



# TDE1890 TDE1891

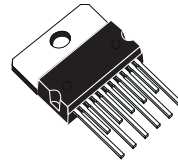
## 2A HIGH-SIDE DRIVER INDUSTRIAL INTELLIGENT POWER SWITCH

- 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

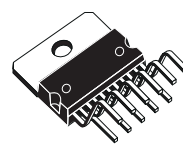
### DESCRIPTION

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

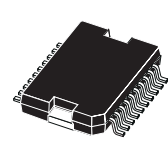
### MULTIPOWER BCD TECHNOLOGY



**MULTIWATT11**  
(In line)



**MULTIWATT11V**



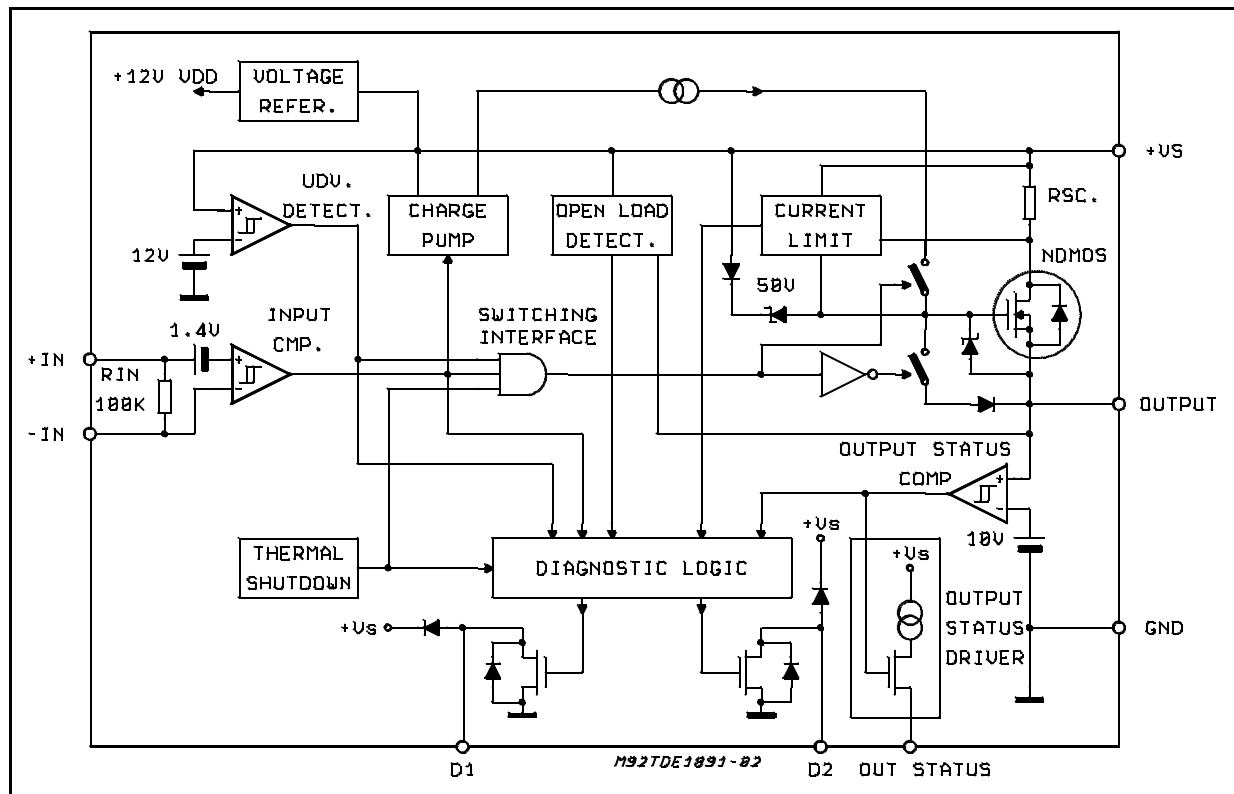
**PowerSO20**

<b>ORDERING NUMBERS:</b>		
TDE1891L	TDE1890V	TDE1890D
	TDE1891V	

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

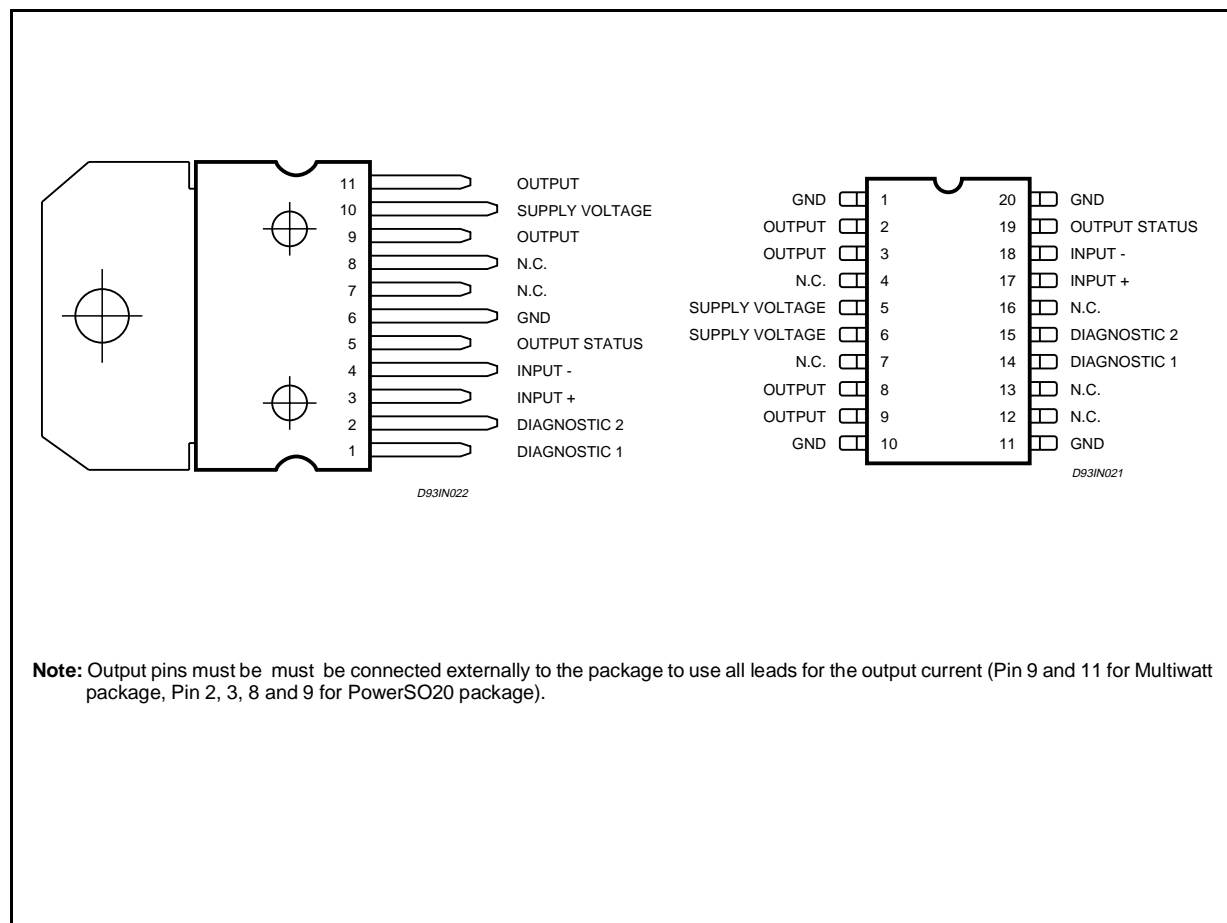
Diagnostic for CPU feedback and extensive use of electrical protections make this device extremely rugged and specially suitable for industrial automation applications.

