VN31

ISO HIGH SIDE SMART POWER SOLID STATE RELAY

Table 1. General Features

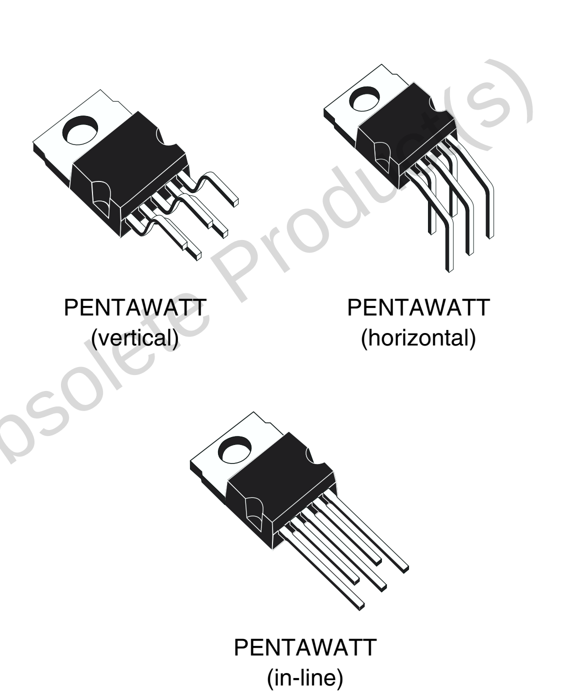
Type	V_{DSS}	$R_{DS(on)}$	I_n (1)	V_{CC}
VN31	60 V	0.03 Ω	11.5 A	26 V

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): 31 A @ T_C= 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

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

Figure 1. Package



DESCRIPTION

The VN31 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 achieved by negative (-18V) load voltage at turn-off.

Table 2. Order Codes

Package	Tube	Tape and Reel
PENTAWATT Vert.	VN31	-
PENTAWATT Hor.	VN31(011Y)	-
PENTAWATT In line	VN31(012Y)	-

