



# VN920DSP

## HIGH SIDE DRIVER

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

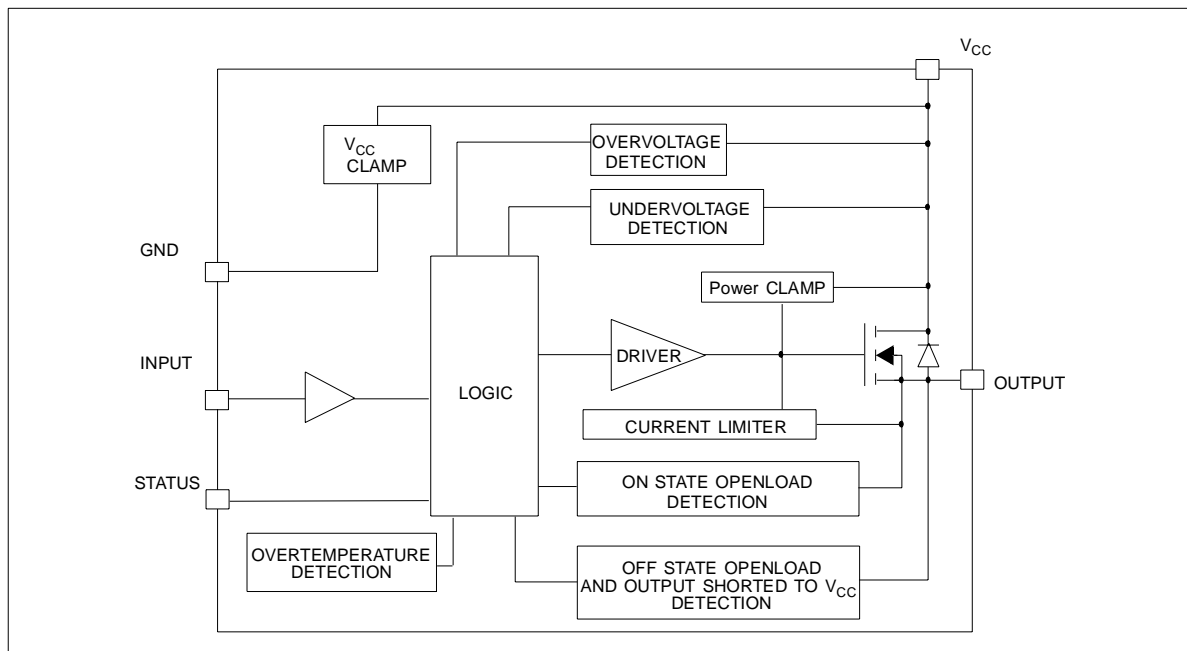
- CMOS COMPATIBLE INPUT
- ON STATE OPEN LOAD DETECTION
- OFF STATE OPEN LOAD DETECTION
- SHORTED LOAD PROTECTION
- UNDERVOLTAGE AND OVERVOLTAGE SHUTDOWN
- PROTECTION AGAINST LOSS OF GROUND
- VERY LOW STAND-BY CURRENT
- REVERSE BATTERY PROTECTION (\*)

### DESCRIPTION

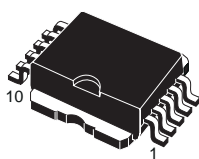
The VN920DSP is a monolithic device made by using STMicroelectronics VIPower M0-3 Technology, intended for driving any kind of load with one side connected to ground.

Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table). Active current limitation

### BLOCK DIAGRAM



(\*) See application schematic at page 8



**PowerSO-10™**

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

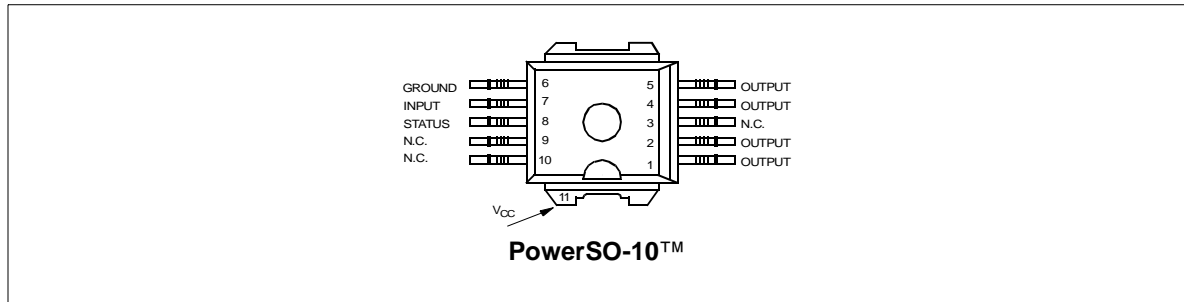
The device detects open load condition both is on and off state. Output shorted to  $V_{CC}$  is detected in the off state. Device automatically turns off in case of ground pin disconnection.

