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# VN920 VN920-B5 / VN920SO

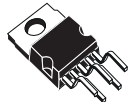
## SINGLE CHANNEL HIGH SIDE SOLID STATE RELAY

| TYPE     | $R_{DS(on)}$ | $I_{OUT}$ | $V_{CC}$ |
|----------|--------------|-----------|----------|
| VN920    |              |           |          |
| VN920-B5 | 16m $\Omega$ | 30 A      | 36 V     |
| VN920SO  |              |           |          |

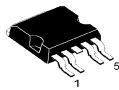
- CMOS COMPATIBLE INPUT
- PROPORTIONAL LOAD CURRENT SENSE
- SHORTED LOAD PROTECTION
- UNDERVOLTAGE AND OVERVOLTAGE SHUTDOWN
- OVERVOLTAGE CLAMP
- THERMAL SHUTDOWN
- CURRENT LIMITATION
- PROTECTION AGAINST LOSS OF GROUND AND LOSS OF  $V_{CC}$
- VERY LOW STAND-BY POWER DISSIPATION
- REVERSE BATTERY PROTECTION (\*)

### DESCRIPTION

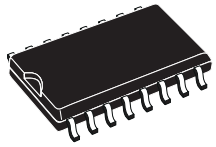
The VN920, VN920-B5, VN920SO is a monolithic device made by using STMicroelectronics VIPower M0-3 Technology, intended for driving any kind of load with one side connected to



**PENTAWATT**



**P<sup>2</sup>PAK**

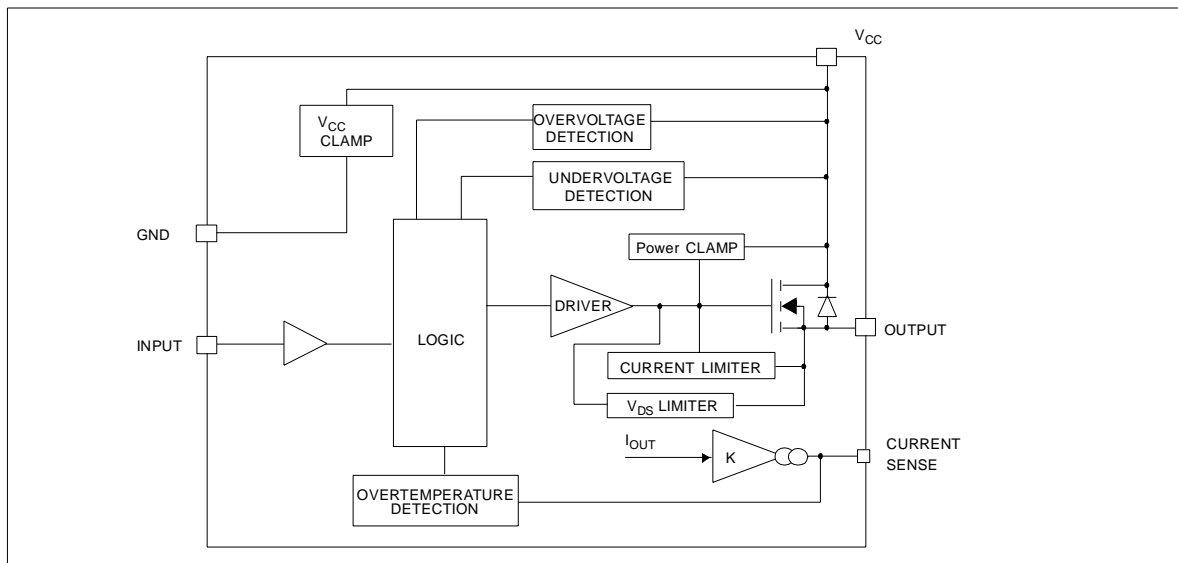


**SO-16L**

| ORDER CODES        |          |              |
|--------------------|----------|--------------|
| PACKAGE            | TUBE     | T&R          |
| PENTAWATT          | VN920    | -            |
| P <sup>2</sup> PAK | VN920-B5 | VN920-B513TR |
| SO-16L             | VN920SO  | VN920SO13TR  |

ground. Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table). Active current limitation combined with thermal shutdown and automatic restart protect the device against overload. The device integrates an analog current sense output which delivers a current proportional to the load current. Device automatically turns off in case of ground pin disconnection.

### BLOCK DIAGRAM



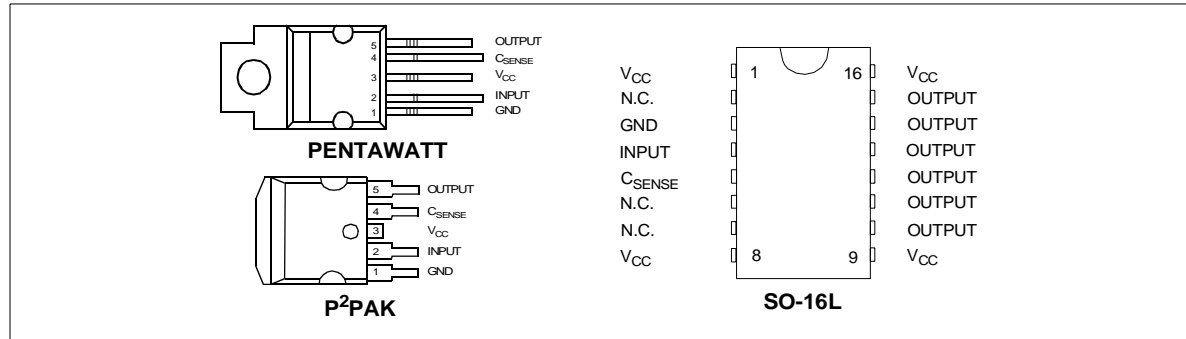
(\*) See application schematic at page 8

# VN920 / VN920-B5 / VN920SO

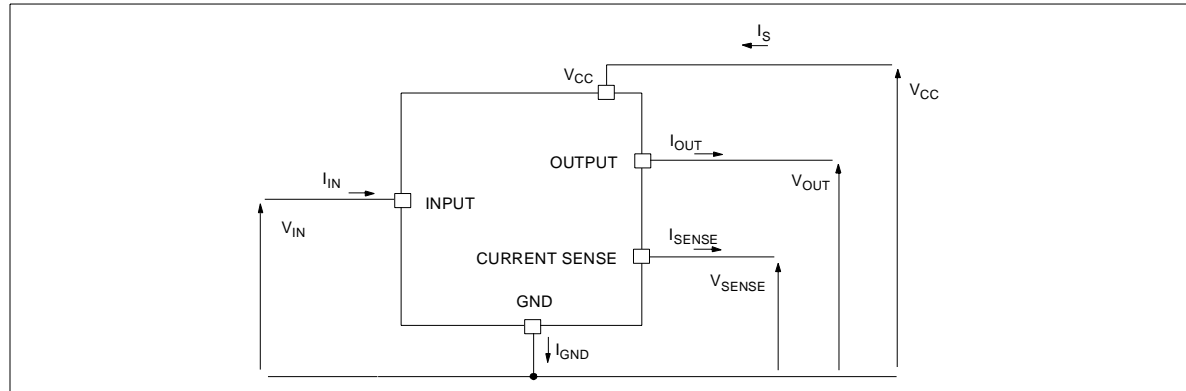
## ABSOLUTE MAXIMUM RATING

| Symbol        | Parameter  | Value              |                    |        | Unit         |
|---------------|--|--------------------|--------------------|--------|--------------|
|               |  | PENTAWATT          | P <sup>2</sup> 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  | - 21               |                    |        | A            |
| $I_{IN}$      | DC Input Current   | +/- 10             |                    |        | mA           |
| $V_{CSSENSE}$ | Current Sense Maximum Voltage  | -3                 |                    |        | V            |
|               |  | +15                |                    |        | V            |
| $V_{ESD}$     | Electrostatic Discharge<br>(Human Body Model: R=1.5K $\Omega$ ; C=100pF)   |                    |                    |        |              |
|               | - INPUT  | 4000               |                    |        | V            |
|               | - CURRENT SENSE  | 2000               |                    |        | 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) |                    | 364                | 352    | mJ           |
| $P_{TOT}$     | Power Dissipation T <sub>C</sub> ≤25 $^{\circ}$ C  | 96.1               | 96.1               | 8.3    | 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 |
|-----------------------|-------------------------------------|-----|-----------|--------------------|---------|------|
|                       |                                     |     | PENTAWATT | P <sup>2</sup> PAK | SO-16L  |      |
| R <sub>thj-case</sub> | Thermal Resistance Junction-case    | Max | 1.3       | 1.3                |         | °C/W |
| R <sub>thj-lead</sub> | Thermal Resistance Junction-lead    | Max |           |                    | 15      | °C/W |
| R <sub>thj-amb</sub>  | Thermal Resistance Junction-ambient | Max | 61.3      | 51.3 (*)           | 65 (**) | °C/W |

(\*) When mounted on a standard single-sided FR-4 board with 0.5cm<sup>2</sup> of Cu (at least 35μm thick).

(\*\*) When mounted on a standard single-sided FR-4 board with 0.5cm<sup>2</sup> of Cu (at least 35μm thick) connected to all V<sub>CC</sub> pins.

**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>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  |     |     | 16  | mΩ   |
|                      |                          | I <sub>OUT</sub> =10A  |     |     | 32  | mΩ   |
|                      |                          | I <sub>OUT</sub> =3A; V <sub>CC</sub> =6V  |     |     | 55  | mΩ   |
| V <sub>clamp</sub>   | Clamp Voltage            | I <sub>CC</sub> =20mA (See note 1)   | 41  | 48  | 55  | V    |
| I <sub>S</sub>       | Supply Current           | Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V                               |     | 10  | 25  | μA   |
|                      |                          | Off State; V <sub>CC</sub> =13V; V <sub>IN</sub> =V <sub>OUT</sub> =0V; T <sub>j</sub> =25°C         |     | 10  | 20  | μA   |
|                      |                          | On State; V <sub>CC</sub> =13V; V <sub>IN</sub> =5V; I <sub>OUT</sub> =0A; R <sub>SENSE</sub> =3.9KΩ |     |     |     | 5    |
| 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 (see figure 2) |     | 50                   |     | μs   |
| t <sub>d(off)</sub>                    | Turn-off Delay Time    | R <sub>L</sub> =1.3Ω (see figure 2) |     | 50                   |     | μs   |
| dV <sub>OUT</sub> /dt <sub>(on)</sub>  | Turn-on Voltage Slope  | R <sub>L</sub> =1.3Ω (see figure 2) |     | See relative diagram |     | V/μs |
| dV <sub>OUT</sub> /dt <sub>(off)</sub> | Turn-off Voltage Slope | R <sub>L</sub> =1.3Ω (see figure 2) |     | See relative diagram |     | V/μs |

## LOGIC INPUT

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

Note 1: V<sub>clamp</sub> and V<sub>OV</sub> are correlated. Typical difference is 5V.

