# HIGH SIDE SMART POWER SOLID STATE RELAY

| TYPE | $V_{DSS}$ | $R_{DS(on)}$ | $I_{OUT}$ | $V_{CC}$ |
|---|---|---|---|---|
| VN05N | 60 V | 0.18 Ω | 13 A | 26 V |

- OUTPUT CURRENT (CONTINUOUS): 13A @ $T_C$=25$^o$C
- 5V LOGIC LEVEL COMPATIBLE INPUT
- THERMAL SHUT-DOWN
- UNDER VOLTAGE SHUT-DOWN
- OPEN DRAIN DIAGNOSTIC OUTPUT
- VERY LOW STAND-BY POWER DISSIPATION

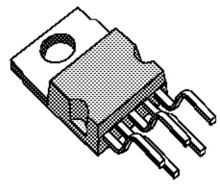
**DESCRIPTION**

The VN05N is a monolithic device made using SGS-THOMSON Vertical Intelligent Power Technology, intended for driving resistive or inductive loads with one side grounded.

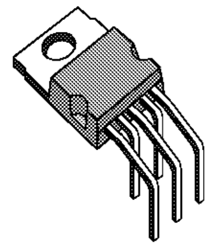
Built-in thermal shut-down protects the chip from over temperature and short circuit.

The input control is 5V logic level compatible.

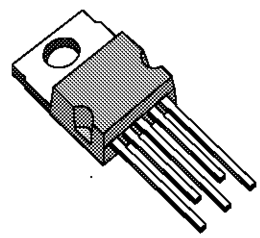
The open drain diagnostic output indicates open circuit (no load) and over temperature status.



**PENTAWATT (vertical)**



**PENTAWATT (horizontal)**

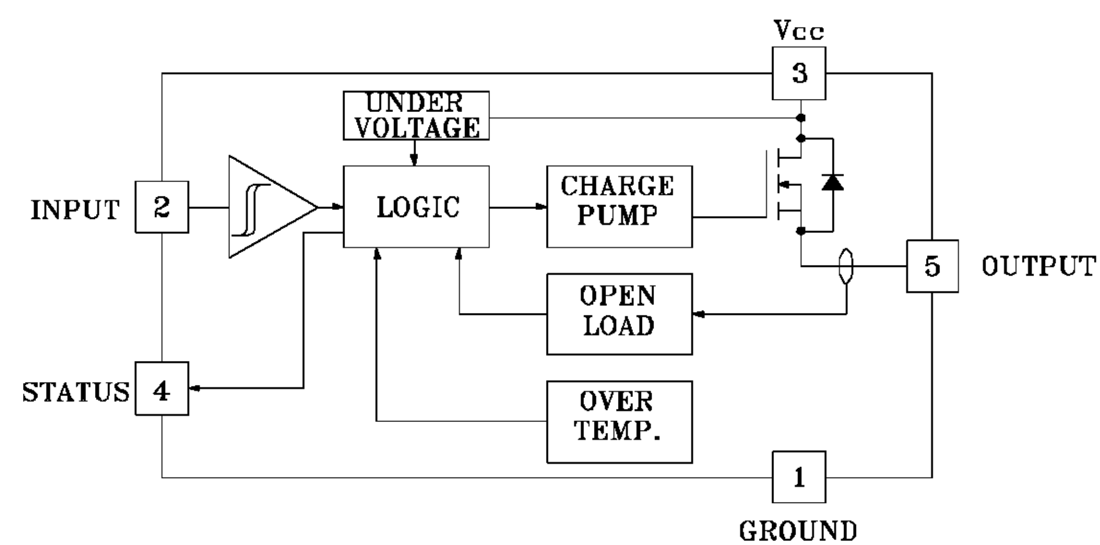


**PENTAWATT (in-line)**

**ORDER CODES:**

| | |
|---|---|
| PENTAWATT vertical | VN05N |
| PENTAWATT horizontal | VN05N (011Y) |
| PENTAWATT in-line | VN05N (012Y) |

