



VNQ05XSP16

QUAD CHANNEL HIGH SIDE SOLID STATE RELAY

TYPE	R _{ON} (*)	I _{OUT}	V _{CC}
VNQ05XSP16	110mΩ	5A (*)	36 V

(*) Per each channel

- OUTPUT CURRENT (CONTINUOUS): 5A
- CMOS COMPATIBLE INPUTS
- MULTIPLEXED PROPORTIONAL LOAD CURRENT SENSE
- 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 (**)

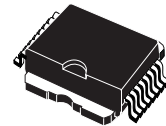
DESCRIPTION

The VNQ05XSP16 is a monolithic device designed in STMicroelectronics VIPower M0-3

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), for each channel	Internally limited	A
I _R	Reverse output current (continuous), for each channel	-5	A
I _{IN}	Input current (IN1,IN2,IN3,IN4,SELA,SELB,SENSEENABLE)	+/- 10	mA
V _{CSENSE}	Current sense maximum voltage	-3 +15	V V
I _{GND}	Ground current at T _{case} ≤25°C (continuous)	-200	mA
V _{ESD}	Electrostatic Discharge (Human Body Model: R=1.5Ω; C=100pF) - INPUT - CURRENT SENSE - OUTPUT - V _{CC}	4000 2000 5000 5000	V V V V
P _{tot}	Power dissipation at T _{case} =25°C	78	W
E _{MAX}	Maximum Switching Energy (L=1.72mH; R _L =0Ω; V _{bat} =13.5V; T _{jstart} =150°C; I _L =7.5A)	76	mJ
T _j	Junction operating temperature	Internally limited	°C
T _c	Case Operating Temperature	- 40 to 150	°C
T _{STG}	Storage temperature	-55 to 150	°C

(**) See application schematic at page 9



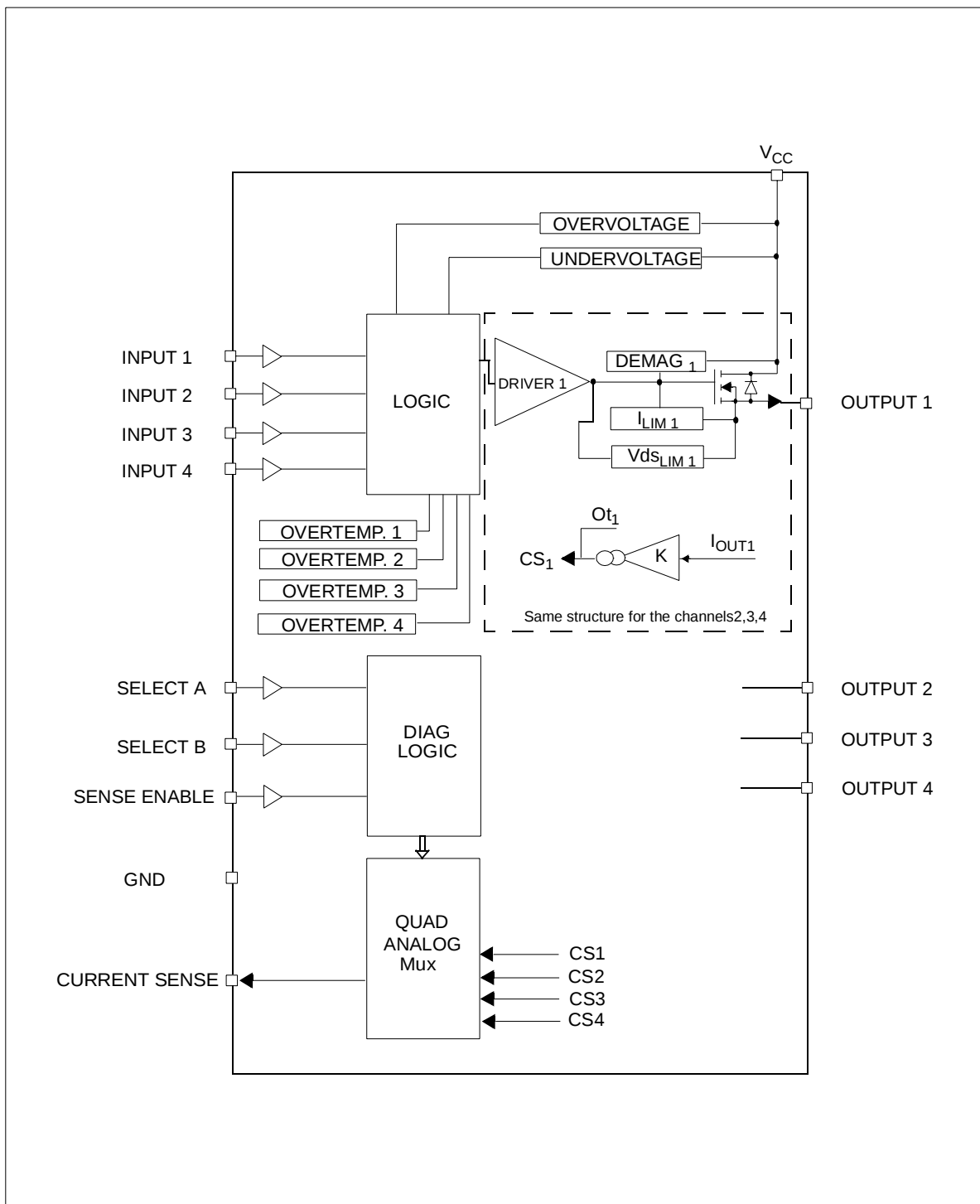
PowerSO-16™

ORDER CODES

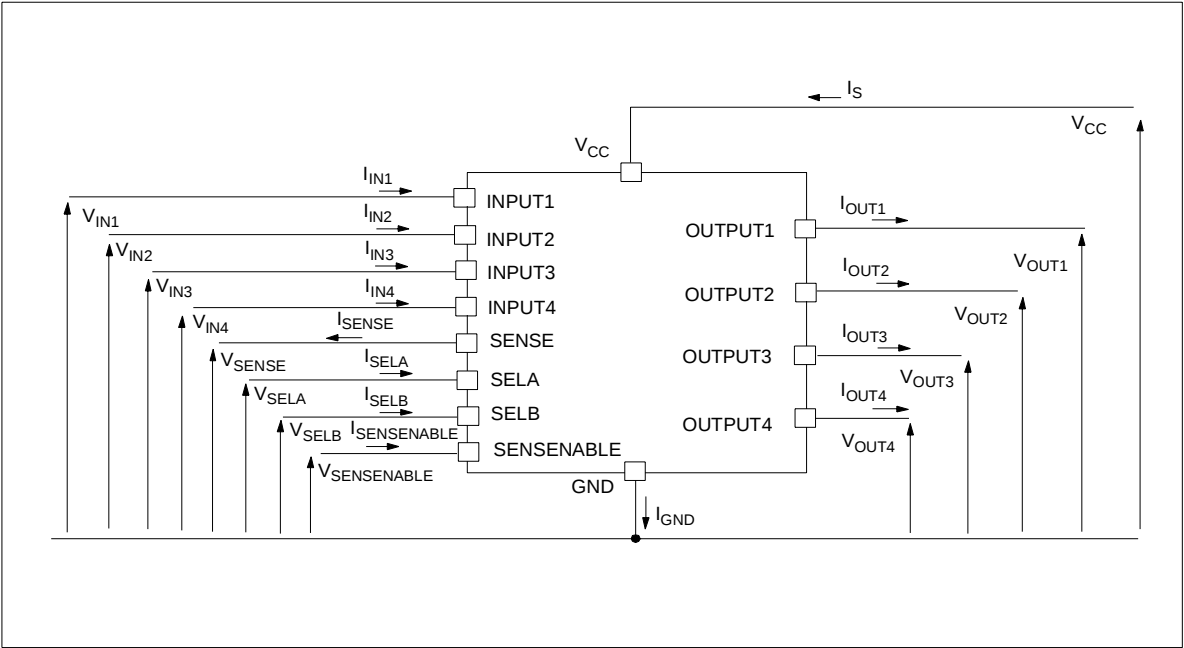
PACKAGE	TUBE	T&R
PowerSO-16™	VNQ05XSP16	VNQ05XSP1613TR

Technology. It is intended for driving any type of multiple loads with one side connected to ground. Active V_{CC} pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table). This device has four independent channels and one multiplexed analog sense output which deliver a current proportional to the selected output current. SenseEnable pin allows to connect any number of VNQ05XSP16 on the same Current Sense line. Active current limitation combined with thermal shut-down and automatic restart protect the device against overload. Device automatically turns off in case of ground pin disconnection.

