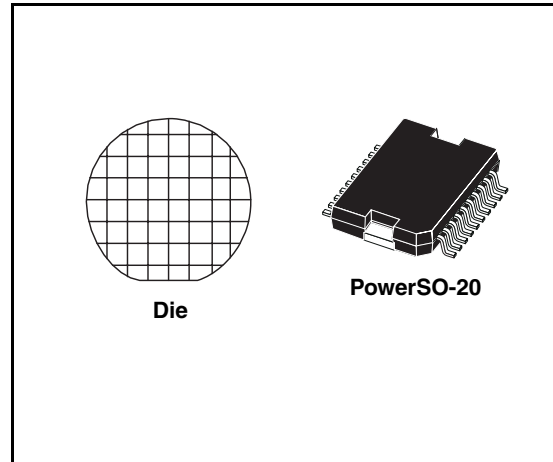


## Quad intelligent power low side switch

### Features

- Quad power low side driver with 3 A output current capability
- Low  $R_{DS(ON)}$  typically 200 m $\Omega$  and 300 m $\Omega$  @  $T_j = 25^\circ\text{C}$
- Internal output clamping structures with  $V_{FB} = 50\text{ V}$  for fast inductive load current recirculation
- Limited output voltage slew rate for low EMI
- Protected  $\mu\text{P}$  compatible enable and input
- Wide operating supply voltage range 4.5 V to 32 V
- Real time diagnostic functions:
  - Output shorted to GND
  - Output shorted to  $V_S$
  - Open load detection in ON and OFF condition
  - Overtemperature detection
- Device protection functions:
  - Overload disable
  - Selective thermal shutdown
  - Signal- and Power-Ground-loss shutdown



### Description

The L9332 is a monolithic integrated quad low side driver realized in an advanced Multipower BCD mixed technology. The device is intended to drive valves in automotive environment.

The inputs are  $\mu\text{P}$  compatible. Particular care has been taken to protect the device against failures, to avoid electromagnetic interferences and to offer extensive real time diagnostic.

**Table 1. Device summary**

Order code	Package	Packing
L9332 <sup>(1)</sup>	PowerSO-20	Tube
L9332-DIE1	Die	–

1. Only for evaluation.

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# Contents

<b>1</b>	<b>Block diagram</b> .....	<b>5</b>
	1.1 Block diagram .....	5
<b>2</b>	<b>Pin description</b> .....	<b>6</b>
<b>3</b>	<b>Pad description</b> .....	<b>7</b>
<b>4</b>	<b>Electrical specifications</b> .....	<b>8</b>
	4.1 Thermal data .....	8
	4.2 Absolute maximum ratings .....	8
	4.3 ESD protection .....	8
	4.4 Electrical characteristics .....	9
	4.5 Diagnostic .....	11
<b>5</b>	<b>Circuit description</b> .....	<b>12</b>
<b>6</b>	<b>Package information</b> .....	<b>15</b>
<b>7</b>	<b>Revision history</b> .....	<b>16</b>

## List of tables

Table 1.	Device summary . . . . .	1
Table 2.	Pin description . . . . .	6
Table 3.	Pad coordinates . . . . .	7
Table 4.	Thermal data . . . . .	8
Table 5.	Absolute maximum ratings . . . . .	8
Table 6.	ESD protection . . . . .	8
Table 7.	Electrical characteristics . . . . .	9
Table 8.	Diagnostic . . . . .	11
Table 9.	Document revision history . . . . .	16

