limits Min.[a]	Typ.[b]	Max.[a]	Unit
Power Supplies						
Supply Voltage	V_{IN}		2.4		5.5	V
Quiescent Current	I_Q	IN = 5 V, $\overline{ON}$/ON = Active, I_{OUT} = 0 A			100	µA
Shutdown Current	I_{SD}	IN = 5 V, $\overline{ON}$/ON = Inactive			1	
Switch Off Current	$I_{S(off)}$	IN = 5 V, $\overline{ON}$/ON = Inactive, V_{OUT} = 0 V, T_A = 25 °C			1	
Enable Inputs						
$\overline{ON}$/ON High	V_{IH}	IN = 2.4 V to 5.5 V	1.5			V
$\overline{ON}$/ON Low	V_{IL}				0.5	
$\overline{ON}$/ON Leakage Current	I_{LH}	$\overline{ON}$/ON = 5 V			1	µA
Turn Off Time	t_{OFF}	IN = 5 V, R_L = 10 Ω		0.5	5	µs
Turn On Time	t_{ON}			55	120	
Output						
On-Resistance	R_{DS}	IN = 5 V, T_A = 25 °C		150	225	mΩ
		IN = 3 V, T_A = 25 °C		180	250	
Current Limit	I_L	R_{SET} = 6.81 kΩ	0.375	0.5	0.625	A
Minimum Current Limit	$I_{L(min)}$			125		mA
Output Short Circuit Current	I_{SH}	R_{SET} = 6.81 kΩ	0.350	0.5	0.650	A
Current Limit Response Time	t_{RESP}	IN = 5 V		4		µs
Undervoltage Lockout						
UVLO Threshold	V_{UVLO}	Rising Edge		1.8	2.4	V
UVLO Hysteresis	V_{HYST}			0.05		
Thermal Shutdown						
Thermal Shutdown Threshold	T				165	°C
Hysteresis	T_{HYST}			20		

Notes:
a. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum (- 40 °C to 85 °C).
b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
c. Guaranteed by design.

PIN CONFIGURATION, ORDERING INFORMATION



TSC75-6 PACKAGE

ORDERING INFORMATION			
Part Number	**Marking**	**Temperature Range**	**Package**
SiP4613ADVP-T1-E3	M3XXX	- 40 °C to 85 °C	PowerPAK TSC75-6
SiP4613BDVP-T1-E3	M4XXX	- 40 °C to 85 °C	PowerPAK TSC75-6

XX = Lot Code
W = Work week Code

PIN DESCRIPTION		
Pin Number	**Name**	**Function**
1	OUT	Switch output
2	GND	Ground pin
3	SET	Current limit level set pin. The level is determinied by the value of a resistor connected from this pin to GND
4	$\overline{\text{ON}}$/ON	Shutdown pin. $\overline{\text{ON}}$/ON, active low on the SiP4613A to turn on the switch, active high to turn off SiP4613A Active high on the SiP4613B to turn on the switch, active low to turn off SiP4613B
5	$\overline{C}_L$	$\overline{C}_L$ pin will go low if SiP4613 is operating in current limited condition
6	IN	Input supply voltage and switch input

