



# VN920DSP

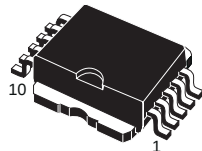
## HIGH SIDE DRIVER

| TYPE     | $R_{DS(on)}$ | $I_{OUT}$ | $V_{CC}$ |
|----------|--------------|-----------|----------|
| VN920DSP | 16 mΩ        | 25 A      | 36 V     |

- CMOS COMPATIBLE INPUT
- 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 (\*)

### DESCRIPTION

The VN920DSP is a monolithic device made by using STMicroelectronics VIPower M0-3 Technology, intended for driving any kind of load with one side connected to ground. Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table). Active current limitation



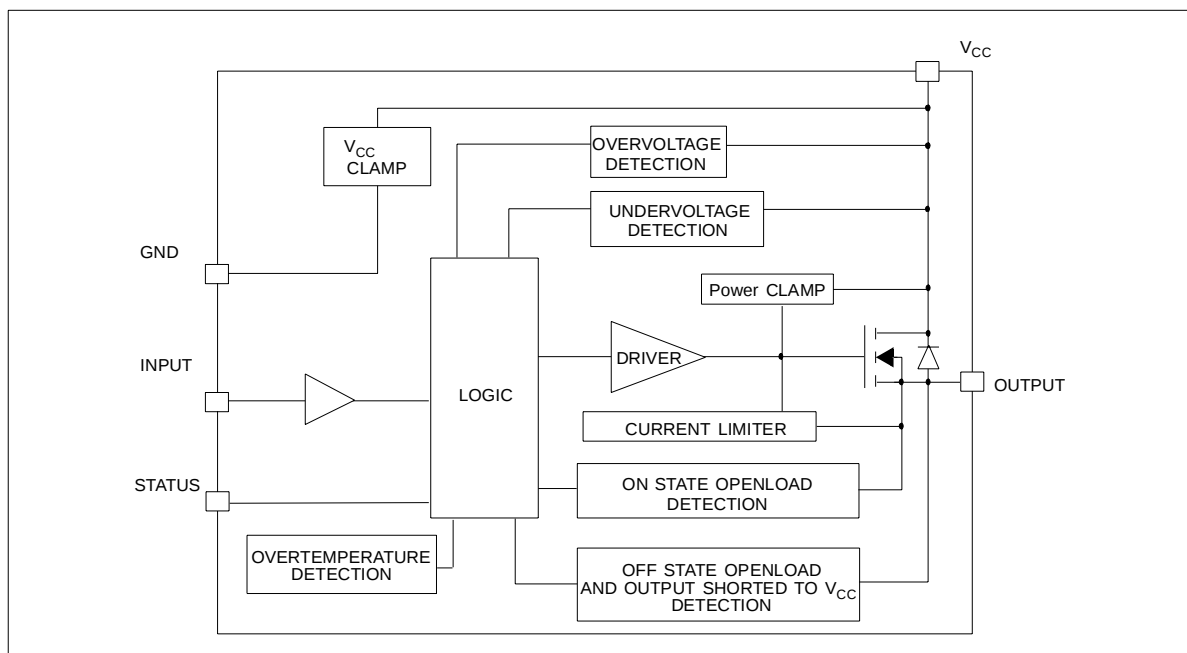
**PowerSO-10™**

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| PowerSO-10™ | VN920DSP | VN920DSP13TR |

combined with thermal shutdown and automatic restart protect the device against overload.

The device detects open load condition both is on and off state. Output shorted to  $V_{CC}$  is detected in the off state. Device automatically turns off in case of ground pin disconnection.

### BLOCK DIAGRAM



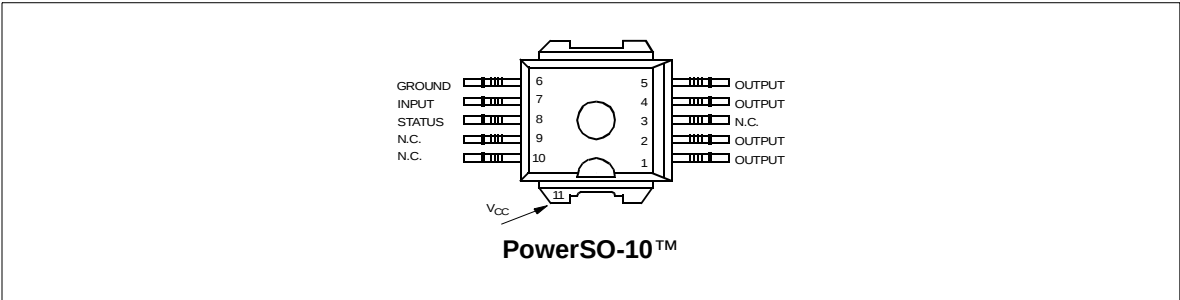
(\*) See application schematic at page 8

VN920DSP

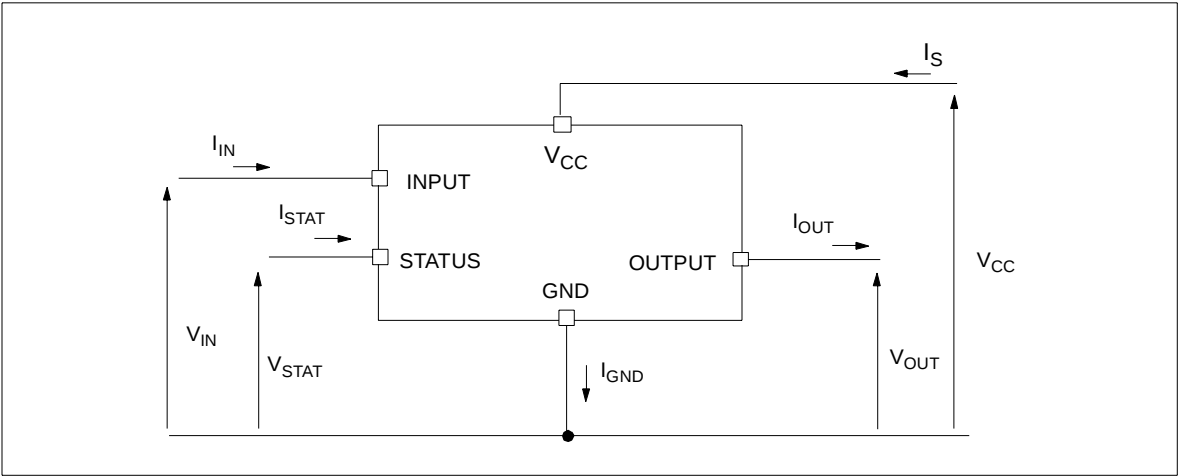
ABSOLUTE MAXIMUM RATING

| 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                                                                                            | - 25               | 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           |
|            | - CURRENT SENSE                                                                                                      | 4000               | V           |
|            | - OUTPUT                                                                                                             | 5000               | V           |
|            | - $V_{CC}$                                                                                                           | 5000               | V           |
| $E_{MAX}$  | Maximum Switching Energy<br>( $L=0.25mH$ ; $R_L=0\Omega$ ; $V_{bat}=13.5V$ ; $T_{jstart}=150^{\circ}C$ ; $I_L=45A$ ) | 362                | mJ          |
| $P_{tot}$  | Power Dissipation $T_C=25^{\circ}C$                                                                                  | 96.1               | 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        | $^{\circ}C$ |

CONNECTION DIAGRAM (TOP VIEW)



CURRENT AND VOLTAGE CONVENTIONS



**THERMAL DATA**

| Symbol         | Parameter                               | Value    | Unit |
|----------------|-----------------------------------------|----------|------|
| $R_{thj-case}$ | Thermal Resistance Junction-case Max    | 1.3      | °C/W |
| $R_{thj-amb}$  | Thermal Resistance Junction-ambient Max | 51.3 (*) | °C/W |

(\*) When mounted on a standard single-sided FR-4 board with 0.5cm<sup>2</sup> of Cu (at least 35µm thick).

