



VN920D-B5 VN920DSO

HIGH SIDE DRIVER

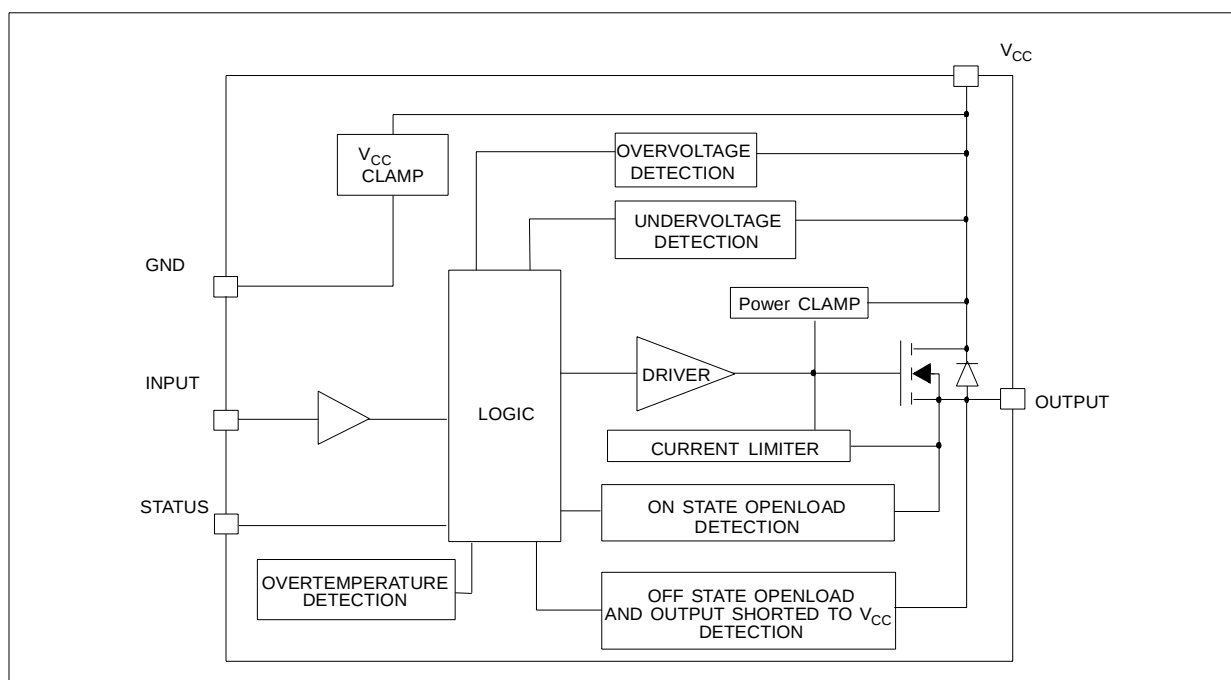
TYPE	$R_{DS(on)}$	I_{OUT}	V_{CC}
VN920D-B5 VN920DSO	18 m Ω	30 A	36 V

- 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 VN920D-B5, VN920DSO are monolithic devices 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

BLOCK DIAGRAM

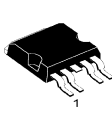


(*) See application schematic at page 8

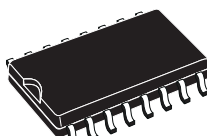
Rev. 1

July 2004

1/22



P²PAK



SO-16L

ORDER CODES		
PACKAGE	TUBE	T&R
SO-16L	VN920DSO	VN920DSO13TR
P ² PAK	VN920D-B5	VN920D-B513TR

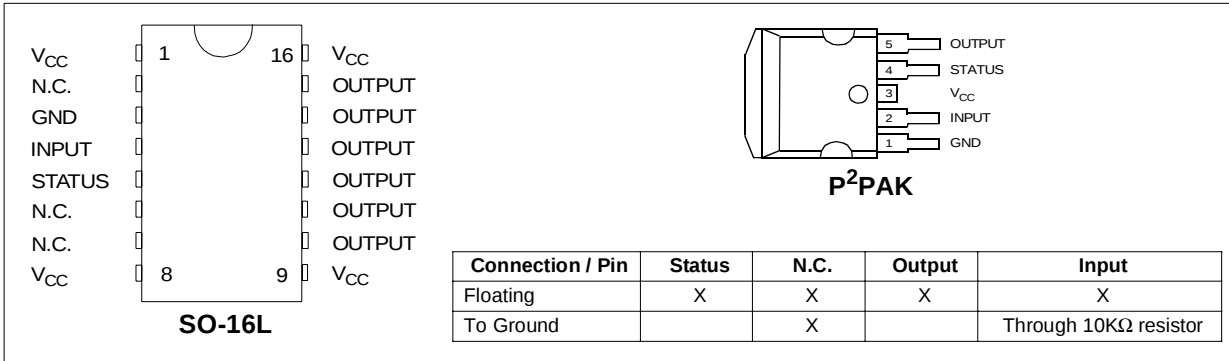
transient compatibility table). Active current limitation combined with thermal shutdown and automatic restart protect the device against overload.

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.

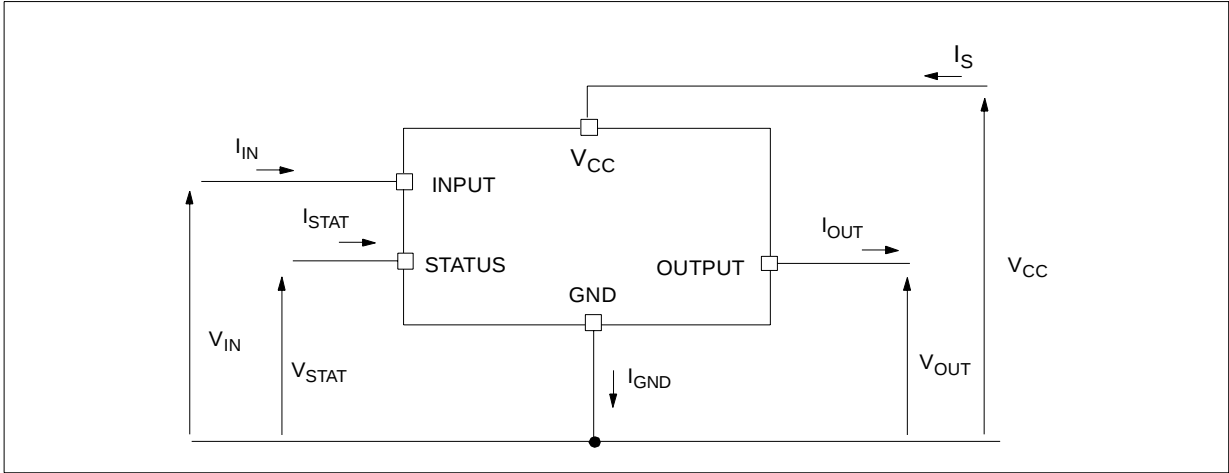
ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value		Unit
		P ² PAK	SO-16L	
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=1.5KΩ; C=100pF)			
	- INPUT	4000		V
	- CURRENT SENSE	4000		V
	- OUTPUT	5000		V
	- V _{CC}	5000		V
E _{MAX}	Maximum Switching Energy (L=0.25mH; R _L =0Ω; V _{bat} =13.5V; T _{jstart} =150°C; I _L =45A)	364	352	mJ
P _{tot}	Power Dissipation T _C =25°C	96.1	8.3	W
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

CONNECTION DIAGRAM (TOP VIEW)



CURRENT AND VOLTAGE CONVENTIONS



THERMAL DATA

Symbol	Parameter		Value		Unit
			P ² PAK	SO-16L	
R _{thj-case}	Thermal Resistance Junction-case	Max	1.3	-	°C/W
R _{thj-lead}	Thermal Resistance Junction-lead	Max	-	15	°C/W
R _{thj-amb}	Thermal Resistance Junction-ambient	Max	51.3 (*)	65 (**)	°C/W

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

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

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

POWER

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V _{CC}	Operating Supply Voltage		5.5	13	36	V
V _{USD}	Undervoltage Shut-down		3	4	5.5	V
V _{USDhyst}	Undervoltage Shut-down hysteresis			0.5		V
V _{OV}	Overvoltage Shut-down		36			V
R _{ON}	On State Resistance	I _{OUT} =10A; T _j =25°C			18	mΩ
		I _{OUT} =10A			36	mΩ
		I _{OUT} =3A; V _{CC} =6V			50	mΩ
I _S	Supply Current	Off State; V _{CC} =13V; V _{IN} =V _{OUT} =0V		10	25	μA
		Off State; V _{CC} =13V; V _{IN} =V _{OUT} =0V; T _j =25°C		10	20	μA
		On State; V _{CC} =13V; V _{IN} =5V; I _{OUT} =0A			5	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 =1.3Ω		50		μs
t _{d(off)}	Turn-off Delay Time	R _L =1.3Ω		50		μs
dV _{OUT} /dt _(on)	Turn-on Voltage Slope	R _L =1.3Ω		See relative diagram		V/μs
dV _{OUT} /dt _(off)	Turn-off Voltage Slope	R _L =1.3Ω		See relative diagram		V/μs

INPUT PIN

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

ELECTRICAL CHARACTERISTICS (continued)**VCC - OUTPUT DIODE**

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_F	Forward on Voltage	$-I_{OUT}=5.5A$; $T_J=150^{\circ}C$			0.7	V

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	μA
C_{STAT}	Status Pin Input Capacitance	Normal Operation $V_{STAT}=5V$			100	pF
V_{SCL}	Status Clamp Voltage	$I_{STAT}=1mA$ $I_{STAT}=-1mA$	6	6.8 -0.7	8	V V

