



# VND810PEP-E

## DOUBLE CHANNEL HIGH SIDE DRIVER

### TARGET SPECIFICATION

**Table 1. General Features**

| TYPE        | R <sub>DS(on)</sub> | I <sub>OUT</sub> | V <sub>CC</sub> |
|-------------|---------------------|------------------|-----------------|
| VND810PEP-E | 160 mΩ (*)          | 3.5 A (*)        | 36 V            |

(\*) Per each channel

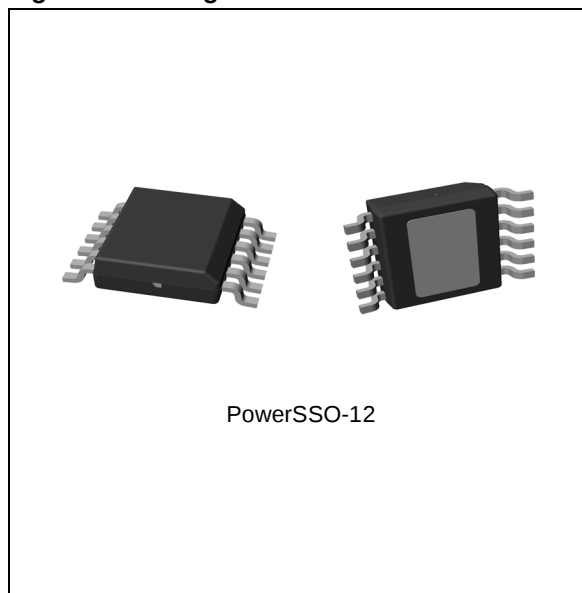
- CMOS COMPATIBLE INPUTS
- OPEN DRAIN STATUS OUTPUTS
- ON STATE OPEN LOAD DETECTION
- OFF STATE OPEN LOAD DETECTION
- SHORTED LOAD PROTECTION
- UNDERVOLTAGE AND OVERVOLTAGE SHUTDOWN
- PROTECTION AGAINST LOSS OF GROUND
- VERY LOW STAND-BY CURRENT
- REVERSE BATTERY PROTECTION (\*\*)
- IN COMPLIANCE WITH THE 2002/95/EC EUROPEAN DIRECTIVE

### DESCRIPTION

The VND810PEP-E is a monolithic device designed in STMicroelectronics VIPower M0-3 Technology, intended for driving any kind of load with one side connected to ground.

Active V<sub>CC</sub> pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table).

**Figure 1. Package**



Active current limitation combined with thermal shutdown and automatic restart protects the device against overload. The device detects open load condition both in on and off state. Output shorted to V<sub>CC</sub> is detected in the off state. Device automatically turns off in case of ground pin disconnection.

**Table 2. Order Codes**

| Package     | Tube        | Tape and Reel |
|-------------|-------------|---------------|
| PowerSSO-12 | VND810PEP-E | VND810PEPTR-E |

Note: (\*\*) See application schematic at page 9

Figure 2. Block Diagram

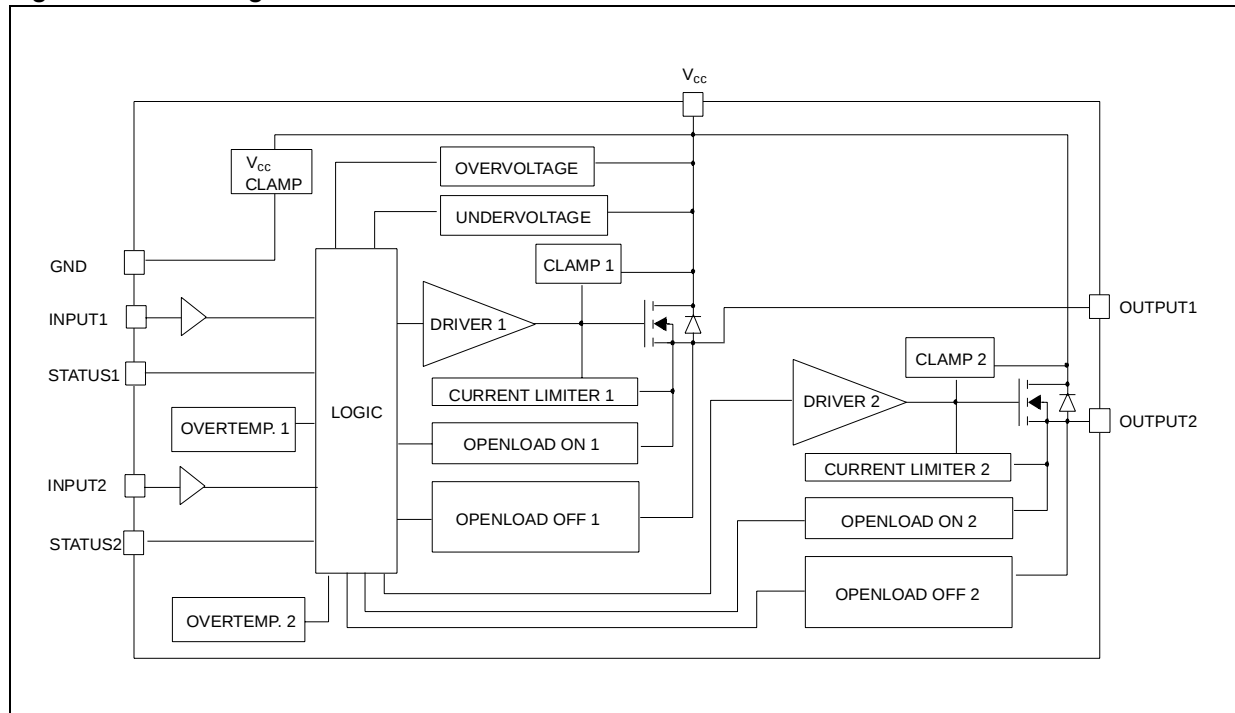
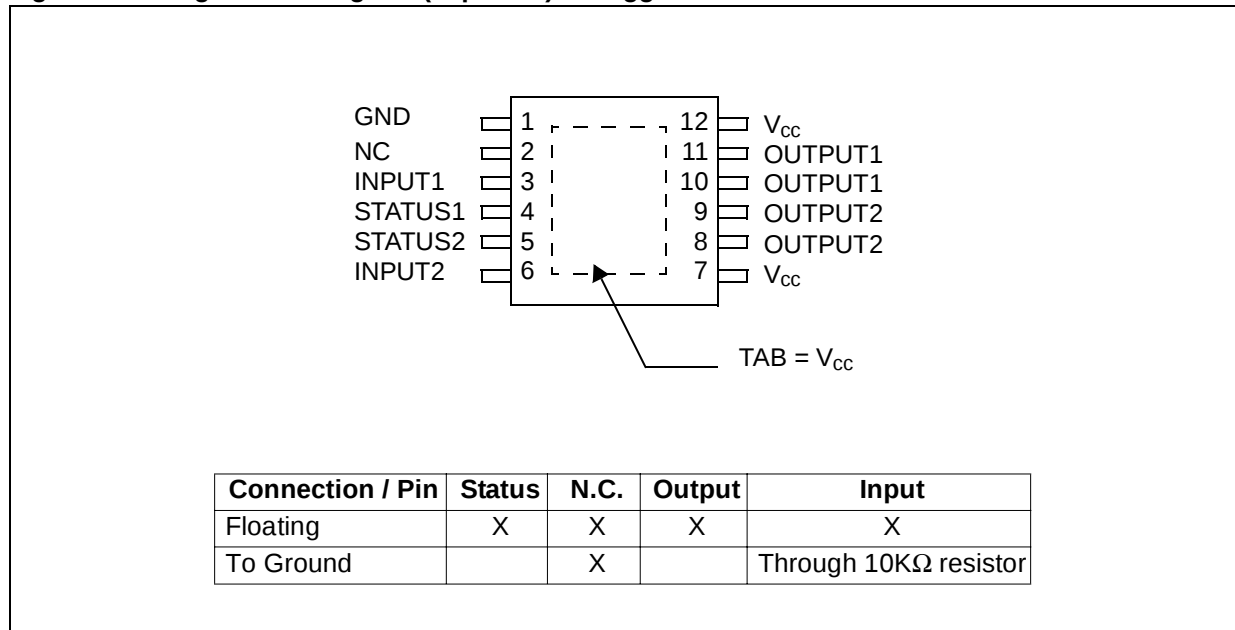
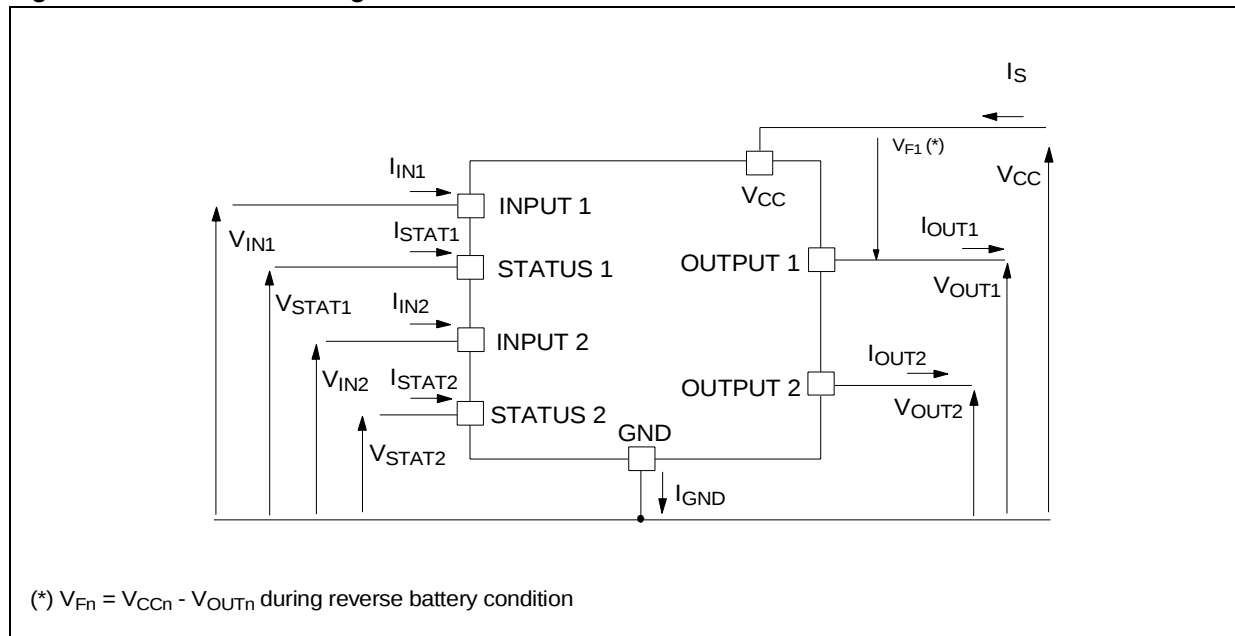


