

## ISO HIGH SIDE SMART POWER SOLID STATE RELAY

**Table 1. General Features**

| Type    | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>OUT</sub> | V <sub>CC</sub> |
|---------|------------------|---------------------|------------------|-----------------|
| VN16BPS | 40 V             | 0.06 Ω              | 5.6 A            | 26 V            |

- MAXIMUM CONTINUOUS OUTPUT CURRENT: 20 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

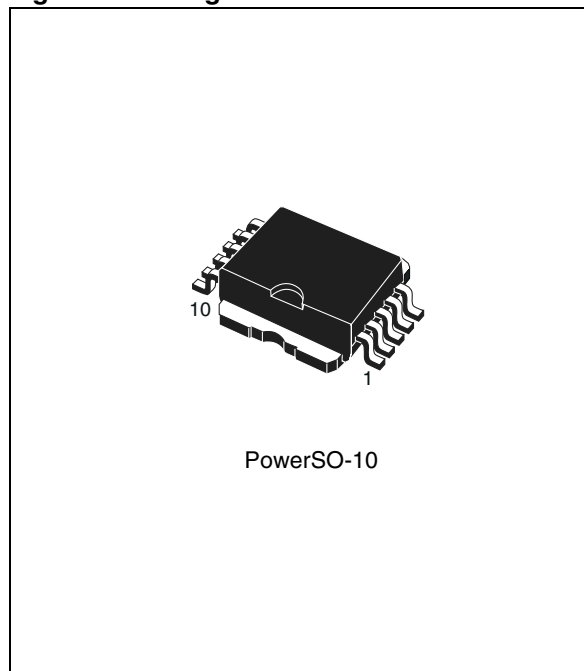
### DESCRIPTION

The VN16BPS 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<sub>CC</sub> and overtemperature. Fast demagnetization of inductive loads is achieved by negative (-18V) load voltage at turn-off.

**Figure 1. Package**



**Table 2. Order Codes**

| Package    | Tube    | Tape and Reel |
|------------|---------|---------------|
| PowerSO-10 | VN16BSP | VN16BSP13TR   |



