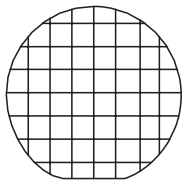
# L9332

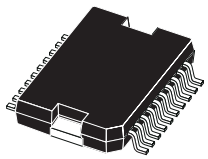
## Quad intelligent power low side switch

## Features

- Quad power low side driver with 3 A output current capability
- Low $R_{DSON}$ typically 200 mΩ and 300 mΩ @ $T_j$ = 25 °C
- Internal output clamping structures with $V_{FB}$ = 50 V for fast inductive load current re circulation
- Limited output voltage slew rate for low EMI
- Protected µP 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



Die



PowerSO-20

## 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 µP 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[1] | PowerSO-20 | Tube |
| L9332-DIE1 | Die | – |

1. Only for evaluation.

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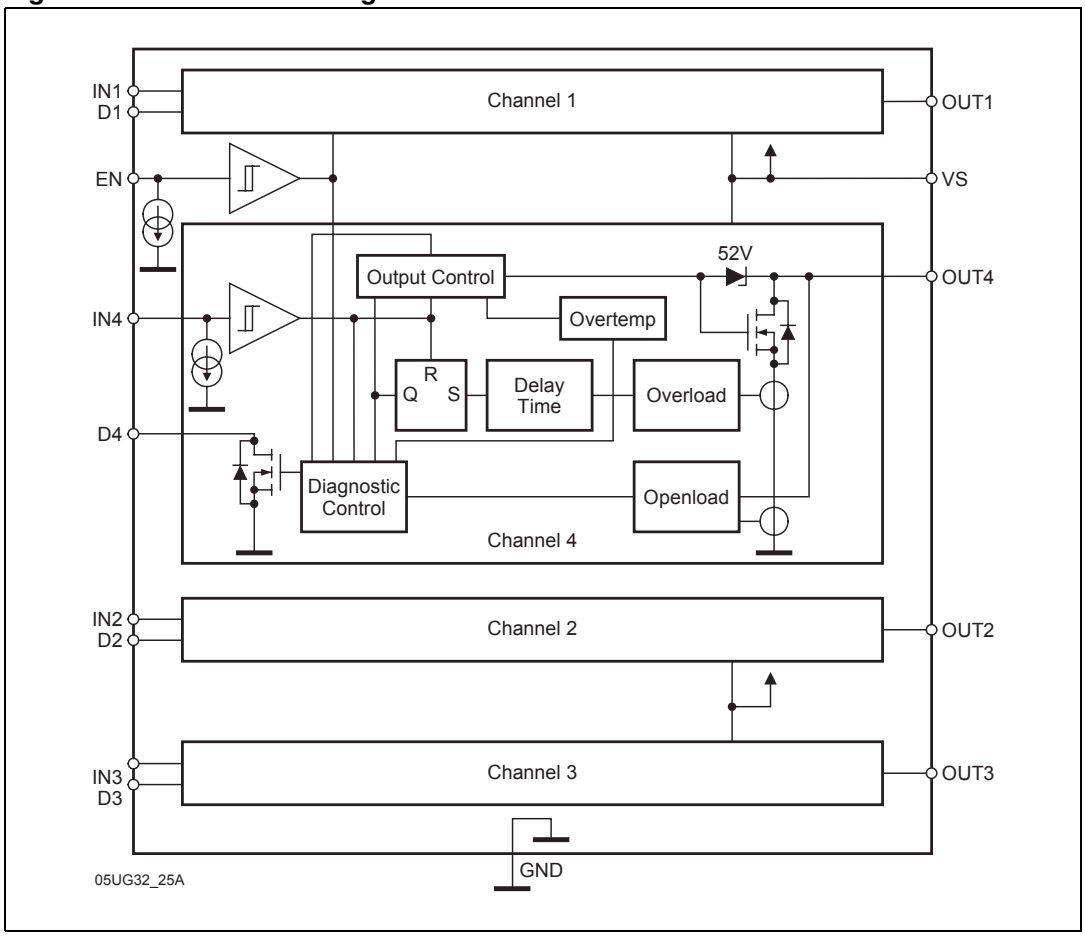
# 1 Block diagram

