



VNQ810P

QUAD CHANNEL HIGH SIDE DRIVER

TARGET SPECIFICATION

| TYPE | R _{DS(on)} | I _{OUT} | V _{CC} |
|---------|---------------------|------------------|-----------------|
| VNQ810P | 160 mΩ (*) | 3.5 A (*) | 36 V |

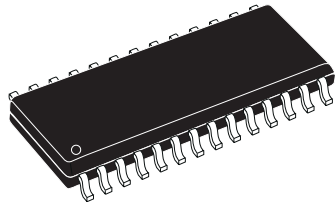
(*) Per each channel

- CMOS COMPATIBLE INPUTS
- OPEN DRAIN STATUS OUTPUTS
- 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 VNQ810P is a quad HSD formed by assembling two VND810 chips in the same SO-28 package. The VND810 is a monolithic device 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



SO-28 (DOUBLE ISLAND)

| ORDER CODES | | |
|-------------|---------|-------------|
| PACKAGE | TUBE | T&R |
| SO-28 | VNQ810P | VNQ810P13TR |

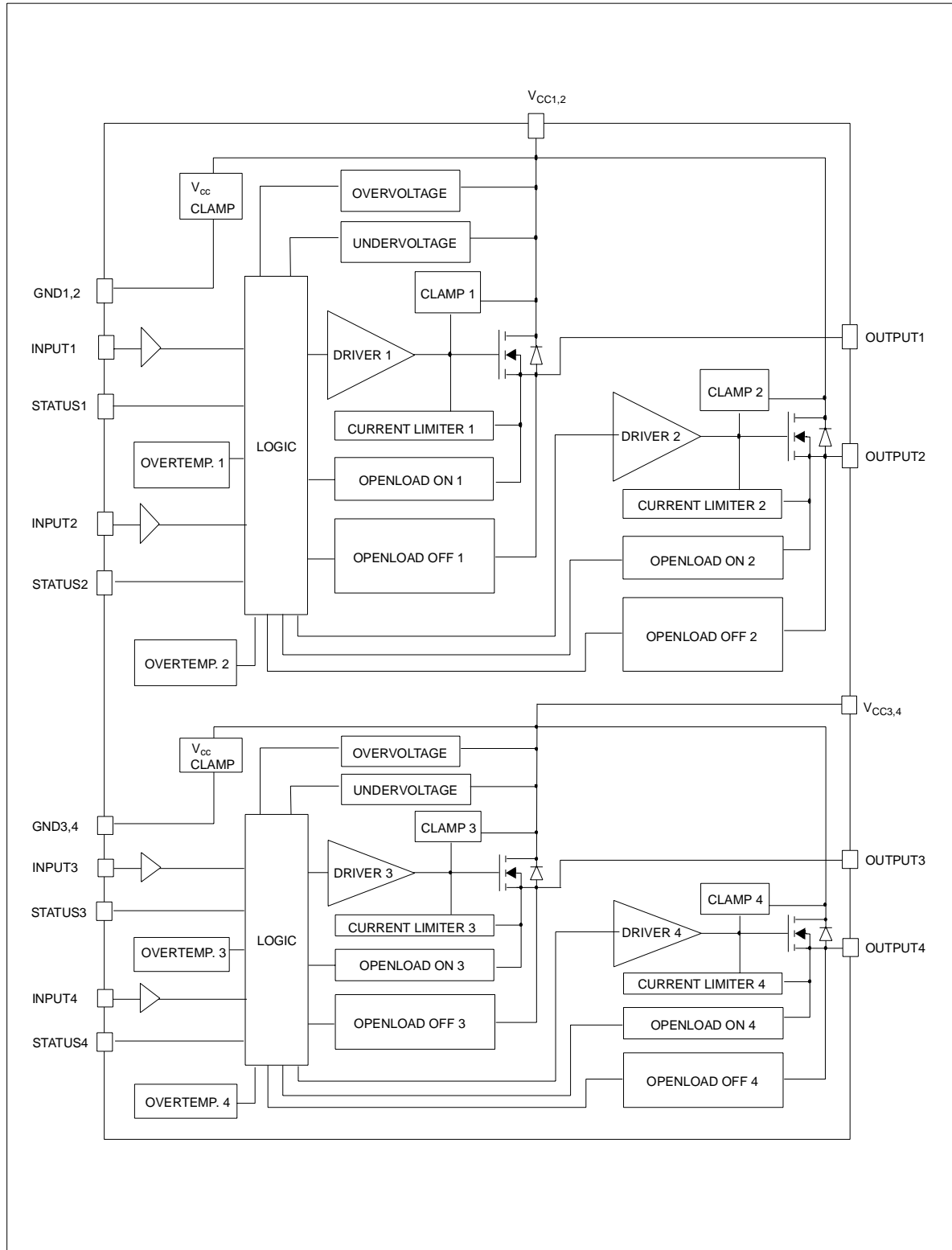
against low energy spikes (see ISO7637 transient compatibility table). Active current limitation combined with thermal shutdown and automatic restart protects the device against overload. The device detects open load condition both in on and off state. Output shorted to V_{CC} is detected in the off state. Device automatically turns off in case of ground pin disconnection.

ABSOLUTE MAXIMUM RATING

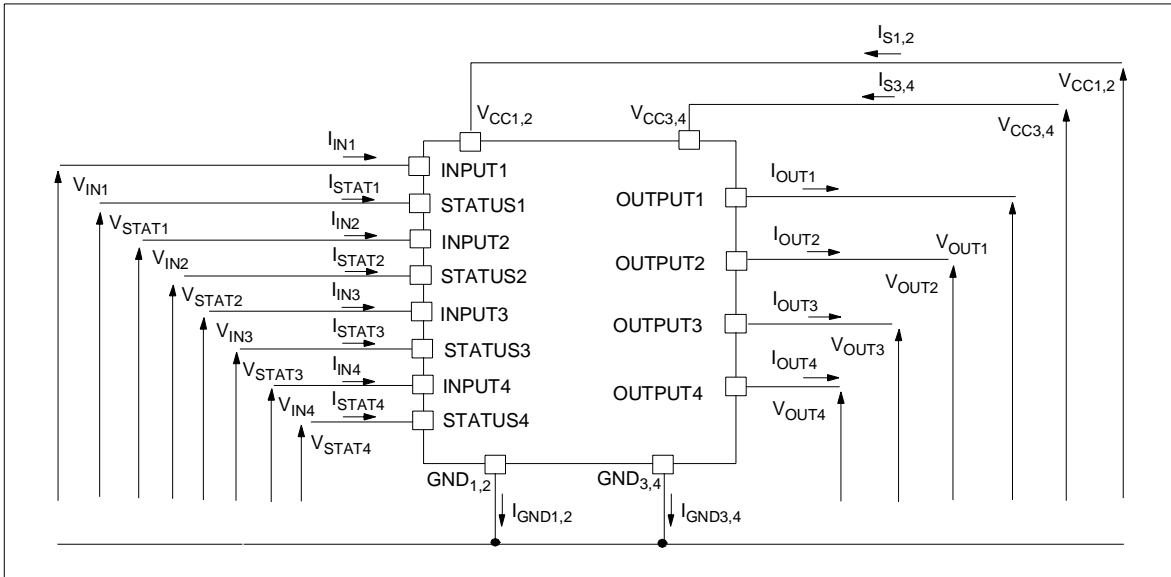
| Symbol | Parameter | Value | Unit |
|--------------------|---|--------------------|------|
| V _{CC} | DC Supply Voltage | 41 | V |
| - V _{CC} | Reverse DC Supply Voltage | - 0.3 | V |
| - I _{gnd} | DC Reverse Ground Pin Current | - 200 | mA |
| I _{OUT} | DC Output Current | Internally Limited | A |
| - I _{OUT} | Reverse DC Output Current | - 6 | 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 |
| | - STATUS | 4000 | V |
| | - OUTPUT | 5000 | V |
| | - V _{CC} | 5000 | V |
| E _{MAX} | Maximum Switching Energy (L=1.38mH; R _L =0Ω; V _{bat} =13.5V; T _{jstart} =150°C; I _L =5A) | 23 | mJ |
| P _{tot} | Power dissipation (per island) at T _{lead} =25°C | 6.25 | W |
| T _j | Junction Operating Temperature | Internally Limited | °C |
| T _{stg} | Storage Temperature | - 55 to 150 | °C |

