



VNQ690SP

QUAD CHANNEL HIGH SIDE SOLID STATE RELAY

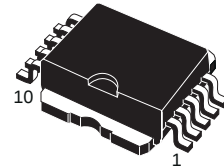
TYPE	R _{DS(on)}	I _{OUT}	V _{CC}
VNQ690SP	90mΩ (*)	10 A	36 V

(*) Per each channel

- OUTPUT CURRENT PER CHANNEL: 10A
- CMOS COMPATIBLE INPUTS
- OPEN LOAD DETECTION (OFF STATE)
- UNDERVOLTAGE & OVERVOLTAGE SHUT- DOWN
- OVERVOLTAGE CLAMP
- THERMAL SHUT-DOWN
- CURRENT LIMITATION
- VERY LOW STAND-BY POWER DISSIPATION
- PROTECTION AGAINST:
 - LOSS OF GROUND & LOSS OF V_{CC}
- REVERSE BATTERY PROTECTION (**)

DESCRIPTION

The VNQ690SP is a monolithic device made by using STMicroelectronics VIPower M0-3



PowerSO-10™

ORDER CODES

PACKAGE	TUBE	T&R
PowerSO-10	VNQ690SP	VNQ690SP13TR

Technology, intended for driving resistive or inductive loads with one side connected to ground. This device has four independent channels. Built-in thermal shut down and output current limitation protect the chip from over temperature and short circuit.

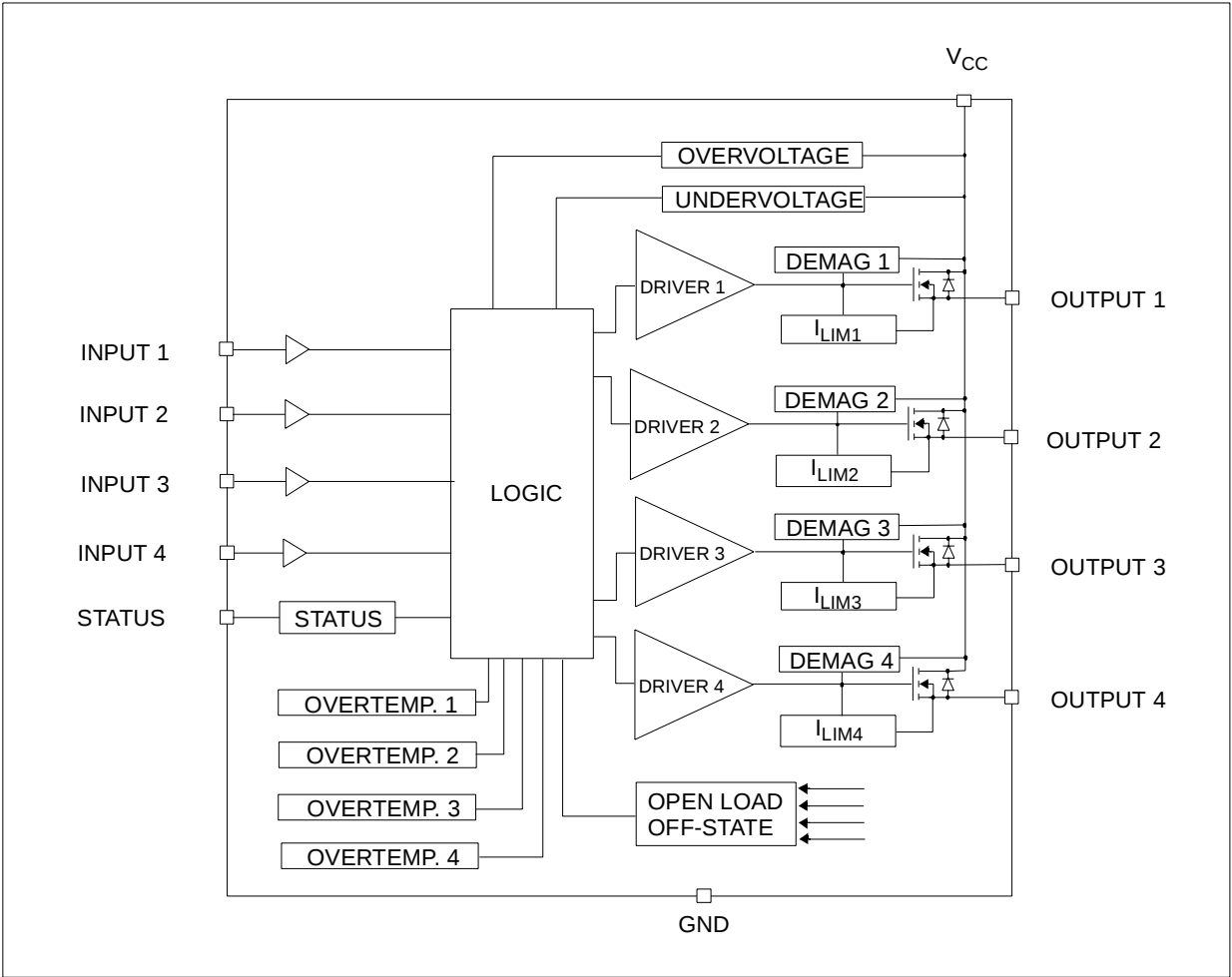
ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value	Unit
V _{CC}	Supply voltage (continuous)	41	V
-V _{CC}	Reverse supply voltage (continuous)	-0.3	V
I _{OUT}	Output current (continuous), per each channel	Internally limited	A
I _R	Reverse output current (continuous), per each channel	-15	A
I _{IN}	Input current	+/- 10	mA
I _{STAT}	Status current	+/- 10	mA
I _{GND}	Ground current at T _C ≤25°C (continuous)	-200	mA
V _{ESD}	Electrostatic Discharge (Human Body Model: R=1.5KΩ; C=100pF)		
	- INPUT	4000	V
	- STATUS	4000	V
	- OUTPUT	5000	V
	- V _{CC}	5000	V
P _{tot}	Power dissipation at T _C =25°C	78	W
E _{MAX}	Maximum Switching Energy (L=0.38mH; R _L =0Ω; V _{bat} =13.5V; T _{jstart} =150°C; I _L =14A)	53	mJ
T _j	Junction operating temperature	-40 to 150	°C
T _{stg}	Storage temperature	-65 to 150	°C

