

HIGH-VOLTAGE HIGH AND LOW SIDE DRIVER

1 FEATURES

- HIGH VOLTAGE RAIL UP TO 600 V
- dV/dt IMMUNITY ± 50 V/nsec IN FULL TEMPERATURE RANGE
- DRIVER CURRENT CAPABILITY: 400 mA SOURCE, 650 mA SINK
- SWITCHING TIMES 70/40 nsec RISE/FALL WITH 1nF LOAD
- 3.3V, 5V, 15V CMOS/TTL INPUTS COMPARATORS WITH HYSTERESYS AND PULL DOWN
- INTERNAL BOOTSTRAP DIODE
- OUTPUTS IN PHASE WITH INPUTS
- DEAD TIME AND INTERLOCKING FUNCTION

2 DESCRIPTION

The L6388 is an high-voltage device, manufactured with the BCD "OFF-LINE" technology.

Figure 1. Package



Table 1. Order Codes

| Part Number | Package |
|-------------|--------------------|
| L6388 | DIP8 |
| L6388D | SO8 |
| L6388D013TR | SO8 in Tape & Reel |

It has a Driver structure that enables to drive independent referenced N Channel Power MOS or IGBT. The Upper (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.

Figure 2. Block Diagram

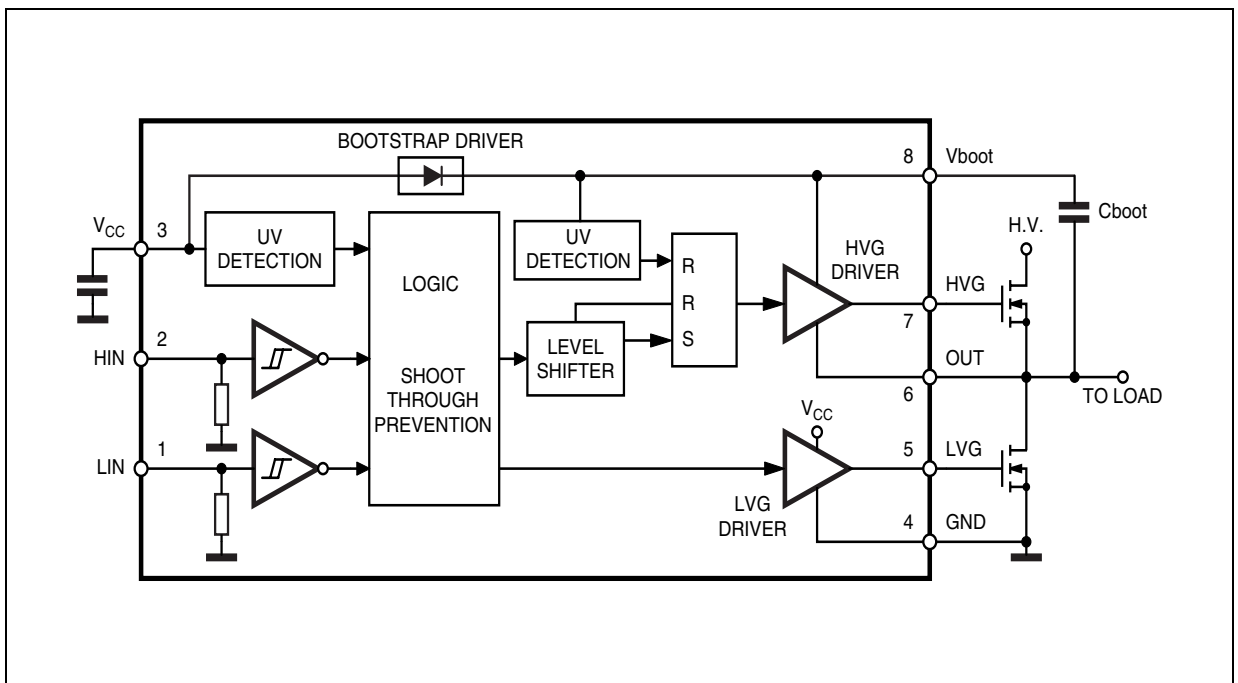
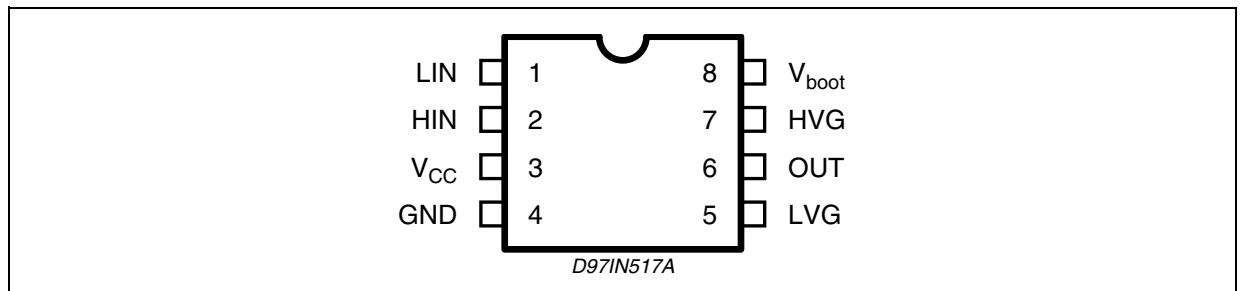