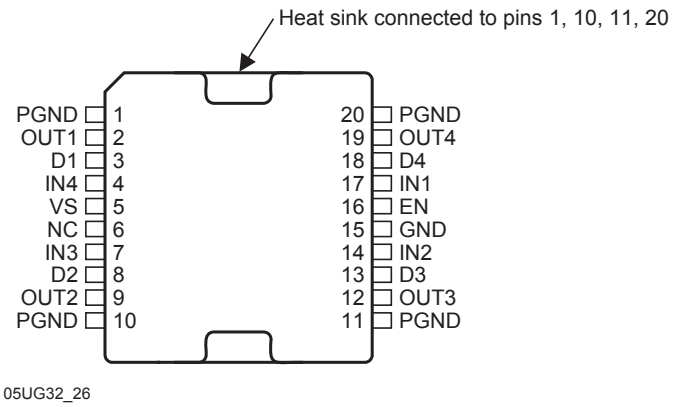
## 1.1 Block diagram

**Figure 1. Block circuit diagram**



# 2 Pin description

**Figure 2. Pin connection (top view)**




PowerSO-20 package (only for engineering samples)

**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**

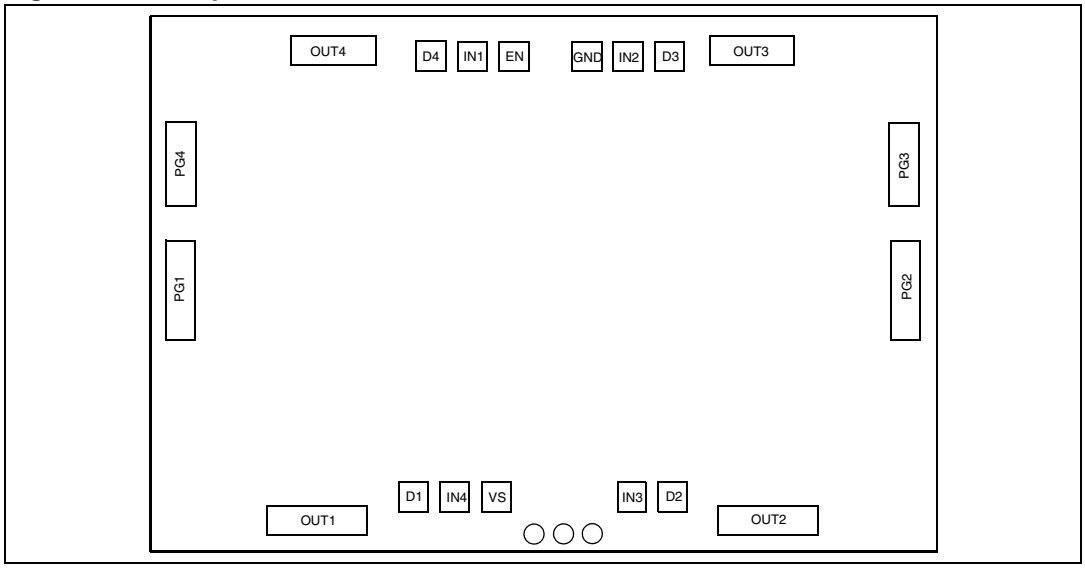



**Table 3. Pad coordinates**

| 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/µs |
| $V_{IN, EN}$ | Input voltage | $\|I\|$ 10 mA | -1.5 to 6 | V |
| $V_D$ | Diagnostic DC output voltage | $\|I\|$ 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 µs | 50 | mJ |
| $E_{O3, 4}$ | | T = 5ms | 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 ≤ $T_{j1}$ ≤ 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. | |
| **Supply** | | | | | | |
| $I_{VS}$ | DC supply current off | | | 5 | 15 | mA |
| $V_{RES}$ | Reset Voltage | | 1.5 | | 4.5 | V |
| **Outputs Out 1 - 4** | | | | | | |
| $V_Z$ | Z-diode clamping voltage | $I_{OCL}$ ≥ 200 mA | 45 | | 60 | V |
| $R_{DSON\ 1,\ 2}$ | Output on resistance | $T_j$ = 25 °C<br>$T_j$ = 150 °C<br>$T_j$ = 175 °C | | 200 | 300<br>500<br>600 | mΩ |
| $R_{DSON\ 3,\ 4}$ | | $T_j$ = 25 °C<br>$T_j$ = 150 °C<br>$T_j$ = 175 °C | | 300 | 450<br>750<br>900 | mΩ |
| $I_{OLE}$ | Output leakage | $T_j$ = 140 °C<br>$V_{out}$ = 20 V | | | 3 | µA |
| | | -40 °C < $T_j$ ≤ 175 °C<br>$V_{out}$ = 20 V | | | 36 | µA |
| | | $T_j$ = 140 °C<br>$V_S$ = 32 V; $V_{out}$ = 4 V | -50 | | -5 | µA |
| | | $T_j$ = 140 °C<br>$V_S$ = 8 V; $V_{out}$ = 4 V | -5 | | 2.5 | µA |
| | | -40 °C < $T_j$ ≤ 175 °C<br>$V_S$ = 8 V; $V_{out}$ = 4 V | | | 25 | µA |
| S | Output slope | Io = 1 A; *Figure 5* | 0.5 | | 4 | V/µs |
| **Inputs IN1-4, EN** | | | | | | |
| $V_{IN,EN\ L}$ | 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 | µA |
| $I_{EN}$ | Enable sink current | | 5 | 20 | 40 | µA |

**Table 7. Electrical characteristics (continued)**

| Symbol | Parameter | Test conditions | Values $T_{j1}$ | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| **Protection and diagnostic functions** | | | | | | |
| $V_{OUV}$ | 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 | $V_{EN} = V_{IN} = 2$ V; $V_S = 6.5$ to 16 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 |
| $T_{sd\text{-}hys}$ | 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 |
| **Diagnostic outputs D1 - D4** | | | | | | |
| $V_{DL}$ | Diagnostic output low voltage | $I_D \leq 2$ mA | | | 1.0 | V |
| $R_{Don}$ | Output resistor | | 50 | | 500 | Ω |
| $I_{DLE}$ | Diagnostic output leakage current | $T_j = 140$ °C $V_D = 14$ V | | 0.1 | 2 | µA |
| | | -40 °C < $T_j \leq 175$ °C $V_D = 14$ V | | | 10 | µA |
| $I_{DCL}$ | Diagnostic output current limitation | | 2 | 28 | 50 | mA |
| **Timing** | | | | | | |
| $t_{ON}$ | Output delay on time | (2) *Figure 5* | 1 | | 25 | µs |
| $t_{OFF}$ | Output delay off time | *Figure 5* | 10 | | 50 | µs |
| $t_{off}$-$t_{on}$ | Delta off on time (channel 1 +2) | < 150 °C | 10 | | 30 | µs |
| | | > 150 °C | 20 | | 40 | µs |
| | Delta off on time (channel 3 +4) | -40 °C < $T_j \leq 175$ °C | 10 | | 30 | µs |
| $t_D$ | Diagnostic delay time | (2) *Figure 5* & *6* | 4 | | 50 | µs |

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

## 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<br>H | X<br>L | off | H | no | |
| Open load on | $I_{Omin} < 30$ mA | H | H | on | L | no | |
| Overtemperature | $T_{jtyp} < 205$ °C | X | X | off | L | $t_D$ | IN=low |
| Over load | $I_{Omin} > 3$ A | H | H | off | L | $t_D$ | IN= low |
| SGND or PGND loss | channel off | X<br>L | L<br>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 alowed 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°C of the output will be reset if the junction temperature decreases about 20 °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**

