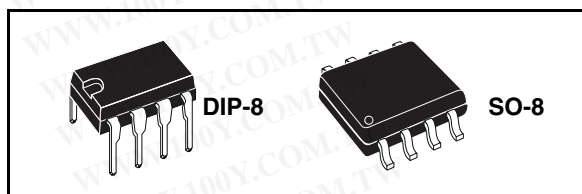




## High-voltage high and low side driver

### Features

- High voltage rail up to 600V
- dV/dt immunity  $\pm 50\text{V/nsec}$  in full temperature range
- Driver current capability:
  - 400mA source,
  - 650mA sink
- Switching times 70/40 nsec rise/fall with 1nF load
- 3.3V, 5V, 15V CMOS/TTL inputs comparators with hysteresis and pull down
- Internal bootstrap diode
- Outputs in phase with inputs
- Dead time and interlocking function



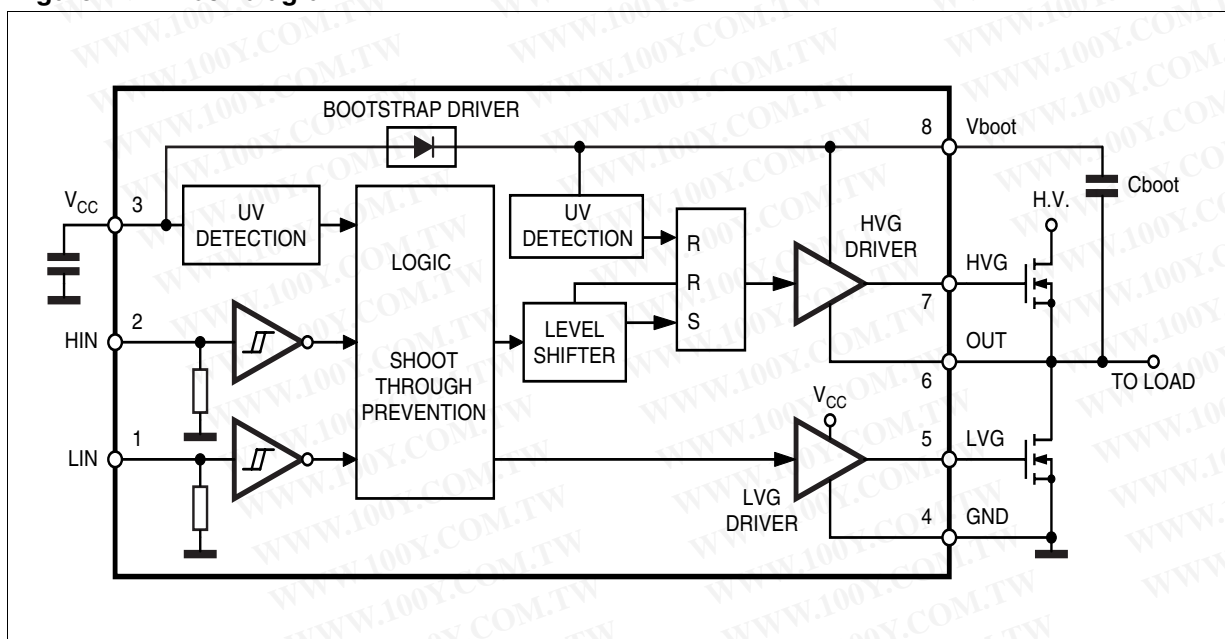
### Description

The L6388E is an high-voltage device, manufactured with the BCD"OFF-LINE" technology.

It has a Driver structure that enables to drive independent referenced N Channel Power MOS or IGBT. The High Side(Floating) Section is enabled to work with voltage Rail up to 600V.

The Logic Inputs are CMOS/TTL compatible for ease of interfacing with controlling devices.

Figure 1. Block diagram



# Contents

|           |   |           |
|-----------|---|-----------|
| <b>1</b>  | <b>Electrical data</b> .....            | <b>3</b>  |
| 1.1       | Absolute maximum ratings .....          | 3         |
| 1.2       | Thermal data .....                      | 3         |
| 1.3       | Recommended operating conditions .....  | 3         |
| <b>2</b>  | <b>Pin connection</b> .....             | <b>4</b>  |
| <b>3</b>  | <b>Electrical characteristics</b> ..... | <b>5</b>  |
| 3.1       | AC operation .....                      | 5         |
| 3.2       | DC operation .....                      | 5         |
| <b>4</b>  | <b>Waveforms definitions</b> .....      | <b>7</b>  |
| <b>5</b>  | <b>Input logic</b> .....                | <b>8</b>  |
| <b>6</b>  | <b>Bootstrap driver</b> .....           | <b>8</b>  |
| 6.1       | CBOOT selection and charging .....      | 8         |
| <b>7</b>  | <b>Typical characteristic</b> .....     | <b>11</b> |
| <b>8</b>  | <b>Package mechanical data</b> .....    | <b>13</b> |
| <b>9</b>  | <b>Order codes</b> .....                | <b>16</b> |
| <b>10</b> | <b>Revision history</b> .....           | <b>17</b> |

