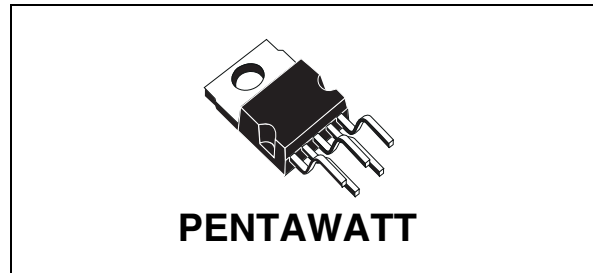


## High side smart power solid state relay

### Features

| Type  | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>OUT</sub> | V <sub>CC</sub> |
|-------|------------------|---------------------|------------------|-----------------|
| VN05N | 60 V             | 0.18 Ω              | 13 A             | 26 V            |

- Output current (continuous): 13A @ T<sub>c</sub>=25°C
- 5V logic level compatible input
- Thermal shutdown
- Under voltage shutdown
- Open drain diagnostic output
- Very low standby power dissipation



### Description

The VN05N is a monolithic device made using STMicroelectronics VIPower technology, intended for driving resistive or inductive loads with one side grounded. Built-in thermal shutdown protects the chip from over temperature and short circuit.

The input control is 5V logic level compatible. The open drain diagnostic output indicates open circuit (no load) and over temperature status.

**Table 1. Device summary**

| Package   | Order codes |
|-----------|-------------|
| PENTAWATT | VN05N       |

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# 1 Block diagram and pin description

Figure 1. Block diagram

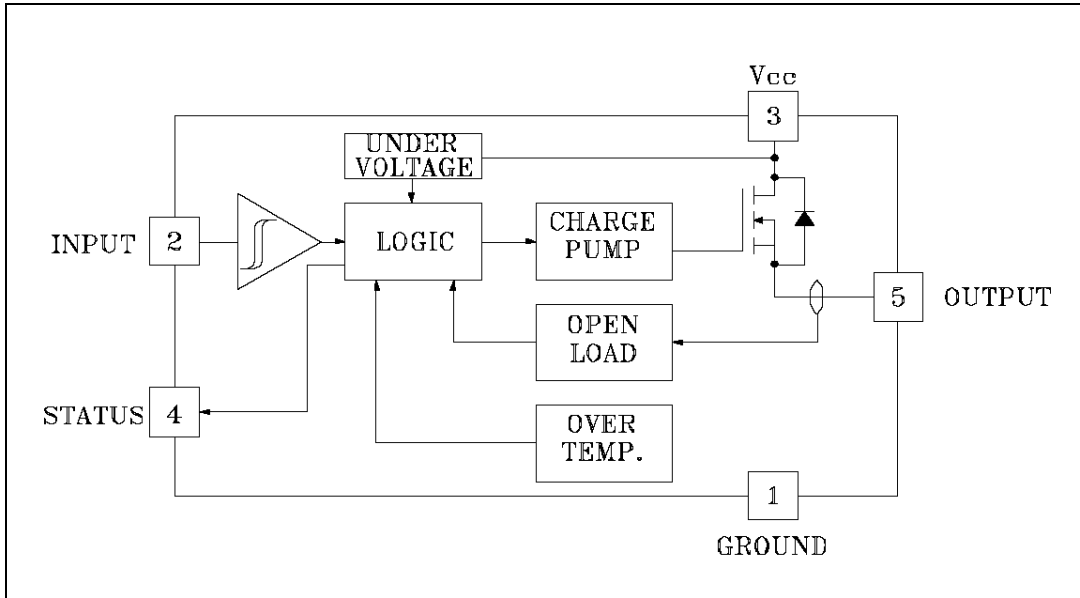
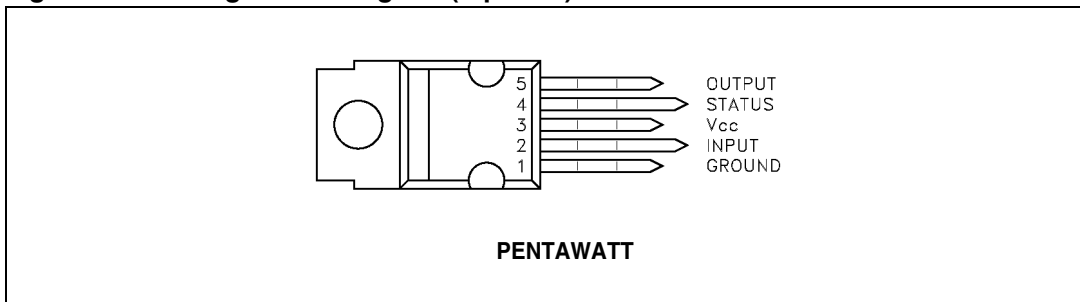
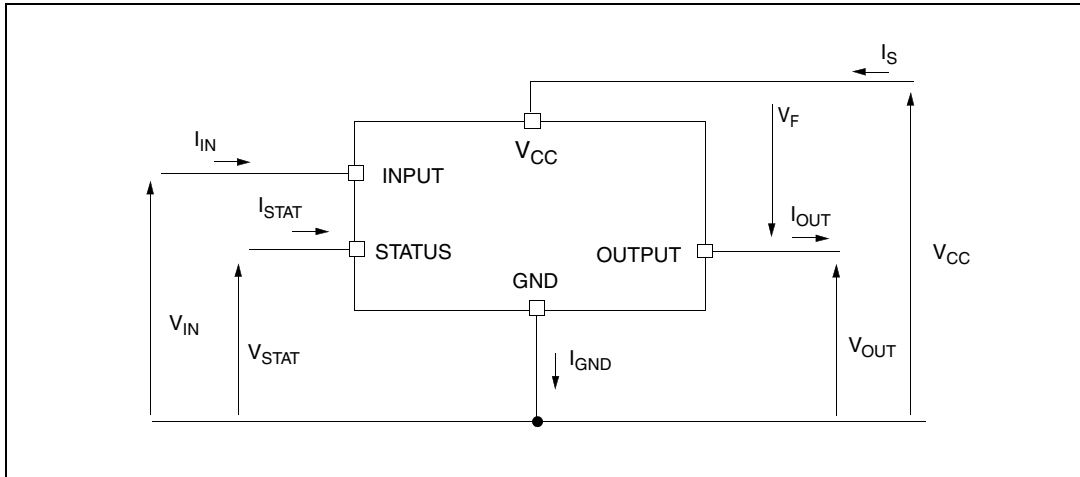