Figure 2. Block Diagram

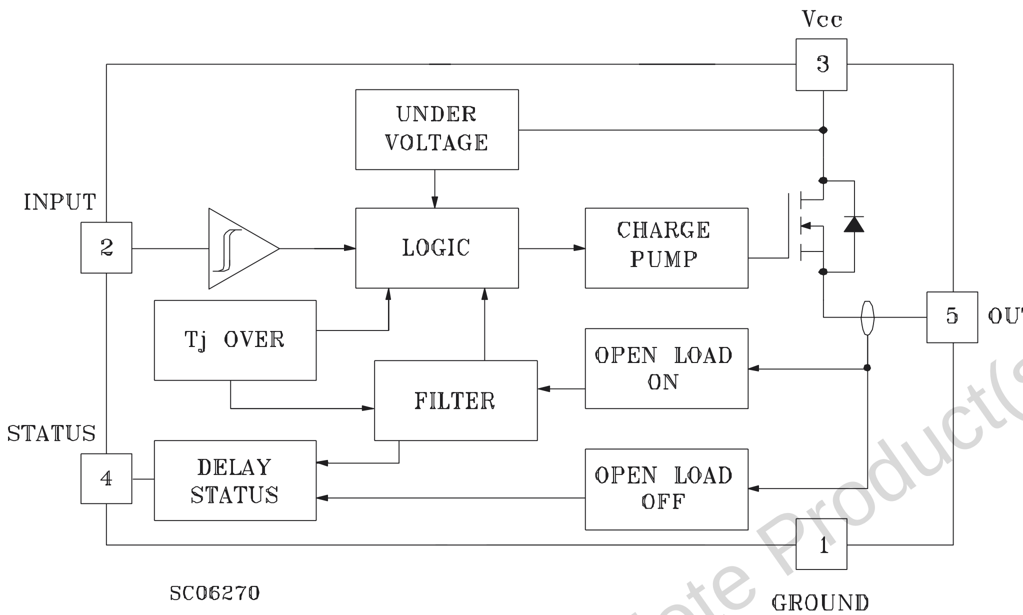


Table 3. Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	60	V
I_{OUT}	Output Current (cont.) at T_c = 85 °C	31	A
I_R	Reverse Output Current at T_c = 85 °C	–31	A
I_{IN}	Input Current	±10	mA
$-V_{CC}$	Reverse Supply Voltage	–4	V
I_{STAT}	Status Current	±10	mA
V_{ESD}	Electrostatic Discharge (1.5 kΩ, 100 pF)	2000	V
P_{tot}	Power Dissipation at T_c = 85 °C	54	W
T_j	Junction Operating Temperature	-40 to 150	°C
T_{stg}	Storage Temperature	-55 to 150	°C

Figure 3. Connection Diagram

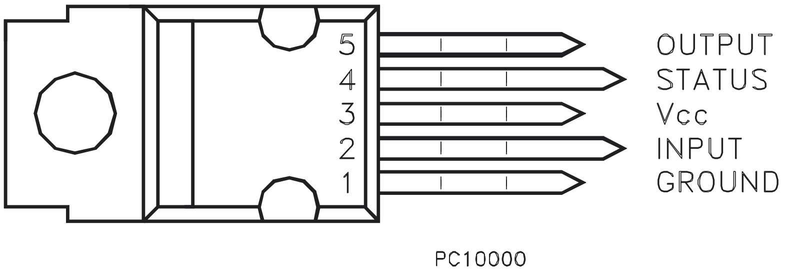


Figure 4. Current and Voltage Conventions

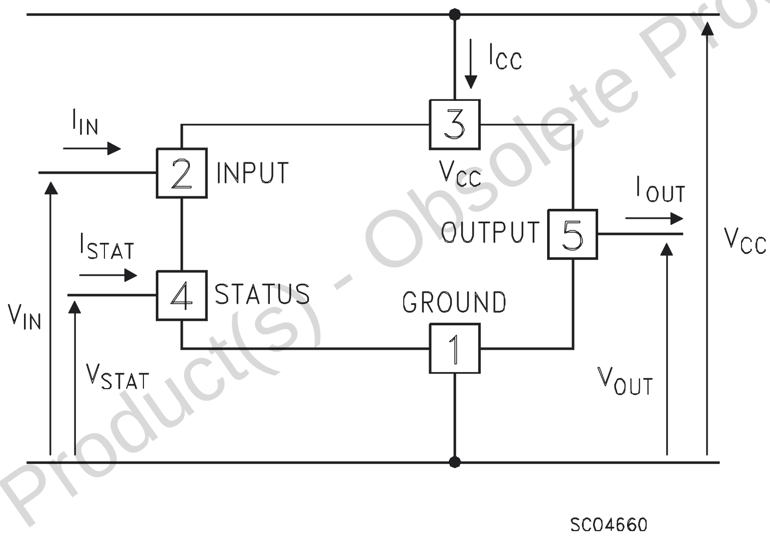


Table 4. Thermal Data

Symbol	Parameter		Value	Unit
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	1.2	°C/W
$R_{thj\text{-}amb}$	Thermal Resistance Junction-ambient	Max	60	°C/W

ELECTRICAL CHARACTERISTICS
(V_{CC} = 13 V; –40 ≤ T_j ≤ 125 °C unless otherwise specified)

Table 5. Power

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply Voltage		5.5	13	26	V
I_n(3)	Nominal Current	T_c = 85 °C; $V_{DS(on)}$ ≤ 0.5	11.5			A
R_{on}	On State Resistance	I_{OUT} = 11.5 A I_{OUT} = 11.5 A; T_j = 25 °C			0.06 0.03	Ω Ω
I_S	Supply Current	Off State; T_j ≥ 25 °C On State			50 15	µA mA
$V_{DS(MAX)}$	Maximum Voltage Drop	I_{OUT} = 25 A; T_c = 85 °C			1.5	V

Note: 3. 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.

