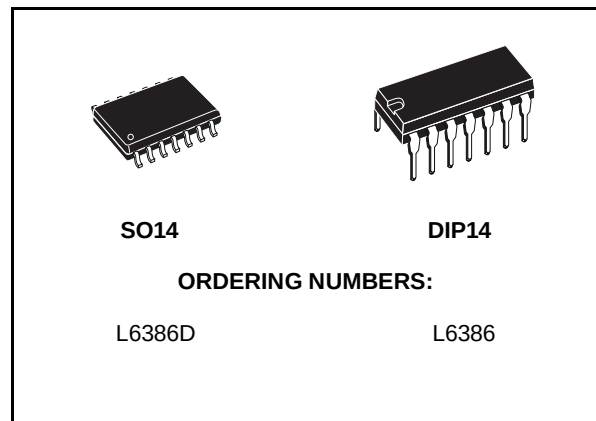


## HIGH-VOLTAGE HIGH AND LOW SIDE DRIVER

- HIGH VOLTAGE RAIL UP TO 600V
- $dV/dt$  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 1nF LOAD
- CMOS/TTL SCHMITT TRIGGER INPUTS WITH HYSTERESIS AND PULL DOWN
- UNDER VOLTAGE LOCK OUT ON LOWER AND UPPER DRIVING SECTION
- INTEGRATED BOOTSTRAP DIODE
- OUTPUTS IN PHASE WITH INPUTS

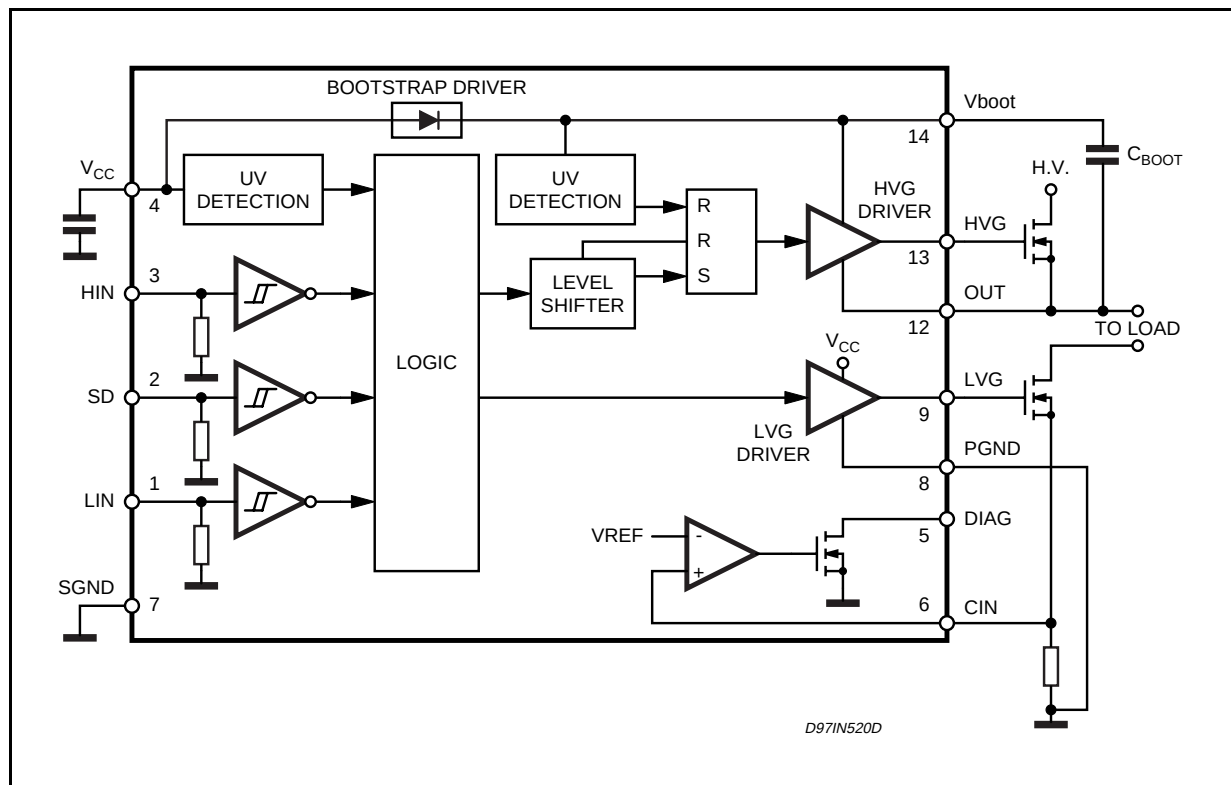


### DESCRIPTION

The L6386 is an high-voltage device, manufactured with the BCD "OFF-LINE" technology. It has a Driver structure that enables to drive inde-

pendent referenced 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.