Table 3. Absolute Maximum Ratings

| 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                                             | - 6                | A           |
| $I_{IN}$   | DC Input Current                                                      | +/- 10             | mA          |
| $I_{stat}$ | DC Status Current                                                     | +/- 10             | mA          |
| $V_{ESD}$  | Electrostatic Discharge (Human Body Model: R=1.5K $\Omega$ ; C=100pF) |                    |             |
|            | - INPUT                                                               | 4000               | V           |
|            | - STATUS                                                              | 4000               | V           |
|            | - OUTPUT                                                              | 5000               | V           |
|            | - $V_{CC}$                                                            | 5000               | V           |
| $P_{tot}$  | Power Dissipation $T_C=25^{\circ}C$                                   | 54                 | W           |
| $T_j$      | Junction Operating Temperature                                        | Internally Limited | $^{\circ}C$ |
| $T_C$      | Case Operating Temperature                                            | - 40 to 150        | $^{\circ}C$ |
| $T_{stg}$  | Storage Temperature                                                   | - 55 to 150        | $^{\circ}C$ |

**Figure 3. Configuration Diagram (Top View) & Suggested Connections for Unused and N.C. Pins****Figure 4. Current and Voltage Conventions****Table 4. Thermal Data**

| Symbol         | Parameter                                 | Value               | Unit |
|----------------|-------------------------------------------|---------------------|------|
| $R_{thj-case}$ | Thermal resistance junction-case (MAX)    | 2.3                 | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient (MAX) | 61 (*)      50 (**) | °C/W |

Note: (\*) When mounted on a standard single-sided FR-4 board with 1cm<sup>2</sup> of Cu (at least 35μm thick) connected to all V<sub>CC</sub> pins.

Note: (\*\*) When mounted on a standard single-sided FR-4 board with 8cm<sup>2</sup> of Cu (at least 35μm thick) connected to all V<sub>CC</sub> pins.

**ELECTRICAL CHARACTERISTICS** (8V<V<sub>CC</sub><36V; -40°C<T<sub>j</sub><150°C unless otherwise specified)

(Per each channel)

