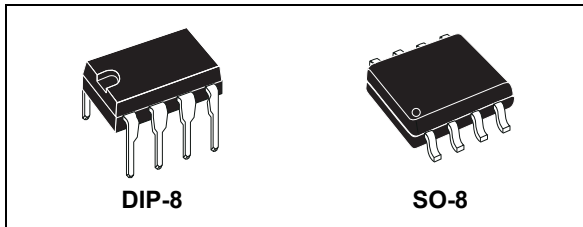


## High voltage high and low-side driver

Datasheet - production data



### Features

- High voltage rail up to 600 V
- $dV/dt$  immunity  $\pm 50$  V/nsec in full temperature range
- Driver current capability:
  - 400 mA source
  - 650 mA sink
- Switching times 50/30 nsec rise/fall with 1 nF load
- CMOS/TTL Schmitt trigger inputs with hysteresis and pull-down
- Undervoltage lockout on lower and upper driving section
- Internal bootstrap diode
- Outputs in phase with inputs

### Applications

- Home appliances
- Induction heating
- HVAC
- Motor drivers
  - SR motors
  - DC, AC, PMDC and PMAC motors
- Asymmetrical half-bridge topologies
- Industrial applications and drives
- Lighting applications
- Factory automation
- Power supply systems

### Description

The L6385E is a simple and compact high voltage gate driver, manufactured with the BCD™ “offline” technology, and able to drive a half-bridge of power MOSFET or IGBT devices. The high-side (floating) section is able to work with voltage rail up to 600 V. Both device outputs can independently sink and source 650 mA and 400 mA respectively and can be simultaneously driven high in order to drive asymmetrical half-bridge configurations.

The L6385E device provides two input pins and two output pins and guarantees the outputs toggle in phase with inputs. The logic inputs are CMOS/TTL compatible to ease the interfacing with controlling devices.

The bootstrap diode is integrated inside the device, allowing a more compact and reliable solution.

The L6385E features the UVLO protection on both lower and upper driving sections ( $V_{CC}$  and  $V_{BOOT}$ ), ensuring greater protection against voltage drops on the supply lines.

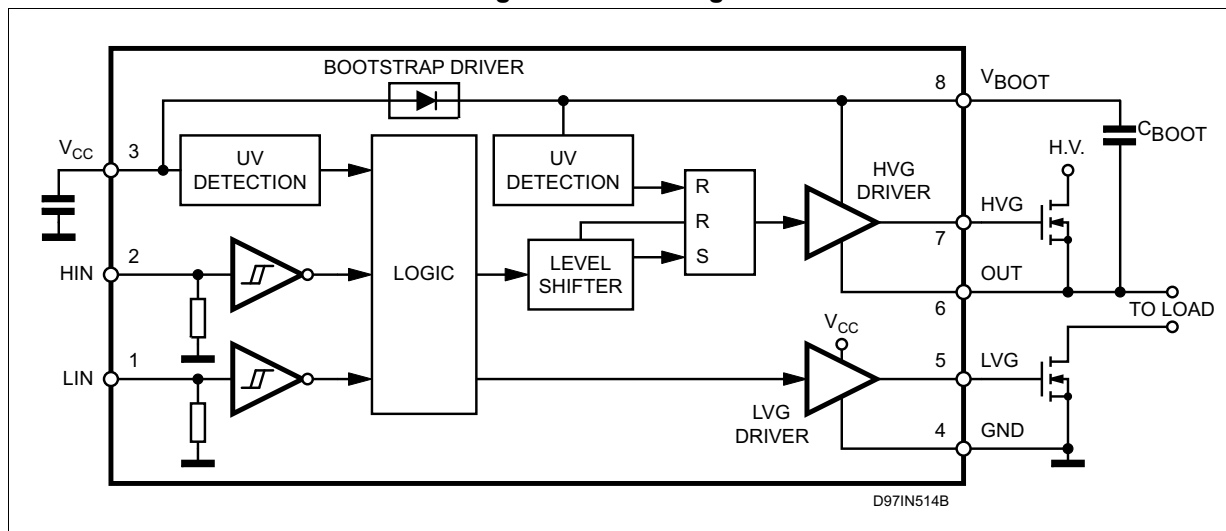
The device is available in a DIP-8 tube and SO-8 tube, and tape and reel packaging options.