Figure 3. Connection Diagrams

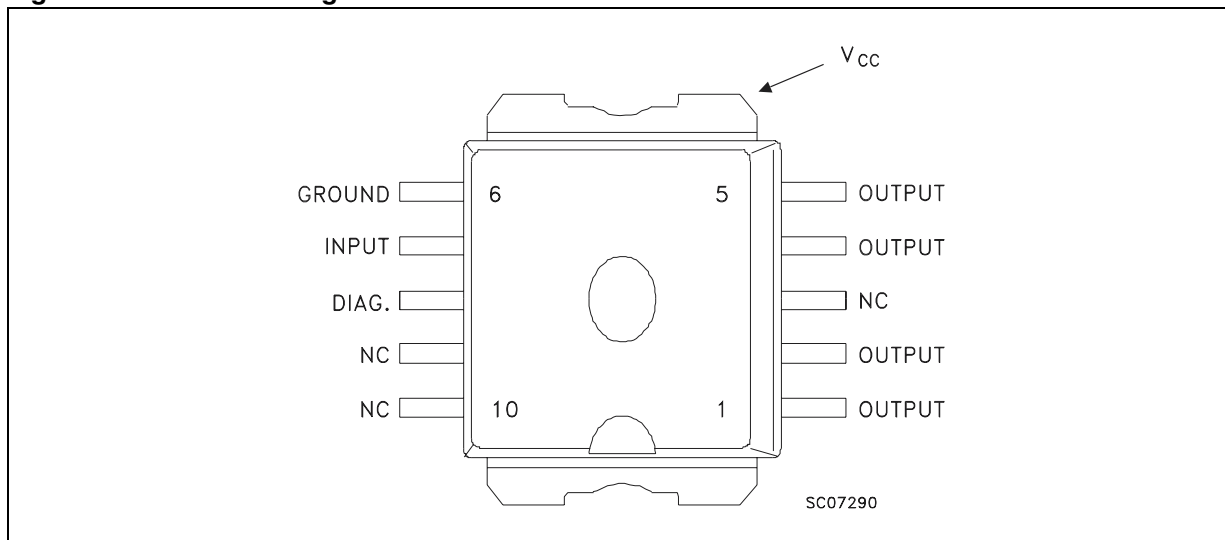


Figure 4. Current and Voltage Conventions

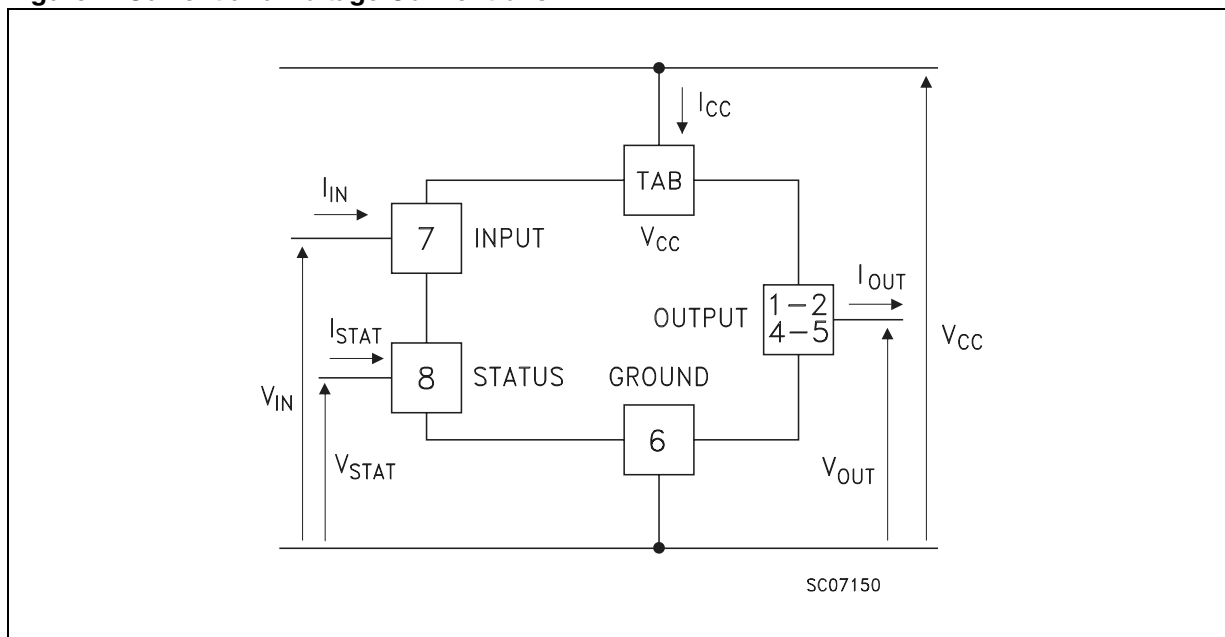


Table 4. Thermal Data

| Symbol         | Parameter                                              | Value | Unit          |
|----------------|--------------------------------------------------------|-------|---------------|
| $R_{thj-case}$ | Thermal Resistance Junction-case Max                   | 1.5   | $^{\circ}C/W$ |
| $R_{thj-amb}$  | Thermal Resistance Junction-ambient <sup>(1)</sup> Max | 50    | $^{\circ}C/W$ |

Note: 1. When mounted using minimum recommended pad size on FR-4 board.

**ELECTRICAL CHARACTERISTICS**(8 < V<sub>CC</sub> < 16 V; -40 ≤ T<sub>j</sub> ≤ 125 °C unless otherwise specified)**Table 5. Power**