**Table 5. Power Outputs**

| Symbol               | Parameter                | Test Conditions                                                                                                                                                                                                                                        | Min. | Typ.          | Max.          | Unit           |
|----------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------|---------------|----------------|
| V <sub>CC</sub>      | Operating Supply Voltage |                                                                                                                                                                                                                                                        | 5.5  | 13            | 36            | V              |
| V <sub>USD</sub>     | Undervoltage Shut-down   |                                                                                                                                                                                                                                                        | 3    | 4             | 5.5           | V              |
| V <sub>OV</sub>      | Overvoltage Shut-down    |                                                                                                                                                                                                                                                        | 36   |               |               | V              |
| R <sub>ON</sub>      | On State Resistance      | I <sub>OUT</sub> =1A; T <sub>j</sub> =25°C<br>I <sub>OUT</sub> =1A; V <sub>CC</sub> >8V                                                                                                                                                                |      |               | 160<br>320    | mΩ<br>mΩ       |
| I <sub>S</sub>       | Supply Current           | Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V<br>Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V;<br>T <sub>j</sub> =25°C<br>On State; V <sub>CC</sub> =13V; V <sub>IN</sub> =5V; I <sub>OUT</sub> =0A |      | 12<br>12<br>5 | 40<br>25<br>7 | μA<br>μA<br>mA |
| I <sub>L(off1)</sub> | Off State Output Current | V <sub>IN</sub> =V <sub>OUT</sub> =0V                                                                                                                                                                                                                  | 0    |               | 50            | μA             |
| I <sub>L(off2)</sub> | Off State Output Current | V <sub>IN</sub> =0V; V <sub>OUT</sub> =3.5V                                                                                                                                                                                                            | -75  |               | 0             | μA             |
| I <sub>L(off3)</sub> | Off State Output Current | V <sub>IN</sub> =V <sub>OUT</sub> =0V; V <sub>CC</sub> =13V; T <sub>j</sub> =125°C                                                                                                                                                                     |      |               | 5             | μA             |
| I <sub>L(off4)</sub> | Off State Output Current | V <sub>IN</sub> =V <sub>OUT</sub> =0V; V <sub>CC</sub> =13V; T <sub>j</sub> =25°C                                                                                                                                                                      |      |               | 3             | μA             |

**Table 6. Switching** (V<sub>CC</sub> =13V)

| Symbol                                 | Parameter              | Test Conditions                                                                     | Min. | Typ.                       | Max. | Unit |
|----------------------------------------|------------------------|-------------------------------------------------------------------------------------|------|----------------------------|------|------|
| t <sub>d(on)</sub>                     | Turn-on delay time     | R <sub>L</sub> =13Ω from V <sub>IN</sub> rising edge to<br>V <sub>OUT</sub> =1.3V   |      | 30                         |      | μs   |
| t <sub>d(off)</sub>                    | Turn-on delay time     | R <sub>L</sub> =13Ω from V <sub>IN</sub> falling edge to<br>V <sub>OUT</sub> =11.7V |      | 30                         |      | μs   |
| (dV <sub>OUT</sub> /dt) <sub>on</sub>  | Turn-on voltage slope  | R <sub>L</sub> =13Ω from V <sub>OUT</sub> =1.3V to<br>V <sub>OUT</sub> =10.4V       |      | See<br>relative<br>diagram |      | V/μs |
| (dV <sub>OUT</sub> /dt) <sub>off</sub> | Turn-off voltage slope | R <sub>L</sub> =13Ω from V <sub>OUT</sub> =11.7V to<br>V <sub>OUT</sub> =1.3V       |      | See<br>relative<br>diagram |      | V/μs |

**Table 7. V<sub>CC</sub> - Output Diode**

| Symbol         | Parameter          | Test Conditions                                | Min | Typ | Max | Unit |
|----------------|--------------------|------------------------------------------------|-----|-----|-----|------|
| V <sub>F</sub> | Forward on Voltage | -I <sub>OUT</sub> =0.5A; T <sub>j</sub> =150°C |     |     | 0.6 | V    |

**Table 8. Status Pin**

| Symbol             | Parameter                    | Test Conditions                                      | Min | Typ         | Max | Unit   |
|--------------------|------------------------------|------------------------------------------------------|-----|-------------|-----|--------|
| V <sub>STAT</sub>  | Status Low Output Voltage    | I <sub>STAT</sub> = 1.6 mA                           |     |             | 0.5 | V      |
| I <sub>LSTAT</sub> | Status Leakage Current       | Normal Operation; V <sub>STAT</sub> = 5V             |     |             | 10  | μA     |
| C <sub>STAT</sub>  | Status Pin Input Capacitance | Normal Operation; V <sub>STAT</sub> = 5V             |     |             | 100 | pF     |
| V <sub>SCL</sub>   | Status Clamp Voltage         | I <sub>STAT</sub> = 1mA<br>I <sub>STAT</sub> = - 1mA | 6   | 6.8<br>-0.7 | 8   | V<br>V |

**ELECTRICAL CHARACTERISTICS** (continued)**Table 9. Logic Input**

| Symbol        | Parameter                | Test Conditions                   | Min. | Typ.        | Max. | Unit    |
|---------------|--------------------------|-----------------------------------|------|-------------|------|---------|
| $V_{IL}$      | Input Low Level          |                                   |      |             | 1.25 | V       |
| $I_{IL}$      | Low Level Input Current  | $V_{IN} = 1.25V$                  | 1    |             |      | $\mu A$ |
| $V_{IH}$      | Input High Level         |                                   | 3.25 |             |      | V       |
| $I_{IH}$      | High Level Input Current | $V_{IN} = 3.25V$                  |      |             | 10   | $\mu A$ |
| $V_{I(hyst)}$ | Input Hysteresis Voltage |                                   | 0.5  |             |      | V       |
| $V_{ICL}$     | Input Clamp Voltage      | $I_{IN} = 1mA$<br>$I_{IN} = -1mA$ | 6    | 6.8<br>-0.7 | 8    | V<br>V  |

**Table 10. Protections** (See note 1)

| Symbol      | Parameter                           | Test Conditions            | Min.          | Typ.          | Max.          | Unit        |
|-------------|-------------------------------------|----------------------------|---------------|---------------|---------------|-------------|
| $T_{TSD}$   | Shut-down Temperature               |                            | 150           | 175           | 200           | $^{\circ}C$ |
| $T_R$       | Reset Temperature                   |                            | 135           |               |               | $^{\circ}C$ |
| $T_{hyst}$  | Thermal Hysteresis                  |                            | 7             | 15            |               | $^{\circ}C$ |
| $t_{SDL}$   | Status Delay in Overload Conditions | $T_j > T_{TSD}$            |               |               | 20            | $\mu s$     |
| $I_{lim}$   | Current limitation                  | $5.5V < V_{CC} < 36V$      | 3.5           | 5             | 7.5<br>7.5    | A<br>A      |
| $V_{demag}$ | Turn-off Output Clamp Voltage       | $I_{OUT} = 1A$ ; $L = 6mH$ | $V_{CC} - 41$ | $V_{CC} - 48$ | $V_{CC} - 55$ | V           |

Note: 1. To ensure long term reliability under heavy overload or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device is subjected to abnormal conditions, this software must limit the duration and number of activation cycles.

**Table 11. Openload Detection**

| Symbol         | Parameter                                      | Test Conditions | Min | Typ | Max  | Unit    |
|----------------|------------------------------------------------|-----------------|-----|-----|------|---------|
| $I_{OL}$       | Openload ON State Detection Threshold          | $V_{IN} = 5V$   | 20  | 40  | 80   | mA      |
| $t_{DOL(on)}$  | Openload ON State Detection Delay              | $I_{OUT} = 0A$  |     |     | 200  | $\mu s$ |
| $V_{OL}$       | Openload OFF State Voltage Detection Threshold | $V_{IN} = 0V$   | 1.5 | 2.5 | 3.5  | V       |
| $t_{DOL(off)}$ | Openload Detection Delay at Turn Off           |                 |     |     | 1000 | $\mu s$ |

Figure 5.