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

| 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>USDhyst</sub> | Undervoltage Shut-down hysteresis |                                                                                              |     | 0.5 |     | V    |
| V <sub>OV</sub>      | Overvoltage Shut-down             |                                                                                              | 36  |     |     | V    |
| R <sub>ON</sub>      | On State Resistance               | I <sub>OUT</sub> =10A; T <sub>j</sub> =25°C                                                  |     |     | 16  | mΩ   |
|                      |                                   | I <sub>OUT</sub> =10A                                                                        |     |     | 30  | mΩ   |
|                      |                                   | I <sub>OUT</sub> =3A; V <sub>CC</sub> =6V                                                    |     |     | 50  | mΩ   |
| I <sub>S</sub>       | Supply Current                    | Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V                       |     | 10  | 25  | µA   |
|                      |                                   | Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V; T <sub>j</sub> =25°C |     | 10  | 20  | µA   |
|                      |                                   | On State; V <sub>CC</sub> =13V; V <sub>IN</sub> =5V; I <sub>OUT</sub> =0A                    |     |     | 5   | 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   |

**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> =1.3Ω |     | 50                   |     | µs   |
| t <sub>d(off)</sub>                    | Turn-off Delay Time    | R <sub>L</sub> =1.3Ω |     | 50                   |     | µs   |
| dV <sub>OUT</sub> /dt <sub>(on)</sub>  | Turn-on Voltage Slope  | R <sub>L</sub> =1.3Ω |     | See relative diagram |     | V/µs |
| dV <sub>OUT</sub> /dt <sub>(off)</sub> | Turn-off Voltage Slope | R <sub>L</sub> =1.3Ω |     | See relative diagram |     | V/µs |

**INPUT PIN**

| Symbol               | Parameter                | Test Conditions        | Min  | Typ  | Max  | Unit |
|----------------------|--------------------------|------------------------|------|------|------|------|
| V <sub>IL</sub>      | Input Low Level          |                        |      |      | 1.25 | V    |
| I <sub>IL</sub>      | Low Level Input Current  | V <sub>IN</sub> =1.25V | 1    |      |      | µA   |
| V <sub>IH</sub>      | Input High Level         |                        | 3.25 |      |      | V    |
| I <sub>IH</sub>      | High Level Input Current | V <sub>IN</sub> =3.25V |      |      | 10   | µA   |
| V <sub>I(hyst)</sub> | Input Hysteresis Voltage |                        | 0.5  |      |      | V    |
| V <sub>ICL</sub>     | Input Clamp Voltage      | I <sub>IN</sub> =1mA   | 6    | 6.8  | 8    | V    |
|                      |                          | I <sub>IN</sub> =-1mA  |      | -0.7 |      | V    |

**ELECTRICAL CHARACTERISTICS** (continued)

## STATUS PIN

| Symbol      | Parameter                    | Test Conditions                | Min | Typ  | Max | Unit    |
|-------------|------------------------------|--------------------------------|-----|------|-----|---------|
| $V_{STAT}$  | Status Low Output Voltage    | $I_{STAT}=1.6mA$               |     |      | 0.5 | V       |
| $I_{LSTAT}$ | Status Leakage Current       | Normal Operation $V_{STAT}=5V$ |     |      | 10  | $\mu A$ |
| $C_{STAT}$  | Status Pin Input Capacitance | Normal Operation $V_{STAT}=5V$ |     |      | 100 | pF      |
| $V_{SCL}$   | Status Clamp Voltage         | $I_{STAT}=1mA$                 | 6   | 6.8  | 8   | V       |
|             |                              | $I_{STAT}=-1mA$                |     | -0.7 |     | V       |

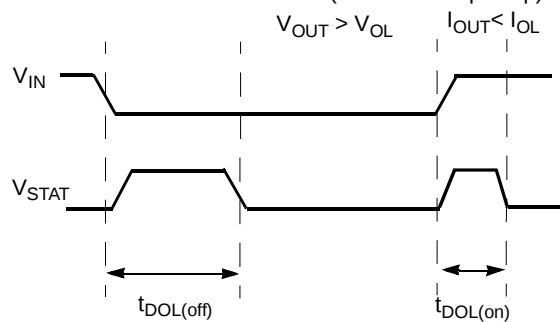
## PROTECTIONS

| 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 condition | $T_j > T_{TSD}$                      |             |             | 20          | $\mu s$     |
| $I_{lim}$   | Current limitation                 | $5.5V < V_{CC} < 36V$                | 30          | 45          | 75          | A           |
|             |                                    |                                      |             |             | 75          | A           |
| $V_{demag}$ | Turn-off Output Clamp Voltage      | $I_{OUT}=2A$ ; $V_{IN}=0V$ ; $L=6mH$ | $V_{CC}-41$ | $V_{CC}-48$ | $V_{CC}-55$ | V           |

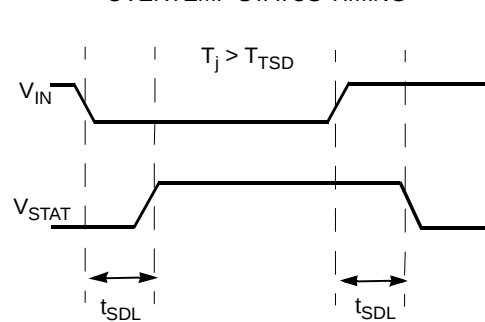
## OPENLOAD DETECTION

| Symbol         | Parameter                                      | Test Conditions | Min | Typ | Max  | Unit    |
|----------------|------------------------------------------------|-----------------|-----|-----|------|---------|
| $I_{OL}$       | Openload ON State Detection Threshold          | $V_{IN}=5V$     | 300 | 500 | 700  | 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 | $\mu s$ |

