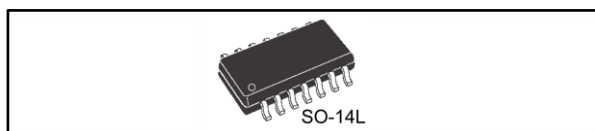


## 0.5 A high-side driver quad intelligent power switch

Datasheet - production data



- Protection against surge transient (IEC 61000-4-5)
- Immunity against burst transient (IEC 61000-4-4)

### Features

- Multipower BCD technology
- 0.5 A output current
- 8 to 35 V supply voltage range
- External programmable current limit
- Non-dissipative overcurrent protection
- Thermal shutdown
- Undervoltage lockout with hysteresis
- Diagnostic output for undervoltage, overtemperature and overcurrent
- External asynchronous reset input
- Presetable delay for overcurrent diagnostic
- Open ground protection

### Description

This device is a monolithic intelligent power switch in multipower BCD technology to drive inductive, capacitive or resistive loads. Diagnostic for CPU feedback and extensive use of electrical protections make this device robust and suitable for general purpose industrial applications.

**Table 1: Device summary**

| Order code  | Package | Packing       |
|-------------|---------|---------------|
| L6377D      | SO-14L  | Tube          |
| L6377D013TR |         | Tape and reel |

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# 1 Pin connections

Figure 1: Pin connections (top view)

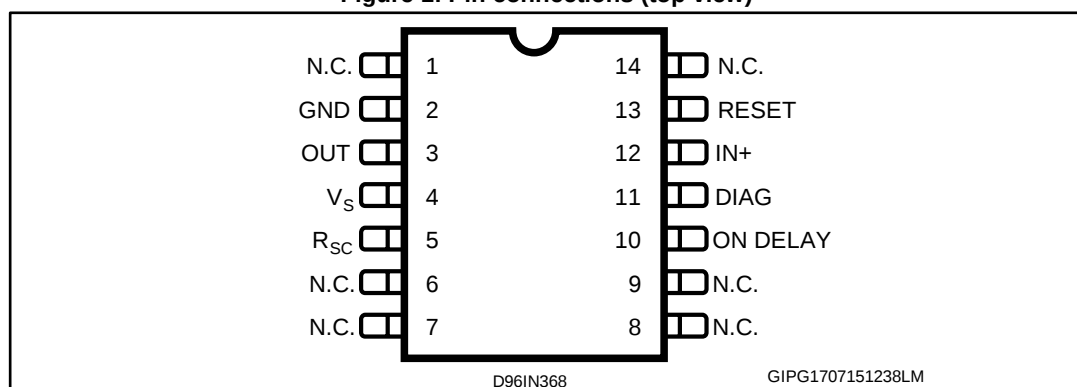


Table 2: Pin description

| Pin               | Pin name        | Function                                                                       |
|-------------------|-----------------|--------------------------------------------------------------------------------|
| 1, 6, 7, 8, 9, 14 | N.C.            | Not connected                                                                  |
| 2                 | GND             | Ground pin                                                                     |
| 3                 | OUT             | High-side output. Controlled output with current limitation                    |
| 4                 | V <sub>S</sub>  | Supply voltage. Range with undervoltage monitoring                             |
| 5                 | R <sub>SC</sub> | Current limiting setting                                                       |
| 10                | ON DELAY        | Delay setting for overcurrent diagnostic                                       |
| 11                | DIAG            | Diagnostic open drain output for overtemperature, undervoltage and overcurrent |
| 12                | IN+             | Comparator non-inverting input                                                 |
| 13                | RESET           | Asynchronous reset input                                                       |

## 2 Maximum ratings

Table 3: Absolute maximum ratings

| Symbol          | Parameter                                         | Value              | Unit |
|-----------------|---------------------------------------------------|--------------------|------|
| $V_S$           | Pin 4: supply voltage ( $t_w \leq 10$ ms)         | 50                 | V    |
|                 | Pin 4: supply voltage (DC)                        | 40                 | V    |
| $V_S - V_{OUT}$ | Pin 4 vs 3: supply to output differential voltage | Internally limited | V    |
| $V_{od}$        | Pin 10: externally forced voltage                 | -0.3 to 7          | V    |
| $I_{od}$        | Pin 10: externally forced current                 | $\pm 1$            | mA   |
| $I_{RESET}$     | Pin 13: reset input current (forced)              | $\pm 2$            | mA   |
| $V_{RESET}$     | Pin 13: reset input voltage                       | -0.3 to 40         | V    |
| $I_{out}$       | Pin 3: output current                             | Internally limited |      |
| $V_{out}$       | Pin 3: output voltage                             | Internally limited | W    |
| $E_{il}$        | Total energy inductive load: ( $T_J = 125$ °C)    | 50                 | mJ   |
| $P_{tot}$       | Power dissipation                                 | Internally limited |      |
| $V_{diag}$      | Pin 11: external voltage                          | -0.3 to 40         | V    |
| $I_{diag}$      | Pin 11: externally forced current                 | -10 to 10          | mA   |
| $I_i$           | Pin 12: input current                             | 20                 | mA   |
| $V_i$           | Pin 12: input voltage                             | -10 to $V_S + 0.3$ | V    |
| $T_{op}$        | Ambient temperature, operating range              | -25 to 85          | °C   |
| $T_J$           | Junction temperature, operating range             | -25 to 125         | °C   |
| $T_{stg}$       | Storage temperature                               | -55 to 150         | °C   |

