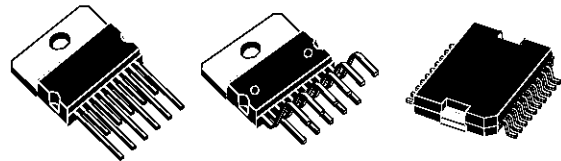


**2A HIGH-SIDE DRIVER**  
**INDUSTRIAL INTELLIGENT POWER SWITCH**

PRELIMINARY DATA

- 2A OUTPUT CURRENT
- 18V TO 35V SUPPLY VOLTAGE RANGE
- INTERNAL CURRENT LIMITING
- THERMAL SHUTDOWN
- OPEN GROUND PROTECTION
- INTERNAL NEGATIVE VOLTAGE CLAMPING TO  $V_s - 50V$  FOR FAST DEMAGNETIZATION
- DIFFERENTIAL INPUTS WITH LARGE COMMON MODE RANGE AND THRESHOLD HYSTERESIS
- UNDERVOLTAGE LOCKOUT WITH HYSTERESIS
- OPEN LOAD DETECTION
- TWO DIAGNOSTIC OUTPUTS
- OUTPUT STATUS LED DRIVER

**MULTIPOWER BCD TECHNOLOGY**



**MULTIWATT11 MULTIWATT11V PowerSO20**  
(In line)

**ORDERING NUMBERS:**

|          |          |          |
|----------|----------|----------|
| TDE1890L | TDE1890V | TDE1890D |
| TDE1891L | TDE1891V | TDE1891D |

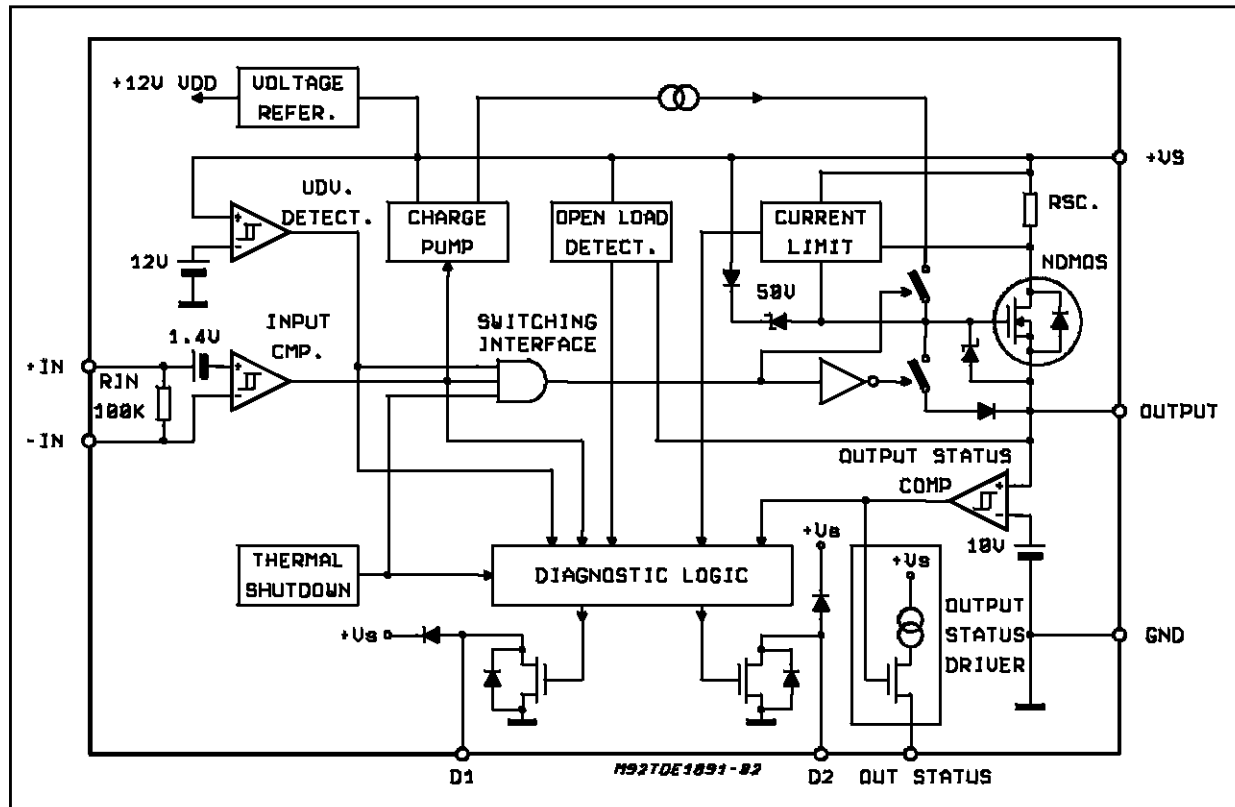
driving inductive or resistive loads. An internal Clamping Diode enables the fast demagnetization of inductive loads.

Diagnostic for CPU feedback and extensive use of electrical protections make this device extremely rugged and specially suitable for industrial automation applications.