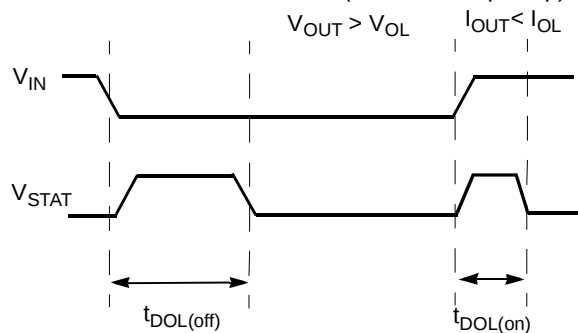
PROTECTIONS

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	μs
I_{lim}	Current limitation	$5.5V < V_{CC} < 36V$	30	45	75 75	A 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

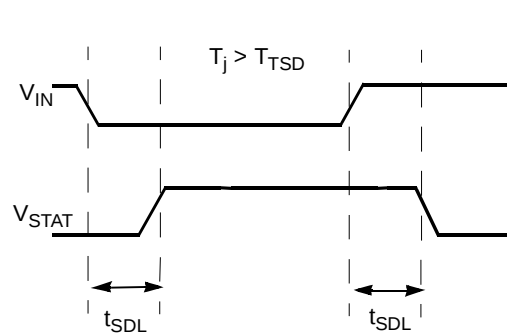
OPENLOAD DETECTION

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	$I_{OUT}=0A$			250	μs
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	μs

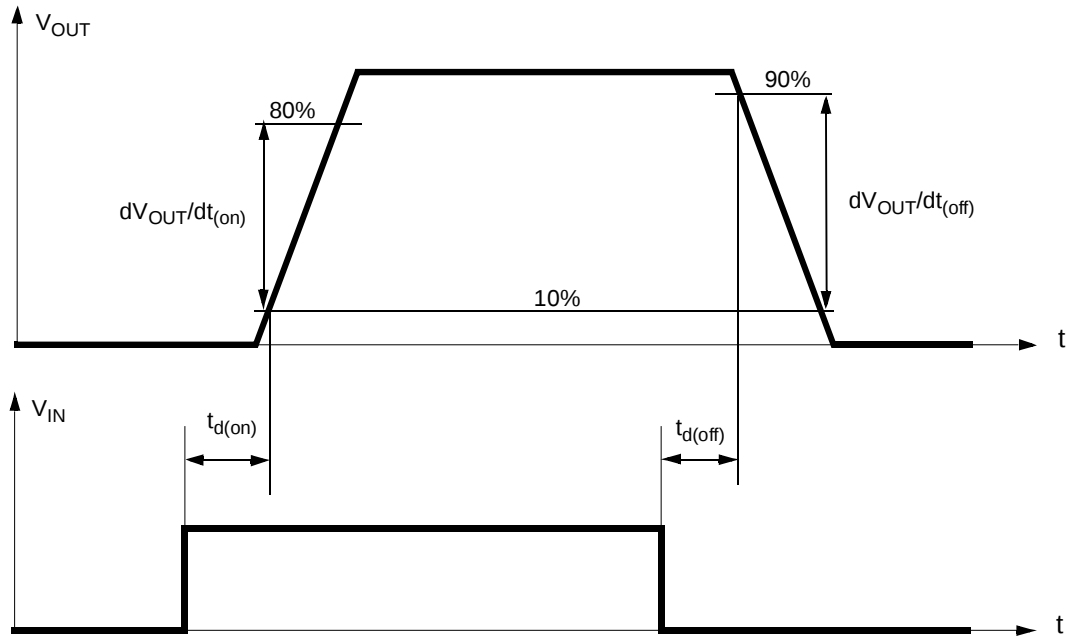
OPEN LOAD STATUS TIMING (with external pull-up)



OVERTEMP STATUS TIMING



Switching time Waveforms



TRUTH TABLE

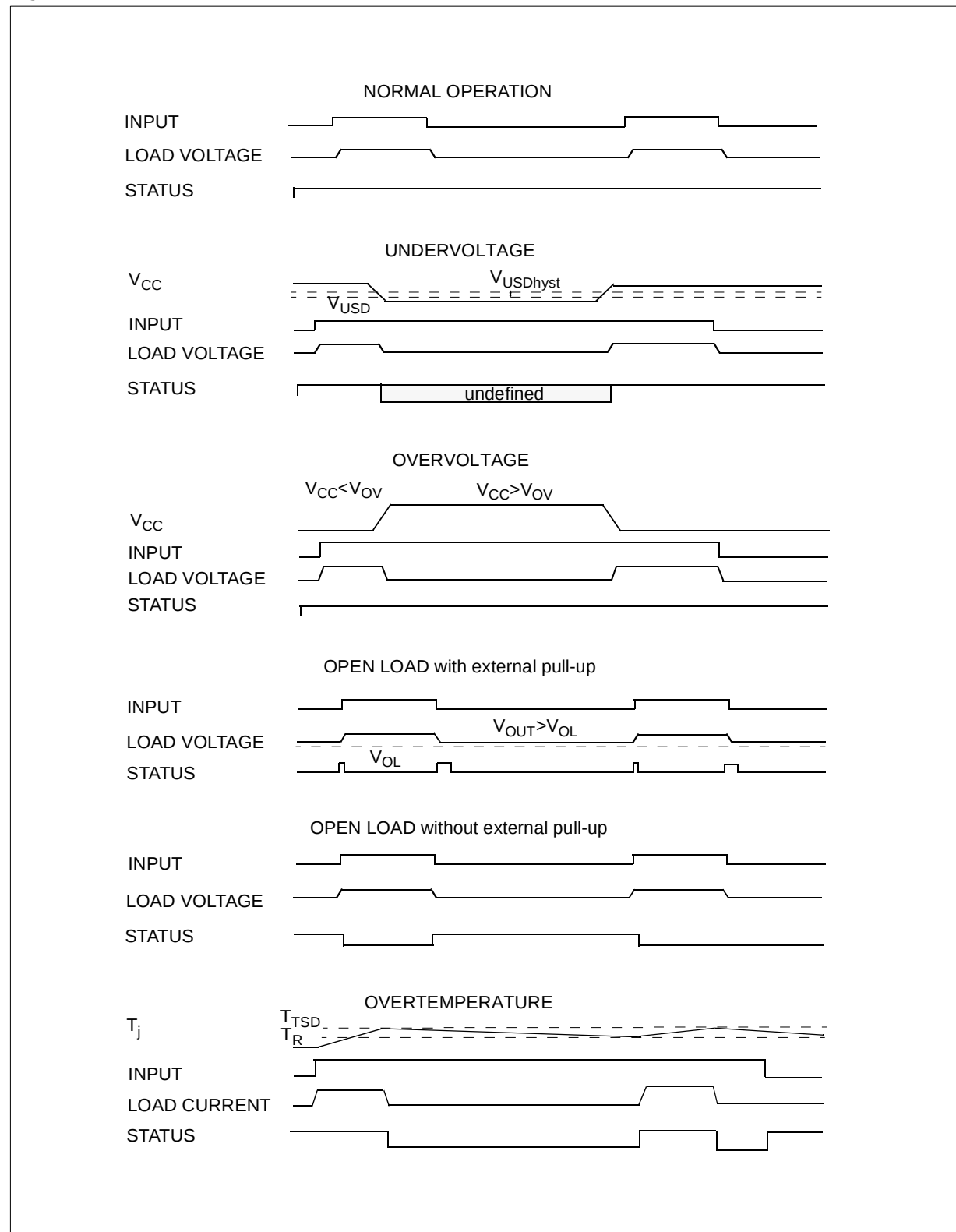
CONDITIONS	INPUT	OUTPUT	STATUS
Normal Operation	L	L	H
	H	H	H
Current Limitation	L	L	H
	H	X	$(T_j < T_{TSD})$ H
	H	X	$(T_j > T_{TSD})$ L
Overtemperature	L	L	H
	H	L	L
Undervoltage	L	L	X
	H	L	X
Overvoltage	L	L	H
	H	L	H
Output Voltage $> V_{OL}$	L	H	L
	H	H	H
Output Current $< I_{OL}$	L	L	H
	H	H	L

