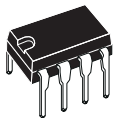
L6384E

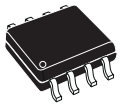
High-voltage half bridge driver

Features

- High voltage rail up to 600V
- dV/dt immunity ±50V/nsec in full temperature range
- Driver current capability:
  - 400mA source,
  - 650mA sink
- Switching times 50/30 nsec rise/fall with 1nF load
- CMOS/TTL Schmitt trigger inputs with hysteresis and pull down
- Shut down input
- Dead time setting
- Under voltage lock out
- Integrated bootstrap diode
- Clamping on V_{CC}
- SO-8/DIP-8 packages



DIP-8

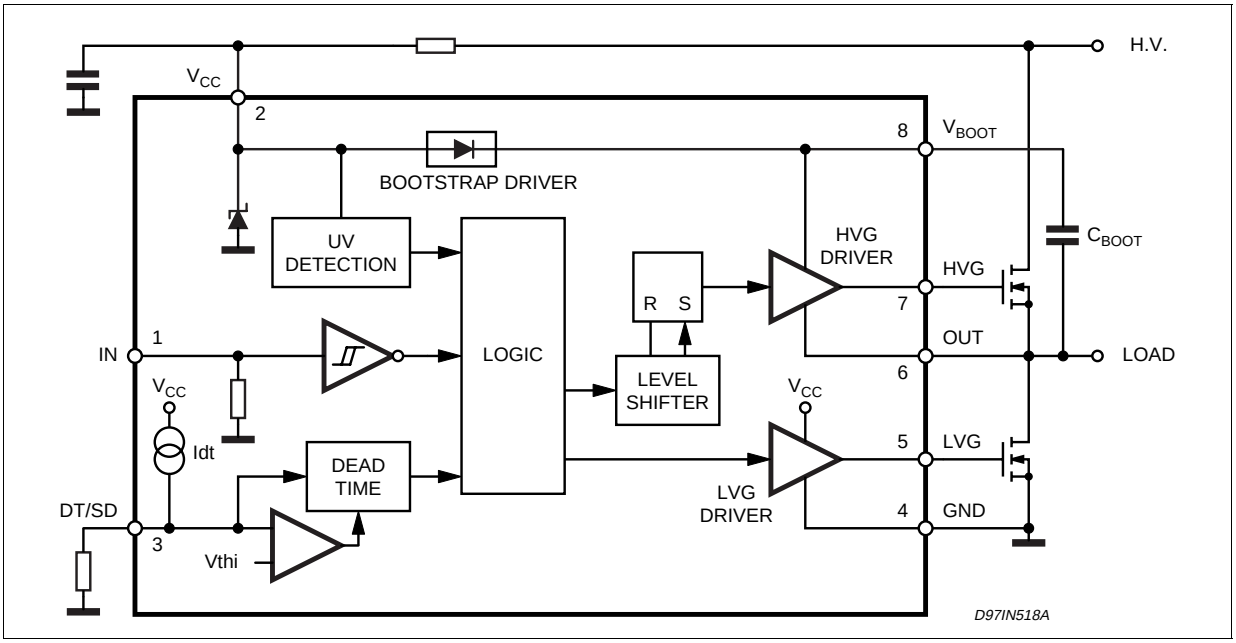


SO-8

Description

The L6384E is an high-voltage device, manufactured with the BCD"OFF-LINE" technology. It has an Half - Bridge Driver structure that enables to drive 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. Matched delays between Low and High Side Section simplify high frequency operation. Dead time setting can be readily accomplished by means of an external resistor.

Figure 1. Block diagram



Contents

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 (1)	- 0.3 to 14.6	V
I_s	Supply current (1)	25	mA
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
V_{sd}	Shut down/dead time voltage	-0.3 to V_{cc} +0.3	V
dV_{out}/d_t	Allowed output slew rate	50	V/ns
P_{tot}	Total power dissipation (T_j = 85 °C)	750	mW
T_J	Junction temperature	150	°C
T_s	Storage temperature	-50 to 150	°C

1. The device has an internal Clamping Zener between GND and the Vcc pin, It must not be supplied by a Low Impedence Voltage Source.