# VN920DSP

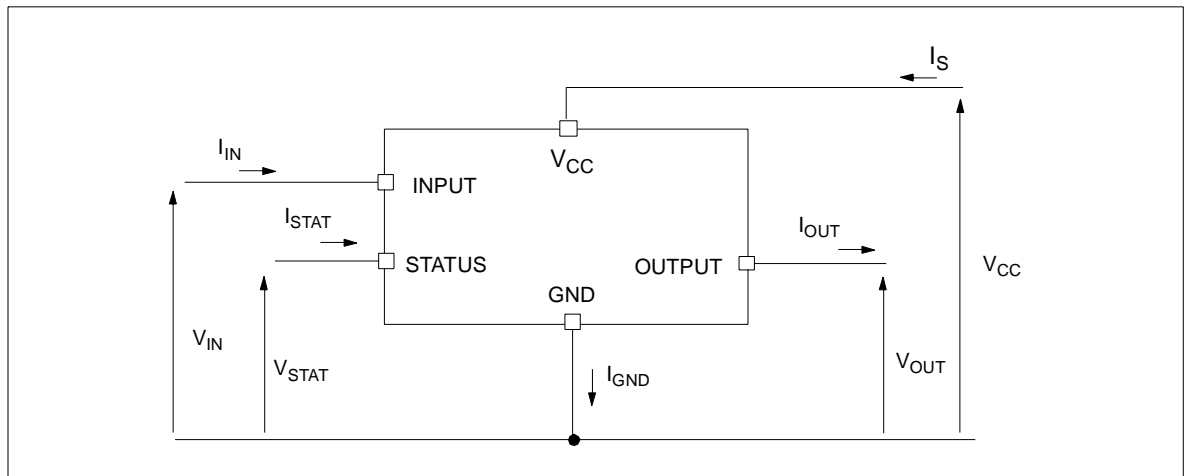
## ABSOLUTE MAXIMUM RATING

| 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 <sub>L</sub> =0 $\Omega$ ; V <sub>bat</sub> =13.5V; T <sub>jstart</sub> =150 $^{\circ}$ C; I <sub>L</sub> =45A) | 362                | mJ           |
| $P_{tot}$  | Power Dissipation T <sub>C</sub> =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 <sub>thj-case</sub> | Thermal Resistance Junction-case    | Max 1.3      | °C/W |
| R <sub>thj-amb</sub>  | 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<br>I <sub>OUT</sub> =10A<br>I <sub>OUT</sub> =3A; V <sub>CC</sub> =6V  |     |          | 16<br>30<br>50 | mΩ<br>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 |     | 10<br>10 | 25<br>20<br>5  | 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             |

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<br>I <sub>IN</sub> =-1mA | 6    | 6.8<br>-0.7 | 8    | V<br>V |

**ELECTRICAL CHARACTERISTICS** (continued)  
STATUS PIN

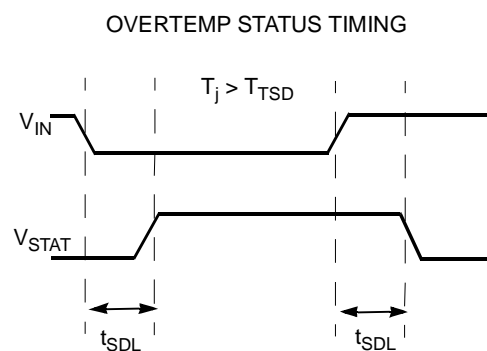
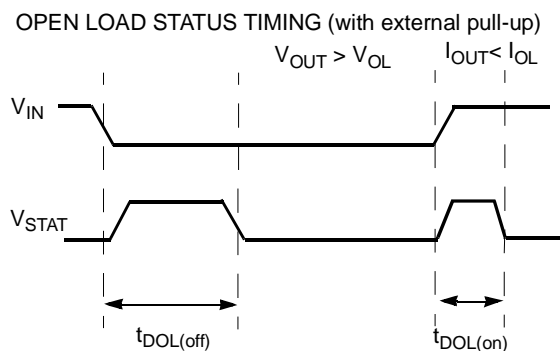
| Symbol      | Parameter                    | Test Conditions                | Min | Typ  | Max | Unit    |
|-------------|------------------------------|--------------------------------|-----|------|-----|---------|
| $V_{STAT}$  | Status Low Output Voltage    | $I_{STAT}=1.6mA$               |     |      | 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

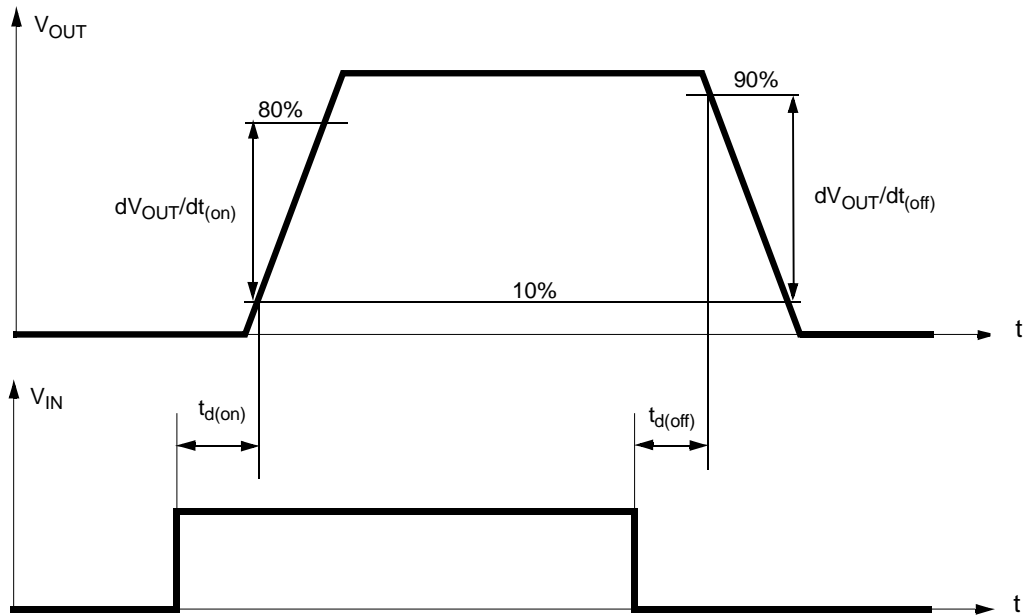
| Symbol      | Parameter                          | Test Conditions                | Min         | Typ         | Max         | Unit        |
|-------------|------------------------------------|--------------------------------|-------------|-------------|-------------|-------------|
| $T_{TSD}$   | Shut-down 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           |
| $V_{demag}$ | 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 | $\mu s$ |



