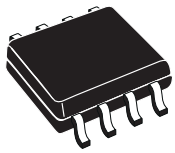
# L6375S

## 0.5 A high-side driver industrial intelligent power switch

## Features

- 0.5 A output current
- 8 V to 35 V supply voltage range
- Internal current limiting
- Thermal shutdown
- Open ground protection
- Internal negative voltage clamping 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
- Immunity against burst transient (IEC 61000-4-4)
- ESD protection (human body model ±2 kV)



**SO-8**

## Description

The L6375S is a monolithic intelligent power switch in BCDmultipower technology, for driving inductive or resistive loads with controlled output voltage slew rate and short-circuit protection.

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**

| Order codes | Op. temp. range | Package | Packaging |
|---|---|---|---|
| L6375S | -25 to +125 °C | SO-8 | Tube |
| L6375STR | | | Tape and reel |

# Contents

# 1 Block diagram and pin description

**Figure 1. Block diagram**

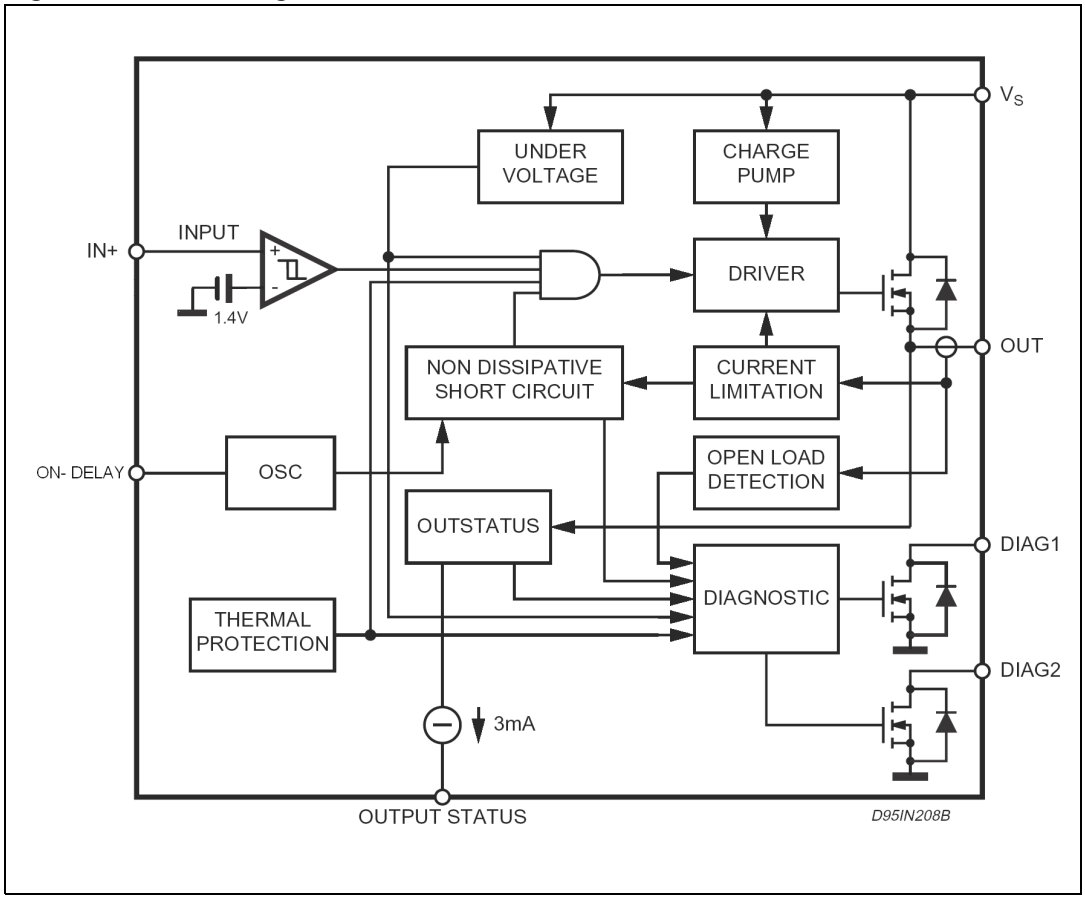
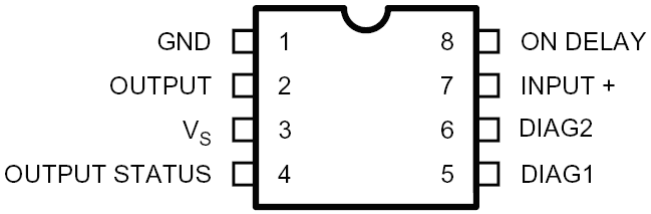