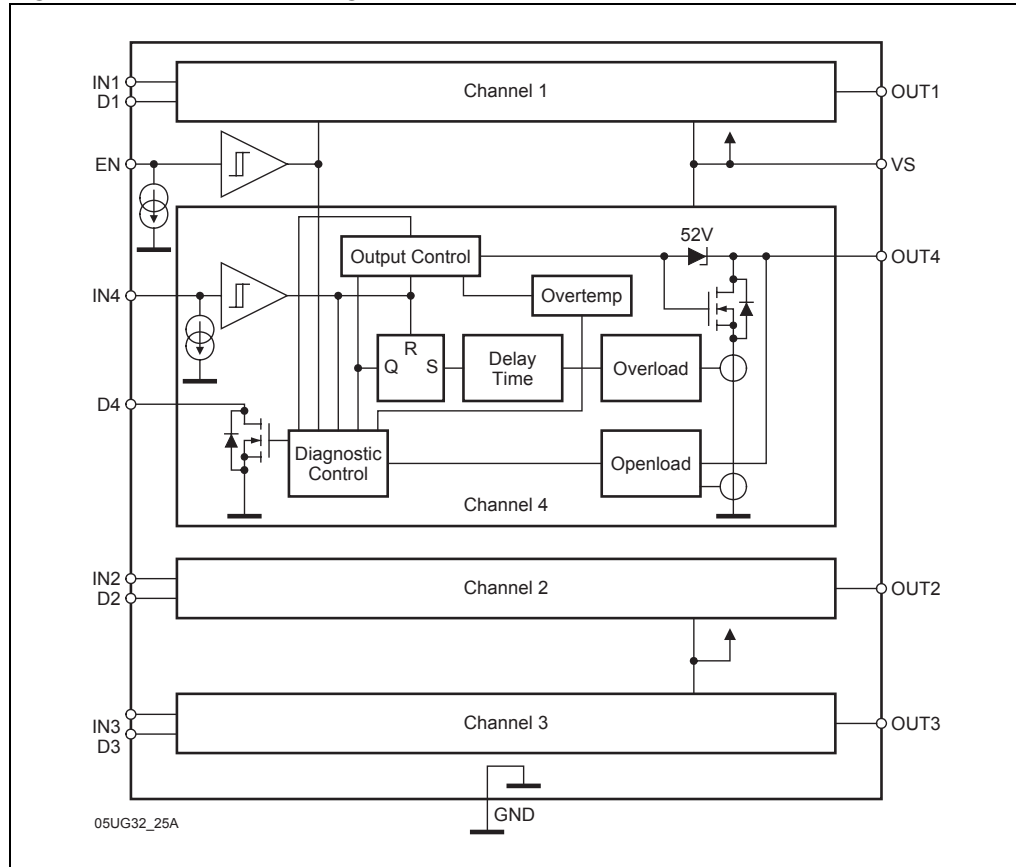
## List of figures

Figure 1.	Block circuit diagram . . . . .	5
Figure 2.	Pin connection (top view) . . . . .	6
Figure 3.	Pad position . . . . .	7
Figure 4.	$t_{EO}$ clamping time . . . . .	12
Figure 5.	Output slope (resistive load for testing) . . . . .	13
Figure 6.	Timing ( $t_{DOL}$ , $t_{DIOU}$ ) . . . . .	13
Figure 7.	Logic diagram . . . . .	14
Figure 8.	PowerSO-20 mechanical data and package dimensions . . . . .	15

# 1 Block diagram

## 1.1 Block diagram

Figure 1. Block circuit diagram



## 2 Pin description

Figure 2. Pin connection (top view)

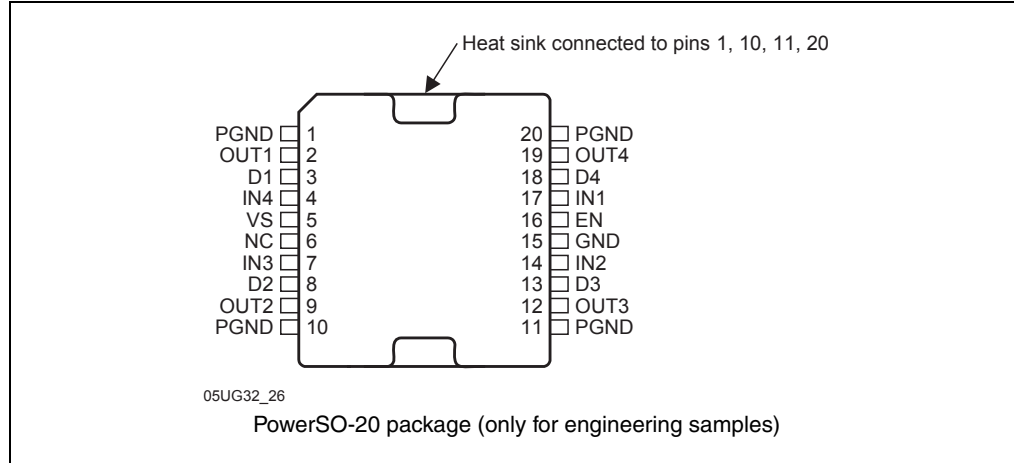


Table 2. Pin description

Pin #.	Pin name	Function
1	GND	Power ground
2	Out1	Output 1 (3 A)
3	D1	Diagnostic 1
4	IN4	Input 4
5	VS	Supply voltage
6	NC	Not connected
7	IN3	Input 3
8	D2	Diagnostic 2
9	Out2	Output 2 (3 A)
10	GND	Power ground
11	GND	Power ground
12	Out3	Output 3 (3 A)
13	D3	Diagnostic 3
14	IN2	Input 2
15	GND	Signal ground
16	EN	Common enable
17	IN1	Input 1
18	D4	Diagnostic 4
19	Out4	Output 4 (3 A)
20	GND	Power ground