## 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                   |

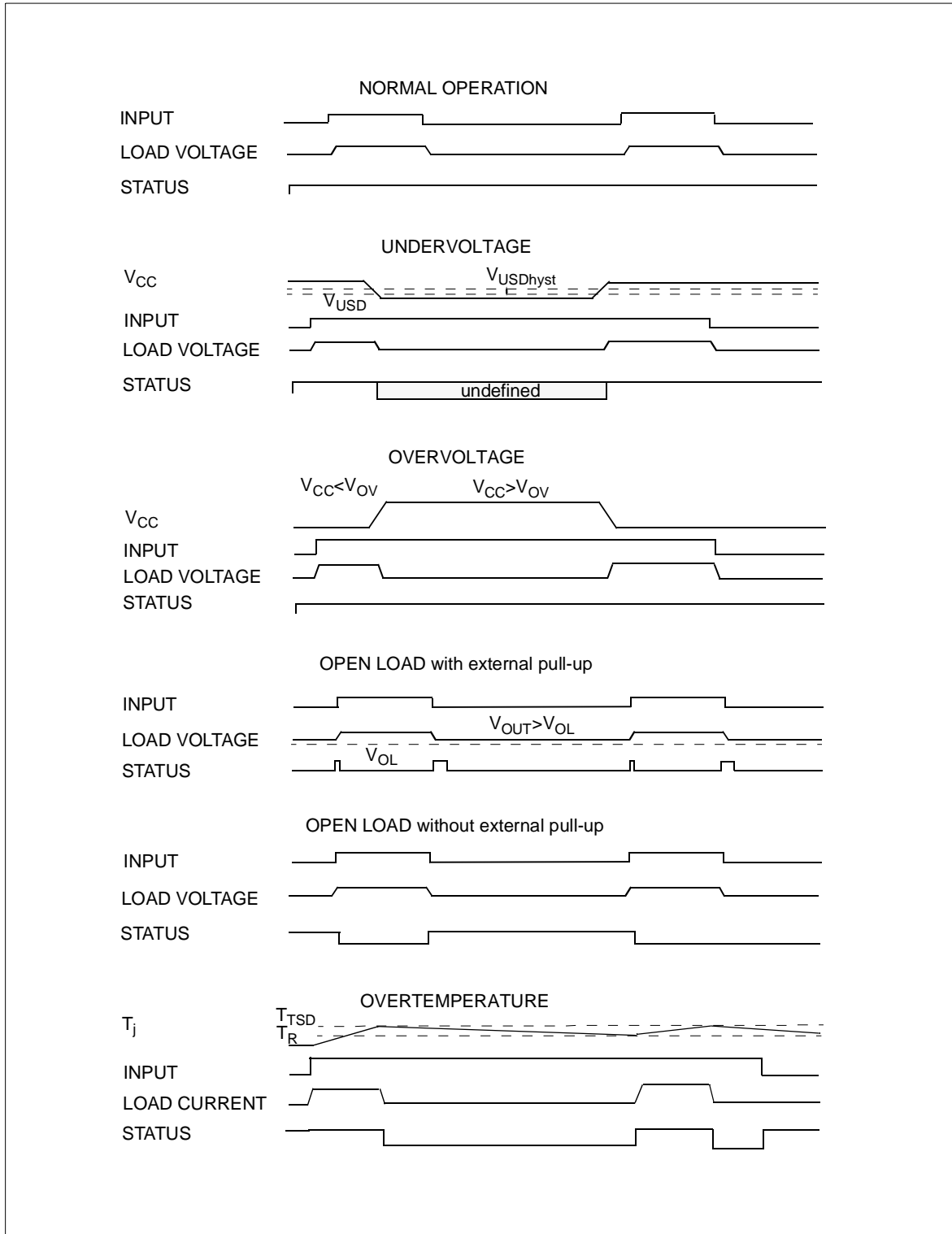
**ELECTRICAL TRANSIENT REQUIREMENTS ON V<sub>CC</sub> PIN**

| ISO T/R 7637/1<br>Test Pulse | TEST LEVELS |         |         |         | Delays and<br>Impedance |
|------------------------------|-------------|---------|---------|---------|-------------------------|
|                              | I           | II      | III     | IV      |                         |
| 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             |

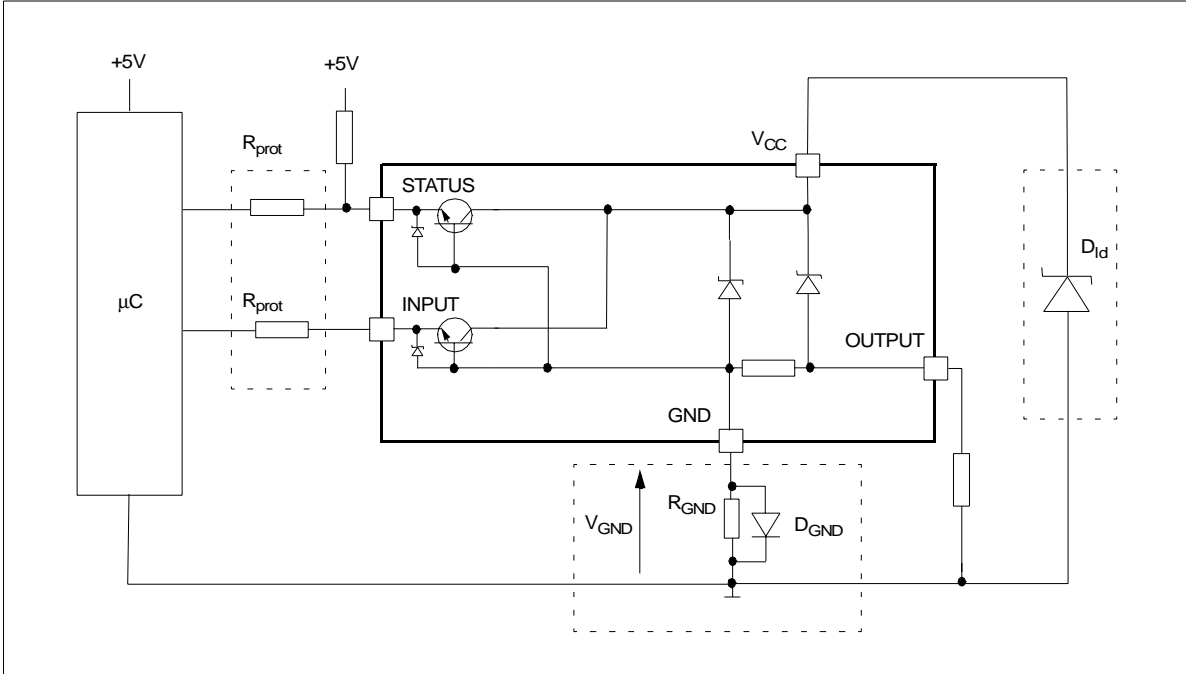
| ISO T/R 7637/1<br>Test Pulse | TEST LEVELS RESULTS |    |     |    |
|------------------------------|---------------------|----|-----|----|
|                              | I                   | II | III | IV |
| 1                            | C                   | C  | C   | C  |
| 2                            | 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  |
|----------|---|
| <b>C</b> | All functions of the device are performed as designed after exposure to disturbance.  |
| <b>E</b> | 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<sub>GND</sub> only). This can be used with any type of load.