Table 4: Thermal data

| Symbol       | Parameter                           | Value    | Unit |
|--------------|-------------------------------------|----------|------|
| $R_{th(JA)}$ | Thermal resistance junction-ambient | 150 max. | °C/W |

### 3 Electrical characteristics

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

Table 5: Electrical characteristics

| Symbol            | Pin | Parameter                                                   | Test conditions                                           | Min. | Typ. | Max.              | Unit |
|-------------------|-----|-------------------------------------------------------------|-----------------------------------------------------------|------|------|-------------------|------|
| DC operation      |     |                                                             |                                                           |      |      |                   |      |
| V <sub>smin</sub> | 4   | Supply voltage for valid diagnostic                         | I <sub>diag</sub> ≥ 0.5 mA;<br>V <sub>diag</sub> = 1.5 V; | 4    |      | 35                | V    |
| V <sub>S</sub>    |     | Operative supply voltage                                    |                                                           | 8    | 24   | 35                | V    |
| V <sub>sth</sub>  |     | Undervoltage lower treshold                                 |                                                           | 7    |      | 8                 | V    |
| V <sub>shys</sub> |     | Undervolatge hysteresis                                     |                                                           | 300  | 500  | 700               | mV   |
| I <sub>q</sub>    |     | Quiescent current                                           | Output pen                                                |      | 800  |                   | μA   |
| I <sub>qo</sub>   |     |                                                             | Output on                                                 |      | 1.6  |                   | mA   |
| V <sub>ith</sub>  | 12  | Input threshold voltage                                     |                                                           | 0.8  | 1.3  | 2                 | V    |
| V <sub>iths</sub> |     | Input threshold hysteresis                                  |                                                           | 50   |      | 400               | mV   |
| V <sub>il</sub>   |     | Input low level voltage                                     |                                                           | -7   |      | 0.8               | V    |
| V <sub>ih</sub>   |     | Input high level voltage                                    | V <sub>S</sub> < 18 V                                     | 2    |      | V <sub>S</sub> -3 | V    |
|                   |     |                                                             | V <sub>S</sub> >18 V                                      | 2    |      | 15                |      |
| I <sub>ib</sub>   |     | Input bias current                                          | V <sub>i</sub> = -7 to 15 V                               | -250 |      | 250               | μA   |
| V <sub>rth</sub>  | 13  | Reset threshold voltage                                     |                                                           | 0.8  | 1.3  | 2                 | V    |
| V <sub>rl</sub>   |     | Reset low level voltage                                     |                                                           | 0    |      | 0.8               | V    |
| V <sub>rh</sub>   |     | Reset high level voltage                                    |                                                           | 2    |      | 40                | V    |
| I <sub>rb</sub>   |     | Reset pull down current                                     |                                                           |      | 5    |                   | μA   |
| I <sub>dch</sub>  | 10  | Delay capacitor charging current                            | ON delay pin shorted-to-ground                            |      | 2.5  |                   | μA   |
| V <sub>rsc</sub>  | 5   | Output voltage on R <sub>SC</sub> pin                       | R <sub>SC</sub> pin floating                              |      | 1.25 |                   | V    |
| I <sub>rsc</sub>  |     | Output current on R <sub>SC</sub> pin                       | R <sub>SC</sub> pin shorted-to-GND                        |      |      | 300               | μA   |
| I <sub>dlkg</sub> | 11  | Diagnostic output leakage current                           | Diagnostic off                                            |      |      | 25                | μA   |
| V <sub>diag</sub> |     | Diagnostic output voltage drop                              | I <sub>diag</sub> = 5 mA                                  |      |      | 1.5               | V    |
| V <sub>don</sub>  | 3   | Output voltage drop                                         | I <sub>out</sub> = 625 mA<br>T <sub>J</sub> = 25 °C       |      | 250  | 350               | mV   |
|                   |     |                                                             | I <sub>out</sub> = 625 mA<br>T <sub>J</sub> = 125 °C      |      | 400  | 500               |      |
| I <sub>olk</sub>  |     | Output leakage current                                      | V <sub>i</sub> = low; V <sub>out</sub> = 0                |      |      | 100               | μA   |
| V <sub>ol</sub>   |     | Output low-state voltage                                    | V <sub>i</sub> = high; pin floating                       |      | 0.8  | 1.5               | V    |
| V <sub>cl</sub>   |     | Internal voltage clamp (V <sub>S</sub> - V <sub>out</sub> ) | I <sub>o</sub> = 200 mA single pulsed = 300 ms            | 48   | 53   | 58                | V    |