FUNCTIONAL BLOCK DIAGRAM

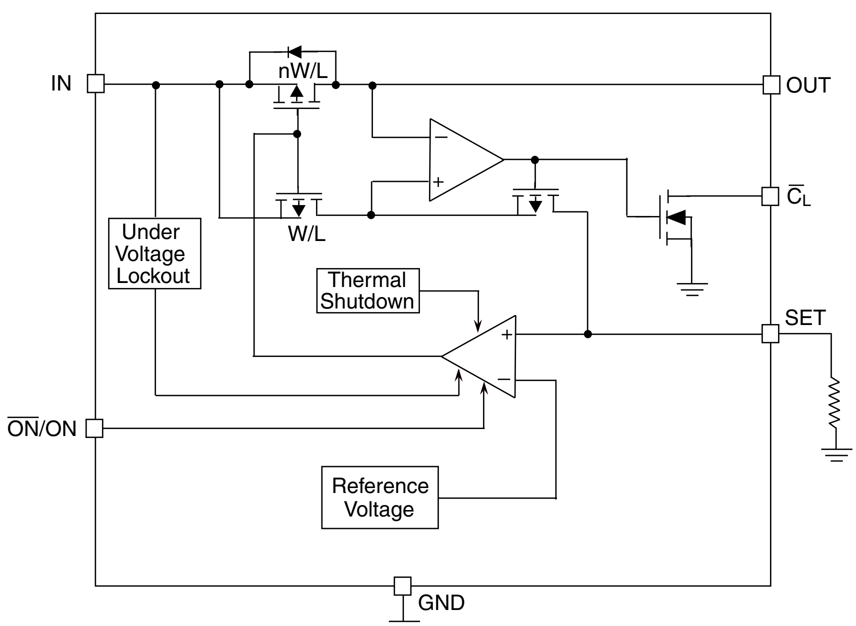


Figure 1. SiP4613A/B Block Diagram

DETAILED DESCRIPTION

The SiP4613A, SiP4613B limits load current by sampling the pass transistor current and passing that through an external resistor, R_{SET}. The voltage across R_{SET}, V_{SET}, is then compared with an internal reference voltage, V_{REF}. In the event that load current surpasses the set limit current, V_{SET} will exceed V_{REF} causing the pass transistor gate voltage to increase, thereby reducing the gate to source voltage of the PMOS switch and regulating its current back down to I_{LIMIT}.

Setting the Current Limit Level

Setting the current limit level on the SiP4613A, SiP4613B requires some care to ensure the maximum current required by the load will not trigger the current limit circuitry. The minimum current limit threshold should be determined by taking the maximum current required by the load, I_{LOAD}, and adding 25 % headroom. The SiP4613A, SiP4613B has a current limit tolerance of 25 %, which is largely a result of process variations from part to part, and also temperature and V_{IN}/V_{OUT} variances. Thus, to ensure that the actual current limit is never below the desired current limit a 1/0.80 = 1.25 coefficient needs to be added to the calculations. Knowing the maximum load current required, the value of R_{SET} is calculated as follows.

$$R_{SET} = R_{SET}\ \text{coefficient}/I_{LIMIT}$$

where $I_{LIMIT} = (I_{LOAD} \times 1.25) \times 1.20$ and R_{SET} coefficient is 3460 for a 500 mA current limit. For typical R_{SET} coefficient values given a limit current refer to the "Typical Characteristics" section.

Operation at Current Limit and Thermal Shutdown

In the event that a load higher than I_{LIMIT} is demanded of the SiP4613A, SiP4613B the load current will stay fixed at the current limit established by R_{SET}. However, since the required current is not supplied, the voltage at OUT will drop. The increase in V_{IN} - V_{OUT} will cause the chip to dissipate more heat. The power dissipation for the SiP4613A, SiP4613B can be expressed as

$$P = I_{LOAD} \times (V_{IN} - V_{OUT})$$

Once this exceeds the maximum power dissipation of the package, the die temperature will rise. When the die temperature exceeds an over-temperature limit of 165 °C, the SiP4613A, SiP4613B will shut down until it has cooled down to 145 °C, before starting up again. As can be seen in the figure below, the SiP4613A, SiP4613B will continue to cycle on and off until the load is reduced or the part is turned off (see figure 4 on next page).

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 for the TSC75-6 package, $\theta_{J\text{-}A}$ = 131 °C/W, and the ambient temperature, T_A, which may be formulaically expressed as:

$$P(\max) = \frac{T_J(\max) - T_A}{\theta_{J-A}} = \frac{125 - T_A}{131}$$

It then follows that assuming an ambient temperature of 70 °C, the maximum power dissipation will be limited to about 419 mW.

There is $\overline{C_L}$ pin designed to indicate the current limit status of SiP4613. A typical 5 kΩ resistor is required to connect between $\overline{C_L}$ pin and IN pin. In the event of the output over load, the current limit flag pin $\overline{C_L}$ will go low to indicate the current limit status of the device. Figure 2 shows the voltage on $\overline{C_L}$ pin go low after output short.