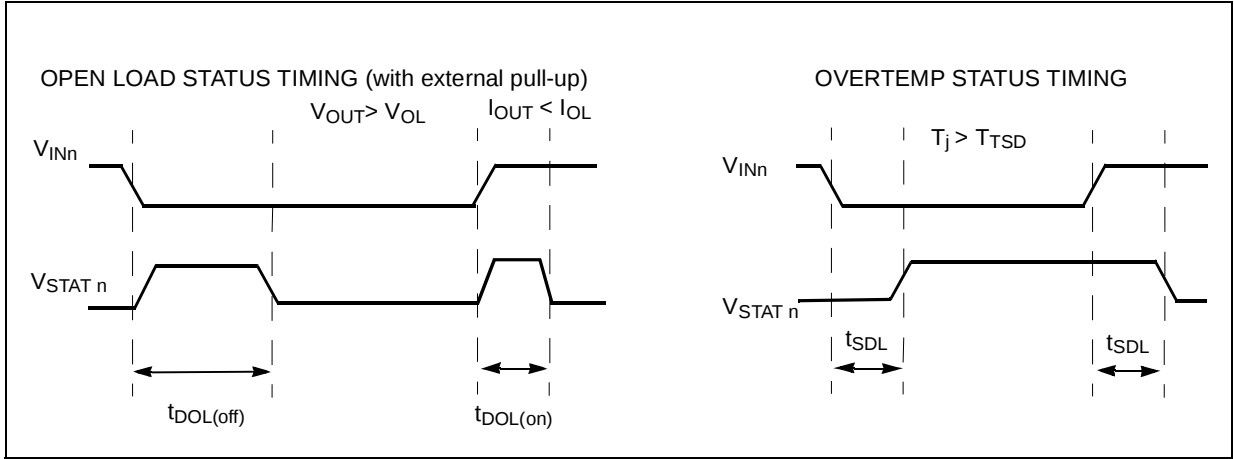


Figure 6. Switching time Waveforms

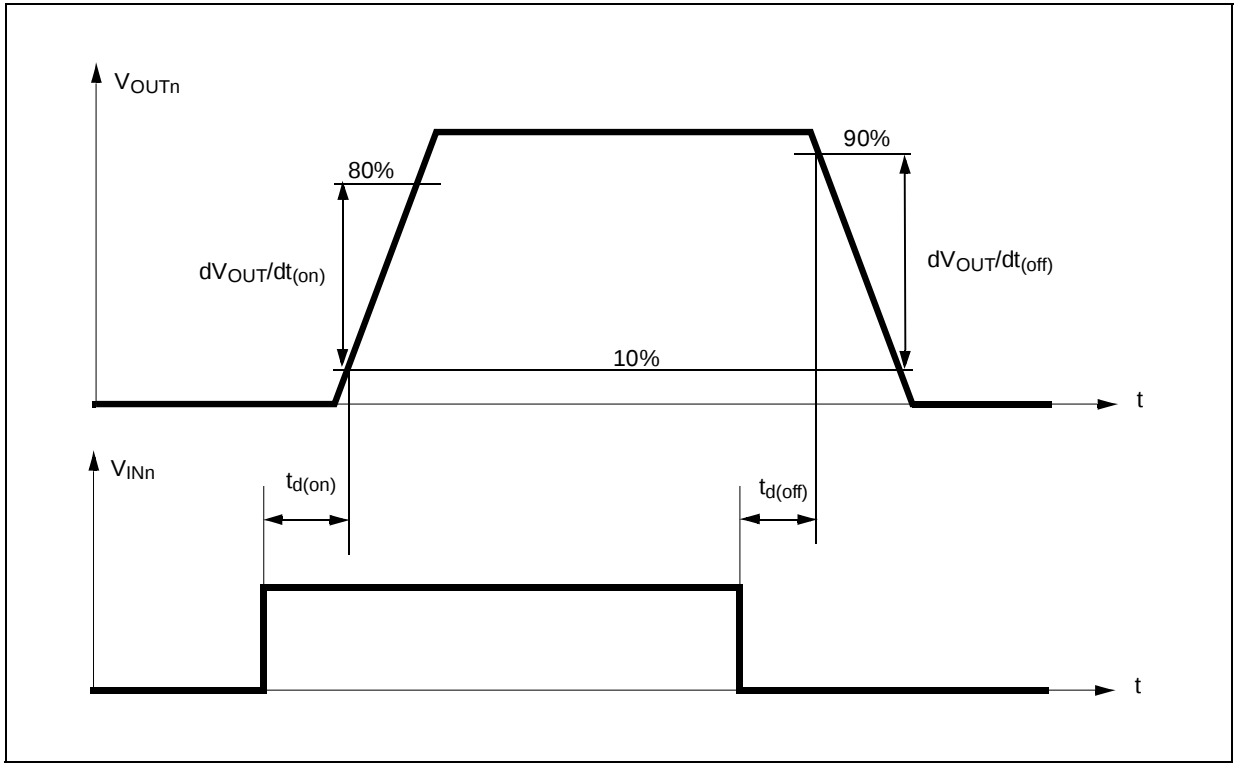


Table 12. Truth Table

| CONDITIONS                        | INPUT <sub>n</sub> | OUTPUT <sub>n</sub> | STATUS <sub>n</sub>                                                                   |
|-----------------------------------|--------------------|---------------------|---------------------------------------------------------------------------------------|
| Normal Operation                  | L<br>H             | L<br>H              | H<br>H                                                                                |
| Current Limitation                | L<br>H<br>H        | L<br>X<br>X         | H<br>(T <sub>j</sub> < T <sub>TSD</sub> ) H<br>(T <sub>j</sub> > T <sub>TSD</sub> ) L |
| Overtemperature                   | L<br>H             | L<br>L              | H<br>L                                                                                |
| Undervoltage                      | L<br>H             | L<br>L              | X<br>X                                                                                |
| Overvoltage                       | L<br>H             | L<br>L              | H<br>H                                                                                |
| Output Voltage > V <sub>OLn</sub> | L<br>H             | H<br>H              | L<br>H                                                                                |
| Output Current < I <sub>OLn</sub> | L<br>H             | L<br>H              | H<br>L                                                                                |

Table 13. Electrical Transient Requirements on V<sub>CC</sub> Pin

| ISO T/R 7637/1<br>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<br>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. |