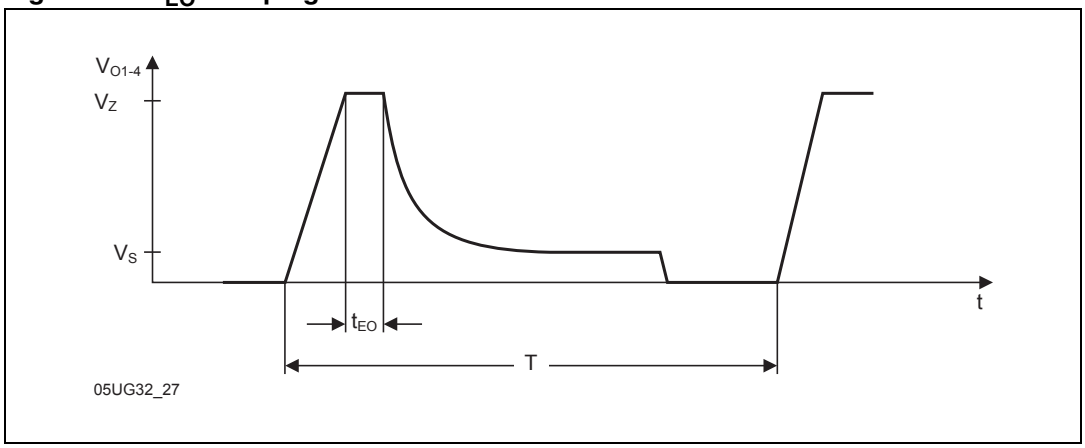


**Figure 5. Output slope (resistive load for testing)**

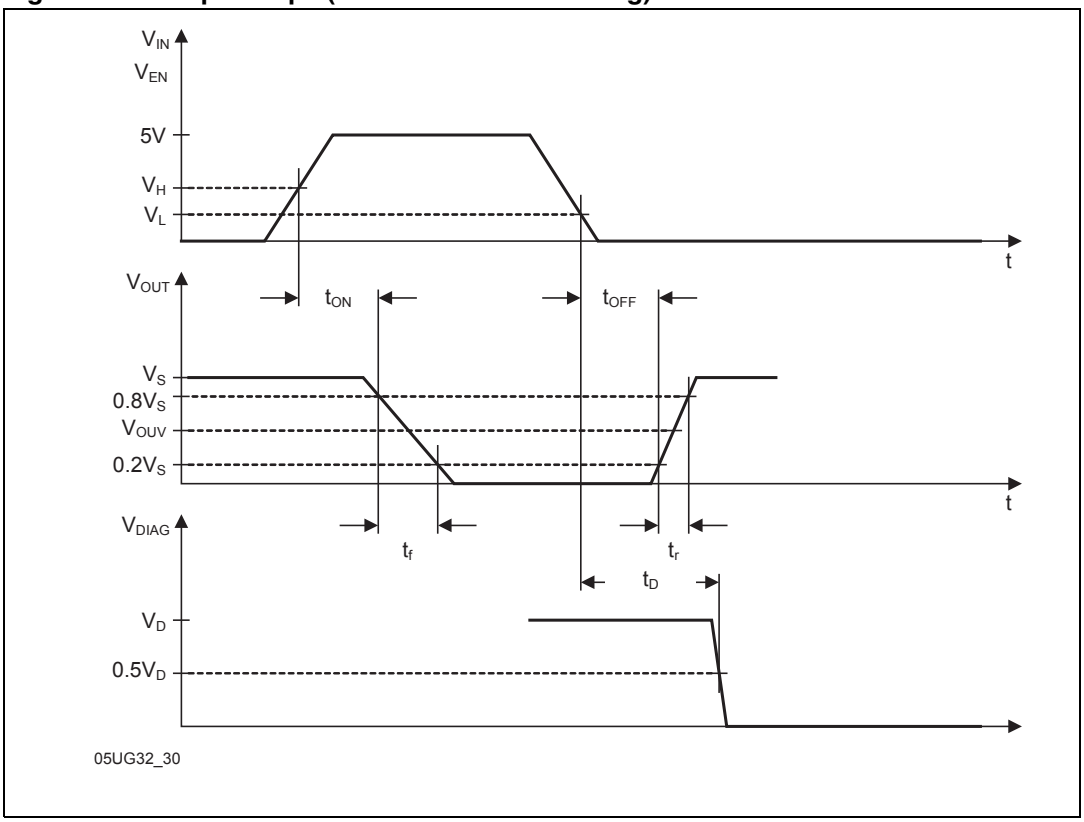



**Figure 6. Timing ($t_{DOL}$, $t_{DIOU}$)**

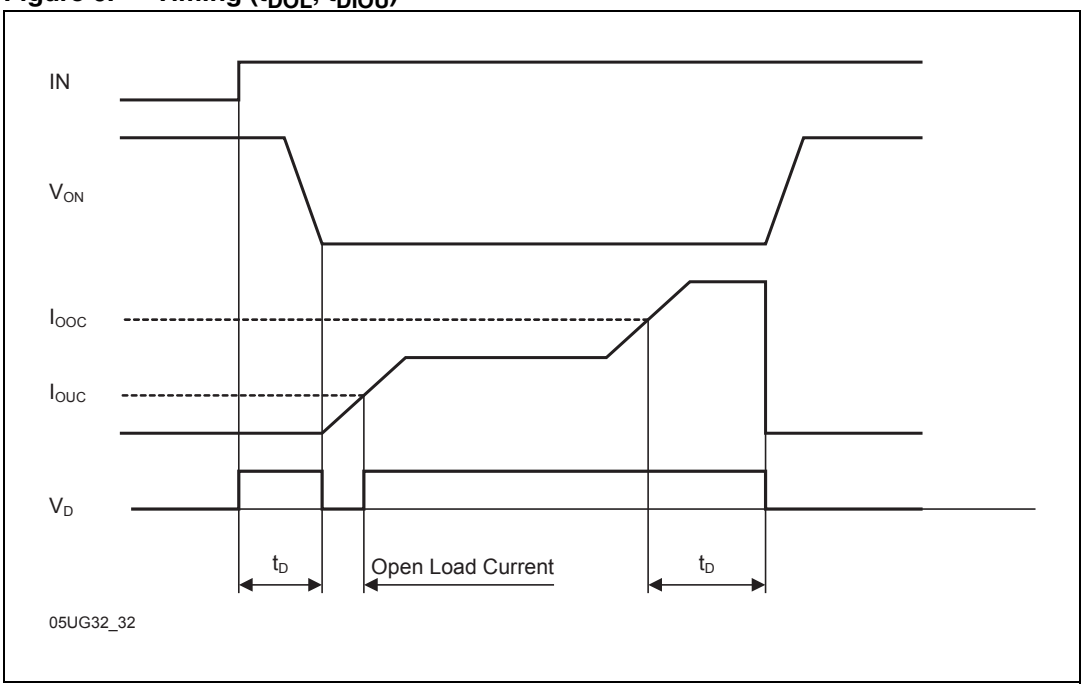
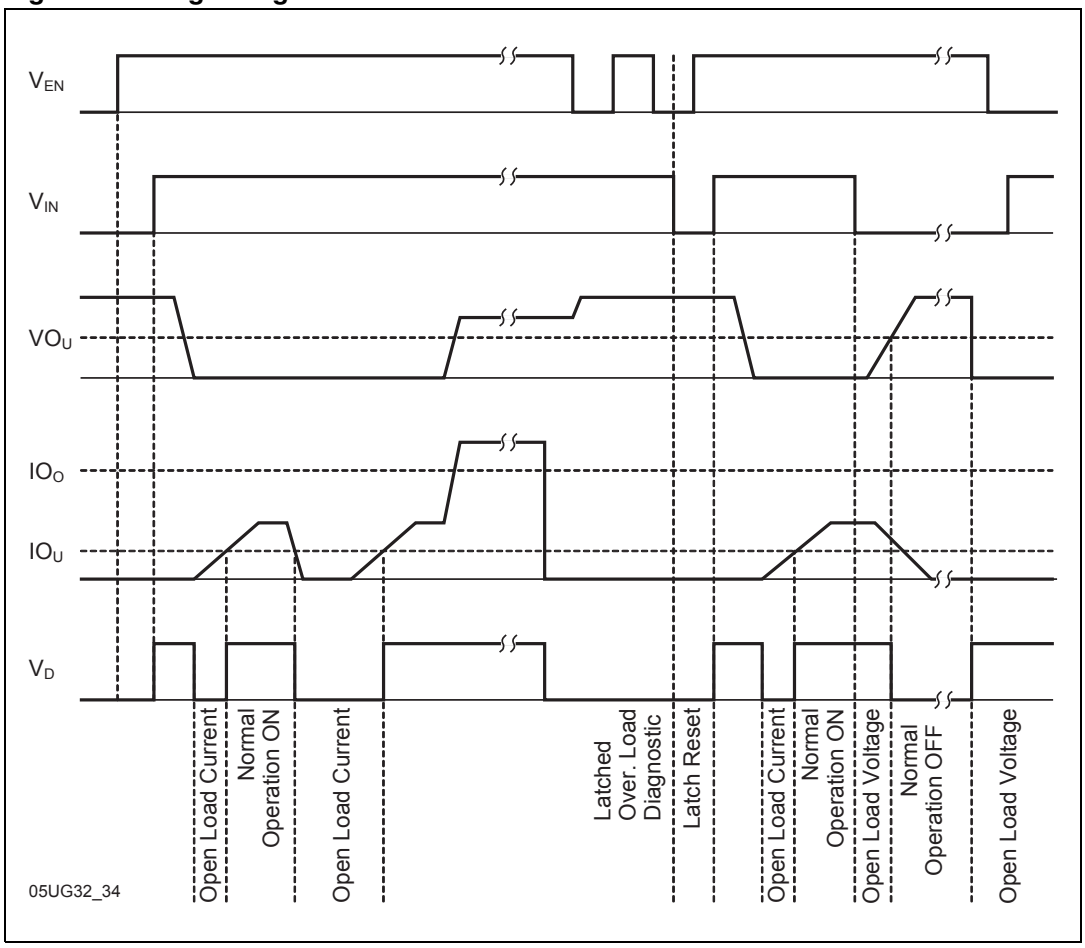


**Figure 7. Logic diagram**



# 6 Package information

In order to meet environmental requirements, ST (also) offers these devices in ECOPACK® packages. ECOPACK® 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.