### BLOCK DIAGRAM

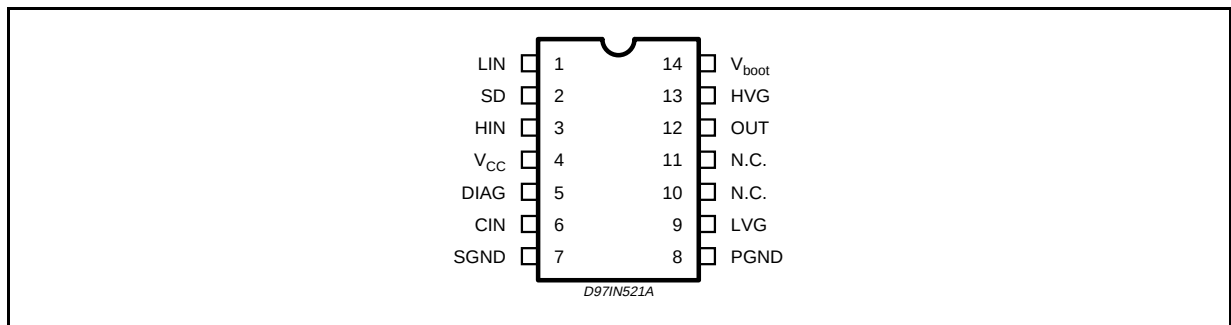


## ABSOLUTE MAXIMUM RATINGS

| Symbol   | Parameter                            | Value            | Unit |
|----------|--------------------------------------|------------------|------|
| Vout     | Output Voltage                       | -3 to Vboot - 18 | V    |
| Vcc      | Supply Voltage                       | - 0.3 to +18     | V    |
| Vboot    | Floating Supply Voltage              | -1 to 618        | V    |
| Vhvg     | Upper Gate Output Voltage            | - 1 to Vboot     | V    |
| Vlvg     | Lower Gate Output Voltage            | -0.3 to Vcc +0.3 | V    |
| Vi       | Logic Input Voltage                  | -0.3 to Vcc +0.3 | V    |
| Vdiag    | Open Drain Forced Voltage            | -0.3 to Vcc +0.3 | V    |
| Vcin     | Comparator Input Voltage             | -0.3 to Vcc +0.3 | V    |
| dVout/dt | Allowed Output Slew Rate             | 50               | V/ns |
| Ptot     | Total Power Dissipation (Tj = 85 °C) | 750              | mW   |
| Tj       | Junction Temperature                 | 150              | °C   |
| Ts       | Storage Temperature                  | -50 to 150       | °C   |

**Note:** ESD immunity for pins 12, 13 and 14 is guaranteed up to 900V (Human Body Model)

## PIN CONNECTION



## THERMAL DATA

| Symbol                | Parameter                              | SO14 | DIP14 | Unit |
|-----------------------|----------------------------------------|------|-------|------|
| R <sub>th j-amb</sub> | Thermal Resistance Junction to Ambient | 165  | 100   | °C/W |

## PIN DESCRIPTION

| N.     | Name    | Type | Function                     |
|--------|---------|------|------------------------------|
| 1      | LIN     | I    | Lower Driver Logic Input     |
| 2      | SD (*)  | I    | Shut Down Logic Input        |
| 3      | HIN     | I    | Upper Driver Logic Input     |
| 4      | VCC     | I    | Low Voltage Supply           |
| 5      | DIAG    | O    | Open Drain Diagnostic Output |
| 6      | CIN     | I    | Comparator Input             |
| 7      | SGND    |      | Ground                       |
| 8      | PGND    |      | Power Ground                 |
| 9      | LVG (*) | O    | Low Side Driver Output       |
| 10, 11 | N.C.    |      | Not Connected                |
| 12     | OUT     | O    | Upper Driver Floating Driver |
| 13     | HVG (*) | O    | High Side Driver Output      |
| 14     | Vboot   |      | Bootstrapped Supply Voltage  |

(\*) The circuit guarantees 0.3V maximum on the pin (@ Isink = 10mA), with VCC >3V. 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 assures low impedance also in SD condition.

## RECOMMENDED OPERATING CONDITIONS

| Symbol     | Pin | Parameter               | Test Condition        | Min.  | Typ. | Max. | Unit |
|------------|-----|-------------------------|-----------------------|-------|------|------|------|
| Vout       | 12  | Output Voltage          |                       | Note1 |      | 580  | V    |
| Vboot-Vout | 14  | Floating Supply Voltage |                       | Note1 |      | 17   | V    |
| fsw        |     | Switching Frequency     | HVG,LVG load CL = 1nF |       |      | 400  | kHz  |
| Vcc        | 4   | Supply Voltage          |                       |       |      | 17   | V    |
| Tj         |     | Junction Temperature    |                       | -45   |      | 125  | °C   |

**Note 1:** if the condition Vboot - Vout < 18V is guaranteed, Vout can range from -3 to 580V.

## ELECTRICAL CHARACTERISTICS

## AC Operation (Vcc = 15V; Tj = 25°C)

| Symbol | Pin          | Parameter                                       | Test Condition | Min. | Typ. | Max. | Unit |
|--------|--------------|-------------------------------------------------|----------------|------|------|------|------|
| ton    | 1.3 vs 9, 13 | High/Low Side Driver Turn-On Propagation Delay  | Vout = 0V      |      | 110  | 150  | ns   |
| toff   |              | High/Low Side Driver Turn-Off Propagation Delay | Vout = 0V      |      | 105  | 150  | ns   |
| tsd    | 2 vs 9,13    | Shut Down to High/Low Side Propagation Delay    | Vout = 0V      |      | 105  | 150  | ns   |
| tr     | 13,9         | Rise Time                                       | CL = 1000pF    |      | 50   |      | ns   |
| tf     | 13,9         | Fall Time                                       | CL = 1000pF    |      | 30   |      | ns   |