# 1 Electrical data

## 1.1 Absolute maximum ratings

**Table 1. Absolute maximum ratings**

| Symbol        | Parameter  | Value                  | Unit |
|---------------|--|------------------------|------|
| $V_{out}$     | Output voltage                                   | -3 to $V_{boot} - 18$  | V    |
| $V_{cc}$      | Supply voltage                                   | - 0.3 to +18           | V    |
| $V_{boot}$    | Floating supply voltage                          | -1 to 618              | V    |
| $V_{hvg}$     | High side gate output voltage                    | -1 to $V_{boot}$       | V    |
| $V_{lvg}$     | Low side gate output voltage                     | -0.3 to $V_{cc} + 0.3$ | V    |
| $V_i$         | Logic input voltage                              | -0.3 to $V_{cc} + 0.3$ | V    |
| $dV_{out}/dt$ | Allowed output slew rate                         | 50                     | V/ns |
| $P_{tot}$     | Total power dissipation ( $T_J = 85\text{ °C}$ ) | 750                    | mW   |
| $T_J$         | Junction temperature                             | 150                    | °C   |
| $T_s$         | Storage temperature                              | -50 to 150             | °C   |

Note: ESD immunity for pins 6, 7 and 8 is guaranteed up to 900 V (Human Body Model)

## 1.2 Thermal data

**Table 2. Thermal data**

| Symbol       | Parameter                              | SO-8 | DIP-8 | Unit |
|--------------|--|------|-------|------|
| $R_{th(JA)}$ | Thermal Resistance Junction to ambient | 150  | 100   | °C/W |

## 1.3 Recommended operating conditions

**Table 3. Recommended operating conditions**

| Symbol         | Pin | Parameter               | Test condition                    | Min | Typ | Max | Unit |
|----------------|-----|-------------------------|-----------------------------------|-----|-----|-----|------|
| $V_{out}$      | 6   | Output voltage          |                                   | (1) |     | 580 | V    |
| $V_{BS}^{(2)}$ | 8   | Floating supply voltage |                                   | (1) |     | 17  | V    |
| $f_{sw}$       |     | Switching frequency     | HVG, LVG load $C_L = 1\text{ nF}$ |     |     | 400 | kHz  |
| $V_{cc}$       | 3   | Supply voltage          |                                   |     |     | 17  | V    |
| $T_J$          |     | Junction temperature    |                                   | -45 |     | 125 | °C   |

1. If the condition  $V_{boot} - V_{out} < 18\text{ V}$  is guaranteed,  $V_{out}$  can range from -3 to 580V

2.  $V_{BS} = V_{boot} - V_{out}$

## 2 Pin connection

Figure 2. Pin connection (Top view)

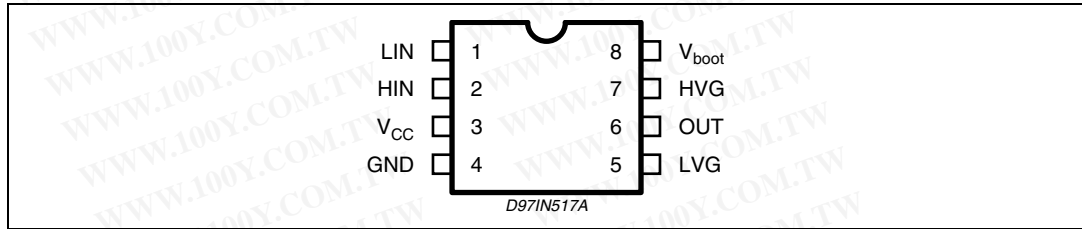


Table 4. Pin description

| N° | Pin                | Type | Function                            |
|----|--------------------|------|-------------------------------------|
| 1  | LIN                | I    | Low side driver logic input         |
| 2  | HIN                | I    | High side driver logic input        |
| 3  | V <sub>CC</sub>    |      | Low voltage power supply            |
| 4  | GND                |      | Ground                              |
| 5  | LVG <sup>(1)</sup> | O    | Low side driver output              |
| 6  | VOUT               | O    | High side driver floating reference |
| 7  | HVG <sup>(1)</sup> | O    | High side driver output             |
| 8  | V <sub>boot</sub>  |      | Bootstrap supply voltage            |

1. The circuit guarantees 0.3V maximum on the pin (@ I<sub>sink</sub> = 10mA). This allows to omit the "bleeder" resistor connected between the gate and the source of the external MOSFET normally used to hold the pin low.

### 3 Electrical characteristics

#### 3.1 AC operation

**Table 5. AC operation electrical characteristics** ( $V_{CC} = 15V$ ;  $T_J = 25^\circ C$ )

| Symbol    | Pin    | Parameter                                       | Test condition | Min | Typ | Max | Unit |
|-----------|--------|---|----------------|-----|-----|-----|------|
| $t_{on}$  | 1 vs 5 | High/low side driver turn-on propagation delay  | $V_{out} = 0V$ |     | 225 | 300 | ns   |
| $t_{off}$ | 2 vs 7 | High/low side driver turn-off propagation delay | $V_{out} = 0V$ |     | 160 | 220 | ns   |
| $t_r$     | 5, 7   | Rise time                                       | $C_L = 1000pF$ |     | 70  | 100 | ns   |
| $t_f$     | 5, 7   | Fall time                                       | $C_L = 1000pF$ |     | 40  | 80  | ns   |
| DT        | 5, 7   | Dead time                                       |                | 220 | 320 | 420 | ns   |