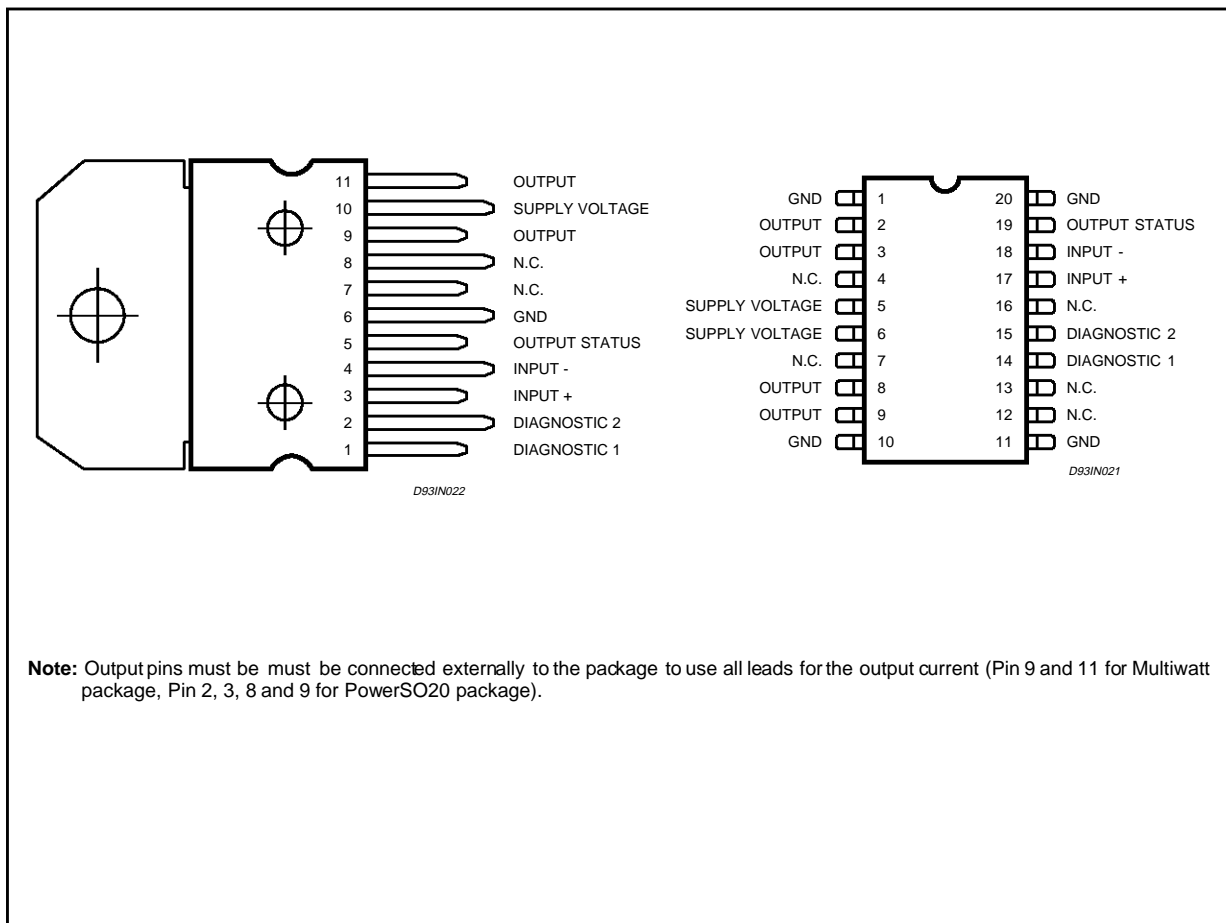
**DESCRIPTION**

The TDE1890/1891 is a monolithic Intelligent Power Switch in Multipower BCD Technology, for

**BLOCK DIAGRAM**



**PIN CONNECTION** (Top view)



**ABSOLUTE MAXIMUM RATINGS**

| Symbol      | Parameter  | Value              | Unit |
|-------------|--|--------------------|------|
| $V_S$       | Supply Voltage (Pin 10) ( $T_W < 10ms$ )                               | 50                 | V    |
| $V_S - V_O$ | Supply to Output Differential Voltage. See also $V_{CI}$ (Pins 10 - 9) | internally limited | V    |
| $V_i$       | Input Voltage (Pins 3/4)   | -10 to $V_S + 10$  | V    |
| $V_i$       | Differential Input Voltage (Pins 3 - 4)                                | 43                 | V    |
| $I_i$       | Input Current (Pins 3/4)   | 20                 | mA   |
| $I_o$       | Output Current (Pin 9). See also $I_{SC}$ (Pin 9)                      | internally limited | A    |
| $P_{tot}$   | Power Dissipation. See also THERMAL CHARACTERISTICS.                   | internally limited | W    |
| $T_{op}$    | Operating Temperature Range ( $T_{amb}$ )                              | -25 to +85         | °C   |
| $T_{stg}$   | Storage Temperature  | -55 to 150         | °C   |
| $E_l$       | Energy Induct. Load $T_J = 85^\circ C$                                 | 1                  | J    |

**THERMAL DATA**

| Symbol           | Description                         |      | Multiwatt | PowerSO20 | Unit |
|------------------|-------------------------------------|------|-----------|-----------|------|
| $R_{th\ j-case}$ | Thermal Resistance Junction-case    | Max. | 1.5       | 1.5       | °C/W |
| $R_{th\ j-amb}$  | Thermal Resistance Junction-ambient | Max. | 35        | -         | °C/W |

**ELECTRICAL CHARACTERISTICS** ( $V_S = 24V$ ;  $T_{amb} = -25$  to  $+85^\circ C$ , unless otherwise specified)

| Symbol     | Parameter  | Test Condition   | Min.        | Typ.                     | Max.                     | Unit                     |
|------------|--|--|-------------|--------------------------|--------------------------|--------------------------|
| $V_{Smin}$ | Supply Voltage for Valid Diagnostics                             | $I_{diag} > 0.5mA$ ; $V_{dg1} = 1.5V$  | 9           |                          | 35                       | V                        |
| $V_S$      | Supply Voltage (operative)                                       |  | 18          | 24                       | 35                       | V                        |
| $I_q$      | Quiescent Current<br>$I_{out} = I_{os} = 0$                      | $V_{il}$<br>$V_{ih}$   |             | 3<br>5                   | 7<br>8                   | mA<br>mA                 |
| $V_{sth1}$ | Undervoltage Threshold 1   | (See fig. 1), $T_{amb} = 0$ to $+85^\circ C$   | 11          |                          |                          | V                        |
| $V_{sth2}$ | Undervoltage Threshold 2   |  |             |                          | 15.5                     | V                        |
| $V_{shys}$ | Supply Voltage Hysteresis  |  |             | 1                        |                          | V                        |
| $I_{sc}$   | Short Circuit Current  | $V_S = 18$ to $35V$ ; $R_L = 2\Omega$  | 2.6         |                          | 5                        | A                        |
| $V_{don}$  | Output Voltage Drop  | $I_{out} = 2.0A$ $T_j = 25^\circ C$<br>$T_j = 125^\circ C$<br>$I_{out} = 2.5A$ $T_j = 25^\circ C$<br>$T_j = 125^\circ C$ |             | 360<br>575<br>440<br>700 | 500<br>800<br>575<br>920 | mV<br>mV<br>mV<br>mV     |
| $I_{oslk}$ | Output Leakage Current   | $V_i = V_{il}$ ; $V_o = 0V$  |             |                          | 500                      | $\mu A$                  |
| $V_{ol}$   | Low State Out Voltage  | $V_i = V_{il}$ ; $R_L = \infty$  |             | 0.8                      | 1.5                      | V                        |
| $V_{cl}$   | Internal Voltage Clamp ( $V_S - V_o$ )                           | $I_o = 1A$<br>Single Pulsed: $T_p = 300\mu s$  | 48          | 53                       | 58                       | V                        |
| $I_{old}$  | Open Load Detection Current                                      | $V_i = V_{ih}$ ; $T_{amb} = 0$ to $+85^\circ C$  | 0.5         |                          | 9.5                      | mA                       |
| $V_{id}$   | Common Mode Input Voltage Range (Operative)                      | $V_S = 18$ to $35V$ ,<br>$V_S - V_{id} < 37V$  | -7          |                          | 15                       | V                        |
| $I_{ib}$   | Input Bias Current   | $V_i = -7$ to $15V$ ; $-I_n = 0V$  | -250        |                          | 250                      | $\mu A$                  |
| $V_{ith}$  | Input Threshold Voltage  | $V+In > V-In$  | 0.8         | 1.4                      | 2                        | V                        |
| $V_{iths}$ | Input Threshold Hysteresis Voltage                               | $V+In > V-In$  | 50          |                          | 400                      | mV                       |
| $R_{id}$   | Diff. Input Resistance   | $0 < +In < +16V$ ; $-In = 0V$<br>$-7 < +In < 0V$ ; $-In = 0V$  |             | 400<br>150               |                          | K $\Omega$<br>K $\Omega$ |
| $I_{lik}$  | Input Offset Current   | $V+In = V-In$ +li<br>$0V < V_i < 5.5V$ -li   | -20<br>-75  | -25                      | +20                      | $\mu A$<br>$\mu A$       |
|            |  | $-In = GND$ +li<br>$0V < V+In < 5.5V$ -li  | -250        | -125                     | +50                      | $\mu A$<br>$\mu A$       |
|            |  | $+In = GND$ +li<br>$0V < V-In < 5.5V$ -li  | -100<br>-50 | -30<br>-15               |                          | $\mu A$<br>$\mu A$       |
|            |  |  |             |                          |                          |                          |
| $V_{oth1}$ | Output Status Threshold 1 Voltage                                | (See fig. 1)   |             |                          | 11.5                     | V                        |
| $V_{oth2}$ | Output Status Threshold 2 Voltage                                | (See fig. 1)   | 8.5         |                          |                          | V                        |
| $V_{ohys}$ | Output Status Threshold Hysteresis                               | (See fig. 1)   |             | 0.7                      |                          | V                        |
| $I_{osd}$  | Output Status Source Current                                     | $V_{out} > V_{oth1}$ ; $V_{os} = 2.5V$   | 2           |                          | 4                        | mA                       |
| $V_{osd}$  | Active Output Status Driver Drop Voltage                         | $V_S - V_{os}$ ; $I_{os} = 2mA$<br>$T_{amb} = -25$ to $+85^\circ C$  |             |                          | 5                        | V                        |
| $I_{oslk}$ | Output Status Driver Leakage Current                             | $V_{out} < V_{oth2}$ ; $V_{os} = 0V$<br>$V_S = 18$ to $35V$  |             |                          | 25                       | $\mu A$                  |
| $V_{dgl}$  | Diagnostic Drop Voltage  | $D1 / D2 = L$ ; $I_{diag} = 0.5mA$<br>$D1 / D2 = L$ ; $I_{diag} = 3mA$   |             |                          | 250<br>1.5               | mV<br>V                  |
| $I_{dglk}$ | Diagnostic Leakage Current                                       | $D1 / D2 = H$ ; $0 < V_{dg} < V_S$<br>$V_S = 15.6$ to $35V$  |             |                          | 25                       | $\mu A$                  |
| $V_{fdg}$  | Clamping Diodes at the Diagnostic Outputs. Voltage Drop to $V_S$ | $I_{diag} = 5mA$ ; $D1 / D2 = H$   |             |                          | 2                        | V                        |