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# 1 Block diagram

Figure 1. Block diagram



## 2 Electrical data

### 2.1 Absolute maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V <sub>OUT</sub>	Output voltage	-3 to V <sub>BOOT</sub> -18	V
V <sub>CC</sub>	Supply voltage	- 0.3 to +18	V
V <sub>BOOT</sub>	Floating supply voltage	-1 to 618	V
V <sub>hvg</sub>	High-side gate output voltage	-1 to V <sub>BOOT</sub>	V
V <sub>lvg</sub>	Low-side gate output voltage	-0.3 to V <sub>CC</sub> +0.3	V
V <sub>i</sub>	Logic input voltage	-0.3 to V <sub>CC</sub> +0.3	V
dV <sub>OUT</sub> /dt	Allowed output slew rate	50	V/ns
P <sub>tot</sub>	Total power dissipation (T <sub>J</sub> = 85 °C)	750	mW
T <sub>J</sub>	Junction temperature	150	°C
T <sub>s</sub>	Storage temperature	-50 to 150	°C
ESD	Human body model	2	kV

### 2.2 Thermal data

Table 2. Thermal data

Symbol	Parameter	SO-8	DIP-8	Unit
R <sub>th(JA)</sub>	Thermal resistance junction to ambient	150	100	°C/W

### 2.3 Recommended operating conditions

Table 3. Recommended operating conditions

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
V <sub>OUT</sub>	6	Output voltage		(1)		580	V
V <sub>BS</sub> <sup>(2)</sup>	8	Floating supply voltage		(1)		17	V
f <sub>sw</sub>		Switching frequency	HVG, LVG load C <sub>L</sub> = 1 nF			400	kHz
V <sub>CC</sub>	3	Supply voltage				17	V
T <sub>J</sub>		Junction temperature		-45		125	°C

1. If the condition V<sub>BOOT</sub> - V<sub>OUT</sub> < 18 V is guaranteed, V<sub>OUT</sub> can range from -3 to 580 V.

2. V<sub>BS</sub> = V<sub>BOOT</sub> - V<sub>OUT</sub>.

### 3 Pin connection

Figure 2. Pin connection (top view)

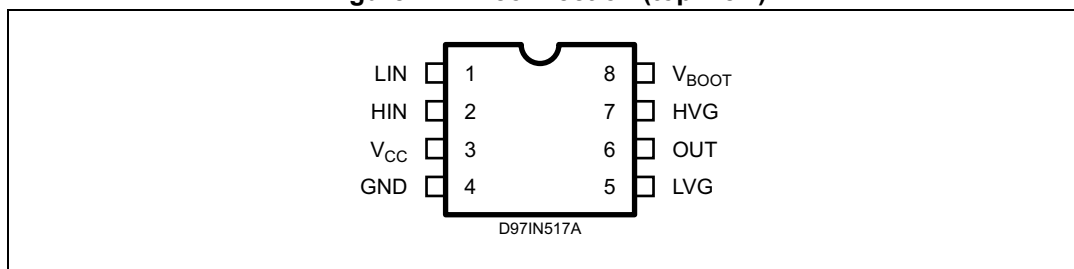


Table 4. Pin description

No.	Pin	Type	Function
1	LIN	I	Low-side driver logic input
2	HIN	I	High-side driver logic input
3	V <sub>CC</sub>	P	Low voltage power supply
4	GND	P	Ground
5	LVG <sup>(1)</sup>	O	Low-side driver output
6	OUT	P	High-side driver floating reference
7	HVG <sup>(1)</sup>	O	High-side driver output
8	V <sub>BOOT</sub>	P	Bootstrap supply voltage

1. The circuit guarantees 0.3 V maximum on the pin (at  $I_{sink} = 10$  mA). 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.

