

## Single high-side smart power solid state relay

Datasheet - production data



### Features

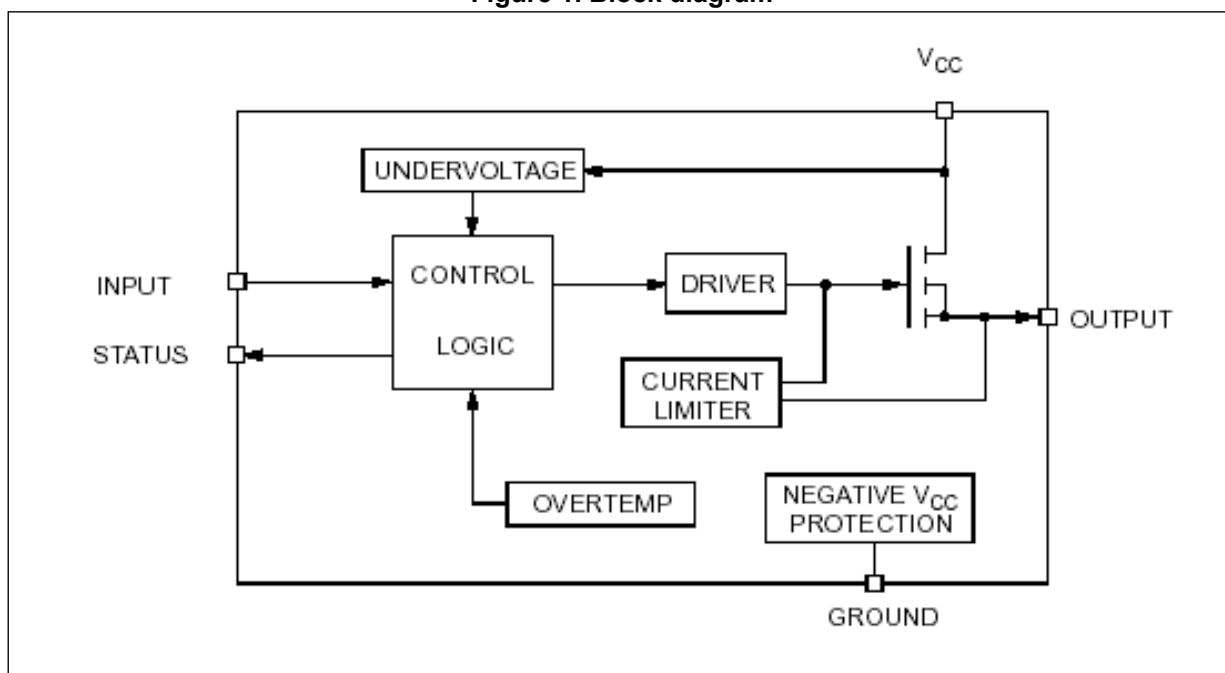
- 10 V to 36 V supply voltage range
- Up to  $I_{OUT} = 2.8$  A operating current
- $R_{DS(on)} = 50$  m $\Omega$
- $V_{demag} = V_{CC} - 55$  V
- Digital input clamped at 32 V

- Protection against:
  - Loss of ground
  - Shorted load and overtemperature
- Built-in current limiter
- Undervoltage shutdown
- Open drain diagnostic output
- Fast demagnetization of inductive loads

### Description

The VN540SP-E is a monolithic devices designed in STMicroelectronics VIPower technology, intended for driving resistive or inductive loads with one side connected to ground. Active current limitation avoids the system power supply dropping in case of shorted load. Built-in thermal shutdown protects the chip from overtemperature. The open drain diagnostic output indicates overtemperature conditions.

Figure 1. Block diagram



## Contents

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# 1 Absolute maximum rating

Table 1. Absolute maximum rating

| Symbol     | Parameter                                                                                                           | Value              | Unit |
|------------|---------------------------------------------------------------------------------------------------------------------|--------------------|------|
| $V_{CC}$   | Power supply voltage                                                                                                | 45                 | V    |
| $-V_{CC}$  | Reverse supply voltage                                                                                              | -4.0               | V    |
| $I_{OUT}$  | Maximum DC load current                                                                                             | Internally limited | A    |
| $I_R$      | Reverse output current                                                                                              | -10                | A    |
| $I_{IN}$   | Input current                                                                                                       | $\pm 10$           | mA   |
| $I_{STAT}$ | Status pin current                                                                                                  | $\pm 10$           | mA   |
| $V_{ESD}$  | Electrostatic discharge (R = 1.5 KW; C = 100 pF)                                                                    | 2000               | V    |
| $P_{TOT}$  | Power dissipation (see thermal thresholds in <a href="#">Table 6 on page 7</a> )                                    | Internally limited | W    |
| $T_J$      | Junction operating temperature                                                                                      | Internally limited | °C   |
| $T_{STG}$  | Storage temperature                                                                                                 | -55 to 150         | °C   |
| $E_{AS}$   | Single pulse avalanche energy<br>( $T_{amb} = 125\text{ °C}$ , $V_{CC} = 24\text{ V}$ , $I_{load} = 2.5\text{ A}$ ) | 17                 | J    |