| Symbol                          | Pin | Parameter                               | Test conditions                                                                   | Min.                                                                  | Typ. | Max. | Unit            |
|---------------------------------|-----|-----------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------|------|------|-----------------|
| I <sub>sc</sub>                 |     | Short-circuit output current            | V <sub>s</sub> = 8 to 35 V;<br>R <sub>I</sub> = 2 Ω; R <sub>sc</sub> = 5 to 30 kΩ | 5/R <sub>sc</sub> = kΩ                                                |      |      | A               |
| T <sub>max.</sub>               |     | Overtemperature upper threshold         |                                                                                   |                                                                       | 150  |      | °C              |
| T <sub>hys</sub>                |     | Overtemperature hysteresis              |                                                                                   |                                                                       | 20   |      | °C              |
| AC operation                    |     |                                         |                                                                                   |                                                                       |      |      |                 |
| t <sub>r</sub> - t <sub>f</sub> | 3   | Rise or fall time                       | V <sub>s</sub> = 24 V; R <sub>I</sub> = 70 Ω R <sub>I</sub> to ground             |                                                                       | 20   |      | μs              |
| t <sub>d</sub>                  |     | Delay time                              |                                                                                   |                                                                       | 5    |      |                 |
| dV/dt                           |     |                                         | Slew rate (rise and fall edge)                                                    | V <sub>s</sub> = 24 V; R <sub>I</sub> = 70 Ω R <sub>I</sub> to ground | 0.7  | 1    | 1.5             |
| t <sub>ON</sub>                 | 10  | On-time during short-circuit condition  | 50 pF < C <sub>DON</sub> < 2 nF                                                   |                                                                       | 1.28 |      | μs/pF           |
| t <sub>OFF</sub>                |     | Off-time during short-circuit condition |                                                                                   |                                                                       | 64   |      | t <sub>ON</sub> |
| f <sub>max.</sub>               |     | Maximum operating frequency             |                                                                                   |                                                                       | 25   |      | kHz             |
| Source drain NDMOS diode        |     |                                         |                                                                                   |                                                                       |      |      |                 |
| V <sub>fSD</sub>                |     | Forward on voltage                      | I <sub>fSD</sub> = 625 mA                                                         |                                                                       | 1    | 1.5  | V               |
| I <sub>fp</sub>                 |     | Forward peak current                    | t <sub>p</sub> = 10 ms; duty cycle = 20%                                          |                                                                       |      | 1.5  | A               |
| t <sub>rr</sub>                 |     | Reverse recovery time                   | I <sub>fSD</sub> = 500 mA;<br>dI <sub>fSD</sub> /dt = 25 A/μs                     |                                                                       | 200  |      | ns              |
| t <sub>fr</sub>                 |     | Forward recovery time                   |                                                                                   |                                                                       | 50   |      | ns              |

