

### VN06SP

### HIGH SIDE SMART POWER SOLID STATE RELAY

TYPE	VDSS	R <sub>DS(on)</sub>	<b>I</b> n(*)	Vcc
VN06SP	60 V	0.18 Ω	1.9 A	26 V

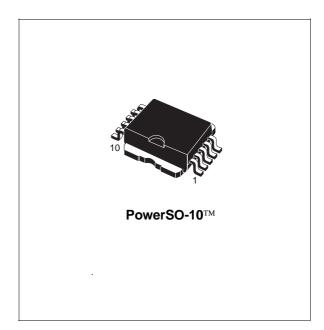
- MAXIMUM CONTINUOUS OUTPUT CURRENT (#):9 A @ T<sub>c</sub>=85°C
- 5 V LOGIC LEVEL COMPATIBLE INPUT
- THERMAL SHUT-DOWN
- UNDER VOLTAGE PROTECTION
- OPEN DRAIN DIAGNOSTIC OUTPUT
- INDUCTIVE LOAD FAST DEMAGNETIZATION
- VERY LOW STAND-BY POWER DISSIPATION

#### DESCRIPTION

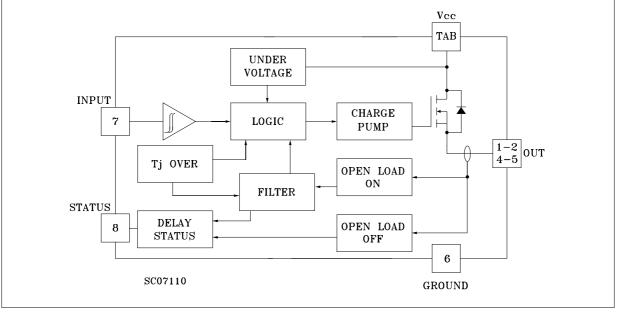
The VN06SP is a monolithic device made using STMicroelectronics VIPower Technology, intended for driving resistive or inductive loads with one side grounded.

Built-in thermal shut-down protects the chip from over temperature and short circuit.

The open drain diagnostic output indicates: open load in off state, and in on state, output shorted to



 $V_{CC}$  and overtemperature. Fast demagnetization of inductive loads is archivied by negative (-18V) load voltage at turn-off.



(\*) In = Nominal current according to ISO definition for high side automotive switch (see note 1)

(#) The maximum continuous output current is the the current at  $T_c = 85$  °C for a battery voltage of 13V which does not activate self protection.

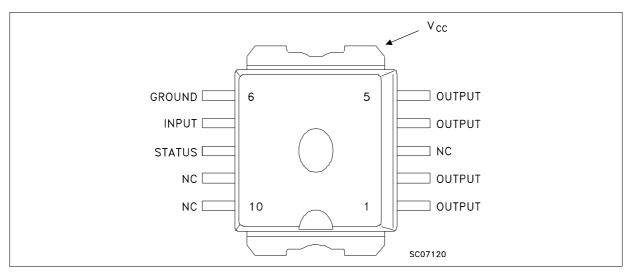
September 2013

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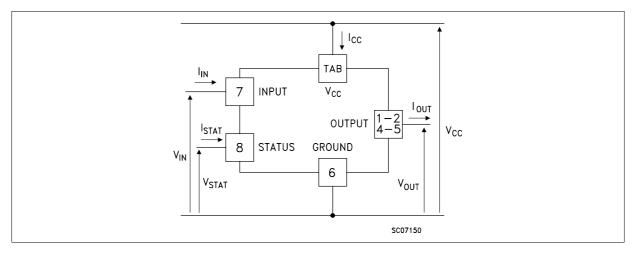
#### ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value	Unit
V <sub>(BR)DSS</sub>	Drain-Source Breakdown Voltage	60	V
I <sub>OUT</sub>	Output Current (cont.) at T <sub>c</sub> = 85 °C	9	Α
I <sub>R</sub>	Reverse Output Current at T <sub>c</sub> = 85 °C	-9	Α
lin	Input Current	±10	mA
-Vcc	Reverse Supply Voltage	-4	V
ISTAT	Status Current	±10	mA
V <sub>ESD</sub>	Electrostatic Discharge (1.5 kΩ, 100 pF)	2000	V
Ptot	Power Dissipation at $T_c = 85 ^{\circ}C$	27	W
Tj	Junction Operating Temperature	-40 to 150	°C
T <sub>stg</sub>	Storage Temperature	-55 to 150	°C