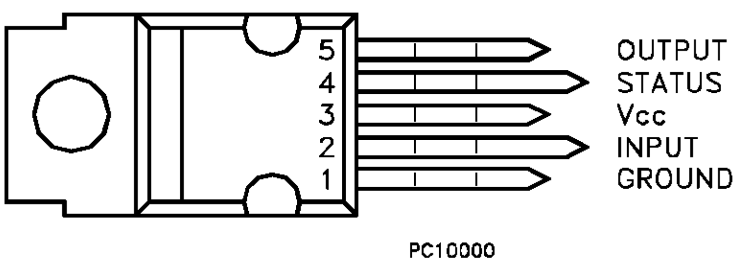
**BLOCK DIAGRAM**



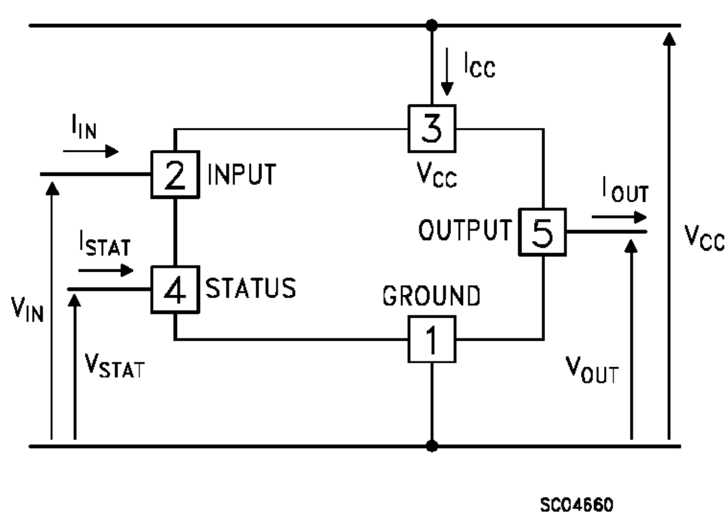
## ABSOLUTE MAXIMUM RATING

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-Source Breakdown Voltage | 60 | V |
| $I_{OUT}$ | Output Current (cont.) | 13 | A |
| $I_R$ | Reverse Output Current | -13 | A |
| $I_{IN}$ | Input Current | ±10 | mA |
| $-V_{CC}$ | Reverse Supply Voltage | -4 | V |
| $I_{STAT}$ | Status Current | ±10 | mA |
| $V_{ESD}$ | Electrostatic Discharge (1.5 kΩ, 100 pF) | 2000 | V |
| $P_{tot}$ | Power Dissipation at $T_c \leq 25$ °C | 56 | W |
| $T_j$ | Junction Operating Temperature | -40 to 150 | °C |
| $T_{stg}$ | Storage Temperature | -55 to 150 | °C |

## CONNECTION DIAGRAM




## CURRENT AND VOLTAGE CONVENTIONS



## THERMAL DATA

| | | | |
|---|---|---|---|
| $R_{thj-case}$<br>$R_{thj-amb}$ | Thermal Resistance Junction-case Max<br>Thermal Resistance Junction-ambient Max | 2.2<br>60 | $^oC/W$<br>$^oC/W$ |

## ELECTRICAL CHARACTERISTICS ($V_{CC}$ = 13 V; -40 ≤ $T_j$ ≤ 125 $^oC$ unless otherwise specified)

POWER

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | | 7 | | 26 | V |
| $R_{on}$ | On State Resistance | $I_{OUT}$ = 6 A<br>$I_{OUT}$ = 6 A $T_j$ = 25 $^oC$ | | | 0.36<br>0.18 | Ω<br>Ω |
| $I_S$ | Supply Current | Off State $T_j$ ≥ 25 $^oC$<br>On State | | | 50<br>15 | µA<br>mA |

SWITCHING

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on Delay Time Of Output Current | $I_{OUT}$ = 6 A Resistive Load<br>Input Rise Time < 0.1 µs $T_j$ = 25 $^oC$ | | 15 | | µs |
| $t_r$ | Rise Time Of Output Current | $I_{OUT}$ = 6 A Resistive Load<br>Input Rise Time < 0.1 µs $T_j$ = 25 $^oC$ | | 30 | | µs |
| $t_{d(off)}$ | Turn-off Delay Time Of Output Current | $I_{OUT}$ = 6 A Resistive Load<br>Input Rise Time < 0.1 µs $T_j$ = 25 $^oC$ | | 20 | | µs |
| $t_f$ | Fall Time Of Output Current | $I_{OUT}$ = 6 A Resistive Load<br>Input Rise Time < 0.1 µs $T_j$ = 25 $^oC$ | | 10 | | µs |
| $(di/dt)_{on}$ | Turn-on Current Slope | $I_{OUT}$ = 6 A<br>$I_{OUT}$ = $I_{OV}$ | | | 0.5<br>2 | A/µs<br>A/µs |
| $(di/dt)_{off}$ | Turn-off Current Slope | $I_{OUT}$ = 6 A<br>$I_{OUT}$ = $I_{OV}$ | | | 2<br>4 | A/µs<br>A/µs |