## 2 Pin connections

Figure 2. Connection diagram (top view)

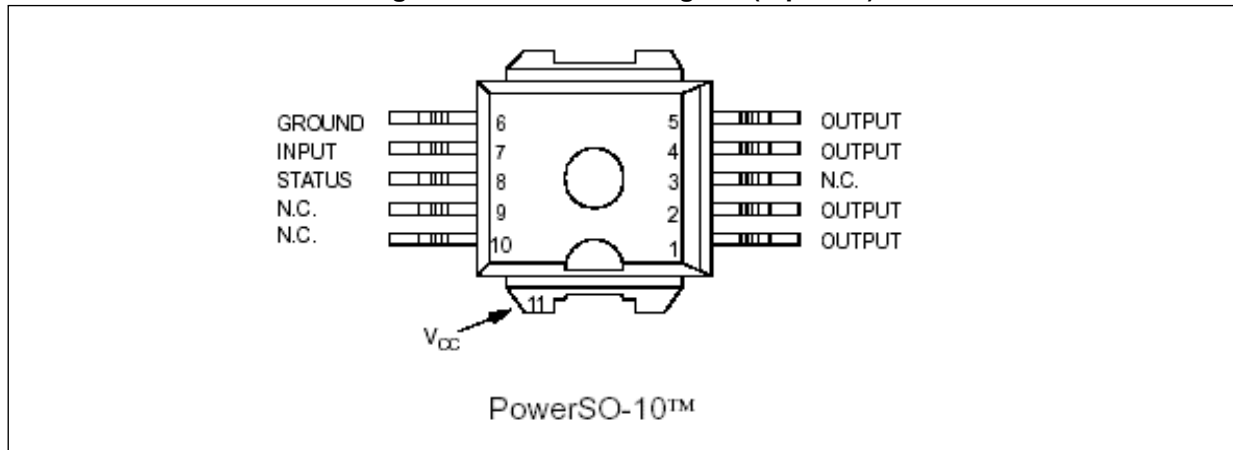
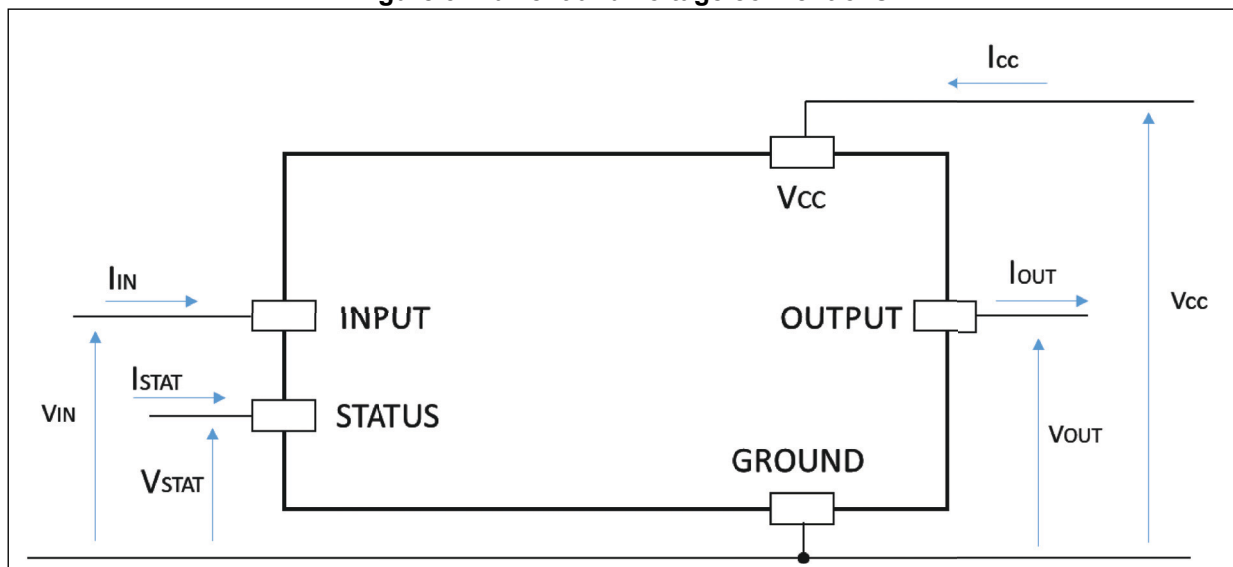


Figure 3. Current and voltage conventions



### 3 Thermal data

Table 2. Thermal data

| Symbol     | Parameter                           |      | Value | Unit |
|------------|-------------------------------------|------|-------|------|
| $R_{thJC}$ | Thermal resistance junction-case    | Max. | 1.5   | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | Max. | 50    | °C/W |

## 4 Electrical characteristics

Electrical characteristics (10 V <  $V_{CC}$  < 36 V; -25 °C <  $T_J$  < 85 °C; unless otherwise specified).