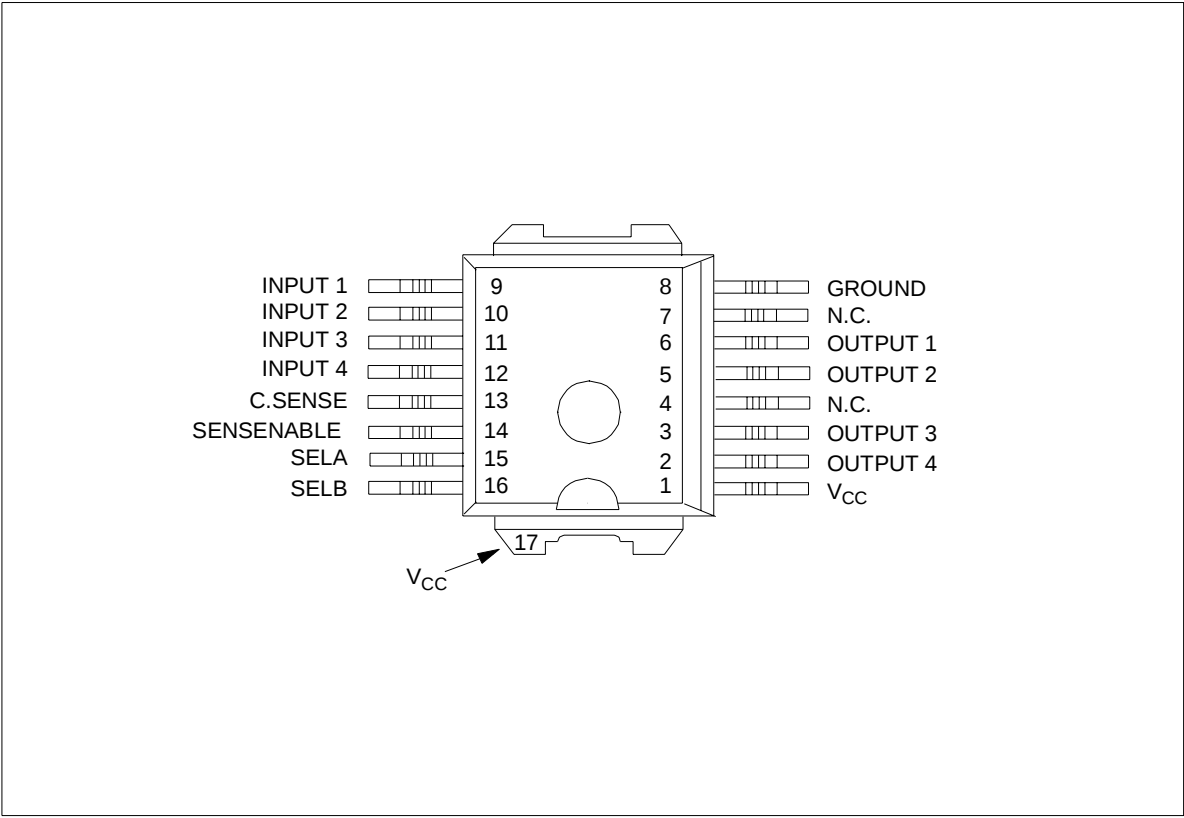
BLOCK DIAGRAM



CURRENT AND VOLTAGE CONVENTIONS



CONNECTION DIAGRAM (TOP VIEW)



THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case (MAX)	1.6	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient (MAX)	51.6 (*)	°C/W

(*) When mounted on FR4 printed circuit board with 0.5 cm² of copper area (at least 35 µm thick) connected to all V_{CC} pins

ELECTRICAL CHARACTERISTICS (8V<V_{CC}<36V; -40°C<T_j<150°C; unless otherwise specified) (Per each channel)
POWER

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V _{CC}	Operating supply voltage		5.5	13	36	V
V _{USD}	Under voltage shut down		3	4	5.5	V
V _{OV}	Overvoltage shut down		36			V
R _{ON}	On state resistance	I _{OUT} 1,2,3,4=1A; T _j =25°C			110	mΩ
		I _{OUT} 1,2,3,4=1A; T _j =150°C			220	mΩ
		I _{OUT} 1,2,3,4=0.5A; V _{CC} =6V			330	mΩ
V _{clamp}	Clamp Voltage	I _{CC} =20mA (See note 1)	41	48	55	V
I _S	Supply current	Off state; Inputs=n.c.; V _{CC} =13V			80	µA
		On state; V _{IN} =5V; V _{CC} =13V; I _{OUT} =0A; R _{SENSE} =3.9kΩ			10	mA
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°C			5	µA
I _{L(off4)}	Off State Output Current	V _{IN} =V _{OUT} =0V; V _{CC} =13V; T _j =25°C			3	µA

SWITCHING (V_{CC}=13V)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
t _{d(on)}	Turn-on delay time	R _L =2.6Ω channels 1,2,3,4 (see figure 2)		40		µs
t _{d(off)}	Turn-off delay time	R _L =2.6Ω channels 1,2,3,4 (see figure 2)		40		µs
(dV _{OUT} /dt) _{on}	Turn-on voltage slope	R _L =2.6Ω channels 1,2,3,4 (see figure 2)		See relative diagram		V/µs
(dV _{OUT} /dt) _{off}	Turn-off voltage slope	R _L =2.6Ω channels 1,2,3,4 (see figure 2)		See relative diagram		V/µs

PROTECTIONS

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I _{lim}	DC short circuit current	V _{CC} =13V 5.5V<V _{CC} <36V	5	7.5	10 10	A A
T _{TSD}	Thermal shut down temperature		150	175	200	°C
T _R	Thermal reset temperature		135			°C
T _{HYST}	Thermal hysteresis		7	15		°C
V _{demag}	Turn-off output voltage clamp	I _{OUT} =2A; L=6mH	V _{CC} -41	V _{CC} -48	V _{CC} -55	V
V _{ON}	Output voltage drop limitation	I _{OUT} =0.1A T _j =-40°C...+150°C		50		mV

Note 1: V_{clamp} and V_{OV} are correlated. Typical difference is 5V.

