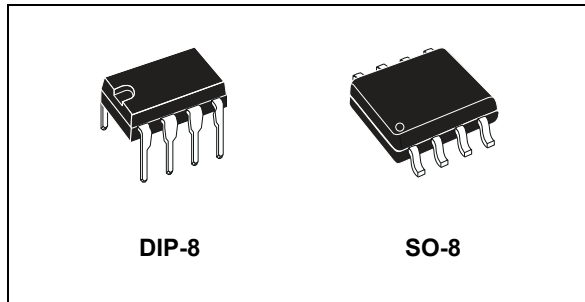


## High voltage high and low-side driver

Datasheet - production data



### Description

The L6387E 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 enabled to work with voltage rail up to 600 V. Both device outputs can independently sink and source 650 mA and 400 mA respectively and cannot be simultaneously driven high thanks to an integrated interlocking function.

The L6387E 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 L6387E features the UVLO protection on the  $V_{CC}$  supply voltage and integrates the bootstrap diode, allowing a more compact and reliable solution.

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

### 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
- Internal bootstrap diode
- Outputs in phase with inputs
- Interlocking function

### Applications

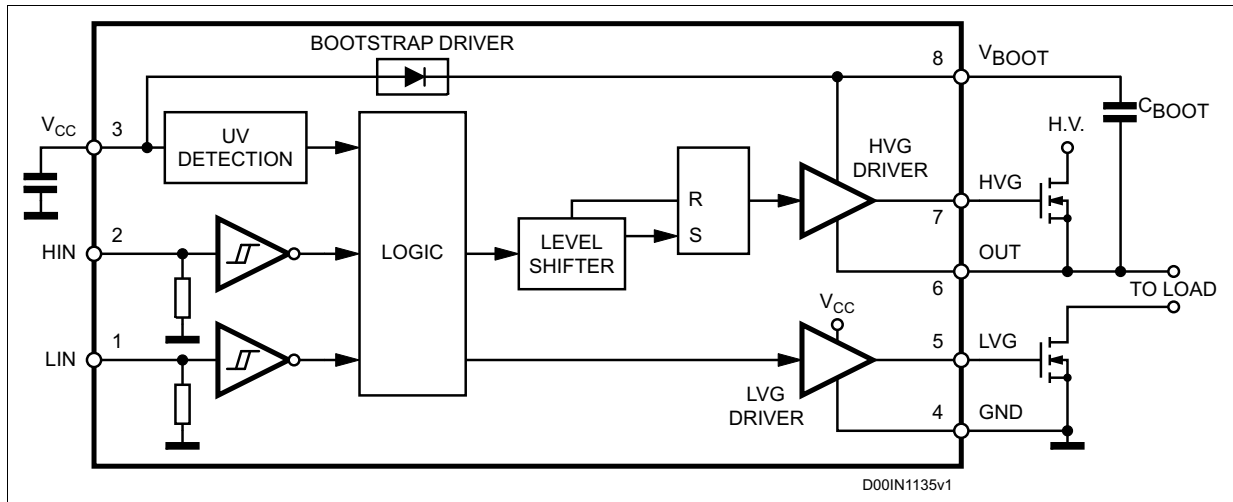
- Home appliances
- Motor drivers
  - DC, AC, PMDC and PMAC motors
- Lighting applications
- Industrial applications and drives
- Induction heating
- HVAC
- Factory automation
- Power supply systems

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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> /d <sub>t</sub>	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)