## DC Operation (Vcc = 15V; Tj = 25°C)

| Symbol                      | Pin   | Parameter                                         | Test Condition        | Min. | Typ. | Max. | Unit |
|-----------------------------|-------|---------------------------------------------------|-----------------------|------|------|------|------|
| Low Supply Voltage Section  |       |                                                   |                       |      |      |      |      |
| Vcc                         | 4     | Supply Voltage                                    |                       |      |      | 17   | V    |
| Vccth1                      |       | Vcc UV Turn On Threshold                          |                       | 11.5 | 12   | 12.5 | V    |
| Vccth2                      |       | Vcc UV Turn Off Threshold                         |                       | 9.5  | 10   | 10.5 | V    |
| Vcchys                      |       | Vcc UV Hysteresis                                 |                       |      | 2    |      | V    |
| Iqccu                       |       | Undervoltage Quiescent Supply Current             | Vcc ≤ 11V             |      | 200  |      | μA   |
| Iqcc                        |       | Quiescent Current                                 | Vcc = 15V             |      | 250  | 320  | μA   |
| Bootstrapped Supply Section |       |                                                   |                       |      |      |      |      |
| Vboot                       | 14    | Bootstrapped Supply Voltage                       |                       |      |      | 17   | V    |
| Vbth1                       |       | Vboot UV Turn On Threshold                        |                       | 10.7 | 11.9 | 12.9 | V    |
| Vbth2                       |       | Vboot UV Turn Off Threshold                       |                       | 8.8  | 9.9  | 10.7 | V    |
| Vbhys                       |       | Vboot UV Hysteresis                               |                       |      | 2    |      | V    |
| Iqboot                      |       | Vboot Quiescent Current                           | Vout = Vboot          |      |      | 200  | μA   |
| Ilk                         |       | Leakage Current                                   | Vout = Vboot = 600V   |      |      | 10   | μA   |
| Rdson                       |       | Bootstrap Driver on Resistance (*)                | Vcc ≥ 12.5V; Vin = 0V |      | 125  |      | Ω    |
| Driving Buffers Section     |       |                                                   |                       |      |      |      |      |
| Iso                         | 9, 13 | High/Low Side Driver Short Circuit Source Current | VIN = Vih (tp < 10μs) | 300  | 400  |      | mA   |
| Isi                         |       | High/Low Side Driver Short Circuit Sink Current   |                       | 500  | 650  |      | mA   |
| Logic Inputs                |       |                                                   |                       |      |      |      |      |
| Vil                         | 1,2,3 | Low Level Logic Threshold Voltage                 |                       |      |      | 1.5  | V    |
| Vih                         |       | High Level Logic Threshold Voltage                |                       | 3.6  |      |      | V    |
| Iih                         |       | High Level Logic Input Current                    | VIN = 15V             |      | 50   | 70   | μA   |
| Iil                         |       | Low Level Logic Input Current                     | VIN = 0V              |      |      | 1    | μA   |

(\*)  $R_{DS(on)}$  is tested in the following way:  $R_{DS(on)} = \frac{(V_{CC} - V_{CBOOT1}) - (V_{CC} - V_{CBOOT2})}{I_1(V_{CC}, V_{CBOOT1}) - I_2(V_{CC}, V_{CBOOT2})}$

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

DC OPERATION (continued)

| Symbol           | Pin | Parameter                                         | Test Condition | Min.  | Typ. | Max.  | Unit |
|------------------|-----|---------------------------------------------------|----------------|-------|------|-------|------|
| Sense Comparator |     |                                                   |                |       |      |       |      |
| Vio              |     | Input Offset Voltage                              |                | -10   |      | 10    | mV   |
| Iio              | 6   | Input Bias Current                                | Vcin ≥ 0.5     |       | 0.2  |       | μA   |
| Vol              | 2   | Open Drain Low Level Output Voltage, Iod = -2.5mA |                |       |      | 0.8   | V    |
| Vref             |     | Comparator Reference voltage                      |                | 0.460 | 0.5  | 0.540 | V    |