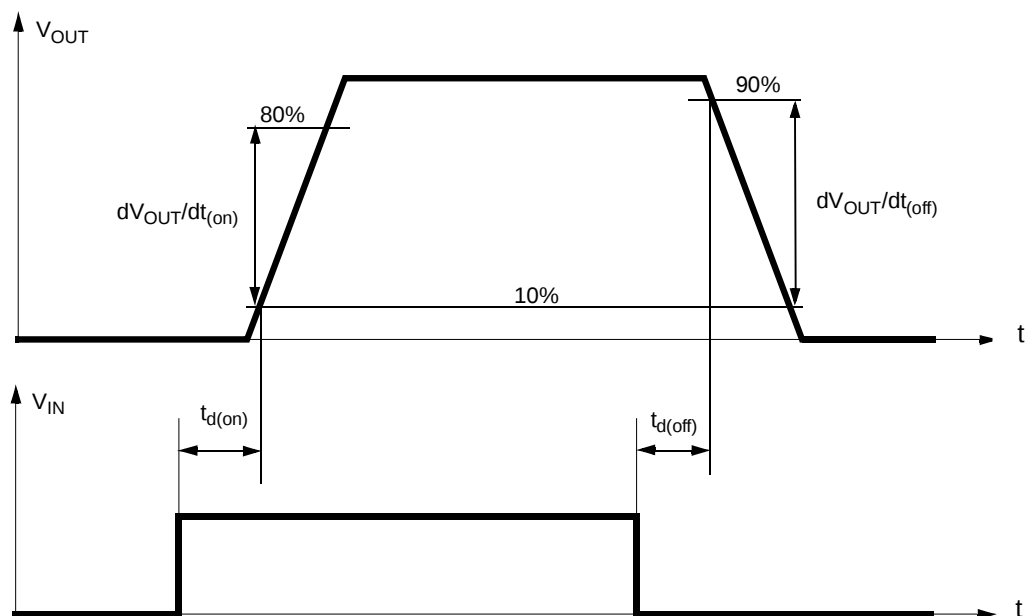
OPEN LOAD STATUS TIMING (with external pull-up)



OVERTEMP STATUS TIMING



## Switching time Waveforms



## TRUTH TABLE

| CONDITIONS                | INPUT | OUTPUT | STATUS              |
|---------------------------|-------|--------|---------------------|
| Normal Operation          | L     | L      | H                   |
|                           | H     | H      | H                   |
| Current Limitation        | L     | L      | H                   |
|                           | H     | X      | $(T_j < T_{TSD})$ H |
|                           | H     | X      | $(T_j > T_{TSD})$ L |
| Overtemperature           | L     | L      | H                   |
|                           | H     | L      | L                   |
| Undervoltage              | L     | L      | X                   |
|                           | H     | L      | X                   |
| Overvoltage               | L     | L      | H                   |
|                           | H     | L      | H                   |
| Output Voltage > $V_{OL}$ | L     | H      | L                   |
|                           | H     | H      | H                   |
| Output Current < $I_{OL}$ | L     | L      | H                   |
|                           | H     | H      | L                   |

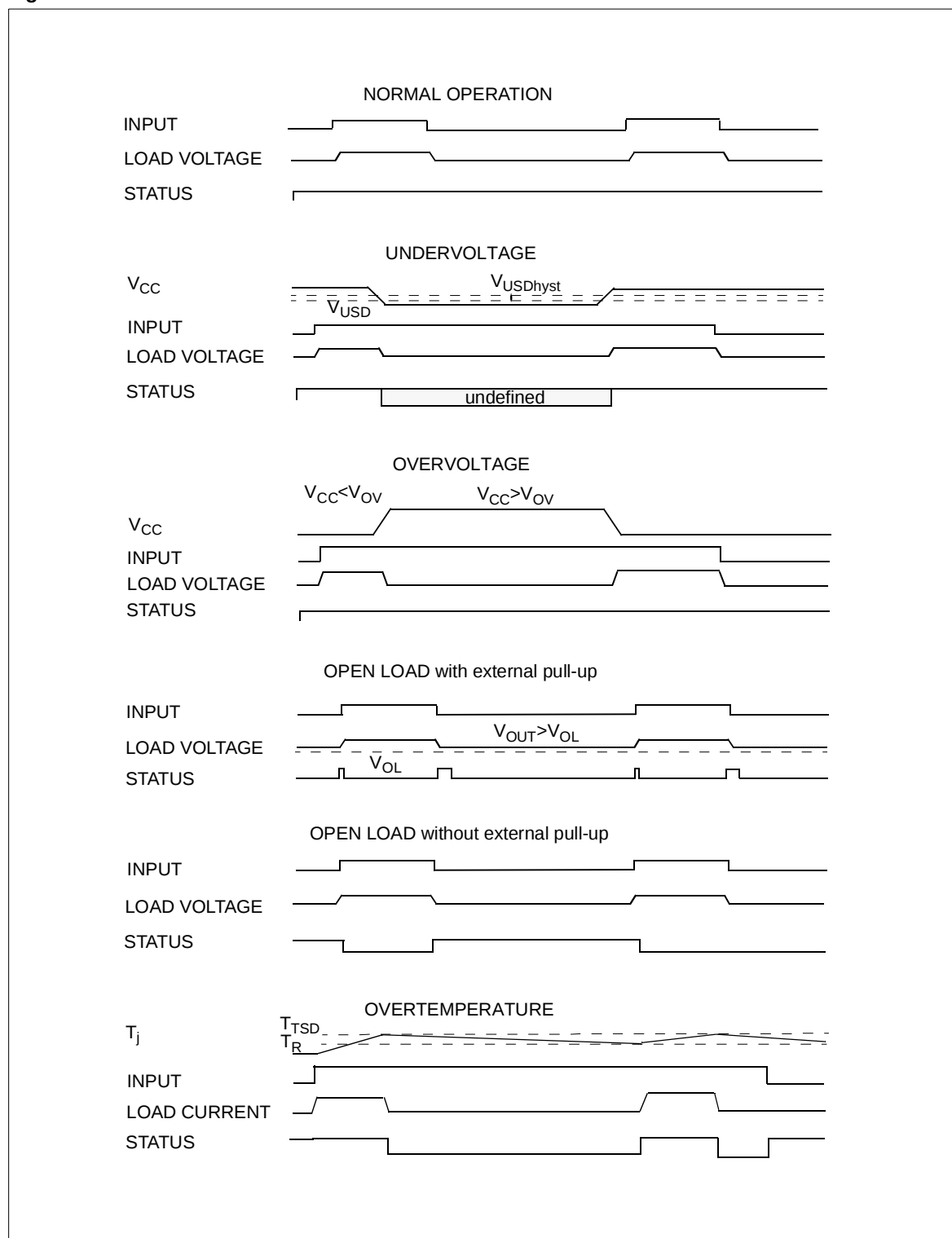
ELECTRICAL TRANSIENT REQUIREMENTS ON  $V_{CC}$  PIN

| 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 $\Omega$        |
| 2                            | +25 V       | +50 V   | +75 V   | +100 V  | 0.2 ms 10 $\Omega$      |
| 3a                           | -25 V       | -50 V   | -100 V  | -150 V  | 0.1 $\mu$ s 50 $\Omega$ |
| 3b                           | +25 V       | +50 V   | +75 V   | +100 V  | 0.1 $\mu$ s 50 $\Omega$ |
| 4                            | -4 V        | -5 V    | -6 V    | -7 V    | 100 ms, 0.01 $\Omega$   |
| 5                            | +26.5 V     | +46.5 V | +66.5 V | +86.5 V | 400 ms, 2 $\Omega$      |

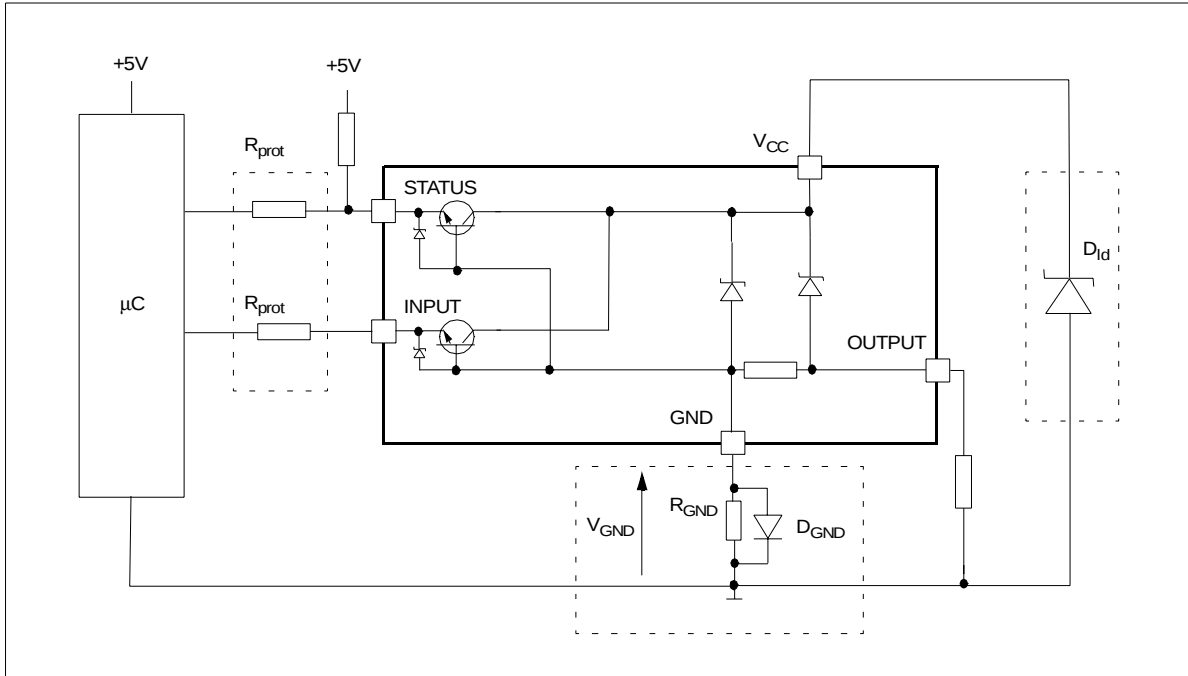
| ISO T/R 7637/1<br>Test Pulse | TEST LEVELS RESULTS |    |     |    |
|------------------------------|---------------------|----|-----|----|
|                              | I                   | II | III | IV |
| 1                            | C                   | C  | C   | C  |
| 2                            | 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. |

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

## 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.

 $\mu\text{C}$  I/Os PROTECTION:

If a ground protection network is used and negative transient 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  $\mu\text{C}$  I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of  $\mu\text{C}$  and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of  $\mu\text{C}$  I/Os.

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

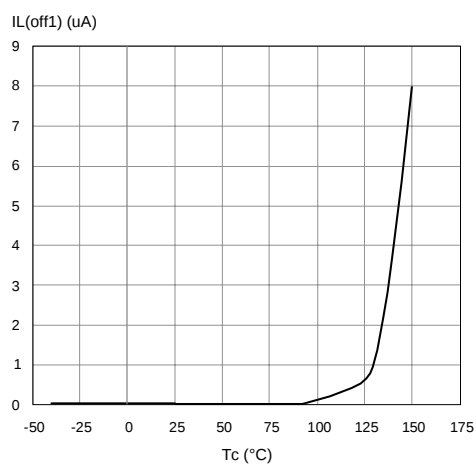
Calculation example:

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

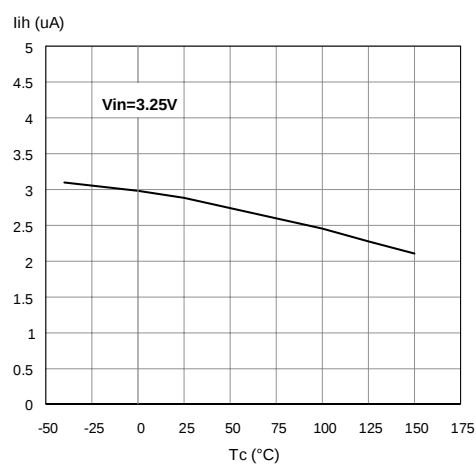
$$5\text{k}\Omega \leq R_{prot} \leq 65\text{k}\Omega.$$