ELECTRICAL TRANSIENT REQUIREMENTS ON V_{CC} PIN

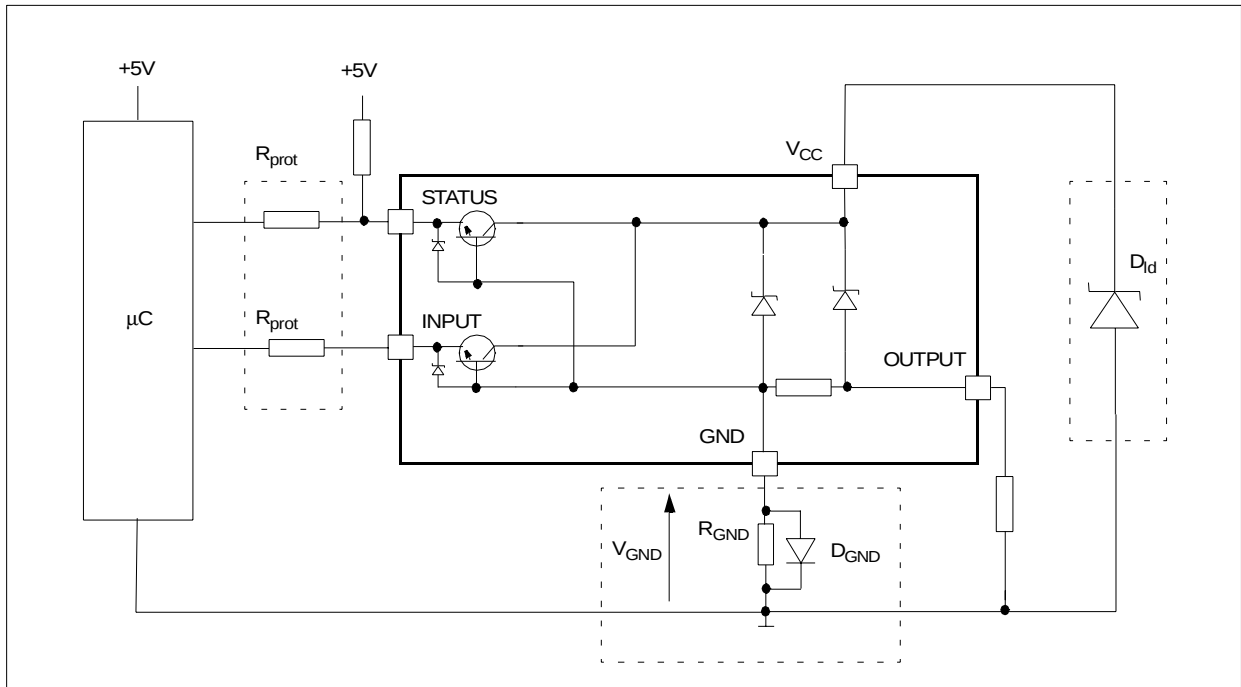
ISO T/R 7637/1 Test Pulse	TEST LEVELS				
	I	II	III	IV	Delays and Impedance
1	-25 V	-50 V	-75 V	-100 V	2 ms 10 Ω
2	+25 V	+50 V	+75 V	+100 V	0.2 ms 10 Ω
3a	-25 V	-50 V	-100 V	-150 V	0.1 μs 50 Ω
3b	+25 V	+50 V	+75 V	+100 V	0.1 μs 50 Ω
4	-4 V	-5 V	-6 V	-7 V	100 ms, 0.01 Ω
5	+26.5 V	+46.5 V	+66.5 V	+86.5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

ISO T/R 7637/1 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.

Figure 1: 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 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.

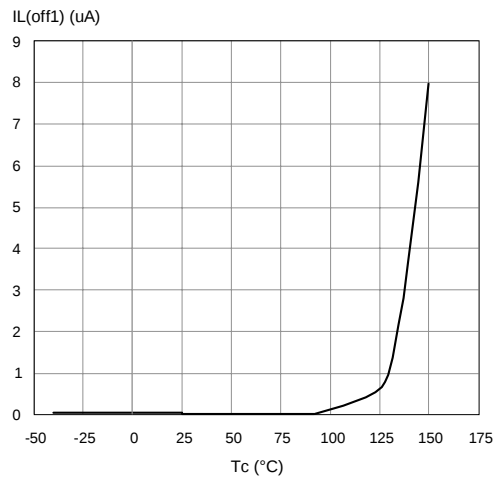
$$-V_{CCpeak} / I_{latchup} \leq R_{prot} \leq (V_{OH\mu C} - V_{IH} - V_{GND}) / I_{IHmax}$$

Calculation example:

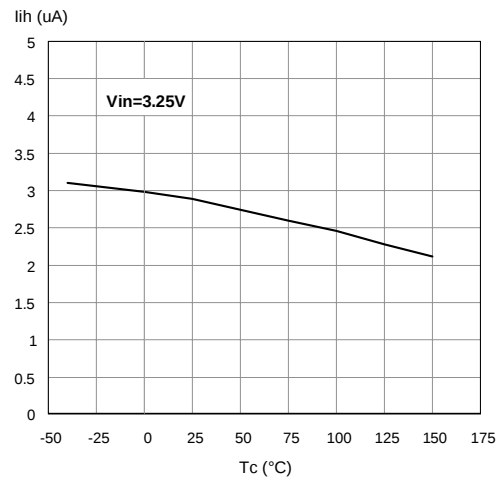
For $V_{CCpeak} = -100\text{V}$ and $I_{latchup} \geq 20\text{mA}$; $V_{OH\mu C} \geq 4.5\text{V}$
 $5\text{k}\Omega \leq R_{prot} \leq 65\text{k}\Omega$.