Figure 1. Timing Waveforms

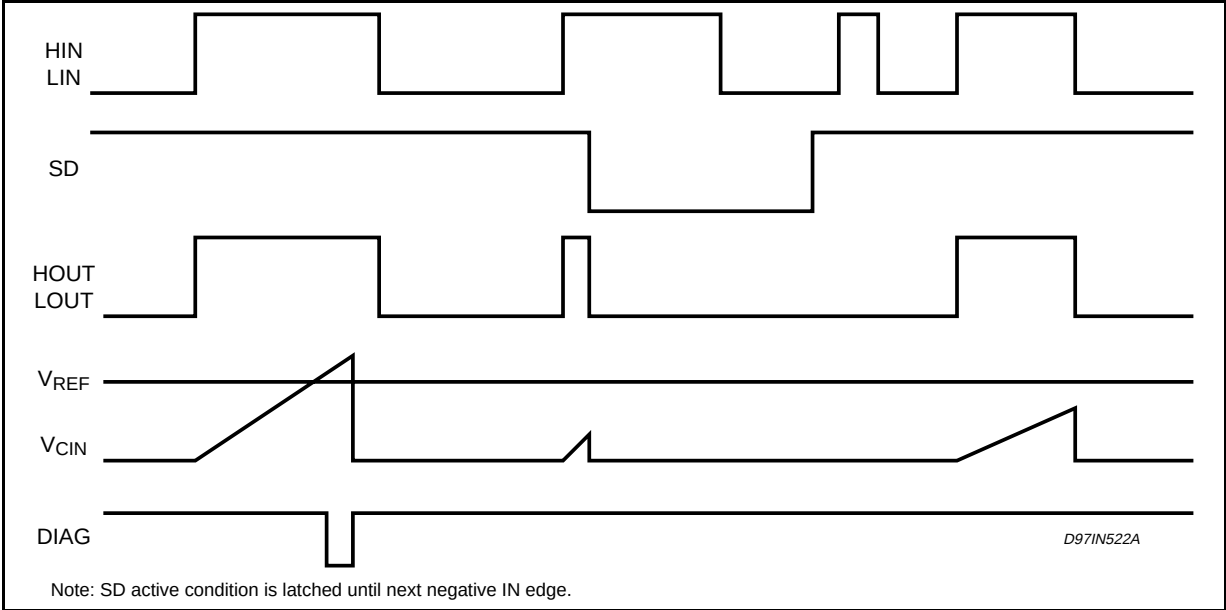


Figure 2. Typical Rise and Fall Times vs. Load Capacitance

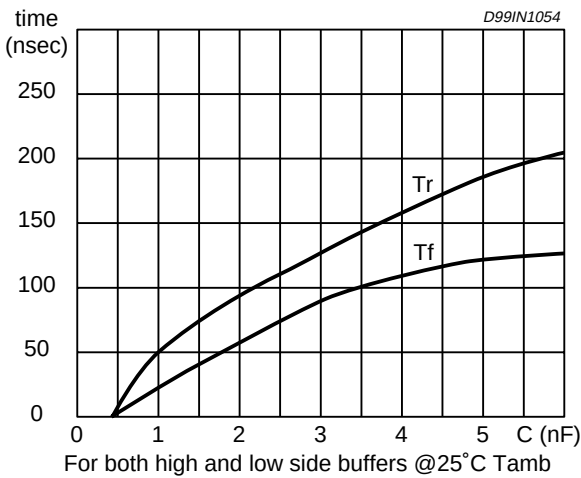
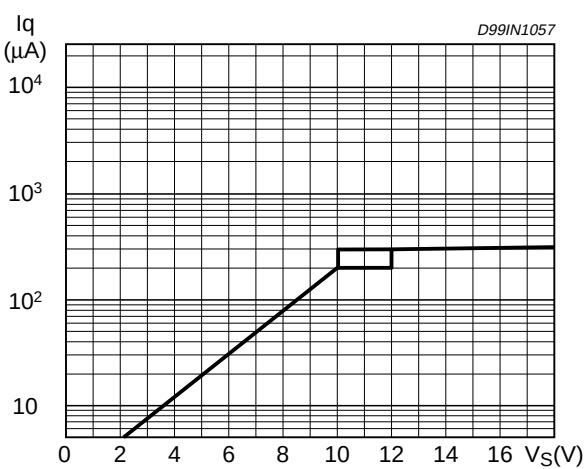


Figure 3. Quiescent Current vs. Supply Voltage



## 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. 4a). In the L6386 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. 4b

An internal charge pump (fig. 4b) provides the DMOS driving voltage.

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

### CBOOT selection and charging:

To choose the proper C<sub>BOOT</sub> value the external MOS can be seen as an equivalent capacitor. This capacitor C<sub>EXT</sub> is related to the MOS total gate charge :

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

The ratio between the capacitors C<sub>EXT</sub> and C<sub>BOOT</sub> is proportional to the cyclical voltage loss .

It has to be:

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

e.g.: if Q<sub>gate</sub> is 30nC and V<sub>gate</sub> is 10V, C<sub>EXT</sub> is 3nF. With C<sub>BOOT</sub> = 100nF the drop would be 300mV.

If HVG has to be supplied for a long time, the C<sub>BOOT</sub> selection has to take into account also the leakage losses.

e.g.: HVG steady state consumption is lower than 200μA, so if HVG T<sub>ON</sub> is 5ms, C<sub>BOOT</sub> has to

supply 1μC to C<sub>EXT</sub>. 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<sub>OUT</sub> is close to GND (or lower) and in the meanwhile the LVG is on. The charging time (T<sub>charge</sub>) of the C<sub>BOOT</sub> 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<sub>DS(on)</sub> (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:

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

where Q<sub>gate</sub> is the gate charge of the external power MOS, R<sub>dson</sub> is the on resistance of the bootstrap DMOS, and T<sub>charge</sub> 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<sub>charge</sub> is 5μs. In fact:

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

V<sub>drop</sub> has to be taken into account when the voltage drop on C<sub>BOOT</sub> 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.

