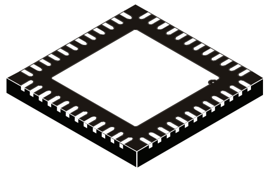
L6370Q

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 ±2kV)



QFN-48
(7 x 7 mm)

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

Contents

1 Block diagram and pin description

Figure 1. Block diagram

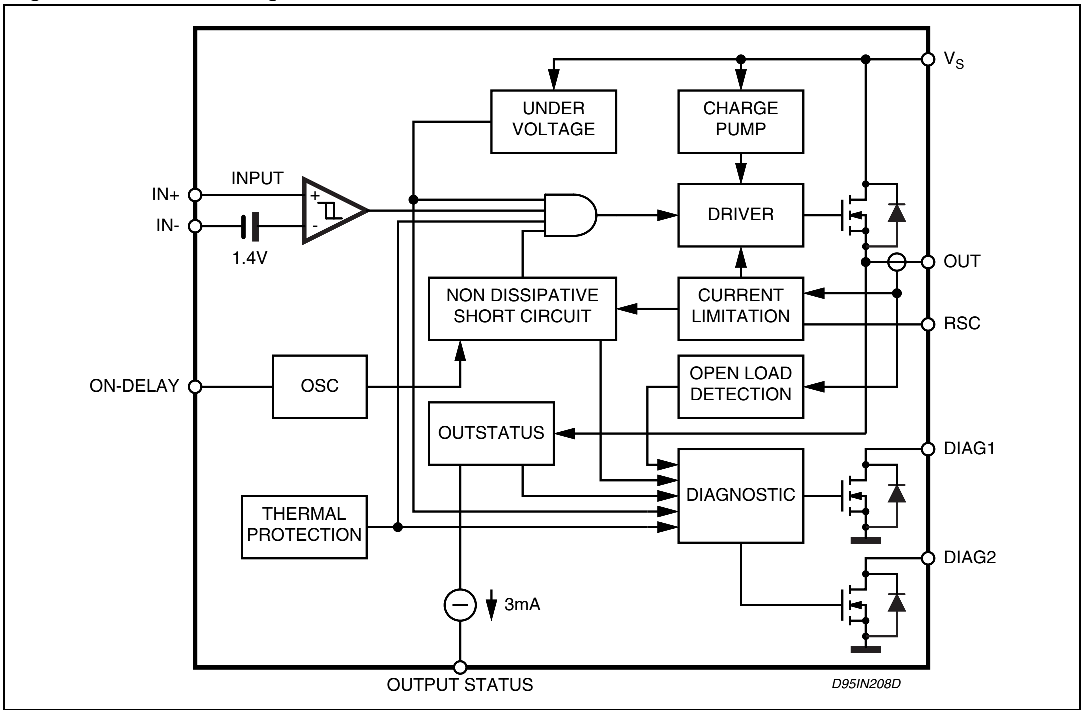
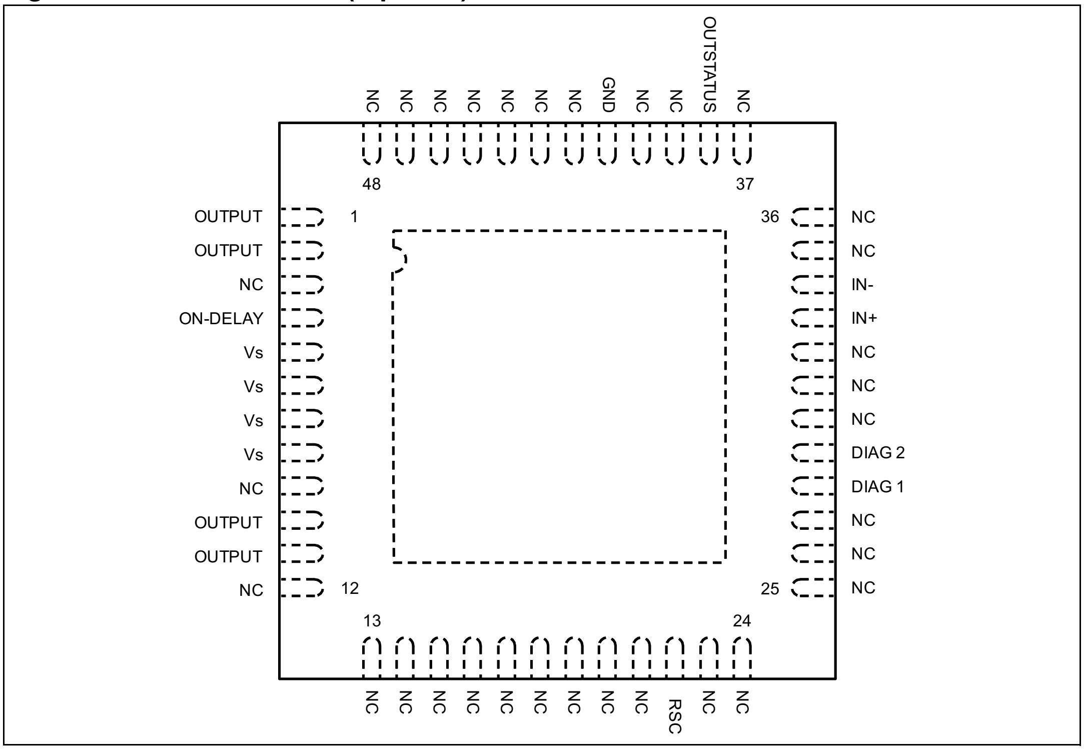


