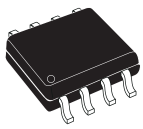
High voltage high- and low-side driver for automotive applications

Datasheet - production data



SO-8

Features

- High voltage rail up to 550 V
- dV/dt immunity ± 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

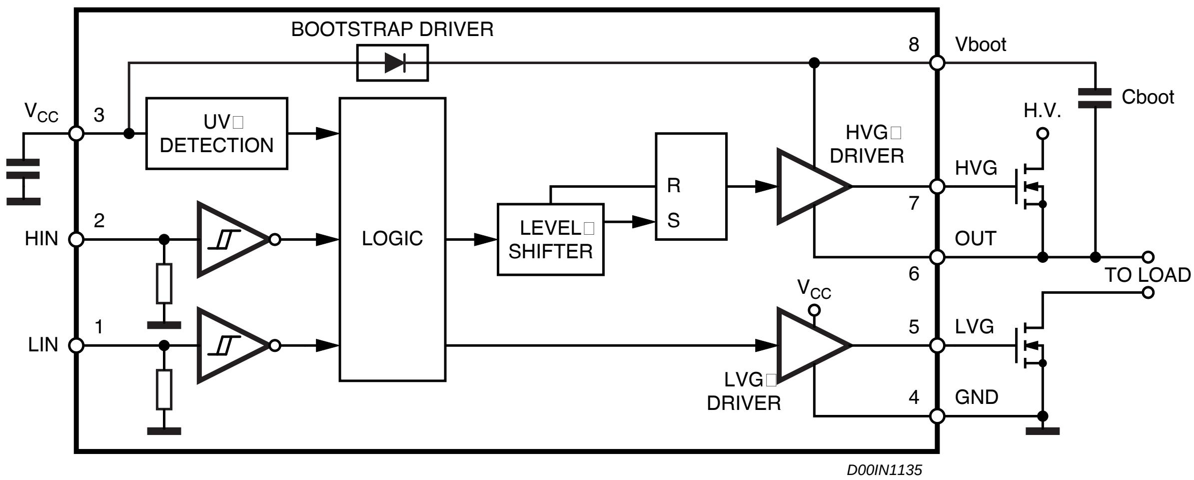
Applications

- 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



Contents

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 °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(2)	530	V
f_{sw}		Switching frequency	HVG, LVG load C_L = 1 nF		400	kHz
T_j		Junction temperature		-40	125	°C

1. $V_{BO} = V_{boot} - V_{out}$.
2. LVG off. V_{CC} = 12 V.

2 Pin connection

Figure 2. Pin connection (top view)

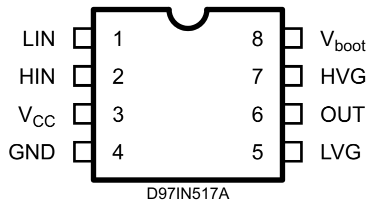


Table 4. Pin description

No.	Pin	Type	Function
1	LIN	I	Low-side driver logic input
2	HIN	I	High-side driver logic input
3	V_{cc}	P	Low voltage power supply
4	GND	P	Ground
5	LVG [(1)]	O	Low-side driver output
6	OUT	P	High-side driver floating reference
7	HVG [(1)]	O	High-side driver output
8	V_{boot}	P	Bootstrap supply voltage

1. The circuit provides less than 1 V on the LVG and HVG pins (at I_{sink} = 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