(**) See application schematic at page 9

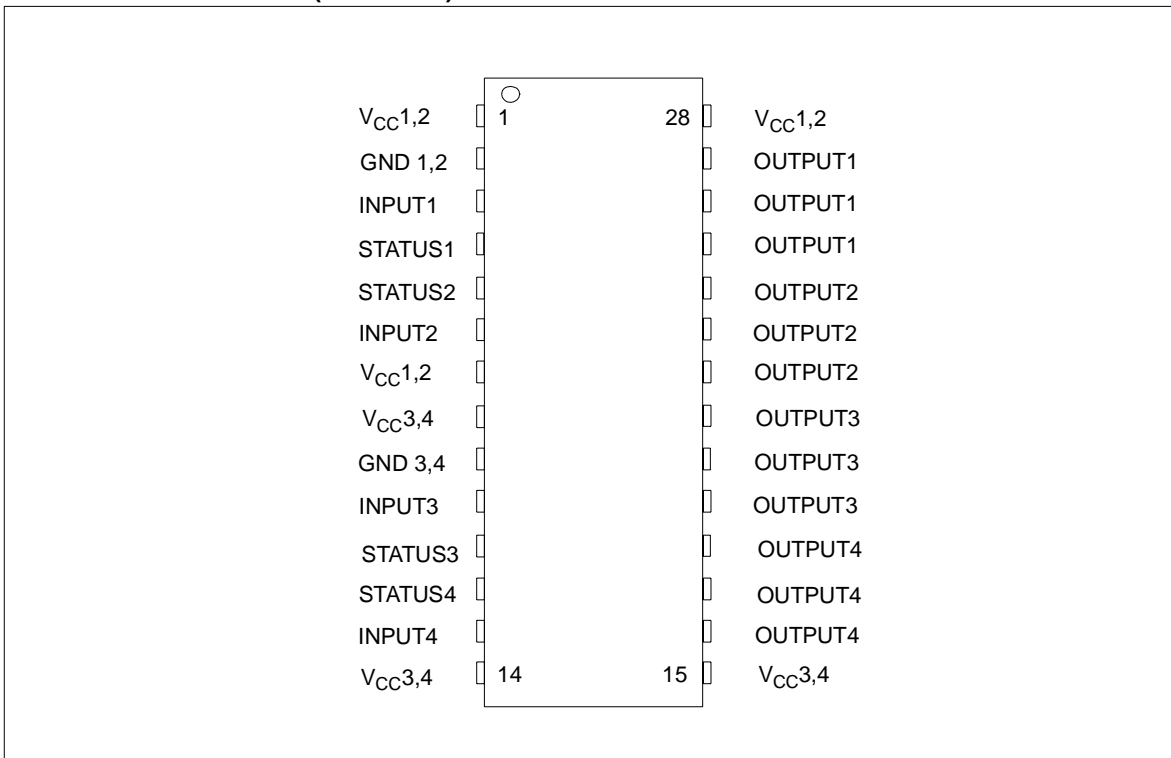
BLOCK DIAGRAM



CURRENT AND VOLTAGE CONVENTIONS



CONNECTION DIAGRAM (TOP VIEW)



VNQ810P

THERMAL DATA (Per island)

| Symbol | Parameter | Value | Unit |
|----------------|--|--------|------|
| $R_{thj-lead}$ | Thermal Resistance Junction-lead per chip | 20 | °C/W |
| $R_{thj-amb}$ | Thermal resistance Junction-ambient (one chip ON) | 60 (*) | °C/W |
| $R_{thj-amb}$ | Thermal resistance Junction-ambient (two chips ON) | 46 (*) | °C/W |

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

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

POWER OUTPUTS (Per each channel)

| 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 _{OV} (**) | Overvoltage Shut-down | | 36 | | | V |
| R _{ON} | On State Resistance | I _{OUT} =1A; T _j =25°C I _{OUT} =1A; V _{CC} >8V | | | 160 320 | mΩ mΩ |
| I _S (**) | Supply Current | Off State; V _{CC} =13V; V _{IN} =V _{OUT} =0V Off State; V _{CC} =13V; V _{IN} =V _{OUT} =0V; T _j =25°C On State; V _{CC} =13V; V _{IN} =5V; I _{OUT} =0A | | 12 12 5 | 40 25 7 | µA µA 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 (Per each Channel) (V_{CC}=13V)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|--|------------------------|---|-----|----------------------------|-----|------|
| t _{d(on)} | Turn-on Delay Time | R _L =13Ω from V _{IN} rising edge to V _{OUT} =1.3V | | 30 | | µs |
| t _{d(off)} | Turn-off Delay Time | R _L =13Ω from V _{IN} falling edge to V _{OUT} =11.7V | | 30 | | µs |
| dV _{OUT} /dt _(on) | Turn-on Voltage Slope | R _L =13Ω from V _{OUT} =1.3V to V _{OUT} =10.4V | | See relative diagram | | V/µs |
| dV _{OUT} /dt _(off) | Turn-off Voltage Slope | R _L =13Ω from V _{OUT} =11.7V to V _{OUT} =1.3V | | See relative diagram | | V/µs |

LOGIC INPUT (Per each channel)

| 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 I _{IN} =-1mA | 6 | 6.8 -0.7 | 8 | V V |

(**) Per island

ELECTRICAL CHARACTERISTICS (continued)

V_{CC} - OUTPUT DIODE

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|----------------|--------------------|--|-----|-----|-----|------|
| V _F | Forward on Voltage | -I _{OUT} =0.5A; T _j =150°C | | | 0.6 | V |

STATUS PIN (Per each channel)

| 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 |

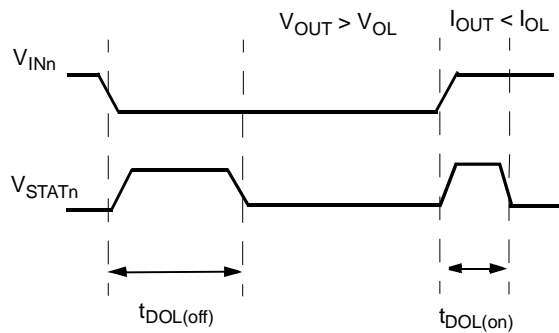
PROTECTIONS (Per each channel)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|--------------------|-------------------------------------|----------------------------------|---------------------|---------------------|---------------------|--------|
| T _{TSD} | Shut-down Temperature | | 150 | 175 | 200 | °C |
| T _R | Reset Temperature | | 135 | | | °C |
| T _{hyst} | Thermal Hysteresis | | 7 | 15 | | °C |
| t _{sdl} | Status Delay in Overload Conditions | T _j >T _{TSD} | | | 20 | μs |
| I _{lim} | Current limitation | 5.5V<V _{CC} <36V | 3.5 | 5 | 7.5 7.5 | A A |
| V _{DEMAG} | Turn-off Output Clamp Voltage | I _{OUT} =1A; L=6mH | V _{CC} -41 | V _{CC} -48 | V _{CC} -55 | V |

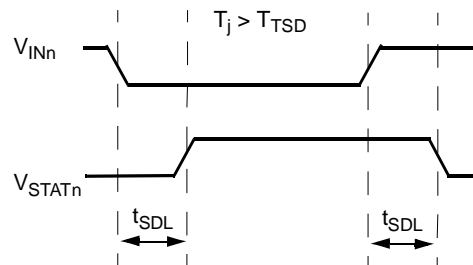
OPENLOAD DETECTION (Per each channel)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|-----------------------|--|----------------------|-----|-----|------|------|
| I _{OL} | Openload ON State Detection Threshold | V _{IN} =5V | 20 | 40 | 80 | mA |
| t _{DOL(on)} | Openload ON State Detection Delay | I _{OUT} =0A | | | 200 | 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 |

