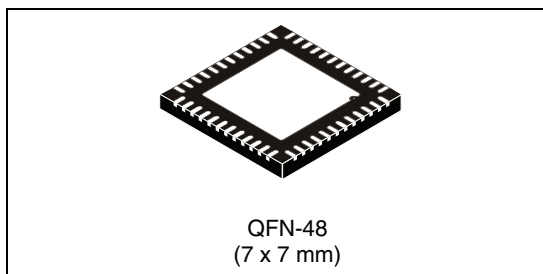


## 2.5 A single high-side smart power switch

### Features

Type	Vdemag	RDSon	Iout	Vs
L6370Q	Vs-50 V	0.1 Ω	2.5 A	50 V

- 2.5 A output current
- 9.5 V to 35 V supply voltage range
- Internal current limiting
- Thermal shutdown
- Open ground protection
- Internal negative voltage clamping to  $V_S - 50 V$  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 (IEC61000-4-5)
- Immunity against burst transient (IEC61000-4-4)
- ESD protection (human body model  $\pm 2kV$ )



### Applications

- Programmable logic control
- Industrial PC peripheral input/output
- Numerical control machines
- Drivers for all type of loads (resistive, capacitive, inductive load)

### 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.

**Table 1. Device summary**

Part number	Package	Packaging
L6370Q	VFQFPN 7x7x1 48L	Tube
L6370QTR		Tape and reel

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# 1 Block diagram and pin description

Figure 1. Block diagram

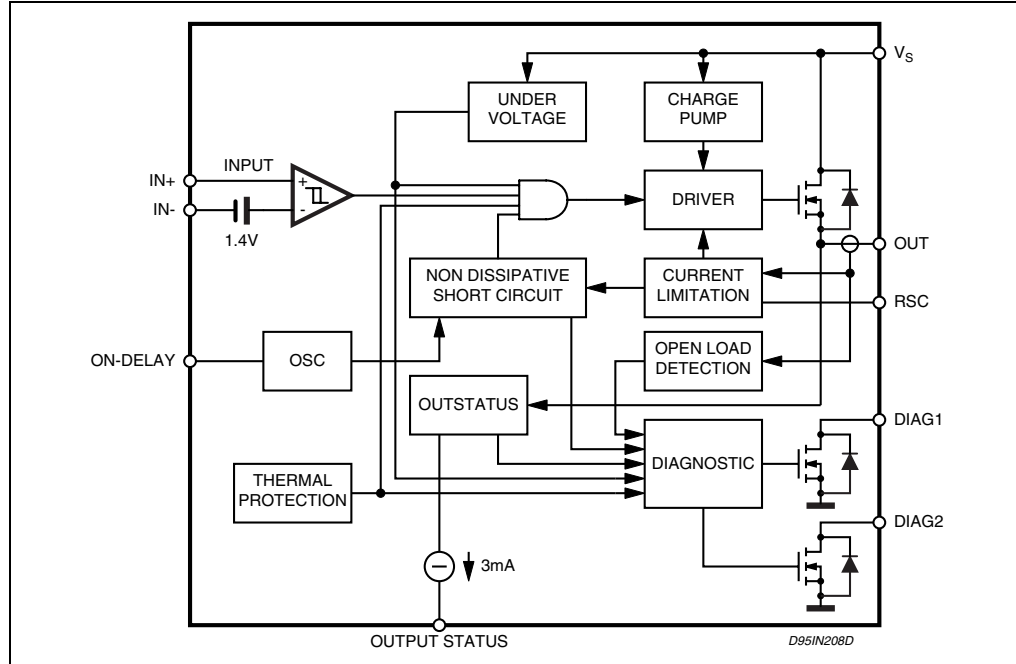
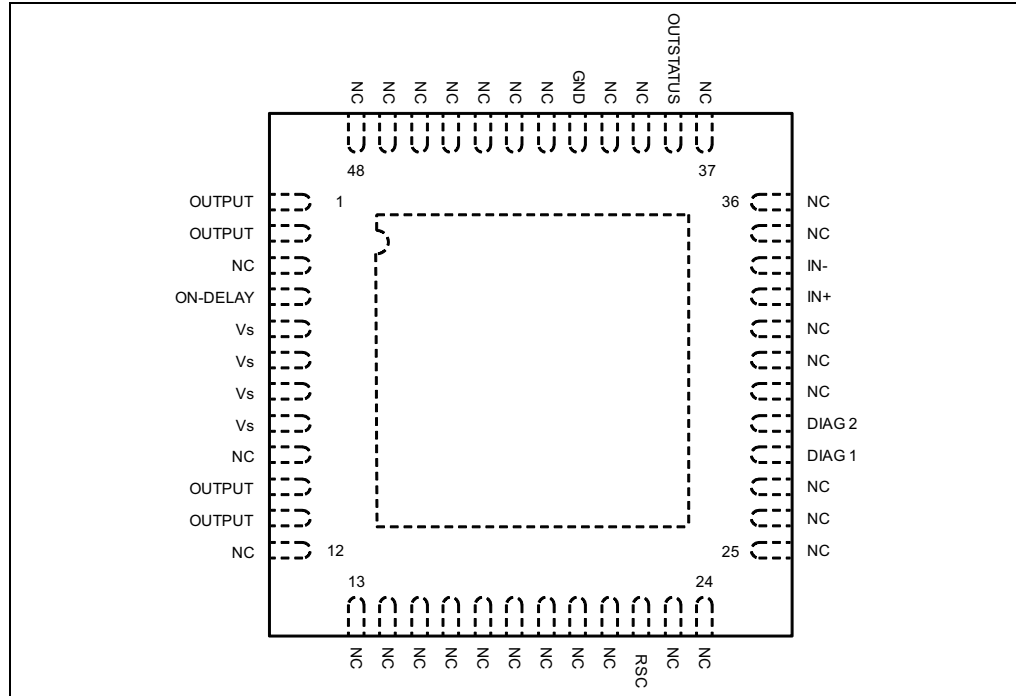