**Figure 2. Pin connection (top view)**




SO-8

## 1.1 Pin description

**Table 2. Pin description**

| Pin n° | Pin name | Function |
|---|---|---|
| 1 | GND | Ground |
| 2 | OUT | High side output with built-in current limitation |
| 3 | $V_S$ | Supply voltage input, the value of the supply voltage is monitored to detect under voltage condition |
| 4 | Output status | 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 *Figure 4*) |
| 5 | DIAG1 | DIAGNOSTIC 1 output. This open drain reports the IC working conditions. (See diagnostic truth *Table 6*) |
| 6 | DIAG2 | DIAGNOSTIC 2 output. This open drain reports the IC working conditions. (See diagnostic truth *Table 6*) |
| 7 | IN+ | Comparator inverting input |
| 8 | ON-DELAY | Programmable ON time interval duration during short circuit operation |

# 2 Electrical specifications

## 2.1 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Supply voltage (tw < 10 ms) | 50 | V |
| $V_S$ | Supply voltage (DC) | 40 | V |
| $V_S$ -$V_{out}$ | Supply to output differential voltage | internally limited | V |
| $V_{od}$ | Externally forced voltage | -0.3 to 7 | V |
| $I_{od}$ | Externally forced current | ±1 | mA |
| $I_{out}$ | Output current (see also Isc) | internally limited | A |
| $V_{out}$ | Output voltage | internally limited | V |
| $P_{TOT}$ | Power dissipation | internally limited | W |
| $V_{diag}$ | External voltage | -0.3 to 40 | V |
| $I_{diag}$ | Externally forced current | -10 to 10 | mA |
| $I_i$ | Input current | 20 | mA |
| $V_i$ | Input voltage | -10 to Vs +0.3 | V |
| $T_{op}$ | Ambient temperature, operating range | -25 to 85 | °C |
| $T_J$ | Junction temperature, operating range (see Overtemperature Protection) | -25 to 125 | °C |
| $T_{STG}$ | Storage temperature | -55 to 150 | °C |
| $E_I$ | Energy inductive load $T_J$ = 85°C | 200 | mJ |

## 2.2 Thermal data

**Table 4. Thermal data**

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $R_{thJA}$ | Thermal resistance junction-ambient | Max | 100(1) | °C/W |
| $R_{thJP}$ | Thermal resistance junction-pins | Max | 15 | °C/W |

1. When mounted on a standard single-sided FR-4 board with 0.5 $cm^2$ of Cu (at least 35 µm) thick connected to all $V_{CC}$ pins. Horizontal mounting and no artificial air flow.

## 2.3 Electrical characteristics

$V_S$ = 24 V; $T_J$ = –25 to +125 °C, unless otherwise specified.