#### **CONNECTION DIAGRAMS**



#### CURRENT AND VOLTAGE CONVENTIONS



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#### THERMAL DATA

R <sub>thj-case</sub>	Thermal Resistance Junction-case	Max	2.4	°C/W
R <sub>thj-amb</sub>	Thermal Resistance Junction-ambient	Max	50	°C/W
When mounted	d using minimum recommended pad size on FR-4 board			

# **ELECTRICAL CHARACTERISTICS** (V<sub>CC</sub> = 13 V; -40 $\leq$ T<sub>j</sub> $\leq$ 125 $^oC$ unless otherwise specified) POWER

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
V <sub>CC</sub>	Supply Voltage		5.5	13	26	V
ln(*)	Nominal Current	$T_c = 85 \ ^{o}C \qquad V_{DS(on)} \le 0.5 \ (note \ 1)$	1.9			Α
$R_{on}$	On State Resistance	I <sub>OUT</sub> = 1.9 A I <sub>OUT</sub> = 1.9 A T <sub>j</sub> = 25 °C			0.36 0.18	Ω Ω
Is	Supply Current	$\begin{array}{lll} \mbox{Off State} & T_j \geq 25 \ ^o\mbox{C} \\ \mbox{On State} & \end{array}$			50 15	μA mA
V <sub>DS(MAX)</sub>	Maximum Voltage Drop	$I_{OUT} = 8.5 \text{ A}$ $T_{c} = 85 ^{\circ}\text{C}$			2.75	V

#### SWITCHING

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
t <sub>d(on)</sub> (^)	Turn-on Delay Time Of Output Current	I <sub>OUT</sub> = 1.9 A Resistive Load Input Rise Time < 0.1 μs		20		μs
t <sub>r</sub> (^)	Rise Time Of Output Current	I <sub>OUT</sub> = 1.9 A Resistive Load Input Rise Time < 0.1 μs		20		μs
t <sub>d(off)</sub> (^)	Turn-off Delay Time Of Output Current	I <sub>OUT</sub> = 1.9 A Resistive Load Input Rise Time < 0.1 μs		25		μs
t <sub>f</sub> (^)	Fall Time Of Output Current	I <sub>OUT</sub> = 1.9 A Resistive Load Input Rise Time < 0.1 μs		6		μs
(di/dt) <sub>on</sub>	Turn-on Current Slope	I <sub>OUT</sub> = 1.9 A I <sub>OUT</sub> = I <sub>OV</sub>		0.08	0.5 1	A/μs A/μs
(di/dt) <sub>off</sub>	Turn-off Current Slope	I <sub>OUT</sub> = 1.9 A I <sub>OUT</sub> = I <sub>OV</sub>		0.2	3 3	A/μs A/μs
$V_{demag}$	Inductive Load Clamp Voltage	I <sub>OUT</sub> = 1.9 A L = 1 mH	-24	-18	-14	V

#### LOGIC INPUT

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
VIL	Input Low Level Voltage				0.8	V
V <sub>IH</sub>	Input High Level Voltage		2		(•)	V
VI(hyst.)	Input Hysteresis Voltage			0.5		V
I <sub>IN</sub>	Input Current		25	250	500 250	μΑ μΑ μΑ
VICL	Input Clamp Voltage	I <sub>IN</sub> = 10 mA I <sub>IN</sub> = -10 mA	5.5	6 -0.7	-0.3	V V

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#### ELECTRICAL CHARACTERISTICS (continued)