Figure 7. Waveforms

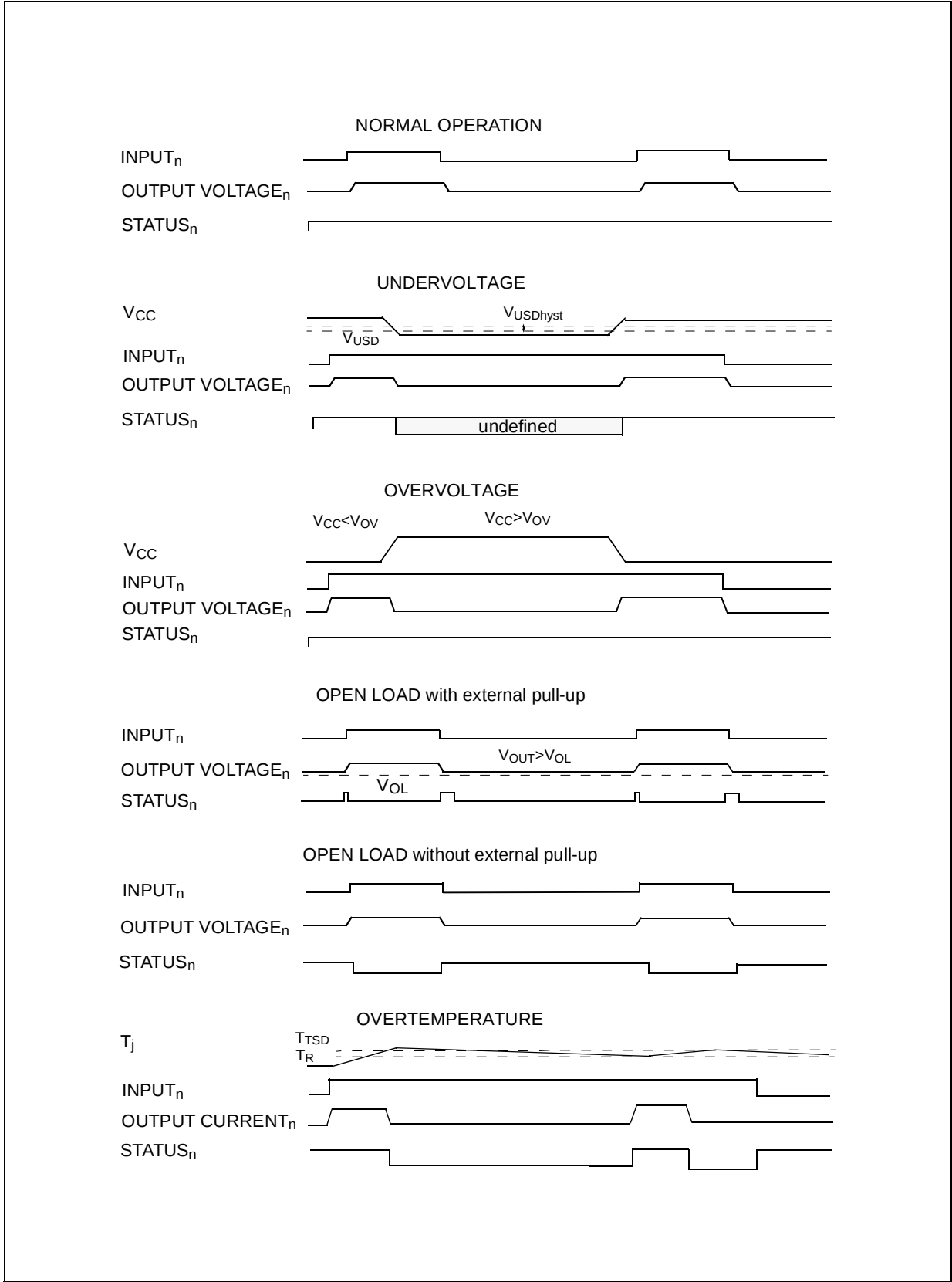
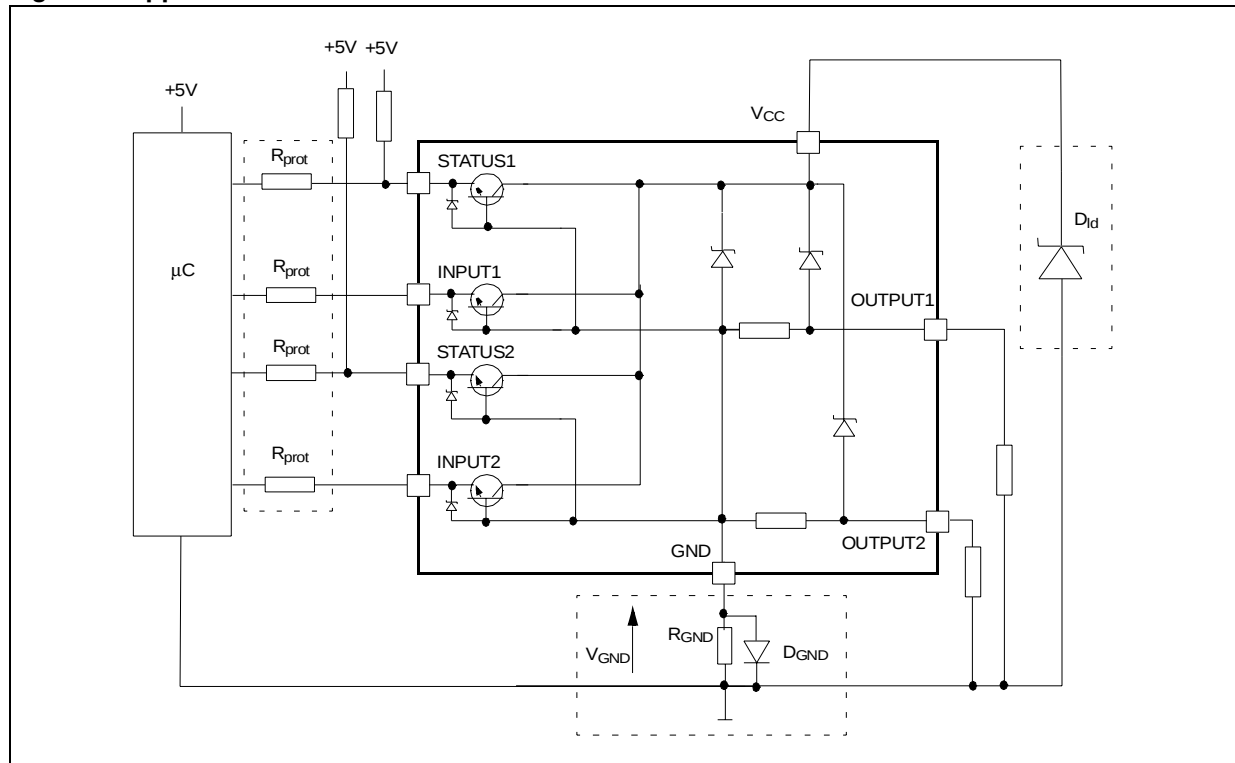


Figure 8. Application Schematic



### 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)  $R_{GND} \leq 600\text{mV} / (I_{S(on)max})$ .
- 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 ( $I_{S(on)max} \times R_{GND}$ ) in the input thresholds and the status output values. This shift will vary depending on 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 ( $R_{GND}=1\text{k}\Omega$ ) 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 ( $\approx 600\text{mV}$ ) 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.

Series resistor in INPUT and STATUS lines are also required to prevent that, during battery voltage transient, the current exceeds the Absolute Maximum Rating.

Safest configuration for unused INPUT and STATUS pin is to leave them unconnected.

### LOAD DUMP PROTECTION

$D_{id}$  is necessary (Voltage Transient Suppressor) 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  $V_{CCpeak} = -100\text{V}$  and  $I_{latchup} \geq 20\text{mA}$ ;  $V_{OH\mu C} \geq 4.5\text{V}$   
 $5\text{k}\Omega \leq R_{prot} \leq 65\text{k}\Omega$ .