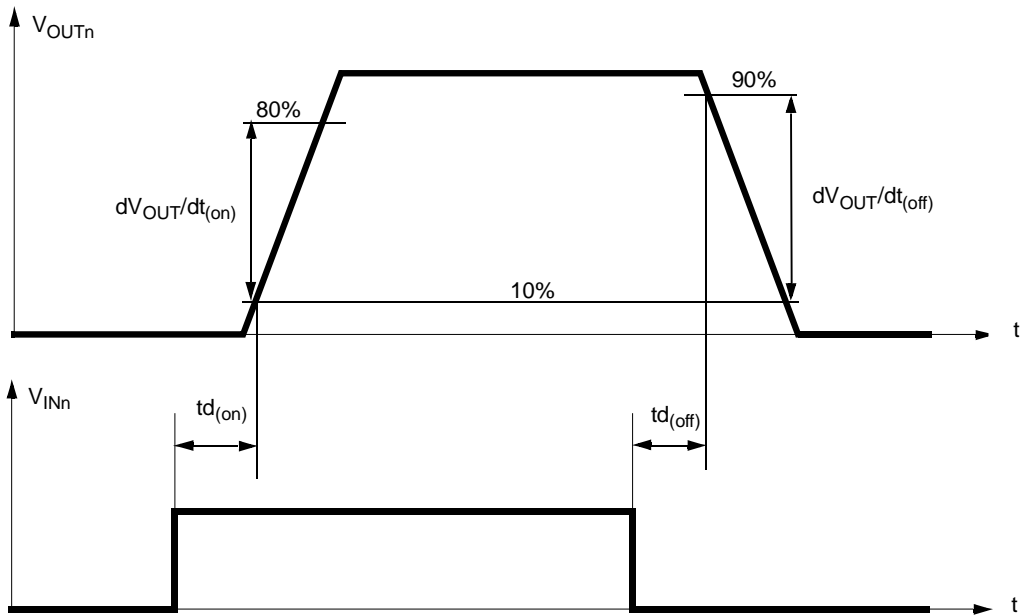
OPEN LOAD STATUS TIMING (with external pull-up)



OVER TEMP 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 |

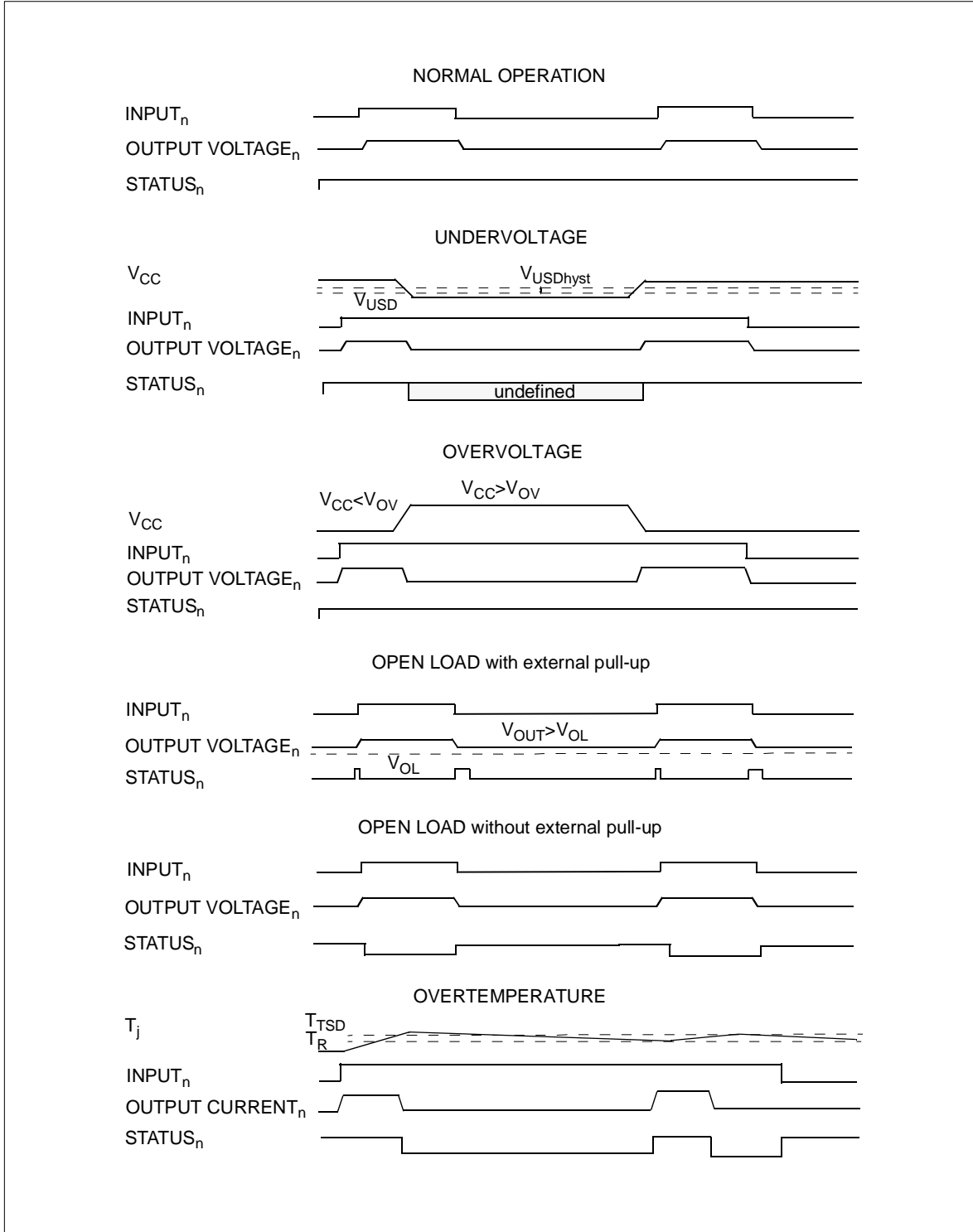
ELECTRICAL TRANSIENT REQUIREMENTS ON V_{CC} PIN

| ISO T/R 7637/1 Test Pulse | TEST LEVELS | | | | Delays and Impedance |
|------------------------------|-------------|---------|---------|---------|-------------------------|
| | I | II | III | IV | |
| 1 | -25 V | -50 V | -75 V | -100 V | 2 ms 10 Ω |
| 2 | +25 V | +50 V | +75 V | +100 V | 0.2 ms 10 Ω |
| 3a | -25 V | -50 V | -100 V | -150 V | 0.1 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 |

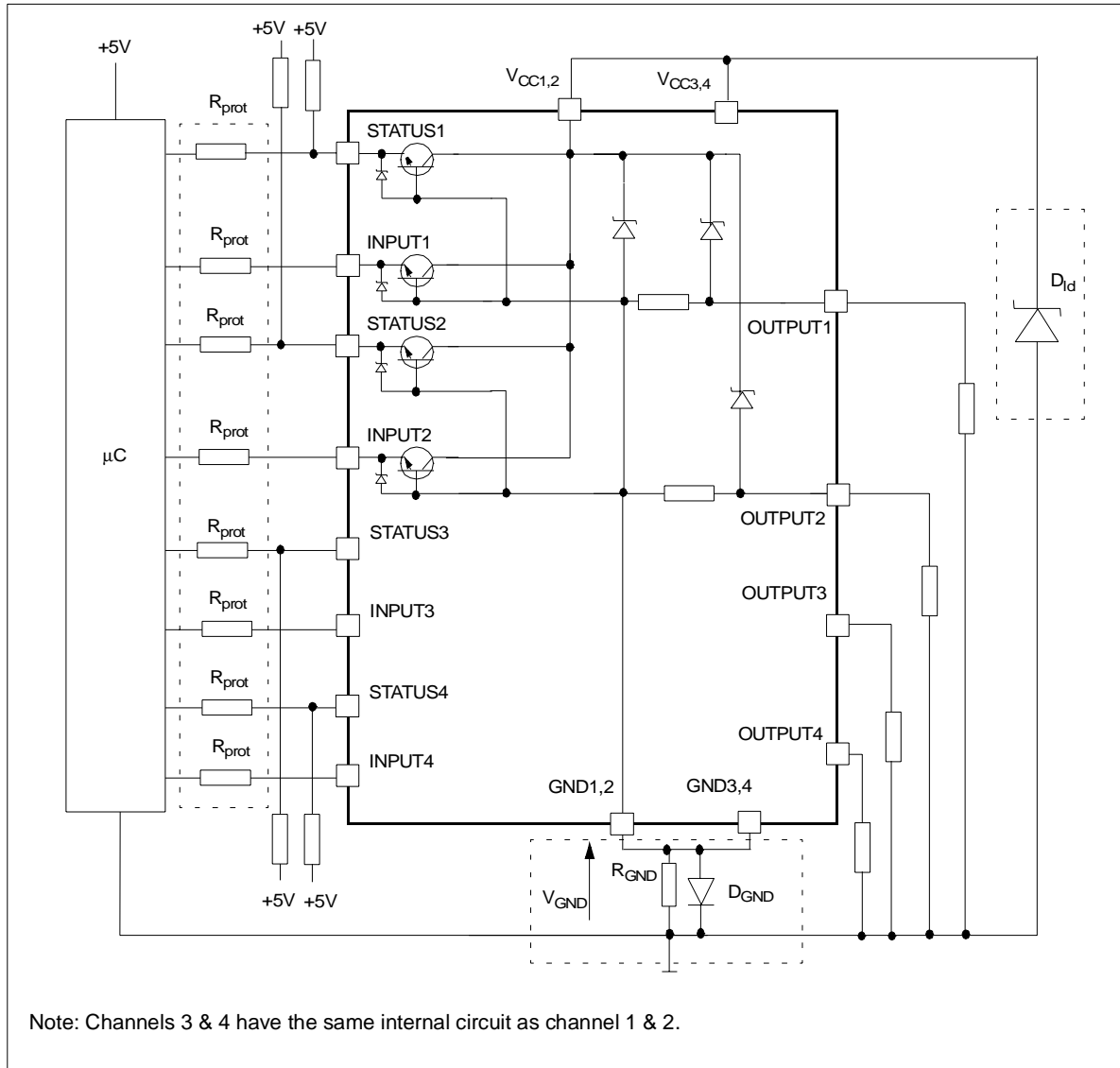
| ISO T/R 7637/1 Test Pulse | TEST LEVELS RESULTS | | | |
|------------------------------|---------------------|----|-----|----|
| | I | II | III | IV |
| 1 | C | C | C | C |
| 2 | C | C | C | C |
| 3a | C | C | C | C |
| 3b | C | C | C | C |
| 4 | C | C | C | C |
| 5 | C | E | E | E |