### 3.1 Schematic diagram

Figure 2: Block diagram

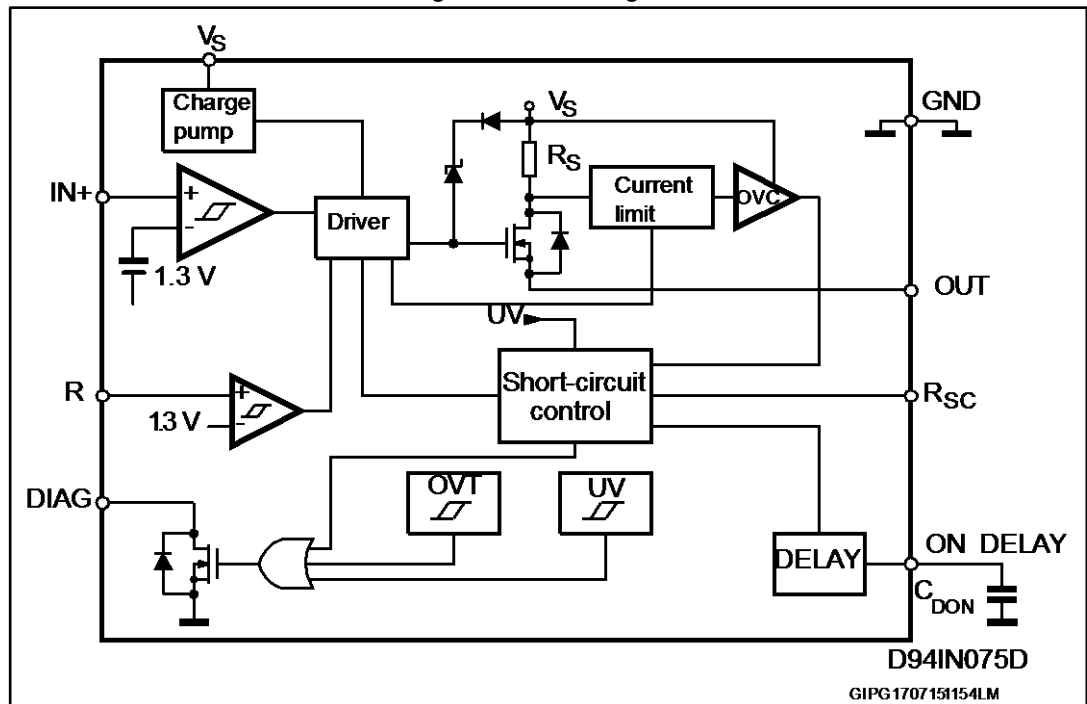


Figure 3: Undervoltage comparator hysteresis

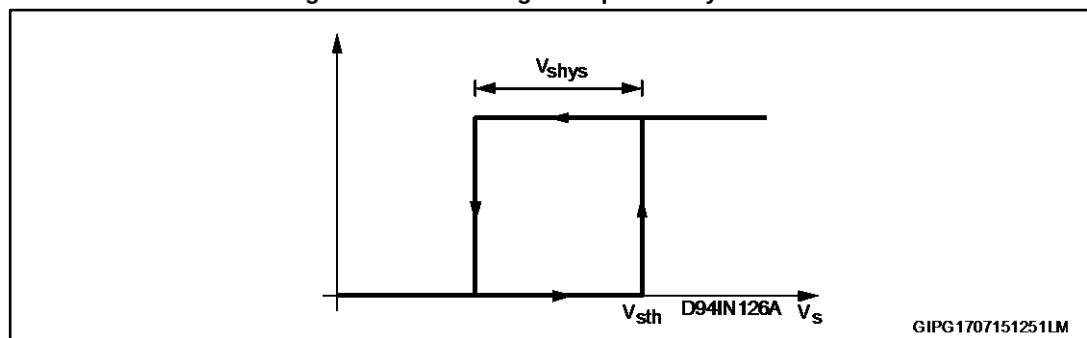
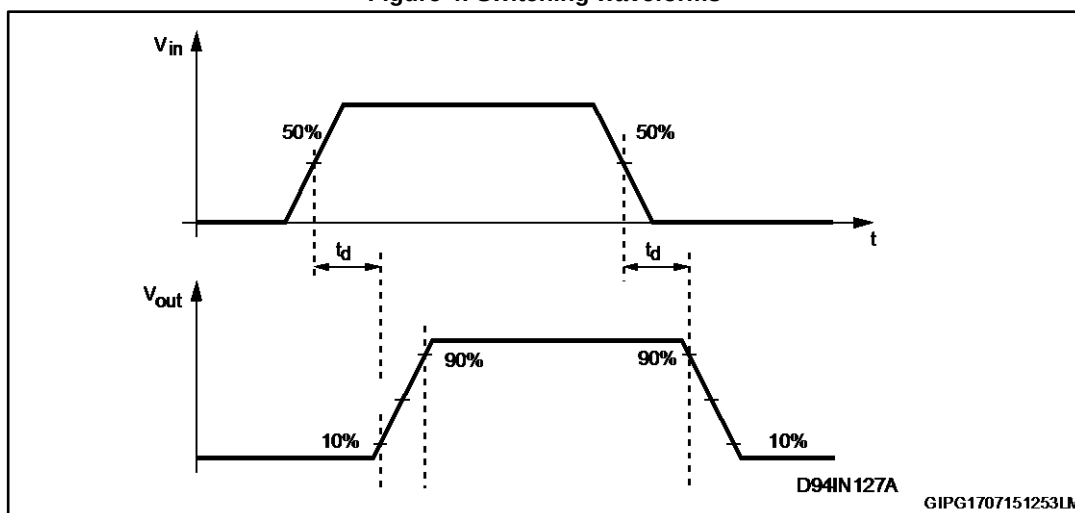


Figure 4: Switching waveforms



### 3.2 Input section

An input and asynchronous reset, TTL/CMOS compatible with wide voltage range and high noise immunity (thanks to a built-in hysteresis) is available.

### 3.3 Overtemperature protection

An on-chip overtemperature protection provides an excellent protection of the device in extreme conditions. Whenever the temperature, measured on a central portion of the chip, exceeds  $T_{max.} = 150\text{ }^{\circ}\text{C}$  (typical value) the device shuts down, and the DIAG output goes low. Normal operation is resumed as the chip temperature (normally after few seconds) falls below  $T_{max.} - T_{hys} = 130\text{ }^{\circ}\text{C}$  (typical value). The hysteresis avoids that an intermittent behavior occurs.