LOGIC INPUT

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Level Voltage | | | | 0.8 | V |
| $V_{IH}$ | Input High Level Voltage | | 2 | | (*) | V |
| $V_{I(hyst.)}$ | Input Hysteresis Voltage | | | 0.5 | | V |
| $I_{IN}$ | Input Current | $V_{IN}$ = 5 V | | 250 | 500 | µA |
| $V_{ICL}$ | Input Clamp Voltage | $I_{IN}$ = 10 mA<br>$I_{IN}$ = -10 mA | | 6<br>-0.7 | | V<br>V |

PROTECTIONS AND DIAGNOSTICS

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{STAT}$ (•) | Status Voltage Output Low | $I_{STAT}$ = 1.6 mA | | | 0.4 | V |
| $V_{USD}$ | Under Voltage Shut Down | | | 6.5 | | V |

**ELECTRICAL CHARACTERISTICS** (continued)

PROTECTION AND DIAGNOSTICS (continued)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{SCL}$ (•) | Status Clamp Voltage | $I_{STAT}$ = 10 mA<br>$I_{STAT}$ = -10 mA | | 6<br>-0.7 | | V<br>V |
| $t_{SC}$ | Switch-off Time in Short Circuit Condition at Start-Up | $R_{LOAD}$ < 10 mΩ $T_c$ = 25 °C | | 1.5 | 5 | ms |
| $I_{OV}$ | Over Current | $R_{LOAD}$ < 10 mΩ -40 ≤ $T_c$ ≤ 125 °C | | | 60 | A |
| $I_{AV}$ | Average Current in Short Circuit | $R_{LOAD}$ < 10 mΩ $T_c$ = 85 °C | | 1.4 | | A |
| $I_{OL}$ | Open Load Current Level | | 5 | | 180 | mA |
| $T_{TSD}$ | Thermal Shut-down Temperature | | 140 | | | °C |
| $T_R$ | Reset Temperature | | 125 | | | °C |

(*) The $V_{IH}$ is internally clamped at 6V about. It is possible to connect this pin to an higher voltage via an external resistor calculated to not exceed 10 mA at the input pin.
(•) Status determination > 100 µs after the switching edge.

## FUNCTIONAL DESCRIPTION

The device has a diagnostic output which indicates open circuit (no load) and over temperature conditions. The output signals are processed by internal logic.

To protect the device against short circuit and over-current condition, the thermal protection turns the integrated Power MOS off at a minimum junction temperature of 140 °C. When the temperature returns to about 125 °C the switch is automatically turned on again.

In short circuit conditions the protection reacts with virtually no delay, the sensor being located in the region of the die where the heat is generated.

## PROTECTING THE DEVICE AGAINST REVERSE BATTERY

The simplest way to protect the device against a continuous reverse battery voltage (-26V) is to insert a Schottky diode between pin 1 (GND) and ground, as shown in the typical application circuit (fig. 3).

The consequences of the voltage drop across this diode are as follows:

– If the input is pulled to power GND, a negative voltage of $-V_F$ is seen by the device. ($V_{IL}$, $V_{IH}$ thresholds and $V_{STAT}$ are increased by $V_F$ with respect to power GND).
– The undervoltage shutdown level is increased by $V_F$.

If there is no need for the control unit to handle external analog signals referred to the power GND, the best approach is to connect the reference potential of the control unit to node [1] (see application circuit in fig. 4), which becomes the common signal GND for the whole control board.

In this way no shift of $V_{IH}$, $V_{IL}$ and $V_{STAT}$ takes place and no negative voltage appears on the INPUT pin; this solution allows the use of a standard diode, with a breakdown voltage able to handle any ISO normalized negative pulses that occours in the automotive environment.