**Table 3. Power section**

| Symbol      | Parameter                  | Test conditions                                                                  | Min.          | Typ.          | Max.          | Unit     |
|-------------|----------------------------|----------------------------------------------------------------------------------|---------------|---------------|---------------|----------|
| $V_{CC}$    | Supply voltage             |                                                                                  | 10            | -             | 36            | V        |
| $R_{ON}$    | On state resistance        | $I_{OUT} = 2.8$ A; $T_J = 25$ °C<br>$I_{OUT} = 2.8$ A                            | -<br>-        | -<br>-        | 50<br>90      | mΩ<br>mΩ |
| $I_S$       | Supply current             | OFF state<br>ON state; $T_J = 125$ °C<br>$I_{OUT} = 0$ A                         | -<br>-        | -<br>-        | 1<br>3        | mA<br>mA |
| $I_{LS}$    | Output leakage current     | Channel OFF<br>$V_{CC} = 45$ V                                                   | -             | -             | 100           | μA       |
| $I_{LGND}$  | Output current at turn-off | $V_{CC} = V_{IN} = V_{GND} = V_{STAT} = 24$ V<br>$T_J = -25$ °C < $T_J$ < 100 °C | -             | -             | 2             | mA       |
| $V_{OL}$    | Low state output voltage   | $V_{IN} = V_{IL}$ ; $R_{LOAD} \geq 10$ MΩ                                        | -             | -             | 1.5           | V        |
| $V_{demag}$ | Output voltage at turn-off | $I_{OUT} = 2.8$ A; $L_{LOAD} \geq 1$ mH                                          | $V_{CC} - 65$ | $V_{CC} - 55$ | $V_{CC} - 45$ | V        |

**Table 4. Switching**

| Symbol          | Parameter                             | Test conditions                                                                           | Min. | Typ. | Max.     | Unit |
|-----------------|---------------------------------------|-------------------------------------------------------------------------------------------|------|------|----------|------|
| $t_{d(ON)}$     | Turn-on delay on output current       | $I_{OUT} = 2.8$ A, resistive load input rise time < 0.1 s, $V_{CC} = 24$ V; $T_J = 25$ °C | -    | 40   | -        | μs   |
| $t_r$           | Rise time of output current           | $I_{OUT} = 2.8$ A, resistive load input rise time < 0.1 s, $V_{CC} = 24$ V; $T_J = 25$ °C | -    | 60   | -        | μs   |
| $t_{d(OFF)}$    | Turn-off delay time of output current | $I_{OUT} = 2.8$ A, resistive load input rise time < 0.1 s, $V_{CC} = 24$ V; $T_J = 25$ °C | -    | 60   | -        | μs   |
| $t_f$           | Fall time of output current           | $I_{OUT} = 2.8$ A, resistive load input rise time < 0.1 s, $V_{CC} = 24$ V; $T_J = 25$ °C | -    | 25   | -        | μs   |
| $di/dt_{(on)}$  | Turn-on current average slope         | $I_{OUT} = 2.8$ A,<br>$I_{OUT} = I_{LIM}$ ; 25 °C < $T_J$ < 140 °C                        | -    | -    | 0.5<br>2 | A/μs |
| $di/dt_{(off)}$ | Turn-off current average slope        | $I_{OUT} = 2.8$ A,<br>$I_{OUT} = I_{LIM}$ ; 25 °C < $T_J$ < 140 °C                        | -    | -    | 2<br>4   | A/μs |

Table 5. Logical input

| Symbol        | Parameter                              | Test conditions                                   | Min.    | Typ.       | Max.     | Unit                           |
|---------------|----------------------------------------|---------------------------------------------------|---------|------------|----------|--------------------------------|
| $V_{IL}$      | Input low level voltage                | -                                                 | -       | -          | 2.0      | V                              |
| $V_{IH}$      | Input high level voltage               | -                                                 | 3.5     | -          | -        | V                              |
| $V_{I(HYST)}$ | Input hysteresis voltage               | -                                                 | -       | 0.5        | -        | V                              |
| $I_{IN}$      | Input current                          | $V_{IN} = 30\text{ V}$<br>$V_{IN} = 2.0\text{ V}$ | -<br>25 | -<br>-     | 300<br>- | $\mu\text{A}$<br>$\mu\text{A}$ |
| $V_{ICL}$     | I/O input clamp voltage <sup>(1)</sup> | $I_{IN} = 1\text{ mA}$<br>$I_{IN} = -1\text{ mA}$ | 32<br>- | 36<br>-0.7 | -<br>-   | V<br>V                         |

1. The input voltage is internally clamped at 32 V minimum, it is possible to connect the input pins to a higher voltage via an external resistor calculate to not exceed 10 mA.