Figure 2. Pin connection (top view)



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 *Table 6.*)

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 *Table 6*.)
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_j=85°C	1	J
P_{TOT}	Power dissipation. Se also thermal characteristics	Internally limited	W
Top	Operating temperature range	-25 to +85	°C
T_{STG}	Storage temperature	-55 to 150	°C

2.2 Thermal data

Table 4. Thermal data

Symbol	Description		Value	Unit
R_{thJC}	Thermal resistance junction to case	Max.	4	°C/W
R_{thJA}	Thermal resistance junction to ambient (1)	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 V; T_J = –25 to +125°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}> 0.5mA; 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 4	mA
V_{sth1}	Undervoltage threshold 1	(See *Figure 4*), T_{amb} = 0 to +85°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 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		200 320	280 440	mV
		I_{out} = 2.5A, T_j = 25°C T_j = 125°C		250 400	350 550	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: T_p = 300 µs	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
I_{ilk}	Input offset current	V +In = V -In +Ii 0V < Vi < 5.5V -Ii	-20 -75	 -25	+20 	µA
		-In = GND +Ii 0V < V+In <5.5V -Ii	 -250	+10 -125	+50 	
		+In = GND +Ii 0V < V-In <5.5V -Ii	-100 -50	-30 -15		

Table 5. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{oth1}	Output status threshold 1 voltage	(See *Figure 3*)	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°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; Idiag= 0.5mA D1 / D2 = L; Idiag= 3mA		40 250		mV
I_{dglk}	Diagnostic leakage current	D1 / D2 = H; 0 < Vdg < 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						
ΘLim	Junction temp. protect.		135	150		°C
ΘTH	Thermal hysteresis			20		°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 = 70Ω; R_l to ground		20		µs
t_d	Delay time			5		µs
dV/dt	Slew rate (rise and fall edge)		0.7	1	1.5	V/µs
t_{ON}	On time during short circuit condition	50pF < C_{DON} < 2nF		1.28		µs/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

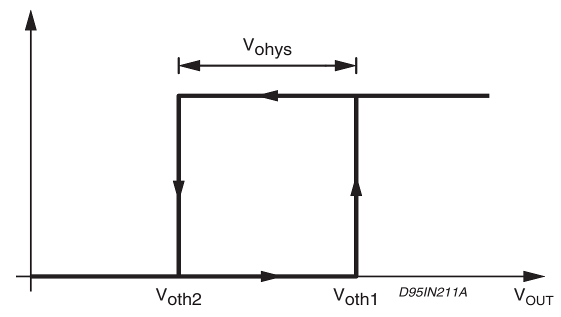


Figure 4. Undervoltage comparator hysteresis

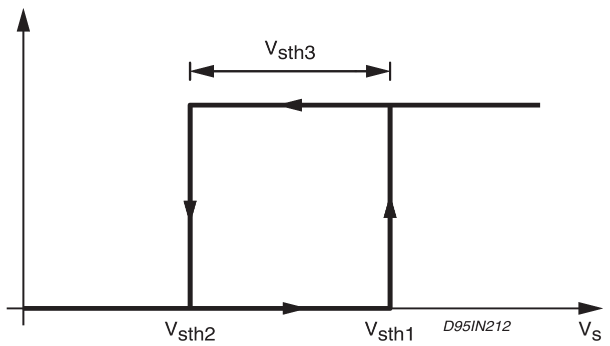
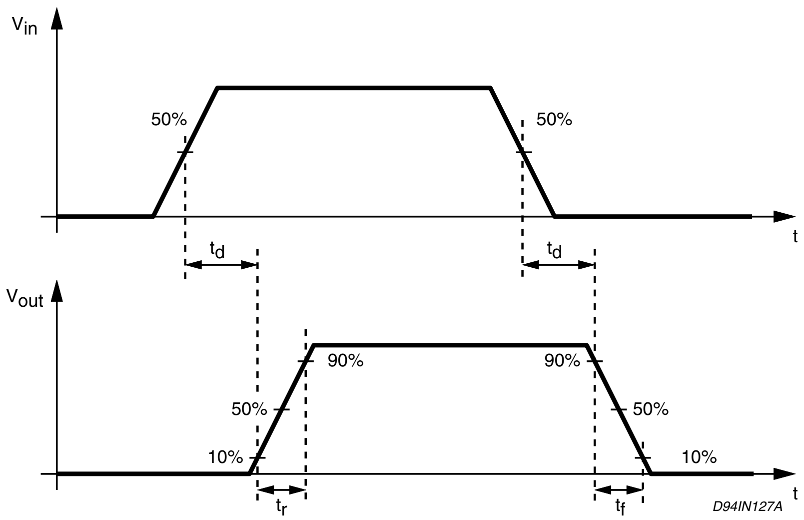


