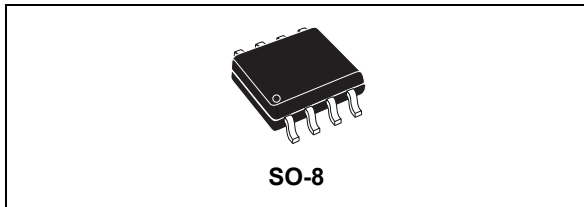


## High voltage high- and low-side driver for automotive applications

Datasheet - production data



### Features

- High voltage rail up to 550 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
- AECQ100 automotive qualified

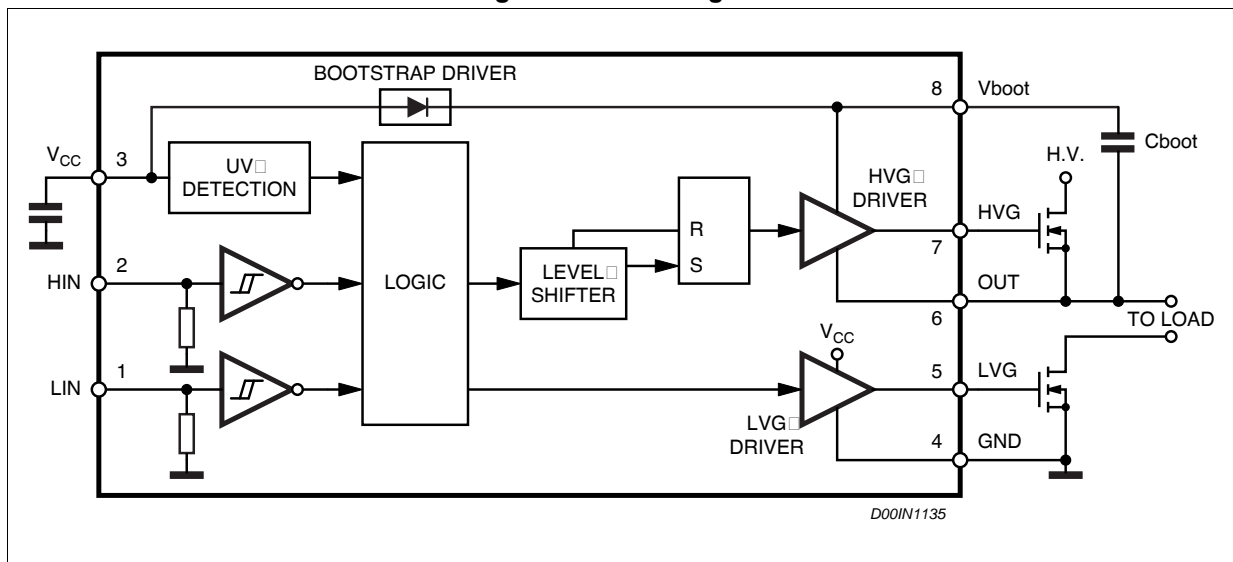
### Applications

- Drive inverters for HEV and EV
- HID ballasts, power supply units
- Motion driver for home appliances, factory automation, industrial drives

### Description

The A6387 is a high voltage device, manufactured with the BCD™ “offline” technology. It is a single chip half-bridge gate driver for N-channel Power MOSFETs or IGBTs. The high-side (floating) section is designed to stand a voltage rail of up to 550 V. The logic inputs are CMOS/TTL compatible for easy interfacing of the microcontroller or DSP.

Figure 1. Block diagram



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# 1 Electrical data

## 1.1 Absolute maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Min.	Max.	Unit
$V_{CC}$	Supply voltage	- 0.3	18	V
$V_{out}$	Output voltage	$V_{boot} - 18$	$V_{boot} + 0.3$	V
$V_{boot}$	Bootstrap voltage	- 0.3	568	V
$V_{hvg}$	High-side gate output voltage	$V_{out} - 0.3$	$V_{boot} + 0.3$	V
$V_{lvg}$	Low-side gate output voltage	- 0.3	$V_{CC} + 0.3$	V
$V_i$	Logic input voltage	- 0.3	$V_{CC} + 0.3$	V
$dV_{out}/dt$	Allowed output slew rate		50	V/ns
$P_{tot}$	Total power dissipation ( $T_A = 85\text{ °C}$ )		750	mW
$T_j$	Junction temperature		150	°C
$T_{stg}$	Storage temperature	-50	150	°C
ESD	Human Body Model	2		kV

