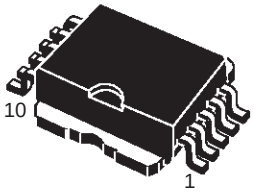
# VN610SP

## SINGLE CHANNEL HIGH SIDE SOLID STATE RELAY

**TARGET SPECIFICATION**

| TYPE | $R_{DS(on)}$ | $I_{OUT}$ | $V_{CC}$ |
|---|---|---|---|
| VN610SP | 10mΩ | 45A | 36 V |

- OUTPUT CURRENT: 45 A
- CMOS COMPATIBLE INPUT
- PROPORTIONAL LOAD CURRENT SENSE
- UNDERVOLTAGE AND OVERVOLTAGE SHUT-DOWN
- OVERVOLTAGE CLAMP
- THERMAL SHUT DOWN
- CURRENT LIMITATION
- VERY LOW STAND-BY POWER DISSIPATION
- PROTECTION AGAINST: LOSS OF GROUND AND LOSS OF $V_{CC}$
- REVERSE BATTERY PROTECTION (*)

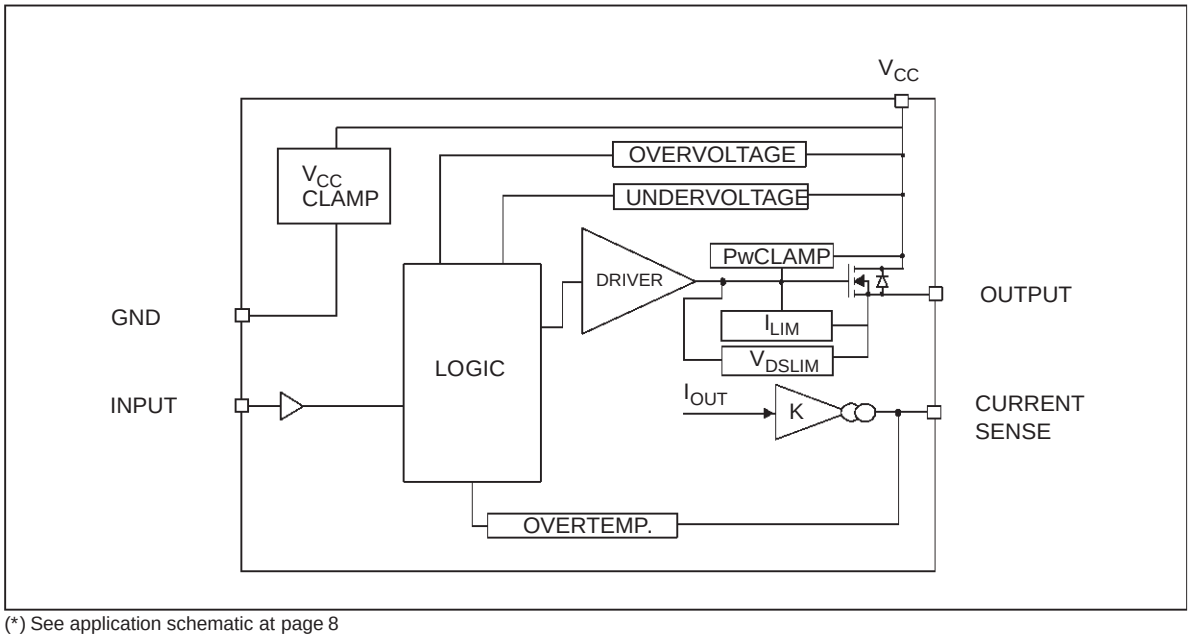



**PowerSO-10™**

### DESCRIPTION

The VN610SP is a monolithic device made using STMicroelectronics VIPower technology. It is intended for driving resistive or inductive loads with one side connected to ground. Active $V_{CC}$ pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table). This device integrates an analog current sense which delivers a current proportional to the load current (according to a known ratio). Active current limitation combined with thermal shut-down and automatic restart protect the device against overload. Device automatically turns off in case of ground pin disconnection.