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 = 1nF			400	kHz
V_{cc}	2	Supply Voltage				V_{clamp}	V
T_j		Junction Temperature		-45		125	°C

1. If the condition Vboot - Vout < 18V is guaranteed, Vout can range from -3 to 580V.
2. $V_{BS} = V_{boot} - V_{out}$

2 Pin connection

Figure 2. Pin connection (Top view)

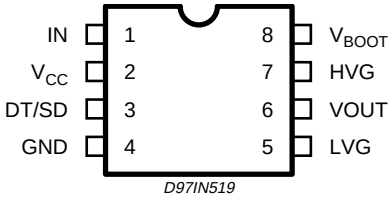


Table 4. Pin description

N°	Pin	Type	Function
1	IN	I	Logic Input: it is in phase with HVG and in opposition of phase with LVG. It is compatible to V_{CC} voltage. [$V_{il\ Max}$ = 1.5V, $V_{ih\ Min}$ = 3.6V]
2	V_{cc}		Supply input voltage: there is an internal clamp [Typ. 15.6V]
3	DT/SD	I	High impedance pin with two functionalities. When pulled lower than V_{dt} [Typ. 0.5V] the device is shut down. A voltage higher than V_{dt} sets the dead time between high side gate driver and low side gate driver. The dead time value can be set forcing a certain voltage level on the pin or connecting a resistor between pin 3 and ground. Care must be taken to avoid below threshold spikes on pin 3 that can cause undesired shut down of the IC. For this reason the connection of the components between pin 3 and ground has to be as short as possible. This pin can not be left floating for the same reason. The pin has not be pulled through a low impedance to V_{CC}, because of the drop on the current source that feeds R_{dt}. The operative range is: V_{dt}....270K · I_{dt}, that allows a dt range of 0.4 - 3.1µs.
4	GND		Ground
5	LVG	O	Low Side Driver Output: the output stage can deliver 400mA source and 650mA sink [Typ. Values]. The circuit guarantees 0.3V max on the pin (@ I_{sink} = 10mA) with V_{CC} > 3V and lower than the turn on threshold. 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; the gate driver ensures low impedance also in SD conditions.
6	V_{out}	O	High Side Driver Floating Reference: layout care has to be taken to avoid below ground spikes on this pin.
7	HVG	O	High Side Driver Output: the output stage can deliver 400mA source and 650mA sink [Typ. Values]. The circuit gurantees 0.3V max between this pin and V_{out} (@ I_{sink} = 10mA) with V_{CC} > 3V and lower than the turn on threshold. 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; the gate driver ensures low impedance also in SD conditions.
8	Vboot		Bootstrap Supply Voltage: it is the high side driver floating supply. The bootstrap capacitor connected between this pin and pin 6 can be fed by an internal structure named "bootstrap driver" (a patented structure). This structure can replace the external bootstrap diode.

3 Electrical characteristics

3.1 AC operation

Table 5. AC operation electrical characteristcs (V_{CC} = 14.4V; T_J = 25°C)

Symbol	Pin	Parameter	Test condition	Min	Typ	Max	Unit
t_{on}	1 vs 5,7	High/low side driver turn-on propagation delay	V_{out} = 0V R_{dt}= 47kΩ		200+ dt		ns
t_{onsd}	3 vs 5,7	Shut down input propagation delay			220	280	ns
t_{off}	1 vs 5,7	High/low side driver turn-off propagation delay	V_{out} = 0V R_{dt} = 47kΩ		250	300	ns
			V_{out} = 0V R_{dt} = 146kΩ		200	250	ns
			V_{out} = 0V R_{dt} = 270kΩ		170	200	ns
t_r	5,7	Rise time	C_L = 1000pF		50		ns
t_f	5,7	Fall time	C_L = 1000pF		30		ns