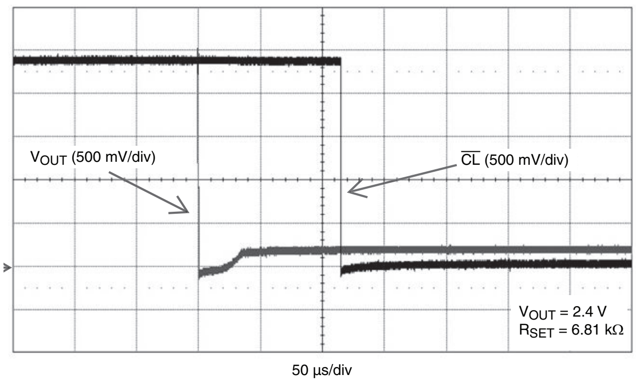


Figure 2

The voltage signal in $\overline{C_L}$ pin is not only used to indicate the output short circuit status. It is also used to indicate the thermal protection status of the device. Once the thermal protection is activated in the severe output short circuit condition, the voltage signal on the $\overline{C_L}$ pin will run into the thermal protection cycling. Figure 3 shows the voltage waveform of $\overline{C_L}$ pin after activation of the thermal protection circuit due to the severe short circuit status of the device's output.

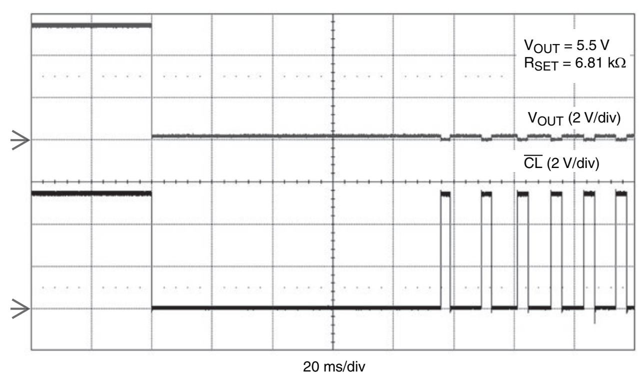


Figure 3