| 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 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) $R_{GND} \leq 600mV / 2(I_{S(on)max})$.
- 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 suggest to utilize Solution 2.

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.

Series resistor in INPUT and STATUS lines are also required to prevent that, during battery voltage transient, the current exceeds the Absolute Maximum Rating.

Safest configuration for unused INPUT and STATUS pin is to leave them unconnected.

LOAD DUMP PROTECTION

D_{ld} is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds V_{CC} max DC rating. The

same applies if the device will be subject to transients on the V_{CC} line that are greater than the ones shown in the ISO T/R 7637/1 table.

μC I/Os PROTECTION:

If a ground protection network is used and negative transient are present on the V_{CC} line, the control pins will be pulled negative. ST suggests to insert a resistor (R_{prot}) in line to prevent the μC I/Os pins to latch-up.

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

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

Calculation example:

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

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

OPEN LOAD DETECTION IN OFF STATE

Off state open load detection requires an external pull-up resistor (R_{PU}) connected between OUTPUT pin and a positive supply voltage (V_{PU}) like the +5V line used to supply the microprocessor.

The external resistor has to be selected according to the following requirements:

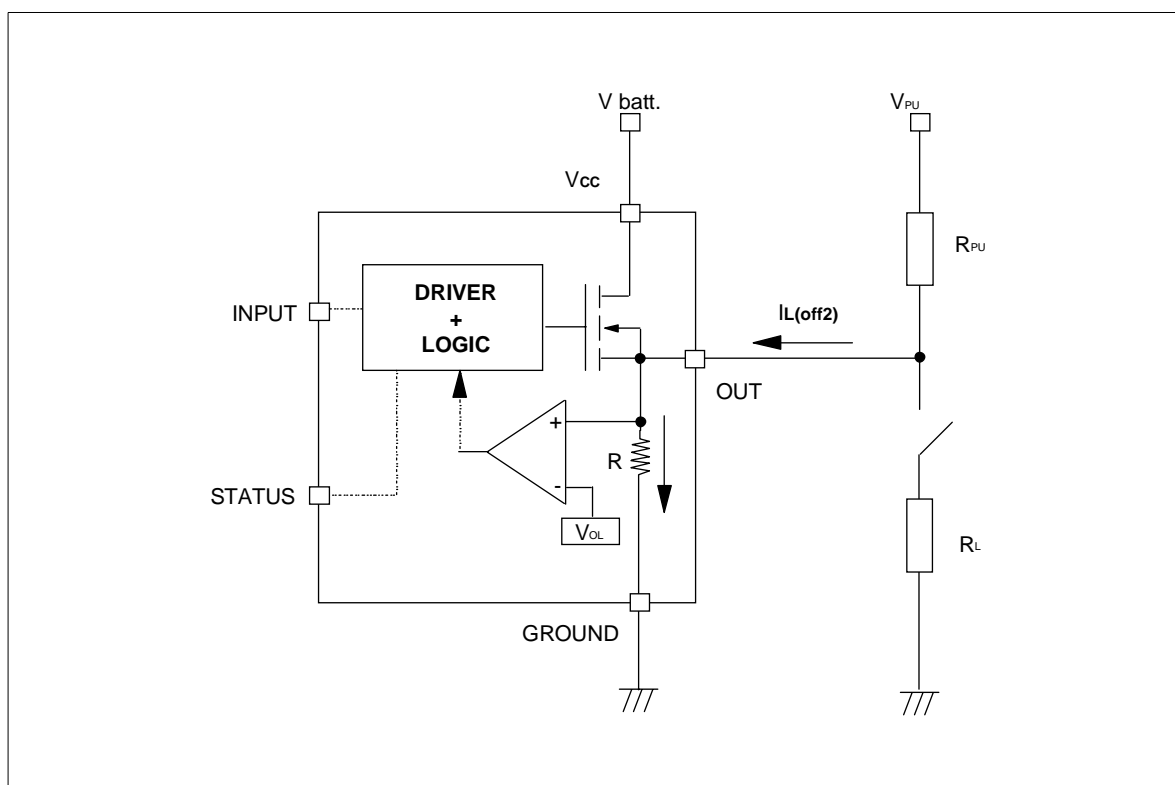
- 1) no false open load indication when load is connected: in this case we have to avoid V_{OUT} to be higher than V_{OLmin} ; this results in the following condition $V_{OUT} = (V_{PU} / (R_L + R_{PU})) R_L < V_{OLmin}$.

- 2) no misdetection when load is disconnected: in this case the V_{OUT} has to be higher than V_{OLmax} ; this results in the following condition $R_{PU} < (V_{PU} - V_{OLmax}) / I_{L(off2)}$.

Because $I_{S(OFF)}$ may significantly increase if V_{OUT} is pulled high (up to several mA), the pull-up resistor R_{PU} should be connected to a supply that is switched OFF when the module is in standby.

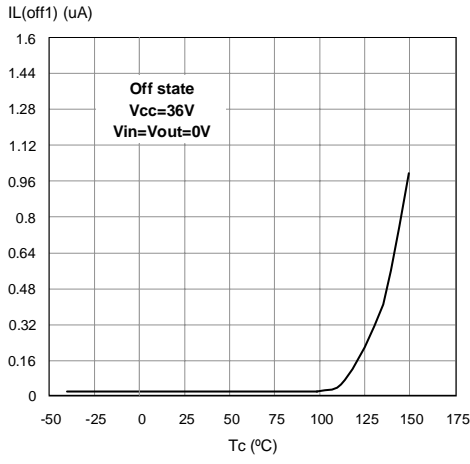
The values of V_{OLmin} , V_{OLmax} and $I_{L(off2)}$ are available in the Electrical Characteristics section.