**TRUTH TABLE**

| | INPUT | OUTPUT | DIAGNOSTIC |
|---|---|---|---|
| Normal Operation | L<br>H | L<br>H | H<br>H |
| Open Circuit (No Load) | H | H | L |
| Over-temperature | H | L | L |
| Under-voltage | X | L | H |

**Figure 1:** Waveforms

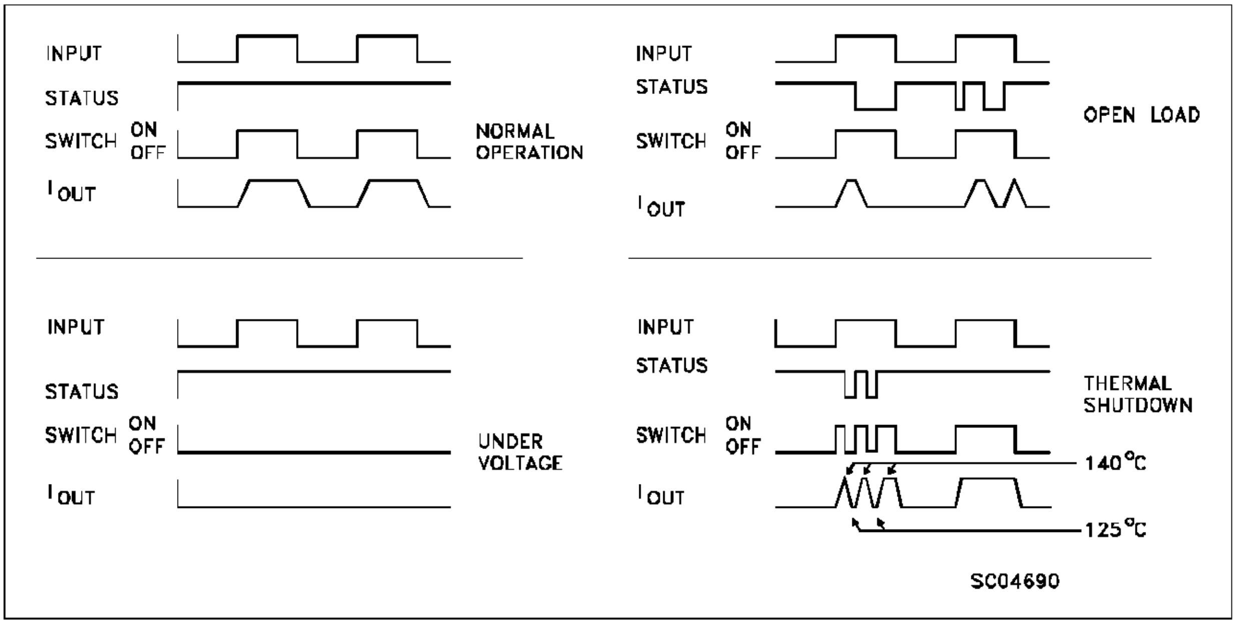