Figure 2. Configuration diagram (top view)



## 2 Electrical specifications

Figure 3. Current and voltage conventions



### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in the “Absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to Absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics sure program and other relevant quality document.

Table 2. Absolute maximum ratings

| Symbol            | Parameter                                   | Value      | Unit |
|-------------------|---|------------|------|
| V(BR)DSS          | Drain-Source breakdown voltage              | 60         | V    |
| I <sub>OUT</sub>  | Output current (cont.)                      | 13         | A    |
| I <sub>R</sub>    | Reverse output current                      | -13        | A    |
| I <sub>IN</sub>   | Input current                               | ±10        | mA   |
| -V <sub>CC</sub>  | Reverse supply voltage                      | -4         | V    |
| I <sub>STAT</sub> | Status current                              | ±10        | mA   |
| VESD              | Electrostatic discharge (1.5 kΩ, 100 pF)    | 2000       | V    |
| P <sub>tot</sub>  | Power dissipation at T <sub>c</sub> ≤ 25 °C | 56         | W    |
| T <sub>j</sub>    | Junction operating temperature              | -40 to 150 | °C   |
| T <sub>stg</sub>  | Storage temperature                         | -55 to 150 | °C   |

## 2.2 Thermal data

**Table 3. Thermal data**

| Symbol         | Parameter                           | Max. value | Unit |
|----------------|-------------------------------------|------------|------|
| $R_{thj-case}$ | Thermal resistance junction-case    | 2.2        | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient | 60         | °C/W |

## 2.3 Electrical characteristics

Values specified in this section are for  $V_{CC} = 13V$ ;  $-40^{\circ}C < T_j < 125^{\circ}C$ , unless otherwise stated.