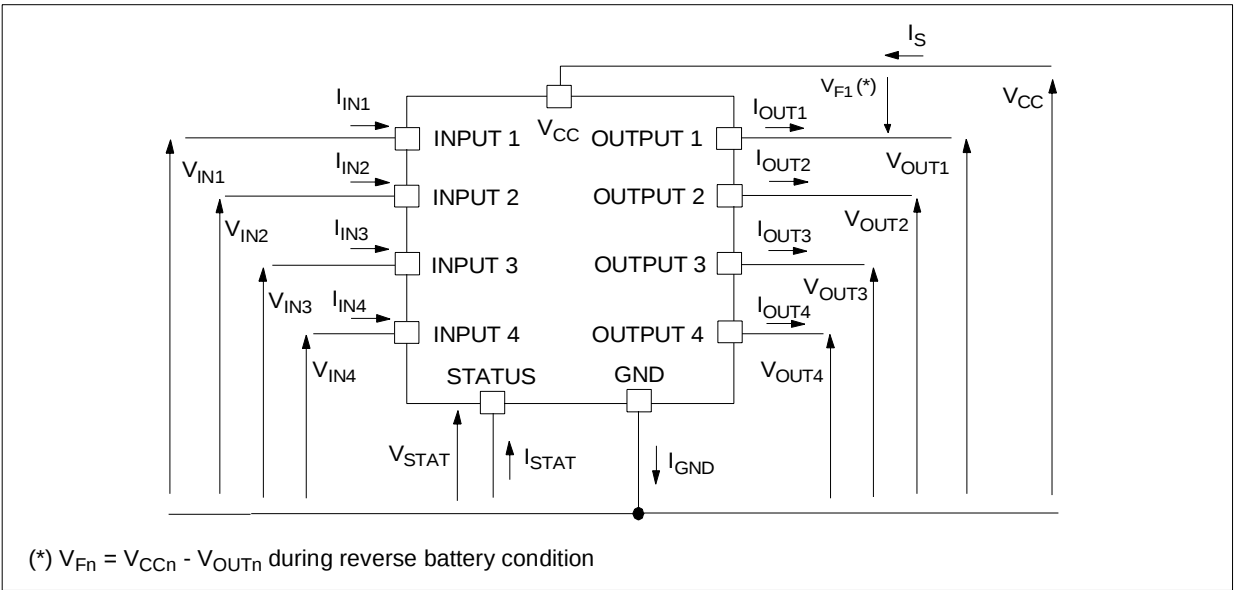
(**) See application schematic at page 8

Rev. 1

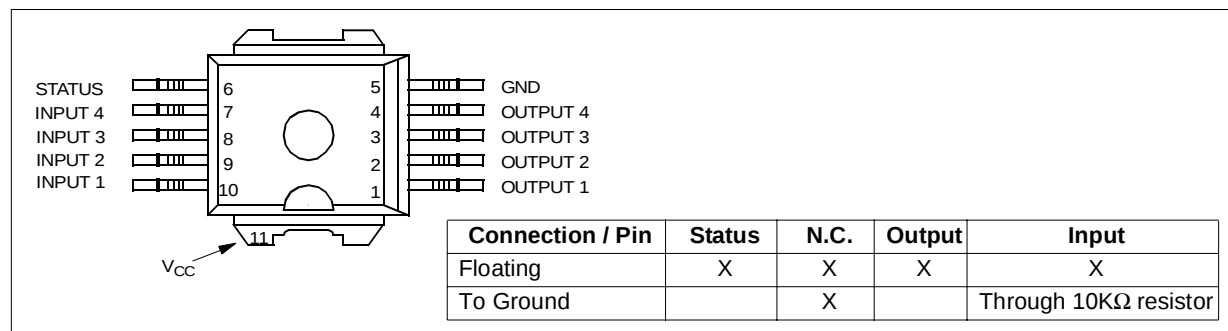
BLOCK DIAGRAM



CURRENT AND VOLTAGE CONVENTIONS



CONFIGURATION DIAGRAM (TOP VIEW) & SUGGESTED CONNECTIONS FOR UNUSED AND N.C. PINS



THERMAL DATA

Symbol	Parameter	Value		Unit
$R_{thj-case}$	Thermal resistance junction-case (MAX) per channel	2		°C/W
R_{tj-amb}	Thermal resistance junction-ambient (MAX)	52 ⁽¹⁾	37 ⁽²⁾	°C/W

(1) When mounted on a standard single-sided FR-4 board with 0.5cm² of Cu (at least 35 μm thick).

(2) When mounted on a standard single-sided FR-4 board with 6cm² of Cu (at least 35 μm thick).

ELECTRICAL CHARACTERISTICS ($V_{CC}=6V$ up to 24V; $-40^{\circ}C < T_J < 150^{\circ}C$ unless otherwise specified)

POWER (per each channel)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{CC}(\#)$	Operating supply voltage		6	13	36	V
$V_{USD}(\#)$	Undervoltage shutdown		3.5	4.6	6	V
$V_{UVhyst}(\#)$	Undervoltage hysteresis		0.2		1	V
$V_{OV}(\#)$	Overvoltage shutdown		36			V
$V_{OVhyst}(\#)$	Overvoltage hysteresis		0.25			V
$I_S(\#)$	Supply current	Off state; $V_{IN}=V_{OUT}=0V$; $V_{CC}=13.5V$		12	40	μA
		Off state; $V_{IN}=V_{OUT}=0V$; $V_{CC}=13.5V$ $T_J=25^{\circ}C$		12	25	μA
		On state; $V_{IN}=3.25V$; $9V < V_{CC} < 18V$		6	12	mA
R_{ON}	On state resistance	$I_{OUT}=1A$; $T_J=25^{\circ}C$; $9V < V_{CC} < 18V$			90	mΩ
		$I_{OUT}=1A$; $T_J=150^{\circ}C$; $9V < V_{CC} < 18V$			180	mΩ
$I_{L(off1)}$	Off State Output Current	$V_{IN}=V_{OUT}=0V$	0		50	μA
$I_{L(off2)}$	Off State Output Current	$V_{IN}=0V$; $V_{OUT}=3.5V$	-75		0	μA
$I_{L(off3)}$	Off State Output Current	$V_{IN}=V_{OUT}=0V$; $V_{CC}=13V$; $T_J=125^{\circ}C$			5	μA
$I_{L(off4)}$	Off State Output Current	$V_{IN}=V_{OUT}=0V$; $V_{CC}=13V$; $T_J=25^{\circ}C$			3	μA

(#) Per device.

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$t_{d(on)}$	Turn-on delay time	$R_L=13\Omega$ channels 1,2,3,4		30		μs
$t_{d(off)}$	Turn-off delay time	$R_L=13\Omega$ channels 1,2,3,4		30		μs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L=13\Omega$ channels 1,2,3,4		See relative diagram		V/μs
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L=13\Omega$ channels 1,2,3,4		See relative diagram		V/μs

ELECTRICAL CHARACTERISTICS (continued)

PROTECTIONS (per each channel) (see note 1)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
T_{TSD}	Shutdown temperature		150	170	200	°C
T_R	Reset temperature		135			°C
T_{hyst}	Thermal hysteresis		7	15	25	°C
I_{LIM}	DC Short circuit current	$9V < V_{CC} < 36V$ $6V < V_{CC} < 36V$	10	14	20 20	A A
V_{demag}	Turn-off output voltage clamp	$I_{OUT}=2A$; $V_{IN}=0V$; $L=6mH$	$V_{CC}-41$	$V_{CC}-48$	$V_{CC}-55$	V
V_{STAT}	Status low output voltage	$I_{STAT}=1.6mA$			0.5	V
I_{LSTAT}	Status leakage current	Normal operation; $V_{STAT}=5V$			10	μA
C_{STAT}	Status pin input capacitance	Normal operation; $V_{STAT}=5V$			25	pF
V_{SCL}	Status clamp voltage	$I_{STAT}=1mA$ $I_{STAT}=-1mA$	6	6.8 -0.7	8	V 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.