Recommended  $R_{prot}$  value is  $10\text{k}\Omega$ .

## OPEN LOAD DETECTION IN OFF STATE

Off state open load detection requires an external pull-up resistor ( $R_{PU}$ ) connected between OUTPUT pin and a positive supply voltage ( $V_{PU}$ ) like the +5V line used to supply the microprocessor.

The external resistor has to be selected according to the following requirements:

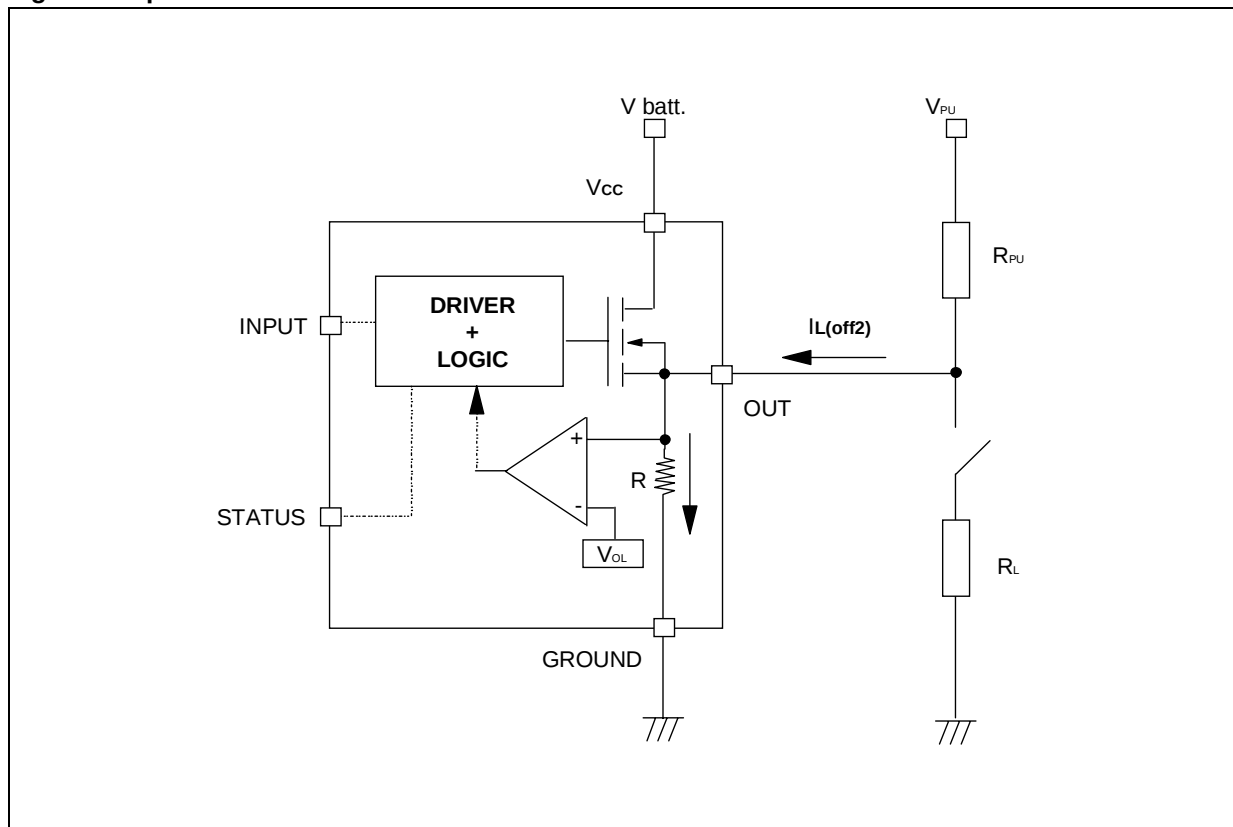
- 1) no false open load indication when load is connected: in this case we have to avoid  $V_{OUT}$  to be higher than  $V_{OLmin}$ ; this results in the following condition  $V_{OUT} = (V_{PU} / (R_L + R_{PU})) R_L < V_{OLmin}$ .

- 2) no misdetection when load is disconnected: in this case the  $V_{OUT}$  has to be higher than  $V_{OLmax}$ ; this results in the following condition  $R_{PU} < (V_{PU} - V_{OLmax}) / I_{L(off2)}$ .

Because  $I_{S(OFF)}$  may significantly increase if  $V_{out}$  is pulled high (up to several mA), the pull-up resistor  $R_{PU}$  should be connected to a supply that is switched OFF when the module is in standby.

The values of  $V_{OLmin}$ ,  $V_{OLmax}$  and  $I_{L(off2)}$  are available in the Electrical Characteristics section.