**Figure 2:** Over Current Test Circuit

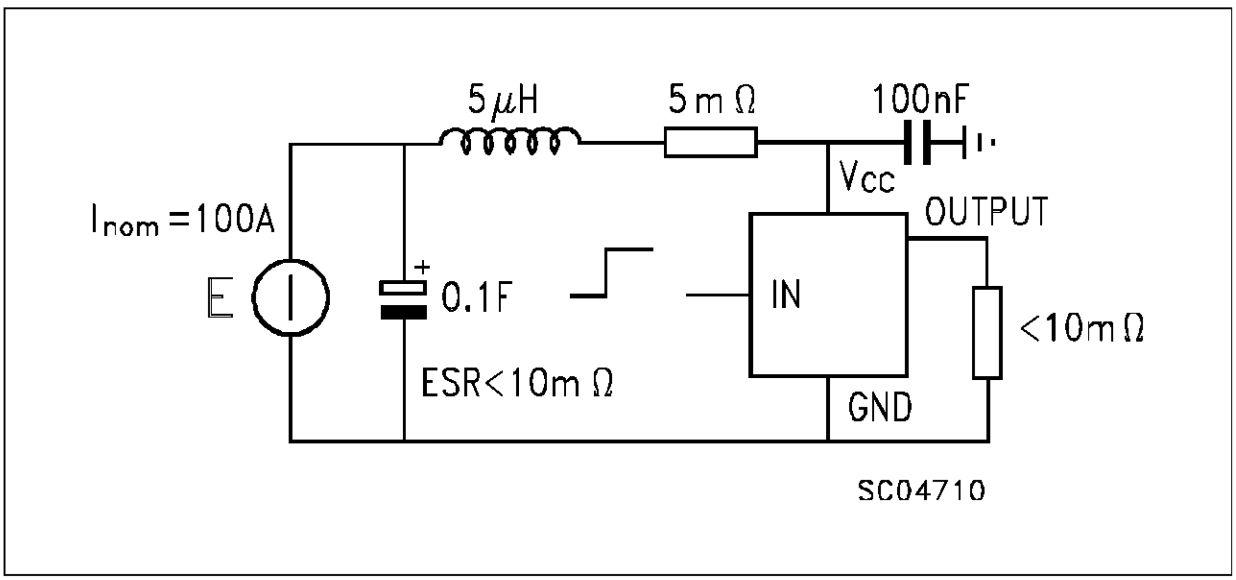


**Figure 3:** Typical Application Circuit With A Schottky Diode For Reverse Supply Protection

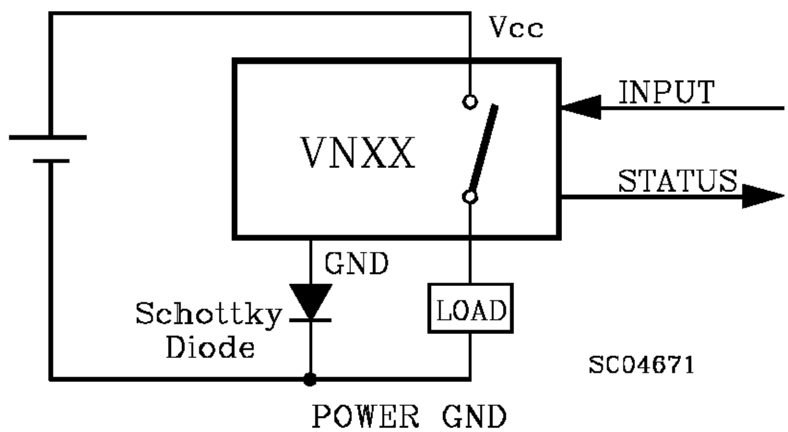
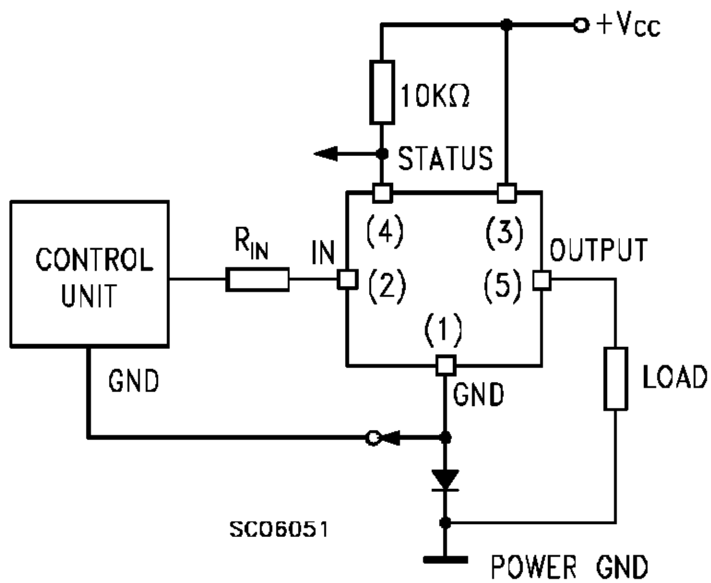
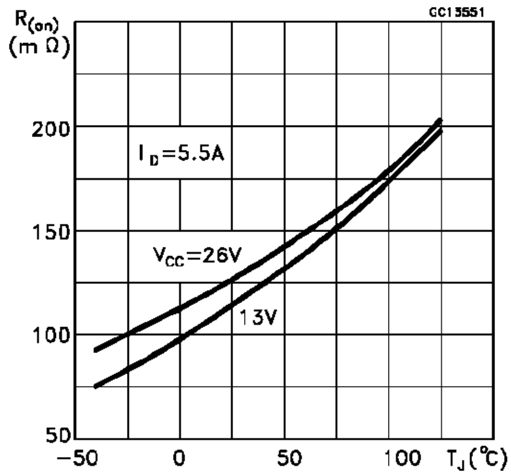