Figure 2. Pin connection (top view)



## 1.1 Pin description

**Table 2. Pin description**

Pin N°	Name	Description
1	OUTPUT	High side output with built-in current limitation
2	OUTPUT	High side output with built-in current limitation
3	NC	Not connected
4	ON-DELAY	Programmable ON time interval duration during short circuit operation
5	Vs	Supply voltage input, the value of the supply voltage is monitored to detect under voltage condition
6	Vs	Supply voltage input, the value of the supply voltage is monitored to detect under voltage condition
7	Vs	Supply voltage input, the value of the supply voltage is monitored to detect under voltage condition
8	Vs	Supply voltage input, the value of the supply voltage is monitored to detect under voltage condition
9	NC	Not connected
10	OUTPUT	High side output with built-in current limitation
11	OUTPUT	High side output with built-in current limitation
12	NC	Not connected
13	NC	Not connected
14	NC	Not connected
15	NC	Not connected
16	NC	Not connected
17	NC	Not connected
18	NC	Not connected
19	NC	Not connected
20	NC	Not connected
21	NC	Not connected
22	RSC	Current limitation setting.
23	NC	Not connected
24	NC	Not connected
25	NC	Not connected
26	NC	Not connected
27	NC	Not connected
28	DIAG1	DIAGNOSTIC 1 output. This open drain reports the IC working conditions. (See diagnostic truth <a href="#">Table 6.</a> )

**Table 2. Pin description (continued)**

Pin N°	Name	Description
29	DIAG2	DIAGNOSTIC 2 output. This open drain reports the IC working conditions. (See diagnostic truth <a href="#">Table 6.</a> )
30	NC	Not connected
31	NC	Not connected
32	NC	Not connected
33	IN+	Comparator inverting input
34	IN-	Comparator non inverting input
35	NC	Not connected
36	NC	Not connected
37	NC	Not connected
38	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
39	NC	Not connected
40	NC	Not connected
41	GND	Ground
42	NC	Not connected
43	NC	Not connected
44	NC	Not connected
45	NC	Not connected
46	NC	Not connected
47	NC	Not connected
48	NC	Not connected