3.2 DC operation

Table 6. DC operation electrical characteristcs (V_{CC} = 14.4V; T_J = 25°C)

Symbol	Pin	Parameter	Test condition	Min	Typ	Max	Unit
Supply voltage section							
V_{clamp}	2	Supply voltage clamping	I_s = 5mA	14.6	15.6	16.6	V
V_{ccth1}	2	V_{CC} UV turn on threshold		11.5	12	12.5	V
V_{ccth2}	2	V_{CC} UV turn off threshold		9.5	10	10.5	V
V_{cchys}		V_{CC} UV Hysteresis			2		V
I_{qccu}		Undervoltage quiescent supply current	$V_{cc} \leq$ 11V		150		µA
I_{qcc}		Quiescent current	V_{in} = 0		380	500	µA
Bootstrapped supply voltage section							
V_{boot}	8	Bootstrap supply voltage				17	V
I_{QBS}		Quiescent current	IN = HIGH			200	µA
I_{LK}		High voltage leakage current	V_{hvg} = V_{out} = V_{boot} = 600V			10	µA
R_{dson}		Bootstrap driver on resistance (1)	$V_{cc} \geq$12.5V; IN = LOW		125		Ω

Table 6. DC operation electrical characteristcs (continued)(V_{CC} = 14.4V; T_J = 25°C)

Symbol	Pin	Parameter	Test condition	Min	Typ	Max	Unit
High/Low side driver							
I_{so}	5,7	Source short circuit current	$V_{IN} = V_{ih}$ (t_p < 10µs)	300	400		mA
I_{si}		Sink short circuit current	$V_{IN} = V_{il}$ (tp < 10µs)	500	650		mA
Logic inputs							
V_{il}	1,3	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} = 15V		50	70	µA
I_{il}		Low level logic input current	V_{IN} = 0V			1	µA
I_{ref}	3	Dead time setting current			28		µA
dt	3 vs 5,7	Dead time setting range (2)	R_{dt} = 47kΩ R_{dt} = 146kΩ R_{dt} = 270kΩ	0.4	0.5 1.5 2.7	 3.1	µs µs µs
V_{dt}	3	Shutdown threshold			0.5		V

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

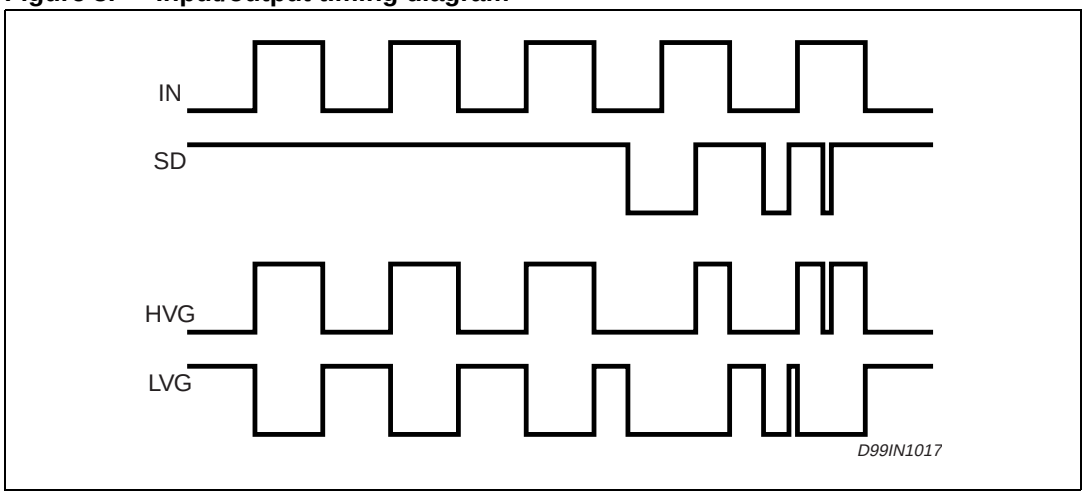
$$R_{DSON} = \frac{(V_{CC} - V_{CBOOT1}) - (V_{CC} - V_{CBOOT2})}{I_1(V_{CC}, V_{CBOOT1}) - I_2(V_{CC}, V_{CBOOT2})}$$

