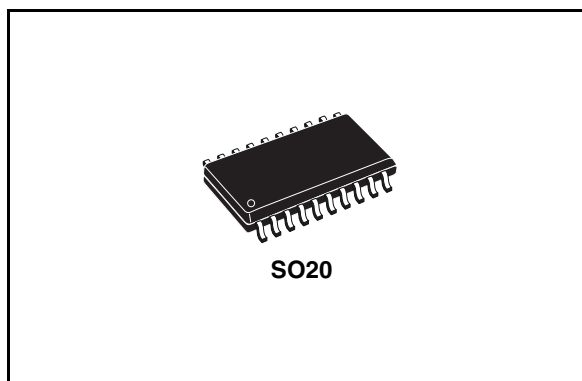


## Dual intelligent power low side switch

### Features

- Multipower BCD technology
- Dual power low side driver with 2 x 5 A
- Low  $R_{DS(ON)}$  typically 200 m $\Omega$  @  $T_J = 25$  °C
- Internal output clamping diodes  $V_{FB} = 50$  V for inductive recirculation
- Limited output voltage slew rate for low EMI
- $\mu$ P compatible enable and input
- Wide operating supply voltage range 4.5 V to 45 V
- Real time diagnostic functions:
  - Output shorted to GND
  - Output shorted to  $V_{SS}$
  - Open load
  - Load bypass
  - Over temperature
- Device protection functions:
  - Overload disable
  - Reverse battery up to -16 V @  $V_S$
  - Thermal shutdown



### Description

The L9386 is a monolithic integrated dual low side driver realized in an advanced Multipower BCD mixed technology.

It is especially intended to drive valves in automotive environment. Its inputs are  $\mu$ P compatible for easy driving. Particular care has been taken to protect the device against failures, to avoid electro-magnetic interferences and to offer extensive real time diagnostic.

**Table 1. Device summary**

Part number	Order code	Package	Packing
L9386	L9386MD	SO20 (12+4+4)	Tube

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# 1 Block and pins connection diagrams

Figure 1. Block diagram

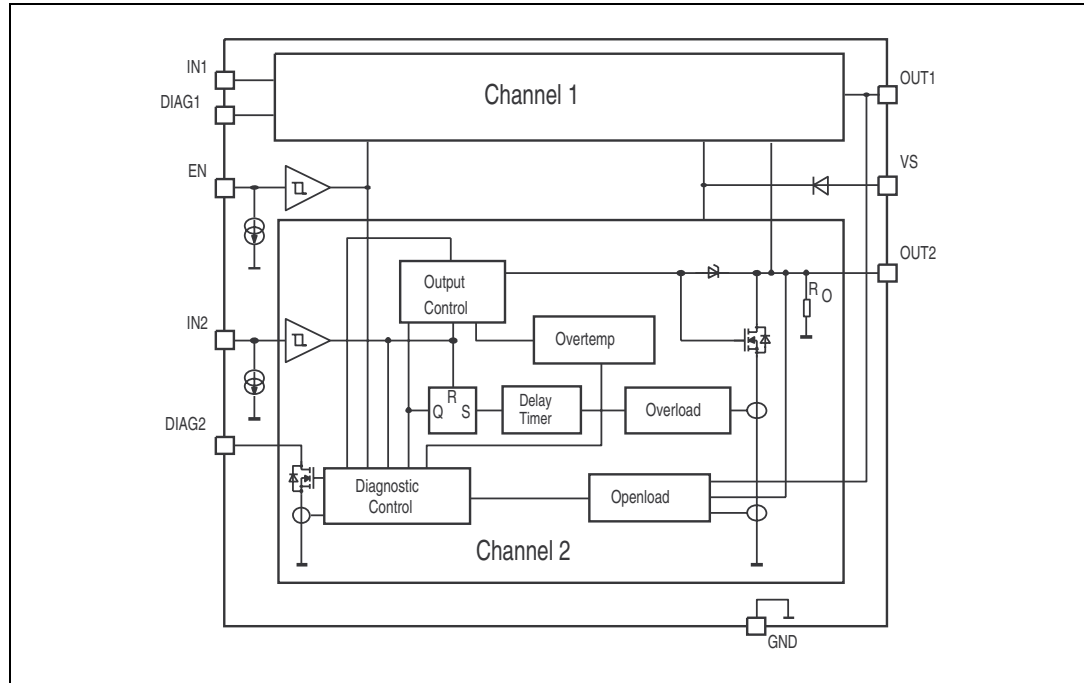
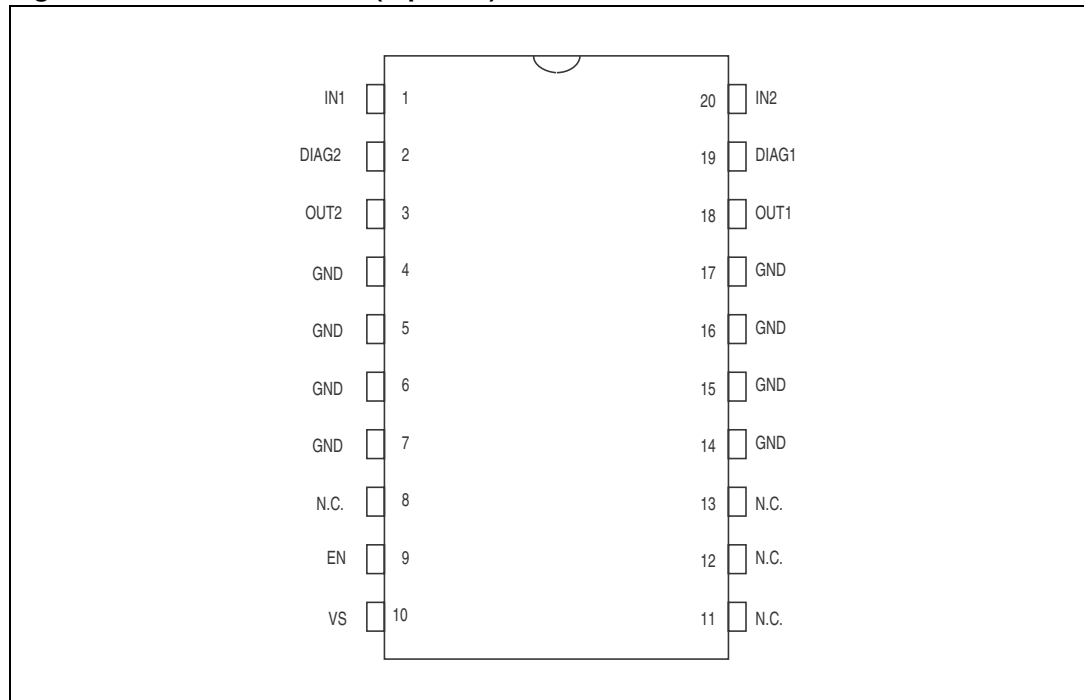