## 2 Electrical specifications

### 2.1 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
Vs	Supply voltage (Tw<10ms)	50	V
Vs-Vo	Supply to output differential voltage. See also Vcl	Internally limited	V
Vod	Externally forced voltage	-0.3 to 7	V
Iod	Externally forced current	±1	mA
Vin	Input voltage	-10 to Vs+10	V
Vi	Differential input voltage	43	V
Iin	Input current	20	mA
Iout	Output current. See also Isc	Internally limited	A
Ei	Energy inductive load T <sub>j</sub> =85°C	1	J
P <sub>TOT</sub>	Power dissipation. Se also thermal characteristics	Internally limited	W
Top	Operating temperature range	-25 to +85	°C
T <sub>STG</sub>	Storage temperature	-55 to 150	°C

### 2.2 Thermal data

**Table 4. Thermal data**

Symbol	Description	Value	Unit
R <sub>thJC</sub>	Thermal resistance junction to case	Max. 4	°C/W
R <sub>thJA</sub>	Thermal resistance junction to ambient <sup>(1)</sup>	Max. 50	

1. Mounted on a 2-side + vias PCB with a ground dissipating area on the bottom side.

## 2.3 Electrical characteristics

( $V_S = 24\text{ V}$ ;  $T_J = -25\text{ to }+125^\circ\text{C}$ , unless otherwise specified)

**Table 5. Electrical characteristics**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{smin}$	Supply voltage for valid diagnostics	$I_{diag} > 0.5\text{mA}$ ; $V_{dg1} = 1.5\text{V}$	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 4	mA
$V_{sth1}$	Undervoltage threshold 1	(See <i>Figure 4</i> ), $T_{amb} = 0\text{ to }+85^\circ\text{C}$	8.5	9	9.5	V
$V_{sth2}$	Undervoltage threshold 2		8	8.5	9	V
$V_{sth3}$	Supply voltage hysteresis		300	500	700	mV
$I_{sc}$	Short circuit current	$V_S = 9.5\text{ to }35\text{V}$ ; $R_L = 2\Omega$ $5\text{k}\Omega < R_{SC} < 30\text{k}\Omega$	15/ $R_{SC}(\text{k}\Omega)$			A
		$0 < R_{SC} < 5\text{k}\Omega$	2.6	3.2	4	A
$V_{don}$	Output voltage drop	$I_{out} = 2.0\text{A}$ , $T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$		200 320	280 440	mV
		$I_{out} = 2.5\text{A}$ , $T_J = 25^\circ\text{C}$ $T_J = 125^\circ\text{C}$		250 400	350 550	mV
$I_{oslk}$	Output leakage current	$V_i = V_{il}$ ; $V_o = 0\text{V}$			500	$\mu\text{A}$
$V_{ol}$	Low state out voltage	$V_i = V_{il}$ ; $R_L = \infty$		0.8	1.5	V
$V_{cl}$	Internal voltage clamp ( $V_S - V_O$ )	$I_O = 1\text{A}$ Single pulsed: $T_p = 300\ \mu\text{s}$	48	53	58	V
$I_{old}$	Open load detection current	$V_i = V_{ih}$ ; $T_{amb} = 0\text{ to }+85^\circ\text{C}$	1	3	6	mA
$V_{id}$	Common mode input voltage range (operative)	$V_S = 18\text{ to }35\text{V}$	-7		15	V
$I_{ib}$	Input bias current	$V_i = -7\text{ to }15\text{V}$ ; $-I_n = 0\text{V}$	-250		250	$\mu\text{A}$
$V_{ith}$	Input threshold voltage	$V + I_n > V - I_n$	0.8	1.4	2	V
$V_{iths}$	Input threshold hysteresis voltage	$V + I_n > V - I_n$	50		400	mV
$R_{id}$	Diff. input resistance	$0 < +I_n < +16\text{V}$ ; $-I_n = 0\text{V}$ $-7 < +I_n < 0\text{V}$ ; $-I_n = 0\text{V}$		400 150		$\text{k}\Omega$
$I_{ilk}$	Input offset current	$V + I_n = V - I_n$ +li	-20		+20	$\mu\text{A}$
		$0\text{V} < V_i < 5.5\text{V}$ -li	-75	-25		
		$-I_n = \text{GND}$ +li		+10	+50	
		$0\text{V} < V + I_n < 5.5\text{V}$ -li	-250	-125		
		$+I_n = \text{GND}$ +li	-100	-30		
		$0\text{V} < V - I_n < 5.5\text{V}$ -li	-50	-15		