#### 3.2 DC operation

**Table 6. DC operation electrical characteristics** ( $V_{CC} = 15V$ ;  $T_J = 25^\circ C$ )

| Symbol                                     | Pin | Parameter                             | Test condition                        | Min | Typ | Max  | Unit     |
|--|-----|---------------------------------------|---------------------------------------|-----|-----|------|----------|
| <b>Low supply voltage section</b>          |     |                                       |                                       |     |     |      |          |
| $V_{ccth1}$                                | 3   | $V_{CC}$ UV turn on threshold         |                                       | 9.1 | 9.6 | 10.1 | V        |
| $V_{ccth2}$                                |     | $V_{CC}$ UV turn off threshold        |                                       | 7.9 | 8.3 | 8.8  | V        |
| $V_{cchys}$                                |     | $V_{CC}$ UV hysteresis                |                                       | 0.9 |     |      | V        |
| $I_{qccu}$                                 |     | Undervoltage quiescent supply current | $V_{CC} \leq 9V$                      |     | 250 | 330  | $\mu A$  |
| $I_{qcc}$                                  |     | Quiescent current                     | $V_{CC} = 15V$                        |     | 350 | 450  | $\mu A$  |
| $R_{dson}$                                 |     | Bootstrap driver on resistance (1)    | $V_{CC} \geq 12.5V$                   |     | 125 |      | $\Omega$ |
| <b>Bootstrapped supply voltage section</b> |     |                                       |                                       |     |     |      |          |
| $V_{Bsth1}$                                | 8   | $V_{BS}$ UV turn on threshold         |                                       | 8.5 | 9.5 | 10.5 | V        |
| $V_{Bsth2}$                                |     | $V_{BS}$ UV turn off threshold        |                                       | 7.2 | 8.2 | 9.2  | V        |
| $V_{BSshys}$                               |     | $V_{BS}$ UV hysteresis                |                                       | 0.9 |     |      | V        |
| $I_{QBS}$                                  |     | $V_{BS}$ quiescent current            | HVG ON                                |     |     | 250  | $\mu A$  |
| $I_{LK}$                                   |     | High voltage leakage current          | $V_{hvg} = V_{out} = V_{boot} = 600V$ |     |     | 10   | $\mu A$  |

**Table 6. DC operation electrical characteristics** (continued)( $V_{CC} = 15V$ ;  $T_J = 25^{\circ}C$ )

| Symbol                      | Pin  | Parameter                      | Test condition                      | Min | Typ | Max | Unit    |
|-----------------------------|------|--------------------------------|-------------------------------------|-----|-----|-----|---------|
| <b>High/low side driver</b> |      |                                |                                     |     |     |     |         |
| $I_{so}$                    | 5,7  | Source short circuit current   | $V_{IN} = V_{ih}$ (tp < 10 $\mu$ s) | 300 | 400 |     | mA      |
| $I_{si}$                    |      | Sink short circuit current     | $V_{IN} = V_{il}$ (tp < 10 $\mu$ s) | 500 | 650 |     | mA      |
| <b>Logic inputs</b>         |      |                                |                                     |     |     |     |         |
| $V_{il}$                    | 1, 2 | Low level logic input voltage  |                                     |     |     | 1.1 | V       |
| $V_{ih}$                    |      | High level logic input voltage |                                     | 1.8 |     |     | V       |
| $I_{ih}$                    |      | High level logic input current | $V_{IN} = 15V$                      |     | 20  | 70  | $\mu$ A |
| $I_{il}$                    |      | Low level logic input current  | $V_{IN} = 0V$                       | -1  |     |     | $\mu$ A |

1.  $R_{DS(on)}$  is tested in the following way:

$$R_{DS(on)} = \frac{(V_{CC} - V_{CBOOT1}) - (V_{CC} - V_{CBOOT2})}{I_1(V_{CC}, V_{CBOOT1}) - I_2(V_{CC}, V_{CBOOT2})}$$

where  $I_1$  is pin 8 current when  $V_{CBOOT} = V_{CBOOT1}$ ,  $I_2$  when  $V_{CBOOT} = V_{CBOOT2}$