Figure 2. Pins connection (top view)



## 2 Electrical specifications

### 2.1 Absolute maximum ratings

**Table 2. Absolute maximum ratings (no damage or latch)**

Symbol	Parameter	Value	Unit
V <sub>SDC</sub>	DC supply voltage	-16 to 45	V
V <sub>STR</sub>	Transient supply voltage (t ≤ 500 ms)	60	V
V <sub>IN,EN</sub>	Input voltage (I ≤ I 10 mA I)	-1.5 to 6	V
V <sub>DDC</sub>	Diagnostic DC output voltage (I ≤ I 50 mA I)	-0.3 to 16	V
V <sub>ODC</sub>	DC output voltage	45	V
V <sub>OTR</sub>	Transient output voltage (R <sub>L</sub> ≥ 4 Ω)	60	V
I <sub>O</sub>	Output load current	internal limited	
I <sub>OR</sub>	Reverse output current limited by load	-4	A
EO	Switch-off energy for inductive loads (t <sub>EO</sub> = 250 μs, T = 5 ms)	50	mJ
T <sub>jEO</sub>	Junction temperature during switch-off Σt = 30 min	175	°C
T <sub>j</sub>	Junction temperature	-40 to +150	°C
T <sub>stg</sub>	Storage temperature	-55 to +150	°C

### 2.2 Thermal data

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
T <sub>jDIS</sub>	Thermal disable junction temperature threshold	160 to 190	°C
R <sub>th j-pins</sub>	Thermal resistance junction to pins	14	°C/W