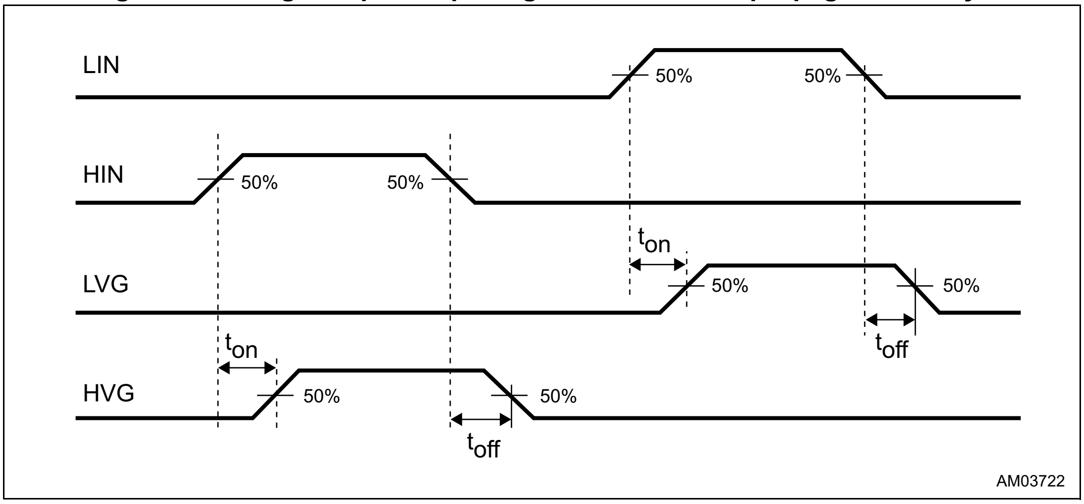
3.1 AC operation

V_{CC} = 15 V; T_J = -40 °C ÷ 125 °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 V V_{boot} = V_{CC} C_L = 1 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 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_{CC} = 15 V; T_J = -40 °C ÷ 125 °C, unless otherwise specified

Table 6. DC operation electrical characteristics

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
Low supply voltage section							
V_{cc_thON}	3	V_{cc} UV turn-on threshold		5.5	6	6.3	V
V_{cc_thOFF}		V_{cc} UV turn-off threshold		5	5.5	6	V
V_{cc_hys}		V_{cc} UV hysteresis		0.3	0.5	0.7	V
I_{qccu}		Undervoltage quiescent supply current	$V_{cc} \leq 5$ V		150	220	µA
I_{qcc}		Quiescent current			250	320	µA
R_{DSon}		Bootstrap driver on resistance(1)	LVG ON		125		Ω
Bootstrapped supply voltage section (2)							
I_{QBO}	8	V_{BO} quiescent current	HVG ON			100	µA
I_{LK}		High voltage leakage current	$V_{hvg} = V_{out} = V_{boot}$ = 550 V			10	µA
High/low-side driver							
I_{so}	5, 7	High/low-side source short-circuit current	$V_{IN} = V_{ih}$ (t_p < 10 µs)	300	400		mA
I_{si}		High/low-side sink short-circuit current	$V_{IN} = V_{il}$ (t_p < 10 µs)	450	650		mA
Logic inputs							
V_{il}	1,2	Low level logic threshold voltage				1.4	V
V_{ih}		High level logic threshold voltage		3.2			V
I_{ih}		High level logic input current	V_{IN} = 15 V	8	20	40	µA
I_{il}		Low level logic input current	V_{IN} = 0 V			1	µA

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

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

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

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

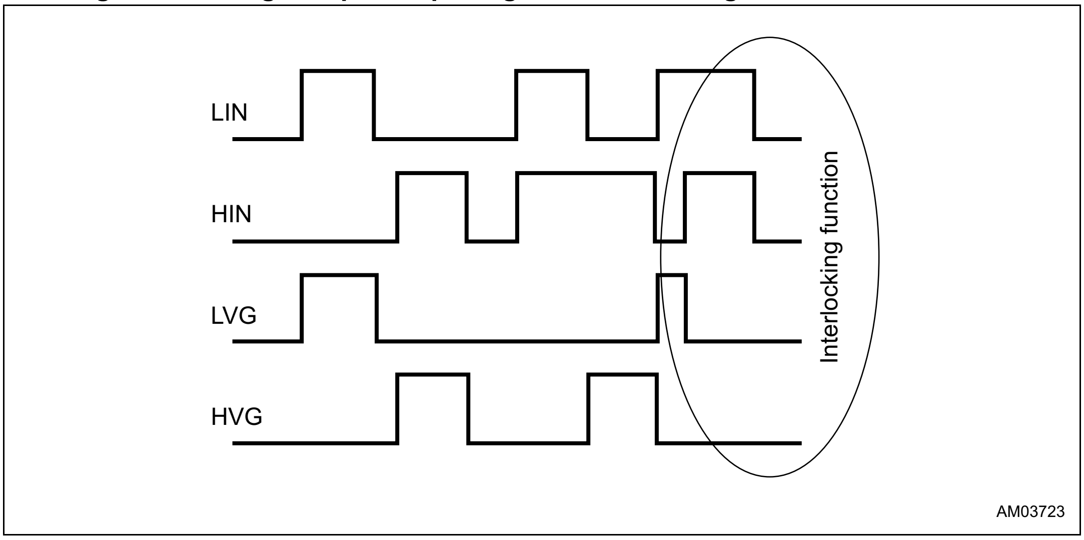
4 Input logic

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:

$$C_{BOOT} >>> C_{EXT}$$

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 µA, therefore, if HVG T_{ON} is 5 ms, C_{BOOT} must supply 0.5 µC to C_{EXT}. This charge on a 1 µF 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 Ω). 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.