The following is an indication on how to dimension the R<sub>GND</sub> resistor.

- 1)  $R_{GND} \leq 600mV / (I_{S(on)max})$ .
- 2)  $R_{GND} \geq (-V_{CC}) / (-I_{GND})$

where -I<sub>GND</sub> 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<sub>GND</sub> (when V<sub>CC</sub><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<sub>S(on)max</sub> 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<sub>GND</sub> will produce a shift (I<sub>S(on)max</sub> \* R<sub>GND</sub>) 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<sub>GND</sub>.

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<sub>GND</sub>) in the ground line.

A resistor (R<sub>GND</sub>=1kΩ) should be inserted in parallel to D<sub>GND</sub> 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 (≈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<sub>Id</sub> is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds V<sub>CC</sub> max DC rating. The same applies if the device will be subject to transients on the V<sub>CC</sub> 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 transient are present on the V<sub>CC</sub> line, the control pins will be pulled negative. ST suggests to insert a resistor (R<sub>prot</sub>) 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.

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

Calculation example:

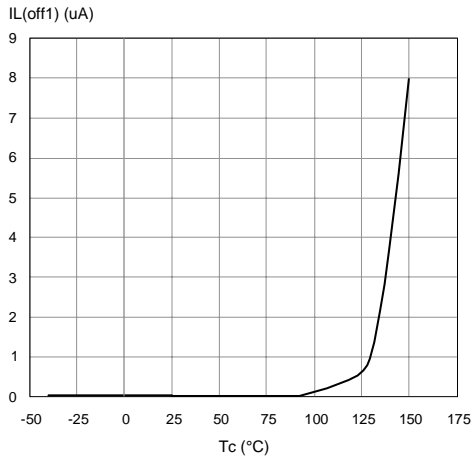
For V<sub>CCpeak</sub>= - 100V and I<sub>latchup</sub> ≥ 20mA; V<sub>OHµC</sub> ≥ 4.5V

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

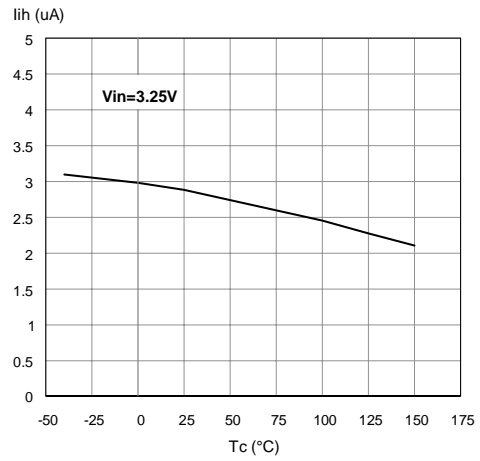
Recommended R<sub>prot</sub> value is 10kΩ.