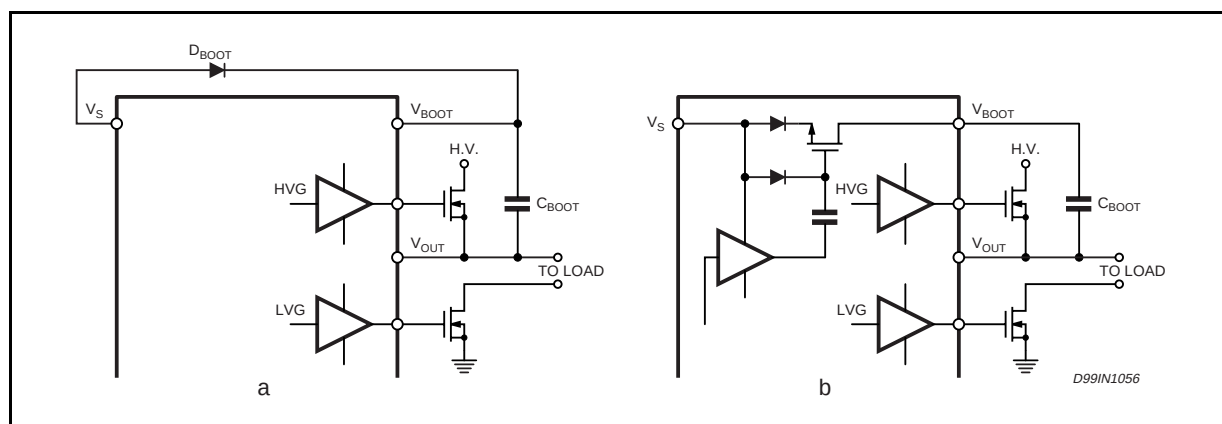


Figure 5. Turn On Time vs. Temperature

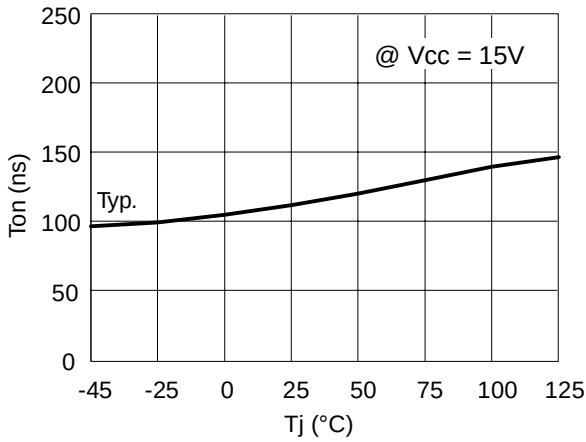


Figure 8. V<sub>BOOT</sub> UV Turn On Threshold vs. Temperature

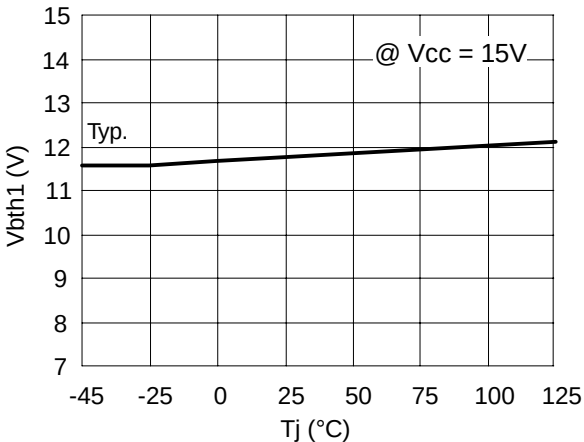


Figure 6. Turn Off Time vs. Temperature

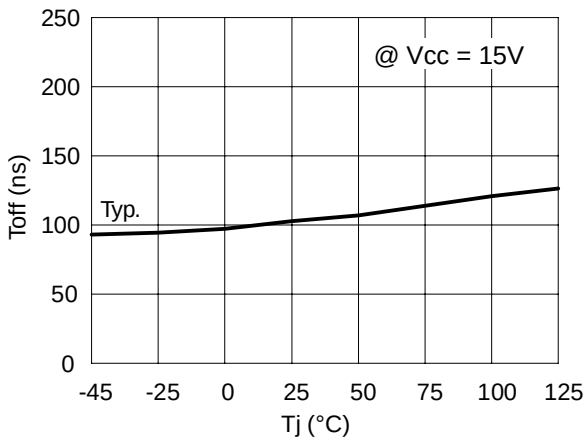


Figure 9. V<sub>BOOT</sub> UV Turn Off Threshold vs. Temperature