### BLOCK DIAGRAM

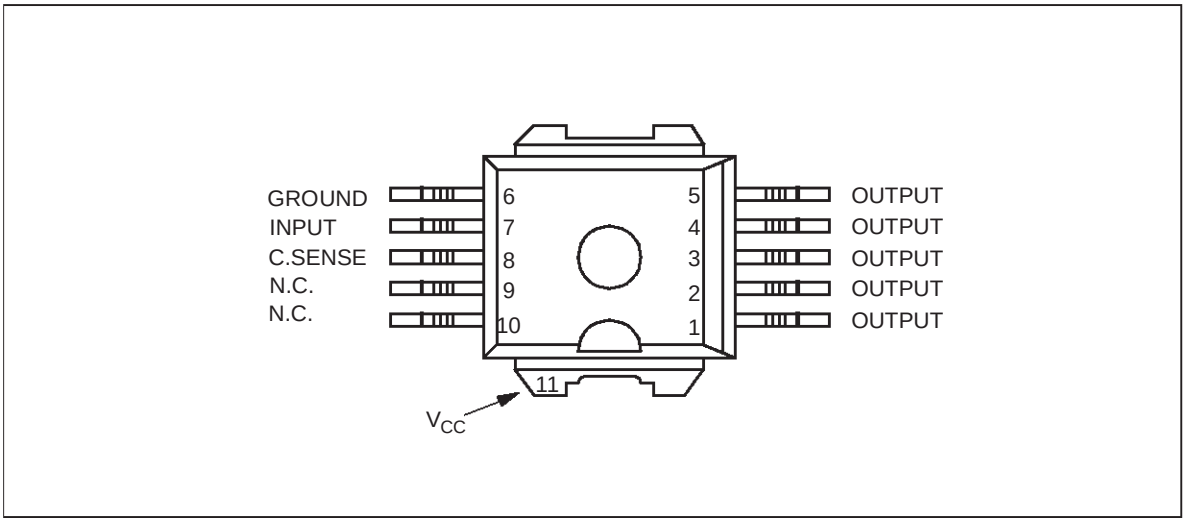



(*) See application schematic at page 8

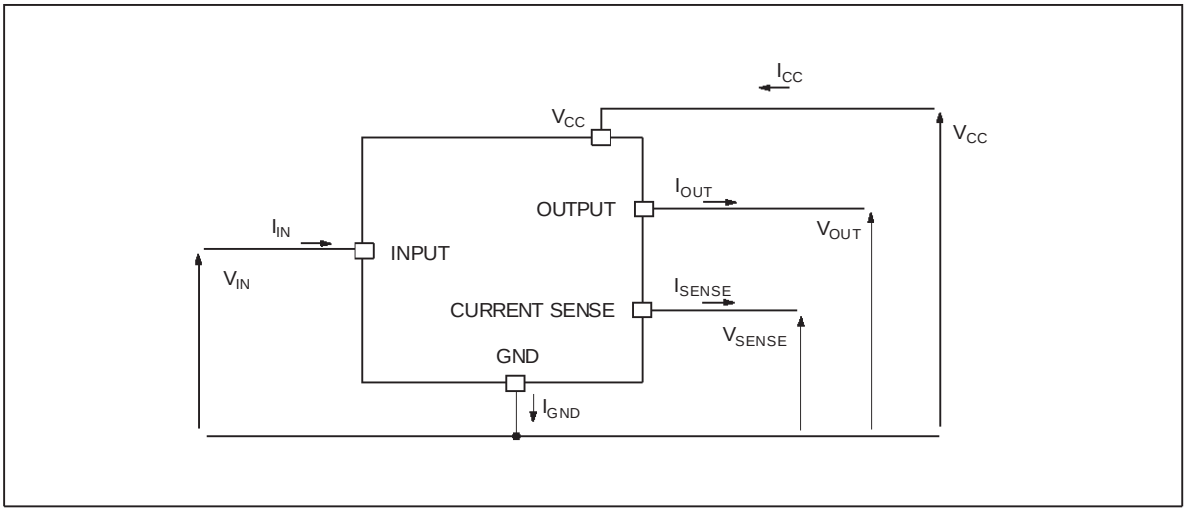
## ABSOLUTE MAXIMUM RATING

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | DC supply voltage | 41 | V |
| $-V_{CC}$ | Reverse DC supply voltage | -0.3 | V |
| $- I_{GND}$ | DC reverse ground pin current | -200 | mA |
| $I_{OUT}$ | DC output current | Internally limited | A |
| $- I_{OUT}$ | Reverse DC output current | -50 | A |
| $I_{IN}$ | DC input current | +/- 10 | mA |
| $V_{CSENSE}$ | Current sense maximum voltage | -3<br>+15 | V<br>V |
| $V_{ESD}$ | Electrostatic discharge (R=1.5kΩ; C=100pF) | 2000 | V |
| $P_{TOT}$ | Power dissipation at $T_C \leq 25°C$ | 125 | W |
| $T_j$ | Junction operating temperature | Internally limited | °C |
| $T_c$ | Case operating temperature | -40 to 150 | °C |
| $T_{STG}$ | Storage temperature | -55 to 150 | °C |

## CONNECTION DIAGRAM (TOP VIEW)




## CURRENT AND VOLTAGE CONVENTIONS



## THERMAL DATA

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $R_{thj\text{-}case}$ | Thermal resistance junction-case | (MAX) | 1 | °C/W |
| $R_{thj\text{-}amb}$ | Thermal resistance junction-ambient | (MAX) | 50 | °C/W |

**ELECTRICAL CHARACTERISTICS** (8V<$V_{CC}$<36V; -40°C<Tj<150°C; unless otherwise specified)

POWER

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Operating supply voltage | | 5.5 | 13 | 36 | V |
| $V_{USD}$ | Undervoltage shutdown | | 3 | 4 | 5.5 | V |
| $V_{OV}$ | Overvoltage shutdown | (See Note 1) | 36 | 42 | 48 | V |