| Symbol                        | Parameter                        | Test Conditions                                                                    | Min.  | Typ. | Max. | Unit |
|-------------------------------|----------------------------------|------------------------------------------------------------------------------------|-------|------|------|------|
| V <sub>CC</sub>               | Supply Voltage                   |                                                                                    | 6     | 13   | 26   | V    |
| I <sub>n</sub> <sup>(2)</sup> | Nominal Current                  | T <sub>c</sub> = 85 °C; V <sub>DS(on)</sub> ≤ 0.5; V <sub>CC</sub> = 13 V          | 5.6   |      | 8.8  | A    |
| R <sub>on</sub>               | On State Resistance              | I <sub>OUT</sub> = I <sub>n</sub> ; V <sub>CC</sub> = 13 V; T <sub>j</sub> = 25 °C | 0.038 |      | 0.06 | Ω    |
| I <sub>S</sub>                | Supply Current                   | Off State; V <sub>CC</sub> = 13 V; T <sub>j</sub> ≥ 25 °C                          |       | 25   | 50   | μA   |
| V <sub>DS(MAX)</sub>          | Maximum Voltage Drop             | I <sub>OUT</sub> = 20 A; V <sub>CC</sub> = 13 V; T <sub>c</sub> = 85 °C            | 1     |      | 1.8  | V    |
| R <sub>j</sub>                | Output to GND Internal Impedance | T <sub>j</sub> = 25 °C                                                             | 5     | 10   | 20   | KΩ   |

Note: 2. I<sub>n</sub> = 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**

| Symbol                             | Parameter                             | Test Conditions                                   | Min.  | Typ. | Max. | Unit |
|------------------------------------|---------------------------------------|---------------------------------------------------|-------|------|------|------|
| t <sub>d(on)</sub> <sup>(3)</sup>  | Turn-on Delay Time Of Output Current  | R <sub>load</sub> = 1.6 Ω                         | 5     | 50   | 500  | μs   |
| t <sub>r</sub> <sup>(3)</sup>      | Rise Time Of Output Current           | R <sub>load</sub> = 1.6 Ω                         | 40    | 100  | 680  | μs   |
| t <sub>d(off)</sub> <sup>(3)</sup> | Turn-off Delay Time Of Output Current | R <sub>load</sub> = 1.6 Ω                         | 10    | 100  | 500  | μs   |
| t <sub>f</sub> <sup>(3)</sup>      | Fall Time Of Output Current           | R <sub>load</sub> = 1.6 Ω                         | 40    | 100  | 680  | μs   |
| (di/dt) <sub>on</sub>              | Turn-on Current Slope                 | R <sub>load</sub> = 1.6 Ω; V <sub>CC</sub> = 13 V | 0.008 |      | 0.1  | A/μs |
| (di/dt) <sub>off</sub>             | Turn-off Current Slope                | R <sub>load</sub> = 1.6 Ω; V <sub>CC</sub> = 13 V | 0.008 |      | 0.1  | A/μs |
| V <sub>demag</sub>                 | Inductive Load Clamp Voltage          | R <sub>load</sub> = 1.6 Ω; L = 1 mH               | -24   | -18  | -14  | V    |

Note: 3. See Switching Time Waveforms.

**Table 7. Logic Input**

| Symbol               | Parameter                | Test Conditions                                     | Min. | Typ.      | Max.   | Unit   |
|----------------------|--------------------------|-----------------------------------------------------|------|-----------|--------|--------|
| V <sub>IL</sub>      | Input Low Level Voltage  |                                                     |      |           | 1.5    | V      |
| V <sub>IH</sub>      | Input High Level Voltage |                                                     | 3.5  |           | Note 4 | V      |
| V <sub>I(hyst)</sub> | Input Hysteresis Voltage |                                                     | 0.2  | 1         | 1.5    | V      |
| I <sub>IN</sub>      | Input Current            | V <sub>IN</sub> = 5 V; T <sub>j</sub> = 25 °C       |      |           | 100    | μA     |
| V <sub>ICL</sub>     | Input Clamp Voltage      | I <sub>IN</sub> = 10 mA<br>I <sub>IN</sub> = -10 mA | 5    | 6<br>-0.7 | 7      | V<br>V |

Note: 4. 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)**Table 8. Protection and Diagnostics** (cont'd)