### BLOCK DIAGRAM



## TDE1890 - TDE1891

### PIN CONNECTION (Top view)



### ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
$V_S$	Supply Voltage (Pin 10) ( $T_W < 10\text{ms}$ )	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 $T_J = 85^\circ\text{C}$	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 $I_{out} = I_{os} = 0$	$V_{il}$ $V_{ih}$		3 5	7 8	mA 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	$I_{out} = 2.0A$ $T_j = 25^\circ C$ $T_j = 125^\circ C$ $I_{out} = 2.5A$ $T_j = 25^\circ C$ $T_j = 125^\circ C$		360 575 440 700	500 800 575 920	mV mV mV 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 ( $V_S - V_o$ )	$I_o = 1A$ 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 $35V$ , $V_S - V_{id} < 37V$	-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	$0 < +In < +16V$ ; $-In = 0V$ $-7 < +In < 0V$ ; $-In = 0V$		400 150		K $\Omega$ K $\Omega$
$I_{ilk}$	Input Offset Current	$V+In = V-In$ $+I_i$ $-20$ $+20$ $\mu A$ $0V < V_i < 5.5V$ $-I_i$ $-75$ $-25$ $\mu A$				
		$-In = GND$ $+I_i$ $+10$ $+50$ $\mu A$ $0V < V+In < 5.5V$ $-I_i$ $-250$ $-125$ $\mu A$				
		$+In = GND$ $+I_i$ $-100$ $-30$ $\mu A$ $0V < V-In < 5.5V$ $-I_i$ $-50$ $-15$ $\mu A$				
$V_{oth1}$	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	$V_S - V_{os}$ ; $I_{os} = 2mA$ $T_{amb} = -25$ to $+85^\circ C$			5	V
$I_{oslk}$	Output Status Driver Leakage Current	$V_{out} < V_{oth2}$ ; $V_{os} = 0V$ $V_S = 18$ to $35V$			25	$\mu A$
$V_{dgl}$	Diagnostic Drop Voltage	$D1 / D2 = L$ ; $I_{diag} = 0.5mA$ $D1 / D2 = L$ ; $I_{diag} = 3mA$			250 1.5	mV V
$I_{dglk}$	Diagnostic Leakage Current	$D1 / D2 = H$ ; $0 < V_{dg} < V_S$ $V_S = 15.6$ 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**  $V_{il} \leq 0.8V$ ,  $V_{ih} \geq 2V$  @  $(V+In > V-In)$



## TDE1890 - TDE1891

### 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

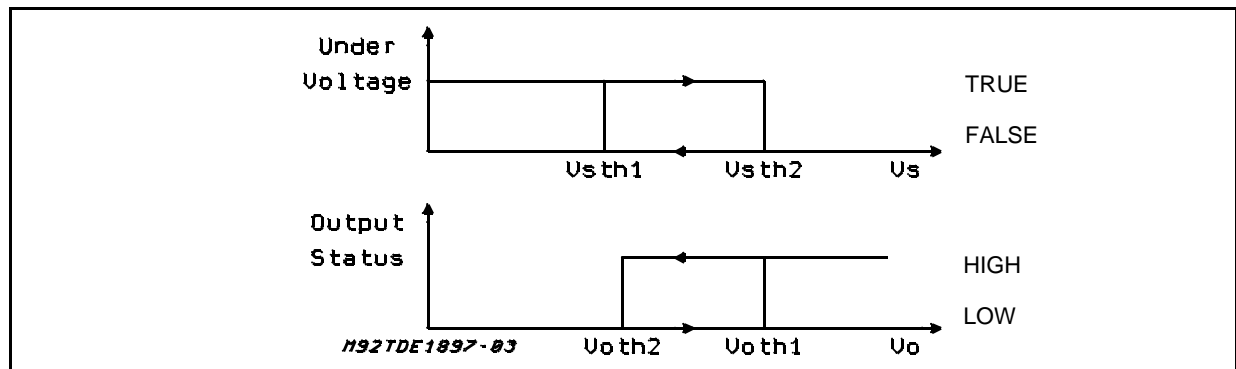
$\emptyset Lim$	Junction Temp. Protect.		135	150		°C
$T_H$	Thermal Hysteresis			30		°C