| $R_{ON}$ | On state resistance | $I_{OUT}$=15A; $T_j$=25°C<br>$I_{OUT}$=15A; $T_j$=150°C<br>$I_{OUT}$=9A; $V_{CC}$=6V | | | 10<br>20<br>35 | mΩ<br>mΩ<br>mΩ |
| $V_{clamp}$ | Clamp Voltage | $I_{CC}$=20 mA<br>(see note 1) | 41 | 48 | 55 | V |
| $I_S$ | Supply current | Off state; INPUT= n.c.; $V_{CC}$=13V<br>On state; $V_{IN}$=5V; $V_{CC}$=13V; $I_{OUT}$=0A; $R_{SENSE}$=3.9K | | | 25<br>5 | µA<br>mA |
| $I_{L(off)}$ | Off state output current | $V_{IN}$=$V_{OUT}$=0V | 0 | | 50 | µA |

Note 1: $V_{clamp}$ and $V_{OV}$ are correlated. Typical difference is 5V.

SWITCHING ($V_{CC}$=13V)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | R1=0.87Ω | | 50 | | µs |
| $t_{d(off)}$ | Turn-on delay time | R1=0.87Ω | | 50 | | µs |
| $(dV_{OUT}/dt)_{on}$ | Turn-on voltage slope | R1=0.87Ω | | 0.3 | | V/µs |
| $(dV_{OUT}/dt)_{off}$ | Turn-off voltage slope | R1=0.87Ω | | 0.3 | | V/µs |
| $W_{ON}$ | Switching losses energy at turn-on | R1=2.6Ω | | 1.0 | | mJ |
| $W_{OFF}$ | Switching losses energy at turn-off | R1=2.6Ω | | 0.5 | | mJ |

PROTECTIONS

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{lim}$ | DC Short circuit current | $V_{CC}$=13V<br>5.5V<$V_{CC}$<36V | 45 | 75 | 120<br>120 | A<br>A |
| $T_{TSD}$ | Thermal shutdown temperature | | 150 | 175 | 200 | °C |
| $T_R$ | Thermal reset temperature | | 135 | | | °C |
| $T_{HYST}$ | Thermal hysteresis | | 7 | 15 | | °C |
| $V_{DEMAG}$ | Turn-off output voltage clamp | $I_{OUT}$=2A; $V_{IN}$=0; L=6mH | Vcc-41 | Vcc-48 | Vcc-55 | V |
| $V_{ON}$ | Output voltage drop limitation | $I_{OUT}$=1.5A<br>$T_j$= -40°C...+150°C | | 50 | | mV |