**Table 4. Power**

| Symbol   | Parameter           | Test conditions   | Min. | Typ. | Max.         | Unit                 |
|----------|---------------------|---|------|------|--------------|----------------------|
| $V_{CC}$ | Supply voltage      |   | 7    |      | 26           | V                    |
| $R_{on}$ | On state resistance | $I_{OUT} = 6\text{ A}$<br>$I_{OUT} = 6\text{ A } T_j = 25^{\circ}C$ |      |      | 0.36<br>0.18 | $\Omega$<br>$\Omega$ |
| $I_S$    | Supply current      | Off state $T_j \geq 25^{\circ}C$<br>On state                        |      |      | 50<br>15     | $\mu A$<br>mA        |

**Table 5. Switching ( $V_{CC}=13V$ )**

| Symbol                | Parameter                             | Test conditions  | Min. | Typ. | Max.     | Unit                   |
|-----------------------|---------------------------------------|--|------|------|----------|------------------------|
| $t_{d(on)}$           | Turn-on delay time of output current  | $I_{OUT} = 6\text{ A}$ resistive load<br>Input rise time $< 0.1\text{ ms}$ $T_j = 25^{\circ}C$ |      | 15   |          | $\mu s$                |
| $t_r$                 | Rise time of output current           | $I_{OUT} = 6\text{ A}$ resistive load<br>Input rise time $< 0.1\text{ ms}$ $T_j = 25^{\circ}C$ |      | 30   |          | $\mu s$                |
| $t_{d(off)}$          | Turn-off delay time of output current | $I_{OUT} = 6\text{ A}$ Resistive load<br>Input rise time $< 0.1\text{ ms}$ $T_j = 25^{\circ}C$ |      | 20   |          | $\mu s$                |
| $t_f$                 | Fall time of output current           | $I_{OUT} = 6\text{ A}$ resistive load<br>Input rise time $< 0.1\text{ ms}$ $T_j = 25^{\circ}C$ |      | 10   |          | $\mu s$                |
| $dV_{OUT}/dt_{(on)}$  | Turn-on current slope                 | $I_{OUT} = 6\text{ A}$<br>$I_{OUT} = IOV$  |      |      | 0.5<br>2 | $A/\mu s$<br>$A/\mu s$ |
| $dV_{OUT}/dt_{(off)}$ | Turn-off current slope                | $I_{OUT} = 6\text{ A}$<br>$I_{OUT} = IOV$  |      |      | 2<br>4   | $A/\mu s$<br>$A/\mu s$ |

**Table 6. Logic inputs**

| Symbol         | Parameter                | Test conditions                                     | Min. | Typ.      | Max. | Unit          |
|----------------|--------------------------|---|------|-----------|------|---------------|
| $V_{IL}$       | Input low level voltage  |   |      |           | 0.8  | V             |
| $V_{IH}^{(1)}$ | Input high level voltage |   | 2    |           |      | V             |
| $V_{I(hyst.)}$ | Input hysteresis voltage |   |      | 0.5       |      | V             |
| $I_{IN}$       | Input current            | $V_{IN} = 5\text{ V}$                               |      | 250       | 500  | $\mu\text{A}$ |
| $V_{ICL}$      | Input clamp voltage      | $I_{IN} = 10\text{ mA}$<br>$I_{IN} = -10\text{ mA}$ |      | 6<br>-0.7 |      | V<br>V        |

1. 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.