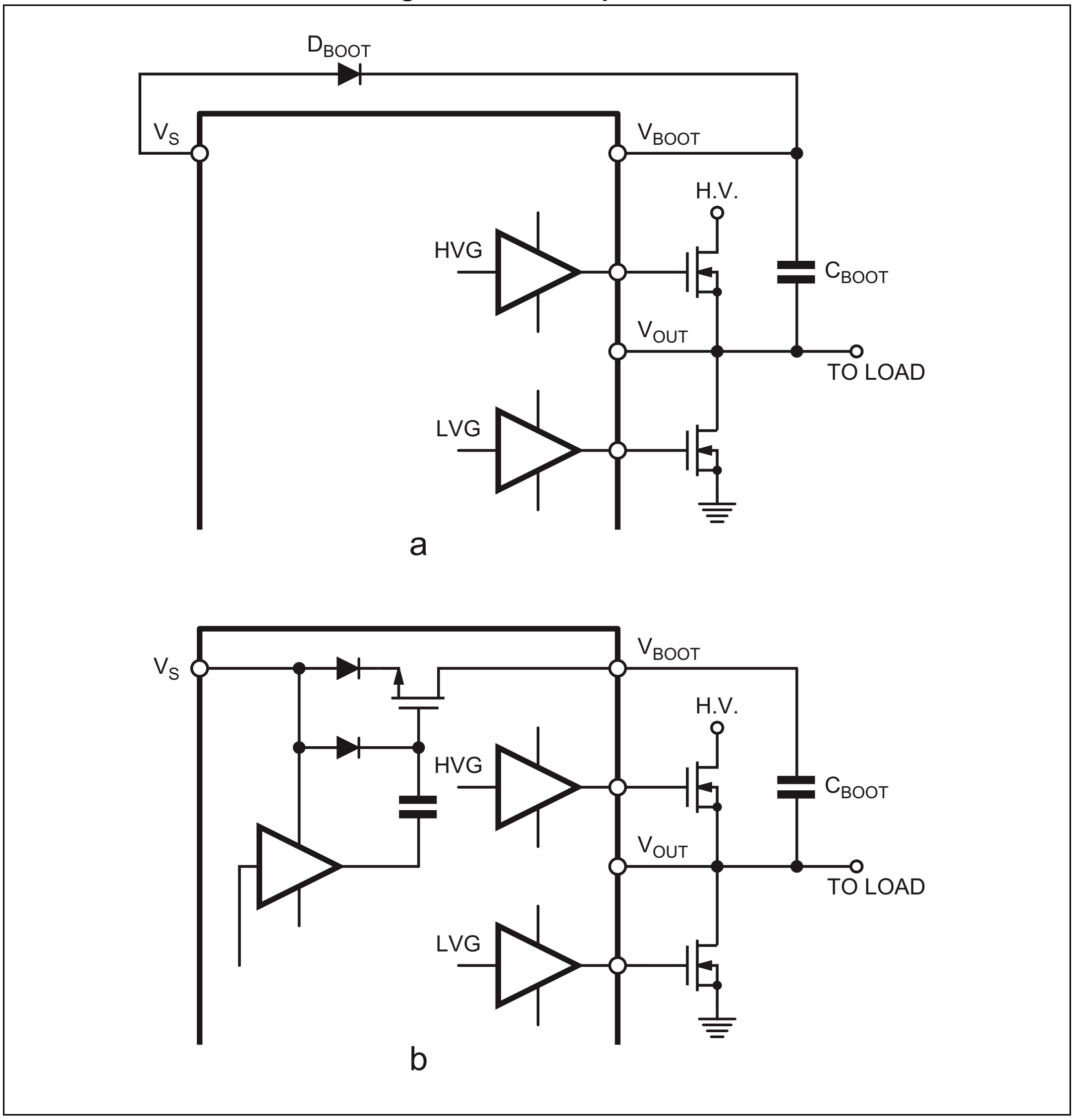
For example: using a power MOS with a total gate charge of 30 nC, the drop on the bootstrap DMOS is about 1 V, if the T_{charge} is 5 µs. In fact:

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

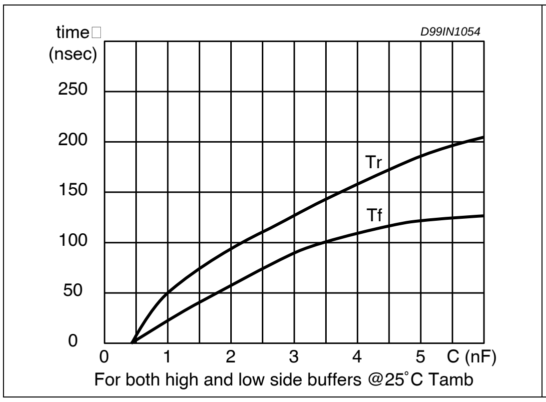


Figure 7. Quiescent current vs. supply voltage

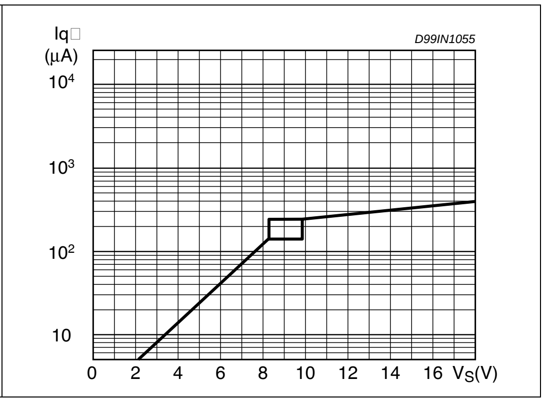


Figure 8. Turn-on time vs. temperature

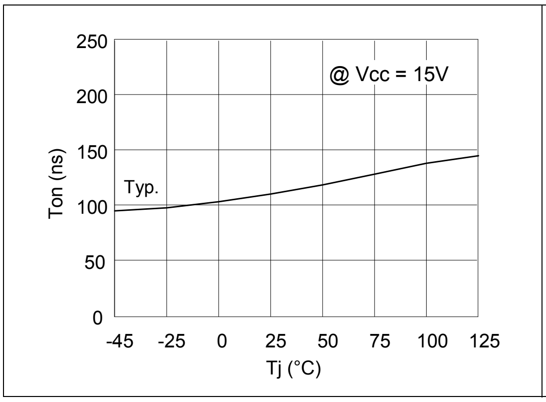


Figure 9. Turn-off time vs. temperature

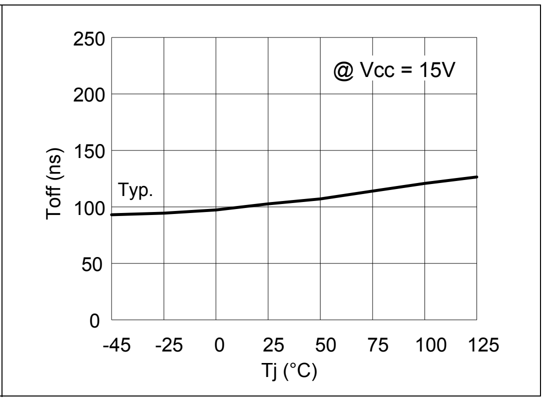


Figure 10. Output source current vs. temperature

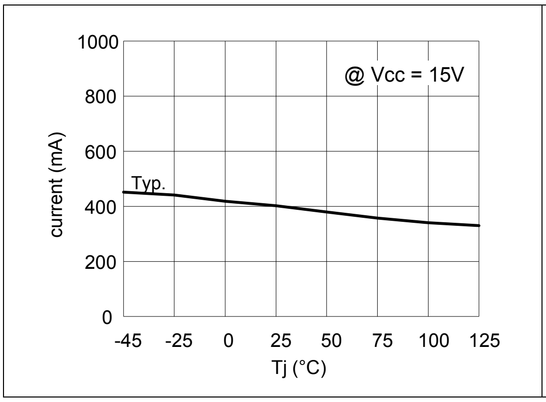
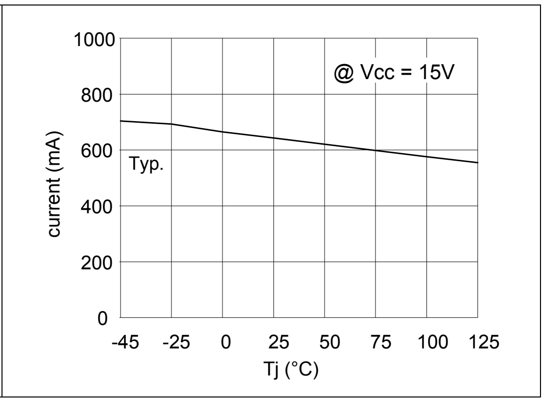


Figure 11. Output sink current vs. temperature



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*. ECOPACK is an ST trademark.