## 1.2 Thermal data

Table 2. Thermal data

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

## 1.3 Recommended operating conditions

Table 3. Recommended operating conditions

Symbol	Pin	Parameter	Test condition	Min.	Max.	Unit
$V_{CC}$	3	Supply voltage		6.3	17	V
$V_{BO}^{(1)}$	8 - 6	Floating supply voltage			17	V
$V_{out}$	7	Output voltage		-6 <sup>(2)</sup>	530	V
$f_{sw}$		Switching frequency	HVG, LVG load $C_L = 1\text{ nF}$		400	kHz
$T_j$		Junction temperature		-40	125	°C

1.  $V_{BO} = V_{boot} - V_{out}$ .

2. LVG off.  $V_{CC} = 12\text{ V}$ .

## 2 Pin connection

Figure 2. Pin connection (top view)

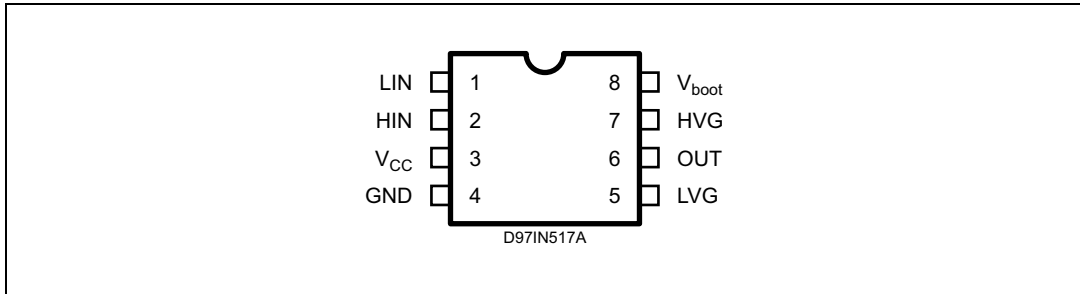


Table 4. Pin description

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 provides less than 1 V on the LVG and HVG pins (at I<sub>sink</sub> = 10 mA). This allows the omitting of the “bleeder” resistor connected between the gate and the source of the external MOSFET normally used to hold the pin low.

### 3 Electrical characteristics

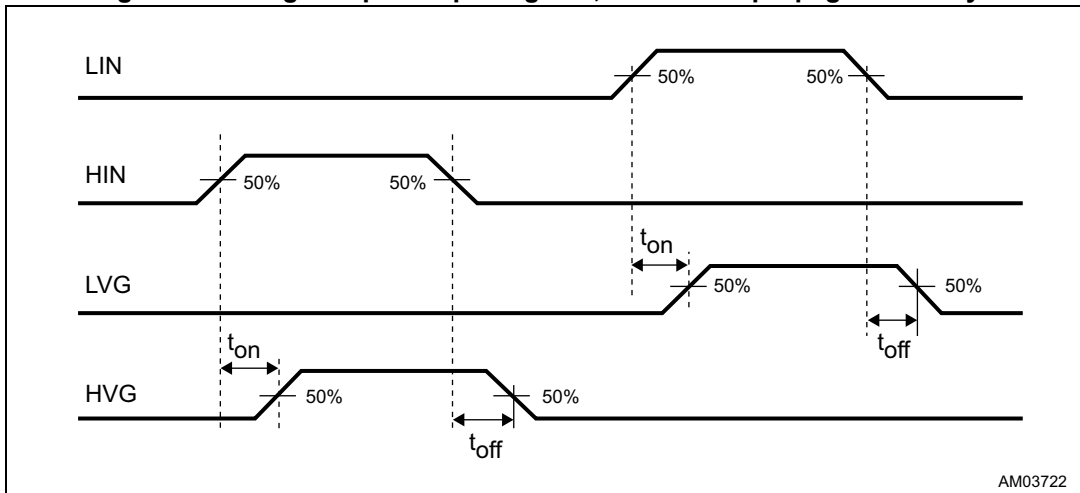
#### 3.1 AC operation

$V_{CC} = 15\text{ V}$ ;  $T_J = -40\text{ }^\circ\text{C} \div 125\text{ }^\circ\text{C}$ , unless otherwise specified.

**Table 5. AC operation electrical characteristics**

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	$V_{out} = 0\text{ V}$ $V_{boot} = V_{CC}$ $C_L = 1\text{ nF}$	40	120	240	ns
$t_{off}$	1 vs. 5 2 vs. 7	High/low-side driver turn-off propagation delay		40	110	210	ns
$t_r$	5, 7	Rise time	$C_L = 1\text{ nF}$		50	100	ns
$t_f$	5, 7	Fall time			30	80	ns

**Figure 3. Timing of input/output signals; turn-on/off propagation delays**



### 3.2 DC operation

V<sub>CC</sub> = 15 V; T<sub>J</sub> = -40 °C ÷ 125 °C, unless otherwise specified

**Table 6. DC operation electrical characteristics**

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
<b>Low supply voltage section</b>							
V <sub>CC_thON</sub>	3	V <sub>CC</sub> UV turn-on threshold		5.5	6	6.3	V
V <sub>CC_thOFF</sub>		V <sub>CC</sub> UV turn-off threshold		5	5.5	6	V
V <sub>CC_hys</sub>		V <sub>CC</sub> UV hysteresis		0.3	0.5	0.7	V
I <sub>qccu</sub>		Undervoltage quiescent supply current	V <sub>CC</sub> ≤ 5 V		150	220	μA
I <sub>qcc</sub>		Quiescent current			250	320	μA
R <sub>DSon</sub>		Bootstrap driver on resistance <sup>(1)</sup>	LVG ON		125		Ω
<b>Bootstrapped supply voltage section <sup>(2)</sup></b>							
I <sub>QBO</sub>	8	V <sub>BO</sub> quiescent current	HVG ON			100	μA
I <sub>LK</sub>		High voltage leakage current	V <sub>hvg</sub> = V <sub>out</sub> = V <sub>boot</sub> = 550 V			10	μA
<b>High/low-side driver</b>							
I <sub>so</sub>	5, 7	High/low-side source short-circuit current	V <sub>IN</sub> = V <sub>ih</sub> (t <sub>p</sub> < 10 μs)	300	400		mA
I <sub>si</sub>		High/low-side sink short-circuit current	V <sub>IN</sub> = V <sub>il</sub> (t <sub>p</sub> < 10 μs)	450	650		mA
<b>Logic inputs</b>							
V <sub>il</sub>	1,2	Low level logic threshold voltage				1.4	V
V <sub>ih</sub>		High level logic threshold voltage		3.2			V
I <sub>ih</sub>		High level logic input current	V <sub>IN</sub> = 15 V	8	20	40	μA
I <sub>il</sub>		Low level logic input current	V <sub>IN</sub> = 0 V			1	μA

1. R<sub>DS(on)</sub> 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<sub>1</sub> is pin 8 current when V<sub>BOOT</sub> = V<sub>BOOT1</sub>, I<sub>2</sub> when V<sub>BOOT</sub> = V<sub>BOOT2</sub>.