## 4 Waveforms definitions

Figure 3. Dead time waveforms definitions

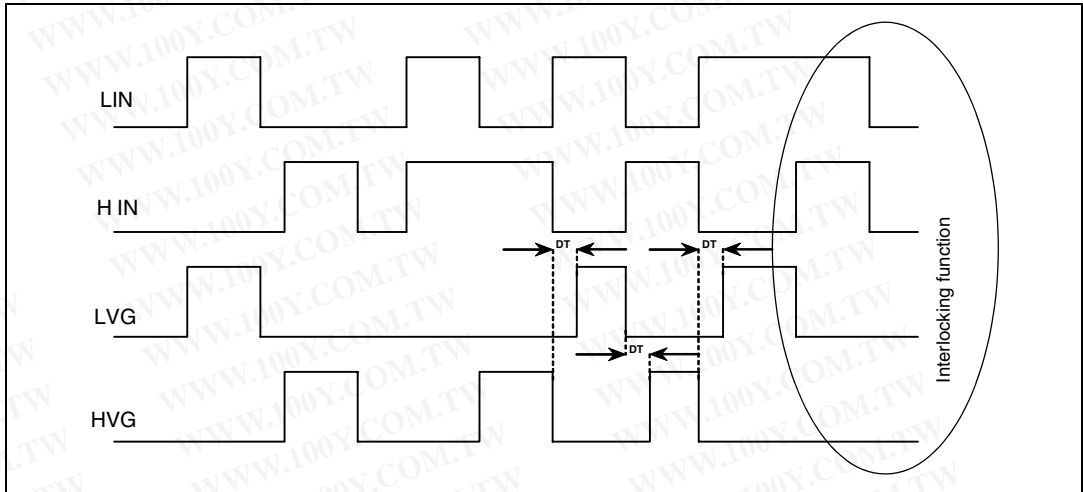
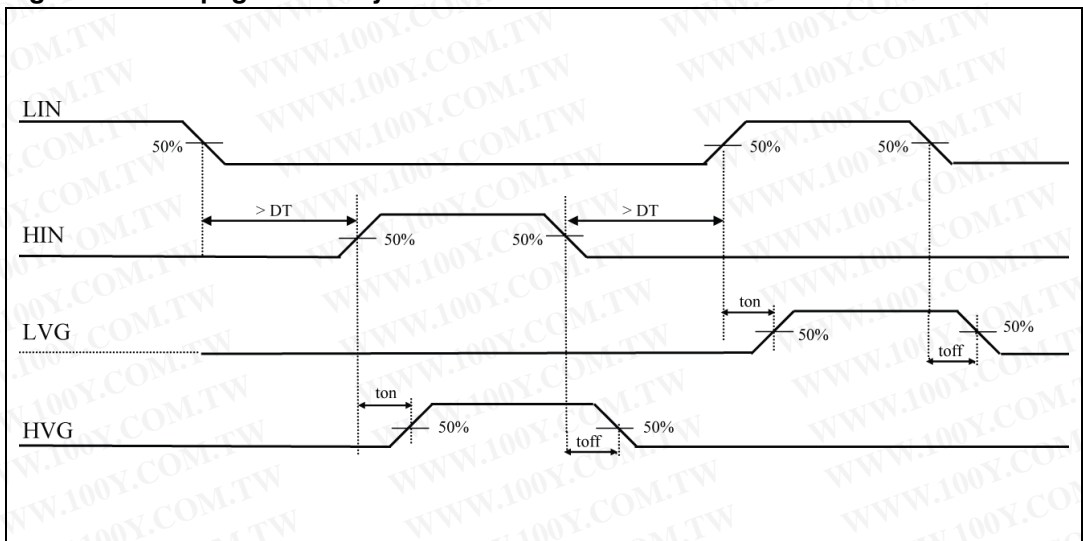


Figure 4. Propagation delay waveform definitions



## 5 Input logic

Input logic is provided with an interlocking circuitry which avoids the two outputs (LVG, HVG) to be active at the same time when both the logic input pins (LIN, HIN) are at a high logic level. In addition, to prevent cross conduction of the external MOSFETs, after each output is turned-off the other output cannot be turned-on before a certain amount of time (DT) (see [Figure 3](#)).

## 6 Bootstrap driver

A bootstrap circuitry is needed to supply the high voltage section. This function is normally accomplished by a high voltage fast recovery diode ([Figure 5 a](#)). In the L6388E a patented integrated structure replaces the external diode. It is realized by a high voltage DMOS, driven synchronously with the low side driver (LVG), with in series a diode, as shown in [Figure 5 b](#). An internal charge pump ([Figure 5 b](#)) provides the DMOS driving voltage. The diode connected in series to the DMOS has been added to avoid undesirable turn on of it.

### 6.1 C<sub>BOOT</sub> selection and charging

To choose the proper C<sub>BOOT</sub> value the external MOS can be seen as an equivalent capacitor. This capacitor C<sub>EXT</sub> is related to the MOS total gate charge:

$$C_{EXT} = \frac{Q_{gate}}{V_{gate}}$$

The ratio between the capacitors C<sub>EXT</sub> and C<sub>BOOT</sub> is proportional to the cyclical voltage loss. It has to be:

$$C_{BOOT} \gg C_{EXT}$$

e.g.: if Q<sub>gate</sub> is 30nC and V<sub>gate</sub> is 10V, C<sub>EXT</sub> is 3nF. With C<sub>BOOT</sub> = 100nF the drop would be 300mV.

If HVG has to be supplied for a long time, the C<sub>BOOT</sub> selection has to take into account also the leakage losses.

e.g.: HVG steady state consumption is lower than 200μA, so if HVG T<sub>ON</sub> is 5ms, C<sub>BOOT</sub> has to supply 1μC to C<sub>EXT</sub>. This charge on a 1μF capacitor means a voltage drop of 1V.

The internal bootstrap driver gives great advantages: the external fast recovery diode can be avoided (it usually has great leakage current).

This structure can work only if V<sub>OUT</sub> is close to GND (or lower) and in the meanwhile the LVG is on. The charging time (T<sub>charge</sub>) of the C<sub>BOOT</sub> is the time in which both conditions are fulfilled and it has to be long enough to charge the capacitor.