**Table 5. Electrical characteristics**

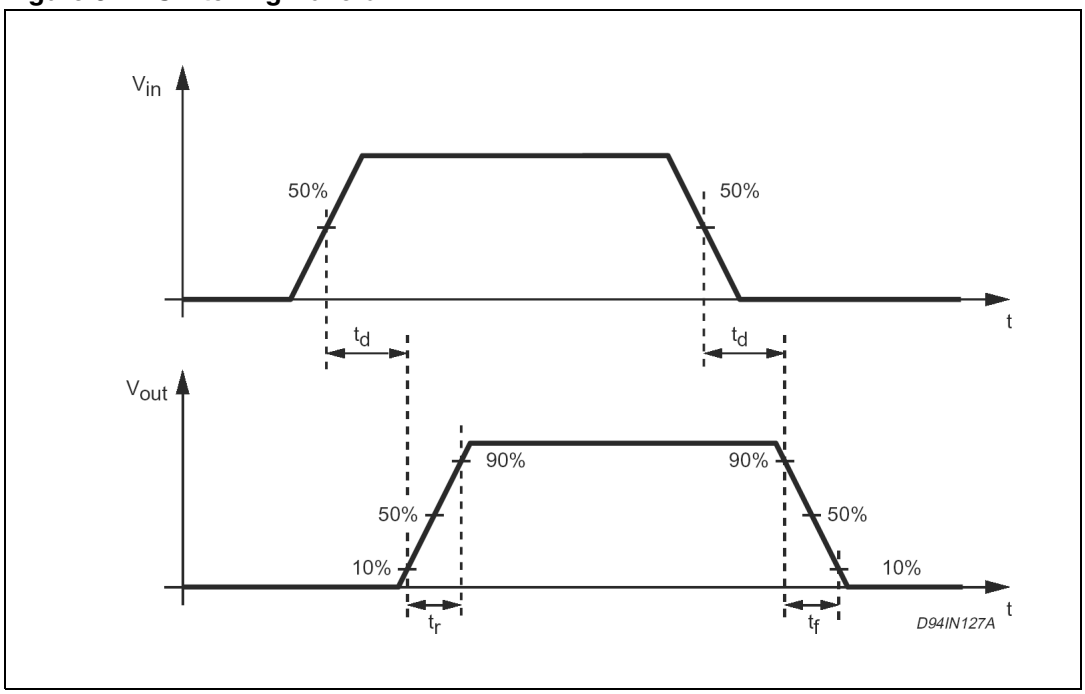
| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{smin}$ | Supply voltage for valid diagnostic | Idiag = > 0.5mA; Vdiag = 1.5V; | 4 | | 35 | V |
| Vs | Operative supply voltage | | 8 | 24 | 35 | V |
| $V_{sth1}$ | Undervoltage threshold 1 | | 7 | 7.5 | 8 | V |
| $V_{sth2}$ | Undervoltage threshold 2 | | 6.5 | 7 | 7.5 | V |
| $V_{shys}$ | Under voltage hysteresis | | 300 | 500 | 700 | mV |
| $I_q$ | Quiescent current | Output open | | 800 | | µA |
| $I_{qo}$ | Quiescent current | Output ON | | 1.6 | | mA |
| $V_{ith}$ | Input threshold voltage | | 0.8 | 1.3 | 2 | V |
| $V_{iths}$ | Input threshold hysteresis | | 50 | | 400 | mV |
| $V_{il}$ | Input low level voltage | | -7 | | 0.8 | V |
| $V_{ih}$ | Input high level voltage | $V_s$ < 18V | 2 | | $V_s$ - 3 | V |
| $V_{ih}$ | Input high level voltage | $V_s$ > 18V | 2 | | 15 | V |
| $I_{ib}$ | Input bias current | $V_i$ = -7 to 15V | -250 | | 250 | µA |
| $I_{dch}$ | Delay capacitor charging current | ON DELAY pin shorted to Ground | | 2.5 | | µA |
| $V_{don}$ | Output voltage drop | Iout = 500mA $T_J$ = 25°C<br>$T_J$ = 125°C<br>Iout =625mA $T_J$ = 25°C<br>$T_J$= 125°C | | 200<br>320<br>250<br>400 | 280<br>440<br>350<br>550 | mV<br>mV<br>mV<br>mV |
| $I_{olk}$ | Output leakage current | $V_i$ = LOW; Vout=0 | | | 100 | µA |
| $V_{ol}$ | Output low state voltage | $V_i$ = HIGH; pin floating | | 0.8 | 1.5 | V |
| $V_{cl}$ | Internal voltage clamp (Vs-Vout) | $I_o$ = 200mA<br>single pulsed = 300ms | 48 | 53 | 58 | V |
| $I_{sc}$ | Short circuit output current | $V_s$ = 8 to 35V; $R_l$ = 2Ω; | 0.75 | 1.1 | 1.5 | A |
| $I_{old}$ | Open load detection current | $V_i$ = $V_{ih}$; $T_A$= 0 to +85°C | 1 | 3 | 6 | mA |
| $V_{oth1}$ | Output status threshold 1 voltage | | 4.5 | 5 | 5.5 | V |
| $V_{oth2}$ | Output status threshold 2 voltage | | 4 | 4.5 | 5 | V |
| $V_{ohys}$ | Output status threshold hysteresis | | 300 | 500 | 700 | mV |
| $I_{osd}$ | Output status source current | Vout > Voth1; Vos = 2.5V | 2 | | 4 | mA |

**Table 5. Electrical characteristics (continued)**

| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{osd}$ | Active output status driver drop voltage | $V_S - V_{OS}$; $I_{OS}$ = 2mA<br>$T_A$ = 0 to +85°C | | 1.5 | 3 | V |
| $I_{oslk}$ | Output status driver leakage current | $V_{out} < V_{oth2}$; $V_{os}$ = 0V<br>$V_S$ = 18 to 35V | | | 25 | µA |
| $V_{dgl}$ | Diagnostic drop voltage | D1 / D2 = L; $I_{diag}$ = 0.5mA<br>D1 / D2 = L; $I_{diag}$ = 3mA | | 40<br>250 | | mV<br>mV |
| $I_{dglk}$ | Diagnostic leakage current | D1 / D2 = H; 0 < $V_{dg}$ < $V_s$<br>$V_S$ = 15.6 to 35V | | | 5 | µA |
| $T_{max}$ | Over temperature upper threshold | | | 150 | | °C |
| $T_{hys}$ | Over temperature hysteresis | | | 20 | | °C |
| **AC operation (pin numbering referred to Minidip package)** | | | | | | |
| $t_r$ -$t_r$ | Rise or fall time | $V_s$ = 24V; $R_l$ =70Ω $R_l$ to ground | | 20 | | µs |
| $t_d$ | Delay time | $V_s$ = 24V; $R_l$ =70Ω $R_l$ to ground | | 5 | | µs |
| dV/dt | Slew rate (rise and fall edge) | | 7 | 1 | 15 | V/µs |
| $t_{ON}$ | On time during short circuit condition | 50pF < $C_{DON}$< 2nF | | 1.28 | | µs/pF |
| $t_{OFF}$ | Off time during short circuit condition | | | 64 | | $t_{ON}$ |
| $f_{max}$ | Maximum operating frequency | | | 25 | | KHz |
| **Source drain NDMOS diode** | | | | | | |
| $V_f$ | Forward on voltage | @ Ifsd = 625mA | | 1 | 1.5 | V |
| $I_{fD}$ | Forward peak voltage | t = 10ms; d = 20% | | | 2 | A |
| $t_{rr}$ | Reverse recovery time | If= 625mA di/dt = 25A/ms | | 200 | | ns |
| $t_{fr}$ | Forward recovery time | | | 50 | | ns |

## 2.4 Switching waveform

**Figure 3. Switching waveform**




## 2.5 Input section

An single ended Input TTL/CMOS compatible with wide voltage range and high noise immunity (thanks to a built in hysteresis) is available.