### Figure 9. Open Load detection in off state



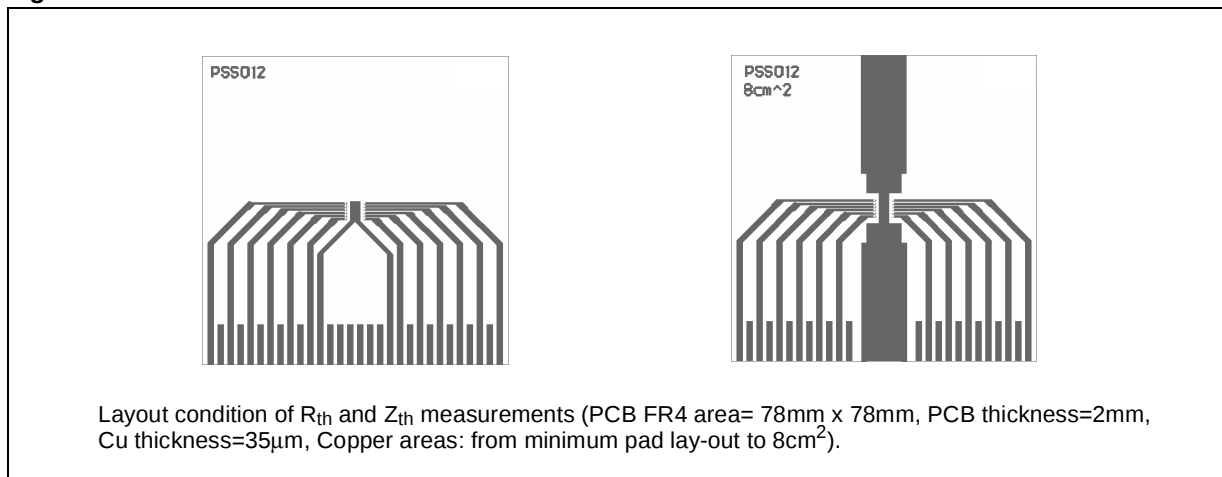
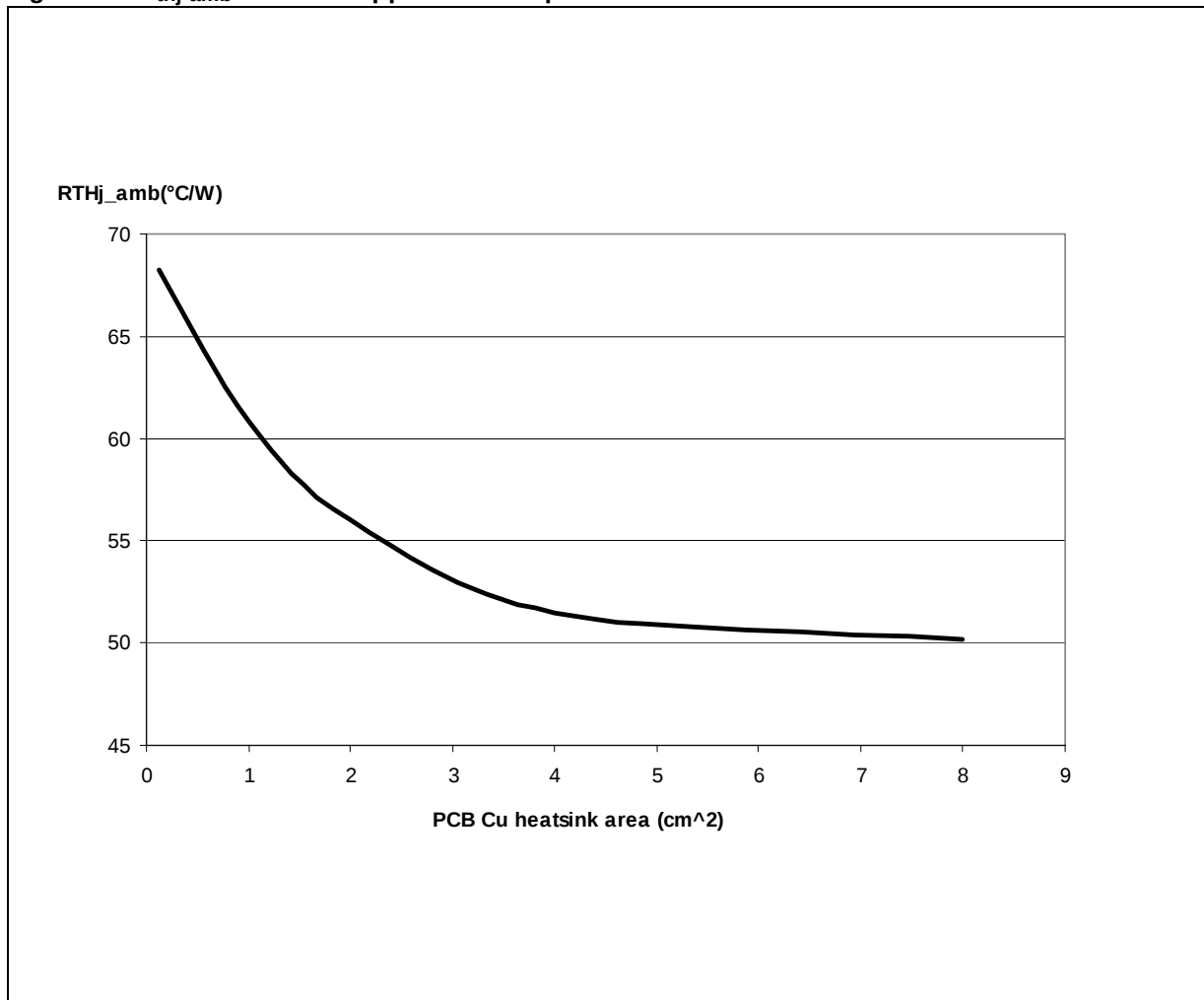
**PowerSSO-12 Thermal Data****Figure 10. PowerSSO-12 PC Board****Figure 11.  $R_{thj-amb}$  Vs PCB copper area in open box free air condition**

Figure 12. PowerSSO-12 Thermal Impedance Junction Ambient Single Pulse

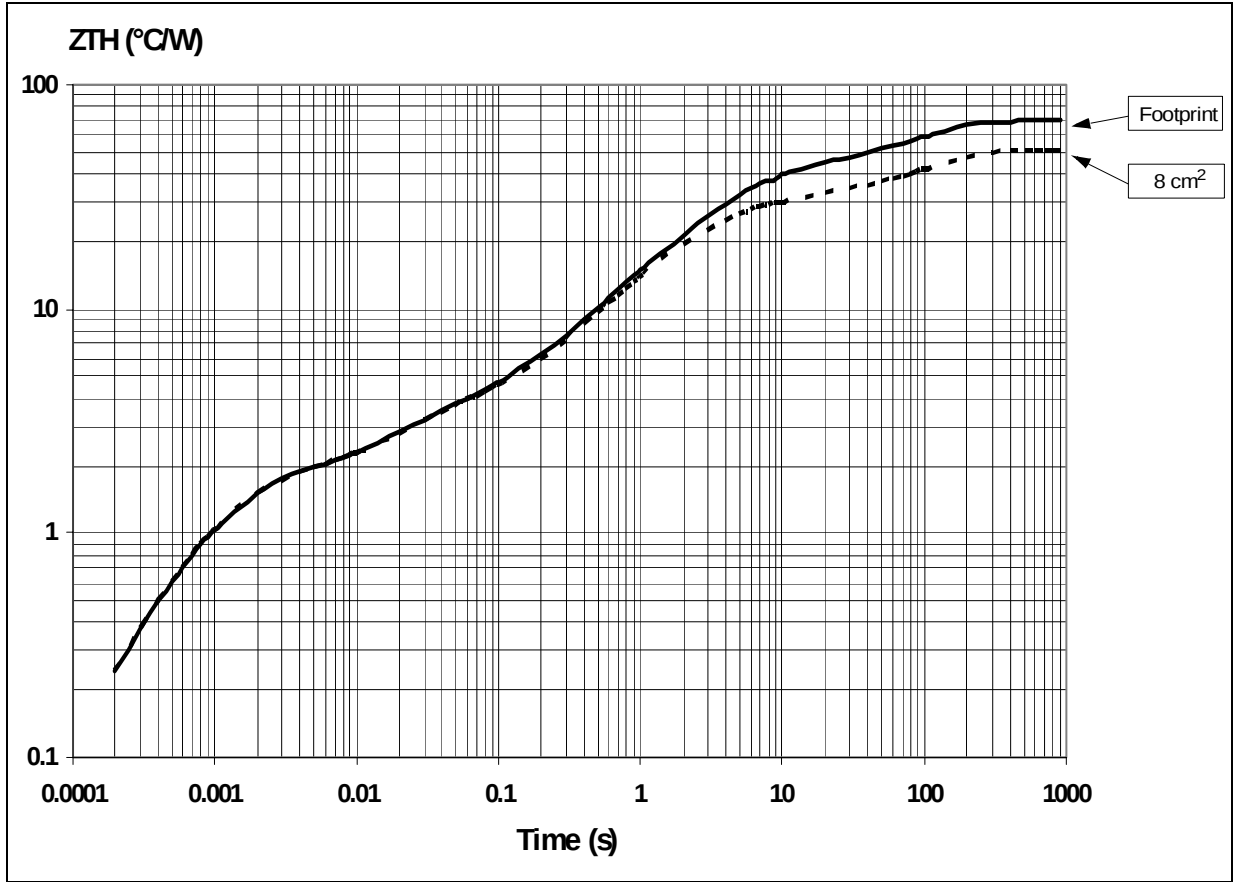
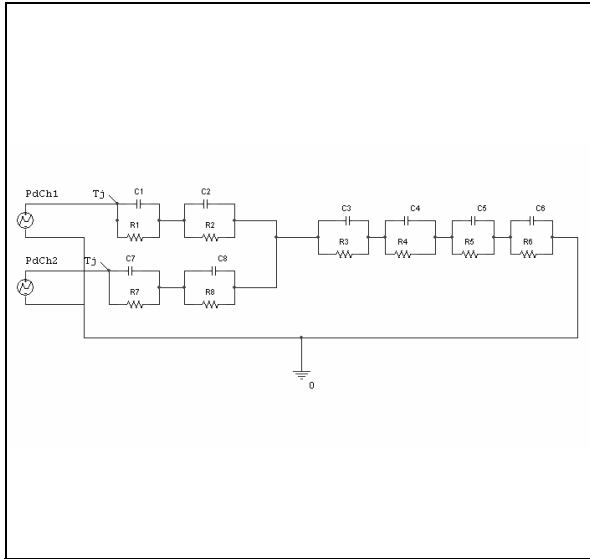