## 4 Electrical characteristics

### 4.1 AC operation

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

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_{on}$	1 vs. 5 2 vs. 7	High/low-side driver turn-on propagation delay	$V_{OUT} = 0\text{ V}$		110		ns
$t_{off}$	1 vs. 5 2 vs. 7	High/low-side driver turn-off propagation delay	$V_{OUT} = 0\text{ V}$		105		ns
$t_r$	5, 7	Rise time	$C_L = 1000\text{ pF}$		50		ns
$t_f$	5, 7	Fall time	$C_L = 1000\text{ pF}$		30		ns

### 4.2 DC operation

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

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Low supply voltage section</b>							
$V_{CC}$	3	Supply voltage				17	V
$V_{CCth1}$		$V_{CC}$ 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			1.3		V
$I_{QCCU}$		Undervoltage quiescent supply current	$V_{CC} \leq 9\text{ V}$		150	220	$\mu\text{A}$
$I_{QCC}$		Quiescent current	$V_{IN} = 15\text{ V}$		250	320	$\mu\text{A}$
$R_{dson}$		Bootstrap driver on resistance <sup>(1)</sup>	$V_{CC} \geq 12.5\text{ V}$		125		$\Omega$
<b>Bootstrapped supply voltage section</b>							
$V_{BS}$	8	Bootstrap supply voltage				17	V
$V_{BSth1}$		$V_{BS}$ 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
$V_{BSHys}$		$V_{BS}$ UV hysteresis			1.3		V
$I_{QBS}$		$V_{BS}$ quiescent current	HVG ON			200	$\mu\text{A}$
$I_{LK}$		High voltage leakage current	$V_{hvg} = V_{OUT} = V_{BOOT} = 600\text{ V}$			10	$\mu\text{A}$
<b>High/low-side driver</b>							
$I_{so}$	5, 7	Source short-circuit current	$V_{IN} = V_{ih}$ ( $t_p < 10\text{ }\mu\text{s}$ )	300	400		mA
$I_{si}$		Sink short-circuit current	$V_{IN} = V_{il}$ ( $t_p < 10\text{ }\mu\text{s}$ )	450	650		mA

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

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Logic inputs</b>							
$V_{il}$	1, 2	Low level logic threshold voltage				1.5	V
$V_{ih}$		High level logic threshold voltage		3.6			V
$I_{ih}$	1, 2	High level logic input current	$V_{IN} = 15\text{ V}$		50	70	$\mu\text{A}$
$I_{il}$		Low level logic input current	$V_{IN} = 0\text{ V}$			1	$\mu\text{A}$

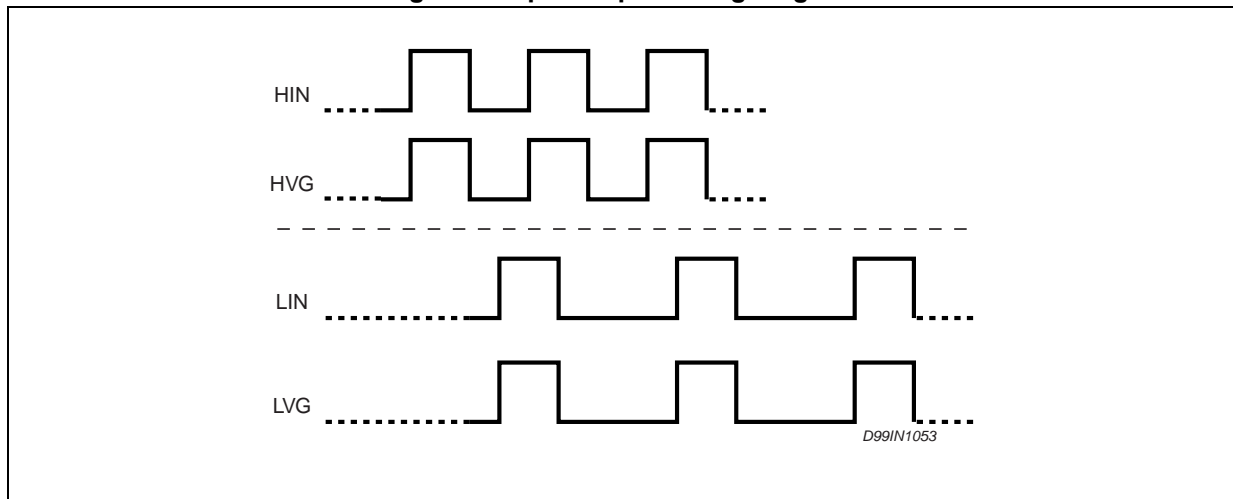
1.  $R_{DS(on)}$  is tested in the following way:

$$R_{DS(on)} = \frac{(V_{CC} - V_{BOOT1}) - (V_{CC} - V_{BOOT2})}{I_1(V_{CC}, V_{BOOT1}) - I_2(V_{CC}, V_{BOOT2})}$$

where  $I_1$  is pin 8 current when  $V_{BOOT} = V_{BOOT1}$ ,  $I_2$  when  $V_{BOOT} = V_{BOOT2}$ .

### 4.3 Timing diagram

Figure 3. Input/output timing diagram



## 5 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 4 a*). In the L6385E device 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 a diode in series, as shown in *Figure 4 b*. An internal charge pump (*Figure 4 b*) provides the DMOS driving voltage. The diode connected in series to the DMOS has been added to avoid undesirable turn-on.

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

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

**Equation 1**

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

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 300 mV.

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 200 μA, so if HVG T<sub>ON</sub> is 5 ms, C<sub>BOOT</sub> has to supply a maximum of 1 μC to C<sub>EXT</sub>. This charge on a 1mF capacitor means a voltage drop of 1 V.

The internal bootstrap driver gives great advantages: the external fast recovery diode can be avoided (it usually has a 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>DSON</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:

**Equation 2**

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

where Q<sub>gate</sub> is the gate charge of the external power MOSFET, R<sub>dson</sub> is the on resistance of the bootstrap DMOS, and T<sub>charge</sub> is the charging time of the bootstrap capacitor.



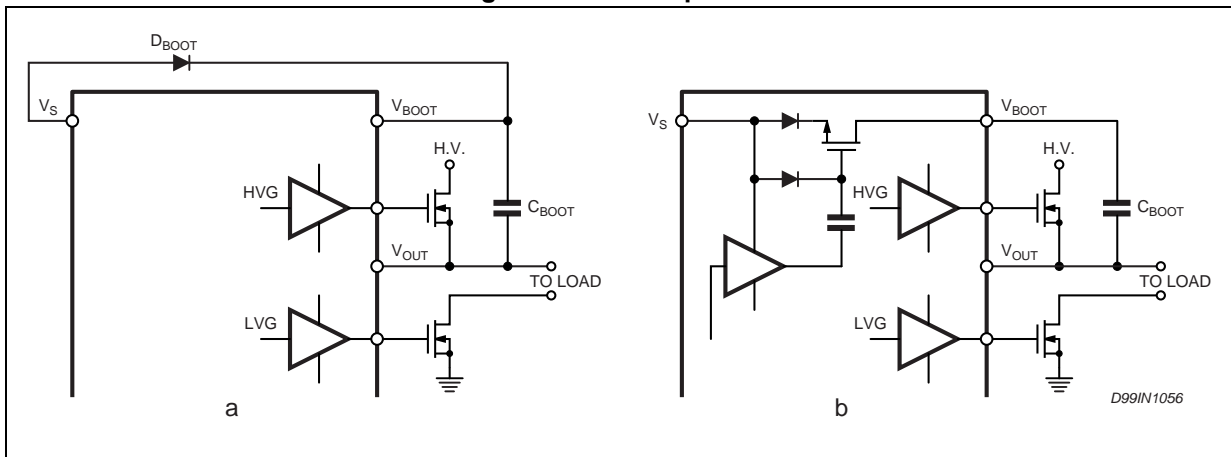
For example: using a power MOSFET with a total gate charge of 30 nC the drop on the bootstrap DMOS is about 1 V, if the  $T_{charge}$  is 5 ms. In fact:

**Equation 3**

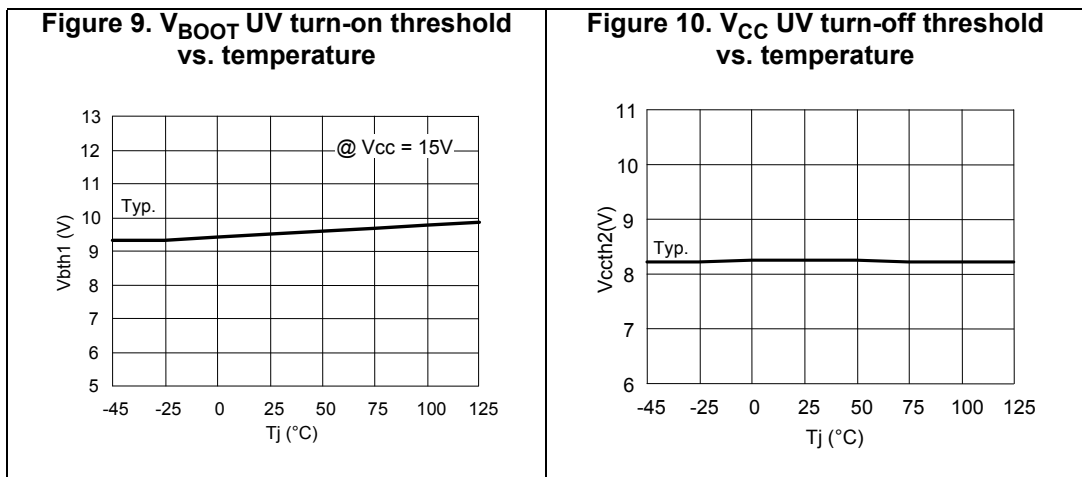
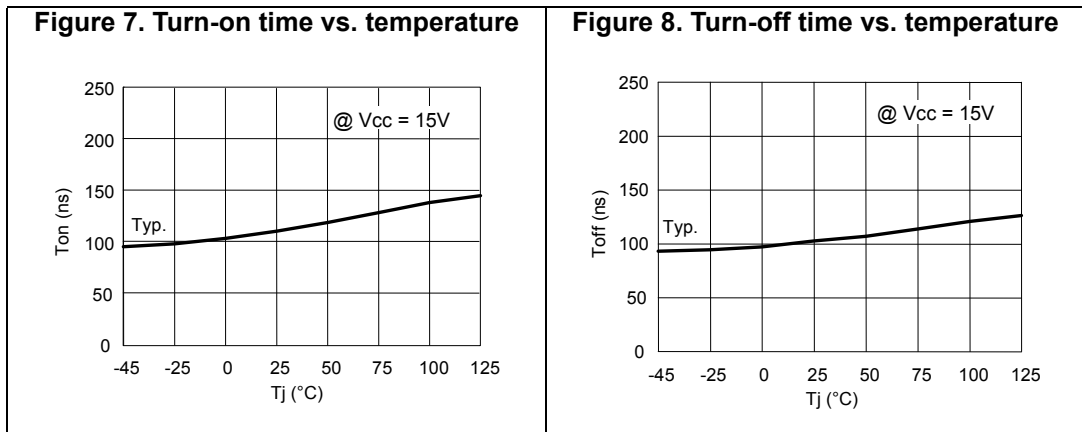
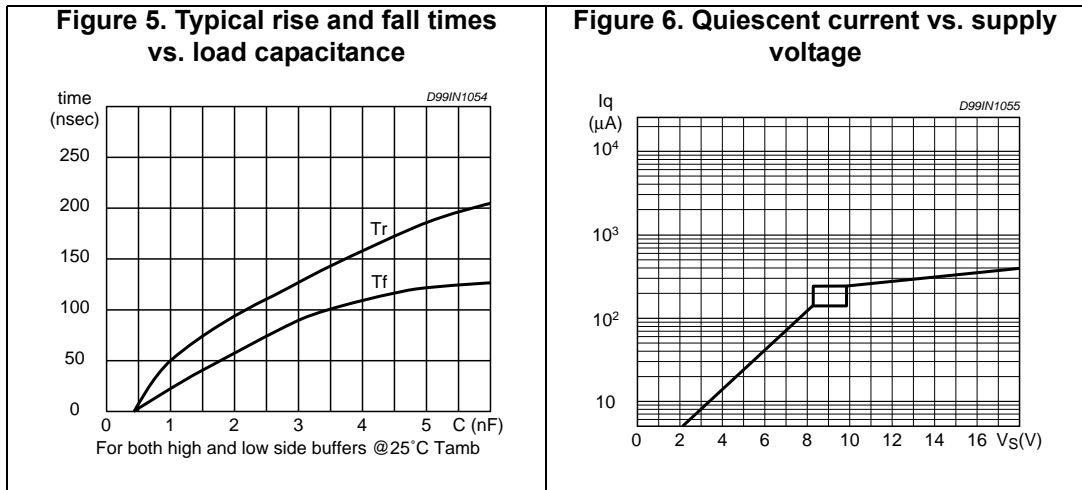
$$V_{drop} = \frac{30nC}{5\mu s} \cdot 125\Omega \sim 0.8V$$

