



VNQ660SP

QUAD CHANNEL HIGH SIDE SOLID STATE RELAY

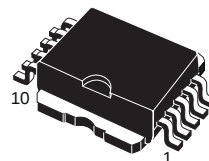
TYPE	$R_{DS(on)}$	I_{OUT}	V_{CC}
VNQ660SP	50m Ω (*)	6A	36 V

(*) Per each channel

- OUTPUT CURRENT PER CHANNEL: 6A
- 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 VNQ660SP is a monolithic device made by using STMicroelectronics VIPower M0-3



PowerSO-10™

ORDER CODES

PACKAGE	TUBE	T&R
PowerSO-10™	VNQ660SP	VNQ660SP13TR

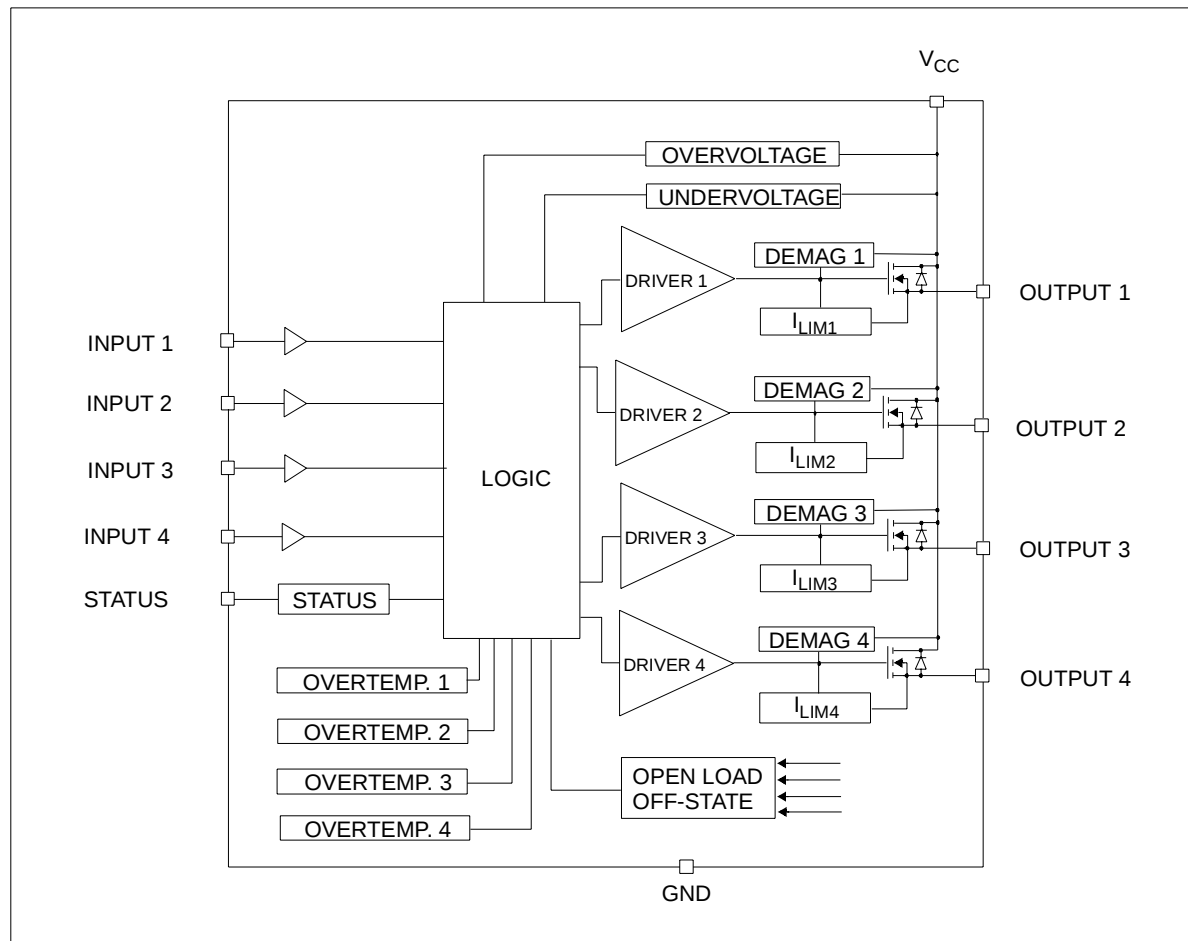
Technology, intended for driving resistive or inductive loads with one side connected to ground. This device has four independent channels. Built-in thermal shut down and output current limitation protect the chip from over temperature and short circuit.

