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# ISO HIGH SIDE SMART POWER SOLID STATE RELAY

#### **Table 1. General Features**

Туре	V <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>n</sub> <sup>(1)</sup>	Vcc
VN21	60 V	0.05 Ω	7 A	26 V

Note: 1. In= Nominal current according to ISO definition for high side automotive switch. 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.

- MAXIMUM CONTINUOUS OUTPUT CURRENT (note 2): 23 A @ T<sub>c</sub>= 85°C
- 5V 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 VN21 is a monolithic device made using STMicroelectronics V.Power Technology, intended for driving resistive or inductive loads with one side grounded.

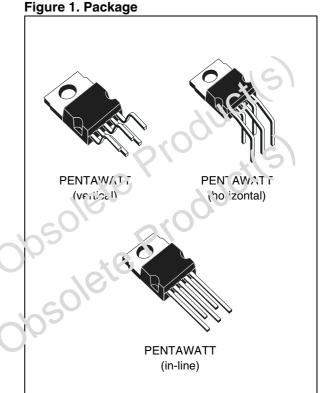
Built-in thermal shut-down protocos the chip from over temperature and short circuit.

The open drain diagnomic output indicates: open load in off state and in on state, output shorted to  $V_{\rm OC}$  and overtemperature. Fast demagnetization of inductive loads is achieved by negative (-18V) load voltage at turn-off.

Note: 2. The maximum continuous output current is the current at  $r_c = 85$  °C for a battery voltage of 13 V which does not activate self protection

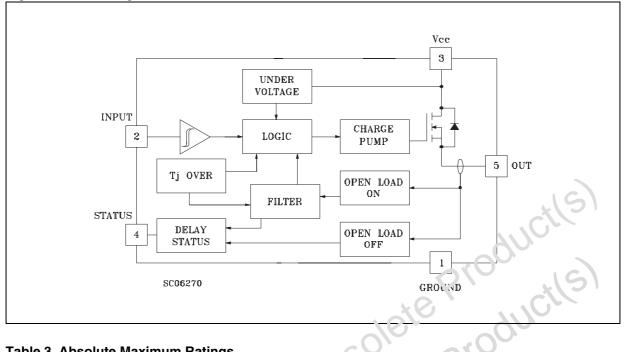
#### Table 2. Order Codes

Package	Tube	Tape and Reel
PENTAWATT Vert.	VN21	—
PENTAWATT Hor.	VN21(011Y)	—
PENTAWATT In line	VN21(012Y)	



REV. 2

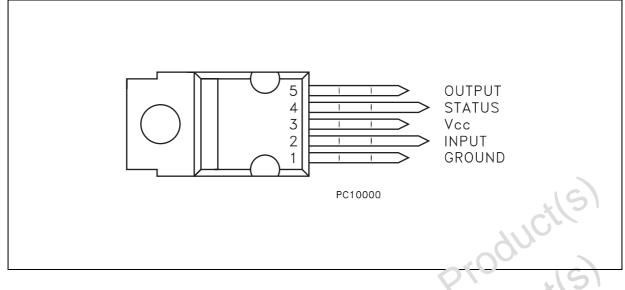
# Figure 2. Block Diagram



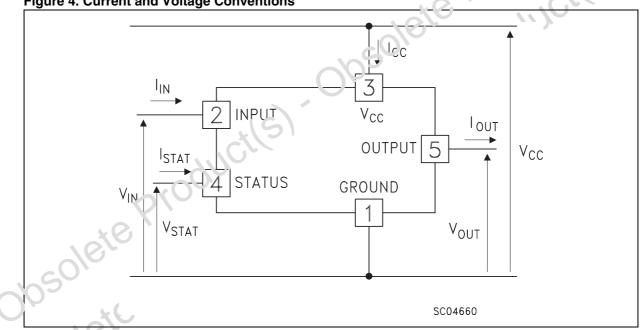
#### **Table 3. Absolute Maximum Ratings**