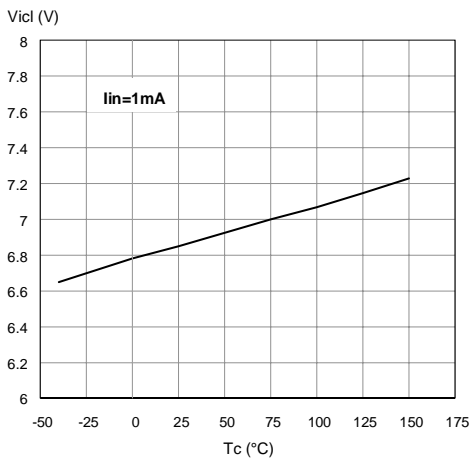
Off State Output Current



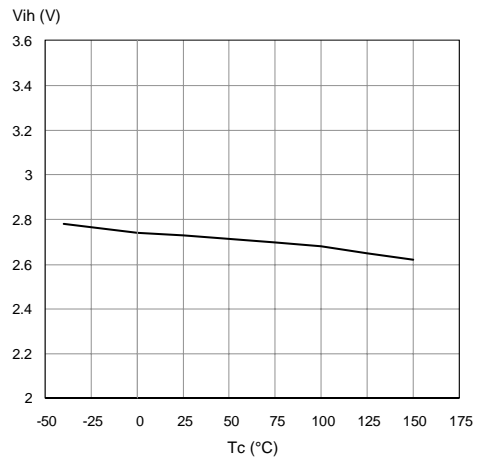
High Level Input Current



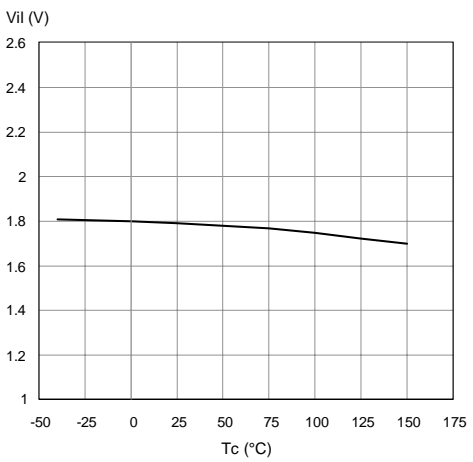
Input Clamp Voltage



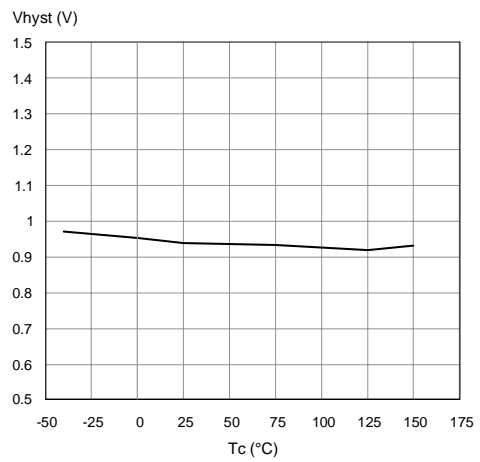
Input High Level



Input Low Level

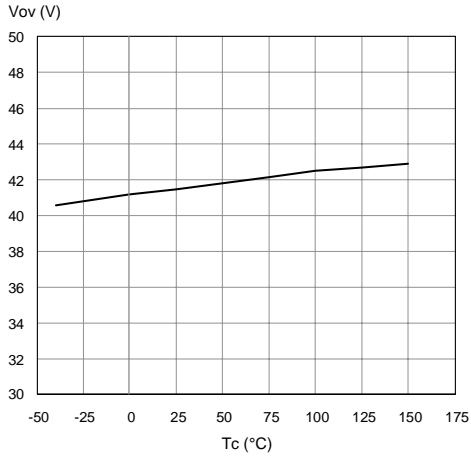


Input Hysteresis Voltage

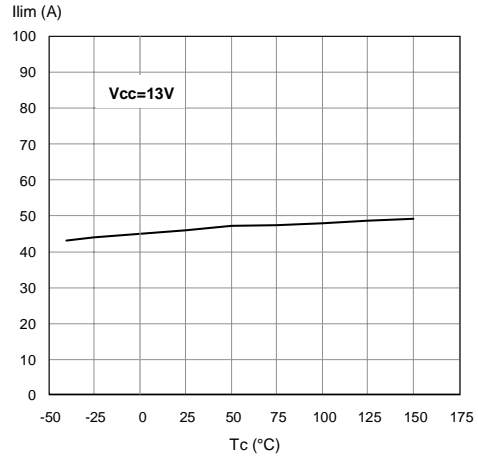


# VN920DSP

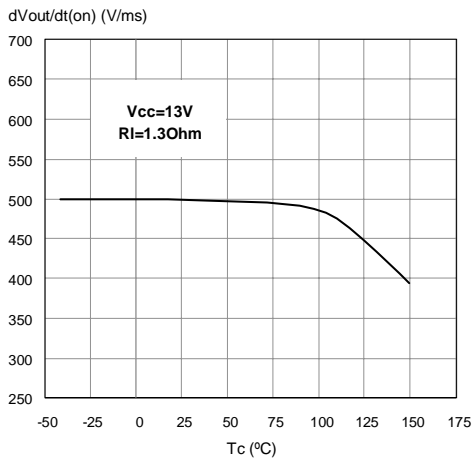
## Overvoltage Shutdown



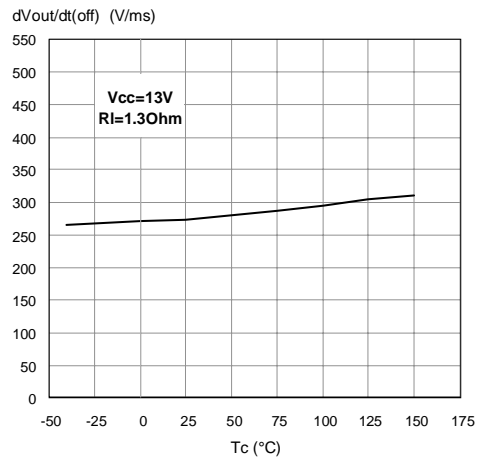
## I<sub>LIM</sub> Vs T<sub>case</sub>



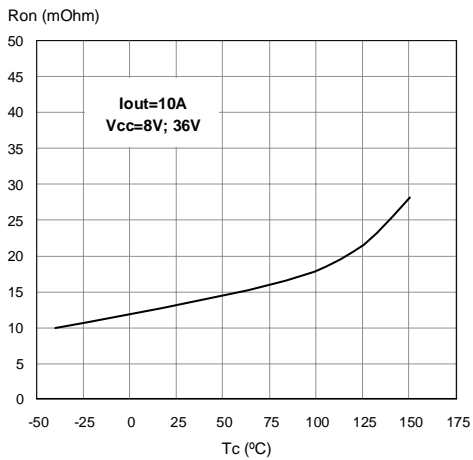
## Turn-on Voltage Slope



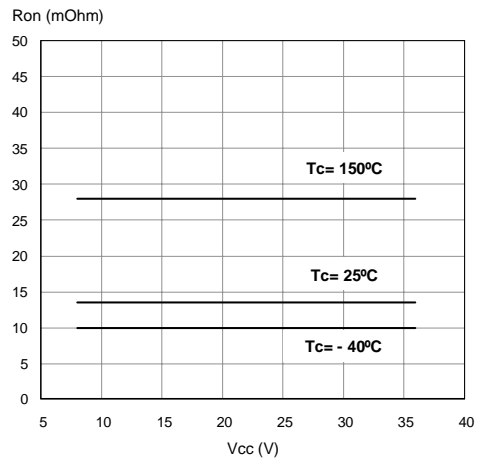
## Turn-off Voltage Slope



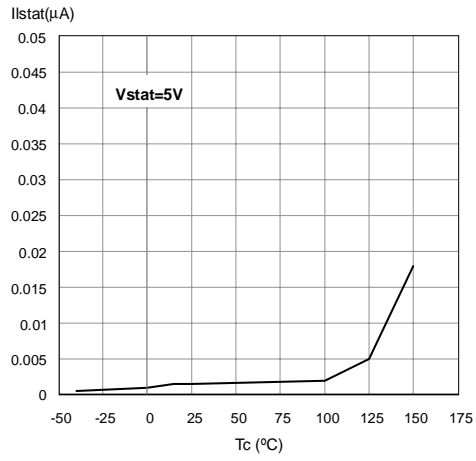
## On State Resistance Vs T<sub>case</sub>



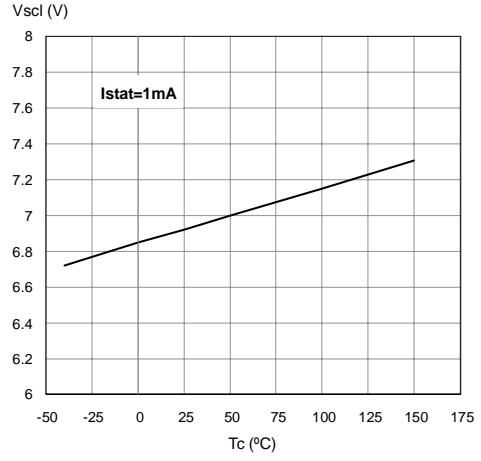
## On State Resistance Vs V<sub>CC</sub>