## 2.6 Overtemperature protection (OVT)

An on-chip over temperature protection provides an excellent protection of the device in extreme conditions. Whenever the temperature - measured on a central portion of the chip exceeds $T_{max}$ = 150 °C (typical value) the device is shut off, and the DIAG2 output goes LOW. Normal operation is resumed as the chip temperature (normally after few seconds) falls below $T_{max}$ - $T_{hys}$ = 130 °C (typical value). The hysteresis avoid that is an intermittent behavior take place.

## 2.7 Undervoltage protection (UV)

The supply voltage is expected to range from 8 to 35 V. In this range the device operates correctly. The supply voltage is continuously monitored to provide an under voltage protection. As $V_s$ falls below $V_{sth}$-$V_{shys}$ (typically 7.5 V, see fig.1) the output power MOS is switched off and DIAG1 and DIAG2 (see Diagnostic truth table). Normal operation is resumed as soon as Vs exceeds Vsth. The hysteretic behavior prevents intermittent operation at low supply voltage.

## 2.8 Overcurrent operation

In order to implement a short circuit protection the output power MOS is driven in linear mode to limit the output current to the $I_{sc}$ (1.1 A typical value). This condition (current limited to the Isc value) lasts for a Ton time interval, that can be set by means of a capacitor ($C_{don}$) connected to the ON DELAY pin according to the following formula:

$T_{on}$ = 1.28 µsec/pF

for

50 pF< $C_{don}$ < 2 nF

After the $T_{on}$ interval has expired the output power MOS is switched off for the $T_{off}$ time interval with:

$T_{off}$ = 64 ·$T_{on}$.

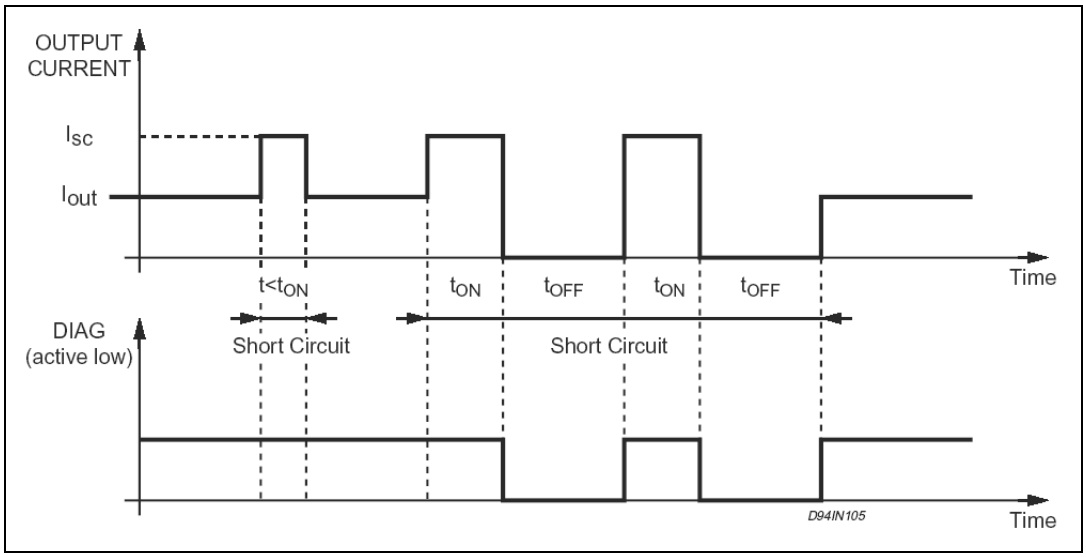
When also the Toff interval has expired, the out-put power MOS is switched ON. At this point in time two conditions may occur

a) The overloads still present, and then the output power MOS is again driven in linear mode (limiting the output current to $I_{SC}$) for another $T_{ON}$, starting a new cycle, or

b) the over load the overload condition is removed, and the output power MOS is no longer driven in linear mode. All these occurrences are presented on the DIAG2 pin (see fig 2).

We call this unique feature non dissipative short circuit protection and it ensures a very safe operation even in permanent overload conditions. Note that choosing the most appropriate value for the Ton interval (i.e. the value of the Cdon capacitor) a delay (the Ton itself) will prevent that a misleading short circuit information is presented on the DIAG2 output, when driving capacitive loads (that acts like short circuit in the very beginning) or incandescent Lamp (a cold filament has a very low resistive value). The non dissipative short circuit protection can be disabled (keeping Ton = 0 but with the output current still limited to Isc, and diagnostic disabled) simply shorting to ground the ON DELAY pin.