Open Load detection in off state

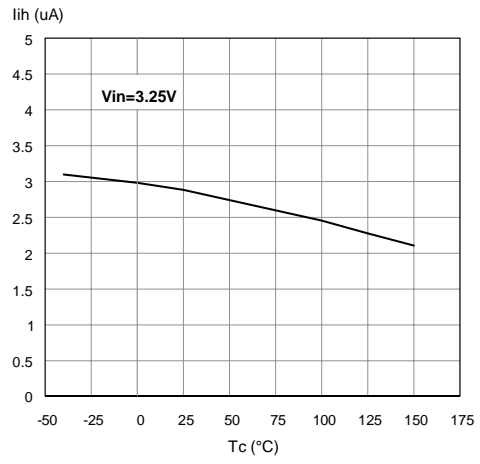


VNQ810P

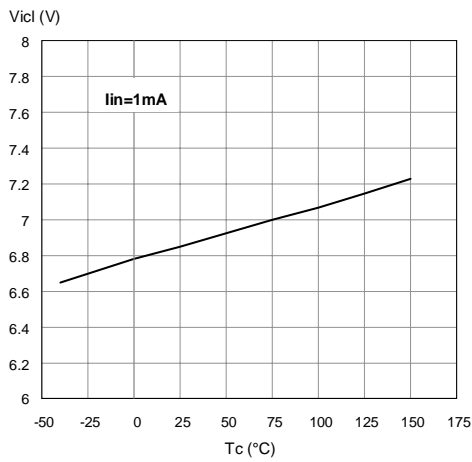
Off State Output Current



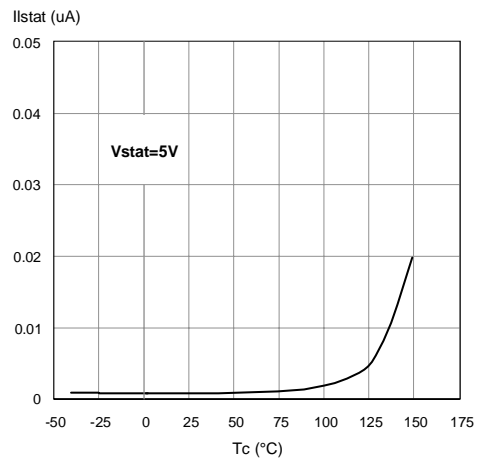
High Level Input Current



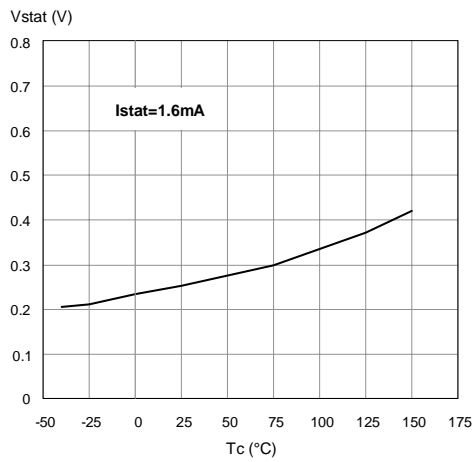
Input Clamp Voltage



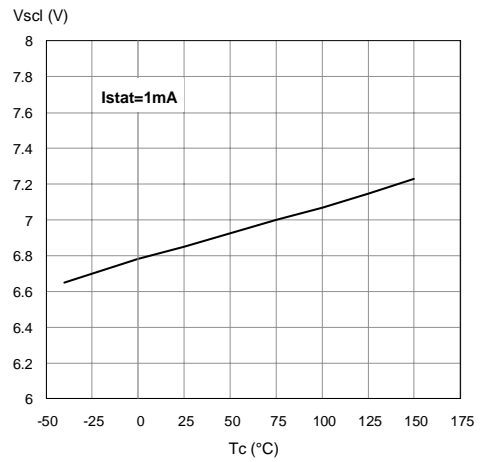
Status Leakage Current



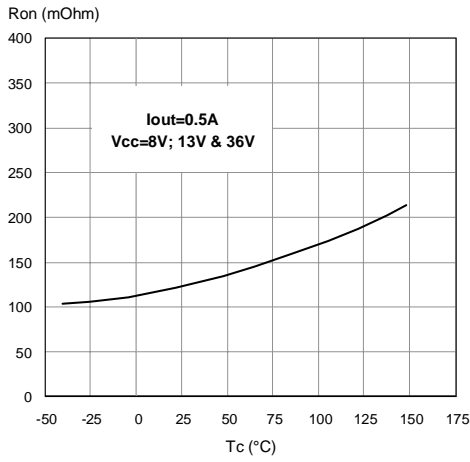
Status Low Output Voltage



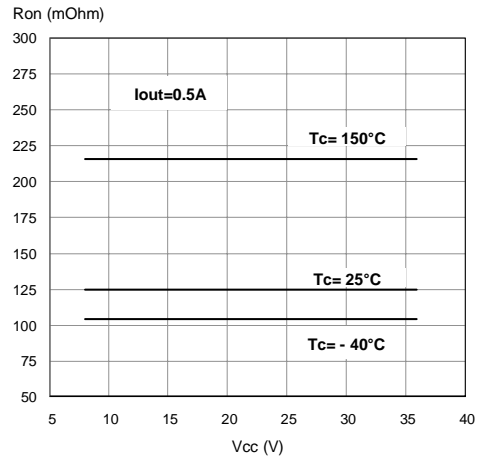
Status Clamp Voltage



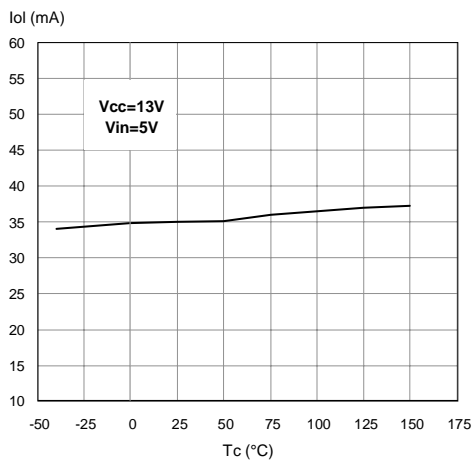
On State Resistance Vs T_{case}



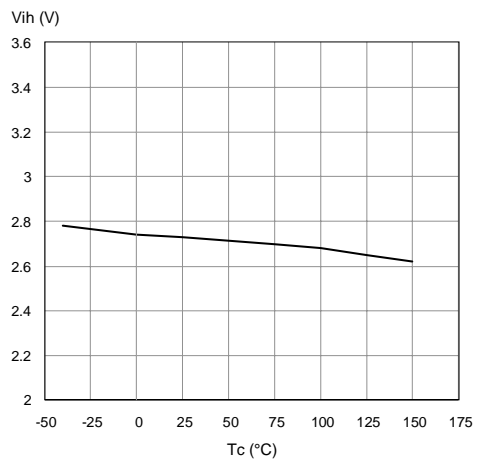
On State Resistance Vs V_{CC}



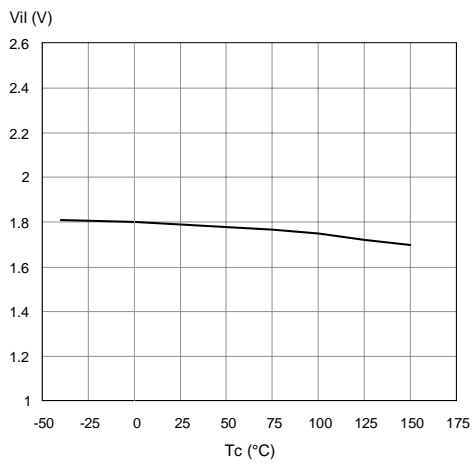
Openload On State Detection Threshold



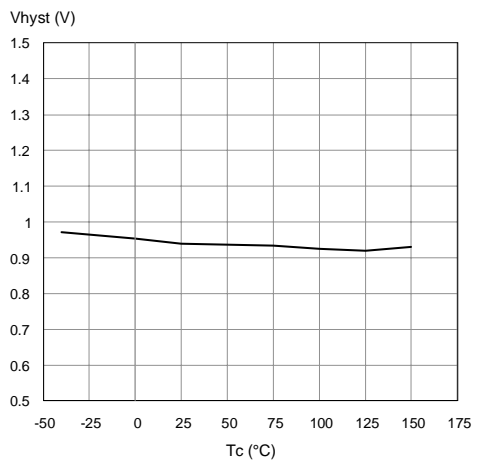
Input High Level



Input Low Level

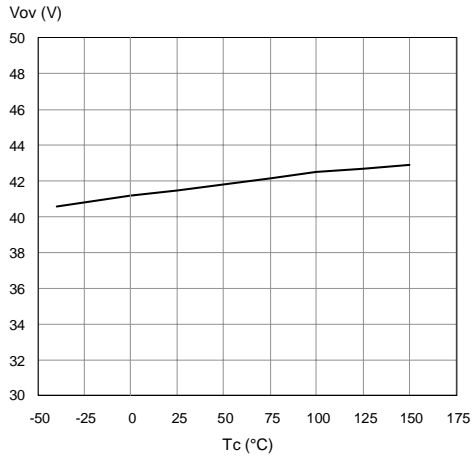