| Symbol                           | Parameter                     | Test Conditions                                         | Min. | Typ.      | 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       |                                                         | 3.5  | 5         | 6    | V      |
| V <sub>SCL</sub>                 | Status Clamp Voltage          | I <sub>STAT</sub> = 10 mA<br>I <sub>STAT</sub> = -10 mA | 5    | 6<br>-0.7 | 7    | V<br>V |
| T <sub>TSD</sub>                 | Thermal Shut-down Temperature |                                                         | 140  | 160       | 180  | °C     |
| T <sub>SD(hyst.)</sub>           | Thermal Shut-down Hysteresis  |                                                         |      | 15        | 50   | °C     |
| T <sub>R</sub>                   | Reset Temperature             |                                                         | 125  |           |      | °C     |
| V <sub>OL</sub> <sup>(5)</sup>   | Open Voltage Level            | Off-State                                               | 2.5  | 3.8       | 5    | V      |
| I <sub>OL</sub>                  | Open Load Current Level       | On-State                                                | 0.15 |           | 0.85 | A      |
| t <sub>povl</sub> <sup>(6)</sup> | Status Delay                  |                                                         |      | 5         | 10   | μs     |
| t <sub>pol</sub> <sup>(6)</sup>  | Status Delay                  |                                                         | 50   | 400       | 2500 | μs     |

Note: 5.  $I_{OL(off)} = (V_{CC} - V_{OL})/R_{OL}$  (see figure 5).

6. t<sub>povl</sub> t<sub>pol</sub>: ISO definition (see figure 6).

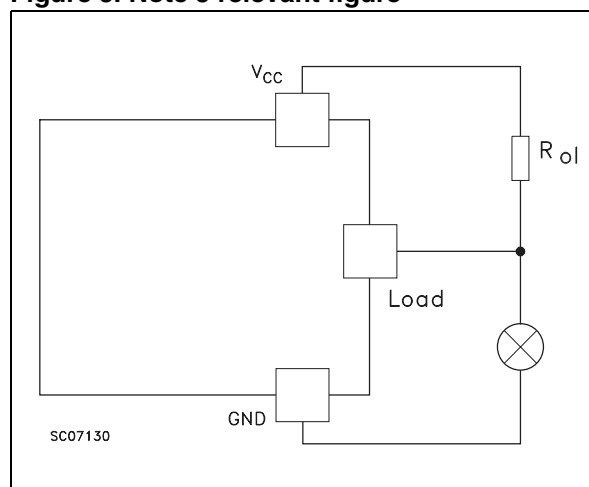
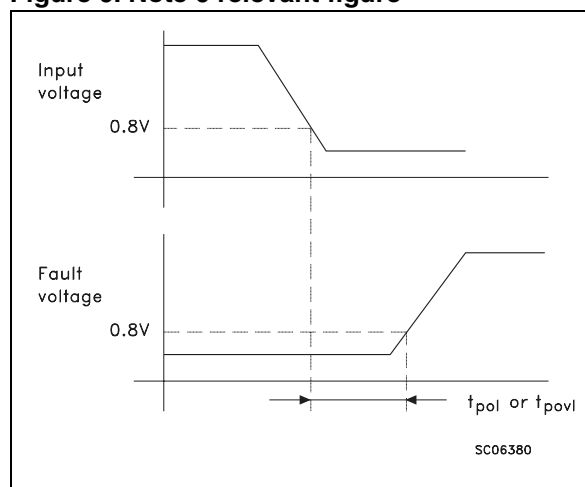
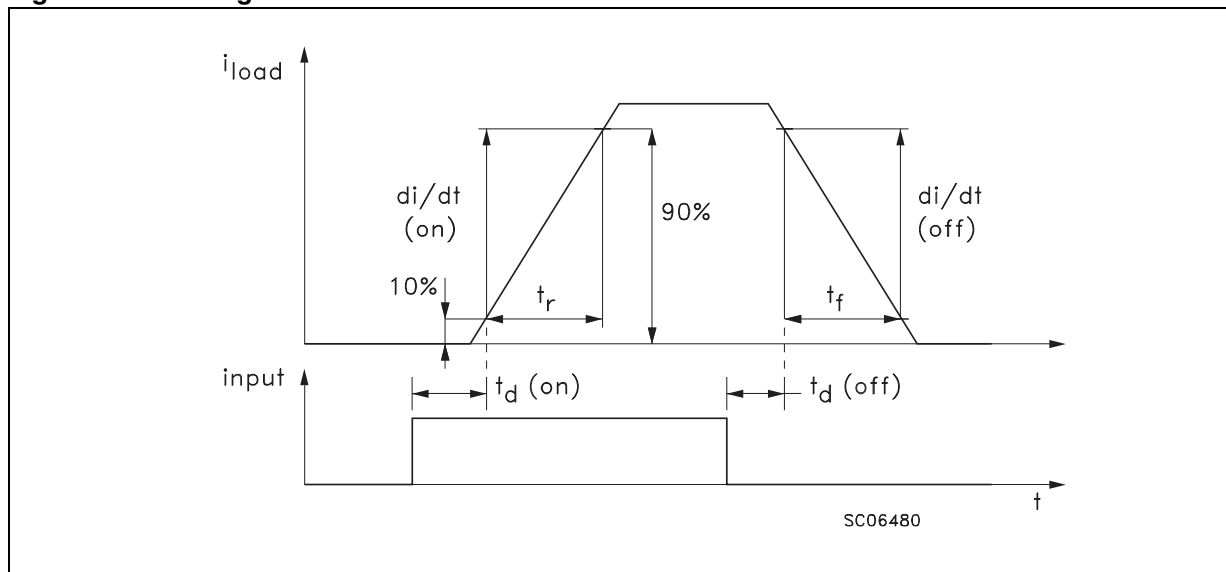
**Figure 5. Note 5 relevant figure****Figure 6. Note 6 relevant figure**