**Figure 8. PowerSO-20 mechanical data and package dimensions**

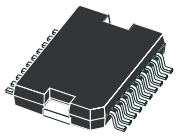
| DIM. | mm | | | inch | | |
|---|---|---|---|---|---|---|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | | | 3.6 | | | 0.142 |
| a1 | 0.1 | | 0.3 | 0.004 | | 0.012 |
| a2 | | | 3.3 | | | 0.130 |
| a3 | 0 | | 0.1 | 0.000 | | 0.004 |
| b | 0.4 | | 0.53 | 0.016 | | 0.021 |
| c | 0.23 | | 0.32 | 0.009 | | 0.013 |
| D (1) | 15.8 | | 16 | 0.622 | | 0.630 |
| D1 (2) | 9.4 | | 9.8 | 0.370 | | 0.386 |
| E | 13.9 | | 14.5 | 0.547 | | 0.570 |
| e | | 1.27 | | | 0.050 | |
| e3 | | 11.43 | | | 0.450 | |
| E1 (1) | 10.9 | | 11.1 | 0.429 | | 0.437 |
| E2 | | | 2.9 | | | 0.114 |
| E3 | 5.8 | | 6.2 | 0.228 | | 0.244 |
| G | 0 | | 0.1 | 0.000 | | 0.004 |
| H | 15.5 | | 15.9 | 0.610 | | 0.626 |
| h | | | 1.1 | | | 0.043 |
| L | 0.8 | | 1.1 | 0.031 | | 0.043 |
| N | 8˚(typ.) | | | | | |
| S | 8˚(max. ) | | | | | |
| T | | 10 | | | 0.394 | |

(1) "D and E1" do not include mold flash or protusions.
- Mold flash or protusions shall not exceed 0.15mm (0.006")
- Critical dimensions: "E", "G" and "a3".

(2) For subcontractors, the limit is the one quoted in jedec MO-166

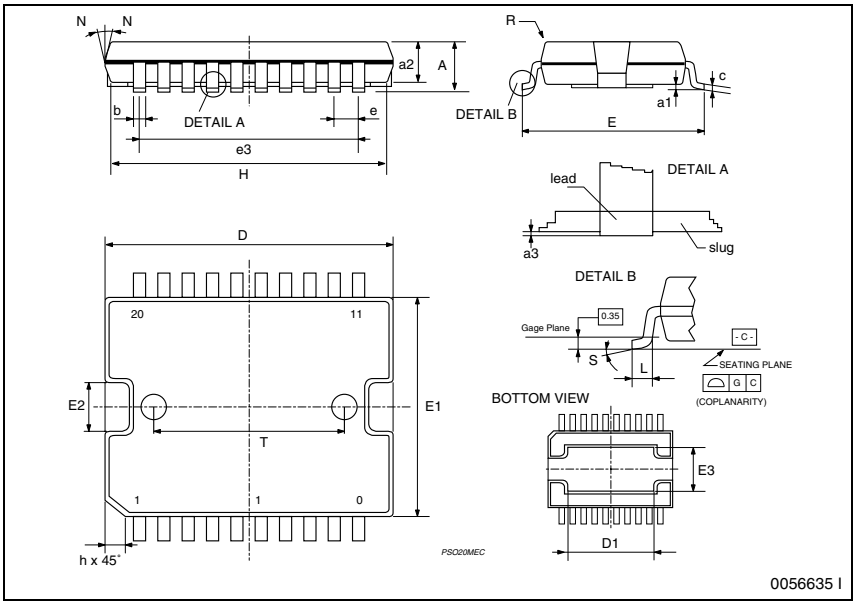
**OUTLINE AND MECHANICAL DATA**

**Weight:** 1.9gr



**JEDEC MO-166**

**PowerSO-20**



# 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 *Table 7: Electrical characteristics*. |

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