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

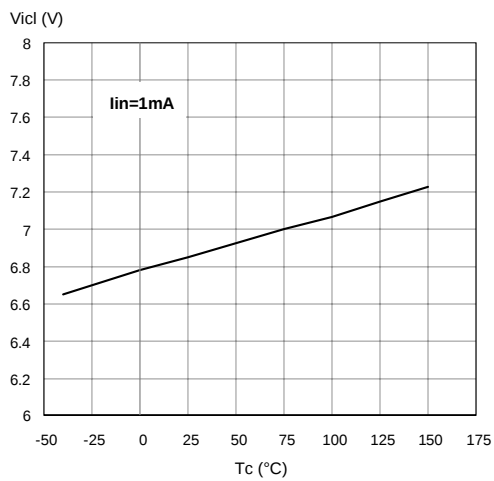
Off State Output Current



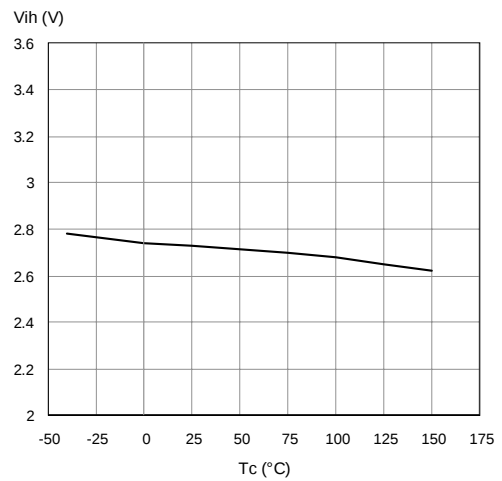
High Level Input Current



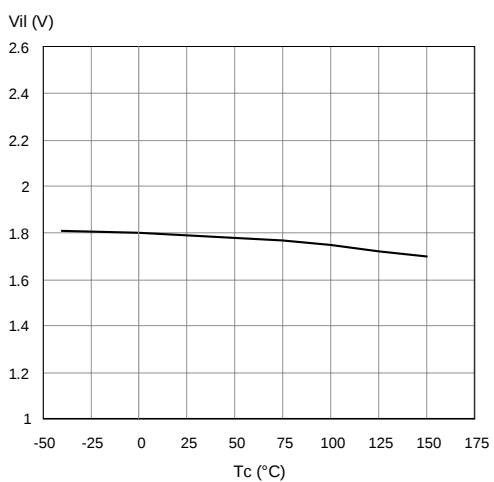
Input Clamp Voltage



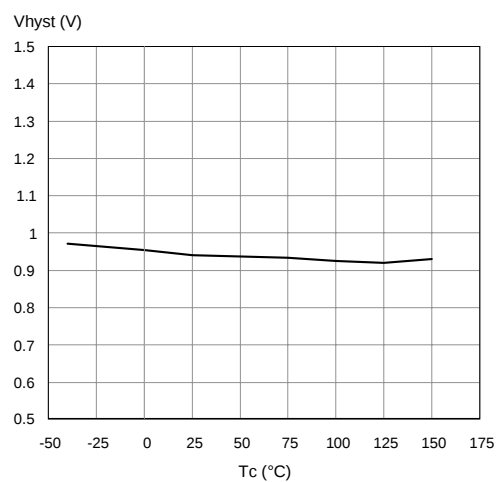
Input High Level



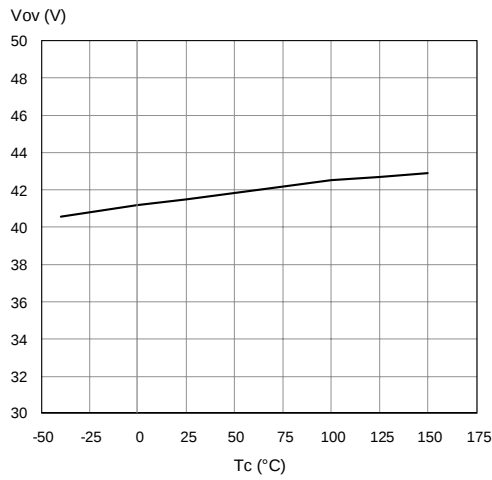
Input Low Level



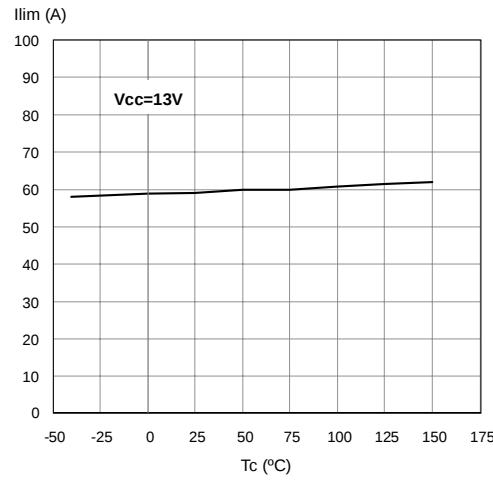
Input Hysteresis Voltage



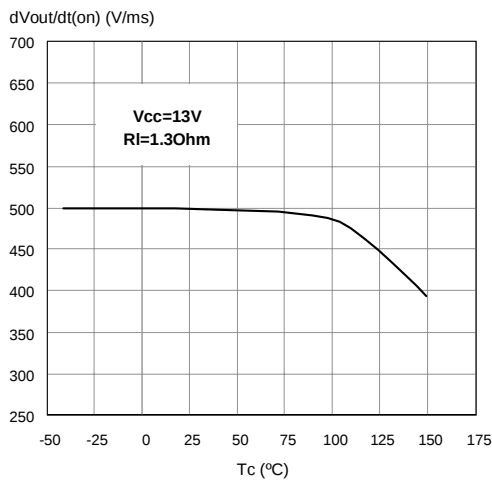
Overvoltage Shutdown



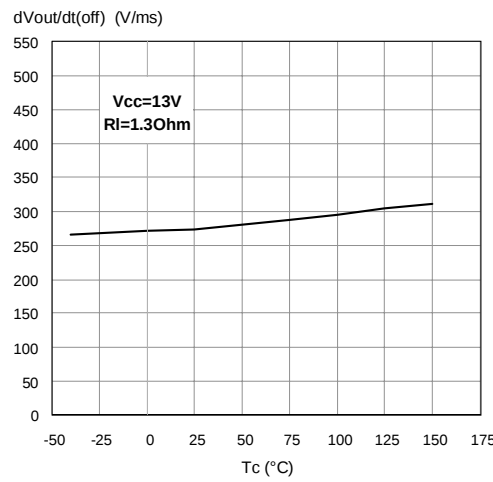
I_{LIM} Vs. T_{case}



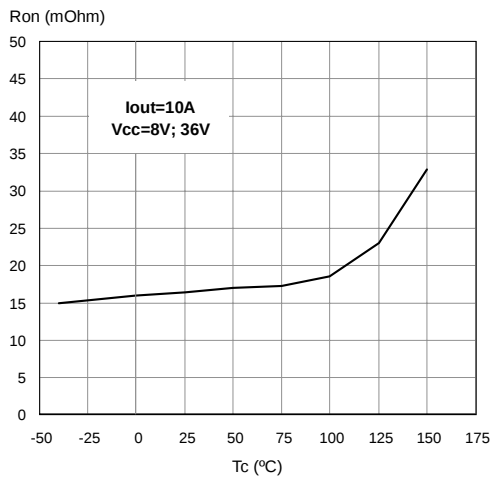
Turn-on Voltage Slope



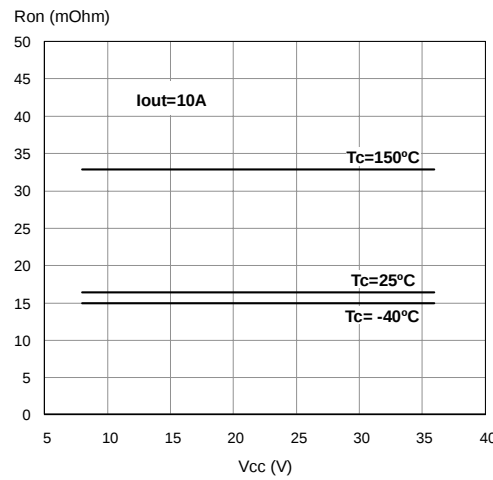
Turn-off Voltage Slope



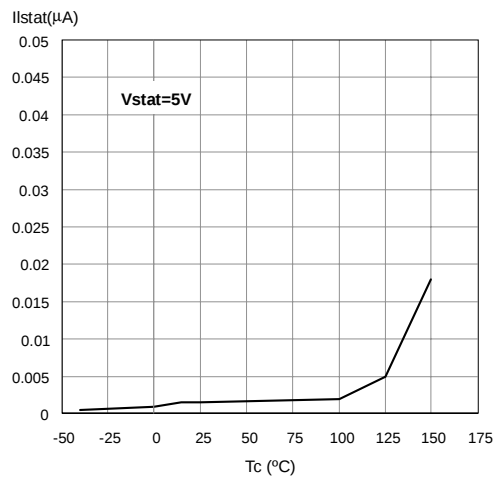
On State Resistance Vs. T_{case}



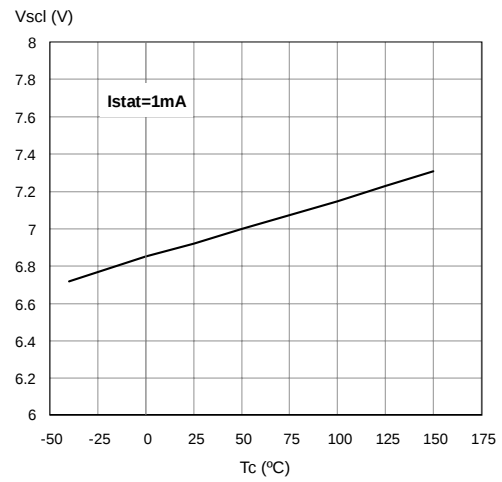
On State Resistance Vs. V_{CC}



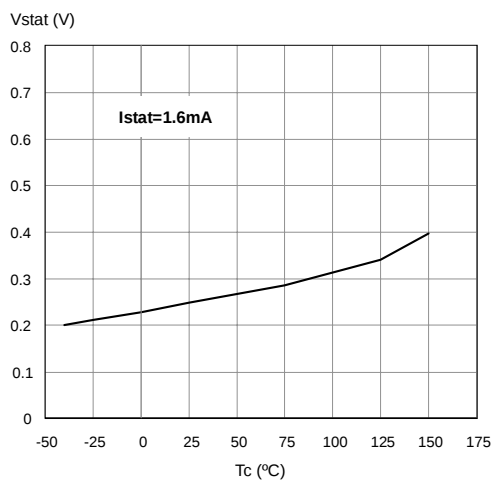
Status Leakage Current

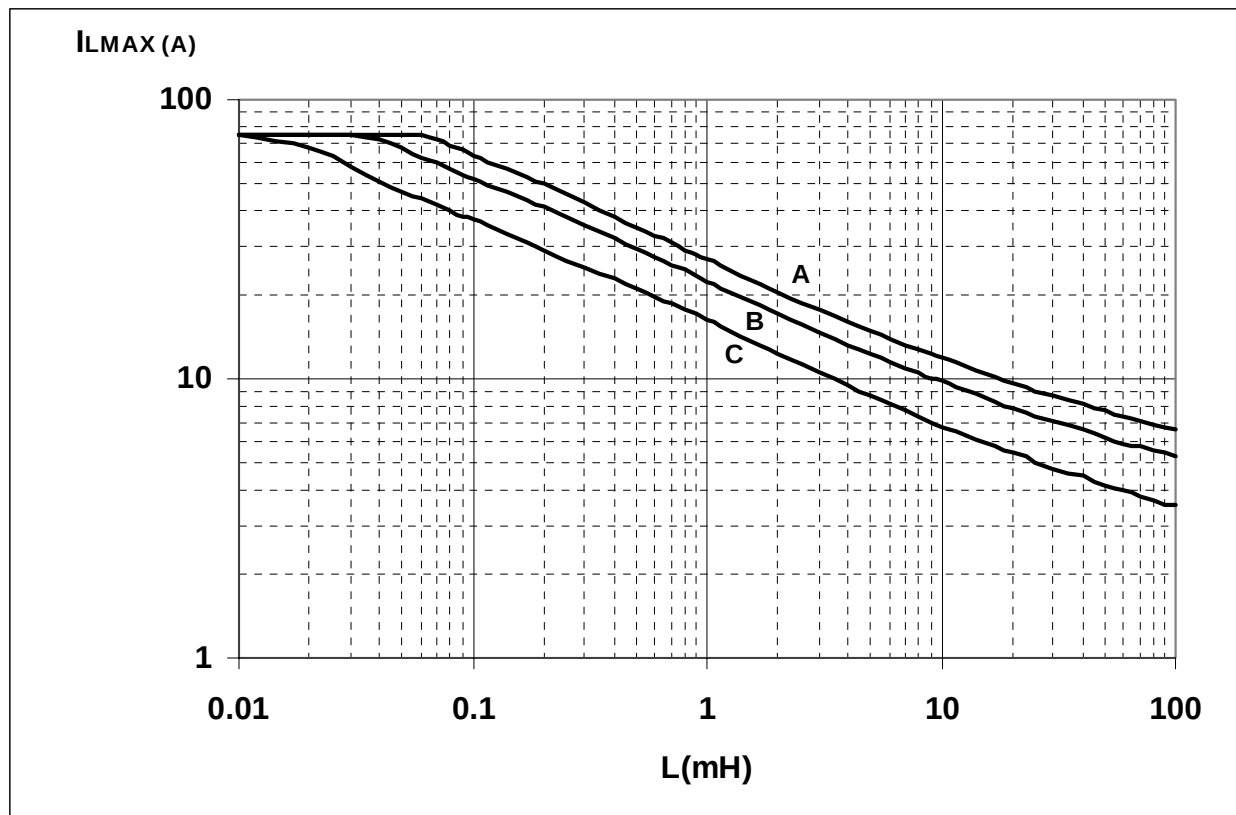


Status Clamp Voltage



Status Low Output Voltage



P²PAK Maximum turn off current versus load inductance

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

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

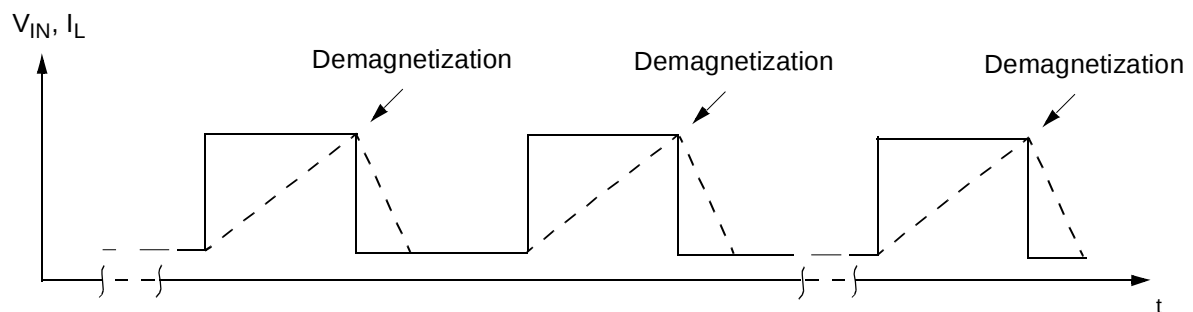
C= Repetitive Pulse at $T_{Jstart}=125^{\circ}C$