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

2. Pin 3 is a high impedence pin. Therefore dt can be set also forcing a certain voltage V_3 on this pin. The dead time is the same obtained with a R_{dt} if it is: $R_{dt} \times I_{ref} = V_3$.

3.3 Timing diagram

Figure 3. Input/output timing diagram



4 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 L6384E 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 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 of it.

4.1 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:

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

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

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

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

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 200µA, so if HVG T_{ON} is 5ms, C_{BOOT} has to supply 1µC to C_{EXT}. 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_{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 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:

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

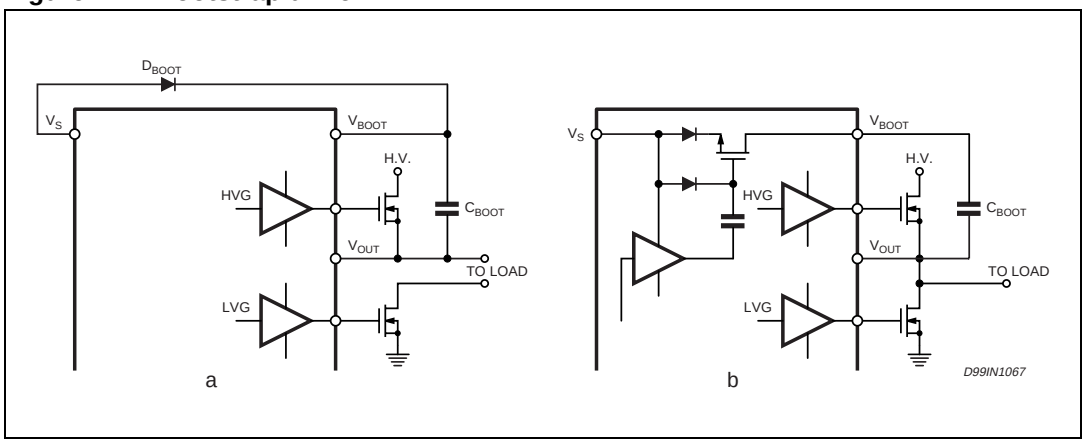
where Q_{gate} is the gate charge of the external power MOS, R_{dson} is the on resistance of the bootstrap DMOS, and T_{charge} is the charging time of the bootstrap capacitor.