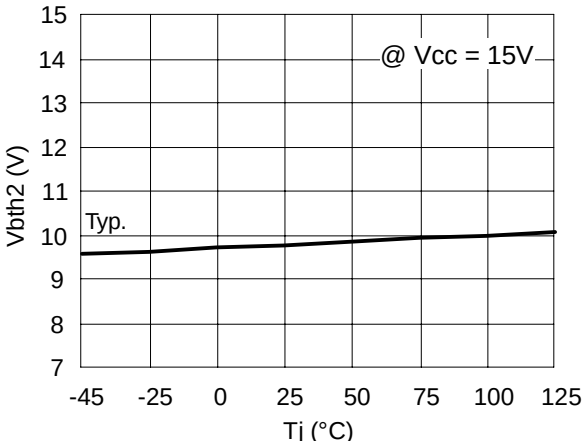


Figure 7. Shutdown Time vs. Temperature

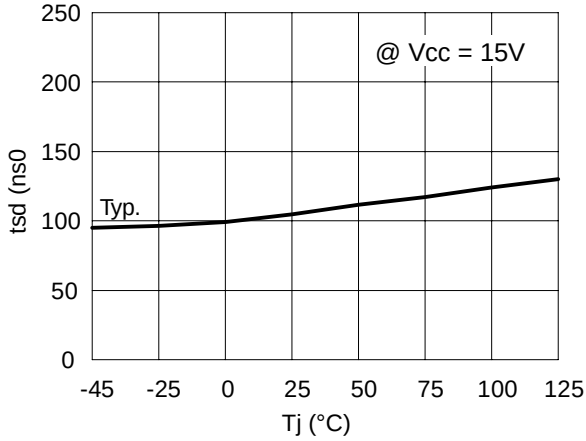
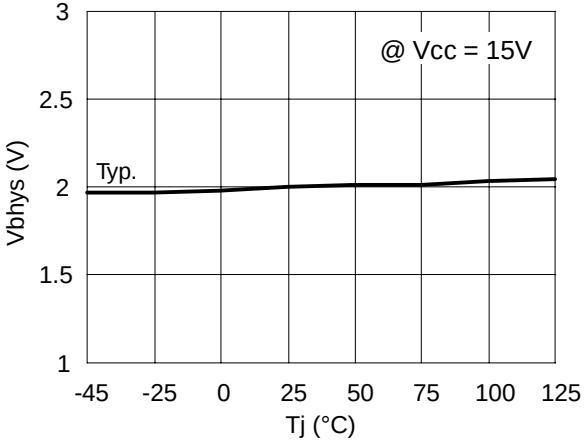
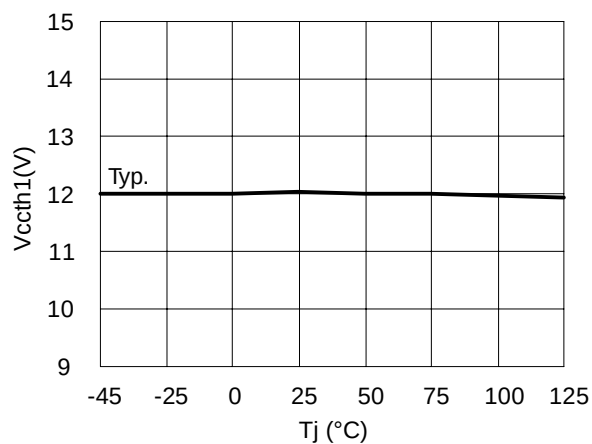
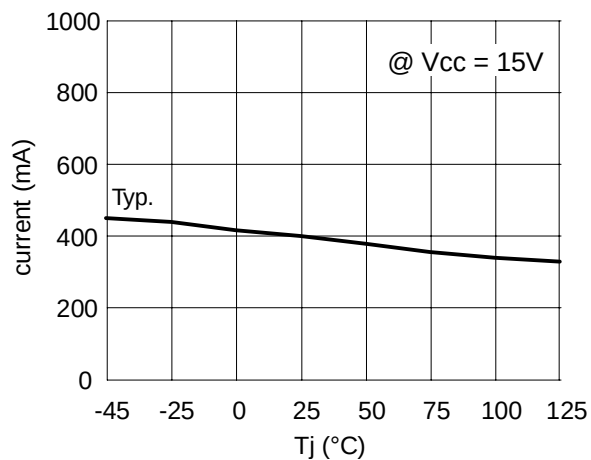
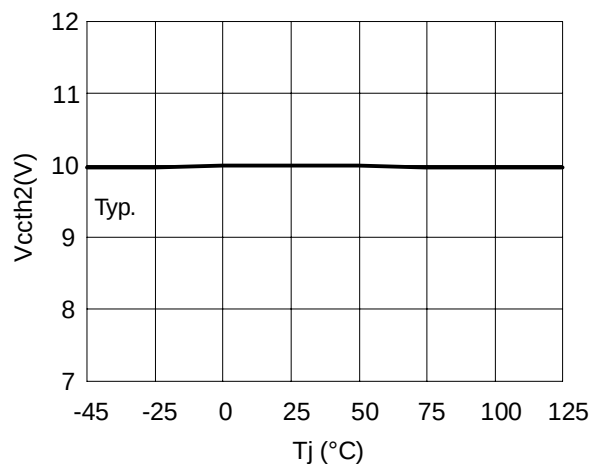
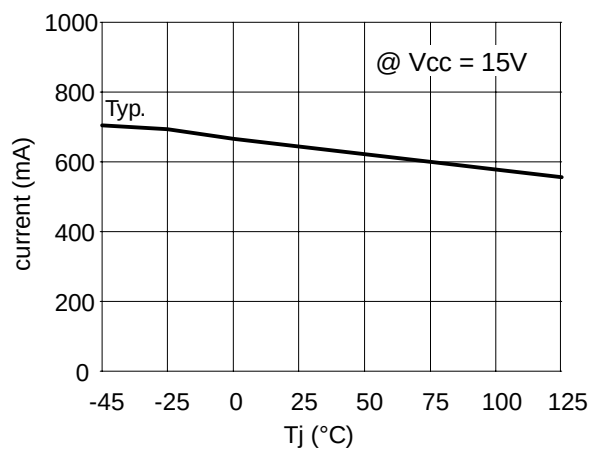
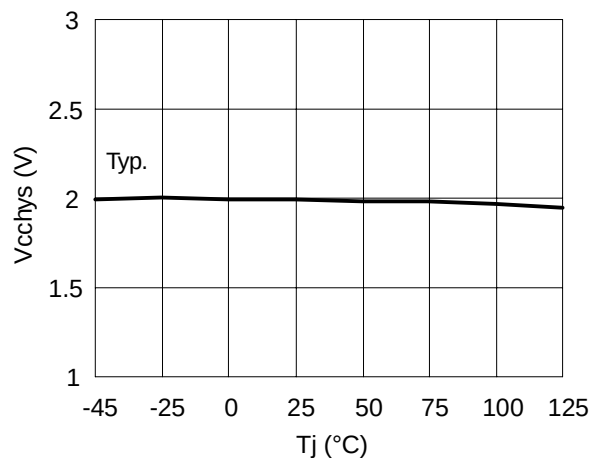