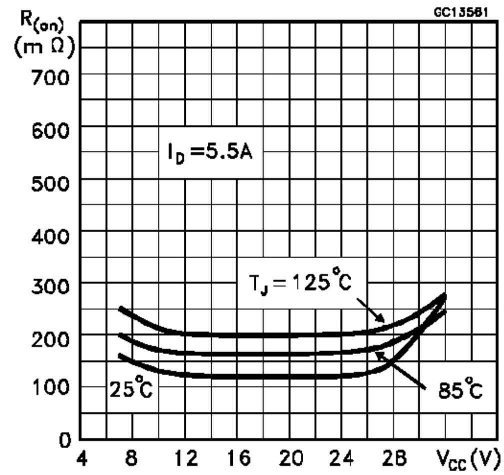

**Figure 4:** Typical Application Circuit With Separate Signal Ground



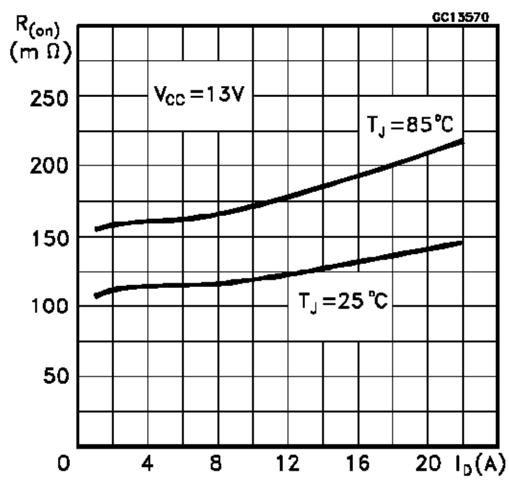
$R_{DS(on)}$ vs Junction Temperature



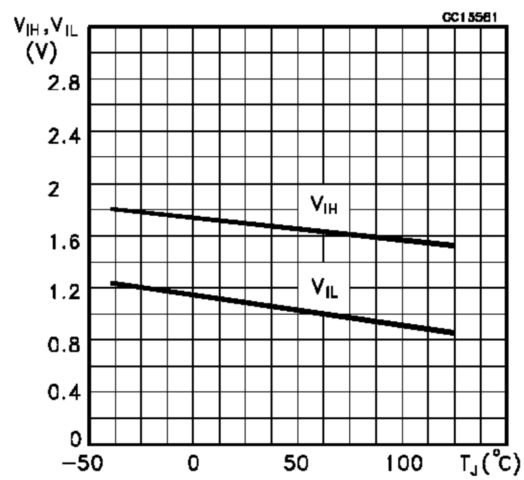

$R_{DS(on)}$ vs Supply Voltage



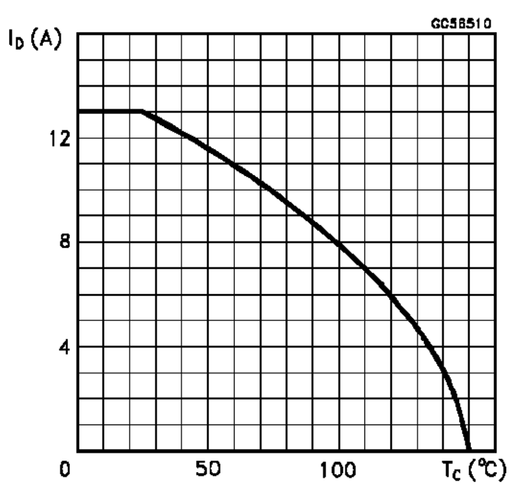

$R_{DS(on)}$ vs Output Current



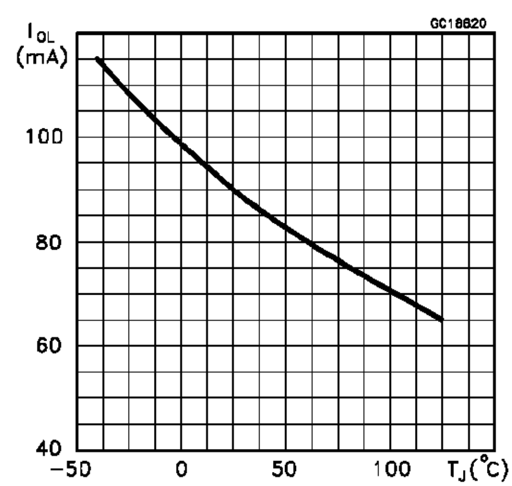

Input voltages vs Junction Temperature




Output Current Derating

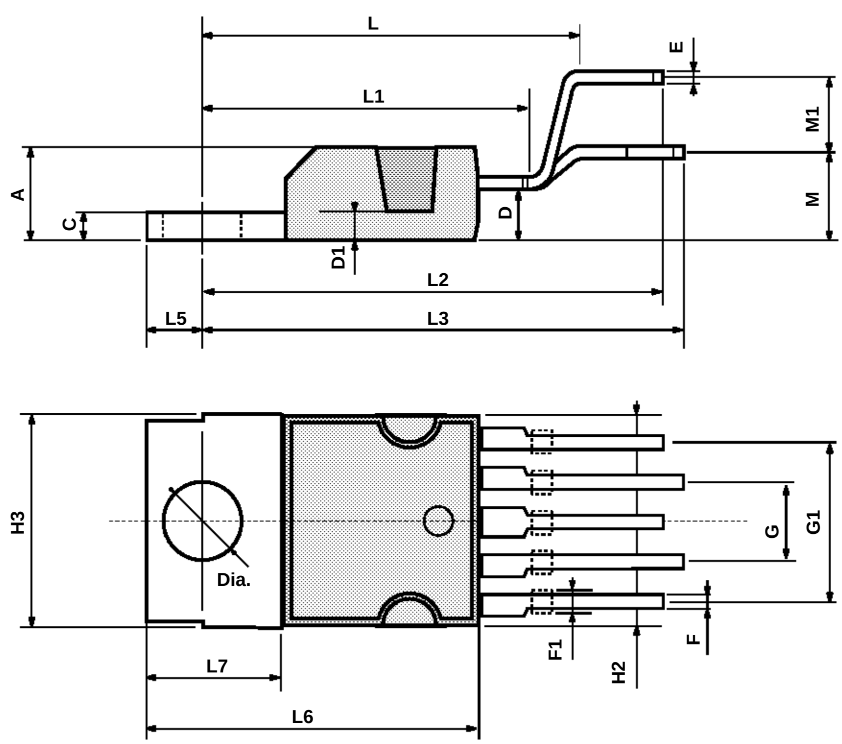