Symbol	Parameter	Value	Unit
V <sub>(BR)DSS</sub>	Drain-Source Breakdown Voltage	60	V
IOUT	Output Current (cont.) at T <sub>c</sub> = 55 °ບ	23	A
I <sub>R</sub>	Reverse Output Current at $T_c = 85 \text{ °C}$	-23	A
I <sub>IN</sub>	Input Current	±10	mA
- V <sub>CC</sub>	Reverse Sul oly Voltage	-4	V
I <sub>STAT</sub>	Status Current	±10	mA
V <sub>ESD</sub>	Electrostatic Discharge (1.5 kΩ, 100 pF)	2000	V
Ριοι	Power Dissipation at $T_c = 85 \text{ °C}$	48	W
Tj	Junction Operating Temperature	-40 to 150	°C
T <sub>stg</sub>	Storage Temperature	-55 to 150	°C

# Figure 3. Connection Diagram







# Table 4. Thermal Data

Symbol	Parameter		Value	Unit
R <sub>thj-case</sub>	Thermal Resistance Junction-case	Max	1.35	°C/W
R <sub>thj-amb</sub>	Thermal Resistance Junction-ambient	Max	60	°C/W

· · — -

# **ELECTRICAL CHARACTERISTICS**

(V\_{CC} = 13 V; –40  $\leq$  Tj  $\leq$  125 °C unless otherwise specified)

# Table 5. Power

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
V <sub>CC</sub>	Supply Voltage		5.5	13	26	V
In <sup>(3)</sup>	Nominal Current	$T_c = 85 \ ^\circ C; \ V_{DS(on)} \leq 0.5$	7			A
R <sub>on</sub>	On State Resistance	I <sub>OUT</sub> = 7 A I <sub>OUT</sub> = 7 A; T <sub>j</sub> = 25 °C			0.10 0.05	Ω Ω
Is	Supply Current	Off State; T <sub>j</sub> ≥ 25 °C On State			50 15	μA mA
V <sub>DS(MAX)</sub>	Maximum Voltage Drop	I <sub>OUT</sub> = 20 A; T <sub>c</sub> = 85 °C			1.3	5 7

Note: 3. In= Nominal current according to ISO definition for high side automotive switch. The Nominal Current is the current at T<sub>c</sub> = 85 °C for battery voltage of 13V which produces a voltage drop of 0.5 V.

#### Table 6. Switching

Table 6. S	Switching		~	<u>)</u>		
Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
t <sub>d(on)</sub> <sup>(4)</sup>	Turn-on Delay Time Of Output Current	I <sub>OUT</sub> = 7 A; Resistive Load Input Rise Time < 0.1 μs		60	6	μs
$t_r^{(4)}$	Rise Time Of Output Current	I <sub>OUT</sub> = 7 A; Resistive Load Input Rise Time < 0.1 u	2	70		μs
$t_{d(off)}^{(4)}$	Turn-off Delay Time Of Output Current	I <sub>OUT</sub> = 7 A; Resistive Load Input Rise Time ~ 0.1 μs		90		μs
$t_{f}^{(4)}$	Fall Time Of Output Current	I <sub>OUT</sub> = / A; Resistive Load Input Γίsε Time < 0.1 μs		25		μs
(di/dt) <sub>on</sub>	Turn-on Current Slope	ICUT = 7 A IOUT = IOV		0.08	0.5 1	A/μs A/μs
(di/dt) <sub>off</sub>	Turn-off Current ອີງງາຍ	I <sub>OUT</sub> = 7 A I <sub>OUT</sub> = I <sub>OV</sub>		0.2	3 3	A/μs A/μs
V <sub>demag</sub>	Inductive Load Clamp Vi 'ti ge	Ι <sub>ΟUT</sub> = 7 A; L = 1 mH	-24	-18	-14	V

Note: 4. See Switching Time Waveforms.

#### Table 7. Logic Input

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
VIL	Input Low Level Voltage				0.8	V
VIH	Input High Level Voltage		2		Note 5	V
VI(hyst)	Input Hysteresis Voltage			0.5		V
I <sub>IN</sub>	Input Current	$V_{IN} = 5 V$ $V_{IN} = 2 V$ $V_{IN} = 0.8 V$	25	250	500 250	μΑ μΑ μΑ
V <sub>ICL</sub>	Input Clamp Voltage	I <sub>IN</sub> = 10 mA I <sub>IN</sub> = -10 mA	5.5	6 -0.7	-0.3	V V

Note: 5. 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.