Table 6. Switching

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$(4)	Turn-on Delay Time Of Output Current	I_{OUT} = 11.5 A; Resistive Load Input Rise Time < 0.1 µs		90		µs
t_r(4)	Rise Time Of Output Current	I_{OUT} = 11.5 A; Resistive Load Input Rise Time < 0.1 µs		100		µs
$t_{d(off)}$(4)	Turn-off Delay Time Of Output Current	I_{OUT} = 11.5 A; Resistive Load Input Rise Time < 0.1 µs		140		µs
t_f(4)	Fall Time Of Output Current	I_{OUT} = 11.5 A; Resistive Load Input Rise Time < 0.1 µs		50		µs
$(di/dt)_{on}$	Turn-on Current Slope	I_{OUT} = 11.5 A I_{OUT} = I_{OV}		0.08	0.5 1	A/µs A/µs
$(di/dt)_{off}$	Turn-off Current Slope	I_{OUT} = 11.5 A I_{OUT} = I_{OV}		0.2	3 3	A/µs A/µs
V_{demag}	Inductive Load Clamp Voltage	I_{OUT} = 11.5 A; L = 1 mH	–24	–18	–14	V

Note: 4. See Switching Time Waveforms.

Table 7. Logic Input

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input Low Level Voltage				0.8	V
V_{IH}	Input High Level Voltage		2		Note 5	V
$V_{I(hyst)}$	Input Hysteresis Voltage			0.5		V
I_{IN}	Input Current	V_{IN} = 5 V V_{IN} = 2 V V_{IN} = 0.8 V	 25	250	500 250	µA µA µA
V_{ICL}	Input Clamp Voltage	I_{IN} = 10 mA I_{IN} = –10 mA	5.5	6 –0.7	 –0.3	V V

Note: 5. The V_{IH} 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)

Table 8. Protection and Diagnostics

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{STAT}	Status Voltage Output Low	I_{STAT} = 1.6 mA			0.4	V
V_{USD}	Under Voltage Shut Down			5		V
V_{SCL}	Status Clamp Voltage	I_{STAT} = 10 mA I_{STAT} = –10 mA		6 –0.7		V V
I_{OV}	Over Current	R_{LOAD} < 10 mΩ; –40 ≤ T_c ≤ 125 °C		140		A
I_{AV}	Average Current in Short Circuit	R_{LOAD} < 10 mΩ; Tc = 85 °C		2.5		A
I_{OL}	Open Load Current Level		5	600	1250	mA
T_{TSD}	Thermal Shut-down Temperature		140			°C
T_R	Reset Temperature		125			°C
V_{OL}(6)	Open Load Voltage Level	Off-State	2.5	3.75	5	V
$t_{1(on)}$(7)	Open Load Filtering Time		1	5	10	ms
$t_{1(off)}$(7)	Open Load Filtering Time		1	5	10	ms
$t_{2(off)}$(7)	Open Load Filtering Time		1	5	10	ms
t_{povl}(7)	Status Delay			5	10	µs
t_{pol}(7)	Status Delay		50	700		µs

Note: 6. $I_{OL(off)} = (V_{CC} - V_{OL})/R_{OL}$ (see figure 5).
7. $t_{1(on)}$: minimum open load duration which activates the status output;
$t_{1(off)}$: minimum load recovery time which desactivates the status output;
$t_{2(off)}$: minimum on time after thermal shut down which desactivates status output;
t_{povl} t_{pol}: ISO definition (see figure 6).