Table 2. Absolute Maximum Rating

| Symbol | Parameter | Value | Unit |
|---------------|--|------------------------|------------------|
| V_{out} | Output Voltage | -3 to $V_{boot} - 18$ | V |
| V_{cc} | Supply Voltage | - 0.3 to +18 | V |
| 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 |
| dV_{out}/dt | Allowed Output Slew Rate | 50 | V/ns |
| P_{tot} | Total Power Dissipation ($T_j = 85^\circ\text{C}$) | 750 | mW |
| T_j | Junction Temperature | 150 | $^\circ\text{C}$ |
| T_{stg} | Storage Temperature | -50 to 150 | $^\circ\text{C}$ |

Note: ESD immunity for pins 6, 7 and 8 is guaranteed up to 900V (Human Body Model)

Figure 3. Pin Connection (Top view)**Table 3. Pin Description**

| N. | Name | Type | Function |
|----|---------|------|-------------------------------------|
| 1 | LIN | I | Low Side Driver Logic Input |
| 2 | HIN | I | High Side Driver Logic Input |
| 3 | Vcc | I | Low Voltage Power Supply |
| 4 | GND | | Ground |
| 5 | LVG (*) | O | Low Side Driver Output |
| 6 | OUT | O | High Side Driver Floating Reference |
| 7 | HVG (*) | O | High Side Driver Output |
| 8 | Vboot | | Bootstrap Supply Voltage |

(*) The circuit guarantees 0.3V maximum on the pin (@ $I_{sink} = 10\text{mA}$). 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.

Table 4. Thermal Data

| Symbol | Parameter | SO8 | Minidip | Unit |
|-----------------|--|-----|---------|--------------------|
| $R_{th\ j-amb}$ | Thermal Resistance Junction to Ambient | 150 | 100 | $^\circ\text{C/W}$ |

Table 5. Recommended Operating Conditions

| Symbol | Pin | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---------------------|-----|-------------------------|-----------------------|--------|------|------|------|
| V _{out} | 6 | Output Voltage | | Note 1 | | 580 | V |
| V _{BS} (*) | 8 | Floating Supply Voltage | | Note 1 | | 17 | V |
| f _{sw} | | Switching Frequency | HVG,LVG load CL = 1nF | | | 400 | kHz |
| V _{cc} | 3 | Supply Voltage | | | | 17 | V |
| T _j | | Junction Temperature | | -45 | | 125 | °C |

Note 1: If the condition V_{boot} - V_{out} < 18V is guaranteed, V_{out} can range from -3 to 580V

(*): V_{BS} = V_{boot} - V_{out}

Table 6. Electrical Characteristics

(V_{cc} = 15V; T_j = 25°C)

| Symbol | Pin | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|--------|-----|-----------|----------------|------|------|------|------|
|--------|-----|-----------|----------------|------|------|------|------|

AC OPERATION

| | | | | | | | |
|------------------|------------------|---|-------------------------|-----|-----|-----|----|
| t _{on} | 1 vs 5 2 vs 7 | High/Low Side Driver Turn-On Propagation Delay | V _{out} = 0V | | 225 | 300 | ns |
| t _{off} | | High/Low Side Driver Turn-Off Propagation Delay | V _{out} = 0V | | 160 | 220 | ns |
| t _r | 7,5 | Rise Time | C _L = 1000pF | | 70 | 100 | ns |
| t _f | 7,5 | Fall Time | C _L = 1000pF | | 40 | 80 | ns |
| DT | 7,5 | Dead Time | | 220 | 320 | 420 | ns |