**ELECTRICAL CHARACTERISTICS** (continued)

CURRENT SENSE ($9V \leq V_{CC} \leq 16V$) (See Fig.1)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $K_1$ | $I_{OUT}/I_{SENSE}$ | $I_{OUT}$=1.5A; $V_{SENSE}$=0.5V; $T_j$= -40°C...150°C | 3300 | 4400 | 6000 | |
| $K_2$ | $I_{OUT}/I_{SENSE}$ | $I_{OUT}$=15A; $V_{SENSE}$=4V; $T_j$=-40°C<br>$T_j$=25°C...150°C | 4200<br>4400 | 4900<br>4900 | 6000<br>5750 | |
| $K_3$ | $I_{OUT}/I_{SENSE}$ | $I_{OUT}$=45A; $V_{SENSE}$=4V; $T_j$=-40°C<br>$T_j$=25°C...150°C | 4200<br>4400 | 4900<br>4900 | 5500<br>5250 | |
| $V_{SENSE}$ | Max analog sense output voltage | $V_{CC}$=5V; $I_{OUT}$ =7.5A; $R_{SENSE}$=10KΩ<br>$V_{CC}$ >8V; $I_{OUT}$=15A; $R_{SENSE}$=10KΩ | 2<br>4 | | | V<br>V |
| $V_{SENSEH}$ | Analog sense output voltage in overtemperature condition | $V_{CC}$=13V; $R_{SENSE}$=3.9KΩ | | 5.5 | | V |

LOGIC INPUT

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{IL}$ | Input low level voltage | | | | 1.25 | V |
| $I_{IL}$ | Low level input current | $V_{IN}$=1.25V | 1 | | | µA |
| $V_{IH}$ | Input high level voltage | | 3.25 | | | V |
| $I_{IH}$ | High level input current | $V_{IN}$=3.25V | | | 10 | µA |
| $V_{I(hyst)}$ | Input hysteresis voltage | | 0.5 | | | V |
| $V_{ICL}$ | Input clamp voltage | $I_{IN}$=1mA<br>$I_{IN}$=-1mA | 6.5 | 7.4<br>-0.7 | 8.5 | V<br>V |

**TRUTH TABLE**

| CONDITIONS | INPUT | OUTPUT | SENSE |
|---|---|---|---|
| Normal operation | L<br>H | L<br>H | 0<br>Nominal |
| Overtemperature | L<br>H | L<br>L | 0<br>$V_{SENSEH}$ |
| Undervoltage | L<br>H | L<br>L | 0<br>0 |
| Overvoltage | L<br>H | L<br>L | 0<br>0 |
| Short circuit to GND | L<br>H | L<br>L | 0<br>0 |
| Short circuit to $V_{CC}$ | L<br>H | H<br>H | 0<br>< Nominal |
| Negative output voltage clamp | L | L | 0 |

## ELECTRICAL TRANSIENT REQUIREMENTS

| ISO T/R 7637/1 Test Pulse | TEST LEVELS | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | Delays and Impedance |
| 1 | -25 V | -50 V | -75 V | -100 V | 2 ms 10 Ω |
| 2 | +25 V | +50 V | +75 V | +100 V | 0.2 ms 10 Ω |
| 3a | -25 V | -50 V | -100 V | -150 V | 0.1 µs 50 Ω |
| 3b | +25 V | +50 V | +75 V | +100 V | 0.1 µs 50 Ω |
| 4 | -4 V | -5 V | -6 V | -7 V | 100 ms, 0.01 Ω |
| 5 | +26.5 V | +46.5 V | +66.5 V | +86.5 V | 400 ms, 2 Ω |

| ISO T/R 7637/1 Test Pulse | TEST LEVELS RESULTS | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| 1 | C | C | C | C |
| 2 | C | C | C | C |
| 3a | C | C | C | C |
| 3b | C | C | C | C |
| 4 | C | C | C | C |
| 5 | C | E | E | E |

| CLASS | CONTENTS |
|---|---|
| C | All functions of the device are performed as designed after exposure to disturbance. |
| E | One or more functions of the device is not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device. |