Conditions:

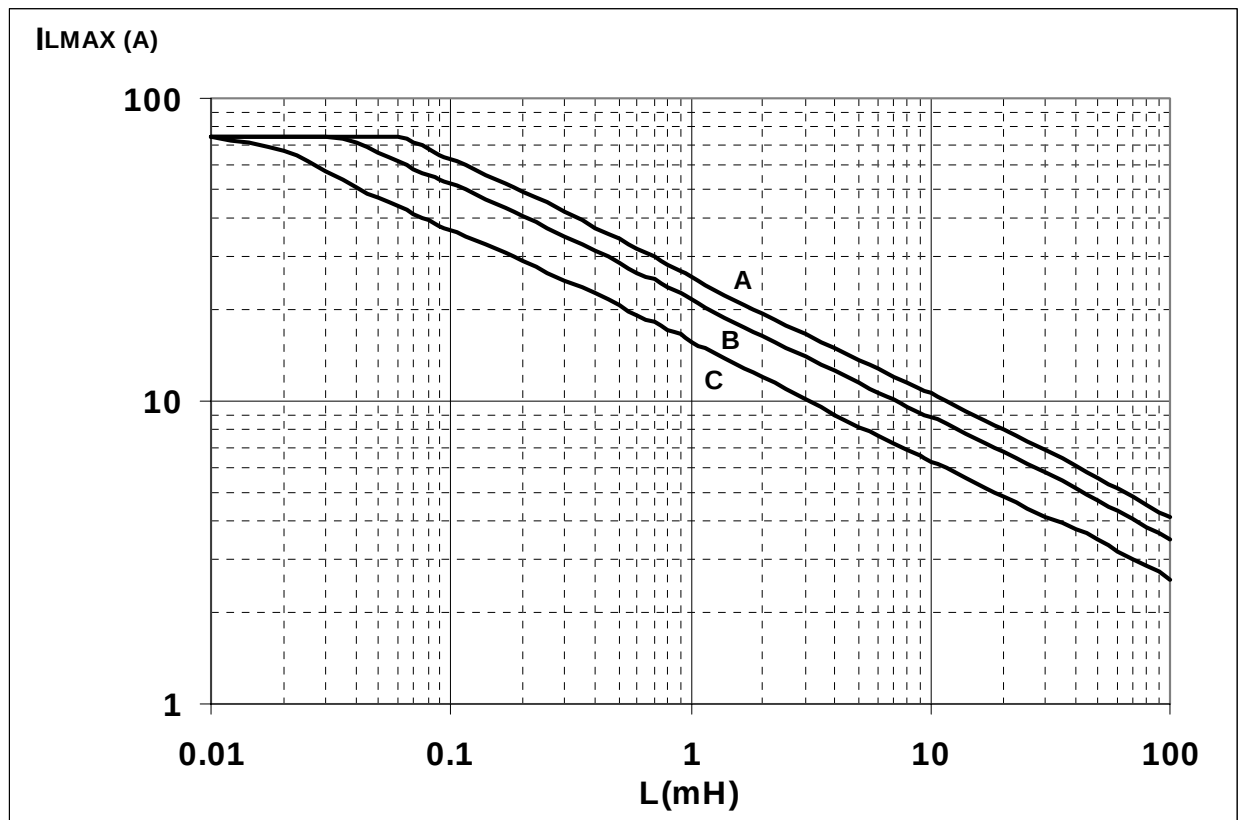
$V_{CC}=13.5V$

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.



SO-16L Maximum turn off current versus load inductance



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

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

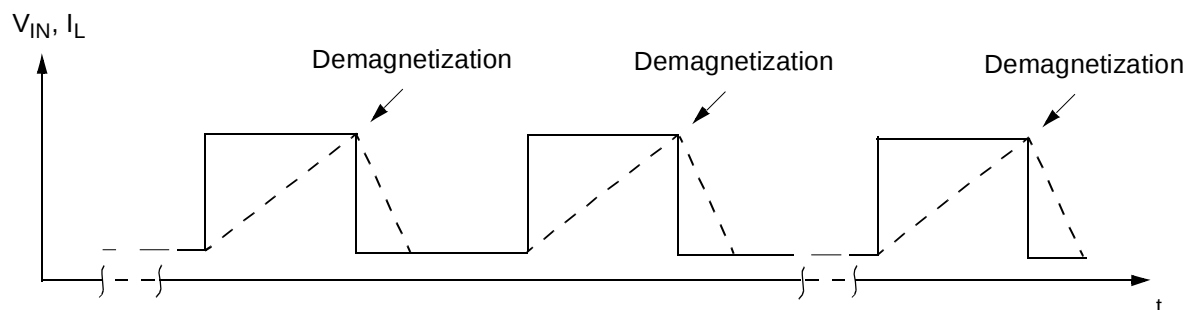
C= Repetitive Pulse at $T_{Jstart}=125^{\circ}C$

Conditions:

$V_{CC}=13.5V$

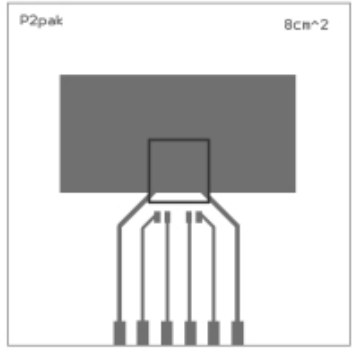
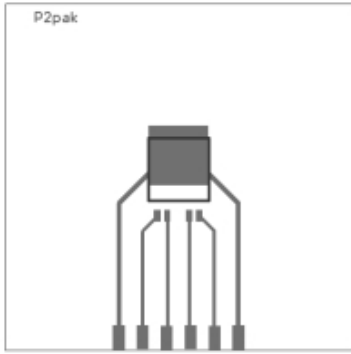
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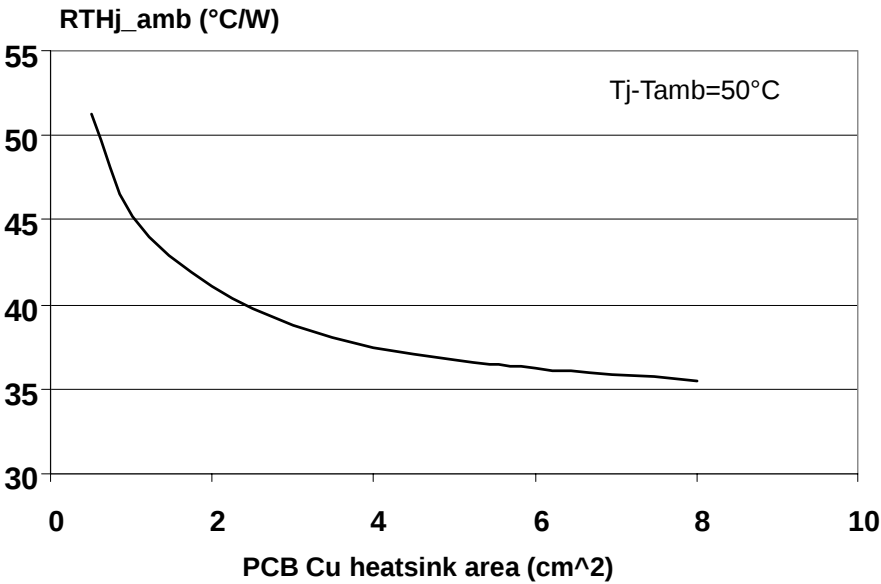
P²PAK THERMAL DATA

P²PAK PC Board



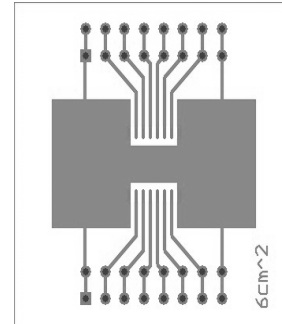
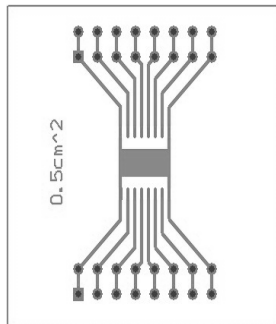
Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area= 60mm x 60mm, PCB thickness=2mm, Cu thickness=35 μ m, Copper areas: 0.97cm², 8cm²).