The thermal protection is the final protection to the device. The device will be completely shut down including the open drain current limit indicator pin $\overline{C_L}$ until the device temperature drop below 145 °C.

Reverse Voltage

The SiP4613A, SiP4613B is designed to control current flowing from IN to OUT. If the voltage on OUT is raised higher than IN current will flow from OUT to IN but the current limit function will not be available, as can be inferred from the block diagram in figure 1. Thus, in applications were OUT is used to charge IN, careful considerations must be taken to limit current through the device and protect it from becoming damaged.

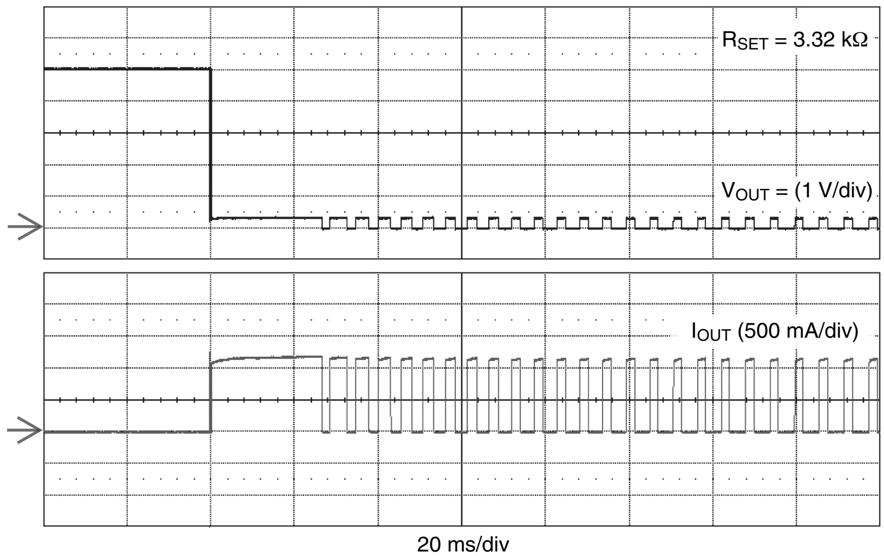
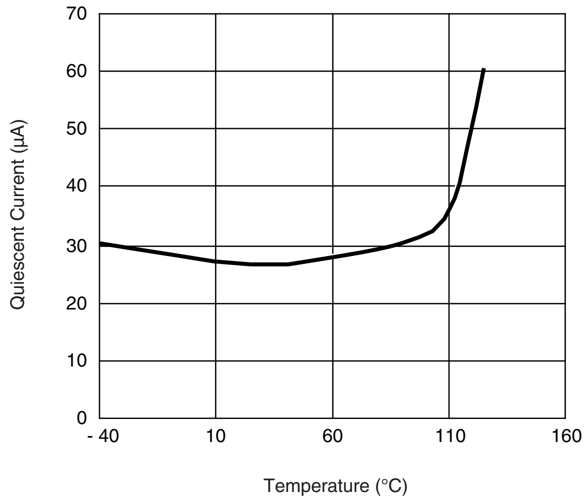
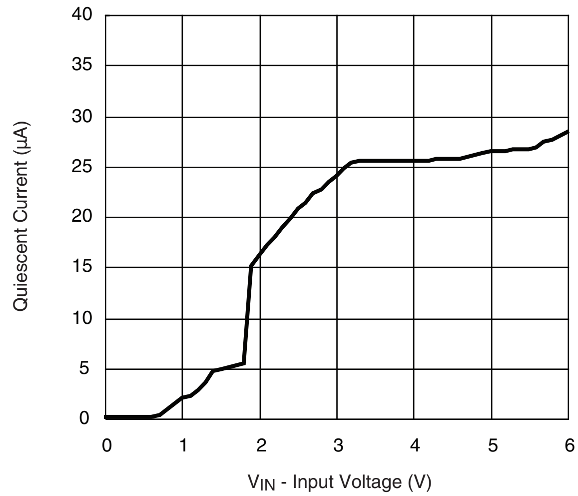