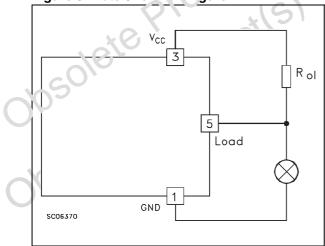
## ELECTRICAL CHARACTERISTICS (cont'd)

Symbol	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
V <sub>USD</sub>	Under Voltage Shut Down			5		V
V <sub>SCL</sub>	Status Clamp Voltage	I <sub>STAT</sub> = 10 mA I <sub>STAT</sub> = -10 mA		6 0.7		V V
I <sub>OV</sub>	Over Current	$R_{LOAD} < 10 \ m\Omega; -40 \le T_c \le 125 \ ^\circ C$			140	A
I <sub>AV</sub>	Average Current in Short Circuit	$R_{LOAD}$ < 10 m $\Omega$ ; $T_c$ = 85 °C		2.5		Α
I <sub>OL</sub>	Open Load Current Level		5	300	700	רו A
T <sub>TSD</sub>	Thermal Shut-down Temperature		140			°C
T <sub>R</sub>	Reset Temperature		125			°C
V <sub>OL</sub> <sup>(6)</sup>	Open Load Voltage Level	Off-State	2.5	25	5	V
t <sub>1(on)</sub> <sup>(7)</sup>	Open Load Filtering Time			5	10	ms
t <sub>1(off)</sub> <sup>(7)</sup>	Open Load Filtering Time	1 C	1	5	10	ms
t <sub>2(off)</sub> (7)	Open Load Filtering Time	010	1	5	10	ms
t <sub>povl</sub> (7)	Status Delay	05	57.	5	10	μs
t <sub>pol</sub> <sup>(7)</sup>	Status Delay	0, 10	50	700		μs

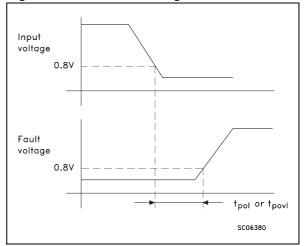
#### **Table 8. Protections and Diagnostics**

Note: 6. I<sub>OL(off)</sub> = (V<sub>CC</sub> -V<sub>OL</sub>)/R<sub>OL</sub> (see figure 5). 7. t<sub>1(on)</sub>: minimum open load duration which activates the status output; t<sub>1(off)</sub>: minimum load recovery time which clear twates the status output;  $t_{2(off)}: \mbox{ minimum on time after thermal situ: down which desactivates status output;} t_{port} t_{pol}: ISO definition (see figure <math display="inline">\mbox{\sc s}).$ 

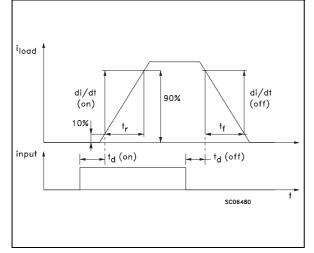




#### Figure 6. Note 7 relevant figure



# Figure 7. 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  $V_{CC}$  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 iese man 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 overlapperature conditions. From the falling eans of the input signal the status output initially low in fault condition (over temperature or open load) will go back with a delay (tpovi) in case cf 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 a 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 typical voltage ( $V_{demag}$ ) of -18V.

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

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 our rent for a fixed V<sub>CC</sub>, V<sub>demag</sub> and f.

#### PROTECTING THE DEVICI: A GAIST LOAD DUMP - TEST PULSE 5

The device is able to withstand the test pulse No. 5 at level II (V<sub>s</sub> = 46.5V) according to the ISO T/R 7637/1 without any external component. This means that all functions of the device are performed as designed after exposure to disturbance at level II. The VN21 is able to vithstand the test pulse No.5 at level III adding an external resistor of 150 ohm between pin 1 and ground plus a filter capacitor of 1000  $\mu$ F between pin 3 and ground (if R<sub>LOAD</sub>  $\leq$  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 pin 1(GND) and ground, as shown in the typical application circuit (Figure 10).

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<sub>f</sub> is seen by the device. (V<sub>IL</sub>, V<sub>IH</sub> thresholds and V<sub>STAT</sub> are increased by V<sub>f</sub> with respect to power GND).
- The undervoltage shutdown level is increased by V<sub>f</sub>.