## 2.3 Electrical characteristics

**Table 4. Electrical characteristics**

(The electrical characteristics are valid within the below defined operative range, unless otherwise specified.)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_S$	Board supply voltage		4.5	12	32	V
$V_D$	Stabilized diagnostic output voltage		-0.3	5	16	V
$T_j$	Junction temperature		-40		150	°C
$I_{SSB}$	Static standby supply current	(1) (2) $V_{EN} = L, V_O \leq V_{O_{UV}}$		0.73	1.5 15	mA
$I_S$	DC supply current	(1) (2) $V_{EN} = V_{IN} = H$		1.3	5 15	mA
$V_{DL}$	Diagnostic output low voltage	(1) $I_D = 2 \text{ mA}$ (2) $I_D = 1 \text{ mA}$		0.35	0.5	V
$I_{DLE}$	Diagnostic output leakage current	$V_S = 0 \text{ V}$ or $V_S = \text{open}$ ; $V_D = 5.5 \text{ V}$ $T_j \leq 125 \text{ °C}$		0.1	2	mA
$I_D$	Diagnostic output current capability	$V_D \leq 16 \text{ V}$ $DIAG = L$	2	6	30	mA
$V_{O_{UV}}$	Open load voltage threshold	$V_{EN} = X, V_{IN} = L$	0.51 xVS	0.55 xVS	0.59 xVS	V
$\Delta V_{O_{UV}1,2}$	Open load difference voltage threshold	(1) $V_{EN} = X, V_{IN1,2} = L$ $V_S \geq V_{OC} \geq V_{O_{UV}}$ $V_{OC} = \text{output voltage of other channel}$ (2)	$V_{OC}^-$ 0.9V	$V_{OC}^-$ 1.25V	$V_{OC}^-$ 1.6V	V
$I_{O_{UC}}$	Open load current threshold	(3) $V_{EN} = V_{IN} = H$ (2)	100 20	320	480	mA
$I_{O_{OC}}$	Over load current threshold	b)	5	7		A
$V_{O_{CL}}$	Output voltage during clamping	$I_{O_{CL}} \geq 100 \text{ mA}$	45	52	60	V
$S_{ON,OFF}$	Output (fall, rise) slew rate	(3) see <a href="#">Figure 4</a>	200	1500	3200	V/ms
$R_{IO}$	Internal output pull down resistor	$V_{EN} = L$	10	20	40	K $\Omega$
$R_{DSON}$	Output on resistance	$V_S > 9.5 \text{ V}$ $I_O = 2 \text{ A}$ $T_j = 25 \text{ °C}$ $T_j = 150 \text{ °C}$		200	300 500	m $\Omega$
$V_{(EN,IN)L}$	Logic input low voltage	$ I_{EN}, I_{IN}  \leq 10 \text{ mA}$ (1) (2)	-1.5 -1.5		1 0.5	V
$V_{(EN,IN)H}$	Logic input high voltage		2.2		5.5	V

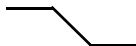
**Table 4. Electrical characteristics (continued)**

(The electrical characteristics are valid within the below defined operative range, unless otherwise specified.)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{(EN,IN)hys}$	Logic input hysteresis		0.2	0.4	1	V
$I_{EN}$	Enable input sink current	$1\text{ V} \leq V_{EN} \leq 5.5\text{ V}$	10	30	60	$\mu\text{A}$
$I_{IN}$	Logic input sink current	$1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	40	95	180	$\mu\text{A}$
$t_{DON}$	Output delay ON time	<sup>(3)</sup> see <i>Figure 4</i>		4	25	$\mu\text{s}$
$t_{DOFF}$	Output delay OFF time	<sup>(3)</sup> see <i>Figure 4</i>	5	15	30	$\mu\text{s}$
$t_{DH-L,Diag.}$	Diag. delay output OFF time	<sup>(3)</sup> see <i>Figure 4</i>	5	30	65	$\mu\text{s}$
$t_{DIOu}$	Diagnostic open load delay time	<sup>(3)</sup> see <i>Figure 6</i>		8	50	$\mu\text{s}$
$t_{DOL}$	Diagnostic overload delay switch-off time	<sup>(3)</sup> see <i>Figure 3</i>	50	160	300	$\mu\text{s}$

- $6.5\text{ V} \leq V_S \leq 16\text{ V}$  (Diagnostic operation range).
- $4.5\text{ V} \leq V_S < 6.5\text{ V}$  and  $16\text{ V} < V_S \leq 32\text{ V}$  (Extended operation range).
- $9\text{ V} \leq V_S \leq 16\text{ V}$  (Nominal operating range)  
 $R_L \leq 6\ \Omega$ ,  $I_O \leq I_{OC}$ .

**Table 5. Diagnostic table (operating range:  $4.5\text{ V} \leq V_S \leq 32\text{ V}$ )**

Conditions		EN	IN	Out	Diag.
Normal function		L	X	off	L
		H	L	off	L
		H	H	on <sup>(1)</sup>	H
GND short	$V_{O_{typ}} < 0.55\text{ V}$	L	X	off	H
Load bypass	$\Delta V_{O_{1,2}} \geq 1.25\text{ V}$	H	L	off	H
Open load	$I_{O_{typ}} < 320\text{ mA}$	H	H	on <sup>(1)</sup>	L
$T_j \text{ typ} \geq 175\text{ }^\circ\text{C}$ overtemperature <sup>(2)</sup>		X	L	off	H
		X	H	off	L
Latched overload $I_{O_{min}} > 5\text{ A}$		X	H	off	L
Reset overload latch		X		D.C.	D.C.