Figure 4. Current Over load Condition. Load Switch turned on with 0.1 Ω load at time = 0 ms.

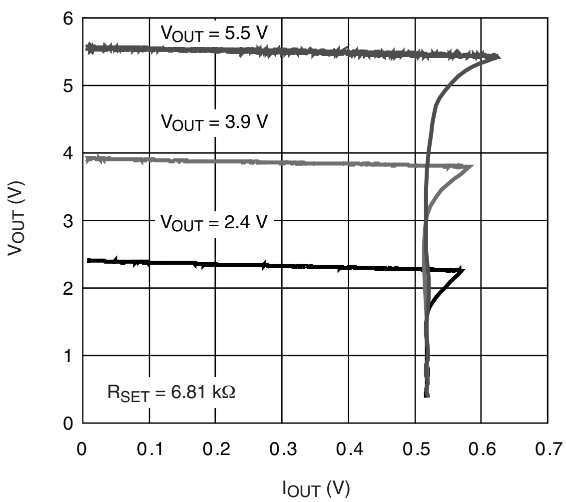
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



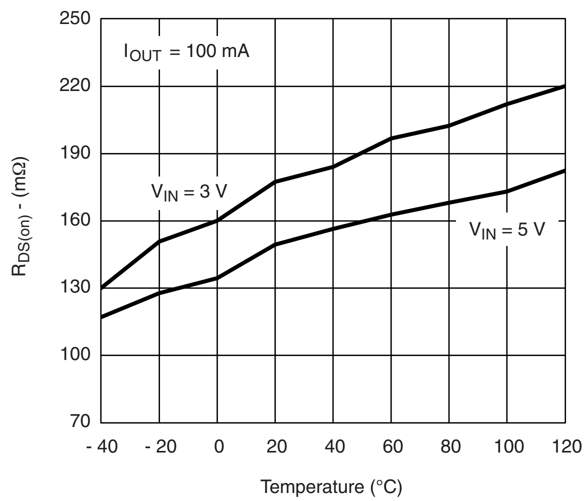
Quiescent Current vs. Temperature



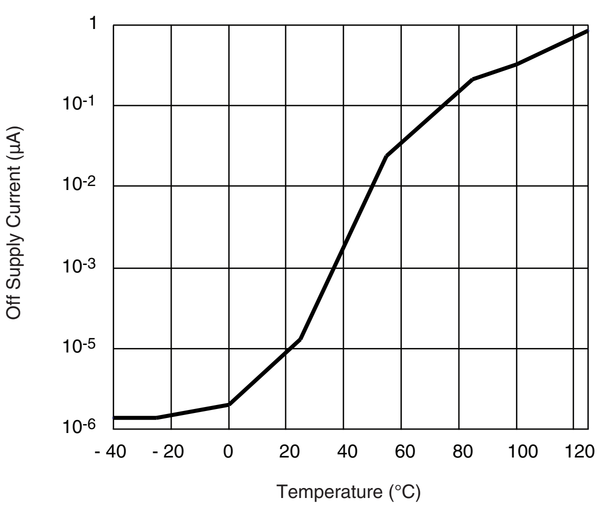
Quiescent Current vs. Input Voltage



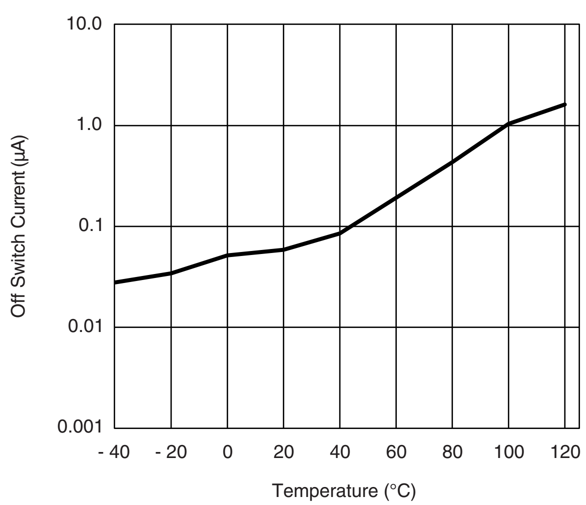
Output Voltage vs. Output Current



$R_{DS(on)}$ vs. Temperature

