1 A Slew Rate Controlled Load Switch in PPAK SC75-6

DESCRIPTION

The SiP4282 is a P-Channel MOSFET power switch IC designed for high-side load switching applications. The output switching transistor is a P-Channel MOSFET device that has a 140 mΩ $R_{DS(ON)}$ typically to increase load switching power handling capacity. The SiP4282 is available in two different versions with turn-on and turn-off characteristics ranging from very fast to slew rate limited. In addition to a fast turn-off time of 4 µs, the SiP4282-3 version offers a shutdown load discharge circuit to instantaneously turn off a load circuit when the switch is disabled.

The SiP4282 load switch operates with an input voltage ranging from 1.8 V to 5.5 V, making it ideal for both 3 V and 5 V systems. The SiP4282 also features an under-voltage lock out which turns the switch off when an input undervoltage condition exists. Input logic levels are TTL and 2.5 V to 5 V CMOS compatible. This device has a very low operating current (typically 2.5 µA), making it ideal for battery-powered applications. In shutdown mode, the supply current decreases to less than 1 µA.

The SiP4282 is available in a lead (Pb)-free 6 pin PPAK SC75-6 package and is specified over - 40 °C to 85 °C temperature range.

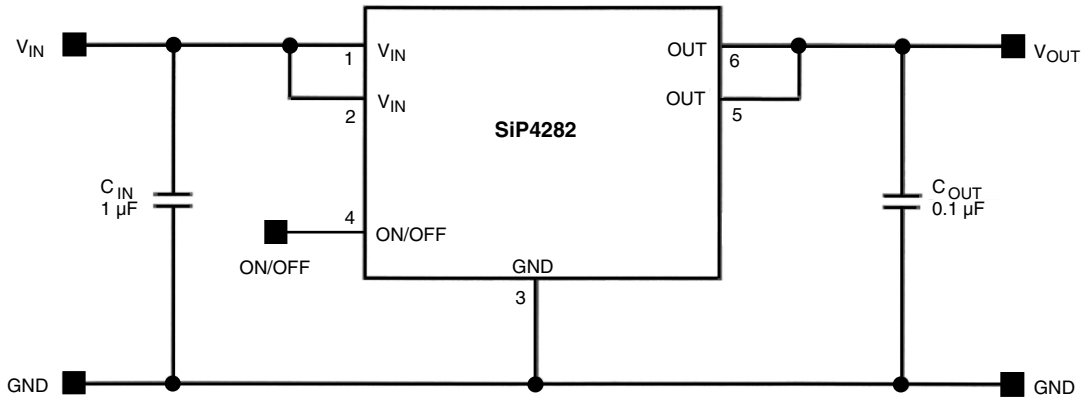
FEATURES

- **1.8 V to 5.5 V Input Voltage range**
- **Very Low $R_{DS(ON)}$, typically 140 mΩ at 5 V and 175 mΩ at 3 V**
- Slew rate limited turn-on time options
  - SiP4282-1: 1 ms
  - SiP4282-3: 100 µs
- Fast shutdown load discharge option
- Low quiescent current, typically 2.5 µA
- Low Shutdown Current < 1 µA
- TTL/CMOS input logic level
- UVLO of 1.4 V
- SC-75 Package

APPLICATIONS

- Cellular telephones
- Digital still cameras
- Personal digital assistants (PDA)
- Hot swap supplies
- Notebook computers
- Personal communication devices
- USB

TYPICAL APPLICATION CIRCUIT



SiP4282 Typical Application Circuit

ABSOLUTE MAXIMUM RATINGS

Parameter		Limit	Unit
Supply Input Voltage (V_{IN})		- 0.3 to 6	V
Enable Input Voltage (V_{ON})		- 0.3 to 6	
Output Voltage (V_{OUT})		- 0.3 to V_{IN} + 0.3	
Maximum Continuous Switch Current (I_{MAX})		1.2	A
Maximum Pulsed Current (I_{DM}) V_{IN}	$V_{IN} \geq 2.5$ V	3	
	$V_{IN} < 2.5$ V	1.6	
ESD Rating (HBM)		4000	V
Junction Temperature (T_J)		- 40 to 150	°C
Thermal Resistance (θ_{JA})[a]	6 pin PPAK SC75	90	°C/W
Power Dissipation (P_D)[b]	6 pin PPAK SC75	610	mW

Notes:

a. Device mounted with all leads and power pad soldered or welded to PC board.