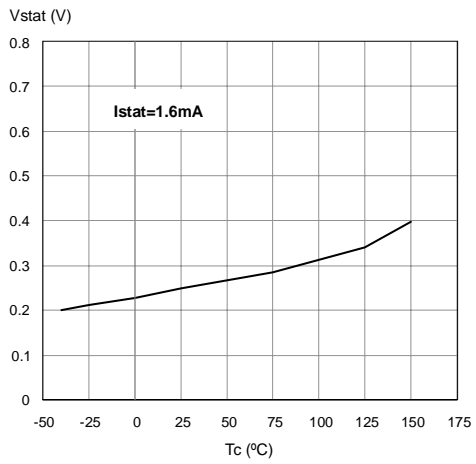
Status Leakage Current



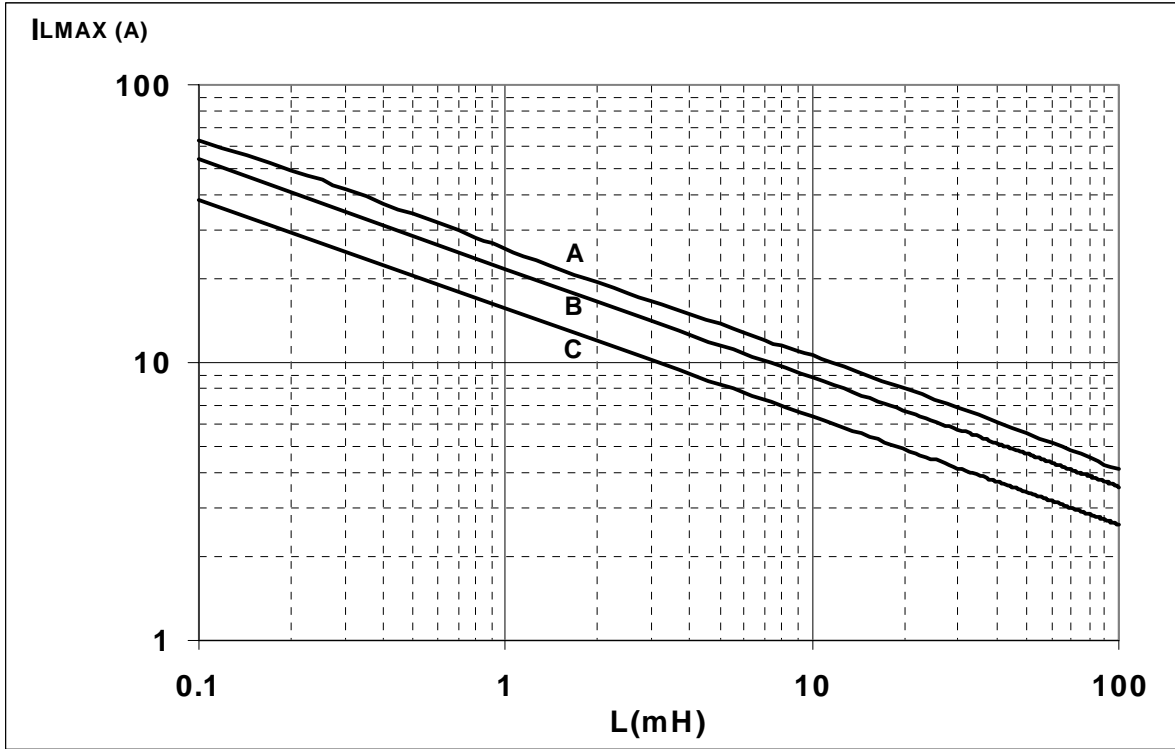
Status Clamp Voltage



Status Low Output Voltage



Maximum turn off current versus load inductance



- A = Single Pulse at  $T_{Jstart}=150^{\circ}C$
- B= Repetitive pulse at  $T_{Jstart}=100^{\circ}C$
- C= Repetitive Pulse at  $T_{Jstart}=125^{\circ}C$

Conditions:

$V_{CC}=13.5V$

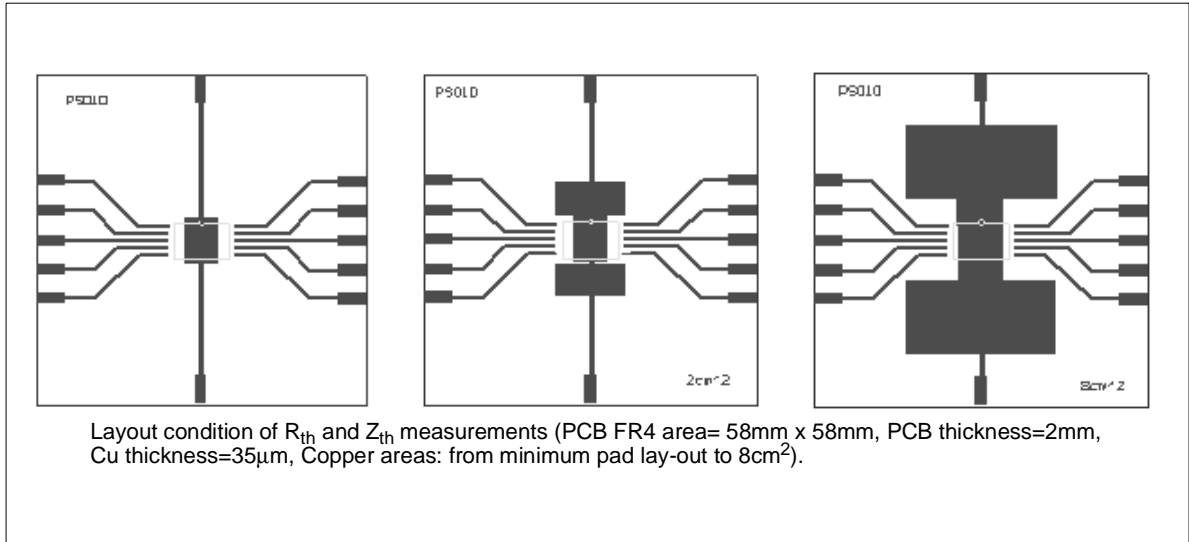
Values are generated with  $R_L=0\Omega$

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.