Open Load vs Junction Temperature



## Pentawatt (vertical) MECHANICAL DATA

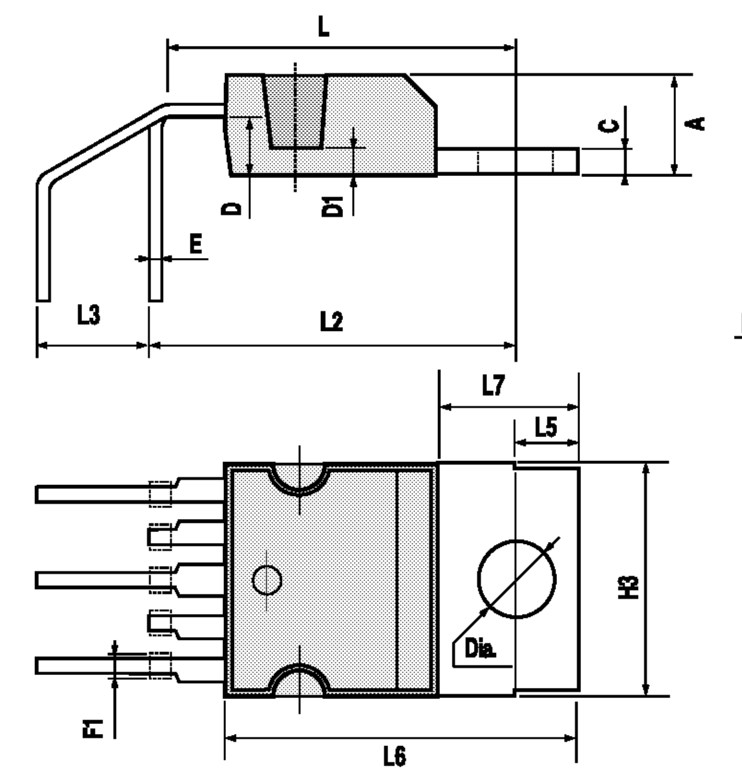
| DIM. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 4.8 | | | 0.189 |
| C | | | 1.37 | | | 0.054 |
| D | 2.4 | | 2.8 | 0.094 | | 0.110 |
| D1 | 1.2 | | 1.35 | 0.047 | | 0.053 |
| E | 0.35 | | 0.55 | 0.014 | | 0.022 |
| F | 0.8 | | 1.05 | 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 | |
| Dia | 3.65 | | 3.85 | 0.144 | | 0.152 |