LOGIC INPUT (per each channel)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IL}	Input Low Level Voltage				1.25	V
V_{IH}	Input High Level Voltage		3.25			V
V_{HYST}	Input Hysteresis Voltage		0.5			V
I_{IH}	Input high level voltage	$V_{IN}=3.25V$			10	μA
I_{IL}	Input Current	$V_{IN}=1.25V$	1			μA
V_{ICL}	Input Clamp Voltage	$I_{IN}=1mA$ $I_{IN}=-1mA$	6	6.8 -0.7	8	V V

OPENLOAD DETECTION (off state) per each channel

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
t_{SDL}	Status Delay	See Figure 1 (Openload detection reading must be performed after T_{DOL}).			20	μs
V_{OL}	Openload Voltage Detection Threshold	$V_{IN}=0V$	1.5	2.5	3.5	V
T_{DOL}	Openload Detection Delay at Turn Off	$V_{CC}=18V$ (*)			300	μs

VCC - OUTPUT DIODE

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_F	Forward on Voltage	$-I_{OUT}=0.9A$; $T_J=150^\circ C$			0.6	V

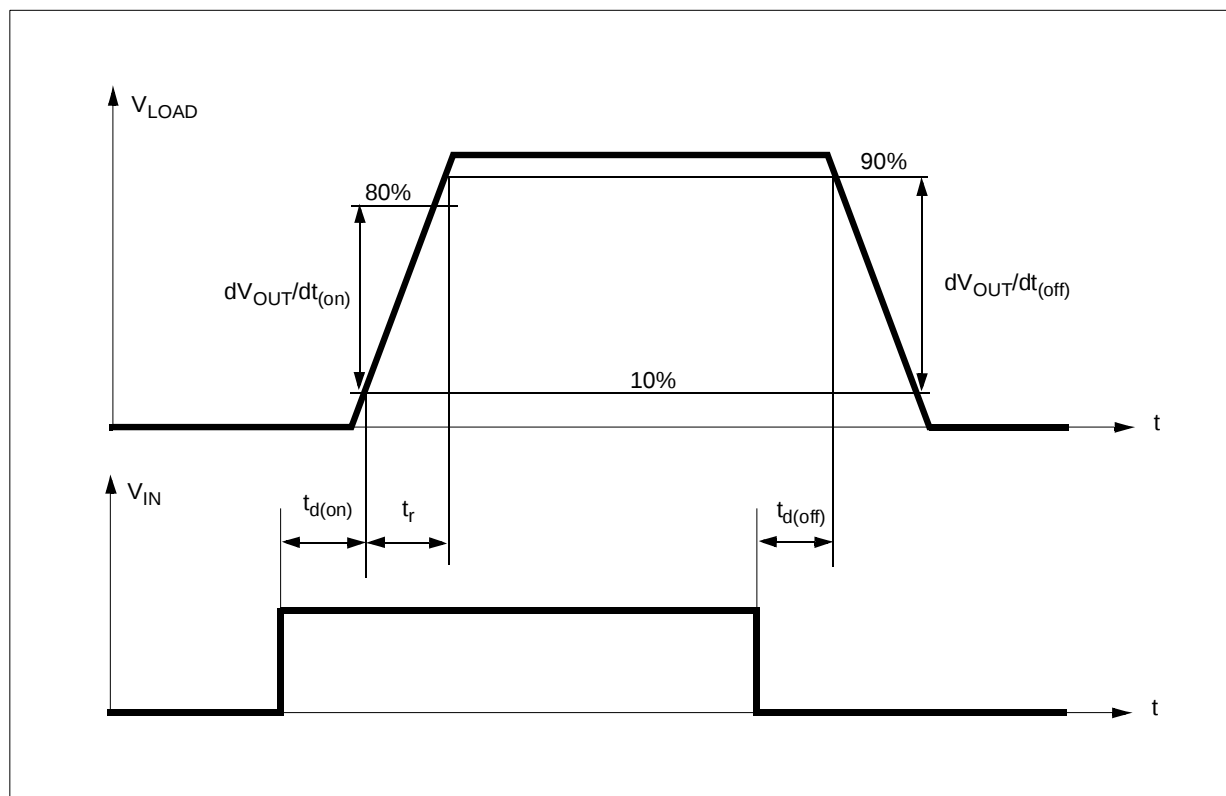
ELECTRICAL TRANSIENT REQUIREMENTS

ISO T/R 7637/1 Test Pulse	TEST LEVELS				Delays and 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 μ s 50 Ω
3b	+25 V	+50 V	+75 V	+100 V	0.1 μ s 50 Ω
4	-4 V	-5 V	-6 V	-7 V	100 ms, 0.01 Ω

ISO T/R 7637/1 Test Pulse	Test Levels Result			
	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 and cannot be returned to proper operation without replacing the device.

SWITCHING CHARACTERISTICS



TRUTH TABLE (per each channel)

CONDITIONS	INPUT	OUTPUT	STATUS
Normal Operation	L	L	H
	H	H	H
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Overvoltage	L	L	H
	H	L	H
Current Limitation	L	L	H
	H	X	H
Output Voltage > V_{OL}	L	H	L
	H	H	H