ABSOLUTE MAXIMUM RATING

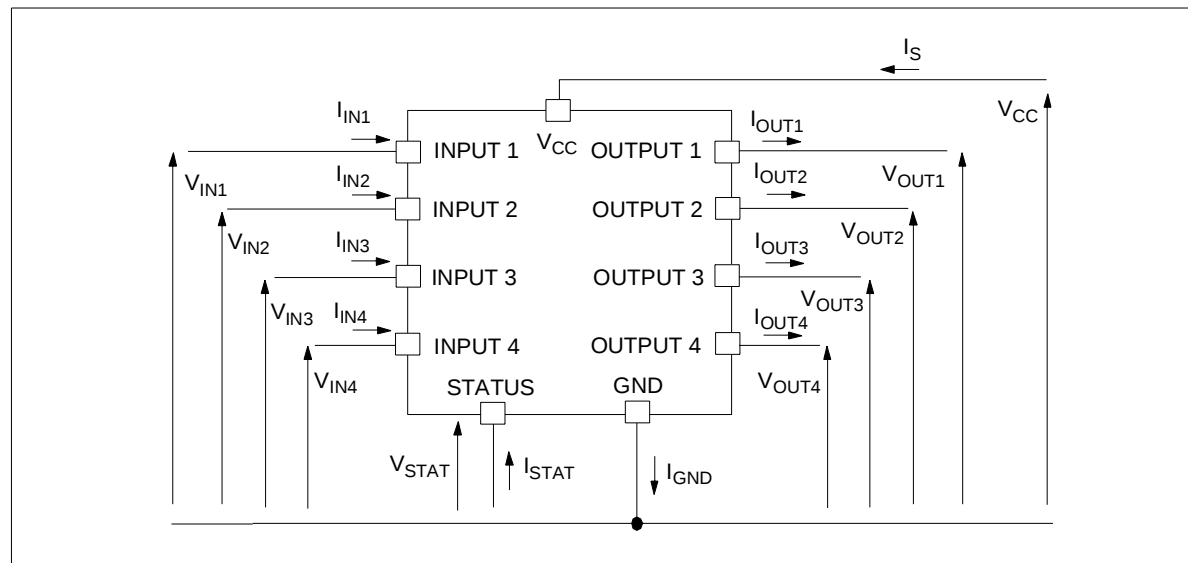
Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage (continuous)	41	V
$-V_{CC}$	Reverse supply voltage (continuous)	-0.3	V
I_{OUT}	Output current (continuous), per each channel	Internally limited	A
I_R	Reverse output current (continuous), per each channel	-15	A
I_{IN}	Input current	+/- 10	mA
I_{STAT}	Status current	+/- 10	mA
I_{GND}	Ground current at $T_C \leq 25^\circ\text{C}$ (continuous)	-200	mA
V_{ESD}	Electrostatic Discharge (Human Body Model: $R=1.5\text{K}\Omega$; $C=100\text{pF}$)		
	- INPUT	4000	V
	- STATUS	4000	V
	- OUTPUT	5000	V
	- V_{CC}	5000	V
P_{tot}	Power dissipation at $T_C=25^\circ\text{C}$	113.6	W
T_j	Junction operating temperature	-40 to 150	$^\circ\text{C}$
T_{stg}	Storage temperature	-65 to 150	$^\circ\text{C}$
E_C	Non repetitive clamping energy at $T_C=25^\circ\text{C}$	150	mJ

(**) See application schematic at page 8

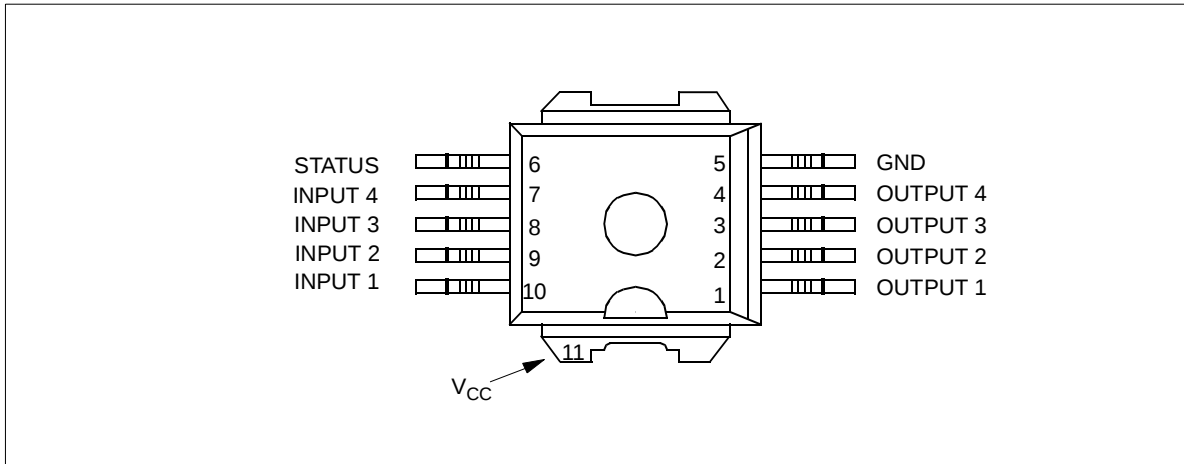
BLOCK DIAGRAM



CURRENT AND VOLTAGE CONVENTIONS



CONNECTION DIAGRAM (TOP VIEW)



THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case (MAX) (all channels on)	1.1	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient (MAX)	51.1 (*)	°C/W

(*) When mounted on a standard single-sided FR-4 board with 0.5cm² of Cu (at least 35 µm thick). Horizontal mounting and no artificial air flow.