CURRENT SENSE (9V < V_{CC} < 16V)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
K ₁	I _{OUT} /I _{SENSE}	I _{OUT} =0.1A; V _{SENSE} =0.5V T _j =-40...+150°C	650	950	1200	
dK ₁ /K ₁	Current Sense Ratio Drift	I _{OUT} =0.1A; V _{SENSE} =0.5V; T _j = -40°C...+150°C	-10		+10	%
K ₂	I _{OUT} /I _{SENSE}	I _{OUT} =1.0A; V _{SENSE} =4V T _j =-40...+150°C	800	1000	1200	
dK ₂ /K ₂	Current Sense Ratio Drift	I _{OUT} =1.0A; V _{SENSE} =4V; T _j =-40°C...+150°C	-8		+8	%
K ₃	I _{OUT} /I _{SENSE}	I _{OUT} =2.0A; V _{SENSE} =4V T _j =-40...+150°C	850	1000	1150	
dK ₃ /K ₃	Current Sense Ratio Drift	I _{OUT} =2.0A; V _{SENSE} =4V; T _j =-40°C...+150°C	-6		+6	%
I _{SENSE0}	Analog Sense Leakage Current	V _{CC} =6...16V; I _{OUT} =0A; V _{SENSE} =0V; T _j =-40°C...+150°C	0		10	μA
V _{SENSE1,2,3,4}	Max analog sense output voltage	V _{CC} =5.5V, I _{OUT1,2,3,4} =1.0A R _{SENSE} =10kΩ V _{CC} >8V, I _{OUT1,2,3,4} =2.0A R _{SENSE} =10kΩ	2 4			V V
V _{SENSEH}	Analog sense output voltage in overtemperature condition	V _{CC} =13V; R _{SENSE} = 3.9kΩ		5.5		V
R _{VSENSEH}	Analog sense output impedance in overtemperature condition	V _{CC} =13V; T _j >T _{TSD} ; All Channels Open		400		Ω
t _{DSENSE}	Current sense delay	V _{CC} =13V; R _{SENSE} =3.9kΩ (see note 2)		300	500	μs

LOGIC CHARACTERISTICS (Inputs, Sela&b, Sensenable)

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 _{I(hyst)}	Input hysteresis voltage		0.5			V
I _{IL}	Low level input current	V _{IN} =1.25V	1			μA
I _{IN}	High level input current	V _{IN} =3.25V			10	μA
V _{ICL}	Input clamp voltage	I _{IN} =1mA I _{IN} =-1mA	6	6.8 -0.7	8	V V

Note 2: current sense signal delay after positive input slope.

Note: Sense pin doesn't have to be left floating.

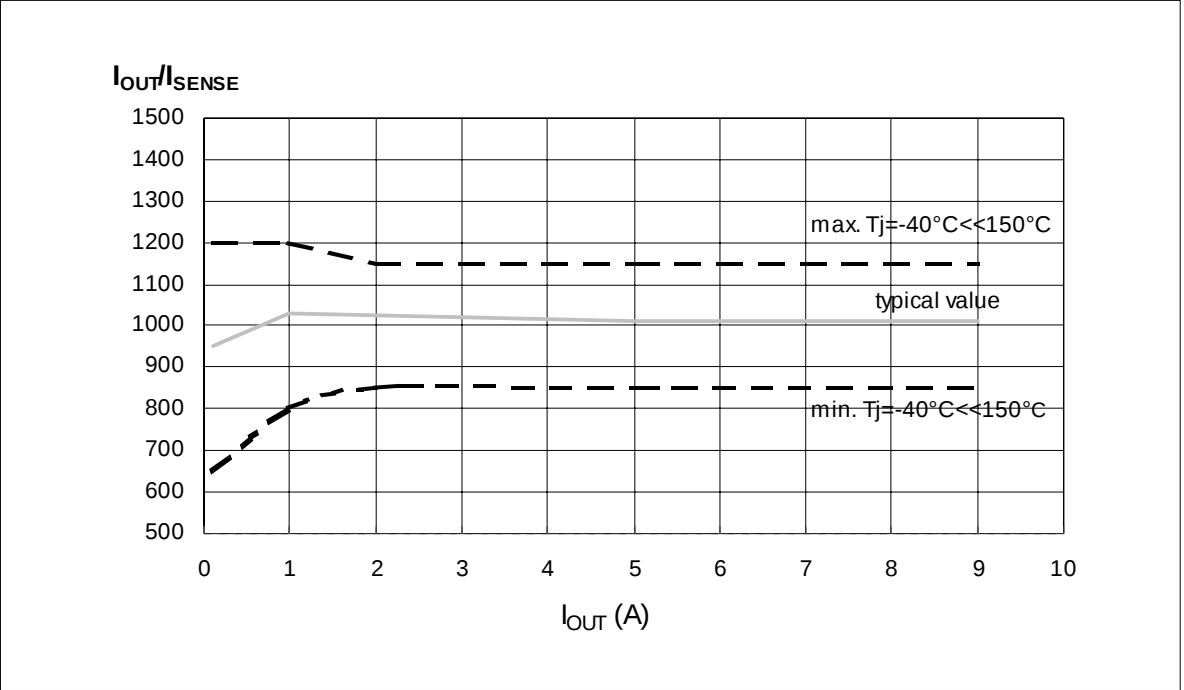
TRUTH TABLE

CONDITIONS	INPUT	OUTPUT	SENSE
Normal operation	L	L	0
	H	H	Nominal
Overtemperature	L	L	0
	H	L	V_{SENSEH}
Undervoltage	L	L	0
	H	L	0
Overvoltage	L	L	0
	H	L	0
Short circuit to GND	L	L	0
	H	L	$(T_j < T_{TSD})$ 0
	H	L	$(T_j > T_{TSD})$ V_{SENSEH}
Short circuit to V_{CC}	L	H	0
	H	H	< Nominal
Negative output voltage clamp	L	L	0

TRUTH TABLE

SENSEENABLE	SELB	SELA	SENSE
L	X	X	High Impedance
H	L	L	$I_{SENSE} = I_{OUT1}/K$
H	L	H	$I_{SENSE} = I_{OUT2}/K$
H	H	L	$I_{SENSE} = I_{OUT3}/K$
H	H	H	$I_{SENSE} = I_{OUT4}/K$

Figure 1: I_{OUT}/I_{SENSE} versus I_{OUT}



ELECTRICAL TRANSIENT REQUIREMENTS

ISO T/R 7637/1 Test Pulse	Test Levels I	Test Levels II	Test Levels III	Test Levels IV	Test Levels Delays and Impedance
1	-25V	-50V	-75V	-100V	2ms, 10Ω
2	+25V	+50V	+75V	+100V	0.2ms, 10Ω
3a	-25V	-50V	-100V	-150V	0.1μs, 50Ω
3b	+25V	+50V	+75V	+100V	0.1μs, 50Ω
4	-4V	-5V	-6V	-7V	10ms, 0.01Ω
5	+26.5V	+46.5V	+66.5V	+86.5V	400ms, 2Ω

ISO T/R 7637/1 Test Pulse	Test Levels Result I	Test Levels Result II	Test Levels Result III	Test Levels Result 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.