The bootstrap driver introduces a voltage drop due to the DMOS R<sub>DS(on)</sub> (typical value: 125 Ω). At low frequency this drop can be neglected. Anyway increasing the frequency it must be taken in to account.

The following equation is useful to compute the drop on the bootstrap DMOS:

$$V_{\text{drop}} = I_{\text{charge}} R_{\text{dson}} \rightarrow V_{\text{drop}} = \frac{Q_{\text{gate}}}{T_{\text{charge}}} R_{\text{dson}}$$

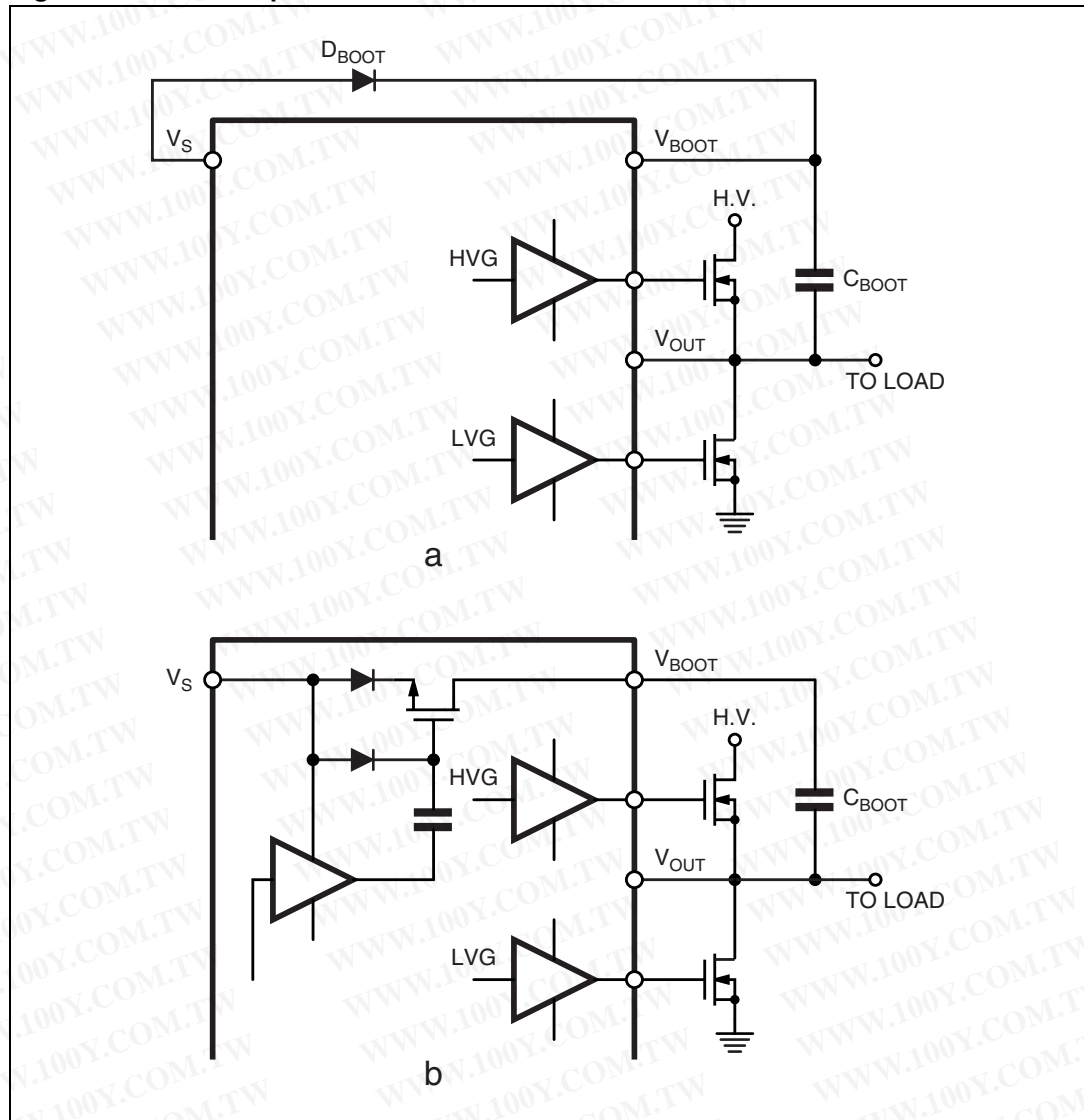
where  $Q_{\text{gate}}$  is the gate charge of the external power MOS,  $R_{\text{dson}}$  is the on resistance of the bootstrap DMOS, and  $T_{\text{charge}}$  is the charging time of the bootstrap capacitor.

For example: using a power MOS with a total gate charge of 30nC the drop on the bootstrap DMOS is about 1V, if the  $T_{\text{charge}}$  is 5 $\mu$ s. In fact:

$$V_{\text{drop}} = \frac{30\text{nC}}{5\mu\text{s}} \cdot 125\Omega \sim 0.8\text{V}$$

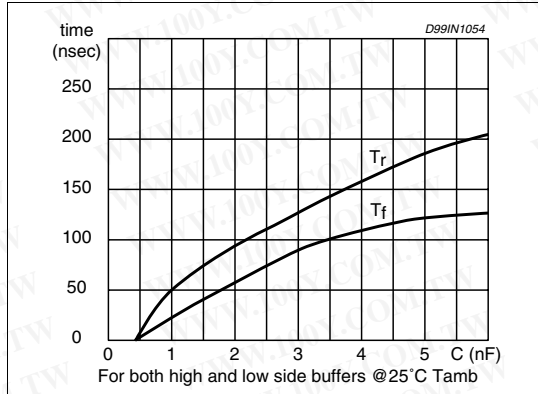
$V_{\text{drop}}$  has to be taken into account when the voltage drop on  $C_{\text{BOOT}}$  is calculated: if this drop is too high, or the circuit topology doesn't allow a sufficient charging time, an external diode can be used.