Figure 1: Status timing waveforms

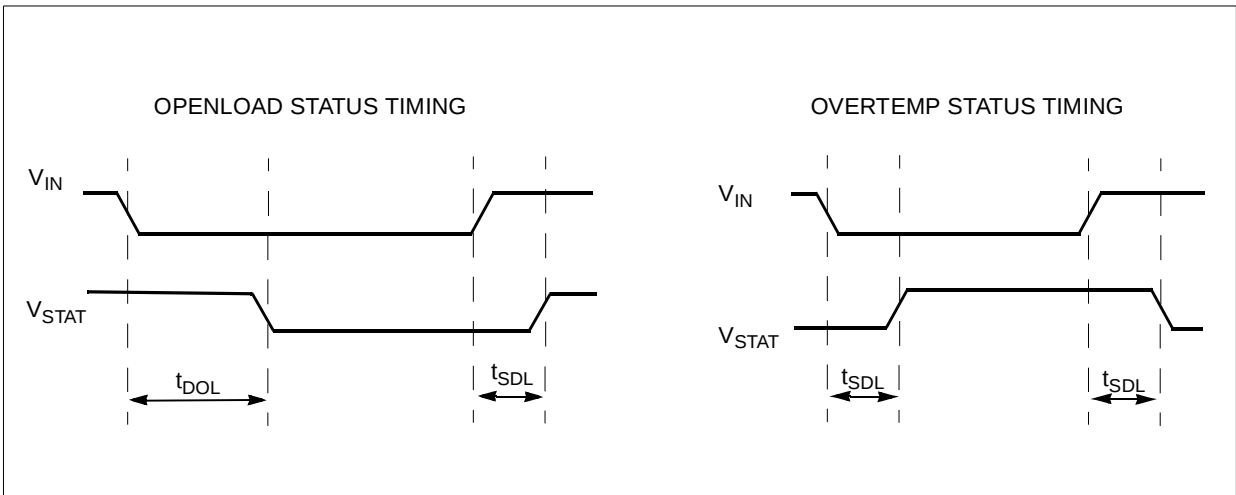
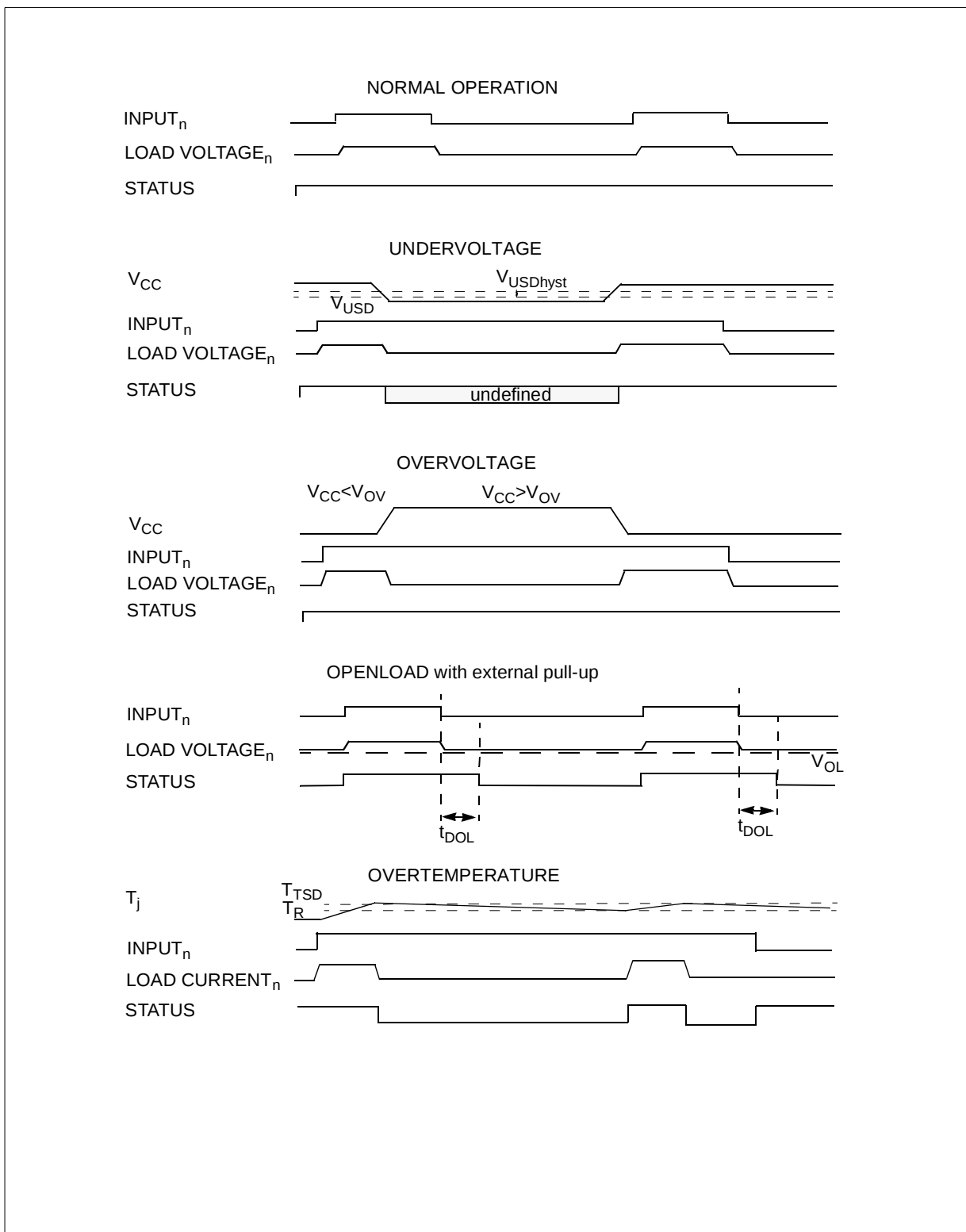
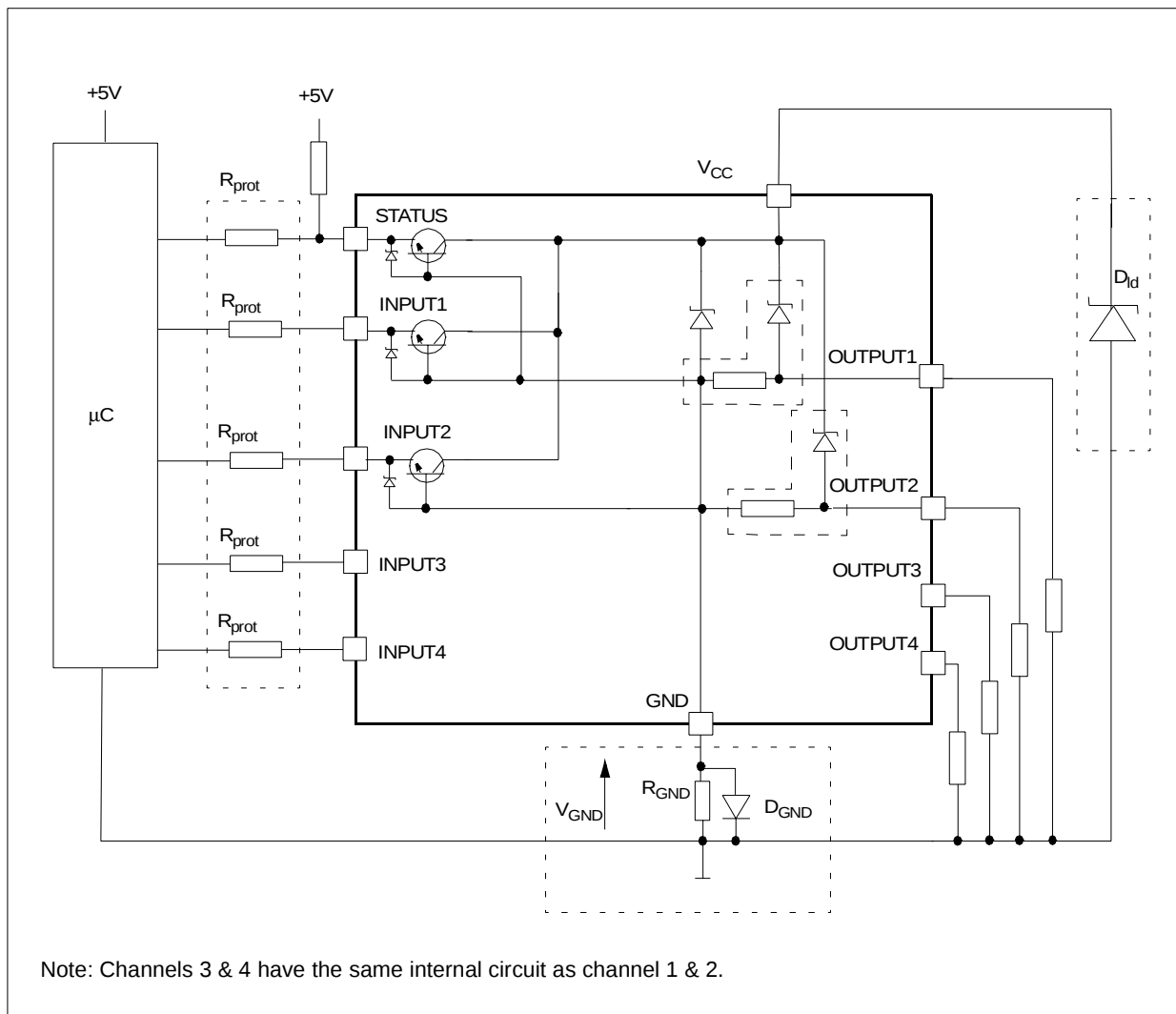


Figure 2: Waveforms



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 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 ($R_{GND} = 1\text{k}\Omega$) 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_{ld} 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 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 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.