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; Input=0V; $V_{CC}=13.5V$		12	40	µA
		Off state; Input=0V; $V_{CC}=13.5V$ $T_j=25^{\circ}C$		12	25	µA
		On state Input=3.25V; $9V < V_{CC} < 18V$		6	12	mA
$R_{DS(on)}$	On state resistance	$I_{OUT}=1A$; $T_j=25^{\circ}C$; $9V < V_{CC} < 18V$		40	50	mΩ
		$I_{OUT}=1A$; $T_j=150^{\circ}C$; $9V < V_{CC} < 18V$		85	100	mΩ
		$I_{OUT}=1A$; $V_{CC}=6V$			130	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.

ELECTRICAL CHARACTERISTICS (continued)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		40	70	μs
$t_{d(off)}$	Turn-off delay time	$R_L=13\Omega$ channels 1,2,3,4		40	140	μs
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L=13\Omega$ channels 1,2,3,4		See relative diagram		$V/\mu s$
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L=13\Omega$ channels 1,2,3,4		See relative diagram		$V/\mu s$

PROTECTIONS (per each channel)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
T_{TSD}	Shutdown temperature		150	170	200	$^{\circ}C$
T_R	Reset temperature		135			$^{\circ}C$
T_{hyst}	Thermal hysteresis		7	15	25	$^{\circ}C$
I_{lim}	DC Short circuit current	$9V < V_{CC} < 36V$ $6V < V_{CC} < 36V$	6	10	18 18	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

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
C_{IN}	Input Capacitance				40	pF
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	(*)			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

(*) See Figure 1

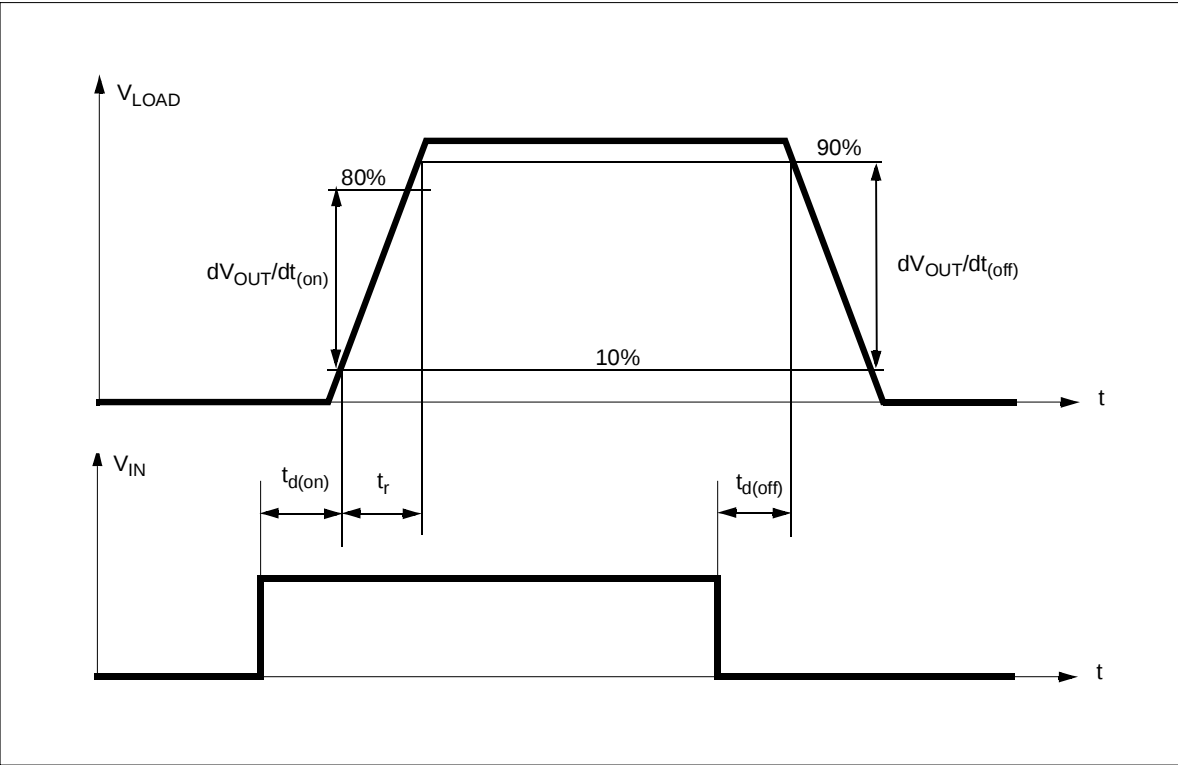
ELECTRICAL TRANSIENT REQUIREMENTS

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

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 H	L H	H H
Current Limitation	L H H	L X X	H ($T_j < T_{TSD}$) H ($T_j > T_{TSD}$) L
Overtemperature	L H	L L	H L
Undervoltage	L H	L L	X X
Overvoltage	L H	L L	H H
Output Voltage $> V_{OL}$	L H	H H	L H
Output Current $< I_{OL}$	L H	L H	H L