Figure 5. Switching waveforms



3.1 Diagnostic truth table

Table 7. Diagnostic truth table

Diagnostic conditions	Input	Output	Diag1	Diag2
Normal operation	L 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}) (1) (pin ON-DELAY grounded)	H L	X 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

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 Vs.
- 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 Isc current (typically 3.2 A) for a time interval (ton) defined by means of the external CON capacitor connected between the ONDELAY pin and GND. Whether the short circuit crease within the ton 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 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 7*.

3.5 Overtemperature protection (OVT)

If the chip temperature exceeds Qlim (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 Θ_{lim}-Θ_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°C) (see Table 3).

Figure 6. L6370 short circuit operation waveforms

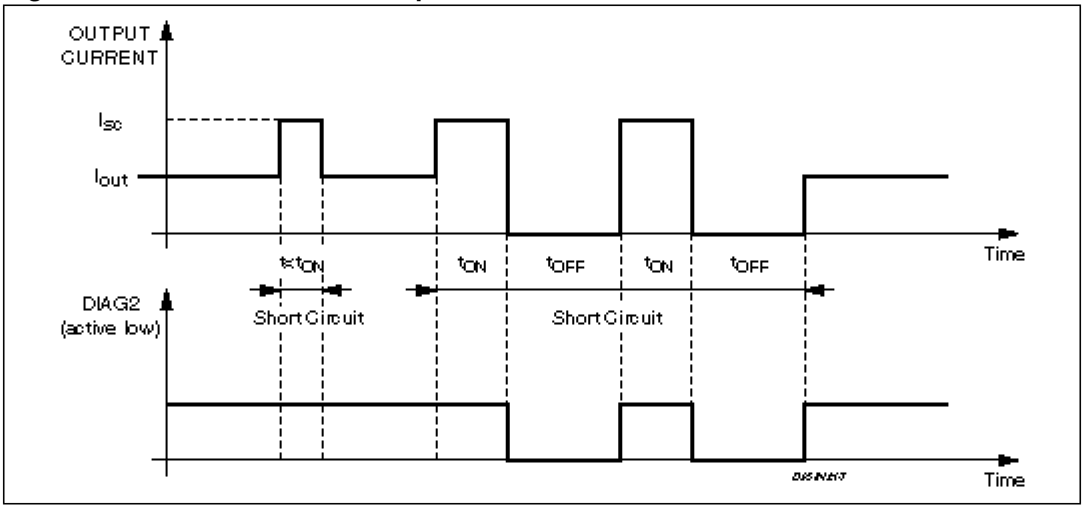
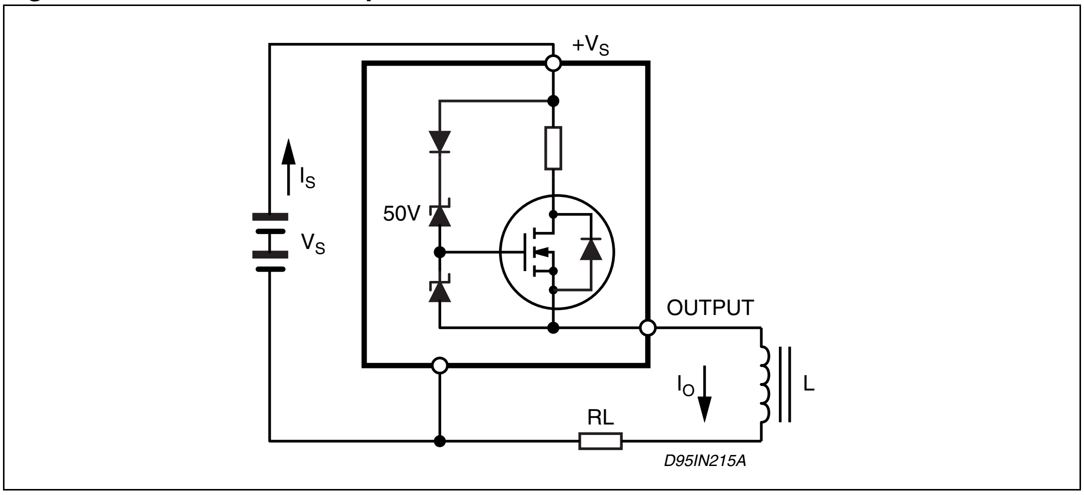