DC OPERATION**Low Supply Voltage Section**

| | | | | | | | |
|--------------------|---|---------------------------------------|-----------------------|-----|-----|------|----|
| V _{ccth1} | 3 | 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 | | 0.9 | | | V |
| I _{qccu} | | Undervoltage Quiescent Supply Current | V _{cc} ≤ 9V | | 250 | 330 | μA |
| I _{qcc} | | Quiescent Current | V _{cc} = 15V | | 350 | 450 | μA |
| R _{dson} | | Bootstrap Driver on Resistance (**) | V _{cc} | | | 125 | |

Bootstrapped Supply Voltage Section

| | | | | | | | |
|--------------------|---|---------------------------------------|--|-----|-----|------|----|
| V _{BSth1} | 8 | 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 | | 0.9 | | | V |
| I _{QBS} | | V _{BS} Quiescent Current | HVG ON | | | 250 | μA |
| ILK | | High Voltage Leakage Current | V _{hvg} = V _{out} = V _{boot} = 600V | | | 10 | μA |

High/Low Side Driver

| | | | | | | | |
|-----------------|-----|------------------------------|---|-----|-----|--|----|
| I _{so} | 5,7 | Source Short Circuit Current | V _{IN} = V _{ih} (tp < 10μs) | 300 | 400 | | mA |
| I _{si} | | Sink Short Circuit Current | V _{IN} = V _{il} (tp < 10μs) | 500 | 650 | | mA |

Table 6. Electrical Characteristics (continued)

(V_{CC} = 15V; T_j = 25°C)

| Symbol | Pin | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---------------------|------|--------------------------------|-----------------------|------|------|------|------|
| Logic Inputs | | | | | | | |
| V _{il} | 1, 2 | Low Level Logic Input Voltage | | | | 1.1 | V |
| V _{ih} | | High Level Logic Input Voltage | | 1.8 | | | V |
| I _{ih} | | High Level Logic Input Current | V _{IN} = 15V | | 20 | 70 | μA |
| I _{il} | | Low Level Logic Input Current | V _{IN} = 0V | -1 | | | μA |

(**) R_{DS(on)} is tested in the following way: $R_{DS(on)} = \frac{(V_{CC} - V_{CBOOT1}) - (V_{CC} - V_{CBOOT2})}{I_1(V_{CC}, V_{CCBOOT1}) - I_2(V_{CC}, V_{CCBOOT2})}$
 where I₁ is pin 8 current when V_{CBOOT} = V_{CBOOT1}, I₂ when V_{CBOOT} = V_{CBOOT2}.