### 3.4 Undervoltage protection

The supply voltage operates correctly in a range from 8 to 35 V. Below 8 V the overall system has to be considered not reliable. To avoid any malfunctioning, the supply voltage is continuously monitored to provide an undervoltage protection. As  $V_s$  falls below  $V_{sth} - V_{shys}$  (typically 7.5 V, see [Figure 4: "Switching waveforms"](#)) the output power MOSFET switches off and DIAG output goes low. Normal operation is resumed as soon as  $V_s$  exceeds  $V_{sth}$ . The hysteretic behaviour prevents intermittent operation at low supply voltage.

## 4 Overcurrent operation

In order to implement a short-circuit protection, the output power MOSFET is driven to linear mode to limit the output current to the  $I_{SC}$  value. This  $I_{SC}$  limit is externally set by an external 1/4 W resistor connected from  $R_{SC}$  pin and GND. The value of the resistor must be chosen according to the following formula:

### Equation 1:

$$I_{SC} (A) = 5/R_{SC} (kohm) \text{ with } 5 < R_{SC} < 30 (kohm).$$

Concerning  $R_{SC} < 5 (kohm)$   $I_{SC}$  is limited to  $I_{SC} = 1.1 A$  (typical value).

This condition (current limited to the  $I_{SC}$  value) lasts for a  $t_{ON}$  time interval, that can be set by a capacitor ( $C_{DON}$ ) connected to the ON DELAY pin according to the following formula:

### Equation 2:

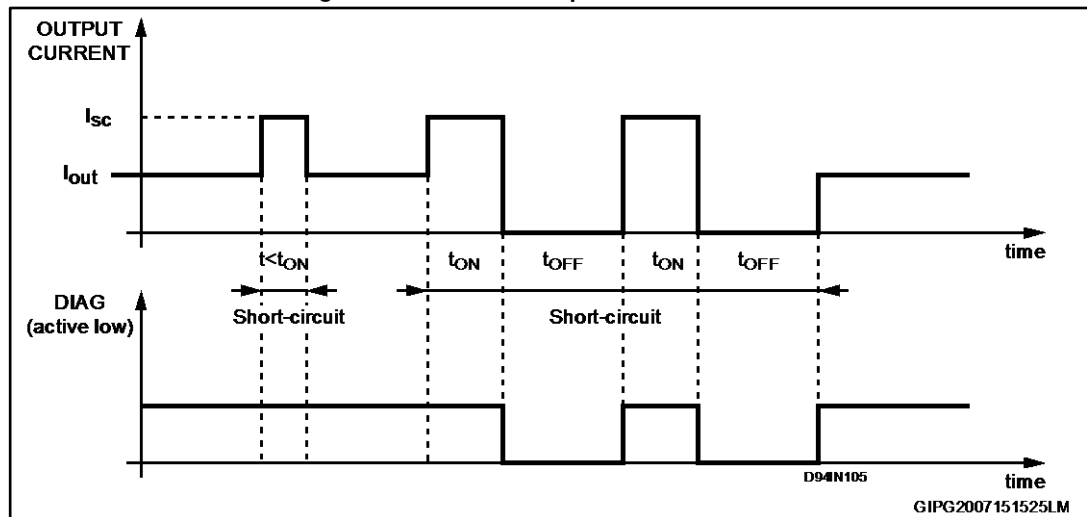
$$t_{ON} = 1.28 \mu\text{sec/pF} \text{ for } 50 \text{ pF} < C_{DON} < 2 \text{ nF}$$

After the  $t_{ON}$  interval has expired the output power MOSFET switches off for the  $t_{OFF}$  time interval:

### Equation 3:

$$t_{OFF} = 64 \cdot t_{ON}.$$

Figure 5: Short-circuit operation waveforms



When the  $t_{OFF}$  interval has expired, the output power MOSFET switches on. In this manner two conditions may occur:

- the overload is still present. In this case, the output power MOSFET is again driven to linear mode (limiting the output current to  $I_{SC}$ ) for another  $t_{ON}$ , starting a new cycle
- the overload condition is removed, and the output power MOSFET is no longer driven to linear mode

Please, see the DIAG pin (see [Figure 5: "Short-circuit operation waveforms"](#)). This unique feature is called short-circuit protection and it ensures a very safe operation even in permanent overload conditions. Note that, the choice of the most appropriate value for the  $t_{ON}$  interval (the value of the  $C_{DON}$  capacitor), a delay (the  $t_{ON}$  itself) prevents a misleading short-circuit information is presented on the DIAG output, when capacitive loads are driven

or incandescent lamp (a cold filament has a very low resistive value). The non-dissipative short-circuit protection can be disabled (keeping  $t_{ON} = 0$  but with the output current still limited to  $I_{SC}$ , and diagnostic disabled) simply shorting to ground the ON DELAY pin.