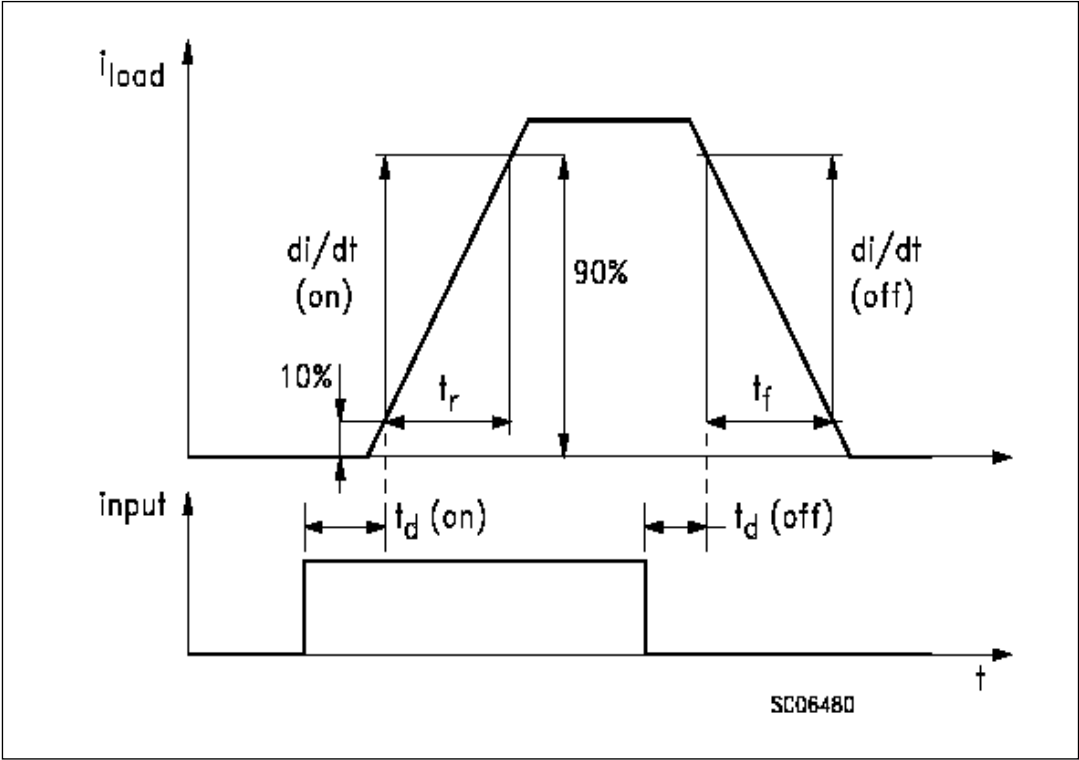
Table 6. Protection and diagnostic

| Symbol          | Parameter                               | Test conditions                                                         | Min. | Typ.       | Max.   | Unit               |
|-----------------|-----------------------------------------|-------------------------------------------------------------------------|------|------------|--------|--------------------|
| $V_{STAT}$      | Status output voltage                   | $I_{STAT} = 5\text{ mA}$ (fault condition)                              | -    | -          | 1      | V                  |
| $V_{SCL}^{(1)}$ | Status clamp voltage                    | $I_{STAT} = 1\text{ mA}$<br>$I_{STAT} = -1\text{ mA}$                   | 32   | 36<br>-0.7 | -<br>- | V<br>V             |
| $I_{STAT}$      | Leakage on diagnostic pin in high state | $V_{STAT} = 5\text{ V}$                                                 | -    | -          | -      | $\mu\text{A}$      |
| $V_{USD}$       | Undervoltage shutdown                   | -                                                                       | 5.0  | -          | 8.0    | V                  |
| $I_{LIM}$       | DC short-circuit current                | $V_{CC} = 24\text{ V}$ ; $R_{LOAD} < 10\text{ m}\Omega$                 | 2.8  | 5.0        | 8.0    | A                  |
| $I_{OVPK}$      | Peak short-circuit current              | $V_{CC} = 24\text{ V}$ ; $V_{IN} = 30$ ; $R_{LOAD} < 10\text{ m}\Omega$ | -    | -          | 4      | A                  |
| $t_{SC}$        | Delay time of current limiter           | -                                                                       | -    | -          | 100    | $\mu\text{s}$      |
| $T_{TSD}$       | Thermal shutdown temperature            | -                                                                       | 150  | 170        | -      | $^{\circ}\text{C}$ |
| $T_R$           | Thermal reset temperature               | -                                                                       | 135  | 155        | -      | $^{\circ}\text{C}$ |