Figure 4. Dead Time Waveforms Definitions

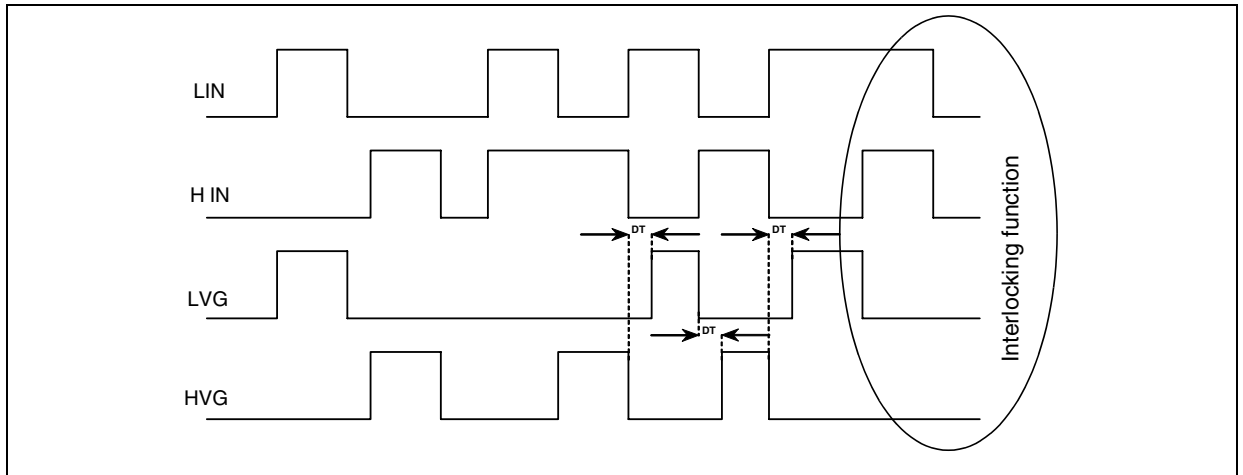
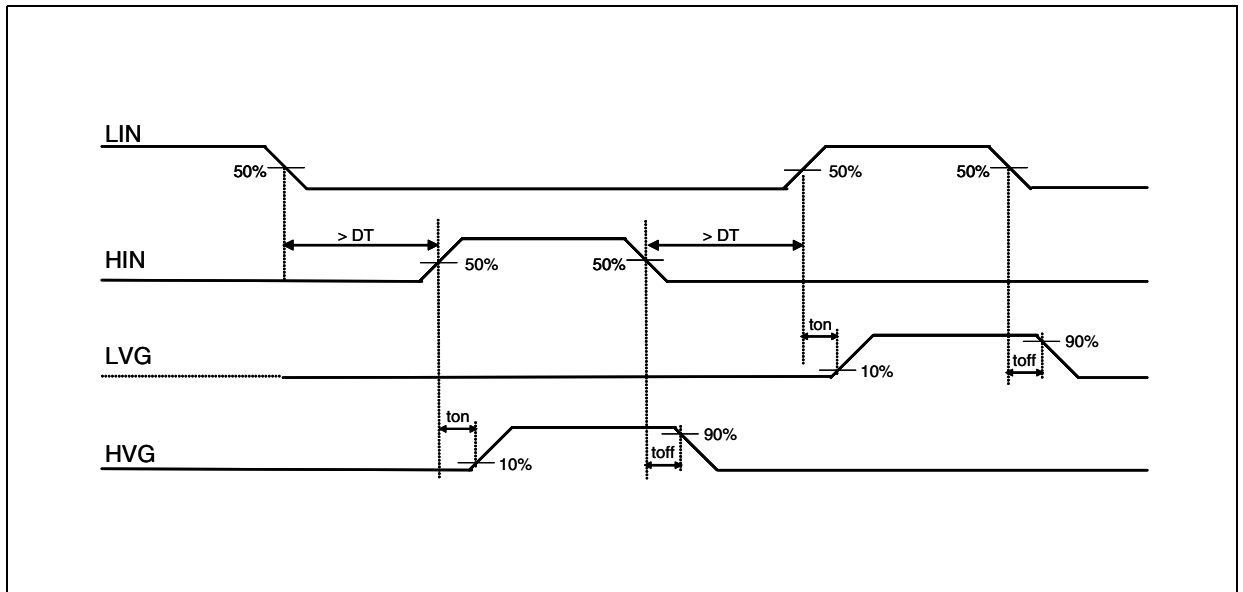


Figure 5. Propagation Delay Waveform Definitions



3 INPUT LOGIC

Input logic is provided with an interlocking circuitry which avoids the two outputs (LVG, HVG) to be active at the same time when both the logic input pins (LIN, HIN) are at a high logic level. In addition, to prevent cross conduction of the external MOSFETs, after each output is turned-off the other output cannot be turned-on before a certain amount of time (DT) (see Figure 4).