Figure 7. Switching Time Waveforms



### FUNCTIONAL DESCRIPTION

The device has a diagnostic output which indicates open load in on-state, open load in off-state, over temperature conditions and stuck-on to  $V_{CC}$ .

From the falling edge of the input signal, the status output, initially low to signal a fault condition (overtemperature or open load on-state), will go back to a high state with a different delay in case of overtemperature ( $tp_{ovl}$ ) and in case of open load ( $tp_{ol}$ ) respectively. This feature allows to discriminate the nature of the detected fault. 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 this 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 inside the Power MOS area. An internal function of the devices ensures the fast demagnetization of inductive loads with a typical voltage ( $V_{demag}$ ) of -18V. This function allows to greatly reduces the power dissipation according to the formula:

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

where  $f$  = switching frequency and

$V_{demag}$  = demagnetization voltage

The maximum inductance which causes the chip temperature to reach the shut-down temperature in a specified thermal environment is a function of the load current for a fixed  $V_{CC}$ ,  $V_{demag}$  and  $f$

according to the above formula. In this device if the GND pin is disconnected, with  $V_{CC}$  not exceeding 16V, it will switch off.

### 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 10), 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<br>H | L<br>H | H<br>H                |
| Over-temperature       | X      | L      | L                     |
| Under-voltage          | X      | L      | H                     |
| Short load to $V_{CC}$ | H<br>L | H<br>H | L<br>L                |
| Open Circuit           | H<br>L | H<br>L | L<br>L <sup>(7)</sup> |

Note: 7. With an additional external resistor.