**Table 7. Protections and diagnostics**

| Symbol           | Parameter  | Test conditions   | Min. | Typ.      | Max. | Unit             |
|------------------|--|---|------|-----------|------|------------------|
| $V_{STAT}^{(1)}$ | Status voltage output low                              | $I_{STAT} = 1.6\text{ mA}$  |      |           | 0.4  | V                |
| $V_{USD}$        | Under voltage shutdown                                 |   |      | 6.5       |      | V                |
| $V_{SCL}^{(1)}$  | Status clamp voltage                                   | $I_{STAT} = 10\text{ mA}$<br>$I_{STAT} = -10\text{ mA}$                         |      | 6<br>-0.7 |      | V<br>V           |
| $t_{SC}$         | Switch-off time in short circuit condition at start-up | $R_{LOAD} < 10\text{ m}\Omega$ $T_c = 25\text{ }^\circ\text{C}$                 |      | 1.5       | 5    | ms               |
| $I_{OV}$         | Over current   | $R_{LOAD} < 10\text{ m}\Omega$<br>$-40 \leq T_c \leq 125\text{ }^\circ\text{C}$ |      |           | 60   | A                |
| $I_{AV}$         | Average current in short circuit                       | $R_{LOAD} < 10\text{ m}\Omega$ $T_c = 85\text{ }^\circ\text{C}$                 |      | 1.4       |      | A                |
| $I_{OL}$         | Open load current level                                |   | 5    |           | 180  | mA               |
| $T_{TSD}$        | Thermal shutdown temperature                           |   | 140  |           |      | $^\circ\text{C}$ |
| $T_R$            | Reset temperature                                      |   | 125  |           |      | $^\circ\text{C}$ |

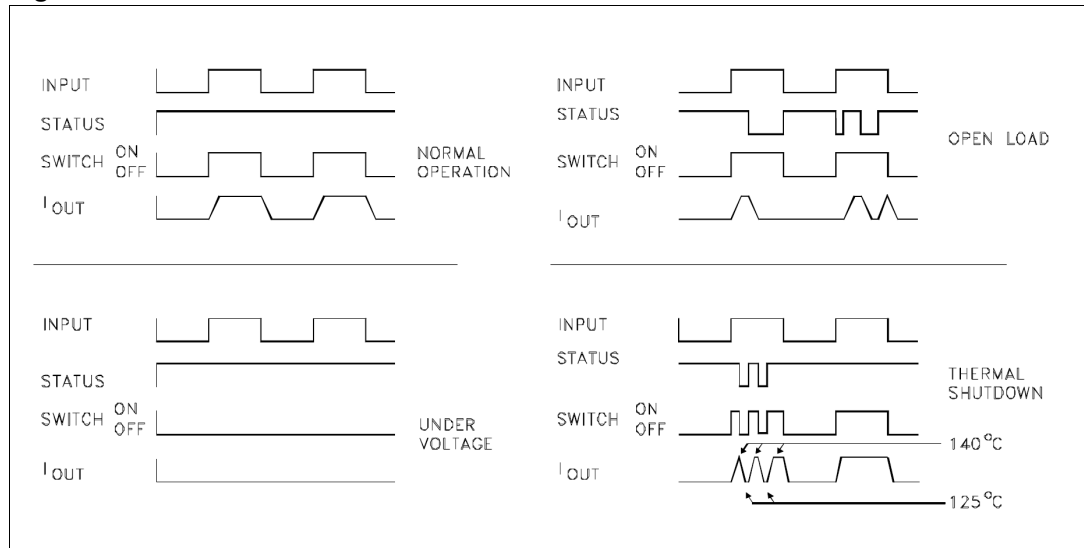
1. Status determination > 100  $\mu\text{s}$  after the switching edge.

**Table 8. Truth table**

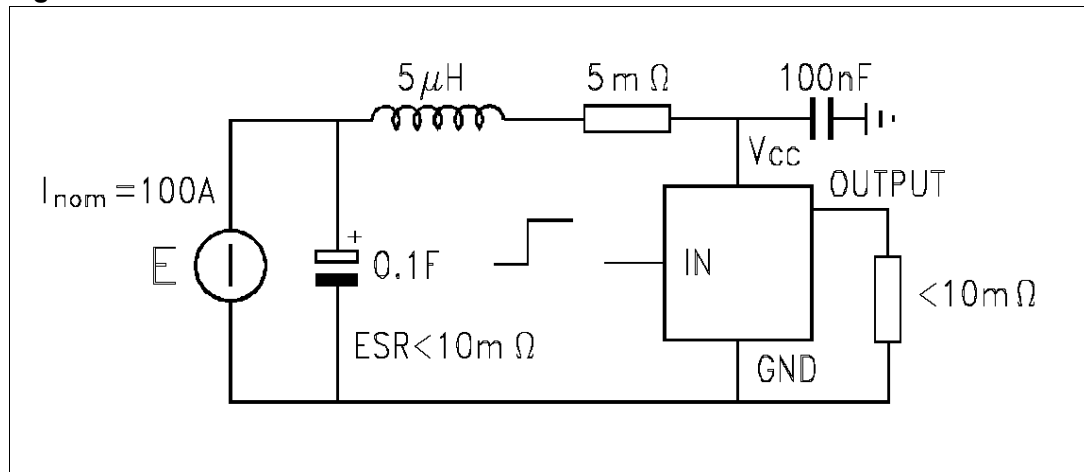
| Conditions             | Input | Output | Diagnostic |
|------------------------|-------|--------|------------|
| Normal operation       | L     | L      | H          |
|                        | H     | H      | H          |
| Open circuit (no load) | H     | H      | L          |
| Over-temperature       | H     | L      | L          |
| Under-voltage          | X     | L      | H          |