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

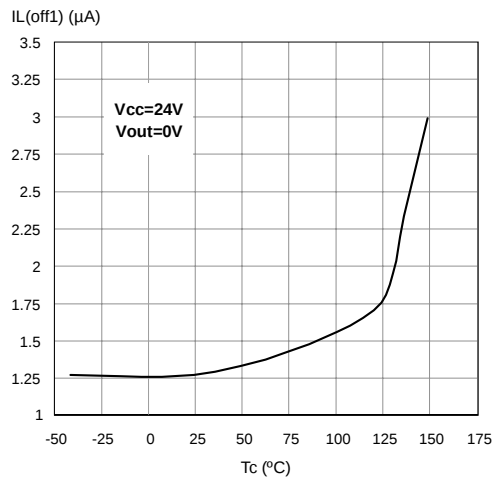
Calculation example:

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

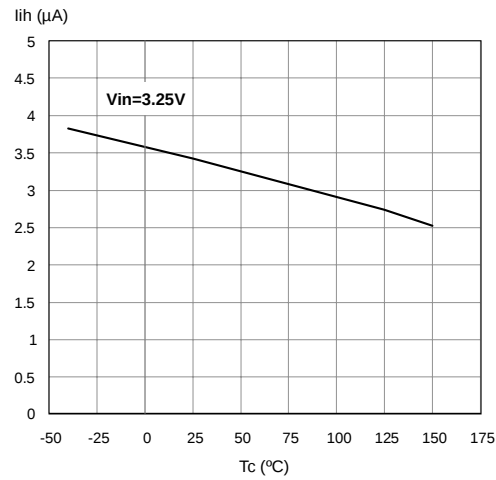
$$5k\Omega \leq R_{prot} \leq 65k\Omega.$$

Recommended R_{prot} value is 10kΩ.

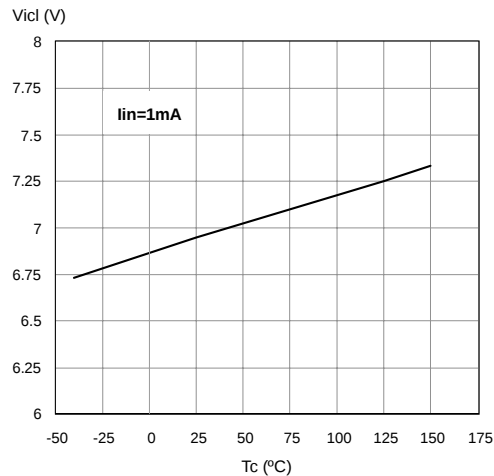
Off State Output Current



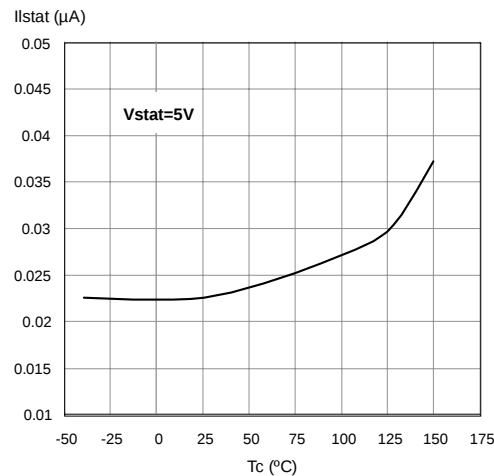
High Level Input Current



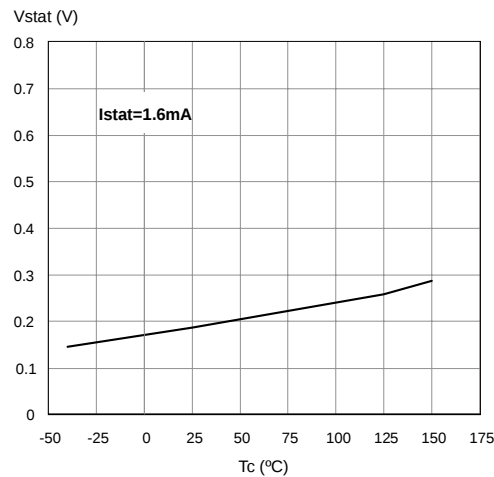
Input Clamp Voltage



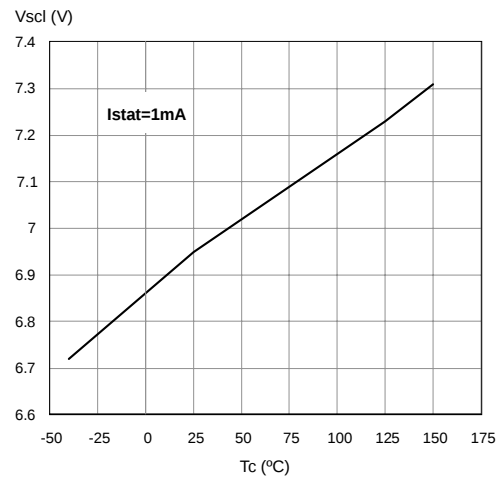
Status Leakage Current

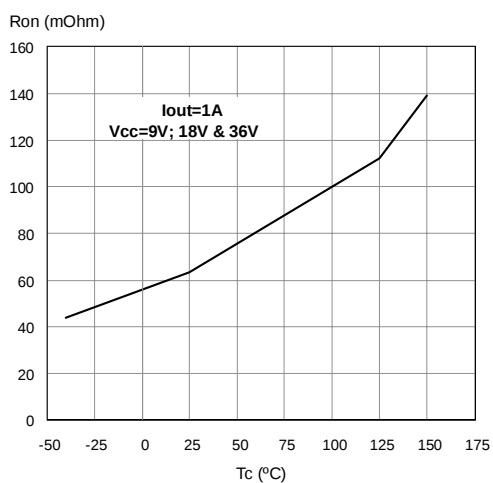
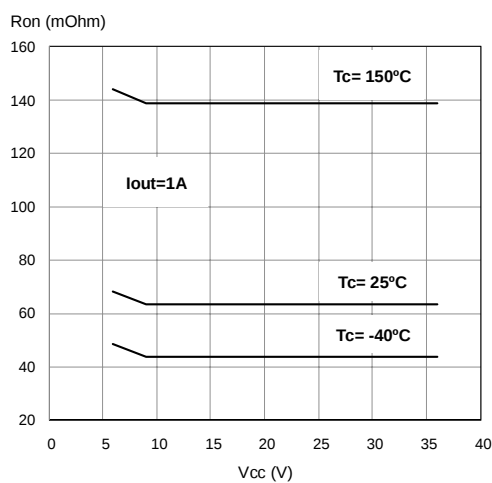
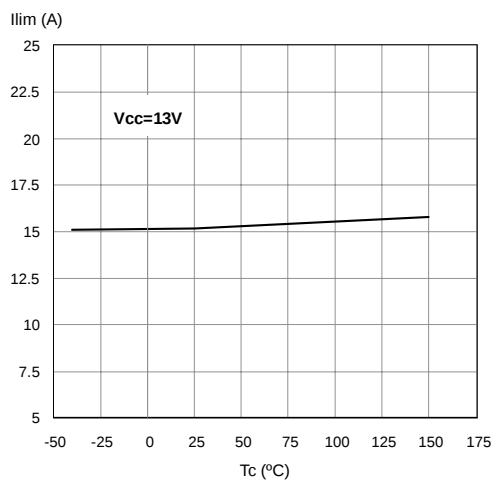