Input Hysteresis Voltage

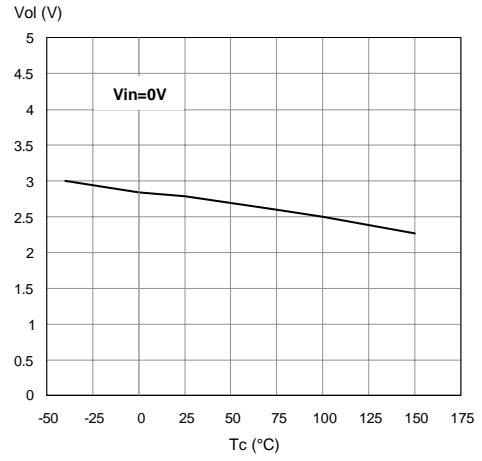


VNQ810P

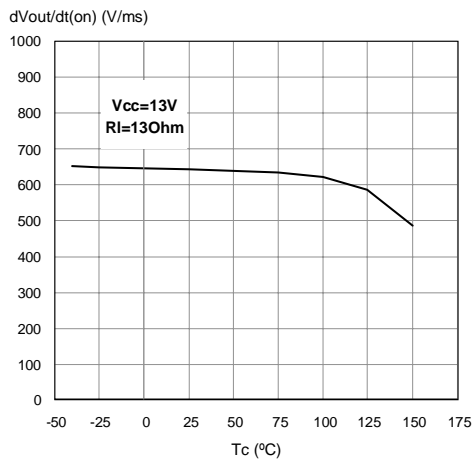
Overvoltage Shutdown



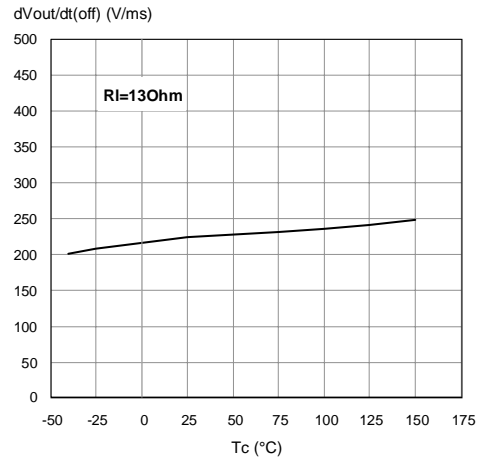
Openload Off State Voltage Detection Threshold



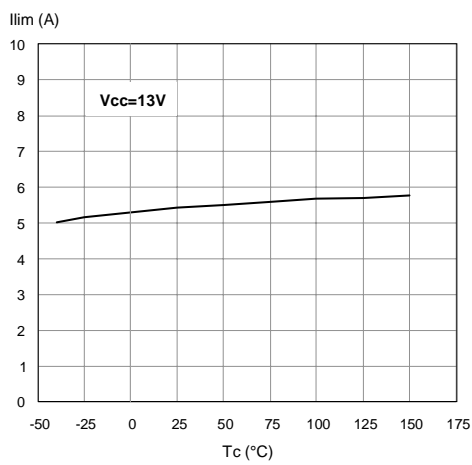
Turn-on Voltage Slope



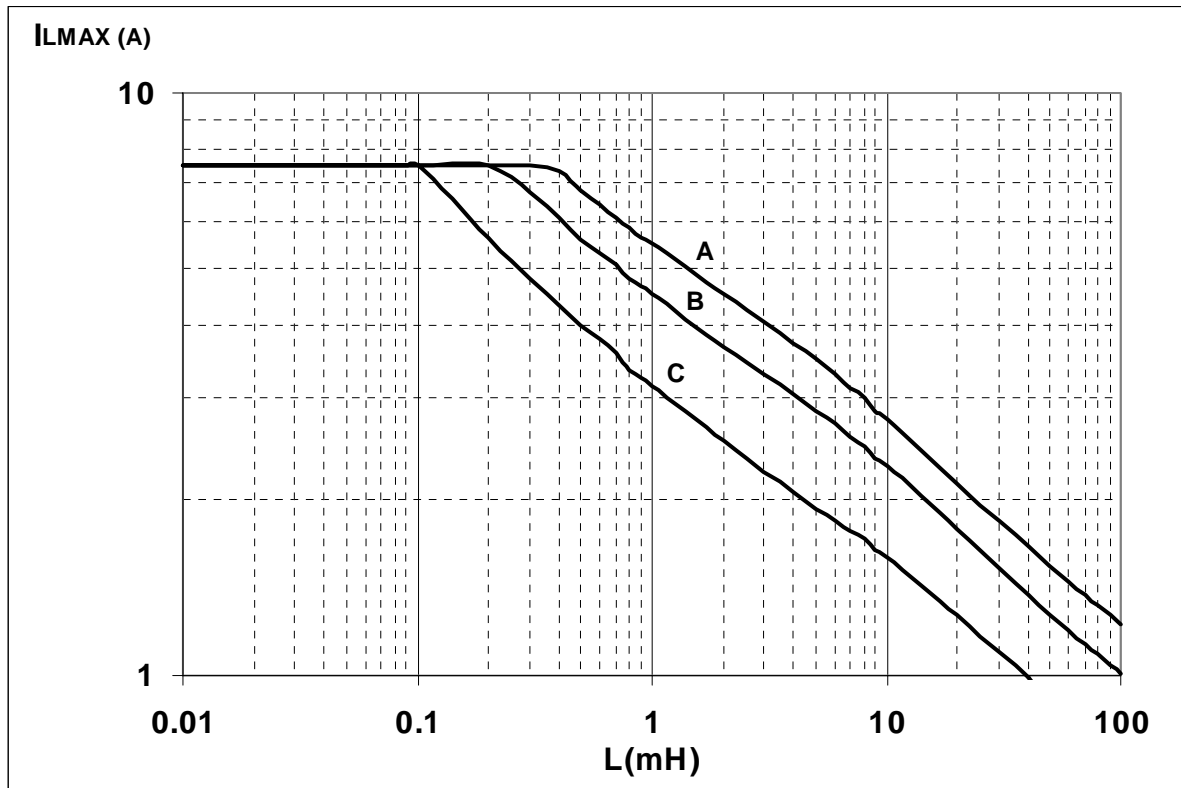
Turn-off Voltage Slope



I_{LIM} Vs T_{case}



Maximum turn off current versus load inductance



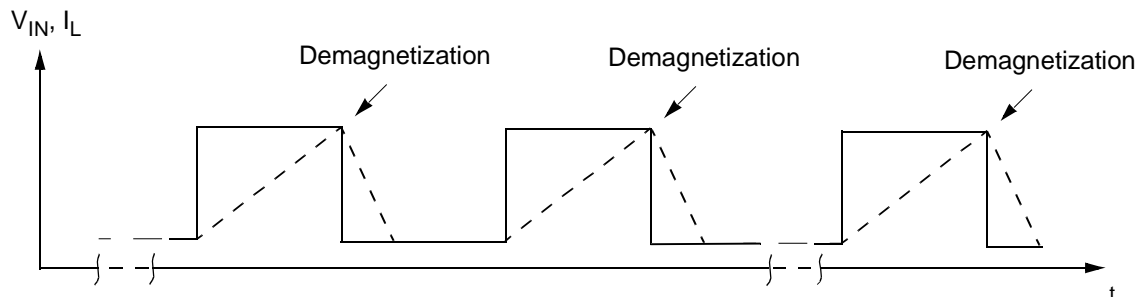
- A = Single Pulse at $T_{Jstart}=150^{\circ}C$
- B= Repetitive pulse at $T_{Jstart}=100^{\circ}C$
- C= Repetitive Pulse at $T_{Jstart}=125^{\circ}C$

Conditions:

$V_{CC}=13.5V$

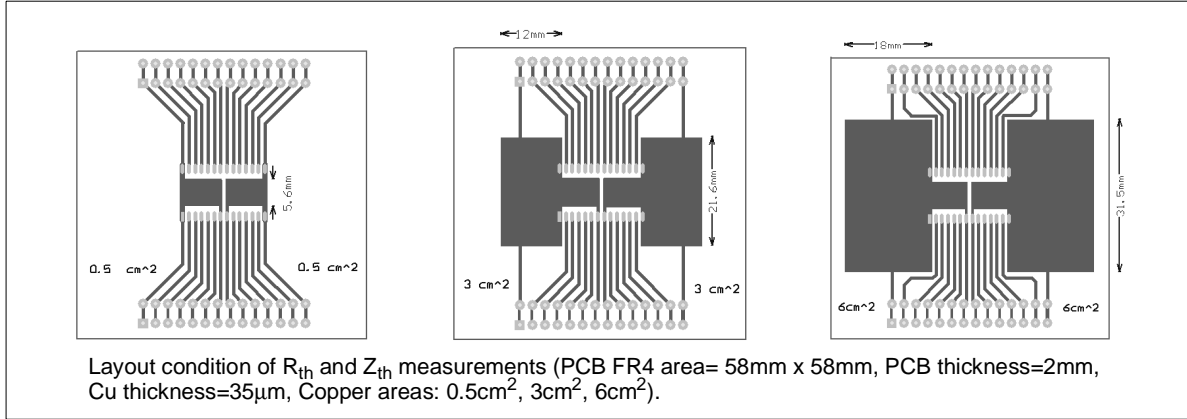
Values are generated with $R_L=0\Omega$

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-28 DOUBLE ISLAND THERMAL DATA