2. V<sub>BO</sub> = V<sub>boot</sub> - V<sub>out</sub>.

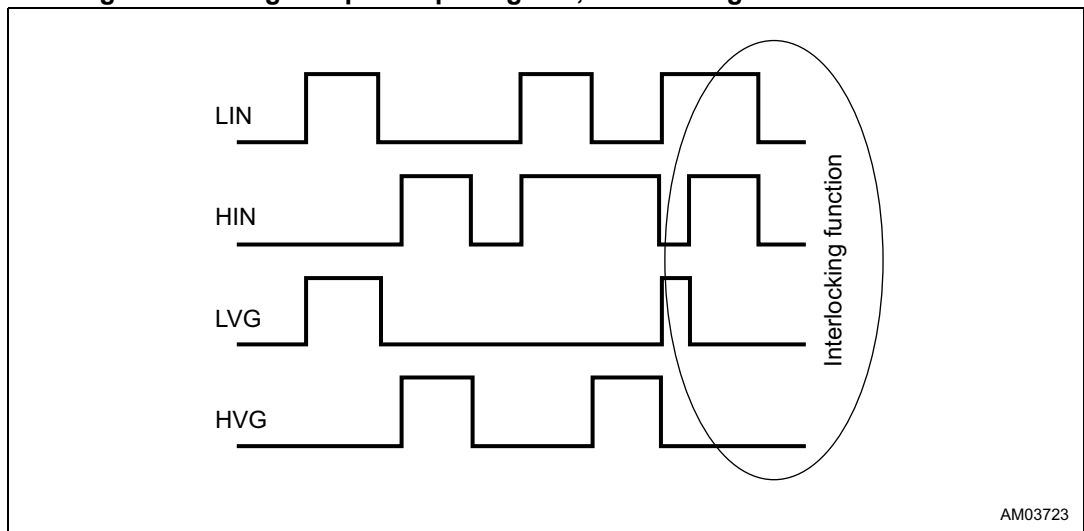
## 4 Input logic

The A6387 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

**Figure 4. Timing of input/output signals; interlocking waveforms definition**



## 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 5 a*). In the A6387 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 5 b*. An internal charge pump (*Figure 5 b*) provides the DMOS driving voltage.

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

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

#### Equation 1

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

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

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

For example: 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 must be supplied for a long period, the  $C_{BOOT}$  selection must take into account also the leakage and quiescent losses.

For example: HVG steady-state consumption is lower than 100  $\mu$ A, therefore, if HVG  $T_{ON}$  is 5 ms,  $C_{BOOT}$  must supply 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 offers a big advantage: the external fast recovery diode can be avoided (it usually has very high leakage current).

This structure can work only if  $V_{OUT}$  is close to GND (or lower) and, in the meantime, the LVG is on. The charging time ( $T_{charge}$ ) of the  $C_{BOOT}$  is the time in which both conditions are fulfilled and it must be long enough to charge the capacitor.

The bootstrap driver introduces a voltage drop due to the DMOS  $R_{DSon}$  (typical value: 125  $\Omega$ ). This drop can be neglected at low switching frequency, but it should be taken into account when operating at high switching frequency.

*Equation 2* 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 MOS,  $R_{DSon}$  is the ON-resistance of the bootstrap DMOS, and  $T_{charge}$  is the charging time of the bootstrap capacitor.



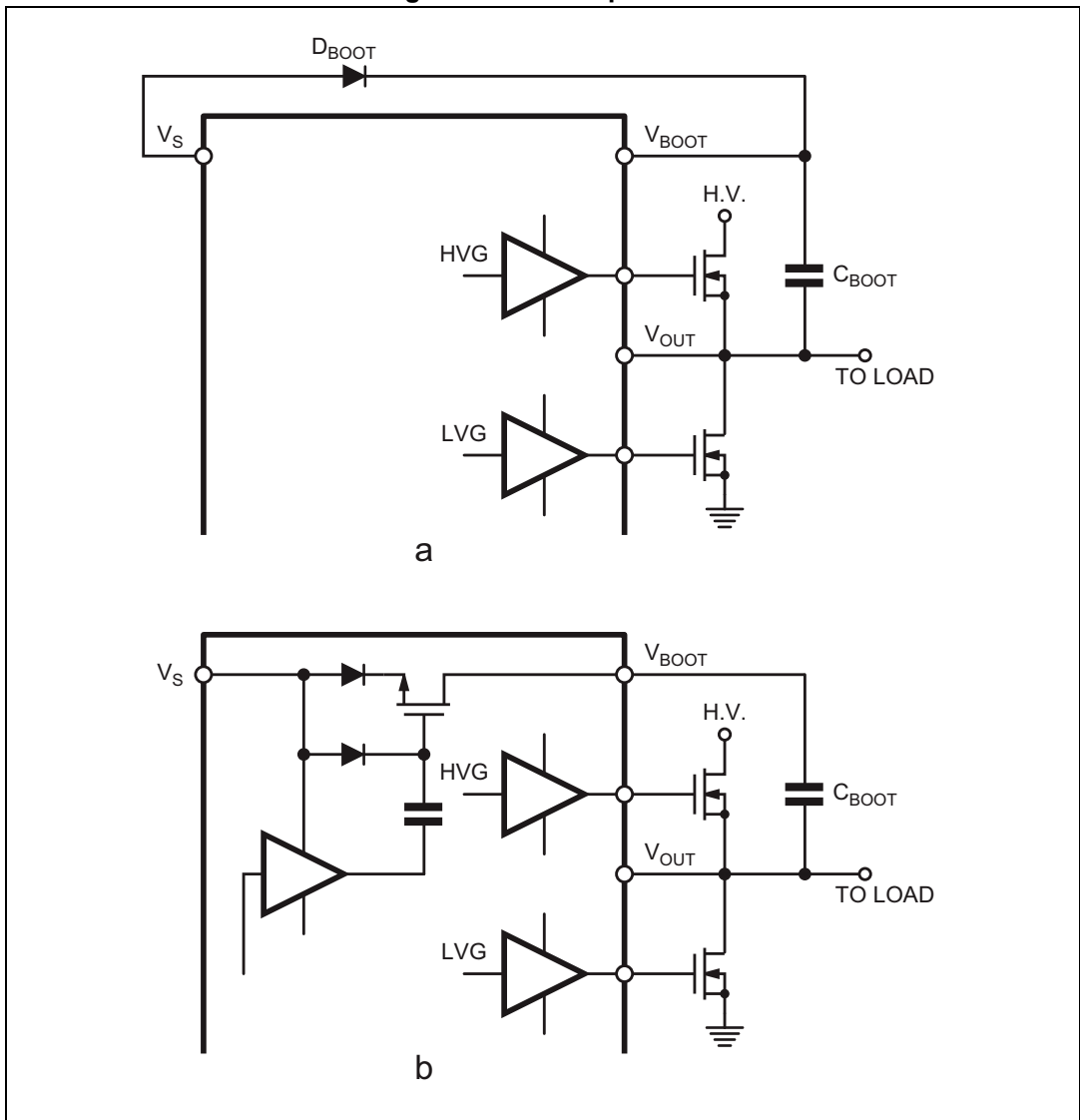
For example: using a power MOS with a total gate charge of 30 nC, the drop on the bootstrap DMOS is about 1 V, if the  $T_{charge}$  is 5  $\mu s$ . In fact:

**Equation 3**

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

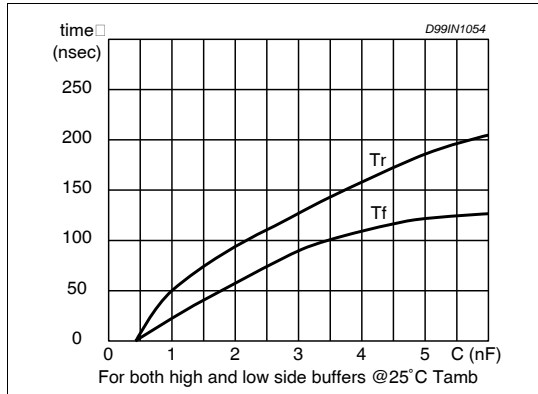
$V_{drop}$  should be taken into account when the voltage drop on  $C_{BOOT}$  is calculated: if this drop is too high, or the circuit topology doesn't allow a sufficient charging time, an external diode can be used.