Figure 5. Bootstrap driver

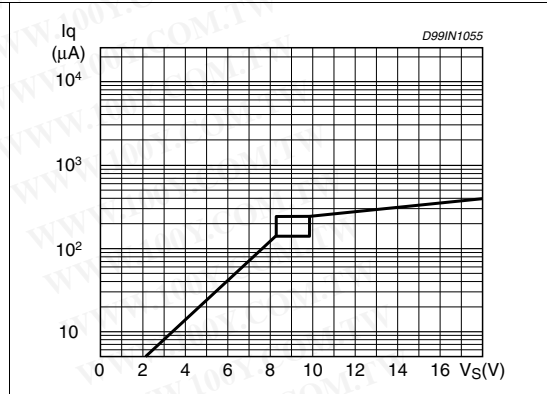


# 7 Typical characteristic

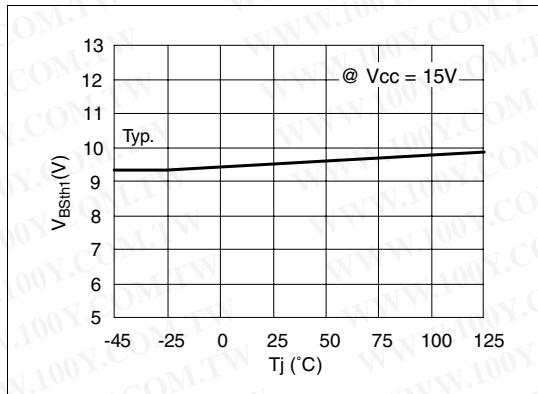
**Figure 6. Typical rise and fall times vs load capacitance**



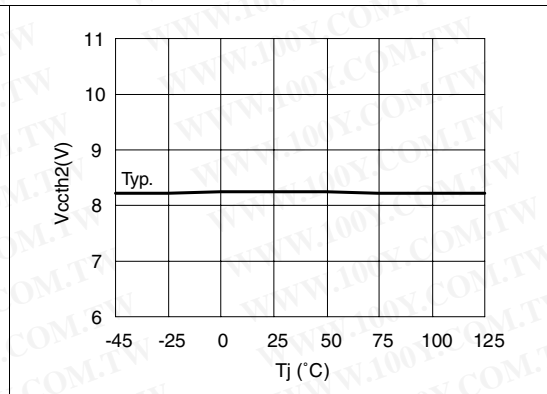
**Figure 7. Quiescent current vs supply voltage**



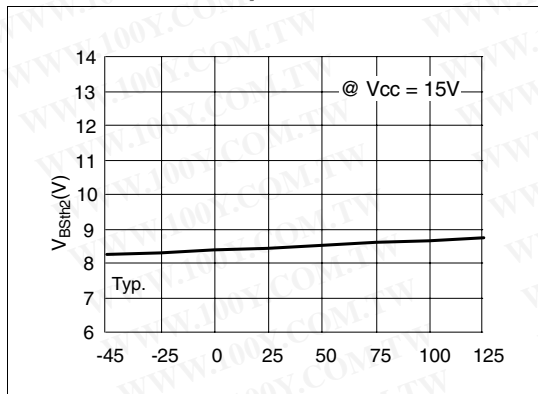
**Figure 8. VBOOT UV turn on threshold vs temperature**