Figure 1: Status timing waveforms

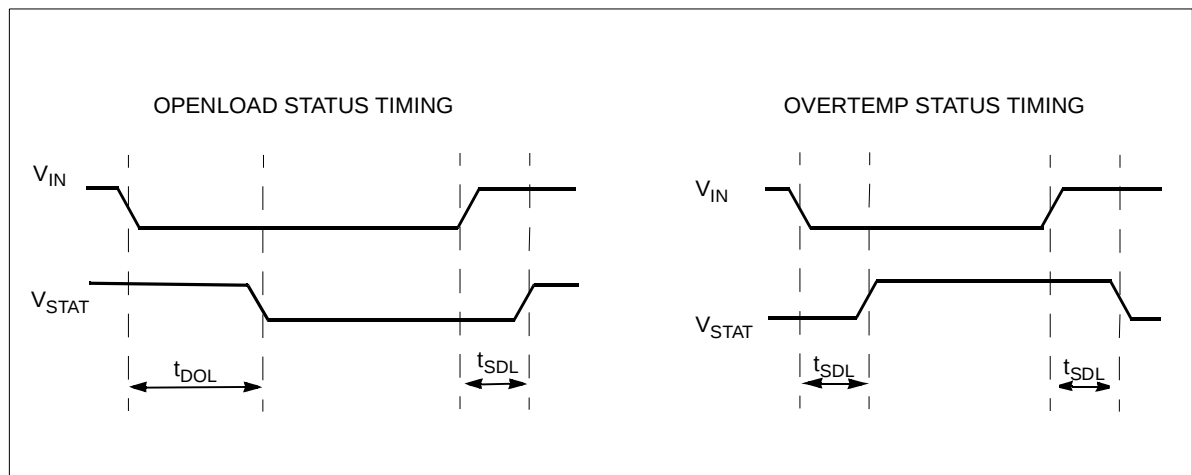
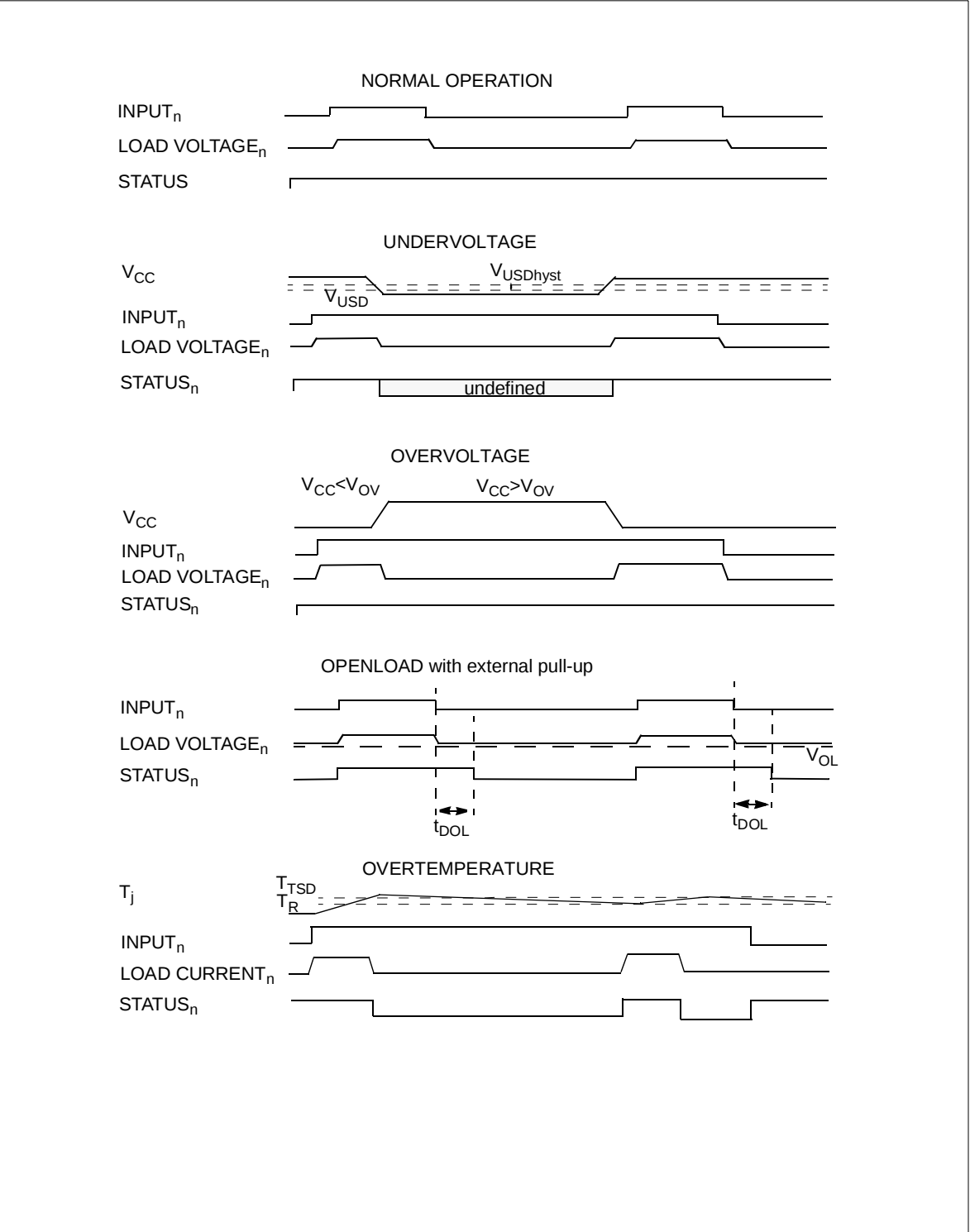
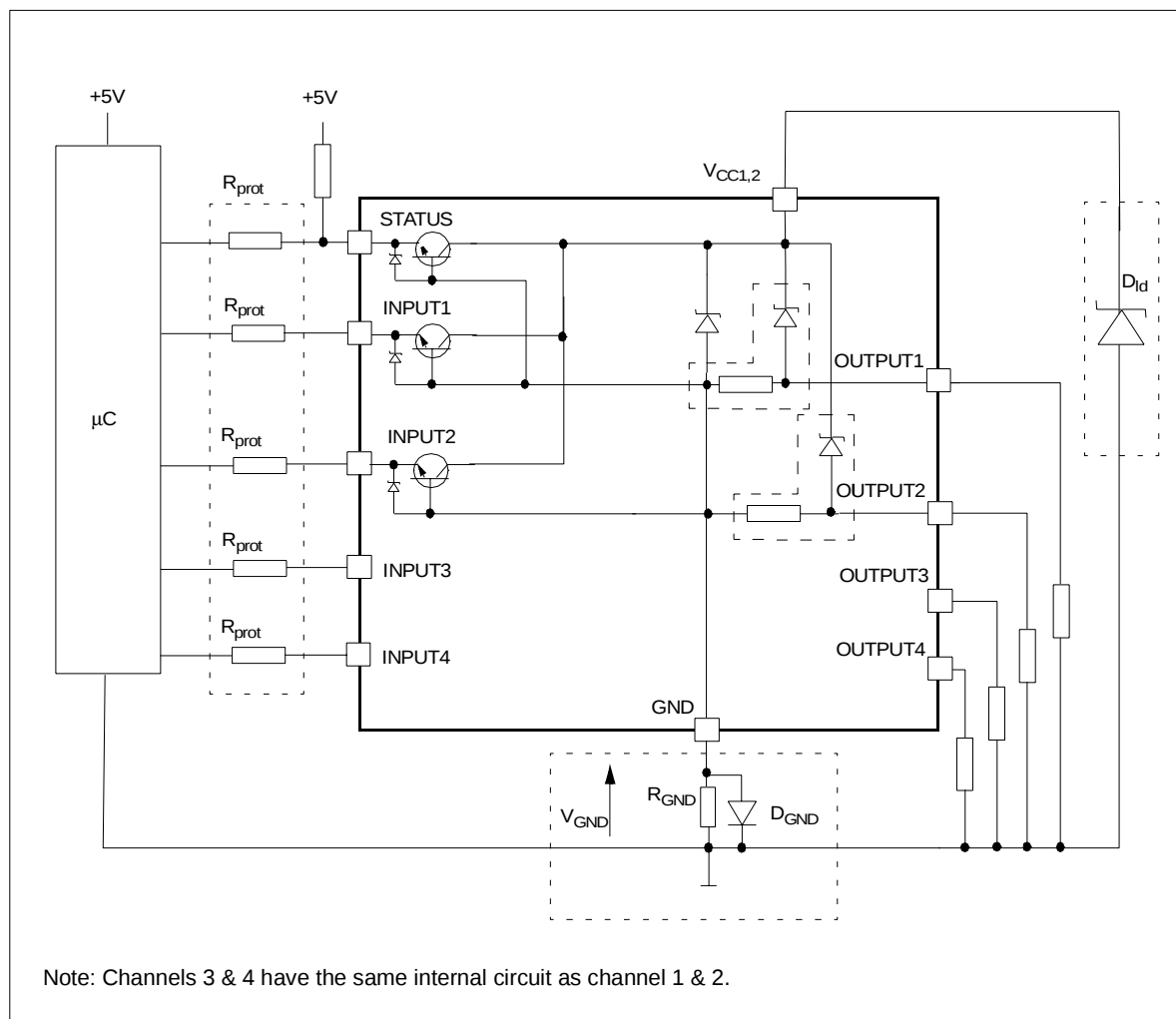


Figure 2: Waveforms



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.

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.

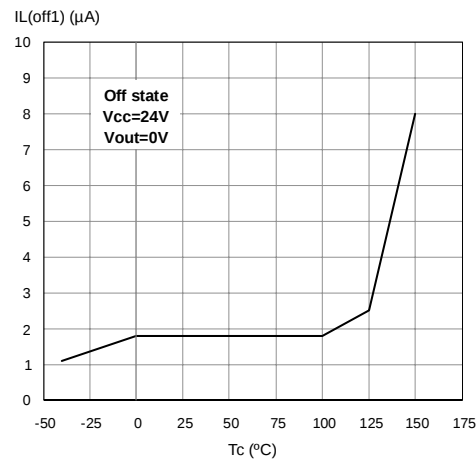
$$-V_{CCpeak}/I_{latchup} \leq R_{prot} \leq (V_{OH\mu C} - V_{IH} - V_{GND}) / I_{IHmax}$$

Calculation example:

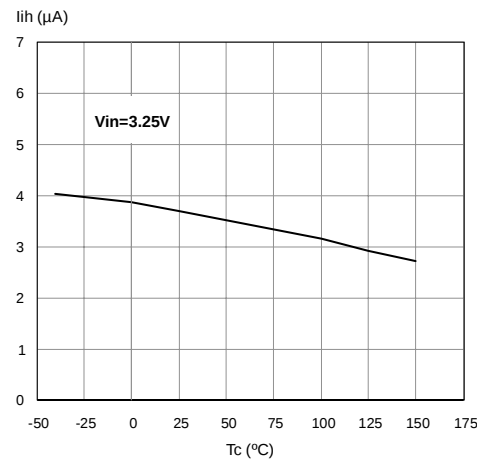
For $V_{CCpeak} = -100V$ and $I_{latchup} \geq 20mA$; $V_{OH\mu C} \geq 4.5V$
 $5k\Omega \leq R_{prot} \leq 65k\Omega$.