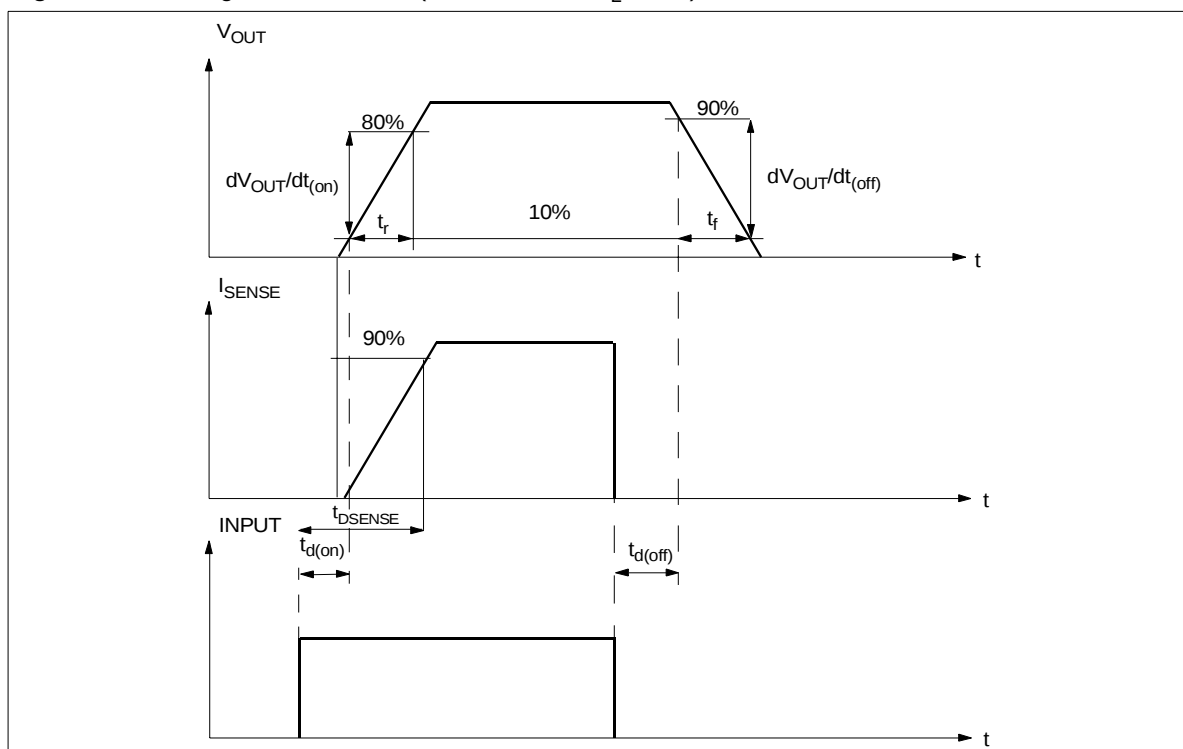
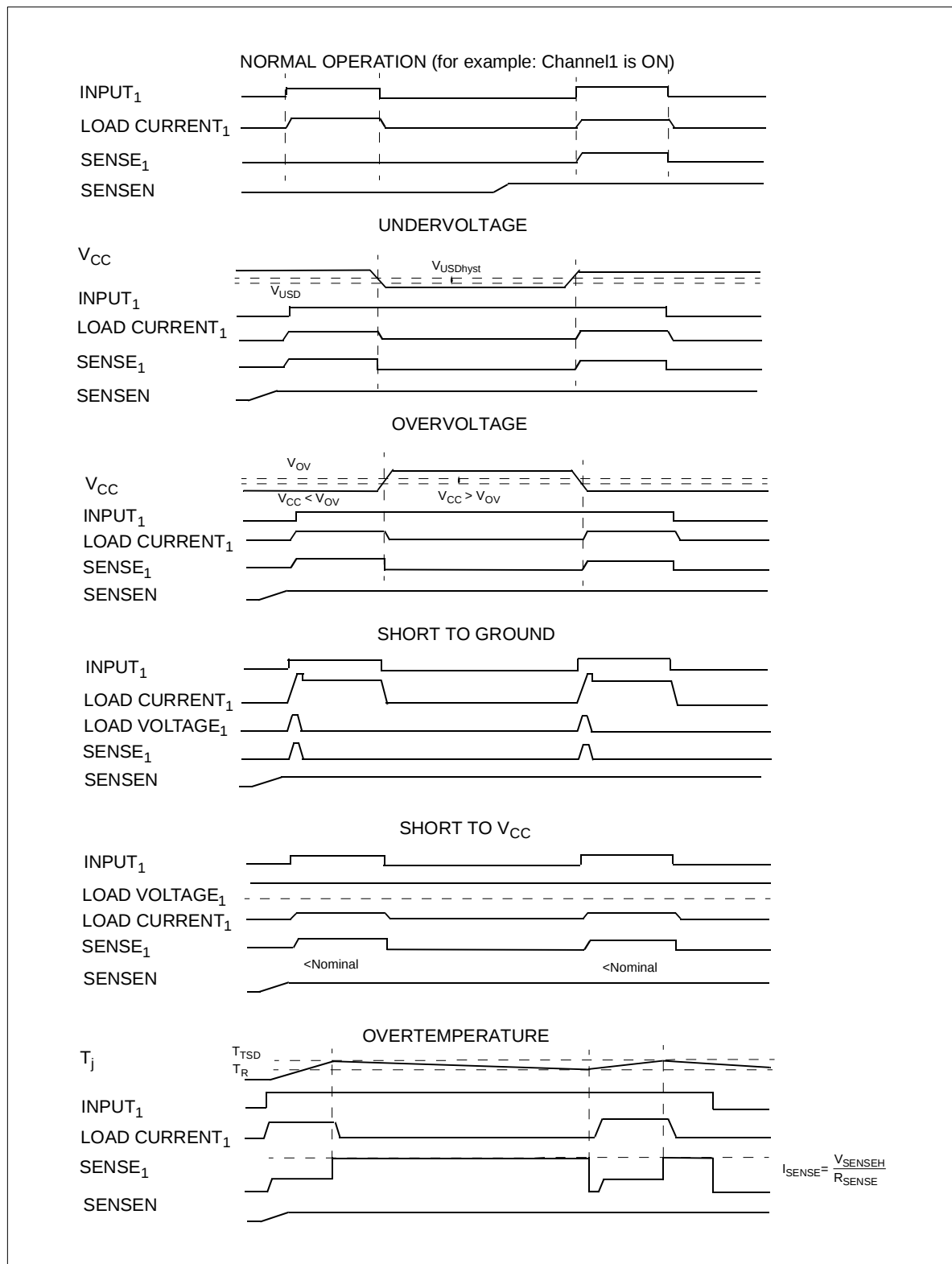
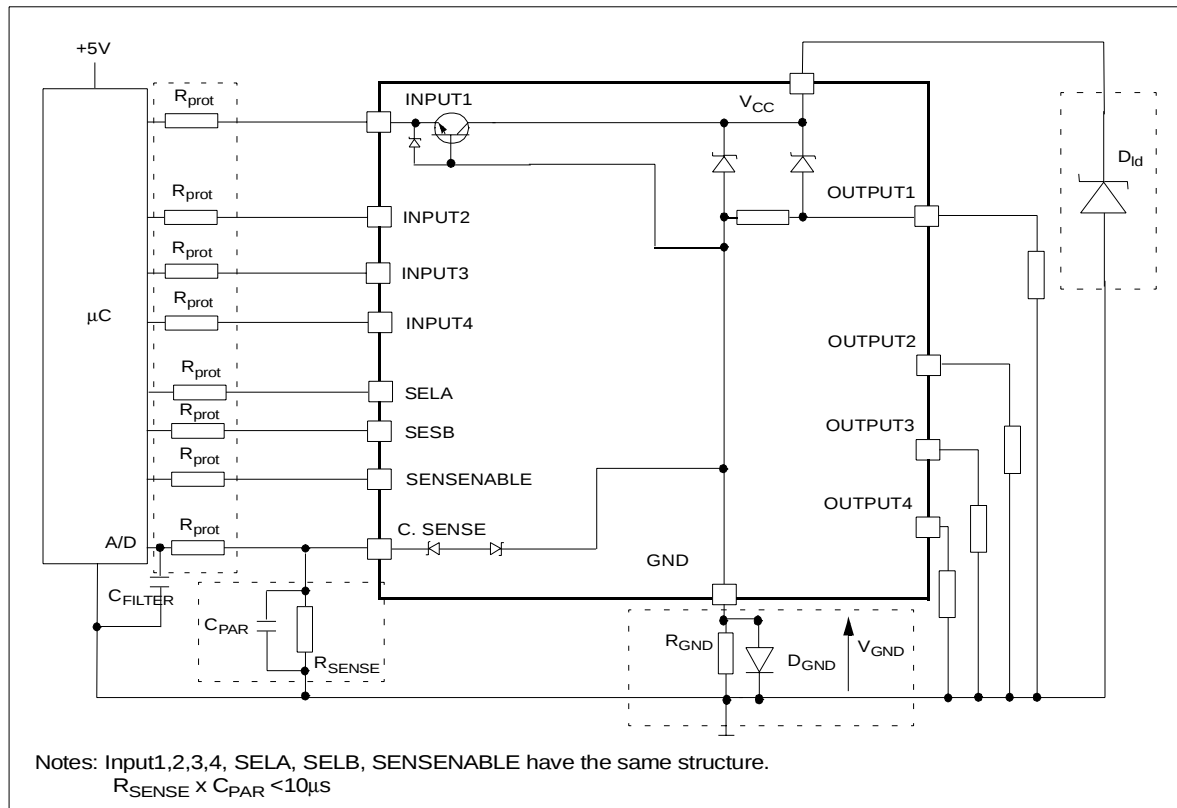
Figure 2: Switching Characteristics (Resistive load $R_L=1.3\Omega$)