## SWITCHING CHARACTERISTICS

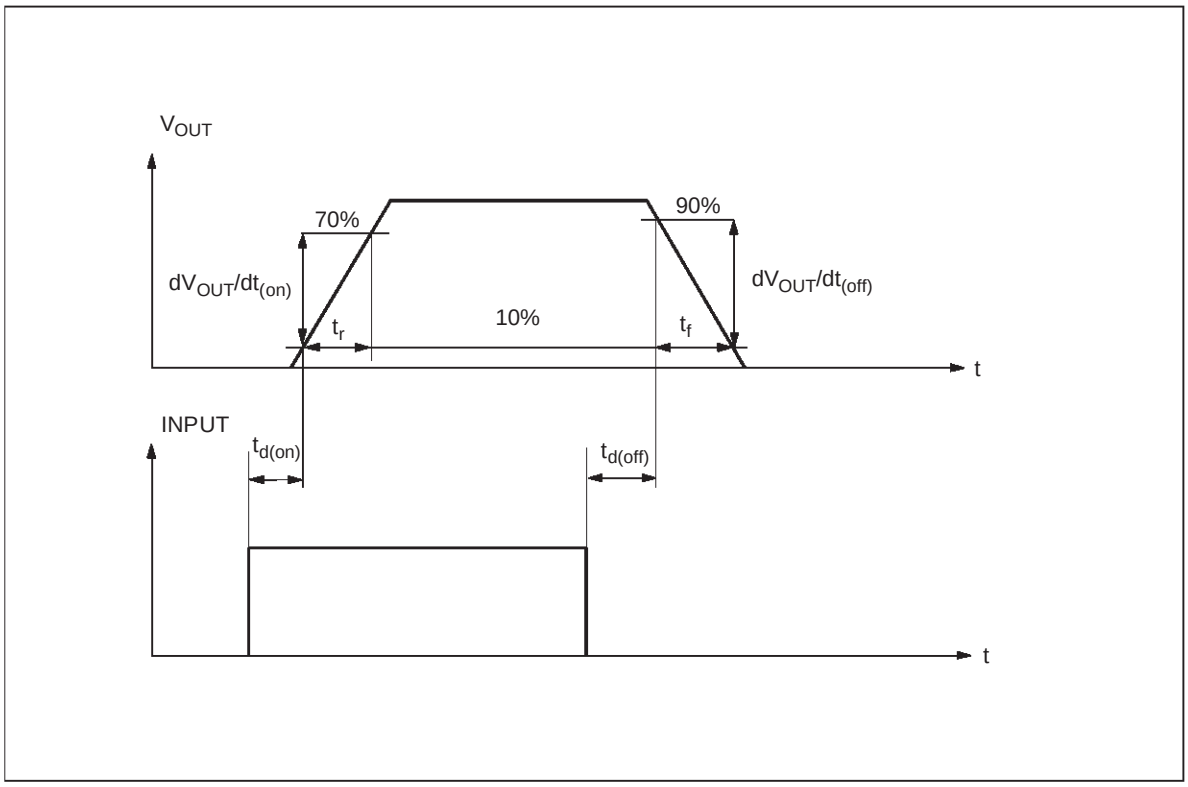