## 5 Demagnetization of inductive loads

The L6377 has an internal clamping Zener diode, which demagnetises inductive loads. Note that the limitation comes from the peak power that the package can handle. Attention must be paid to a proper thermal design of the board. If load current or inductive value are too big, the peak power dissipation is too high, an external Zener plus diode can perform a demagnetisation versus ground or versus  $V_s$  (see [Figure 5: "Short-circuit operation waveforms"](#) and [Figure 6: "Input comparator hysteresis"](#)). The breakdown voltage of the external Zener diode must be chosen considering the internal clamping voltage ( $V_{cl}$ ) and the supply voltage ( $V_s$ ) according to:

**Equation 4:**

$$V_Z < V_{cl(min.)} - V_{s(max.)}$$

for demagnetisation versus ground or

**Equation 5:**

$$V_{s(max.)} < V_Z < V_{cl(min.)}$$

for demagnetisation versus  $V_s$ .

Figure 6: Input comparator hysteresis

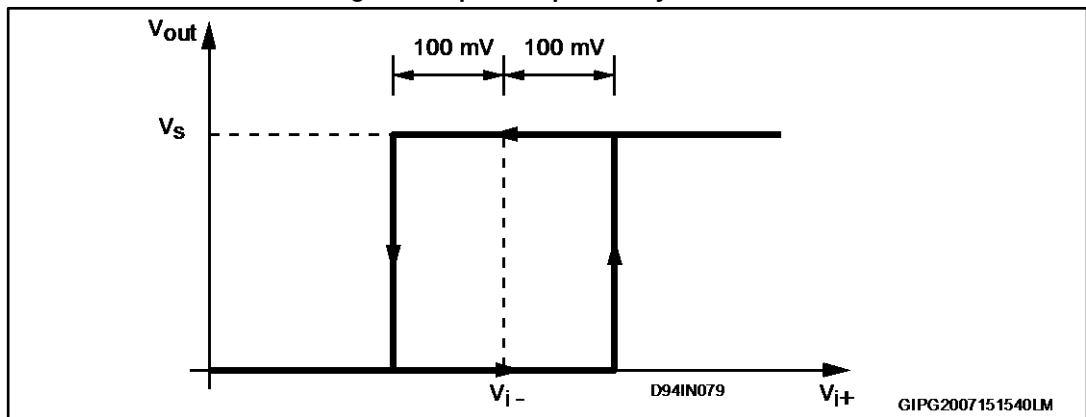
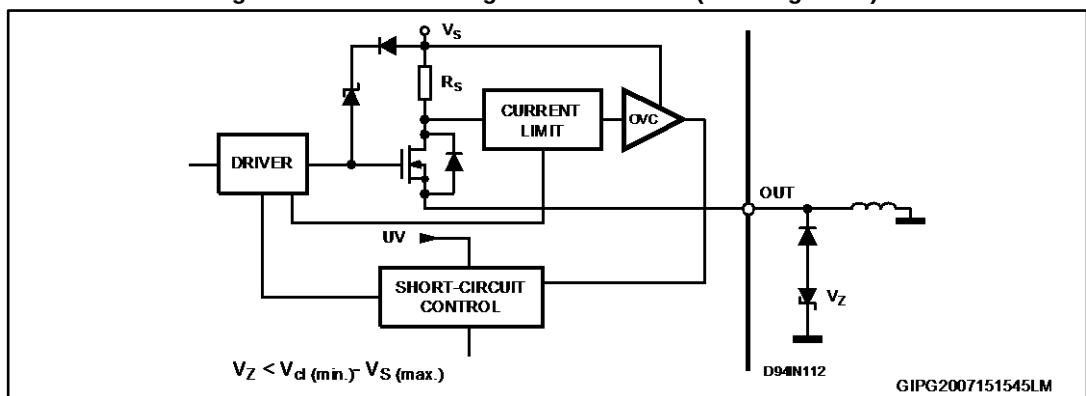
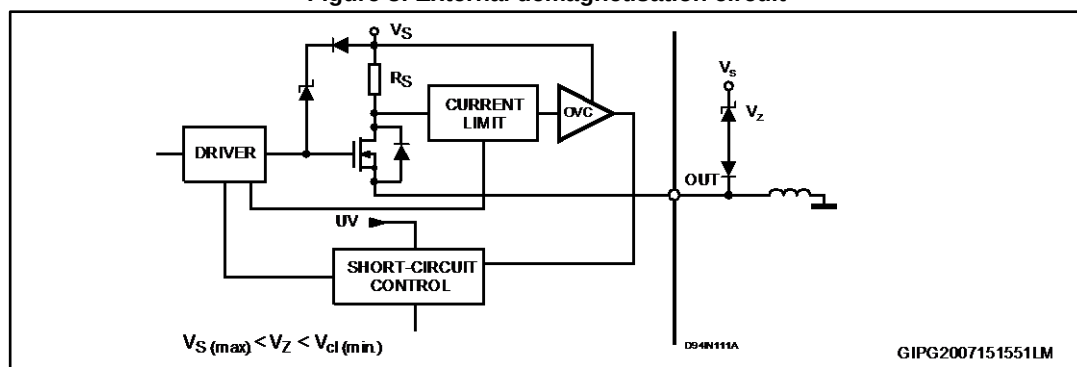