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



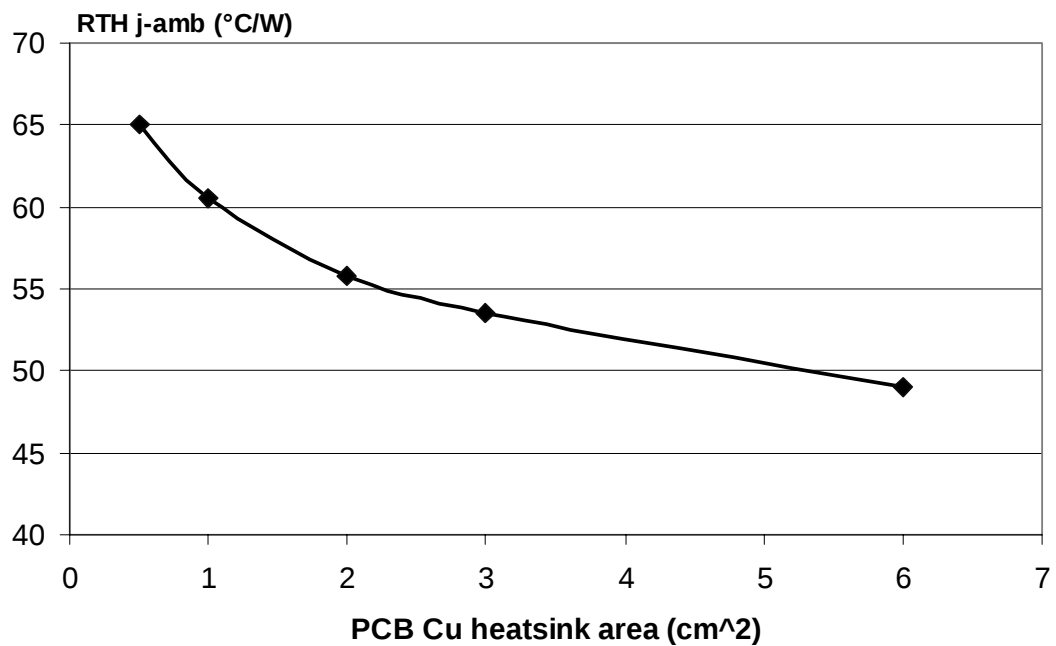
SO-16L THERMAL DATA

SO-16L PC Board

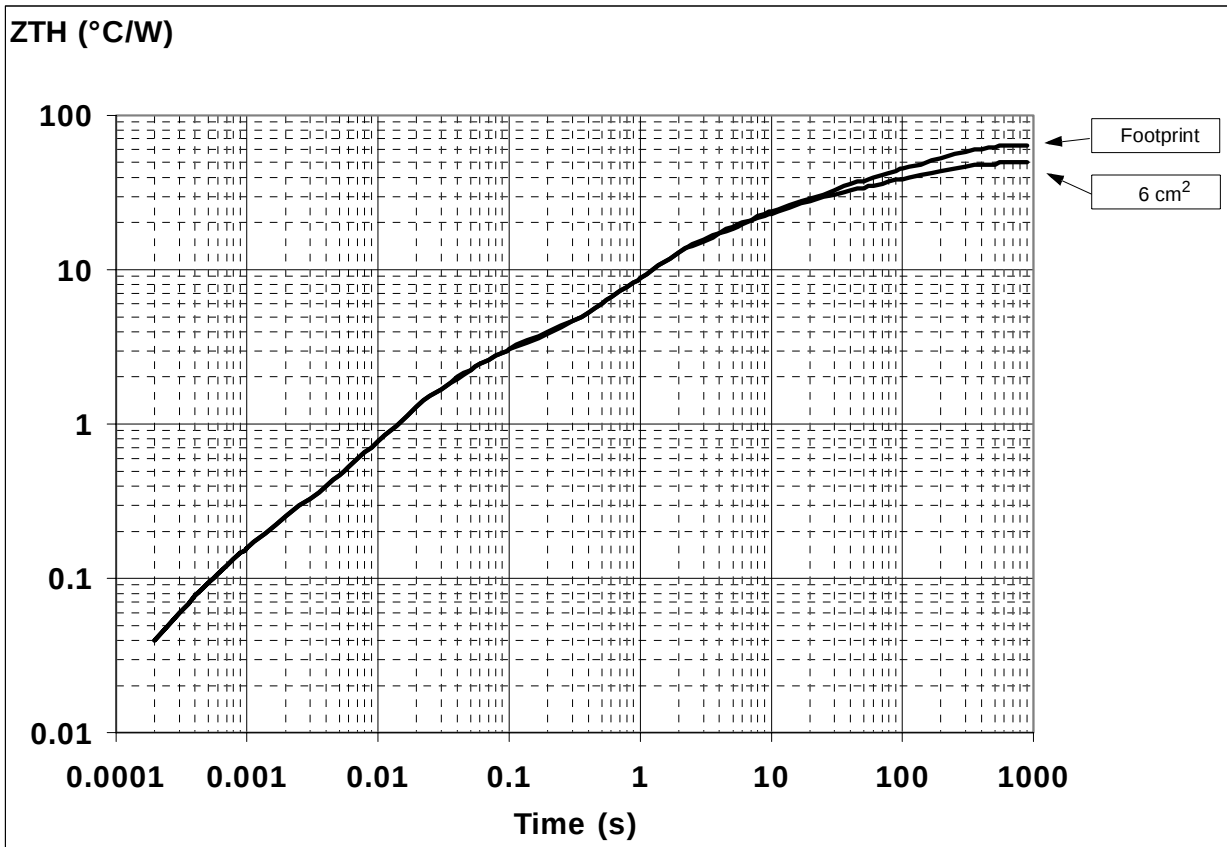


Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area= 41mm x 48mm, PCB thickness=2mm, Cu thickness=35 μm , Copper areas: 0.5 cm^2 , 6 cm^2).

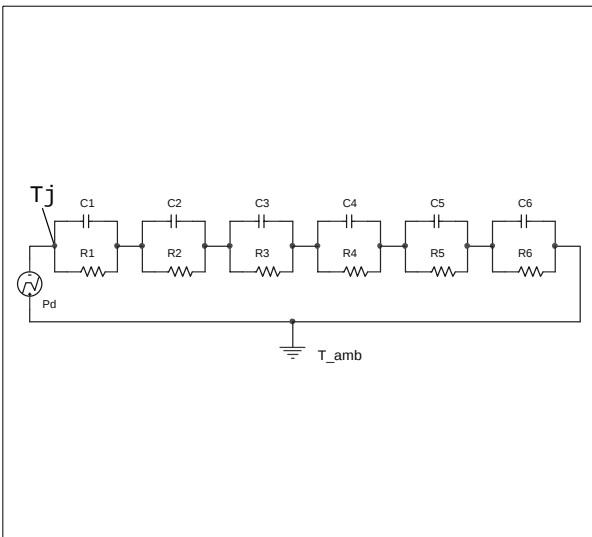
$R_{thj-amb}$ Vs. PCB copper area in open box free air condition



SO-16L Thermal Impedance Junction Ambient Single Pulse



Thermal fitting model of a single channel HSD in SO-16L



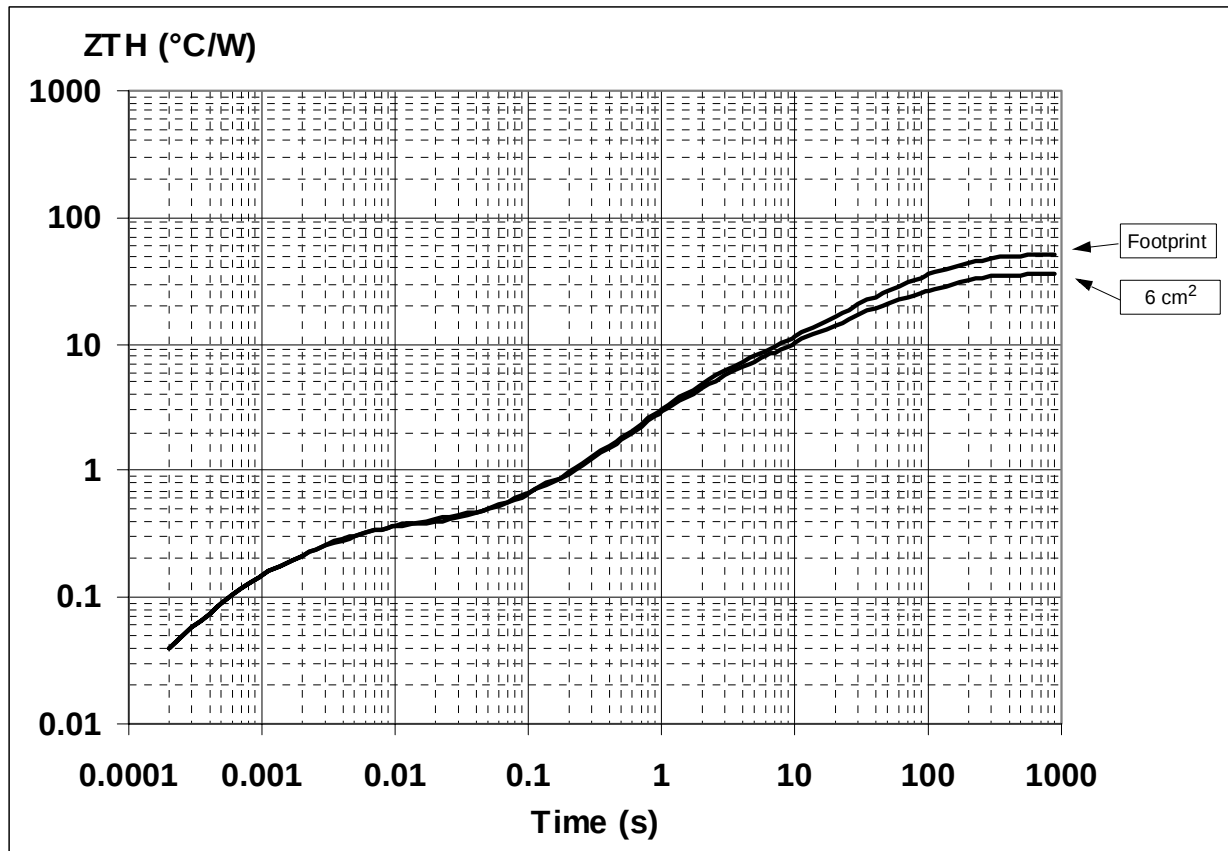
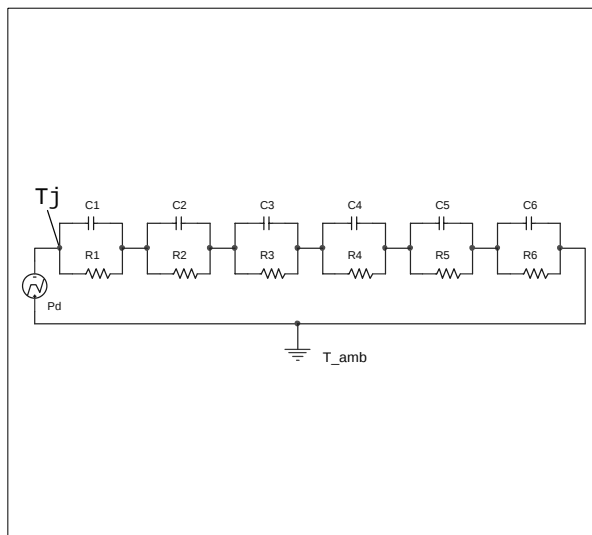
Pulse calculation formula