**Figure 4. Non dissipative short circuit protection operation**



## 2.9 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 see diagnostic Truth Table.

- Short circuit versus ground.
- Short circuit versus VS.
- Under voltage (UV)
- Over temperature (OVT)
- Open load, if the output current is less than 3 mA (typical value).

## 2.10 Demagnetization of inductive loads

An internal zener diode, limiting the voltage across the Power MOS to between 50 and 60 V (Vcl), 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 200 mJ (at $T_J$ = 85 °C)

## 2.11 Diagnostic truth table

**Table 6. Diagnostic truth table**

| Diagnostic conditions | Input | Output | Diag1 | Diag2 |
|---|---|---|---|---|
| Normal operation | L<br>H | L<br>H | H<br>H | H<br>H |
| Open load condition ($I_o$< $I_{old}$) | L<br>H | L<br>H | H<br>L | H<br>H |
| Short to $V_S$ | L<br>H | H<br>H | L<br>L | H<br>H |
| Short circuit to ground ($I_O$ = $I_{SC}$) (1)<br>(pin ON-DELAY grounded) | H<br>L | X<br>L | H<br>H | H<br>H |
| Output DMOS open | L<br>H | L<br>L | H<br>L | H<br>H |
| Overtemperature | L<br>H | L<br>L | H<br>H | L<br>L |
| Supply undervoltage ($V_S$< $V_{sth2}$) | L<br>H | L<br>L | L<br>L | L<br>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 Application circuits