### 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 H	L H	H H	H H
Open Load Condition ( $I_o < I_{old}$ )	L H	L H	H L	H H
Short to $V_S$	L H	H H	L L	H H
Short Circuit to Ground ( $I_o = I_{sc}$ ) (**)	TDE1891	H <H (*)	H	L
	TDE1890	H L	H H	H H
Output DMOS Open	L H	L L	H L	H H
Overttemperature	L H	L L	H H	L L
Supply Undervoltage ( $V_S < V_{sth2}$ )	L H	L L	L 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

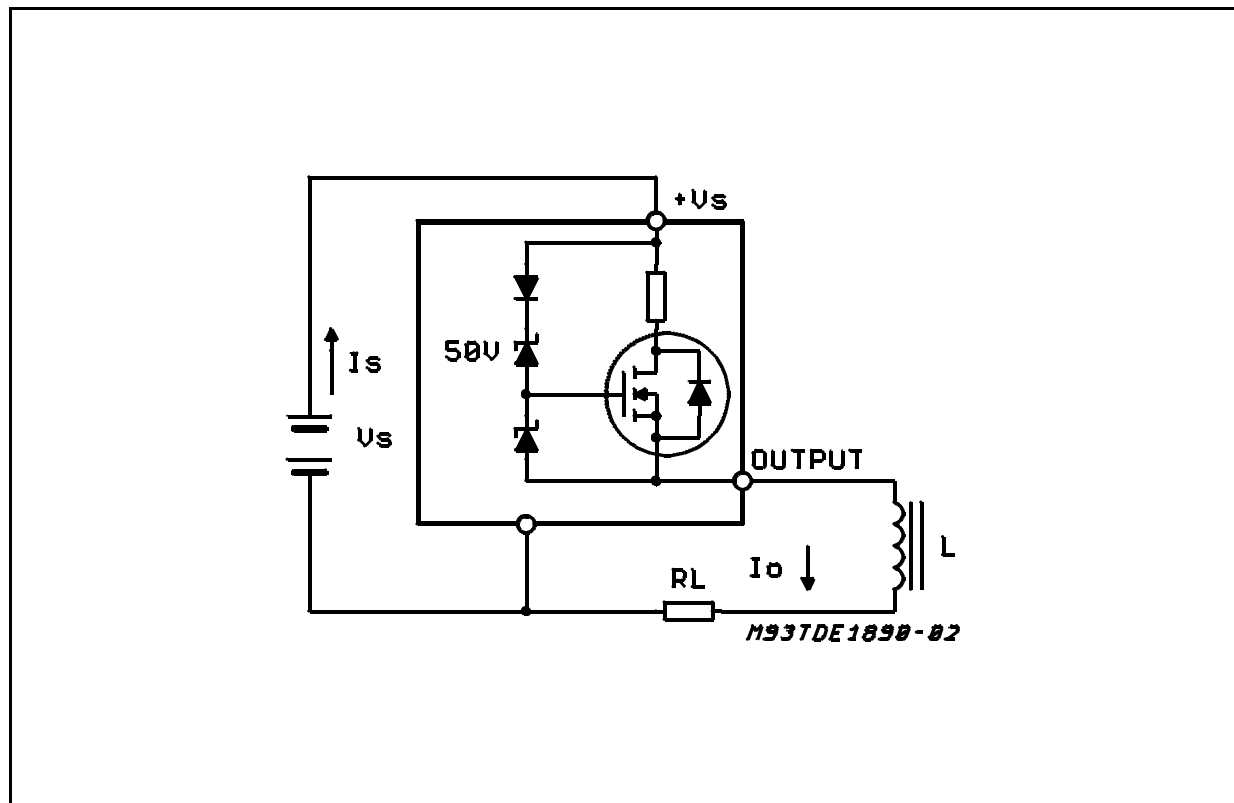


Figure 3: Demagnetization Cycle Waveforms

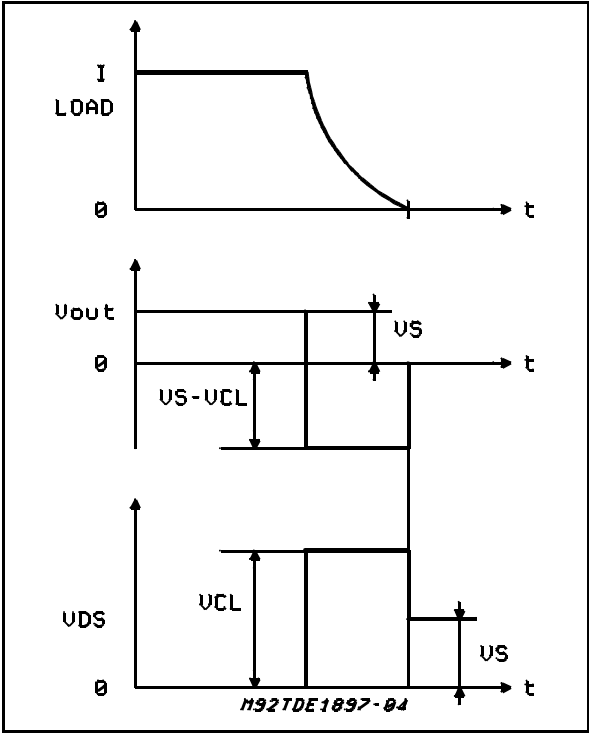


Figure 4: Normalized  $R_{DS(on)}$  vs. Junction Temperature

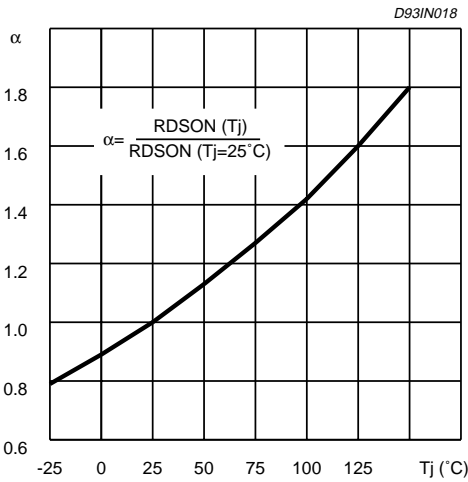
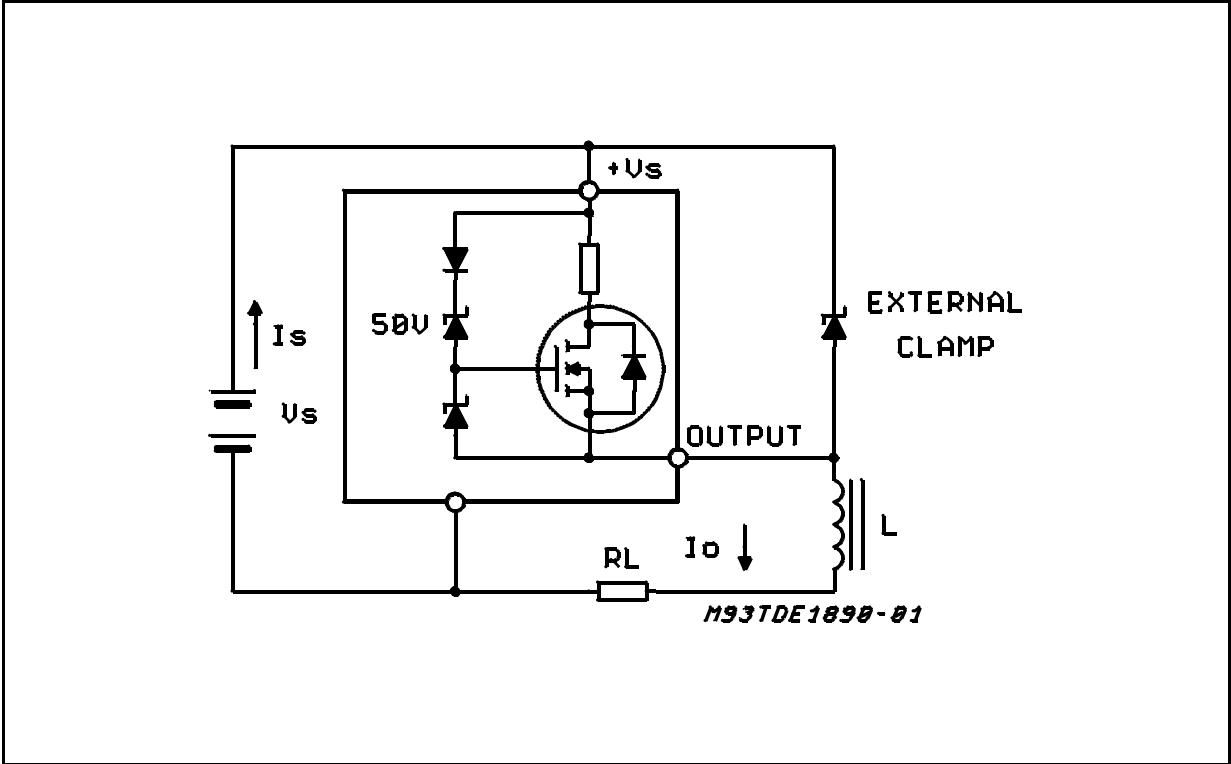