Figure 6. Typical Rise and Fall Times vs. Load Capacitance

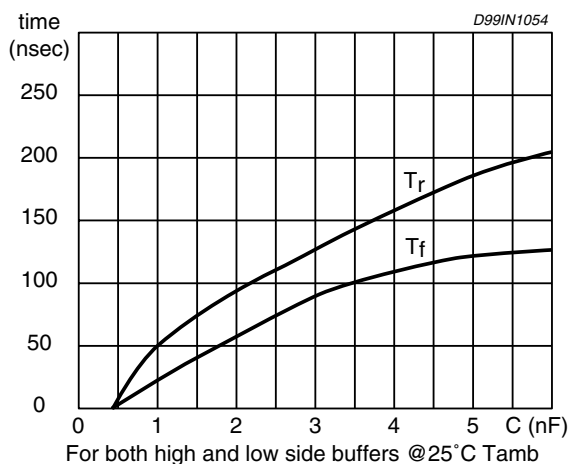
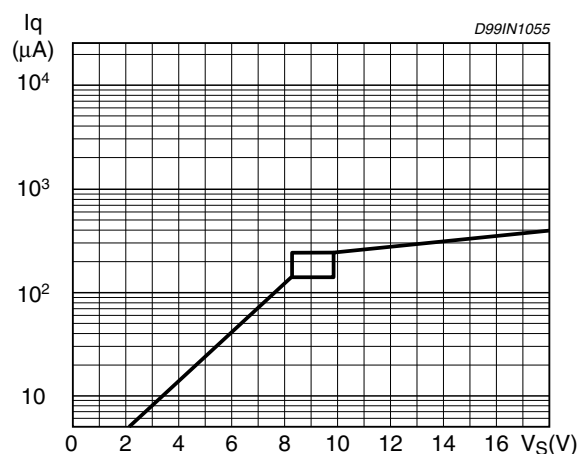


Figure 7. Quiescent Current vs. Supply Voltage



3.1 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 (fig. 8a). In the L6388 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 fig. 8b

An internal charge pump (fig. 8b) provides the DMOS driving voltage .

The diode connected in series to the DMOS has been added to avoid undesirable turn on of it.

3.2 CBOOT 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:

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

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

If HVG has to be supplied for a long time, the CBOOT 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, CBOOT 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 RDSON (typical value: 125 Ohm). 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:

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

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:

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

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 8. Bootstrap Driver.