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{oth1}$	Output status threshold 1 voltage	(See <a href="#">Figure 3</a> )	4.5	5	5.5	V
$V_{oth2}$	Output status threshold 2 voltage		4	4.5	5.0	V
$V_{ohys}$	Output status threshold hysteresis		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 $+85^{\circ}C$		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	$\mu A$
$V_{dgl}$	Diagnostic drop voltage	D1 / D2 = L; $I_{diag} = 0.5mA$ D1 / D2 = L; $I_{diag} = 3mA$		40 250		mV
$I_{dglk}$	Diagnostic leakage current	D1 / D2 = H; $0 < V_{dg} < V_S$ $V_S = 9.5$ to $35V$			5	$\mu A$
<b>Source drain NDMOS diode</b>						
$V_{fsd}$	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
<b>Thermal characteristics</b>						
$\Theta_{Lim}$	Junction temp. protect.		135	150		$^{\circ}C$
$\Theta_{TH}$	Thermal hysteresis			20		$^{\circ}C$

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

## 2.4 AC operation

Table 6. AC operation

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_r - t_f$	Rise or fall time	$V_S = 24V$ ; $R_l = 70\Omega$ ; $R_l$ to ground		20		$\mu s$
$t_d$	Delay time			5		$\mu s$
dV/dt	Slew rate (rise and fall edge)		0.7	1	1.5	$V/\mu s$
$t_{ON}$	On time during short circuit condition	$50pF < C_{DON} < 2nF$		1.28		$\mu s/pF$
$t_{OFF}$	Of time during short circuit condition			64		$t_{ON}$
$f_{max}$	Maximum operating frequency			25		KHz