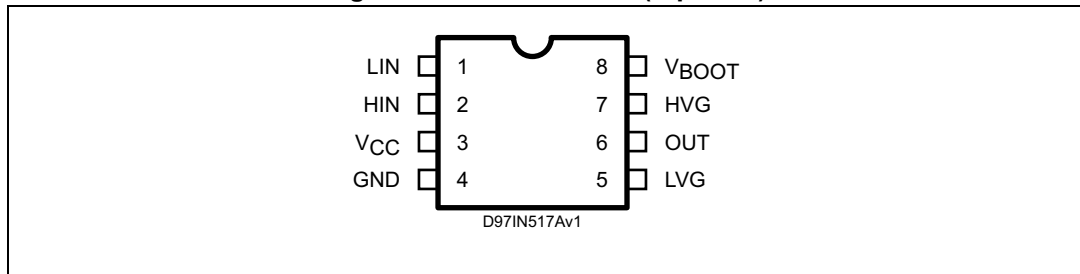


Table 4. Pin description

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  $I_{\text{sink}} = 10 \text{ mA}$ ). 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		5.5	6	6.5	V
$V_{CCth2}$		$V_{CC}$ UV turn-off threshold		5	5.5	6	V
$V_{CCchys}$		$V_{CC}$ UV hysteresis			0.5		V
$I_{QCCU}$		Undervoltage quiescent supply current	$V_{CC} \leq 5\text{ V}$		150	220	$\mu\text{A}$
$I_{QCC}$		Quiescent current	$V_{CC} = 15\text{ V}$		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
$I_{QBS}$		$V_{BS}$ quiescent current	HVG ON			100	$\mu\text{A}$
$I_{LK}$		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 (continued) ( $V_{CC} = 15\text{ V}$ ;  $T_J = 25\text{ }^\circ\text{C}$ )

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
$I_{ih}$		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 the pin 8 current when  $V_{BOOT} = V_{BOOT1}$ ,  $I_2$  when  $V_{BOOT} = V_{BOOT2}$ .

## 5 Input logic

L6387E input logic is  $V_{CC}$  (17 V) compatible. An interlocking feature is offered (see [Table 7](#)) to avoid undesired simultaneous turn-ON of both power switches driven.

**Table 7. Input logic**

Input		Output	
HIN	LIN	HVG	LVG
0	0	0	0
0	1	0	1
1	0	1	0
1	1	0	0



## 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 3 a*). In the L6387E 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 3 b*. An internal charge pump (*Figure 3 b*) provides the DMOS driving voltage. The diode connected in series to the DMOS has been added to avoid undesirable turn-on.

### $C_{BOOT}$ selection and charging

To choose the proper  $C_{BOOT}$  value, the external MOSFET can be seen as an equivalent capacitor. This capacitor  $C_{EXT}$  is related to the MOSFET total gate charge:

#### Equation 1

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

The ratio between the  $C_{EXT}$  and  $C_{BOOT}$  capacitors is proportional to the cyclical voltage loss. It has to be:

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

E.g.: if  $Q_{gate}$  is 30 nC and  $V_{gate}$  is 10 V,  $C_{EXT}$  is 3 nF. With  $C_{BOOT} = 100$  nF the drop would be 300 mV.

If HVG has to be supplied for a long time, the  $C_{BOOT}$  selection has to take into account also the leakage losses.

E.g.: HVG steady state consumption is lower than 100  $\mu$ A, so if HVG  $T_{ON}$  is 5 ms,  $C_{BOOT}$  has to supply a maximum of 0.5  $\mu$ C to  $C_{EXT}$ . This charge on a 1  $\mu$ F capacitor means a voltage drop of 0.5 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  $V_{OUT}$  is close to GND (or lower) and in the meanwhile the LVG is on. The charging time ( $T_{charge}$ ) of the  $C_{BOOT}$  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  $R_{DSON}$  (typical value: 125  $\Omega$ ). At low frequency this drop can be neglected. Anyway increasing the frequency it must be taken into 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  $Q_{gate}$  is the gate charge of the external power MOSFET,  $R_{dson}$  is the on-resistance of the bootstrap DMOS, and  $T_{charge}$  is the charging time of the bootstrap capacitor.