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

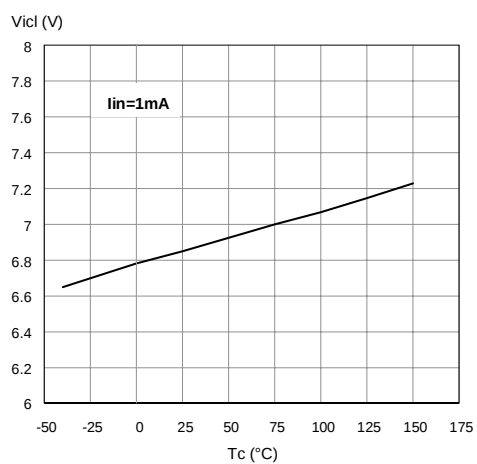
Off State Output Current



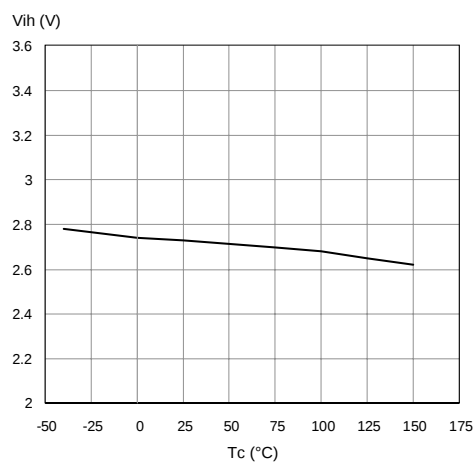
High Level Input Current



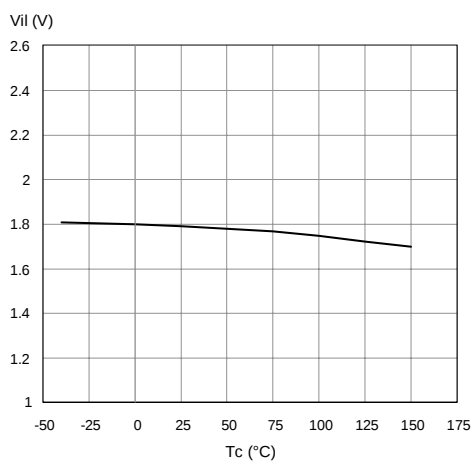
Input Clamp Voltage



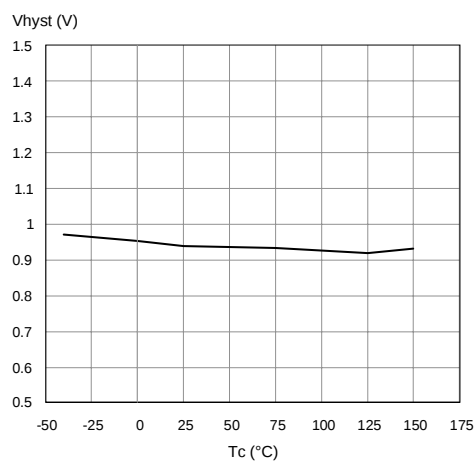
Input High Level



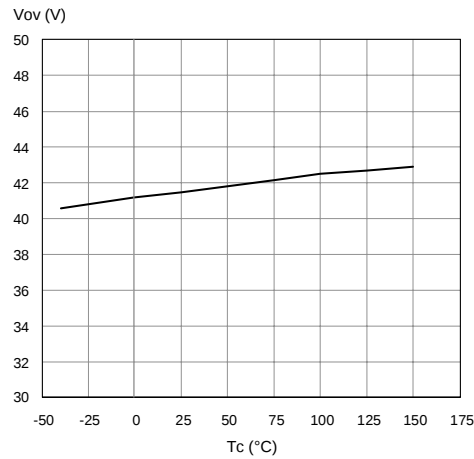
Input Low Level



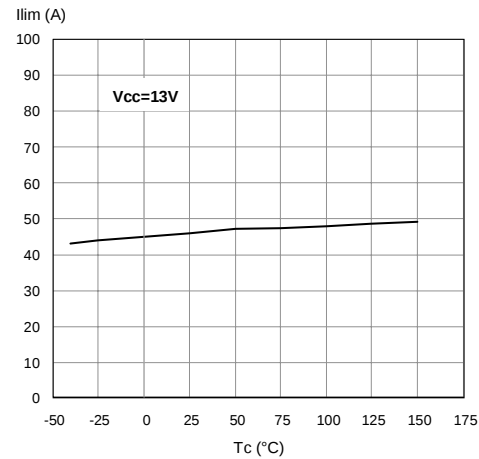
Input Hysteresis Voltage



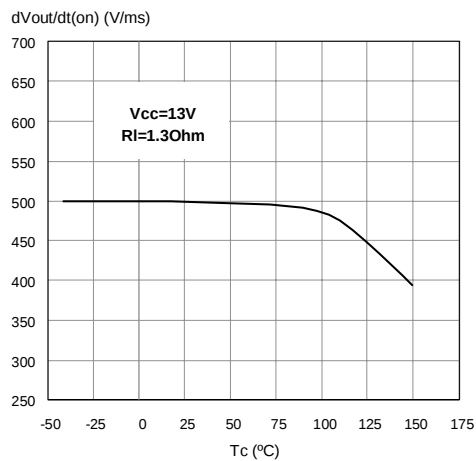
Overvoltage Shutdown



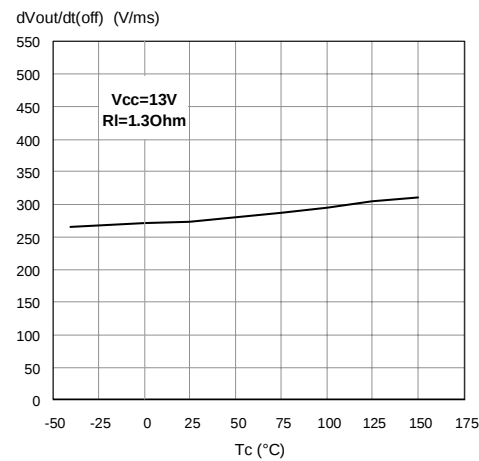
I<sub>LIM</sub> Vs T<sub>case</sub>



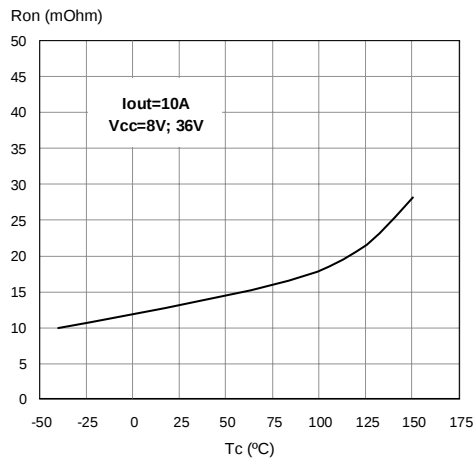
Turn-on Voltage Slope



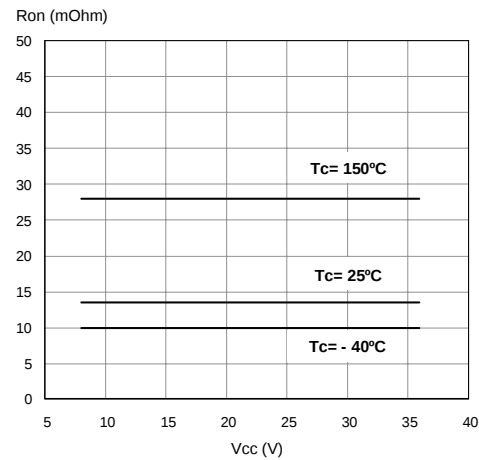
Turn-off Voltage Slope



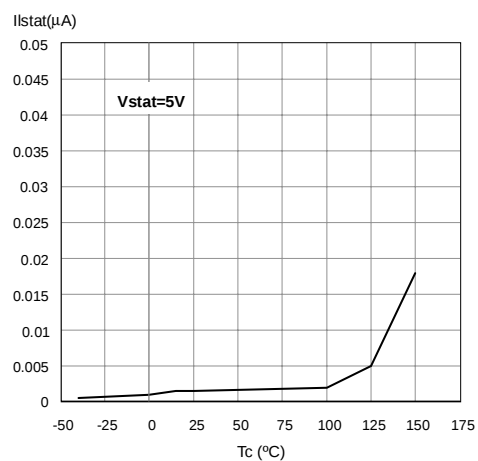