**PROTECTION AND DIAGNOSTICS** 

Symbol	mbol Parameter Test Conditions		Min.	Тур.	Max.	Unit
V <sub>STAT</sub>	Status Voltage Output Low	I <sub>STAT</sub> = 1.6 mA			0.4	V
Vusd	Under Voltage Shut Down			5		V
VSCL	Status Clamp Voltage	I <sub>STAT</sub> = 10 mA I <sub>STAT</sub> = -10 mA		6 -0.7		V V
lov	Over Current	$R_{LOAD} < 10 \text{ m}\Omega$ -40 $T_c$ 125 °C			60	Α
I <sub>AV</sub>	Average Current in Short Circuit	$R_{LOAD} < 10 \text{ m}\Omega$ $T_c = 85 ^{\circ}\text{C}$		1.4		А
I <sub>OL</sub>	Open Load Current Level		5	80	180	mA
$T_{TSD}$	Thermal Shut-down Temperature		140			°C
T <sub>R</sub>	Reset Temperature		125			°C
V <sub>OL</sub>	Open Load Voltage Level	Off-State (note 2)	2.5	3.75	5	V
t <sub>1(on)</sub>	Open Load Filtering Time	(note 3)	1	5	10	ms
t <sub>1(off)</sub>	Open Load Filtering Time	(note 3)	1	5	10	ms
$t_{2(off)}$	Open Load Filtering Time	(note 3)	1	5	10	ms
t <sub>povl</sub>	Status Delay	(note 3)		5	10	μs
t <sub>pol</sub>	Status Delay	(note 3)	50	700		μs

(^) See Switchig Time Waveforms

() The V<sub>IH</sub> is internally clamped at 6V about. It is possible to connect this pin to an higher voltage via an external resistor calculated to not exceed 10 mA at the input pin.

note 1:The Nominal Current is the current at  $T_c = 85$  °C for battery voltage of 13V which produces a voltage drop of 0.5 V note 21  $(1 - 1)^{1/2}$  (cos figure)

note  $2:I_{OL(off)} = (V_{CC} - V_{OL})/R_{OL}$  (see figure)

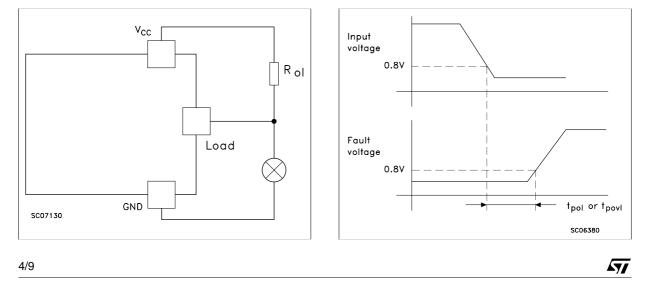
note  $3:t_{1(on)}:$  minimum open load duration which acctivates the status output

 $t_{1(\mbox{\scriptsize off})}$  : minimum load recovery time which desactivates the status output

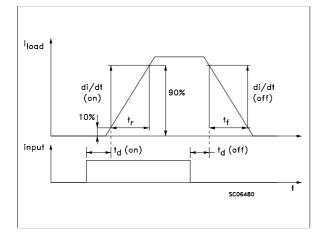
 $t_{2(\text{off})}$ : minimum on time after thermal shut down which desactivates status output  $t_{\text{pov}}$  to definition (see figure).

#### Note 2 Relevant Figure

#### Note 3 Relevant Figure



#### Switching Time Waveforms



#### FUNCTIONAL DESCRIPTION

The device has a diagnostic output which indicates open load conditions in off state as well as in on state, output shorted to V<sub>CC</sub> and overtemperature. The truth table shows input, diagnostic and output voltage level in normal operation and in fault conditions. The output signals are processed by internal logic. The open load diagnostic output has a 5 ms filtering. The filter gives a continuous signal for the fault condition after an initial delay of about 5 ms. This means that a disconnection during normal operation, with a duration of less than 5 ms does not affect the status output. Equally, any re-connection of less than 5 ms during a disconnection duration does not affect the status output. No delay occur for the status to go low in case of overtemperature conditions. From the falling edge of the input signal the status output initially low in fault condition (over temperature or open load) will go back with a delay (t<sub>boyl</sub>)in case of overtemperature condition and a delay (tpol) in case of open load. These feature fully comply with International Standard Office (I.S.O.) requirement for automotive High Side Driver.