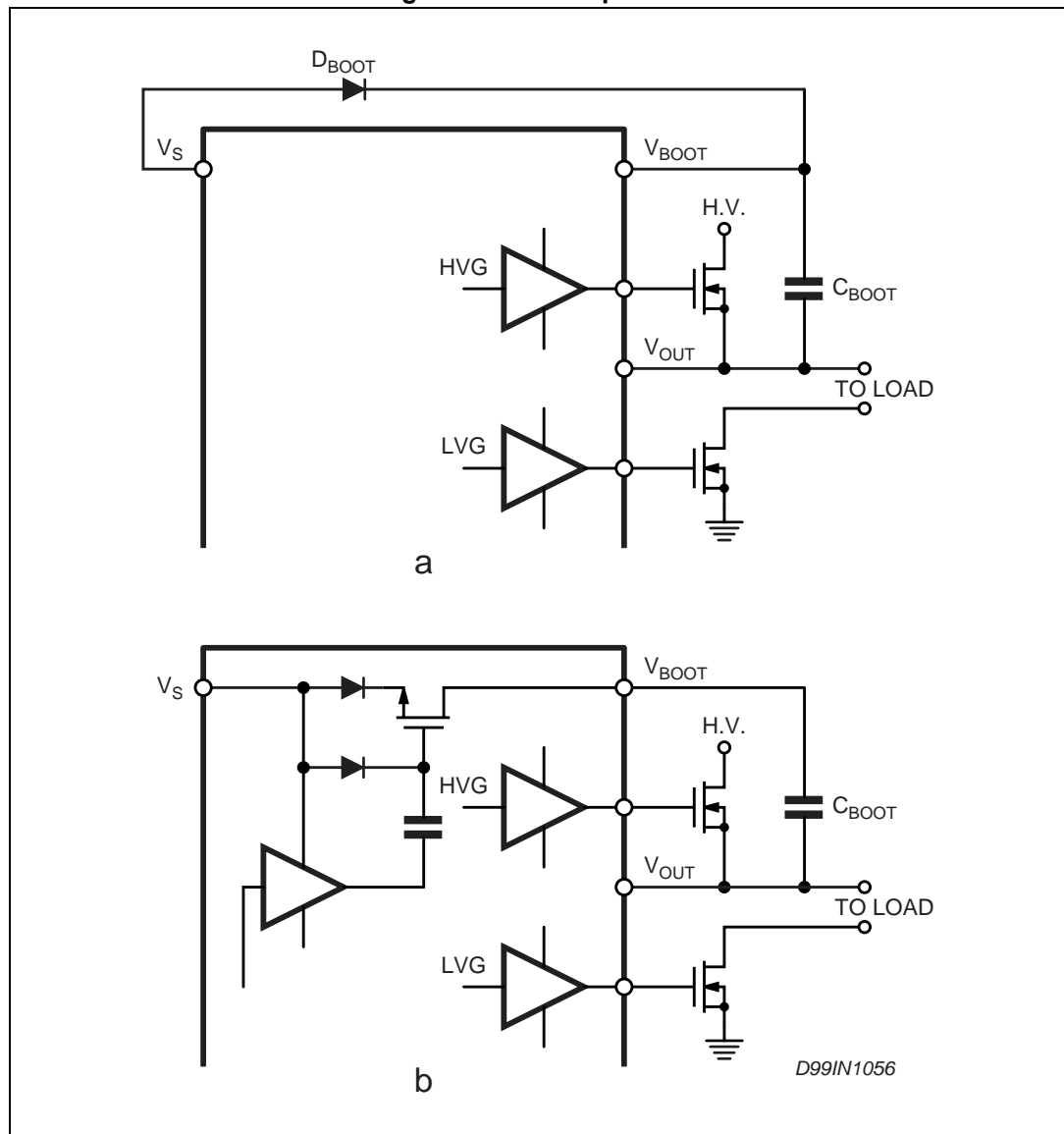
For example: using a power MOSFET with a total gate charge of 30 nC the drop on the bootstrap DMOS is about 1 V, if the  $T_{charge}$  is 5  $\mu$ s. In fact:

**Equation 3**

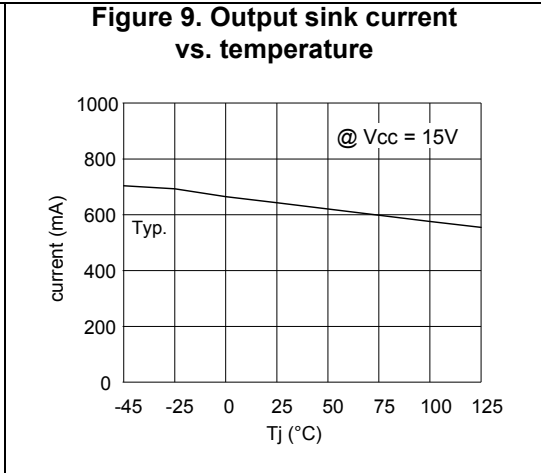
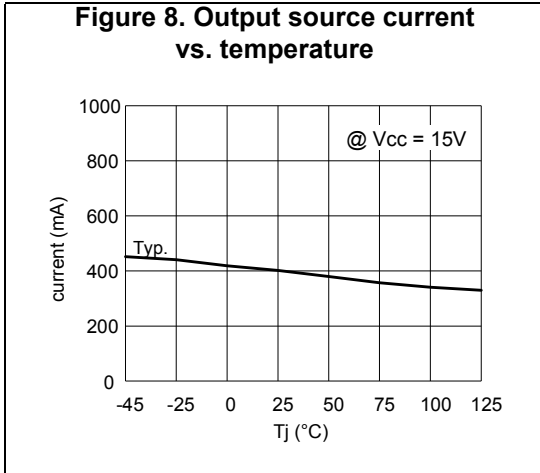
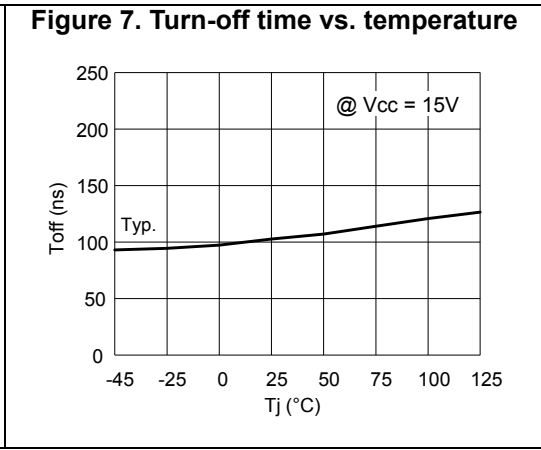
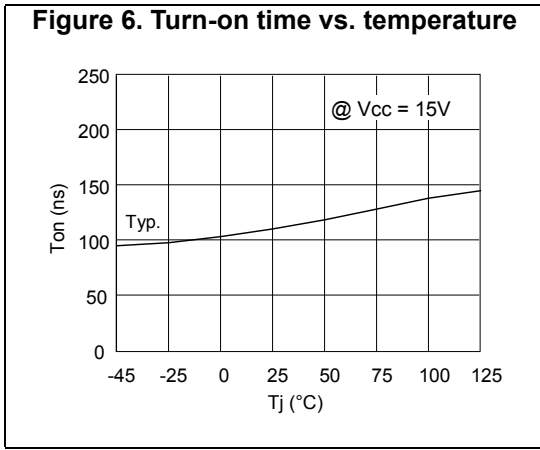
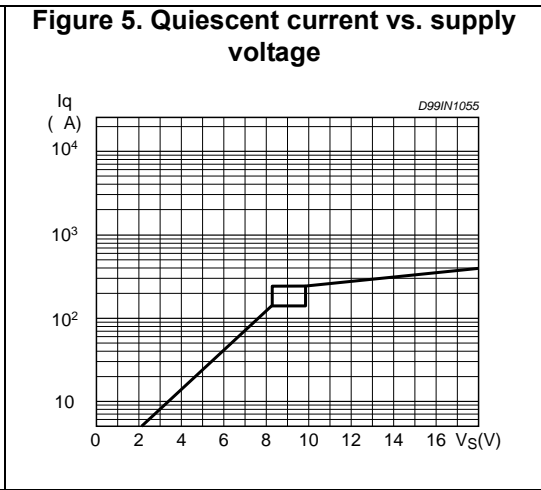
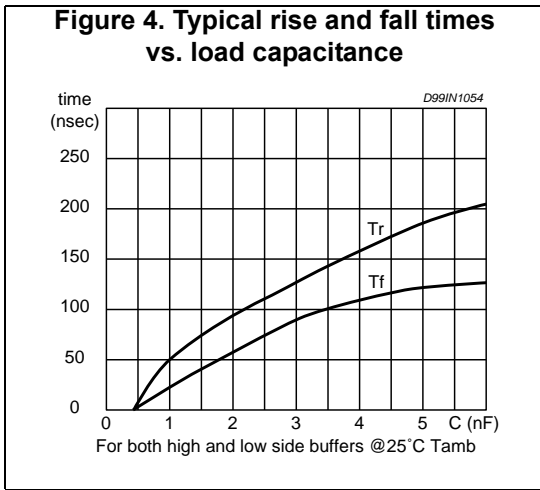
$$V_{drop} = \frac{30nC}{5\mu s} \cdot 125\Omega \sim 0.8V$$