**Figure 5. Inductive load equivalent circuit**

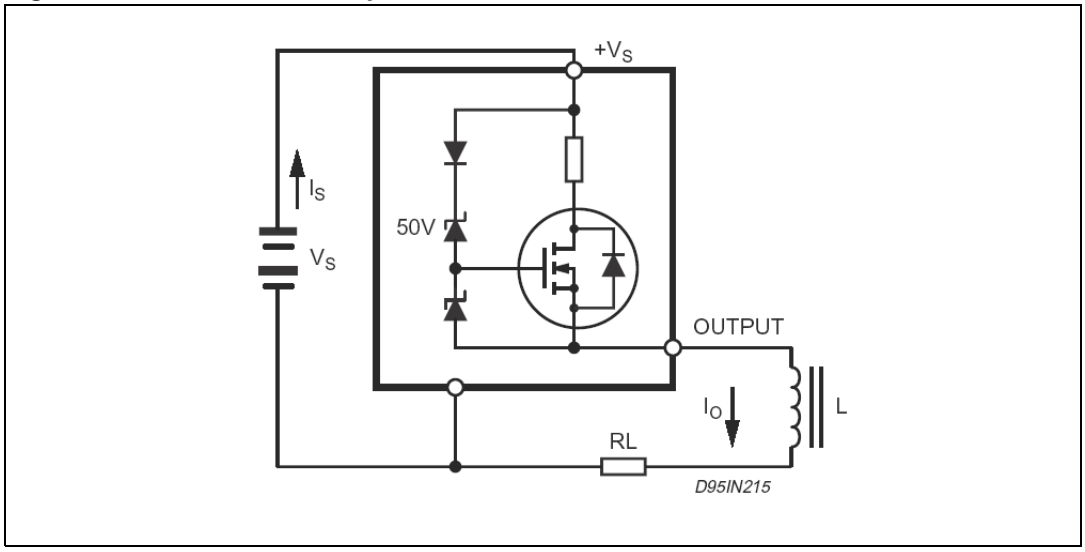



**Figure 6. External demagnetisation circuit (versus ground)**

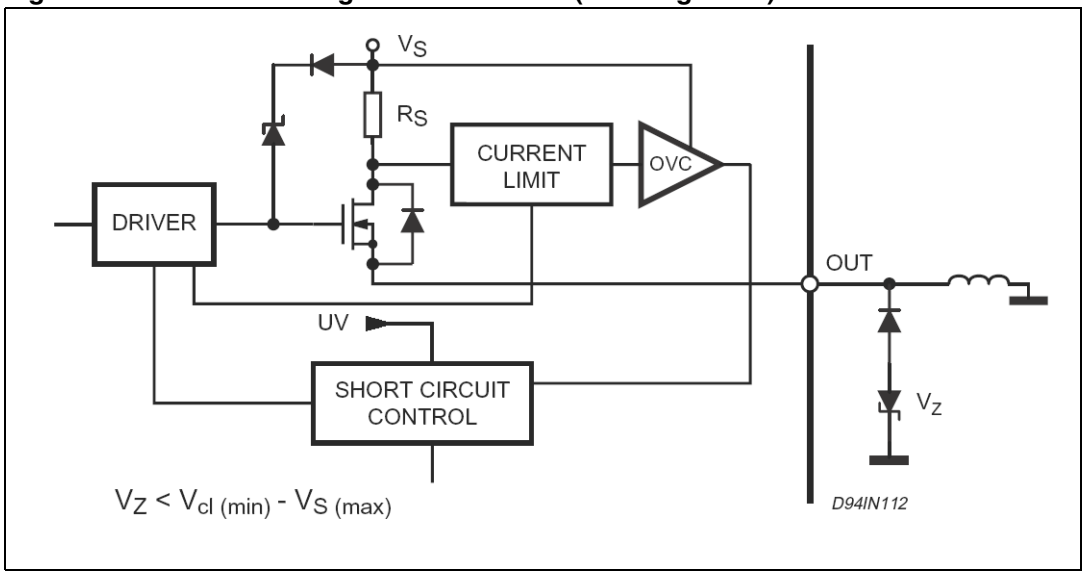


**Figure 7. External demagnetisation circuit (versus vs)**

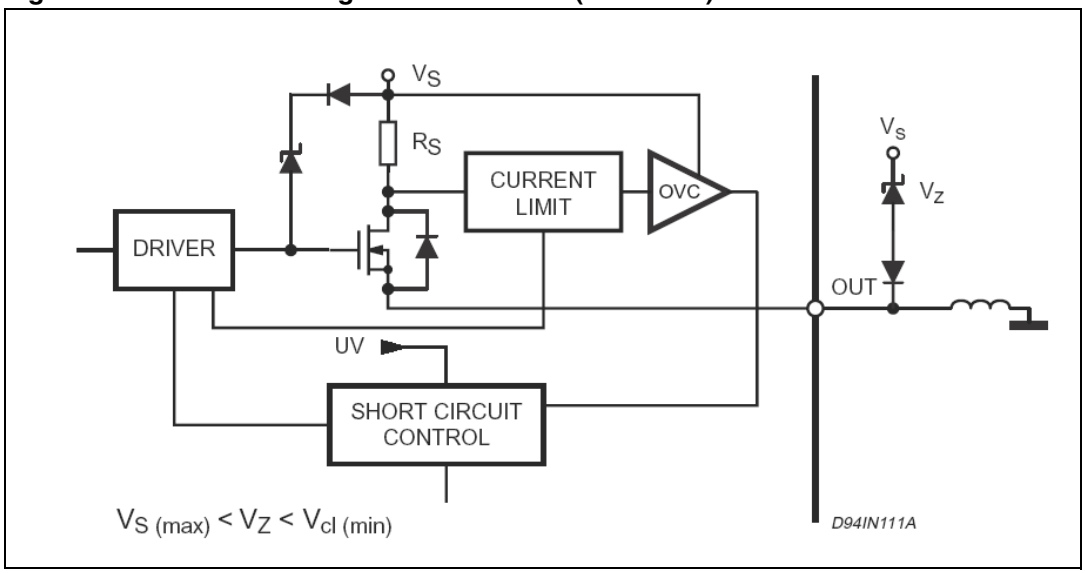
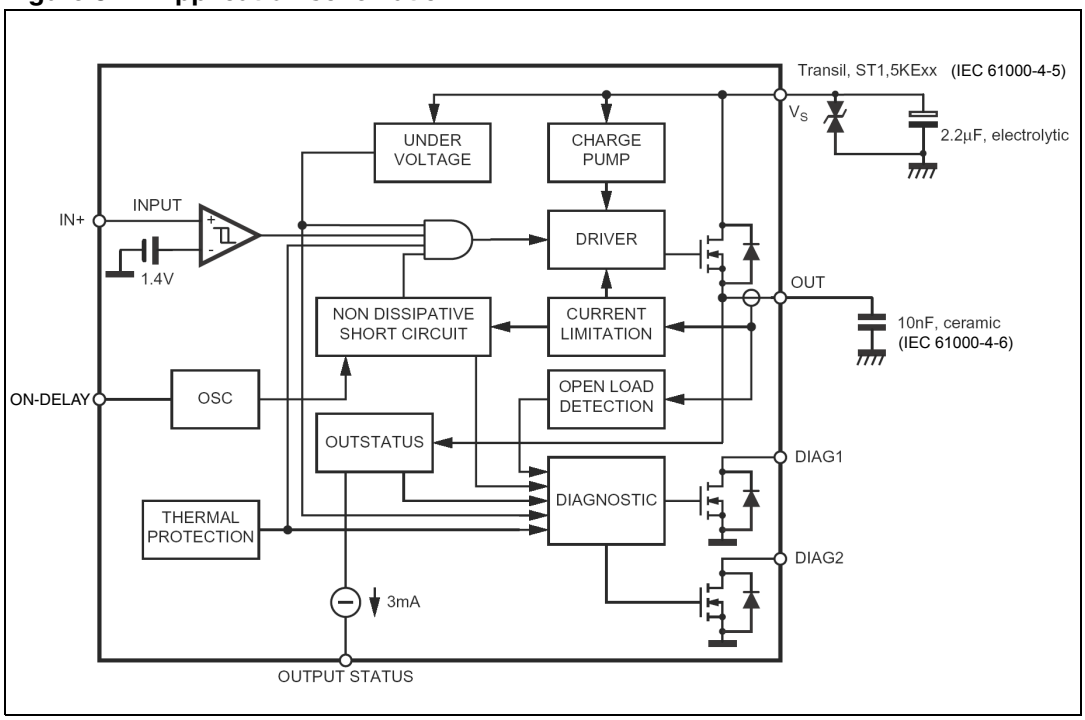