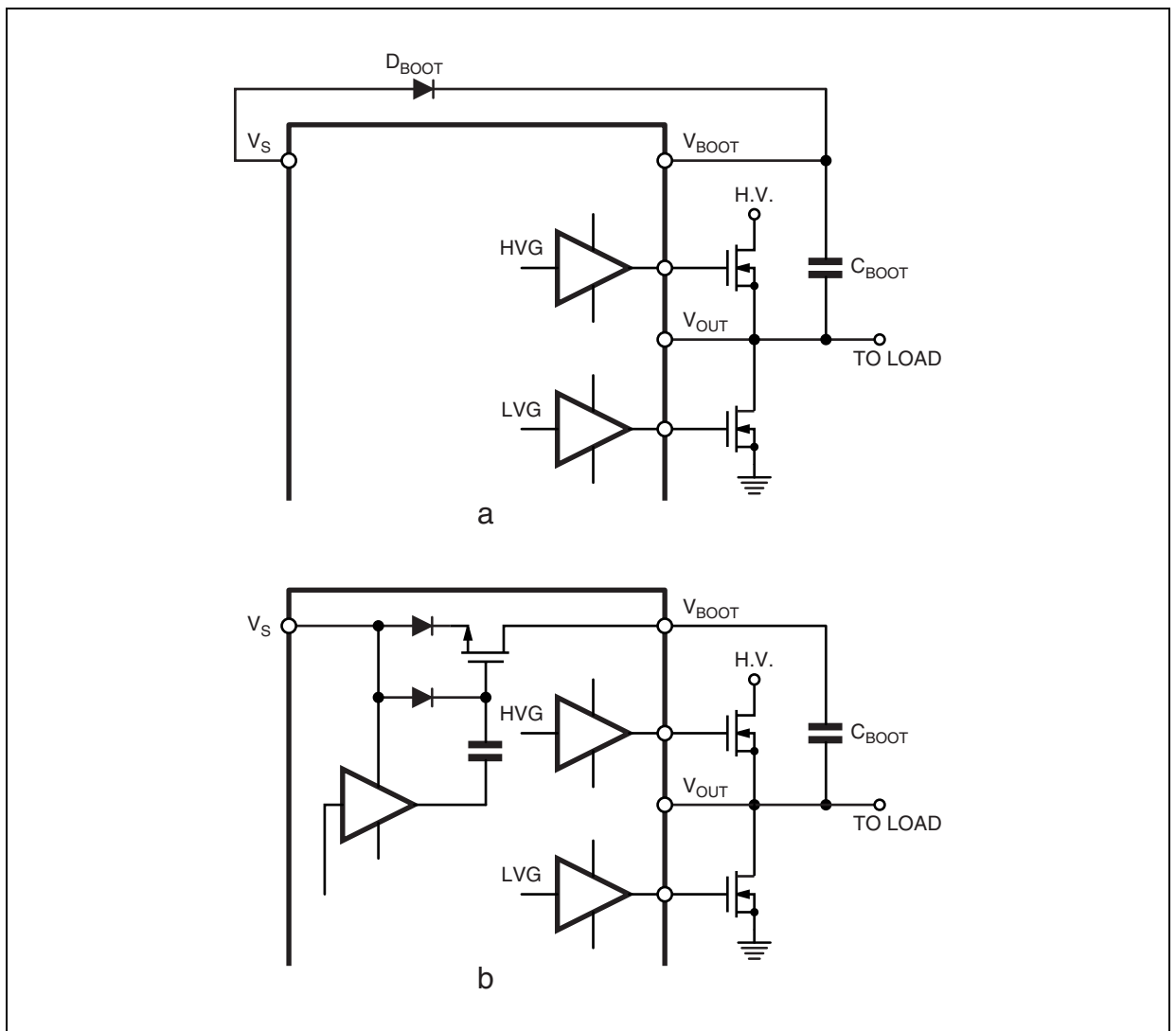


Figure 9. V_{BOOT} UV Turn On Threshold vs. Temperature

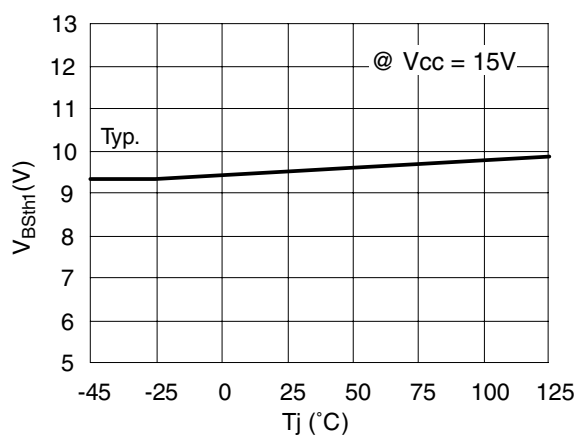


Figure 12. V_{CC} UV Turn Off Threshold vs. Temperature

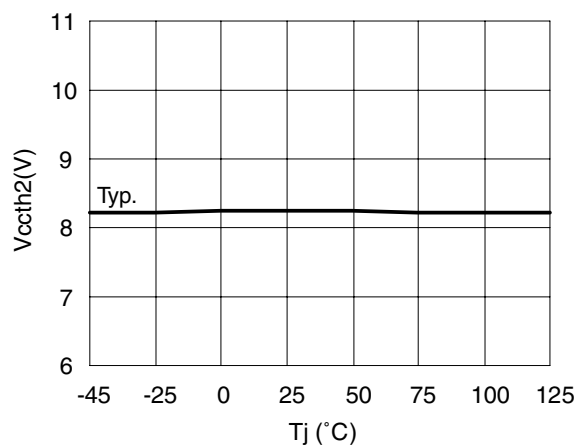


Figure 10. V_{BOOT} UV Turn Off Threshold vs. Temperature

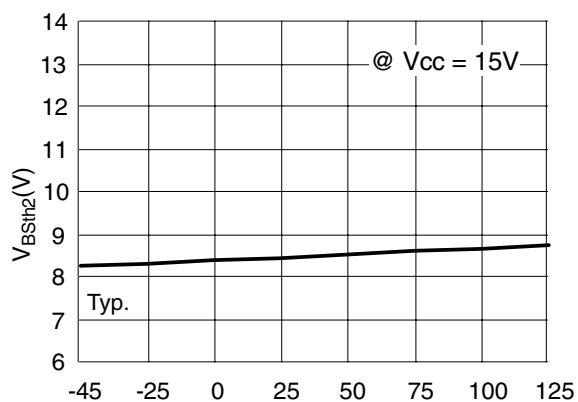


Figure 13. Output Source Current vs. Temperature

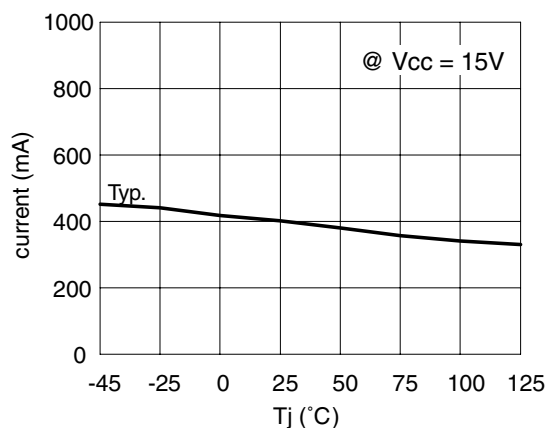