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

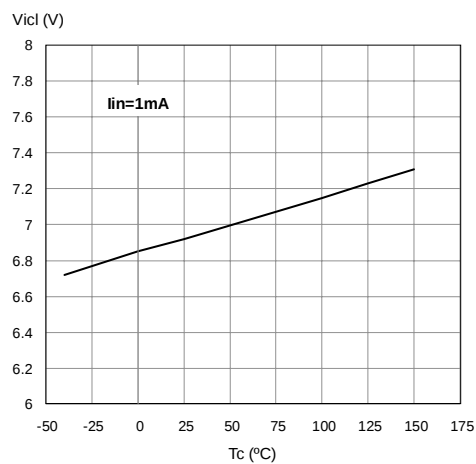
Off State Output Current



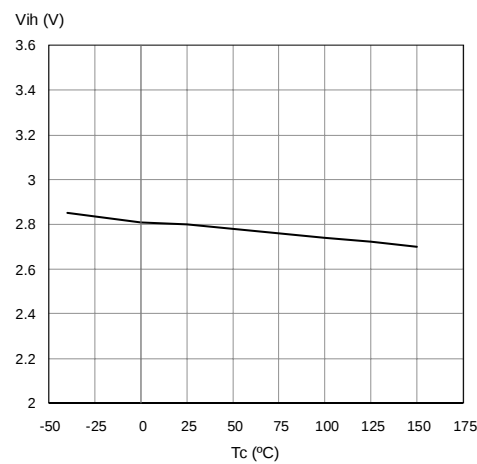
High Level Input Current



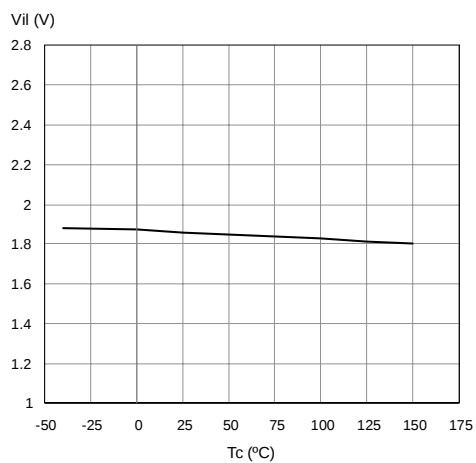
Input Clamp Voltage



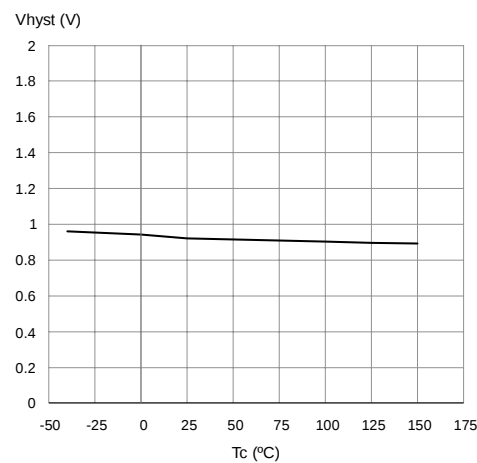
Input High Level



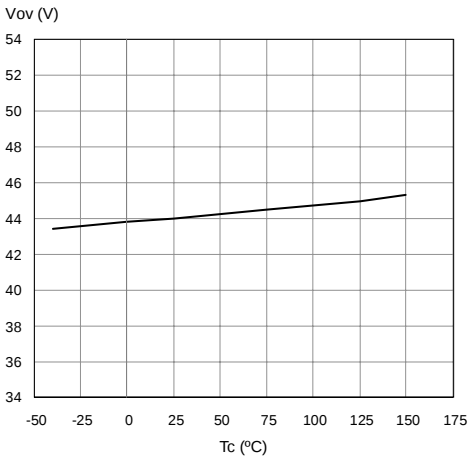
Input Low Level



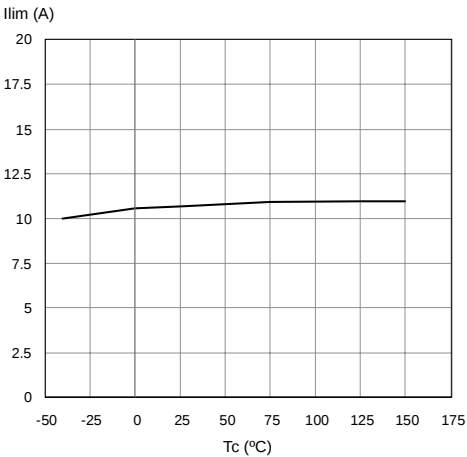
Input Hysteresis Voltage



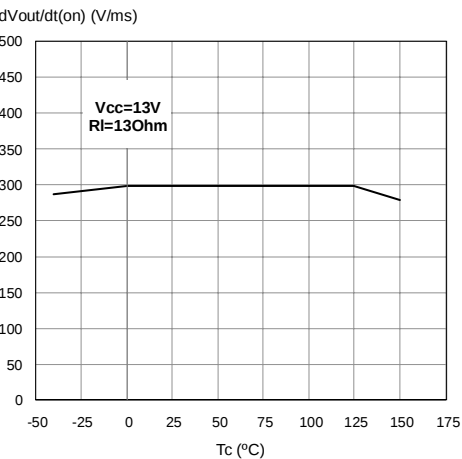
Overvoltage Shutdown



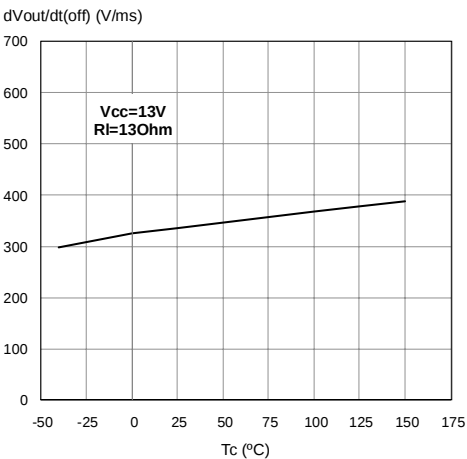
I_{LIM} Vs T_{case}



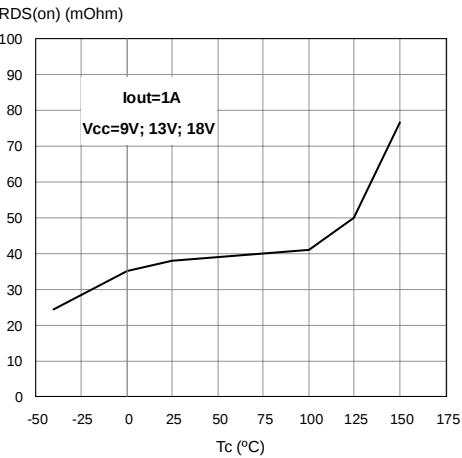
Turn-on Voltage Slope



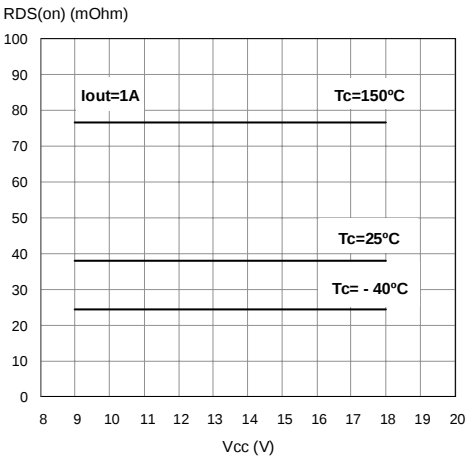