Note  $V_{il} \leq 0.8V$ ,  $V_{ih} \geq 2V$  @ ( $V+In > V-In$ )

**SOURCE DRAIN NDMOS DIODE**

| Symbol    | Parameter             | Test Condition                   | Min. | Typ. | Max. | Unit |
|-----------|-----------------------|----------------------------------|------|------|------|------|
| $V_{fSD}$ | Forward On Voltage    | @ $I_{fSD} = 2.5A$               |      | 1    | 1.5  | V    |
| $I_{fP}$  | Forward Peak Current  | $t = 10ms; d = 20\%$             |      |      | 6    | A    |
| $t_{rr}$  | Reverse Recovery Time | $I_f = 2.5A$ $di/dt = 25A/\mu s$ |      | 200  |      | ns   |
| $t_{fr}$  | Forward Recovery Time |                                  |      | 100  |      | ns   |

**THERMAL CHARACTERISTICS**

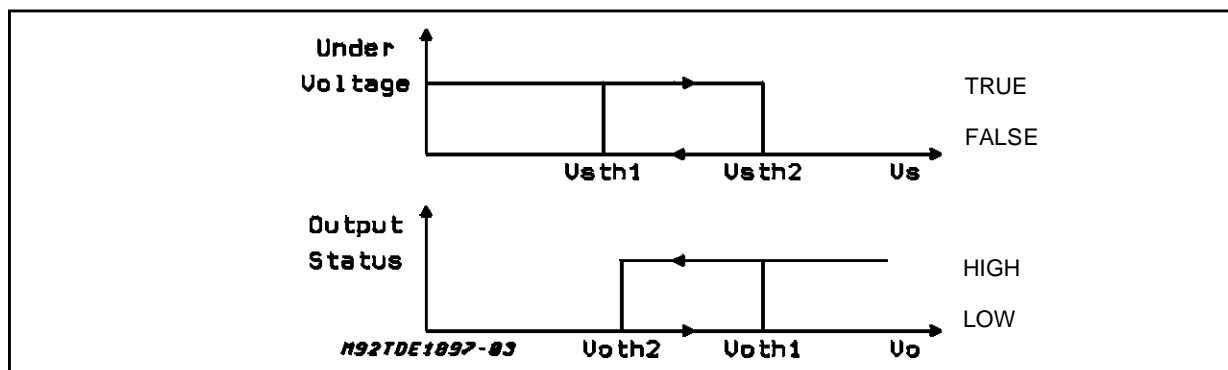
|                 |                         |  |     |     |  |    |
|-----------------|-------------------------|--|-----|-----|--|----|
| $\emptyset$ Lim | Junction Temp. Protect. |  | 135 | 150 |  | °C |
| $T_H$           | Thermal Hysteresis      |  |     | 30  |  | °C |

**SWITCHING CHARACTERISTICS ( $V_S = 24V; R_L = 12\Omega$ )**

|           |                                     |  |  |  |     |         |
|-----------|-------------------------------------|--|--|--|-----|---------|
| $t_{on}$  | Turn on Delay Time                  |  |  |  | 200 | $\mu s$ |
| $t_{off}$ | Turn off Delay Time                 |  |  |  | 40  | $\mu s$ |
| $t_d$     | Input Switching to Diagnostic Valid |  |  |  | 200 | $\mu s$ |

Note  $V_{il} \leq 0.8V, V_{ih} \geq 2V @ (V+In > V-In)$

**Figure 1**



**DIAGNOSTIC TRUTH TABLE**

| Diagnostic Conditions                           | Input          | Output | Diag1  | Diag2 |
|---|----------------|--------|--------|-------|
| Normal Operation                                | L              | L      | H      | H     |
|   | H              | H      | H      | H     |
| Open Load Condition ( $I_o < I_{old}$ )         | L              | L      | H      | H     |
|   | H              | H      | L      | H     |
| Short to $V_S$                                  | L              | H      | L      | H     |
|   | H              | H      | L      | H     |
| Short Circuit to Ground ( $I_o = I_{sc}$ ) (**) | <b>TDE1891</b> | H      | <H (*) | L     |
|   | <b>TDE1890</b> | H      | H      | H     |
| Output DMOS Open                                | L              | L      | H      | H     |
|   | H              | L      | L      | H     |
| Overtemperature                                 | L              | L      | H      | L     |
|   | H              | L      | H      | L     |
| Supply Undervoltage ( $V_S < V_{sth2}$ )        | L              | L      | L      | L     |
|   | H              | L      | L      | L     |

(\*) According to the intervention of the current limiting block.

(\*\*) A cold lamp filament, or a capacitive load may activate the current limiting circuit of the IPS, when the IPS is initially turned on. TDE1891 uses Diag2 to signal such condition, TDE1890 does not.