Figure 11. V_{CC} UV Turn On Threshold vs. Temperature

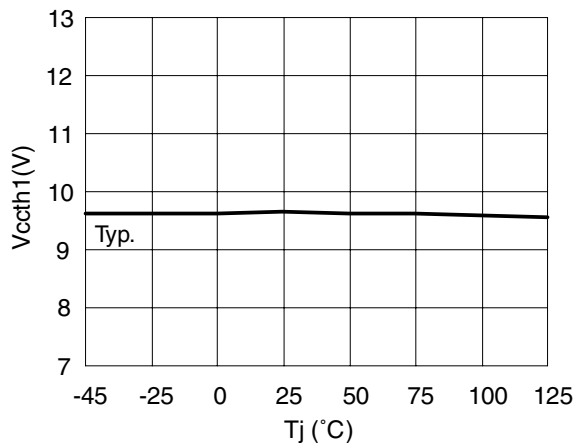


Figure 14. Output Sink Current vs. Temperature

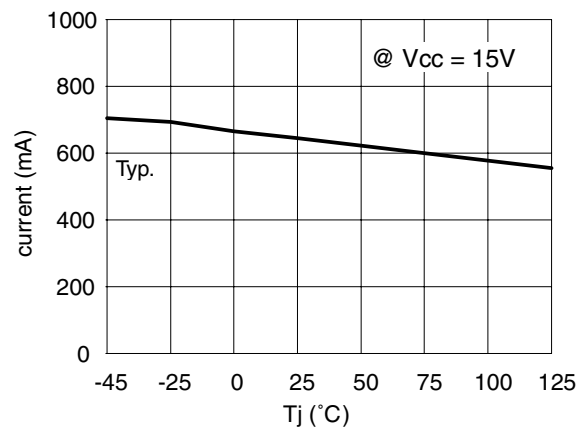
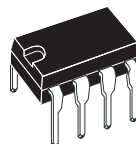


Figure 15. DIP8 Mechanical Data & Package Dimensions

| 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

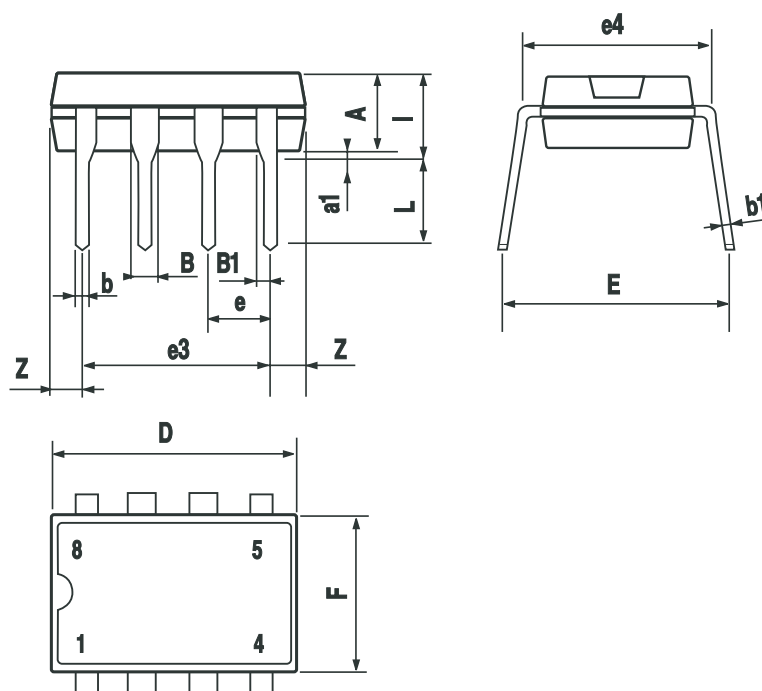
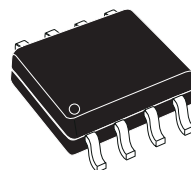


