# SGS-THOMSON MICROELECTRONICS

L6370

2.5A HIGH-SIDE DRIVER
INDUSTRIAL INTELLIGENT POWER SWITCH

- 2.5A OUTPUT CURRENT
- 9.5V 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
- NON DISSIPATIVE SHORT CIRCUIT PROTECTION
- PROTECTION AGAINST AND SURGE TRANSIENT (IEC 801-5)
- IMMUNITY AGAINST BURST TRANSIENT (IEC 801-4)
- ESD PROTECTION (HUMAN BODY MODEL ±2KV)

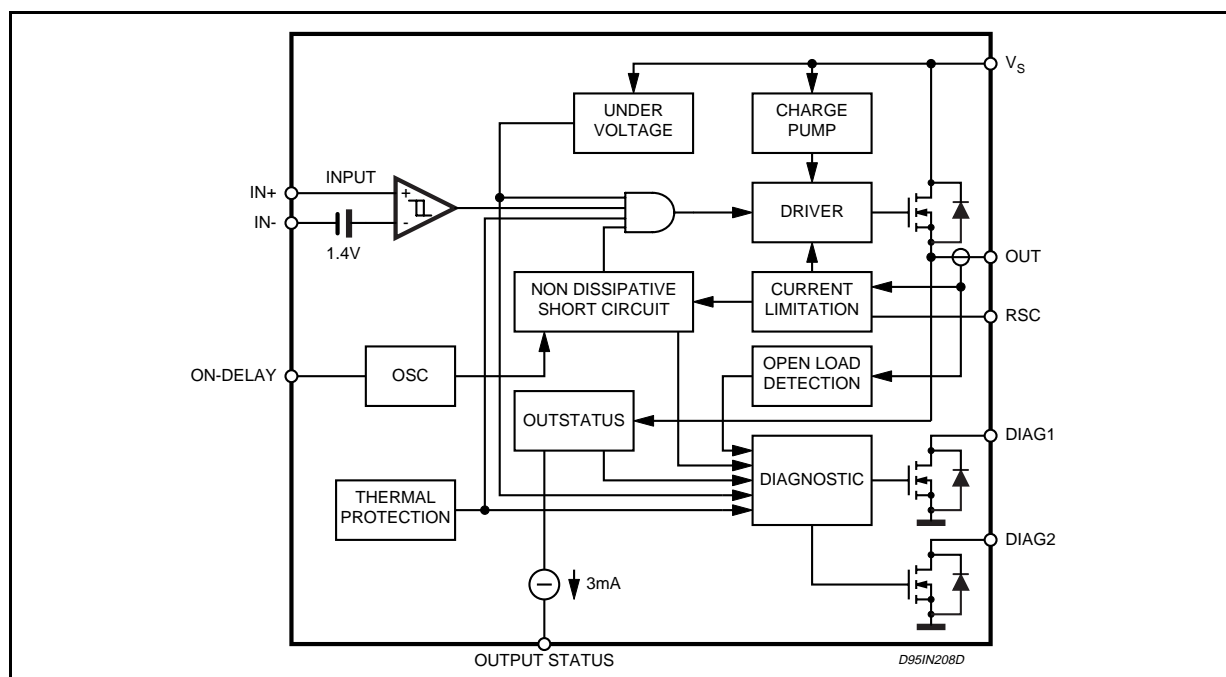### MULTIPOWER BCD TECHNOLOGY
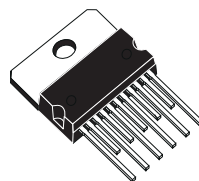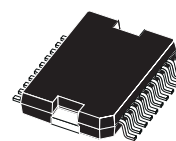
MULTIWATT11 (in line)   **PowerSO20**

ORDERING NUMBERS: L6370L (MULTIWATT11)
L6370D (PowerSO20)