**APPLICATION INFORMATION****DEMAGNETIZATION OF INDUCTIVE LOADS**

An internal zener diode, limiting the voltage across the Power MOS to between 50 and 60V ( $V_{cl}$ ), provides safe and fast demagnetization of inductive loads without external clamping devices.

The maximum energy that can be absorbed from an inductive load is specified as 1J (at  $T_j = 85^\circ\text{C}$ ).

To define the maximum switching frequency three points have to be considered:

- 1) The total power dissipation is the sum of the On State Power and of the Demagnetization Energy multiplied by the frequency.
- 2) The total energy  $W$  dissipated in the device during a demagnetization cycle (fig. 2, 3) is:

$$W = V_{cl} \frac{L}{R_L} \left[ I_o - \frac{V_{cl} - V_s}{R_L} \log \left( 1 + \frac{V_s}{V_{cl} - V_s} \right) \right]$$

Where:

$V_{cl}$  = clamp voltage;  
 $L$  = inductive load;  
 $R_L$  = resistive load;  
 $V_s$  = supply voltage;  
 $I_o = I_{LOAD}$

- 3) In normal conditions the operating Junction temperature should remain below  $125^\circ\text{C}$ .

If the demagnetization energy exceeds the rated value, an external clamp between output and  $+V_s$  must be externally connected (see fig. 5).

The external zener will be chosen with  $V_{zener}$  value lower than the internal  $V_{cl}$  minimum rated value and significantly (at least 10V) higher than the voltage that is externally supplied to pin 10, i.e. than the supply voltage.

Alternative circuit solutions can be implemented to divert the demagnetization stress from the TDE1890/1, if it exceeds 1J. In all cases it is recommended that at least 10V are available to demagnetize the load in the turn-off phase.

A clamping circuit connected between ground and the output pin is not recommended. An interruption of the connection between the ground of the load and the ground of the TDE1890/1 would leave the TDE1890/1 alone to absorb the full amount of the demagnetization energy.