Figure 5. Note 6 relevant figure

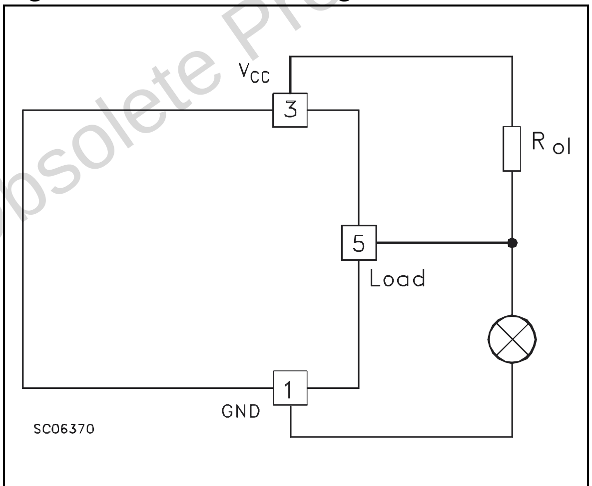


Figure 6. Note 7 relevant figure

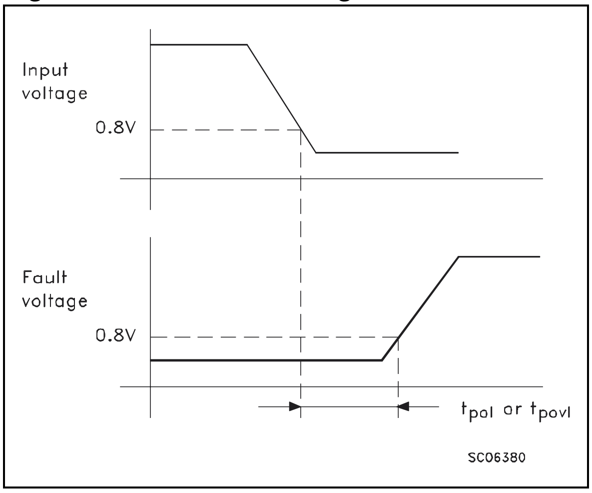
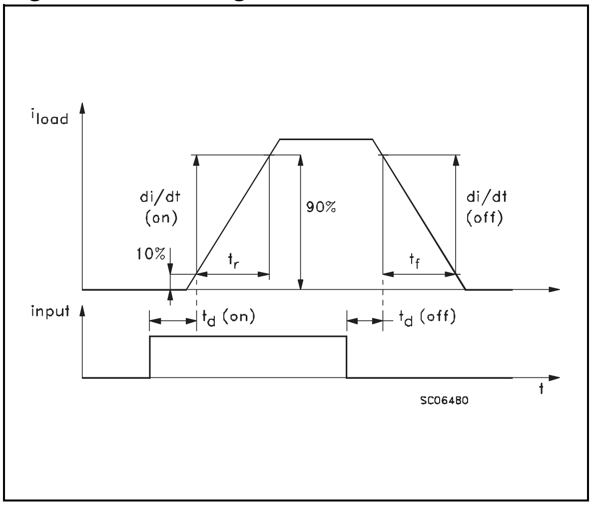


Figure 7. Switching Time Waveforms



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 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_{povl})in case of overtemperature condition and a delay (t_{pol}) 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:

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

where f = switching frequency and

V_{demag} = 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 any external component. This means that all functions of the device are performed as designed after exposure to disturbance at level II. The VN31 is able to withstand 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 µF between pin 3 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 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_f is seen by the device. (V_{IL}, V_{IH} thresholds and V_{STAT} are increased by V_f with respect to power GND).
– The undervoltage shutdown level is increased by V_f.

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.

Table 9. Truth Table

	Input	Output	Diagnostic
Normal Operation	L H	L H	H H
Open Circuit (No Load)	H	H	L
Over-temperature	H	L	L
Under-voltage	X	L	H
Short load to V_{CC}	L	H	L