DESCRIPTION
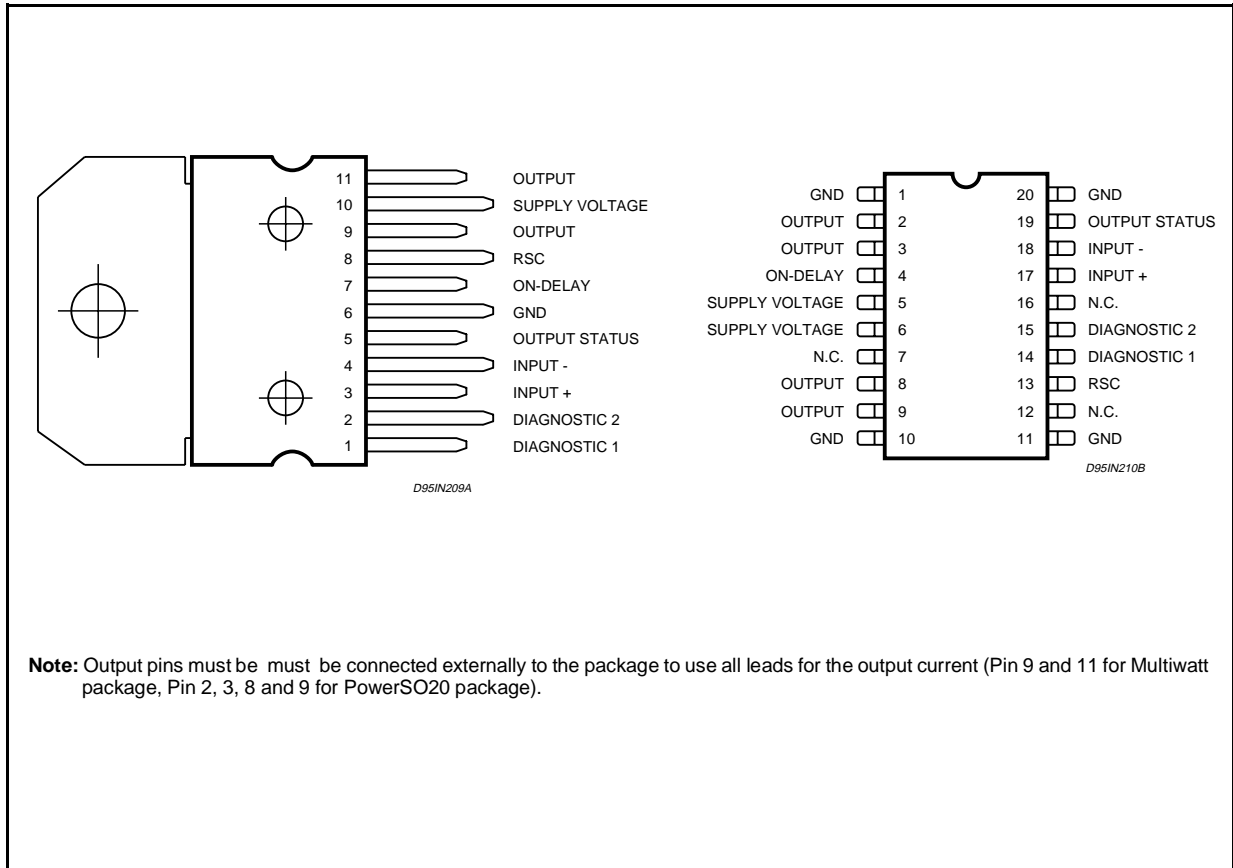
The L6370 is a monolithic Intelligent Power Switch in Multipower BCD Technology, for driving inductive or resistive loads. An internal Clamping Diode enables the fast demagnetization of inductive loads. Diagnostic for CPU feedback and extensive use of electrical protections make this device extremely rugged and specially suitable for industrial automation applications.

BLOCK DIAGRAM

PIN CONNECTION (Top view)

	11		OUTPUT
	10		SUPPLY VOLTAGE
	9		OUTPUT
	8		RSC
	7		ON-DELAY
	6		GND
	5		OUTPUT STATUS
	4		INPUT -
	3		INPUT +
	2		DIAGNOSTIC 2
	1		DIAGNOSTIC 1

D95IN209A

GND	1		20	GND
OUTPUT	2		19	OUTPUT STATUS
OUTPUT	3		18	INPUT -
ON-DELAY	4		17	INPUT +
SUPPLY VOLTAGE	5		16	N.C.
SUPPLY VOLTAGE	6		15	DIAGNOSTIC 2
N.C.	7		14	DIAGNOSTIC 1
OUTPUT	8		13	RSC
OUTPUT	9		12	N.C.
GND	10		11	GND

D95IN210B

Note: Output pins must be must be connected externally to the package to use all leads for the output current (Pin 9 and 11 for Multiwatt package, Pin 2, 3, 8 and 9 for PowerSO20 package).