**Fig 1:** $I_{OUT}/I_{SENSE}$ versus $I_{OUT}$

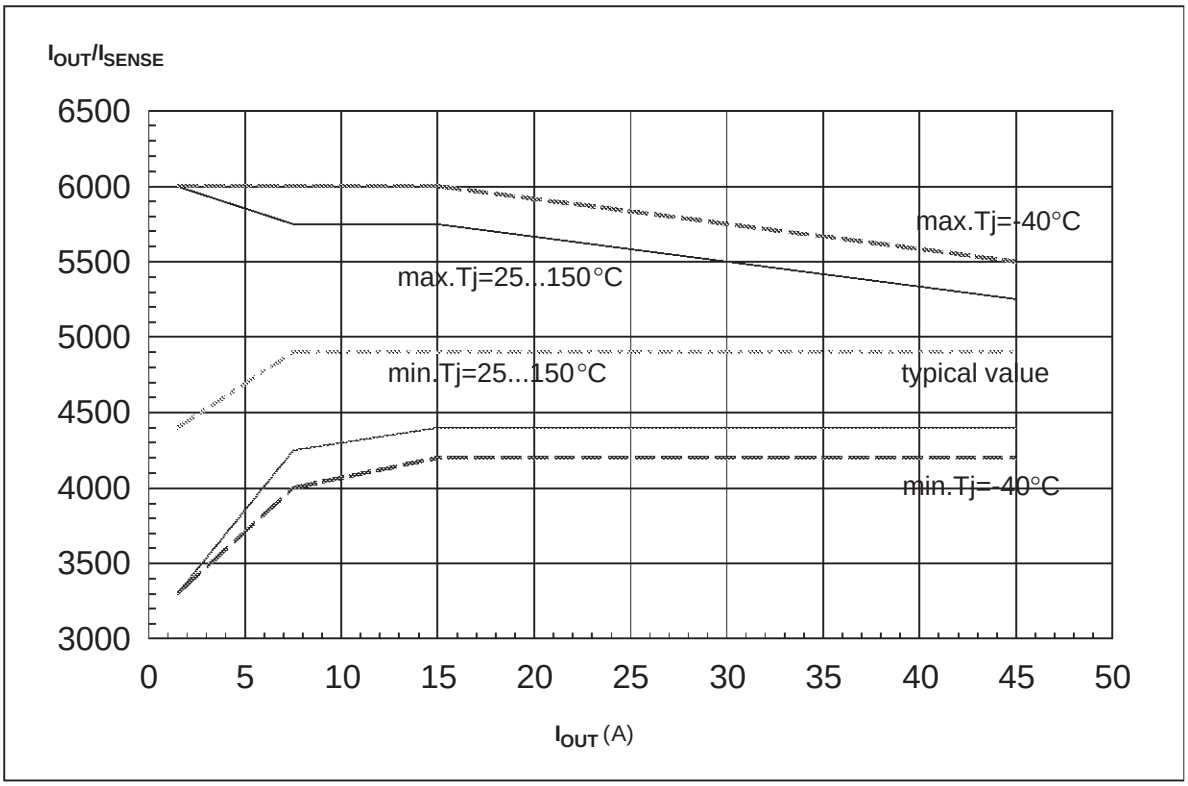