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

where $\delta = t_p / T$

Thermal Parameter

Arealisland (cm ²)	Footprint	6
R1 (°C/W)	0.02	
R2 (°C/W)	0.1	
R3 (°C/W)	2.2	
R4 (°C/W)	12	
R5 (°C/W)	15	
R6 (°C/W)	35	20
C1 (W.s/°C)	0.0015	
C2 (W.s/°C)	7.00E-03	
C3 (W.s/°C)	1.50E-02	
C4 (W.s/°C)	0.14	
C5 (W.s/°C)	1	
C6 (W.s/°C)	5	8

P²PAK Thermal Impedance Junction Ambient Single PulseThermal fitting model of a single channel HSD in P²PAK

Pulse calculation formula

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

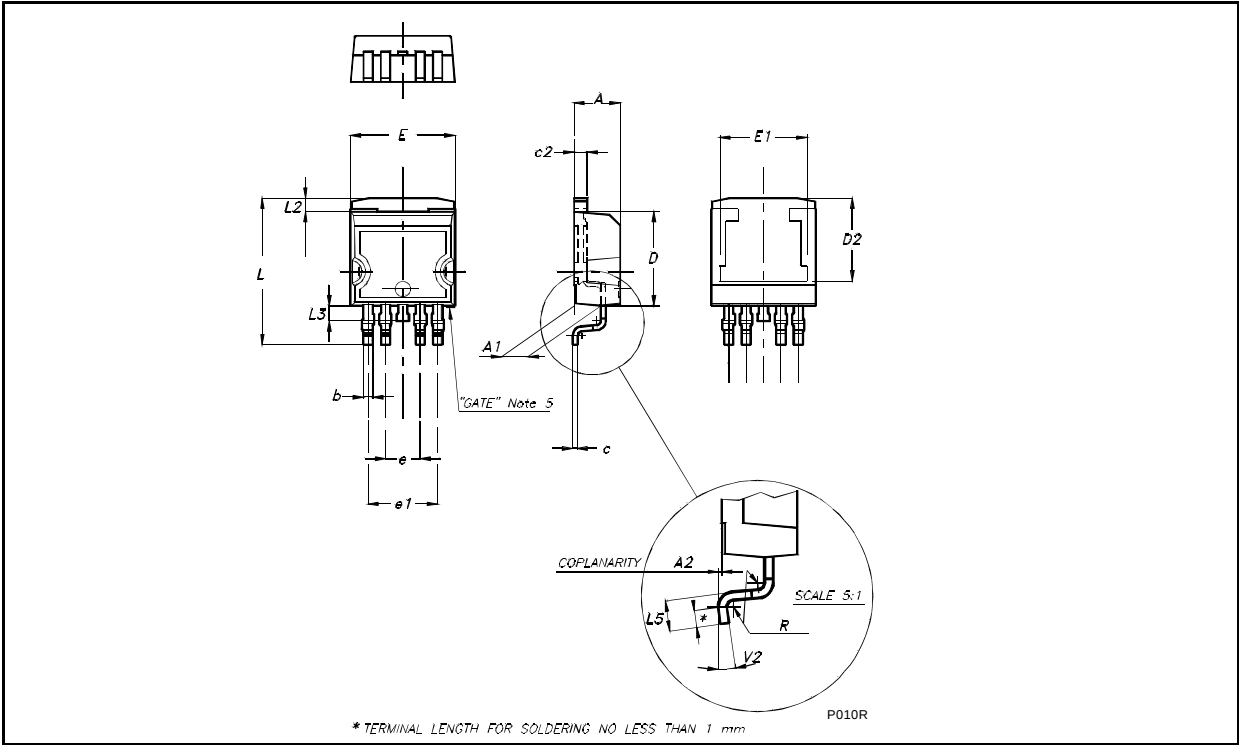
$$\text{where } \delta = t_p / T$$

Thermal Parameter

Arealisland (cm ²)	Footprint	6
R1 ($^{\circ}\text{C/W}$)	0.02	
R2 ($^{\circ}\text{C/W}$)	0.1	
R3 ($^{\circ}\text{C/W}$)	0.22	
R4 ($^{\circ}\text{C/W}$)	4	
R5 ($^{\circ}\text{C/W}$)	9	
R6 ($^{\circ}\text{C/W}$)	37	22
C1 (W.s/ $^{\circ}\text{C}$)	0.0015	
C2 (W.s/ $^{\circ}\text{C}$)	0.007	
C3 (W.s/ $^{\circ}\text{C}$)	0.015	
C4 (W.s/ $^{\circ}\text{C}$)	0.4	
C5 (W.s/ $^{\circ}\text{C}$)	2	
C6 (W.s/ $^{\circ}\text{C}$)	3	5

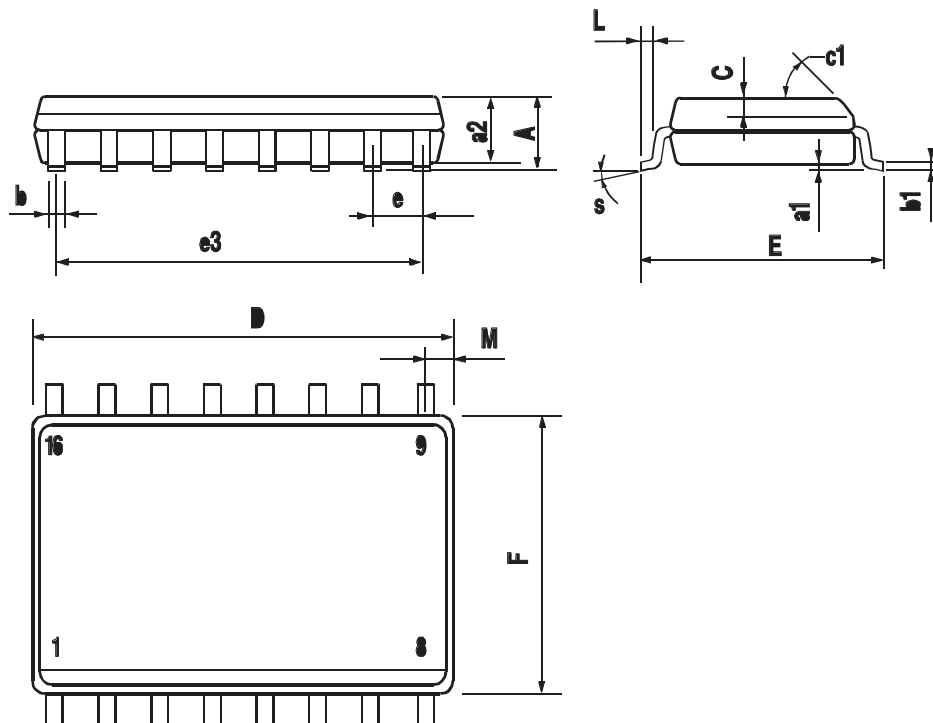
P²PAK MECHANICAL DATA

DIM.	mm.		
	MIN.	TYP	MAX.
A	4.30		4.80
A1	2.40		2.80
A2	0.03		0.23
b	0.80		1.05
c	0.45		0.60
c2	1.17		1.37
D	8.95		9.35
D2		8.00	
E	10.00		10.40
E1		8.50	
e	3.20		3.60
e1	6.60		7.00
L	13.70		14.50
L2	1.25		1.40
L3	0.90		1.70
L5	1.55		2.40
R		0.40	
V2	0°		8°
Package Weight	1.40 Gr (typ)		



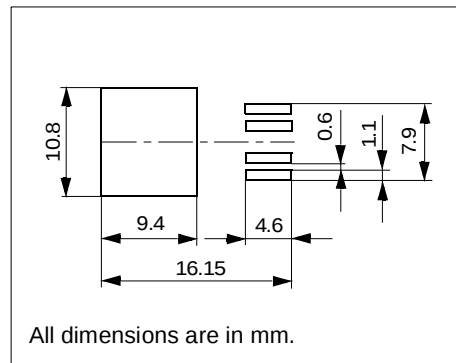
SO-16L MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.2	0.004		0.008
a2			2.45			0.096
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.012
C		0.5			0.020	
c1	45° (typ.)					
D	10.1		10.5	0.397		0.413
E	10.0		10.65	0.393		0.419
e		1.27			0.050	
e3		8.89			0.350	
F	7.4		7.6	0.291		0.300
L	0.5		1.27	0.020		0.050
M			0.75			0.029
S	8° (max.)					