## VN920 / VN920-B5 / VN920SO

### ELECTRICAL CHARACTERISTICS (continued)

CURRENT SENSE ( $9V \leq V_{CC} \leq 16V$ ) (See Fig. 1)

| Symbol        | Parameter  | Test Conditions   | Min          | Typ          | Max          | Unit     |
|---------------|--|---|--------------|--------------|--------------|----------|
| $K_1$         | $I_{OUT}/I_{SENSE}$  | $I_{OUT}=1A; V_{SENSE}=0.5V;$<br>$T_j = -40^\circ C \dots 150^\circ C$                          | 3300         | 4400         | 6000         |          |
| $dK_1/K_1$    | Current Sense Ratio Drift                                  | $I_{OUT}=1A; V_{SENSE}=0.5V;$<br>$T_j = -40^\circ C \dots +150^\circ C$                         | -10          |              | +10          | %        |
| $K_2$         | $I_{OUT}/I_{SENSE}$  | $I_{OUT}=10A; V_{SENSE}=4V; T_j=-40^\circ C$<br>$T_j=25^\circ C \dots 150^\circ C$              | 4200<br>4400 | 4900<br>4900 | 6000<br>5750 |          |
| $dK_2/K_2$    | Current Sense Ratio Drift                                  | $I_{OUT}=10A; V_{SENSE}=4V;$<br>$T_j=-40^\circ C \dots +150^\circ C$                            | -8           |              | +8           | %        |
| $K_3$         | $I_{OUT}/I_{SENSE}$  | $I_{OUT}=30A; V_{SENSE}=4V; T_j=-40^\circ C$<br>$T_j=25^\circ C \dots 150^\circ C$              | 4200<br>4400 | 4900<br>4900 | 5500<br>5250 |          |
| $dK_3/K_3$    | Current Sense Ratio Drift                                  | $I_{OUT}=30A; V_{SENSE}=4V;$<br>$T_j=-40^\circ C \dots +150^\circ C$                            | -6           |              | +6           | %        |
| $I_{SENSE0}$  | Analog Sense Leakage Current                               | $V_{CC}=6 \dots 16V; I_{OUT}=0A; V_{SENSE}=0V;$<br>$T_j=-40^\circ C \dots +150^\circ C$         | 0            |              | 10           | $\mu A$  |
| $V_{SENSE}$   | Max Analog Sense Output Voltage                            | $V_{CC}=5.5V; I_{OUT}=5A; R_{SENSE}=10K\Omega$<br>$V_{CC}>8V; I_{OUT}=10A; R_{SENSE}=10K\Omega$ | 2<br>4       |              |              | V<br>V   |
| $V_{SENSEH}$  | Sense Voltage in Overtemperature conditions                | $V_{CC}=13V; R_{SENSE}=3.9K\Omega$  |              | 5.5          |              | V        |
| $R_{VSENSEH}$ | Analog Sense Output Impedance in Overtemperature Condition | $V_{CC}=13V; T_j>T_{TSD};$ Output Open  |              | 400          |              | $\Omega$ |
| $t_{DSENSE}$  | Current sense delay response                               | to 90% $I_{SENSE}$ (see note 2)   |              |              | 500          | $\mu s$  |

### 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          |             | $^\circ C$ |
| $I_{lim}$   | DC Short Circuit Current       | $V_{CC}=13V$<br>$5V < V_{CC} < 36V$              | 30          | 45          | 75<br>75    | A<br>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          |
| $V_{ON}$    | Output Voltage Drop Limitation | $I_{OUT}=1A; T_j=-40^\circ C \dots +150^\circ C$ |             | 50          |             | mV         |

Note 2: current sense signal delay after positive input slope

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

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

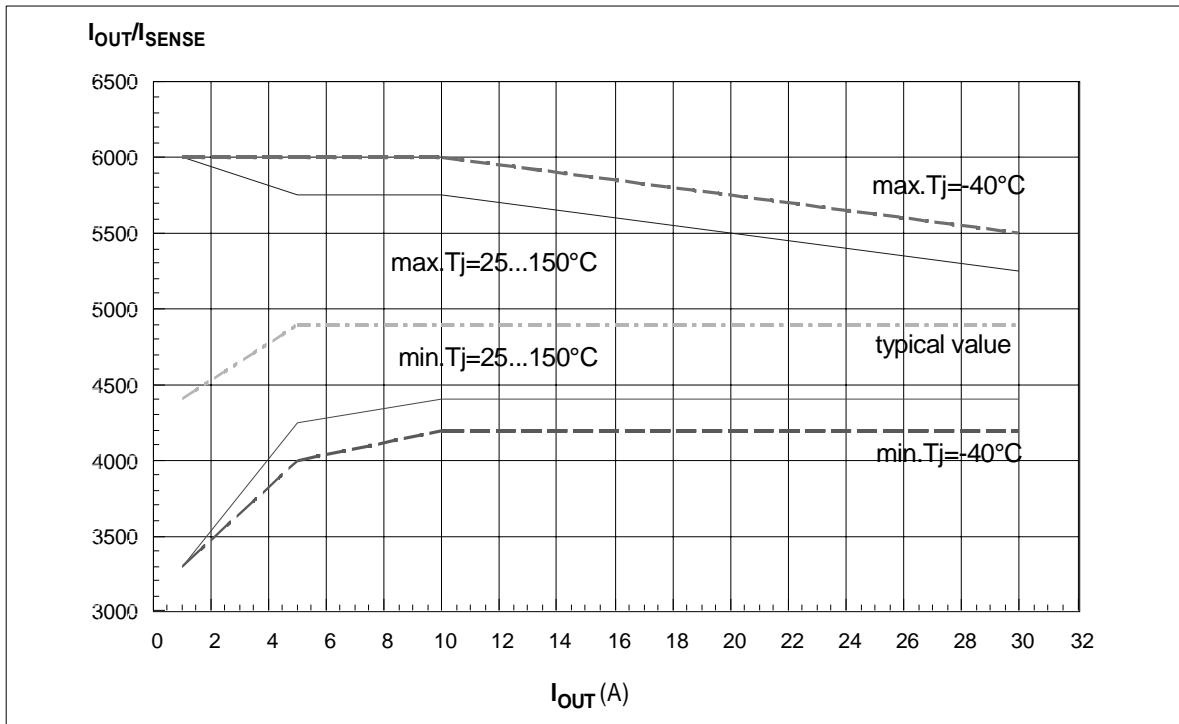
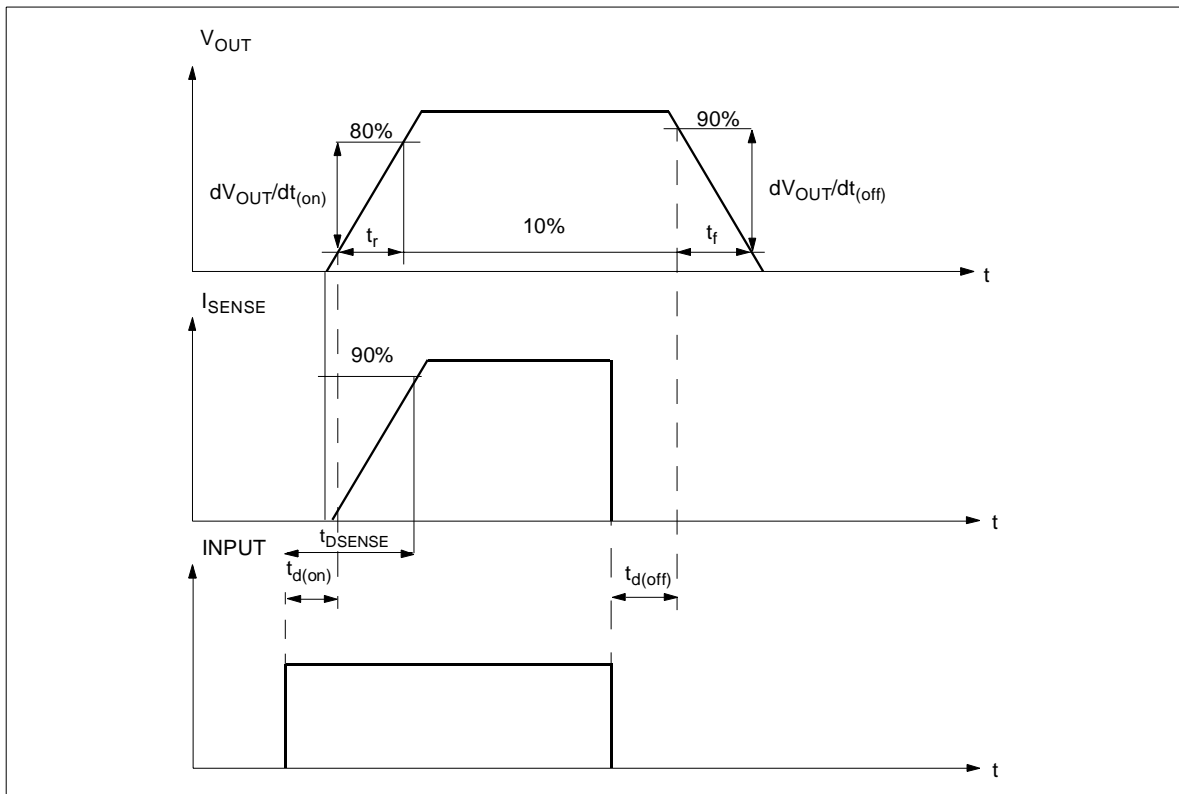


Figure 2: Switching Characteristics (Resistive load  $R_L = 1.3\Omega$ )