To protect the device against short circuit and over current conditions, the thermal protection turns the integrated Power MOS off at а minimum junction temperature of 140 °C. When the temperature returns to 125 °C the switch is automatically turned on again. In short circuit the protection reacts with virtually no delay, the sensor being located in the region of the die where the heat is generated. Driving inductive loads, an internal function of the device ensures the fast demagnetization with a

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typical voltage (V<sub>demag</sub>) of -18V.

This function allows to greatly reduce the power dissipation according to the formula:

 $P_{dem} = 0.5 \bullet L_{load} \bullet (I_{load})^2 \bullet [(V_{CC}+V_{demag})/V_{demag}]$ •f

where f = switching frequency and

V<sub>demag</sub> = demagnetization voltage

Based on this formula it is possible to know the value of inductance and/or current to avoid a thermal shut-down. The maximum inductance which causes the chip temperature to reach the shut down temperature in a specific thermal environment, is infact a function of the load current for a fixed  $V_{CC}$ ,  $V_{demag}$  and f.

## PROTECTING THE DEVICE AGAIST LOAD DUMP - TEST PULSE 5

The device is able to withstand the test pulse No. 5 at level II ( $V_s = 46.5V$ ) according to the ISO T/R 7637/1 without anv external component. This means that all functions of the device are performed as designed after exposure to disturbance at level II. The VN06SP is able to withstand the test pulse No.5 at level III adding an external resistor of 150 ohm between GND pin and ground plus a filter capacitor of 1000  $\mu$ F between V<sub>CC</sub> pin and ground (if  $R_{LOAD} \leq 20 \Omega$ ).

### PROTECTING THE DEVICE AGAINST REVERSE BATTERY

The simplest way to protect the device against a continuous reverse battery voltage (-26V) is to insert a Schottky diode between GND pin and ground, as shown in the typical application circuit (fig.3).

The consequences of the voltage drop across this diode are as follows:

If the input is pulled to power GND, a negative voltage of  $-V_f$  is seen by the device. (Vil, Vih thresholds and Vstat are increased by Vf with respect to power GND).

The undervoltage shutdown level is increased by Vf.

If there is no need for the control unit to handle external analog signals referred to the power GND, the best approach is to connect the reference potential of the control unit to node [6] (see application circuit in fig. 4), which becomes the common signal GND for the whole control board avoiding shift of  $V_{ih}$ ,  $V_{il}$  and  $V_{stat}$ . This solution allows the use of a standard diode.

#### **TRUTH TABLE**

	INPUT	OUTPUT	DIAGNOSTIC
Normal Operation	L	L	Н
	Н	Н	Н
Open Circuit (No Load)	Н	Н	L
Over-temperature	Н	L	L
Under-voltage	Х	L	Н
Short load to V <sub>CC</sub>	L	Н	L

#### Figure 1: Waveforms

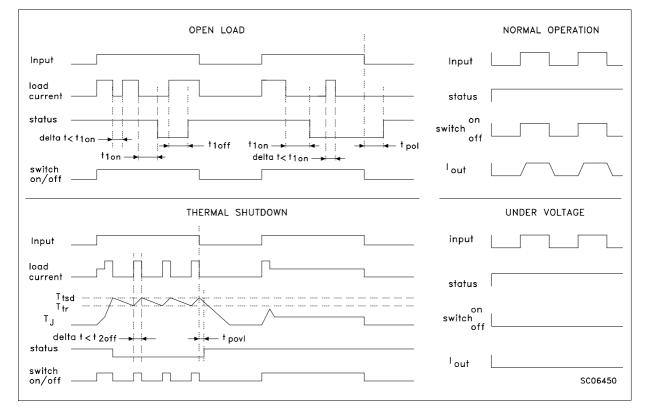
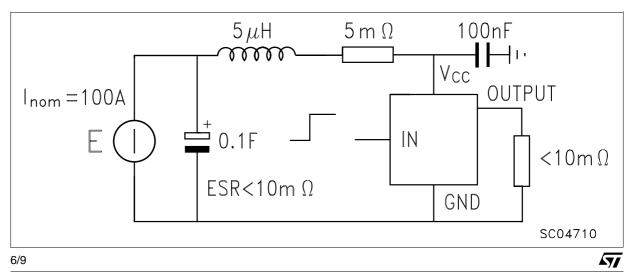
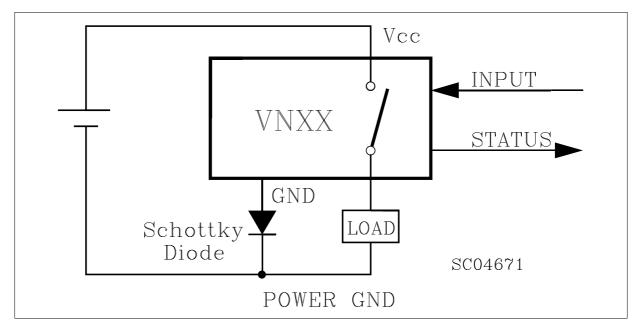