**Figure 8. Application schematic**



# 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 7. SO-8 mechanical data

| Dim. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | Min | Typ | Max | Min | Typ | Max |
| A | | | 1.75 | | | 0.068 |
| a1 | 0.1 | | 0.25 | 0.003 | | 0.009 |
| a2 | | | 1.65 | | | 0.064 |
| a3 | 0.65 | | 0.85 | 0.025 | | 0.033 |
| b | 0.35 | | 0.48 | 0.013 | | 0.018 |
| b1 | 0.19 | | 0.25 | 0.007 | | 0.010 |
| C | 0.25 | | 0.5 | 0.010 | | 0.019 |
| c1 | 45 (typ.) | | | | | |
| D | 4.8 | | 5.0 | 0.188 | | 0.196 |
| E | 5.8 | | 6.2 | 0.228 | | 0.244 |
| e | | 1.27 | | | 0.050 | |
| e3 | | 3.81 | | | 0.150 | |
| F | 3.8 | | 4.0 | 0.14 | | 0.157 |
| L | 0.4 | | 1.27 | 0.015 | | 0.050 |
| M | | | 0.6 | | | 0.023 |
| S | 8º (max.) | | | | | |

Figure 9. Package dimensions

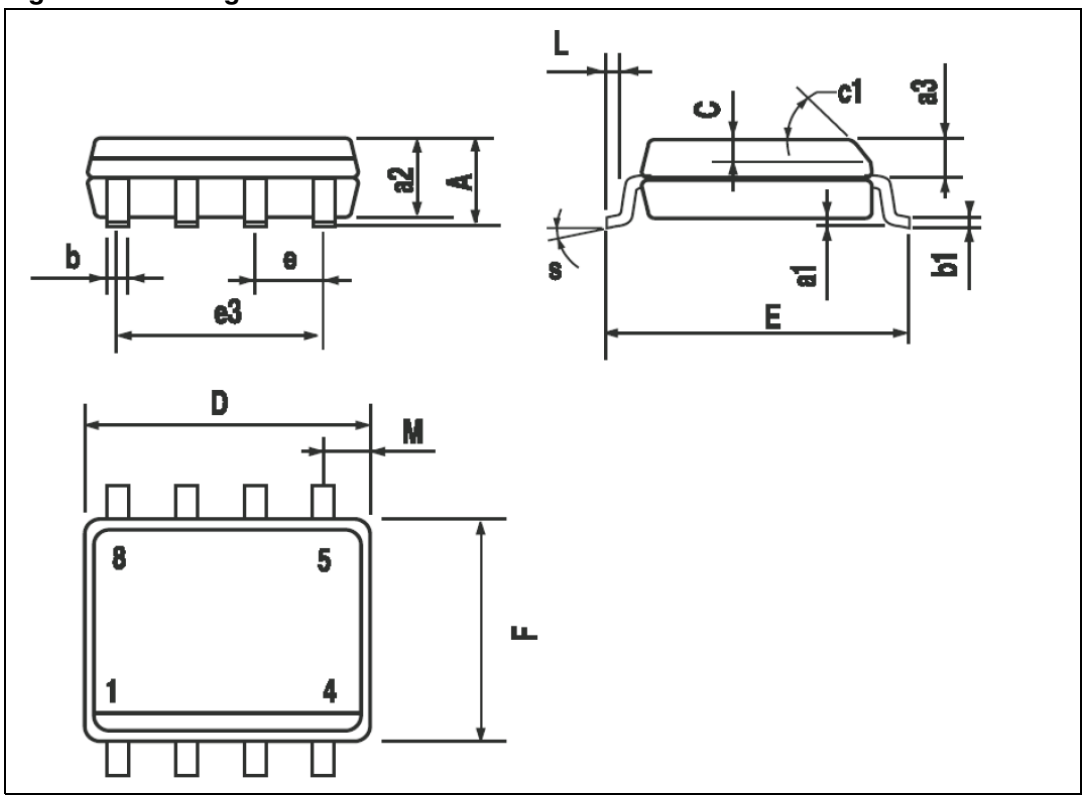
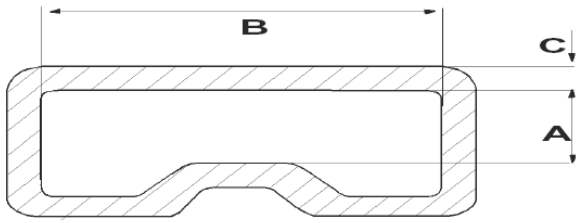
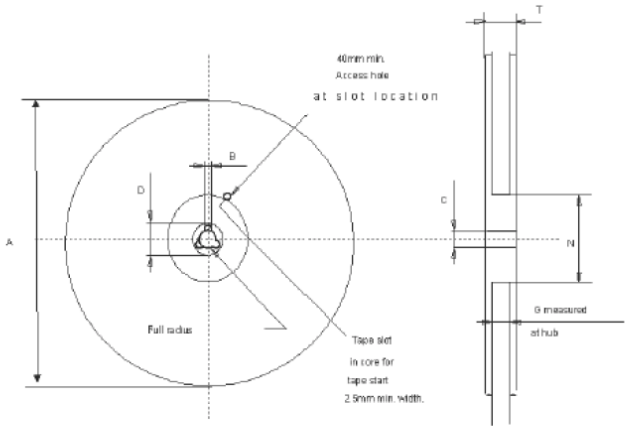