b. Derate 11.1 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})	1.8 to 5.5	V
Operating Temperature Range	- 40 to 85	°C

SPECIFICATIONS

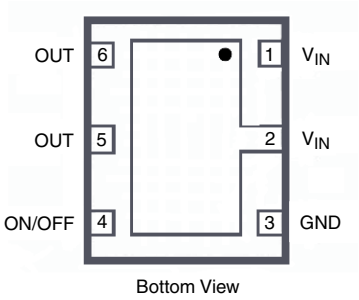
Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 5.0, T_A = - 40 °C to 85 °C (Typical values are at T_A = 25 °C)	Limits - 40 °C to 85 °C Min[a]	Typ[b]	Max[a]	Unit
SiP4282 All Versions						
Operating Voltage[c]	V_{IN}		1.8	-	5.5	V
Under Voltage Lockout	V_{UVLO}	V_{IN} Falling	1.0	1.4	1.8	
Under Voltage Lockout Hysteresis	$V_{UVLO(hyh)}$		-	250	-	mV
Quiescent Current	I_Q	ON/OFF = active	-	2.5	4	µA
Off Suply Current	$I_{Q(OFF)}$	ON/OFF = inactive, OUT = open	-	-	1	
Off Switch Current	$I_{SD(OFF)}$	ON/OFF = inactive, V_{OUT} = 0	-	-	1	
On-Resistance	$R_{DS(on)}$	V_{IN} = 5 V, T_A = 25 °C	-	140	230	mΩ
		V_{IN} = 4.2 V, T_A = 25 °C	-	150	250	
		V_{IN} = 3 V, T_A = 25 °C	-	175	290	
		V_{IN} = 1.8 V, T_A = 25 °C	-	300	480	
On-Resistance Temp-Coefficient	TC_{RDS}		-	2800	-	ppm/°C
ON/OFF Input Low Voltage	V_{IL}	V_{IN} = 2.7 V to 5.5 V[d]	-	-	0.8	V
ON/OFF Input High Voltage	V_{IH}	V_{IN} = 2.7 V to ≤ 4.2 V	2	-	-	
		V_{IN} > 4.2 V to 5.5 V	2.4	-	-	
ON/OFF Input Leakage	I_{SINK}	$V_{ON/OFF}$ = 5.5 V	-	-	1	µA
SiP4282-1 Version						
Output Turn-On Delay Time	$T_{D(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	20	40	µs
Output Turn-On Rise Time	$T_{(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	1000	1500	
Output Turn-Off Delay Time	$T_{D(OFF)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	4	10	

SPECIFICATIONS

Parameter	Symbol	Test Conditions Unless Specified V_{IN} = 5.0, T_A = - 40 °C to 85 °C (Typical values are at T_A = 25 °C)	Limits - 40 °C to 85 °C Min[a]	Typ[b]	Max[a]	Unit
SiP4282-3 Version						
Output Turn-On Delay Time	$T_{D(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	20	40	µs
Output Turn-On Rise Time	$T_{(ON)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	100	150	
Output Turn-Off Delay Time	$T_{D(OFF)}$	V_{IN} = 5 V, R_{LOAD} = 10 Ω, T_A = 25 °C	-	4	10	
Output Pull-Down Resistance	R_{PD}	ON/OFF = Inactive, T_A = 25 °C	-	150	250	Ω

Notes:
a) The algebriac 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) Part requires minimum start-up of $V_{IN} \geq$ 2.0 V to ensure operation down to 1.8 V.
d) For V_{IN} outside this range consult typical ON/OFF threshold curve.

PIN CONFIGURATION



Bottom View

PPAK SC75-6 Package

PIN DESCRIPTION

Pin Number PPAK SC75-6	Name	Function
1, 2	V_{IN}	This pin is the P-Channel MOSFET source connection. Bypass to ground through a 1 µF capacitor.
3	GND	Ground Connection
4	ON/OFF	Enable Input
5, 6	OUT	This pin is the P-Channel MOSFET drain connection. Bypass to ground through a 0.1 µF capacitor.

SELECTION GUIDE

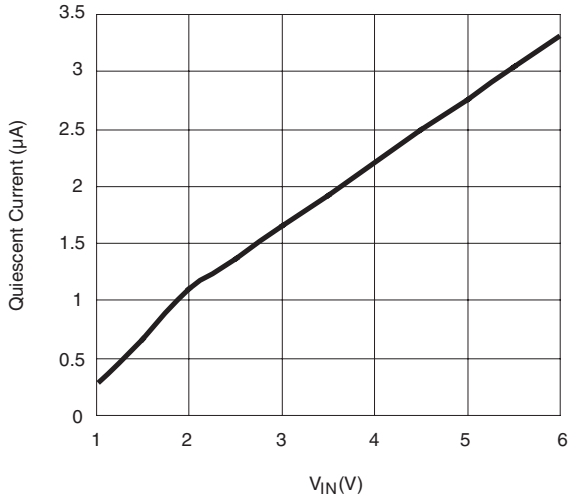
Part Number	Slew Rate (typ)	Active Pull Down	Enable
SiP4282-1-T1-E3	1 ms	No	Active high
SiP4282-3-T1-E3	100 µs	Yes	Active high

ORDERING INFORMATION

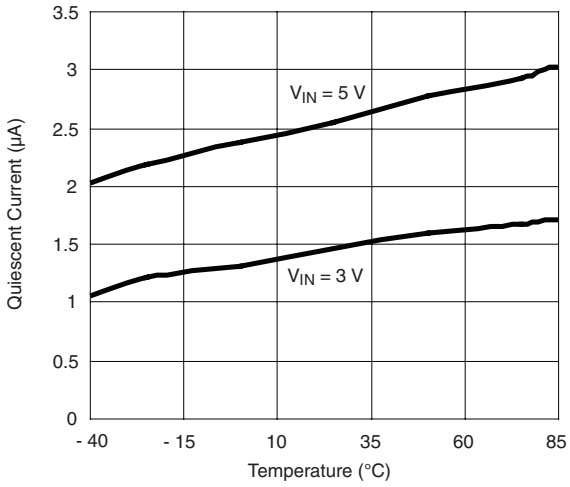
Part Number	Marking	Temperature Range	Package
SiP4282DVP-1-T1-E3	L7XXX	- 40 °C to 85 °C	PPAK SC75-6
SiP4282DVP-3-T1-E3	L9XXX		PPAK SC75-6

Notes:
XXX = Lot Code

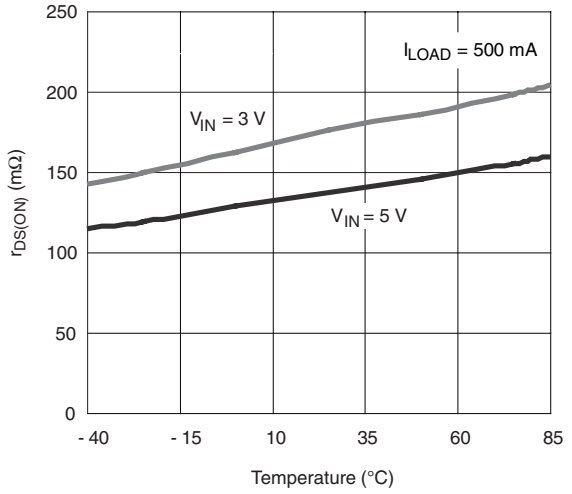
TYPICAL CHARACTERISTICS internally regulated, 25 °C, unless otherwise noted



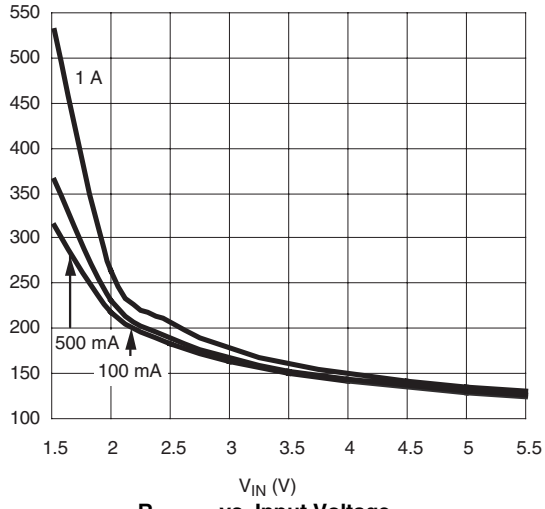
Quiescent Current vs. Input Voltage



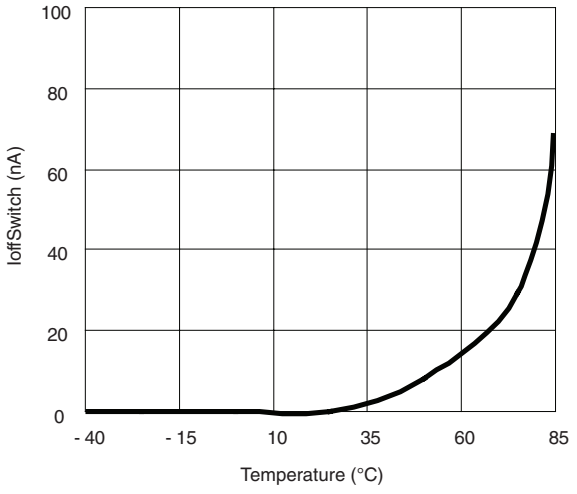
Quiescent Current vs. Temperature



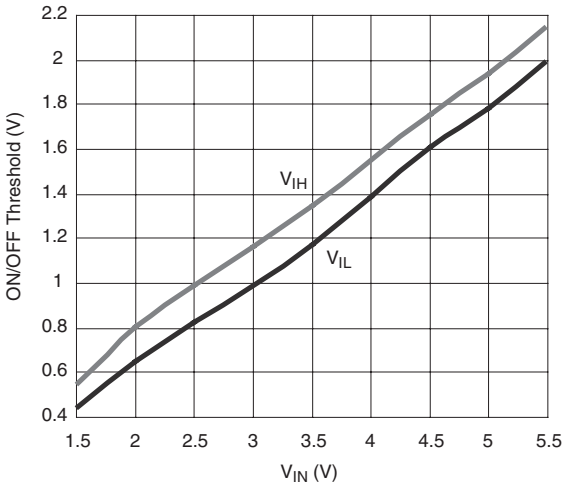
$R_{DS(ON)}$ vs. Temperature



$R_{DS(ON)}$ vs. Input Voltage

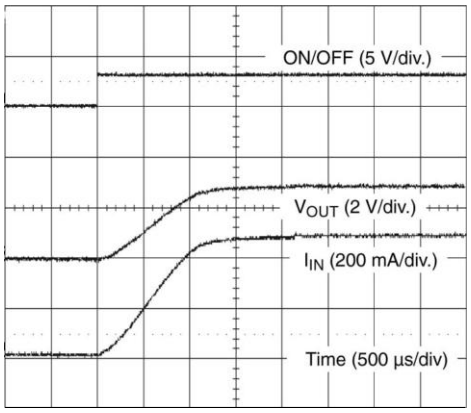


Off Switch Current vs. Temperature

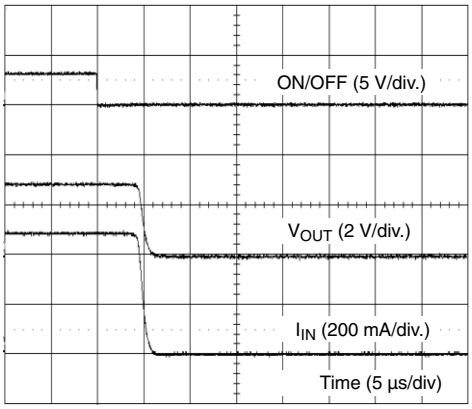


ON/OFF Threshold vs. Input Voltage

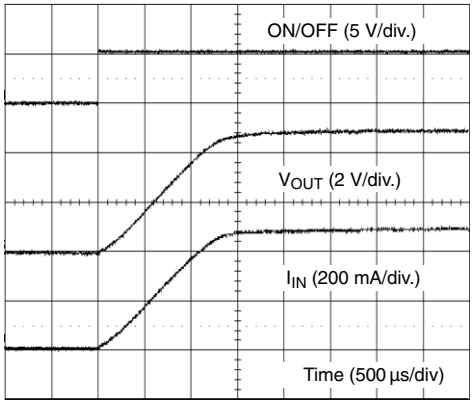
TYPICAL WAVEFORMS



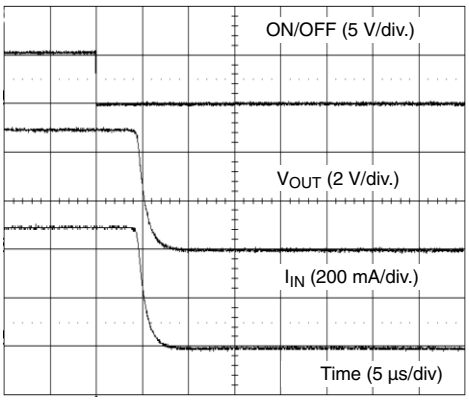
SiP4282-1 Turn-On (V_{IN} = 3 V, R_{LOAD} = 6 Ω)



SiP4282-1 Turn-Off (V_{IN} = 3 V, R_{LOAD} = 6 Ω)

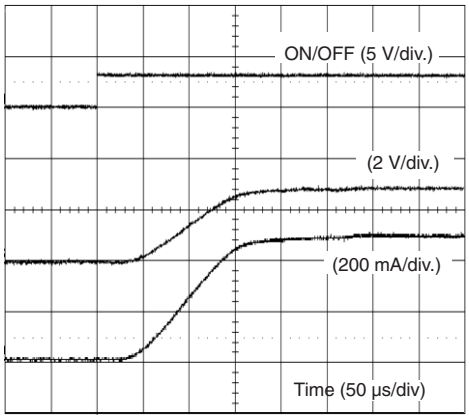


SiP4282-1 Turn-On (V_{IN} = 5 V, R_{LOAD} = 10 Ω)

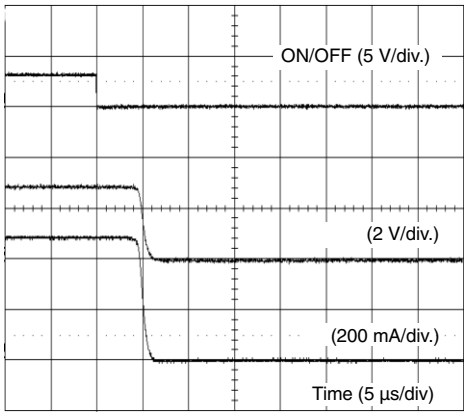


SiP4282-1 Turn-Off (V_{IN} = 5 V, R_{LOAD} = 10 Ω)

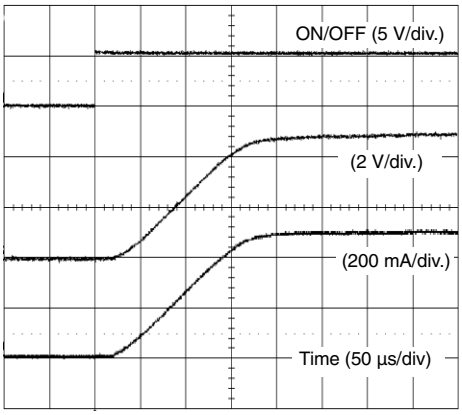
TYPICAL WAVEFORMS



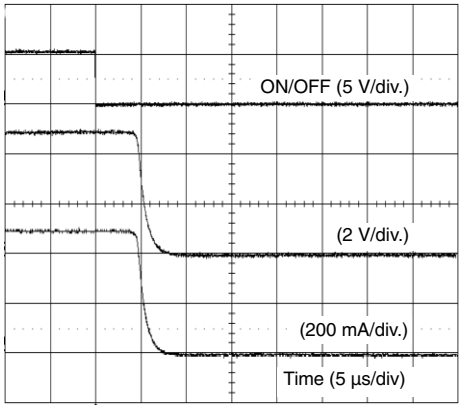
SiP4282-3 Turn-On (V_{IN} = 3 V, R_{LOAD} = 6 Ω)



SiP4282-3 Turn-Off (V_{IN} = 3 V, R_{LOAD} = 6 Ω)