### 3 Pad description

Figure 3. Pad position

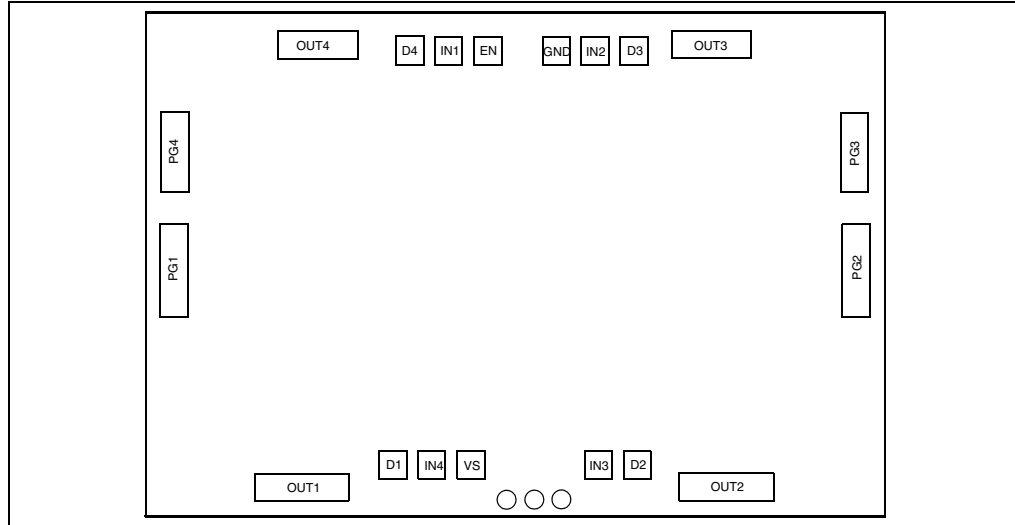


Table 3. Pad coordinates

Pin #	Pad name	Description	Size	X	Y
1	PG1	Power ground	510*150	-136	1846
2	Out1	Output 1 (3 A)	510*150	-1219	1152
3	D1	Diagnostic 1	150 *150	-1093	662
4	IN4	Input 4	150 *150	-1093	452
5	VS	Supply voltage	150 *150	-1093	242
7	IN3	Input 3	150 *150	-1093	-446
8	D2	Diagnostic 2	150 *150	-1093	-656
9	Out2	Output 2 (3 A)	510 *150	-1219	-1148
10	PG2	Power ground	510 *150	-138	-1842
11	PG3	Power ground	430 *150	624	-1842
12	Out3	Output 3 (3 A)	430 *150	1195	-1064
13	D3	Diagnostic 3	150 *150	1181	-557
14	IN2	Input 2	150 *150	1181	-347
15	GND	Signal ground	150 *150	1181	-137
16	EN	Common enable	150 *150	1181	156
17	IN1	Input 1	150 *150	1181	365
18	D4	Diagnostic 4	150 *150	1181	575
19	Out4	Output 4 (3 A)	430 *150	1196	1067
20	PG4	Power ground	430*150	624	1846

## 4 Electrical specifications

### 4.1 Thermal data

Table 4. Thermal data

Symbol	Parameter	Value	Unit
$R_{TH(j-c)}$	Thermal resistance junction to case for Power SO-20	3	°C/W

### 4.2 Absolute maximum ratings

Table 5. Absolute maximum ratings

Symbol	Parameter	Conditions	Value	Unit
$V_S$	DC supply voltage		-0.3 to 32	V
$V_{SP}$	Supply voltage pulse (duration <200 ms)		-0.3 to 45	V
$ dV_S/dt $	Supply voltage slope		10	V/ $\mu$ s
$V_{IN, EN}$	Input voltage	10 mA	-1.5 to 6	V
$V_D$	Diagnostic DC output voltage	50 mA	-0.3 to 16	V
$V_{ODC}$	DC output voltage		-0.3 to 45	V
$I_O$	DC output current out		3	A
$I_{OR}$	Reverse output current		-3	A
$E_{O1, 2}$	Switch-off energy for inductive loads	$t_{EO} = 250 \mu$ s	50	mJ
$E_{O3, 4}$		$T = 5$ ms	30	mJ
$\Delta V_{GND}$	GND potential difference		0.3	V
$T_j$	Junction temperature	$\Sigma t \leq 4800$ h	-40 to 145	°C
		$\Sigma t \leq 1200$ h	145 to 160	°C
		$\Sigma t \leq 160$ h	160 to 170	°C
		$\Sigma t \leq 50$ h	170 to 175	°C
$T_{stg}$	Storage temperature		-40 to 175	°C