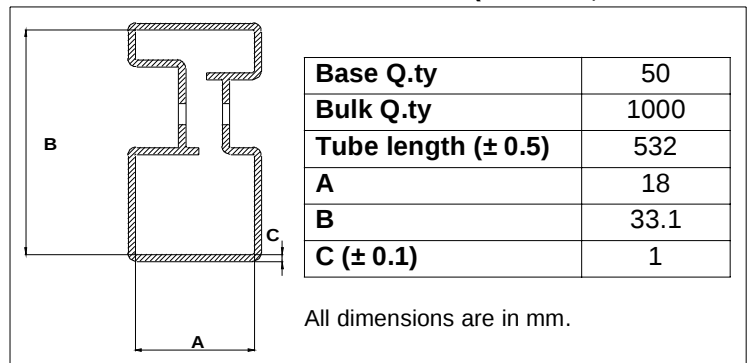


VN920D-B5 / VN920DSO

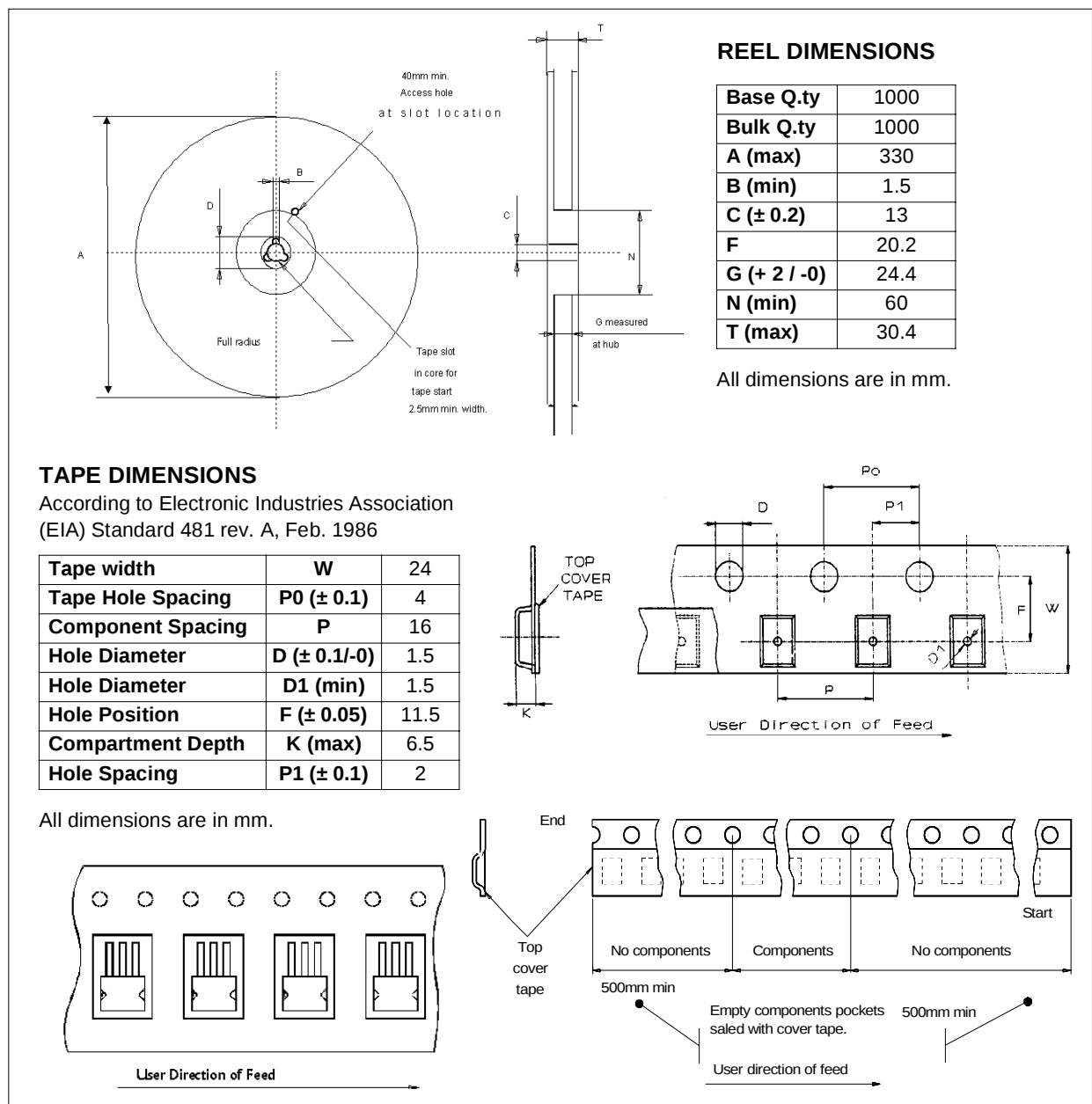
P²PAK SUGGESTED PAD LAYOUT



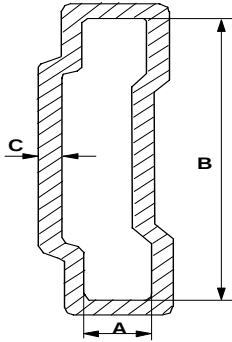
P²PAK TUBE SHIPMENT (no suffix)



TAPE AND REEL SHIPMENT (suffix "13TR")



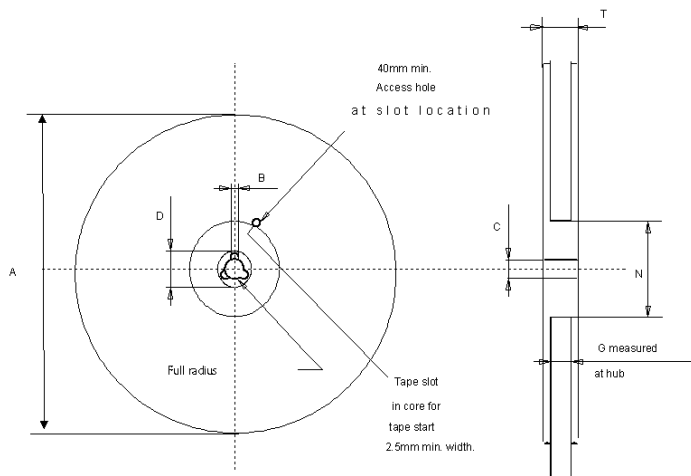
SO-16L TUBE SHIPMENT (no suffix)



Base Q.ty	50
Bulk Q.ty	1000
Tube length (± 0.5)	532
A	3.5
B	13.8
C (± 0.1)	0.6

All dimensions are in mm.

TAPE AND REEL SHIPMENT (suffix "13TR")



REEL DIMENSIONS

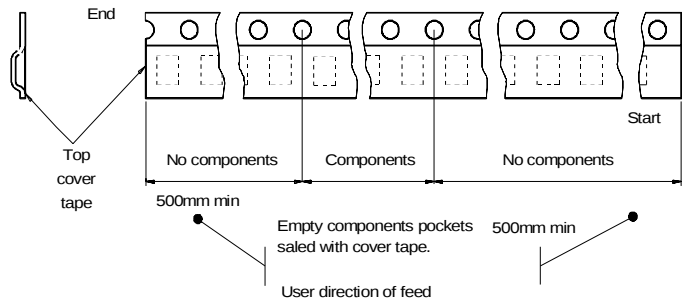
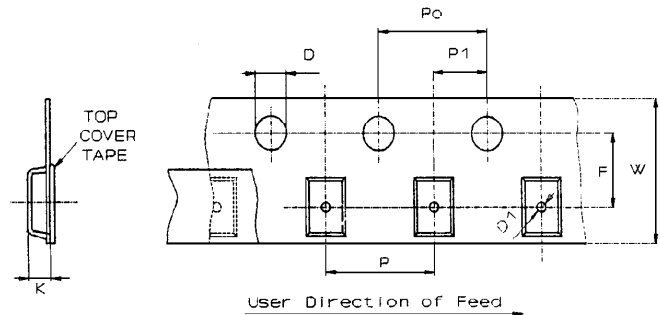
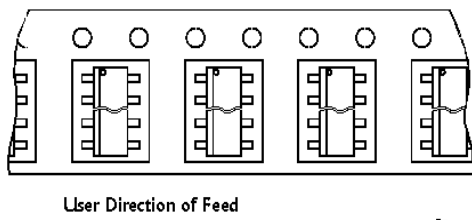
Base Q.ty	1000
Bulk Q.ty	1000
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	16.4
N (min)	60
T (max)	22.4

TAPE DIMENSIONS

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

Tape width	W	16
Tape Hole Spacing	P0 (± 0.1)	4
Component Spacing	P	12
Hole Diameter	D ($\pm 0.1/-0$)	1.5
Hole Diameter	D1 (min)	1.5
Hole Position	F (± 0.05)	7.5
Compartment Depth	K (max)	6.5
Hole Spacing	P1 (± 0.1)	2

All dimensions are in mm.



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