$V_{drop}$  has to be taken into account when the voltage drop on  $C_{BOOT}$  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.

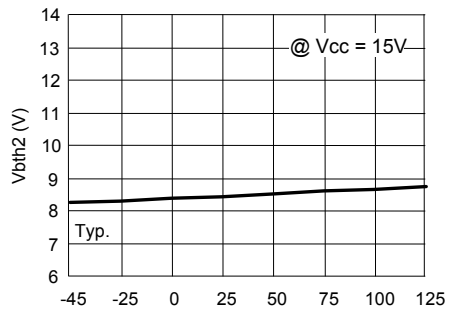
**Figure 4. Bootstrap driver**



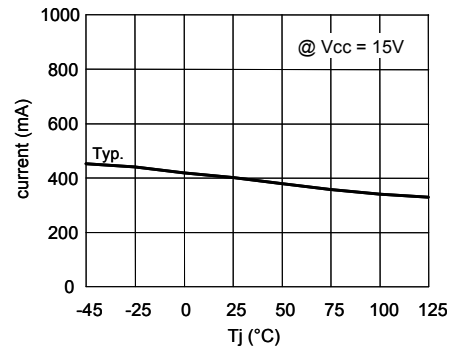
## 6 Typical characteristic



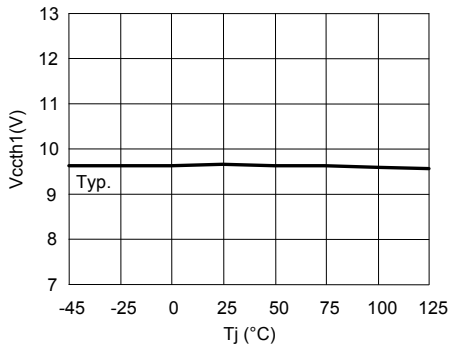
**Figure 11.  $V_{BOOT}$  UV turn-off threshold vs. temperature**



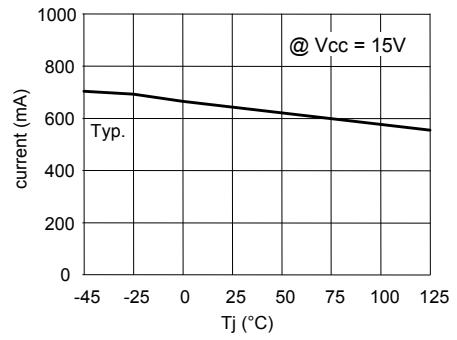
**Figure 12. Output source current vs. temperature**



**Figure 13.  $V_{CC}$  UV turn-on threshold vs. temperature**



**Figure 14. Output sink current vs. temperature**



## 7 Package information

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.

### 7.1 DIP-8 package information

Figure 15. DIP-8 package outline

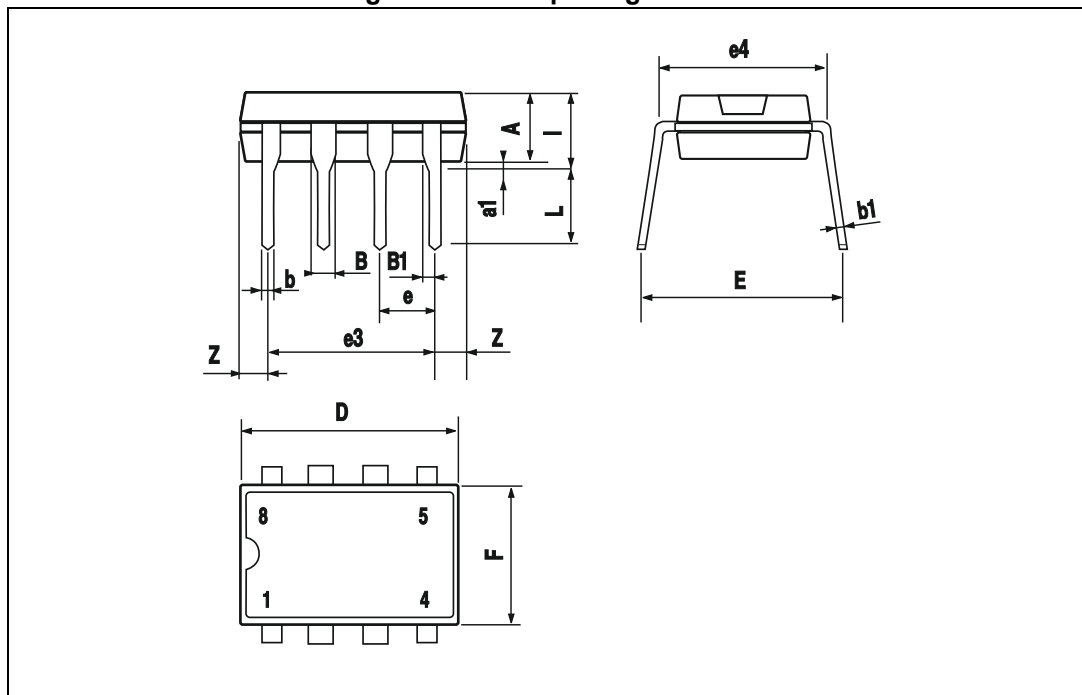


Table 7. DIP-8 package mechanical data

Symbol	Dimensions (mm)			Dimensions (inch)		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0.260
I			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