Status Low Output Voltage

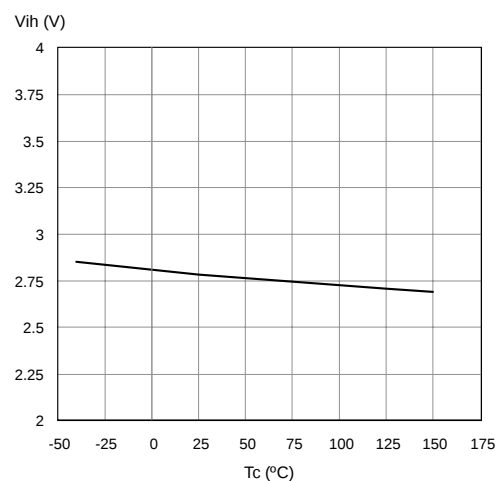


Status Clamp Voltage

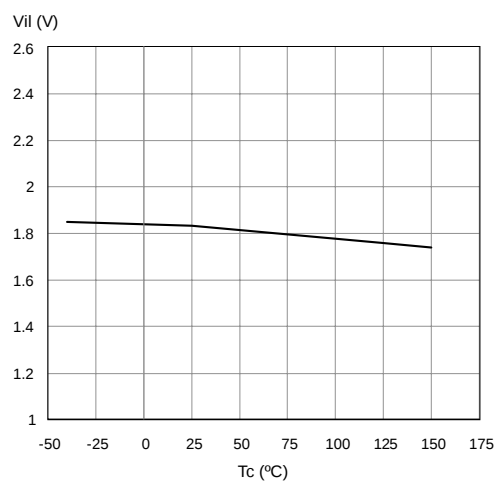


On State Resistance Vs T_{case} On State Resistance Vs V_{CC}  I_{LIM} Vs T_{case} 

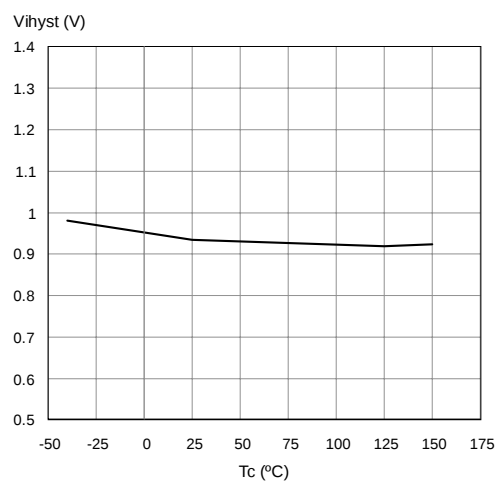
Input High Level



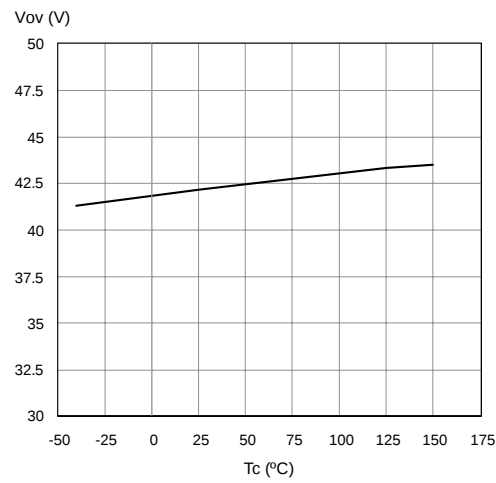
Input Low Level



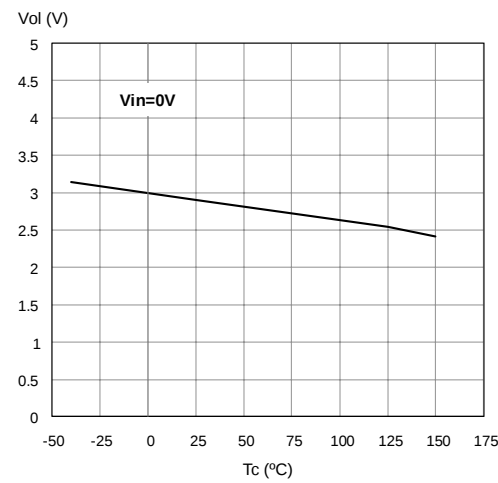
Input Hysteresis Voltage



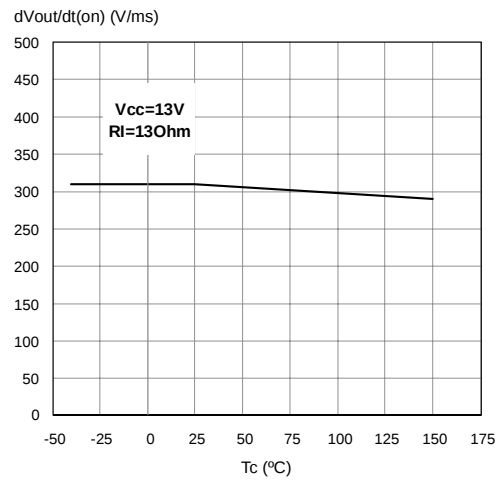
Overvoltage Shutdown



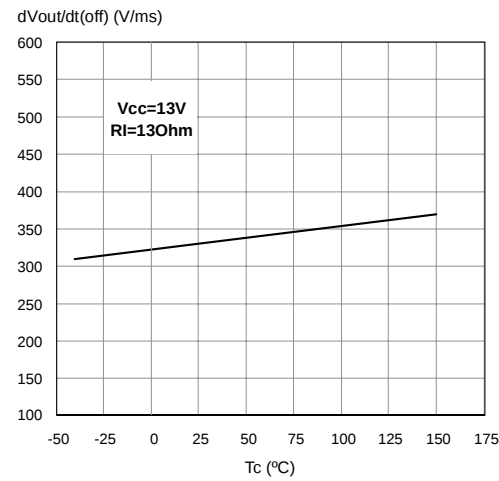
Openload Off State Voltage Detection Threshold