Figure 3: 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) $R_{GND} \leq 600mV / (I_{S(on)max})$.
- 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 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 ($R_{GND} = 1k\Omega$) 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 ($\approx 600mV$) 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_{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.

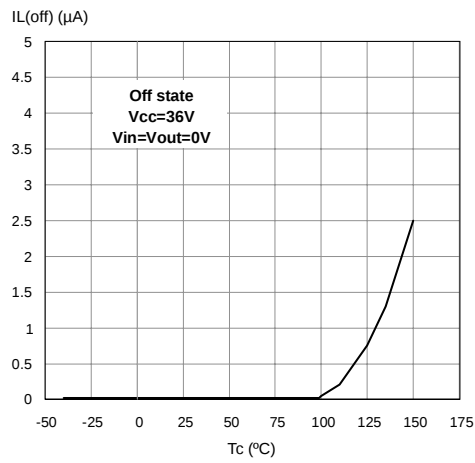
The value of these resistors is a compromise between the leakage current of μC and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of μC I/Os.

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

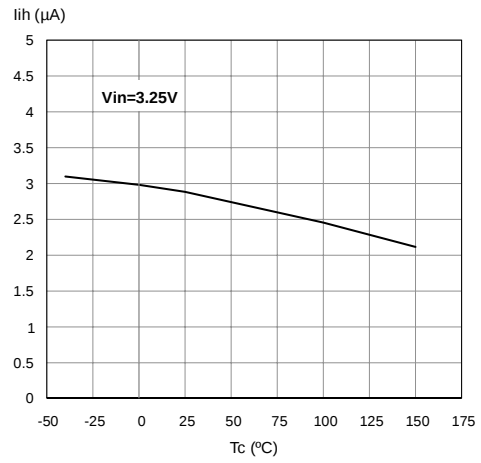
For $V_{CCpeak} = -100V$ and $I_{latchup} \geq 20mA$; $V_{OH\mu C} \geq 4.5V$
 $5k\Omega \leq R_{prot} \leq 65k\Omega$.