Note: For diagnostic output (Dx Pins), maximum supply voltage during Latch-up = 20V

### 4.3 ESD protection

Table 6. ESD protection

Symbol	Parameter	Test conditions	Value	Unit
$V_O$	Outputs test voltage	Versus GND + PG shorted	3.75	kV
$V_{s, IN EN D}$	All other pins	Versus GND	2	kV

Note: Tested according to JEDEC (Norm: JESD22-A114C.01).



## 4.4 Electrical characteristics

$V_S = 4.5$  to  $32$  V;  $-40$  °C  $\leq T_{j1} \leq 175$  °C, unless other-wise specified.

Function is guaranteed until thermal shut down threshold;

**Table 7. Electrical characteristics**

Symbol	Parameter	Test conditions	Values $T_{j1}$			Unit
			Min.	Typ.	Max.	
<b>Supply</b>						
$I_{VS}$	DC supply current off			5	15	mA
$V_{RES}$	Reset Voltage		1.5		4.5	V
<b>Outputs Out 1 - 4</b>						
$V_Z$	Z-diode clamping voltage	$I_{OCL} \geq 200$ mA	45		60	V
$R_{DSON\ 1,2}$	Output on resistance	$T_j = 25$ °C		200	300	m $\Omega$
		$T_j = 150$ °C			500	
		$T_j = 175$ °C			600	
$R_{DSON\ 3,4}$		$T_j = 25$ °C		300	450	m $\Omega$
		$T_j = 150$ °C			750	
		$T_j = 175$ °C			900	
$I_{OLE}$	Output leakage	$T_j = 140$ °C $V_{out} = 20$ V			3	$\mu$ A
		$-40$ °C $< T_j \leq 175$ °C $V_{out} = 20$ V			36	$\mu$ A
		$T_j = 140$ °C $V_S = 32$ V; $V_{out} = 4$ V	-50		-5	$\mu$ A
		$T_j = 140$ °C $V_S = 8$ V; $V_{out} = 4$ V	-5		2.5	$\mu$ A
		$-40$ °C $< T_j \leq 175$ °C $V_S = 8$ V; $V_{out} = 4$ V			25	$\mu$ A
S	Output slope	$I_o = 1$ A; <i>Figure 5</i>	0.5		4	V/ $\mu$ s
<b>Inputs IN1-4, EN</b>						
$V_{IN,EN\ L}$	Logic input/enable low voltage				1.0	V
$V_{IN,EN\ H}$	Logic input/enable high voltage	IN, EN	2.0			V
$V_{EN,IN\ hys}$	Logic input hysteresis		50	100		mV
$I_{IN}$	Input sink current	$V_{IN} > 1$ V (1)	5	20	40	$\mu$ A
$I_{EN}$	Enable sink current		5	20	40	$\mu$ A