SO-28 Double island PC Board

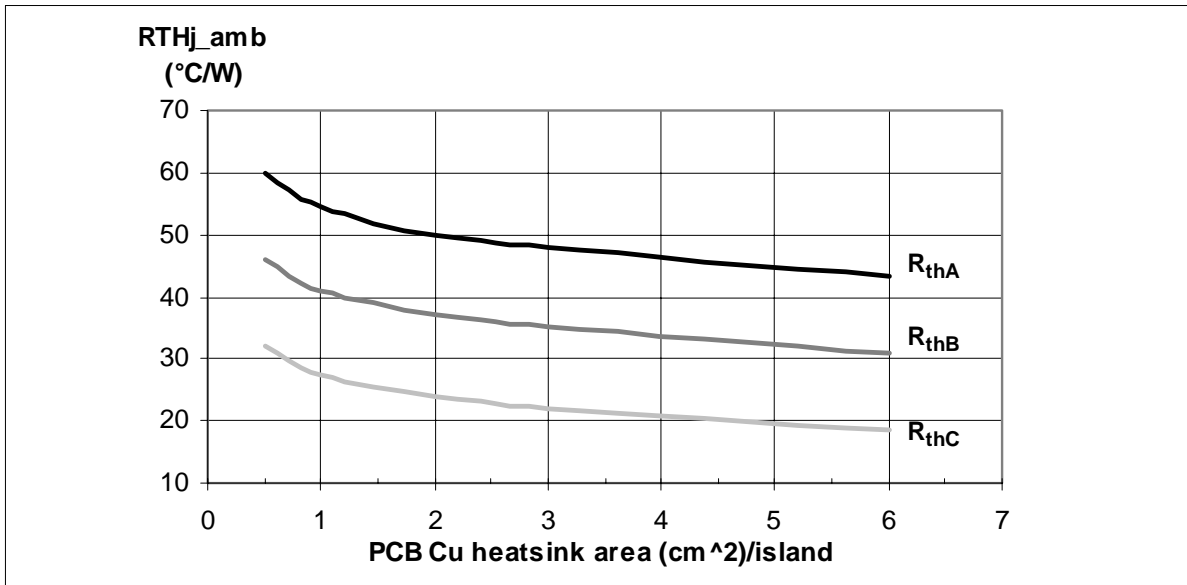


Thermal calculation according to the PCB heatsink area

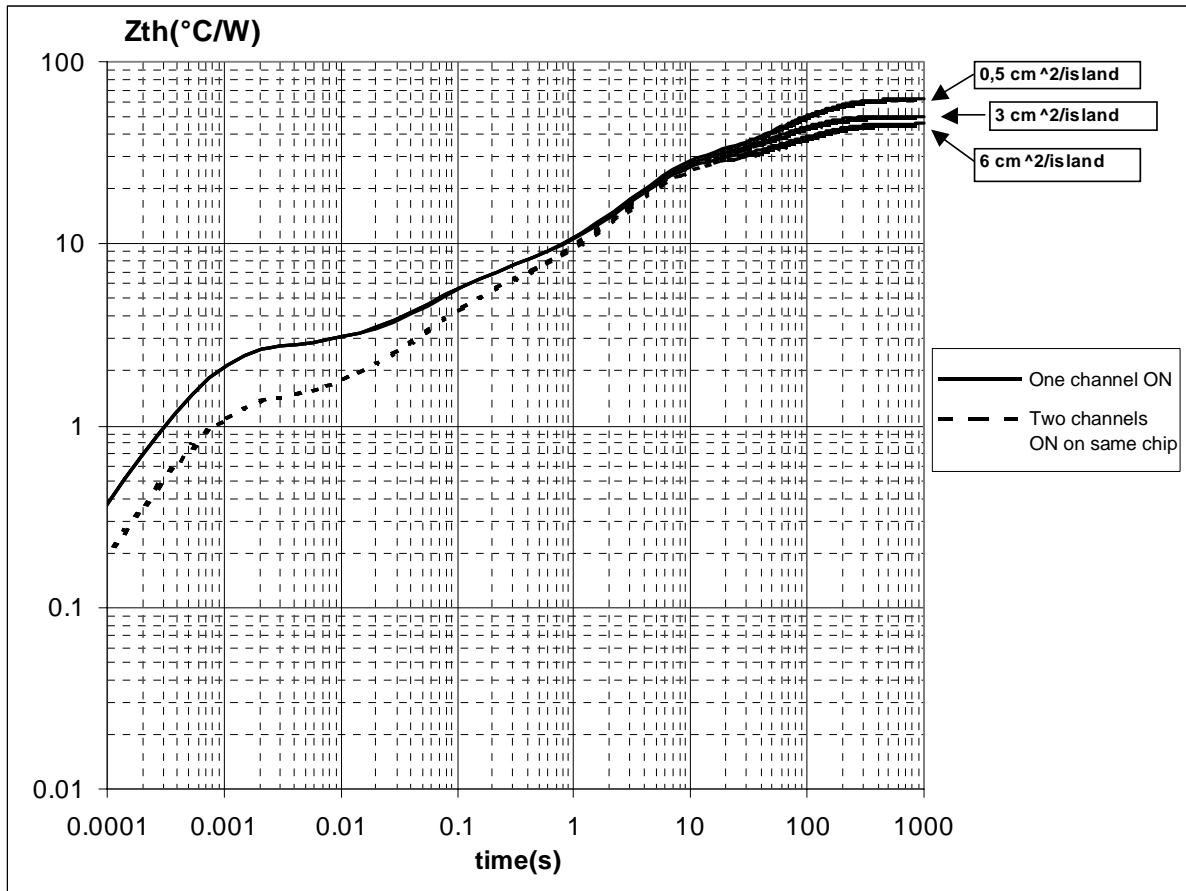
| Chip 1 | Chip 2 | T_{jchip1} | T_{jchip2} | Note |
|--------|--------|---|---|------------------------------|
| ON | OFF | $R_{thA} \times P_{dchip1} + T_{amb}$ | $R_{thC} \times P_{dchip1} + T_{amb}$ | |
| OFF | ON | $R_{thC} \times P_{dchip2} + T_{amb}$ | $R_{thA} \times P_{dchip2} + T_{amb}$ | |
| ON | ON | $R_{thB} \times (P_{dchip1} + P_{dchip2}) + T_{amb}$ | $R_{thB} \times (P_{dchip1} + P_{dchip2}) + T_{amb}$ | $P_{dchip1} = P_{dchip2}$ |
| ON | ON | $(R_{thA} \times P_{dchip1}) + R_{thC} \times P_{dchip2} + T_{amb}$ | $(R_{thA} \times P_{dchip2}) + R_{thC} \times P_{dchip1} + T_{amb}$ | $P_{dchip1} \neq P_{dchip2}$ |

R_{thA} = Thermal resistance Junction to Ambient with one chip ON
 R_{thB} = Thermal resistance Junction to Ambient with both chips ON and $P_{dchip1} = P_{dchip2}$
 R_{thC} = Mutual thermal resistance

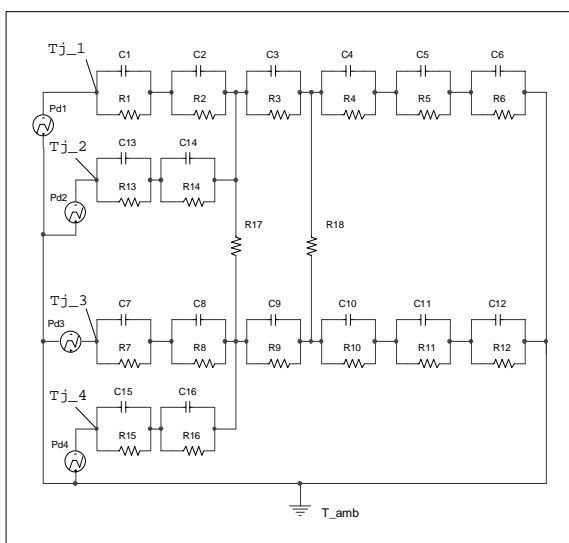
$R_{thj-amb}$ Vs. PCB copper area in open box free air condition