On State Resistance Vs T<sub>case</sub>



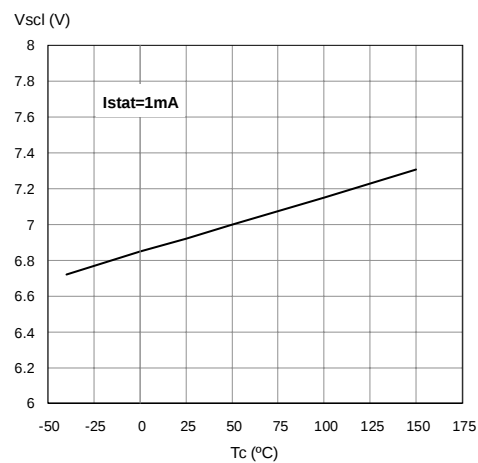
On State Resistance Vs V<sub>CC</sub>



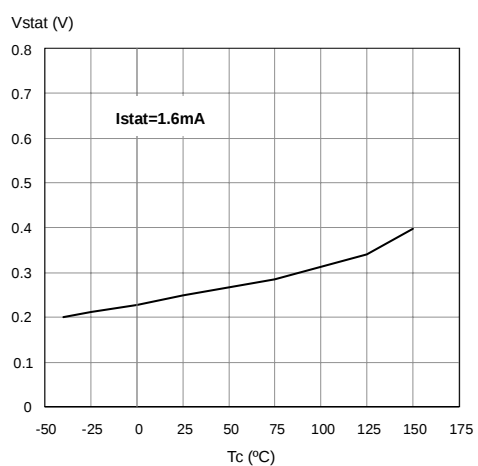
## Status Leakage Current



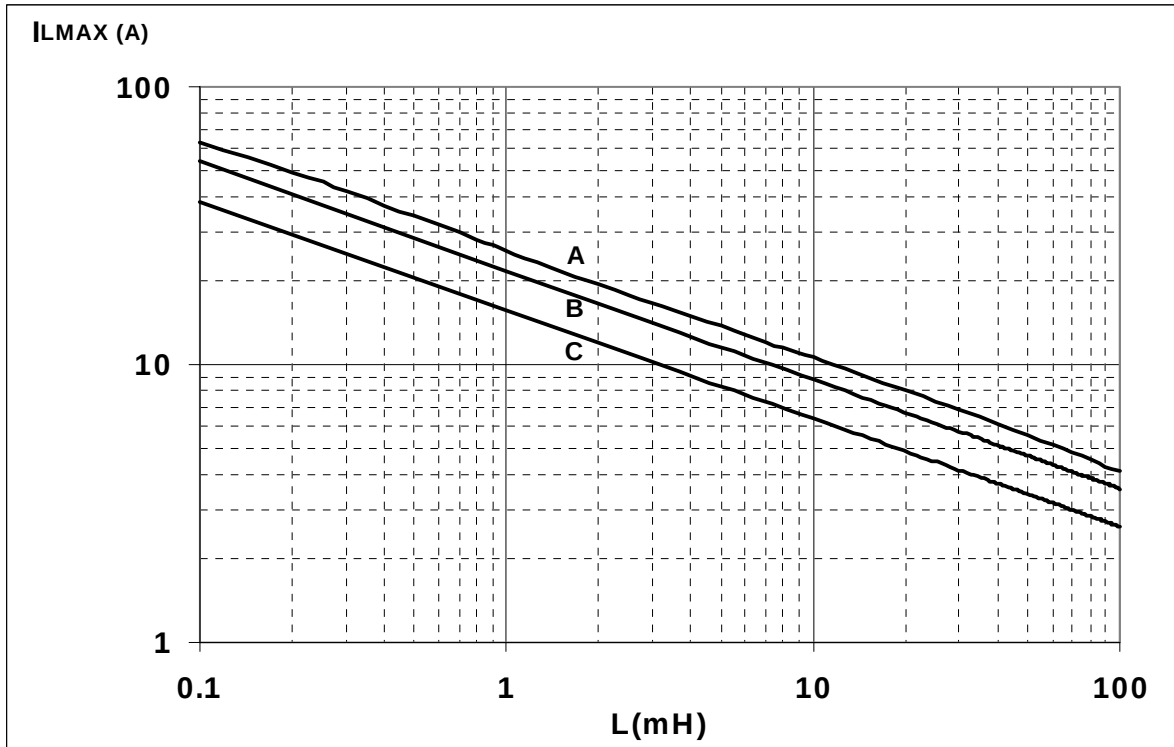
## Status Clamp Voltage



## Status Low Output Voltage



## Maximum turn off current versus load inductance



A = Single Pulse at  $T_{Jstart}=150^{\circ}\text{C}$

B = Repetitive pulse at  $T_{Jstart}=100^{\circ}\text{C}$

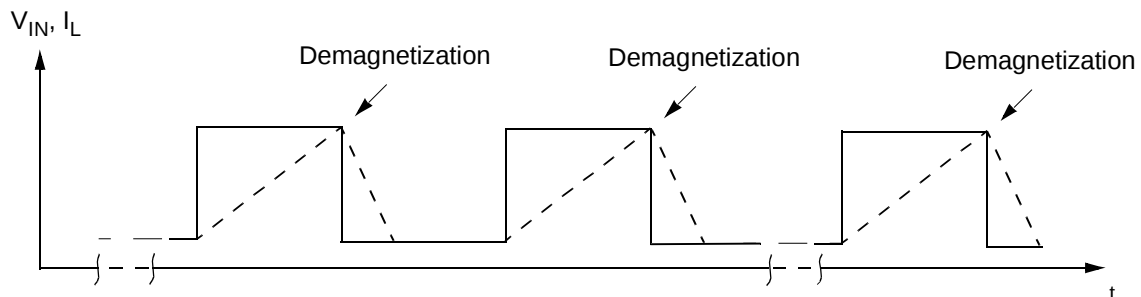
C = Repetitive Pulse at  $T_{Jstart}=125^{\circ}\text{C}$

Conditions:

$V_{CC}=13.5\text{V}$

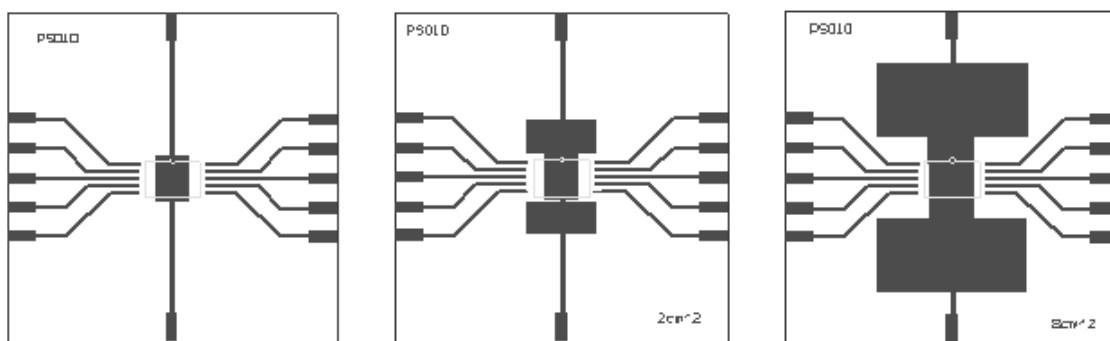
Values are generated with  $R_L=0\Omega$

In case of repetitive pulses,  $T_{Jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.