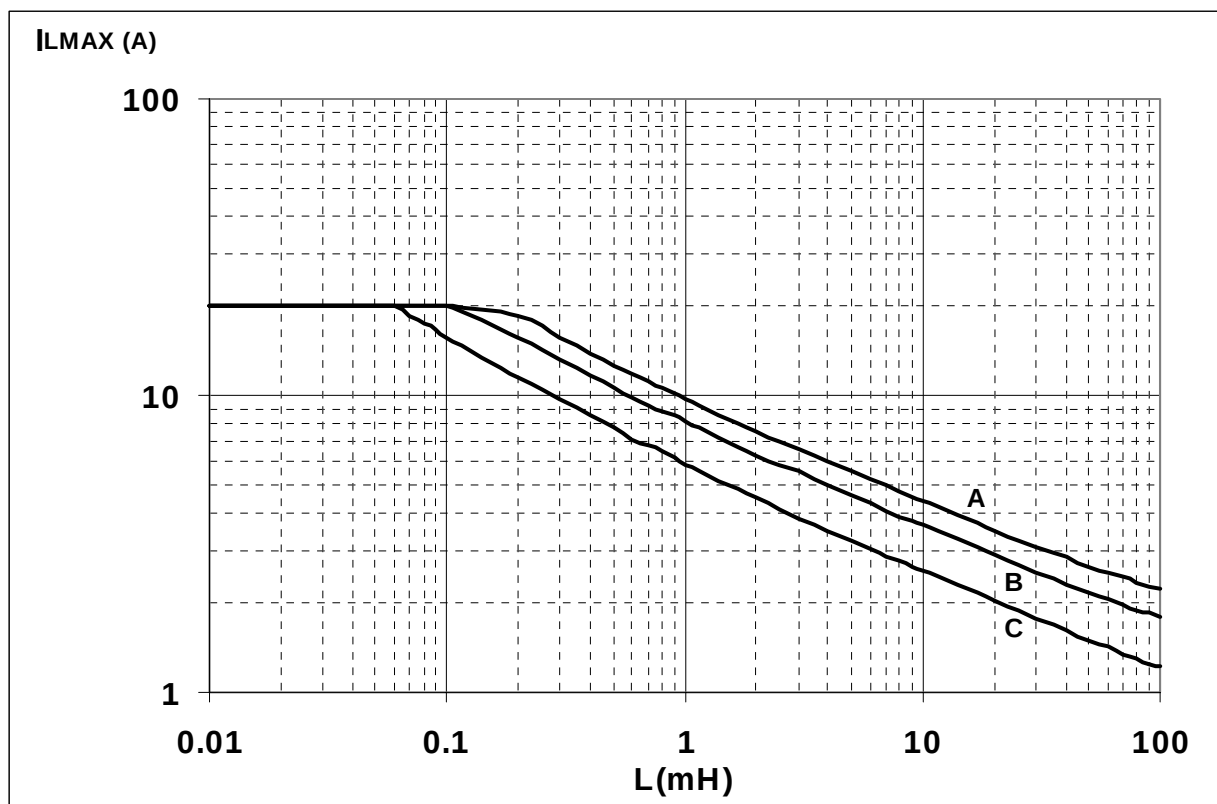
Turn-on Voltage Slope



Turn-off Voltage Slope



Maximum turn off current versus load inductance



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

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

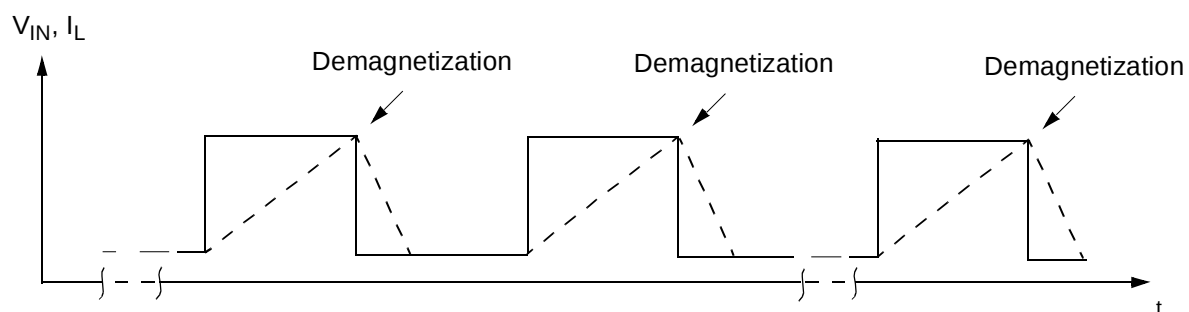
C= Repetitive Pulse at $T_{jstart}=125^{\circ}\text{C}$

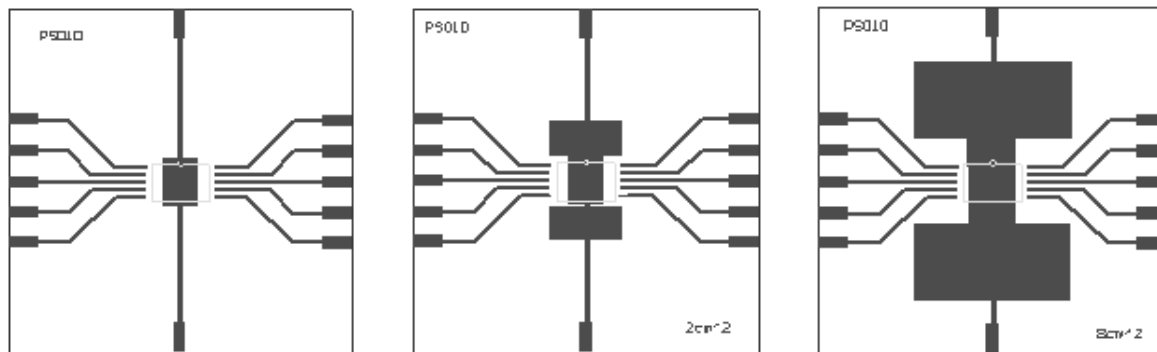
Conditions:

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

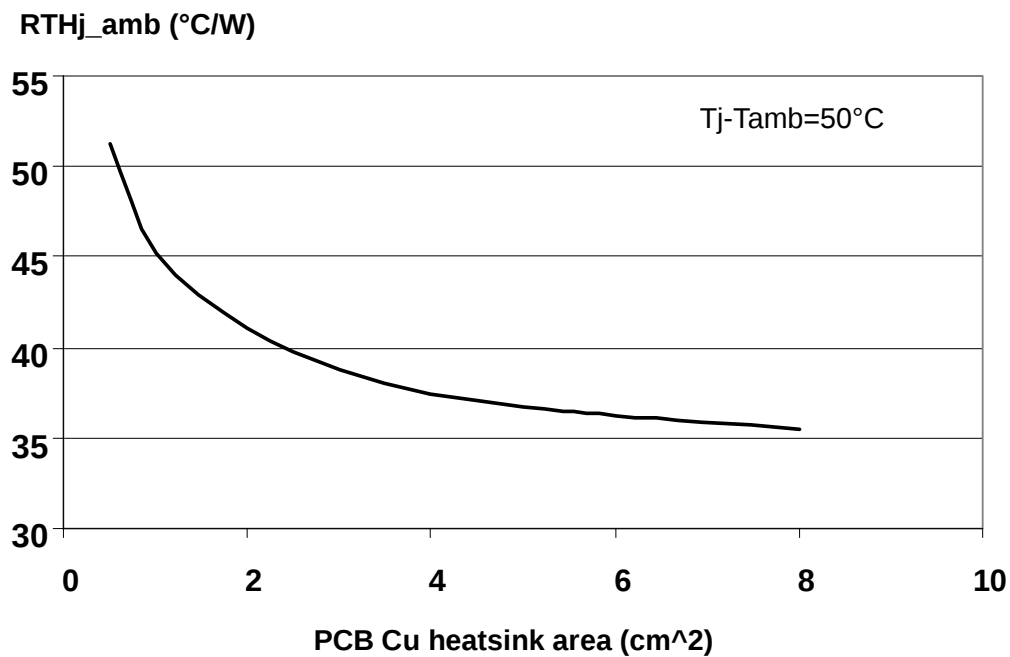
Values are generated with $R_L=0\Omega$

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.