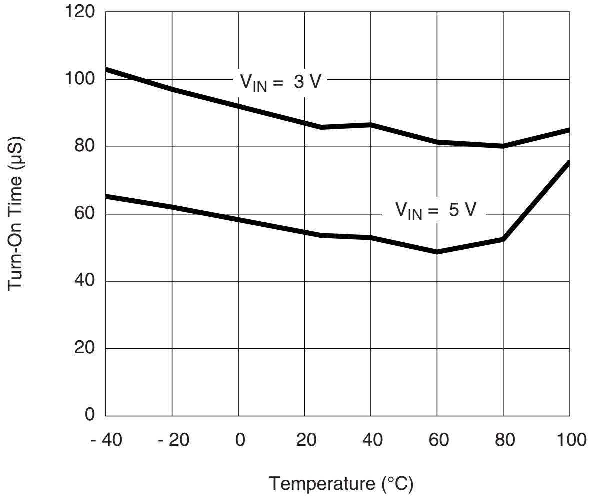


Off Supply Current vs. Temperature

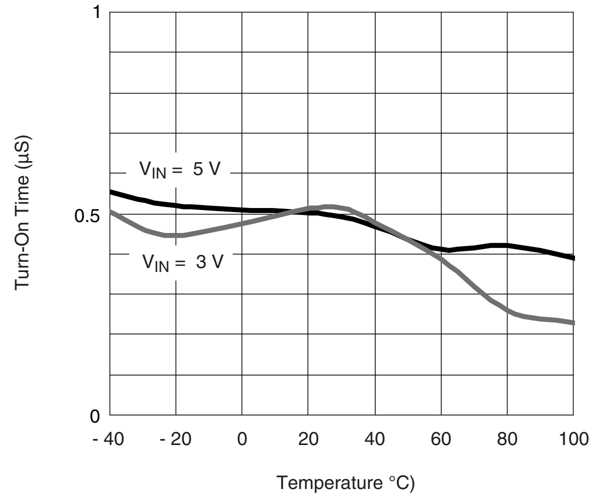


Off Switch Current vs. Temperature

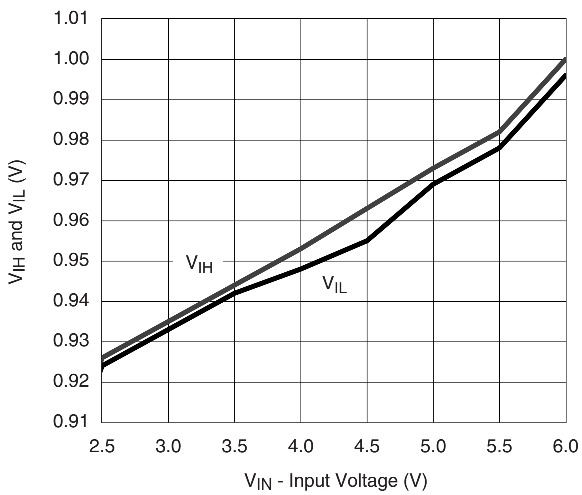
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



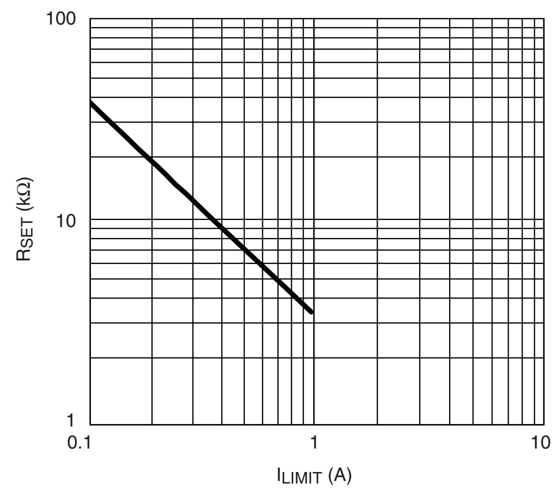
Turn-On vs. Temperature
R_L = 10 Ω, C_L = 0.47 µF



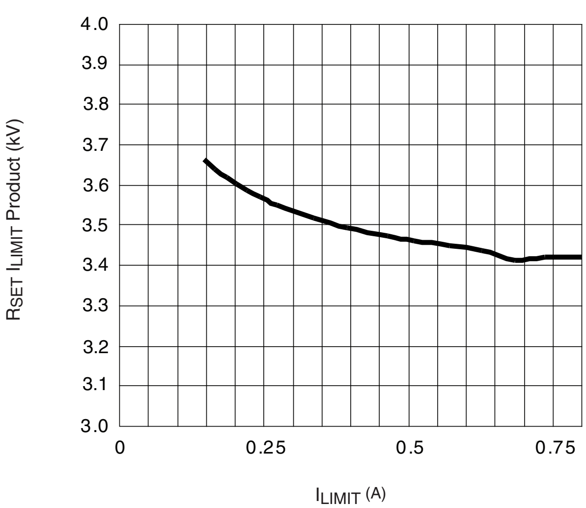
Turn-Off vs. Temperature
R_L = 10 Ω, C_L = 0.47 µF