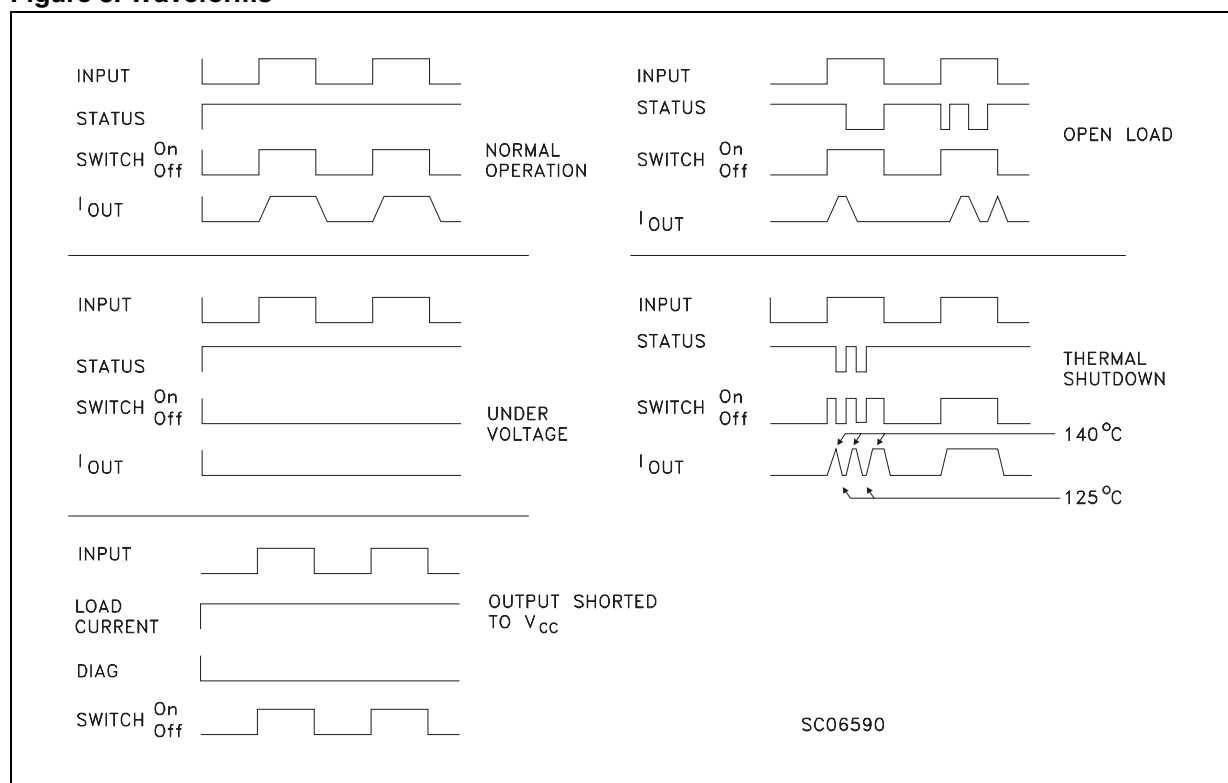
**Figure 8. Waveforms**

Figure 9. Over Current Test Circuit

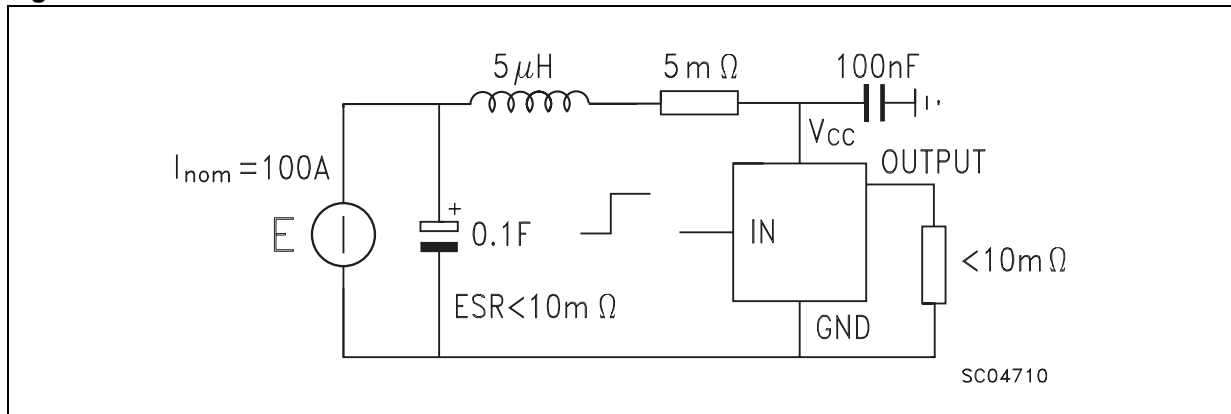


Figure 10. Typical Application Circuit With A Schottky Diode For Reverse Supply Protection