Figure 7: External demagnetisation circuit (versus ground)



**Figure 8: External demagnetisation circuit**



## 6 Package information

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

### 6.1 SO-14L package information

Figure 9: SO-14L package outline

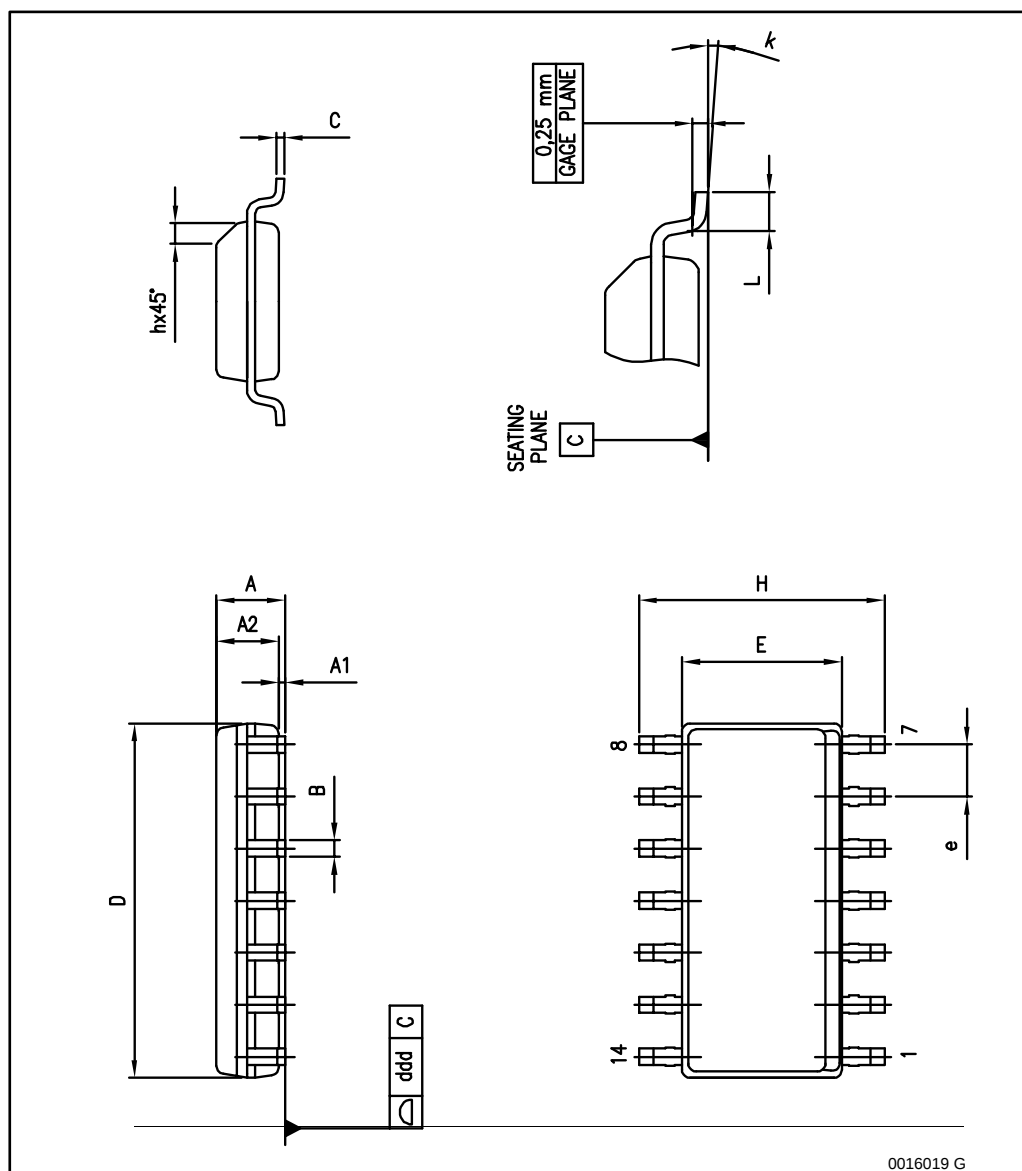


Table 6: SO-14L package mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 1.35 |      | 1.75 |
| A1   | 0.10 |      | 0.25 |
| A2   | 1.10 | 3.30 | 1.65 |
| B    | 0.19 |      | 0.25 |
| C    | 1.14 | 1.52 | 1.78 |
| D    | 8.55 |      | 8.75 |
| E    | 3.80 |      | 4.00 |
| e    |      | 1.27 |      |
| H    | 5.80 |      | 6.20 |
| h    | 0.25 |      | 0.50 |
| L    | 0.40 |      | 1.27 |
| k    | 0    |      | 8    |
| ddd  |      |      | 0.10 |