Figure 8. Waveforms

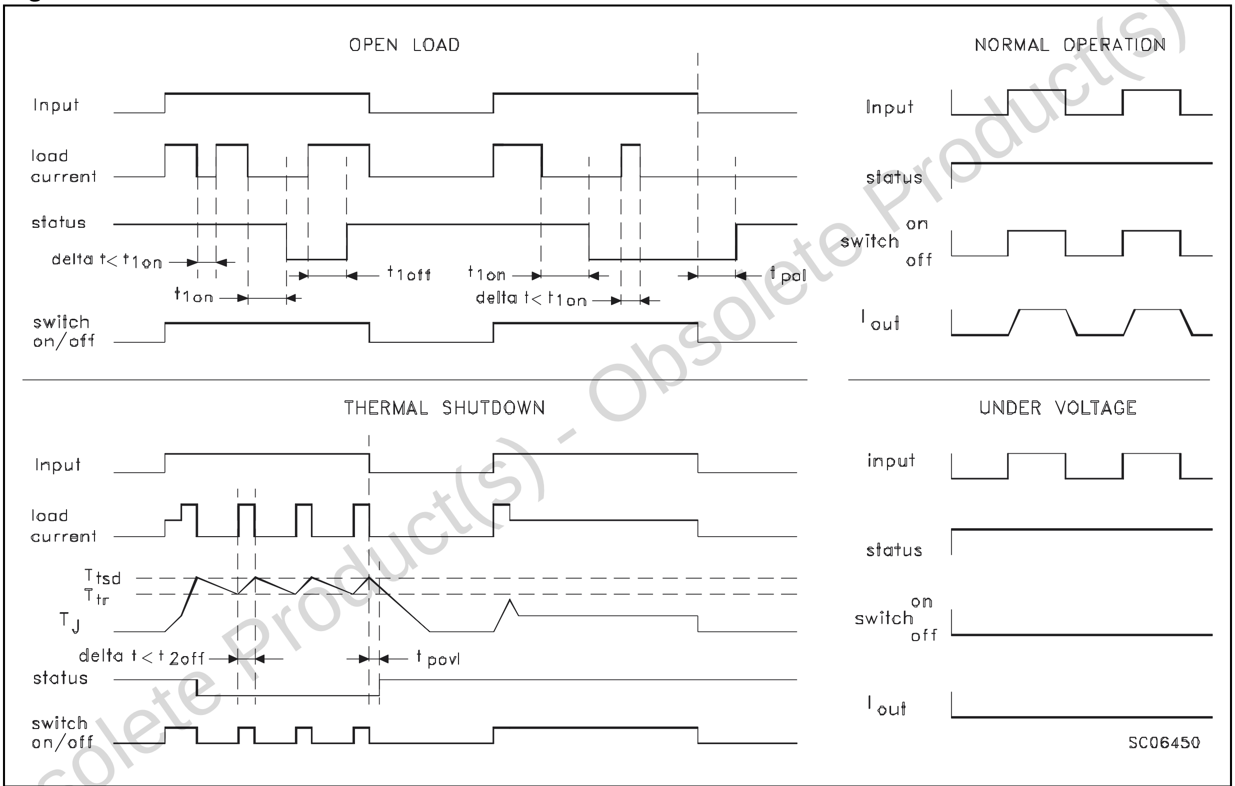


Figure 9. Over Current Test Circuit

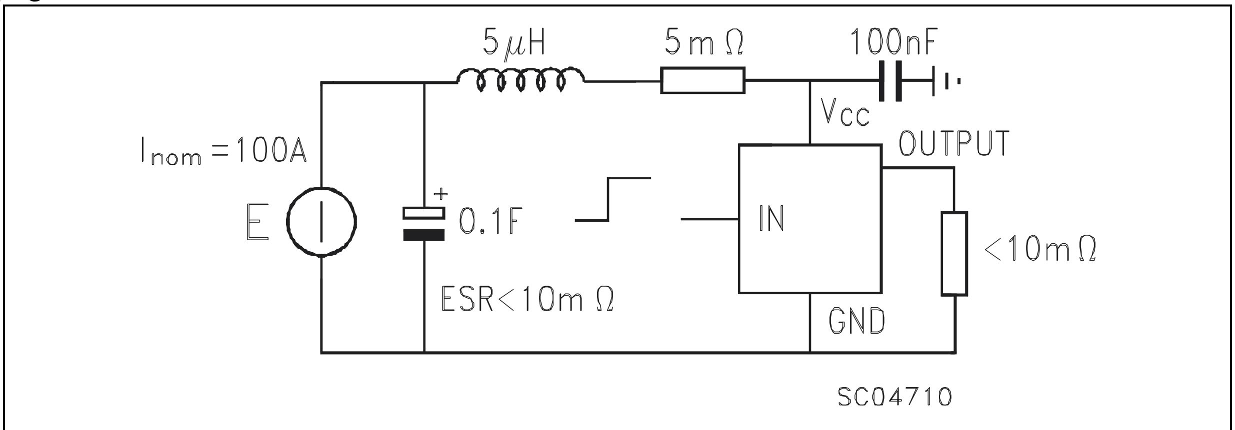