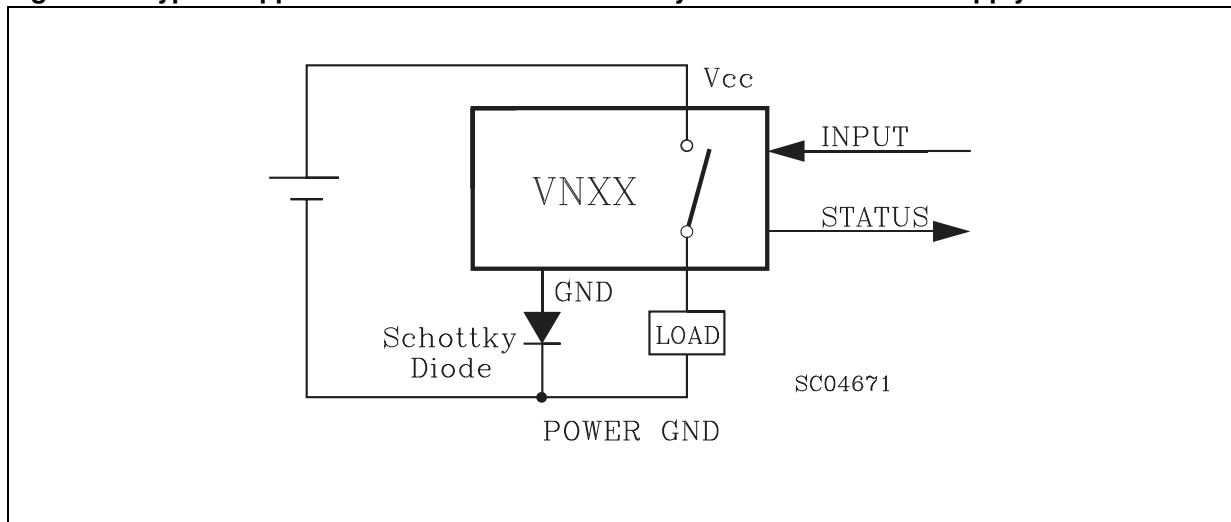
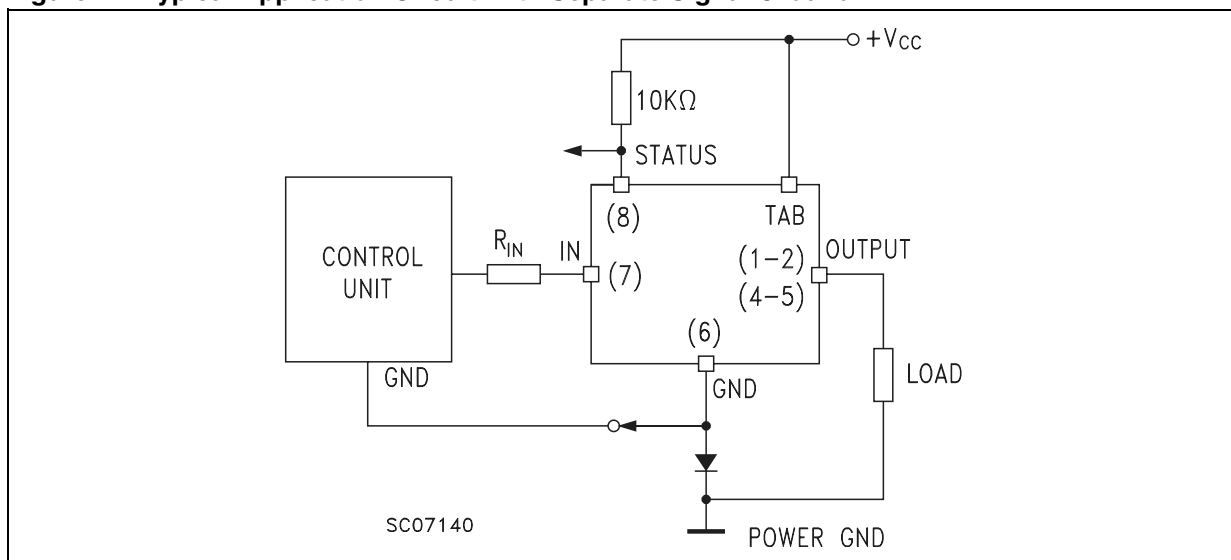