Table 7. Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Values $T_{j1}$			Unit
			Min.	Typ.	Max.	
<b>Protection and diagnostic functions</b>						
$V_{OUV}$	Output open load voltage threshold		0.525 x $V_S$	0.55 x $V_S$	0.575 x $V_S$	V
$V_{OUV\ hys}$	Output open load voltage hysteresis		10		250	mV
$I_{OUC}$	Output open load current threshold	$V_{EN} = V_{IN} = 2\text{ V};$ $V_S = 6.5\text{ to }16\text{ V}$	30	80	140	mA
$I_{OOC\ 1, 2, 3, 4}$	Over load current threshold		3		8	A
$T_{SD}$	Thermal shut down		185	205	225	°C
$T_{sd-hys}$	TSD hysteresis			20		K
$V_{PGL}$	Power-GND-loss threshold		1	2.5	4	V
$V_{SGL}$	Signal-GND-loss threshold		0.1		0.6	V
<b>Diagnostic outputs D1 - D4</b>						
$V_{DL}$	Diagnostic output low voltage	$I_D \leq 2\text{ mA}$			1.0	V
$R_{Don}$	Output resistor		50		500	$\Omega$
$I_{DLE}$	Diagnostic output leakage current	$T_j = 140\text{ °C}$ $V_D = 14\text{ V}$		0.1	2	$\mu\text{A}$
		$-40\text{ °C} < T_j \leq 175\text{ °C}$ $V_D = 14\text{ V}$			10	$\mu\text{A}$
$I_{DCL}$	Diagnostic output current limitation		2	28	50	mA
<b>Timing</b>						
$t_{ON}$	Output delay on time	<sup>(2)</sup> <i>Figure 5</i>	1		25	$\mu\text{s}$
$t_{OFF}$	Output delay off time	<i>Figure 5</i>	10		50	$\mu\text{s}$
$t_{off-t_{on}}$	Delta off on time (channel 1 +2)	$< 150\text{ °C}$	10		30	$\mu\text{s}$
		$> 150\text{ °C}$	20		40	$\mu\text{s}$
	Delta off on time (channel 3 +4)	$-40\text{ °C} < T_j \leq 175\text{ °C}$	10		30	$\mu\text{s}$
$t_D$	Diagnostic delay time	<sup>(2)</sup> <i>Figure 5 &amp; 6</i>	4		50	$\mu\text{s}$

- Open pins (EN, IN) are detected as low
- $V_S = 9\text{ to }16\text{ V} \wedge I_{OUC} \leq I_O \leq I_{OOC}$

## 4.5 Diagnostic

**Table 8. Diagnostic**

Conditions		EN	IN	OUT	DIAG.	Filter	Reset
Normal function		L	X	off	L		
		H	L	off	L		
		H	H	on	H		
Open load off	$V_{Otyp} < 0.55 \times V_S$	L H	X L	off	H	no	
Open load on	$I_{Omin} < 30 \text{ mA}$	H	H	on	L	no	
Overtemperature	$T_{jtyp} < 205 \text{ °C}$	X	X	off	L	$t_D$	IN=low
Over load	$I_{Omin} > 3 \text{ A}$	H	H	off	L	$t_D$	IN= low
SGND or PGND loss	channel off	X L	L H	off	H	$t_D$	
SGND or PGND loss	channel on	H	H	off	L	$t_D$	IN=low

## 5 Circuit description

The L9332 is a quad low side driver for inductive loads like valves in automotive environment. The internal pull down current sources at the ENable and INput pins assure in case of open input conditions that the device is switched off. An output voltage slope limitation for  $du/dt$  is implemented to reduce the EMI. This is valid up to the clamping voltage  $V_Z$ . This active flyback voltage limitation clamps the output voltage during the flyback phase.

It is allowed to connect two power stages from one device in parallel if external free wheeling diodes are used in the application. For the  $R_{on}$  calculation the parallel resistivity is expected. The nominal current is 70% of the sum of the nominal currents of the used channels.

Each driver is protected against short circuit at  $V_{OUT} < 32$  V and thermal overload. In short circuit condition the output will be disabled after a short delay time  $t_D$ . The thermal disable for  $T_J > 175^\circ\text{C}$  of the output will be reset if the junction temperature decreases about  $20^\circ\text{C}$  below the disable threshold temperature.

The overtemperature, overload and groundloss information is stored until IN is low.

For the real time error diagnosis the voltage and the current of the outputs are compared with internal fixed values  $V_{OUV}$  for OFF and  $I_{OUC}$  for ON conditions to recognize open load in OFF and ON conditions.

The diagnostic output level in connection with different ENable and INput conditions allows to recognize different fail states, like overtemp, short to  $V_S$ , short to GND, bypass to GND and disconnected load (see diagnostic table).

The diagnostic output is protected against short circuit. Exceeding the over load current threshold  $I_{OOC}$ , the output current will be limited internally during the diagnostic overload delay switch-off time  $t_D$ .

The device complies the ISO pulses imposed to the supply voltage of the valves without any failures of the functionality. Therefore some diagnostic functions are internal filtered. The diagnostic table shows the corresponding filter time for each detected signal.

**Figure 4.  $t_{EO}$  clamping time**

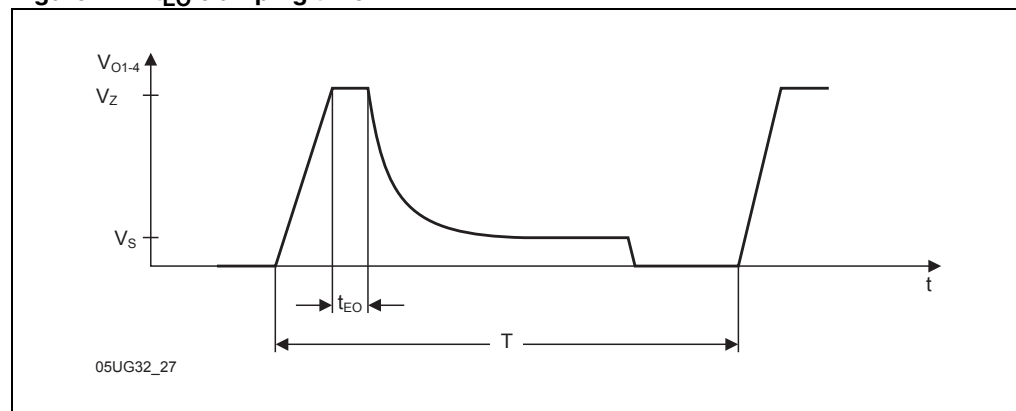


Figure 5. Output slope (resistive load for testing)

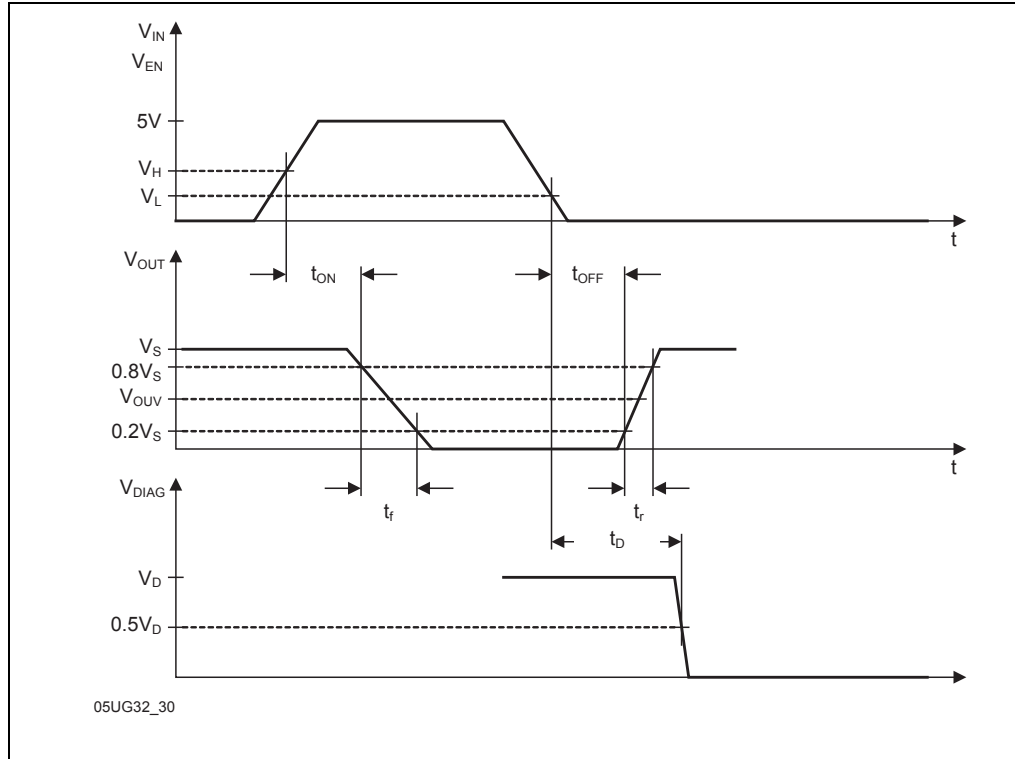


Figure 6. Timing ( $t_{DOL}$ ,  $t_{DIU}$ )