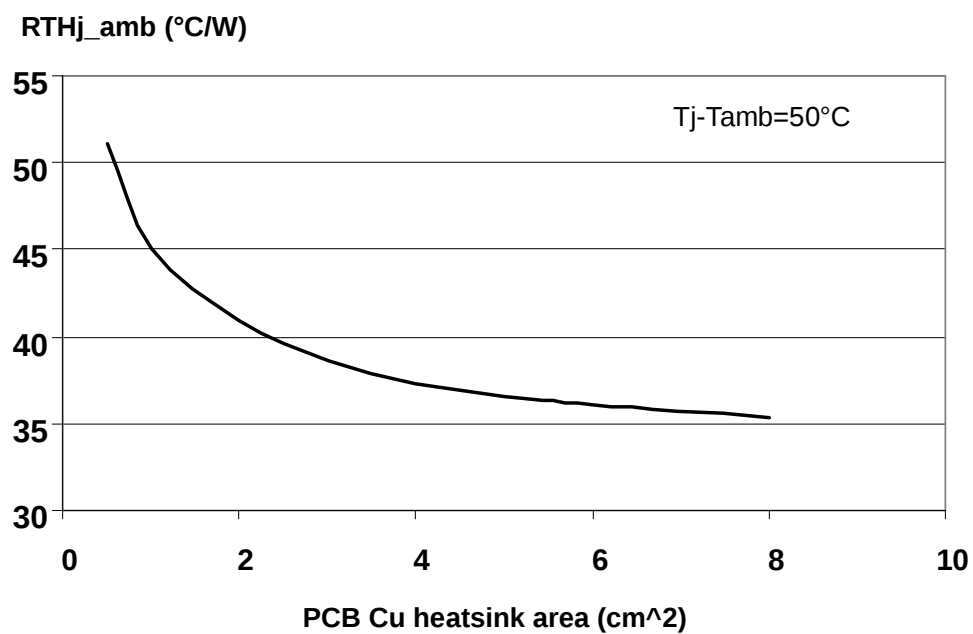
## PowerSO-10™ THERMAL DATA

### PowerSO-10™ PC Board

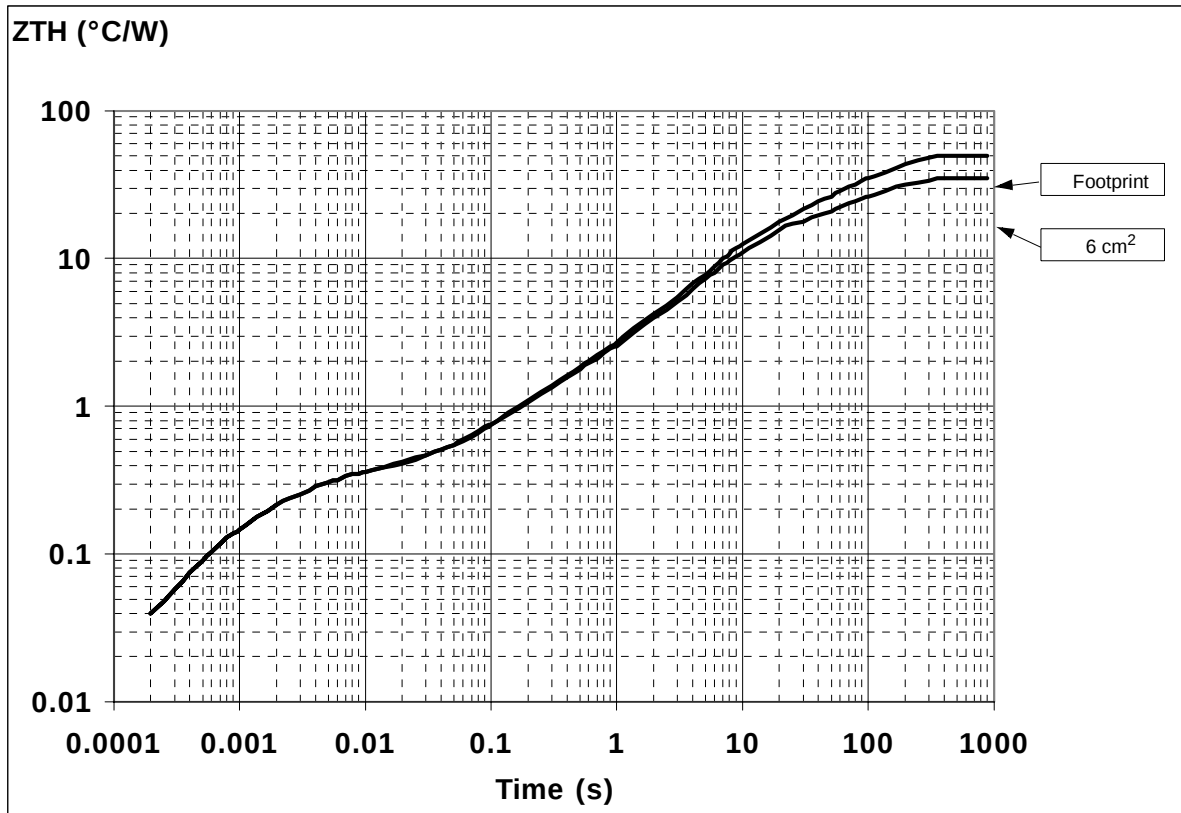


Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area= 58mm x 58mm, PCB thickness=2mm, Cu thickness=35 $\mu$ m, Copper areas: from minimum pad lay-out to 8cm<sup>2</sup>).

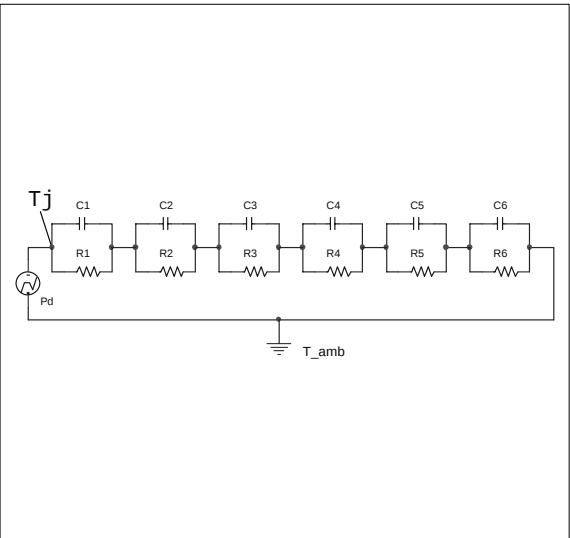
### $R_{thj-amb}$ Vs PCB copper area in open box free air condition



PowerSO-10 Thermal Impedance Junction Ambient Single Pulse



Thermal fitting model of a single channel HSD in PowerSO-10



Pulse calculation formula

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

where  $\delta = t_p / T$

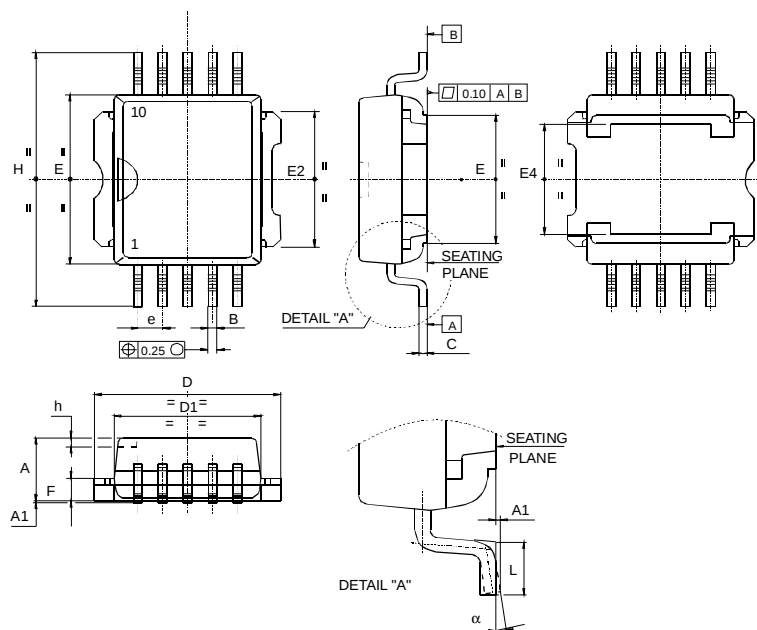
Thermal Parameter

| Area/island (cm <sup>2</sup> ) | Footprint | 6  |
|--------------------------------|-----------|----|
| R1 (°C/W)                      | 0.02      |    |
| R2 (°C/W)                      | 0.1       |    |
| R3 (°C/W)                      | 0.2       |    |
| R4 (°C/W)                      | 0.8       |    |
| R5 (°C/W)                      | 12        |    |
| R6 (°C/W)                      | 37        | 22 |
| C1 (W.s/°C)                    | 0.0015    |    |
| C2 (W.s/°C)                    | 7.00E-03  |    |
| C3 (W.s/°C)                    | 0.015     |    |
| C4 (W.s/°C)                    | 0.3       |    |
| C5 (W.s/°C)                    | 0.75      |    |
| C6 (W.s/°C)                    | 3         | 5  |