**Figure 10. SO-8 tape and reel information**




| | |
|---|---|
| Base Q.ty | 100 |
| Bulk Q.ty | 2000 |
| Tube Length( ± 0.5) | 532 |
| A | 3.2 |
| B | 6 |
| C( ± 0.1) | 0.6 |




Reel Dimension

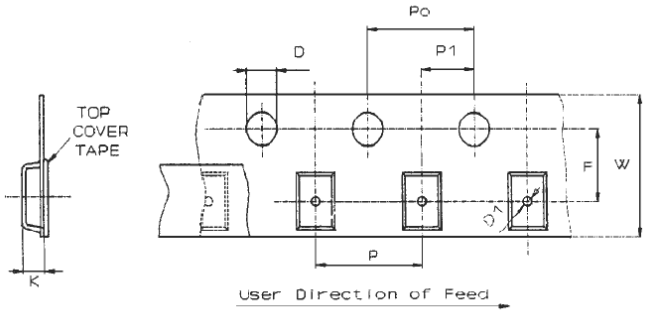
| | |
|---|---|
| Base Q.ty | 2500 |
| Bulk Q.ty | 2500 |
| A(Max) | 330 |
| B(Min) | 1.5 |
| C( ± 0.2 ) | 13 |
| F | 20.2 |
| G( +2/-0 ) | 12.4 |
| N( Min ) | 60 |
| T( Max ) | 18.4 |

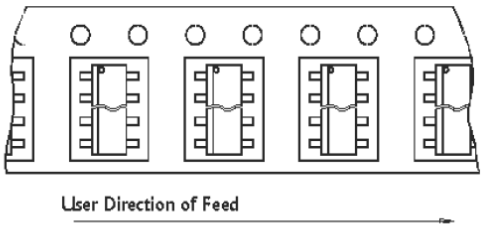
Tape Dimension

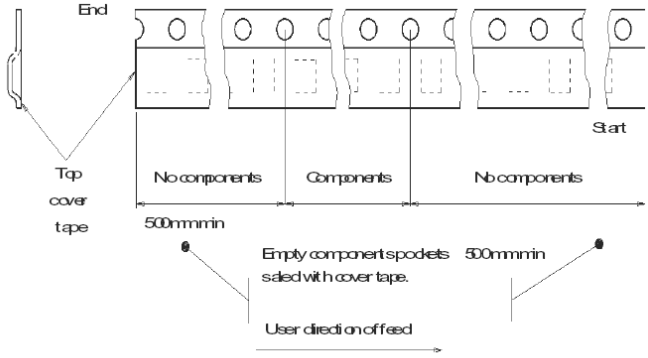
According to Electronic Industries Association(EIA) Standard 481 rev. A, Feb 1986

| | | |
|---|---|---|
| Tape Width | W | 12 |
| Tape Hole Spacing | P0 ( ± 0.1 ) | 4 |
| Component Spacing | P | 8 |
| Hole Diameter | D( ± 0.2/-0 ) | 1.5 |
| Hole Diameter | D1( Min ) | 1.5 |
| Hole Position | F( ± 0.05 ) | 5.5 |
| Compartament Depth | K( Max ) | 4.5 |
| Hole Spacing | P1( ± 0.1) | 2 |

All dimension are in mm.



# 5 Revision history

Table 8. Revision history

| Date | Revision | Changes |
|---|---|---|
| 18-Sep-2006 | 1 | Initial release |
| 19-Jun-2007 | 2 | Truth table updated |
| 05-Jul-2007 | 3 | Typo in *Table 5 on page 6* |
| 16-Jul-2007 | 4 | Pin out updated |
| 15-Oct-2007 | 5 | Updated *Table 4 on page 5* |
| 29-Jun-2009 | 6 | Updated *Table 5 on page 6* |
| 12-Mar-2010 | 7 | Updated *Table 5 on page 6* |

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