### 3 Circuit description

Figure 3. Output status hysteresis

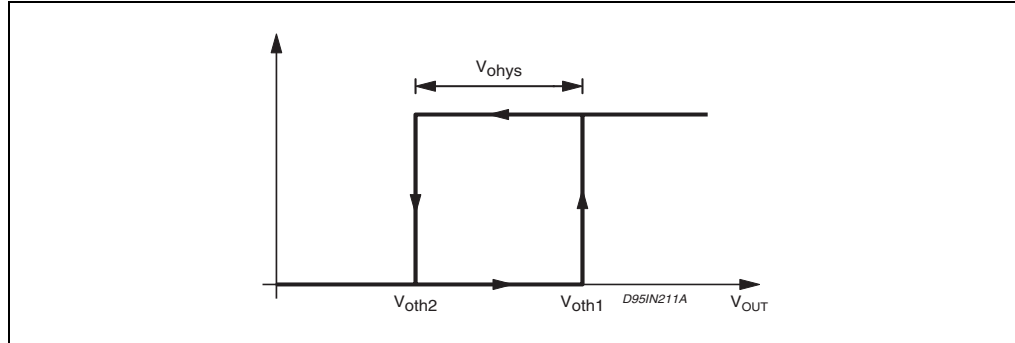


Figure 4. Undervoltage comparator hysteresis

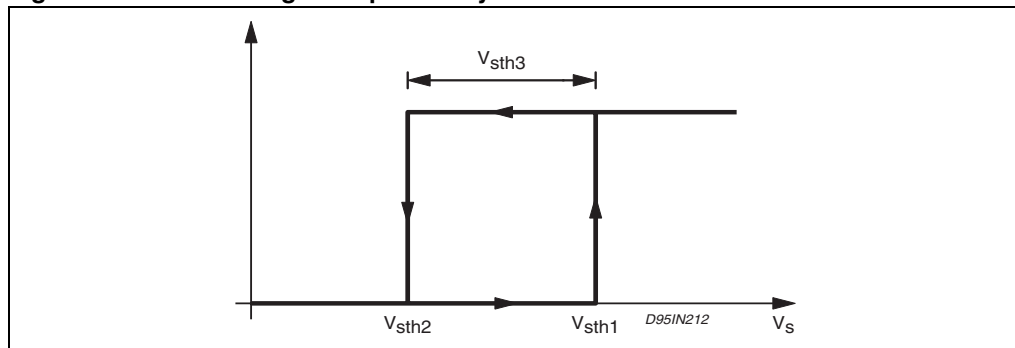
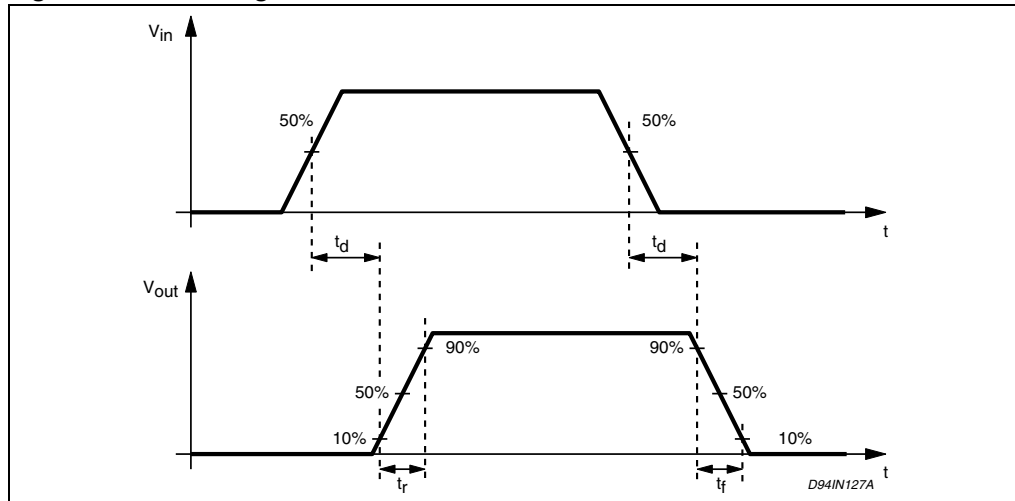


Figure 5. Switching waveforms



### 3.1 Diagnostic truth table

**Table 7. 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 ( $I_O = I_{SC}$ ) <sup>(1)</sup> (pin ON-DELAY grounded)	H	X	H	H
	L	L	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

1. A cold lamp filament, or a capacitive load may activate the current limiting circuit of the IPS, when the IPS is initially turned on.

### 3.2 Input section

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

### 3.3 Diagnostic logic

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

- Short circuit versus ground. A current limiting circuit fixes at  $I_{SC} = 3.2$  A (typical value) the maximum current that can be sourced from the OUTPUT pin (for more details see short circuit operation section).
- Short circuit versus  $V_S$ .
- Under voltage (UV)
- Over temperature (OVT)
- Open load, if the output current is less than 3 mA (typical value).
- Output DMOS open according to the diagnostic truth [Table 7](#).

### 3.4 Short circuit operation

In order to minimize the power dissipation when the output is shorted to grounded, an innovative, non dissipative short circuit 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 overcurrent is sinked by the load, the output devices is driven in linear mode, sourcing the  $I_{sc}$  current (typically 3.2 A) for a time interval ( $t_{on}$ ) defined by means of the external  $C_{ON}$  capacitor connected between the ONDELAY 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 [Figure 7](#)) for another  $t_{ON}$  interval and the sequence starts again, or, whether not, the normal condition operation is resumed.

The  $t_{ON}$  interval can be set to lasts between 64 ms and 2.56 ms for a  $C_{ON}$  capacitor value ranging between 50 pF and 2 nF 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  $I_{sc}$  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 7](#).

### 3.5 Overtemperature protection (OVT)

If the chip temperature exceeds  $Q_{lim}$  (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.

### 3.6 Undervoltage protection (UV)

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

In this range the device operates correctly. Below 9.5 V the overall system has to be considered not reliable.