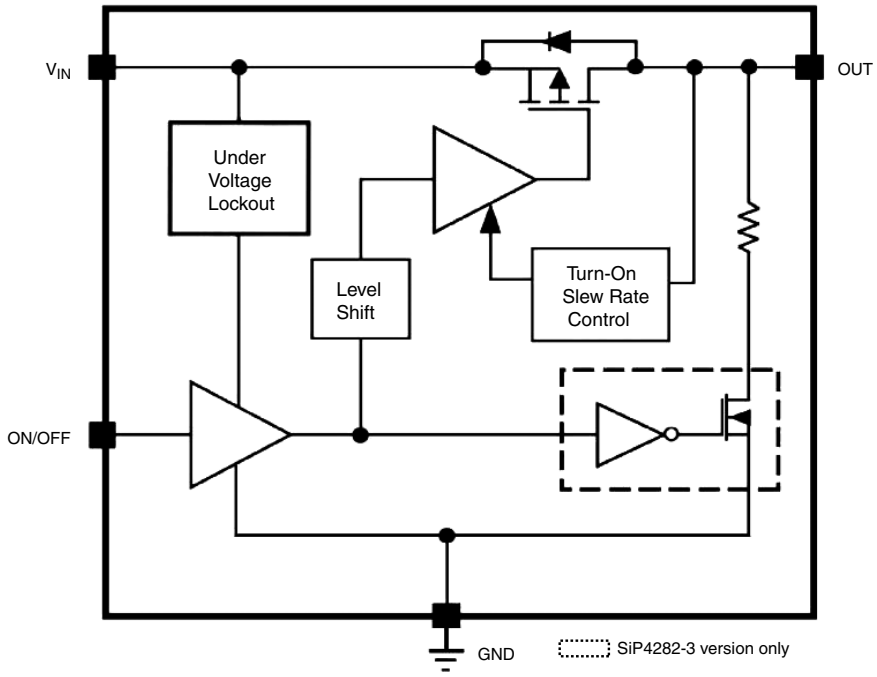


SiP4282-3 Turn-On (V_{IN} = 5 V, R_{LOAD} = 10 Ω)



SiP4282-3 Turn-Off (V_{IN} = 5 V, R_{LOAD} = 10 Ω)

BLOCK DIAGRAM



SiP4282 Functional Block Diagram

DETAILED DESCRIPTION

The SiP4282 is a P-Channel MOSFET power switches designed for high-side slew rate controlled load-switching applications. Once turned on, the slew-rate control circuitry is activated and current is ramped in a linear fashion until it reaches the level required for the output load condition. This is accomplished by first elevating the gate voltage of the MOSFET up to its threshold voltage and then by linearly increasing the gate voltage until the MOSFET becomes fully enhanced. At this point, the gate voltage is then quickly increased to the full input voltage to reduce $R_{DS(ON)}$ of the MOSFET switch and minimize any associated power losses.

The SiP4282-1 version has a modest 1 ms turn on slew rate feature, which significantly reduces in-rush current at turned on time and permits the load switch to be implemented with a small input capacitor, or no input capacitor at all, saving cost and space. In addition to a 100 µs minimized slew rate, the SIP4282-3 features a shutdown output discharge circuit which is activated at shutdown (when the part is disabled through the ON/OFF pin) and discharges the output pin through a small internal resistor hence, turning off the load.
In instances where the input voltage falls below 1.4 V (typically) the under voltage lock-out circuitry protects the MOSFET switch from entering the saturation region or operation by shutting down the chip.

APPLICATION INFORMATION

Input Capacitor

While a bypass capacitor on the input is not required, a 1 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 SiP4282 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 or larger across V_{OUT} and GND is recommended to insure proper slew operation. C_{OUT} may be increased without limit to accommodate any load transient condition with only minimal affect on the SiP4282 turn on slew rate time. There are no ESR or capacitor type requirement.

Enable

The ON/OFF pin is compatible with both TTL and CMOS logic voltage levels.

Protection Against Reverse Voltage Condition

The P-channel MOSFET pass transistor has an intrinsic diode that is reversed biased when the input voltage is greater than the output voltage. Should V_{OUT} exceed V_{IN}, this intrinsic diode will become forward biased and allow excessive current to flow into the IC thru the V_{OUT} pin and potentially damage the IC device. Therefore extreme care should be taken to prevent V_{OUT} from exceeding V_{IN}.

In conditions where V_{OUT} exceeds V_{IN} a Schottky diode in parallel with the internal intrinsic diode is recommended to protect the SiP4282.

Thermal Considerations

The SiP4282 is 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 ABS MAX 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 90 °C/W) the power pad of 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 for the SC-75 PPAK package, θ_{J-A} = 90 °C/W, and the ambient temperature, T_A, which may be formulaically expressed as:

$$P\ (max) = \frac{T_J\ (max) - T_A}{\theta_{J-A}} = \frac{125 - T_A}{90}$$

It then follows that, assuming an ambient temperature of 70 °C, the maximum power dissipation will be limited to about 610 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 occurs at an input voltage of 1.8 V and is equal to 480 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 3300 ppm/°C. Continuing with the calculation we have

$R_{DS(ON)}$ (at 70 °C) = 480 mΩ x (1 + 0.0033 x (70 °C - 25 °C)) = 551 mΩ

The maximum current limit is then determined by

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

which in case is 1.05 A. Under the stated input voltage condition, if the 1.05 A current limit is exceeded the internal die temperature will rise and eventually, possibly damage the device.

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