Figure 10. Typical Application Circuit With A Schottky Diode For Reverse Supply Protection

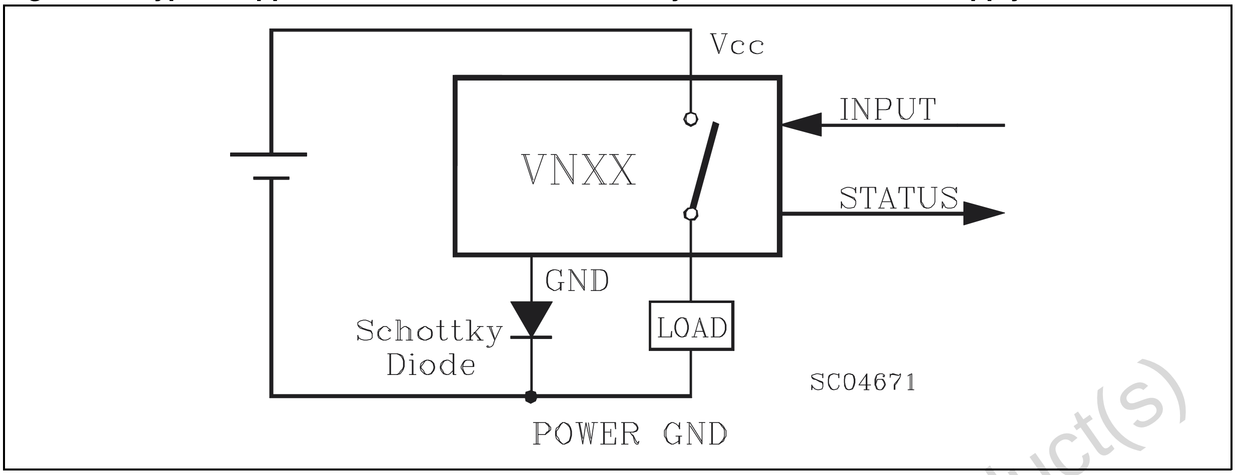
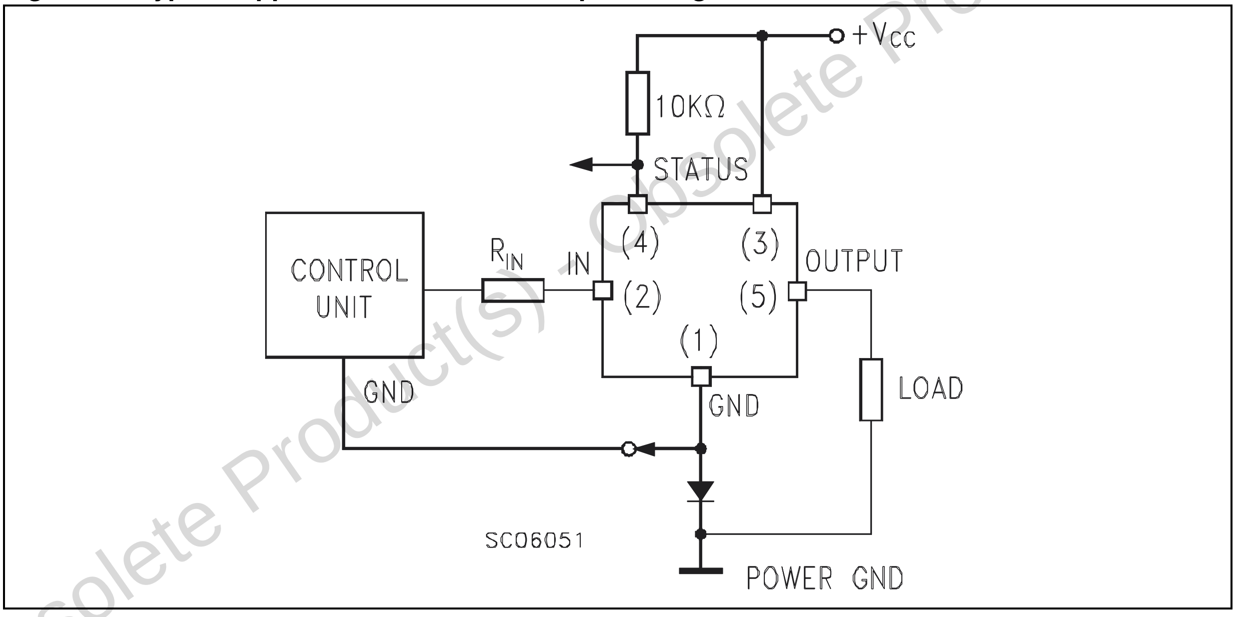