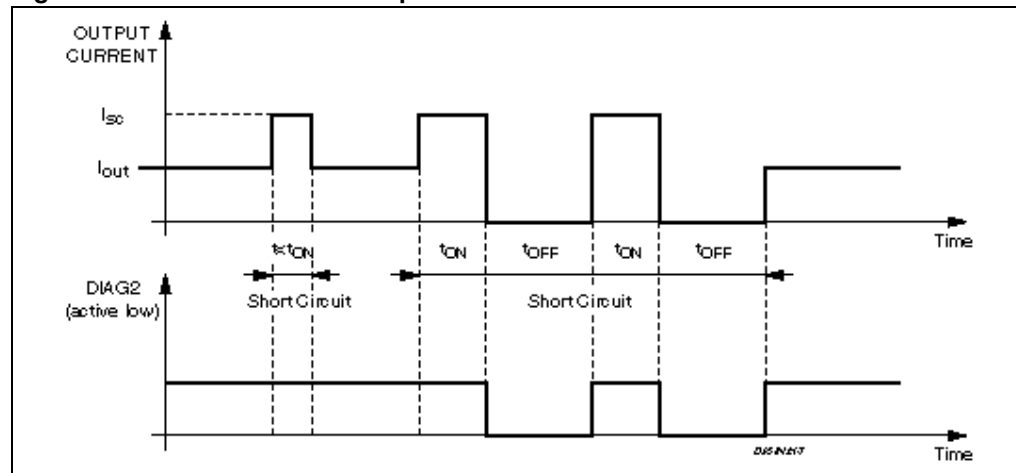
Protection will thus shut off the output whenever the supply voltage falls below the mask fixed by the  $V_{sth1}$  (9 V typ.) and  $V_{sth2}$  (8.5 V typ.).

The hysteresis (see [Figure 4](#)) 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 7](#)).

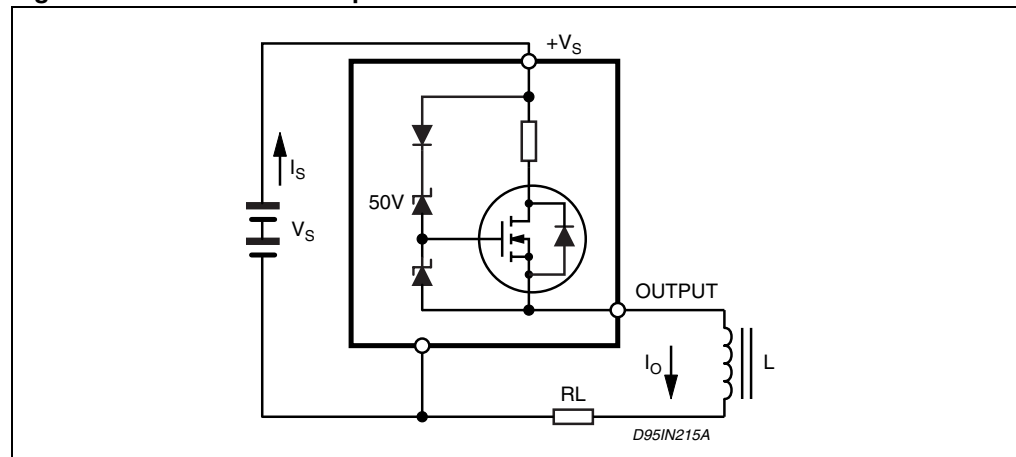
### 3.7 Demagnetization of inductive loads

An internal zener diode, limiting the voltage across the Power MOS to between 50 and 60 V ( $V_{cl}$ ), 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  $T_j = 85^\circ\text{C}$ ) (see [Table 3](#)).