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

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

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



5 Typical characteristic

Figure 5. Typical rise and fall times vs load capacitance

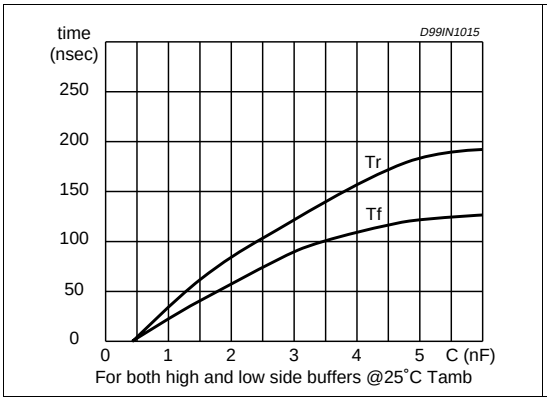


Figure 6. Quiescent current vs supply voltage

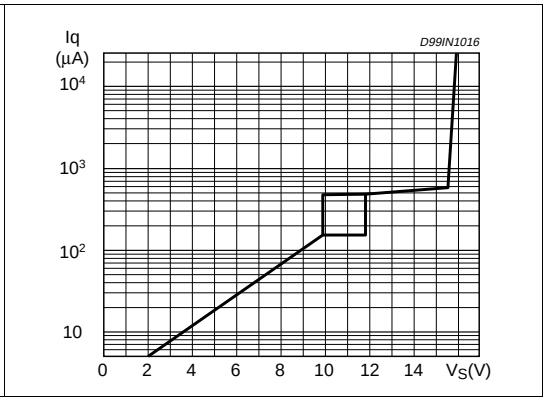


Figure 7. Dead time vs resistance

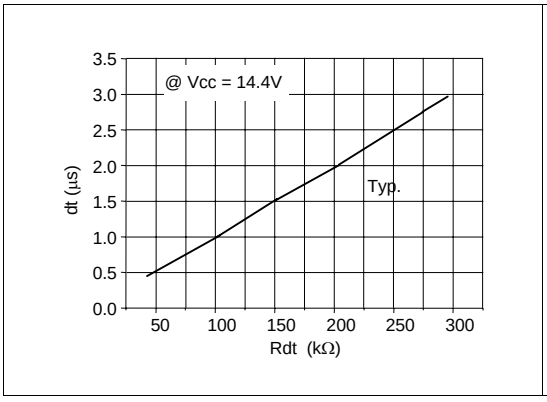


Figure 8. Driver propagation delay vs temperature