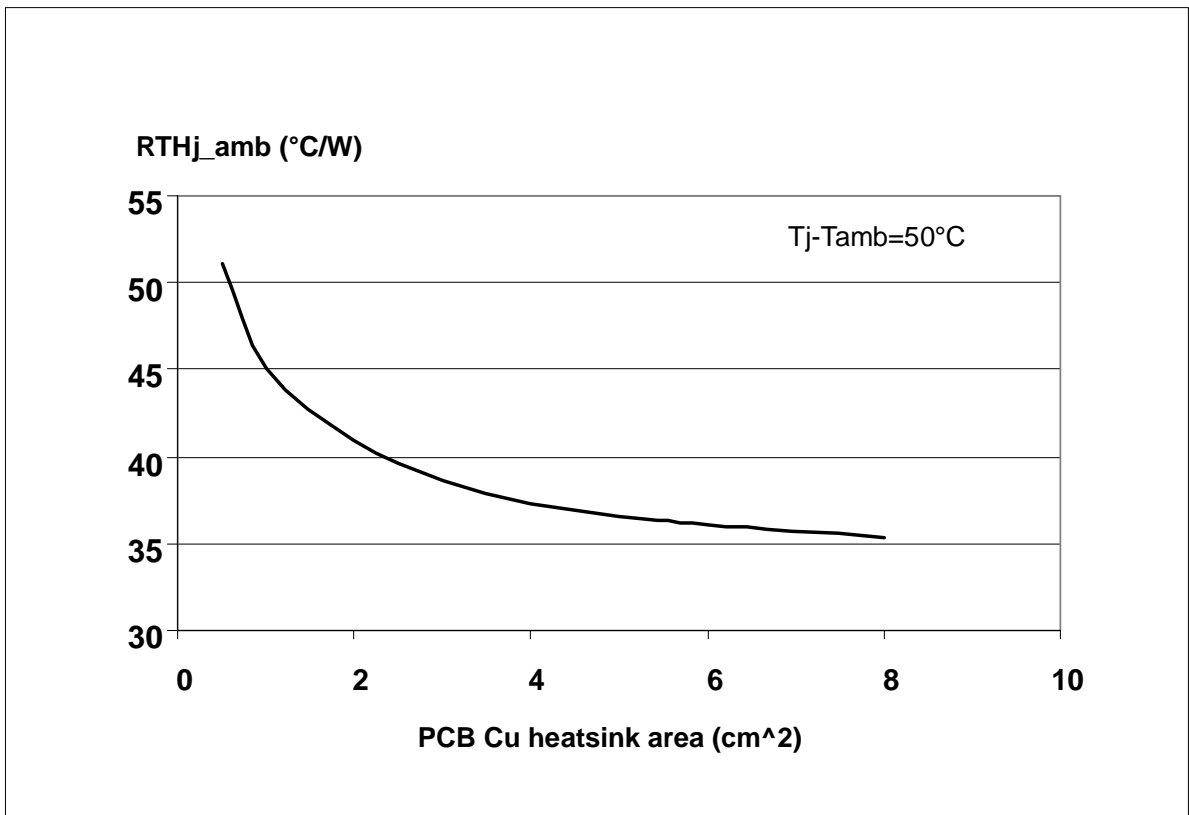


**PowerSO-10™ THERMAL DATA**

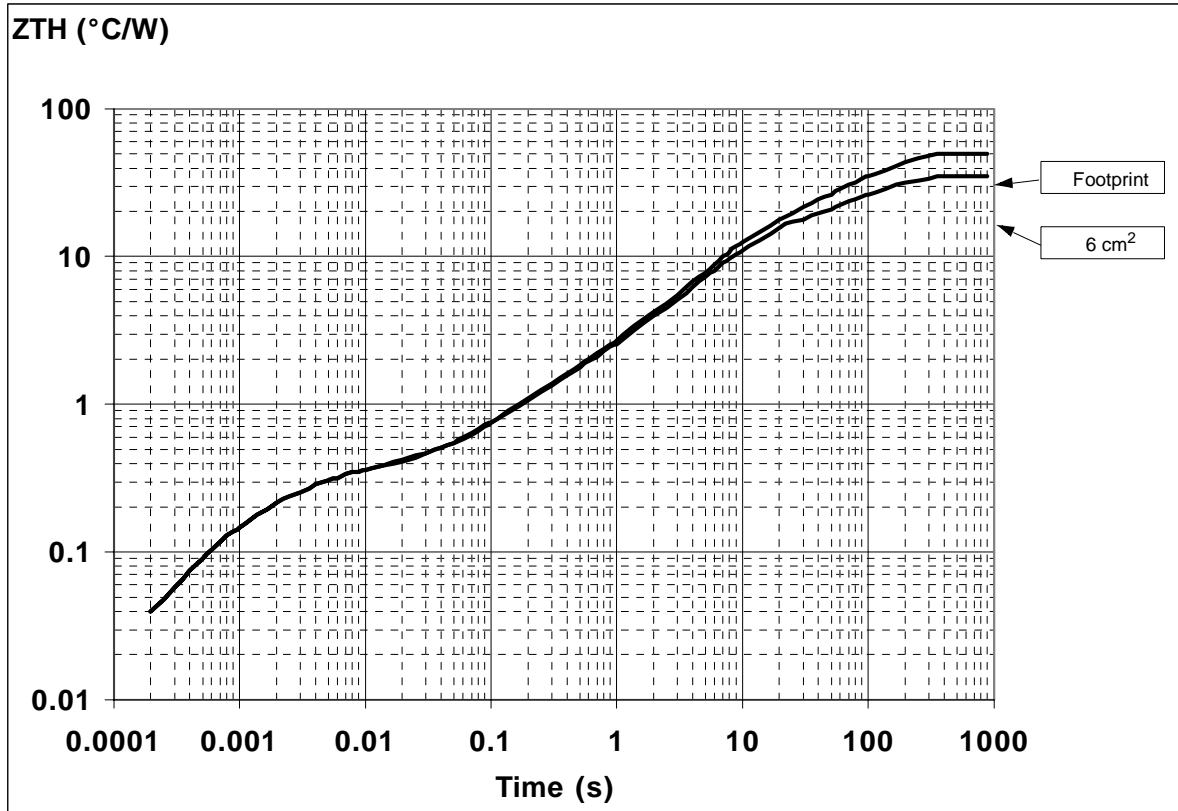
**PowerSO-10™ PC Board**



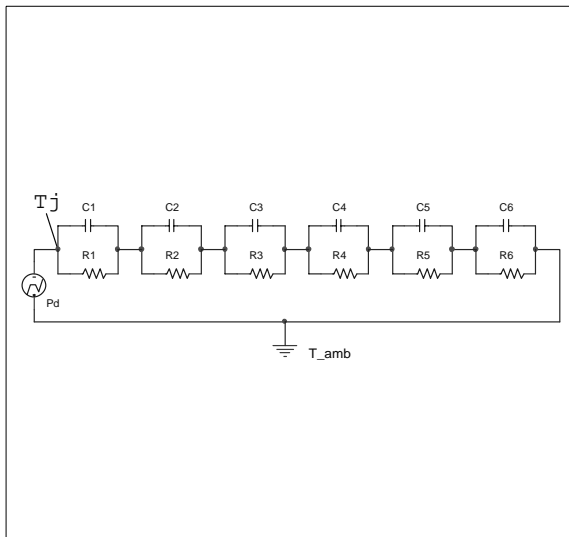
**$R_{thj-amb}$  Vs PCB copper area in open box free air condition**



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  $\delta = t_p/T$

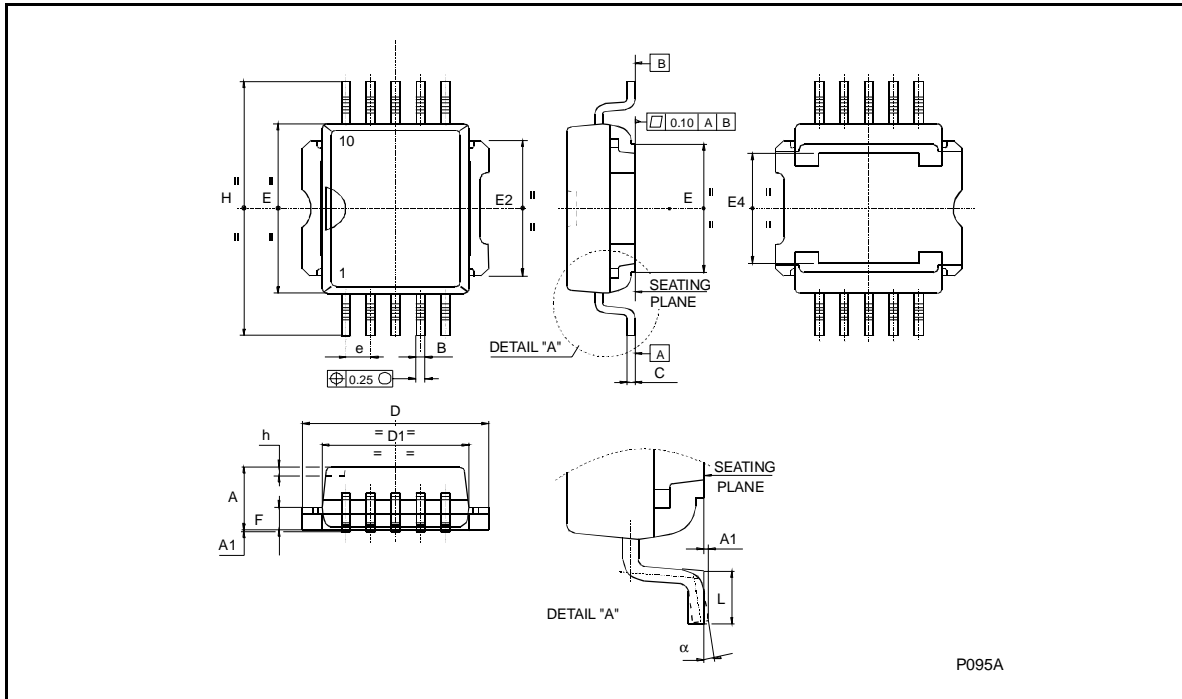
Thermal Parameter

| 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  |
| α      | 0°    |      | 8°    | 0°    |       | 8°     |
| α (*)  | 2°    |      | 8°    | 2°    |       | 8°     |

(\*) Muar only POA P013P



# VN920DSP

## PowerSO-10™ SUGGESTED PAD LAYOUT



## TUBE SHIPMENT (no suffix)

All dimensions are in mm.

|                   | Base Q.ty | Bulk Q.ty | Tube length (±0.5) | A    | B    | C (±0.1) |
|-------------------|-----------|-----------|--------------------|------|------|----------|
| <b>Casablanca</b> | 50        | 1000      | 532                | 10.4 | 16.4 | 0.8      |
| <b>Muar</b>       | 50        | 1000      | 532                | 4.9  | 17.2 | 0.8      |

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

### REEL DIMENSIONS

|             |      |
|-------------|------|
| Base Q.ty   | 600  |
| Bulk Q.ty   | 600  |
| A (max)     | 330  |
| B (min)     | 1.5  |
| C (±0.2)    | 13   |
| F           | 20.2 |
| G (+2 / -0) | 24.4 |
| N (min)     | 60   |
| T (max)     | 30.4 |

All dimensions are in mm.

### TAPE DIMENSIONS

According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

|                   |             |      |
|-------------------|-------------|------|
| Tape width        | W           | 24   |
| Tape Hole Spacing | P0 (±0.1)   | 4    |
| Component Spacing | P           | 24   |
| Hole Diameter     | D (±0.1/-0) | 1.5  |
| Hole Diameter     | D1 (min)    | 1.5  |
| Hole Position     | F (±0.05)   | 11.5 |
| Compartment Depth | K (max)     | 6.5  |
| Hole Spacing      | P1 (±0.1)   | 2    |

All dimensions are in mm.



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