**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                              |

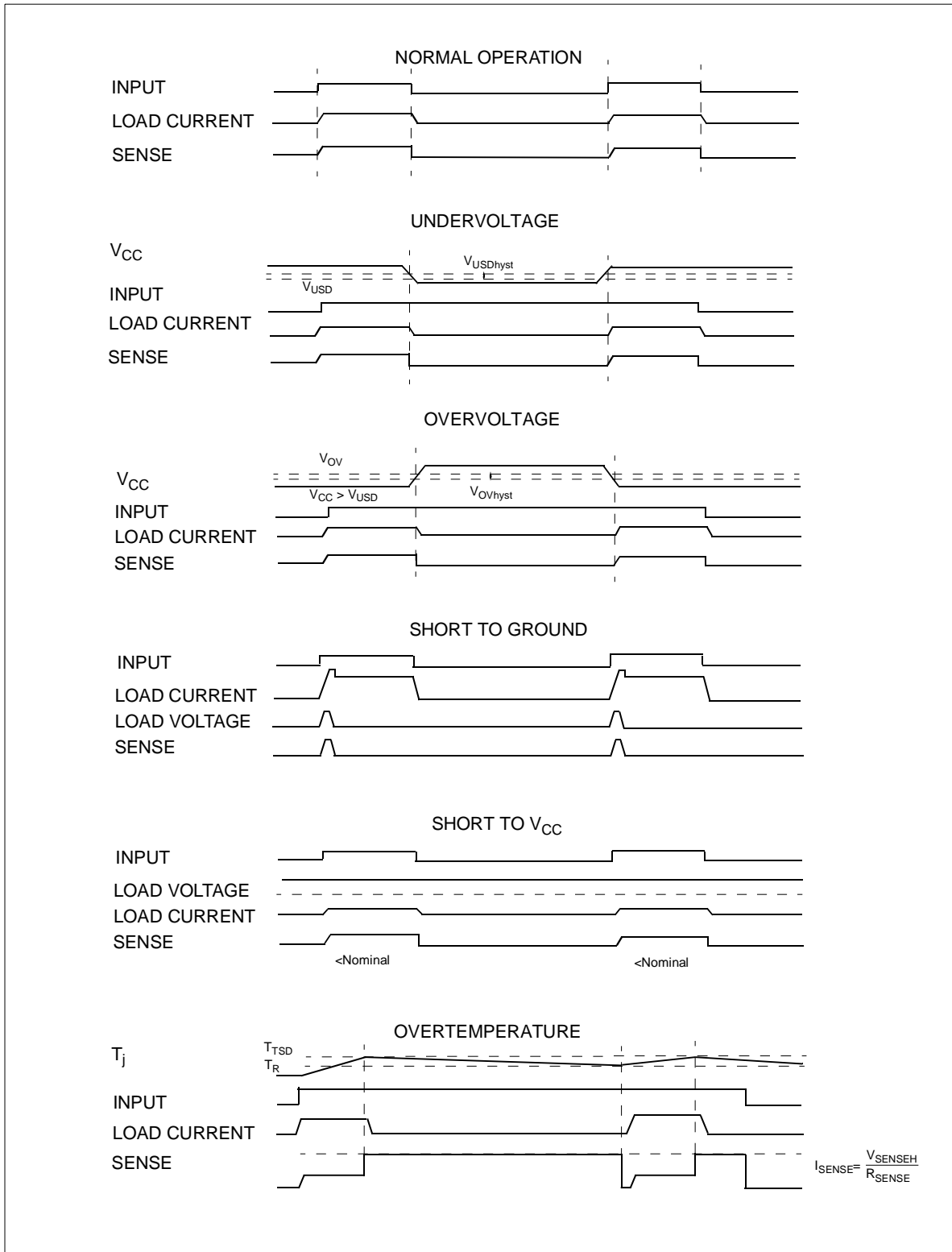
**ELECTRICAL TRANSIENT REQUIREMENTS**

| 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 $\Omega$        |
| 2                            | +25 V       | +50 V   | +75 V   | +100 V  | 0.2 ms 10 $\Omega$      |
| 3a                           | -25 V       | -50 V   | -100 V  | -150 V  | 0.1 $\mu$ s 50 $\Omega$ |
| 3b                           | +25 V       | +50 V   | +75 V   | +100 V  | 0.1 $\mu$ s 50 $\Omega$ |
| 4                            | -4 V        | -5 V    | -6 V    | -7 V    | 100 ms, 0.01 $\Omega$   |
| 5                            | +26.5 V     | +46.5 V | +66.5 V | +86.5 V | 400 ms, 2 $\Omega$      |

| 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  |

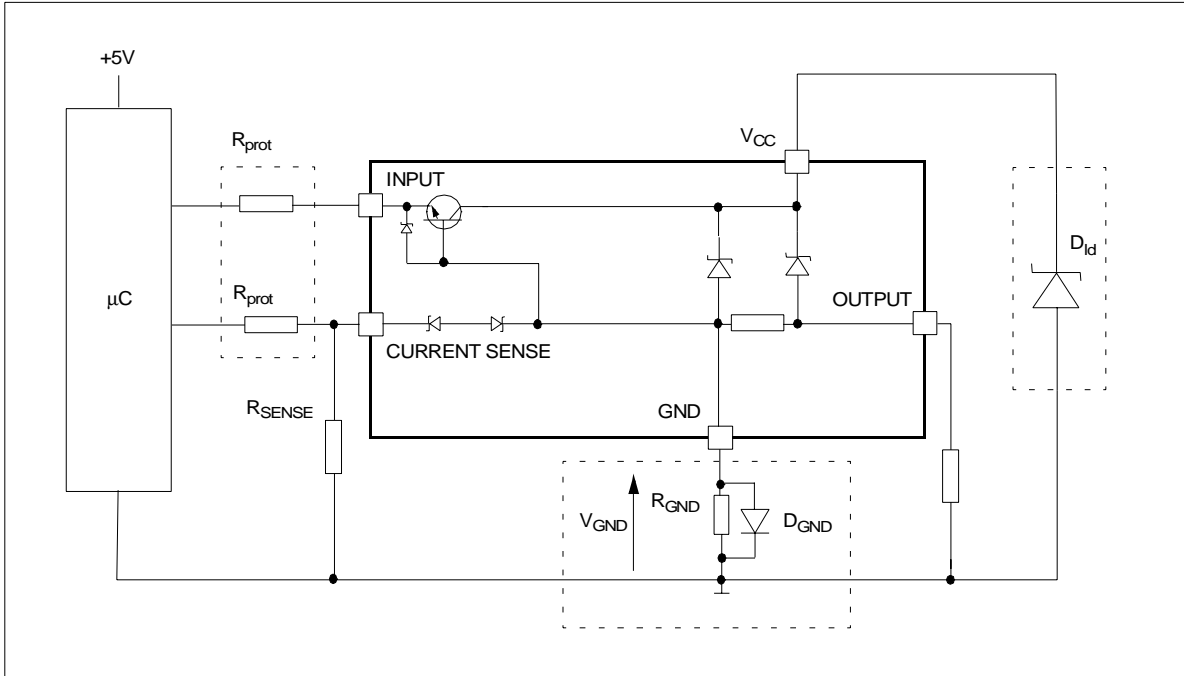
| CLASS | CONTENTS  |
|-------|---|
| C     | All functions of the device are performed as designed after exposure to disturbance.  |
| E     | One or more functions of the device is not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device. |

Figure 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)  $R_{GND} \leq 600\text{mV} / (I_{S(on)max})$ .
- 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**

$D_{Id}$  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  $\mu\text{C}$  I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of  $\mu\text{C}$  and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of  $\mu\text{C}$  I/Os.

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

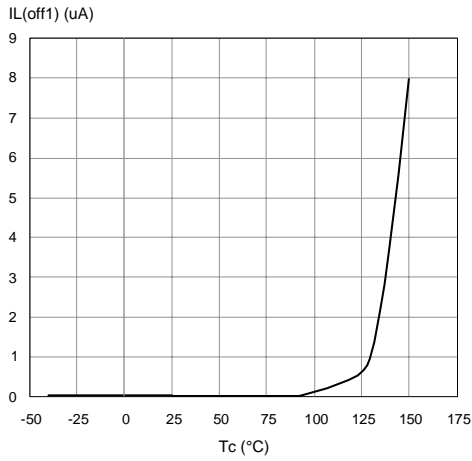
Calculation example:

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

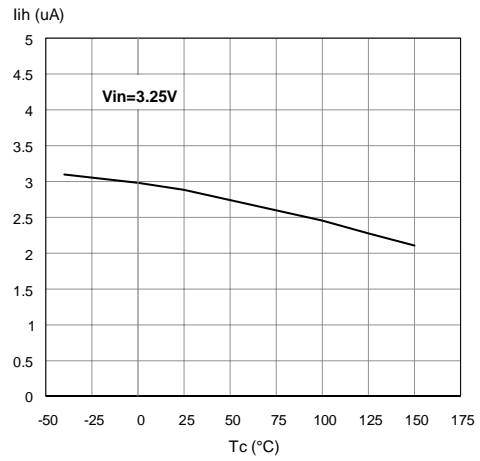
$$5\text{k}\Omega \leq R_{prot} \leq 65\text{k}\Omega$$