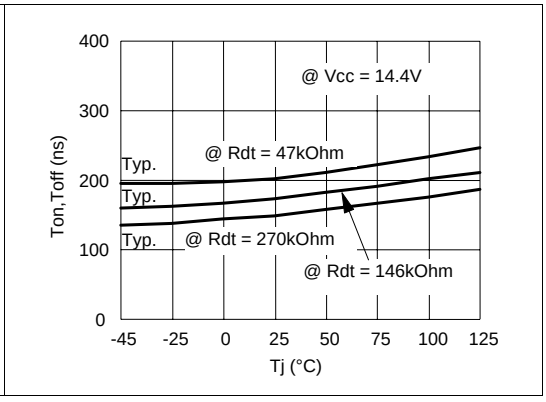


Figure 9. Dead time vs temperature

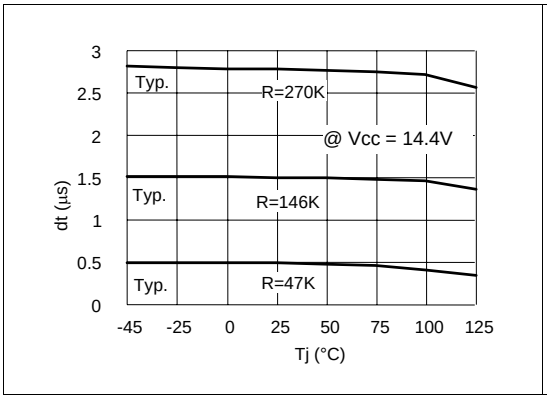


Figure 10. Shutdown threshold vs temperature

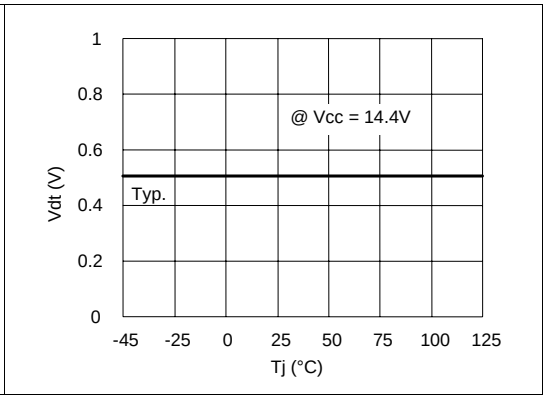


Figure 11. Vcc UV turn On vs temperature

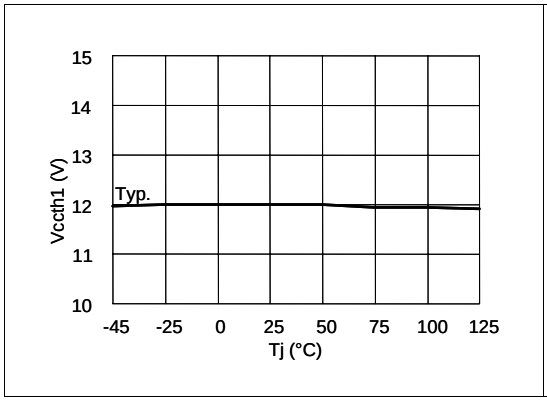


Figure 12. Output source current vs temperature

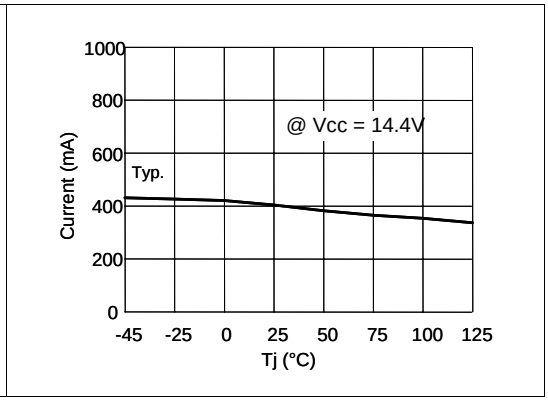


Figure 13. Vcc UV turn Off vs temperature

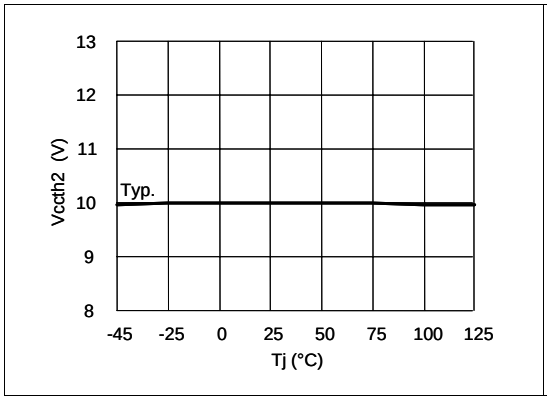
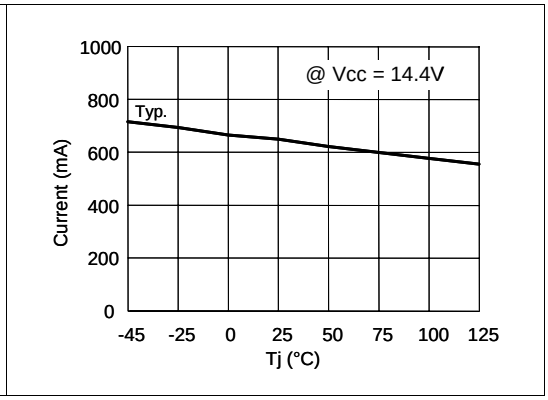