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

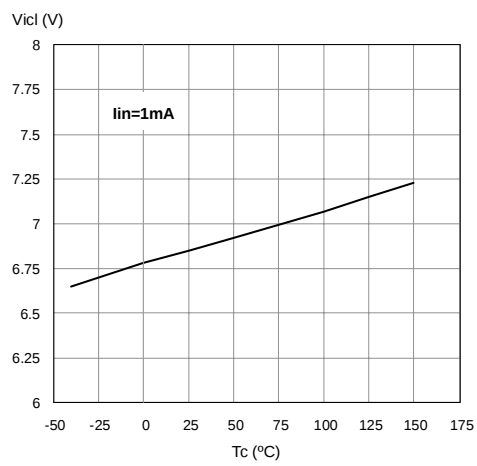
Off State Output Current



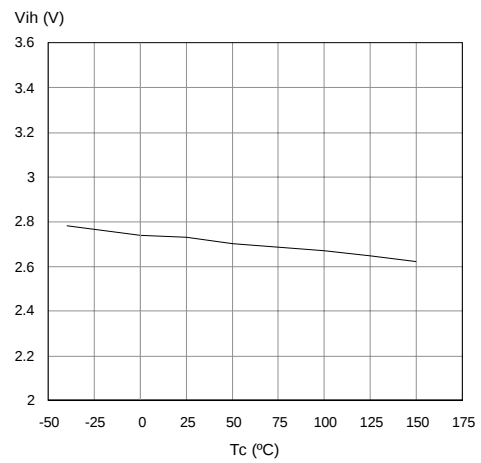
High Level Input Current



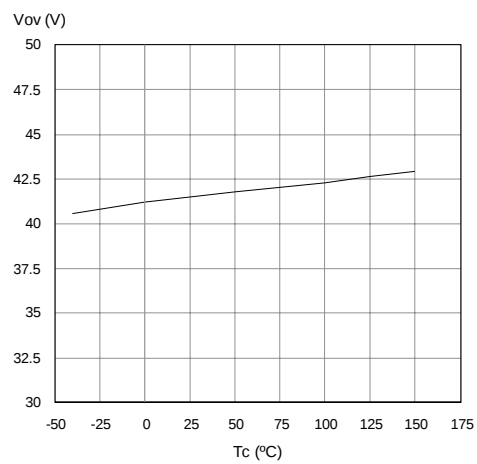
Input Clamp Voltage



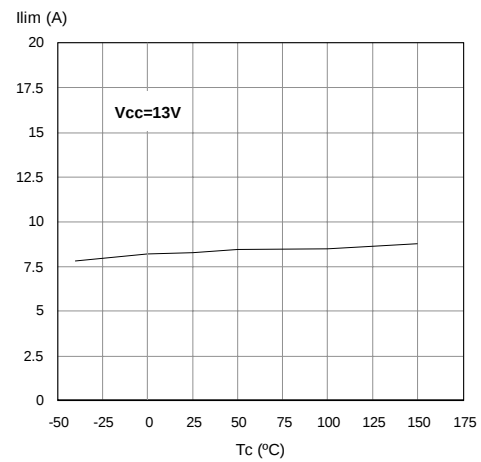
Input High Level



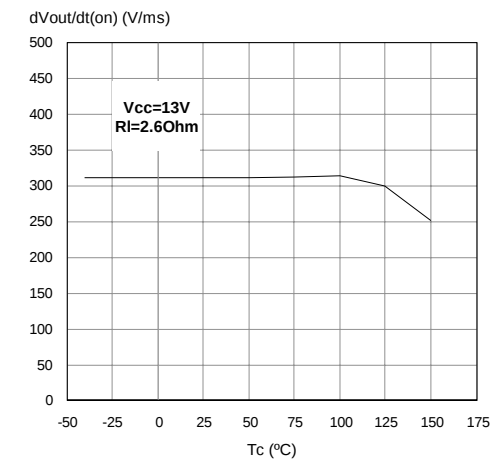
Overvoltage Shutdown



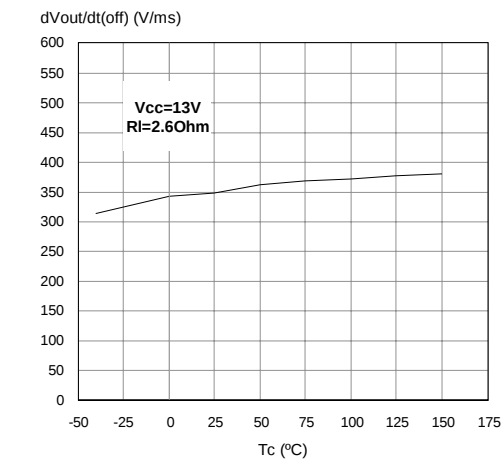
I_{LIM} Vs T_{case}



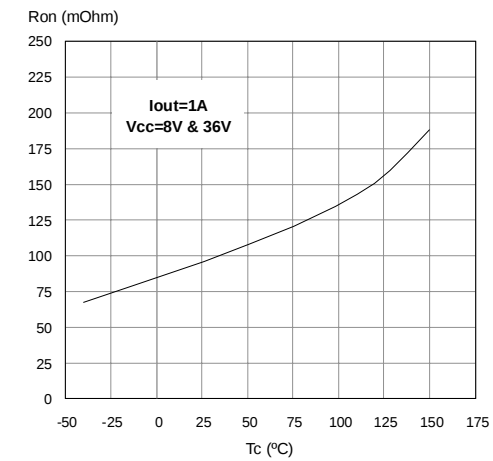
Turn-on Voltage Slope



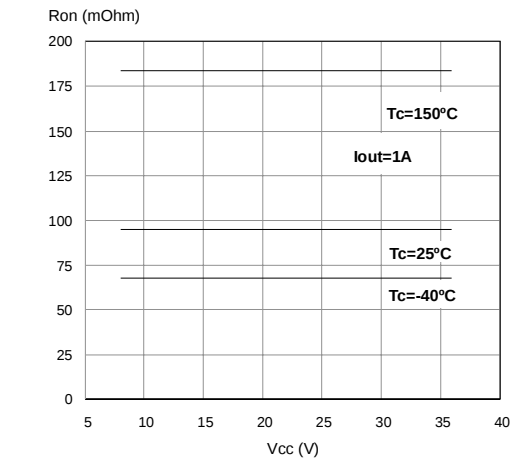
Turn-off Voltage Slope



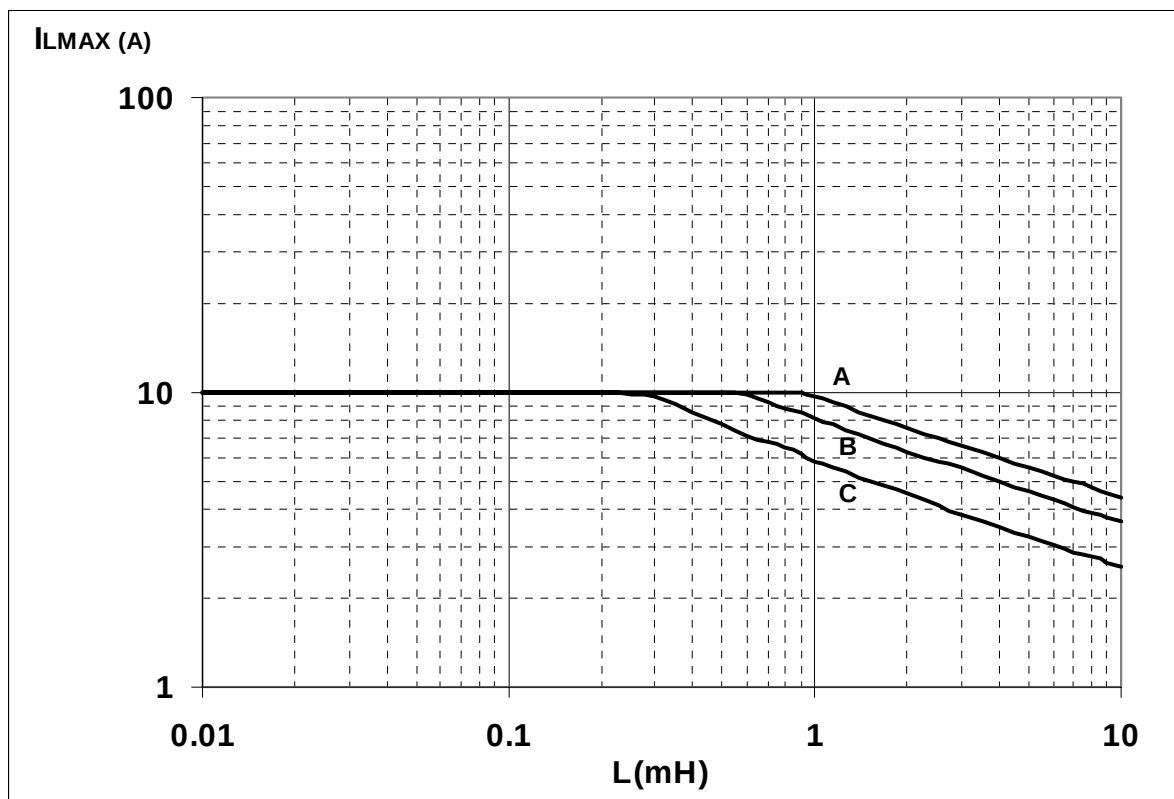
On State Resistance Vs T_{case}



On State Resistance Vs V_{CC}



Maximum turn off current versus load inductance



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

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

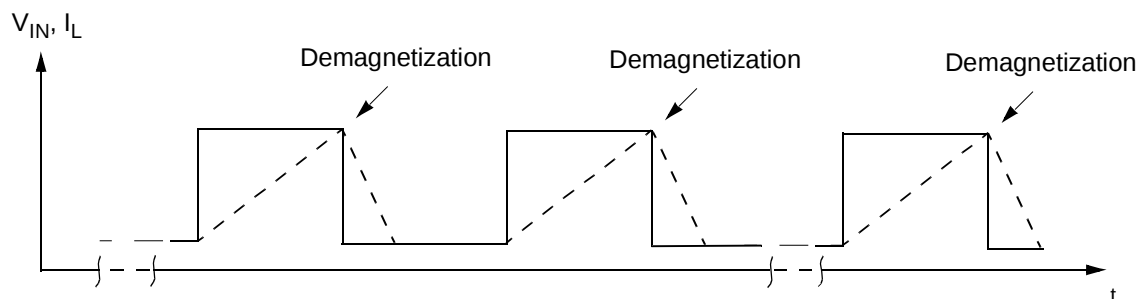
C = Repetitive Pulse at $T_{Jstart}=125^{\circ}\text{C}$

Conditions:

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

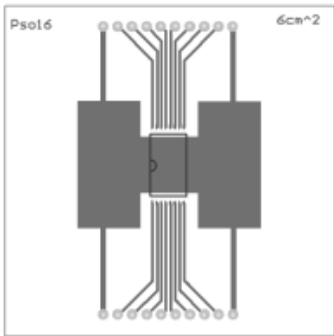
Values are generated with $R_L=0\Omega$

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.