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

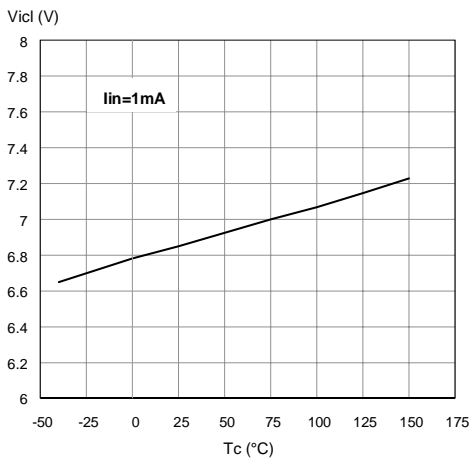
Off State Output Current



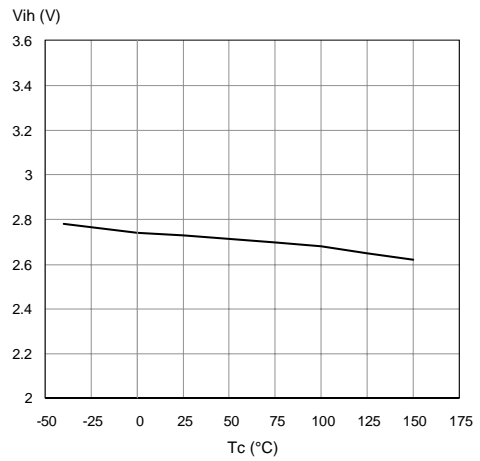
High Level Input Current



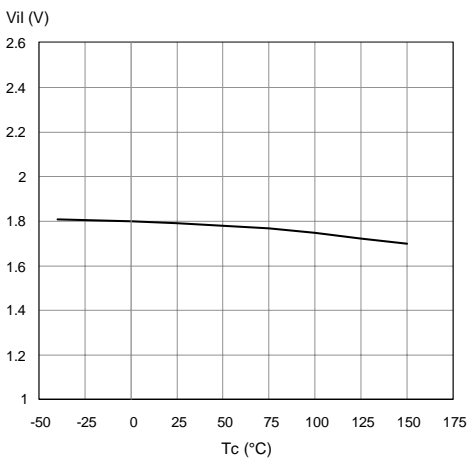
Input Clamp Voltage



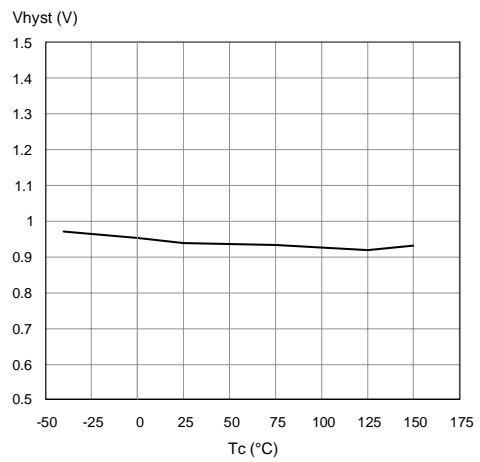
Input High Level



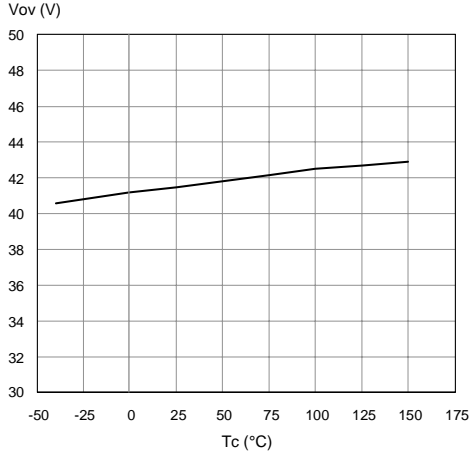
Input Low Level



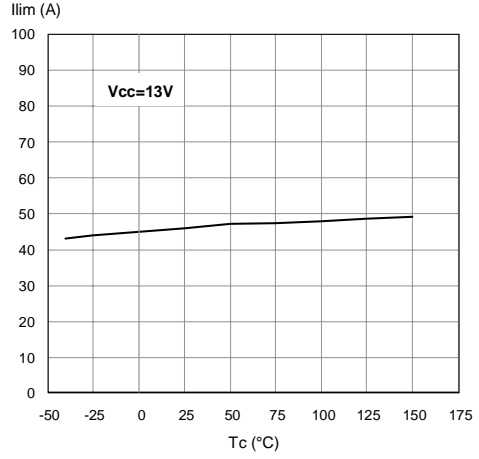
Input Hysteresis Voltage



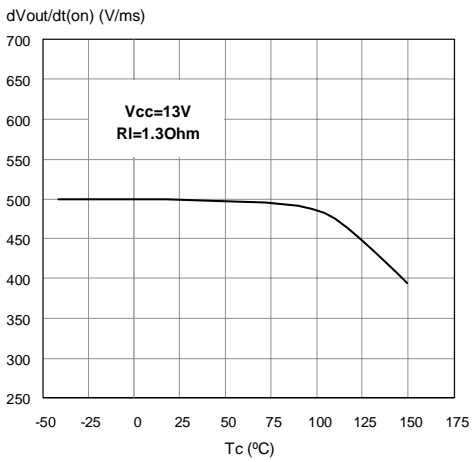
Overvoltage Shutdown



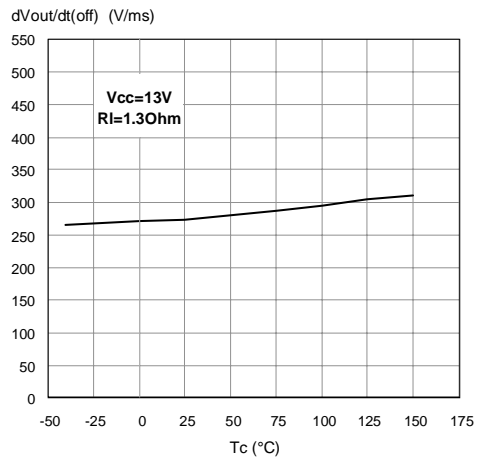
I<sub>LIM</sub> Vs T<sub>case</sub>



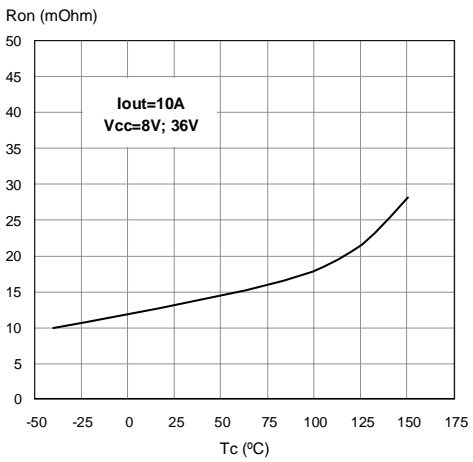
Turn-on Voltage Slope



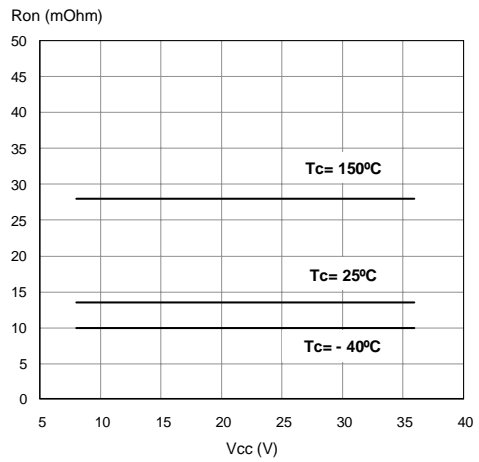
Turn-off Voltage Slope



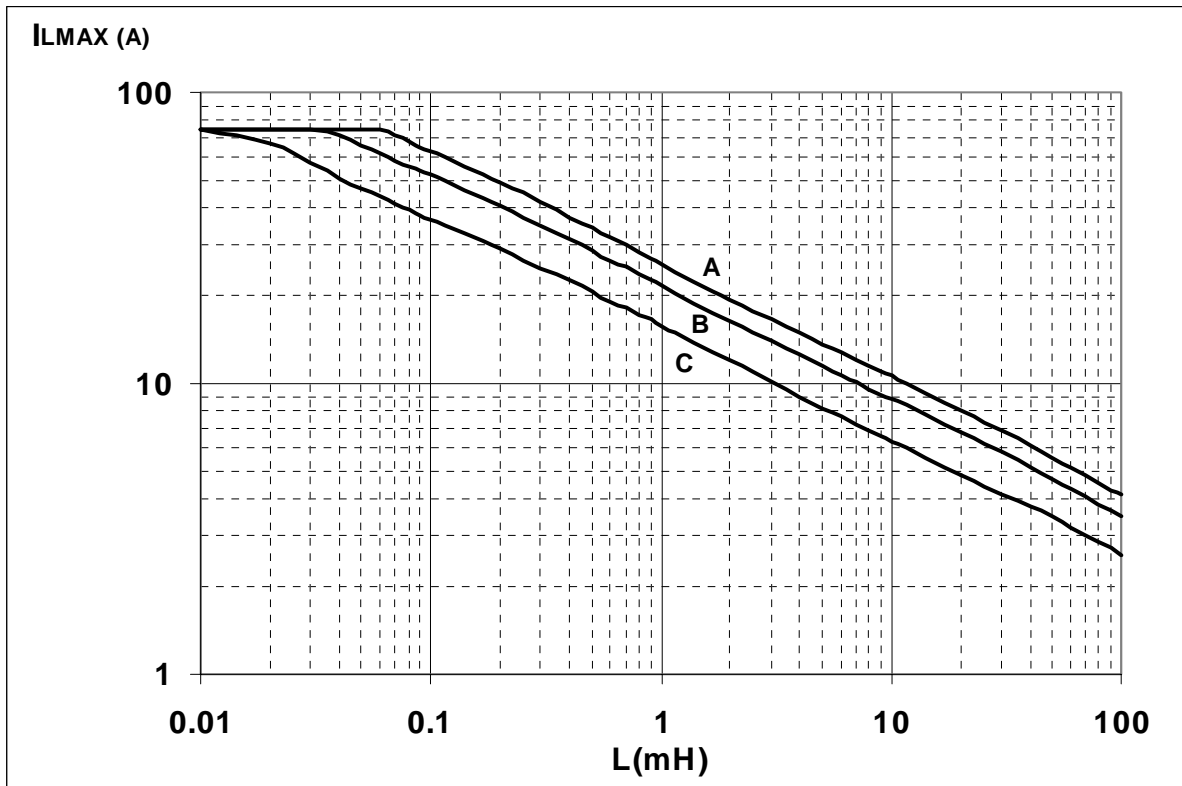
On State Resistance Vs T<sub>case</sub>



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



SO-16L Maximum turn off current versus load inductance



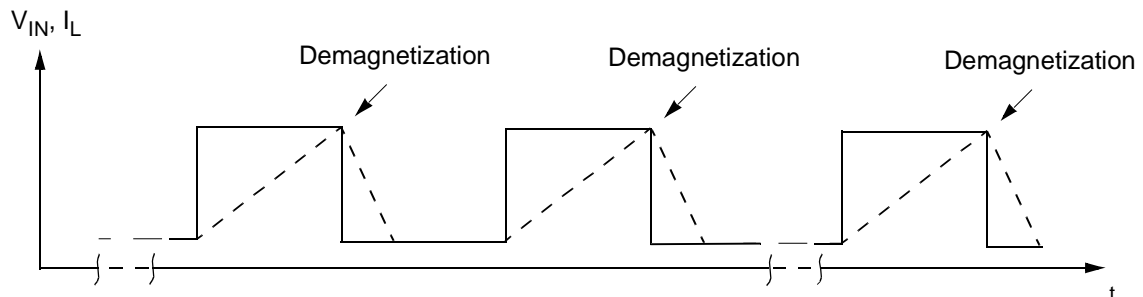
- A = Single Pulse at  $T_{jstart}=150^{\circ}C$
- B= Repetitive pulse at  $T_{jstart}=100^{\circ}C$
- C= Repetitive Pulse at  $T_{jstart}=125^{\circ}C$

Conditions:

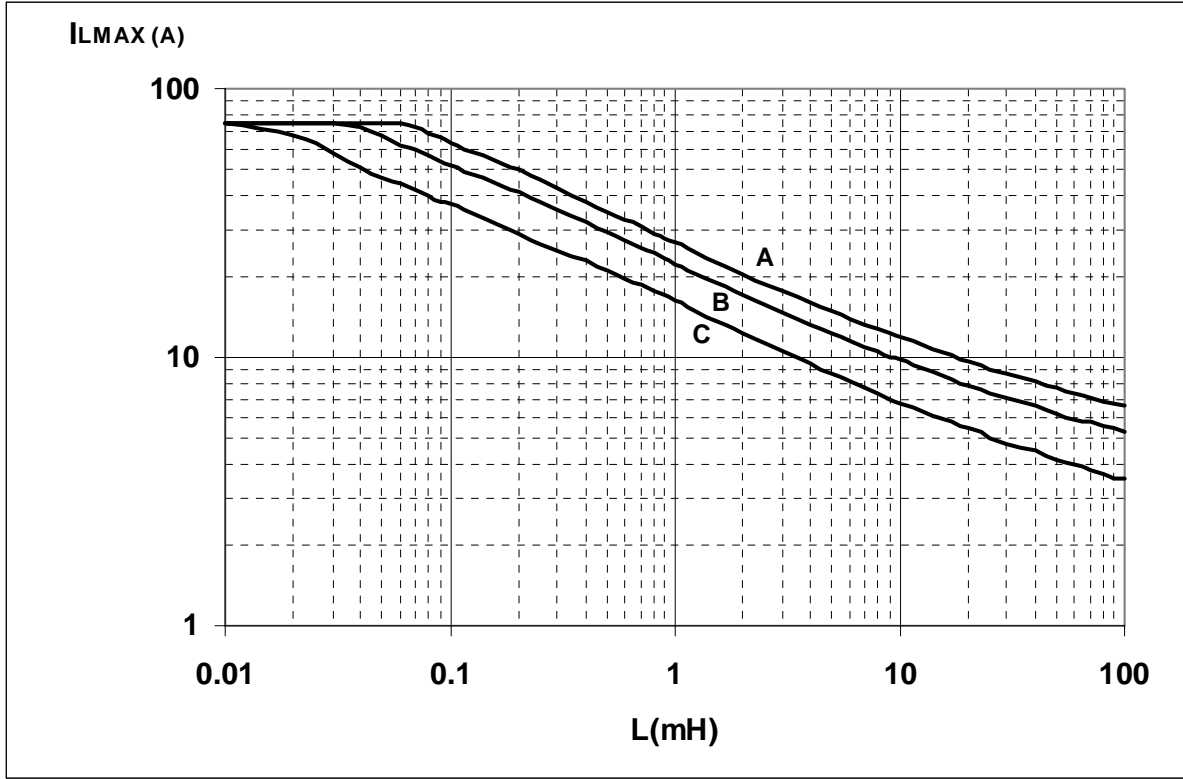
$V_{CC}=13.5V$

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.



P<sup>2</sup>PAK Maximum turn off current versus load inductance



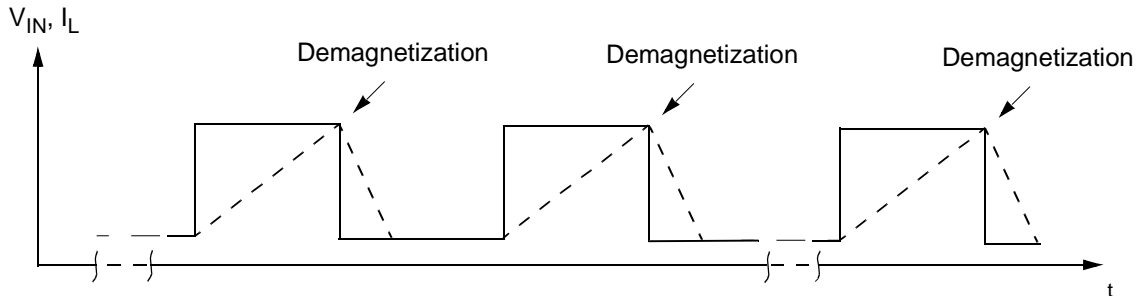
- A = Single Pulse at  $T_{jstart}=150^{\circ}C$
- B= Repetitive pulse at  $T_{jstart}=100^{\circ}C$
- C= Repetitive Pulse at  $T_{jstart}=125^{\circ}C$

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.



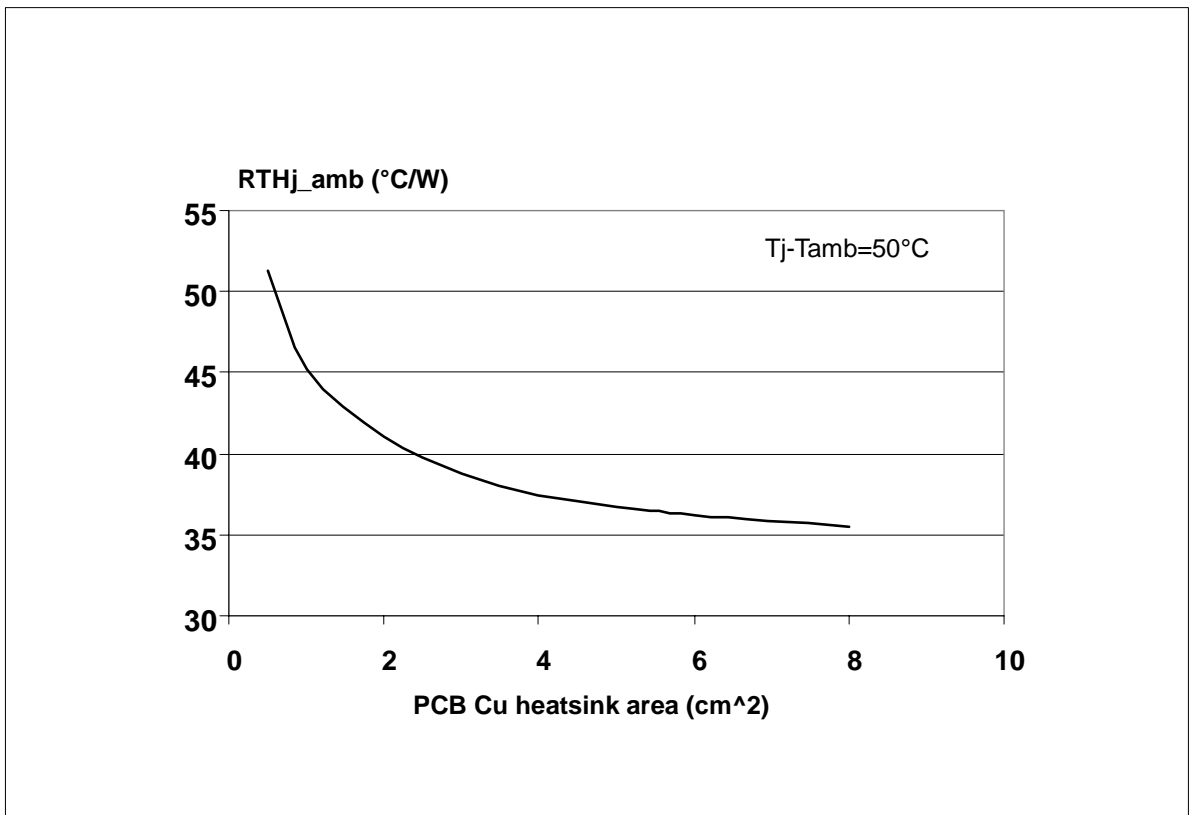
**P<sup>2</sup>PAK THERMAL DATA**

**P<sup>2</sup>PAK PC Board**



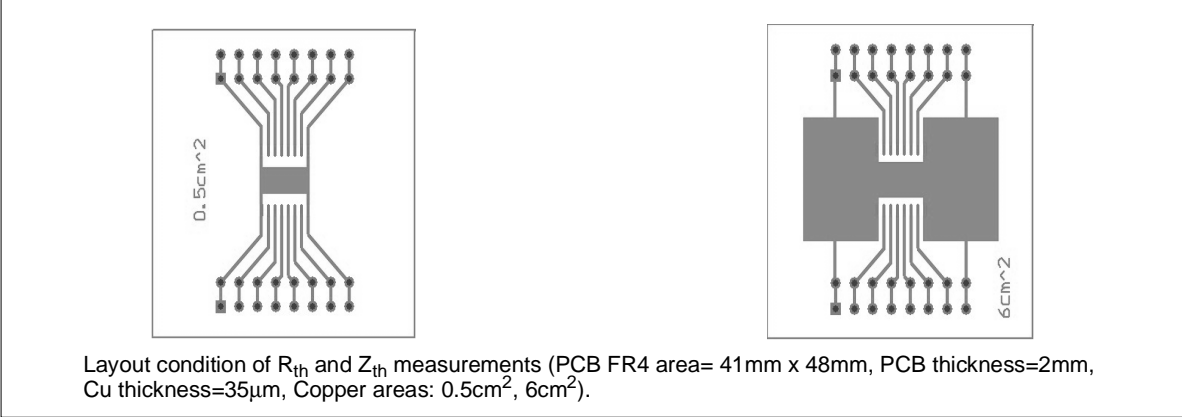
Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area= 60mm x 60mm, PCB thickness=2mm, Cu thickness=35 $\mu$ m, Copper areas: 0.97cm<sup>2</sup>, 8cm<sup>2</sup>).