Figure 5.



## 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  $R_{DS(on)}$  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  $R_{DS(on)}$  and temperature is therefore:

$$R_{DS(on)} = R_{DS(on)0} (1 + k) (T_j - 25)$$

where:

$T_j$  is the silicon temperature in °C

$R_{DS(on)0}$  is  $R_{DS(on)}$  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:  
 $P_{out} = I_{out}^2 \cdot R_{DS(on)}$  ( $I_{out}$  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:  $P_{os} = I_{os} \cdot (V_s - V_{os})$ .

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  $R_{DS(on)}$  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  $T_{amb}$ :

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

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

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

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

$$I_{outx} = \sqrt{\frac{\frac{\Theta_{Lim} - T_{amb}}{R_{th}} - P_q - P_{os}}{R_{DS(on)x}}}$$

where  $R_{DS(on)x}$  is  $R_{DS(on)}$  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:

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

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

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

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

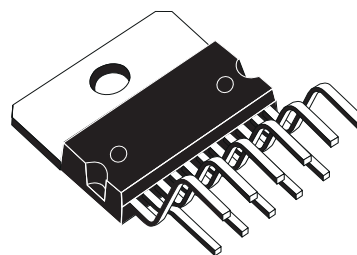
- The supply voltage is at maximum value of industrial bus (30V instead of the 24V nominal value). This means also that  $I_{outx}$  rises of 25% (2.5A instead of 2A).