Figure 11. Typical Application Circuit With Separate Signal Ground





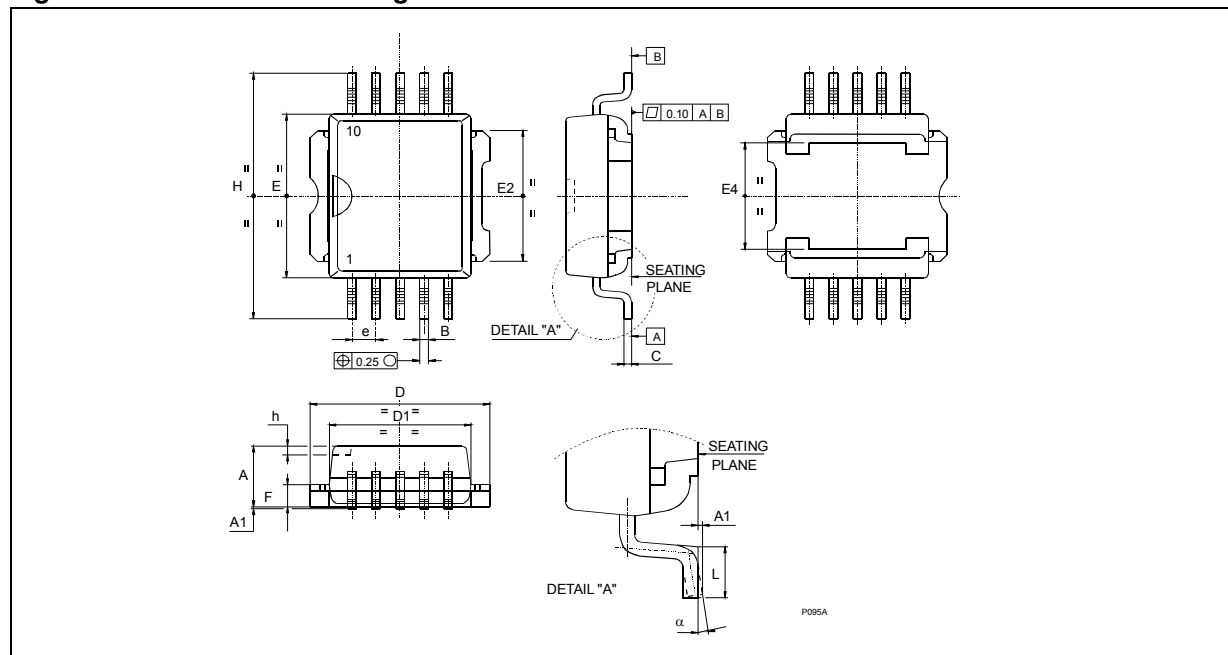
## PACKAGE MECHANICAL

Table 10. Power SO-10 Mechanical Data

| Symbol            | millimeters |      |       |
|-------------------|-------------|------|-------|
|                   | Min         | Typ  | Max   |
| A                 | 3.35        |      | 3.65  |
| A <sup>(8)</sup>  | 3.4         |      | 3.6   |
| A1                | 0.00        |      | 0.10  |
| B                 | 0.40        |      | 0.60  |
| B <sup>(8)</sup>  | 0.37        |      | 0.53  |
| C                 | 0.35        |      | 0.55  |
| C <sup>(8)</sup>  | 0.23        |      | 0.32  |
| D                 | 9.40        |      | 9.60  |
| D1                | 7.40        |      | 7.60  |
| E                 | 9.30        |      | 9.50  |
| E2                | 7.20        |      | 7.60  |
| E2 <sup>(8)</sup> | 7.30        |      | 7.50  |
| E4                | 5.90        |      | 6.10  |
| E4 <sup>(8)</sup> | 5.90        |      | 6.30  |
| e                 |             | 1.27 |       |
| F                 | 1.25        |      | 1.35  |
| F <sup>(8)</sup>  | 1.20        |      | 1.40  |
| H                 | 13.80       |      | 14.40 |
| H <sup>(8)</sup>  | 13.85       |      | 14.35 |
| h                 |             | 0.50 |       |
| L                 | 1.20        |      | 1.80  |
| F <sup>(8)</sup>  | 0.80        |      | 1.10  |
| a                 | 0°          |      | 8°    |
| α <sup>(8)</sup>  | 2°          |      | 8°    |

Note: 8. Muar only POA P013P.

Figure 12. Power SO-10 Package Dimensions



Note: Drawing is not to scale.

## 2 Revision history

**Table 1. Document revision history**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>     |
|-------------|-----------------|--------------------|
| 12-Mar-1988 | 1               | Initial release.   |
| 18-Jun-2004 | 2               | Stylesheet update. |
| 23-Sep-2013 | 3               | Updated Disclaimer |

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