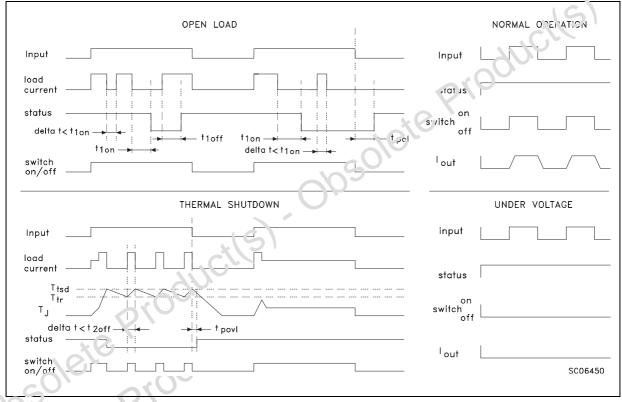
If there is no need for the control unit to handle external analog signals referred to the power GND, the best approach is to connect the reference potential of the control unit to node [1] (see application circuit in Figure 11), which becomes the common signal GND for the whole control board avoiding shift of  $V_{IH}$ ,  $V_{IL}$  and  $V_{STAT}$ . This solution allows the use of a standard diode.

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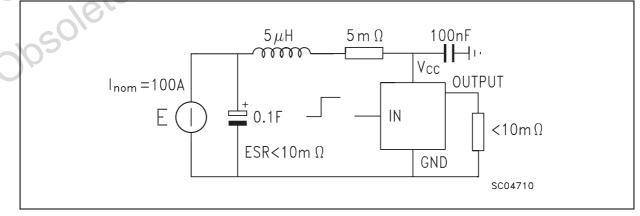
# Table 9. Truth Table

	Input	Output	Diagnostic
Normal Operation	L H	L H	H H
Open Circuit (No Load)	Н	Н	L
Over-temperature	Н	L	L
Under-voltage	X	L	Н
Short load to V <sub>CC</sub>	L	Н	L

# Figure 8. Waveforms



# Figure 9. Over Current Test Circuit



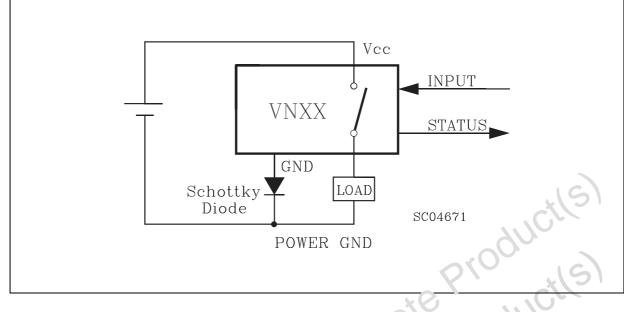
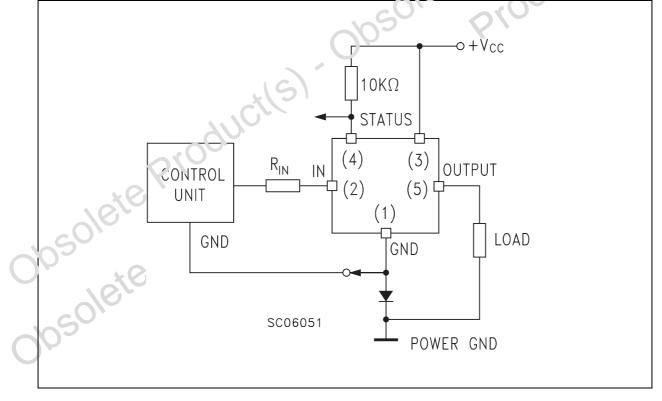


Figure 10. Typical Application Circuit With A Schottky Diode For Reverse Supply Protection