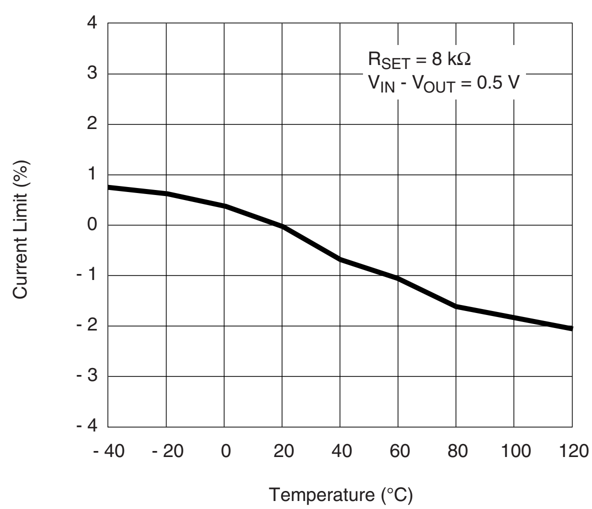
V_{IH} and V_{IL} vs. V_{IN}



R_{SET} vs. I_{LIMIT}

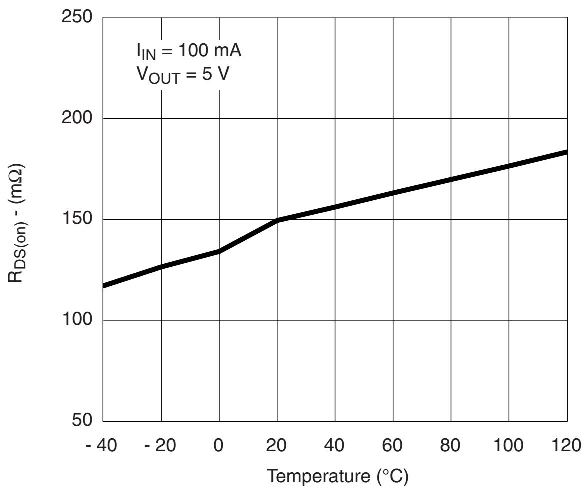


R_{SET} Coefficient vs. I_{LIMIT}

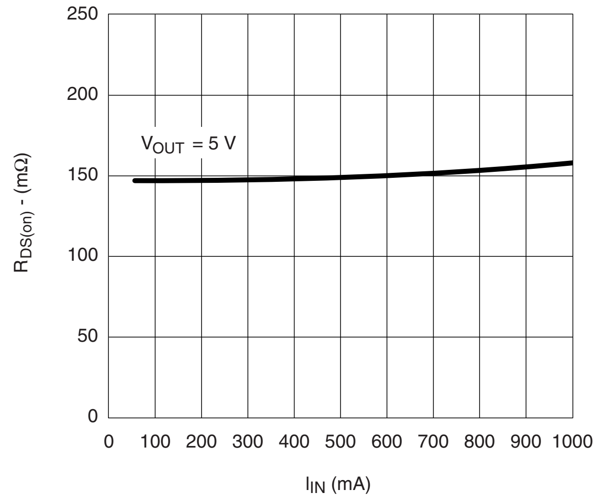


Current Limit vs. Temperature

TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted

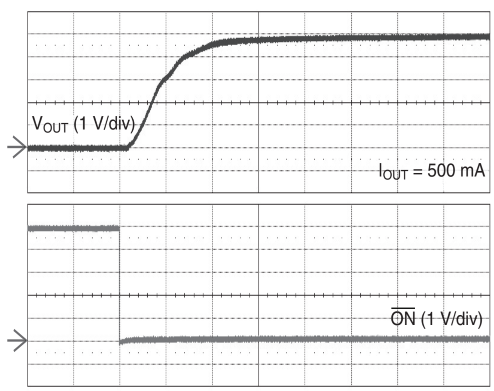


$R_{DS(on)\_reverse}$ vs. Temperature



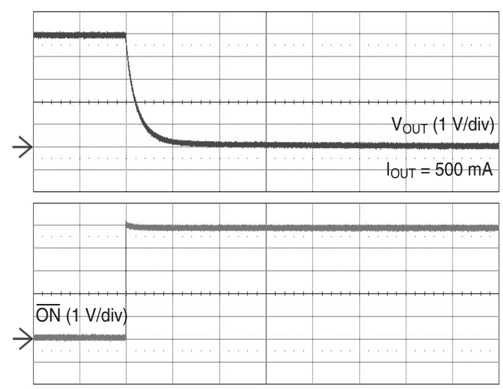
$R_{DS(VOUT-IN)}$ vs. Current

TYPICAL WAVEFORMS



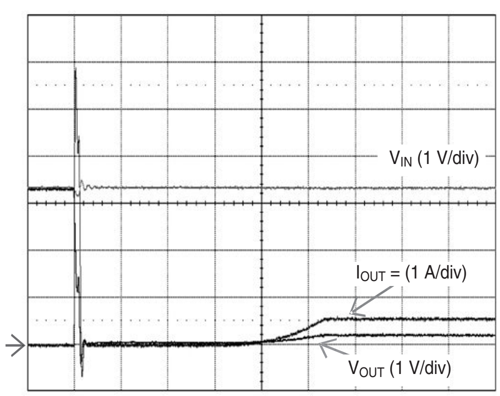
20 µs/div

Turn On



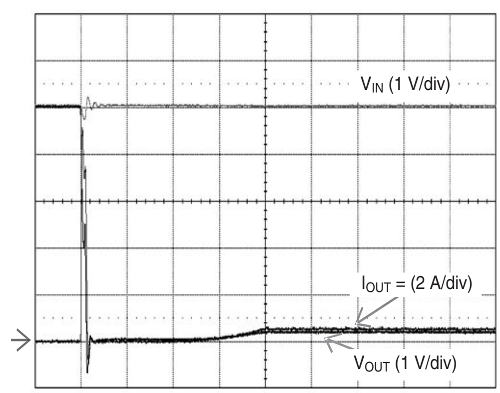
20 µs/div

Turn Off



10 µs/div

Short Circuit through 0.3 Ω, V_{in} = 3.3 V



10 µs/div

Short Circuit through 0.3 Ω, V_{in} = 5 V