1. Status determination > 100 ms after the switching edge.

5 Switching characteristics

Figure 4. Switching characteristics



6 Truth table

Table 7. Truth table

| Conditions                           | INPUT | OUTPUT | STATUS |
|--------------------------------------|-------|--------|--------|
| Normal operation                     | L     | L      | H      |
|                                      | H     | H      | H      |
| Overtemperature                      | L     | L      | H      |
|                                      | H     | L      | L      |
| Undervoltage                         | L     | L      | H      |
|                                      | H     | L      | H      |
| Shorted load<br>(current limitation) | L     | L      | H      |
|                                      | H     | H      | H      |



## 7 Test circuits and waveforms

Figure 5. Peak short test circuit

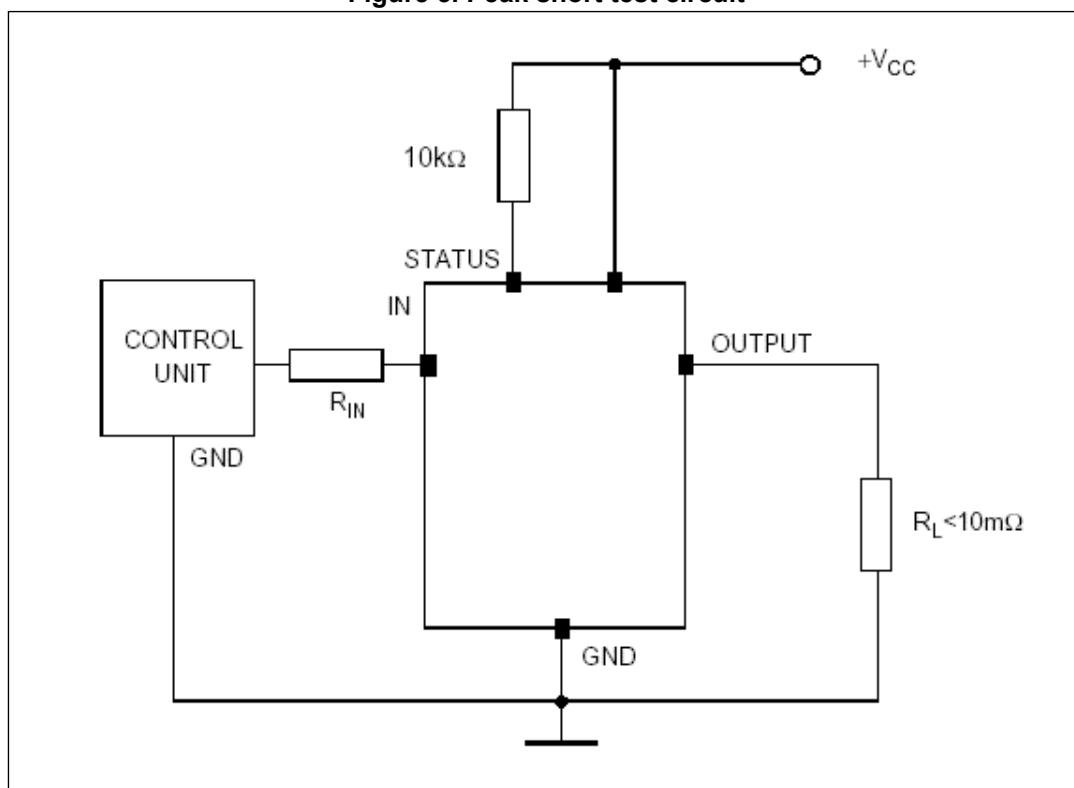


Figure 6. Switching waveforms

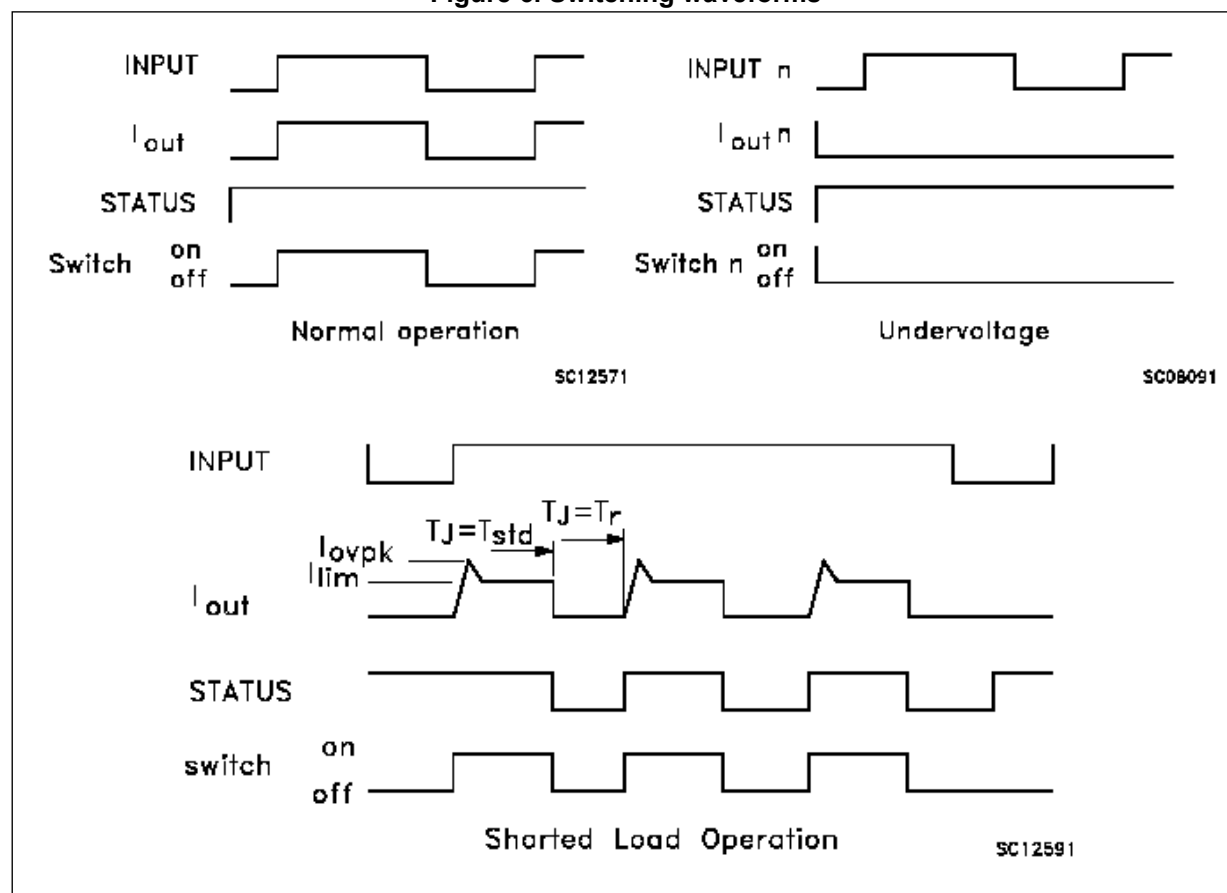
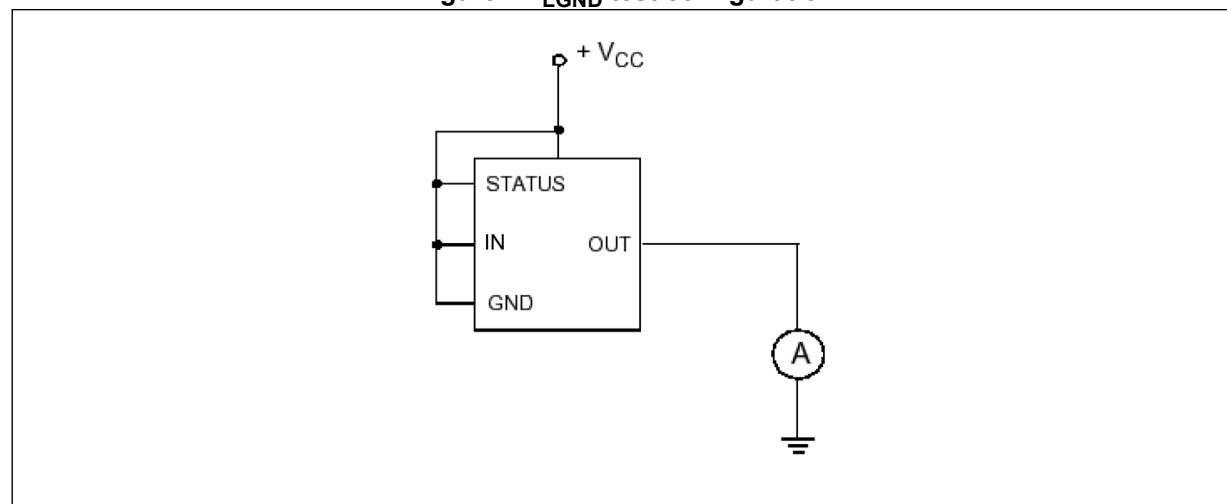
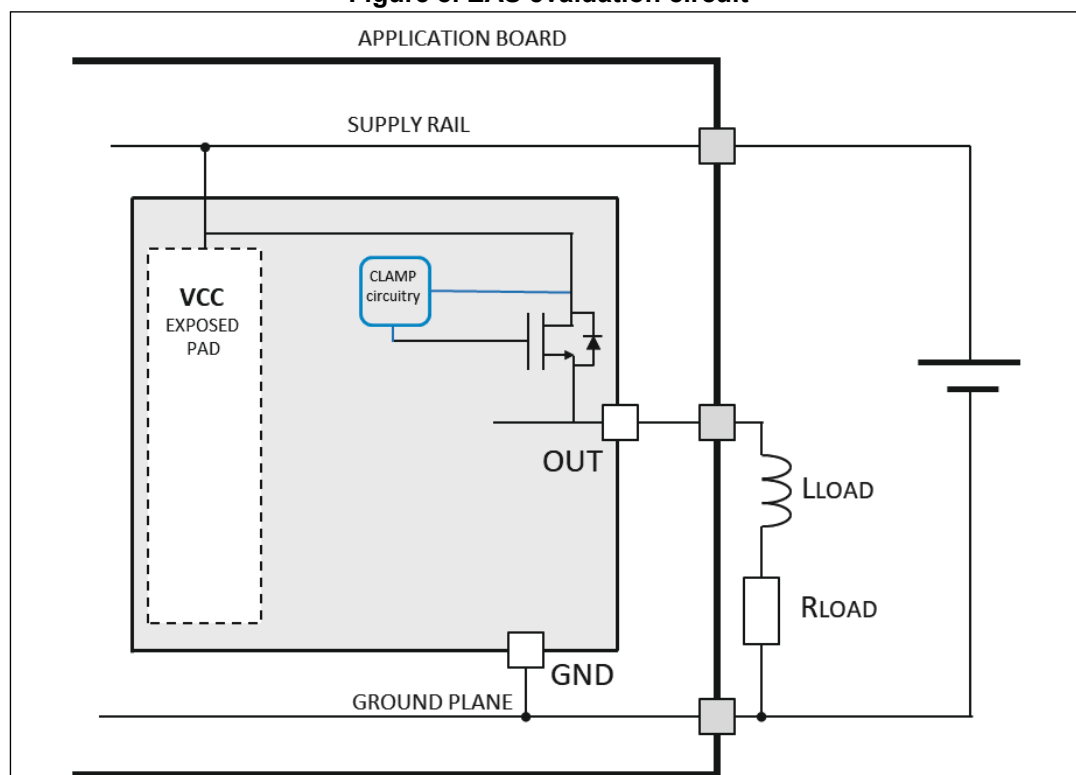
Figure 7.  $I_{LGND}$  test configuration