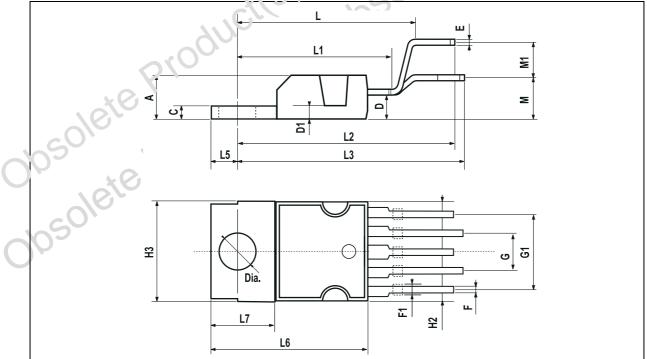


# PACKAGE MECHANICAL

Symbol		millimeters	
Symbol	Min	Тур	Мах
A			4.8
С			1.37
D	2.4		2.8
D1	1.2		1.35
E	0.35		0.55
F	0.8		1.05
F1	1		1.4
G	3.2	3.4	Ĵ.Ł
G1	6.6	6.8	7
H2			10.4
H3	10.05	0	10.4
L2	23.05	23.4	23.8
L3	25.3	25.65	26.1
L5	2.6		3
L6	15.1		15.8
L7	6		6.6
Dia.	3.65	U XO	3.85

# Table 10. PENTAWATT (vertical) Mechanical Data

# Figure 12. PENTAWATT (vertical) Pacing Dimensions



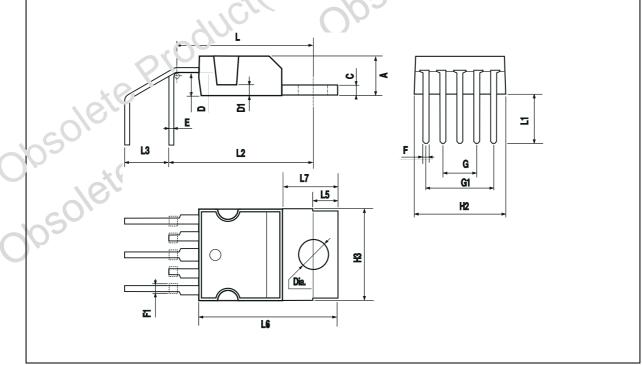
Note: Drawing is not to scale.

VN21

Symbol		millimeters	
Symbol	Min	Тур	Мах
А			4.8
С			1.37
D	2.4		2.8
D1	1.2		1.35
E	0.35		0.55
F	0.8		1.05
F1	1		1.4
G	3.2	3.4	3.6
G1	6.6	6.8	75
H2			10.4
H3	10.05		10.4
L	14.2		15
L1	5.7	0	6.2
L2	14.6		15.2
L3	3.5		4.1
L5	2.6		3
L6	15.1	50	15.8
L7	6		6.6
Dia.	3.65		3.85

# Table 11. PENTAWATT (horizontal) Mechanical Data

# Figure 13. PENTAWATT (horizontal) Paciage Dimensions

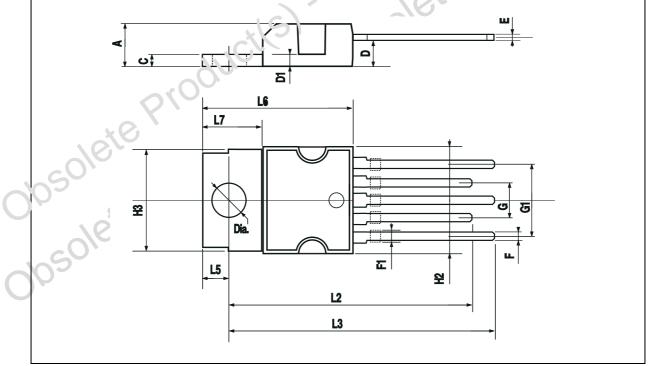


Note: Drawing is not to scale.

Symbol	millimeters		
	Min	Тур	Мах
А			4.8
С			1.37
D	2.4		2.8
D1	1.2		1.35
E	0.35		0.55
F	0.8		1.05
F1	1		1.4
G	3.2	3.4	3.6
G1	6.6	6.8	75
H2			10,4
H3	10.05		10.4
L2	23.05	23.4	23.8
L3	25.3	25.65	26.1
L5	2.6		3
L6	15.1		15.8
L7	6		6.6
Dia.	3.65	1.50	3.85

# Table 12. PENTAWATT (in-line) Mechanical Data

# Figure 14. PENTAWATT (in-line) Package Dimensions



Note: Drawing is not to scale.



## **REVISION HISTORY**

#### Table 13. Revision History

Date	Revision	Description of Changes
September-1994	1	First Issue
18-June-2004	2	Stylesheet update. No content change.

Obsolete Product(s) - Obsolete Product(s) Obsolete Product(s) - Obsolete Product(s) Obsolete Product(s) - Obsolete Product(s)



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