$V_{drop}$  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 3. Bootstrap driver**



# 7 Typical characteristic



## 8 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.

### 8.1 DIP-8 package information

Figure 10. DIP-8 package outline

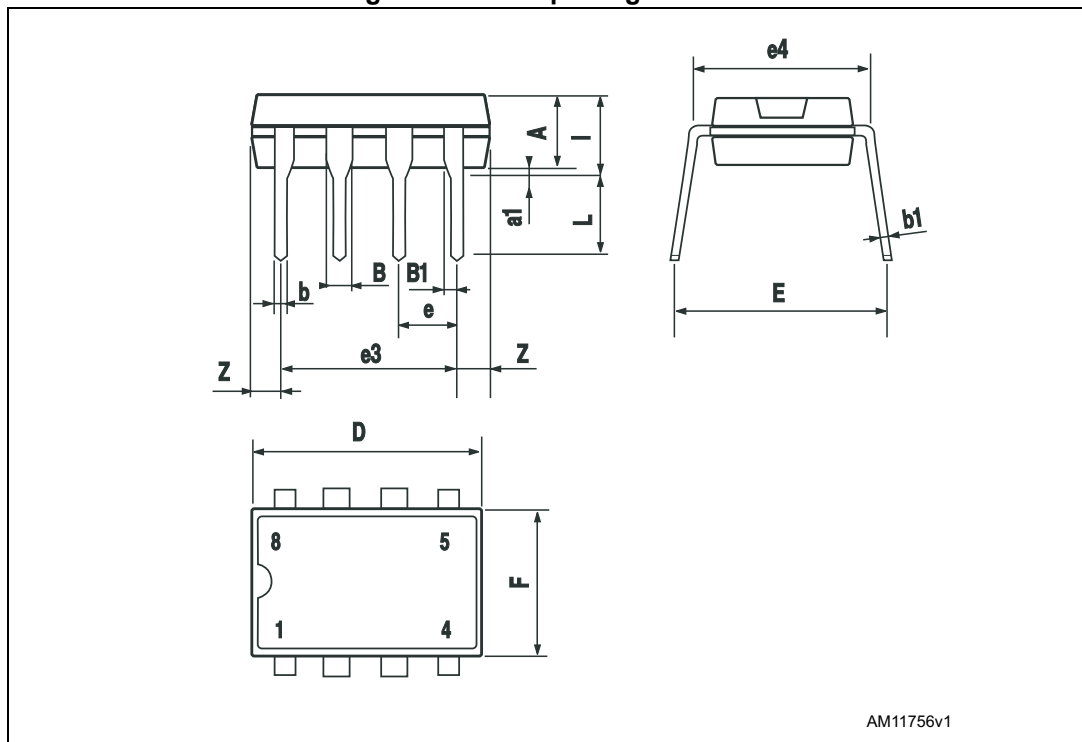


Table 8. DIP-8 package mechanical data

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

## 8.2 SO-8 package information

Figure 11. SO-8 package outline

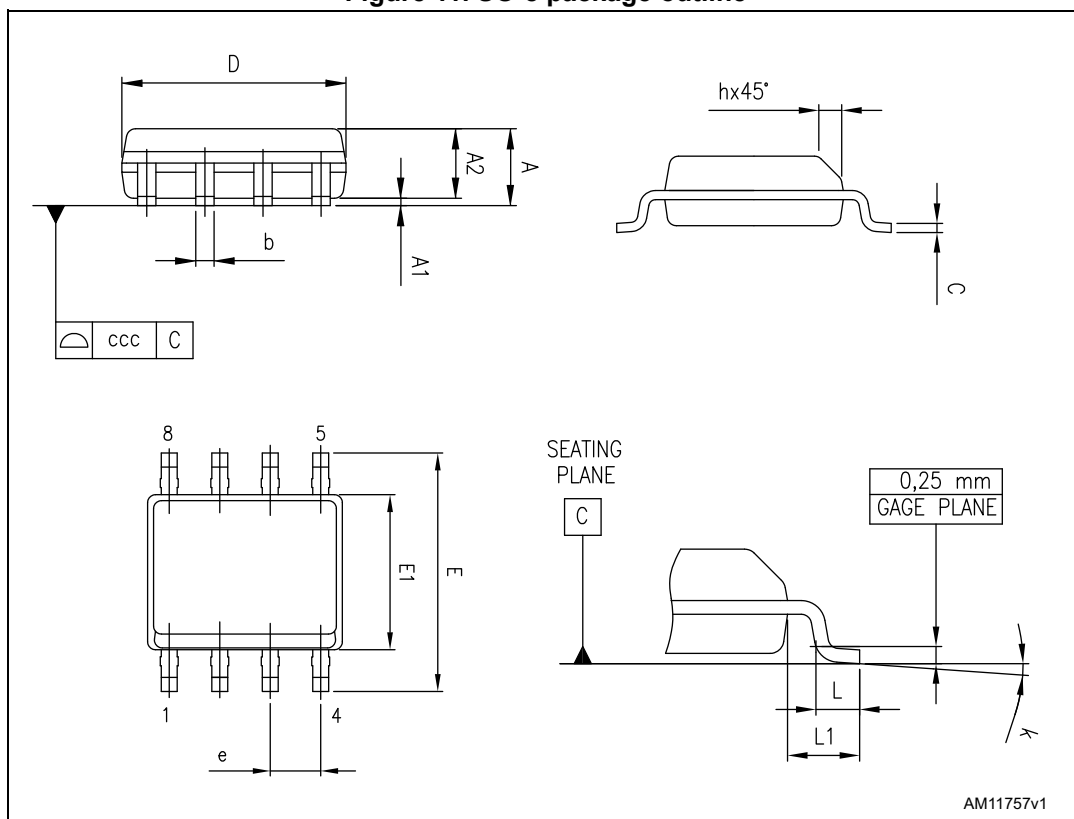


Table 9. SO-8 package mechanical data

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.

## 9 Order codes

**Table 10. Order codes**

Part number	Package	Packaging
L6387E	DIP-8	Tube
L6387ED	SO-8	Tube
L6387ED013TR	SO-8	Tape and reel

## 10 Revision history

**Table 11.**

Date	Revision	Changes
11-Oct-2007	1	First release
19-Sep-2008	2	Minor text changes on <a href="#">Table 7</a>
19-Jun-2014	3	<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, updated title).</p> <p>Updated <a href="#">Figure 1: Block diagram on page 3</a> (moved from page 1 to page 3, added title to <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 "Types").</p> <p>Added cross-references in <a href="#">Section 5: Input logic on page 8</a>.</p> <p>Updated <a href="#">Section 6: Bootstrap driver on page 9</a> (updated values of "E.g.: HVG").</p> <p>Numbered <a href="#">Equation 1 on page 9</a>, <a href="#">Equation 2 on page 9</a> and <a href="#">Equation 3 on page 10</a>.</p> <p>Updated <a href="#">Section 8: Package information on page 12</a> [updated/added titles, reversed order of <a href="#">Figure 10</a> and <a href="#">Table 9</a>, <a href="#">Figure 11</a> and <a href="#">Table 10</a> (numbered tables), removed 3D package figures, minor modifications].</p> <p>Minor modifications throughout document.</p>
20-Oct-2015	4	<p>Updated <a href="#">Table 1 on page 4</a> (added ESD row).</p> <p>Updated note 1. below <a href="#">Table 6 on page 6</a> (replaced <math>V_{\text{BOOTx}}</math> by <math>V_{\text{BOOTx}}</math>).</p> <p>Added <a href="#">Section 9: Order codes on page 16</a> (moved <a href="#">Table 10</a> from page 1, updated title).</p> <p>Minor modifications throughout document.</p>



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