Figure 8. EAS evaluation circuit



## 8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. These packages have a Lead-free second level interconnect. 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® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 8.1 PowerSO-10 package information

Figure 9. PowerSO-10 package outline

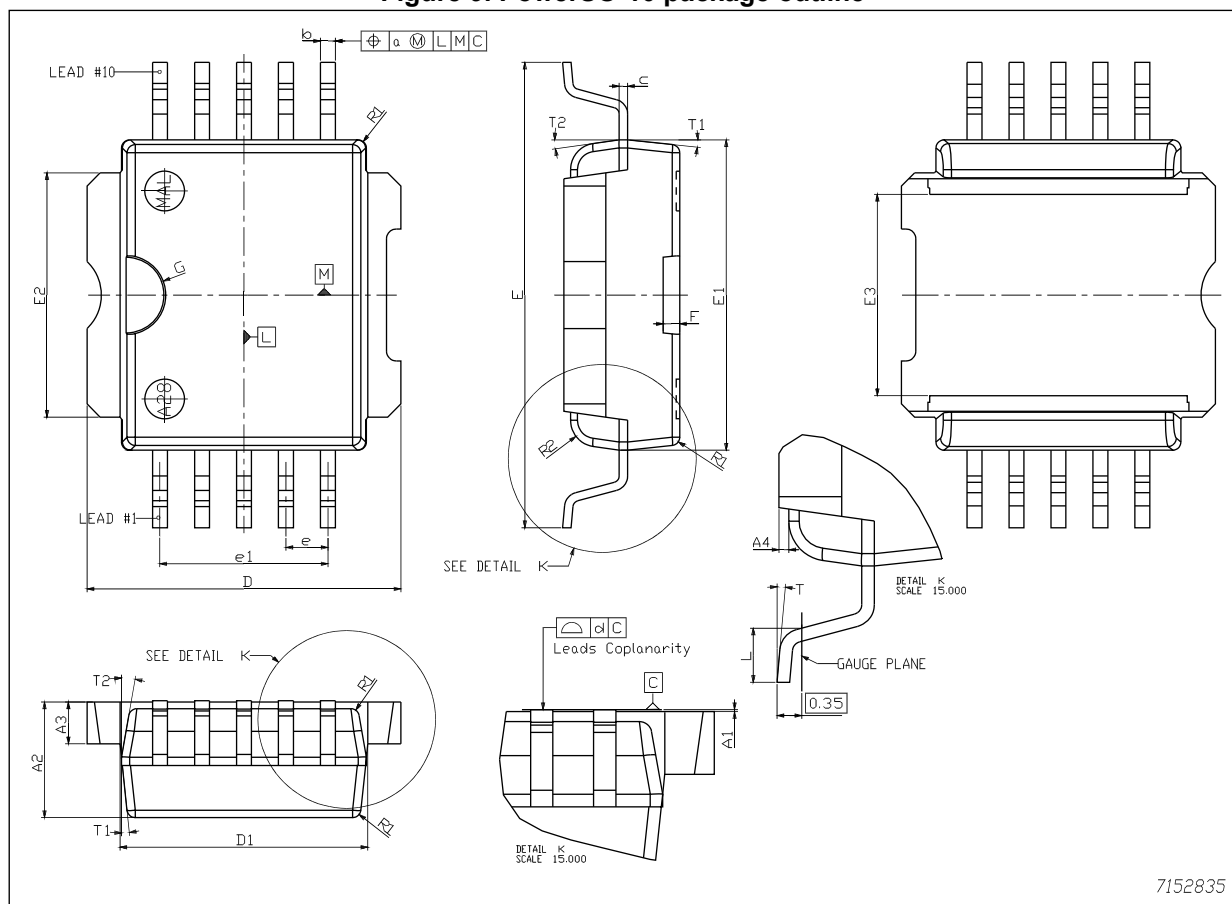


Table 8. PowerSO-10 package mechanical data

| Symbol | Dimensions (mm) |        |        | Dimensions (inch) |        |        | Note |
|--------|-----------------|--------|--------|-------------------|--------|--------|------|
|        | Typ.            | Min.   | Max.   | Typ.              | Min.   | Max.   |      |
| A1     | 0.05            | 0      | 0.1    | 0.0019            | 0.0004 | 0.003  | -    |
| A2     | 3.5             | 3.4    | 3.6    | 0.137             | 0.135  | 0.139  | -    |
| A3     | 1.3             | 1.2    | 1.4    | 0.05              | 0.048  | 0.052  | -    |
| A4     | 0.2             | 0.15   | 0.25   | 0.007             | 0.006  | 0.01   | -    |
| a      | 0.2             | -      | -      | 0.007             | -      | -      | -    |
| b      | 0.45            | 0.37   | 0.53   | 0.017             | 0.015  | 0.019  | -    |
| c      | 0.27            | 0.23   | 0.32   | 0.01              | 0.009  | 0.011  | -    |
| D      | 9.5             | 9.4    | 9.6    | 0.374             | 0.372  | 0.377  | -    |
| D1     | 7.5             | 7.4    | 7.6    | 0.295             | 0.292  | 0.298  | -    |
| d      | 0.05            | 0      | 0.1    | 0.0015            | 0      | 0.0035 | -    |
| E      | 14.1            | 13.85  | 14.35  | 0.555             | 0.547  | 0.562  | -    |
| E1     | 9.4             | 9.3    | 9.5    | 0.37              | 0.367  | 0.372  | (1)  |
| E2     | 7.4             | 7.3    | 7.5    | 0.292             | 0.291  | 0.295  | -    |
| E3     | 6.1             | 5.9    | 6.3    | 0.24              | 0.234  | 0.246  | -    |
| e      | 1.27            | -      | -      | 0.05              | 0.048  | 0.051  | -    |
| e1     | 5.08            | -      | -      | 0.2               | -      | -      | -    |