Figure 12. SO-8 package outline

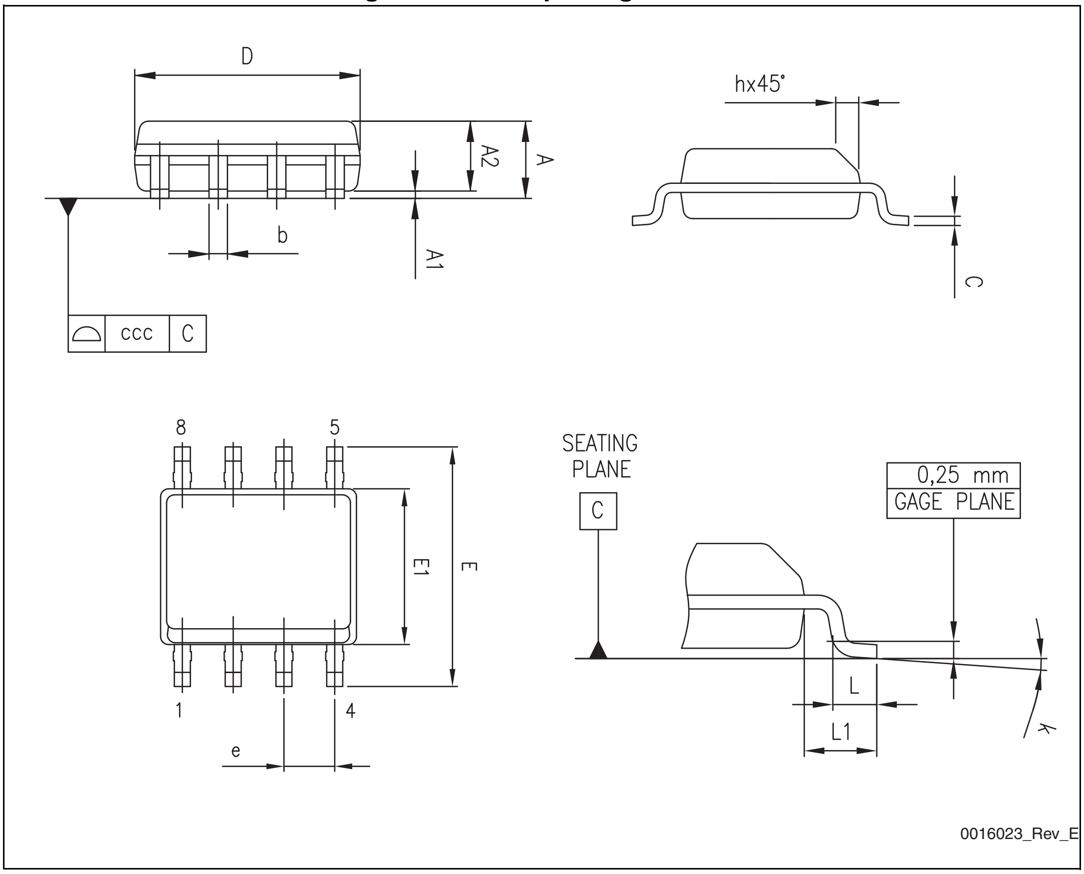


Table 8. SO-8 package mechanical data

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: *Section : Features on page 1* (added “AECQ100 compliant”). *Section : Applications on page 1* added: – Drive inverters for HEV and EV, – HID ballasts, power supply units, – Motion driver for home appliances, factory automation, industrial drives. *Table 1 on page 3* (removed note below *Table 1*). Minor corrections throughout document.
22-Oct-2013	3	Updated *Section : Features on page 1* (“replaced AECQ100 compliant” by “AECQ100 automotive qualified”).
14-Apr-2014	4	Updated *Section 3.1: AC operation on page 5* (added *Figure 3*). Updated *Section 4: Input logic on page 7* (added *Figure 4*).
04-Feb-2015	5	Updated *Table 1* (added *Human Body Model* parameter). Updated minimum supply voltage in *Table 3* and maximum V_{cc} UV turn-on threshold voltage in *Table 6*. Corrected typo in $R_{DS(on)}$ testing equation in footnote of *Table 6*. Updated *Figure 5: Bootstrap driver*.

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Телефон: 8 (812) 309-75-97 (многоканальный)
Факс: 8 (812) 320-03-32
Электронная почта: ocean@oceanchips.ru
Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А