Turn-off Voltage Slope



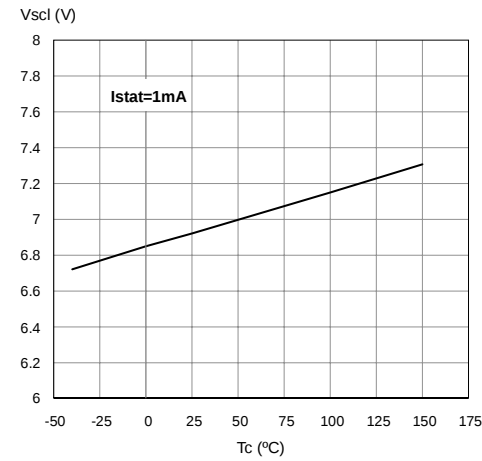
On State Resistance Vs T_{case}



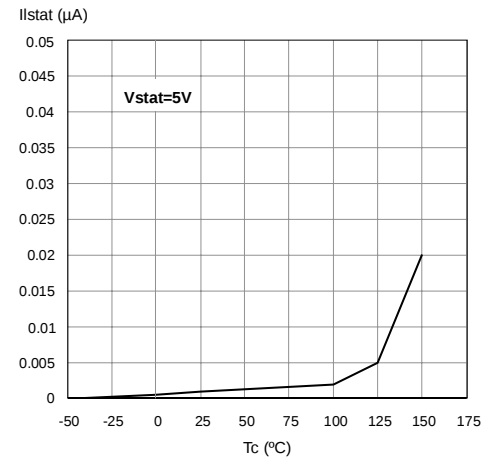
On State Resistance Vs V_{CC}



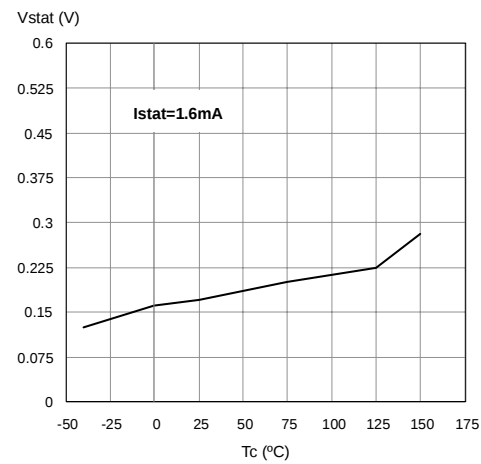
Status Clamp Voltage



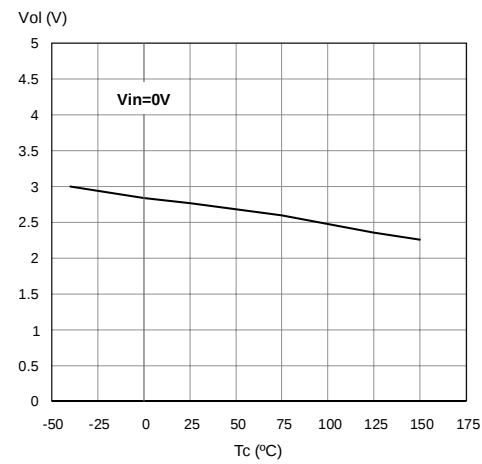
Status Leakage Current



Status Low Output Voltage

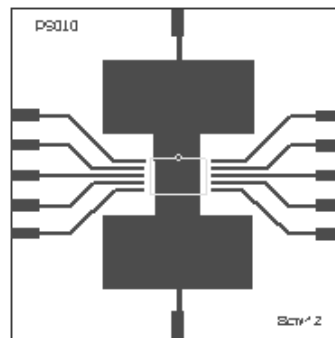
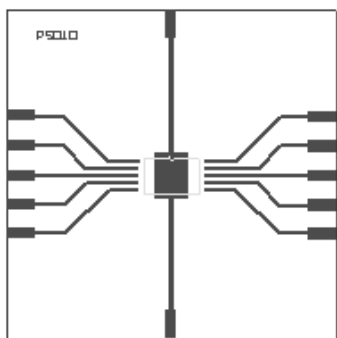


Open Load Off State Voltage Detection Threshold



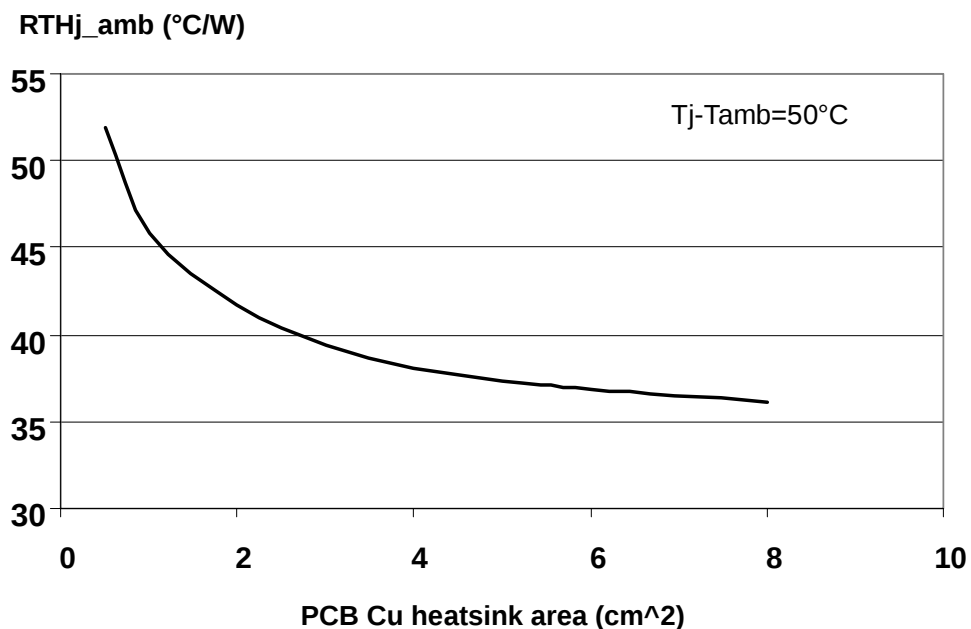
PowerSO-10™ THERMAL DATA

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



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