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

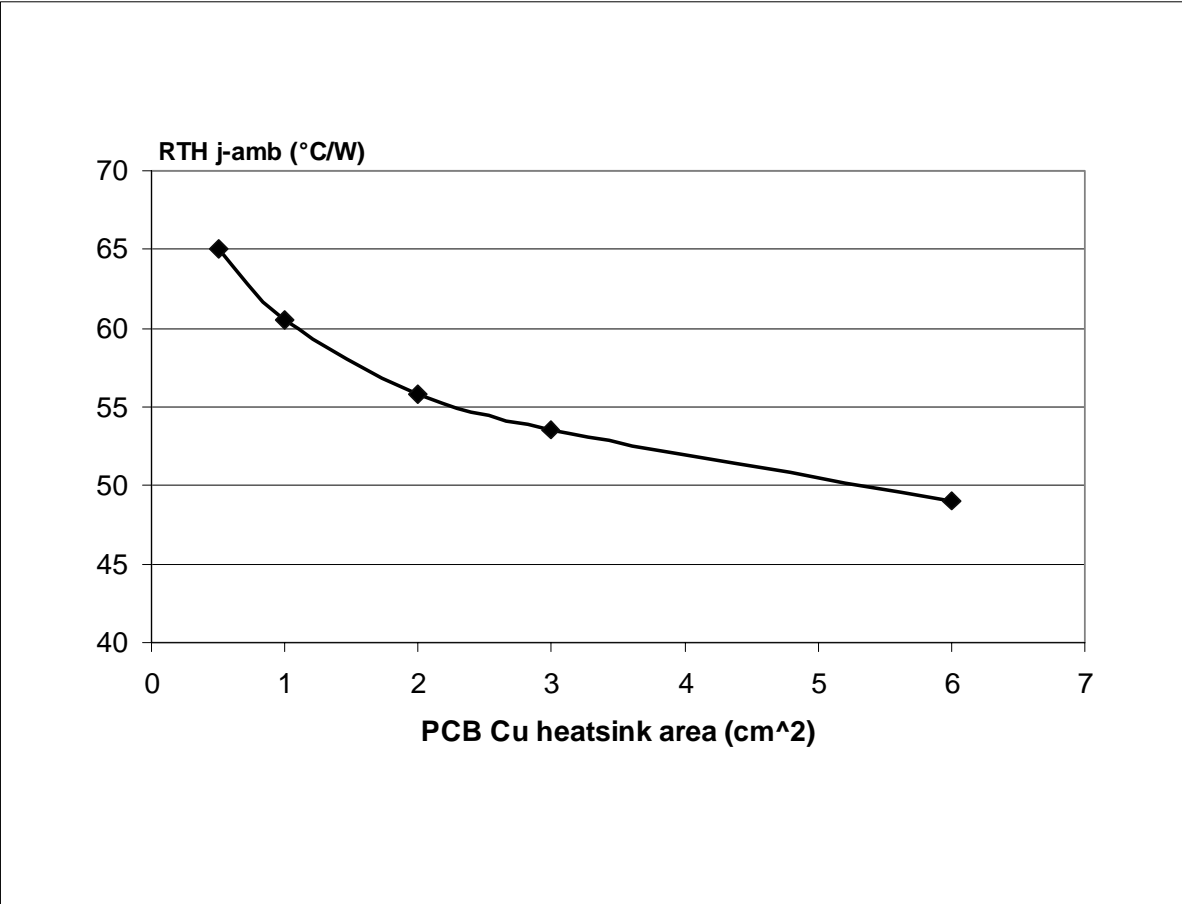


**SO-16L THERMAL DATA**

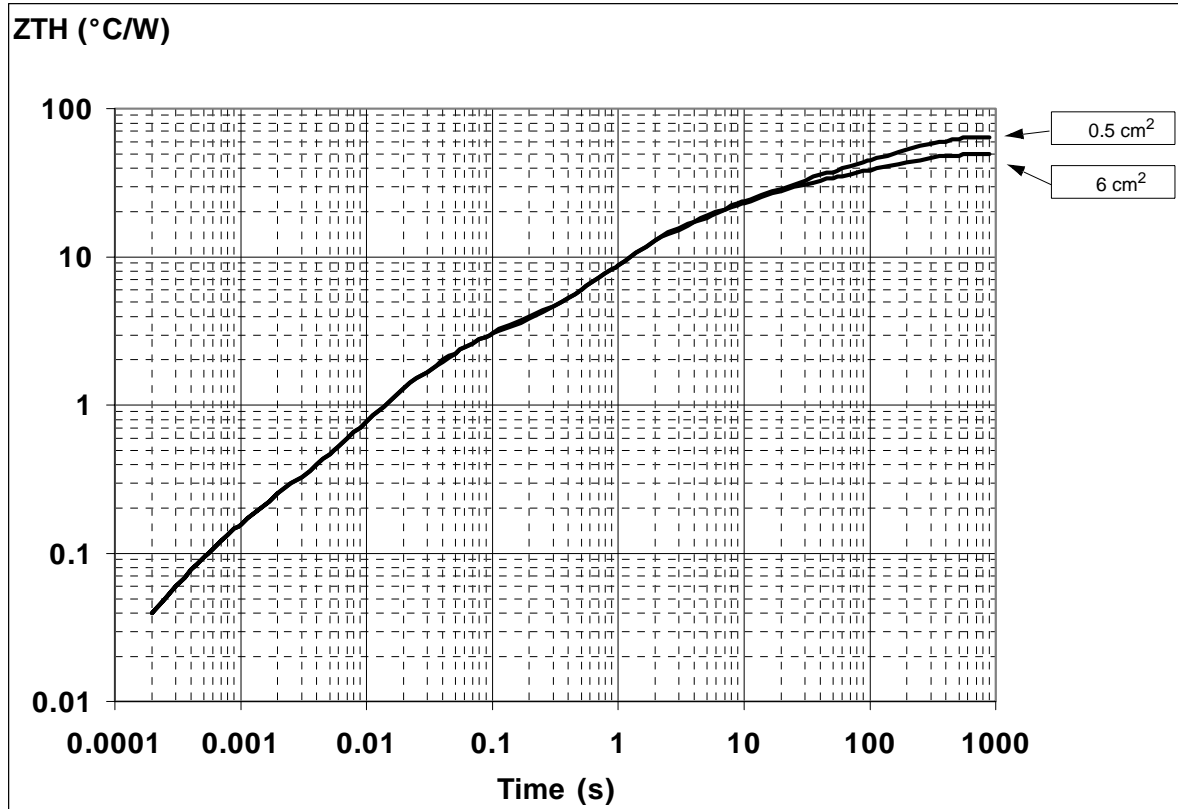
**SO-16L PC Board**



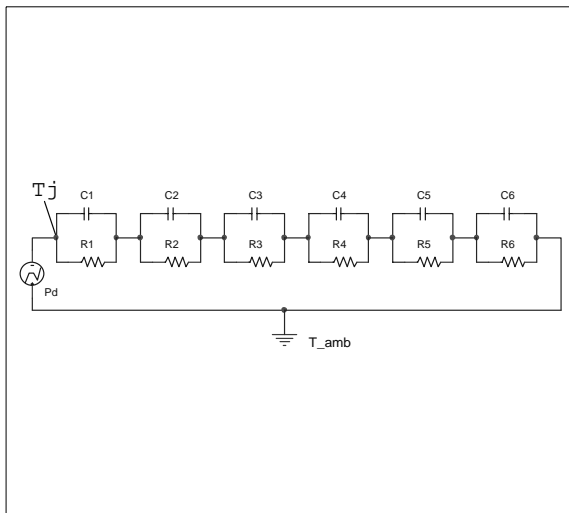
**$R_{thj-amb}$  Vs PCB copper area in open box free air condition**



SO-16L Thermal Impedance Junction Ambient Single Pulse



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



Pulse calculation formula

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

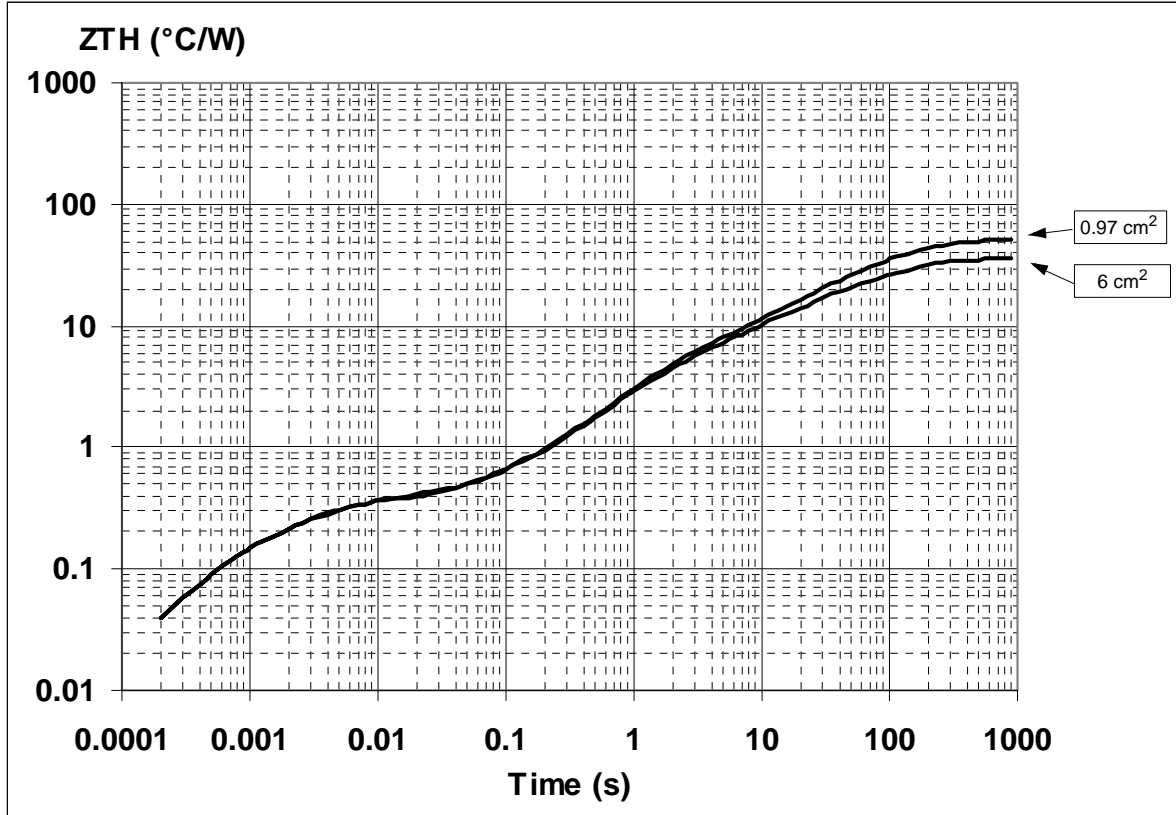
where  $\delta = t_p/T$

Thermal Parameter

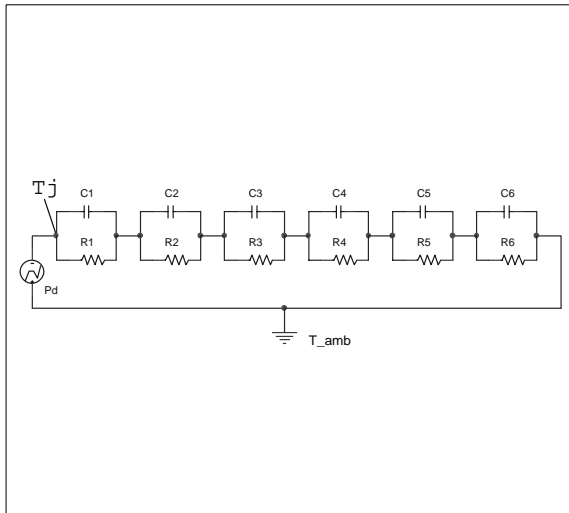
| Area/island (cm <sup>2</sup> ) | 0.5      | 6  |
|--------------------------------|----------|----|
| R1 (°C/W)                      | 0.02     |    |
| R2 (°C/W)                      | 0.1      |    |
| R3 (°C/W)                      | 2.2      |    |
| R4 (°C/W)                      | 12       |    |
| 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  |