ABSOLUTE MAXIMUM RATINGS (Pin numbering referred to Multiwatt package)

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_{Cl} (Pins 10 - 9)	internally limited	V
V_{od}	Externally Forced Voltage (Pin7)	-0.3 to 7	V
I_{od}	Externally Forced Voltage (Pin7)	± 1	mA
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 ISC (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°C	1	J

THERMAL DATA

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

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PIN FUNCTION (pin numbering referred to Multiwatt package)

N.	Name	Function
1	DIAG1	DIAGNOSTIC 1 output. This open drain reports the IC working conditions. (See Diagnostic truth table)
2	DIAG1	DIAGNOSTIC 2 output. This open drain reports the IC working conditions. (See Diagnostic truth table)
3	IN -	Comparator non inverting input
4	IN+	Comparator inverting input
5	OUTSTATUS	This current source output is capable of driving a LED to signal the status of the output pin. The pin is active (source current) when the output pin is considered high (See fig 1)
6	GND	Ground
7	ON-DELAY	Programmable ON time interval duration during short circuit operation
8	RSC	Current limitation setting.
9	OUTPUT	High Side output with built-in current limitation
10	V_S	Supply Volatge Input, the value of the supply voltage is monitored to detect under voltage condition
11	OUTPUT	High Side output with built-in current limitation

ELECTRICAL CHARACTERISTICS (V_S = 24V; T_J = −25 to +125°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	4		35	V
V_s	Supply Voltage (operative)		9.5	24	35	V
I_q	Quiescent Current $I_{out} = I_{os} = 0$	V_{il} V_{ih}		0.8 3	1.4 5	mA mA
V_{sth1}	Undervoltage Threshold 1	(See fig. 1), Tamb = 0 to +85°C	8.5	9	9.5	V
V_{sth2}	Undervoltage Threshold 2		8	8.5	9	V
V_{shys}	Supply Voltage Hysteresis		300	500	700	mV
I_{sc}	Short Circuit Current	V_S = 9.5 to 35V; R_L = 2Ω 5kΩ < R_{SC} < 30kΩ	15/R_{SC} (kΩ)			A
		0 < R_{SC} < 5kΩ	2.6	3.2	4	A
V_{don}	Output Voltage Drop	I_{out} = 2.0A T_j = 25°C T_j = 125°C I_{out} = 2.5A T_j = 25°C T_j = 125°C		200 320 250 400	280 440 350 550	mV mV mV mV
I_{oslk}	Output Leakage Current	$V_i = V_{il}$; V_o = 0V			500	µA
V_{ol}	Low State Out Voltage	$V_i = V_{il}$; R_L = ∞		0.8	1.5	V
V_{cl}	Internal Voltage Clamp (V_S - V_O)	I_O = 1A Single Pulsed: Tp = 300µs	48	53	58	V
I_{old}	Open Load Detection Current	$V_i = V_{ih}$; T_{amb} = 0 to +85°C	1	3	6	mA
V_{id}	Common Mode Input Voltage Range (Operative)	V_S = 18 to 35V	−7		15	V
I_{ib}	Input Bias Current	V_i = −7 to 15V; −In = 0V	−250		250	µA
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		KΩ KΩ
I_{ilk}	Input Offset Current	V+In = V−In +Ii 0V < V_i <5.5V −Ii	−20 −75	−25	+20	µA µA
		−In = GND +Ii 0V < V+In <5.5V −Ii	−250	+10 −125	+50	µA µA
		+In = GND +Ii 0V < V−In <5.5V −Ii	−100 −50	−30 −15		µA µA

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ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{oth1}	Output Status Threshold 1 Voltage	(See fig. 1)	4.5	5	5.5	V
V_{oth2}	Output Status Threshold 2 Voltage	(See fig. 1)	4	4.5	5.0	V
V_{ohys}	Output Status Threshold Hysteresis	(See fig. 1)	300	500	700	mV
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	$V_s - V_{os}$; $I_{os} = 2mA$ $T_{amb} = 0$ to $+85°C$		1.5	3	V
I_{oslk}	Output Status Driver Leakage Current	$V_{out} < V_{oth2}$; $V_{os} = 0V$ $V_S = 9.5$ to $35V$			25	µA
V_{dgl}	Diagnostic Drop Voltage	D1 / D2 = L ; $I_{diag} = 0.5mA$ D1 / D2 = L ; $I_{diag} = 3mA$		40 250		mV mV
I_{dglk}	Diagnostic Leakage Current	D1 / D2 = H ; $0 < V_{dg} < V_s$ $V_S = 9.5$ to $35V$			5	µA
SOURCE DRAIN NDMOS DIODE						
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/µs		200		ns
t_{fr}	Forward Recovery Time			100		ns
THERMAL CHARACTERISTICS						
Θ Lim	Junction Temp. Protect.		135	150		°C
ΘT_H	Thermal Hysteresis			20		°C

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

AC OPERATION (pin numbering referred to Multiwatt package)

Symbol	Pin	Parameter	Test Condition	Min.	Typ.	Max.	Unit
t_r - t_f	9 vs 4	Rise or Fall Time	$V_S = 24V$; $R_l = 70\Omega$; R_l to ground		20		µs
t_d	9 vs 3	Delay Time			5		µs
dV/dt	9, 11	Slew Rate (Rise and Fall Edge)		0.7	1	1.5	V/µs
t_{ON}	7	On time during Short Circuit Condition	50pF $< C_{DON} < 2nF$		1.28		µs/pF
tOFF		Of time during hort Circuit Condition			64		t_{ON}
f_{max}		Maximum Operating Frequency			25		KHz

Figure 1: Output Status Hysteresis

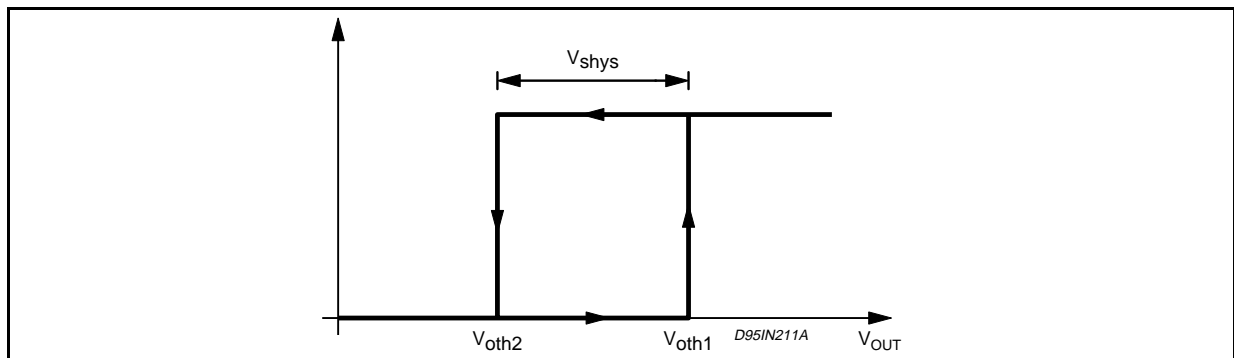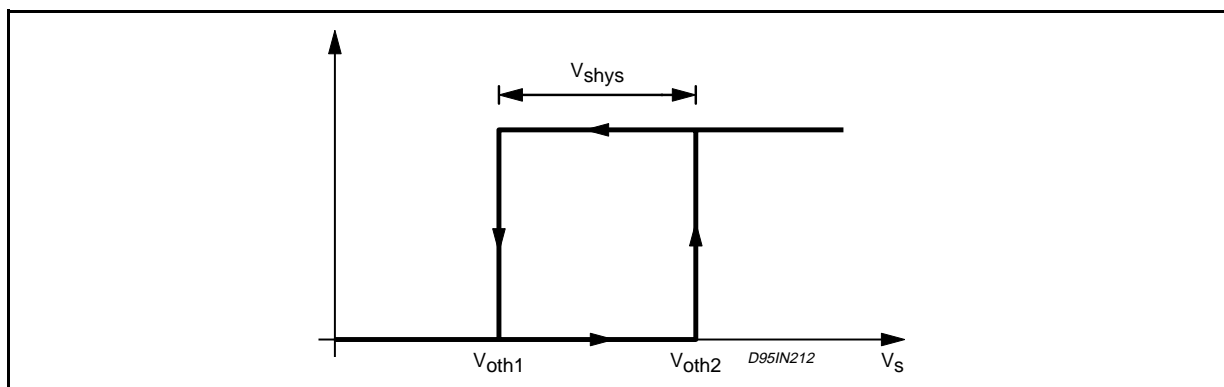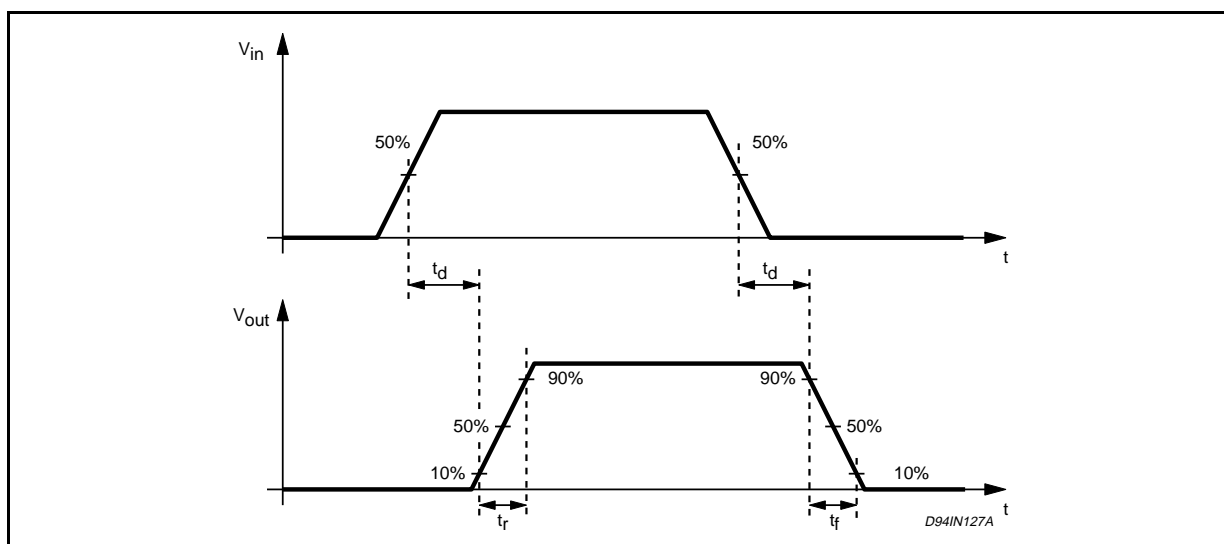**SGS-THOMSON**
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Figure 2: Undervoltage Comparator Hysteresis

Figure 3: Switching Waveforms

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 ($I_O = I_{SC}$) (**) (pin ON-DELAY grounded)	H	H (*) L	H H	H H
Output DMOS Open	L H	L L	H L	H H
Overtemperature	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.

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INPUT SECTION

The input section is an high impedance differential stage with high common and differential mode range. There's built-in offset of +1.4V (typical value) and an hysteresis of 400mV (maximum value), to ensure high noise immunity.

DIAGNOSTIC LOGIC

The operating conditions of the device are permanently monitored and the following occurences are signalled via the DIAG1/DIAG2 open-drain output pins:

-Short Circuit versus ground.
A current limiting circuit fixes at Isc = 3.2A (typical value) the maximum current that can be sourced from the OUTPUT pin (for more details see short circuit operation section).
- Short Circuit versus Vs.
- Under Voltage(UV)
- Over Temperature (OVT)
- Open Load, if the output current is less than 3mA (typical value).
- Output DMOS Open
according to the diagnostic Truth Table:

SHORT CIRCUIT OPERATION

in order to minimise the power dissipation when the output is shorted to grounded, an innovative, non dissipative short cicuit protection (patent pending) is implemented, avoiding, thus the intervention of the thermal protection in most cases.

Whenever the output is shorted to ground, or, generally speaking, an over current is sinked by the load, the output devices is driven in linear mode, sourcing the Isc current (typically 3.2A) for a time interval (t_{on}) defined by means of the external C_{ON} capacitor connected between the ON-DELAY pin and GND. Whether the short circuit crease within the t_{on} interval the DIAG2 output status is not affected, acting as a Programmable Diagnostic Delay.
This function allow the device to drive a capacitive load or a filament lamp (that exhibits a very low resistance during the initial heading phase) without the intervention of the diagnostic.
If the short circuit lasts for the whole t_{ON} interval, the output DMOS is switched OFF and the DIAG2 goes low, for a time interval t_{OFF} lasting 64 times t_{ON}.
At the end of the t_{OFF} interval if the short circuit condition is still present, the output DMOS is turned ON (and the DIAG2 goes high - see fig4) for another t_{ON} interval and the sequence starts again, or, whether not, the normal condition op-

eration is resumed.
The t_{ON} interval can be set to lasts between 64μs and 2.56ms for a C_{ON} capacitor value ranging between 50pF and 2nF to have:

$$t_{ON} (\mu s) = 1.28 \, C_{ON} (pF)$$

If the ON-DELAY pin is grounded the non dissipative short circuit protection is disabled, and the Isc current is delivered until the Overtemperature Protection shuts the device off. The behaviour of the DIAG2 output is, in this situation, showed in the Diagnostic Truth Table.

OVERTEMPERATURE PROTECTION (OVT)

If the chip temperature exceeds Θ_{lim} (measured in a central position in the chip) the chip deactivates itself.
The following actions are taken:

all the output stage is switched off;

the signal DIAG2 is activated (active low).

Normal operation is resumed as soon as (typically after some seconds) the chip temperature monitored goes back below $\Theta_{lim} - \Theta_H$.
The different thresholds with hysteretic behavior assure that no intermittent conditions can be generated.

UNDERVOLTAGE PROTECTION (UV)

The supply voltage is expected to range from 9.5V to 35V, even if its reference value is considered to be 24V.

In this range the device operates correctly.
Below 9.5V the overall system has to be considered not reliable.
Protection will thus shut off the output whenever the supply voltage falls below the mask fixed by the V_{sth1} (9V typ.) and V_{sth2} (8.5V typ.).

The hysteresis (see fig. 2) ensures a non intermittent behavior at low supply voltage with a superimposed ripple.
The Under Voltage status is signalled via the DIAG1 and DIAG2 outputs (see the Diagnostic Truth Table) .

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 Tj = 85°C) (see figure 2)
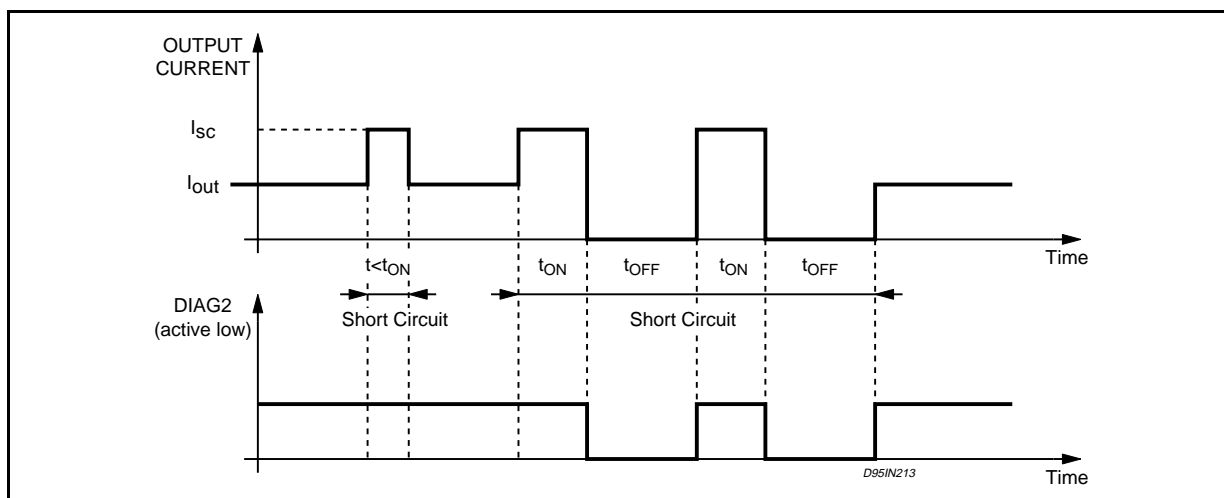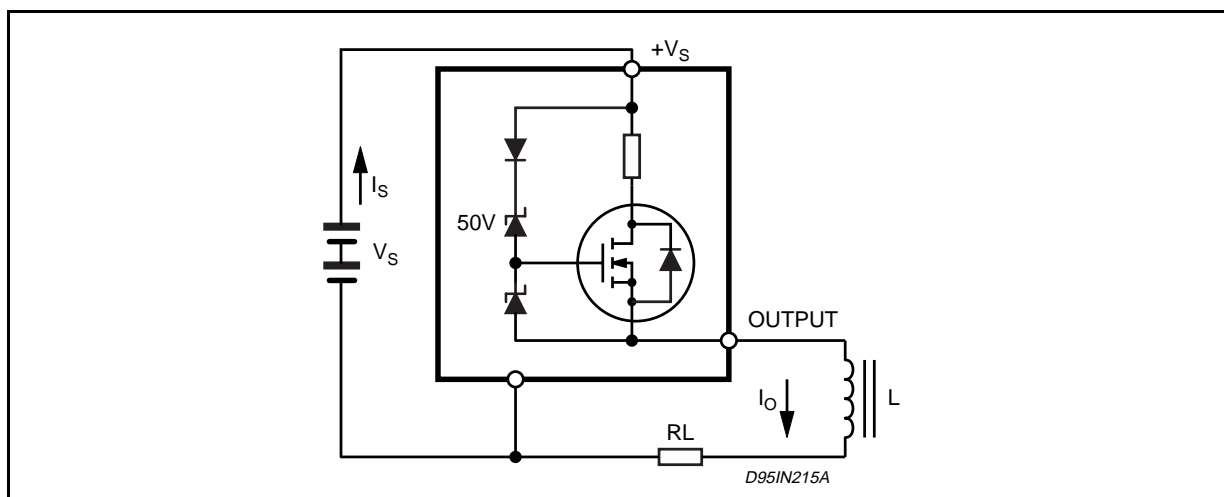
Figure 4: L6370 Short Circuit OperationWaveforms

Figure 5: Inductive Load Equivalent Circuit

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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

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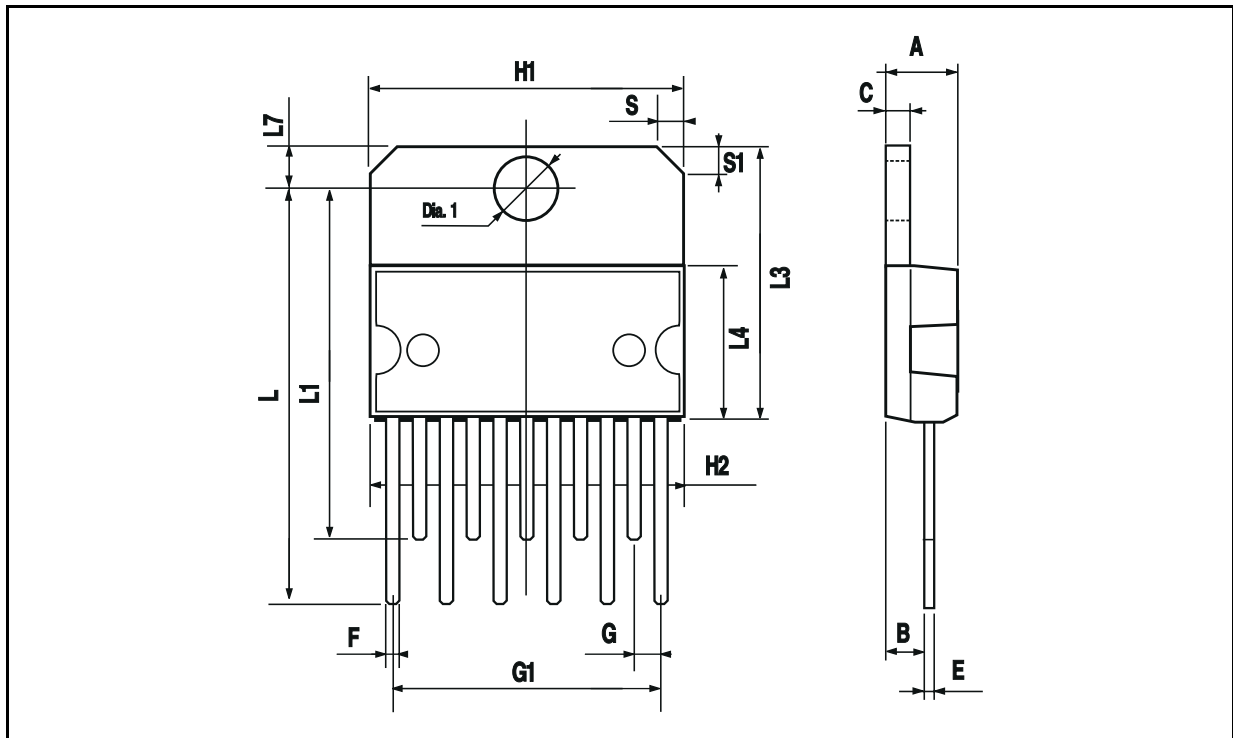
PowerSO20 PACKAGE MECHANICAL DATA

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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