**Figure 4. Waveforms**

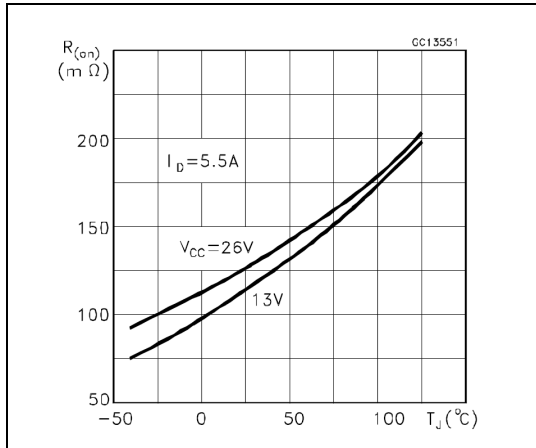


**Figure 5. Over current test circuit**

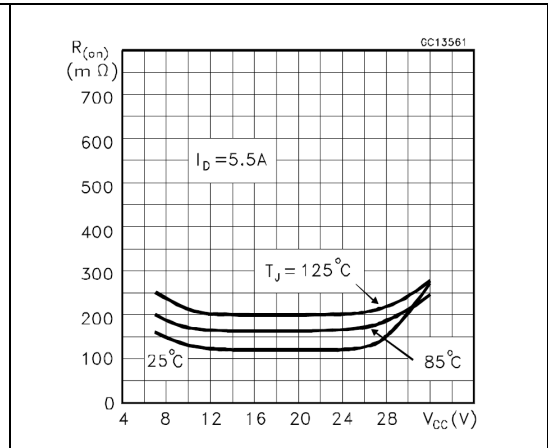


## 2.4 Electrical characteristics curves

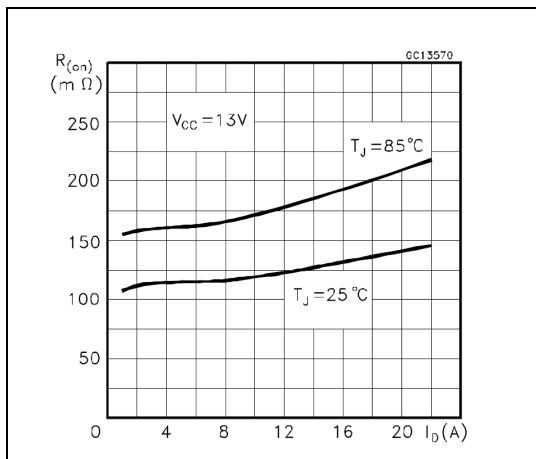
**Figure 6.  $R_{DS(on)}$  vs junction temperature**