**Figure 9. VCC UV turn off threshold vs temperature**



**Figure 10. VBOOT UV turn off threshold vs temperature**



**Figure 11. Output source current vs temperature**

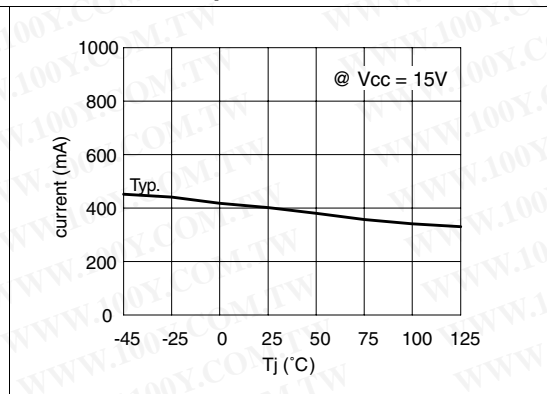


Figure 12.  $V_{CC}$  UV turn on threshold vs temperature

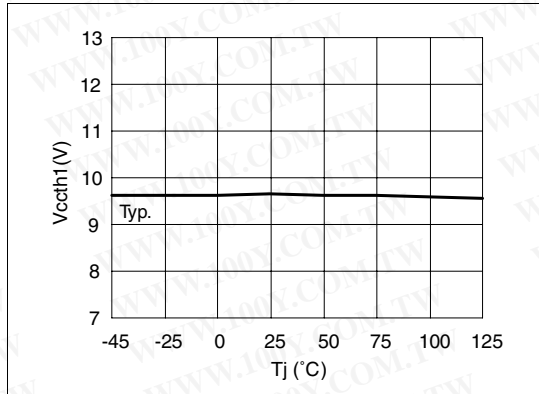
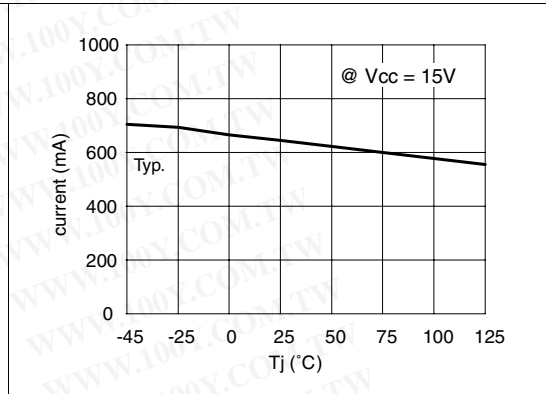


Figure 13. Output sink current vs temperature



## 8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

Figure 14. DIP-8 mechanical data and package dimensions

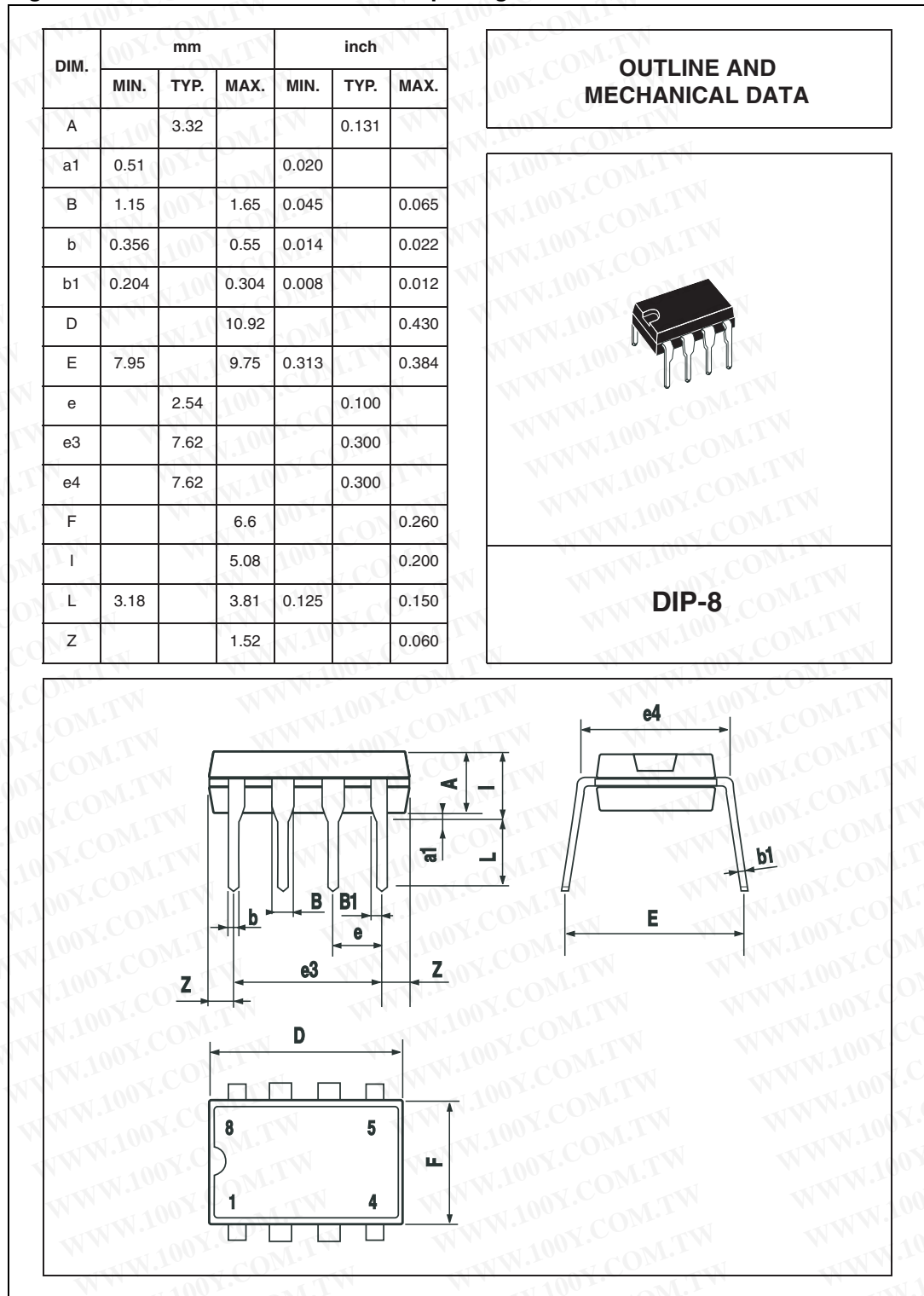
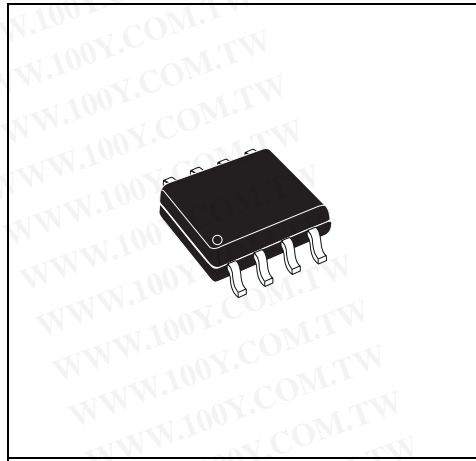