Figure 14. Output sink current vs temperature



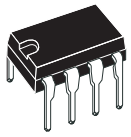
6 Package mechanical data

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

Figure 15. DIP-8 mechanical data and package dimensions

DIM.	mm			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

OUTLINE AND MECHANICAL DATA



DIP-8

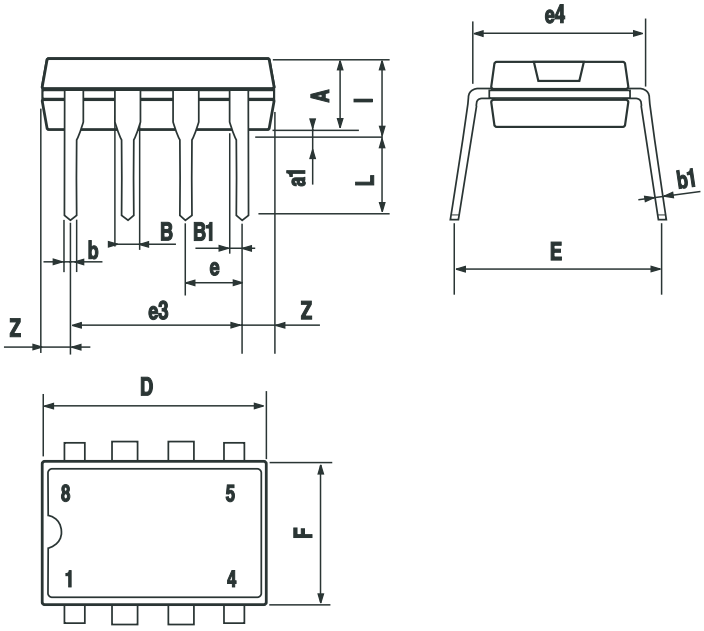
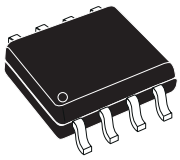


Figure 16. SO-8 mechanical data and package dimensions

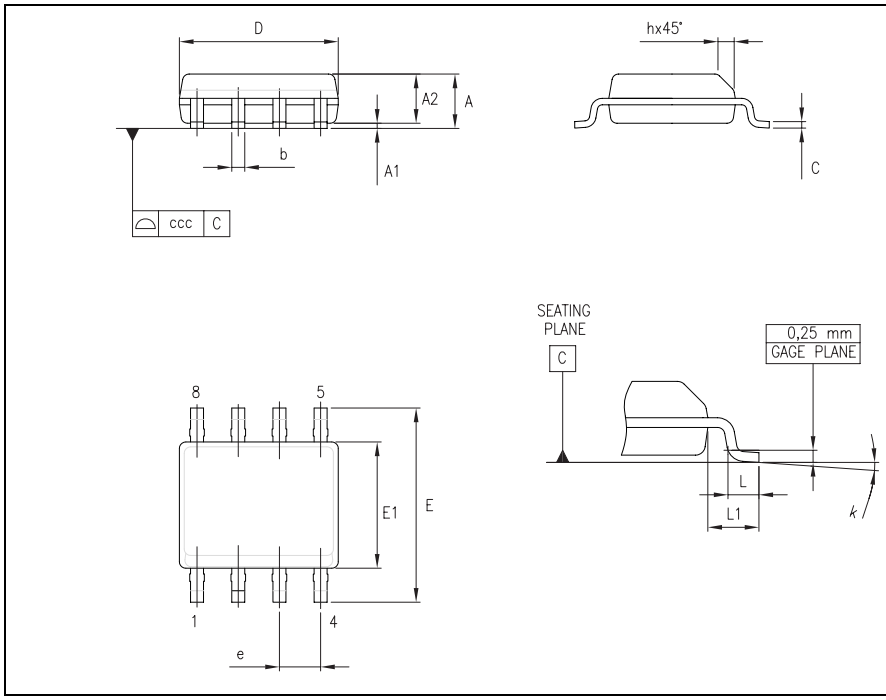
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.750			0.0689
A1	0.100		0.250	0.0039		0.0098
A2	1.250			0.0492		
b	0.280		0.480	0.0110		0.0189
c	0.170		0.230	0.0067		0.0091
D (1)	4.800	4.900	5.000	0.1890	0.1929	0.1969
E	5.800	6.000	6.200	0.2283	0.2362	0.2441
E1(2)	3.800	3.900	4.000	0.1496	0.1535	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, potrusions 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



7 Order codes

Table 7. Order codes

Part number	Package	Packaging
L6384E	DIP-8	Tube
L6384ED	SO-8	Tube
L6384ED013TR	SO-8	Tape and reel

8 Revision history

Table 8. Document revision history

Date	Revision	Changes
12-Oct-2007	1	First release

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