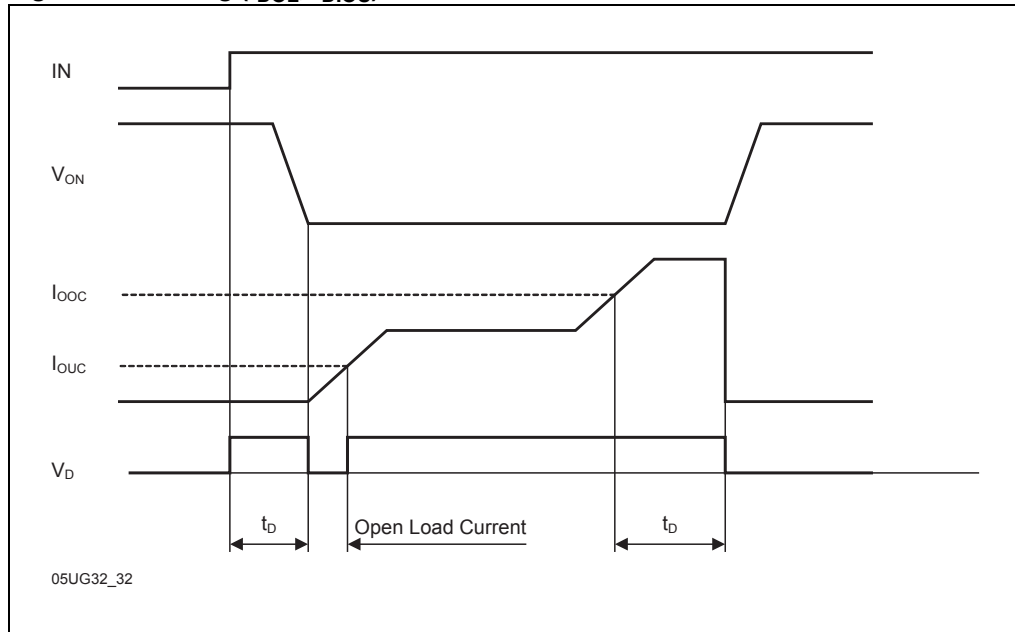
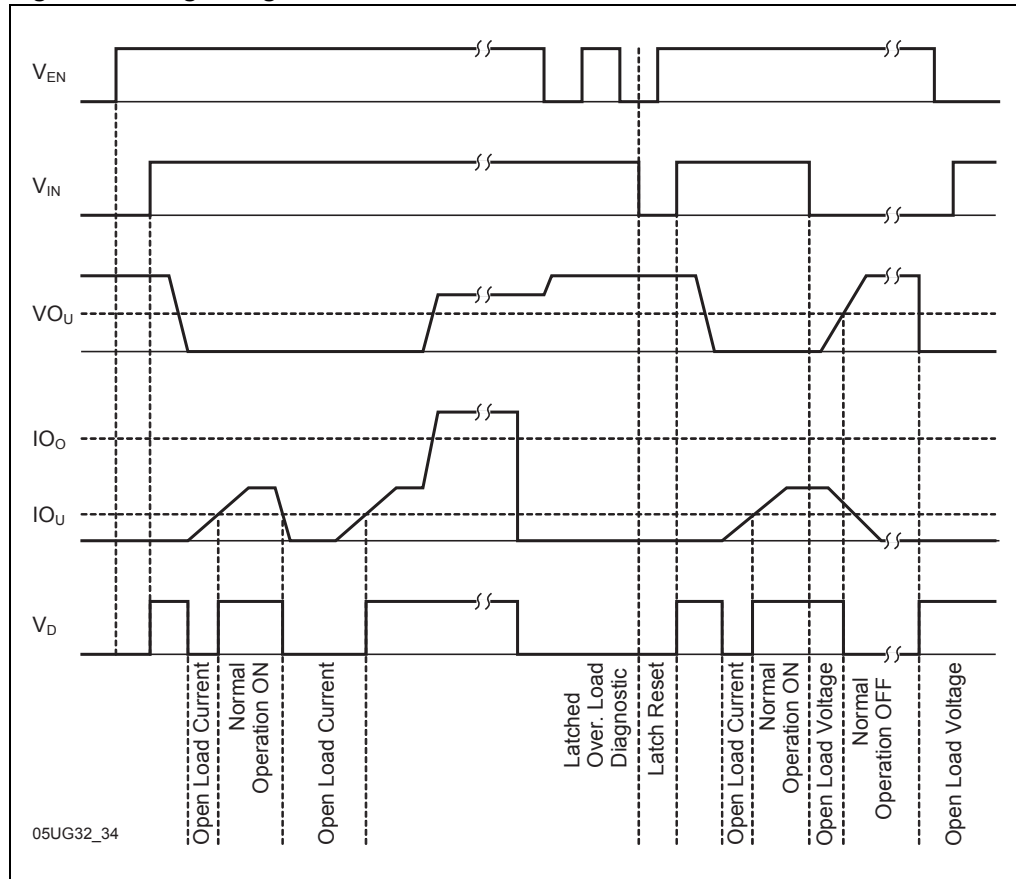