- for  $4.5\text{ V} \leq V_S < 6.5\text{ V}$ ,  $I_O \leq 2\text{ A}$  diag. table is valid.
- If one diag. status shows the overtemperature recognition, in parallel this output will be switched OFF internally. The corresponding channel should be switched OFF additional by its Input or ENABLE signal, otherwise the overload latch will be set after  $t_{DOL}$  is passed. This behavior will be related to the overdrop sensing which will be used as over load recognition.

Figure 3. Diagnostic overload delay time

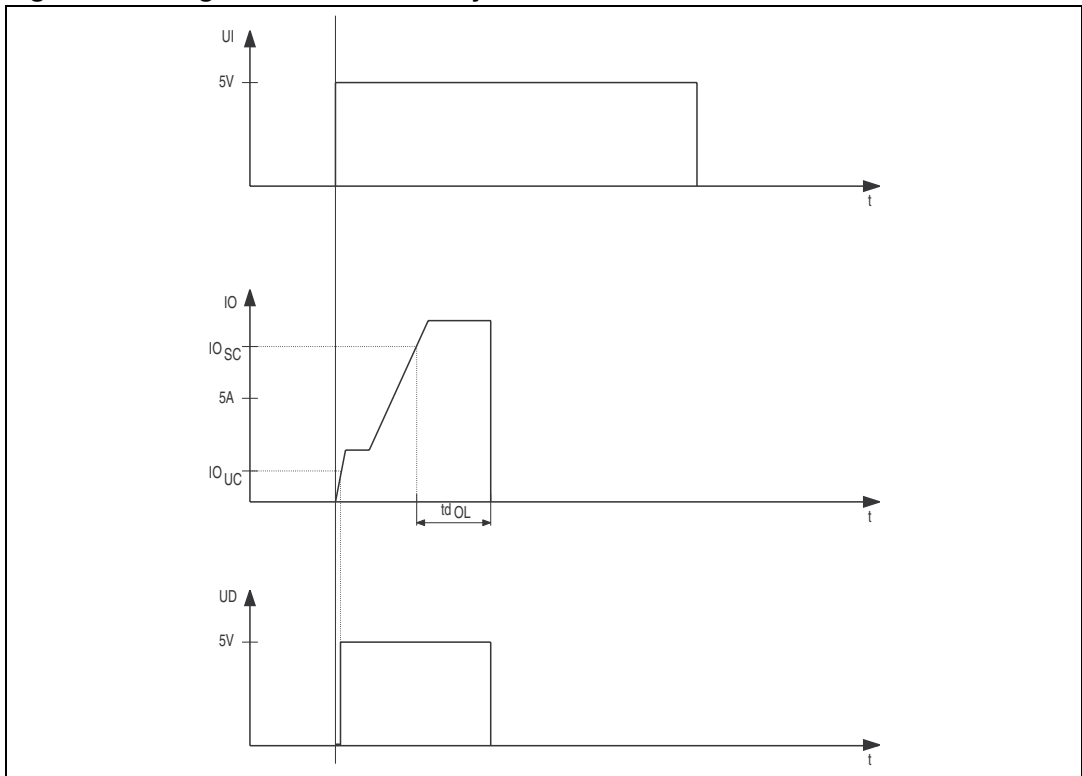


Figure 4. Output slope

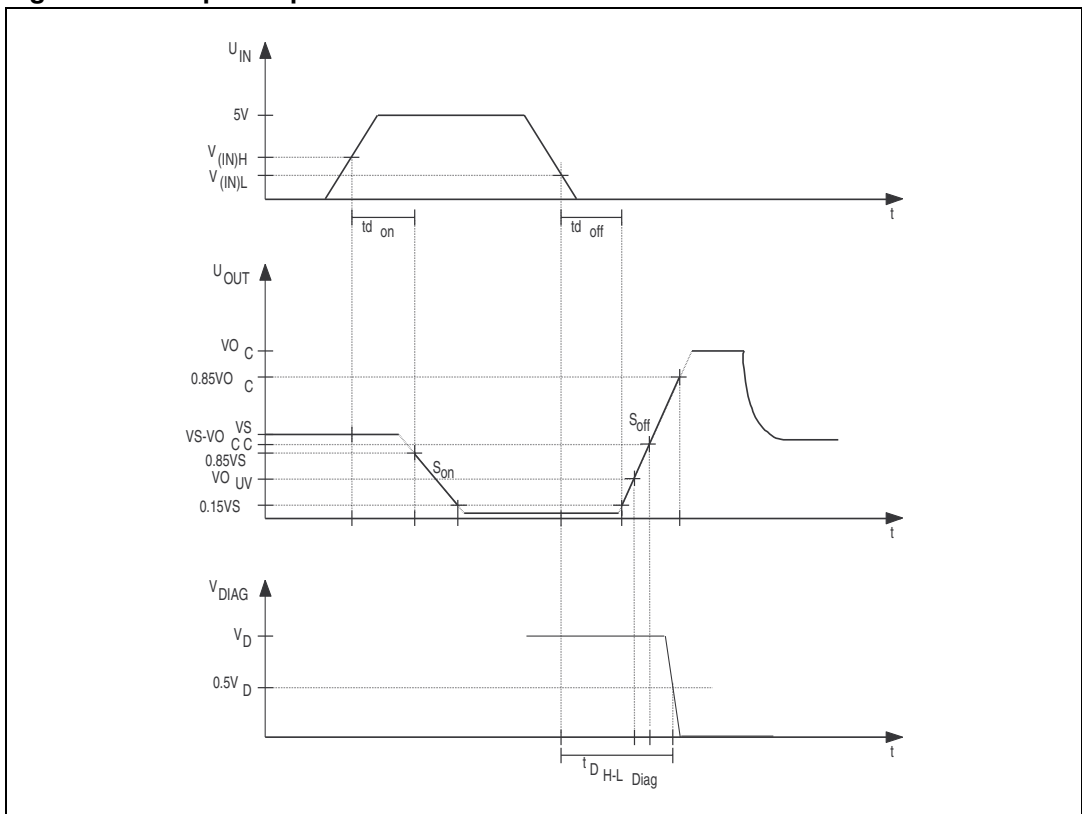