Figure 11. Typical Application Circuit With Separate Signal Ground

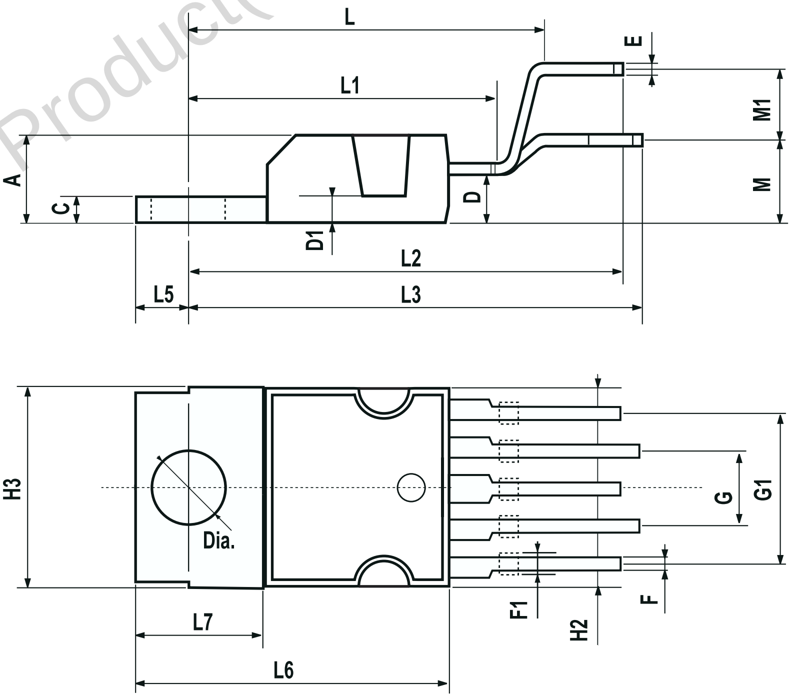


PACKAGE MECHANICAL

Table 10. PENTAWATT (vertical) Mechanical Data

Symbol	millimeters		
	Min	Typ	Max
A			4.8
C			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	7
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		3.85