**Figure 2:** Inductive Load Equivalent Circuit

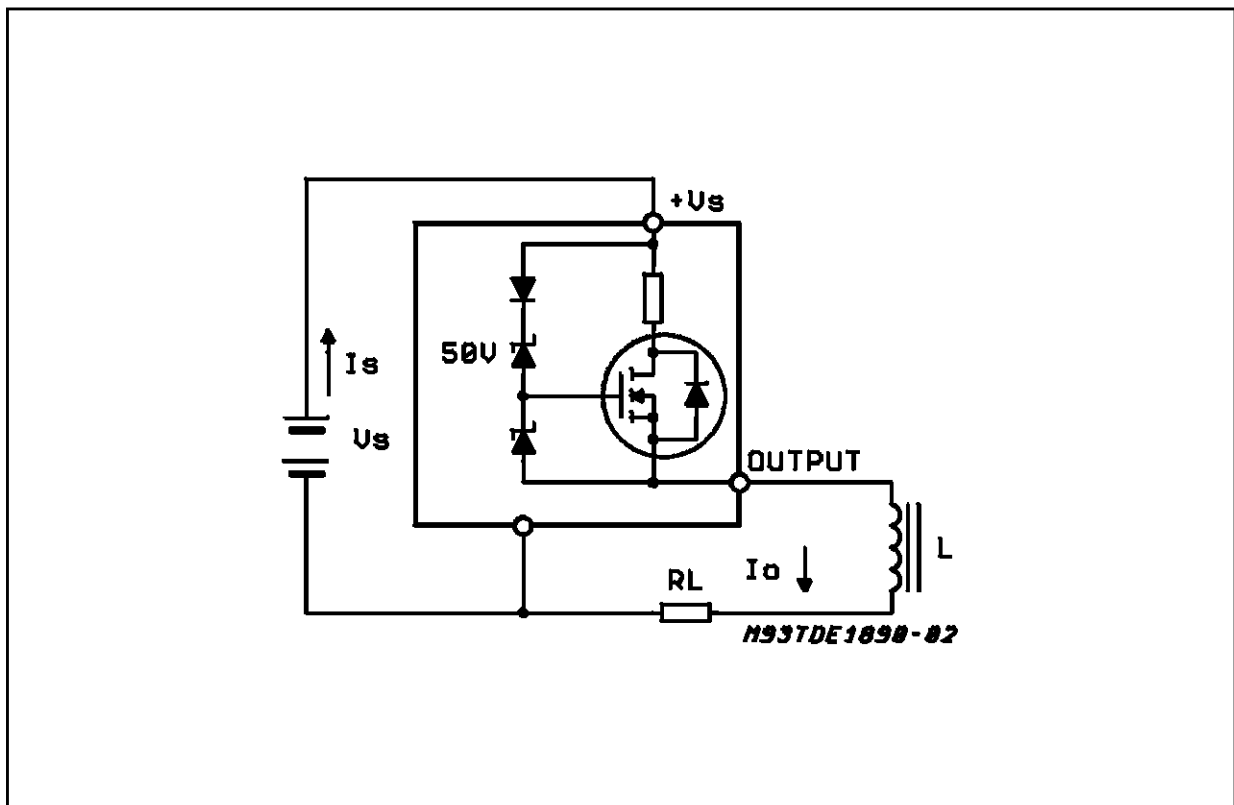


Figure 3: Demagnetization Cycle Waveforms

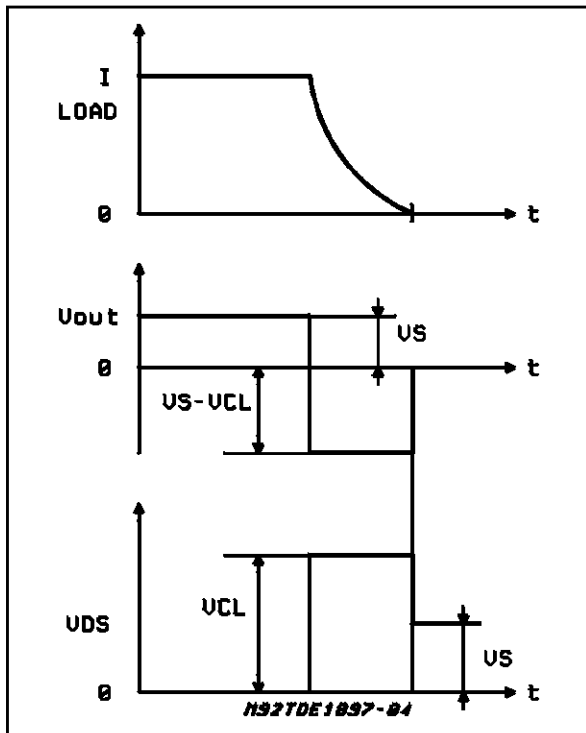


Figure 4: Normalized  $R_{DS(on)}$  vs. Junction Temperature

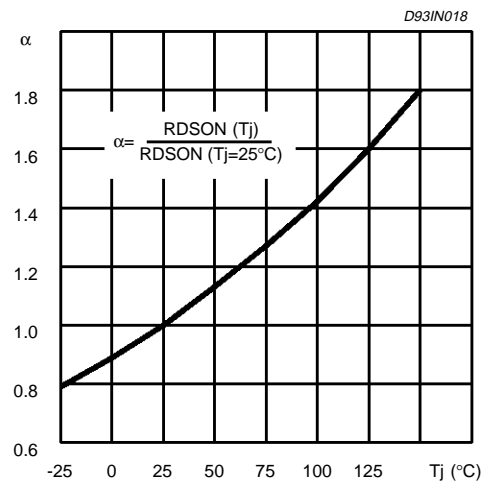
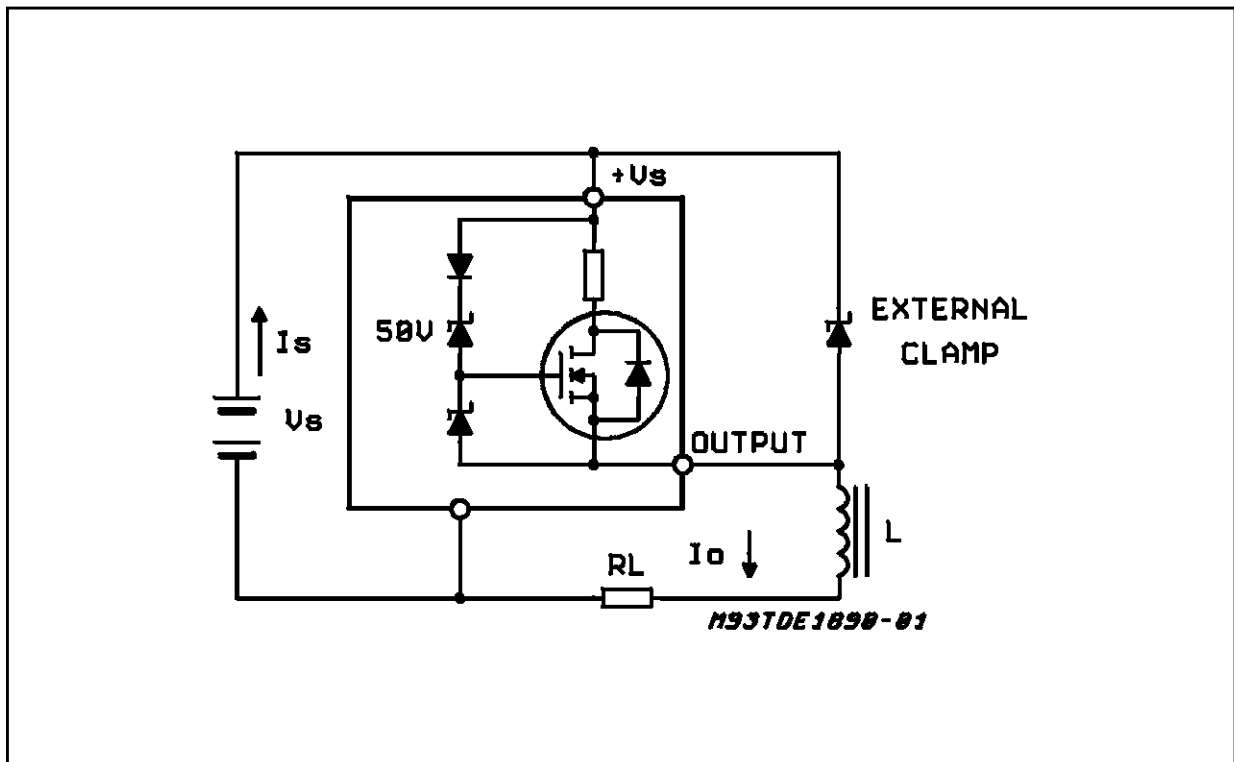


Figure 5.



**WORST CONDITION POWER DISSIPATION IN THE ON-STATE**

In IPS applications the maximum average power dissipation occurs when the device stays for a long time in the ON state. In such a situation the internal temperature depends on delivered current (and related power), thermal characteristics of the package and ambient temperature.

At ambient temperature close to upper limit (+85°C) and in the worst operating conditions, it is possible that the chip temperature could increase so much to make the thermal shutdown procedure untimely intervene.

Our aim is to find the maximum current the IPS can withstand in the ON state without thermal shutdown intervention, related to ambient temperature. To this end, we should consider the following points:

- 1) The ON resistance  $R_{DSON}$  of the output NDMOS (the real switch) of the device increases with its temperature. Experimental results show that silicon resistivity increases with temperature at a constant rate, rising of 60% from 25°C to 125°C. The relationship between  $R_{DSON}$  and temperature is therefore:

$$R_{DSON} = R_{DSON0} (1 + k) (T_j \pm 25)$$

where:

- $T_j$  is the silicon temperature in °C
- $R_{DSON0}$  is  $R_{DSON}$  at  $T_j=25^\circ\text{C}$
- $k$  is the constant rate ( $k = 4.711 \cdot 10^{-3}$ ) (see fig. 4).

- 2) In the ON state the power dissipated in the device is due to three contributes:

- a) power lost in the switch:  
 $P_{out} = I_{out}^2 \cdot R_{DSON}$  ( $I_{out}$  is the output current);
- b) power due to quiescent current in the ON state  $I_q$ , sunk by the device in addition to  $I_{out}$ :  $P_q = I_q \cdot V_s$  ( $V_s$  is the supply voltage);
- c) an external LED could be used to visualize the switch state (OUTPUT STATUS pin). Such a LED is driven by an internal current source (delivering  $I_{os}$ ) and therefore, if  $V_{os}$  is the voltage drop across the LED, the dissipated power is:  $P_{os} = I_{os} \cdot (V_s \pm V_{os})$ .

Thus the total ON state power consumption is given by:

$$P_{on} = P_{out} + P_q + P_{os} \quad (1)$$

In the right side of equation 1, the second and

the third element are constant, while the first one increases with temperature because  $R_{DSON}$  increases as well.

- 3) The chip temperature must not exceed  $\Theta_{Lim}$  in order do not lose the control of the device. The heat dissipation path is represented by the thermal resistance of the system device-ambient ( $R_{th}$ ). In steady state conditions, this parameter relates the power dissipated  $P_{on}$  to the silicon temperature  $T_j$  and the ambient temperature  $T_{amb}$ :

$$T_j \pm T_{amb} = P_{on} \cdot R_{th} \quad (2)$$

From this relationship, the maximum power  $P_{on}$  which can be dissipated without exceeding  $\Theta_{Lim}$  at a given ambient temperature  $T_{amb}$  is:

$$P_{on} = \frac{\Theta_{Lim} \pm T_{amb}}{R_{th}}$$

Replacing the expression (1) in this equation and solving for  $I_{out}$ , we can find the maximum current versus ambient temperature relationship:

$$I_{outx} = \sqrt{\frac{\frac{\Theta_{Lim} \pm T_{amb}}{R_{th}} \pm P_q \pm P_{os}}{R_{DSONx}}}$$

where  $R_{DSONx}$  is  $R_{DSON}$  at  $T_j=\Theta_{Lim}$ . Of course,  $I_{outx}$  values are top limited by the maximum operative current  $I_{outx}$  (2A nominal). From the expression (2) we can also find the maximum ambient temperature  $T_{amb}$  at which a given power  $P_{on}$  can be dissipated:

$$T_{amb} = \Theta_{Lim} \pm P_{on} \cdot R_{th} = \Theta_{Lim} \pm (I_{out}^2 \cdot R_{DSONx} + P_q + P_{os}) \cdot R_{th}$$

In particular, this relation is useful to find the maximum ambient temperature  $T_{ambx}$  at which  $I_{outx}$  can be delivered:

$$T_{ambx} = \Theta_{Lim} \pm (I_{outx}^2 \cdot R_{DSONx} + P_q + P_{os}) \cdot R_{th} \quad (4)$$

Referring to application circuit in fig. 6, let us consider the worst case:

- The supply voltage is at maximum value of industrial bus (30V instead of the 24V nominal value). This means also that  $I_{outx}$  rises of 25% (2.5A instead of 2A).