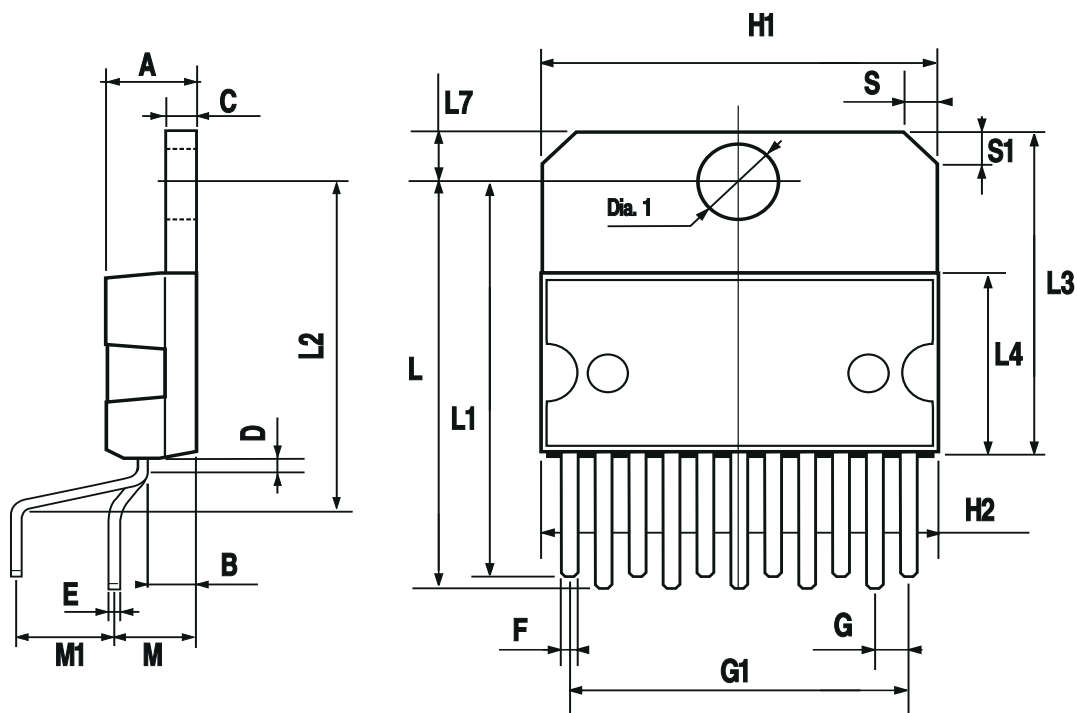


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.88		0.95	0.035		0.037
G	1.45	1.7	1.95	0.057	0.067	0.077
G1	16.75	17	17.25	0.659	0.669	0.679
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.87	0.886
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	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.73	5.08	5.43	0.186	0.200	0.214
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

## OUTLINE AND MECHANICAL DATA



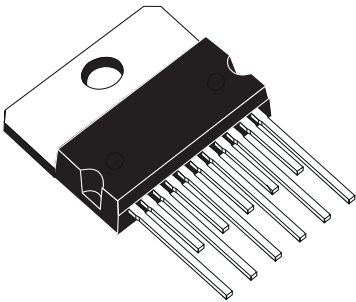
**Multiwatt11 V**



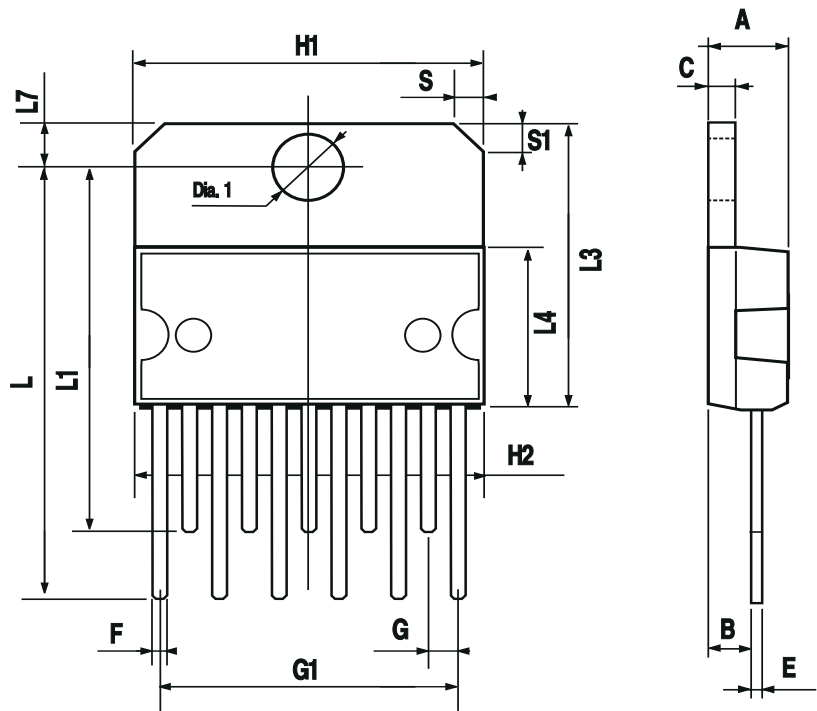
TDE1890 - TDE1891

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

OUTLINE AND  
MECHANICAL DATA



Multiwatt11 (In-Line)