P010E

## Pentawatt (horizontal) MECHANICAL DATA

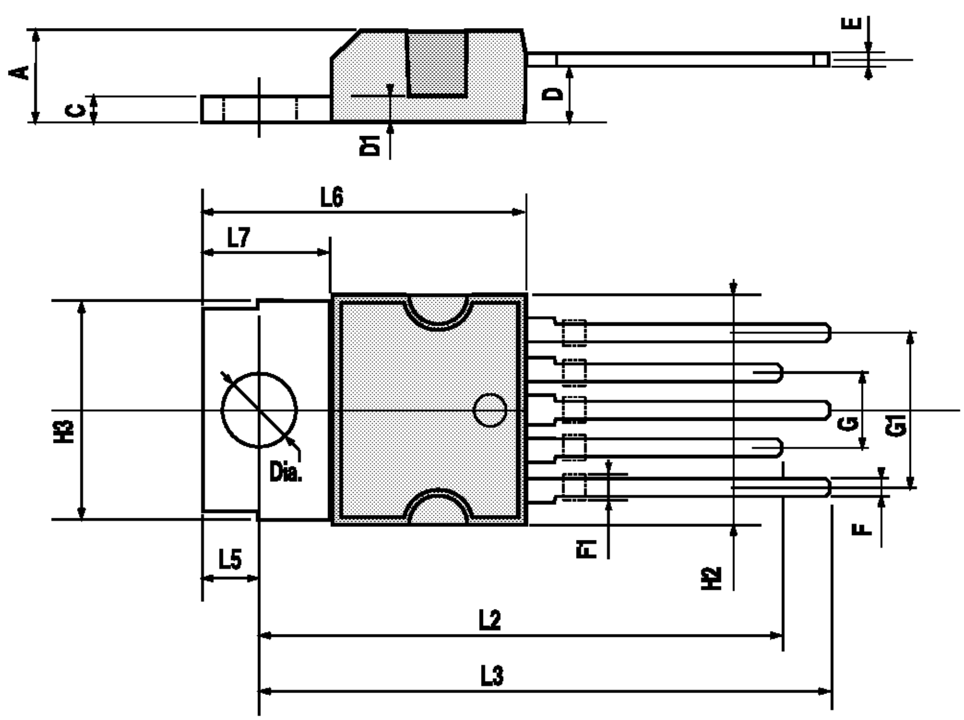
| DIM. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 4.8 | | | 0.189 |
| C | | | 1.37 | | | 0.054 |
| D | 2.4 | | 2.8 | 0.094 | | 0.110 |
| D1 | 1.2 | | 1.35 | 0.047 | | 0.053 |
| E | 0.35 | | 0.55 | 0.014 | | 0.022 |
| F | 0.8 | | 1.05 | 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 | 14.2 | | 15 | 0.559 | | 0.590 |
| L1 | 5.7 | | 6.2 | | | 0244 |
| L2 | 14.6 | | 15.2 | | | 0.598 |
| L3 | 3.5 | | 4.1 | 0.137 | | 0.161 |
| 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 |
| Dia | 3.65 | | 3.85 | 0.144 | | 0.152 |




P010F

## Pentawatt (In- Line) 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 |
| L2 | 23.05 | 23.4 | 23.8 | 0.907 | 0.921 | 0.937 |
| L3 | 25.3 | 25.65 | 26.1 | 0.996 | 1.010 | 1.028 |
| 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 |
| Dia | 3.65 | | 3.85 | 0.144 | | 0.152 |

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