Figure 5. Open load voltage detection block diagram

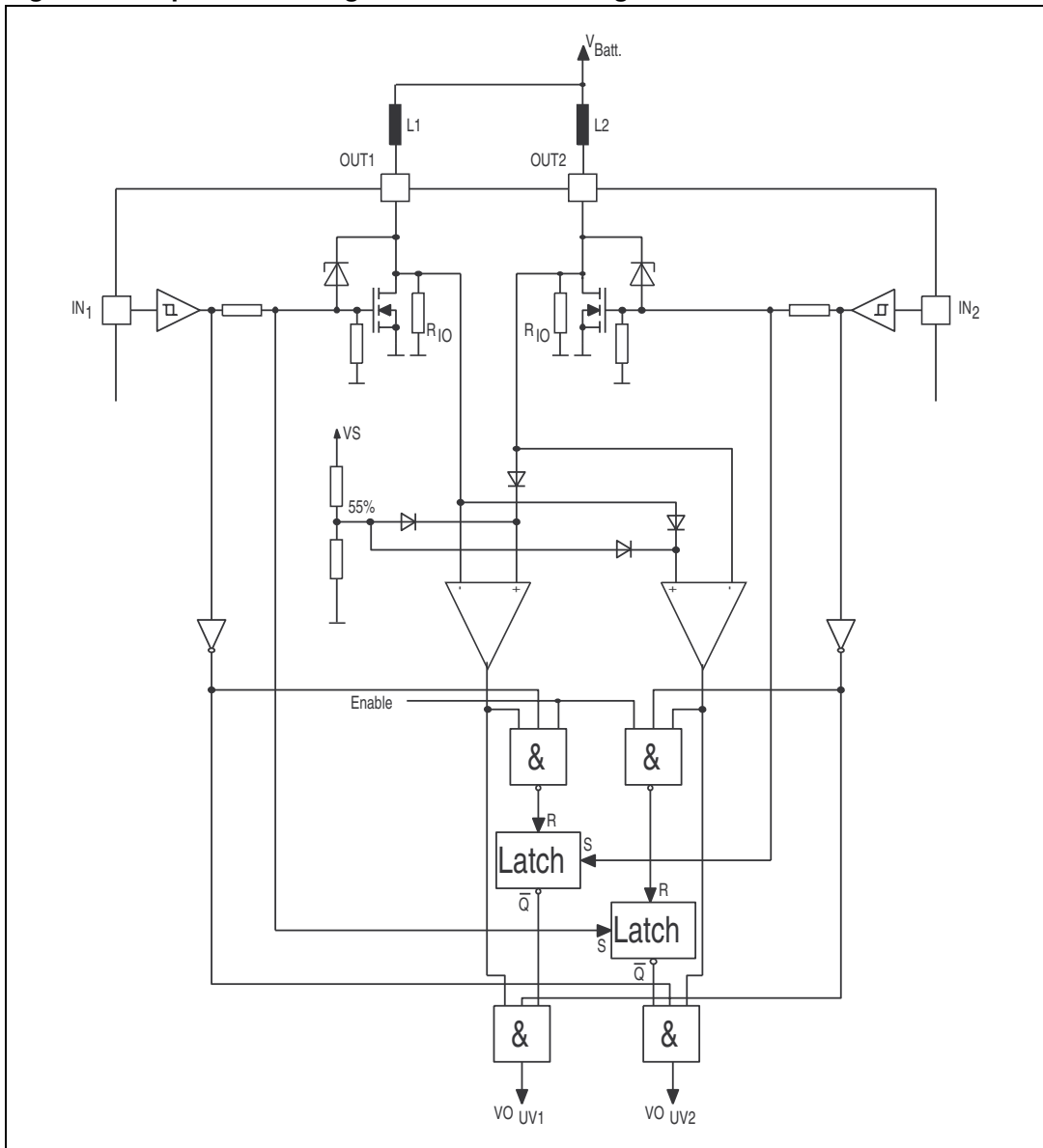
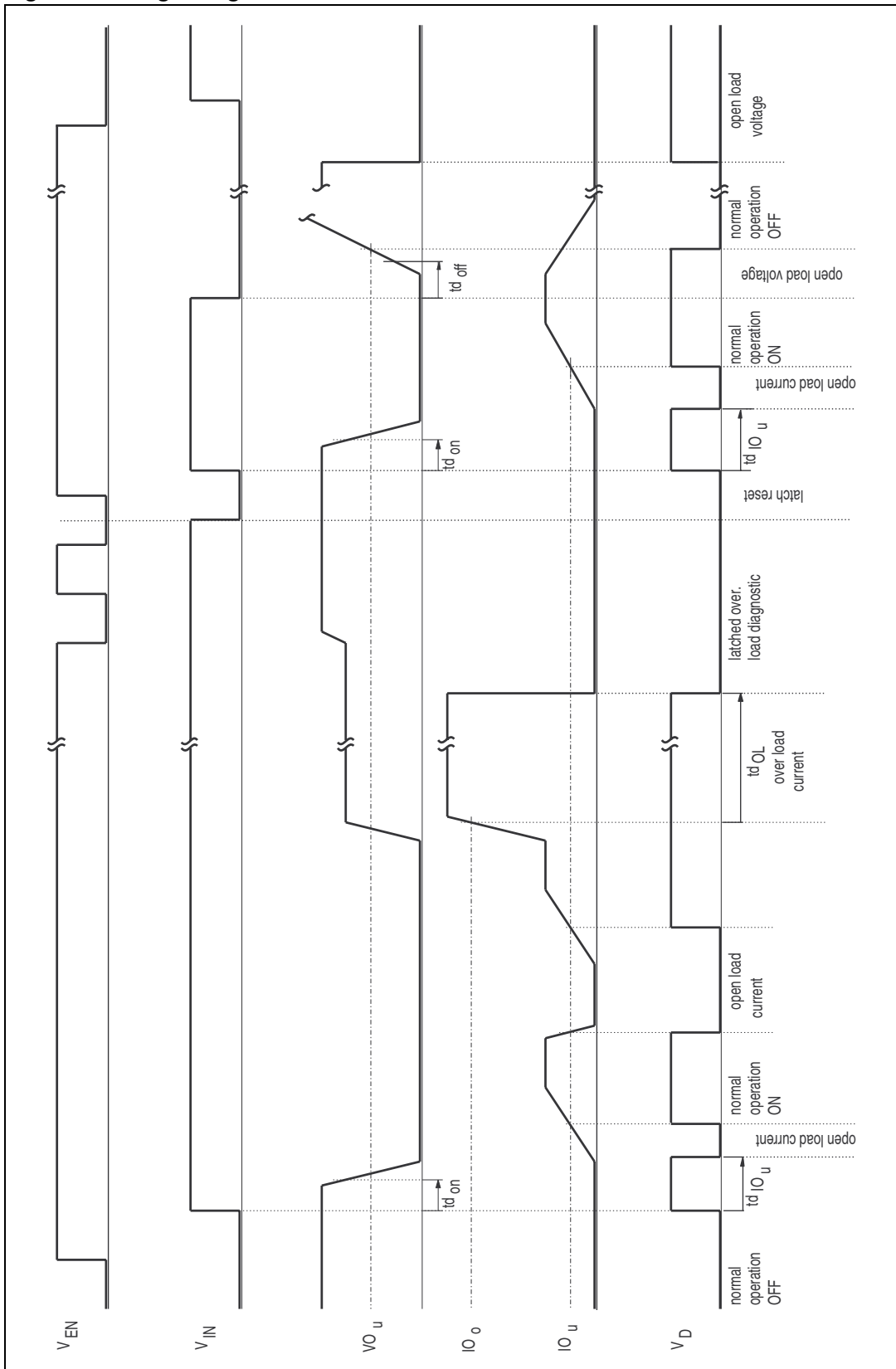




Figure 6. Logic diagram



## 2.4 Circuit description

The L9386 is a dual low side driver for inductive loads like valves in automotive environment.