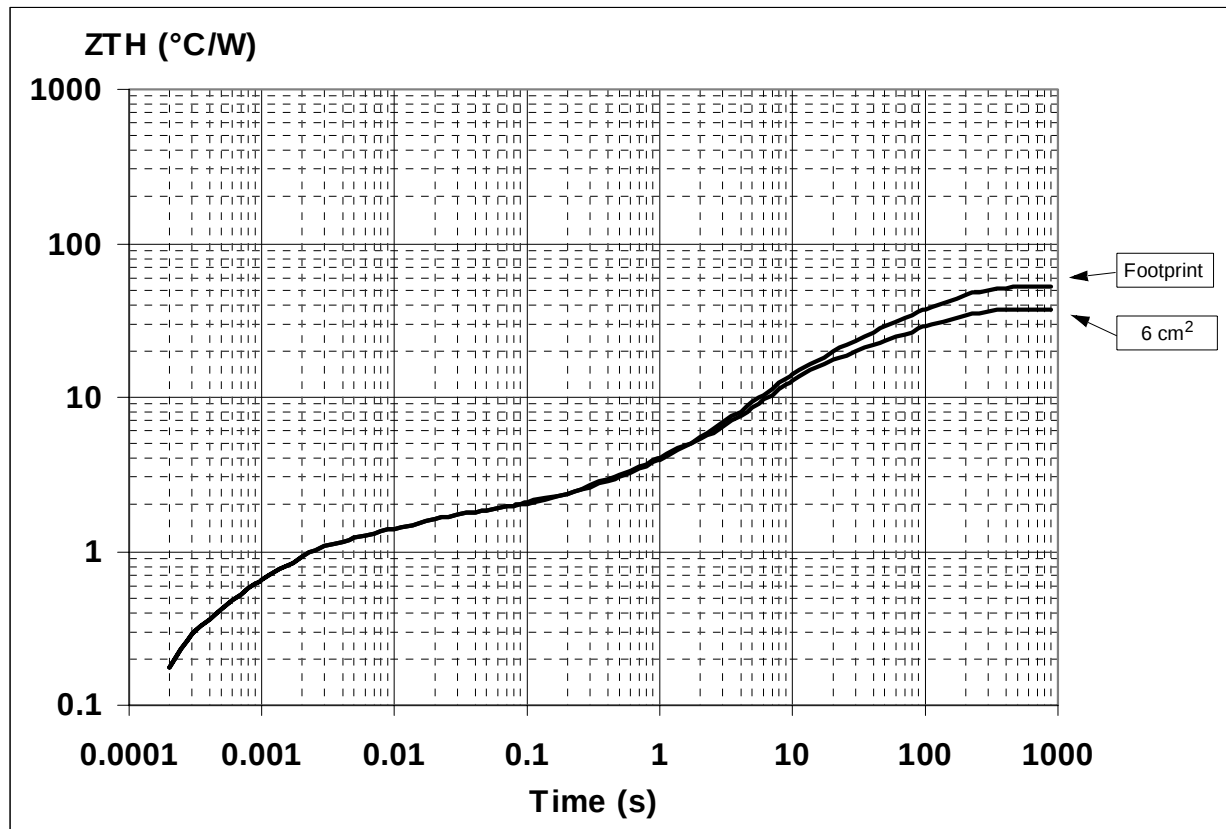


PowerSO-10™ THERMAL DATA**PowerSO-10™ PC Board**

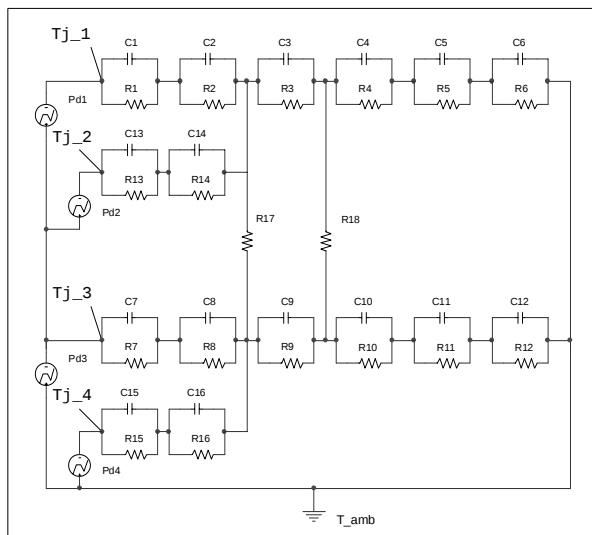
Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area= 58mm x 58mm, PCB thickness=2mm, Cu thickness=35 μ m, Copper areas: from minimum pad lay-out to 8cm²).

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

Thermal Impedance Junction Ambient Single Pulse



Thermal fitting model of a quad HSD in PowerSO-16



Pulse calculation formula

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

$$\text{where } \delta = t_p / T$$

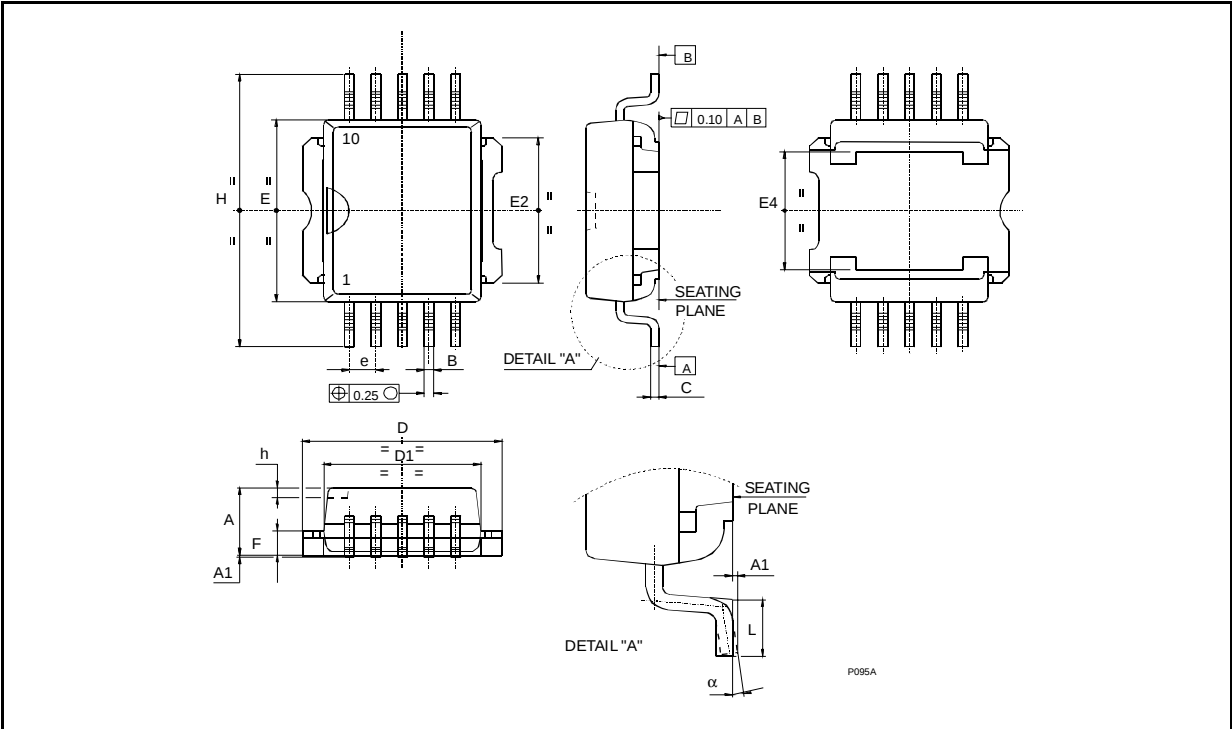
Thermal Parameter

Area/island (cm ²)	Footprint	6
R1 (°C/W)	0.18	
R2 (°C/W)	0.8	
R3 (°C/W)	0.7	
R4 (°C/W)	0.8	
R5 (°C/W)	13	
R6 (°C/W)	37	22
C1 (W.s/°C)	0.0006	
C2 (W.s/°C)	1.50E-03	
C3 (W.s/°C)	1.75E-02	
C4 (W.s/°C)	0.4	
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



REVISION HISTORY

Date	Revision	Description of Changes
Jul 2004	1	- Minor changes - Current and voltage convention update (page 2). - "Configuration diagram (top view) & suggested connections for unused and n.c. pins" insertion (page 3). - 6 cm² Cu condition insertion in Thermal Data table (page 3). - V_{CC} - OUTPUT DIODE section update (page 4). - PROTECTIONS note insertion (page 4) - Revision History table insertion (page 18). - Disclaimers update (page 19).

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