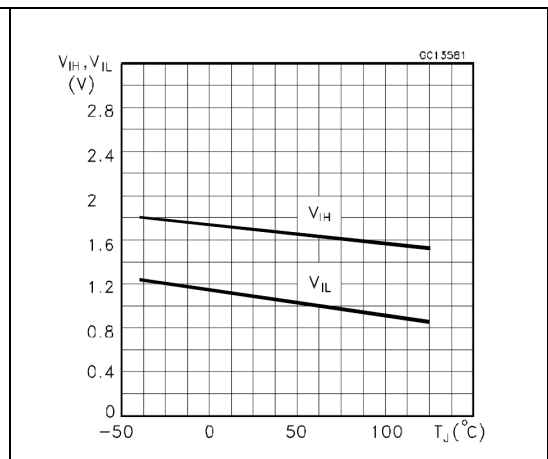
**Figure 7.  $R_{DS(on)}$  vs supply voltage**



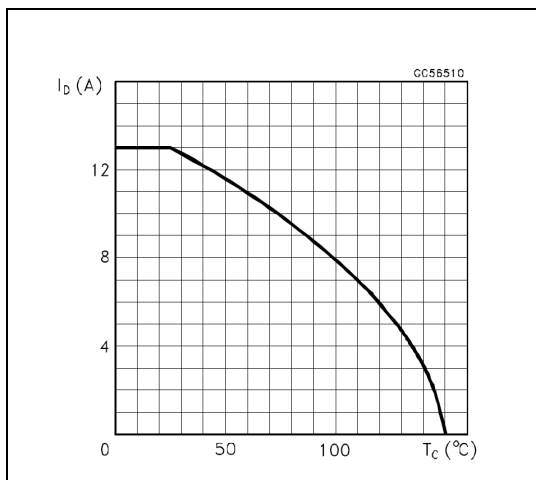
**Figure 8.  $R_{DS(on)}$  vs output current**



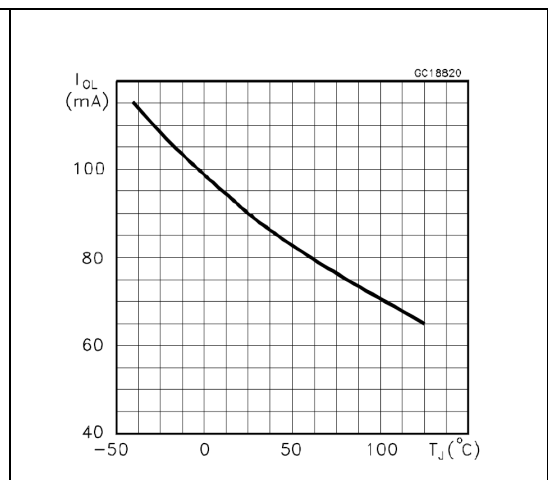
**Figure 9. Input voltages vs junction temperature**