The device is enabled by a common CMOS compatible ENABLE high signal. The internal pull down current sources at the ENABLE and INPUT pins protect the device in open input conditions against malfunctions. An output slope limitation for  $du/dt$  is implemented to reduce the EMI. An integrated active flyback voltage limitation clamps the output voltage during the flyback phase to 50V.

Each driver is protected against short circuit and thermal overload. In short circuit condition the output will be disabled after a short delay time  $t_{DOL}$  to suppress spikes. This disable is latched until a negative slope occur at the correspondent input pin. The thermal disable for  $T_J > 175\text{ °C}$  of the output will be resetted if the junction temperature decreases about  $20\text{ °C}$  below the disable threshold temperature.

For the real time error diagnosis the voltage and the current of the outputs are compared with internal fixed values  $V_{O_{UV}}$  for OFF and  $I_{O_{UC}}$  for ON conditions to recognize open load ( $R_L \geq 20\text{ k}\Omega$ ,  $R_L > 38\Omega$ ) in ON and OFF conditions. The diagnostic operates also in the extended supply voltage range of  $4.5\text{ V} \leq V_S \leq 32\text{ V}$ .

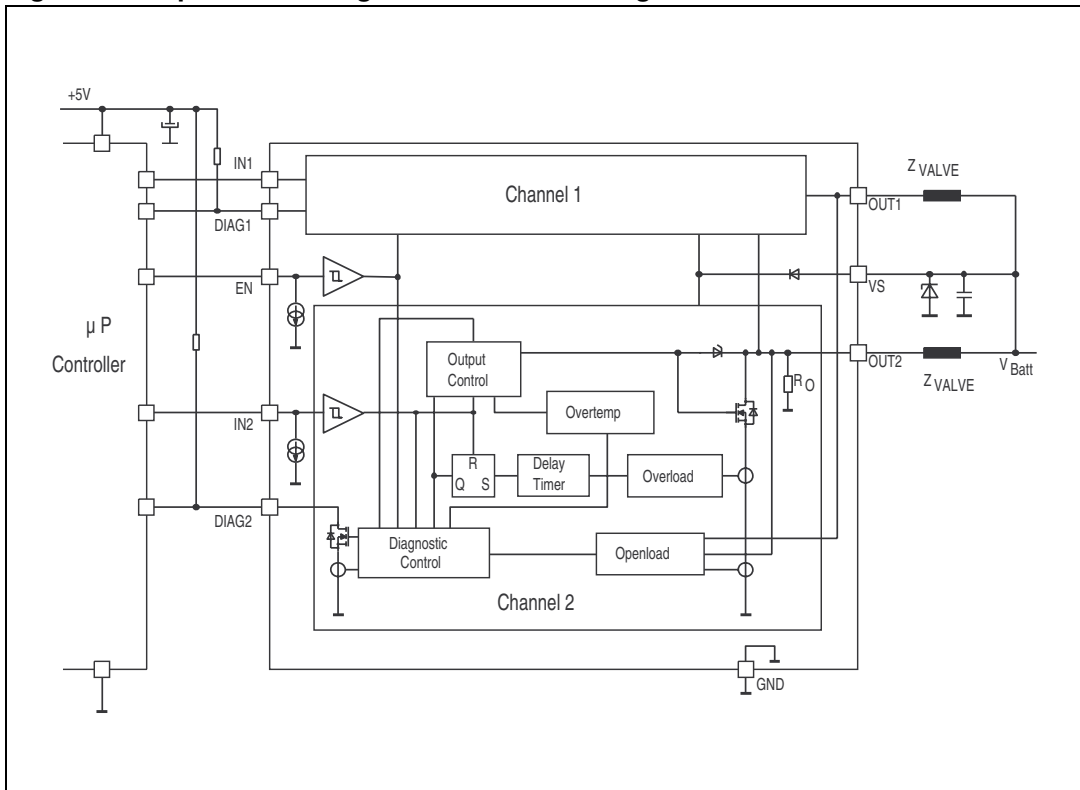
Also the output voltages  $VO_{1,2}$  are compared against each other in OFF condition with a fixed offset of  $\Delta VO_{UV\ 1,2}$  to recognize GND bypasses. To suppress mail  $\Delta VO$  diagnoses during the flyback phases of the compared output, the  $\Delta VO$  diagnostic

includes a latch function. Reaching the flyback clamping voltage  $VO_C$  the diagnostic signal is resetted by a latch. To activate again this kind of diagnostic a low signal at the correspondent INPUT or the ENABLE pin must occur (see also [Figure 5](#)).

The diagnostic output level in connection with different ENABLE and INPUT conditions allows to recognize different fail states, like overtemperature, short to VSS, short to GND, bypass to GND and disconnected load (see also [Table 5 on page 6](#)).