**TDE1890 - TDE1891**

- All electrical parameters of the device, concerning the calculation, are at maximum values.
- Thermal shutdown threshold is at minimum value.

Therefore:

$V_s = 30V$ ,  $R_{DS(ON)0} = 0.23\Omega$ ,  $I_q = 8mA$ ,  $I_{os} = 4mA$   
 @  $V_{os} = 2.5V$ ,  $\Theta_{Lim} = 135^\circ C$

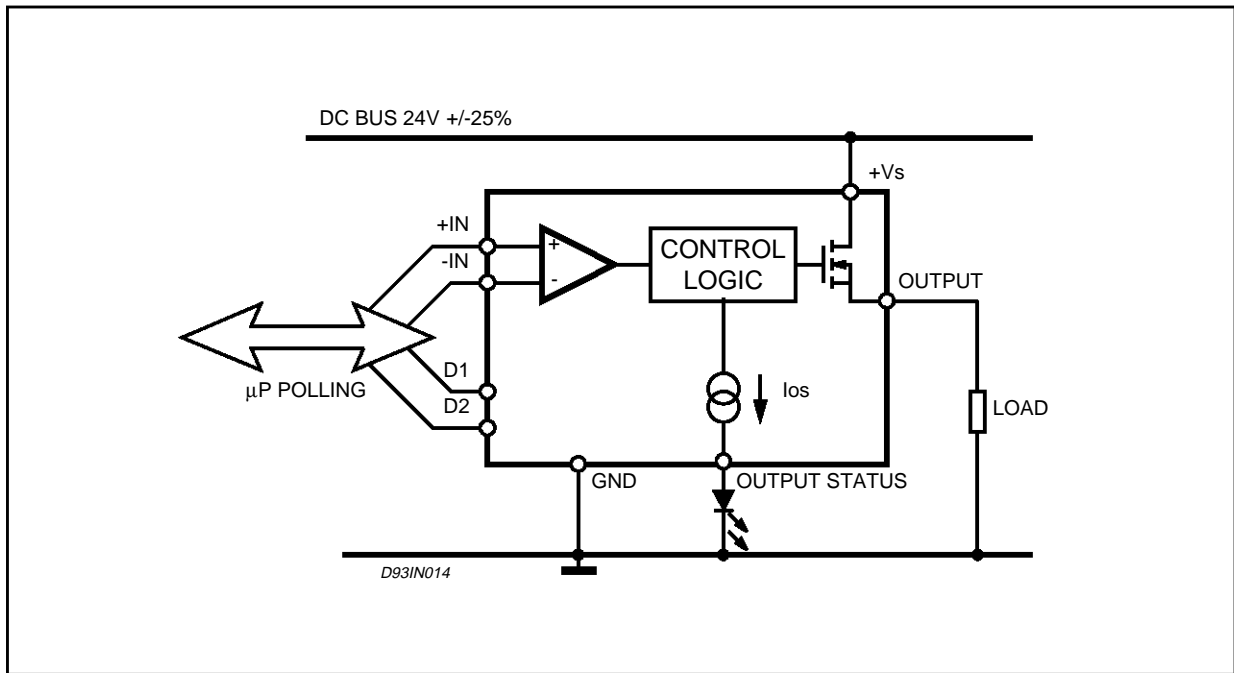
$R_{th(j-amb)} = 35^\circ C/W$

It follows:

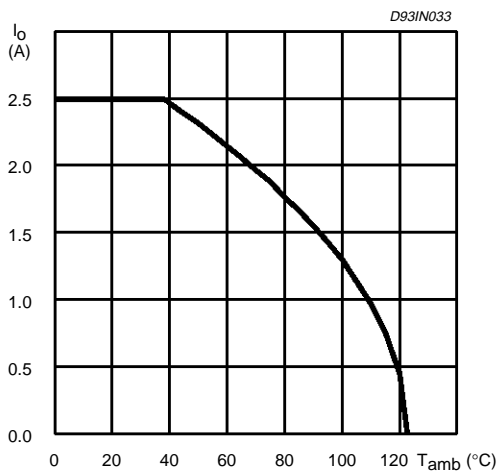
$I_{outx} = 2.5A$ ,  $R_{DS(ON)x} = 0.386\Omega$ ,  $P_q = 240mW$ ,  
 $P_{os} = 110mW$

From equation 4 we can see that, without any heatsink, it is not possible to operate in the ON steady state at the maximum current value. A derating curve for this case is reported in fig. 7. Using an external heatsink, in order to obtain a total  $R_{th}$  of  $15^\circ C/W$ , we obtain the derating curve reported in fig. 8.