Figure 13. Thermal fitting model of a double channel HSD in PowerSSO-12



Pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where  $\delta = t_p / T$

Table 14. Thermal Parameter

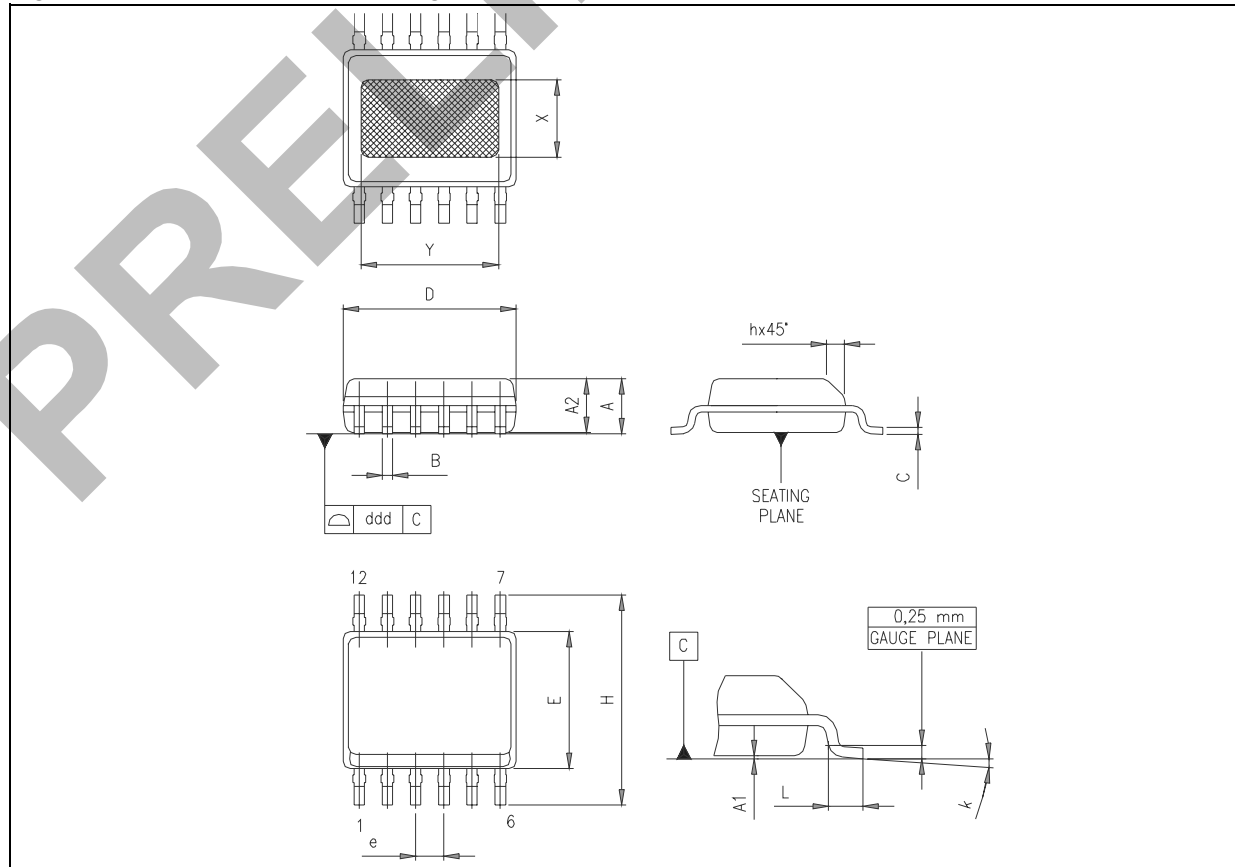
| Area/island (cm <sup>2</sup> ) | Footprint | 8     |
|--------------------------------|-----------|-------|
| R1/R7 (°C/W)                   | 0.1       |       |
| R2/R3/R8 (°C/W)                | 1.5       |       |
| R4 (°C/W)                      | 8         |       |
| R5 (°C/W)                      | 28        | 18    |
| R6 (°C/W)                      | 30        | 22    |
| C1/C7 (W.s/°C)                 | 0.0001    |       |
| C2/C8 (W.s/°C)                 | 0.0007    |       |
| C3 (W.s/°C)                    | 0.015     |       |
| C4 (W.s/°C)                    | 0.1       |       |
| C5 (W.s/°C)                    | 0.15      | 0.017 |
| C6 (W.s/°C)                    | 3         | 5     |

## PACKAGE MECHANICAL

Table 15. PowerSSO-12™ Mechanical Data

| Symbol | millimeters |       |       |
|--------|-------------|-------|-------|
|        | Min         | Typ   | Max   |
| A      | 1.250       |       | 1.620 |
| A1     | 0.000       |       | 0.100 |
| A2     | 1.100       |       | 1.650 |
| B      | 0.230       |       | 0.410 |
| C      | 0.190       |       | 0.250 |
| D      | 4.800       |       | 5.000 |
| E      | 3.800       |       | 4.000 |
| e      |             | 0.800 |       |
| H      | 5.800       |       | 6.200 |
| h      | 0.250       |       | 0.500 |
| L      | 0.400       |       | 1.270 |
| k      | 0°          |       | 8°    |
| X      | 1.900       |       | 2.500 |
| Y      | 3.600       |       | 4.200 |
| ddd    |             |       | 0.100 |

Figure 14. PowerSSO-12™ Package Dimensions



**REVISION HISTORY****Table 16. Revision History**

| <b>Date</b> | <b>Revision</b> | <b>Description of Changes</b>            |
|-------------|-----------------|------------------------------------------|
| Oct. 2004   | 1               | - First Issue                            |
| Nov. 2004   | 2               | - PowerSSO-12 Thermal Charact. insertion |
| Nov. 2004   | 3               | - PC Board copper area correction        |
| Nov. 2004   | 4               | - Thermal data correction.               |

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