The diagnostic output is also protected against short to  $UD_{max}$ . Overstepping the over load current threshold  $IO_o$ , the output current will be limited internally during the diagnostic overload delay switch-off time  $t_{DOL}$ .

Figure 7. Open load voltage detection block diagram

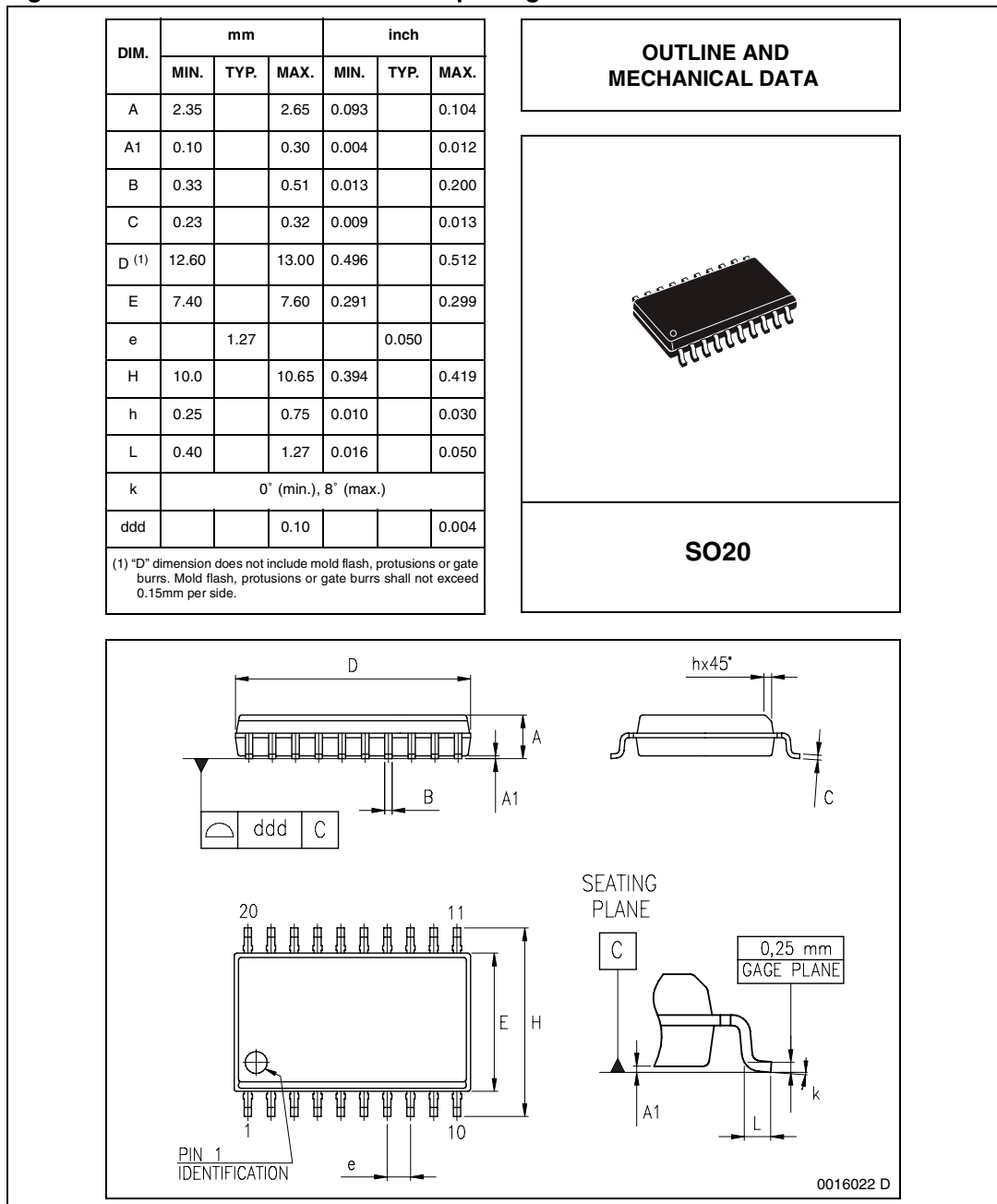


### 3 Package information

In order to meet environmental requirements, ST (also) offers these devices in ECOPACK<sup>®</sup> packages. ECOPACK<sup>®</sup> packages are lead-free. 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](http://www.st.com).

**Figure 8. SO20 mechanical data and package dimensions**



## 4 Revision history

**Table 6. Document revision history**

Date	Revision	Changes
16-Jan-2002	1	Initial release.
20-Sep-2003	2	Changed company name and logo.
16-Jul-2008	3	Document reformatted. Added <a href="#">Table 1: Device summary on page 1</a> .

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