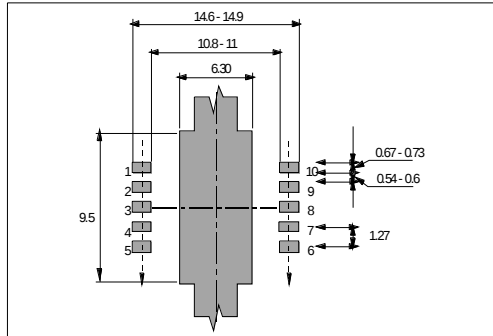
## PowerSO-10™ MECHANICAL DATA

| DIM.         | mm.   |      |       | inch  |       |        |
|--------------|-------|------|-------|-------|-------|--------|
|              | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.   |
| A            | 3.35  |      | 3.65  | 0.132 |       | 0.144  |
| A (*)        | 3.4   |      | 3.6   | 0.134 |       | 0.142  |
| A1           | 0.00  |      | 0.10  | 0.000 |       | 0.004  |
| B            | 0.40  |      | 0.60  | 0.016 |       | 0.024  |
| B (*)        | 0.37  |      | 0.53  | 0.014 |       | 0.021  |
| C            | 0.35  |      | 0.55  | 0.013 |       | 0.022  |
| C (*)        | 0.23  |      | 0.32  | 0.009 |       | 0.0126 |
| 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  |
| E2           | 7.20  |      | 7.60  | 0.283 |       | 300    |
| E2 (*)       | 7.30  |      | 7.50  | 0.287 |       | 0.295  |
| E4           | 5.90  |      | 6.10  | 0.232 |       | 0.240  |
| E4 (*)       | 5.90  |      | 6.30  | 0.232 |       | 0.248  |
| e            |       | 1.27 |       |       | 0.050 |        |
| F            | 1.25  |      | 1.35  | 0.049 |       | 0.053  |
| F (*)        | 1.20  |      | 1.40  | 0.047 |       | 0.055  |
| H            | 13.80 |      | 14.40 | 0.543 |       | 0.567  |
| H (*)        | 13.85 |      | 14.35 | 0.545 |       | 0.565  |
| h            |       | 0.50 |       |       | 0.002 |        |
| L            | 1.20  |      | 1.80  | 0.047 |       | 0.070  |
| L (*)        | 0.80  |      | 1.10  | 0.031 |       | 0.043  |
| $\alpha$     | 0°    |      | 8°    | 0°    |       | 8°     |
| $\alpha$ (*) | 2°    |      | 8°    | 2°    |       | 8°     |

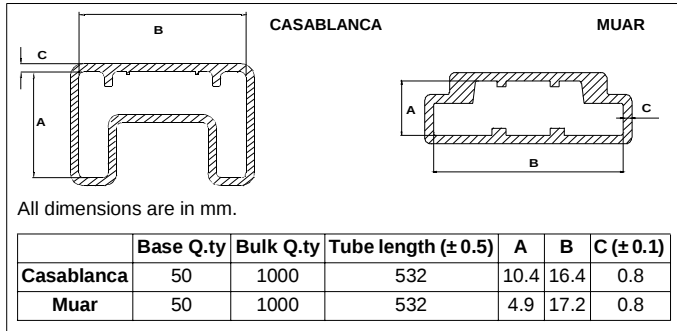
(\*) Muar only POA P013P



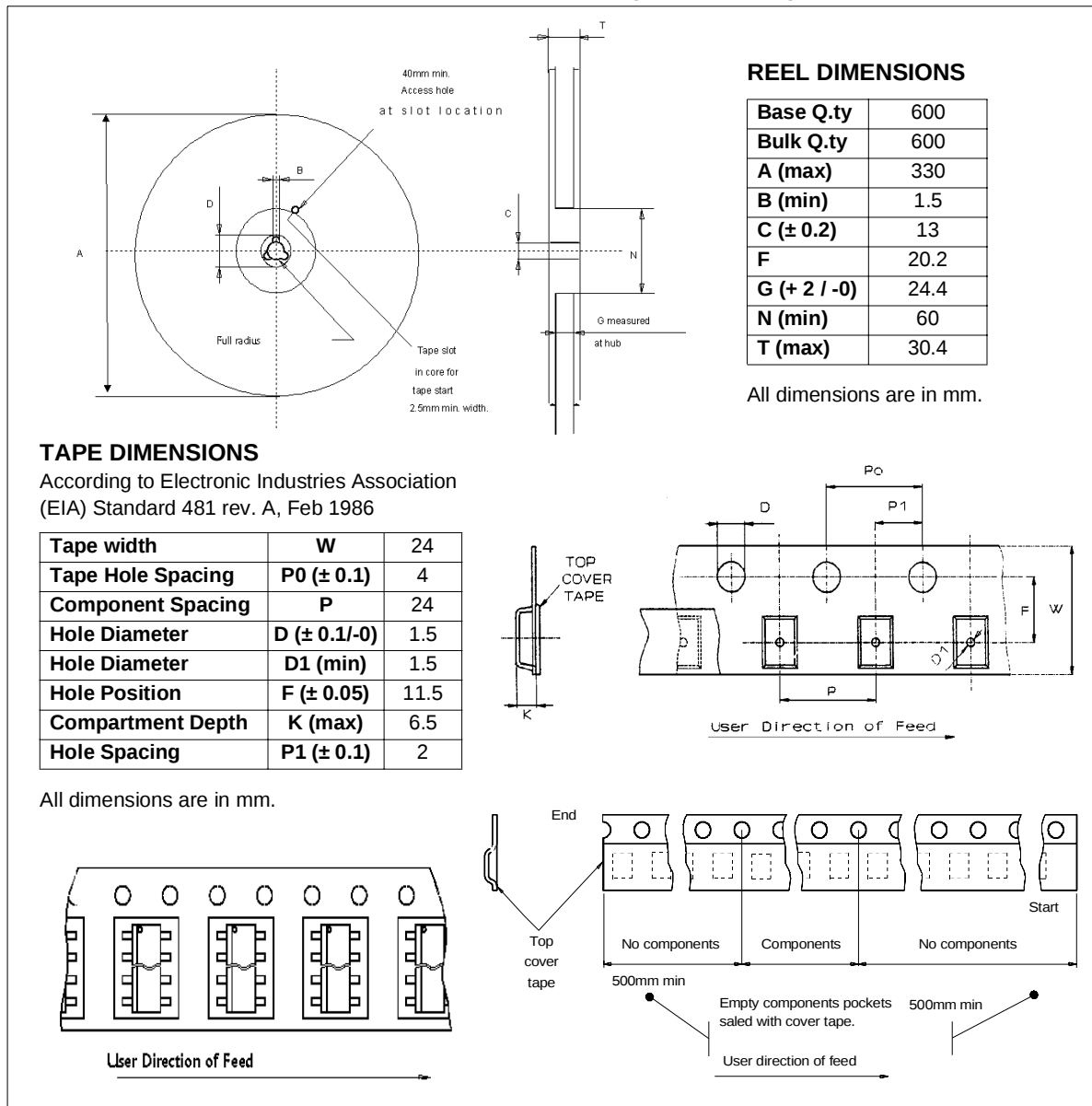
**PowerSO-10™ SUGGESTED PAD LAYOUT**



**TUBE SHIPMENT (no suffix)**



**TAPE AND REEL SHIPMENT (suffix "13TR")**



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