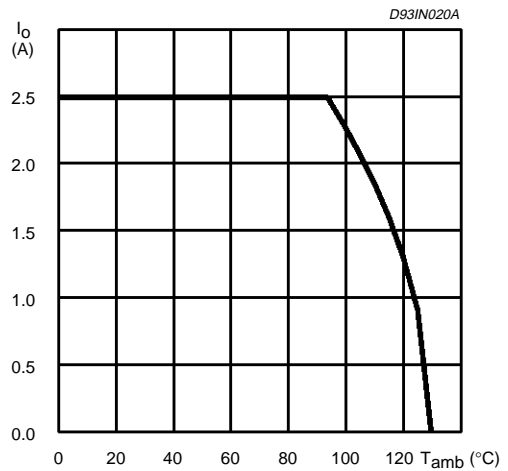
**Figure 6:** Application Circuit



**Figure 7:** Max. Output Current vs. Ambient Temperature (Multiwatt without heatsink,  $R_{th(j-amb)} = 35^\circ C/W$ )



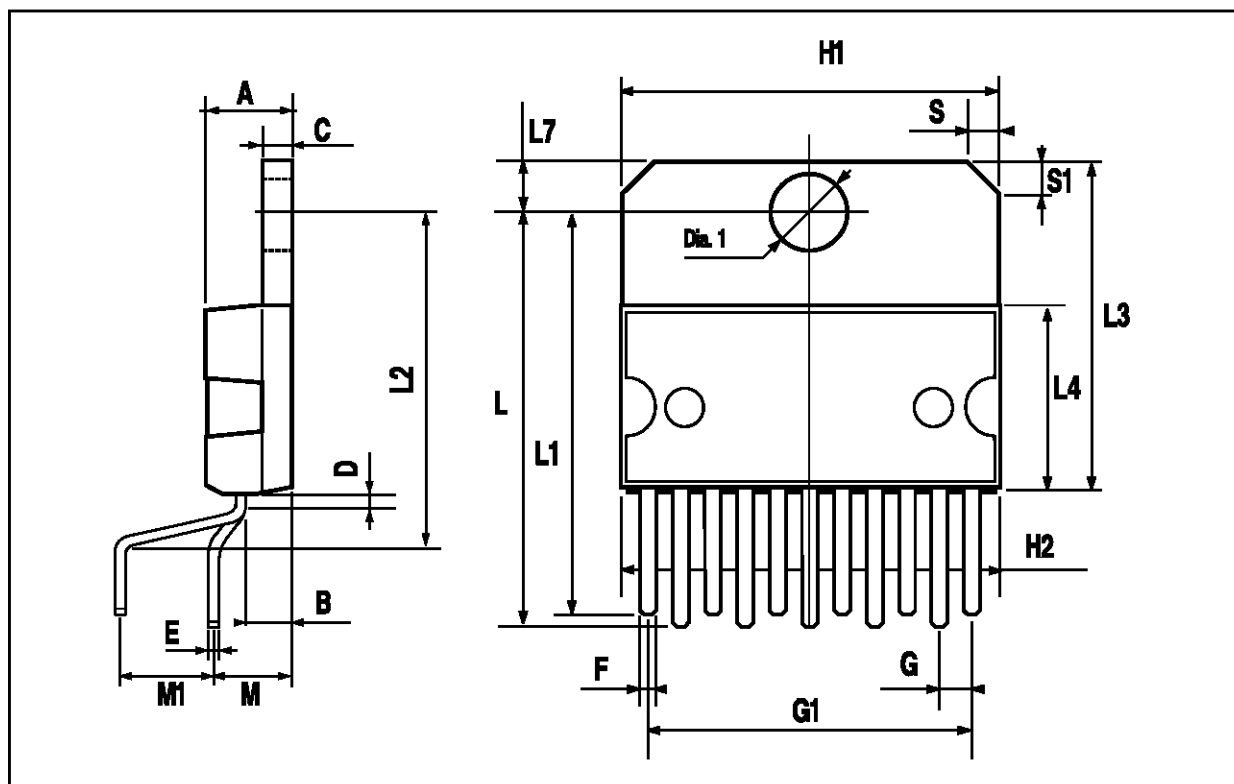
**Figure 8:** Max. Output Current vs. Ambient Temperature (Multiwatt with heatsink,  $R_{th(j-amb)} = 15^\circ C/W$ )





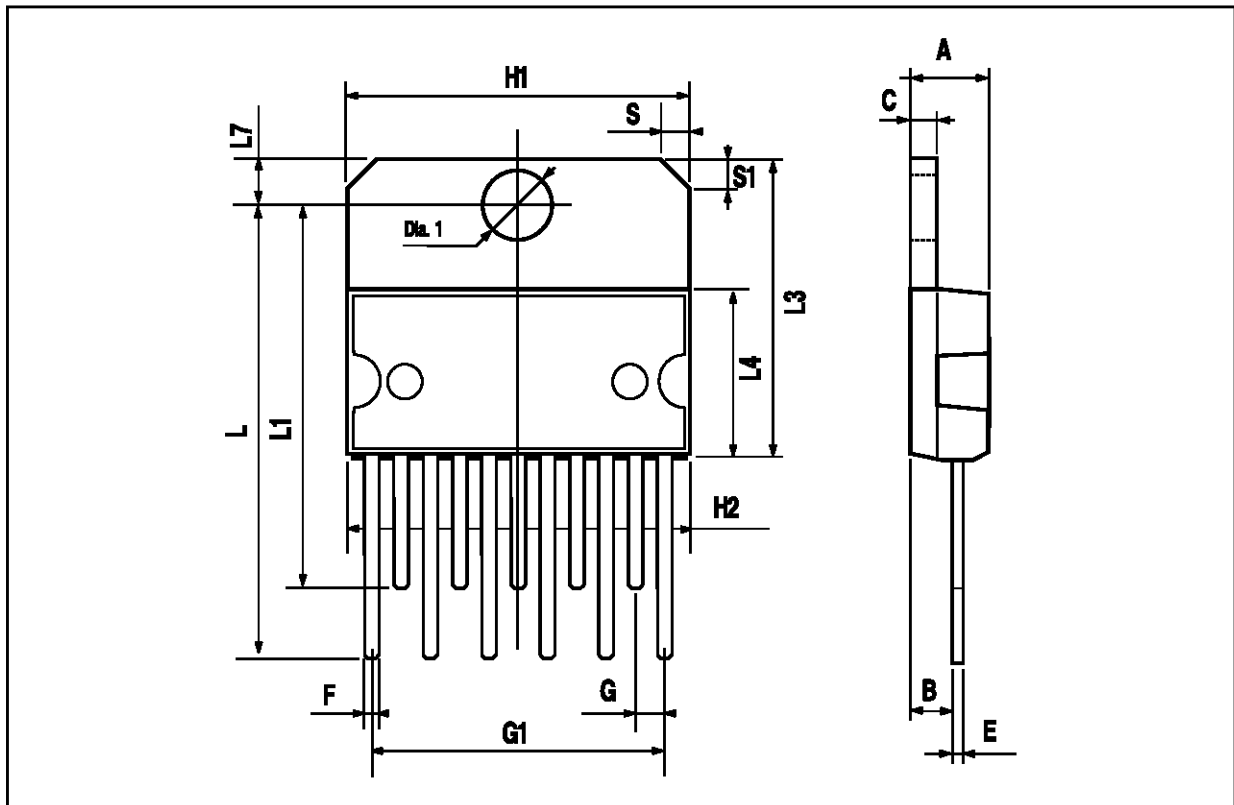
## MULTIWATT11 (Vertical) PACKAGE MECHANICAL DATA

| DIM. | mm    |      |       | inch  |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |       |      | 5     |       |       | 0.197 |
| B    |       |      | 2.65  |       |       | 0.104 |
| C    |       |      | 1.6   |       |       | 0.063 |
| D    |       | 1    |       |       | 0.039 |       |
| E    | 0.49  |      | 0.55  | 0.019 |       | 0.022 |
| F    | 0.88  |      | 0.95  | 0.035 |       | 0.037 |
| G    | 1.57  | 1.7  | 1.83  | 0.062 | 0.067 | 0.072 |
| G1   | 16.87 | 17   | 17.13 | 0.664 | 0.669 | 0.674 |
| H1   | 19.6  |      |       | 0.772 |       |       |
| H2   |       |      | 20.2  |       |       | 0.795 |
| L    | 21.5  |      | 22.3  | 0.846 |       | 0.878 |
| L1   | 21.4  |      | 22.2  | 0.843 |       | 0.874 |
| L2   | 17.4  |      | 18.1  | 0.685 |       | 0.713 |
| L3   | 17.25 | 17.5 | 17.75 | 0.679 | 0.689 | 0.699 |
| L4   | 10.3  | 10.7 | 10.9  | 0.406 | 0.421 | 0.429 |
| L7   | 2.65  |      | 2.9   | 0.104 |       | 0.114 |
| M    | 4.1   | 4.3  | 4.5   | 0.161 | 0.169 | 0.177 |
| M1   | 4.88  | 5.08 | 5.3   | 0.192 | 0.200 | 0.209 |
| S    | 1.9   |      | 2.6   | 0.075 |       | 0.102 |
| S1   | 1.9   |      | 2.6   | 0.075 |       | 0.102 |
| Dia1 | 3.65  |      | 3.85  | 0.144 |       | 0.152 |