Figure 7. Inductive load equivalent circuit



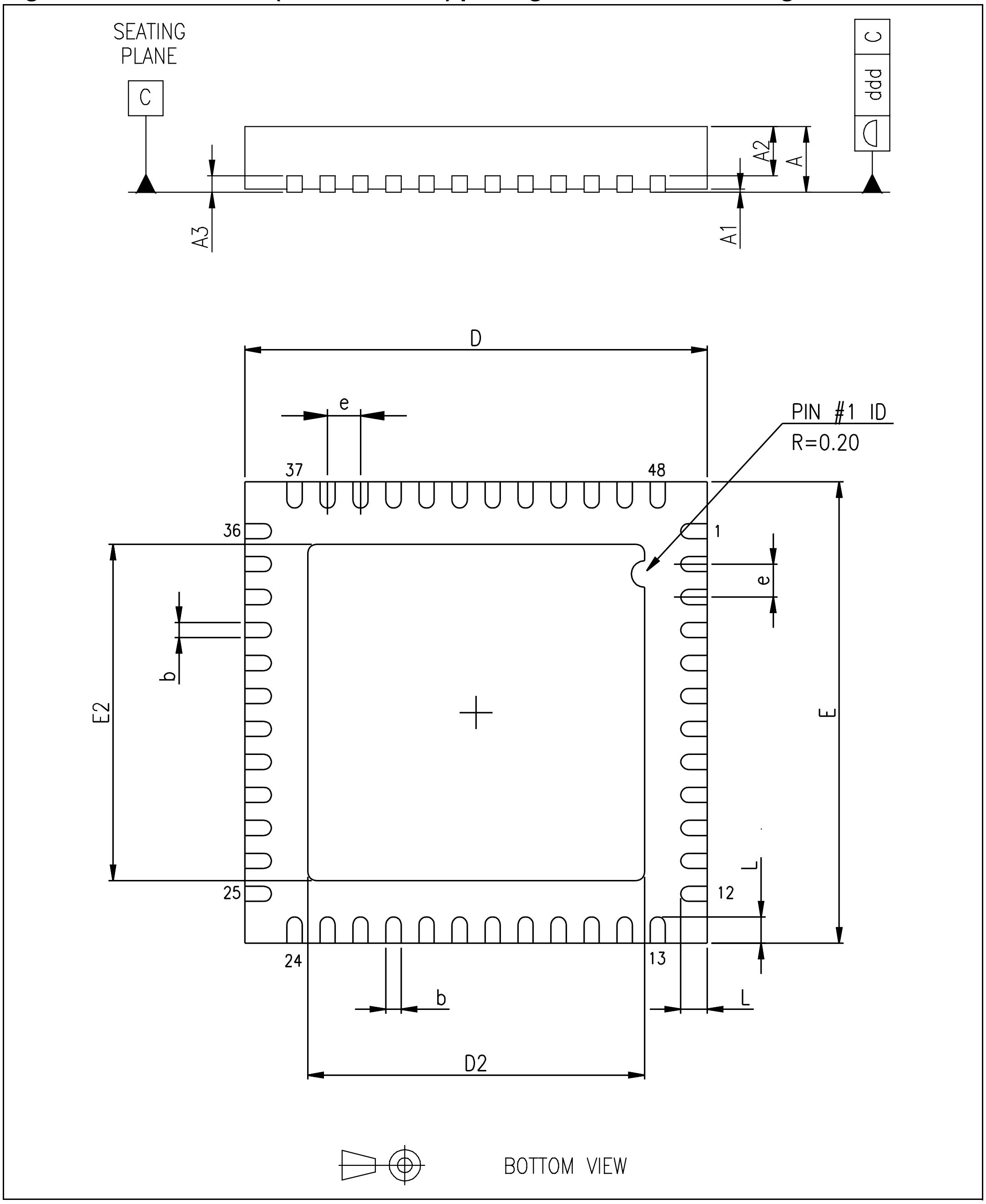
4 Package mechanical data

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. 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.

Please Read Carefully: