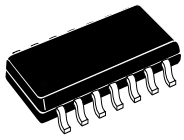
L6494

High voltage high and low-side 2 A gate driver

Datasheet - production data



SO-14

Features

- Transient withstand voltage 600 V
- dV/dt immunity ± 50 V/ns in full temperature range
- Driver current capability:
  - 2 A source typ. at 25 °C
  - 2.5 A sink typ. at 25 °C
- Short propagation delay: 85 ns
- Switching times 25 ns rise/fall with 1 nF load
- Integrated bootstrap diode
- Single input and shutdown pin
- Adjustable deadtime
- 3.3 V, 5 V TTL/CMOS inputs with hysteresis
- UVLO on both high-side and low-side sections
- Compact and simplified layout
- Bill of material reduction
- Flexible, easy and fast design

Applications

- Motor driver for home appliances, factory automation, industrial drives and fans
- HID ballasts
- Induction heating
- Welding
- Industrial inverters
- UPS
- Power supply units
- DC-DC converters

Description

The L6494 is a high-voltage device manufactured with the BCD6 “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 DC voltage rail up to 500 V, with 600 V transient withstand voltage. The logic inputs are CMOS/TTL compatible down to 3.3 V for easy interfacing control units such as microcontrollers or DSP.

The device is a single input gate driver with programmable deadtime, and also features an active-low shutdown pin.

Both device outputs can sink and source 2 A and 2.5 A respectively, making the L6494 particularly suited for medium and high capacity power MOSFETs\IGBTs.

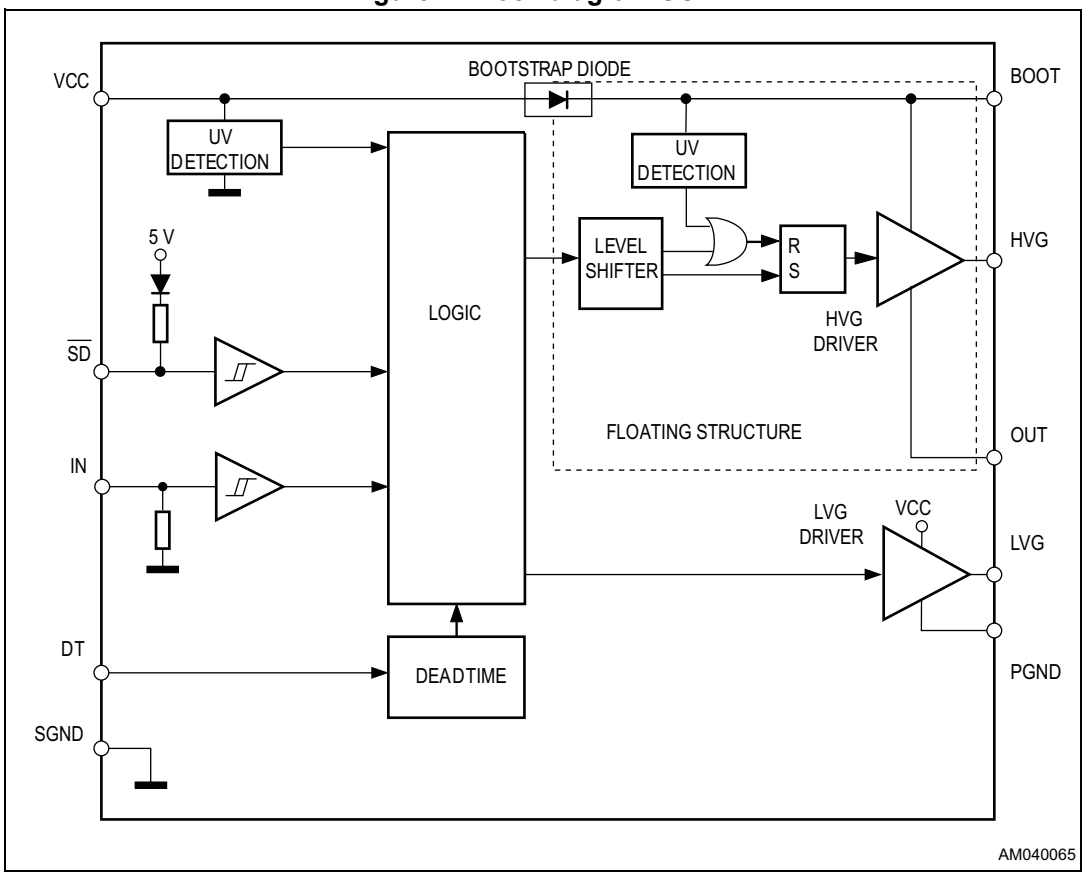
The independent UVLO protection circuits present on both the lower and upper driving sections prevent the power switches from being operated in low efficiency or dangerous conditions.

The integrated bootstrap diode as well as all of the integrated features of this driver make the application PCB design simpler and more compact, and help reducing the overall bill of material.

Contents

1 Block diagram

Figure 1. Block diagram SO-14



2 Pin description and connection diagram

Figure 2. Pin connection SO-14 (top view)

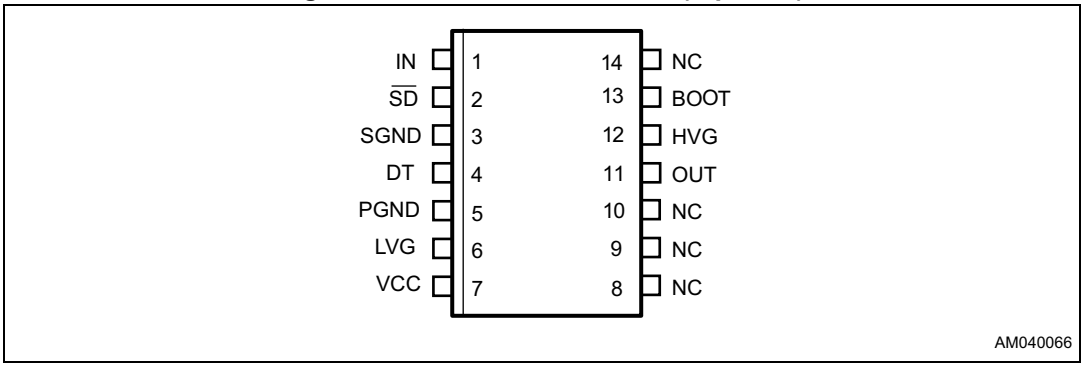


Table 1. Pin description

Pin no.	Pin name	Type	Function
1	IN	I	Output drivers logic input (is in phase with HVG and in opposition of phase with LVG)
2	$\overline{SD}$	-	Shutdown logic input (active-low)
4	DT	I	Deadtime setting
6	LVG(1)	O	Low-side driver output
7	VCC	P	Low-side section supply voltage
11	OUT	P	High-side (floating) section common voltage
12	HVG(1)	O	High-side driver output
13	BOOT	P	High-side (bootstrapped) section supply voltage
3	SGND	P	Signal ground
5	PGND	P	Power ground
8, 9, 10, 14	NC	-	Not connected

1. The circuit guarantees less than 1 V on the LVG and HVG pins (at I_{sink} = 10 mA), with V_{CC} > 3 V. This allows omitting the “bleeder” resistor connected between the gate and the source of the external MOSFET normally used to hold the pin low.

3 Electrical data

3.1 Absolute maximum ratings

Table 2. Absolute maximum ratings(1)

Symbol	Parameter	Value		Unit
		Min.	Max.	
V_{CC}	Supply voltage	-0.3	21	V
V_{PGND}	Low-side driver ground	V_{CC} - 21	V_{CC} + 0.3	V
V_{OUT}	Output voltage	V_{BOOT} - 21	V_{BOOT} + 0.3	V
V_{BOOT}	Boot DC voltage	-0.3	500	V
	Boot transient withstand voltage (T_{pulse} < 1 ms)	-	620	V
V_{hvg}	High-side gate output voltage	V_{OUT} - 0.3	V_{BOOT} + 0.3	V
V_{lvg}	Low-side gate output voltage	PGND - 0.3	V_{CC} + 0.3	V
V_i	Logic input pins voltage	-0.3	15	V
dV_{OUT}/dt	Allowed output slew rate	-	50	V/ns
P_{TOT}	Total power dissipation (T_A = 25 °C) SO-14	-	1	W
T_J	Junction temperature	-	150	°C
T_{stg}	Storage temperature	-50	150	°C
ESD	Human body model	2	kV	-

1. Each voltage referred to SGND unless otherwise specified.

3.2 Thermal data

Table 3. Thermal data

Symbol	Parameter	Package	Value	Unit
$R_{th(JA)}$	Thermal resistance junction to ambient	SO-14	120	°C/W

3.3 Recommended operating conditions

Table 4. Recommended operating conditions

Symbol	Pin	Parameter	Test condition	Min.	Max.	Unit
V_{CC}	VCC	Supply voltage	-	10	20	V
V_{PS}(1)	SGND - PGND	Low-side driver ground	-	-5	+5	V
V_{BO}(2)	BOOT - OUT	Floating supply voltage	-	9.3	20	V
V_{OUT}	OUT	OUT DC voltage	-	- 9(3)	480	V
		OUT transient withstand voltage	T_{pulse} < 1 ms	-	600	V
f_{SW}	-	Maximum switching frequency	HVG, LVG load C_L = 1 nF	-	800	kHz
T_J	-	Junction temperature	-	-40	125	°C

1. $V_{PS} = V_{PGND}$ - SGND.
2. $V_{BO} = V_{BOOT} - V_{OUT}$.
3. LVG off. V_{CC} = 12.5 V. Logic is operational if V_{BOOT} > 5 V.

4 Electrical characteristics

Table 5. Electrical characteristics (V_{CC} = 15 V; T_J = +25 °C; PGND = SGND)

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
Low-side section supply							
V_{CC_hys}	VCC vs. SGND	V_{CC} UV hysteresis	-	1.2	1.5	1.8	V
V_{CC_thON}		V_{CC} UV turn ON threshold	-	9.0	9.5	10.0	V
V_{CC_thOFF}		V_{CC} UV turn OFF threshold	-	8.2	8.7	9.2	V
I_{QCCU}		Undervoltage quiescent supply current	V_{CC} = $\overline{SD}$ = 7 V IN = SGND	-	135	200	µA
I_{QCC}		Quiescent current	V_{CC} = 15 V $\overline{SD}$ = 5 V; IN = SGND	-	490	700	µA
High-side floating section supply(1)							
V_{BO_hys}	BOOT vs. OUT	V_{BO} UV hysteresis	-	0.8	1.0	1.2	V
V_{BO_thON}		V_{BO} UV turn ON threshold	-	8.0	8.6	9.1	V
V_{BO_thOFF}		V_{BO} UV turn OFF threshold	-	7.5	8.0	8.5	V
I_{QBOU}		Undervoltage V_{BO} quiescent current	V_{BO} = $\overline{SD}$ = 7 V IN = SGND	-	20	30	µA
I_{QBO}		V_{BO} quiescent current	VBO = 15 V $\overline{SD}$ = IN = 5 V	-	90	120	µA
I_{LK}		High-voltage leakage current	V_{hvg} = V_{out} = V_{boot} = 600 V	-	-	8	µA
$R_{DS(on)}$		Bootstrap diode on-resistance(2)	-	-	175	-	Ω
Output driving buffers							
I_{SO}	LVG, HVG	High/low-side source short-circuit current	LVG/HVG ON T_J = 25 °C	1.6	2	-	A
			Full temperature range	1.25	-	-	A
I_{SI}		High/low-side sink short-circuit current	LVG/HVG ON T_J = 25 °C	2	2.5	-	A
			Full temperature range	1.55	-	-	A
Logic inputs							
V_{il}	IN, $\overline{SD}$ vs. SGND	Low level logic threshold voltage	-	0.95	-	1.45	V
V_{ih}		High level logic threshold voltage	-	2	-	2.5	V
I_{INh}	IN vs. SGND	IN logic “1” input bias current	IN = 15 V	120	200	260	µA
I_{INl}		IN logic “0” input bias current	IN = 0 V	-	-	1	µA
I_{SDh}	$\overline{SD}$ vs. SGND	$\overline{SD}$ logic “1” input bias current	$\overline{SD}$ = 15 V	-	-	1	µA
I_{SDl}		$\overline{SD}$ logic “0” input bias current	$\overline{SD}$ = 0 V	14	17	23	µA

Table 5. Electrical characteristics (V_{CC} = 15 V; T_J = +25 °C; PGND = SGND) (continued)

Symbol	Pin	Parameter	Test condition	Min.	Typ.	Max.	Unit
SD_{R_PU}	$\overline{SD}$ vs. SGND	$\overline{SD}$ pull-up resistor	-	185	250	310	kΩ
IN_{R_PD}	IN vs. SGND	IN pull-down resistor	-	58	75	125	kΩ
Dynamic characteristics (see *Figure 3* and *Figure 4*)							
t_{on}	$\overline{SD}$ vs. LVG/HVG	High/low-side driver turn-on propagation delay	V_{out} = 0 V; Vb_{oot} = V_{CC}; C_L = 1 nF; V_i = 0 to 3.3 V	-	85	120	ns
t_{off}	$\overline{SD}$ vs. LVG/HVG; IN vs. LVG/HVG	High/low-side driver turn-off propagation delay	-	-	85	120	ns
MT	-	Delay matching, HS and LS turn-on/off(3)	-	-	-	30	ns
t_r	LVG, HVG	Rise time	C_L = 1 nF	-	25	-	ns
t_f		Fall time	C_L = 1 nF	-	25	-	ns
DT	-	Deadtime setting range(4)	R_{DT} = 0 Ω, C_L = 1 nF,	0.26	0.40	0.54	µs
			R_{DT} = 100 kΩ, C_L = 1 nF, C_{DT} = 100 nF	2.10	2.70	3.30	µs
			R_{DT} = 200 kΩ, C_L = 1 nF, C_{DT} = 100 nF	4.00	5.00	6.00	µs
MDT	-	Matching deadtime(4)	R_{DT} = 0 Ω, C_L = 1 nF,	-	-	85	ns
			R_{DT} = 100 kΩ, C_L = 1 nF, C_{DT} = 100 nF	-	-	350	ns
			R_{DT} = 200 kΩ, C_L = 1 nF, C_{DT} = 100 nF	-	-	700	ns

1. $V_{BO} = V_{boot} - V_{out}$.
2. R_{DSON} is tested in the following way:

$$R_{DSON} = [(V_{CC} - V_{BOOT1}) - (V_{CC} - V_{BOOT2})] / [I_1 (V_{CC}, V_{BOOT1}) - I_2 (V_{CC}, V_{BOOT2})]$$

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

3. MT = max. ($|t_{on}$ (LVG) - t_{off} (LVG)|, $|t_{on}$ (HVG) - t_{off} (HVG)|, $|t_{off}$ (LVG) - t_{on} (HVG)|, $|t_{off}$ (HVG) - t_{on} (LVG)|).
4. MDT = | DT_{LH} - DT_{HL} | see *Figure 4*.

Figure 3. $\overline{SD}$ timings

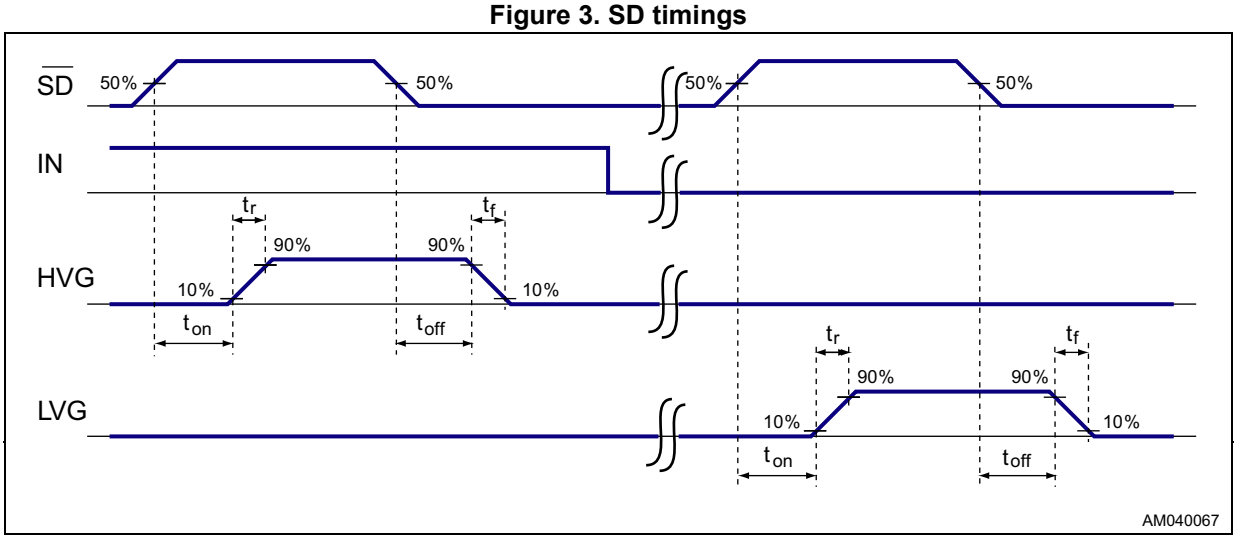


Figure 4. IN timings and deadtime

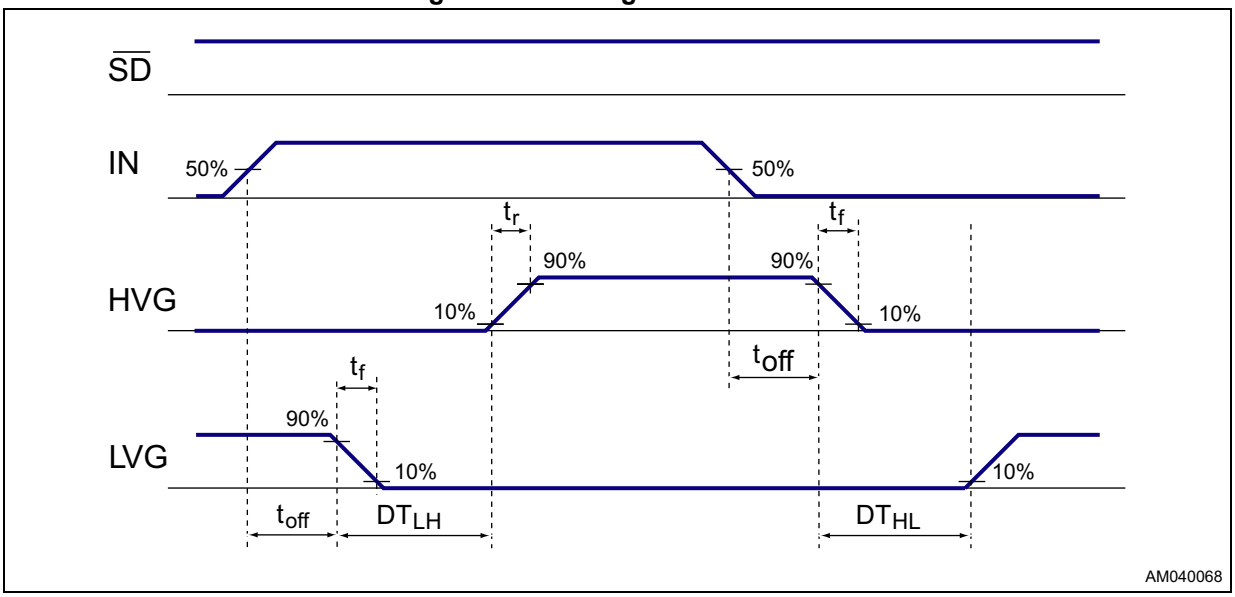
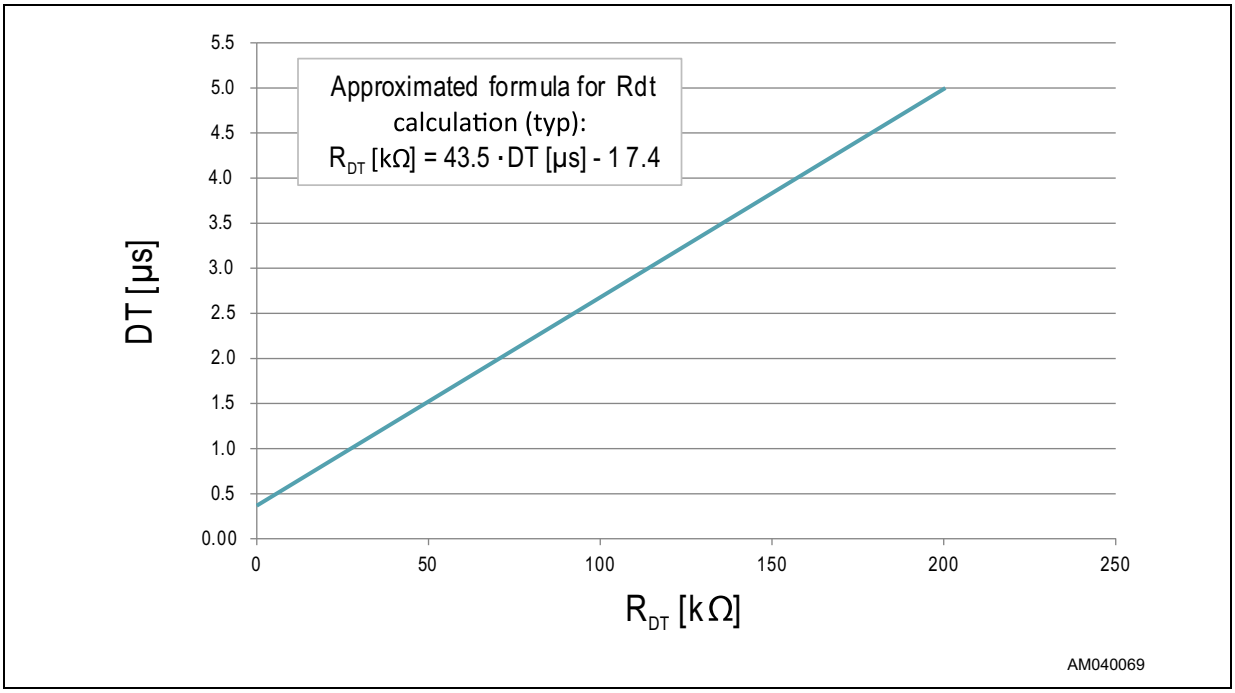


Figure 5. Typical deadtime vs. DT resistor value



5 Truth table

Table 6. Truth table

Input		Output	
$\overline{SD}$	IN	LVG	HVG
L	X(1)	L	L
H	L	H	L
H	H	L	H

1. X = don't care.

6 Typical application diagram

Figure 6. Typical application diagram

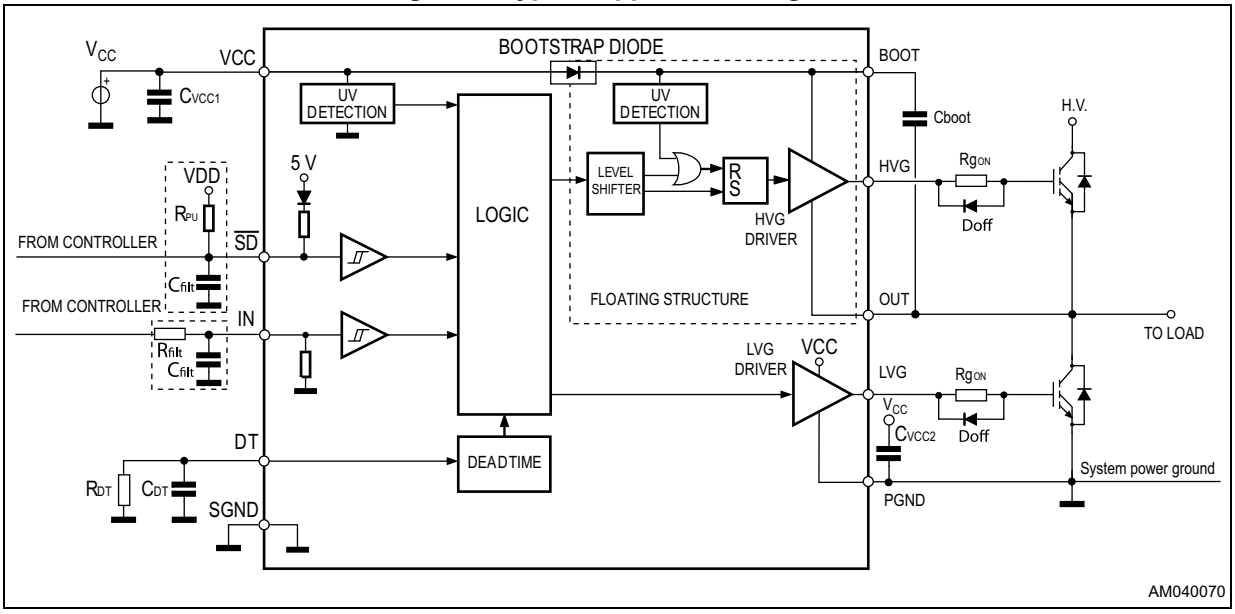
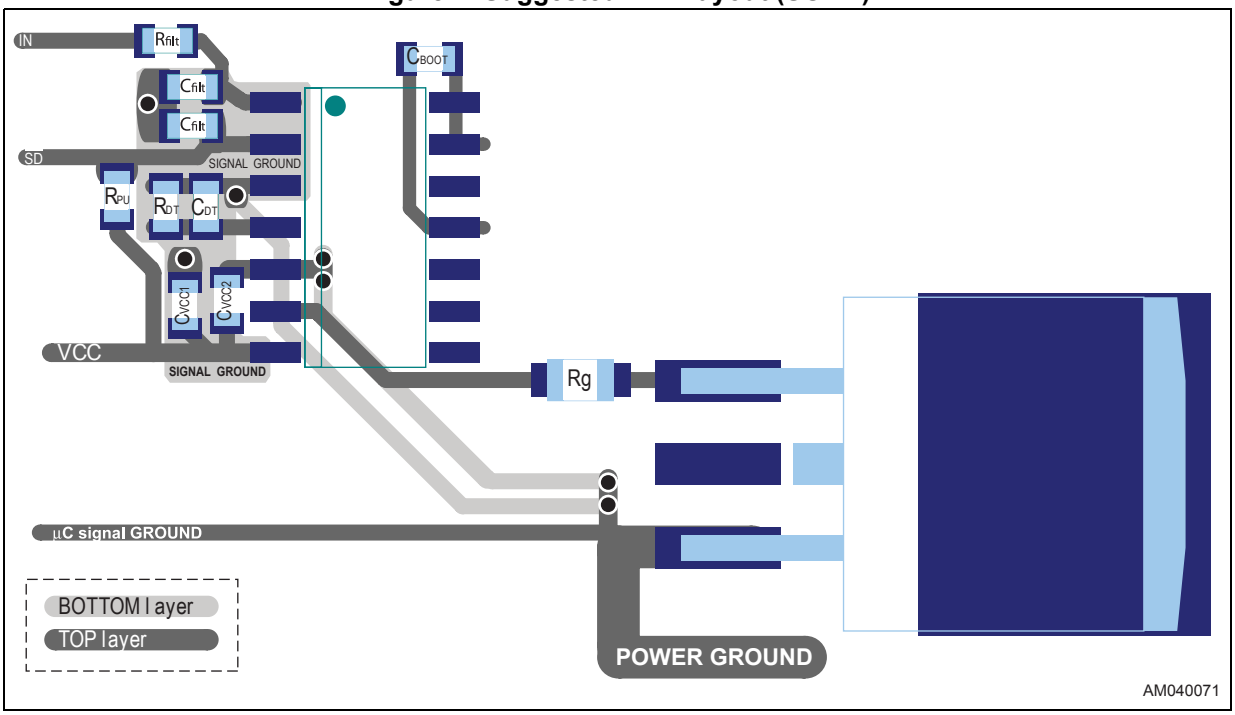


Figure 7. Suggested PCB layout (SO-14)



7 Bootstrap driver

A bootstrap circuitry is needed to supply the high voltage section. This function is usually accomplished by a high voltage fast recovery diode (*Figure 8*). In the L6494 an integrated structure replaces the external diode.

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 has to be:

Equation 2

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

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

If HVG has to be supplied for a long time, the C_{BOOT} selection has also to take into account the leakage and quiescent losses.

HVG steady-state consumption is lower than 120 µA, so if HVG T_{ON} is 5 ms, C_{BOOT} has to supply 0.6 µC. This charge on a 1 µF capacitor means a voltage drop of 0.6 V.

The internal bootstrap driver gives a great advantage: 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 SGND (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 $R_{DS(on)}$ (typical value: 175 Ω). At low frequency this drop can be neglected. Anyway, the rise of frequency has to take into account.

The following equation is useful to compute the drop on the bootstrap DMOS:

Equation 3

$$V_{drop} = I_{charge} R_{DS(on)} \rightarrow V_{drop} = \frac{Q_{gate}}{T_{charge}} R_{DS(on)}$$

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

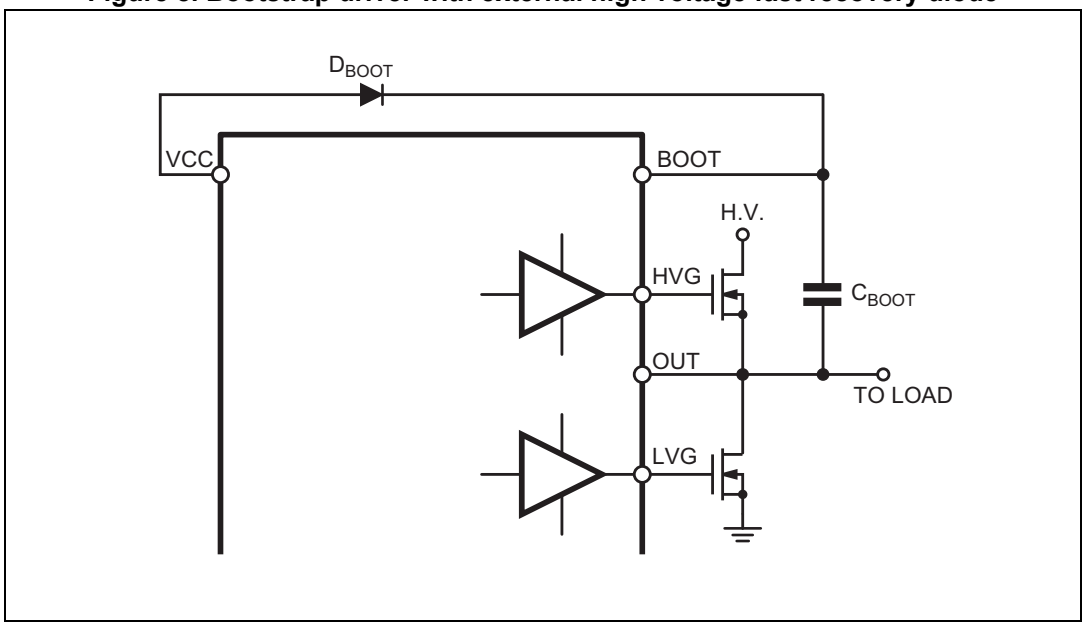
For example: using a power MOS with a total gate charge of 30 nC the drop on the bootstrap DMOS is about 1 V, if the T_{charge} is 5 µs. In fact:

Equation 4

$$V_{drop} = \frac{30nC}{5\mu s} \cdot 175\Omega \sim 1V$$

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 with external high voltage fast recovery diode



8 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.

8.1 SO-14 package information

Figure 9. SO-14 package outline

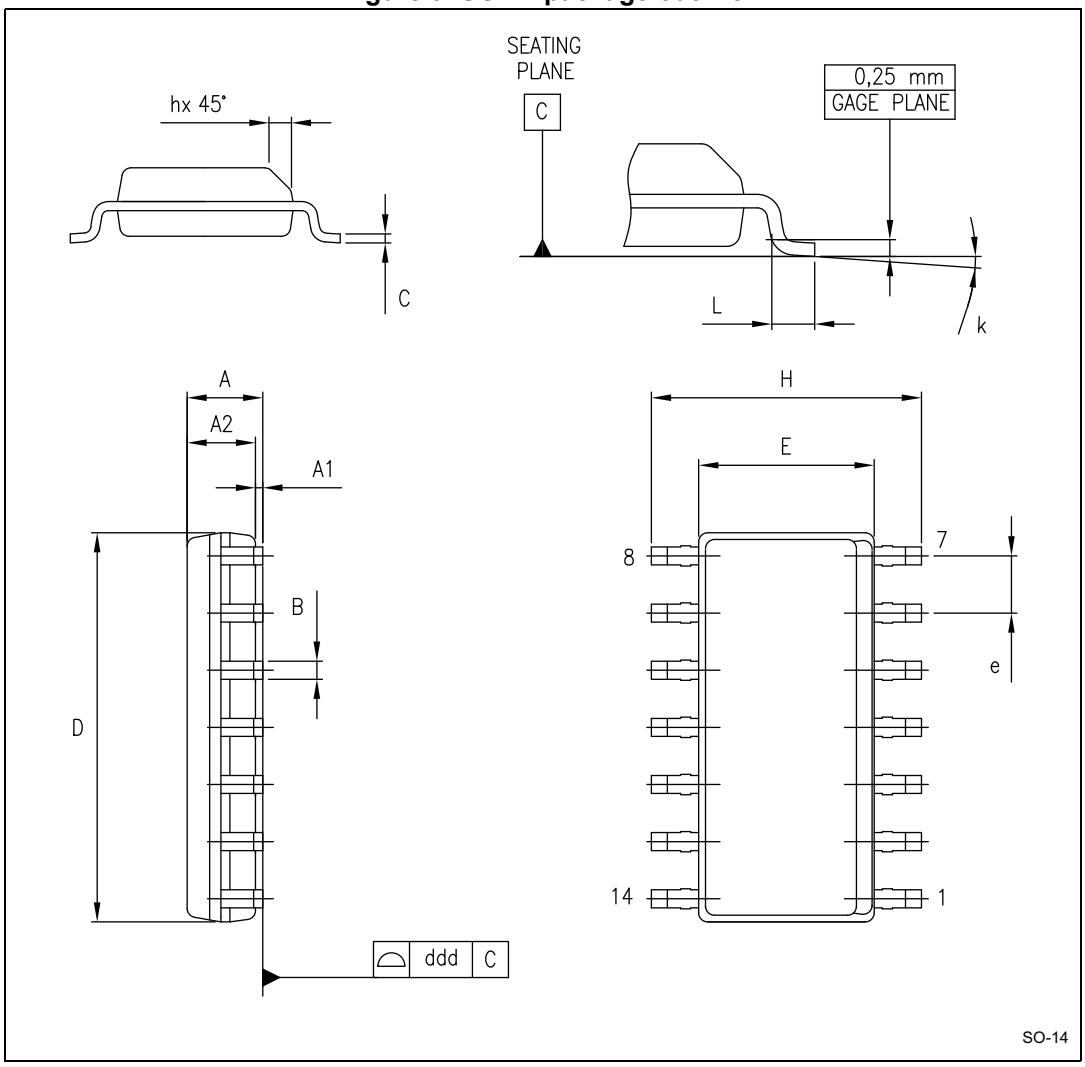
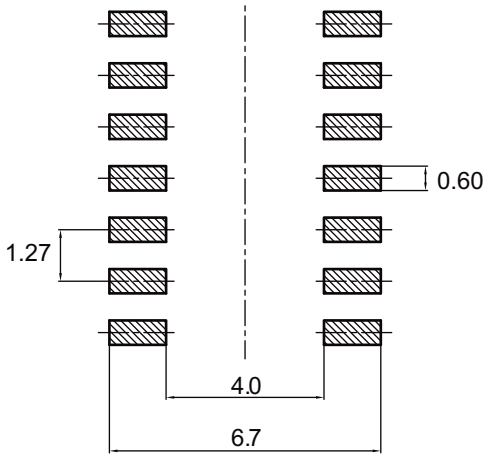


Table 7. SO-14 package mechanical data

Symbol	Dimensions (mm)		
	Min.	Typ.	Max.
A	1.35	-	1.75
A1	0.10	-	0.25
A2	1.10	-	1.65
B	0.33	-	0.51
C	0.19	-	0.25
D	8.55	-	8.75
E	3.80	-	4.00
e	-	1.27	-
H	5.80	-	6.20
h	0	-	-
25	-	0.50	-
L	0.40	-	1.27
k	0	-	8
ddd	-	-	0.10

Figure 10. SO-14 package suggested land pattern



9 Ordering information

Table 8. Device summary

Order code	Package	Packaging
L6494LD	SO-14	Tube
L6494LDTR	SO-14	Tape and reel

10 Revision history

Table 9. Document revision history

Date	Revision	Changes
08-Feb-2017	1	Initial release.