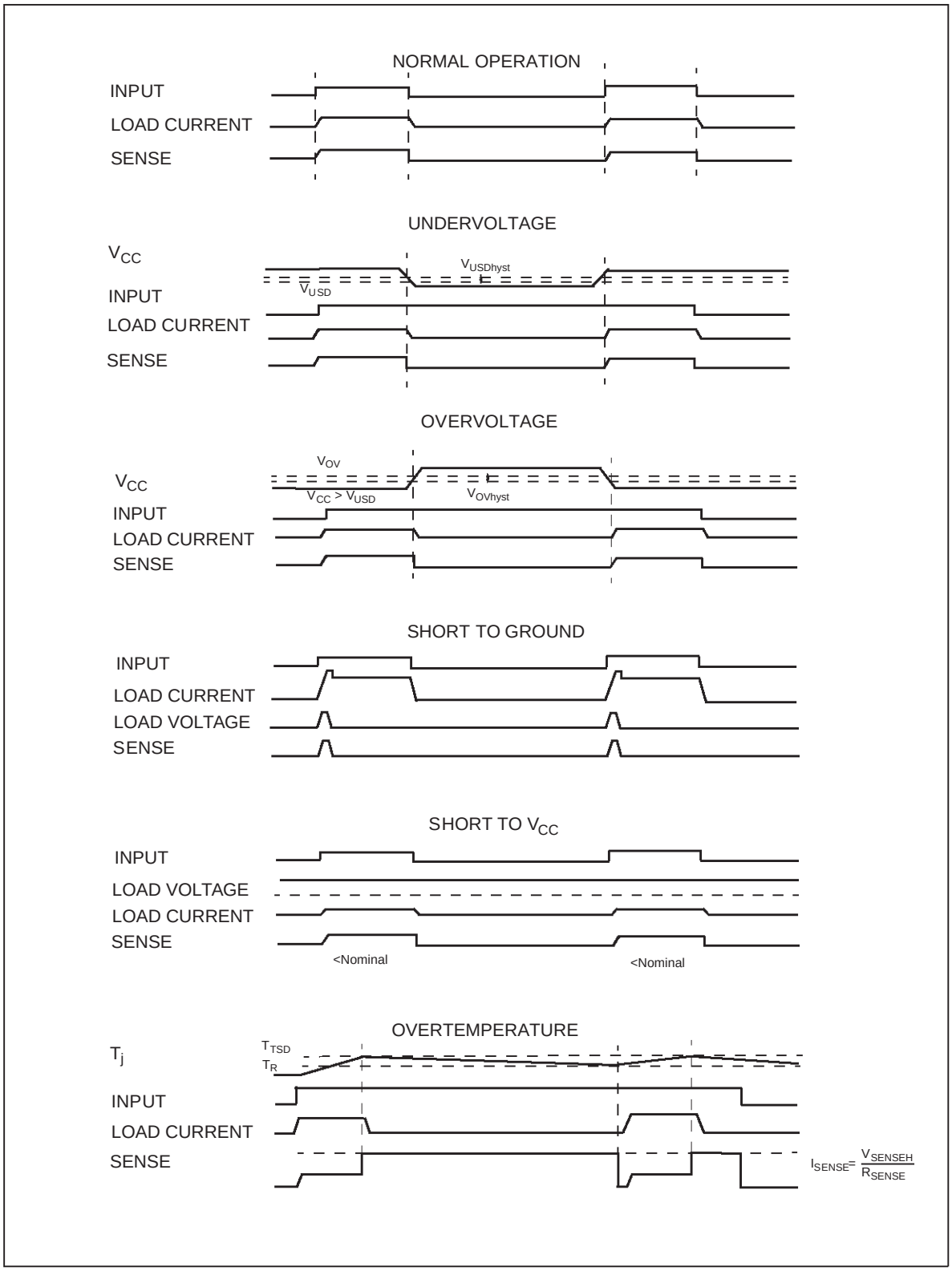
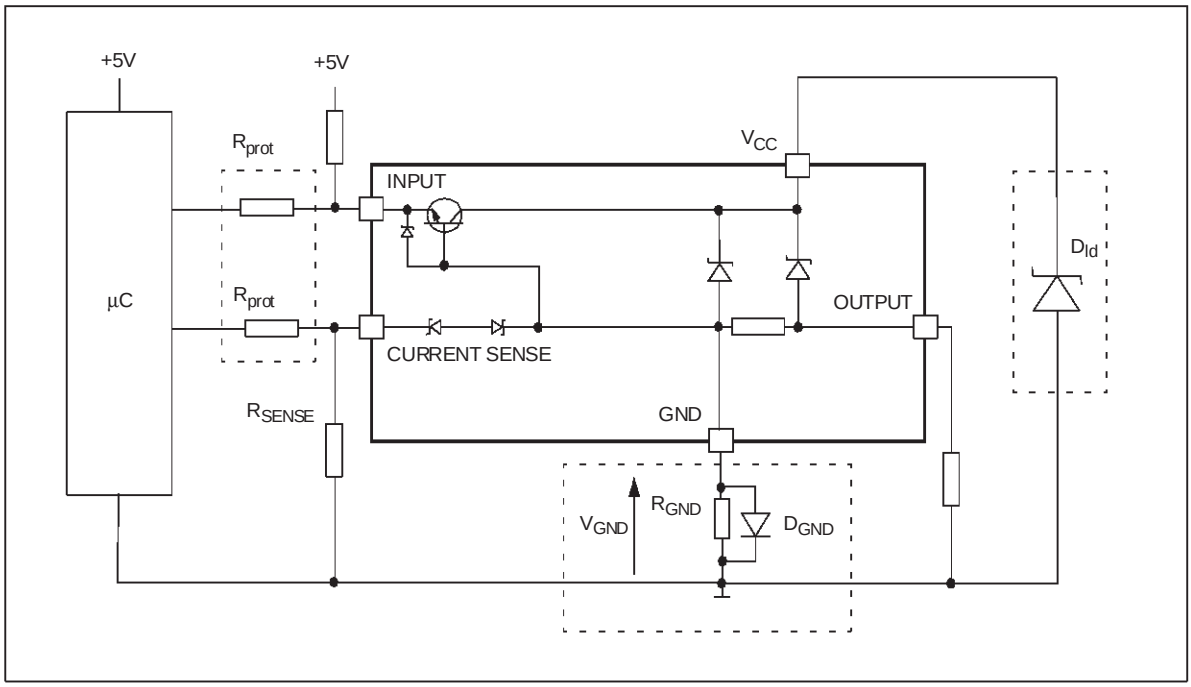