**MULTIWATT11 (In line) PACKAGE MECHANICAL DATA**

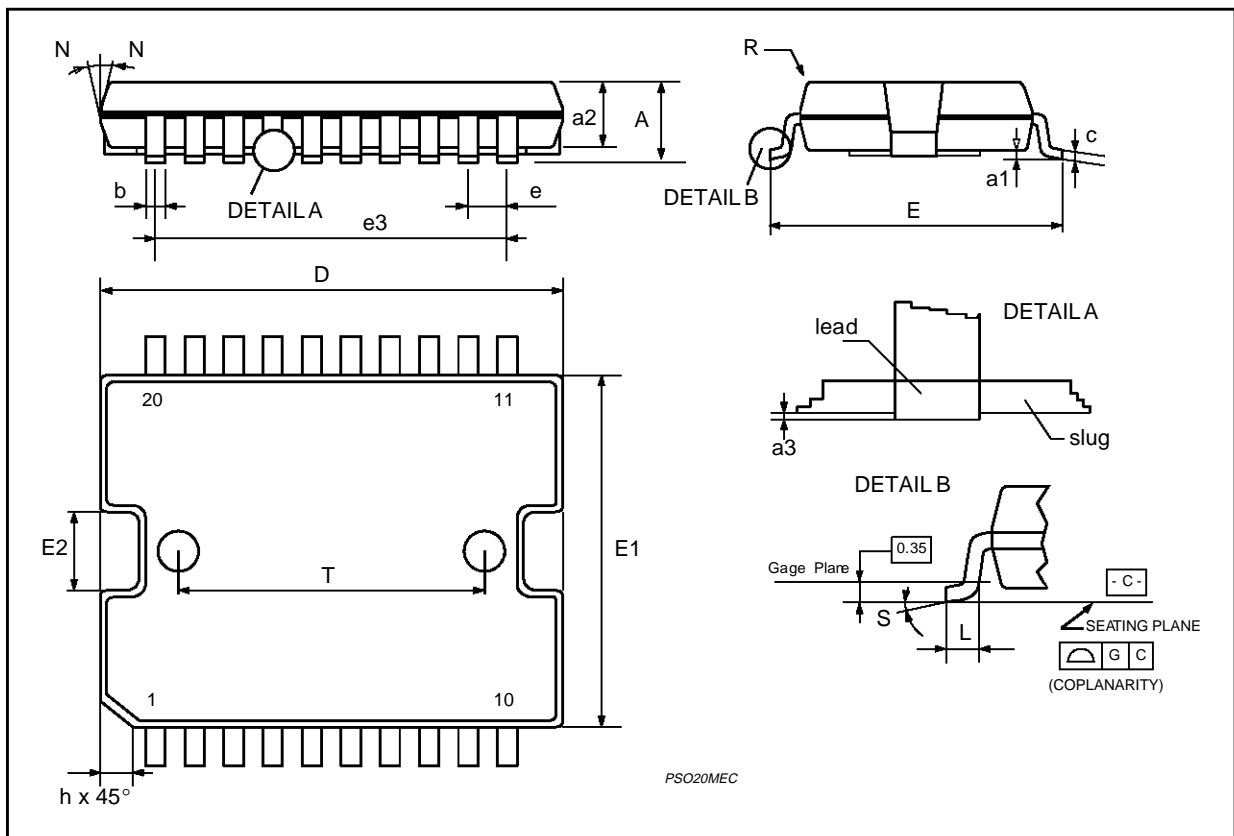
| DIM. | mm    |      |       | inch  |       |       |
|------|-------|------|-------|-------|-------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A    |       |      | 5     |       |       | 0.197 |
| B    |       |      | 2.65  |       |       | 0.104 |
| C    |       |      | 1.6   |       |       | 0.063 |
| E    | 0.49  |      | 0.55  | 0.019 |       | 0.022 |
| F    | 0.88  |      | 0.95  | 0.035 |       | 0.037 |
| G    | 1.57  | 1.7  | 1.83  | 0.062 | 0.067 | 0.072 |
| G1   | 16.87 | 17   | 17.13 | 0.664 | 0.669 | 0.674 |
| H1   | 19.6  |      |       | 0.772 |       |       |
| H2   |       |      | 20.2  |       |       | 0.795 |
| L    | 26.4  |      | 26.9  | 1.039 |       | 1.059 |
| L1   | 22.35 |      | 22.85 | 0.880 |       | 0.900 |
| L3   | 17.25 | 17.5 | 17.75 | 0.679 | 0.689 | 0.699 |
| L4   | 10.3  | 10.7 | 10.9  | 0.406 | 0.421 | 0.429 |
| L7   | 2.65  |      | 2.9   | 0.104 |       | 0.114 |
| S    | 1.9   |      | 2.6   | 0.075 |       | 0.102 |
| S1   | 1.9   |      | 2.6   | 0.075 |       | 0.102 |
| Dia1 | 3.65  |      | 3.85  | 0.144 |       | 0.152 |



**PowerSO20 PACKAGE MECHANICAL DATA**

| DIM.   | mm         |       |       | inch   |        |        |
|--------|------------|-------|-------|--------|--------|--------|
|        | MIN.       | TYP.  | MAX.  | MIN.   | TYP.   | MAX.   |
| A      |            |       | 3.60  |        |        | 0.1417 |
| a1     | 0.10       |       | 0.30  | 0.0039 |        | 0.0118 |
| a2     |            |       | 3.30  |        |        | 0.1299 |
| a3     | 0          |       | 0.10  | 0      |        | 0.0039 |
| b      | 0.40       |       | 0.53  | 0.0157 |        | 0.0209 |
| c      | 0.23       |       | 0.32  | 0.009  |        | 0.0126 |
| D (1)  | 15.80      |       | 16.00 | 0.6220 |        | 0.6299 |
| E      | 13.90      |       | 14.50 | 0.5472 |        | 0.570  |
| e      |            | 1.27  |       |        | 0.050  |        |
| e3     |            | 11.43 |       |        | 0.450  |        |
| E1 (1) | 10.90      |       | 11.10 | 0.4291 |        | 0.437  |
| E2     |            |       | 2.90  |        |        | 0.1141 |
| G      | 0          |       | 0.10  | 0      |        | 0.0039 |
| h      |            |       | 1.10  |        |        |        |
| L      | 0.80       |       | 1.10  | 0.0314 |        | 0.0433 |
| N      | 10° (max.) |       |       |        |        |        |
| S      | 8° (max.)  |       |       |        |        |        |
| T      |            | 10.0  |       |        | 0.3937 |        |

(1) "D and E1" do not include mold flash or protrusions  
 - Mold flash or protrusions shall not exceed 0.15mm (0.006")



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