**Figure 10. Output current derating**

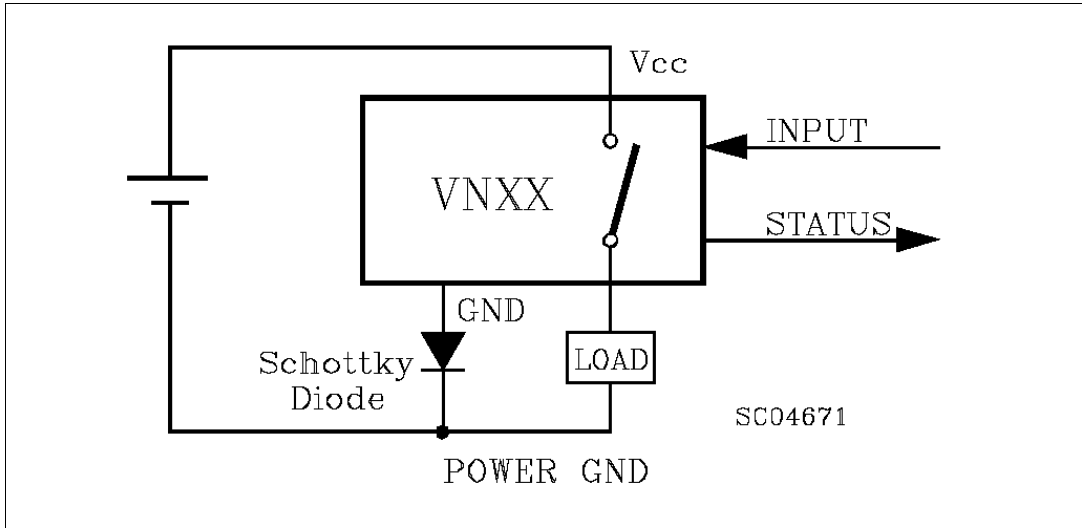


**Figure 11. Open load vs junction temperature**

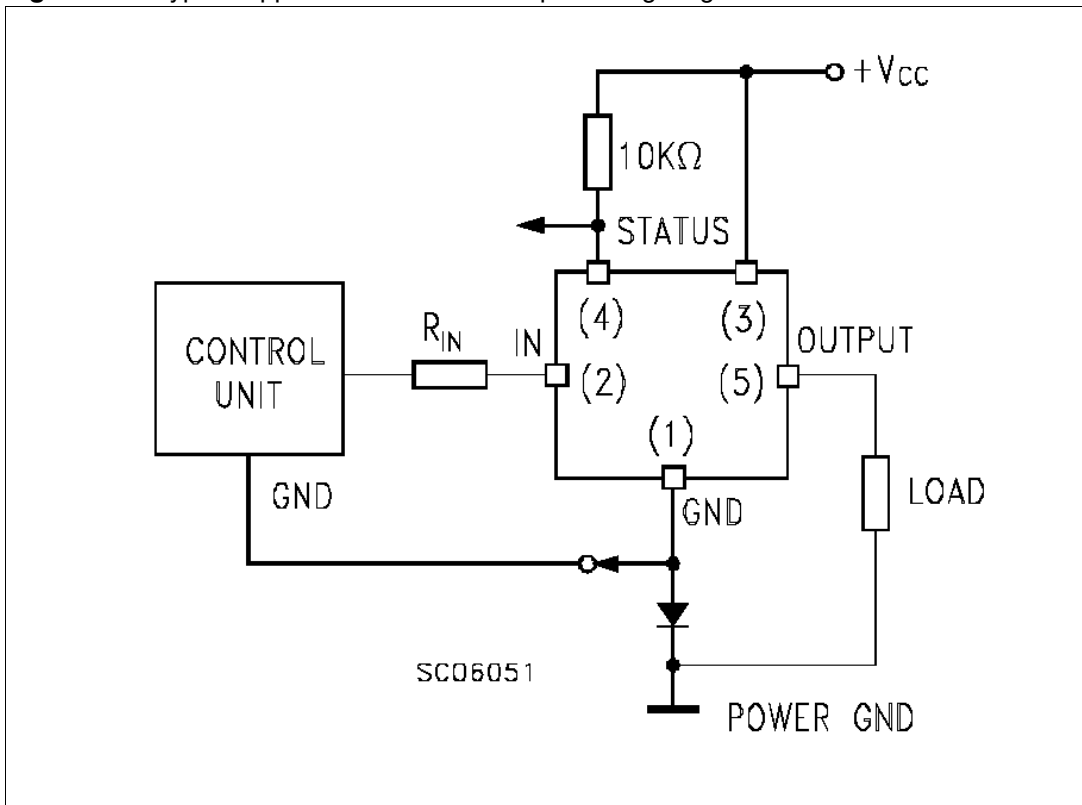


### 3 Application information

**Figure 12.** Typical application circuit with a schottky diode for reverse supply protection



**Figure 13.** Typical application circuit with separate signal ground



### 3.1 Functional description

The device has a diagnostic output which indicates open circuit (no load) and over temperature conditions. The output signals are processed by internal logic. To protect the device against short circuit and over-current condition, the thermal protection turns the integrated Power MOS off at a minimum junction temperature of 140°C. When the temperature returns to about 125°C the switch is automatically turned on again. In short circuit conditions the protection reacts with virtually no delay, the sensor being located in the region of the die where the heat is generated.

### 3.2 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 12](#)).

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 [Figure 13](#)), which becomes the common signal GND for the whole control board. In this way no shift of  $V_{IH}$ ,  $V_{IL}$  and  $V_{STAT}$  takes place and no negative voltage appears on the INPUT pin; this solution allows the use of a standard diode, with a breakdown voltage able to handle any ISO normalized negative pulses that occurs in the automotive environment.