Figure 12. PENTAWATT (vertical) Package Dimensions

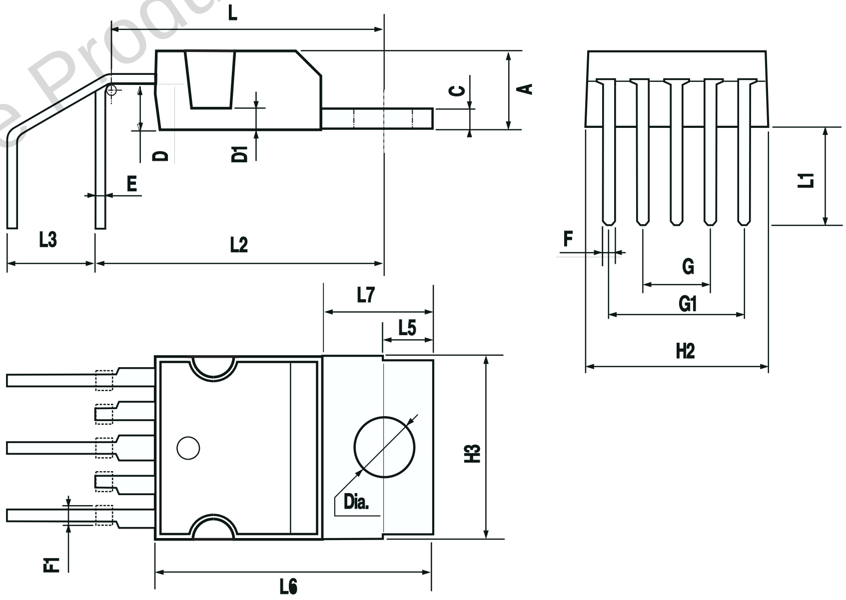


Note: Drawing is not to scale.

Table 11. PENTAWATT (horizontal) Mechanical Data

Symbol	millimeters		
	Min	Typ	Max
A			4.8
C			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	7
H2			10.4
H3	10.05		10.4
L	14.2		15
L1	5.7		6.2
L2	14.6		15.2
L3	3.5		4.1
L5	2.6		3
L6	15.1		15.8
L7	6		6.6
Dia.	3.65		3.85

Figure 13. PENTAWATT (horizontal) Package Dimensions

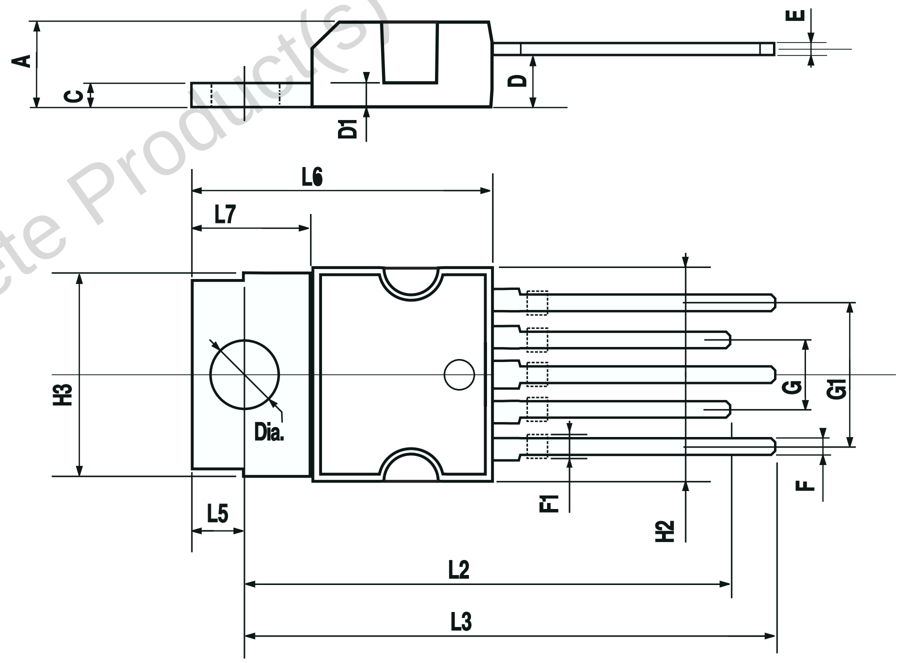


Note: Drawing is not to scale.

Table 12. PENTAWATT (in-line) Mechanical Data

Symbol	millimeters		
	Min	Typ	Max
A			4.8
C			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	7
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		3.85

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.

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