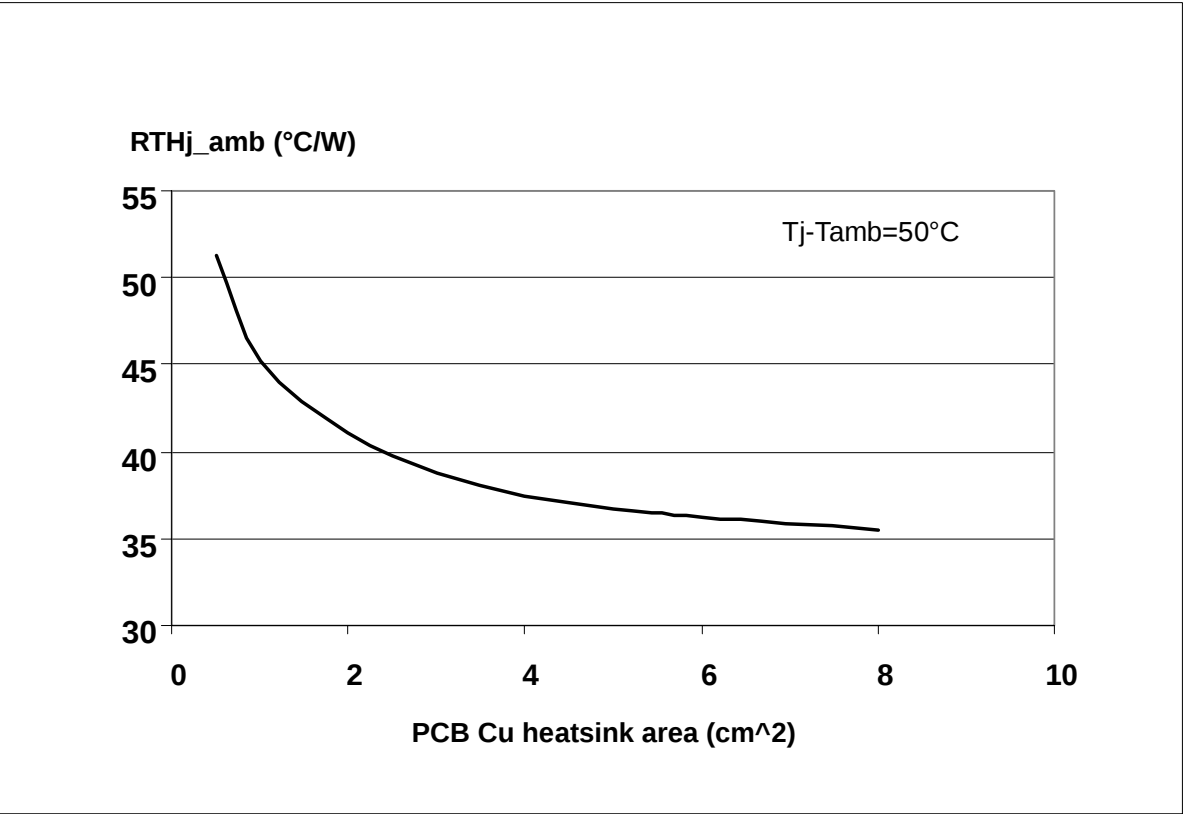
PowerSO-16™ THERMAL DATA

PowerSO-16™ PC Board

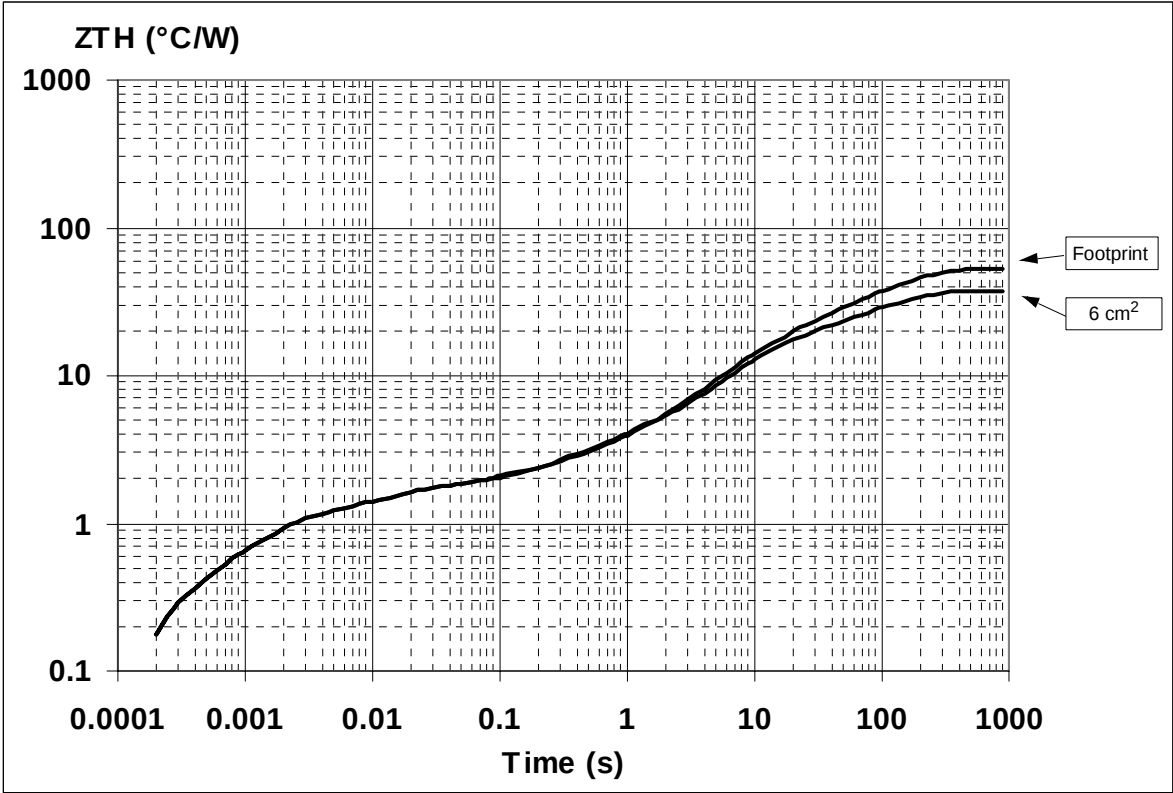


Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area= 60mm x 60mm, PCB thickness=2mm, Cu thickness=35 μ m, Copper areas: 6cm²).

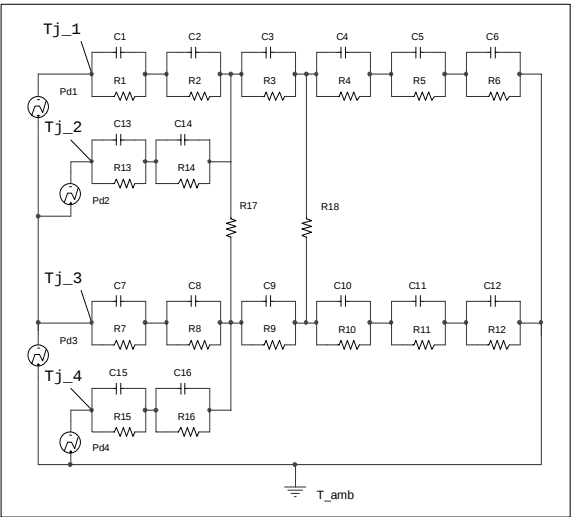
$R_{thj-amb}$ Vs PCB copper area in open box free air condition