## 4 Package and packing information

### 4.1 ECOPACK<sup>®</sup> packages

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. ECOPACK<sup>®</sup> packages are lead-free. The category of Second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label.

ECOPACK is an ST trademark. ECOPACK specifications are available at [www.st.com](http://www.st.com).

### 4.2 PENTAWATT mechanical data

Figure 14. PENTAWATT package dimensions

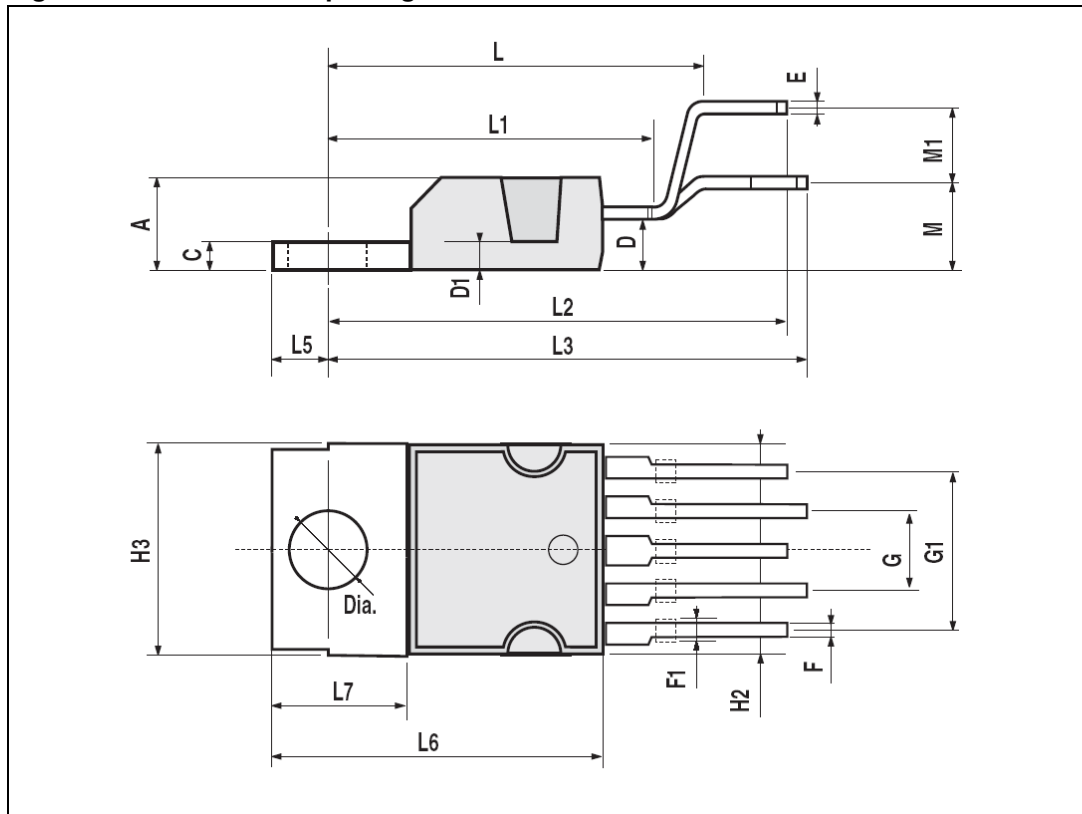


Table 9. PENTAWATT mechanical data

| Dim.  | mm    |       |      |
|-------|-------|-------|------|
|       | 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     |       | 17.85 |      |
| L1    |       | 15.75 |      |
| L2    |       | 21.4  |      |
| L3    |       | 22.5  |      |
| L5    | 2.6   |       | 3    |
| L6    | 15.1  |       | 15.8 |
| L7    | 6     |       | 6.6  |
| M     |       | 4.5   |      |
| M1    |       | 4     |      |
| Diam. | 3.65  |       | 3.85 |

## 5 Revision history

**Table 10. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| Sep-1994    | 1        | Initial release.  |
| 05-Nov-2008 | 2        | Document converted in corporate template.<br>Added <a href="#">Section 4.1: ECOPACK® packages</a> . |

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