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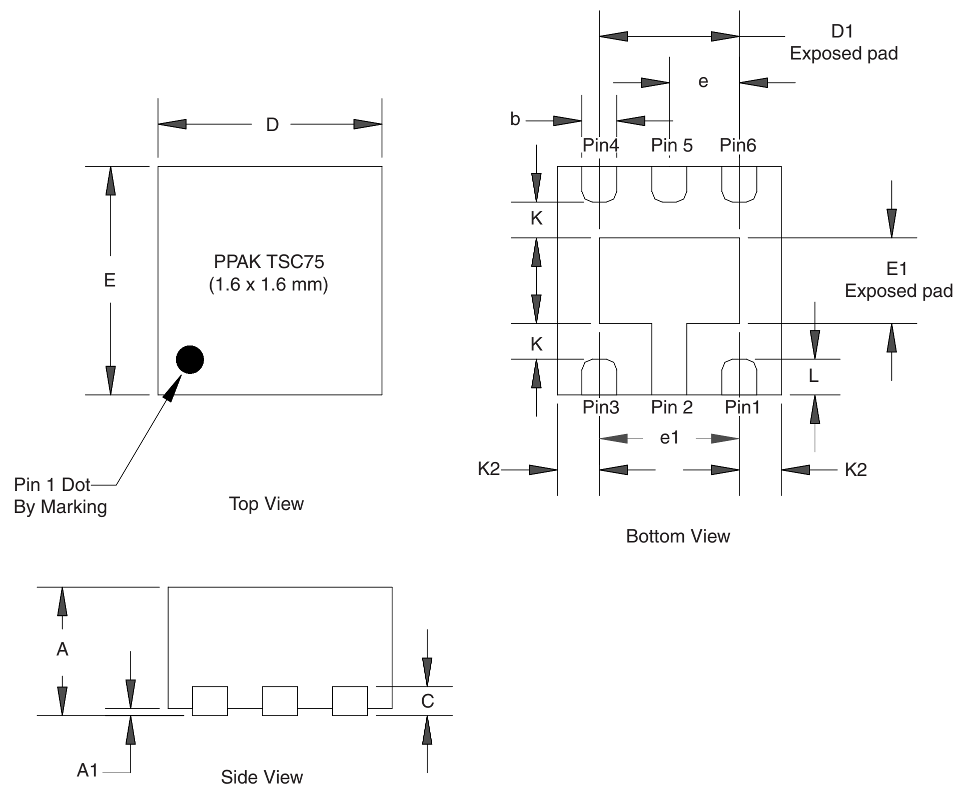
PowerPAK® TSC75-6L (Power IC only)



DIM	MILLIMETERS			INCHES		
	Min	Nom	Max	Min	Nom	Max
A	0.50	0.55	0.65	0.020	0.022	0.026
A1	0	-	0.05	0	-	0.002
b	0.20	0.25	0.30	0.008	0.010	0.012
C	0.10	0.15	0.20	0.006	0.008	0.010
D	1.55	1.60	1.65	0.0061	0.063	0.065
D1	0.95	1.00	1.05	0.037	0.039	0.041
E	1.55	1.60	1.65	0.061	0.063	0.065
E1	0.55	0.60	0.65	0.022	0.024	0.026
e	0.50 BSC			0.020 BSC		
e1	1.00 BSC			0.039 BSC		
K	0.15	-	-	0.006	-	-
K2	0.20	-	-	0.008		
L	0.20	0.25	0.30	0.008	0.010	0.012
ECN: S-61919-Rev. A, 02-Oct-06 DWG: 5955						

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