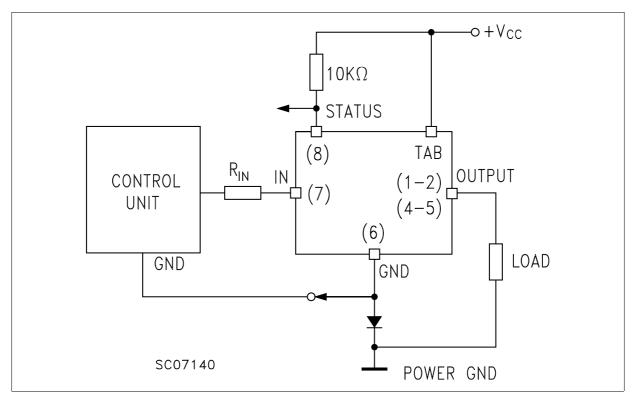
Figure 2: Over Current Test Circuit





#### Figure 3: Typical Application Circuit With A Schottky Diode For Reverse Supply Protection

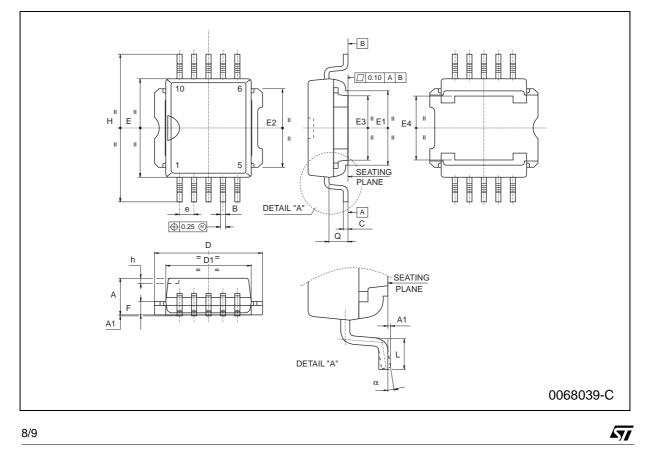
Figure 4: Typical Application Circuit With Separate Signal Ground



#### VN06SP

### PowerSO-10 MECHANICAL DATA

DIM.		mm			inch	
Divi.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
А	3.35		3.65	0.132		0.144
A1	0.00		0.10	0.000		0.004
В	0.40		0.60	0.016		0.024
С	0.35		0.55	0.013		0.022
D	9.40		9.60	0.370		0.378
D1	7.40		7.60	0.291		0.300
E	9.30		9.50	0.366		0.374
E1	7.20		7.40	0.283		0.291
E2	7.20		7.60	0.283		0.300
E3	6.10		6.35	0.240		0.250
E4	5.90		6.10	0.232		0.240
е		1.27			0.050	
F	1.25		1.35	0.049		0.053
Н	13.80		14.40	0.543		0.567
h		0.50			0.002	
L	1.20		1.80	0.047		0.071
q		1.70			0.067	
α	0°		8°			



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