**Figure1: Waveforms**



## APPLICATION SCHEMATIC




### GND PROTECTION NETWORK AGAINST REVERSE BATTERY

Solution 1: Resistor in the ground line ($R_{GND}$ only). This can be used with any type of load.

The following is an indication on how to dimension the $R_{GND}$ resistor.

1) $R_{GND} \leq 600mV / (I_{S(on)max})$.

2) $R_{GND} \geq (-V_{CC}) / (-I_{GND})$

where $-I_{GND}$ is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device's datasheet.

Power Dissipation in $R_{GND}$ (when $V_{CC}$<0: during reverse battery situations) is:

$P_D= (-V_{CC})^2/R_{GND}$

This resistor can be shared amongst several different HSD. Please note that the value of this resistor should be calculated with formula (1) where $I_{S(on)max}$ becomes the sum of the maximum on-state currents of the different devices.

Please note that if the microprocessor ground is not common with the device ground then the $R_{GND}$ will produce a shift ($I_{S(on)max} * R_{GND}$) in the input thresholds and the status output values. This shift will vary depending on how many devices are ON in the case of several high side drivers sharing the same $R_{GND}$.

If the calculated power dissipation leads to a large resistor or several devices have to share the same resistor then the ST suggests to utilize Solution 2 (see below).

Solution 2: A diode ($D_{GND}$) in the ground line.

A resistor ($R_{GND}$=1kΩ) should be inserted in parallel to $D_{GND}$ if the device will be driving an inductive load.

This small signal diode can be safely shared amongst several different HSD. Also in this case, the presence of the ground network will produce a shift (j 600mV) in the input threshold and the status output values if the microprocessor ground is not common with the device ground. This shift will not vary if more than one HSD shares the same diode/resistor network.

### LOAD DUMP PROTECTION

$D_{ld}$ is necessary (Transil or MOV) if the load dump peak voltage exceeds $V_{CC}$ max DC rating. The same applies if the device will be subject to transients on the $V_{CC}$ line that are greater than the ones shown in the ISO T/R 7637/1 table.

### µC I/Os PROTECTION:

If a ground protection network is used and negative transients are present on the $V_{CC}$ line, the control pins will be pulled negative. ST suggests to insert a resistor ($R_{prot}$) in line to prevent the µC I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of µC and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of µC I/Os.

$-V_{CCpeak}/I_{latchup} \leq R_{prot} \leq (V_{OH\mu C}-V_{IH}-V_{GND}) / I_{IHmax}$

Calculation example:

For $V_{CCpeak}$= - 100V and $I_{latchup} \geq$ 20mA; $V_{OH\mu C} \geq$ 4.5V

5kΩ ≤ $R_{prot}$ ≤ 10kΩ.

Recommended $R_{prot}$ value is 65kΩ.

# PowerSO-10™ MECHANICAL DATA

| DIM. | mm. | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | 3.35 | | 3.65 | 0.132 | | 0.144 |
| A1 | 0.00 | | 0.10 | 0.000 | | 0.004 |
| B | 0.40 | | 0.60 | 0.016 | | 0.024 |
| c | 0.35 | | 0.55 | 0.013 | | 0.022 |
| D | 9.40 | | 9.60 | 0.370 | | 0.378 |
| D1 | 7.40 | | 7.60 | 0.291 | | 0.300 |
| E | 9.30 | | 9.50 | 0.366 | | 0.374 |
| E1 | 7.20 | | 7.40 | 0.283 | | 0.291 |
| E2 | 7.20 | | 7.60 | 0.283 | | 300 |
| E3 | 6.10 | | 6.35 | 0.240 | | 0.250 |
| E4 | 5.90 | | 6.10 | 0.232 | | 0.240 |
| e | | 1.27 | | | 0.050 | |
| F | 1.25 | | 1.35 | 0.049 | | 0.053 |
| H | 13.80 | | 14.40 | 0.543 | | 0.567 |
| h | | 0.50 | | | 0.002 | |
| Q | | 1.70 | | | 0.067 | |
| α | 0° | | 8° | | | |