**Figure 6. L6370 short circuit operation waveforms**



**Figure 7. Inductive load equivalent circuit**



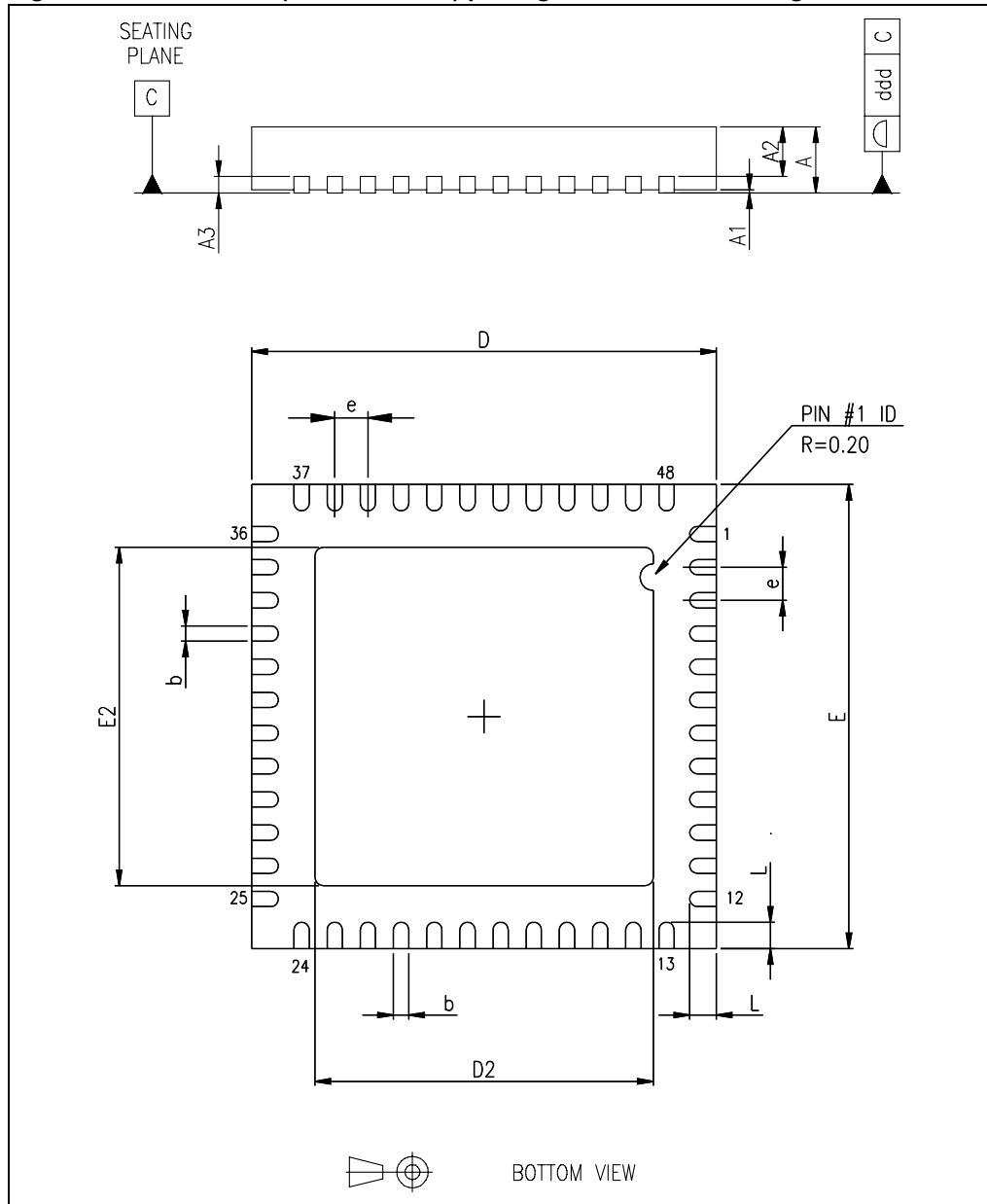
## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

**Table 8. VFQFPN48 (7 x 7 x 1.0 mm) package mechanical data**

Dim.	(mm)		
	Min.	Typ.	Max.
A	0.80	0.90	1.00
A1		0.02	0.05
A2		0.65	1.00
A3		0.25	
b	0.18	0.23	0.30
D	6.85	7.00	7.15
D2	4.95	5.10	5.25
E	6.85	7.00	7.15
E2	4.95	5.10	5.25
e	0.45	0.50	0.55
L	0.30	0.40	0.50
ddd		0.08	

Figure 8. VFQFPN48 (7 x 7 x 1.0 mm) package mechanical drawing



## 5 Revision history

Table 9. Document revision history

Date	Revision	Changes
04-Oct-2011	1	Initial release.

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