Figure 16. SO8 Mechanical Data & Package Dimensions

| DIM. | mm | | | inch | | |
|-------|----------------------|------|------|-------|-------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | 1.35 | | 1.75 | 0.053 | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.10 | | 1.65 | 0.043 | | 0.065 |
| B | 0.33 | | 0.51 | 0.013 | | 0.020 |
| C | 0.19 | | 0.25 | 0.007 | | 0.010 |
| D (1) | 4.80 | | 5.00 | 0.189 | | 0.197 |
| E | 3.80 | | 4.00 | 0.15 | | 0.157 |
| e | | 1.27 | | | 0.050 | |
| H | 5.80 | | 6.20 | 0.228 | | 0.244 |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| k | 0° (min.), 8° (max.) | | | | | |
| ddd | | | 0.10 | | | 0.004 |

Note: (1) Dimensions D does not include mold flash, protrusions or gate burrs.
Mold flash, protrusions or gate burrs shall not exceed 0.15mm (.006inch) in total (both side).

OUTLINE AND MECHANICAL DATA



SO-8

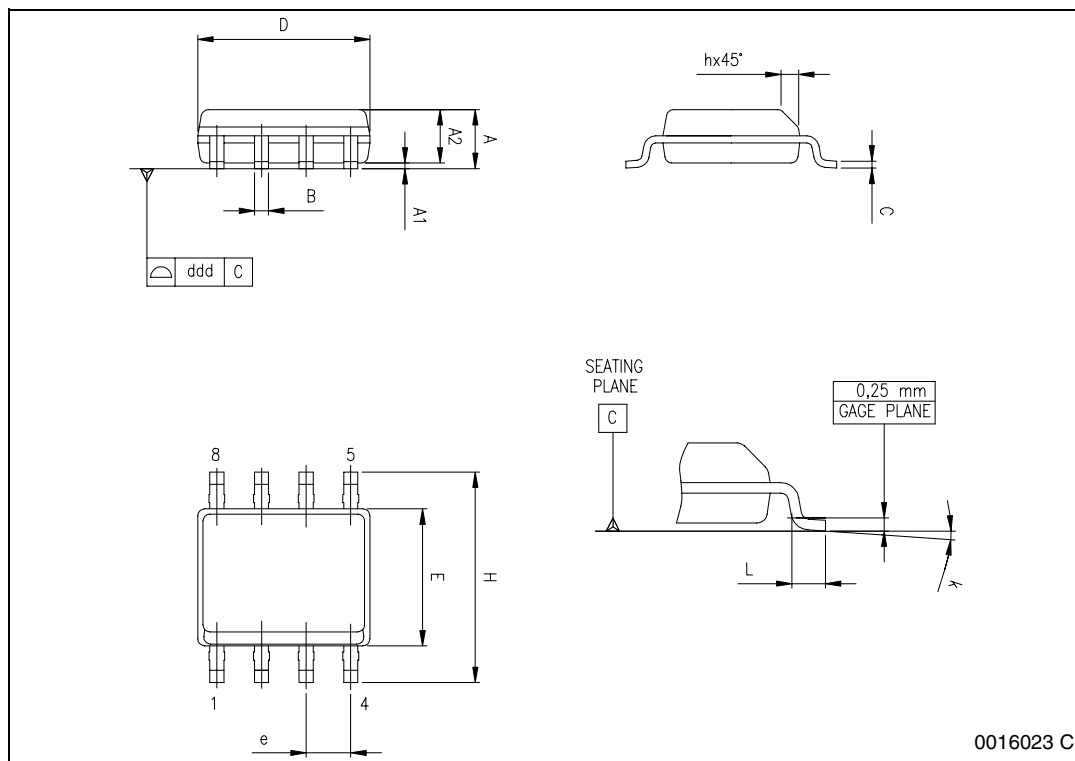


Table 7. Revision History

| Date | Revision | Description of Changes |
|--------------|-----------------|--|
| January 2005 | 1 | First Issue |
| May 2005 | 2 | Changed from Preliminary Data to Final |

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