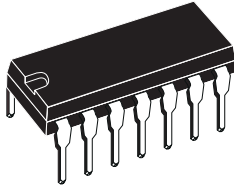
Figure 10. V<sub>BOOT</sub> UV Hysteresis



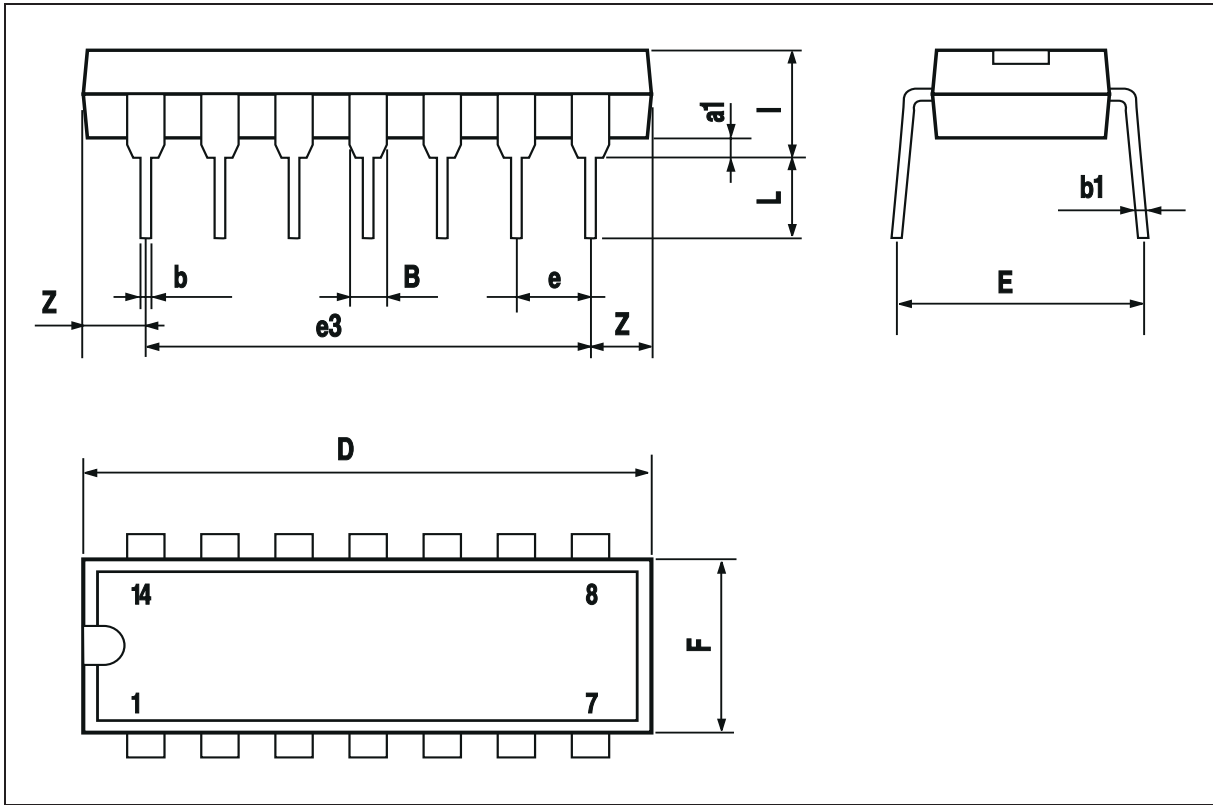
**Figure 11. Vcc UV Turn On Threshold vs. Temperature****Figure 14. Output Source Current vs. Temperature****Figure 12. Vcc UV Turn Off Threshold vs. Temperature****Figure 15. Output Sink Current vs. Temperature****Figure 13. Vcc UV Hysteresis vs. Temperature**