| F      | 0.5             | -      | -      | 0.019             | -      | -      | -    |
| G      | 1.2             | -      | -      | 0.047             | -      | -      | -    |
| L      | 1               | 0.8    | 1.1    | 0.039             | 0.033  | 0.043  | -    |
| R1     | -               | -      | 0.25   | -                 | -      | 0.01   | -    |
| R2     | 0.8             | -      | -      | 0.031             | -      | -      | -    |
| T      | 5 deg.          | 2 deg. | 8 deg. | 5 deg.            | 3 deg. | 7 deg. | -    |
| T1     | 6 deg.          | -      | -      | 6 deg.            | -      | -      | -    |
| T2     | 10 deg.         | -      | -      | 10 deg.           | -      | -      | -    |

1. Resin protrusions not included (max. value: 0.15 mm per side).

## 9 Ordering information

Table 9. Order codes

| Package    | Tube      | Tape and reel |
|------------|-----------|---------------|
| PowerSO-10 | VN540SP-E | VN540SPTR-E   |

## 10 Revision history

Table 10. Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                               |
|-------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2-Nov-2005  | 1        | Initial release.                                                                                                                                                                                                                                                                      |
| 09-May-2018 | 2        | Removed VN540-12-E and PENTAWATT(012Y) from the whole document.<br>Updated $P_{TOT}$ and $E_{AS}$ in <a href="#">Table 1 on page 3</a> .<br>Added <a href="#">Figure 8 on page 11</a> .<br>Updated <a href="#">Section 8 on page 12</a> .<br>Minor modifications throughout document. |
| 05-Oct-2020 | 3        | Removed VN540-E and PENTAWATT from the whole document.<br>Updated <a href="#">Section 8</a><br>Updated <a href="#">Figure 3</a> and <a href="#">Figure 8</a> .                                                                                                                        |

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