**P<sup>2</sup>PAK Thermal Impedance Junction Ambient Single Pulse**



**Thermal fitting model of a single channel HSD in P<sup>2</sup>PAK**



**Pulse calculation formula**

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

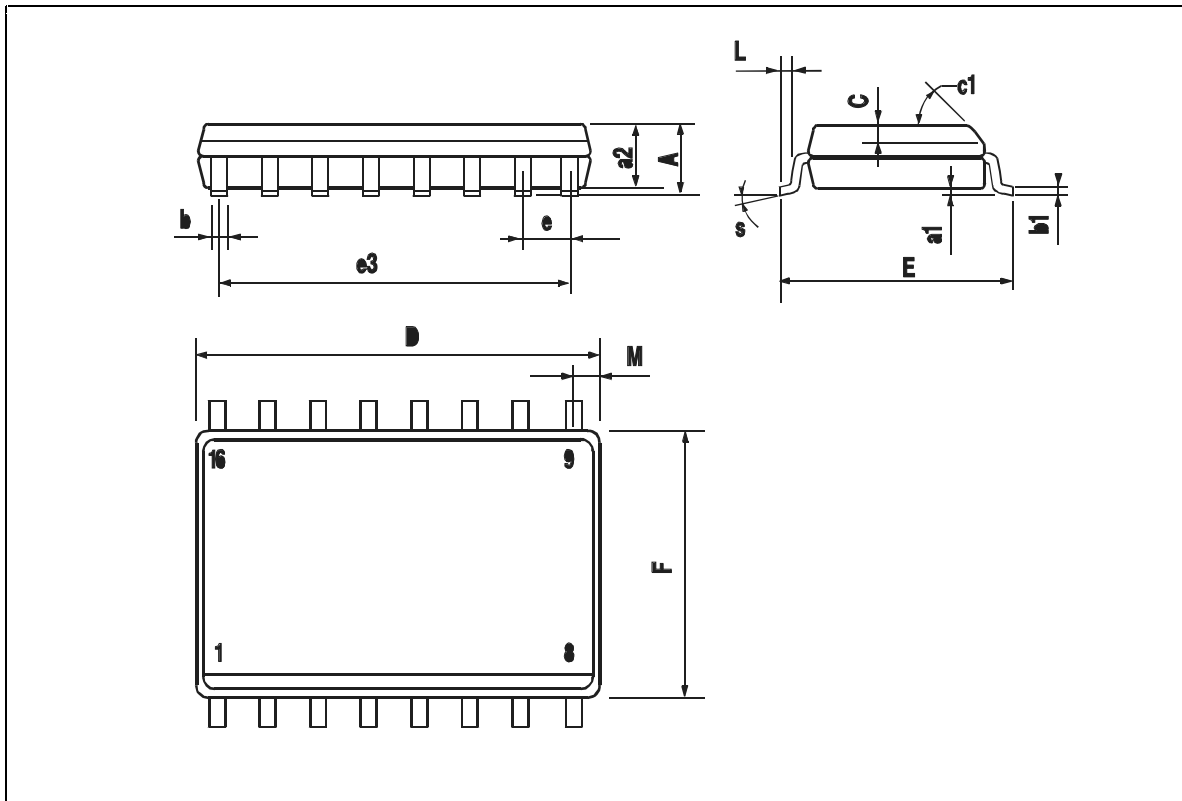
where  $\delta = t_p/T$

**Thermal Parameter**

| Area/island (cm <sup>2</sup> ) | 0.97   | 6  |
|--------------------------------|--------|----|
| R1 (°C/W)                      | 0.02   |    |
| R2 (°C/W)                      | 0.1    |    |
| R3 (°C/W)                      | 0.22   |    |
| R4 (°C/W)                      | 4      |    |
| R5 (°C/W)                      | 9      |    |
| R6 (°C/W)                      | 37     | 22 |
| C1 (W.s/°C)                    | 0.0015 |    |
| C2 (W.s/°C)                    | 0.007  |    |
| C3 (W.s/°C)                    | 0.015  |    |
| C4 (W.s/°C)                    | 0.4    |    |
| C5 (W.s/°C)                    | 2      |    |
| C6 (W.s/°C)                    | 3      | 5  |

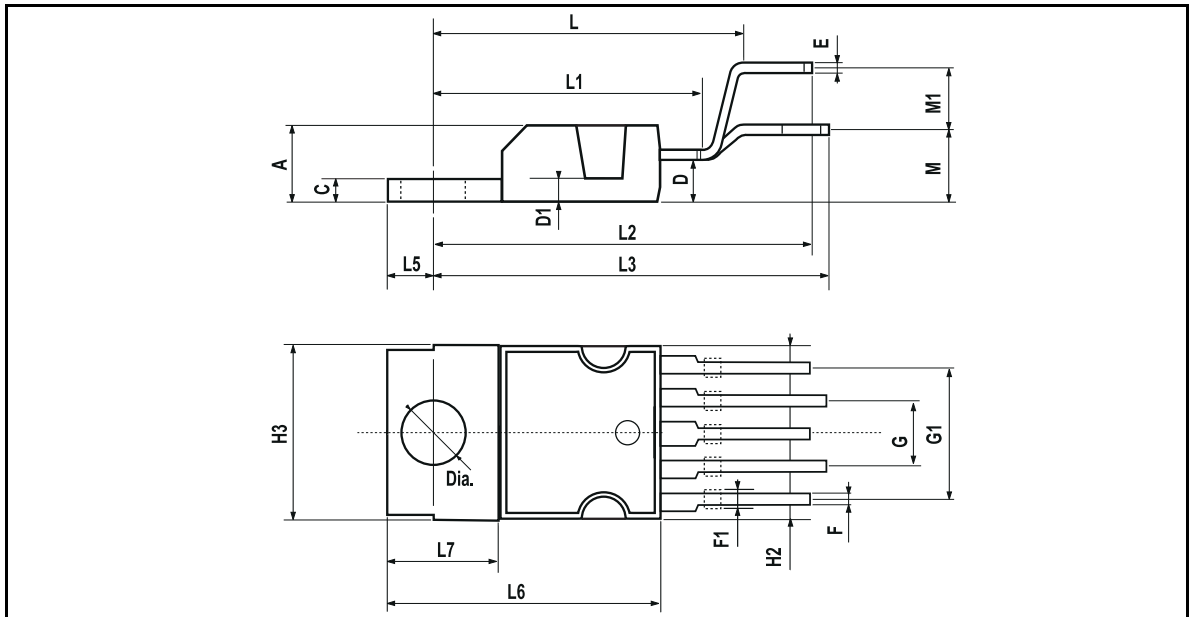
**SO-16L MECHANICAL DATA**

| 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.)  |      |       |       |       |       |



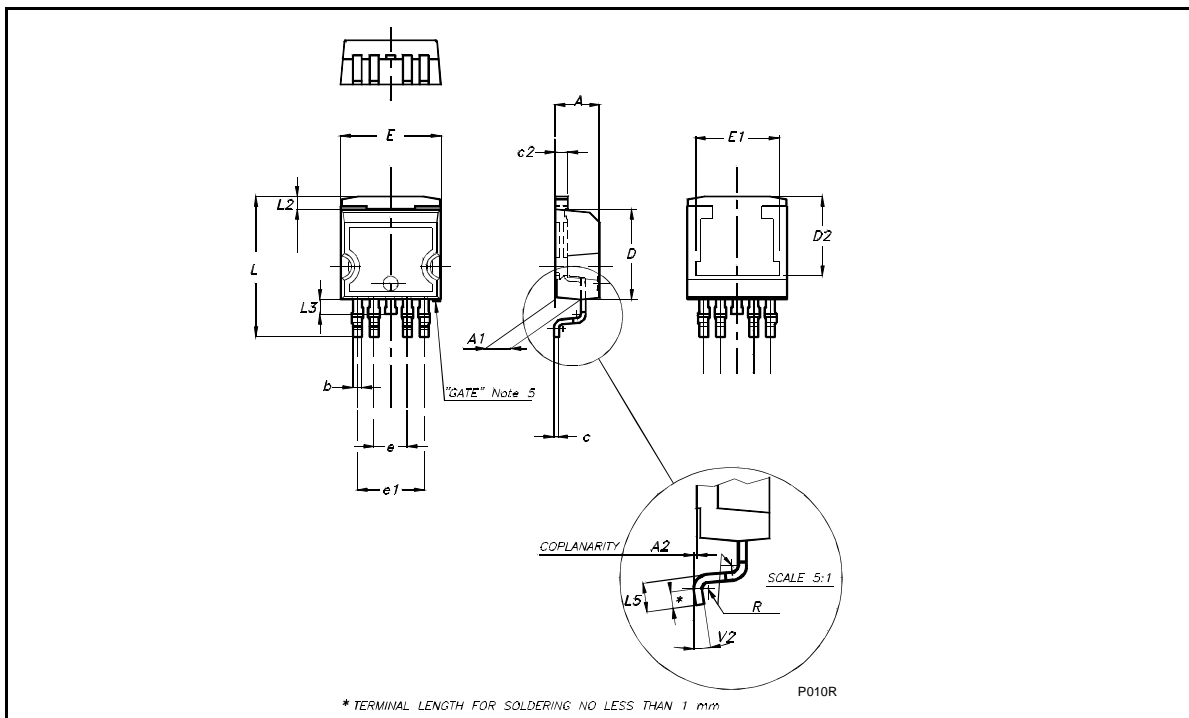
**PENTAWATT (VERTICAL) MECHANICAL DATA**

| DIM.  | mm.   |       |      | inch  |       |       |
|-------|-------|-------|------|-------|-------|-------|
|       | MIN.  | TYP   | MAX. | MIN.  | TYP.  | MAX.  |
| A     |       |       | 4.8  |       |       | 0.189 |
| C     |       |       | 1.37 |       |       | 0.054 |
| D     | 2.4   |       | 2.8  | 0.094 |       | 0.110 |
| D1    | 1.2   |       | 1.35 | 0.047 |       | 0.053 |
| E     | 0.35  |       | 0.55 | 0.014 |       | 0.022 |
| F     | 0.8   |       | 1.05 | 0.031 |       | 0.041 |
| F1    | 1     |       | 1.4  | 0.039 |       | 0.055 |
| G     | 3.2   | 3.4   | 3.6  | 0.126 | 0.134 | 0.142 |
| G1    | 6.6   | 6.8   | 7    | 0.260 | 0.268 | 0.276 |
| H2    |       |       | 10.4 |       |       | 0.409 |
| H3    | 10.05 |       | 10.4 | 0.396 |       | 0.409 |
| L     |       | 17.85 |      |       | 0.703 |       |
| L1    |       | 15.75 |      |       | 0.620 |       |
| L2    |       | 21.4  |      |       | 0.843 |       |
| L3    |       | 22.5  |      |       | 0.886 |       |
| L5    | 2.6   |       | 3    | 0.102 |       | 0.118 |
| L6    | 15.1  |       | 15.8 | 0.594 |       | 0.622 |
| L7    | 6     |       | 6.6  | 0.236 |       | 0.260 |
| M     |       | 4.5   |      |       | 0.177 |       |
| M1    |       | 4     |      |       | 0.157 |       |
| Diam. | 3.65  |       | 3.85 | 0.144 |       | 0.152 |