## 7.2 SO-8 package information

Figure 16. SO-8 package outline

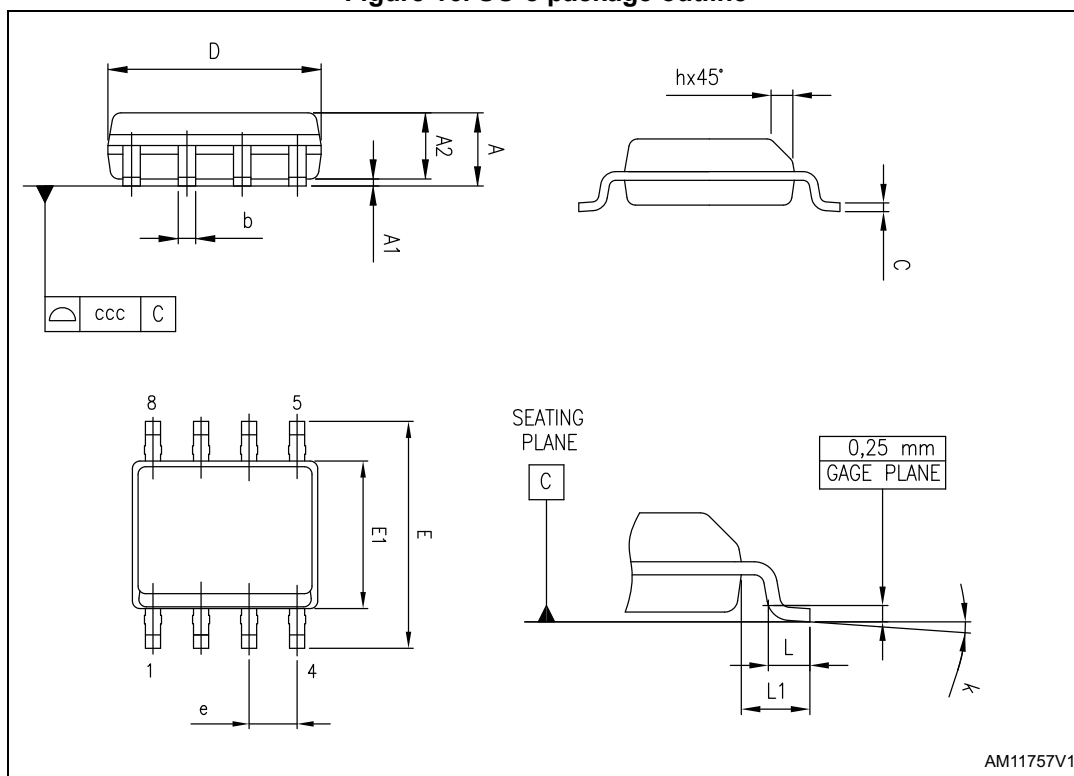


Table 8. SO-8 package mechanical data

Symbol	Dimensions (mm)			Dimensions (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 <sup>(1)</sup>	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 <sup>(2)</sup>	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			0.10			0.0039

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

## 8 Order codes

**Table 9. Order codes**

Order code	Package	Packaging
L6385E	DIP-8	Tube
L6385ED	SO-8	Tube
L6385ED013TR	SO-8	Tape and reel

## 9 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
02-Oct-2007	1	First release
19-Jun-2014	2	<p>Added <a href="#">Section : Applications on page 1</a>.</p> <p>Updated <a href="#">Section : Description on page 1</a> (replaced by new description).</p> <p>Updated <a href="#">Table 1: Device summary on page 1</a> (moved from page 15 to page 1, renamed title of <a href="#">Table 1</a>).</p> <p>Updated <a href="#">Figure 1: Block diagram on page 3</a> (moved from page 1 to page 3, added <a href="#">Section 1: Block diagram on page 3</a>).</p> <p>Updated <a href="#">Section 2.1: Absolute maximum ratings on page 4</a> (removed note below <a href="#">Table 2: Absolute maximum ratings</a>).</p> <p>Updated <a href="#">Table 5: Pin description on page 5</a> (updated “Pin” and “Type”).</p> <p>Updated <a href="#">Section : C<sub>BOOT</sub> selection and charging on page 8</a> (updated values of “E.g.: HVG”).</p> <p>Numbered <a href="#">Equation 1 on page 8</a>, <a href="#">Equation 2 on page 8</a> and <a href="#">Equation 3 on page 9</a>.</p> <p>Updated <a href="#">Section 7: Package information on page 12</a> [updated/added titles, reversed order of <a href="#">Figure 15</a> and <a href="#">Table 8</a>, <a href="#">Figure 16</a> and <a href="#">Table 9</a> (numbered tables), removed 3D package figures, minor modifications].</p> <p>Minor modifications throughout document.</p>
01-Dec-2014	3	<p>Updated <a href="#">Section : Description on page 1</a>.</p> <p>Updated <a href="#">Table 6 on page 6</a> (corrected typo in units of “I<sub>so</sub>” and “I<sub>si</sub>” parameters).</p>
23-Sep-2015	4	<p>Updated <a href="#">Table 1 on page 4</a> (added ESD parameter and value).</p> <p>Updated note 1. below <a href="#">Table 6 on page 6</a> (replaced V<sub>CBOOTx</sub> by V<sub>BOOTx</sub>).</p> <p>Moved <a href="#">Table 9 on page 16</a> (moved from page 1 to page 16, added/updated titles).</p> <p>Minor modifications throughout document.</p>



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