SO-28 Thermal Impedance Junction Ambient Single Pulse



Thermal fitting model of a four channels HSD in SO-28



Pulse calculation formula

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

where $\delta = t_p/T$

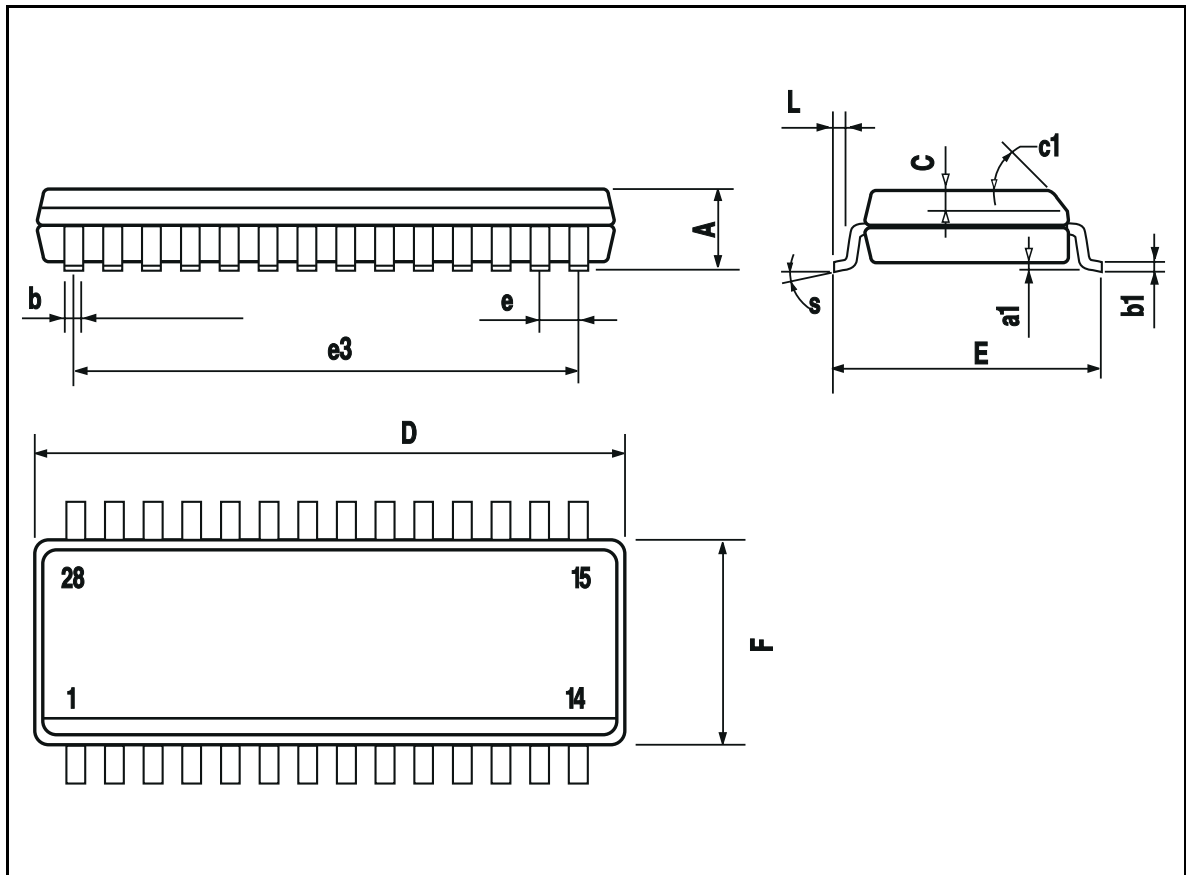
Thermal Parameter

| Area/island (cm ²) | 0.5 | 6 |
|--------------------------------|----------|----|
| R1=R7=R13=R15 (°C/W) | 0.35 | |
| R2=R8=R14=R16 (°C/W) | 1.8 | |
| R3=R9 (°C/W) | 4.5 | |
| R4=R10 (°C/W) | 11 | |
| R5=R11 (°C/W) | 15 | |
| R6=R12 (°C/W) | 30 | 13 |
| C1=C7=C13=C15 (W.s/°C) | 0.0001 | |
| C2=C8=C14=C16 (W.s/°C) | 7.00E-04 | |
| C3=C9 (W.s/°C) | 6.00E-03 | |
| C4=C10 (W.s/°C) | 0.2 | |
| C5=C11 (W.s/°C) | 1.5 | |
| C6=C12 (W.s/°C) | 5 | 8 |
| R17=R18 (°C/W) | 150 | |

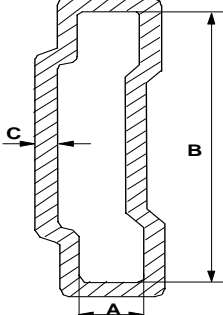


SO-28 MECHANICAL DATA

| DIM. | mm. | | | inch | | |
|------|-----------|-------|-------|-------|-------|-------|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | | | 2.65 | | | 0.104 |
| a1 | 0.10 | | 0.30 | 0.004 | | 0.012 |
| b | 0.35 | | 0.49 | 0.013 | | 0.019 |
| b1 | 0.23 | | 0.32 | 0.009 | | 0.012 |
| C | | 0.50 | | | 0.020 | |
| c1 | 45 (typ.) | | | | | |
| D | 17.7 | | 18.1 | 0.697 | | 0.713 |
| E | 10.00 | | 10.65 | 0.393 | | 0.419 |
| e | | 1.27 | | | 0.050 | |
| e3 | | 16.51 | | | 0.650 | |
| F | 7.40 | | 7.60 | 0.291 | | 0.299 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| S | 8 (max.) | | | | | |



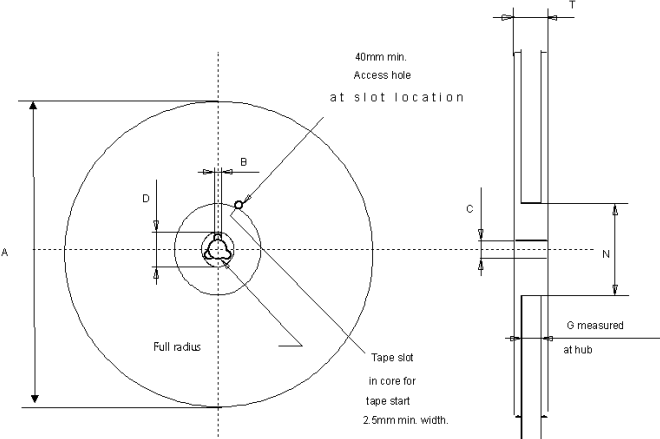
SO-28 TUBE SHIPMENT (no suffix)



| | |
|----------------------------|------|
| Base Q.ty | 28 |
| Bulk Q.ty | 700 |
| 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")

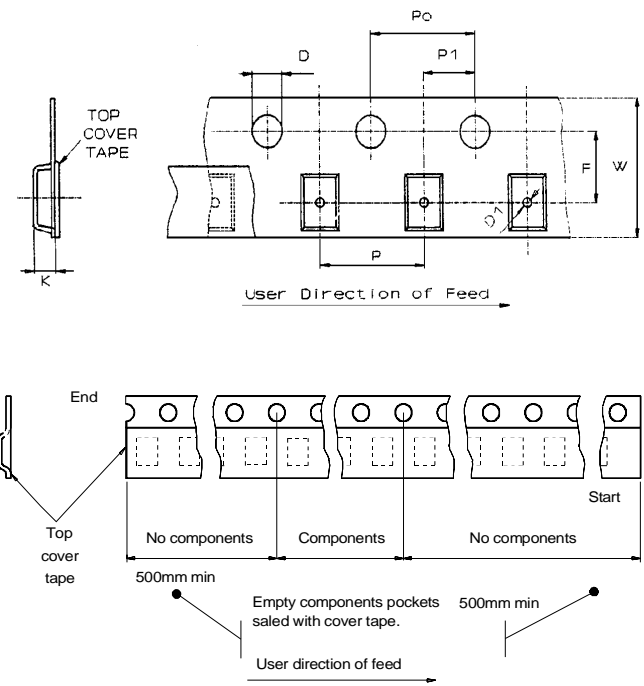


| | |
|----------------------|------|
| Base Q.ty | 1000 |
| Bulk Q.ty | 1000 |
| A (max) | 330 |
| B (min) | 1.5 |
| C (± 0.2) | 13 |
| F | 20.2 |
| G (+ 2 / - 0) | 16.4 |
| N (min) | 60 |
| T (max) | 22.4 |

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 (± 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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