Thermal Impedance Junction Ambient Single Pulse



Thermal fitting model of a quad HSD in PowerSO-16



Pulse calculation formula

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

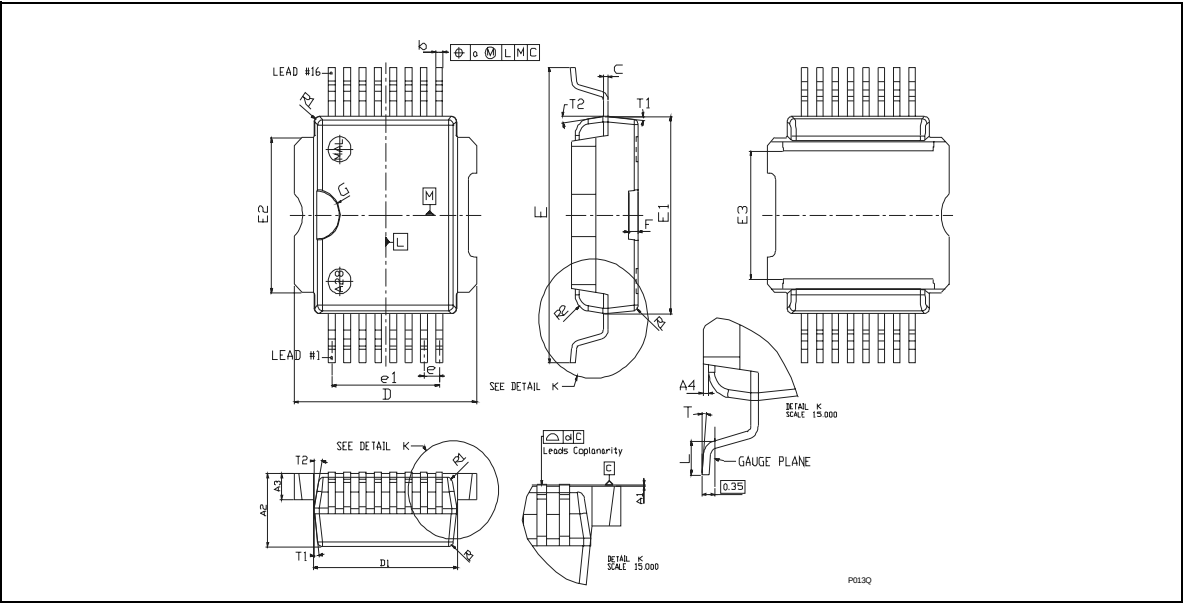
where $\delta = t_p / T$

Thermal Parameter

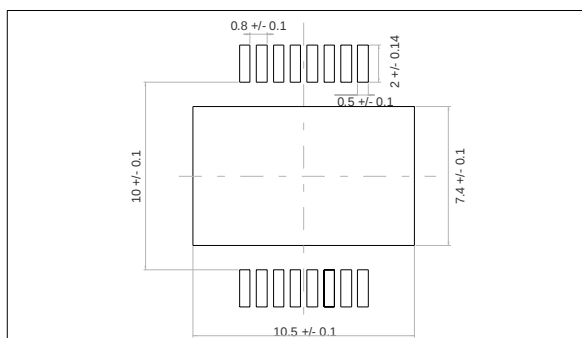
Area/island (cm ²)	Footprint	6
R1 (°C/W)	0.18	
R2 (°C/W)	0.8	
R3 (°C/W)	0.7	
R4 (°C/W)	0.8	
R5 (°C/W)	13	
R6 (°C/W)	37	22
C1 (W.s/°C)	0.0006	
C2 (W.s/°C)	1.50E-03	
C3 (W.s/°C)	1.75E-02	
C4 (W.s/°C)	0.4	
C5 (W.s/°C)	0.75	
C6 (W.s/°C)	3	5

POWERSO-16™ MECHANICAL DATA

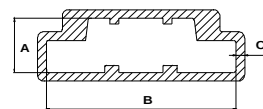
DIM.	mm.		
	MIN.	TYP	MAX.
A1	0	0.05	0.1
A2	3.4	3.5	3.6
A3	1.2	1.3	1.4
A4	0.15	0.2	0.25
a		0.2	
b	0.27	0.35	0.43
c	0.23	0.27	0.32
D	9.4	9.5	9.6
D1	7.4	7.5	7.6
d	0	0.05	0.1
E (1)	13.85	14.1	14.35
E1	9.3	9.4	9.5
E2	7.3	7.4	7.5
E3	5.9	6.1	6.3
e		0.8	
e1		5.6	
F		0.5	
G		1.2	
L	0.8	1	1.1
R1			0.25
R2		0.8	
T	2°	5°	8°
T1	6° (typ.)		
T2	10° (typ.)		
Package Weight	(typ.)		



PowerSO-16™ SUGGESTED PAD LAYOUT



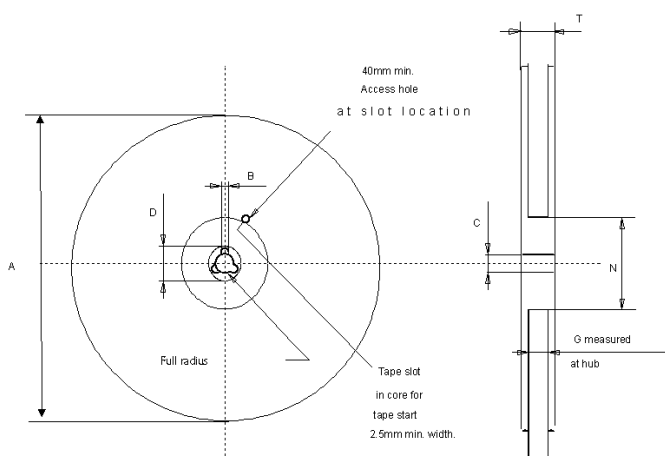
TUBE SHIPMENT (no suffix)



All dimensions are in mm.

Base Q.ty	Bulk Q.ty	Tube length (±0.5)	A	B	C (±0.1)
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

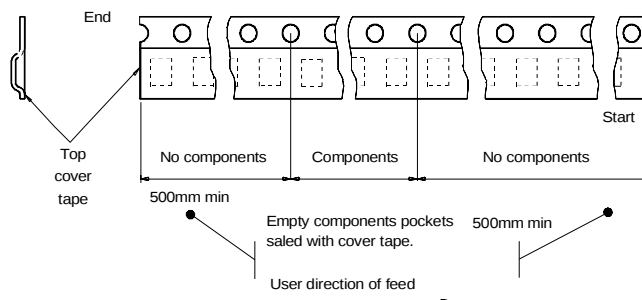
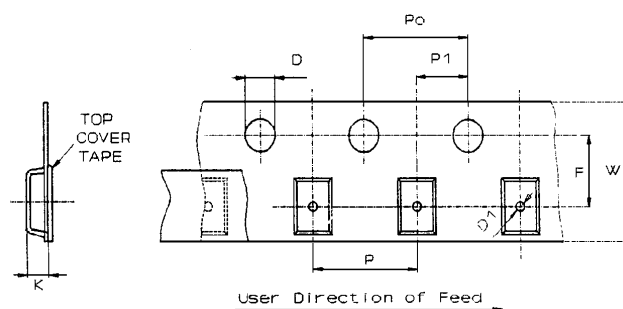
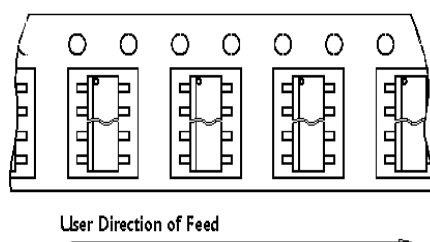
All dimensions are in mm.

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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