Figure 15. SO-8 mechanical data and package dimensions

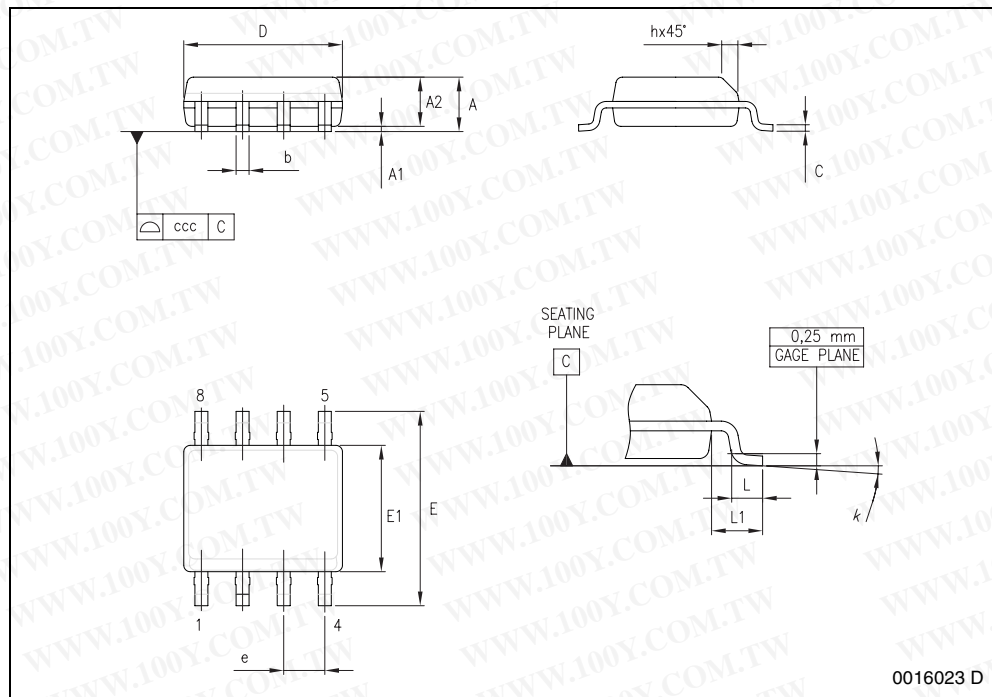
| DIM.  | mm    |       |       | inch   |        |        |
|-------|-------|-------|-------|--------|--------|--------|
|       | MIN.  | TYP.  | MAX.  | MIN.   | TYP.   | MAX.   |
| A     |       |       | 1.750 |        |        | 0.0689 |
| A1    | 0.100 |       | 0.250 | 0.0039 |        | 0.0098 |
| A2    | 1.250 |       |       | 0.0492 |        |        |
| b     | 0.280 |       | 0.480 | 0.0110 |        | 0.0189 |
| c     | 0.170 |       | 0.230 | 0.0067 |        | 0.0091 |
| D (1) | 4.800 | 4.900 | 5.000 | 0.1890 | 0.1929 | 0.1969 |
| E     | 5.800 | 6.000 | 6.200 | 0.2283 | 0.2362 | 0.2441 |
| E1(2) | 3.800 | 3.900 | 4.000 | 0.1496 | 0.1535 | 0.1575 |
| e     |       | 1.270 |       |        | 0.0500 |        |
| h     | 0.250 |       | 0.500 | 0.0098 |        | 0.0197 |
| L     | 0.400 |       | 1.270 | 0.0157 |        | 0.0500 |
| L1    |       | 1.040 |       |        | 0.0409 |        |
| k     | 0°    |       | 8°    | 0°     |        | 8°     |
| ccc   |       |       | 0.100 |        |        | 0.0039 |

Notes: 1. Dimensions D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm in total (both side).  
 2. Dimension "E1" does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25mm per side.

**OUTLINE AND MECHANICAL DATA**



**SO-8**



0016023 D

## 9 Order codes

**Table 7. Order codes**

| Part number  | Package | Packaging     |
|--------------|---------|---------------|
| L6388E       | DIP-8   | Tube          |
| L6388ED      | SO-8    | Tube          |
| L6388ED013TR | SO-8    | Tape and reel |

## 10 Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes       |
|-------------|----------|---------------|
| 11-Oct-2007 | 1        | First release |

勝特力材料 886-3-5753170  
勝特力电子(上海) 86-21-34970699  
勝特力电子(深圳) 86-755-83298787  
[Http://www.100y.com.tw](http://www.100y.com.tw)

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