| DIM. | mm   |       |      | inch  |       |       |
|------|------|-------|------|-------|-------|-------|
|      | MIN. | TYP.  | MAX. | MIN.  | TYP.  | MAX.  |
| a1   | 0.51 |       |      | 0.020 |       |       |
| B    | 1.39 |       | 1.65 | 0.055 |       | 0.065 |
| b    |      | 0.5   |      |       | 0.020 |       |
| b1   |      | 0.25  |      |       | 0.010 |       |
| D    |      |       | 20   |       |       | 0.787 |
| E    |      | 8.5   |      |       | 0.335 |       |
| e    |      | 2.54  |      |       | 0.100 |       |
| e3   |      | 15.24 |      |       | 0.600 |       |
| F    |      |       | 7.1  |       |       | 0.280 |
| I    |      |       | 5.1  |       |       | 0.201 |
| L    |      | 3.3   |      |       | 0.130 |       |
| Z    | 1.27 |       | 2.54 | 0.050 |       | 0.100 |

**OUTLINE AND  
MECHANICAL DATA**



**DIP14**

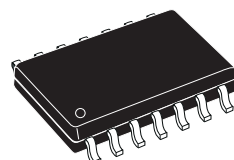




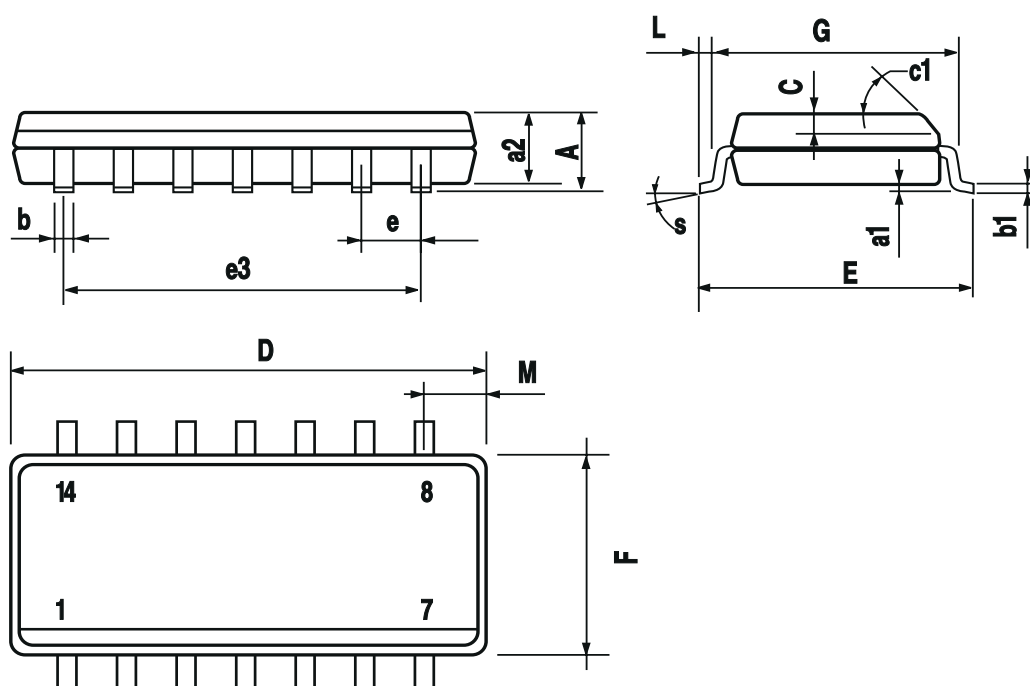
| DIM.  | mm         |      |       | inch  |       |       |
|-------|------------|------|-------|-------|-------|-------|
|       | MIN..      | TYP. | MAX.. | MIN.. | TYP.. | MAX.. |
| A     |            |      | 1.75  |       |       | 0.069 |
| a1    | 0.1        |      | 0.25  | 0.004 |       | 0.009 |
| a2    |            |      | 1.6   |       |       | 0.063 |
| b     | 0.35       |      | 0.46  | 0.014 |       | 0.018 |
| b1    | 0.19       |      | 0.25  | 0.007 |       | 0.010 |
| C     |            | 0.5  |       |       | 0.020 |       |
| c1    | 45° (typ.) |      |       |       |       |       |
| D (1) | 8.55       |      | 8.75  | 0.336 |       | 0.344 |
| E     | 5.8        |      | 6.2   | 0.228 |       | 0.244 |
| e     |            | 1.27 |       |       | 0.050 |       |
| e3    |            | 7.62 |       |       | 0.300 |       |
| F (1) | 3.8        |      | 4     | 0.150 |       | 0.157 |
| G     | 4.6        |      | 5.3   | 0.181 |       | 0.209 |
| L     | 0.4        |      | 1.27  | 0.016 |       | 0.050 |
| M     |            |      | 0.68  |       |       | 0.027 |
| S     | 8° (max)   |      |       |       |       |       |

(1) D and F do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm (.006inch).

## OUTLINE AND MECHANICAL DATA



**SO14**



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