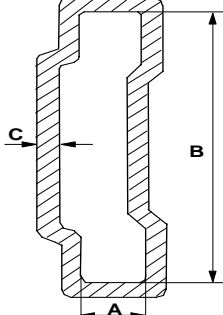


**P<sup>2</sup>PAK MECHANICAL DATA**

| 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) |      |       |



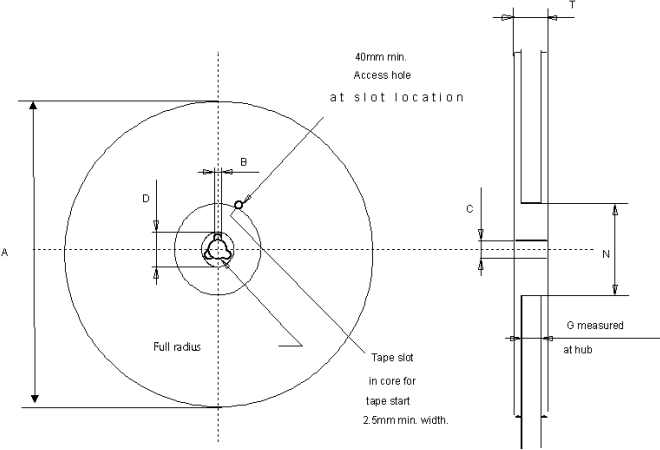
**SO-16L TUBE SHIPMENT (no suffix)**



|   |      |
|---|------|
| <b>Base Q.ty</b>                          | 50   |
| <b>Bulk Q.ty</b>                          | 1000 |
| <b>Tube length (<math>\pm 0.5</math>)</b> | 532  |
| <b>A</b>                                  | 3.5  |
| <b>B</b>                                  | 13.8 |
| <b>C (<math>\pm 0.1</math>)</b>           | 0.6  |

All dimensions are in mm.

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

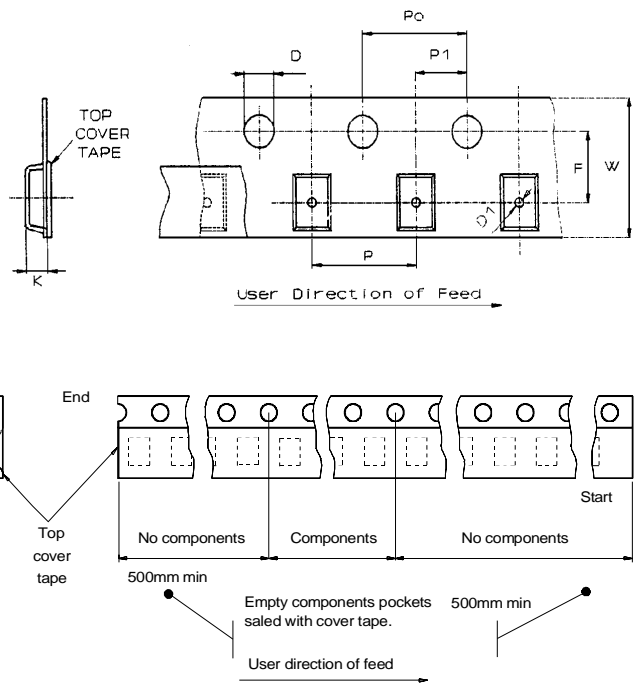


|                                 |      |
|---------------------------------|------|
| <b>Base Q.ty</b>                | 1000 |
| <b>Bulk Q.ty</b>                | 1000 |
| <b>A (max)</b>                  | 330  |
| <b>B (min)</b>                  | 1.5  |
| <b>C (<math>\pm 0.2</math>)</b> | 13   |
| <b>F</b>                        | 20.2 |
| <b>G (+ 2 / - 0)</b>            | 16.4 |
| <b>N (min)</b>                  | 60   |
| <b>T (max)</b>                  | 22.4 |

**TAPE DIMENSIONS**

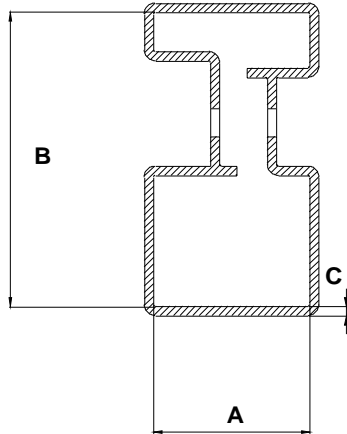
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

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



All dimensions are in mm.

**PENTAWATT TUBE SHIPMENT (no suffix)**

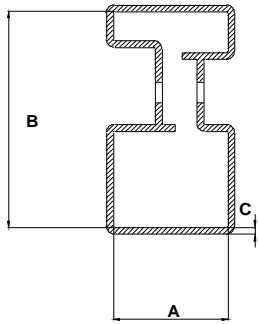


|   |      |
|---|------|
| <b>Base Q.ty</b>                          | 50   |
| <b>Bulk Q.ty</b>                          | 1000 |
| <b>Tube length (<math>\pm 0.5</math>)</b> | 532  |
| <b>A</b>                                  | 18   |
| <b>B</b>                                  | 33.1 |
| <b>C (<math>\pm 0.1</math>)</b>           | 1    |

All dimensions are in mm.

**VN920 / VN920-B5 / VN920SO**

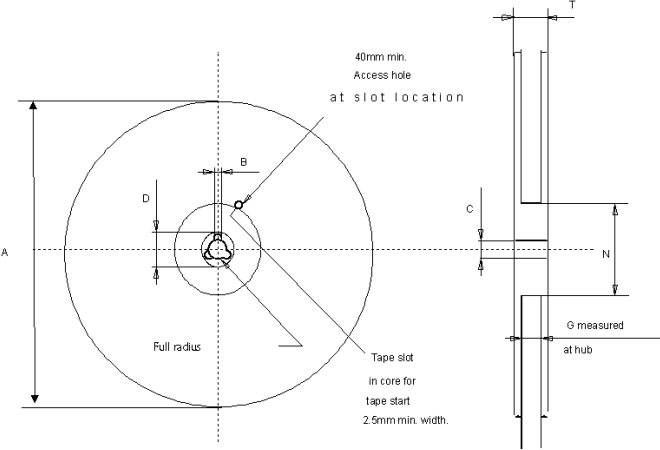
**P<sup>2</sup>PAK TUBE SHIPMENT (no suffix)**



|                            |      |
|----------------------------|------|
| <b>Base Q.ty</b>           | 50   |
| <b>Bulk Q.ty</b>           | 1000 |
| <b>Tube length (± 0.5)</b> | 532  |
| <b>A</b>                   | 18   |
| <b>B</b>                   | 33.1 |
| <b>C (± 0.1)</b>           | 1    |

All dimensions are in mm.

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



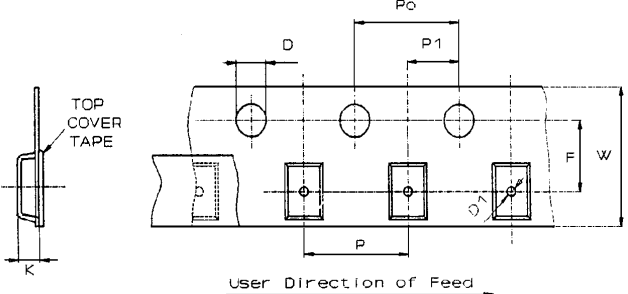
|                     |      |
|---------------------|------|
| <b>Base Q.ty</b>    | 1000 |
| <b>Bulk Q.ty</b>    | 1000 |
| <b>A (max)</b>      | 330  |
| <b>B (min)</b>      | 1.5  |
| <b>C (± 0.2)</b>    | 13   |
| <b>F</b>            | 20.2 |
| <b>G (+ 2 / -0)</b> | 24.4 |
| <b>N (min)</b>      | 60   |
| <b>T (max)</b>      | 30.4 |

All dimensions are in mm.

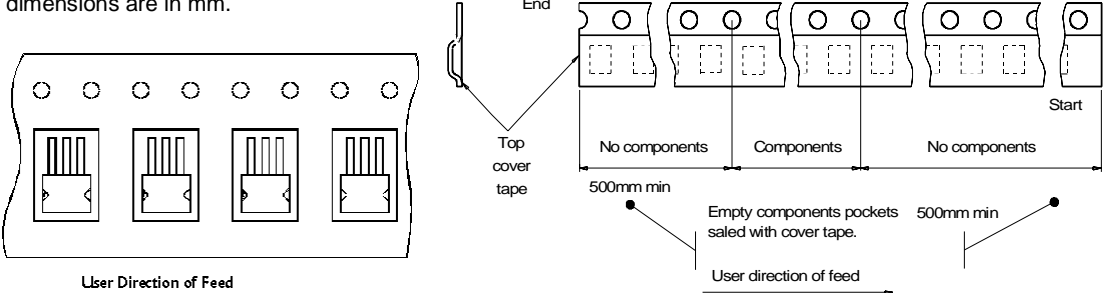
**TAPE DIMENSIONS**

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


|                          |                     |      |
|--------------------------|---------------------|------|
| <b>Tape width</b>        | <b>W</b>            | 24   |
| <b>Tape Hole Spacing</b> | <b>P0 (± 0.1)</b>   | 4    |
| <b>Component Spacing</b> | <b>P</b>            | 16   |
| <b>Hole Diameter</b>     | <b>D (± 0.1/-0)</b> | 1.5  |
| <b>Hole Diameter</b>     | <b>D1 (min)</b>     | 1.5  |
| <b>Hole Position</b>     | <b>F (± 0.05)</b>   | 11.5 |
| <b>Compartment Depth</b> | <b>K (max)</b>      | 6.5  |
| <b>Hole Spacing</b>      | <b>P1 (± 0.1)</b>   | 2    |



All dimensions are in mm.



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