Figure 7. Logic diagram

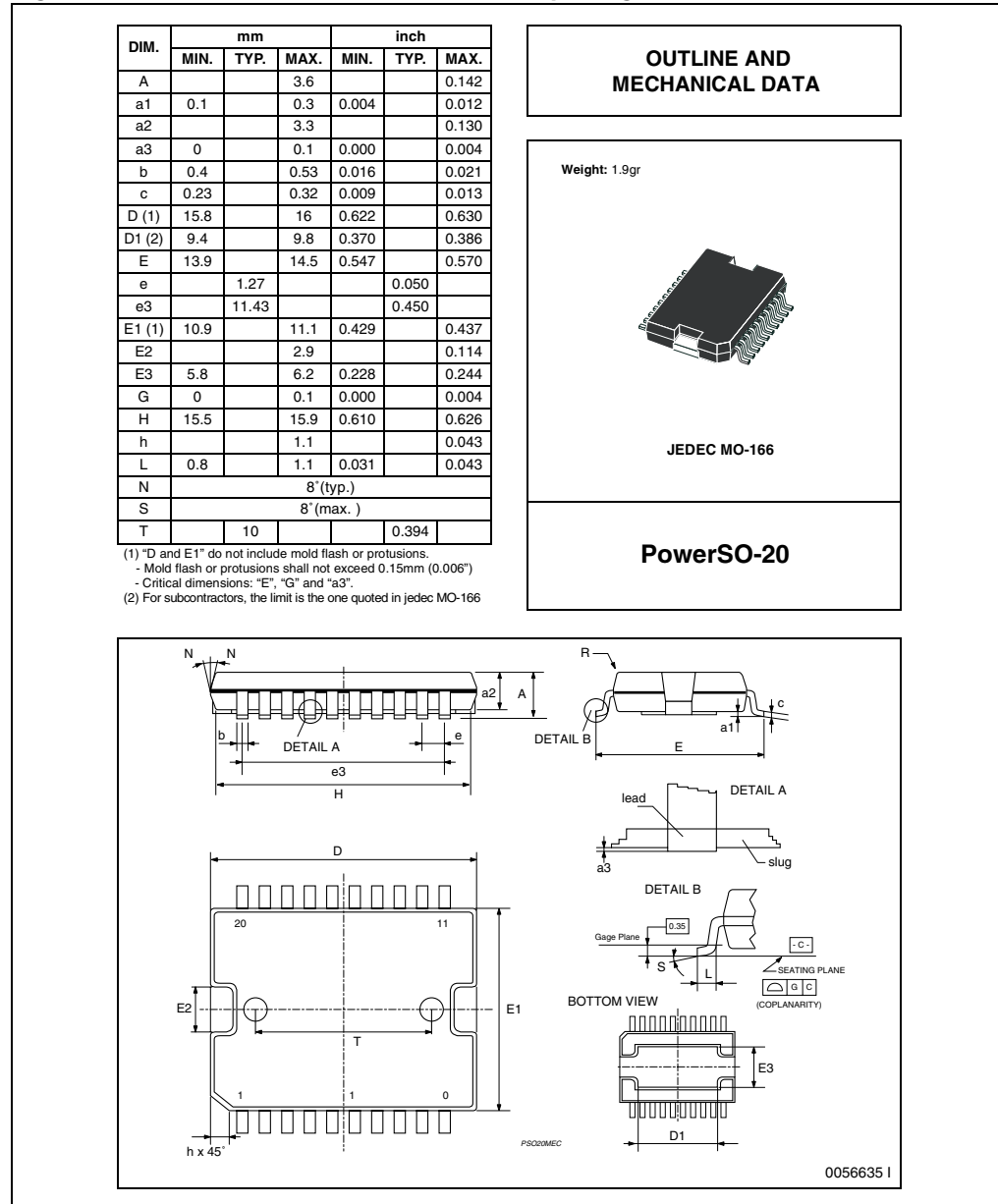


## 6 Package information

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. PowerSO-20 mechanical data and package dimensions**



## 7 Revision history

Table 9. Document revision history

Date	Revision	Changes
14-Feb-2008	1	Initial release.
28-Mar-2008	2	Updated the $I_{OLE}$ , $I_{DLE}$ and $t_{off}$ - $t_{on}$ parameters on <a href="#">Table 7: Electrical characteristics</a> .



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