**Figure 5. Bootstrap driver**

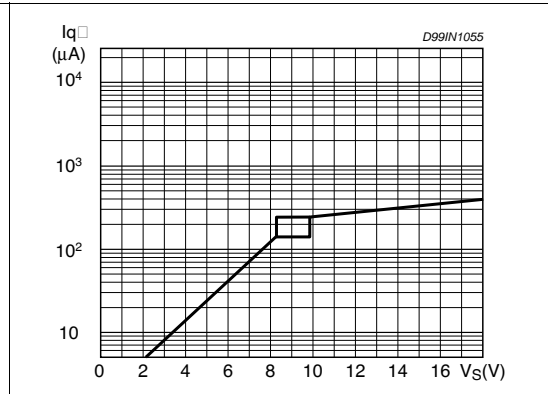


# 6 Typical characteristic

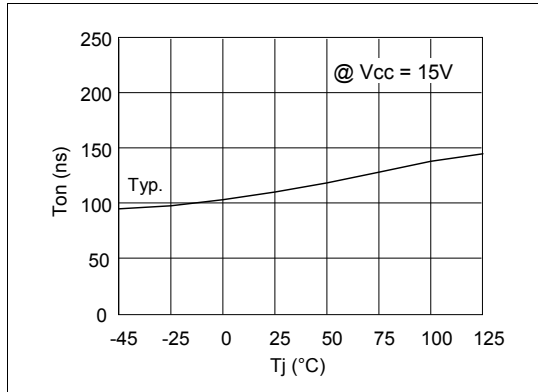
**Figure 6. Typical rise and fall times vs. load capacitance**



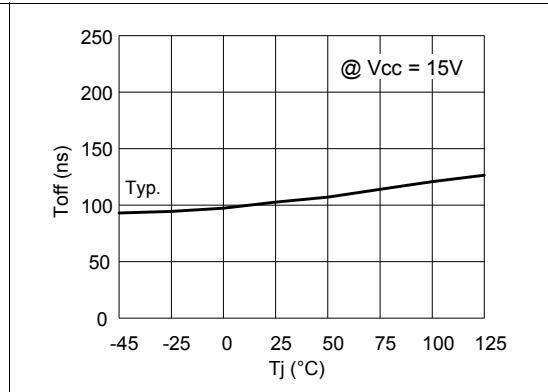
**Figure 7. Quiescent current vs. supply voltage**



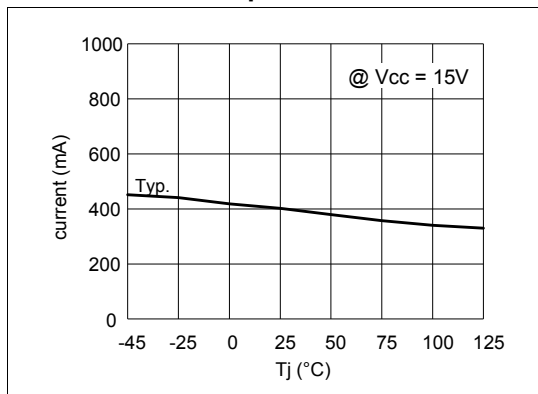
**Figure 8. Turn-on time vs. temperature**



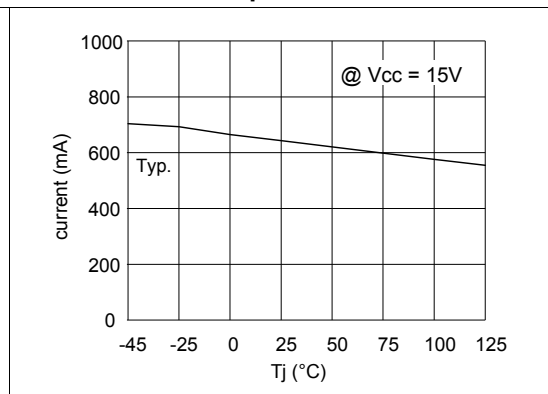
**Figure 9. Turn-off time vs. temperature**