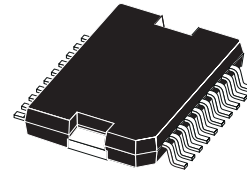


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	8° (typ.)					
S	8° (max.)					
T		10			0.394	

(1) "D and E1" do not include mold flash or protrusions.  
- Mold flash or protrusions shall not exceed 0.15mm (0.006")  
- Critical dimensions: "E", "G" and "a3".

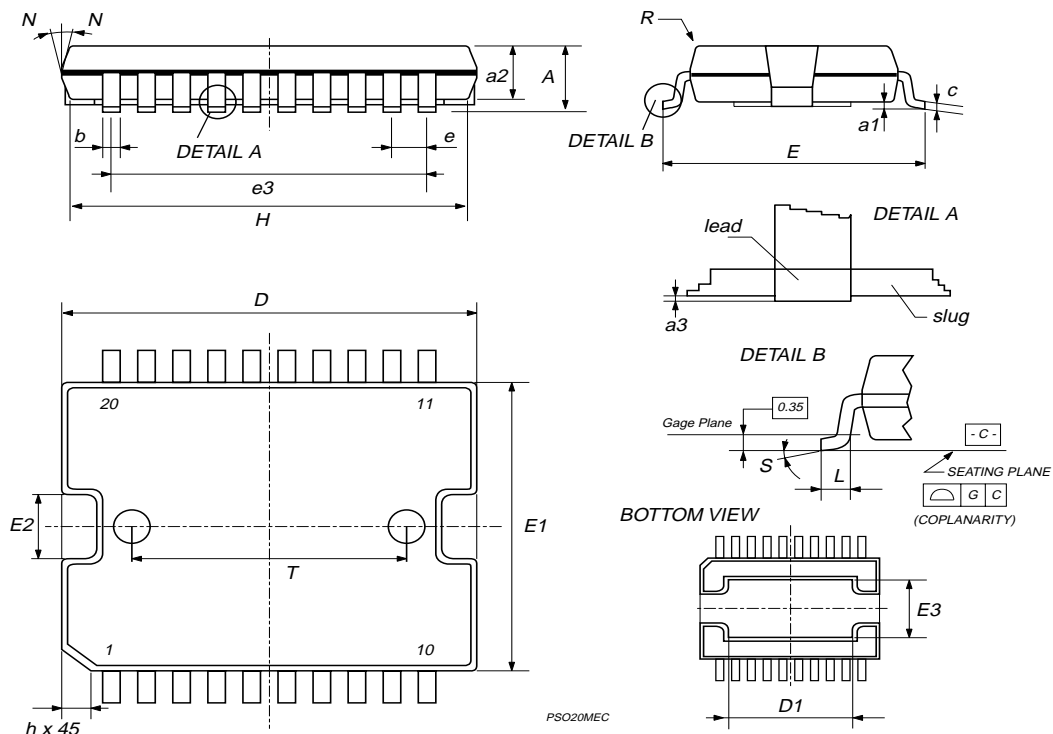
## OUTLINE AND MECHANICAL DATA

Weight: 1.9gr



JEDEC MO-166

**PowerSO20**



0056635

Information furnished is believed to be accurate and reliable. However, STMicroelectronics assumes no responsibility for the consequences of use of such information nor for any infringement of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of STMicroelectronics. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. STMicroelectronics products are not authorized for use as critical components in life support devices or systems without express written approval of STMicroelectronics.

The ST logo is a registered trademark of STMicroelectronics.  
All other names are the property of their respective owners

© 2003 STMicroelectronics - All rights reserved

### **STMicroelectronics GROUP OF COMPANIES**

Australia – Belgium - Brazil - Canada - China – Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States

[www.st.com](http://www.st.com)