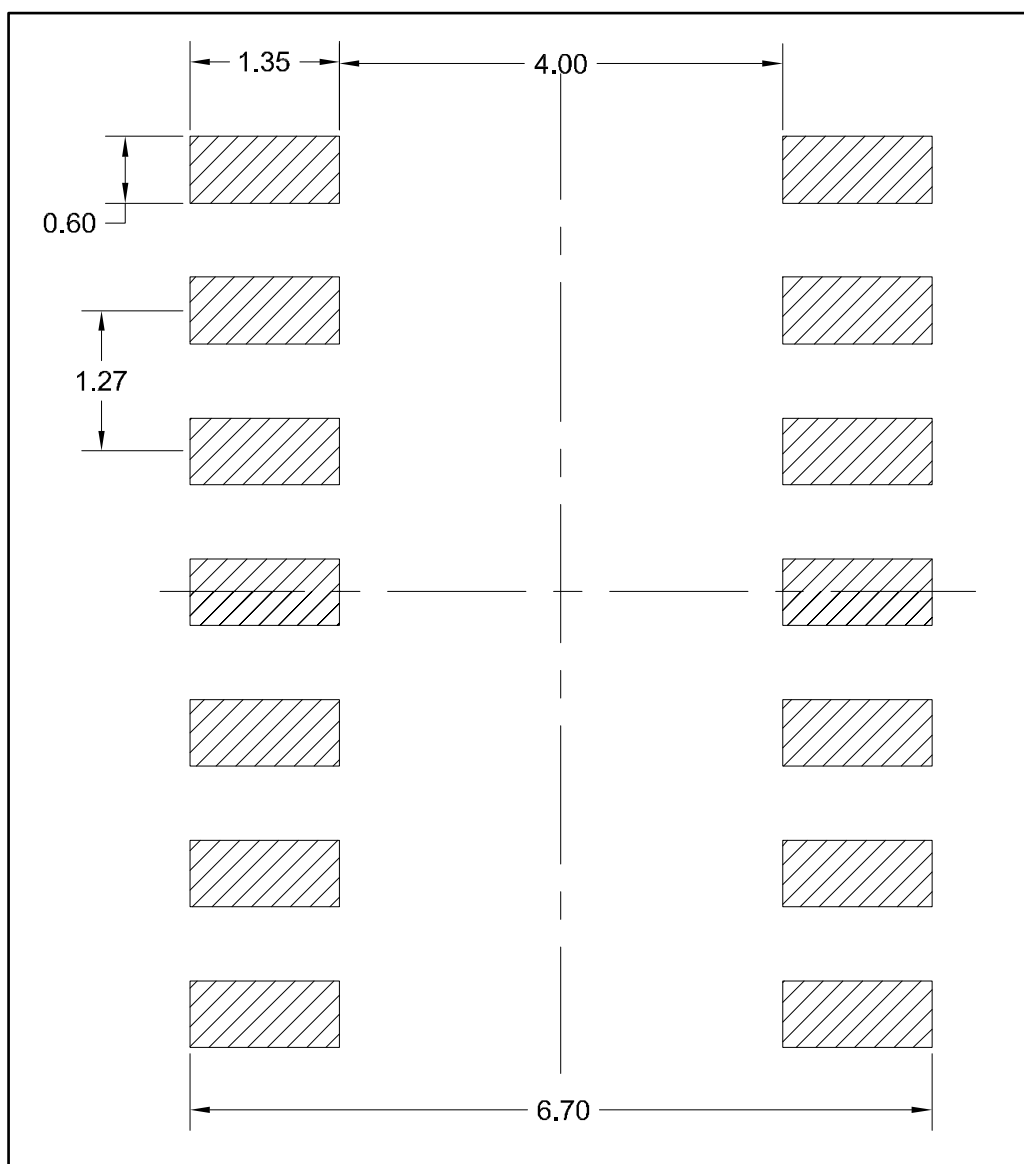


Dimension D doesn't include mold flash, protrusions or gate burrs, which do not exceed 0.15 mm per side.



Drawing dimensions include single and matrix versions.

Figure 10: SO-14L recommended footprint outline



## 7 Revision history

**Table 7: Document revision history**

| Date        | Revision | Changes                                                                                      |
|-------------|----------|----------------------------------------------------------------------------------------------|
| 17-Aug-2001 | 1        | Initial release.                                                                             |
| 19-Apr-2005 | 2        | Changed style sheet                                                                          |
| 22-Jun-2007 | 3        | Changed style sheet                                                                          |
| 25-Feb-2008 | 4        | Removed obsolete package DIP-14                                                              |
| 24-Jul-2015 | 5        | Updated $I_{\text{RESET}}$ and $V_{\text{RESET}}$ parameter in the table of maximum ratings. |

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