**Figure 10. Output source current vs. temperature**



**Figure 11. 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.

Figure 12. SO-8 package outline

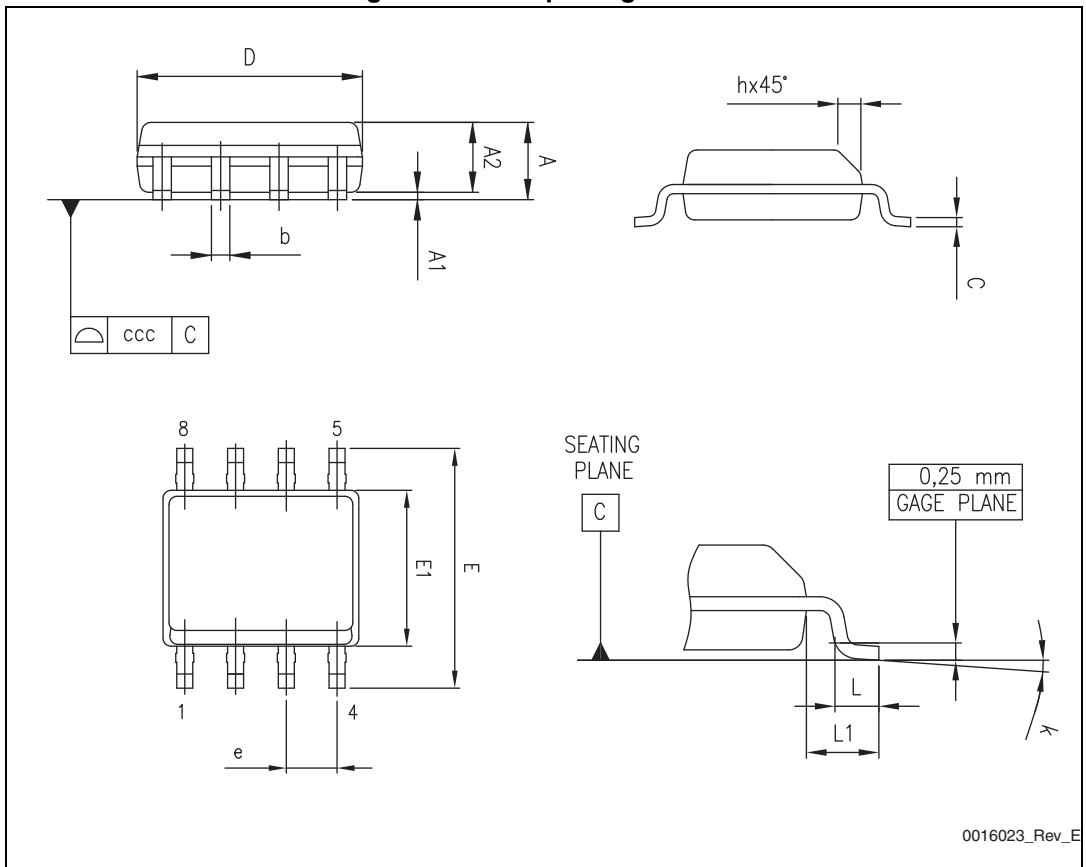


Table 8. SO-8 package mechanical data

Symbol	Dimensions (mm)		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

## 8 Ordering information

**Table 9. Ordering information**

Order code	Package	Packaging
A6387D	SO-8	Tube
A6387DTR	SO-8	Tape and reel

## 9 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
05-Jul-2012	1	First release
10-Oct-2013	2	Updated: <a href="#">Section : Features on page 1</a> (added "AECQ100 compliant"). <a href="#">Section : Applications on page 1</a> added: – Drive inverters for HEV and EV, – HID ballasts, power supply units, – Motion driver for home appliances, factory automation, industrial drives. <a href="#">Table 1 on page 3</a> (removed note below <a href="#">Table 1</a> ). Minor corrections throughout document.
22-Oct-2013	3	Updated <a href="#">Section : Features on page 1</a> ("replaced AECQ100 compliant" by "AECQ100 automotive qualified").
14-Apr-2014	4	Updated <a href="#">Section 3.1: AC operation on page 5</a> (added <a href="#">Figure 3</a> ). Updated <a href="#">Section 4: Input logic on page 7</a> (added <a href="#">Figure 4</a> ).
04-Feb-2015	5	Updated <a href="#">Table 1</a> (added <i>Human Body Model</i> parameter). Updated minimum supply voltage in <a href="#">Table 3</a> and maximum $V_{CC}$ UV turn-on threshold voltage in <a href="#">Table 6</a> . Corrected typo in $R_{DS(on)}$ testing equation in footnote of <a href="#">Table 6</a> . Updated <a href="#">Figure 5: Bootstrap driver</a> .

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